Specification

SERCOS interface

Version 2.10 (Update 05.2007)

Project: **SERCOS interface 16 Mbit/s**
Document Type **Specification**
File: **sercos16v2_10en-SI.doc**

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Published by

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History:

sercos16v2_6en-2005-07-14.doc
1. Cross references as link (some cross references have been without link)
2. Missing cross references have been inserted in annexe C (IDN-description).
3. All changes have been accepted of Word.
4. Programme shedules (contents, charts, pictures) have been drawn up newly.
5. Spelling of Hex-numbers have been changed standarized (0xnnn).
6. Some shortenings have been deleted (chapter 3).
7. Some formattings of chapter 13 have been changed.

sercos16v2_7en-2005-07-14.doc
1. Operation mode interpolation (new)
2. Operation mode positioning (new)
3. Electronic gearing is deleted (S-0-0231 to S-0-0253 and S-0-0350 to S-0-0355)
4. Auxiliary interpolation position value (S-0-0056) is deleted

sercos16v2_8en-2005-08-23.doc
1. all modifications of V2_7 accepted.
2. Version for IGS and TWG

sercos16v2_9en-2005-11-01.doc
1. Extended data container inserted
2. S-0-0147 expanded with limit switch and positive stop
3. Set absolute Position (S-0-0447/0448) (not yet inserted)
4. S-0-0014 Bit12,13 reserved for S III, Bit14: FIBBR
5. S-0-0012 Bit 12, Communication warning
6. Version for SI and TWG

sercos16v2_10en
1. Set absolute position Clause 14.6.3 and S-0-0447/0448 inserted
2. S-0-0099: better description
3. SVC error codes reserved for control unit
4. Error handling: ADR checking added
5. Drive status: Bit 4 defined for PL1 and PL2
6. SVC: new Error code 0x700D invalid floating point number
7. Expanded operation modes (S-0-0520/0521 Axis control/Status inserted)

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1 Scope

This Specification defines a real-time optical serial interface between the control unit and its associate drives, which is utilized to transmit cyclic and non-cyclic data.

This interface is intended to apply to industrial machines, such as machine tools, with multiple drives and can be operated in torque, velocity, or position interface operation modes.

NOTE – In this specification, SERCOS interface refers to this serial data link for real-time communication between controls and drives.

2 Normative references

IEC 60874-2: 1993, *Connectors for optical fibres and cables – Part 2: Sectional specification for fibre optic connector – Type F-SMA*

ISO/IEC 646:1991, *Information technology – ISO 7-bit coded character set for information interchange*

ISO/IEC 3309: 1993, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – Frame structure*

ISO/IEC 7498-1: 1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

ISO/IEC 7776: 1995, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – Description of the X.25 LAPB-compatible DTE data link procedures*

IEC 61508: *Functional safety of electrical, electronic and programmable electronic safety-related systems*

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this Specification, the following terms and definitions apply.

3.1.1 access procedure*: procedure by which one station gains access to the network and transmits data***.**

3.1.2 attenuation: *fact that the optical power at the receiver is less than at the transmitter.*

3.1.3 bit stuffing: *procedure by which after five logical '1's, the transmitter automatically inserts a zero which is then removed again by the receiver. This zero causes a change in signal edges which makes it possible for the receiver to retrieve a receiving clock.*
Note: Adapted from ISO/IEC 3309.

3.1.4 broadcast*: Transmission to all devices in a network without any acknowledgment by the receivers.*

3.1.5 coded character set; code: *Set of unambiguous rules that establishes a character set and one-to-one relationship between the characters of the set and their representation by one or more bit combinations.*

3.1.6 communication cycle: *Accumulation of all telegrams between two master synchronization telegrams.*

3.1.7 control word: *Two adjacent bytes inside the master data telegram containing commands for the addressed drive.*

3.1.8 cycle time: *Time span between two consecutive cyclically recurring events.*

3.1.9 cyclic communication: *The periodic exchange of telegrams***.**

3.1.10 cyclic data: *The part of the telegram which does not change its meaning during cyclic operation of the interface.*

3.1.11 cyclic operation: *Devices in the communication network are addressed and queried one after the other at fixed, constant time intervals***.**

3.1.12 data exchange - demand dependent; non cyclic transmission (service channel): *Transmission of information after a request was sent by the master***.**

3.1.13 drive enable: *Command to close the feedback loop(s).*

3.1.14 drive on: *Command that the power stage can be activated.*

3.1.15 drive (amplifier) telegram (AT): *Telegram sent by the drive (slave).*

3.1.16 F-SMA connector: *Connector meeting the F-SMA standard in accordance with IEC 60874-2.*

3.1.17 feedback: *Measured process values.*

3.1.18 feedforward: *Command value used to compensate the lag in the control loop.*

3.1.19 fibre optic cable: *Transmission medium for serial data transmission of optical signals.*

3.1.20 fill signals: *Sequence of seven '1's followed by a '0'.*

3.1.21 frame check sequence (FCS): *Check character sequence consists of 16 bits which is generated by means of a cyclic redundancy check (CRC) character polynomial in accordance with the ITU-T X.25. [See ISO/IEC 3309 and ISO 7776].*

3.1.22 identification number (IDN): *Designation of operating data under which a data block is preserved with its attribute, name, unit, minimum and maximum input values, and the data.*

3.1.23 SERCOS interface: *SEriell Real time COmmunication System interface.*

3.1.24 ISO/OSI reference model: *Communication layers which are architecture guidelines for defining communication protocols [see ISO/IEC 7498]*

3.1.25 machine zero point: *Machine related point (in each axis) to which all position data are referred.*

3.1.26 master data telegram (MDT): *Telegram transmitted by the master sending data to the slave(s) in a single ring.*

3.1.27 master synchronization telegram (MST): *Telegram transmitted by the master, which sends a time synchronization signal to the slave(s) in a single ring.*

3.1.28 master: *Station which assigns the other stations in the ring (i.e., slaves) the right to transmit.*

3.1.29 non-cyclic transmission: *Non-periodic exchange of data at the request of the master.*

3.1.30 no return to zero inverted (NRZI) (coding of data): *Signal exchanges taking place only at regular, fixed points in time in synchronization with the transmitting clock pulse of the bit rate. A signal edge change is assigned to a logical 0 only.*

3.1.31 operating cycle: *Period of the control loop within the drive or the control unit.*

3.1.32 phase locked loop [digital] (DPLL): *Circuit which retrieves the receiving clock from the received data stream.*

3.1.33 physical layer (bit transmission layer): *First layer of the ISO-OSI reference model layers in which the bit transmission is defined.*

3.1.34 protocol: *Convention about the data formats, time sequences, and error correction in the data exchange of communication systems.*

3.1.35 recovery of clock: *Sufficiently frequent alternation of the signal, which makes it possible for the receiver to retrieve the receiving clock from the data stream with the help of the phase locked loop.*

3.1.36 reference point: *Feedback–system related point (in each axis) to which the feedback and command values are referred to after a homing procedure.*

3.1.37 repeater function: *Telegram that has been received is passed on reclocked and logically unchanged to the next station on the ring.*

3.1.38 ring structure: *Network topology in which the transmission medium is routed from station to station in the form of a ring. The information is transmitted only in one direction.*

3.1.39 scaling data: *Data which determines the weight of the transferred operation data.*

3.1.40 slave: *Device in the ring which is assigned the right to transmit by the master.*

3.1.41 status word: *Two adjacent bytes inside the drive telegram containing status information.*

3.1.42 (telegram) address field: *Address field (eight bits) containing the address of the device.*

3.1.43 telegram: *Message.*

3.1.44 (telegram) delimiter: *Beginning and ending identifiers of a telegram (eight bits: 01111110).*

3.1.45 topology: *Physical network architecture with respect to the connection between the stations of the communication system.*

3.1.46 transmission medium: *Collective term for the real form of the physical connection between the stations of a communication network. For instance, fibre optic cable.*

3.1.47 zero bit stream: *Consists exclusively of logical zeros which, in NRZI coding, results in a regular signal edge change on the transmission line (only used in test mode).*

3.2 Abbreviations

For the purpose of this specification, the following abbreviations apply:

3.2.1 ADR: *address of a telegram. Drive address is XX* [$1 \leq XX \leq 254$]

3.2.2 AHS: *service transport handshake of the drive*

3.2.3 AT: *drive (amplifier) telegram*

3.2.4 $\mathbf{AT_m}$**:** *drive (amplifier) telegram from drive XX which is assigned to data record m*

3.2.5 BOF: *begin of frame*

3.2.6 C1D: *class 1 diagnostic*

3.2.7 C2D: *class 2 diagnostic*

3.2.8 C3D: *class 3 diagnostic*

3.2.9 CP: *communication phase*

3.2.10 CRC: *cyclic redundancy check*

3.2.11 DAT: *duration of drive telegram*

3.2.12 DMDT: *duration of master data telegram*

3.2.13 DMST: *duration of master sync telegram*

3.2.14 DPLL: *digital phase locked loop*

3.2.15 EOF: *end of frame*

3.2.16 FCS: *frame check sequence*

3.2.17 HCS: *Hard clad silica (glass fibre)*

3.2.18 HS: *handshake (see AHS and MHS)*

3.2.19 IDLE: *data transmission interrupted*

3.2.20 IDN: *identification number*

3.2.21 i: *sequence of different rings on one control unit, labelled as i = 1...I*

3.2.22 I: *number of rings on one control unit*

3.2.23 INFO: *information*

3.2.24 IPOSYNC: *synchronization for drive interpolator*

3.2.25 **K:** *number of data records in the MDT (see also M)*

3.2.26 **k:** *time sequence of data records in the MDT, labelled as k= 1 ... K*

3.2.27 **LED:** *light emitting diode*

3.2.28 **LSB:** *least significant bit*

3.2.29 **M:** *number of drives in one ring (see also K)*

3.2.30 **m:** *time sequence of the ATs, labelled as m = 1 ... M*

3.2.31 **MDT:** *master data telegram*

3.2.32 **MHS:** *service transport handshake of the master*

3.2.33 **MSB:** *most significant bit*

3.2.34 **MST:** *master sync telegram*

3.2.35 **n:** velocity

3.2.36 **n_{min}:** *shut-off velocity in the drive after C1D error*

3.2.37 **n_x:** *velocity threshold*

3.2.38 **NC:** *numerical control (also control unit or controller)*

3.2.39 **NRZI:** *no return to zero inverted*

3.2.40 **OSI:** *open system interconnection*

3.2.41 **P:** *power*

3.2.42 **P_x:** *power threshold*

3.2.43 **POF:** *Polymere optical fibre (plastic fibre)*

3.2.44 **RxCLK:** *receiving clock*

3.2.45 **RxD:** *received data*

3.2.46 **SLKN:** *slave identification parameter, slave arrangement*

3.2.47 **T:** *torque*

3.2.48 **T_{limit}:** *limit value for the torque*

3.2.49 **T_x:** *threshold torque*

3.2.50 **t_1:** *AT transmission starting time*

3.2.51 **$t_{1.m}$:** *AT transmission starting time with data record m of drive XX*

3.2.52 **$t_{1min.m}$:** *shortest AT transmission starting time with data record m of drive XX after receiving the MST*

3.2.53 **t_{1min}:** *shortest AT transmission starting time*

3.2.54 **t_2:** *MDT transmission starting time*

3.2.55 **t_3:** *command value valid time*

3.2.56 **t_4:** *feedback acquisition capture point*

3.2.57 **t_5:** *minimum feedback processing time*

3.2.58 **$t_{5.m}$:** *the minimum time which drive XX with data record m needs to process its captured feedback value for the next AT*

3.2.59 **t_{ATAT}:** *transmit to transmit recovery time in a slave with several drives*

3.2.60 **t_{ATMT}:** *transmit/receive transmission time*

3.2.61 **$t_{ATMT.M}$:** *transmit/receive transmission time which drive M needs between transmitting its AT and being prepared for receiving an MDT*

3.2.62 **t_{MTSG}:** *command value processing time*

3.2.63 **$t_{MTSG.K}$:** *time required by the slave which is served by the last data record(s) in the MDT to make the command values available for that drive XX which is assigned to data record K*

3.2.64 **t_{MTSY}:** *receive to receive recovery time in a slave*

3.2.65 **$t_{MTSY.K}$:** *recovery time of the last slave after the reception of an MDT to switch over for receiving the next MST (the last slave is the one which is served with data record K)*

3.2.66 **t_{Ncyc}:** *control unit cycle time*

3.2.67 **t_{Rcyc}:** *drive control loop cycle time*

3.2.68 **t_{Scyc}:** *communication cycle time*

3.2.69 **TxCLK:** *transmitting clock*

3.2.70 **TxD:** *transmitted data*

3.2.71 **XX:** *address of a drive*

3.2.72 **$(1\ 0\ 0\ \ldots)_B$:** *binary digits*

3.2.73 **0xhh...(h = 0 to 9, A to F):** *hexadecimal digits*

NOTE – Unassigned digits are decimal.

4 General requirements

4.1 Overview

The SERCOS interface uses optical data transmission between control units and drives. As a result, interference is eliminated.

The exact number of drives which can be serviced per ring depends on the cycle time, the selected data volume, and the transmission rate. The number of drives per control unit can also be expanded by using more fibre optic rings. The following details (see Table 1) are valid under normal operating conditions.

Number of drives per ring (examples)

Table 1 - Number of drives per ring (examples)

Cycle time	Data record per drive (MDT + AT)	Transmission rate	Number of drives	Data rate (non-cyclic Data)	Spare time
2 ms	32 Byte	2 Mbit/s	8	8 kbit/s (2 bytes)	390µs
1 ms	32 Byte	4 Mbit/s	8	16 kbit/s (2 bytes)	125µs
1 ms	36 Byte	8 Mbit/s	15	32 kbit/s (4 bytes)	208µs
0,5 ms	36 Byte	16 Mbit/s	14	128 kbit/s (8 bytes)	113µs
2 ms	Standard Telegram 2,3,4 (16 Byte)	16 Mbit/s	112	8 kbit/s (2 bytes)	330µs

The SERCOS interface specification standardizes the formats and scaling factors for operation data exchange between control units and drives. During initialization, the operation of the interface is configured according to the performance characteristics of the control unit and the drives. Therefore, the velocity and/or position control is implemented by either the drive or the control unit. Due to the flexibility of data message formats, other control structures and operating modes besides the ones presently used are now possible.

The control unit is capable of synchronizing all connected drives by way of cyclic data exchange for command and feedback values, including exact equidistant timing and synchronization of gated measurements and command values. Communication cycle times may be selected between 62 µs, 125 µs, 250 µs or any integer multiple of 250 µs.

In addition, the control panel of the control unit can be used to display and input drive-specific data, parameters and diagnostic information which are available via an asynchronous service channel and standardized data records.

Command and feedback values in short or long words can be transmitted between the control unit and each drive in both directions. Optional data (e.g., parameters, diagnostic texts) are transmitted in segments during every cycle. This data can be requested individually by the control unit. Errors in command and feedback values are corrected automatically through cyclic communication. The last valid command and feedback values are used until the next cycle. Two consecutive erroneous transmissions will cause the drives to halt.

4.2 System overview

This subclause provides information about the fundamental technical characteristics of the SERCOS interface, without establishing specific definitions. For the reader who is unfamiliar with this interface, this subclause will serve as a preface to the specific details which follow in later clauses.

NOTE – The user of this specification, who is already familiar with the fundamental characteristics of this interface may skip this subclause and continue with the specifics in clause 5.

With the SERCOS interface, a control unit can serve one or several ring structures, depending on the requirements. One example is shown in Figure 1.

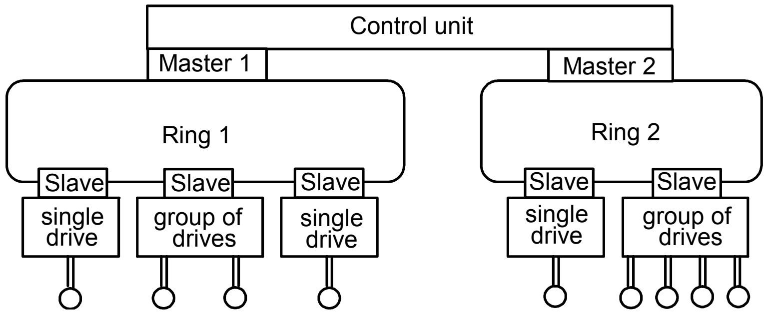


Figure 1 - Topology overview

The connection of the control unit on a ring is called a master. This master directs and controls any communication within one ring.

A slave is the connection between one or more drives and the ring. As shown in Figure 1, a group of drives such as several feed drives can be clustered and tied into the ring through a single connection. Individual participants are connected to each other via transmission segments which consist of fibre optics made of plastic or glass and standardized connectors.

The information exchanged in such a ring depends greatly on the distribution of tasks between the control unit and the drives. Direct exchange of information takes place only between the control unit and the drives and not among the drives themselves.

4.2.1 Operating modes

In a machine, several drives perform tasks which are coordinated by the control unit. Figure 2 shows only one of several drives. The coordinated command values are shown on the left side of Figure 2. In the current control structures, the closed control loops for torque, velocity, and position are cascaded. This example shows a cascaded structure where all relevant time constants decrease for underlying control circuits (at least by a factor of two to four).

The SERCOS interface is capable of handling all the operating modes shown in Figure 2, including:

a) only torque control in the drives;

b) velocity and torque control in the drives;

c) all closed control loops, including position control in the drives.

d) drive controlled interpolation and positioning

NOTE – Velocity and torque control in the drives [b) above] corresponds to the concept of commonly used analogue interfaces.

For torque control, typical cycle times of 250 µs can be achieved by using microcomputers to control the motor torque. Whether or not torque command values can be transmitted via an interface with the same cycle time depends on the ability of the control unit to generate new command values every 250 µs. Such a short cycle time creates quite a load for the SERCOS interface. A ring with such a short cycle time can only support a few drives. In this case, it may be necessary to implement several rings (see Figure 1).

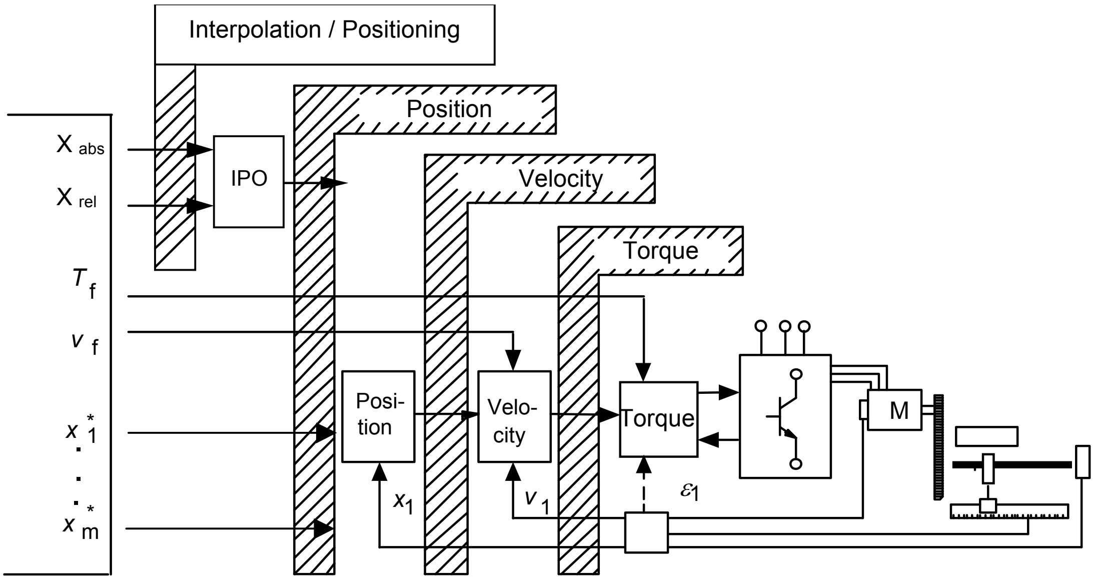


Figure 2 - Operation modes

A contouring control system with good dynamic properties and with minimum following distance can be created. The control unit can generate coordinated commands for position, velocity, and torque for all axes based on a dynamic path model. Since with digital data transmission there is practically no limitation of resolution, it is possible to put all closed control loops inside the drives. In this configuration both position command values as well as feedforward signals for velocity and torque can be transmitted by the control unit.

Where desired, different operating modes can be applied to different axes. In addition, each axis can have a main operating mode and several secondary operating modes, which the control unit can toggle during operation.

Drives which are equipped with a SERCOS interface do not need to be capable of all the operating modes mentioned above. The only requirement is to adequately document the particular mode of operation (or variation thereof) and the subset of variables and parameters supported by the appropriate components (see clause 13 for communication classes and the defined profiles for drives and machine applications).

4.2.2 Transmission modes

The SERCOS interface allows for synchronization during cyclic data transmission. This means that the operating cycle of the control unit can be synchronized with the communication cycle and operating cycle of the drive so that beats between individual cycles can be prevented and the dead times in the control loops can be reduced to a minimum. It also implies that new command signals become active concurrently in all drives and that all drives take measurements at the same time, so that they can be sent back to the control unit as feedback values. This requires that the transmission cycles are strictly equidistant.

The data in the control loops need to be precise and punctual. Untimely data are of no value. When a transmission error is discovered, the communication cycle continues and the old data or an estimated value may be used for one communication cycle. To repeat the transmission with old data (for the purpose of correcting the error) is meaningless, since during the next communication cycle (e.g., 1 ms later), new command data will be transmitted. In the event of repeated transmission errors, a predetermined reaction, such as halting the system, shall ensue.

The non-cyclic transmission mode does not have to fulfill strict real-time requirements. The correctness of the data is acknowledged or is secured by repeating the transmission.

4.2.3 Data contents

Annexes A and B contain a comprehensive list of transmittable data (as well as procedure commands) which are predetermined in the SERCOS interface. This is where the reader will find a description of individual data. In this subclause an overview is presented, organized according to the mode of transmission (cyclic/non-cyclic) and the mode of operation. Table 2 shows data that are typically transmitted cyclically (which means fast and synchronous).

During a communication cycle, one control word is sent from the control unit to each drive and a status word is sent back from each drive to the control unit. Configurable operation data can be transmitted bidirectionally between the control unit and each drive cyclically. Table 2 gives some typical representations. The three operating modes are shown with command and feedback values.

Table 2 - Typical operation data for cyclic transmission

	Position data	Velocity data	Torque data
Control unit to drive	Control word		
	Position command value Additive position command value	Velocity command value Additive velocity command value	Torque command value Additive torque command value
Drive to control unit	Status word		
	Position feedback value 1 Position feedback value 2	Velocity feedback value	Torque feedback value

Both the control word and the status word are organized into a drive-related and a transmit-related part. Non-cyclic transmissions are controlled by means of the transmit-related part (control/acknowledge steps). Each control and status word reserves two additional real-time bits for cyclic transmission.

The drive-related part of the control word contains the desired modes of operation. This part is also used to transmit the commands for 'drive on' and 'drive enable'. The drive-related part of the status word transmits grouped messages of errors and warnings which are divided into three classes. This part also issues messages indicating whether the drive is ready to operate or ready for power-up.

Table 3 demonstrates that typically a much broader spectrum of data is exchanged by the non-cyclic transmission mode. However, this exchange is much slower than the cyclic mode.

Table 3 - Typical data for non-cyclic transmission

Data related to the operating mode of the SERCOS interface		
Position data	Velocity data	Torque data
Positive limit value	Positive limit value	Positive limit value
Negative limit value	Negative limit value	Negative limit value
	Bipolar limit value	Bipolar limit value
Polarities	Polarities	Polarities
Reference distance 1	Homing velocity	
Reference distance 2		
Reversal clearance		
Position switch points 1 to 16		
Probe value 1 or 2 positive edge		
Probe value 1 or 2 negative edge		

As mentioned earlier, a component (drive or control unit) which is equipped with the SERCOS interface does not need to support all possible data and procedure commands included in this specification. The system provides lists of data and procedure commands which are applicable for the appropriate component. These lists can be read from a drive by means of the control unit, thus providing all necessary information concerning that particular drive.

The data to be transmitted and the sequence shall be determined during initialization.

Finally, during initialization it is useful to transmit scaling data as a group. In this way the data formats used by the internal operating algorithms of the drive will be recalculated and changed in accordance with the specifications of SERCOS interface.

4.2.4 Data block

The SERCOS interface is not just a data transmission system. It provides a large number of data and procedure commands which can be used for the operation of machines and their control units and drives.

All data, procedure commands and all supplementary information are summarized in a data block which contains a name, attribute, units, minimum and maximum input values as well as the data itself.

Access to the data or to the supplementary information is only possible via an identification number (IDN). There are 2^{16} IDNs available. The range from 0 to 32 767 is reserved for standard data which are defined by the SERCOS interface.

There will always be special applications for which none of the generally defined parameters apply. IDNs 32 768 to 65 535 are reserved for product specific data which can be defined by the manufacturers of control units and drives. No general compatibility can exist for these data and procedure commands.

4.2.5 Telegram structure

The general telegram structure is shown in Figure 3. All telegram delimiters are initiated during bit transfer and are invisible on higher layers.

4.2.5.1 Addresses and frame check sequence

Telegrams which originate from the master have the destination address in the address field. One special destination address is the broadcast address (255). This address is used exclusively by the master. Telegrams which originate from the drives have the source address in their address fields.

The frame check sequence is calculated automatically using a standardized CRC-check.

4.2.5.2 Data record

In Figure 3, parts b) to e), only the data field of a telegram is shown.

b) the master sync telegram (MST);

c) the telegram from drive 'XX' (AT_m);

d) the master data telegram (MDT).

The data field of the MDT consists of K data records, where K = M is the total number of drives in the ring. The data field of the AT consists only of one data record.

As shown in Figure 3 e), all data records consist of two parts: a fixed structure and a variable structure, which is configured during initialization, depending on the application. The fixed structure consists of the following:

– for the MDT: a control word and the 'container for non-cyclic data transfer of the master';

– for the ATs: a status word and the 'container for non-cyclic data transfer of the drive (amplifier = A)'.

The variable structure (i.e., length, amount and sequence of 2-, 4- and 8-byte sizes) of the configurable part of the data record is specified during initialization based on the application. This serves as a container for data which is transmitted cyclically.

When initialization is complete, the length of every data field is known and remains constant during operation. This ensures that all telegrams within the communication cycle (see Figure 6) have fixed lengths during operation and are transmitted according to a time-fixed pattern (see Figure 5).

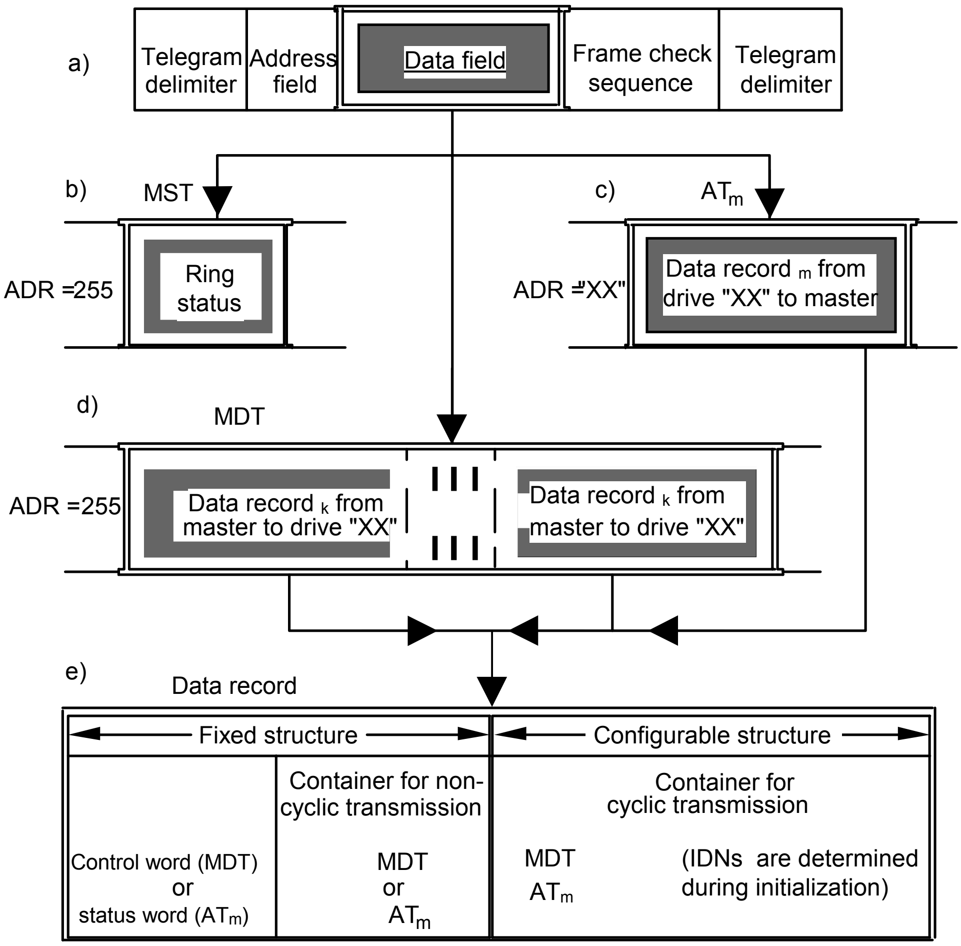


Figure 3 - Overview of data field structure (CP3 and CP4)

4.3 Data transmission

In clause 4.2, several system characteristics were outlined. That subclause deals with communication functions, as well as hierarchical functions which are not a part of the communication area and hence are not part of the ISO/OSI reference model (see ISO/IEC 7498).

This subclause introduces transfer layers as well as appropriate protection measures in accordance with levels 1 and 2 in the ISO/OSI reference model (see ISO/IEC 7498).

Figure 4 is a schematic showing the organization of the transfer layers between the master and slave. The highest transfer layer is the non-cyclic transfer. It has its own transfer security mechanism. Application layers lie above non-cyclic transfers (not shown in Figure 4). They are procedure commands which are themselves supported by non-cyclic transfers.

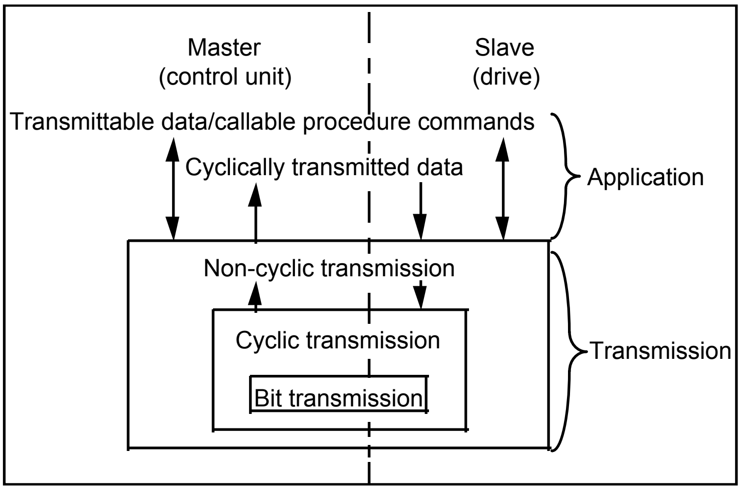


Figure 4 - Transfer layers

Non-cyclic transfer is supported by cyclic transfer. The user has access to cyclic, as well as non-cyclic transfer. Fundamentally, all data is transferable non-cyclically (slow) and only a subset is meant to be transmitted cyclically.

4.3.1 Access to the transfer medium

Figure 5 shows the access to the ring. It is regulated through a timeslot method. During initialization, every drive is told when to transmit its data to the ring. Thus, every drive has the ability to use its internal clock to access the ring. In this way a deterministic, strictly synchronous execution can be achieved with minimal administrative effort. This simple method is possible because the data traffic flow is so strictly defined.

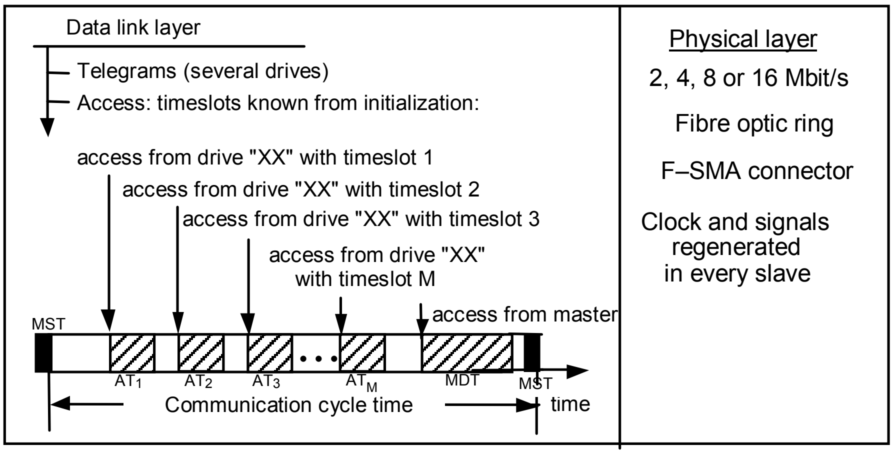


Figure 5 - Timed access methods

4.3.2 Communication cycle

As shown in Figure 6, all cyclic data is exchanged between the master and all its drives during a single communication cycle (e.g., 1 ms).

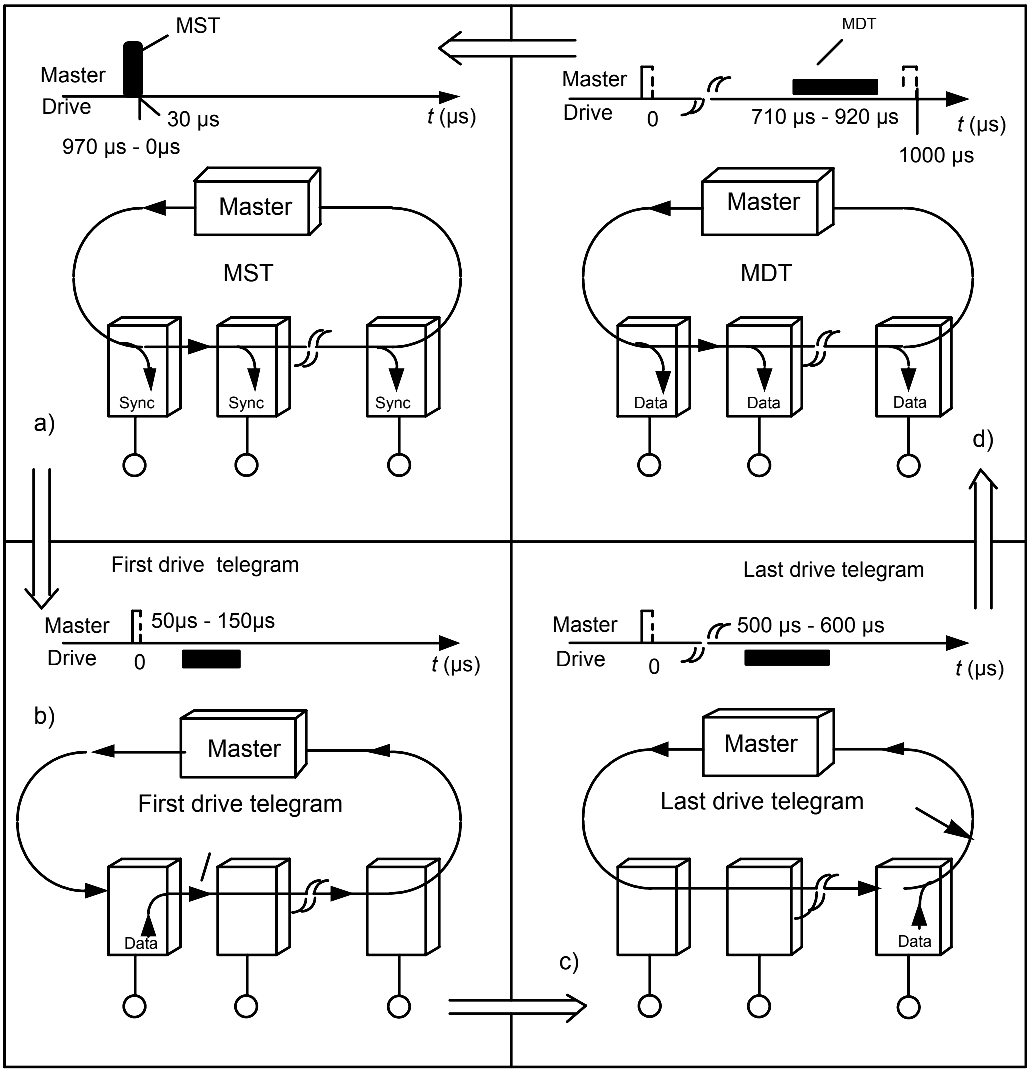


Figure 6 – Communication cycle

As shown in Figure 6 a), the communication cycle starts when the master broadcasts a MST to all units. All drives receive this message concurrently. On the basis of this MST, every drive shall synchronize its transmit timeslot and its feedback acquisition capture point, and should synchronize its internal processing, especially its control loops. This type of synchronization minimizes and stabilizes the dead time of the command signal, which improves the dynamic behaviour as compared to control loops which are not synchronized by a synchronization telegram.

The synchronization telegram is very short (approx. 30 µs at 2 Mbit/s). Its data field, which is only 1 byte long, determines the command status of the ring (= desired communication phase). Since this condition remains constant during operation, even bit stuffing will not cause any temporal fluctuations.

As shown in Figure 6 b), when the first predetermined timeslot is reached, the first drive transmits its drive telegram (AT) to the ring. The AT has its own address (= source address) and the data for the master (e.g., feedback values, status).

An AT sent in this fashion is simply passed on by other drives to the master (repeater function). As shown in Figure 6 c), all other drives transmit their ATs to the master during their predetermined timeslots.

The master monitors whether all drives transmit correctly. After receiving the first AT, the control unit can start evaluating and processing this AT based on the required tasks.

At the end of the cycle, as shown in Figure 6 d), the master transmits a lengthy MDT to all drives. This broadcast of data is received concurrently by all drives. Each drive knows its data slot within the MDT as defined during initialization. In this manner, all axes are supplied with new command values synchronously.

Immediately after the communication cycle has elapsed, the master starts the next cycle with the MST. Allowable times are: 62 µs, 125 µs, 250 µs as well as integer multiples of 250 µs.

Short communication cycle times only allow for a few participants and are mainly used for 'torque control' operating mode. Longer communication cycle times allow for more participants and are therefore used for 'position control' operating mode.

The cycle time during which the control unit provides new command values for the drives is called t_{Ncyc}. The operating cycle inside of the control unit should be an integer multiple of the communication cycle time. If the operating cycle time is longer than the communication cycle time, the same calculated values can be transmitted n times in consecutive telegrams:

$t_{\mathrm{Ncyc}} = n * t_{\mathrm{Scyc}}$, n = 1,2... (n is not related to the abbreviations).

Developers of micro-processor controlled drives have to take care that the operating algorithm inside the drive should be oriented to the data transmission:

- one or more internal operating cycles of the drive should fit into the communication cycle: $z * t_{\mathrm{Rcyc}} = t_{\mathrm{Scyc}}$, z = 1,2... (z is an integer);
- the operating algorithm should be synchronized with the MST.

When the drive control program is executed several times during a control unit operating cycle and a communication cycle, intermediate values for command values have to be interpolated inside the drives.

4.3.3 Non-cyclic data transfer

Non-cyclic transfer is initiated and controlled by the master. Its entire control will be executed by the master. A slave cannot start a non-cyclic transfer; it can only respond.

Non-cyclic transfers are based on cyclic transfers, as mentioned earlier.

In CP1 and CP2 two bytes are reserved in the MDT and in the AT respectively for the required non cyclic data exchange. The non cyclic container in MDT and AT can be extended up to 8 bytes in CP3 and CP4. When longer data are to be transmitted (e.g., a name or a list of IDNs), the transmission has to be distributed over several communication cycles.

Parts of the control word respective of the status word provide the handshake signals required for transport and process control. Unlike the cyclic data where data cannot be repeated, the receiver does not need to react in the same cycle. The master recognizes the situation where a slave has not yet taken the required data from the non cyclic container and repeat the transmission up to 10 times. Once the non cyclic container is empty, the master may send more data. At the end of the last transmission, the processing can begin in the slave (i.e., reading or writing data). This is indicated to the master to prevent the master from overloading the slave with data. After a successful command read and processing, the slave sends data back to the master. In this case, the same acknowledgment method is employed as when the master sends data to the slave.

The duration of the process (timeout) is not set via the SERCOS interface. The master can, however, break the process in the slave at any time, provided that a break is still possible in the slave.

When an error occurs during the processing in the slave, for example when data is write protected, an error flag is set in the drive status word. Simultaneously, the reason for the error is transmitted in the non cyclic container.

4.3.4 Procedure commands

The master can transmit procedure commands to the drives. Depending on the type of procedure command, it may trigger lengthy and complex processes within the drive. Examples of such processes are:

- drive-controlled homing procedure;
- probing cycle procedure;
- park axis procedure;
- drive-controlled synchronous operation procedure.

Procedure commands have technically the same structure as other data. The attribute identifies that the data is handled as a procedure command. In this case, the operation data is replaced by the procedure command control. The non cyclic containers are used for the command transmission and transmission control similar to the non-cyclic data exchange. The processing in the slave typically starts a complex function.

Because there is a bit available in the status word to indicate changes in the procedure command acknowledgement (i.e., procedure command executed), it is possible to activate more than one procedure command at the same time or to start a required data exchange when one or more procedure commands are activated.

The master has the ability to set or activate a procedure command in the slave via the procedure command control so as to enable, interrupt, or cancel the processing. When an error occurs in a slave, a detailed error message is transmitted to the master.

4.4 Initialization

After powering up, the system goes through several states (i.e., communication phases) before the normal operating state (= Communication phase 4) is reached. This subclause discusses these phases (communication phases 0 to 3).

Communication phase 0 (CP0)

After the master electronics are supplied with power and internal initialization and checks have been successfully concluded, the master begins transmitting master synchronization telegrams (MST). The 'communication phase 0' condition is set.

When the slave electronics is powered up, it will work as a 'repeater'. This means the slave passes the received telegrams on to the next participant on the ring. When all physically present slaves are working as repeaters in the ring, the MSTs will be sent on to the input of the master.

After the master has received its own MST 10 times without interruption, it then switches to communication phase 1. Thus, the master shall be able to transmit and receive a telegram simultaneously. A slave, however, only needs to either transmit or receive a telegram at any given point in time.

As shown in the following phases, communication is set up in steps through:

- the insertion of a rudimentary drive and master-data telegram;
- successive completion of above-mentioned telegrams; and
- the introduction of timeslots for all telegrams.

Communication phase 1 (CP1)

The master issues 'communication phase 1' as the current communication phase through its MST and begins to transmit the MDT of communication phase 1. Each drive is addressed individually by the master. The MDT contains only *one* data record, the cyclic container is not installed. The content of the non cyclic container has no influence and the control word remains constant.

The information which is being transmitted by the MDT mentioned above is given by the address 'XX'. During communication phase 1, when a drive receives a MDT addressing it, it responds with a rudimentary communication phase 1 AT to indicate that the drive is present and ready for communication phase 2.

The master will attempt to receive a response from one of the drives. If necessary the master may ask several times. When all drives have responded, the master switches to communication phase 2.

Communication phase 2 (CP2)

The MDT in communication phase 2 has the following structure:

- the address of a defined drive;
- only *one* data record;
- the data record has no container for cyclic transfer.

For communication phase 2, the protocol for non-cyclic transfer is operating. However, during one cycle, data exchange can take place with a single drive only.

In communication phase 2:

a) communication parameters (e.g., timeslots for subsequent communication phases);
b) the parameters that define the cyclic transmission configuration

shall be exchanged.

Before defining these configuration parameters, the control unit shall know which parameters can be supported by the individual drives (including modes of operation). The operator can retrieve this information from manufacturer's specifications for specific drives. The control unit can retrieve the same information from the list of supported data and procedure commands stored in the drive (see IDN S-0-0017, IDN S-0-0025).

In communication phase 2, additional data beyond the minimum structure [a) and b)] can be transmitted, such as data for the selection of drive characteristics. However, this additional data can also be transmitted during later, more time-efficient communication phases.

The master then sends the procedure command ‘CP3 transition check' to each drive. During the processing of this procedure command, each drive checks internally whether error free operation in communication phase 3 is possible (i.e., if the drive has received the necessary parameters for communication phase 3). After every drive has responded to this procedure command with a 'procedure command correctly executed', the master can issue a communication phase 3 in the MST.

Communication phase 3 (CP3)

In communication phase 3, the entire communication cycle and all telegrams contained therein is complete just as in normal operation (= communication phase 4), with the exception that the contents of the containers for cyclic transfer are still meaningless. The timeslots which were defined in communication phase 2 are in effect from now on. As of this communication phase, the master can exchange data with the all drives through simultaneous, non-cyclic transfer. Thus, the data for selection of the drive characteristics can be transmitted to the drives in a more time-efficient manner in communication phase 3.

Finally, the master sends the procedure command 'CP4 transition check' to each drive. At this point each drive checks internally whether error-free operation in communication phase 4 will be possible. After every drive has responded to this procedure command with 'procedure command correctly executed,' the master can issue communication phase 4 in the MST (i.e., normal operation). This completes the initialization.

4.5 Error and status messages

Grouped messages of diagnostic classes 1, 2 and 3 (C1D, C2D, C3D) are used in the status word of each drive.

A C1D message means that an error condition was discovered in the drive, leading to a shut-down with subsequent $T = 0$ after the speed is less than n_{min}. This process is executed by the drive itself.

A C2D message means a warning indicating a possible shut-down.

C3D messages are pure status messages (e.g., ‘$n_{feedback} < n_x$’ or ‘$T > T_x$’).

5 Transfer medium and physical layer

5.1 General

This clause specifies the physical layer in detail (e.g., optical signals on the output of the master) including the signal specifications (e.g., transmission rate, jitter).

Some signal names and signal parameters are represented as abbreviations (e.g., RxD). Abbreviations help to organize the block diagrams more clearly. The specification determines signal parameter conditions (e.g., upper, lower limits; intervals).

5.2 Topology

5.2.1 Line connection between the control unit and the drives

The topology consists of optical point-to-point transmission lines and subscribers. A transmission line consists of fibre optic cables having no optical branches. Transmission takes place in only one direction. The master and the slaves are part of the network (subscribers).

Figure 7 shows the structure in connection with the control unit and the drives. The control unit may encompass one or more masters. A master handles only one ring on the physical layer as well as in the overlying protocol layers. Slaves are used to connect the drives to the optical fibre ring. On the physical layer, a slave represents the connection of one or more drives to the optical fibre ring. Logically, one slave with several drives acts the same as several slaves with one drive each. Although the slaves are connected to each other physically through the optical fibre ring, all transmission of information takes place directly between the master and the drives. A star-shaped topology is created if every master has only one slave connected to itself.

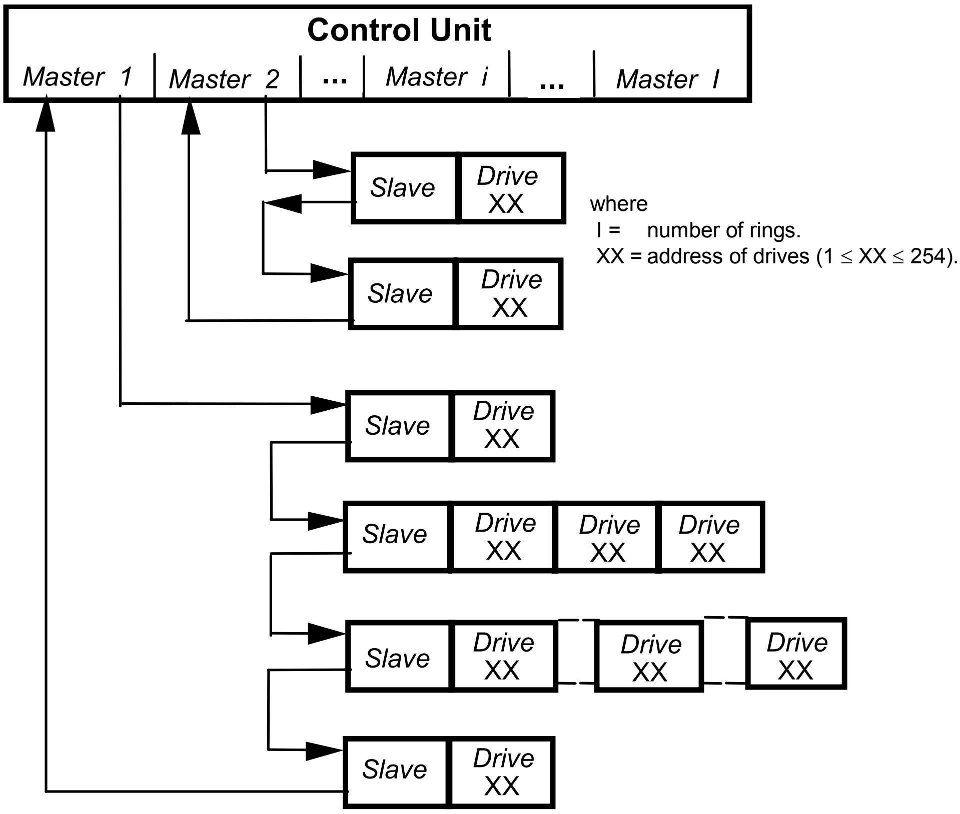


Figure 7 - Topology

Figure 7 displays the topology. The physical arrangement of slaves in the rings is independent from the set drive address for the slave, as well as from the timing sequence of transmitting the drive telegrams.

The number of drives in a ring is M = K. The sequence of the AT is labelled as 1, 2, ..., M and the sequence of the drive data records in the MDT is labelled as 1, 2, … K.

The SERCOS interface determines any exchange of information within a ring. Any cooperation of rings is controlled by the control unit and is not subject to this specification.

5.2.2 Structure of the transmission lines

The connectors used correspond to standard F-SMA connectors (see IEC 60874-2). The transmitter and receiver components are built into light-proof housings, which have F-SMA connections for optical interfaces. The structure of the optical transmission line is shown in Figure 8.

The driver circuit for the transmitting LED is activated by an electrical impulse. The high-performance LED (transmitter) emits light of a wavelength of 650 nm. The transmission power is switchable between 'low attenuation' and 'high attenuation'. Attenuation taking place along the transmission line is caused by the fibre optic cable and possibly other couplings (additional F-SMA plug connections). These additional couplings may become necessary when routing through a wall, for example. The factors which contribute to attenuation along the line are explained in more detail in annex G.

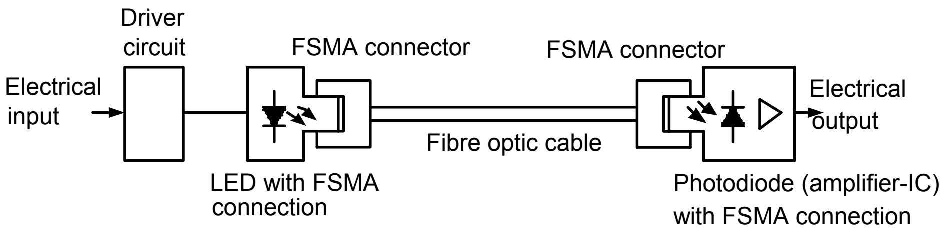


Figure 8 - Optical transmission line

The fibre optic cable is made of plastic or glass and has a step index profile or graded index profile. Fibre optic cables and cores can be used. For fibre optic materials currently in use, the attenuation is approximately 220 dB/km for plastic and 6 dB/km for glass.

The receiver component consists of a photodiode and an (integrated) amplifier circuit.

The signal is allowed to be inverted while passing through a slave (i.e., a light-on signal at the optical slave input does not necessarily lead to a light-on signal at the optical output).

5.3 Optical signals on the transmission line

Optical power levels on the transmission line have units of dBm or µW which are related as follows:

$$\textbf{Level [dBm]} = 10 \times \log(\textbf{Level [µW]} / 1000\ \mu W)$$

$$\textbf{Level [µW]} = 10^{\text{Level [dBm] / 10 dBm}} \times 1000\ \mu W$$

The optical signals given in Table 4, Table 5 and Table 7 for the transmitter, the receiver, and the transmission line are measured with a plastic fibre cable (POF) with a 1 mm core diameter and a length of 1 m or with a glass fibre cable (HCS) with 200 µm diameter and a length of 1 m as specified in Table 6.

Optical levels and edges (status changes) along the transmission line are specified by means of the following parameters:

a) $\boldsymbol{P_{TmaxL}}$, the maximum transmission power at an optically low level. When the optical signal falls below this level, it is at a logic low state;
b) $\boldsymbol{P_{TminH}}$, the minimum transmission power at an optically high level. When the optical signal goes above this level, it is at a logic high state;
c) $\boldsymbol{P_{TmaxH}}$, the maximum transmission power at an optically high level. Stationary signals shall never exceed this limit. A rising optical edge, however, may dynamically exceed the upper limit of the optically high level. This makes it possible to accent the rising edge (minimizing the rise time). Both the magnitude, as well as the duration of the excess signal level are limited;
d) $\boldsymbol{k_{OS}}$, factor for optical power overshoot. This parameter indicates the factor by which the maximum optical transmission power may be exceeded dynamically. The excess power level is only permissible during an optical status change from low to high (rising signal edge).

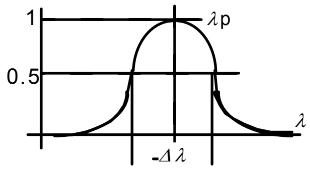
The optical signal shall pass through P_{TmaxL} to P_{TminH} in a monotonic manner (which means that the signal noise is less than 100 nW = –40 dBm). Therefore, the logic high level between P_{RmaxL} and P_{RminH}, can be recognized definitely without generating additional signal changes.

5.3.1 Transmitter specifications

Unless stated otherwise, these specifications are valid throughout the temperature range from 0 °C to +70 °C.

A transmitter shall follow the specifications in Table 4.

Table 4 - Transmitter specifications (all data for λp)

Position	Attenuation at 650 nm		
Optical transmission power fibre type	low POF	high POF	high HCS
Unit	dBm (µW)	dBm (µW)	dBm (µW)
Maximum transmission power at low optical level: P_{TmaxL}	-31,2 (0,75)	-28,2 (1,5)	-33,2 (0,5)
Minimum transmission power at high optical level: P_{TminH}	-10,5 (90)	-7,5 (180)	-18 (16)
Maximum transmission power at high optical level: P_{TmaxH}	-5,5 (280)	-3,5 (450)	-10 (100)
Transmitting diode wavelength - Peak wavelength - Spectral bandwidth	λ_P = 640 nm - 675 nm $\Delta\lambda \leq$ 30 nm (25°C)		
Optical spectrum			
Exceeding high level by a maximum factor	k_{OS} = 120%		
Temperature range	0°C bis 70°C		

5.3.2 Receiver specifications

Unless stated otherwise, these specifications are valid throughout the temperature range from 0°C to +70°C.

In order to process the data correctly, the receiver shall meet the requirements shown in Table 5. Since the bandwidth of the fibre optic cable is relatively wide, distortion of the optical signals is insignificant.

Table 5 - Receiver specifications (all data for λp)

Wavelength Fibre type	650 nm POF	 HCS
Units	dBm (µW)	dBm (µW)
Maximum received power at low optical level: P_{RmaxL}	-31,2 (0,75)	-33,2 (0,5)
Minimum received power at high optical level: P_{RminH}	-20 (10)	-22 (6,3)
Maximum received power at high optical level: P_{RmaxH}	-5 (316)	-7 (200)
Dynamic power (P_{RmaxH} to P_{RminH})	15 dB	
Bit error rate	$\leq 10^{-9}$	
Temperature range	0°C bis 70°C	

5.3.3 Fibre optic cable

The fibre optic cable consists of plastic or glass with a step index profile or graded index profile. (see example in Table 6 and Figure 9).

Structural example:

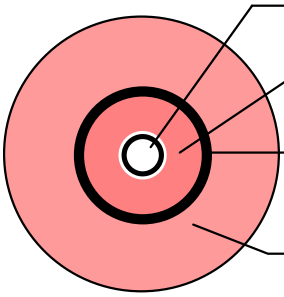


Figure 9 - Structure of a single-core cable (example

Table 6 - Cable specifications (example)

	plastic fibre POF	**glass fibre HCS**
Core diameter Cladding diameter	980 µm 1 000 µm	200 µm 230 µm
Numeric aperture Bandwidth	0,47 ≥ 5 MHz * 1 km	0,37 ≥ 10 MHz * 1 km

5.3.4 Connectors

Connectors for fibre optic cables shall:

- correspond to F-SMA standard (see IEC 60874-2);
- have a quality level of at least 5;
- have a metallic connector ring.

In addition, it is recommended that fibre optic cables have a strain relief.

5.3.5 System data of the optical transmission path

The optical power levels are shown in Figure 10.

Table 7 - System data of the optical transmission line

Position	Attenuation at 650 nm		
Optical transmission power Fibre type Unit	low POF dBm (µW)	high POF dBm (µW)	high HCS dBm (µW)
Maximum transmission power at low optical level: P_{TmaxL}	-31,2 (0,75)	-28,2 (1,5)	-33,2 (0,5)
Minimum transmission power at high optical level: P_{TminH}	-10,5 (90)	-7,5 (180)	-18 (16)
Maximum transmission power at high optical level: P_{TmaxH}	-5,5 (280)	-3,5 (450)	-10 (100)

Wavelength Fibre type	650 nm POF	 HCS
Units	dBm (µW)	dBm (µW)
Maximum received power at low optical level: P_{RmaxL}	-31,2 (0,75)	-33,2 (0,5)
Minimum received power at high optical level: P_{RminH}	-20 (10)	-22 (6,3)
Maximum received power at high optical level: P_{RmaxH}	-5 (315)	-7 (200)
Dynamic power (P_{RmaxH} to P_{RminH})	15 dB	

Position	Attenuation at 650 nm		
Optical transmission power Fibre type	low POF	high POF	high HCS
System reserve (including lifetime of transmitting diode)	≥ 5,1 dB	≥ 5,1 dB	≥ 2 dB
System value (P_{TminH} to P_{RminH})	9,5 dB	12,5 dB	4 dB
Line attenuation (System value – System reserve) **Measuring cable attenuation** (typical)	≤ 4,4 dB 0,2 dB/m	≤ 7,4 dB 0,2 dB/m	≤ 2 dB 10 dB/km
Cable length	≥ 22 m	≥ 37 m	≥ 200 m

Transmission rate	2, 4, 8 and 16 Mbit/s (NRZI)
Bit error rate	≤ 10^{-9}
Temperature range	0°C to 70°C

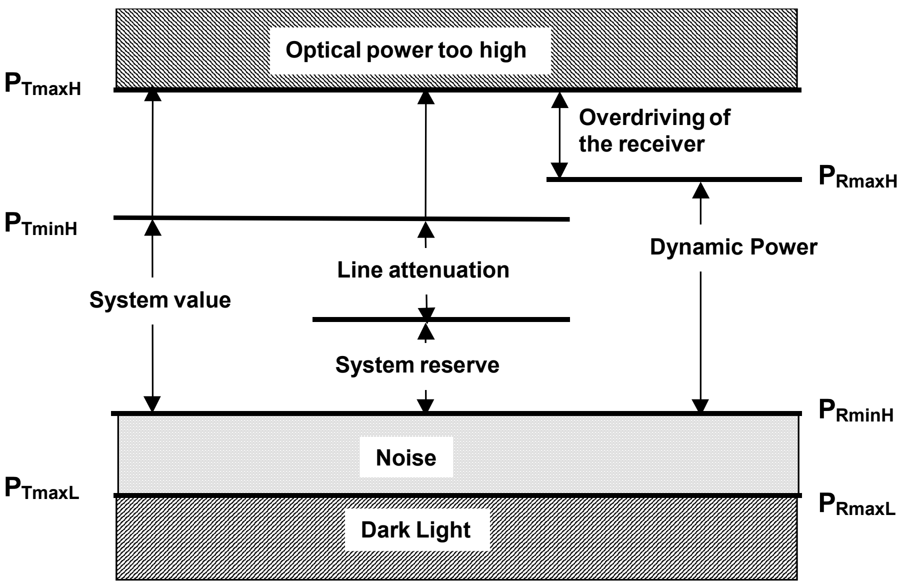


Figure 10 - Optical power levels

5.4 Time performance of bit transmission

The distance between rising and falling edges of the optical signal are specified in this subclause. An edge is a change in level between the optically low and optically high levels. The specification is based on an envelope which has been defined for the optical signal. Any optical output signal of a transmitter shall remain within this specific envelope at all times. Furthermore, the run-time performance between optical slave input and output is specified. A slave shall be synchronized to the transmission clock of the bit stream coming into its optical input. Although the transmission clock of a slave may deviate from the clock at its input for a short time, the slave needs to be synchronized to the predetermined clock (e.g., by means of a phase locked loop). Thus, all units connected to the ring are required by definition to transmit the same averaged transmission clock pulse. In other words, all units use the transmission clock pulse of the master.

The slave is synchronized to the transmission clock on its optical input by means of light-on edges (rising edges).

5.4.1 Master and slave in test mode

In this subclause, the run-time performance at the optical output of the master is specified while the master is operating both in its normal and test modes. The test mode can be activated externally by special means (e.g., pressing a key). Master and slave shall then be able to provide a continuous signal light, as well as a zero bit stream at the optical output, without the presence of an input signal.

Continuous light signal test mode:

A continuous light signal implies a logical high level without a level change at the optical output. This mode is only required for the master. The slave may generate a continuous light signal, depending on whether or not a continuous light signal comes in at the optical input. Due to its function as a repeater the slave shall be able to echo the light at its optical output, which it receives at its optical input (or the lack thereof),.

NOTE – A slave is allowed to invert the optical signal.

Zero bit stream test mode:

The zero bit stream test mode implies that the transmitter shall transmit consecutive zeros which, based on the NRZI code, result in continuous level changes in the signalling pattern of the transmission clock (this results in a 1 MHz signal for a data rate at 2 Mbit/s). A slave shall use its local clock to synchronize the transmitting clock at its optical output signal. No clock adjustments may occur at the optical output (e.g., due to the phase locked loop, → t_{cad}) and only statistically distributed jitter of the optical signal is allowed. This requirement is important because it allows the system to isolate and separate jitter noise (→ J_{noise}) from possible clock adjustments due to the phase locked loop (→ t_{cad}), as will be discussed later. The curve shapes of optical signals which are generated while the system is in the zero bit stream test mode, are not allowed to deviate from the signals during normal mode near the rising and falling edges (e.g., different rise and fall times, different excess levels during the test mode). Specifically, the same driver circuit shall be used during the zero bit stream test mode as is used during normal mode.

The following parameters are used to specify the optical output signal of the master and slave (see Figure 11 and Figure 12):

a) t_r**:** this is the time delay between points 1 and 2 (= 1-1' or 2-2'). It is the upper limit of the time required by the optical signal to pass through P_{TmaxL} to P_{TminH} on the rising edge. This time doesn't correspond to the rise time of the transmitter which is given between 10% and 90% of the optical signal in the data sheet.

b) t_f**:** this is the time delay between points 3 and 4 (= 3-3' or 4-4'). It is the upper limit of the time required by the optical signal to pass through P_{TminH} to P_{TmaxL} on the falling edge. This time doesn't correspond to the fall time of the transmitter which is given between 10% and 90% of the optical signal in the data sheet.

NOTE – See item g) regarding t_r and t_f.

c) **t_{OS}:** this parameter indicates length of time the maximum optical transmission power may be exceeded dynamically. This interval starts at time ①.

d) **t_{BIT}:** this is the arithmetic mean value (measured over several seconds) of the transmission clock period (duration of a bit cell) by the master (not in test mode) and corresponds to the reciprocal value of the data rate. The nominal duration is described by t_{BITnom}.

t_{BIT} is measured between edges with the same direction (= 2*t_{BIT}) at optical power levels of 0,5 * P_{TminH} ± 20 %. t_{BIT} is considered to be constant in the range of seconds. Only fluctuations due to noise are allowed.

A relatively long measurement duration of t_{BIT} ensures that the influence of short-term deviations of the delays between edges (jitter → J_{noise}) is negligible.

Hence, t_{BIT} describes the time between points 1 and 3, as well as the time between points 3 and 5 (which corresponds to point 1 of the next period) (see Figure 11).

e) **$t_{BITtest}$:** this is the arithmetic mean value measured over several seconds of the master or slave transmission clock period (duration of a bit cell) in the zero bit stream test mode. All measurements and properties of $t_{BITtest}$ correspond to t_{BIT}.

f) **J_{noise}:** this parameter describes the jitter of the optical signal. It is the purely statistical deviation of the distance between both edges, compared with the value $t_{BITtest}$ measured over a long time interval.

J_{noise} is obtained by overlaying the signals of several periods (e.g., on an oscilloscope) such that they come together at one optical power level (e.g., P_{TmaxL} on the falling or rising edge). The jitter of the optical signal is then determined by the width of the overlaid optical signals (which gives a time). This width may not exceed the value J_{noise} in the power region between P_{TmaxL} and P_{TminH} resp. vice versa.

By this definition, the jitter of the optical signals is limited, that is, the signal curve shapes shall be reproducible in the power region P_{TmaxL} through P_{TminH} resp. vice versa.

g) **Remark:** Note that the times t_r and t_f are not fully available as rise time and fall time. Due to non-symmetrical ON/OFF performance of the driver circuit (duty cycle, propagation delay), the falling edge can be time-shifted with respect to the rising edge, resulting in a remaining difference for $t_{BITtest}$. In this case, the high level can be extended by some time interval and the low level could be shortened by the same interval. This extending/shortening interval is not considered part of the rising and falling interval. In addition, the signal with added J_{noise} shall remain completely within the envelope, which implies that the jitter shall be taken into consideration for the times t_r and t_f.

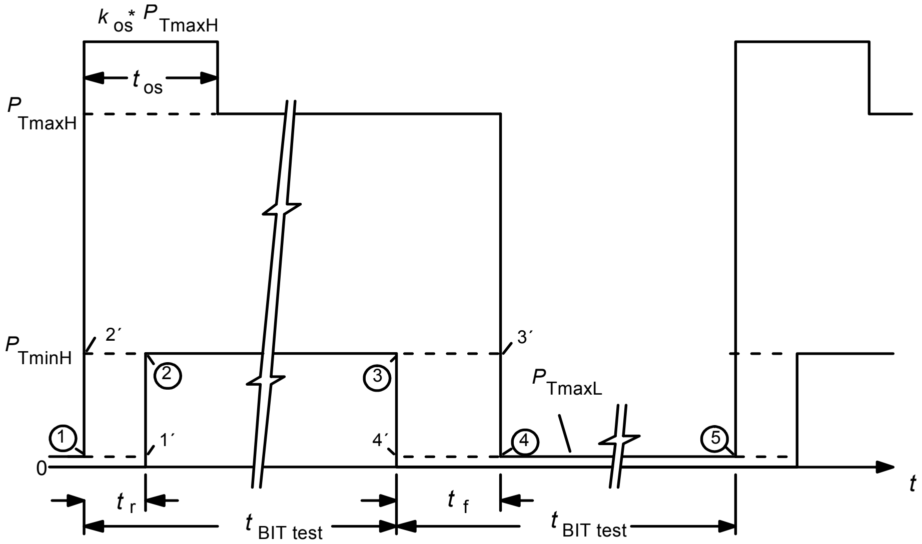


Figure 11 - Optical signal envelope

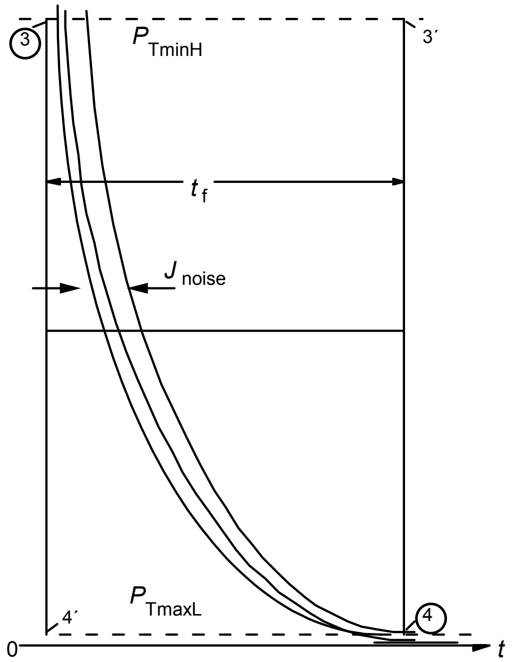


Figure 12 - Display of jitter (J_{noise})

5.4.2 Data rate

The data rate is the baud rate measured at the optical output of the master. Its nominal value is 2 Mbit/s, 4 Mbit/s, 8 Mbit/s or 16 Mbit/s. The measured value is allowed to deviate by ±0,01%. The data rate is a time average measured over several seconds. The short-term performance (nanoseconds range) may deviate slightly and is specified through $J_{noise.}$ (see Table 8).

Table 8 - Transmission data parameters

Transmission rate (data rate)	2 Mbit/s ± 0,0002 Mbit/s	4 Mbit/s ± 0,0004 Mbit/s	8 Mbit/s ± 0,0008 Mbit/s	16 Mbit/s ± 0,0016 Mbit/s
Bit times				
t_{BIT} [ns]	500 ± 0,05	250 ± 0,025	125 ± 0,0125	62,5 ± 0,00625

t_{BITnom} [ns]	500	250	125	62,5
$t_{BITtest}$ [ns]	500 ± 0,05	250 ± 0,025	125 ± 0,0125	62,5 ± 0,00625
Data frequency (max.)	1 MHz	2 MHz	4 MHz	8 MHz
Times for curve shapes				
t_{os} [ns]	200	100	50	25
t_r [ns]	100	40	20	10
t_f [ns]	150	110	25	15
Jitter [ns]	$0 \le J_{noise} \le 10$	$0 \le J_{noise} \le 10$	$0 \le J_{noise} \le 5$	$0 \le J_{noise} \le 5$

5.4.3 Input-output performance of the slave

In this subclause, the input-output performance of the slave synchronization performance is specified. A slave receives a signal with a certain clock at its optical input. The mean value of this clock is equal to the transmitting clock of the master. In the long run, a slave shall be synchronized to this clock (by evaluation of one of the rising or falling edges).

The slave generates its own local clock. This local clock is used to receive and to transmit data. The local clock of a slave runs freely between the synchronizing edges of the incoming bit stream. During synchronization, the slave adjusts the phases of the local clock (phase locked loop). This performance can be observed at the optical output because the duration of the high or low level becomes shortened or lengthened with respect to the average bit duration (t_{BIT}). The amount of shortening or lengthening is called clock adjustment time t_{cad}.

Clock adjustment time is not allowed to exceed a specific value (t_{cadmax}). In addition, the implemented maximum clock adjustment time ($t_{cadreal}$) of every slave shall be specified by the manufacturer (e.g., $t_{BIT}/16$).

The optical signal shall run through the range $P_{TmaxL} - P_{TminH}$ resp. vice versa of the envelope always at the same position (taking J_{noise} into account). If the envelope can be shifted over the optical signal (due to short rise and fall times), this possible shift shall not be taken into account as a 'bonus' to the clock adjustment.

A slave shall be able to receive signals correctly if their clock adjustment time is smaller or equal to the maximum clock adjustment time, $t_{cadreal}$, implemented in that slave. When the slaves are physically located in the ring in an ascending $t_{cadreal}$ sequence, the system makes sure that correct receiving conditions are established for any slave. The receiver of the master, being the last unit in the ring, shall be able to process the maximum allowable clock adjustment time t_{cadmax}.

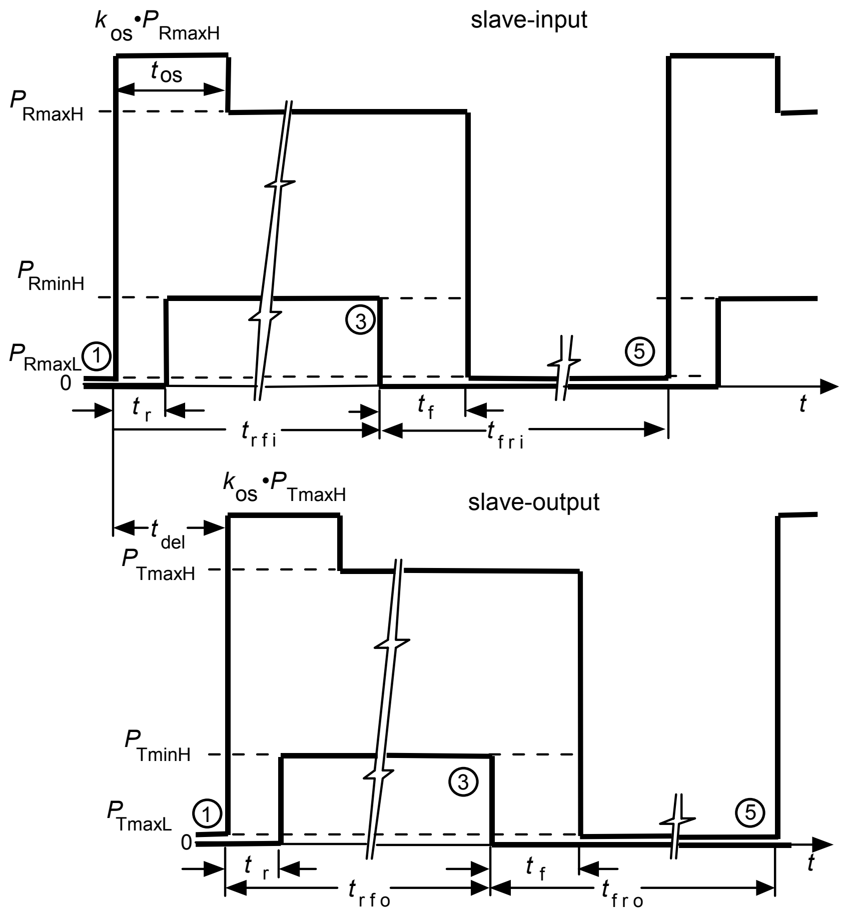


Figure 13 - Input-output performance of a slave

In addition to the clock adjustment time just described, a minimum clock adjustment time (t_{cadmin}) shall be specified. Every slave shall be able to process data when the clock has been adjusted by t_{cadmin} at its input. The input/output performance of a slave is specified by the following parameters:

a) t_{rfi}: this is the time between points 1 and 3 in Figure 13 on the receiver input.

b) t_{fri}: this is the time between points 3 and 5 in Figure 13 on the receiver input.

c) $t_{cadreal}$: this is the maximum clock adjustment time (shortening or lengthening a level) which a slave generates at its optical output. This value is specified by the manufacturer. The slave shall also be able to correctly process this maximum clock adjustment time at its input, within the scope of the specified bit error rate.

d) t_{cadmin}: this is the minimum clock adjustment time which a slave shall be able to process correctly within the scope of the specified bit error rate.

e) t_{cadmax}: this is the upper limit for $t_{cadreal}$ and also describes the maximum clock adjustment time the master shall be able to process correctly within the scope of the specified bit error rate.

f) t_{rfo}: this is the time between points 1 and 3 in Figure 13 at the transmitter output.

g) t_{fro}: this is the time between points 3 and 5 in Figure 13 at the transmitter output.

h) t_{del}: this is the time delay of the envelope between the optical input and output, measured at the slave (see Figure 13). This parameter describes the signal delay (run-time) of the optical signal through a slave in a repeater mode (see also Table 13). The delay is measured between the light-ON edge at the optical input and the associated light signal edge at the optical output (in non-inverting slaves, this is the light-ON edge; in inverting slaves, this is the light-OFF edge).

A receiver can be fed with an input signal as defined by a) or b) of Table 9. Changing between cases a) and b) is not allowed. Thus the clock adjustment time will shorten or lengthen only the high level, or only the low level.

Table 9 - Possible slave input signals

Case	t_{rfi}	t_{fri}
a)	$i * t_{BIT} - t_{cadreal} \le t_{rfi} \le i * t_{BIT} + t_{cadreal}$	$j * t_{BIT}$
b)	$i * t_{BIT}$	$j * t_{BIT} - t_{cadreal} \le t_{rfi} \le j * t_{BIT} + t_{cadreal}$
NOTES		
1	i and j are ordinary digits; i is not identical to the sequence of rings as given in the abbreviations	
2	Normal operation	When switching from telegram to fill signal and vice versa
i, j	1 … 8	1 … 12
i + j	2 … 16	2 … 20

With these specific input signals, the slave shall be able to do the following tasks:

1) receive and process data correctly within the scope of the bit error rate;
2) generate valid output signals.

Valid output signals have a signal timing within the specified limits and are generated according to cases c) or d) of Table 10. The slave can either shorten or lengthen only the high level or only the low level through clock adjustment. Alternating between the two is not allowed.

Table 10 - Possible slave output signals

Case	t_{rfo}	t_{fro}
c)	$m * t_{BIT} - t_{cadreal} \le t_{rfo} \le m * t_{BIT} + t_{cadreal}$	$n * t_{BIT}$
d)	$m * t_{BIT}$	$n * t_{BIT} - t_{cadreal} \le t_{rfo} \le n * t_{BIT} + t_{cadreal}$
NOTE – m and n are ordinary digits. They are not identical to the explanation given in the abbreviations.		

Four cases (shown in Table 11) are distinguished for the allowable values m and n:

Table 11 - Valid slave output signals

Status\slave	Non-inverting slave		Inverting slave	
Repeater	i = m; j = n		i = n; j = m	
Slave transmits own telegram	Normal operation i,j = 8 m,n = 1 .. 8 m+n = 2 .. 16	When switching from telegram to fill signal (1 .. 12) (2 .. 20)	Normal operation i,j =8 m,n = 1 .. 8 m+n = 2 .. 16	When switching from telegram to fill signal (1 .. 12) (2.. 20)
NOTE – Numbers in brackets represent values which may occur when switching from telegram to fill signal.				

5.4.3.1 Clock Adjustment

The limit values of clock adjustment times are specified in Table 12.

Table 12 - Specifications of the clock adjustment times

t_{cadmin}	$= t_{BITnom} / 64$
t_{cadmax}	$= t_{BITnom} / 11$

$t_{cadreal}$	$0 \le t_{cadreal} \le t_{cadmax}$

5.4.3.2 Signal delay due to the slave

Signal delay due to the slave (in repeater mode) is specified in Table 13.

Table 13 – Optical signal delay in a slave

Baudrate	$t_{del-max}$	$t_{del-SERCON}$	$t_{del-optic}$
2 Mbit/s	750 ns	400 ns	350 ns
4 Mbit/s	375 ns	200 ns	175 ns
8 Mbit/s	250 ns	100 ns	150 ns
16 Mbit/s	200 ns	50 ns	150 ns

5.4.4 Idealized waveform

The idealized waveform is characterized by status changes of the optical signal. The optical signal is replaced by rectangular wave shapes of equal height and infinitely short rise and fall times. The status change (edge) of the idealized waveform (rectangle) is defined at the transmitter output as the instant of time at which the optical power is 0,5 * P_{TminH} ± 20%. Both threshold levels (low attenuation and high attenuation) always fall within the interval P_{TmaxL} and P_{TminH}.

All subsequent times are measured between the status changes defined above.

5.5 Bit coding

Signals on the transmission lines are NRZI-coded (NRZI = no return to zero inverted). Signal changes are only allowed to take place in synchronization with the transmitting clock. Every time a zero is transmitted, the signal changes its status in synchronization with the transmitting clock, whereas the signal remains unchanged when a 1 is transmitted.

By a suitable method (i.e., bit-stuffing), the transmitter ensures that enough zeros occur in the transmitted bit stream. This generates additional signal changes. In this way, conditions are created which make it possible to retrieve a receiving clock from the received signal. The retrieved receiving clock also has a fixed phase position with respect to the clock of the transmitter. The clock is retrievable by means of a digital phase locked loop (DPLL) which is synchronized to the signal change of the received signal transformed to an electrical signal. Figure 14 d) is an example of a NRZI-coded signal. Therefore, the transmitting clock provides the pattern for the system timing via the signal transitions.

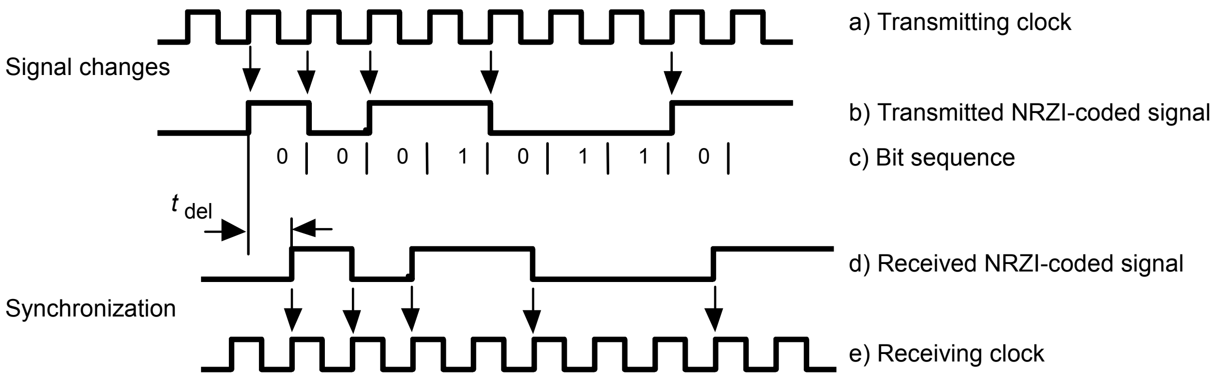


Figure 14 - Example of an NRZI-coded signal

5.6 Telegrams and fill characters

On the physical level, it is sufficient to know that a telegram starts and ends with the bit sequence $(01111110)_B$. This bit sequence is also known as a delimiter. Due to bit-stuffing, this bit sequence is prevented from occurring inside the telegram (see Figure 15).

←Administrative segment→		←User application data→	←Administrative segment→	
Telegram delimiter (BOF)	Address field (ADR)	Data field (configurable length)	Frame check sequence field (FCS)	Telegram delimiter (EOF)
01111110	8 bits	j x 8 bit	16 bits	01111110

Figure 15 - General telegram structure

Other fields of the telegram belong to higher protocol layers and are discussed elsewhere.

When a unit does not place its own telegram on the ring, two possibilities arise:

a) the master transmits a so-called fill signal (fill bits) between its own telegrams. They consist of a sequence of one binary 0 and seven binary 1's (i.e., $01111111)_B$. This generates a symmetric fill signal with 16 times the period of the transmitting clock, due to NRZI-coding;

b) Between its own telegrams, a slave transmits with its synchronized local clock the physically regenerated, received signals (repeater mode).

During the transition from telegram to fill signal (master) or from telegram to repeater mode (slave), signal changes shall follow the pattern of the current clock.

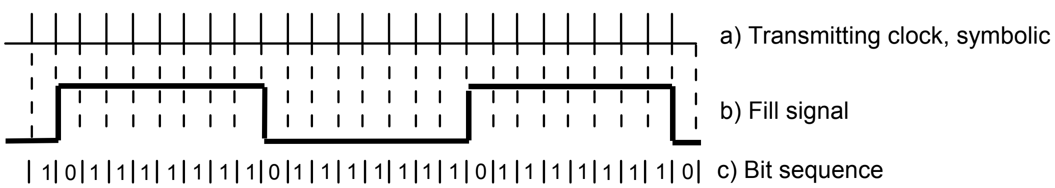


Figure 16 - Fill signal

NOTE – Due to bit-stuffing and a), the slave physically located first in the ring can derive its local clock from its received signal at any time. Because of b), this is also the case for all subsequent units, all the way to the receiver of the master. In this way, digital phase locked loops, which are eventually used to obtain the local clock, remain locked on, preventing time-consuming synchronization before the start of the actual telegram.

5.7 Connection to the optical fibre

In this subclause, the connection to the optical fibre for master and slave as well as their interaction are described in more detail.

Table 14 shows all basic functions to be performed by a connection.

Table 14 - Basic functions of the connection

	Function to be performed by →	Master	Slave
1	Retrieve clock from received signal	x	x
2	Regenerate and transmit received signal		x
3	Transmit 01111111 as fill signal	x	
4	Transmit own telegram	x	x
5	Phase-correct and spike-free transition between numbers	4 → 3 3 → 4	4 → 2 2 → 4

5.7.1 Master connection

Figure 17 shows an example of the functions of connecting a master.

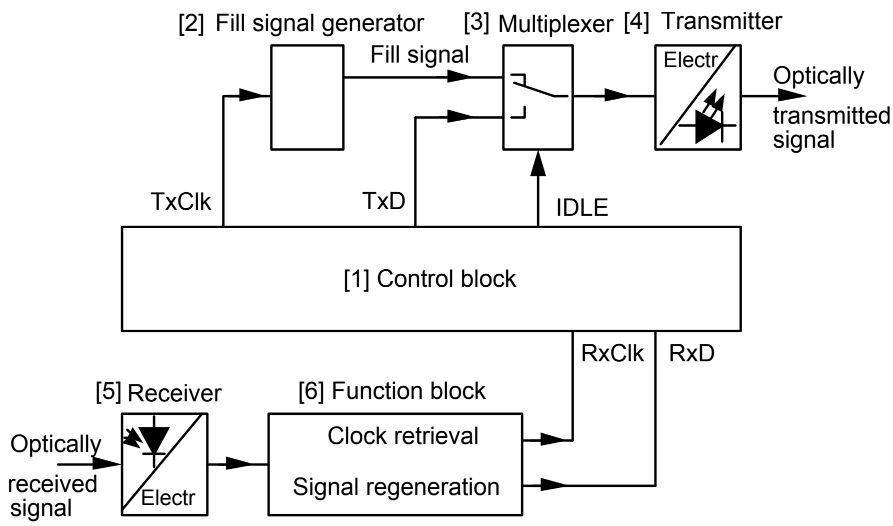


Figure 17 - Functions of a master connection

The control block [1] constructs the telegram to be sent according to Figure 17 and converts it into a NRZI-coded signal. When receiving a telegram, the master's control block recognizes the NRZI-coded and regenerated telegram as one for the master based upon its telgram delimiters and the address field. In addition the control block [1] checks the telegram and transmits only correct data fields to the signal processing unit.

Except for NRZI coding/decoding and the generation/recognition of the telegram delimiters, the functions above will be discussed with higher protocol layers.

5.7.1.1 Generating a fill signal

According to Figure 17, the control block [1] generates the transmitting clock (TxClk) for the master. This is sent to the fill signal generator [2], where the fill signal is generated according to Figure 16.

When the master is transmitting the fill signal (IDLE = 1), the signal reaches the electro-optical converter [4] via the switch [3]. The switch works such that a signal change at its output always coincides with the pattern of the transmitting clock. In this way, subsequent units can use phase locked loops for clock retrieval. Thus they can always be synchronized to the transmitting clock of the master.

Function block [6] will be discussed in clause 5.7.2.

5.7.1.2 Switching from fill signal to telegram delimiters and vice versa

During transitions from fill signal $(01111111)_B$ to telegram delimiters:

a) the bit string $(01111111)_B$ may be interrupted at any point; and
b) up to two arbitrary (transitioning) bits ‘xx’ may be inserted (reason: simplifies implementation).

All signal changes generated this way shall, however, shall be synchronized with the transmitting clock.

Figure 18 shows some examples of valid signal patterns of the transmitting signal during transitions from fill signal to a telegram to be sent, where occasionally inserted (transitioning) bits are shaded.

As shown in Figure 18, bit sequences having several delimiters can be generated. The receiver shall be able to recognize the highlighted, double-lined signal as the leading telegram delimiter.

During the transition from telegram delimiters to fill signals, i.e., after the bit sequence $(01111110)_B$ (delimiter):

a) up to four arbitrary transitioning bits may be inserted;
b) followed by switching to an arbitrary point in the bit sequence $(01111111)_B$ (fill bits).

All generated signal changes shall be synchronized to the transmitting clock. Figure 19 shows some examples. Occasionally inserted (transitioning) bits are shaded. It is possible to have several delimiters appear. A receiver shall be able to recognize the first delimiter as an enclosing telegram delimiter.

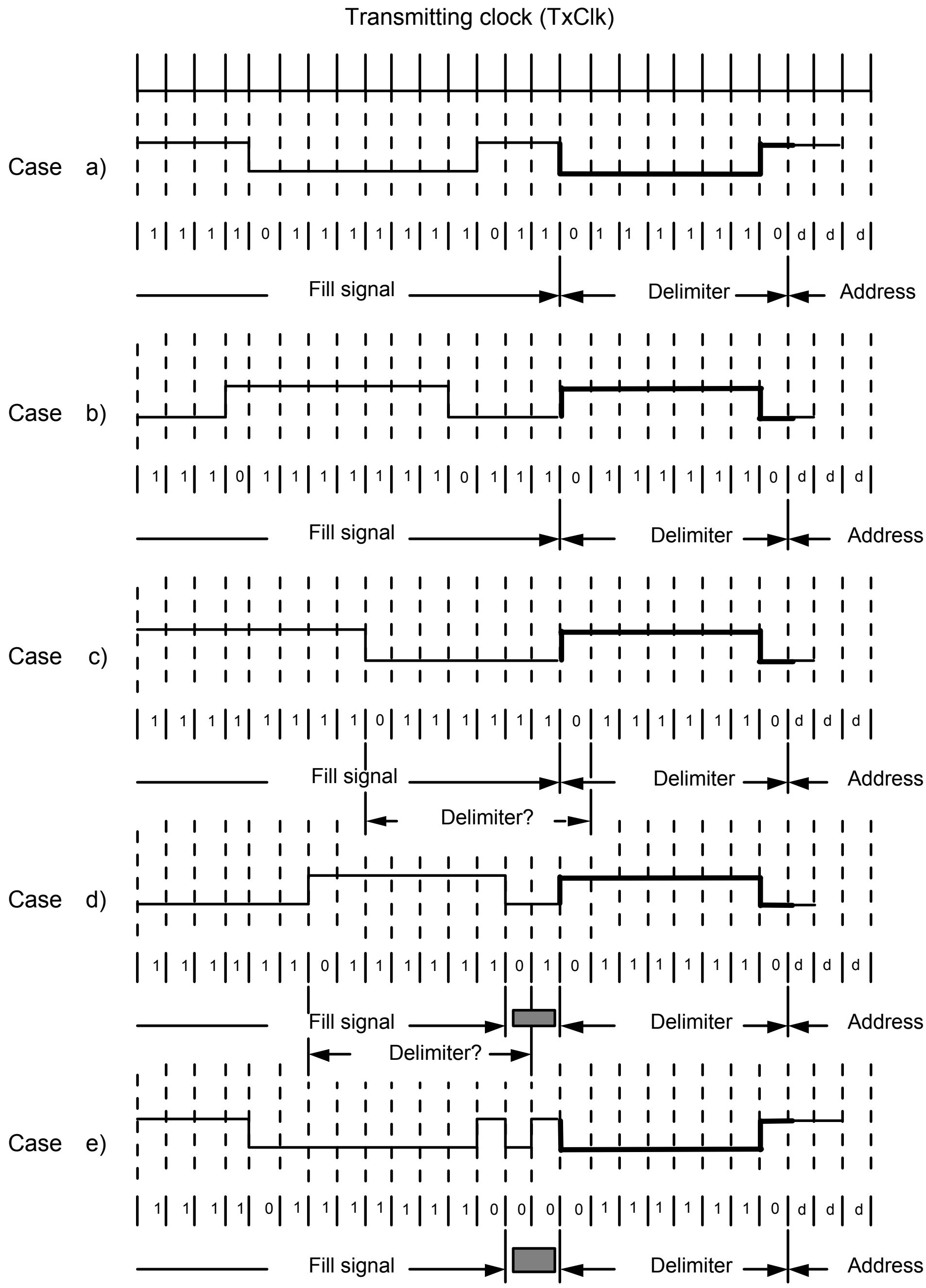


Figure 18 - Valid transmitting signals during the transition from fill signal to telegram delimiters

In Figure 19, case e) is identified by the fact that two consecutive edges of opposite directions are separated by a maximum of 12 transmitting clock cycles (t_{BIT}) and two sequential edges with the same direction are separated by a maximum of 20 transmitting clock cycles (t_{BIT}). This is important for the proper operation of a DPLL.

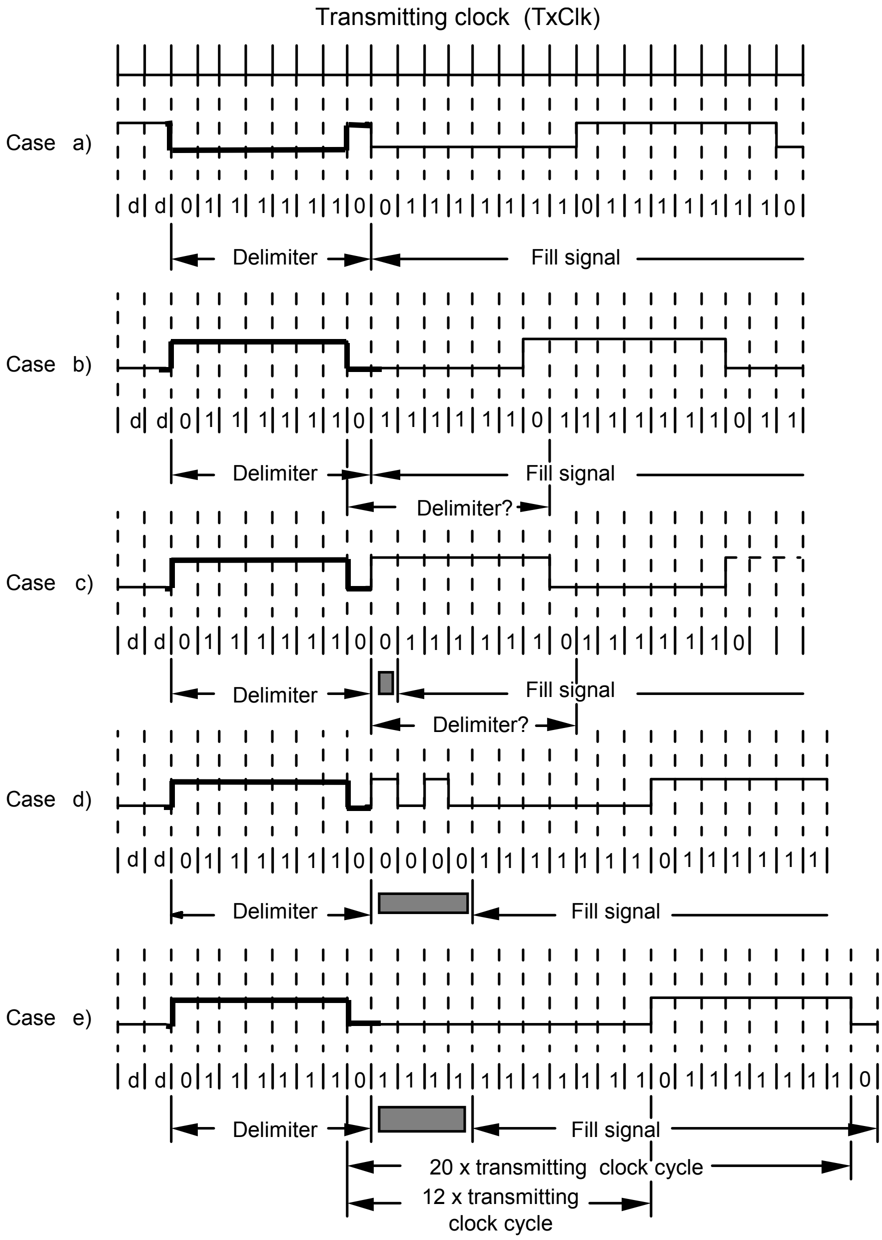


Figure 19 - Valid transmitting signals during the transition from telegram delimiter to fill signal

5.7.2 Slave connection

Figure 20 shows the functions of a slave connection.

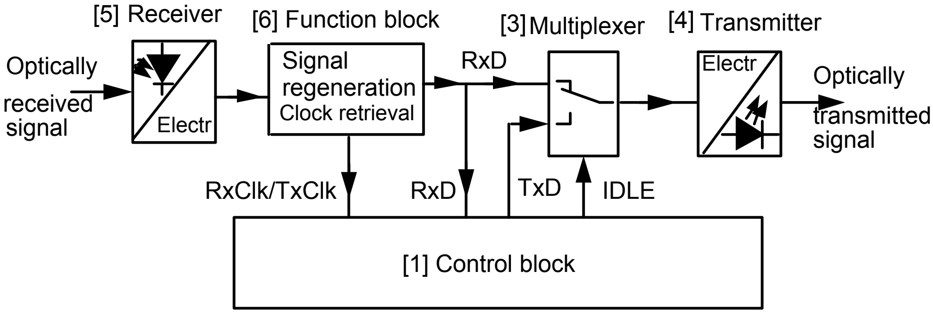


Figure 20 - Functions of a slave connection

The function block [6] has the following tasks:

a) to retrieve the clock from the electrical received signal (clock retrieval, possibly with DPLL). The clock retrieved in [6] is used as transmitting and receiving clock for [1] (note, that for the master, transmitting and receiving clocks are different signals);
b) to regenerate the received signal, care shall be taken that any signal changes occur synchronously with the clock retrieved in a). Where the slave does not need to transmit its own telegram, the regenerated received signal is sent (repeater mode, IDLE = 1).

The multiplexer [3] shall work according to the transitioning parameters as shown in clause 5.7.1.2.

Power supply:

In order to perform the above functions, the electronic components shall continue to work (e.g., during start-up and diagnostics), even when the power supply of the associated drives is shut-down. The slaves shall at least be able to regenerate the stream of data and to function as repeaters by transmitting the data.

5.7.3 Interactions of the connections

In Figure 21, the interaction of the connection of two slaves in a ring is illustrated. The assumption is made that slave 1 is in the process of transmitting a telegram to the master. The multiplexer [3] in the master passes the fill signal so that the function block [6] of slave 1 can retrieve the clock. Slave 2 multiplexer [3] passes its regenerated received signal (i.e., the slave 1 telegram) to the master. The master, in turn, retrieves the receiver clock from the received signal by means of its function block [6]. Note that all three phase locked loops in Figure 21 shall be synchronized at any time. This synchronization shall always be maintained, even when a transition [3] is activated. During switch over of [3], it is important to avoid any signal edges which do not follow the clock pattern.

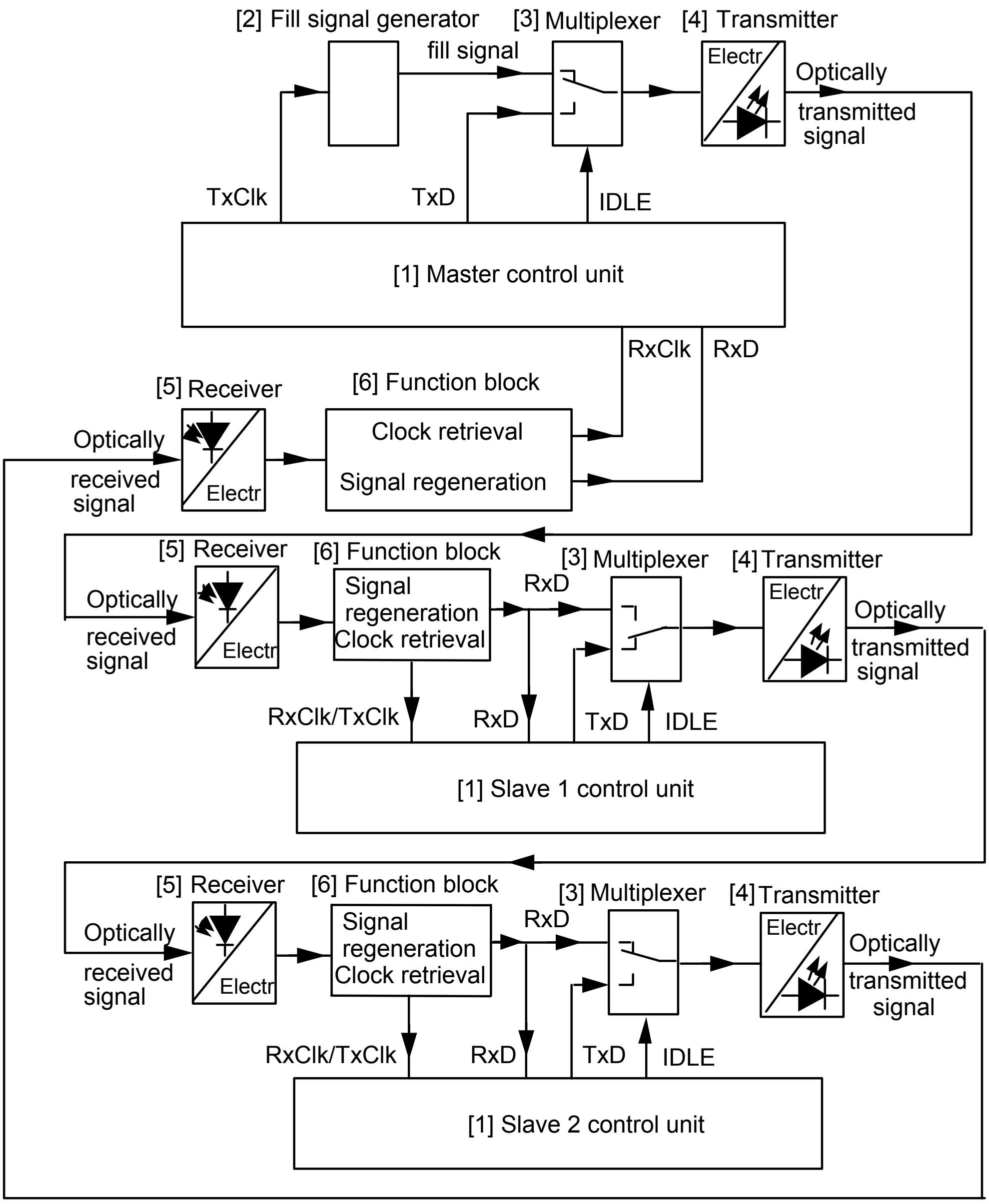


Figure 21 - Ring with two slaves

6 Data transfer and data link layer

6.1 General

In this clause, the structure of telegrams (frame structure) is described.

The interface specification recognizes three types of telegrams:

a) master synchronization telegram (MST). This type of telegram is broadcast by the master at the beginning of a transmission cycle. MSTs are very short and serve to synchronize the timing within the transmission cycle.
b) master data telegram (MDT). The master sends this type of telegram once during a cycle. MDTs are lengthy and serve to transmit data from the control unit to the drives (e.g., command values).
c) drive telegrams (AT). These telegrams are sent by the slaves and serve to transmit data from the drives to the control unit (e.g., feedback values).

As determined by these definitions, no direct data transmission takes place between drives.

6.2 Telegram structure

Data transmission takes place in telegrams (see Figure 15 for general telegram structure).

6.2.1 Telegram delimiters

All frames shall start and end with the delimiter '01111110'. All data stations which are attached to the data link shall continuously search for this sequence.

6.2.2 *Bit* stuffing

Bit stuffing ensures that no delimiter appears within the address field, data field, and frame check sequence. This is accomplished as follows:

– the transmitter shall examine the frame contents between the two delimiters, including the address field, the data field, and the frame check sequence and shall insert a ‘0’ bit after all sequences of five continuous '1' bits to ensure the delimiter is not simulated inside the telegram;

– the receiver shall examine the frame content and shall discard any '0' which directly follows five continuous '1' bits.

6.2.3 Address field

Addresses shall have values between 0 ≤ ADR ≤ 255. An address of 0 is the restricted address (no-station address) and 255 is the broadcast address (all-station address).

The address XX of a drive is 0 ≤ XX ≤ 254 and is set on the device (e.g., via a selector). In a ring, no two drive addresses may be set to the same value XX ≥ 1. Only XX = 0 may occur several times and indicates that no drive telegrams are being generated by this drive. This makes it possible to remove drives logically from the ring (e.g., for testing purposes). The repeater function of associated slaves, however, shall remain intact. The content of the address field is defined differently depending on the current communication phase as shown below:

a) non-cyclic operation (CP0 ... CP2). These communication phases are used during the initialization of the interface. In this case non-cyclic means that the master can communicate during one cycle with one drive only;

b) cyclic operation (CP3, CP4). These communication phases are used during initialization (CP3) and during normal operation (CP4) of the interface. In this case cyclic means that, during a given cycle, the control unit can communicate with all drives (with XX ≥ 1).

6.2.3.1 Content of the address field during transmission

Drive telegram (AT):

- a telegram which is sent by a slave shall have values in its address field which are set on the drives assigned to it (source addressing). All values between 1 ≤ XX ≤ 254 are allowed.

Master synchronization telegram (MST):

- the MST is sent by the master and contains the value 255 in its address field.

Master data telegram (MDT):

- the MDT is sent by the master and contains in its address field the value of the drive which is going to receive the telegram (target addressing).

  a) Non-cyclic operation of the interface: all addresses excluding 0 and 255 are allowed.
  b) Cyclic operation of the interface: only the value 255 (broadcast address) is allowed.

The contents are arranged in Table 15.

Table 15 - Address field values during transmitting

	Communication phase

Transmitter		Non-cyclic operation (phases 0, 1, 2)	Cyclic operation (phases 3, 4)
master	MST	255	255
master	MDT	1 ≤ ADR ≤ 254	255
slave	AT	1 ≤ ADR ≤ 254	

6.2.3.2 Content of the address field during receiving

Slave:

a) during cyclic operation, a slave receives all telegrams with the value 255 in the address field (all other values indicate ATs which the slave does not receive);
b) during non-cyclic operation, the slave receives the MSTs (ADR = 255) and all telegrams whose address fields have values between 1 ≤ ADR ≤ 254, and which are set on the drives assigned to the slave.

Master:

The master receives all telegrams with values between 1 ≤ ADR ≤ 254 in their address fields.

The contents are arranged in Table 16.

Table 16 - Address field values during reception

		Communication phase	
Receiver		Non-cyclic operation (phases 0, 1, 2)	Cyclic operation (phases 3, 4)
slave	MST	255	255
slave	MDT	1 ≤ ADR ≤ 254	255
master	AT	1 ≤ ADR ≤ 254	

6.2.4 Data field

All transmitted data is allowed to have arbitrary bit sequences of length j x 8 bits, as long as it follows the rules as described in later clauses.

6.2.5 Frame check sequence (FCS) field

The frame check sequence consists of a 16-bit sequence. It shall be the ‘1’s complement of the sum (modulo 2) of:

a) the remainder of:
$X^K * (X^{15} + X^{14} + . . + X^2 + X + 1)$divided (modulo 2) by the generator polynomial
$X^{16} + X^{12} + X^5 + 1$
where K is the number of bits in the frame existing between, but not including, the final bit of the opening delimiter and the first bit of the frame check sequence excluding bits inserted for transparency (bit stuffing bits),
b) the remainder of the division (modulo 2) by the generator polynomial
$X^{16} + X^{12} + X^5 + 1$
of the product of X^{16} by the content of the frame existing between, but not including, the final bit of the opening delimiter and the first bit of the frame check sequence excluding bits inserted for transparency.

As a typical implementation, at the transmitter, the initial content of the register of the device computing the remainder of the division is preset to all 1’s and is then modified by division of the operator polynomial (as described above) of the address and data fields; the ones complement of the resulting remainder is transmitted as the 16-bit frame check sequence.

At the receiver, the initial content of the register of the device computing the remainder is preset to all 1’s. The final remainder after multiplication by X^{16} and then division (modulo 2) by the generator polynomial,

$X^{16} + X^{12} + X^{5} + 1$,

of the serial incoming protected bits and the frame check sequence will be:

0001 1101 0000 1111 (X^{15} through X^{0}, respectively)

in the absence of transmission errors.

NOTE – This text is identical to ISO/IEC 3309, 4.6.2

6.2.6 Order of bit transmission

The order of bit transmission of the address and data fields shall be low-order bit first (i.e., the first bit of the sequence number that is transmitted shall have the weight 2^{0}). Where two bytes make up a 16-bit word or where four bytes form a 32-bit word, the lowest-valued byte will always be transferred first.

When there are several operation data in the configurable part of the data record, then the LSB of the low byte of the first operation data shall be sent first.

The frame check sequence shall be transmitted to the line commencing with the bit of the coefficient with the highest term (X^{15}).

6.2.7 Invalid telegrams

A telegram is invalid:

a) where it is not properly bounded by delimiters at the beginning and the end;
b) where the bit sequence enclosed by the delimiters does not correspond to the length defined during initialization (e.g., shorter than 32 bits).

Invalid telegrams shall be ignored by the receiver. Telegrams ending with seven or more sequential binary 1's instead of the defined delimiter shall be ignored by the receiver.

6.3 Timing of the transmission (communication cycles)

A synchronous error-free media access control is used. Telegrams are exchanged in fixed communication cycles. The master starts the communication cycle strictly equidistant with the communication cycle time t_{Scyc}, by transmitting the master synchronization telegram (MST).

This MST is transmitted as a broadcast telegram to all stations and reaches all drives simultaneously not taking into account the time delay of the ring. The MST is especially short, since it only has information about the status of the ring in its data field. The content of the data field remains constant during the same communication phase so that bit-stuffing (see clause 6.2.2) does not cause jitter at the end of the telegram.

The drive telegram is called AT_m, where m represents the number of the transmission timeslot for the associated drive XX (m = 1, 2 ... M; M = the number of drives in the ring). The transmission timeslot describes the time interval within which a slave is allowed to transmit an AT from one of its connected drives. The beginning of the mth AT transmission timeslot follows $t_{1.m}$ after the end of the MST. This timeslot is stored by the drive (slave) as an IDN (i.e., in a variable slave memory which can be read or written to by the master).

The sequence of timeslots determines the timing of the ATs, which is independent of the physical order of the ring as well as the defined drive address. The master is the recipient of the ATs. Slave units positioned between the master and the transmitting slave transmit the telegrams by means of its repeater function.

The MDT is sent out at time t_2 after the end of the MST after all ATs have been sent within a communication cycle. All drives are receivers of the MDT. The next cycle starts with the transmitting of the next MST.

From now on, ‘beginning of frame’ (telegram), BOF, is the signal edge point which marks the leading binary 0 of the opening delimiter. Similarly, end of frame (telegram), EOF, is the signal edge point of the last binary 0 of the closing delimiter.

6.3.1 Transfer medium access

Figure 22 shows the medium access during CP3 and CP4 (cyclic operation). The medium access during CP0 - CP2, which are used during initialization, is given in clause 8.

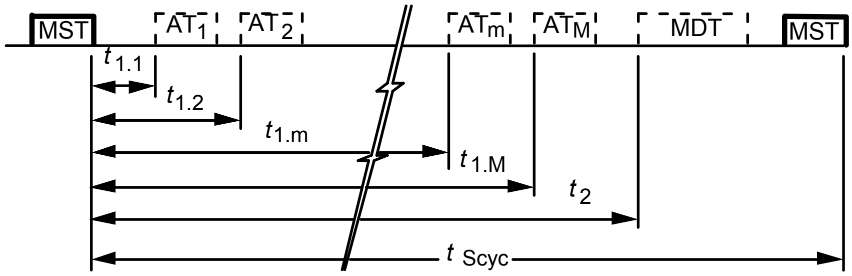


Figure 22 - Access to the transfer medium

Medium access is specified by time parameters which shall follow specific limits. Some times are allowed to have a certain amount of jitter.

6.3.1.1 Cycle times

The following reference values have been determined for the cycle time, t_{Scyc} (communication cycle time), of the transmission cycles:

t_{Scyc} = 62µs, 125µs, 250µs to 65 ms (in 250µs increments)

This cycle time is allowed to have some jitter. The jitter describes the deviations from the t_{Scyc} value in the distance between the ends of two MSTs. J_{tScyc} is determined as follows:

Jitter MST	2 Mbit/s and 4 Mbit/s	8 Mbit/s and 16 Mbit/s
J_{tScyc}	min {5 µs; 0,005 * t_{Scyc}} + 4 * t_{BIT}	1 µs

Therefore, the actual time interval between the end of an MST and the end of the jth following MST has a minimum value of:

j x t_{Scyc} * 0,9999 – J_{tScyc} (j = 1, 2, 3, ...)

and a maximum value of:

j x t_{Scyc} * 1,0001 + J_{tScyc} (j = 1, 2, 3, ...)

NOTE – j is an ordinary integer and not related to the abbreviations.

The factors 0,9999 or 1,0001 take into account the deviation of the communication cycle time t_{Scyc}, compared to the accuracy of the usual crystal oscillators (±100 ppm). Note that the jitter shall not accumulate over several periods (i.e., the average value shall be zero).

6.3.1.2 Telegram transmission times

During the initialization phase, the master inquires about some time parameters from the slaves (see clause 6.3.2). With this information, it is possible to calculate a collision-free distribution of transmission timeslots for the telegrams within the communication cycles.

The master proceeds to transmit the AT transmission starting time, $t_{1.m}$, for all connected drives to each slave as well as the transmission starting time of the MDT t_2. These starting times of the transmitting timeslots for the telegrams are defined next. Jitter has been incorporated in $t_{1.m}$ and t_2:

t_2 MDT transmission starting time: this is the nominal time interval between the end of the MST and the beginning of the MDT during CP3 and CP4. The master stores this time interval in an IDN in the drives.

J_{t2} Jitter in t_2: this is the maximum deviation of the beginning of the MDT. It is the allowed deviation of the time interval t_2. J_{t2} is determined as follows:

Jitter MDT	2 Mbit/s and 4 Mbit/s	8 Mbit/s and 16 Mbit/s
J_{t2}	min {5 µs; 0,005 * t_{Scyc}} + 4 * t_{BIT}	1 µs

The actual time interval between the end of a MST and the beginning of a MDT shall lie between t_2 - J_{t2} and t_2 + J_{t2}.

t_1 AT transmission starting time: this is the nominal time interval between the end of the MST and the beginning of the AT. Every drive has its determined $t_{1.m}$. This parameter has been determined by the master and is stored in the associated drive as an IDN.

J_{t1} Jitter in t_1: this is the maximum deviation of the beginning of the AT. It is the allowed deviation of the time interval t_1. J_{t1} is determined as follows:

Jitter AT	2 Mbit/s and 4 Mbit/s	8 Mbit/s and 16 Mbit/s
J_{t1}	min {5 µs; 0,005 * t_{Scyc}} + 4 * t_{BIT}	1 µs

The actual time interval between the end of a MST and the beginning of an AT_m shall lie between $t_{1.m}$ - J_{t1} and $t_{1.m}$ + J_{t1}.

Figure 22 shows the starting times of the transmission timeslots.

6.3.2 Time parameters

6.3.2.1 Time parameter for the time intervals between telegrams

The following time parameters are characteristic values of slaves. They are requested by the master from every slave during initialization, excluding the values for t_{ATRP} and t_{RPAT}.

t_{1min} Shortest AT transmission starting time. $t_{1min.m}$ is the minimum time after the MST that drive XX with data record m can transmit its AT. This parameter is stored in all drives as an IDN.

t_{ATRP} Maximum transition time of a slave to switch from transmitting the AT to the repeater function (see Figure 19). This time interval shall not exceed 4 * t_{BIT}

t_{RPAT} Maximum transition time of a slave to switch from repeater function to transmit the AT (see Figure 18). This time interval shall not exceed 2 * t_{BIT}

$t_{ATMT.M}$ Transmit/receive transition time in the drive M (ADR XX) to switch from transmitting an AT to the ready state for receiving the MDT. This parameter is stored in all drives as an IDN.

$t_{MTSY.K}$ Receive to receive recovery time needed by the slave which is served with data record K in order to be ready to receive the MST from the end of the MDT. This parameter is stored in all drives as an IDN.

t_{ATAT} Transmit to transmit recovery time needed by a slave with several drives, in order to transmit another drive telegram after the end of a drive telegram. The actual time required may be exceeded by J_{t1}. This parameter is stored as an IDN in all drives which belong to the same slave. Otherwise, such an IDN is not available.

The minimum distance to be maintained between the end of one AT and the following telegram can be determined from the following parameters:

a) t_{ATRP}, where another AT follows the current AT which is not sent by the same slave;
b) t_{ATAT}, where another AT follows the current AT which is sent by the same slave;
c) t_{ATMT}, where the MDT follows the AT.

These defined time parameters are shown in Figure 23.

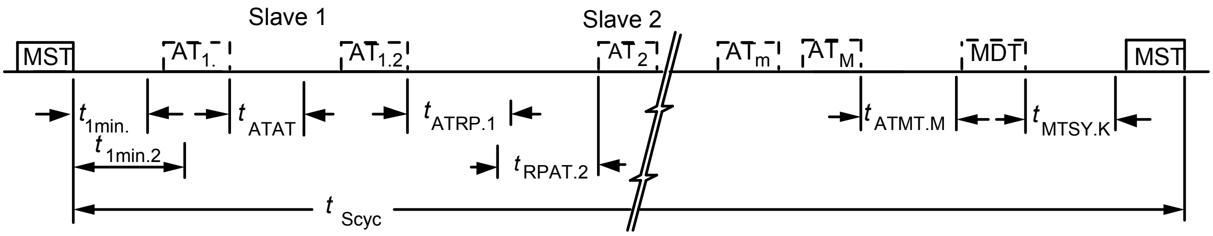


Figure 23 - Required time intervals between telegrams

7 Protocol structure

7.1 General

In this clause, the data exchange between the master and the slaves and vice versa is described. The data exchange in the SERCOS interface consists of the transmission of operation data and procedure commands. All operation data and procedure commands are assigned to an IDN. Every IDN has an associated data block which consists of several elements.

Table 17 - Data block structure

Element number	Content	Requirements
Element 1	IDN	mandatory
Element 2	Name	optional
Element 3	Attribute	mandatory
Element 4	Unit	optional
Element 5	Minimum input value	optional (mandadory for S-0-0001 and S-0-0002)
Element 6	Maximum input value	optional (mandadory for S-0-0001 and S-0-0002)
Element 7	Operation data	mandatory

The SERCOS interface distinguishes between cyclic and non-cyclic data exchanges (service channel). During the cyclic exchange, only element 7 (operation data) of a data block can be transmitted. The transmission of all elements of the data block can only take place via the service channel. Non-cyclic data exchange takes place in steps in special data fields of the telegrams.

The type and length of the data exchange depends on the condition of the SERCOS interface and on the mode of operation of the drives which are connected to the slaves. The most important operation modes are:

- position control;
- velocity control;
- torque control.

Important information, such as status signals from the drives or control signals to the drives, is always transmitted cyclically. All other operation data can be transmitted cyclically (e.g., command values, feedback values) or non-cyclically (e.g., limit values) depending on the application.

7.2 General protocol structure

In the SERCOS interface, all data exchange between the master and slaves or drives takes place through defined telegrams (the general structure of a telegram is shown in Figure 15.)

There are three different telegram types (see Figure 3).

7.2.1 Administrative segment

The following fields, also shown in Figure 15, are part of the administrative segments of the telegram:

– telegram delimiter (BOF);
– address field (ADR);
– frame check sequence (FCS);
– telegram delimiter (EOF).

The administrative segment of the telegram is required for the transmission of any telegram. Telegrams coming from the master can be addressed to a specific target. The master can also use a broadcast address to transmit messages to all drives concurrently. Drive telegrams (ATs) contain the source address.

When using the appropriate components for the SERCOS interface, the setting up and processing of the administrative segment is greatly simplified since these components handle and support this task automatically.

7.2.2 Data field

The data field contains specific information and is handled differently according to the three telegram types and the status of the interface.

In the MST, the data field consists of just one information byte which indicates the operation status of the interface.

During cyclic operation, the MDT is handled as a broadcast telegram to save time. The data field of the MDT is divided into as many data records as there are drives serviced by the master (see Figure 24). The MDT contains all the data records, which are cyclically sent to all connected drives by the master.

Data record 1 Drive address XX	Data record 2 Drive address XX	...	Data record k Drive address XX	...	Data record K Drive address XX	

Figure 24 - Data fields of the master data telegram

Individual data records can have different lengths. During initialization every data record is assigned to its respective drive (having an address XX).

The data field of the AT has only one data record, which is sent from the drive to the control unit cyclically (see Figure 25). The data records of individual ATs can be of different lengths depending on the drive application.

Data record m Drive address XX

Figure 25 - Data field of the drive telegram

Every drive data record in the MDT or AT contains a fixed and a configurable part. The fixed part of the data record is always present, while the structure of the configurable part of the data record is determined for every drive by initialization parameters, according to its operation mode and the desired data volume.

When a drive operates in several operation modes, a configurable part of the data record shall be selected, which transmits the sum of all the required cyclic data.

The structure of the MDT and the AT differs in individual communication phases during the initialization of the interface:

a) During CP0, only the MST is sent by the master. During CP1 and CP2, telegram exchange takes place only between the master and each individual drive. The MDT and the AT are reduced to the fixed part of the data record.

b) During CP3 and CP4, telegram exchange takes place between the master and all drives, based on timing and telegram parameters defined in the communication parameters for cyclic operation. During CP3, the operation data in the configurable data records are not yet valid.

In clause 7.3 and 7.4, the telegram structure for cyclic operation is described. Clause 8 deals with the changing telegram structures in CP0 through CP2.

The slave exists as the physical junction of the fibre optic ring to the SERCOS interface. Logically, a slave acts like an individual drive. Therefore, a slave with several drives processes several data records from the MDT and transmits several ATs.

The structure and length of telegrams remain constant during the cyclic operation of the SERCOS interface. Telegrams can be changed only by reinitializing the system.

The serial transmission of every part of a telegram always starts with the least significant bit (except for the FCS field, which starts its sequence with the bit that is assigned with the highest-valued coefficient, X^{15}). In the telegram examples which follow, the LSB is marked with a ■ symbol. Each telegram example shows the transmission sequence of bits from left to right. The detailed examples of the individual fields differ in that the LSB is located on the right and the MSB is shown on the left side. Where a field consists of several bytes, the lowest-valued byte is transmitted first and the highest-valued byte is sent last (except for the FCS). When there are several operation data in the configurable part of the data record, then the LSB of the low byte of the first operation data shall be sent first.

7.3 Cyclic data exchange (CP4)

7.3.1 Master synchronization telegram (MST)

Every cycle of cyclic data exchange starts with the transmission of the master synchronization telegram (see Figure 26) sent by the master. The MST is sent with a broadcast target address, i.e., all connected drives shall receive the telegram. Therefore, all slaves have received a synchronization marker to which every connected drive coordinates its functional synchronization and its transmit timeslot.

Figure 26 - Structure of the Master Synchronization Telegram

Contents of the individual fields of the master synchronization telegram:

7.3.1.1 BOF telegram delimiter (beginning of frame)

Length: 1 byte

Contents:

0	1	1	1	1	1	1	0
MSB							LSB

Figure 27 - BOF field

Function: indicates the start of the telegram.

7.3.1.2 ADR target address

Length: 1 byte

Contents:

1	1	1	1	1	1	1	1
MSB							LSB

Figure 28 - ADR field

Function: target address of the telegram; $(11111111)_B$ is the broadcast address (i.e., the telegram is received by all drives).

7.3.1.3 INFO (information)

Length: 1 byte

Contents:

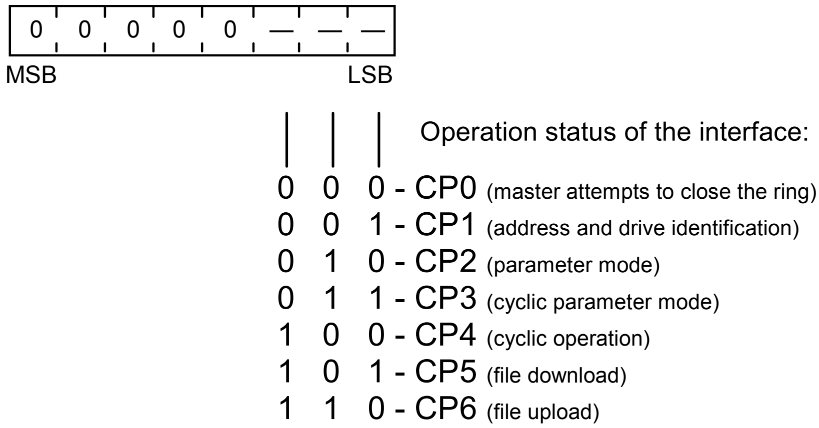


Figure 29 - MST INFO field

Function: Operation status of the interface.

7.3.1.4 FCS Frame check sequence

Length: 2 bytes

Contents:

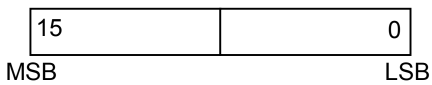


Figure 30 - FCS field

Function: CRC information according to 4.6.2 of ISO/IEC 3309 and ITU-T X.25, 3.6 of ISO 7776; generator polynomial: $G(x) = X^{16} + X^{12} + X^5 + 1$.

NOTE – The FCS is the only field which is sent in reverse sequence during the transmission of the telegrams. The transmission of the FCS starts with the bit that is assigned to the highest-valued coefficient (X^{15}). This function is executed and supported automatically by the appropriate interface elements.

7.3.1.5 EOF telegram delimiter (end of frame)

Length: 1 byte

Contents:

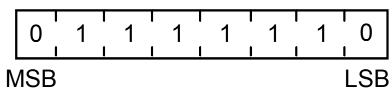


Figure 31 - EOF field

Function: indicates the end of the telegram.

7.3.2 Master data telegram (MDT)

The MDT has the structure shown in Figure 32. The MDT is a broadcast telegram and is sent by the master with a broadcast target address (i.e., all connected drives shall receive the telegram). The data field of the MDT has as many data records as there are drives which are serviced by the master. Individual data records may vary in length. The assignment of a data record to a drive with address XX takes place during initialization via IDN S-0-0009.

Every drive data record in the MDT consists of a fixed and a configurable part (see Figure 32, centre). The fixed part of the data record contains the fields 'control' and 'master service INFO' (see Figure 33). In CP1 and CP2, the Master service INFO field is always 2 bytes long. The length is adjusted by the telegram type (S-0-0015) for CP3 and CP4.

The configurable part of the data record (see Figure 32, bottom) can be used for individual data records for any drive. Only element 7 (operation data, see Figure 34) of the data block, however, and operation data configured in two, four or eight byte strings can be used. The telegram type parameter S-0-0015 determines which operation data is included in the configurable part of the data record. The appropriate operation data for standard telegrams is defined by this parameter. The structure of the application telegram is determined by the configuration list labeled IDN S-0-0024.

General structure of the MDT:

7.3.2.1 BOF telegram delimiter (begin of frame)

Refer to Figure 27

7.3.2.2 ADR target address

Refer to Figure 28

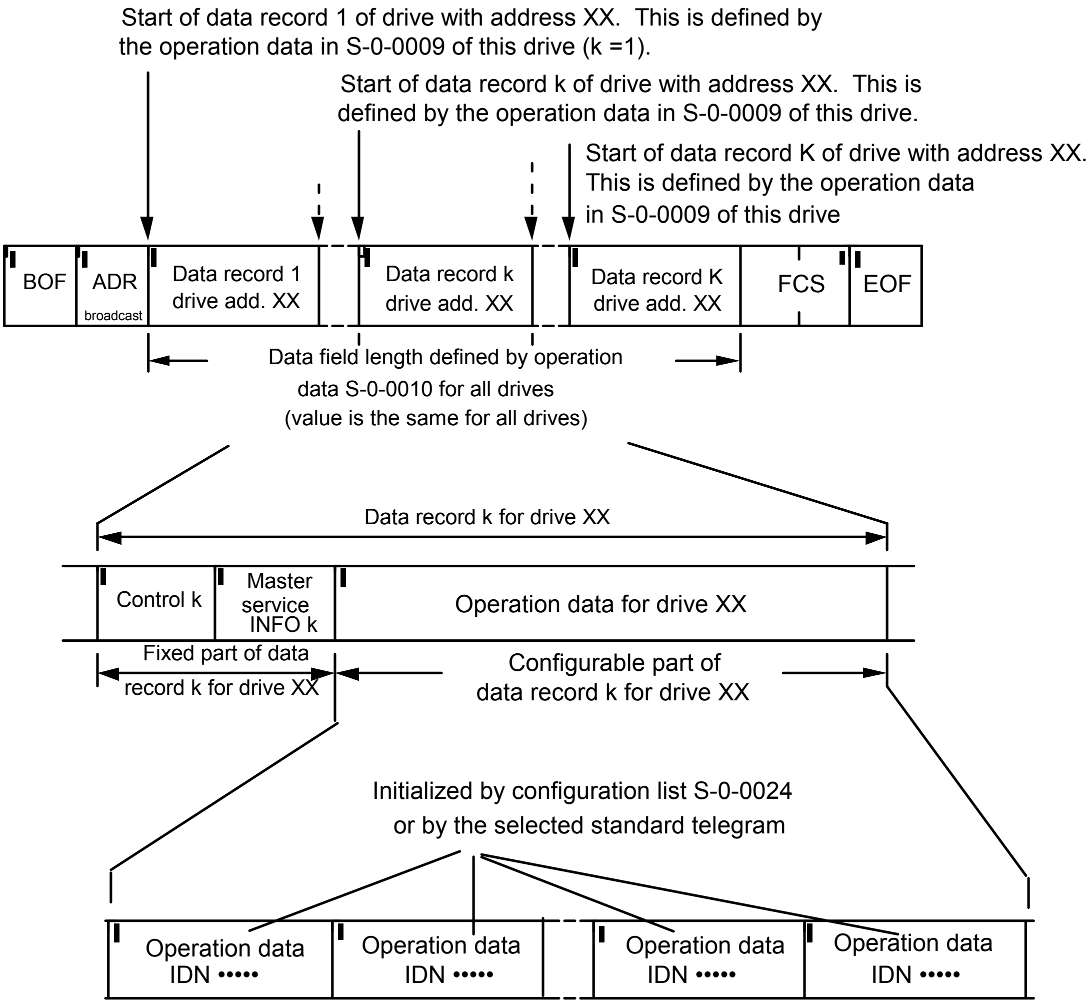


Figure 32 - Structure of the Master Data Telegram

Contents of individual fields of the MDT:

7.3.2.3 Control k - control word for drive XX

Length: two bytes

Table 18 – Control word description

Bit No.	**Control word description**
Bits 15-13	
1 1 1	Drive should follow command values
Bit 15 (MSB)	Drive ON/OFF (see clause 14.11)
0	Drive OFF: when changing from 1 -> 0: the „maximum drive off delay time“ (S-0-0273) is started, drive is decelerated as best as possible limited by the „emergency stop deceleration“ (S-0-0429), followed by disabling of the torque at n_{min}, after the „drive off delay time“ (S-0-0207). The power stage can remain in an activated state (only possible when bit 14=1). After the „maximum drive off delay time“ (S-0-0273) is elapsed, the locking of brake is initiated and the torque is disabled.
1	Drive ON: when changing from 0 -> 1: drive follows the command values of the control unit after the drive on delay time (S-0-0206).
Bit 14	Enable drive (see clause 14.11)
0	Not enabled: when changing from 1 –> 0, torque is immediately disabled and the power stage pulses are blocked (independent of bits 15 and 13).
1	Enable Drive: when changing from 0 –> 1, the enable is delayed in the drive by the drive enable delay time (S-0-0295). The enable delay is required at use of a contactor in the motor cable.
Bit 13	Halt/restart drive (may be used to stop the drive regardless of the presently active control unit function)
0	Halt drive: when changing from 1 –> 0, a) drive internal interpolator is inactive: drive is halted according to the „drive halt acceleration bipolar“ parameter (S-0-0372) and the control loop remains closed (only possible when bits 15 and 14 are set to 1). b) drive internal interpolator is active: drive is halted according to the active parameters of the interpolator and the control loop remains closed (only possible when bits 15 and 14 are set to 1).
1	Restart drive: when changing from 0 –> 1, a) drive internal interpolator is inactive: original function is continued. Only in velocity control the drive has to use the „drive halt acceleration bipolar“ (S-0-0372). In position control the control unit has to set the position command value to the position feedback value before bit 13 is set. b) Drive internal interpolator is active: original function is continued maintaining the active parameters of the interpolator.
Bit 12	Reserved
Bit 10	IPOSYNC: Control unit synchronization bit
0/1	This bit is initially set to 0. It becomes valid in CP3 and shall remain valid during drive-controlled functions. This bit is toggled with the control unit cycle time (t_{Ncyc}) indicating the update of the command values (function: used to synchronize the interpolation in the control unit with the fine interpolator in the drive)
Bits 11,9, 8	Operation mode (see clause 14.5)
0 0 0	Primary operation mode (defined by operation data S-0-0032).
0 0 1	Secondary operation mode 1 (defined by operation data S-0-0033)
0 1 0	Secondary operation mode 2 (defined by operation data S-0-0034)
0 1 1	Secondary operation mode 3 (defined by operation data S-0-0035)
1 0 0	Secondary operation mode 4 (defined by operation data S-0-0284)
1 0 1	Secondary operation mode 5 (defined by operation data S-0-0285)
1 1 0	Secondary operation mode 6 (defined by operation data S-0-0286)
1 1 1	Secondary operation mode 7 (defined by operation data S-0-0287)
Bit 7	Real-time control bit 2 (S-0-0302, see clause 12.4)
Bit 6	Real-time control bit 1 (S-0-0300, see clause 12.4)
Bits 5, 4, 3	Data block element (see clause 11.1.3)
0 0 0	Service channel not active, close service channel or break a transmission in progress

Bit No.	Control word description
0 0 1	IDN of the operation data. The service channel is closed for the previous IDN and opened for a new IDN
0 1 0	Name of operation data
0 1 1	Attribute of operation data
1 0 0	Unit of the operation data
1 0 1	Minimum input value
1 1 0	Maximum input value
1 1 1	Operation data
Bit 2	(see clause 7.4.2)
0	Transmission in progress
1	Last transmission
Bit 1	R/W (read/write) see clause 7.4.2
0	Read service INFO
1	Write service INFO
Bit 0	MHS (see clause 7.4.2)
0/1	Service transport handshake of the master

7.3.2.4 Master service INFO k

Length: two bytes in CP1 and CP2
2, 4, 6 or 8 bytes in CP3 and CP4, programmable by telegram type (S-0-0015)

Contens:

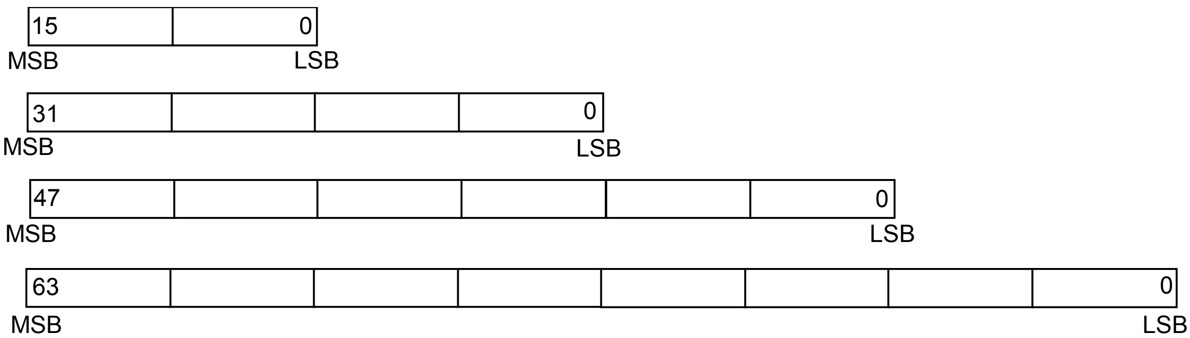


Figure 33 - Master service INFO field k

Function: service channel from master to drive XX

The master service INFO field is the container for the non–cyclic data exchange from the master to a drive which takes place in steps in special data fields of the telegram (see clause 7.4).

7.3.2.5 Configurable part of data record k

Length: one or several two-byte, four-byte or eight-byte fields

Contents: two, four or eight bytes of operation data

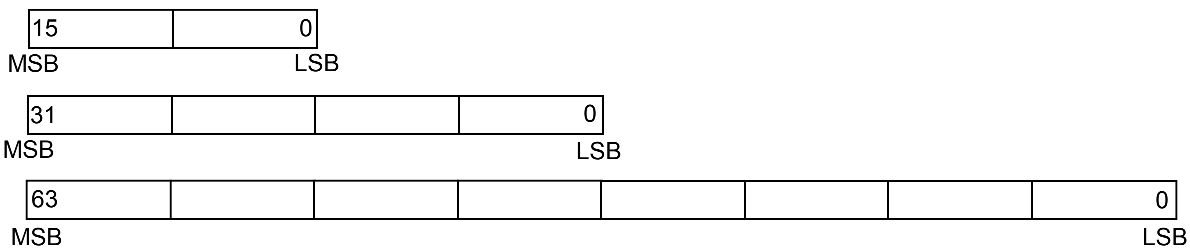


Figure 34 - Operation data of the MDT

Function: operation data (element 7) which are transmitted cyclically from the master to a drive.

7.3.2.6 FCS frame check sequence

Refer to Figure 30

7.3.2.7 EOF telegram delimiter (end of frame)

Refer to Figure 31

7.3.2.8 Examples of Master Data Telegrams

In order to simplify the use of the SERCOS interface, several standard telegrams with fixed structure for data records have been defined for various drive operation modes. The selection of the appropriate standard telegram is determined by the telegram type parameter (S-0-0015) for each drive.

The following example shows a MDT where all data records k are set for the ‘velocity control’ operation mode with standard telegram 2. Every data record of the MDT contains in the configurable part the appropriate drive operation data (element 7), which is velocity command value (S-0-0036).

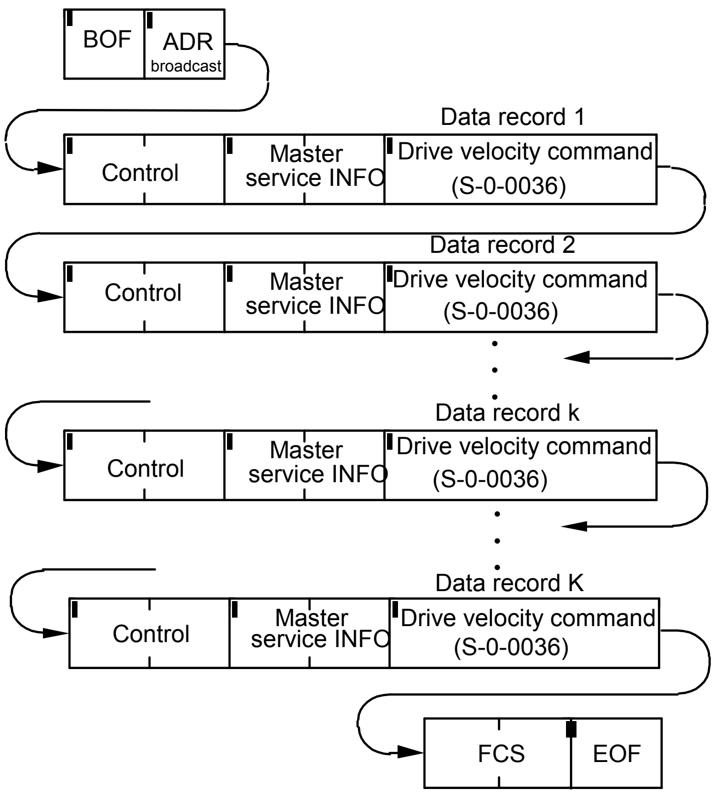


Figure 35 - Example of MDT

(standard telegram 2 for velocity control operation mode)

7.3.3 Drive telegram (AT)

The AT has the structure shown in Figure 36. The AT is sent with its source address from the drive (slave) to the master.

The data field of the AT consists of a data record with a fixed and a configurable part (see Figure 36, centre). The fixed part of the data record contains the fields ‘status’ and ‘drive service INFO’. In CP1 and CP2 the drive service INFO field is always 2 bytes long. The length is adjusted by the telegram type (S-0-0015) for CP3 and CP4.

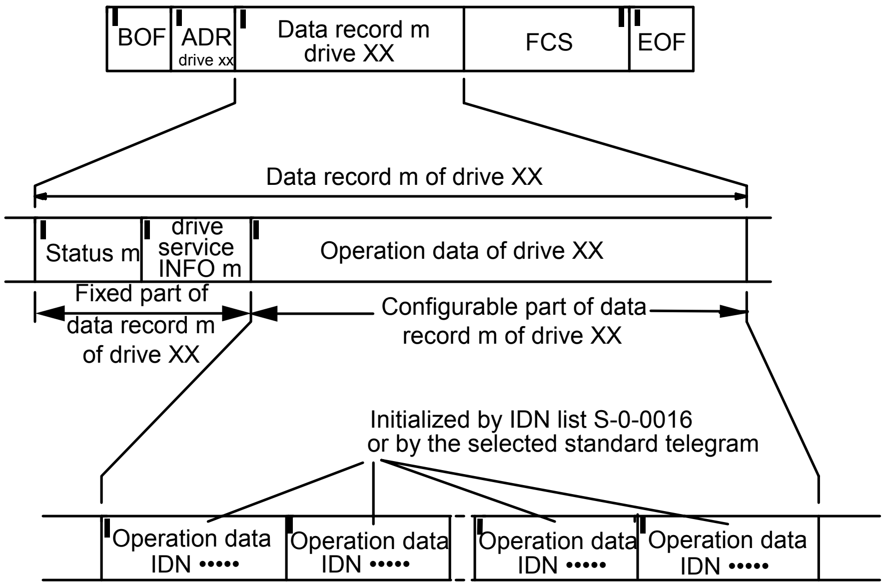


Figure 36 - Structure of the Drive Telegram

The configurable part of the data record (see Figure 36, bottom) can be used for individual data records for any drive. However, only element 7 (operation data, see Figure 38) of the data block and operation data of fixed length (2, 4 or 8 bytes) can be used.

Telegram type parameter S-0-0015 determines which operation data are included in the configurable part of the data record. The appropriate operation data for standard telegrams is predefined by this parameter. The structure of an application telegram is determined by the configuration list labelled S-0-0016.

7.3.3.1 Telegram delimiter (beginning of frame)

Refer to Figure 27

7.3.3.2 ADR (source address)

Length: one byte
Contents: (refer to Figure 28)
Function: address of drive XX

Contents:
All values are allowed except:
– $(00000000)_B$ - reserved;
– $(11111111)_B$ - broadcast address
Each drive shall have a unique address!

7.3.3.3 Status m – status word of drive XX

Length: two bytes

Table 19 – Status word description

Bit No.	Status word description
Bits 15, 14	'Ready to operate' (see clause 14.11)
0 0	Drive not ready, internal checks not yet concluded successfully
0 1	Drive logic ready for main power on (power stage section)
1 0	Drive ready and main power applied, drive is free of torque, power stage pulses are blocked
1 1	Drive ready to operate, 'enable drive' is set and active. Power stage is active
Bit 13	Drive shut-down error in C1D (S-0-0011, see clause 14.11)
0	No shut-down

Bit No.	**Status word description**
1	Drive is shut-down due to error
Bit 12	Change bit for C2D (S-0-0012)
0	No change
1	Change
Bit 11	Change bit for C3D (S-0-0013)
0	No change
1	Change
Bits 10, 9, 8	Actual operation mode (see clause 14.5)
0 0 0	Primary operation mode (defined by S-0-0032)
0 0 1	Secondary operation mode 1 (defined by S-0-0033)
0 1 0	Secondary operation mode 2 (defined by S-0-0034)
0 1 1	Secondary operation mode 3 (defined by S-0-0035)
1 0 0	Secondary operation mode 4 (defined by S-0-0284)
1 0 1	Secondary operation mode 5 (defined by S-0-0285)
1 1 0	Secondary operation mode 6 (defined by S-0-0286)
1 1 1	Secondary operation mode 7 (defined by S-0-0287)
Bit 7	Real-time status bit 2 (S-0-0306, see clause 12.4)
Bit 6	Real-time status bit 1 (S-0-0304, see clause 12.4)
Bit 5	Procedure command change bit (see clause 7.5)
0	No change in procedure command acknowledgement
1	Changing procedure command acknowledgment
Bit 4	Parameterization levels (PL1, PL2)
0	PL1 and PL2 not active
1	PL1 or PL2 active
Bit 3	Status command value processing
0	Drive ignores the command values (e.g., during Halt drive, drive controlled functions, programmed delay times)
1	Drive follows the command values
Bit 2	Error in service channel (see clause 7.4.2)
0	No error
1	Error in service channel, error message in drive service INFO
Bit 1	Busy (see clause 7.4.2)
0	Step finished, ready for new step
1	Step in progress, new step not allowed
Bit 0	AHS (see clause 7.4.2)
0/1	Service transport handshake of the drive

7.3.3.4 Drive service INFO m

Length: two bytes in CP1 and CP2
2, 4, 6 or 8 bytes in CP3 and CP4, programmable by telegram type (S-0-0015)

Contens:

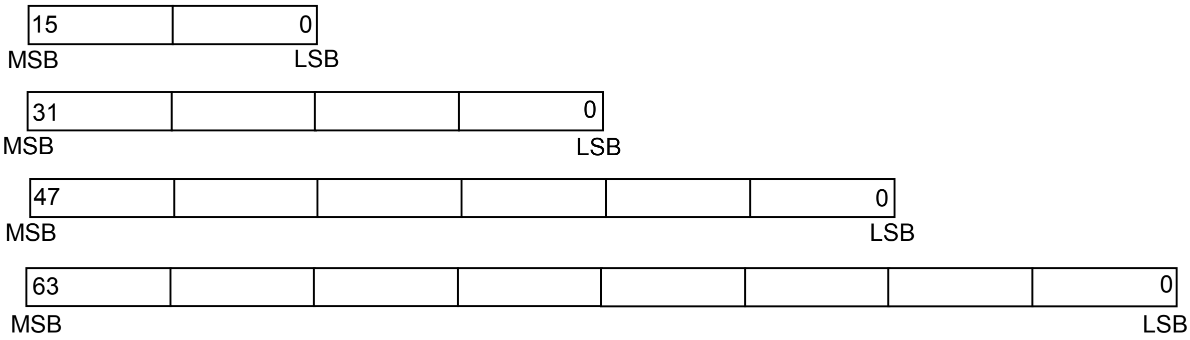


Figure 37 - Drive service INFO field m

Function: service channel from drive XX to master.

The drive service INFO field is the container for the non-cyclic data exchange from a drive to the master which takes place in steps in special data fields of the telegram (see clause 7.4).

7.3.3.5 Configurable part of data record m

Length: one or several two-byte, four-byte or eight-byte fields

Contents: two, four or eight bytes of operation data

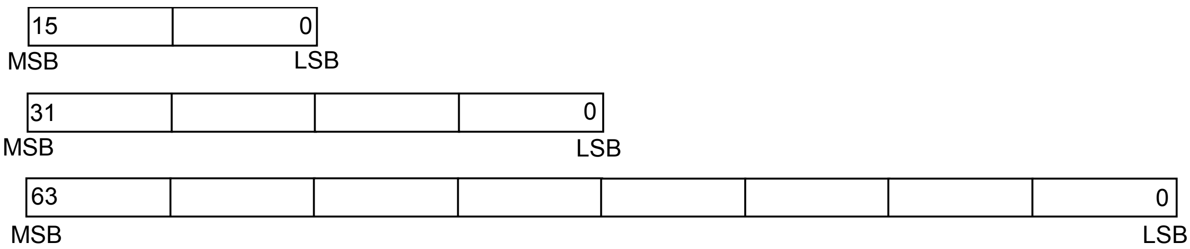


Figure 38 - Operation data of the AT

Function: contains operation data (element 7) which are transmitted cyclically from a drive to the master.

7.3.3.6 FCS frame check sequence

Refer to Figure 30

7.3.3.7 EOF telegram delimiter (end of frame)

Refer to Figure 31

7.3.3.8 Example of Drive Telegram

In order to simplify the use of the SERCOS interface, several standard telegrams with fixed structure for data records have been defined for various drive operation modes. The selection of the appropriate standard telegram is determined by the telegram type parameter (S-0-0015) for each drive.

The following example shows an AT where the data record m is set for the ‘velocity control’ operation mode with standard telegram 2. The data record of the AT contains in the configurable part the appropriate drive operation data (element 7) which is velocity feedback value (S-0-0040).

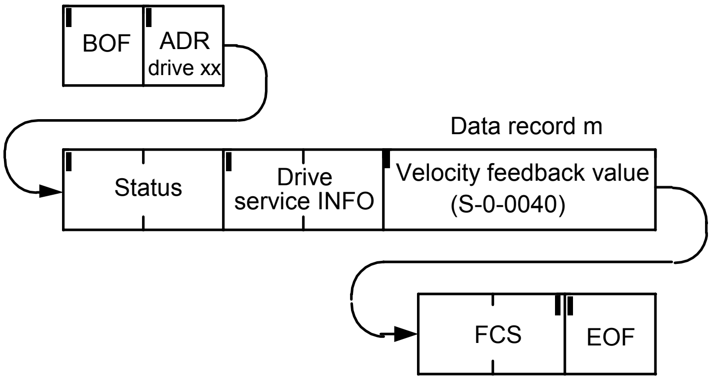


Figure 39 - Example of a Drive Telegram

(standard telegram 2 for velocity control operation mode)

7.3.4 Timing diagram for cyclic operation

During cyclic operation of the SERCOS interface, all telegrams are transmitted in predetermined timeslots. All timing is in reference to the end of the MST. The appropriate timing is established for every drive during CP2.

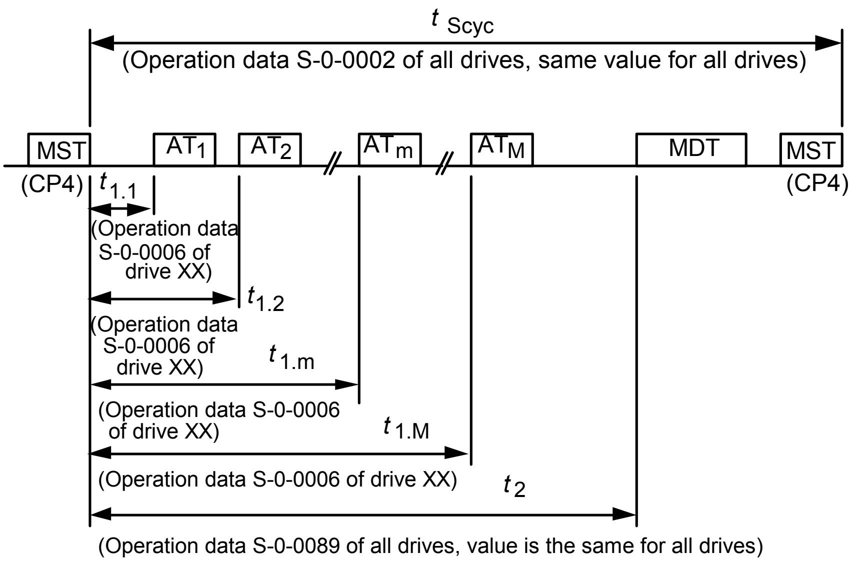


Figure 40 - Timing diagram for cyclic operation

7.4 Non-cyclic data exchange (service channel)

7.4.1 General

In addition to the cyclic transmission of data, the SERCOS interface provides the ability to transmit non-cyclic data. To transmit this data, the drive service INFO field is reserved for the service channel (see 'service INFO' in clause 7.3.2.4 and 7.3.3.4) in the MDT and in the AT. Special control and status bits in the control word of the MDT or the status word of the AT are used to control execution in the service channel. Therefore, the master is able to support a separate service channel for every connected drive.

During a non-cyclic transmission, the following operations are possible:

– initialization of the SERCOS interface;
– transmission of all elements of a data block;
– transmission of procedure commands;
– changing limit values on demand;
– changing control loop parameters on demand;

– obtaining detailed status messages from a drive;
– diagnostic functions.

Any non-cyclic transmission via the service channel is always initiated and controlled by the master. The operations, 'read element' or 'write element', are from the perspective of the master. All operations are always related to the last transmitted IDN.

The service channel is initialized during CP1 and is functional for the remainder of the communication phases.

The master and the drive each have one transport timing control. This synchronizes the non-timed process of the service channel handling with the transmission starting time of the MDT at t_2, or of the AT at $t_{1.m}$ (see Figure 41). Furthermore, the transport timing control writes the service information and the service control and status bits in the appropriate telegram fields just before t_2 or $t_{1.m}$.

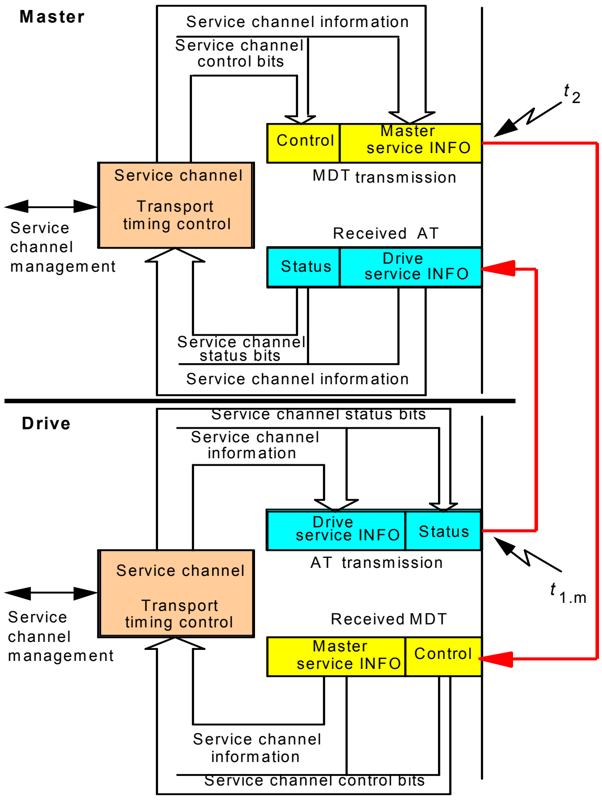


Figure 41 - Service channel data transport scheme

7.4.2 Service channel transport mechanism

The non-cyclic transport of operation data or of a procedure command is handled via a predetermined handling and proceeding sequence (see Figure 42 and Figure 43) for individual actions. The master shall strictly follow the outline of these diagrams.

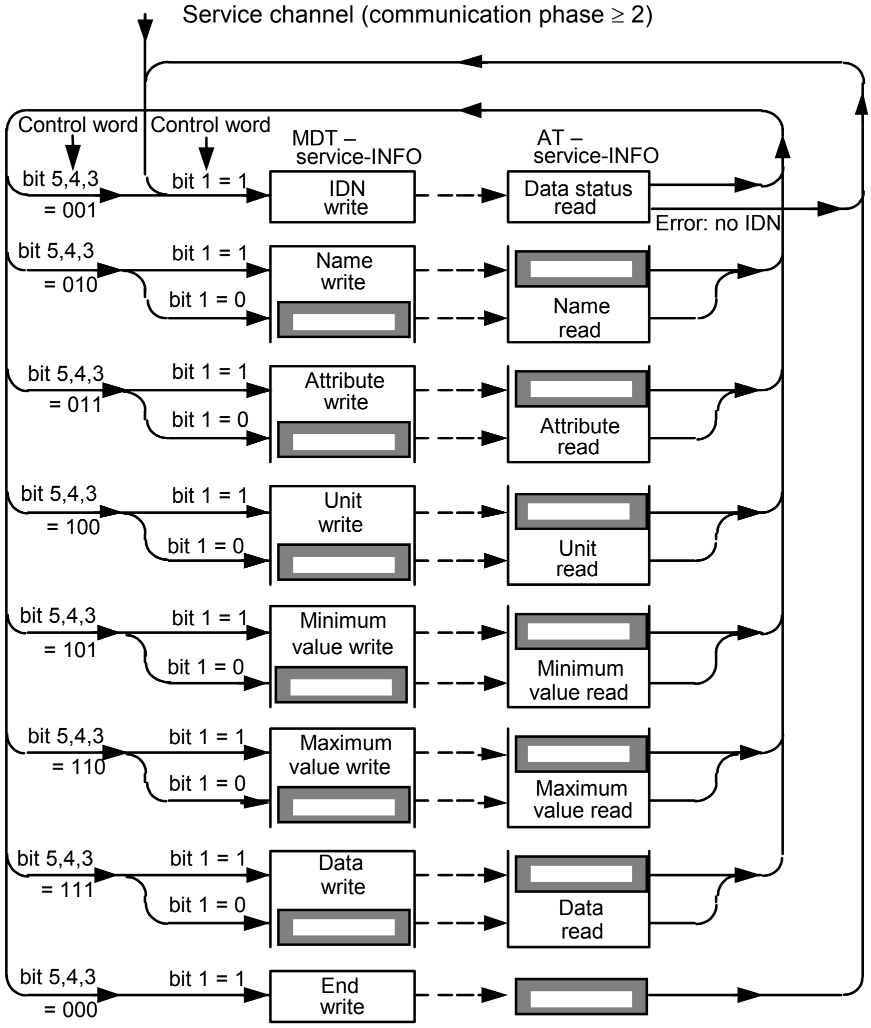


Figure 42 - Service channel handling diagram

The transmission starts with the opening of the service channel by sending the IDN of the data block (element 1). The slave (drive) responds by writing the data status or the procedure command acknowledgment of the received IDN.

During the next step, the master indicates which elements of the data block shall be processed. For this purpose, the master sets bits 5, 4 and 3 accordingly in the master control word. Following this, the master indicates in bit 1 whether the element will be read or written to. While writing, the master service INFO field of the MDT is filled with the appropriate data for the drive (contents of the drive service INFO field are invalid). When reading is selected, the drive inserts the appropriate data in the drive service INFO field of the AT (contents of the master service INFO field of the MDT are invalid).

Depending on the length of the data block elements which need to be transmitted and of the length of the service INFO field, several steps may be required.

Example: Every step transports two bytes of data.

The Table 20 shows the necessary steps for the individual elements of a data block.

Table 20 – List of IDNs element and step numbers

Element number	Description	Requirement	Number of steps	
1	IDN	Mandatory	1	
2	Name	Optional	2 to 32	
3	Attribute	Mandatory	2	
4	Unit	Optional	2 to 8	
5	Minimum input value	Optional	1, 2 or 4	
6	Maximum input value	Optional	1, 2 or 4	
7	Operation data	Mandatory	Fixed length:	1, 2 or 4
			Variable length:	2 to 32768
0	Closing the service channel		1	

The master indicates in bit 2 of the master control word a transmission in progress (bit 2 = 0) or the transmission of the last 2 bytes (bit 2 = 1). A transport with just one step is immediately set by the master as the last transmission (bit 2 = 1).

The error messages “element transmission too short” or “element transmission too long” are executed by the drive only when the length of the actual transmitted element is not in coincidence with the states of bit 2 in the control word.

The non-cyclic transmission of operation data or a procedure command ends with the deactivation of the service channel (writing the bits 5, 4, and 3 in the master control word with 0) or transmission of the IDN for the next operation data or procedure command.

Changing the data block element during transmission in progress is possible without an error message only when the following bits have the status given below in Table 21:

Table 21 - Condition for modifying data block elements

Information	SVC control bit	SVC status bit	bit value
Transmission in progress	bit 2		0
Handshake bits equal	bit 0	bit 0	MHS = AHS
Busy		bit 1	0

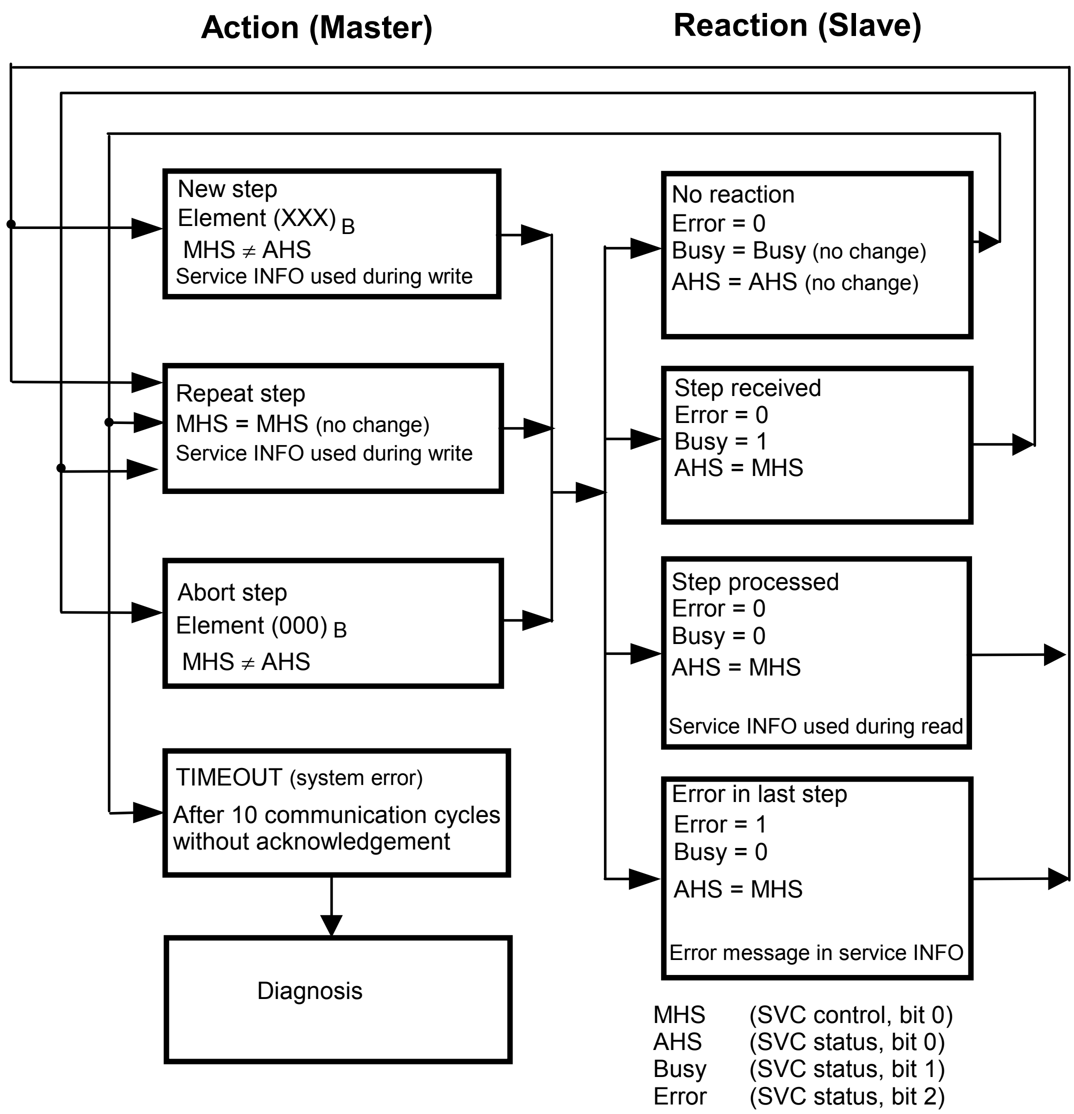


Figure 43 - Communication step proceeding diagram

7.4.2.1 Handshake bits

During non-cyclic transmissions, the transport of every step is secured by two service transport handshake bits. These are the bits 0 in the control word of the master (MHS) and in the status word of the drive (AHS) (see Table 18 and Table 19).

For every new step during the transmission, the master toggles the MHS-bit. The drive recognizes by the toggled MHS-bit that a new step needs to be executed. After the drive has received the required step and secured it for processing, it proceeds to set its AHS-bit equal to the MHS-bit. By comparing the MHS-bit with the AHS-bit, the master and the drives are always able to recognize the actual transport status during non-cyclic transmission.

The following applies to the master's perspective:

Drive AHS-bit = master MHS-bit:

→ the step was received by the drive and secured, drive starts processing. The master shall wait for processing acknowledgment (busy bit = 0, bit 1 in the status word).

Drive AHS-bit ≠ master MHS-bit:

→ the steps were not yet received or secured by the drive. The master shall repeat the last step.

The following applies to the drive's perspective:

Master MHS-bit = drive AHS-bit:

→ the master does not require a new step, drive repeats the last step.

Master MHS-bit ≠ drive AHS-bit:

→ the master requests a new step.

The service transport handshake bits enable the drives and the master to insert 'wait cycles' during the transmission, e.g.:

- when more than one cycle will be required for receiving or transmitting a step;
- when a new step has not been recognized due to an error during the transmission;
- when the master will not issue any new steps at this time.

During every 'wait cycle', the master or the drive transmits the data of the previous interface cycle into the service INFO field.

After a maximum of 10 communication cycles, the master sets a 'timeout' condition when the drive does not acknowledge the proper reception of a step by matching its AHS-bit (see clause 9.5).

7.4.2.2 Busy bit

The drive is able to control any non-cyclic transmission through the busy bit. The busy bit indicates that the drive is processing or just finishing the requested step at this time. Not until the drive sends the processing acknowledgement (busy bit = 0) is the master allowed to start the next step. The busy bit allows the drive to prevent the master from forcing the steps on the drive too quickly.

The SERCOS interface defines no 'timeout' parameter for the processing acknowledgment of the drive. After some time, the master should be able to interrupt a step which was not acknowledged by the drive, by closing the service channel.

7.4.2.3 Service channel error messages

Errors can occur in the transport mechanism of the service channel (e.g., when the lengths of the operation data differ between the master and the drive, or vice versa, or where the IDN is undefined). In order to announce errors discovered by the drive, an error bit (bit 2) is defined in the AT status word. When this bit is set, the service INFO field of the AT contains an error code.

The drive is allowed to report an error message only when a new processing step is issued by the master, that is:

- when master MHS-bit ≠ drive AHS-bit (step not yet secured);

or

- busy bit = 1 (step still in process).

When the drive recognizes an error, it ignores the actual step, interrupts and acknowledges by:

- setting the AHS-bit equal to the MHS-bit (when not already acknowledged in a previous cycle);
- setting the error bit to 1 (bit 2 status word);
- sending the error codes in the service INFO field (see Table 22);
- setting the busy bit to 0.

Where the master intends to repeat the transmission of an element after an error message, the lowest-valued byte of the element is transmitted first.

All possible error messages are shown in Table 22; the unused codings are reserved.

The transport mechanism in the possible steps for the service channel data transfer is shown in an example in annex I.

Table 22 - Error messages

Error code	Description
0x0nnn	**General error**
0x0000	No error in the service channel
0x0001	Service channel not open
0x0009	Invalid access to closing the service channel
0x1nnn	**Element 1 (Ident number)**
0x1001	No IDN
0x1009	Invalid access to element 1
0x2nnn	**Element 2 (Name)**
0x2001	No name
0x2002	Name transmission too short
0x2003	Name transmission too long
0x2004	Name cannot be changed (read only)
0x2005	Name is write-protected at this time
0x3nnn	**Element 3 (Attribute)**
0x3002	Attribute transmission too short
0x3003	Attribute transmission too long
0x3004	Attribute cannot be changed (read only)
0x3005	Attribute is write-protected at this time
0x4nnn	**Element 4 (Unit)**
0x4001	No units
0x4002	Unit transmission too short
0x4003	Unit transmission too long
0x4004	Unit cannot be changed (read only)
0x4005	Unit is write-protected at this time
0x5nnn	**Element 5 (Minimum input value)**
0x5001	No minimum input value
0x5002	Minimum input value transmission too short
0x5003	Minimum input value transmission too long
0x5004	Minimum input value cannot be changed (read only)
0x5005	Minimum input value is write-protected at this time
0x6nnn	**Element 6 (Maximum input value)**
0x6001	No maximum input value
0x6002	Maximum input value transmission too short
0x6003	Maximum input value transmission too long
0x6004	Maximum input value cannot be changed (read only)
0x6005	Maximum input value is write-protected at this time
0x7nnn	**Element 7 (Operation data)**
0x7002	Operation data transmission too short
0x7003	Operation data transmission too long
0x7004	Operation data cannot be changed (read only)

Error code	Description
0x7005	Operation data is write-protected at this time (e.g. Communication phase)
0x7006	Operation data is smaller than the minimum input value
0x7007	Operation data is greater than the maximum input value
0x7008	Invalid operation data: Configured IDN will not be supported, invalid bit number or bit combination
0x7009	Operation data write protected by a password
0x700A	Operation data is write protected, it is configured cyclically. (IDN is configured in the MDT or AT. Therefore writing via the service channel is not allowed).
0x700B	Invalid indirect addressing: (e.g., data container, list handling)
0x700C	Operation data is write protected, due to other settings. (e.g., parameter, operation mode, drive enable, drive on etc.)
0x700D	invalid floating point number
0x700E	reserved
0x700F	reserved
0x7010	Procedure command already active
0x7011	Procedure command not interruptible
0x7012	Procedure command at this time not executable (e.g., in this phase the procedure command can not be activated).
0x7013	Procedure command not executable (invalid or false parameters)
0xEnnn	**reserved for Control unit internal error codes**
0xFnnn	**reserved for Control unit internal error codes**

7.4.3 Service channel initialization

In CP1, each service channel starts with the following status:

- the MHS-bit in the MDT and the AHS-bit in the AT are set to 1 (see Figure 59 and Figure 60). All other control or status bits of the service channel are set to 0;
- any bits in the service INFO fields are invalid.

Starting with CP2, the service INFO fields in the MDT and the AT become valid. This implies that the master, and a slave servicing several drives, freeze the status of the service channel before switching from one drive to another. When addressing this drive again at a later time, the master is set to this frozen status.

7.5 Procedure command functions via the service channel

In the SERCOS interface, procedure command functions can be transmitted through the service channel. A procedure command is considered a special type of non-cyclic data which, when transmitted through the service channel, invokes fixed functional processes in both the drives and the master. These processes may take up some time. Hence, a procedure command only causes a functional process to start. After a procedure command has started its function, the service channel becomes available again immediately for the transmission of non-cyclic data or for more procedure commands.

Contrary to non-cyclic data transmission whose proceeding is finished with the last transmitted step, the end of a procedure command during a lengthy procedure command execution is indicated by the procedure command change bit (bit 5 in the AT status word). The master is also able to interrupt a procedure command during its execution which is not possible for non-cyclic data transmission.

Every procedure command has been assigned an IDN and an appropriate data block. Not all elements of the data block are defined, however, and other elements have a predetermined form. Procedure commands are described in more detail in clause 14. In this subclause, only special processes of the procedure command functions in the service channel are discussed.

7.5.1 Procedure command control and acknowledgment

A procedure command function always prompts a procedure command control from the master to the drive and a procedure command acknowledgment from a drive to the master. The procedure command control is integrated in element 7 of the data block (element 7 is always represented as a bit list for procedure commands) (see Table 23).

Procedure command control allows procedure commands to be:

– set;
– enabled for execution;
– interrupted during execution;
– cancelled.

The drive acknowledges the transmission of a procedure command from the master via the service channel with its AHS-bit and the busy bit in its status word.

Table 23 - Procedure command control

Bits 15-2	(Reserved)
Bit 1	
0	Interrupt procedure command execution
1	Enable procedure command execution
Bit 0	
0	Cancel procedure command
1	Set procedure command

When starting the initializing (CP0), all procedure commands inside the master shall be disabled and then the procedure command control shall be updated appropriately internally in the master.

The procedure command acknowledgment is part of the data status (see Table 24).

In order to receive a procedure command acknowledgment, the master writes the IDN of the procedure command via the service channel.

When acknowledging a procedure command, the drive indicates the actual status of the procedure command as given in Table 24. Bits 0 and 1 of the procedure command acknowledgment are simply copies of the procedure command control and indicate the actual status of the procedure command.

The procedure commands are treated as non-cyclical data in the Slave.
If the master activates a procedure command, it can take several communication cycles till the slave generates the corresponding procedure command acknowledgment. Therefore the master should scan the procedure command acknowledgment as shown in Figure 45.

Table 24 - Procedure command acknowledgment (data status)

Bits 15-9	(Reserved)
Bit 8	
0	Operation data is valid
1	Operation data is invalid
Bits 7-4	(Reserved)
Bit 3	
0	No procedure command error
1	Error, procedure command execution is impossible
Bit 2	
0	Procedure command executed correctly
1	Procedure command not yet executed

Bit 1	
0	Procedure command execution interrupted in the drive
1	Procedure command execution enabled in the drive
Bit 0	
0	Procedure command not yet set in the drive by the master
1	Procedure command set in the drive

With the starting of the initializing (CP0), all procedure commands within the slave shall be disabled and then the procedure command acknowledgment shall be updated appropriately internally in the slave.

7.5.1.1 Procedure command change bit

In order to inform the master of the end of a procedure command being executed in the drive, a procedure command change bit has been reserved in the status word (bit 5).

Only the following changes in the procedure command acknowledgment will set the procedure command change bit:

– procedure command executed correctly (positive acknowledgment, bit 2 changes from 1 to 0);
– error, procedure command execution impossible (negative acknowledgment, bit 3 changes from 0 to 1).

All other changes of the procedure command acknowledgment (e.g., an interrupt) are not indicated by the procedure command change bit.

The master shall read the data status by writing the IDN of the procedure command and check the procedure command acknowledgment contained therein. This indicates whether the procedure command was executed positively or negatively.

At negative procedure command acknowledgment, the master should read the diagnosis (if desired) before the procedure command is cancelled.

When a procedure command is cancelled by the master, all effects of the procedure command on the procedure command change bit in the drive are cancelled as well. Where the master has activated several procedure commands concurrently, all resulting procedure command acknowledgments shall be checked after setting the procedure command change bit in order to determine which procedure command caused the change.

As a rule, the master shall cancel a procedure command after it has been processed, irrespective of whether it was acknowledged positively or negatively.

A procedure command is cancelled by setting bit 0 in the procedure command control to 0. This is independent from the actual procedure command execution state.

The state machine Figure 44 describes the allowed state changes for procedure commands using the following abbreviations:

CB: procedure command change bit (status word, bit 5)
CC: procedure command control
CA: procedure command acknowledgment

For procedure command control (CC), only the following values are allowed:

000000XX X = 0 or 1

When the CC is invalid, (> $(11)_B$), the drive generates the error message: ‘invalid data’ in the drive service INFO.

A state change to 'procedure command not set' (CA = $(00000000)_B$), is only possible by canceling the procedure command.

Where more than one procedure command execution is active and the 'procedure command change bit' is set by more than one procedure command, this bit is reset in the status word when all procedure commands which had set the bit are cancelled.

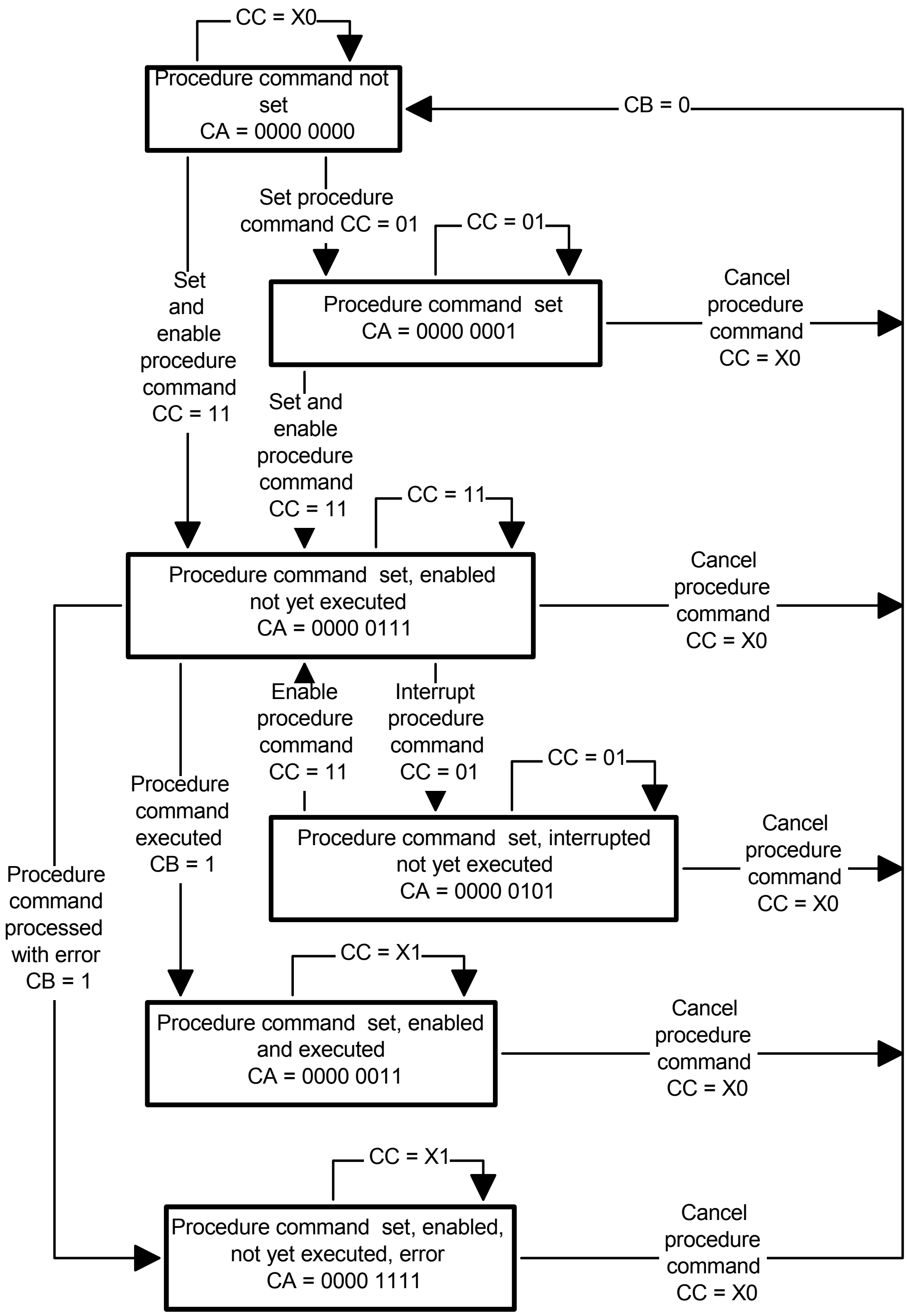


Figure 44 - State machine for procedure command execution

Figure 45 shows the sequence of procedure command handling should be met by the master:

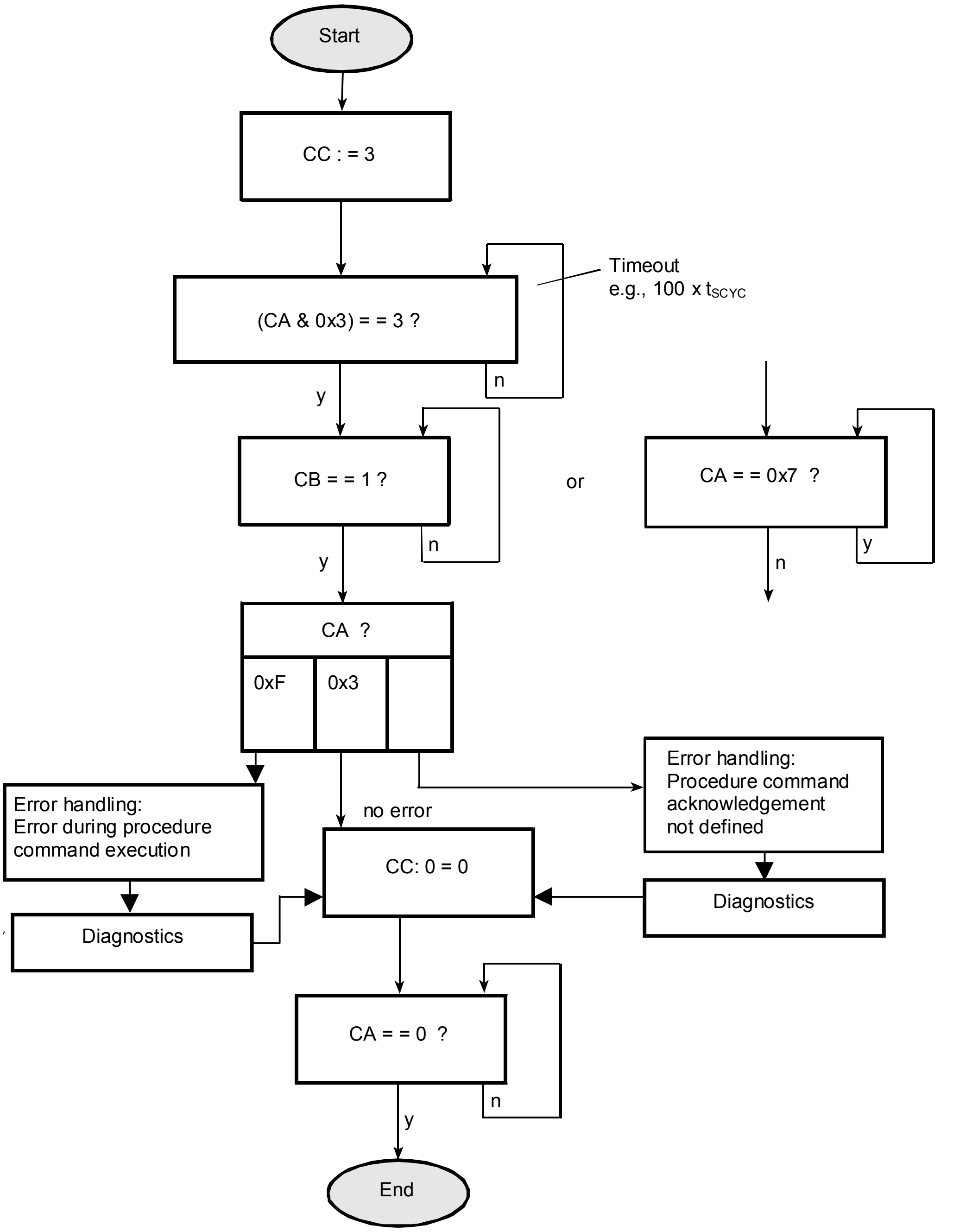


Figure 45 - Interaction of procedure command control and acknowledgement

7.5.1.2 Procedure command execution

In the following examples of processes, the interactions between the master and the drive are shown, including procedure command executions with or without interruption and procedure command executions with error messages. In addition, annex J contains a sample detailed description of the effects of procedure command executions in the service channel.

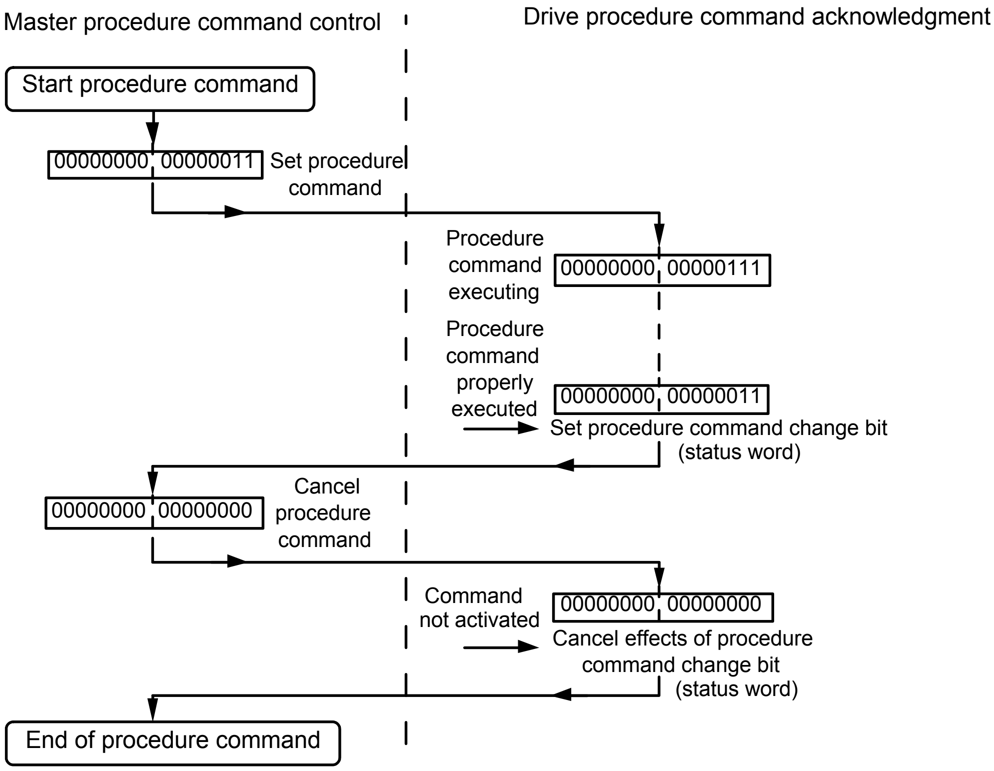


Figure 46 - Procedure command execution without interrupt

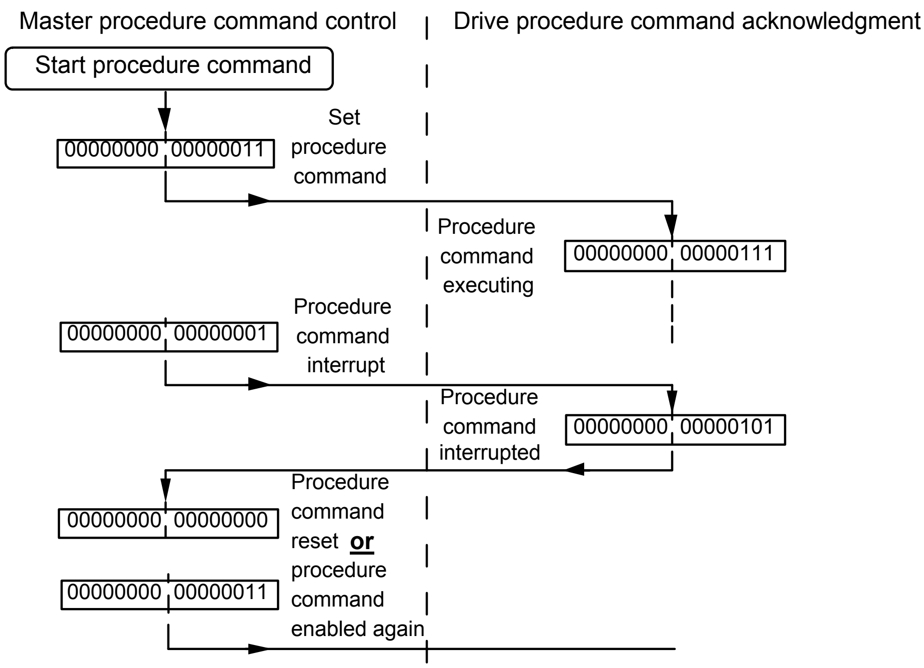


Figure 47 - Procedure command execution with interrupt

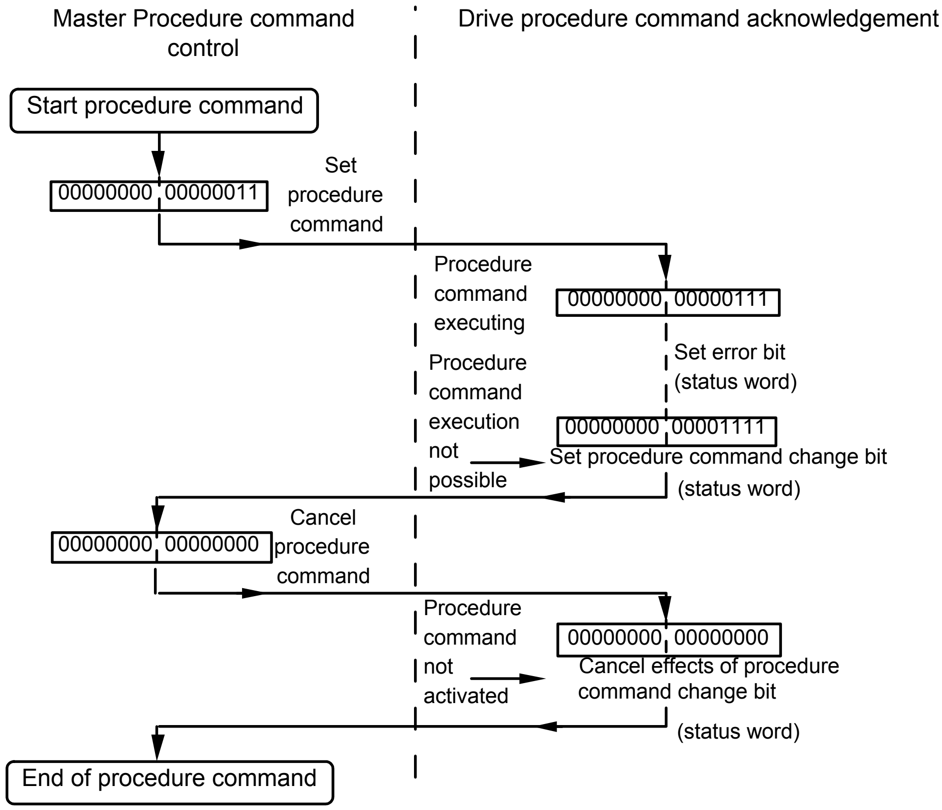


Figure 48 - Procedure command execution with error message

7.6 File Transfer

This clause outlines methods for the download and upload of files to and from a slave. During the download process a binary data file of arbitrary length is transferred from the master to the slave. During upload, binary data is recovered from the slave.

File lengths, file contents, how the file is to be used, and where the file is to be located in the drive's memory space is not part of this specification. A file may contain a header defining how the file is to be used (file type, size, location, etc.). The specification of a header is left to the manufacturer. This means that files are not necessarily interchangeable between drives of different manufacturers.

The service channel mechanism, which allows transmission of only 2 bytes of data per communication cycle, is unsatisfactory for the transfer of large files. To facilitate the transfer of large files, two additional communication phases will be used, Phase 5 (CP5) which is to be used to download files and is characterized by a large File Block in the MDT and Phase 6 (CP6) which is to be used to upload files and is characterized by a large File Block in the AT.

Files may contain firmware for a slave that could affect its performance during phases 1, 2, 3, or 4. Because of this, if an error occurred during a file download a slave might not be able to reach phase 1, 2, 3, or 4. For this reason, phases 5 and 6 can only be reached from phase 0. Figure 49 shows the allowable communication phase transitions. The communication phase can be returned to phase 0 from any phase.

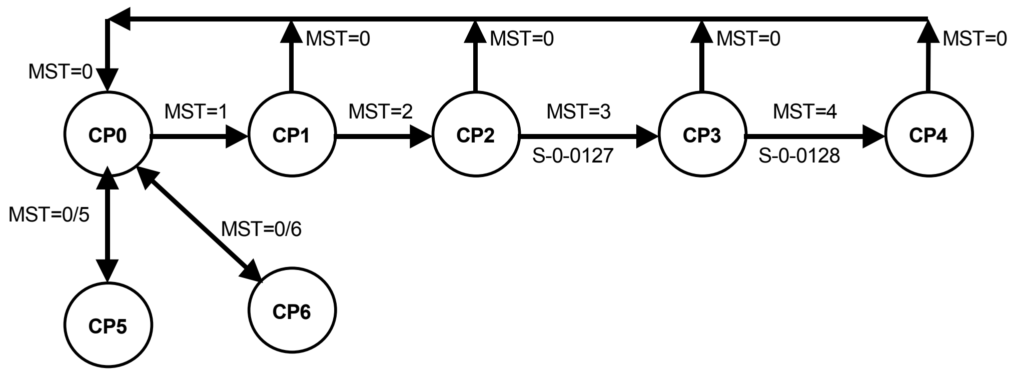


Figure 49 - Phase transitions

7.6.1 File download (CP5)

In CP5 data exchange in any one cycle is possible only between the Master and one slave. CP5 is used for the download of files to slaves. To do so, the Master transmits an MDT with a specific slave address. The slave responds by transmitting its status in an AT. The Master can identify a slave by checking the address field in the AT.

The addresses XX = 0 and XX = 255 may not be used in the transmission of the MDT. No slave shall react in CP5 when address 0 or 255 is used in the transmission of the MDT.

Leave communication phase 5 (CP5 to CP0 transition):

It is anticipated that some slaves will not be able to advance from CP0 to CP1 following CP5 download. Should this be the case, the slave must report an error when the CP0 to CP1 transition is attempted. In addition, operation manuals for the slave must detail the required procedure for returning the slave to normal operation.

7.6.1.1 Telegram transmission times in CP5

The communication cycle time is preset by the Master so that $t_{scyc} \geq 1000\mu s$. The Telegram Transmission Starting Times during CP5 are shown in Figure 50.

In order to provide sufficient time for data transmission it is necessary to use Telegram Transmission Start Times that are different from the Telegram Transmission Start Times of CP1.

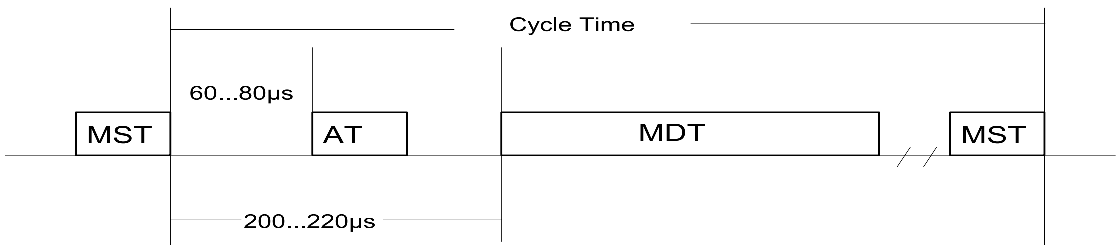


Figure 50 - Telegram transmission times in CP5

7.6.1.2 MDT stucture for CP5

Figure 51 shows the form of the Master Data Telegram for CP5.

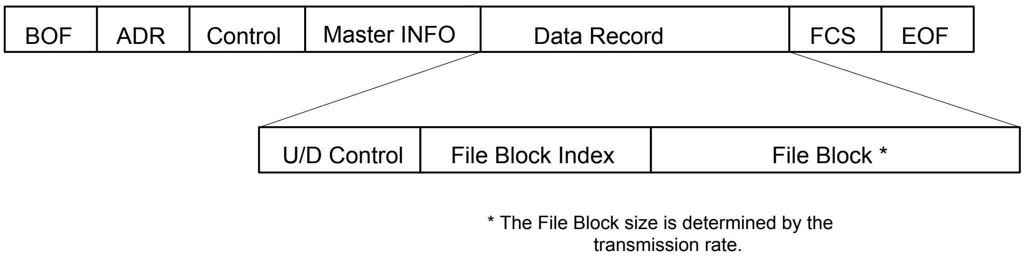


Figure 51 - Structure of MDT in CP5

The BOF, ADR, Control, Master Service INFO, FCS, and EOF fields of the CP5 MDT are identical to the fields of the CP1 MDT (see clause 8.3.2). The Control Word and the Master Service INFO are unused in CP5. The Data Record for the CP5 MDT contains a 4 byte U/D Control word, 4 byte File Block Index, and a File Block. The File Block size is set by the transmission rate as shown in Table 25.

Table 25 – File block size in CP5

Transmission rate	File block size	MDT length	AT length
2 Mbit/s	128 byte	140 byte	12 byte
4 Mbit/s	256 byte	268 byte	12 byte
8 Mbit/s	512 byte	524 byte	12 byte
16 Mbit/s	1024 byte	1036 byte	12 byte

7.6.1.3 U/D Control Word in CP5

The Table 26 defines the bits for the U/D Control Word in the CP5 MDT.

Table 26 – U/D Control word in CP5

Bit 31	File type qualifier
0	SERCOS interface defined file types
1	User defined file types
Bit 30 - 16	File type identification number
Bit 15 - 3	(Reserved)
Bit 2	Enable
0	No file block transfer requested U/D Control word = 0x0001 U/D Status word = 0x0001
1	File block transfer requested
Bit 1	Final Block
0	Not last block of file transfer
1	Final block of file transfer
Bit 0	U/D Handshake
0/1	U/D Handshake of master

Before a file transfer may begin, the enable bit, bit 2 in the U/D Control word, must be set low and the U/D Handshake bit, bit 0 in the U/D Control word must be set high. When the slave handshake bit matches the master handshake bit, file transfers may begin. File transfers are initiated as follows:

Step 1: Set the File Block Index to 0x0000.

Step 2: Set the data to be transferred to the MDT File Block Data field.

Step 3: Set the file type identification number to the File Type Qualifier and File Type Identification Number bits to the file type to be sent.

Step 4: Set the Enable bit true

Step 5: Toggle U/D Handshake bit.

The master must not change the MDT until the slave has toggled the U/D Handshake bit in the AT to match that of the MDT. If the slave has not toggled the U/D Handshake bit within 10 communication cycles, a fault in the slave should be assumed.

When the slave toggles the U/D Handshake bit to match that of the master, the slave may also set the U/D Busy bit in the AT indicating that it is processing the data file block being transferred. Only the U/D Handshake bit in the U/D Status word is valid while the U/D Busy bit is set. When the slave has completed transfer of the data block and verified the file type and block number, it will return the File Type Qualifier, File Type Identification Number, set error bits as appropriate and clear the U/D Busy bit in the AT. The master must not initiate a new data transfer to the same slave until the U/D Handshake bit in that slave AT matches that of the master and the U/D Busy bit is 0.

Subsequent data blocks may be sent by incrementing the file block index of step 1 above and repeating steps 2 through 5. In the event the slave returns an error condition on receipt of any file block, the master may repeat the same file block by leaving the File Block Index unchanged.

The Final Block bit is set true when transferring the last block in a series of data transfers. This bit may be used in the slave to complete the file transfer process. This process is not part of this specification.

7.6.1.4 File Block Index and File Block in CP5 (MDT)

A file can be divided into File Blocks that can be downloaded to a slave one File Block at a time. The contents of a file, use and placement of the file by the slave are dependent upon manufacturer implementation. The File Block Index is used to indicate which File Block is being transmitted. File blocks are normally sent sequentially beginning with File Block 0 and incrementing the block number until the entire file has been sent.

7.6.1.5 AT stucture for CP5

Figure 52 shows the form of the Drive (Amplifier) Telegram for CP5.

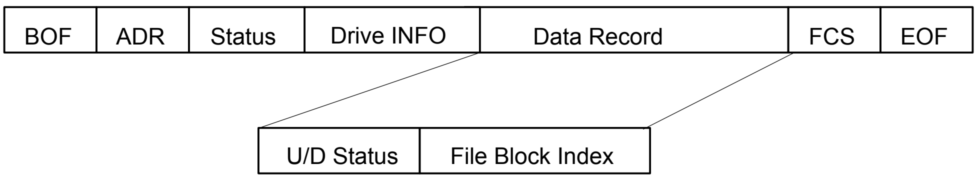


Figure 52 - Structure of AT in CP5

The BOF, ADR, Status, Drive Service INFO, FCS, and EOF fields of the CP5 AT are identical to the fields of the CP1 AT (see clause 8.3.2). The Status Word and the Drive Service INFO are unused in CP5. The Data Record for the CP5 AT contains a 4 byte U/D Status word and 4 byte File Block Index.

7.6.1.6 U/D Status Word in CP5

The Table 27 defines the bits for the U/D Status word in the CP5 AT.

Table 27 – U/D Status word in CP5

Bit 31	File type qualifier
0	SERCOS interface defined file types
1	User defined file types
Bit 30 - 16	File type identification number
Bit 15 - 4	(Reserved)

Bit 3	File transfer error
0	No error
1	Download error, error message in file block index in AT
Bit 2	U/D Busy
0	Slave completed previous request
1	Previous request accepted and in progress
Bit 1	Final Block
0	Acknowledge: not last block of file transfer
1	Acknowledge: final block of file transfer
Bit 0	U/D Handshake
0/1	U/D Handshake of slave

When the slave sees a U/D Handshake bit in the MDT change from matching that of the slave AT to not matching and the Enable bit is set in the MDT, the slave should save the type number sent in the File Type Qualifier and File Type fields, the block index number sent in the File Block Index field, and the data in the Data Block. If further processing of the file type, file block and data are necessary, the slave should set the U/D Busy bit true and then toggle the U/D Handshake bit in the U/D Status word of the AT to indicate it has received the data and is processing it. The U/D Handshake bit in the AT must be set to match that of the MDT in less than or equal to 10 communication cycles or the master will assume a fault has occurred.

Note: The slave must save all data in the MDT before toggling the U/D Handshake bit in the U/D Status Word.

The slave should then verify that the File Type Qualifier, File Type, File Block Index and data from the MDT are valid. If no error is found the data transferred should be applied as appropriate in the slave. When the slave has completed processing the file data, the file type number and data block number should be returned in the File Type bits and File Block Index fields of the AT respectively. Clearing the U/D Busy bit will notify the master that the operation is complete, and that the File Type, File Block Number and the File transfer error bit in the AT are valid and the slave is free to accept more data.

If the Final Block bit was set in the MDT the slave should take appropriate action for the final block of data transfer in the slave. This action is not part of this specification.

If either the file type number or the file block number are invalid or the data field contains unexpected or erroneous data, the slave should set the File transfer error bit true and place a 32 bit error code in the File Block Number field in the AT. Error codes are defined in Table 28.

7.6.1.7 File Block Index in CP5 (AT)

Before the slave toggles the U/D Handshake bit in the AT to match the MDT and sets the U/D Busy bit to 0, it must set the File Block Index field to the value of the File Type Qualifier and File Block Index received in the MDT. The master may use this value to verify the correct block is being transferred.

If an error occured the slave should replace the File Block Index with a 32 bit error code. The Table 28 defines the error message in the File Block Index in the CP5 AT.

Table 28 – File block index in CP5

Bit 31 -16	User defined error message
Bit 15 - 4	(Reserved)
Bit 3	File checksum error
0	No error
1	Error
Bit 2	File type error
0	No error

1	File type not supported
Bit 1	File block data error
0	No error
1	Data transferred not valid
Bit 0	File block index error
0	No error
1	Invalid file block index number

7.6.1.8 U/D Control Word and U/D Status Word Handshaking in CP5

Figure 53 shows the functional relationship between the Enable and U/D Handshake bits in the CP5 MDT and the U/D Busy and the U/D Handshake bit in the CP5 AT.

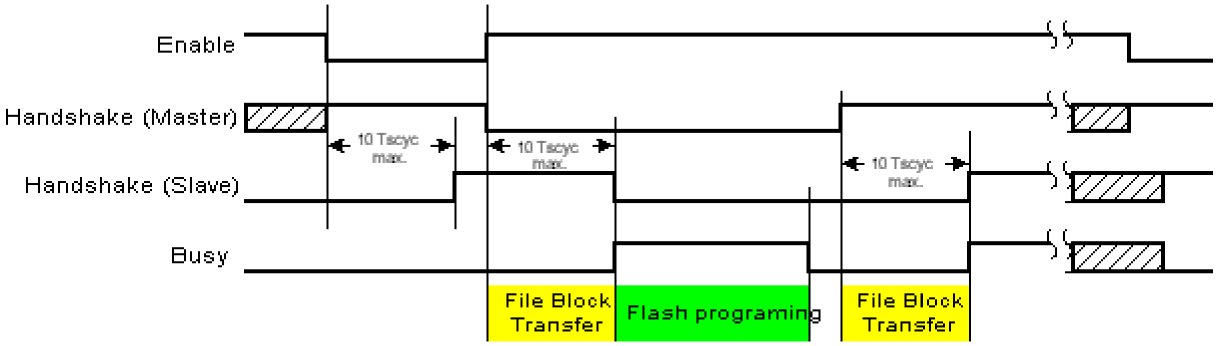


Figure 53 - Timing of U/D bits in CP5

7.6.2 File upload (CP6)

CP6 data exchange in any one cycle is possible only between the Master and one slave. CP6 is used to upload of files from slaves. To do so, the Master transmits an MDT with a specific slave address. The slave responds by transmitting its status in an AT. The Master can identify a slave by checking the address field in the AT.

The addresses XX = 0 and X = 255 may not be used in the transmission of the MDT. No slave shall react in CP6 when address 0 or 255 is used in the transmission of the MDT.

7.6.2.1 Telegram transmission times in CP6

The communication cycle time is preset by the Master so that $t_{scyc} \geq 1000µs$. The Telegram Transmission Starting Times during CP6 are shown in Figure 54.

In order to provide sufficient time for data transmission it is necessary to use Telegram Transmission Start Times that are different from the Telegram Transmission Start Times of CP1.

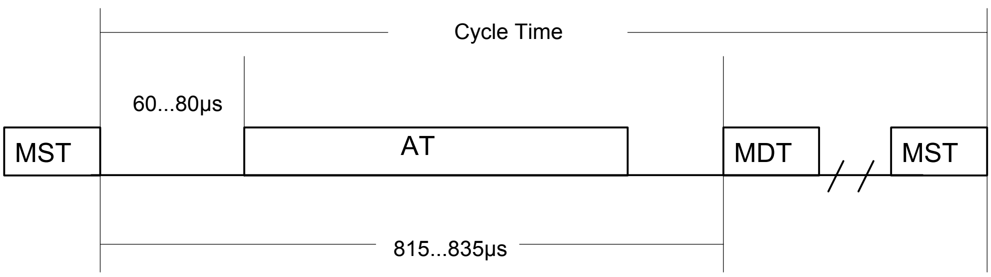


Figure 54 - Telegram transmission times in CP6

7.6.2.2 MDT structure for CP6

Figure 55 shows the form of the Master Data Telegram for CP6.

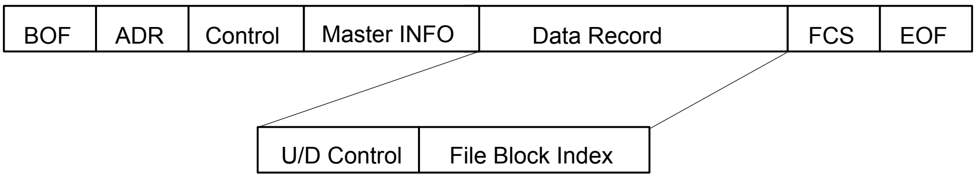


Figure 55 - Structure of MDT in CP6

The BOF, ADR, Control, Master Service INFO, FCS, and EOF fields of the CP5 MDT are identical to the fields of the CP1 MDT (see clause 8.3.2). The Control Word and the Master Service INFO are unused in CP6. The Data Record for the CP6 MDT contains a 4 byte U/D Control word and 4 byte File Block Index.

7.6.2.3 U/D Control Word in CP6

The Table 29 defines the bits for the U/D Control word in the CP6 MDT.

Table 29 – U/D Control word in CP6

Bit 31	File type qualifier
0	SERCOS interface defined file types
1	User defined file types
Bit 30 - 16	File type identification number
Bit 15 - 3	(Reserved)
Bit 2	Enable
0	No file block transfer requested U/D Control word = 0x0001 U/D Status word = 0x0001
1	File block transfer requested
Bit 1	(Reserved)
Bit 0	U/D Handshake
0/1	U/D Handshake of master

Before a file transfer may begin, the enable bit, bit 2 in the U/D Control word, must be set low and the U/D Handshake bit, bit 0 in the U/D Control word must be set high. When the slave handshake bit matches the master handshake bit, file transfers may begin. File transfers are initiated as follows:

Step 1: Set the File Block Index to 0x0000.

Step 2: Set the file type number to the File Type Qualifier and File Type Identification Number bits to the file type to be sent.

Step 3: Set the Enable bit true.

Step 4: Toggle the U/D Handshake bit.

The slave will respond by setting the U/D Busy bit true and toggling the U/D Handshake bit in the U/D Status word of the AT. (Note: It is not necessary for the slave to set the U/D Busy bit true if it can respond with the requested data within the 10 communication cycle period allowed for the U/D Handshake bit to toggle.)

After toggling the U/D Handshake bit the slave should verify the file type and block number and respond by setting the file type to the File Type bits and the block index number to the File Block

Index field respectively, and by setting or clearing the File Transfer Error bit, and place data as appropriate in the Data Block field of the AT. Finally, the slave should clear the U/D Busy bit in the U/D Status word to tell the master that the data is now valid. Only the U/D Handshake in the U/D Status word is valid when the U/D Busy bit is true. The master must not initiate a new data transfer until the U/D Handshake bit in the slave AT matches that of the master and the U/D Busy bit is 0.

Subsequent data blocks may be requested by incrementing the file block index of step 1 above and repeating steps 2 through 4. Transfer the entire file, this process is repeated until an error is reported or until the Final Block bit in the AT is set true.

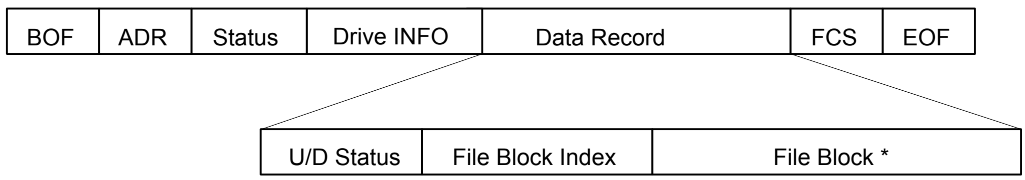
In the event the slave returns an error condition on receipt of any file block, the master may request the same file block by leaving the File Block Index unchanged.

7.6.2.4 File Block Index in CP6 (MDT)

A file can be divided into File Blocks that can be uploaded from a slave one File Block at a time. The contents of a file, use and placement of the file by the slave are dependent upon manufacturer implementation. The File Block Index is used to indicate which File Block is to be uploaded. File blocks are normally requested sequentially beginning with File Block 0 and incrementing the block number until the entire file has been received as indicated by the Final Block bit in the AT.

7.6.2.5 AT structure for CP6

Figure 56 shows the form of the Drive (Amplifier) Telegram for CP6.



* The File Block size is determined by the transmission rate.

Figure 56 - Structure of AT in CP6

The BOF, ADR, Status, Drive Service INFO, FCS, and EOF fields of the CP6 AT are identical to the fields of the CP1 AT (see clause 8.3.2). The Status Word and the Drive Service INFO are unused in CP6. The Data Record for the CP6 AT contains a 4 byte U/D Status word, a 4 byte File Block Index and a File Block. The File Block size is set by the transmission rate as shown in Table 30.

Table 30 – File block size in CP6

Transmission rate	File block size	MDT length	AT length
2 Mbit/s	128 byte	12 byte	140 byte
4 Mbit/s	256 byte	12 byte	268 byte
8 Mbit/s	512 byte	12 byte	524 byte
16 Mbit/s	1024 byte	12 byte	1036 byte

7.6.2.6 U/D Status Word in CP6

The Table 31 defines the bits for the U/D Status Word in the CP6 AT.

Table 31 – U/D Status word in CP6

Bit 31	File type qualifier
0	SERCOS interface defined file types

1	User defined file types
Bit 30 - 16	File type identification number
Bit 15 - 4	(Reserved)
Bit 3	File transfer error
0	No error
1	Upload error, error message in file block index in AT
Bit 2	U/D Busy
0	Slave completed previous request
1	Previous request accepted and in progress
Bit 1	Final Block
0	Not last block of file being transferred
1	Final block of file being transferred
Bit 0	U/D Handshake
0/1	U/D Handshake of slave

When the slave sees a U/D Handshake bit in the MDT change from matching that of the slave AT to not matching and the Enable bit is set in the MDT, the slave should save the type number sent in the File Type Qualifier and File Type fields and the block index number sent in the File Block Index field. If the file type number and the block index are supported by the slave, the slave should fill the Data Block field with the requested data and toggle the U/D Handshake bit in the AT to match that of the MDT. If the time required to fill the data field would exceed 10 communication cycle, the slave should set the U/D Busy bit and toggle the U/D Handshake bit before attempting to fill the data field. When the data field if updated, the slave should then set the U/D Busy bit to 0 to signal the master that the data is now valid. In either case, the U/D Handshake bit in the AT must be set to match that of the MDT in 10 or less communication cycles or the master will assume a fault has occurred.

The slave may set the Final Block bit in the U/D Status word to indicate the final block of the file. Definition of Final File block is not part of this specification.

If either the file type number or the file block number are invalid, the slave should set the File Transfer Error bit in the AT as appropriate and place a 32 bit error code in the File Block Number field in the AT. Error codes are defined in Table 32.

The master will only read data in the U/D Status word and the Data field when the U/D Handshake bit matches that of the master and the U/D Busy bit is 0.

7.6.2.7 File Block Index and File Block in CP6 (AT)

Before the slave toggles the U/D Handshake bit in the AT to match the MDT and sets the U/D Busy bit to 0, it must set the File Block Index field to the value of the File Type Quaifier and File Block Index received in the MDT. The master may use this value to verify the correct block is being transferred.

If an error occured the slave should replace the File Block Index with a 32 bit error code. The Table 32 defines the error message in the File Block Index in the CP6 AT.

Table 32 – File block index in CP6

Bit 31 -16	User defined error message
Bit 15 - 3	(Reserved)
Bit 2	File type error
0	No error
1	File type not supported
Bit 1	(Reserved)
Bit 0	File block index error

0	No error
1	Invalid file block index number

7.6.2.8 U/D Control Word and U/D Status Word Handshaking in CP6

Figure 57 shows the functional relationship between the Enable and U/D Handshake bits in the CP6 MDT and the U/D Busy and the U/D Handshake bit in the CP6 AT.

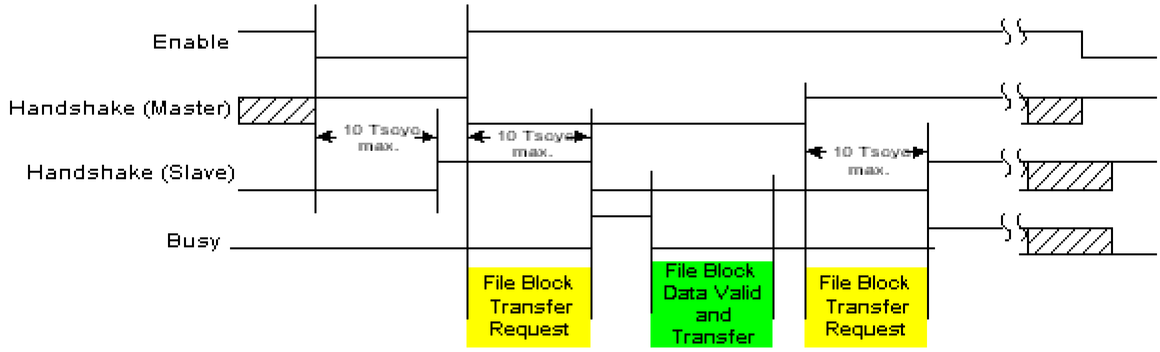


Figure 57 - Timing of U/D bits in CP6

8 Initialization of the SERCOS interface

8.1 General

This clause describes the structuring of the communication after the network has been completed and all stations have been powered up. This initialization is divided up into five communication phases (CPs). CP0 and CP1 are used for recognizing the participating drives. In CP2, the timing and data structure of the protocols for CP3 and CP4 are prepared.

The initialization takes place in ascending sequence. The master initiates the CP by setting the INFO byte of the MST (see Figure 29). The initialization is concluded by switching to CP4, which is cyclical operation with valid cyclical data. The power stages of the drives may be switched on in CP4 only.

8.2 Communication phase 0 (CP0)

After all the stations in the network have been powered up, and after internal checks are error-free, all drives operating in repeater mode only. The master sends MST's, monitoring its receiver for receipt of same to verify ring closure.

CP0 may be entered from any higher phase, and is the only phase which may be entered from any other phase. Ring initialization always begins with CP0.

8.2.1 Structure of the telegrams

During CP0, the master only sends the MST and the fill signal (see Figure 16 and Figure 26).

8.2.2 Telegram transmission timing

The communication cycle time is preset by the master with $t_{Scyc} \geq 1$ ms (see Figure 58).

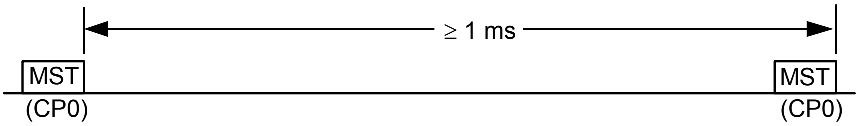


Figure 58 - Timing diagram for CP0

8.2.3 Leaving communication phase 0 (CP0)

The master waits for its MST to be received. When the ring is closed (i.e., all the slaves in the ring are in the repeater mode), the master initiates CP1 after it has received its own MSTs for at least 10 successive cycles.

When the ring cannot be closed within the time set by the control unit, there shall be a message. The scope of the message and at what point it has to be activated is a function of the control unit.

Where CP0 is initiated as a response to a previous communication error (see clause 9), a routine in the control unit may be used to cause an automatic advance routine to CP2 with the possibility of error diagnostics. This routine is not part of this specification.

8.3 Communication phase 1 (CP1)

In CP1 any data exchange during one cycle is only possible between the master and one drive. CP1 is used for recognizing the drives connected to the ring. To do so, the master addresses each drive specifically with the drive address. The addresses can be stored in the control unit to verify that all drives are present. It is also possible to find all drives in the ring by calling all allowed drive addresses and waiting for an answer. The addresses of the connected drives may be compared with the addresses known to the master. Deviations shall be evaluated by the control unit (e.g., generate an error message). The drive shall answer to a MDT which is addressed to it by sending an AT in the next cycle.

The address XX = 0 may not be used in the inquiry. Drives that are not participating in the communication use this address as their address (see clause 6). Drives that are not being addressed in CP1 and whose address is not 0 shall behave like drives with the address 0. No drive shall react in CP1 when address 0 or 255 is queried.

8.3.1 Operational sequence in phase 1 (CP1)

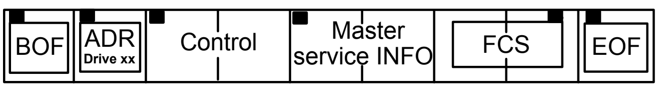
At the beginning of CP1, it is not certain that the physical slave is ready to receive the MDT. It might happen that a drive's repeater operates (the ring is closed) but start-up routines are still being processed internally. Thus a particular drive address might have to be queried several times. The master begins with the lowest address in the ring (or uses any other strategy) and it expects a response within the HS timeout (see clause 9.5).

The master repeats this request until the addressed drive acknowledges or until the HS timeout. When a drive does not respond, it is addressed again after some time is elapsed (not part of this specification).

This request procedure is repeated until the drive identification time has elapsed. This time can be set by means of the control unit data. The drive identification time is not part of this specification.

8.3.2 Structure of the telegrams

Drive specific identification MDTs (ID request telegrams) are used to request the drive addresses. Their structure is shown in Figure 59.



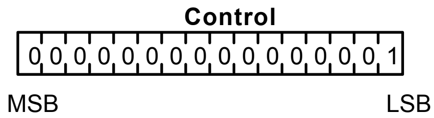


Figure 59 - Structure of the ID request telegram

The addressed drive responds by sending the identification AT (ID acknowledge telegram) as shown in Figure 60.

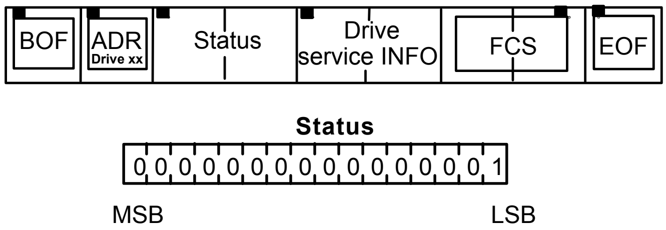


Figure 60 - Structure of the ID acknowledge telegram

Master service INFO (2 bytes) and drive service INFO (2 bytes) are part of the ID request and ID acknowledge telegrams but their content has no meaning during CP1.

8.3.3 Telegram transmission timing

The communication cycle time is preset by the master with $t_{Scyc} \geq 1$ ms. The telegram transmission starting times during CP1 and CP2 are shown in Figure 61.

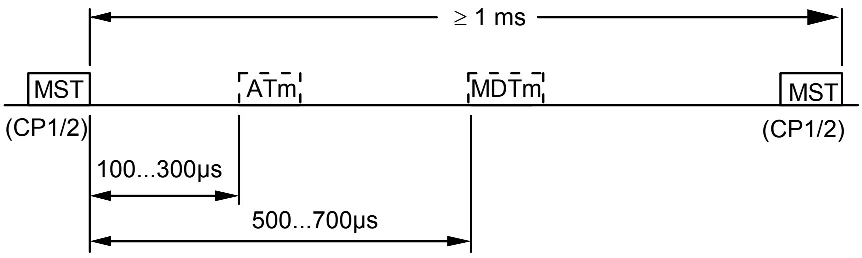


Figure 61 - Telegram transmission starting times of CP1 and CP2

An AT is sent by a slave only when the MDT, which was received before the last MST, was directed at its own address.

8.3.4 Leaving communication phase 1 (CP1)

After the master has identified the drives on the ring and no error has occurred, the MST INFO field is used to initiate CP2.

When the drive identification time is exceeded or deviations to the stored drive addresses are detected, the initialization is not continued. The control unit may respond with an error message. This is not part of this specification.

8.4 Communication phase 2 (CP2)

During CP2, the drives are addressed specifically by their addresses. For CP2 and higher on the service channel for the non-cyclic data exchange can be used with complete functionality.

As a minimum, the communication parameters transmission starting times and transfer timeslots required for cyclical operation, and the parameters for determining the length and the contents of the MDT and AT, are transmitted to the drives. The slave shows in „IDN-list of operation data for CP2“ which data in CP2 shall be transferred (see S-0-0018). The automatic timeslot determination is not required, but it is supported by the interface.

The entire information exchange takes place via the mechanisms of the non-cyclic data exchange (see clause 7.4). The reliability of transmission is guaranteed by the HS bits and the HS-timeout. Further parameter exchanges can take place in CP2 or CP3. No drive shall react in CP2 when the addresses 0 or 255 are queried.

8.4.1 Structure of the telegrams

Telegrams in CP2 have the same structure as in CP1, but the contents of master service INFO and drive service INFO are now valid.

8.4.2 Telegram transmission timing

Telegram transmission starting times are the same as in CP1 (see Figure 61). An AT is sent by a slave only when the MDT, which was received before the last MST, was directed at its own address.

8.4.3 Leaving Communication phase 2 (CP2)

Switching from CP2 to CP3 is initiated by the master by means of the procedure command 'CP3 transition check' as defined in S-0-0127 via the non-cyclic data exchange. Then the slave has to determine the validity of the parameters for cyclical operation and acknowledge the procedure command positively (e.g. 'Procedure command executed correctly'). After the positive procedure command acknowledgment, the master must delete the procedure command in the drive, before the master may initiate CP3.

When the drive is not yet ready to switch over (i.e., the parameters required for cyclical operation have not yet been completely calculated), the drive shall set the procedure command acknowledgment – 'procedure command not yet executed'.

When there are additional invalid parameters still present after the procedure command has been processed, the slave shall respond with the procedure command acknowledgment – 'Error, procedure command execution impossible'. In that case, the master shall remain in CP2 and, depending on the capabilities of the control unit, try to renew the parameters identified as invalid or to send an error message to make possible further initialization by means of an intervention by the operator. In case of error the slave shall save the invalid data in the „IDN-list of invalid operation data for CP2" (see S-0-0021).

After the master has transmitted further parameters (dependent of S-0-0021) to the slave in CP2, the procedure command "CP 3 transition check" has to be activated once more.

The check for validity of the parameters by the slave can refer only to general criteria (e.g., minimum, maximum). It cannot recognize if all parameters that have been transmitted by the master are correct with respect to the control data and the total installation. This means that even when a slave acknowledges the 'CP3 transition check' positively, there may be incorrect communication parameters with respect to the total installation which can lead to a disruption of cyclical communication.

When CP2 was attained by an automatic advance routine after an error, this error shall be corrected first before a transition to CP3 can take place.

The master also can switch to CP0 (see clause 8.7). The cause may be communication errors (see clause 9) or human intervention (e. g., the operator).

8.5 Communication phase 3 (CP3)

In the first cycle of phase 3 it is not necessary to send an AT.

Starting with CP3, the exchange of data is done via the telegrams defined for cyclic operation. Also the timeslots for cyclic operation are used. The MDT is sent with the broadcast address.

During CP3, the parameters for the drives are set by means of the non-cyclic data exchange. The slave shows in „IDN-list of operation data for CP3" which data in CP3 shall be transferred (see S-0-0019). Transmission reliability for the non-cyclic data exchange is guaranteed by the HS bits and the HS timeout. (See clause 9).

8.5.1 Structure of the telegrams

The MDT is structured as shown in Figure 32. Only the fixed part of the data records is used. The configurable part of the data records doesn't care, but it shall have the number of bytes required for cyclical operation. The positions of the fixed part of the data records relevant to the individual drives were transmitted during CP2 with the corresponding communication parameters.

In the control word of the MDT, bit 10 (control unit synchronization bit) is valid from CP3 on. This bit is set to 0 during phases 0 to 2. In CP3, the control unit has to start the interpolation cycle and keep it steady. Bit 10 of the control word in the MDT is inverted with each interpolation cycle.

The AT is structured as shown in Figure 36. Only the fixed part of the data record is used. The configurable part of the data record doesn't care, but it shall have the number of bytes required for cyclical operation.

8.5.2 Telegram transmission timing

Telegram transmission starting times are specified by the parameters which were transmitted during CP2 and correspond to the timeslots for cyclical operation (see Figure 70).

8.5.3 Leaving communication phase 3 (CP3)

The transition from CP3 to CP4 is initiated by the master by means of a procedure command 'CP4 transition check' as defined in S-0-0128 via the non-cyclic data exchange. Subsequently, the slave shall determine the validity of the parameters, complete the processing of the parameters that are required for operating the drive, and acknowledge the procedure command positively (e.g., 'Procedure command executed correctly'). After the positive procedure command acknowledgement, the master must delete the procedure command in the drive, before the master may initiate CP4.

When the drive is not yet ready to switch over (i.e., the parameters required for operating the drive have not yet been completely calculated), the drive shall set the procedure command acknowledgement – 'procedure command not yet executed'.

Where there are additional invalid parameters still present after the procedure command has been processed, the slave shall respond with the procedure command acknowledgment – 'Error, procedure command execution impossible'. In that case, the master shall remain in CP3 and, depending on the capabilities of the control unit, try to re-establish the parameters identified as invalid or send an error message indicating that human intervention (e.g., operator) is required. In case of error the slave shall save the invalid data in the „IDN-list of invalid operation data for CP3“ (see S-0-0022).

After the master has transmitted further parameters (dependent of S-0-0022) to the slave in CP3, the procedure command "CP 4 transition check" has to be activated once more.

The master also can switch to CP0 (see clause 8.7). The cause may be communication errors (see clause 9) or human intervention (e. g., the operator).

8.6 Communication phase 4 (CP4) – end of initialization

Upon switching to CP4 cyclical operation, the initialization is complete. The power stage of the drives may be switched on only in CP4. (See clause 9).

8.6.1 Structure of the telegrams

The MDT is structured as shown in Figure 32. The configurable parts of the data records are filled with command values which have been determined by the parameters transmitted during

CP2. The positions of the fixed part of the data records relevant to the individual drives were transmitted during CP2 with the corresponding communication parameters.

The AT is structured as shown in Figure 36. The configurable part of the data record is filled with actual values which are determined by the parameters transmitted in CP2.

8.6.2 Telegram transmission timing

Telegram transmission starting times are specified by the communication parameters which were transmitted during CP2.

8.6.3 Leaving communication phase 4 (CP4)

CP4 can only be terminated by a return to CP0 (see clause 8.7). The reason for this may be communication errors (see clause 9), or human intervention (e.g., operator). Any drive which recognizes CP0 shall shut-down itself in the best possible manner (e.g., work piece specific retracting routines, torque disabling). The method of shutting down the drives is not part of this specification.

8.7 Switching to communication phase 0 (CP0)

When switching the control unit from communication phase 3 or 4 (CP3/4) to communication phase 0 (CP0), after switching within two communication cycles MST have to be sent with phase 0 by the control unit.
If this is not the case, the drives will recognise MST-failure in the CP3 or CP4. The first MST of the CP0 should be in the raster of the communication cycle time.

In Figure 62 three cases are shown:

Case 1: During switching, no MST failure. The control changes over in one communication cycle time and sends MST with phase 0. The drive does not recognise a MST failure.

Case 2: During switching, one MST fails. The control needs longer than one communication cycle and sends afterwards MST with phase 0. The drive does not recognise a double MST failure.

Case 3: **Error:** During switching, two MSTs fail. The control needs longer than two communication cycles and sends afterwards MST with phase 0. The drive recognises a double MST failure and generates an error of class 1 diagnostics.

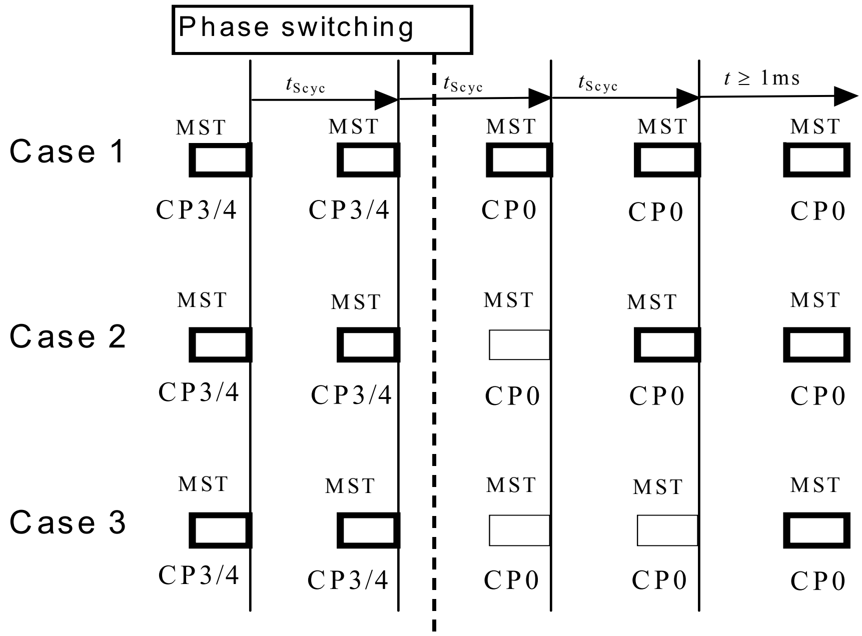


Figure 62 - Switching to CP0

9 Communication error handling

9.1 Drive shut-down functions

Error handling is based on the principle that drives shall always be equipped with monitoring functions to guarantee an automatic shut-down in situations that prevent a correct response to commands from the control unit (master).

Since the SERCOS interface provides for operation only in CP4, the drives shall respond by shutting down automatically when there are CPs present, other than CP4 in the MST.

Drives shall automatically shut-down where a communication error impairs their ability to guarantee their correct functioning. This is the case where MSTs or MDTs fail twice in succession during CP4 in a drive.

As described above, drives which are unable to respond properly shall shut-down themselves. This does not necessarily mean that the control unit shall respond with an interrupt and reinitialization when telegram failures occur in CP4. Rather, there may be certain procedures stored in the control unit which can be executed before shut-down, depending on the error situation. These procedures are part of the control unit.

When the slave sets the ‘communication error’ bit in the class 1 diagnostic (C1D, S-0-0011), then the diagnostic message, S-0-0095, can be used to read a character set string describing the error.

9.2 Failure of telegrams

By definition, a telegram is valid when:

a) the CRC check finds no error;
b) the telegram arrives within the defined time tolerance limits;
c) the length of the telegram is correct, and
d) the address (ADR) of the telegram is correct.

Additionally, the MST is only valid if the INFO byte indicates a valid communication phase (0 to 4).

9.2.1 Failure of a telegram (MST, MDT, AT)

When a failure occurs in an MST, MDT or AT, the master and the slave shall respond as follows:

a) on the basis of the last correct command values, the drive can calculate internal command values to replace the missing telegram;
b) the synchronization of the interface shall be maintained;
c) several counters (internal) shall be incremented for missing telegrams;
d) an AT is sent only when the MST has been received.

Table 33 shows the error patterns for all communication phases when two successive MSTs fail:

Table 33 - Loss or failure of master synchronization telegram (MST)

CP	Reaction in master	Reaction in the drive (slave)
0	The master registers the ring as open. The ring is closed only after the master has received a defined number of successive MSTs (see clause 8) without any errors. This is the pre-condition for operating in CP1.	None
1	None. Beginning with CP1, the master no longer performs monitoring of the MST.	None
2	None	None
3	None	The slave automatically returns to CP0 and waits for the MST of CP0. The drive sets the 'communication error bit' in C1D (see S-0-0011).
4	None	The slave automatically returns to CP0 and waits for the MST of CP0. In addition, all its connected and running drives are shut-down in the best possible way. The drives set the 'communication error bit' in C1D (see S-0-0011).
NOTE – Monitoring, see clause 9.4.		

Table 34 shows the error patterns for all CPs when the slave registers two successive MDT failures:

Table 34 - Failure of master data telegrams (MDT)

CP	Reaction in master 1)	Reaction in the drive (slave) 2)
0		None
1		None
2		None
3		None
4		In CP4, the failure of two successive MDTs will result in the best possible shut-down of those drives that are controlled by the slave. The slave returns to CP0 and waits for the MST of CP0. The drives set the 'communication error bit' in C1D (see S-0-0011).
NOTES 1) Reaction in the master: no reaction in any CP. The master will react indirectly to the behaviour of the drive. 2) Monitoring, see clause 9.4		

Table 35 shows the error patterns for all CPs when the master registers two successive AT failures.

Table 35 - Failure of drive telegrams (AT)

CP	Reaction in master [4)]	Reaction in the drive (slave) [4)]
1	The master responds by indicating on the display that a drive is missing[1) 5)]	None [3)]
2	The master returns to CP0 and attempts to close the ring[5)].	None [3)]
3	The master returns to CP0 and attempts to close the ring[2)].	None [3)]
4	The master responds where applicable, with an error handling procedure stored in the control unit, and then returns to CP0 and attempts to close the ring[2)].	None [3)]

NOTES

1) The master registers a drive has failed according to the specifications in clause 9.2.

2) Error pattern: failure of two successive ATs of the same address. (The first cycle in CP3 doesn't need an AT. Therefore this missing AT is not counted.)

3) Reaction in the drive: the drives react indirectly to the reset to CP0.

4) Monitoring, see clause 9.4.

5) A failure of AT will be recognized by the master if during handshake timeout no response of the addressed drive was received.

9.3 Changing the communication phases

9.3.1 Ascending communication phases

The sequence of communication phases shall be maintained in ascending order (0,1,..,4 or 0↔5 or 0↔6). Where this sequence is not maintained, the slave shall return to CP0. The communication error bit is set in C1D.

9.3.2 Descending communication phases

A change of the CPs in descending order is only accomplished through CP0. The progression from CP0 is accomplished in accordance with clause 8.

When the master switches from a higher CP to a lower CP other than CP0, the slave shall then immediately return to CP0 and wait for the MST of CP0 from the master. The communication error bit is then set in C1D.

9.4 Monitoring (overview)

9.4.1 Monitoring in the master

	CP0	CP1	CP2	CP3	CP4
MST monitoring with:					
CRC checking	X	–	–	–	–
Telegram length checking	X	–	–	–	–
MDT monitoring with:					
CRC checking	–	–	–	–	–
Telegram length checking	–	–	–	–	–
AT monitoring with:					
CRC checking	–	X	X	X	X
Telegram length checking	–	X	X	X	X
Timing check	–	X	X	X	X
Address check (ADR)	–	X	X	X	X

Error counters 1 (count successive telegram failures, maximum value = 2)					
Count of MST failures	X	–	–	–	–
Count of MDT failures	–	–	–	–	–
Count of AT failures	–	–	–	X	X
Error counters 2 (count all telegram failures, maximum value = 2^{16}– 1)					
MST error counter (S-0-0028)	–	–	–	–	–
MDT error counter (S-0-0029)	–	–	–	–	–
Count of AT failures	–	–	–	X	X
NOTE – X = monitoring/checking is necessary; – = monitoring/checking is not necessary					

9.4.2 Monitoring in the drive (slave)

	CP0	CP1	CP2	CP3	CP4
MST monitoring with:					
CRC checking	X	X	X	X	X
Telegram length checking	X	X	X	X	X
INFO–byte	X	X	X	X	X
Timing check	–	–	–	X	X
MDT monitoring with:					
CRC checking	–	X	X	X	X
Telegram length checking	–	X	X	X	X
Timing check	–	X	X	X	X
Address check (ADR)	–	X	X	X	X
AT monitoring with:					
CRC checking	–	–	–	–	–
Telegram length checking	–	–	–	–	–
Error counters 1 (count successive telegram failures, maximum value = 2)					
Count of MST failures	–	–	–	X	X
Count of MDT failures	–	–	–	–	X
Count of AT failures	–	–	–	–	–
Error counters 2 (count all telegram failures, maximum value =2^{16}– 1)					
MST error counter (S-0-0028)	–	–	–	X	X
MDT error counter (S-0-0029)	–	–	–	–	X
Count of AT failures	–	–	–	–	–
NOTE – X = monitoring/checking is necessary ; – = monitoring/checking is not necessary					

9.5 Reaction to handshake timeout

A handshake (HS) timeout occurs where any addressed drive does not acknowledge its AHS-bit in the Status word after 10 communication cycles in CP2 to CP4. During CP1, a drive is registered as not present where the AHS-bit has not been set to a logical '1' within the maximum drive identification time (see clause 8).

CP	Reaction in master	Reaction in the drive (slave)

2-4	Error message is sent to the operator. The master responds with an error handling procedure that may be stored in the control unit and then switches back to CP0	No response possible.

9.6 Reaction to error messages in the service channel

A valid error message for the master is present in the service channel when the drive sets bit 2 in the drive status word to logical '1' and the AHS-bit of the drive equals the MHS-bit of the master control word (see clause 7.4).

CP	Reaction in master	Reaction in the drive (slave)
2-4	Display of an error message	The step currently being processed is interrupted, the busy bit (bit 1 – status word) is set to '0' (see clause 7.4).

9.7 Error counters in the master and the slave

Error counters 1 in the master count successive MST failures in CP0 and successive AT failures starting in CP3. There is one MST counter 1 and different AT counters 1 for each drive. When one of these counters has the value 2, the master has to return to CP0 and the system can only be restarted by means of a new initialization (see Table 36).

Table 36 - States of error counters 1 in the master for MST and AT failures

Telegram failure according to 10.2	Error counters 1 (MST, AT) + 1
Telegram valid	Error counters 1 (MST, AT) = 0
Error counters 1 (MST, AT) ≥ 2	Return to CP0

Error counter 1 (for MST-failures in the drives) counts successive MST-failures in CP3 and CP4. When the MST-counter 1 of a drive has the value 2, the appropriate slave returns to CP0 and waits for the MST of CP0. (During CP4, all its connected and running drives are shut-down in the best possible way.) The drive sets the communication error bit in C1D (see Table 37.).

Table 37 - States of error counter 1 in the drives for MST-failures in CP3 and CP4

MST failures according to clause 9.2	Error counter 1 (MST) + 1
MST valid	Error counter 1 (MST) = 0
Error counter 1 (MST) ≥2	Return to CP0, wait for MST of CP0, shut-down in CP4 only, set communication error bit in C1D

Error counter 1 for MDT-failures in the drives counts successive MDT-failures in CP4. When the MDT counter of a drive has the value 2, the appropriate slave returns to CP0 and waits for the MST of CP0. All its connected and running drives are shut-down in the best possible way. The drive sets the communication error bit in C1D (see Table 38.)

Table 38 - States of error counter 1 in the drives for MDT-failures in CP4

MDT failures according to clause 9.2	Error counter 1 (MDT) + 1
MDT valid	Error counter 1 (MDT) = 0
Error counter 1 (MDT) ≥ 2	Return to CP0, wait for MST of CP0, shut-down drives, set communication error bit in C1D

The master has an AT error counter 2 for each drive which counts independently, in accordance with clause 9.2. If more than two consecutive ATs are invalid, the invalid ATs over two are not counted. The counters are reset to 0 during the transition from CP2 to CP3 and are incremented in CP3 and CP4 to a maximum value of 2^{16}–1, 0xFFFF. There are different counters for each drive. The counters for AT-failures shall be readable in the master for certification. (see Table 39)

Table 39 - States of error counters 2 in the master for AT-failures

CP0, CP1, CP2	
Telegram failures according to clause 9.2	Error counters 2 (AT): not changed
Telegram valid	Error counters 2 (AT): not changed
Transition from CP2 to CP3	All error counters 2 (AT) = 0

CP3, CP4	
Telegram failures according to clause 9.2	Error counters 2 (AT) + 1
Telegram valid	Error counters 2 (AT): not changed
Error counters 2 (AT) = 0xFFFF	Error counters 2 (AT): not changed

Error counter 2 (for MST-failures in the drives) counts all MST-failures in accordance with clause 9.2 in CP3 and CP4. If more than two consecutive MSTs are invalid, the invalid MSTs over two are not counted. This MST error counter has the IDN S-0-0028 in every drive and can be read and reset by the master from CP2 on(see Table 40). The maximum value for this counter is 0xFFFF.

Table 40 - States of error counter 2 in the drives for MST-failures

CP0, CP1, CP2	
Telegram failures according to clause 9.2	Error counter 2 (MST): not changed
Telegram valid	Error counter 2 (MST): not changed
Transition from CP2 to CP3	Error counter 2 (MST): = 0

CP3, CP4	
Telegram failures according to clause 9.2	Error counter 2 (MST) + 1
Telegram valid	Error counter 2 (MST): not changed
Error counter 2 (MST) = 0xFFFF	Error counter 2 (MST): not changed

Error counter 2 for MDT-failures in the drive count all MDT-failures in accordance with clause 9.2 in CP4. If more than two consecutive MDTs are invalid, the invalid MDTs over 2 are not counted. This MDT error counter has the IDN S-0-0029 in every drive and can be read and reset by the master from CP2 on (see Table 41). The maximum value for this counter is 0xFFFF.

Table 41 - States of error counter 2 in the drives for MDT-failures

CP0, CP1, CP2, CP3	
Telegram failures according to clause 9.2	Error counter 2 (MDT): not changed
Telegram valid	Error counter 2 (MDT): not changed
Transition from CP3 to CP4	Error counter 2 (MDT): = 0

CP4	
Telegram failures according to clause 9.2	Error counter 2 (MDT) +1
Telegram valid	Error counter 2 (MDT): not changed
Error counter 2 (MDT) = 0xFFFF	Error counter 2 (MDT): not changed

10 Synchronization mechanisms

If on a machine several drives from different manufacturers are moving in co-ordination with one control (contouring control), certain technical requirements must be fulfilled.

- Process the command values
- capture the feedback values
- Synchronize different cycle times and fine interpolators in the drives.

If the above technical conditions are not fulfilled, certain contour deviations may occur.

10.1 Handling of command and feedback values

The MST not only controls the access to the ring but also assists in orienting the processing within the drives. Designs are possible in which the drives can provide feedback values for the control unit. These values shall be captured in all affected drives simultaneously. The capture point indicated by t_4 referenced to the end of the MST is stored in the drives as an IDN. The drives already have a default time interval t_5 stored as an IDN. This time interval indicates the minimum amount of time needed between the capture point t_4 and the end of the next MST, to allow the drive to proceed the captured feedback value for the following AT (in the next SERCOS cycle).

t_3 has been defined as another parameter. This parameter indicates after which time interval, counting from the end of the MST, the drive is allowed to access the new command values transmitted in the MDT. The master stores t_3 as an IDN in the drives. In order to determine t_3, the parameter t_{MTSG} (command value proceeding time) has to be stored in the drives as an IDN. This parameter describes the minimum time required by the slave to proceed the new command value(s) for the drive(s) after the MDT.

Figure 63 illustrates these time intervals.

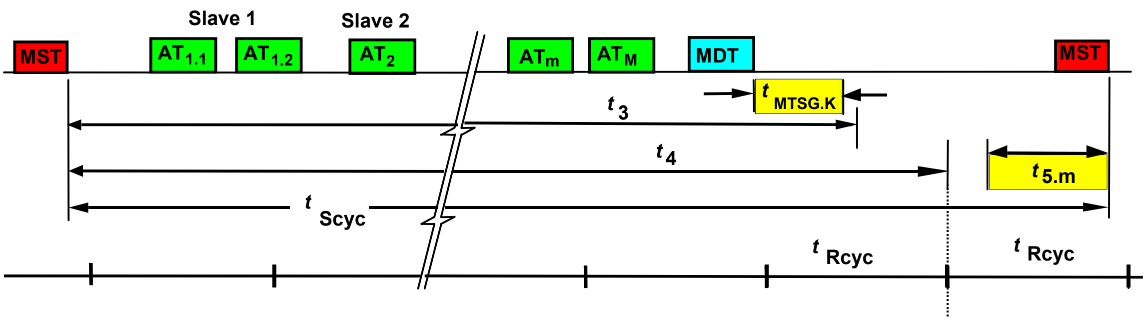


Figure 63 - Validity of command values and feedback acquisition time in the drives

10.2 Synchronization of the control loops in the drives

The feedback values are captured in time t_4 in the drive. Therefore it makes sense to synchronize also the control loops (cycles time t_{Rcyc}) in the drive at that time (see Figure 63 and Figure 64). The drives need a certain time to activate a newly received command value in the control loop. The command values available at time t_3 are activated in the control loop to the next time t_4. If the time between t_3 and t_4 is to small, then the command values are only activated in the next cycle at time t_4.

If a drive is programmed to detect that times t_3 and t_4 are in a critical range, it is recommented the drive generate a diagnostic message. The drives manufacturers should document the dependencies of time t_3 and t_4 and the diagnostic message in the drive's manual.

The synchronization time must fulfill the following conditions:

- t_{Ncyc} = n * t_{Scyc}, n = 1,2... (where n is an integer),
- z * t_{Rcyc} = t_{Scyc}, z = 1,2... (where z is an integer).

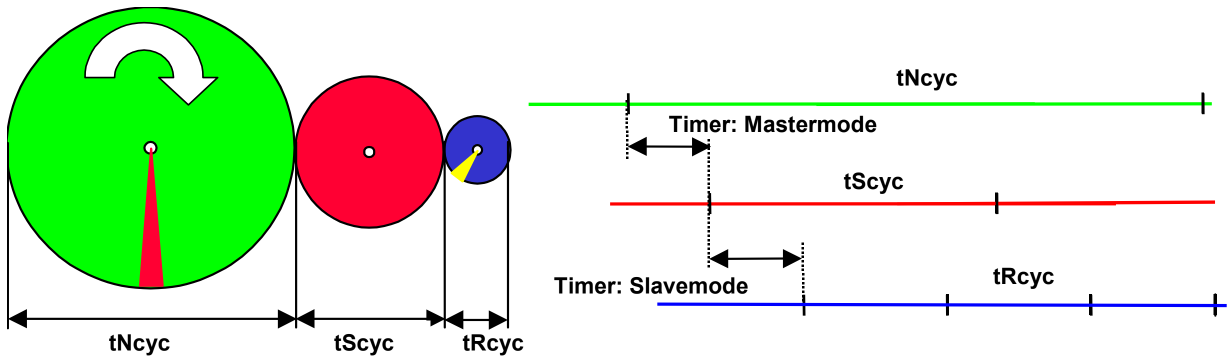


Figure 64 - Synchronization of cycle times

10.3 Position loop with fine interpolator

At time t_4 the fine interpolator provides the corresponding received position command value to the position control. At the same time the last received position command value is provided to the fine interpolator (see Figure 65). The fine interpolator calculates the differences in the position command values (Δ_{Pos}) for all steps (position control cycles). The differences in the position command values are calculated with:

- the ratio of the NC-cycle time and the drive cycle time,
- the position command values,
- eventually the velocity and acceleration
- type and order of fine interpolation.

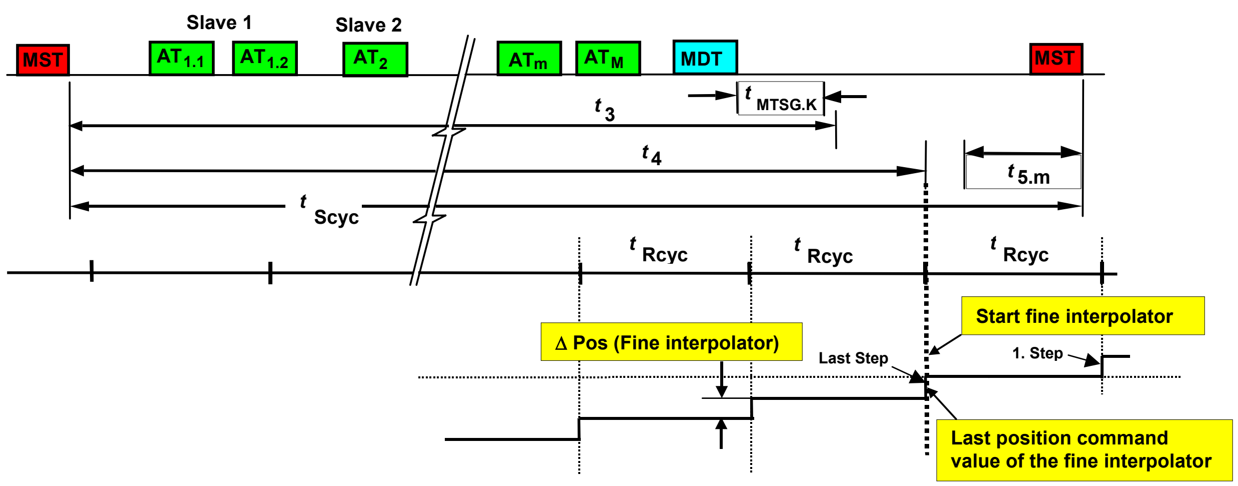


Figure 65 - Synchronization of the control loops and the fine interpolator

11 Data contents

11.1 Data types and data structure

11.1.1 General data

Operation data: all data which are handled by the SERCOS interface have been assigned an IDN and are called operation data. IDNs are not sorted according to specific criteria (i.e., IDNs do not reveal that operation data belong to a certain group). Unsorted operation data are assigned IDNs in ascending order. The order is described in detail in this clause. Operation data include parameters, SERCOS interface procedure commands, and command and feedback values. Element 7 of the data block is also called operation data or simply 'data' (see data block structure, Table 17).

Parameters: parameters are used to make adjustments in the drives and the control unit in order to ensure the error-free operation of the system (see also initialization data).

System procedure commands: system procedure commands are used to activate functions in the drives or between the control unit and the drives (see clause 7.5).

Command and feedback values: command and feedback values are usually included in the telegrams as cyclic data (see also cyclic data).

11.1.2 Data terms

Service channel data:

Service channel data are data communicated between the control unit and the drives and transferred via the service channel. An example of such a demand would be the display or input of certain data on the control unit terminal.

All data can be read or input as service channel data in order to have the option to display all data on demand on the control unit or to set them in special situations at any time.

During start-up or service, the takeover of cyclic data in the drive should be disabled. Then these normally cyclic transferred data can be written as data on demand (non-cyclic data exchange).

Cyclic data:

Data are cyclic if they are part of the configurable data record of telegrams, which is transferred during every communication cycle. The design allows for the exchange of 'cyclic data' of any length, arbitrarily assembled in two-byte and four-byte strings, between the control unit and the drives.

During CP2, it is determined which data will be transmitted cyclically by the control unit for each individual drive as well as the data which will be received by the control unit from each individual drive.

Command and feedback values are generally defined as cyclic data.

Initialization data:

This data initializes the communication system and defines the operation parameters of the control and the drives.

Initialization data are partially transferable only during specific communication phases. For more detailed information, see clause 8.

Initialization data are addressed specifically by the manufacturers in the user manuals for the drives.

11.1.3 Data block structure

All operation data are assigned IDNs

Every IDN has an underlying data block. Data blocks are used in different data types to supply additional information, which is required to allow the display and input of data and the use of universal routines by means of the control terminal.

This additional information is necessary for handling arbitrary drive-related data. With this information, anonymous operation data can be interpreted by the control unit.

The data block structure is shown in Table 17. In a data block, elements 1, 3, and 7 are mandatory and are always present. Elements 2, 4, 5, and 6 are optional and can be supported. Elements 5 and 6 are mandatory for cycle time parameters (S-0-0001, S-0-0002) only. The appropriate elements of the data blocks are selected via the service channel control bits in the control word.

11.1.3.1 Element 1: structure of IDN

When written and read via the service channels, the appropriate data are addressed by means of the IDNs (see clause 7.4). Beyond that, operation data within the configurable part of the data records of the AT and MDT are defined by means of the IDNs.

IDNs have a range of 2^{16} which is subdivided into the two ranges for standard data and product data. Every range is subdivided into eight parameter sets.

IDNs are generally transferred in telegrams as 16-bit binary numbers.

Operation data which are not included in standard data but which are required for a specific function of the product, shall be specified by the appropriate manufacturer in the product data record.

Structure of IDNs:

15	14		12	11											0
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Bit 15: 0 - Standard data (normative)
1 - Product data (determined by manufacturer)
Bits:14–12 - Parameter set 0 – 7
Bits: 11–0 - Data block number from 0 to 4 095

General structure of IDNs:

X	–	X	–	XXXX
S – Standard data **P – Product data**		**Parameter set** **0 to 7**		**Data block number** **0 to 4095**

Example: S–2–0100 (Velocity proportional gain in parameter set 2)

Since this specification encompasses only standardized operation data in parameter set 0.

11.1.3.2 Element 2: name of operation data

The name consists of 64 bytes maximum. It has two length specifications of two bytes each, and a character string of 60 characters maximum (60 bytes). Bytes 1 and 2 of the name specify the length of the programmed text in bytes. Bytes 3 and 4 of the name indicate the maximum number of characters available for text in a drive if the name is changeable. Text longer than that specified by these bytes cannot be stored in the drives. Length specifications of the initial four bytes are coded for hexadecimal digits.

Name length: maximum 64 bytes

The Name structure is shown in Figure 66.

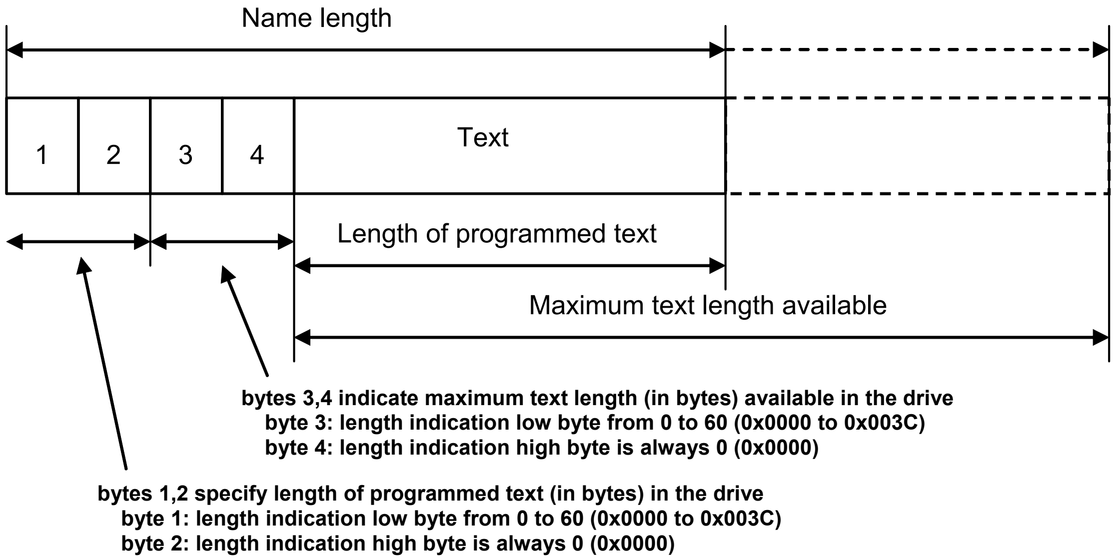


Figure 66 – Name stucture

It is advisable to program text length in even numbers since the service channel can only transfer words.

If the programmed text has a length of 0, only the two length indications are transmitted. Bytes 1 and 2 will then contain the value 0.

Reading: in order to complete a read command in the service channel, the master requires bytes 1 and 2. Bytes 3 and 4 are only read by the master to prevent writing text which is too long.

Writing: when writing a name, the master sets bytes 1 and 2 according to the length of the programmed text. The text shall not be longer than specified in bytes 3 and 4. During writing the drive ignores bytes 3 and 4 and inserts its available length during reading.

11.1.3.3 Element 3: attribute of operation data

Every data block has an attribute which allows for an intelligible representation of various operation data by means of universal routines. The attribute contains all information which is needed to display operation data intelligibly. The attribute makes it possible to convert the transferred operation data into intelligible display data and vice versa. The conversion has no impact on the data itself. If data needs to be scaled, specific scaling parameters are supplied. Every scaling modification needs a change in the attributes of the affected data (see Table 42).

Attribute structure: Length four bytes

Table 42 – Attributes of operation data

Bit 31	(Reserved)
Bit 30	Write protected in CP4
0 1	Operation data is write-able Operation data is write protected
Bit 29	Write protected in CP3
0 1	Operation data is write-able Operation data is write protected
Bit 28	Write protected in CP2
0 1	Operation data is write-able Operation data is write protected

Bits 27-24	Decimal point: Places after the decimal point indicate the position of the decimal point for the display and input of appropriate operation data. This is additional display information. Decimal point = 0, for data type "floating-point number".
0000 1111	no places after decimal point 15 places after decimal point (maximum)
Bit 23	(Reserved)
Bits 22-20	Data type and display format: Data type and display format are used to convert the operation data and the minimum and maximum input value to the correct display format
 000 001 010 011 100 101 110 111	Data type ....Display format binary number ....binary unsigned integer..unsigned decimal integer ....signed decimal unsigned integer..hexadecimal extended character set.................................text unsigned integer..IDN floating-point number...................................signed decimal with exponent (float) (single or double precision, ANSI/IEEE Std 754-1995) reserved For extended character set, see annex E.
Bit 19	Function of operation data: the function of operation data indicates that this operation data is used to call up procedure command functions in a drive.
0 1	Operation data or parameter Procedure command
Bits 18-16	Data length: data length is required so that the control unit is able to complete service channel data transfers correctly.
000 001 010 011 100 101 110 111	reserved operation data is two bytes long operation data is four bytes long operation data is eight bytes long variable length with one-byte data strings variable length with two-byte data strings variable length with four-byte data strings variable length with eight-byte data strings
Bits 15-0	Conversion factor: the conversion factor is an unsigned integer used to convert numeric data to display format. The conversion factor shall be set to a value of 1 when it is not needed for data display (e.g., for binary display, character string or floating-point number).

The display formats and data length shall have any of the valid combinations (“yes” marked) in Table 43.

Table 43 - Valid combinations of the display formats

	Display format						
Data length	**binary**	**unsigned dec**	**signed dec**	**hex**	**text**	**IDN**	**float**
2 byte	yes	yes	yes	yes		yes	
4 byte	yes	yes	yes	yes			yes
8 byte	yes	yes	yes	yes			yes
1 byte list		yes		yes	yes		
2 byte list	yes	yes	yes	yes		yes	
4 byte list	yes	yes	yes	yes			yes
8 byte list	yes	yes	yes	yes			yes

11.1.3.4 Element 4: operation data unit

The unit element consists of 16 bytes maximum. It has two length specifications of two bytes each, and a character string of 12 characters maximum (12 bytes). Bytes 1 and 2 of the unit specify the length in the programmed text in bytes. Bytes 3 and 4 of the unit indicate the maximum number of characters available for text in a drive where it is changeable. Text longer than that specified by these bytes cannot be stored in the drives. Length specifications of the initial four bytes are coded for hexadecimal digits. Operation data has no unit where the data type is either a binary number or a character string.

Unit length: maximum 16 bytes

The Unit structure is shown in Figure 67.

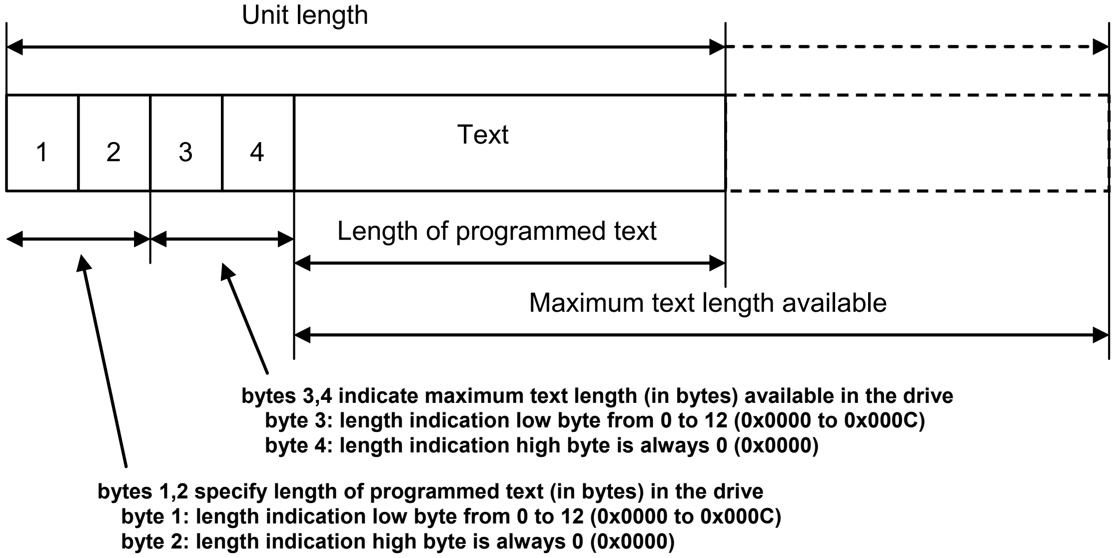


Figure 67 – Unit structure

It is advisable to program text length in even numbers since the service channel can only transfer words.

If the programmed text has the length 0 only the two length indications are transmitted. Bytes 1 and 2 will then contain the value 0.

Reading: in order to complete a read command in the service channel, bytes 1 and 2 are required by the master. Bytes 3 and 4 are only read by the master to prevent writing text which is too long.

Writing: when writing a unit, the master sets bytes 1 and 2 according to the length of the programmed text. The text shall not be longer than specified in bytes 3 and 4. During writing the drive ignores bytes 3 and 4 and inserts its available length during reading.

11.1.3.5 Element 5: minimum input value of operation data

The minimum input value is the smallest numerical value for the operation data which can be processed by the drive.

When, in a write request, the value for the operation data is lower than the minimum input value, the operation data is not changed.

The operation data has no minimum input values if a binary number with fixed or variable length or a character string or IDN is used.

Data length: same as operation data.

Display: The minimum input value is displayed like the operation data.

11.1.3.6 Element 6: maximum input value of operation data

The maximum input value is the largest numerical value for the operation data which can be processed by the drive.

When, in a write request for the operation data, the maximum input value is exceeded, the operation data is not changed.

If the operation data is a binary number, then the supported bits are set in the maximum input value. The master therefore recognizes which bits are supported by the slave in this parameter.

The operation data has no maximum input value if a character string or IDN is used.

Data length: same as operation data.

Display: the maximum input value is displayed like the operation data.

11.1.3.7 Element 7: operation data

The operation data length is divided in four groups:

- fixed length with two bytes;
- fixed length with four bytes;
- fixed length with eight bytes;
- variable length up to 65 532 bytes.

Length specifications for the variable length only are coded in the initial four bytes for hexadecimal digits.

Structure of operation data with variable length is shown in Figure 68.

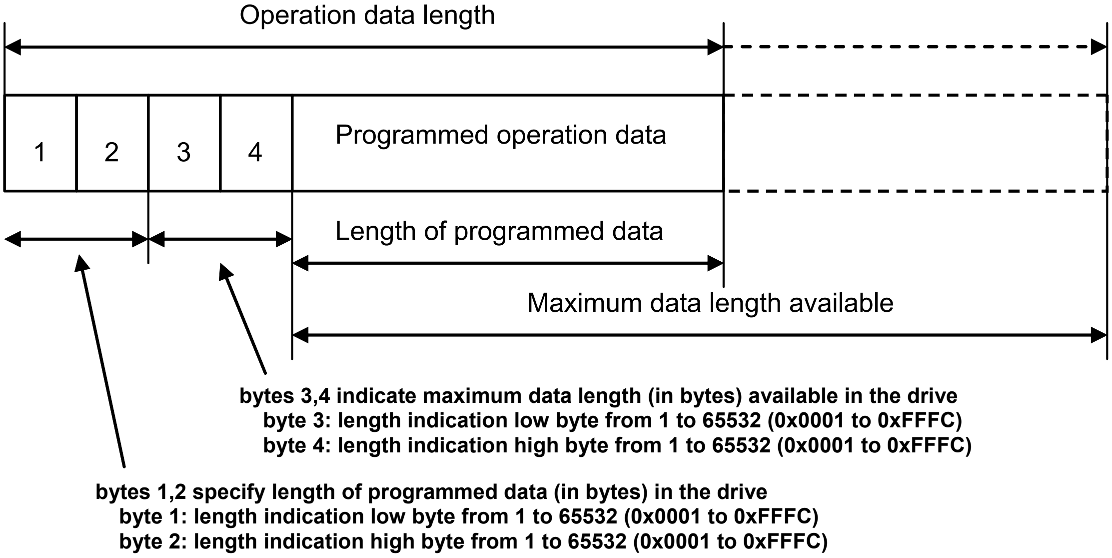


Figure 68 - Structure of operation data with variable length

Operation data with variable length consists of length indicators in the initial four bytes, followed by the programmed operation data.

Files or tables can be loaded from the control unit to the drives or vice versa by means of the transfer of operation data with variable length (e.g., the IDN-list of all operation data in a drive).

It is advisable to program the length of the operation data in an even number of bytes since the service channel can only transfer words.

When the operation data has the length 0, only the two length indications are transmitted. Bytes 1 and 2 will then contain the value 0.

Reading: in order to complete a read command in the service channel correctly, the master requires bytes 1 and 2. Bytes 3 and 4 are only read by the master to prevent writing operation data which is too long.

Writing: when writing operation data, the master sets bytes 1 and 2 according to the length of the programmed data. The data shall not be longer than specified in bytes 3 and 4. During writing, the drive ignores bytes 3 and 4 and inserts its available length during reading.

1. 2.	3. 4.	←			Length of list					→
12 00	12 00	01 00	02 00	03 00	05 00	06 00	07 00	09 00	0A 00	0B 00
		S-0-0001 list element #0	S-0-0002 list element #1	S-0-0003 list element #2	S-0-0005 list element #3	S-0-0006 list element #4	S-0-0007 list element #5	S-0-0009 list element #6	S-0-0010 list element #7	S-0-0011 list element #8

Bytes 3 and 4 indicate the maximum length for operation data available in the drive; example length = 18 bytes 0x0012

Bytes 1 and 2 indicate the length for programmed operation data; example length = 18 bytes 0x0012

Figure 69 - Example of the structure of an IDN-list

11.1.3.8 Data status

The content of 'data status' is related to the entire data block. 'Data status' contains conditions which change dynamically. When opening the service channel via an IDN, the current data status is transferred automatically to the master. This enables the control unit to respond to procedure command acknowledgements during transmission of a procedure command. The data status (procedure command acknowledgment) shall be reset by the drive during every renewed initialization.

Bits 0-3 are only present for procedure commands (procedure command acknowledgment).

Changes in the procedure command acknowledgement by:

– bit 2: procedure command executed correctly (1 → 0 = positive acknowledgement), or
– bit 3: procedure command execution is impossible (0 → 1 = negative acknowledegment)

lead to setting the Procedure command change bit in the status word of the drive (see clause 7.5).

Bit 8 is set by the drive if the data block is recognized as invalid, such as when the data memory is checked for data loss and a checksum error is set.

Structure of the data status (see also Table 24):

Bits 15-9	(Reserved)
Bit 8	
0	Operation data is valid
1	Operation data is invalid
Bits 7-4	(Reserved)
Bit 3	
0	No procedure command error
1	Error, procedure command execution is impossible
Bit 2	
0	Procedure command executed correctly
1	Procedure command not yet executed
Bit 1	
0	Procedure command execution interrupted in the drive
1	Procedure command execution enabled in the drive
Bit 0	

0	Procedure command not yet set in the drive by the master
1	Procedure command set in the drive

12 Communication function groups

12.1 Communication parameters

The communication parameters give the communication structure to the SERCOS interface. Communication parameters shall be transmitted during communication phase 2 (CP2) and activated during communication phase 3 (CP3) in both the master and the slave.

IDN	Description
S-0-0001	Control unit cycle time (t_{Ncyc})
S-0-0002	Communication cycle time (t_{Scyc})
S-0-0003	Shortest AT transmission starting time (t_{1min})
S-0-0006	AT transmission starting time (t_1)
S-0-0005	Minimum feedback processing time (t_5)
S-0-0007	Feedback acquisition capture point (t4)
S-0-0004	Transmit/receive transition time (t_{ATMT})
S-0-0087	Transmit to transmit recovery time (t_{ATAT})
S-0-0089	MDT transmission starting time (t_2)
S-0-0088	Receive to receive recovery time (t_{MTSY})
S-0-0090	Command value proceeding time (t_{MTSG})
S-0-0008	Command value valid time (t_3)
S-0-0009	Position of data record in MDT
S-0-0010	Length of MDT
S-0-0096	Slave arrangement (SLKN)
S-0-0127	CP3 transition check
S-0-0128	CP4 transition check

12.1.1 Transmission starting times and transfer timeslots

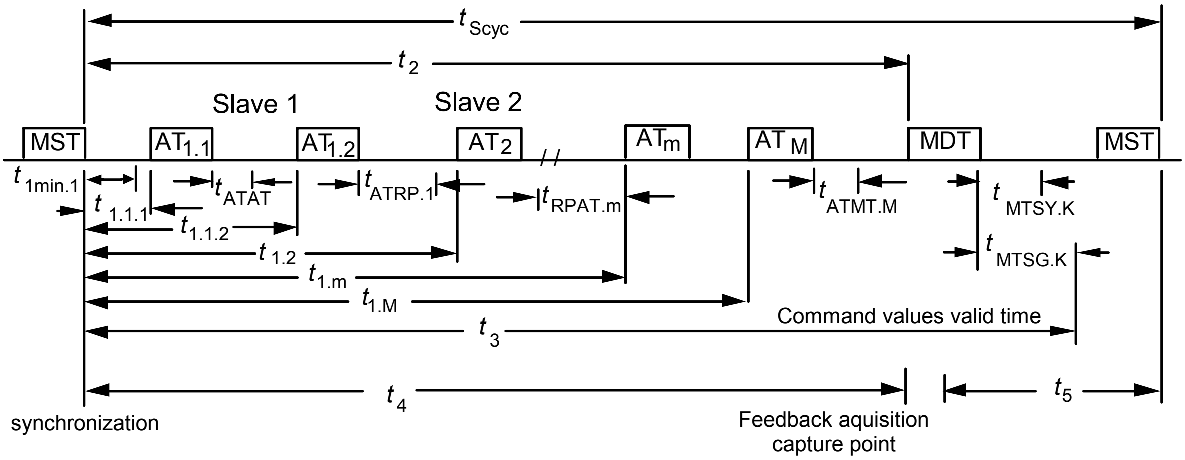


Figure 70 - Timing diagram for CP3/CP4

IDN	Description
	Slave timing:
S-0-0003	Shortest AT transmission starting time (t_{1min})
S-0-0004	Transmit/receive transition time (t_{ATMT})
S-0-0087	Transmit to transmit recovery time (t_{ATAT})
	NOTE – The parameters t_{ATRP} and t_{RPAT} have no IDNs (see clause 6.3.2.1)
S-0-0088	Receive to receive recovery time (t_{MTSY})
S-0-0090	Command value proceeding time (t_{MTSG})
	Drive timing:
S-0-0005	Minimum feedback processing time (t_5)
	Parameter computed and programmed by the master:
S-0-0006	AT transmission starting time (t_1)
S-0-0007	Feedback acquisition capture point (t_4)
S-0-0089	MDT transmission starting time (t_2)
S-0-0008	Command value valid time (t_3)
S-0-0001	Control unit cycle time (t_{Ncyc})
S-0-0002	Communication cycle time (t_{Scyc})
S-0-0009	Position of data record in MDT
S-0-0010	Length of MDT
S-0-0015	Telegram type
	Additional with application telegram:
S-0-0016	- Configuration list of AT
S-0-0024	- Configuration list of MDT

Refer to annex H for computation of transmission starting times and transfer timeslots.

12.2 Definition of telegram contents

The telegram contents of the configurable data records are determined either by the standard or application telegrams. This determination takes place in the telegram type parameter. For the structure of telegrams, refer to clause 7.2.

All feedback values which are contained in the AT for cyclic data shall be updated with valid data every cycle during CP4. In the MDT, the command values to be transmitted cyclically shall remain valid in CP4 depending on the operation mode.

12.2.1 Standard telegrams

When a standard telegram is chosen, operation data and the associated sequence in the configurable data record of the AT, as well as the MDT, are defined for a given drive.

IDN	Description
S-0-0015	Telegram type

12.2.1.1 Standard telegram-0

No cyclic data are exchanged between the control unit and the drive in a standard telegram-0. Only the fixed data record is defined. Data exchange takes place through the service channel.

12.2.1.2 Standard telegram-1

Standard telegram-1 supports the torque control operation mode in the drive.

Configurable data record in the MDT:
Data field 1
Torque command value
S-0-0080
(2 Byte)

Configurable data record in the AT:
Data field 1
(0 Byte)

Standard telegram-1 has no configurable data record in the AT. The AT contains the fixed data record only.

12.2.1.3 Standard telegram-2

Standard telegram-2 supports the velocity control operation mode in the drive. The position feedback acquisition and the closing of the position loop takes place in the control unit.

Configurable data record in the MDT:
Data field 1
Velocity command value
S-0-0036
(4 Byte)

Configurable data record of the AT:
Data field 1
Velocity feedback value
S-0-0040
(4 Byte)

12.2.1.4 Standard telegram-3

Standard telegram-3 supports the velocity control operation mode in the drive. The position feedback acquisition takes place in the drive. The position loop is closed in the control unit.

Configurable data record in the MDT:
Data field 1
Velocity command value
S-0-0036
(4 Byte)

Configurable data record of the AT:
Data field 1
Position feedback value 1 or 2
S-0-0051 or S-0-0053
(4 Byte)

The content of the data field 1 of the AT depends on the telegram type parameter (S-0-0015).

12.2.1.5 Standard telegram-4

Standard telegram-4 supports the position control operation mode in the drive. The position feedback acquisition takes place in the drive as well as the closing of the position loop.

Configurable data record in the MDT:
Data field 1

Configurable data record of the AT:
Data field 1

Position command value S-0-0047 (4 Byte)	Position feedback value 1 or 2 S-0-0051 or S-0-0053 (4 Byte)

The content of the data field 1 of the AT depends on the telegram type parameter (S-0-0015).

12.2.1.6 Standard telegram-5

Standard telegram-5 supports the velocity and position control operation mode in the drive. Switching modes between velocity and position control is also possible by means of standard telegram-5.

Configurable data record in the MDT:

Data field 1	Data field 2
Position command value S-0-0047 (4 Byte)	Velocity command value S-0-0036 (4 Byte)

Configurable data record of the AT:

Data field 1	Data field 2
Position feedback value 1 S-0-0051 or Position feedback value 2 S-0-0053 (4 Byte)	Velocity feedback value S-0-0040 (4 Byte)

The content of the data field 1 of the AT depends on the telegram type parameter (S-0-0015).

12.2.1.7 Standard telegram-6

Standard telegram-6 supports the velocity control operation mode in the drive. The position feedback acquisition and the closing of the position loop takes place in the control unit.

Configurable data record in the MDT:

Data field 1
Velocity command value S-0-0036 (4 Byte)

Configurable data record in the AT:

Data field 1
(0 Byte)

Standard telegram-6 has no configurable data record in the AT. The AT contains the fixed data record only.

12.2.2 Configuration of the MDT (Application telegram)

The length of the ‘configurable data record’ in the MDT is limited by the ‘length of the configurable data record in the MDT’ (S-0-0186). Cyclic data are assigned to the data fields in the configurable data record by means of the sequence of IDNs given in the configuration list of the MDT (S-0-0024).

Configured cyclic data are always transmitted in sequential data fields beginning with data field 1. No empty data fields are allowed in the MDT.

IDN	Description
S-0-0015	Telegram type
S-0-0024	Configuration list of MDT
S-0-0188	IDN–list of configurable data in the MDT
S-0-0186	Length of the configurable data record in the MDT

12.2.3 Configuration of the AT (Application telegram)

The length of the ‘configurable data record’ of the AT is limited by the ‘length of the configurable data record in the AT’ (S-0-0185). Cyclic data are assigned to the data fields in the configurable data record by means of the sequence of IDNs given in the configuration list of the AT (S-0-0016).

Configured cyclic data are always transmitted in sequential data fields beginning with data field 1. No empty data fields are allowed in the AT.

IDN	Description
S-0-0015	Telegram type
S-0-0016	Configuration list of AT
S-0-0187	IDN–list of configurable data in the AT
S-0-0185	Length of the configurable data record in the AT

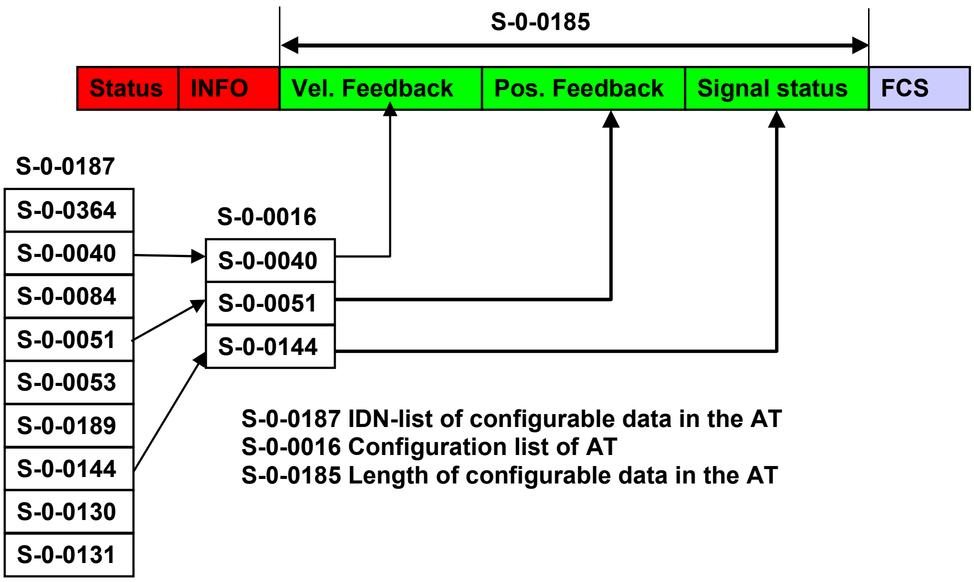


Figure 71 - AT configuration (example)

12.3 List transfer via the service channel

With this function the control unit can divide the transport of parameters of large variable length into several smaller ones. It is also possible to transfer only elements of the lists without having to transfer the whole list. A current transfer can thus be interrupted in order to send prior data via the service channel. After that the control unit can resume the earlier transfer at the exact point where it had been interrupted. When accessing the list segment the drive checks for plausibility. In case of an error the drive signals 'invalid indirect addressing' (0x700B) via the service channel. This function requires the following parameters:

IDN	Description
S-0-0394	List IDN
S-0-0395	List index
S-0-0396	Number of list elements
S-0-0397	List segment

12.4 Real-time bits

For using the real time bits the following parameters are available:

IDN	Description
S-0-0300	Real-time control bit 1
S-0-0302	Real-time control bit 2

S-0-0301	Allocation of real-time control bit 1
S-0-0303	Allocation of real-time control bit 2
S-0-0413	Bit number allocation of real-time control bit 1
S-0-0414	Bit number allocation of real-time control bit 2
S-0-0304	Real-time status bit 1
S-0-0306	Real-time status bit 2
S-0-0305	Allocation of real-time status bit 1
S-0-0307	Allocation of real-time status bit 2
S-0-0415	Bit number allocation of real-time status bit 1
S-0-0416	Bit number allocation of real-time status bit 2

12.4.1 Functions of Real time bits

Two real-time bits are reserved in the control word of the MDT and in the status word of the AT, which may be used with special assignments (IDNs). Assignments are transmitted on demand via the service channel. The real-time bits are signals which indicate some selected status or event (e.g., level of switching signals) in the master or the drives. This status or event from the master to the drive and vice versa is represented in real time.

Real-time control bits (in the control word of the MDT) are distinguished from real-time status bits (in the status word of the AT).

Real-time bits are assigned a logic meaning by means of the following assignments:

- The master uses assignment S-0-0301 and S-0-0413 to inform the drive which logical value (S-0-nnnn) the master has assigned to real-time control bit 1 (S-0-0300) in the control word (bit 6) of the MDT.
- The master uses assignment S-0-0303 and S-0-0414 to inform the drive which logical value (S-0-nnnn) the master has assigned to real-time control bit 2 (S-0-0302) in the control word (bit 7) of the MDT.
- The master uses assignment S-0-0305 and S-0-0415 to instruct the drive which logical value (S-0-nnnn) the drive should assign to real-time status bit 1 (S-0-0304) in the status word (bit 6) of the AT.
- The master uses assignment S-0-0307 and S-0-0416 to instruct the drive which logical value (S-0-nnnn) the drive should assign to real-time status bit 2 (S-0-0306) in the status word (bit 7) of the AT.

All logical assignments shall be IDNs of binary operation data (bits, switching signals).

Any real-time bits activated through these assignments maintain their meaning until the master overwrites or erases them with S-0-0000 or until another IDN changes the logical assignment.

When there is a write access over the service channel to the operation data of an IDN which is assigned to a real-time control bit, the drive generates the error: 'operation data is write protected at this time' or „operation data is write protected, it is configured cyclically“.
When the real time bit is allocated by IDN and bit number, it is not possible to write-protect the whole binary value. In this case an error code cannot be generated.

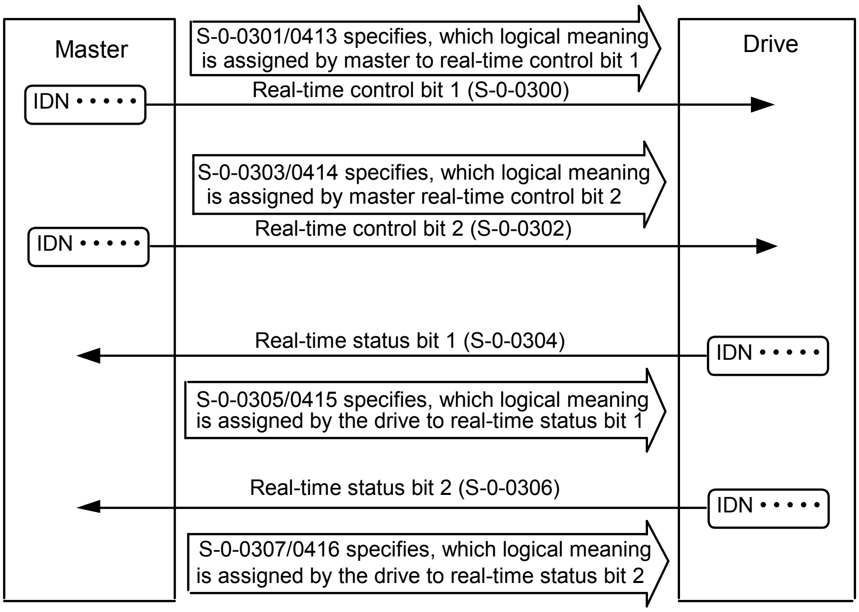


Figure 72 - Function of the real-time bits

12.4.2 Allocation of real-time bits

Allocation sequence of real-time control bits:
When changing the allocation the control unit shall first allocate the S-0-0000 to S-0-0301/0303. This invalidates the real-time control bit in the drive. Afterwards the control unit must copy the new bit to the real-time control bit. After the new bit number (S-0-0413/0414) and the new IDN (S-0-0301/0303) have been allocated, the drive may evaluate the new real-time control bit.

Allocation sequence of real-time status bits:
When the allocation is alternated by IDN (S-0-0305/0307) and/or bit number (S-0-0415/0416) undefined states of real-time status bits occur. The control unit shall detect this and shall not evaluate the respective data.
The drive must copy the alternated bit to the real-time status bit when it sets the BUSY bit = 0 at the latest.

12.4.2.1 Case 1

Allocation of an IDN ≠ 0 to a real-time bit, when no other allocation to this real-time bit is active (see Figure 73).

The state of the real-time control bit shall be defined at the latest when element 7 of S-0-0301/0303 is written. The state of the real-time status bit shall be defined at the latest before the busy bit is reset.

The evaluation of the real-time control bit shall be started in the drive before the busy bit is reset. The evaluation of the real-time status bit shall not be started in the master before the drive has reset the busy bit.

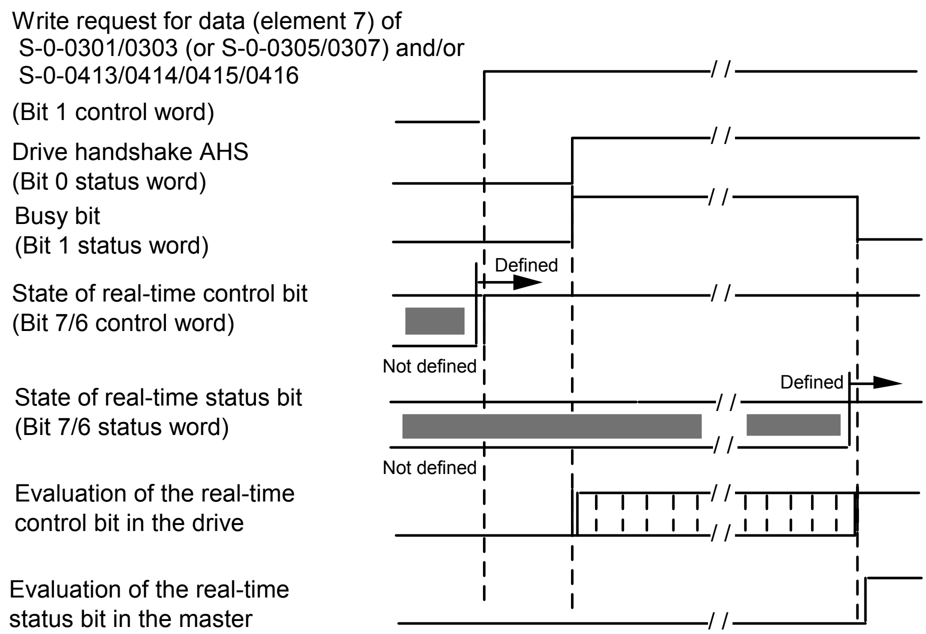


Figure 73 - Allocation of IDN ≠ 0 to the real-time bits

(no other allocation was active before)

12.4.2.2 Case 2

Allocation of IDN = 0 to a real-time bit, when another allocation to this real-time bit is active (see Figure 74).

The state of the real-time control bit shall remain defined until the drive resets the busy bit. The state of the real-time status bit shall be at least defined until the drive sets the busy bit.

The evaluation of the real-time control bit shall be stopped before the drive resets the busy bit. The evaluation of the real-time status bit shall be stopped in the control unit when element 7 is written.

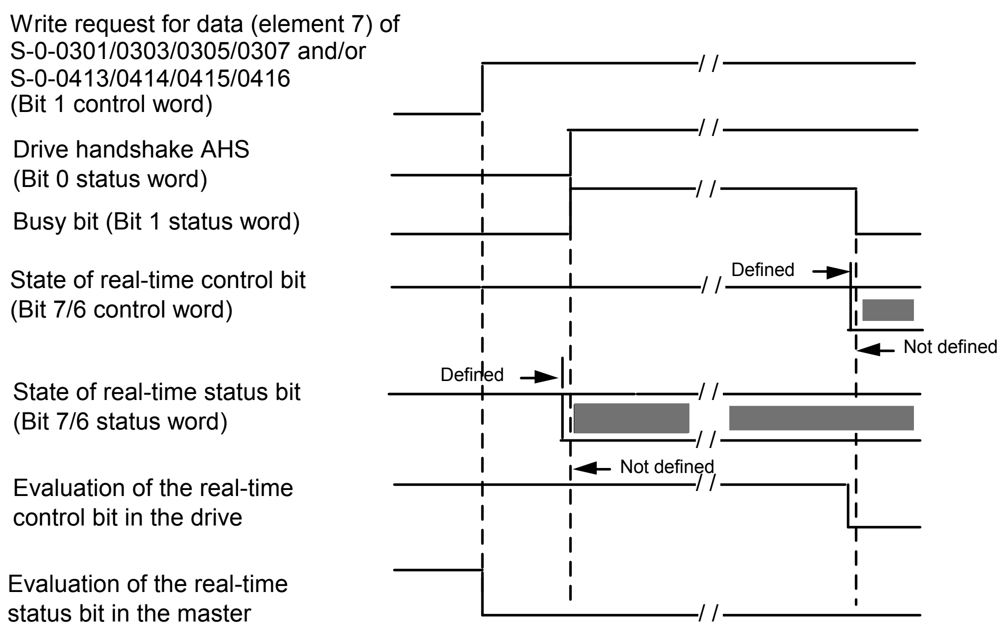


Figure 74 - Allocation of IDN = 0 to the real-time bits

(other allocation was active before)

12.4.2.3 Case 3

Allocation of an IDN ≠ 0 to a real-time bit, when another allocation to this real-time bit is active (see Figure 75).

The state of the old real-time control bit shall remain defined by the control unit until the write request for element 7 has been sent. When the busy bit is set by the drive, the new real-time control bit shall be sent. The evaluation of the old real-time control bit is done in the drive no longer than the busy bit is reset.

In the period from writing element 7 until the busy bit is reset, it is up to the control unit to take care that the value of the transmitted real-time control bit does not lead to disallowed operation states or errors. Generally, this is only possible for 'not active' real-time control bits, for which the value in the drive has no meaning at this time.

The transition from an active real-time control bit to another is only safe if the allocation via IDN S-0-0000 is used (case 2, case 1). The control unit has to handle the switching according to these rules.

The state of the old real-time status bit shall not become undefined before the write request is received. The state of the new real-time status bit shall be defined before the busy bit is reset.

The evaluation of the real-time status bit in the control unit for the old allocation shall only be done until the write request for element 7 is sent. The new assignment shall not be evaluated before the drive has reset the busy bit.

In the case of an error, the old allocation remains valid. In this case the evaluation is allowed again as soon as the busy bit is reset.

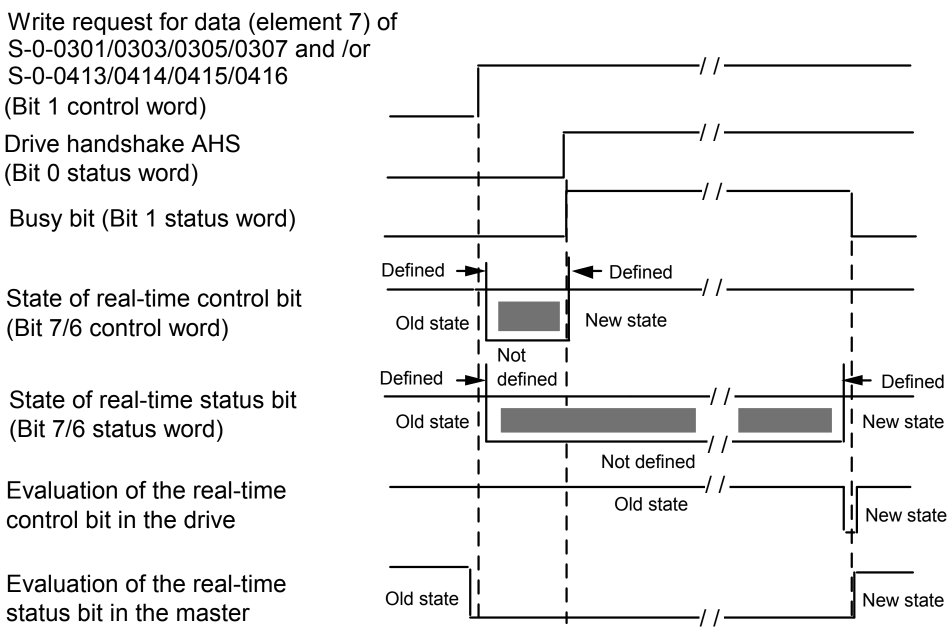


Figure 75 - Allocation of IDN ≠ 0 to the real-time bits

(other allocation was active before)

12.5 Signal control word and signal status word

Signals can be transmitted in real-time from the control unit to the drives and vice versa by means of the signal control word and signal status word. For this purpose, the signal control word needs to be integrated in the MDT and the signal status word in the AT. Bits in the signal control/status word are

definable by means of the configuration list of the signal control/status word (see S-0-0027/0026) and of the „Bit number allocation list for signal control/status word” (see S-0-0329/0328).
If the IDN S-0-0329/0328 are not supported by the drive, the bit 0 of the IDN is configured automatically.

IDN	Description
S-0-0145	Signal control word
S-0-0027	Configuration list for signal control word
S-0-0329	Bit number allocation list for signal control word
S-0-0144	Signal status word
S-0-0026	Configuration list for signal status word
S-0-0328	Bit number allocation list for signal status word

Bit number of signal status word:		0	1	2	3	4	5	6	
configured IDN (signal)		S-0-0403	S-0-0013	S-0-0000	S-0-0013	S-0-0013	S-0-0013	S-0-0330	
0E 00	20 00	93 01	0D 00	00 00	0D 00	0D 00	0D 00	4A 01	S-0-0026
configured bit number (signal)		0	5	x	9	0	4	0	
0E 00	20 00	00 00	05 00	00 00	09 00	00 00	04 00	00 00	S-0-0328
		Bit 0 of S-0-0403	Bit 5 of S-0-0013		Bit 9 of S-0-0013	Bit 0 of S-0-0013	Bit 4 of S-0-0013	Bit 0 of S-0-0330	
1. 2.	3. 4.	←————— Length of list —————→							

Byte 3 and 4 indicate maximum data length available in the drive.

Example: Length = 32 Bytes 0x0020

Byte 1 and 2 indicate length of programmed data in the drive.

Example: Length = 14 Bytes 0x000E

Figure 76 - Configuration example of signal status word

12.6 Data container

12.6.1 Standard Data container

List of ident numbers of standard data container:

IDN	Description
	Data container A
S-0-0360	MDT data container A1
S-0-0364	AT data container A1
S-0-0457	MDT data container A9
S-0-0487	AT data container A9
S-0-0368	Data container A pointer
S-0-0362	MDT data container A list index
S-0-0366	AT data container A list index
S-0-0370	MDT data container A/B configuration list
S-0-0371	AT data container A/B configuration list

S-0-0444	IDN-list of configurable data in the AT data container
S-0-0445	IDN-list of configurable data in the MDT data container
	Data container B
S-0-0361	MDT data container B1
S-0-0365	AT data container B1
S-0-0459	MDT data container B2
S-0-0489	AT data container B2
S-0-0369	Data container B pointer
S-0-0363	MDT data container B list index
S-0-0367	AT data container B list index

Two standard data container groups (A and B) are defined for the MDT and AT, serving as placeholders in the MDT and AT. The contents of the data containers can be dynamically changed by the master as necessary, or based upon the operation mode. Additionally, a data container pointer (S-0-0368 and S-0-0369) is required for each of the container groups, as well as a configuration list for the MDT- and AT containers (S-0-0370/0371). Data containers are 4 or 8 bytes long. If the configured operation data is only 2 or 4 bytes long, it is placed in the lower part of the data container. In this case the higher part is not used.

The data container pointers contain an 8-bit pointer that defines what operation data should be placed in the data container. The pointer is the offset, within the data container configuration list (S-0-0370/0371) from the start of the IDN list to the desired IDN. The master places the desired operation data in the MDT data container, while the slave places the desired operation data in the AT data container.

The master enters into the MDT data container A/B configuration list the IDN for the operation data that are to be sent via the MDT data container as needed from the master to the slave.

The master enters into the AT data container A/B configuration list the IDN for the operation data that are to be sent via the AT data container as needed from the slave to the master.

The addressing IDNs (S-0-0368/0369) can be configured in the cyclic data of the MDT. Thereby, a switching of the operation data in the data containers within a communication cycle is possible (see Figure 77).

All configurable data for the MDT and AT data container are optionally stored in the IDN lists of configurable data (S-0-0444/0445).

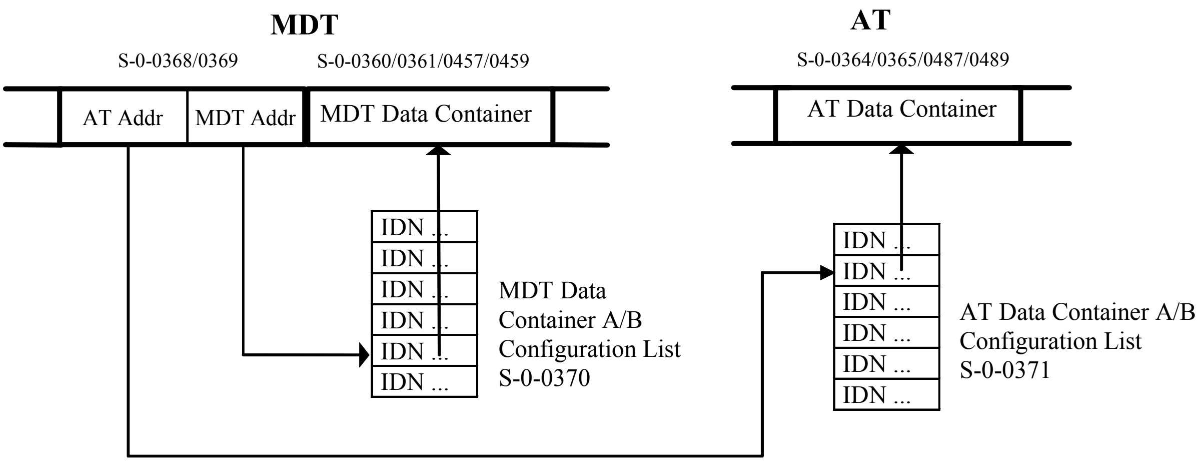


Figure 77 - Data container configuration without acknowledge (slave)

The addressing IDNs (S-0-0368/0369) can also be configured in the cyclic data of the AT. In this case the addressing (acknowledgement) according to the contents of the data container will be transmitted. The slave generates the acknowledgement by copying the pointer of MDT to the pointer of AT. If the pointer of the data container is situated outside of the configuration list for the MDT or AT data container or the data does not fit in the data container, the contents of the data container are not valid. The slave sets the corresponding pointer (acknowledgement) in the AT on 255. The data in MDT or AT data container will be ignored (see Figure 78). The master has to compare the addressing (S-0-0368/0369) of MDT and AT. If the result is equal, than the slave accepted the MDT data or wrote the requested data into the AT.

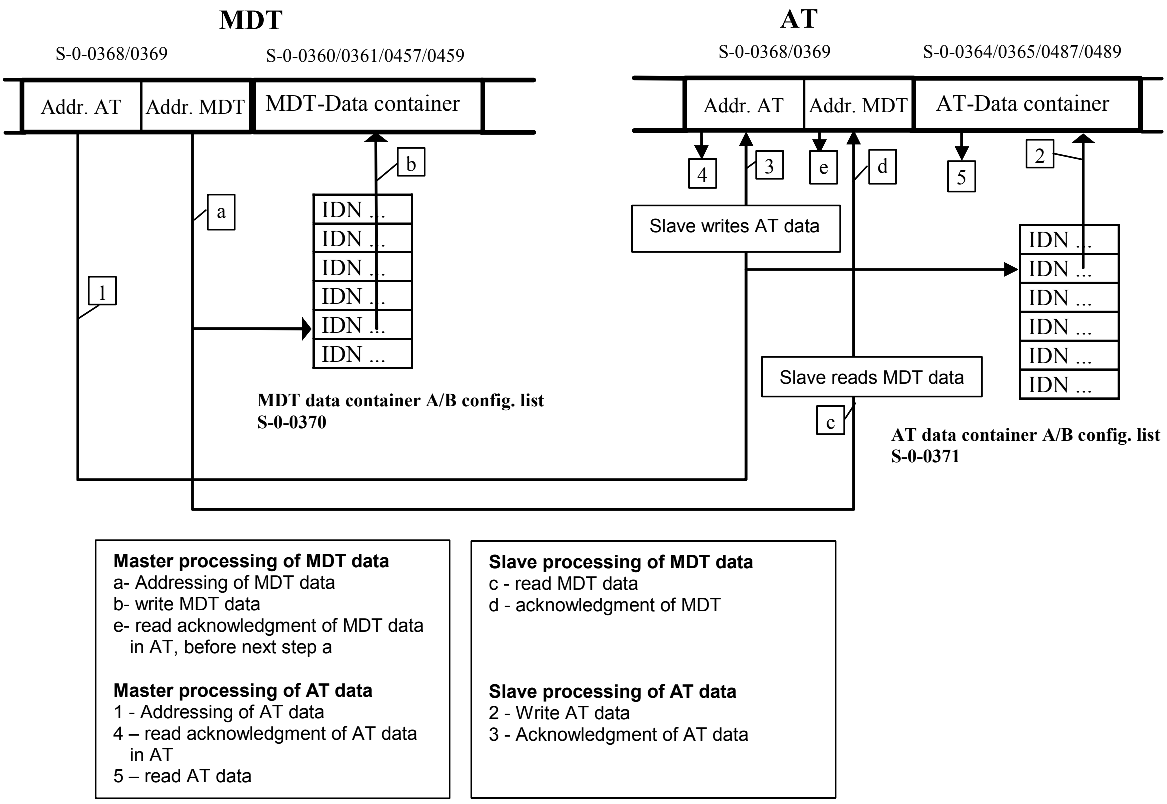


Figure 78 - Data container configuration with acknowledge (slave)

12.6.1.1 Transmission of list elements of data with variable length

If in the MDT/AT-data container A or B an IDN with a variable length is configured, the corresponding data element of this list will be addressed via the list index (S-0-0362/0366 and S-0-0363/0367).

The list index of the MDT/AT data container consists of a 16 bit address. Via index 65535 the data container can be defined not valid by the master and/or slave.

The master sets the addressed list element into the MDT data container. The slave sets the addressed list element into the AT data container.

The list index of MDT/AT data container can be configured in the cyclic data of the MDT. Thereby, a switching of the list elements in the data container during a communication cycle is possible. During writing on the MDT data container with the list index the length of a list cannot be changed.

The list index of MDT/AT data container can also be configured into the cyclic data of the AT. In this way a processing acknowledgement of the MDT/AT data container is possible. The slave reads the list index of MDT/AT data container from the MDT and acknowledges it in the AT.

If the list index is situated outside of the list, the list index of MDT/AT will be set in the AT (acknowledgement) on value 65535 and/or the pointer of data container in AT (acknowledgement) on value 255. All data in the MDT/AT data container will be ignored by the master and/or slave.

Figure 79 shows the processing of list elements via data containers.

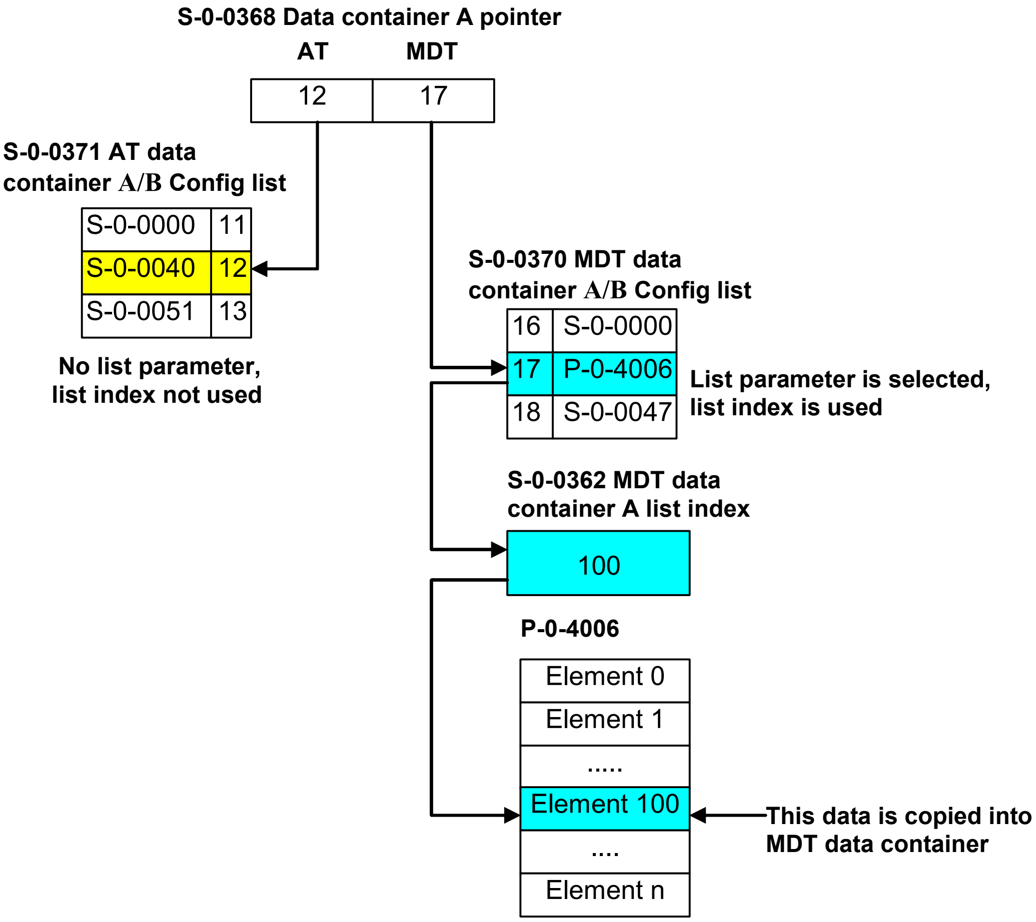


Figure 79 – Processing of list index in the MDT data container (example)

12.6.1.2 Configurable combinations of Standard data container

The data container A1 or A9 can be configured both in the MDT and AT.

The data container B1 or B2 may be configured only in combination with the data containers A1 or A9.

Data lengths of data containers:
Data container A1 and B1: 4 bytes
Data container A9 and B2: 8 bytes

Valid combinations of data container configurations:

MDT data container	AT data container
A1	-
-	A1
A1	A1
A9	-
-	A9

A9	A9
A1	A9
A9	A1
A1 & B1	-
-	A1 & B1
A1 & B1	A1 & B1
A9 & B1	-
-	A9 & B1
A9 & B1	A9 & B1
A1 & B2	-
-	A1 & B2
A1 & B2	A1 & B2
A9 & B2	-
-	A9 & B2
A9 & B2	A9 & B2

12.6.2 Extended data container (preferred function)

In the application telegram configuration the IDN in the cyclic part of the MDT and AT can´t be changed during operation. The extended data container offers multiplexed switching between different cyclic data in MDT and AT about a common addressing mechanism.

In order to use this mechanism the data containers should be configured in MDT and AT.

Via data containers you can

exchange more data in MDT and AT in spite of limited length of data record,

access discret list elements by means of both list index parameters (S-0-0362/0366)

transfer multiplexed data in every cycle with a cycletime of tscyc * number of multiplex levels by incrementing the addressing (S-0-0368).

There are 8 data containers with 4 bytes (A1-A8) and 2 datacontainers with 8 bytes (A9 and A10) lenth defined for MDT and AT.

12.6.2.1 Configuration of the extended data container

For each MDT- and AT- data container (A1-A10) there is a configuration list. In these configuration lists those IDNs are filled in whose data is transmitted in MDT- respectively AT- data container depending on addressing and list index. The configuration lists can be written in CP2 only.

All configuration lists shall have the same size. Unused list elements shall be programmed with S-0-0000.

The number of configurable IDNs in the configuration lists (length of the list) and the number of supported data container is determined in the communication classes.

12.6.2.2 Addressing of the data container

Addressing of data containers (A1 to A10) for MDT and AT is set in IDN S-0-0368. The configured cata containers in MDT are addressed conjoint in IDN S-0-0368 bit 0-7. The configured cata containers in AT are addressed conjoint in IDN S-0-0368 bit 8-15.

Addressing in MDT and acknowledgement in AT (S-0-0368) have to be configured as cyclic data. The function is identical to the standard data container.

Figure 80 shows an example of configuration lists with a number of 32 levels.

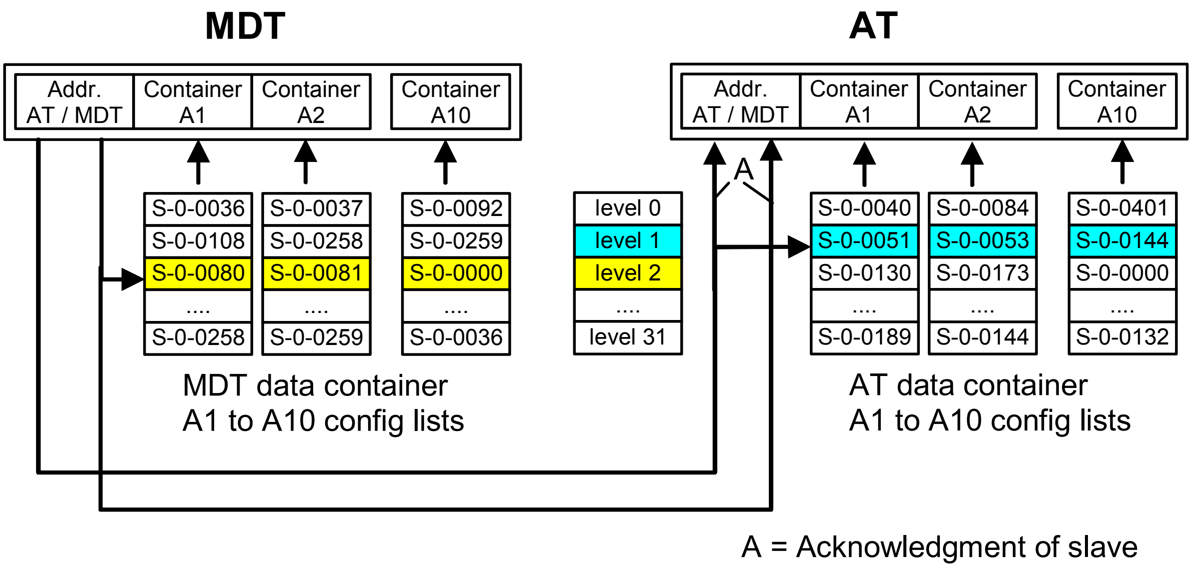


Figure 80 – Structure of extended data container

12.6.2.3 Addressing with list index

There is a list index for each MDT- and AT- data container (S-0-0362/0366). For this reason the configured list parmeter shall have the same length or shall only be configured in a unique data container. The slave checks the configured list for the same length in CP2 and generates an error, if the length is unequal. Errors in the CP4 are therefore avoided.
If an error is reported about the list index, none of the data containers are allowed to be evaluated in the master and in the slave.

The addressing is identical to the standard data container.

12.6.2.4 Usage of the data containers

Data in the configutation lists is selected by addressing and is transmitted to the slaves via MDT data containers (A1-A10).

Data in the configutation lists is selected by addressing and is transmitted to the master via AT data containers (A1-A10).

12.6.2.5 IDNs of extended data container

The following lists shows the defined IDNs of extended data containers.

The extended data container specifies 8 data container with 4 byte (A1-A8) and 2 data container with 8 byte (A9 and A10) length.

- List of MDT- and AT data container:

IDN	Description
	MDT data container
S-0-0360	MDT data container A1
S-0-0450	MDT data container A2
S-0-0451	MDT- data container A3
S-0-0452	MDT- data container A4

IDN	Description
S-0-0453	MDT- data container A5
S-0-0454	MDT- data container A6
S-0-0455	MDT- data container A7
S-0-0456	MDT- data container A8
S-0-0457	MDT data container A9
S-0-0458	MDT- data container A10
	AT data container
S-0-0364	AT data container A1
S-0-0480	AT data container A2
S-0-0481	AT data container A3
S-0-0482	AT data container A4
S-0-0483	AT data container A5
S-0-0484	AT data container A6
S-0-0485	AT data container A7
S-0-0486	AT data container A8
S-0-0487	AT data container A9
S-0-0488	AT data container A10

- For the addressing and the list index 3 parameters are specified:

IDN	Description
S-0-0368	Data container A pointer
S-0-0362	MDT data container A list index
S-0-0366	AT data container A list index

Configuration lists of MDT and AT data containers:

IDN	Description
	MDT data container configuration lists
S-0-0370	MDT data container A1 configuration list
S-0-0490	MDT data container A2 configuration list
S-0-0491	MDT data container A3 configuration list
S-0-0492	MDT data container A4 configuration list
S-0-0493	MDT data container A5 configuration list
S-0-0494	MDT data container A6 configuration list
S-0-0495	MDT data container A7 configuration list
S-0-0496	MDT data container A8 configuration list
S-0-0497	MDT data container A9 configuration list
S-0-0498	MDT data container A10 configuration list
	AT data container configuration lists
S-0-0371	AT data container A1 configuration list
S-0-0500	AT data container A2 configuration list
S-0-0501	AT data container A3 configuration list
S-0-0502	AT data container A4 configuration list
S-0-0503	AT data container A5 configuration list
S-0-0504	AT data container A6 configuration list

IDN	Description
S-0-0505	AT data container A7 configuration list
S-0-0506	AT data container A8 configuration list
S-0-0507	AT data container A9 configuration list
S-0-0508	AT data container A10 configuration list

IDN lists of configurable data in the data container:

IDN	Description
S-0-0444	IDN-list of configurable data in the AT data container
S-0-0445	IDN-list of configurable data in the MDT data container

12.6.3 Data container diagnostic

The parameters in the data container are checked during initialization as well as during operation in CP4. If a slave detects an error in the data container it generates the corresponding diagnostic message.

12.6.3.1 Data not configurable

IDN can not be configured in MDT or AT data container. It has to make sure that the IDNs in the configuration lists can be transmitted as cyclic data. The slave checks it with procedure command S-0-0127.

12.6.3.2 Invalid addressing of the MDT and AT data container

In CP4 the slave checks whether the addressing pointes outside the configuration list. In this case the appropriate addressing in AT is set to 0xFF. The whole content of the data containers is invalid. Therefore all configutation lists shall be programmed with the same length. Unused list elements have to be programmed with S-0-0000.

In CP4 the slave checks wether the list index points to a not initialized entry in the appropriate list parameter. In this case the appropriate addressing in AT is set to 0xFF and the list index is set to 0xFFFF. Therefore all list parameters shall be programmed with the same length. Unsued list elements have to be set to 0x0.

12.7 Automatical Baudrate Recognition in the Slave

In a slave it is possible to recognize the baudrate (transmission rate) automatically. During the period, the slave is carrying out the recognition of baudrate, this should be shown by the slave, during this time the ring will be opened. The SERCOS-Slave is only allowed to activate this function in phase 0 (CP0). Sequence of phases see Figure 81.

The master determines the baudrate and all slaves adjust to this baudrate. In case the ring is not closed after a given time, the master should try to close the ring with 2Mbit/s (see Figure 83). In phase 2 the master is able to recognize the maximum possible baudrate at the ring by using the IDN S-0-0376. If the master afterwards switches with the active baudrate prevailing at that time in Phase 0, it is then possible to adjust the maximum possible baudrate (send MSTs of CP0 with new baudrate). If the master recognizes the ring as closed, the phase run up will be started.

The course of the automatic baudrate recognition is not fixed by SERCOS interface, it must not offend against the norm or the standard specification. The automatic baudrate recognition must never affect or interfere the controlling process.

This Application Note serves as a guideline (see Figure 82).

1. After powering up the slave switches in CP0 the optical transmitter to continuous light (for receiver controlling the optical threshold), thereby the SERCOS-ring is opened. As

continuous light is sent, no edges are generated. In this situation the wiring of the fiber optic cable can be easily carried out or checked. The receiver function of the slave will be activated. Query of FIBBR and RDIST (bits of SERCON816), afterwards check MST of CP0.

2. After having recognized the change of edge at the start of the signal, the Slave tries to receive MSTs with the baudrate activated at last.
3. In case the Slave receives a number of MSTs of the CP0, which has been fixed by the manufacturer, the repeater will be closed.
4. In case the Slave does not receive any MST of CP0 (former baudrate has been changed by the Master) within a defined time (baudrate timeout is determined by the drive manufacturer), it starts with the recognition of baudrate with 2Mbit/s.
5. After a recognition period has been successfully finished, the SERCOS-ring is closed and the slave waits for MSTs of CP1.

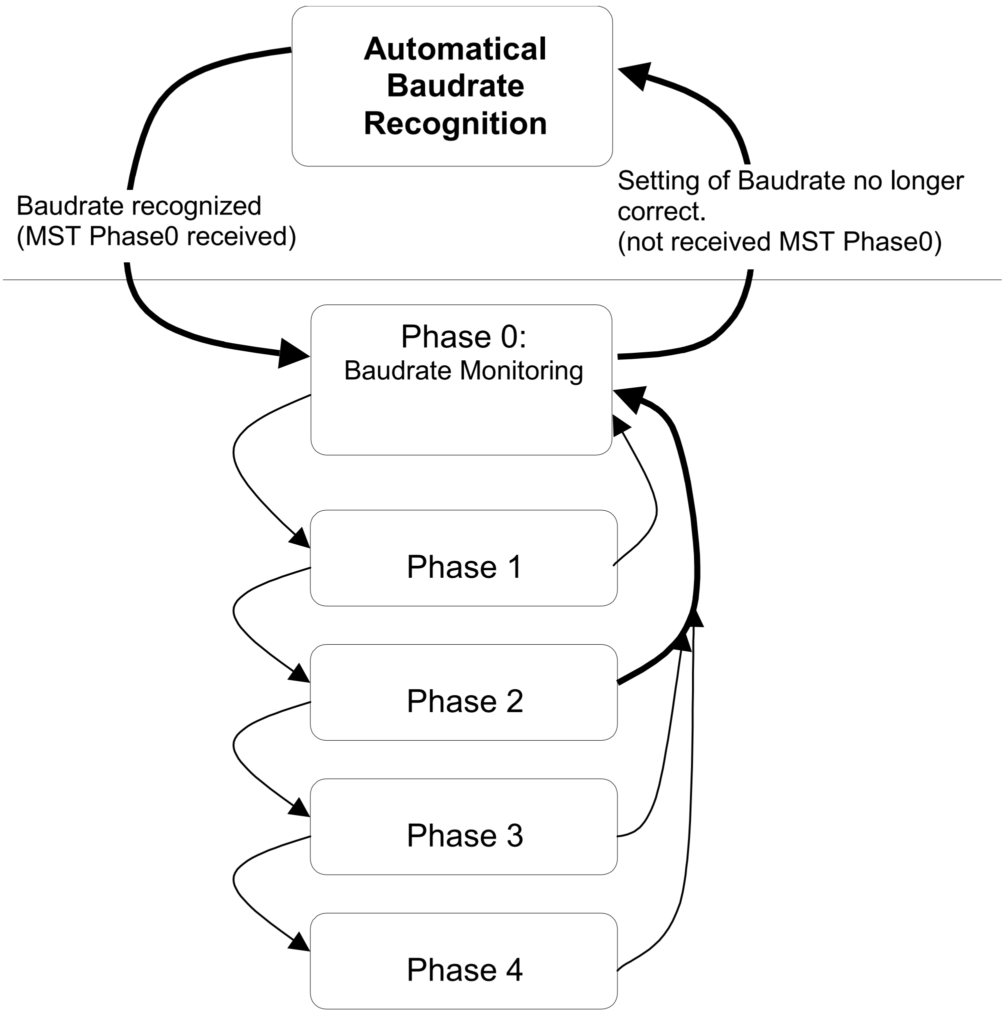


Figure 81 - Sequence of Phases

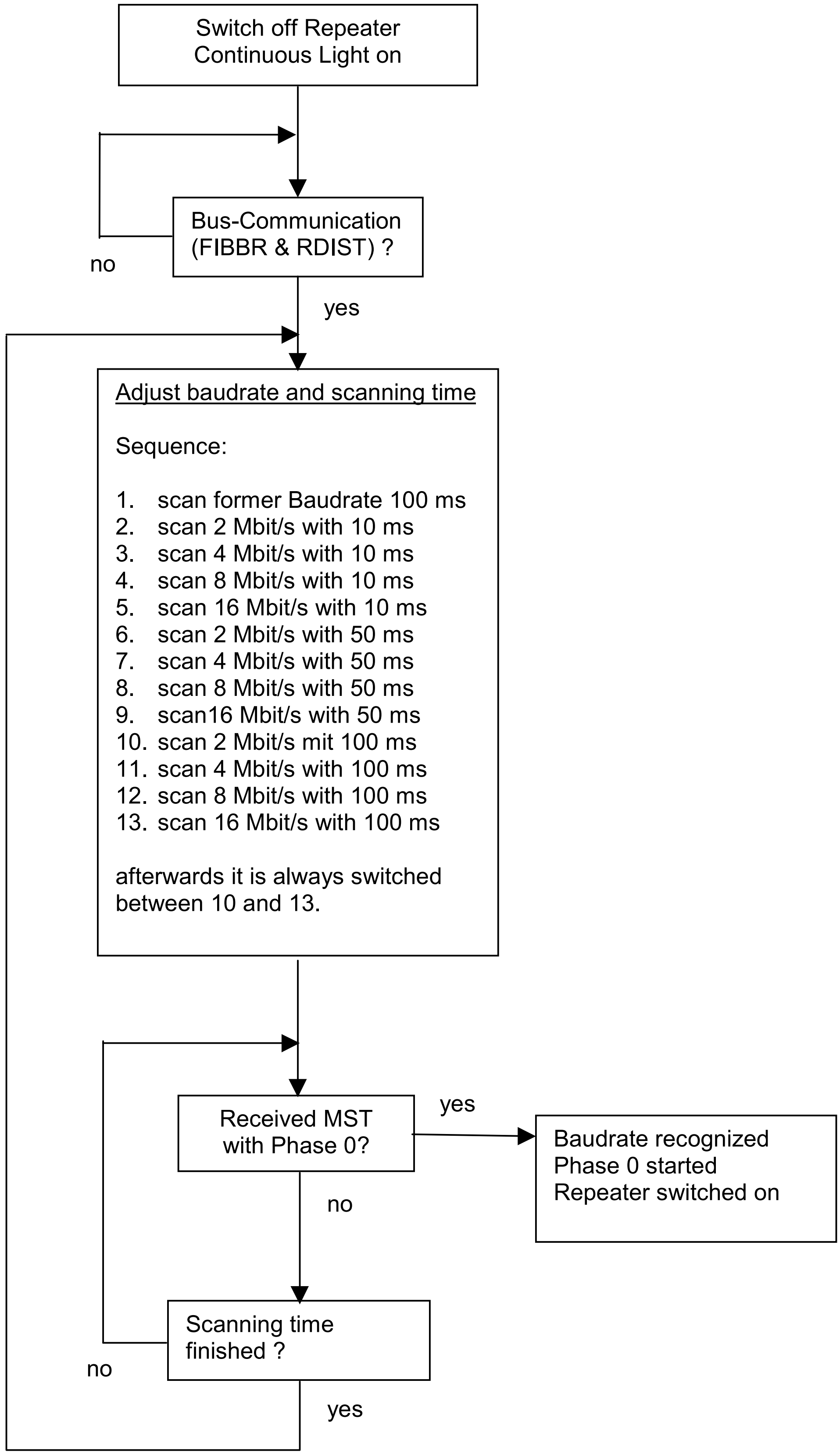


Figure 82 - Automatical baudrate recognition

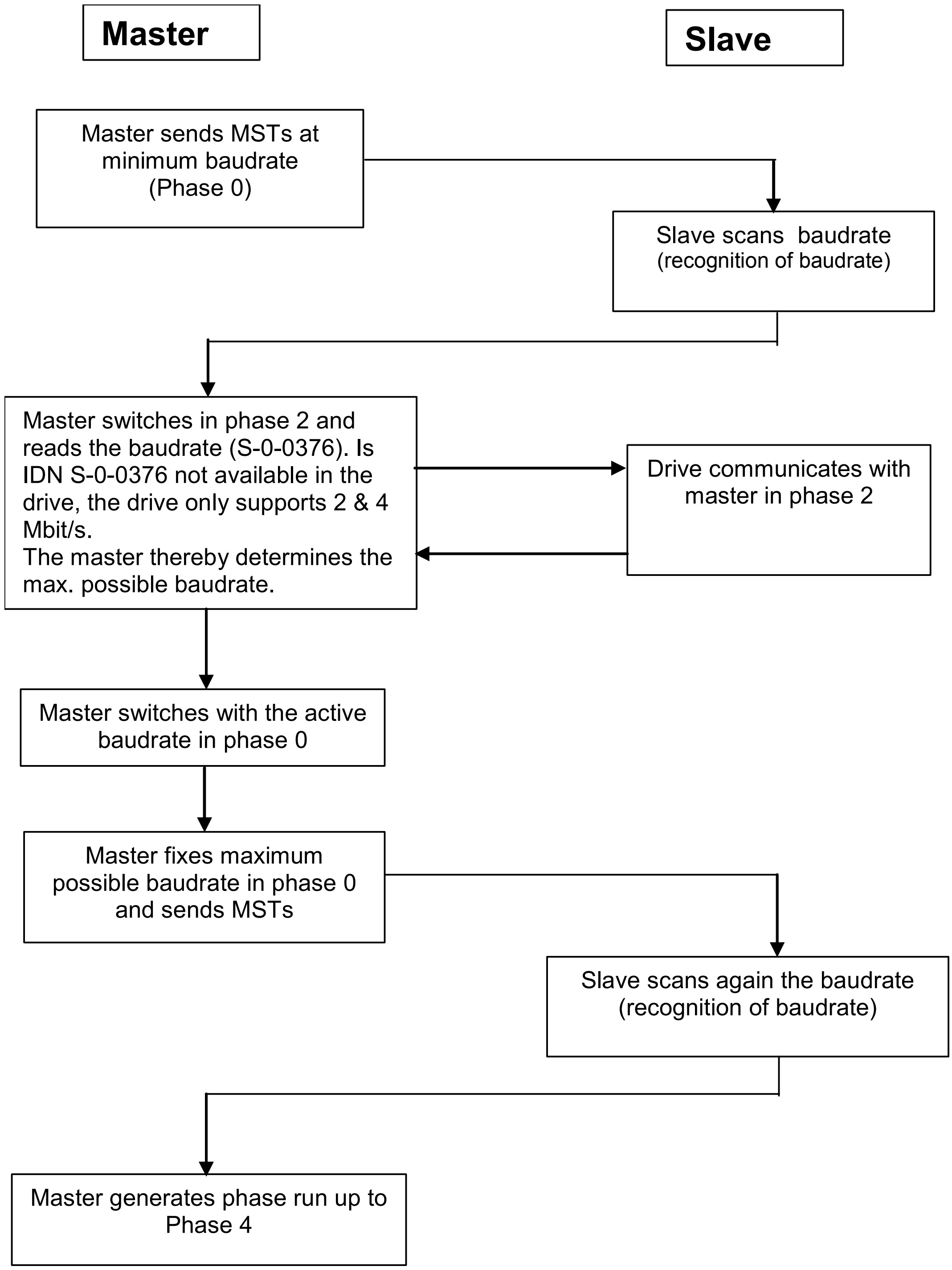


Figure 83 - Process in the master (example)

13 Communication classes (normative)

13.1 Introduction

Through the introduction of communication classes into the SERCOS interface specification, the interoperability of SERCOS interface components produced by various manufacturers is simplified. All functions which affect the operation of the master or slaves are defined under different application profiles.

The SERCOS communication is subdivided in 3 classes. By definition, the communication classes follow a hierarchical structure. This means that a higher communication class assumes the requirements of a lower communication class. Each communication class contains a certain range of function groups and IDNs. An illustration of this procedure is shown in Figure 84.

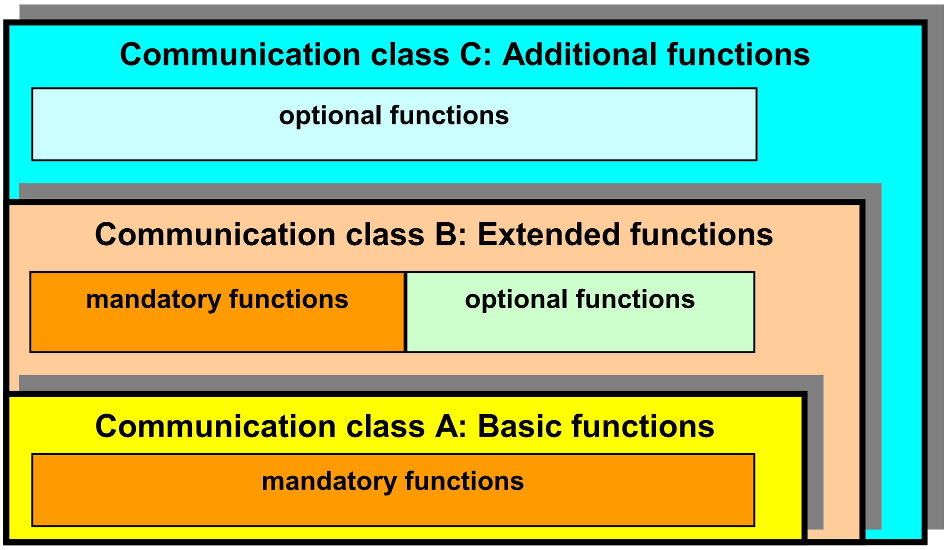


Figure 84 – Structure of Communication classes

SERCOS interface components shall be described by supported:

- compliance classes (mandatory) one or more;
- additional functions (optional);
- communication cycle time (mandatory),
- transmission rate (mandadory).

Example:

Drive component: class B position control.

Additional functions:

- position feedback (slave)
- positive stop drive procedure
- probing cycle: level 1
- communication cycle time: 0,5 ms, granularity 1
- transmission rate: 2 Mbit/s and 4 Mbit/s.

13.2 Communication class A

This class consists of all parameters that are required in order to allow the exchange of data in a way that is consistent with the SERCOS interface protocol. Each SERCOS interface component, (drive, control unit, etc.), shall support these parameters in order to close a SERCOS interface ring and operate fault free up to CP4, independent of the device.

Communication Class A includes the following basic communication-related functions:

- Ring Configuration
  - Timing
  - Standard Telegram
  - Phase run-up
- Service Channel Protocol
- Communucation error handling
- Information & Diagnostics
- Status Word (RTChannel)

- Control Word (RTChannel)

FG 1A	Ring Configuration : Timing		
IDN	**Description**	**Capability**	**Comments**
S-0-0001	Control unit cycle time (t_{Ncyc})	W	If the control unit uses a value different from S-0-0002, this must be supported, as must the Control Unit Synchronization Bit (control word, bit 10)
S-0-0002	Communication cycle time (t_{Scyc})	W	
S-0-0003	Shortest AT transmission starting time (t_{1min})	R	
S-0-0004	Transmit/receive transition time (t_{ATMT})	R	
S-0-0005	Minimum feedback processing time (t_5)	R	
S-0-0006	AT transmission starting time (t_1)	W	
S-0-0007	Feedback acquisition capture point (t_4)	W	
S-0-0008	Command value valid time (t_3)	W	
S-0-0087	Transmit to transmit recovery time (t_{ATAT})	R	This parameter must be provided even the slave does not support multiple devices. If the slave doesn't support multiple devices this parameter is set to "0".
S-0-0088	Receive to receive recovery time (t_{MTSY})	R	
S-0-0089	MDT transmission starting time (t_2)	W	
S-0-0090	Command value proceeding time (t_{MTSG})	R	
S-0-0096	Slave arrangement (SLKN)	R	

FG 1B	Ring Configuration : Telegram Configuration		
IDN	**Description**	**Capability**	**Comments**
S-0-0009	Position of data record in MDT	W	
S-0-0010	Length of MDT	W	
S-0-0015	Telegram type	W	Standard telegrams only

FG 1C	Ring Configuration : Phase run-up		
IDN	**Description**	**Capability**	**Comments**
S-0-0021	IDN-list of invalid operation data for CP2	R	
S-0-0022	IDN-list of invalid operation data for CP3	R	
S-0-0028	MST error counter	R	
S-0-0029	MDT error counter	R	
S-0-0127	CP3 transition check	W	
S-0-0128	CP4 transition check	W	
RTChannel	Procedure command change	R	Status word, bit 5

FG 1F	Service channel protocol		
IDN	**Description**	**Capability**	**Comments**
RTChannel	Service Channel AT	R	Status word, bit 0..2
RTChannel	Service Channel MDT	W	Control word, bit 0..5

FG 2	Information & Diagnostics		
IDN	**Description**	**Capability**	**Comments**
S-0-0011	Class 1 diagnostic	R	Bit 12 for communication required only. Other bits defined by functional description of the profiles.
S-0-0012	Class 2 diagnostic	R	required for function part of the profiles
S-0-0013	Class 3 diagnostic	R	required for function part of the profiles

S-0-0014	Interface status	R	Bits 0..8 for communication required only.
S-0-0017	IDN-list of all operation data	R	
S-0-0025	IDN-list of all procedure commands	R	
S-0-0028	MST error counter	R	
S-0-0029	MDT error counter	R	
S-0-0030	Manufacturer version	R	
S-0-0095	Diagnostic message	R	
S-0-0096	Slave arrangement (SLKN)	R	
S-0-0099	Reset class 1 diagnostic	W	
S-0-0134	Master control word	R	
S-0-0135	Drive status word	R	
S-0-0143	SERCOS interface version	R	
RTChannel	Drive shut down error	R	Status word, bit 13

The **baud rates** and **cycle times** to be supported are defined by the detailed descriptions of the different profiles.
Remark: The scanning of baudrates by the master should be deactivated as this may interfere with the automatic baudrate recognition by the drive which is an optional feature (communication class C).

The following IDNs have to be written by the control unit in CP2. The control unit can not rely on defaults or previously stored parameters.
The drive has to accept these parameters in CP 2.
The control unit may or may not write additional parameters in CP2.
The drive has to accept all other parameters in CP3, as well.
IDN write access in CP2:

IDN	Name	Access	Comment
S-0-0001	Control unit cycle time (t_{Ncyc})	CP2-W	Ring Timing
S-0-0002	Communication cycle time (t_{Scyc})	CP2-W	Ring Timing
S-0-0006	AT transmission starting time (t_1)	CP2-W	Ring Timing
S-0-0007	Feedback acquisition capture point (t_4)	CP2-W	Ring Timing
S-0-0008	Command value valid time (t_3)	CP2-W	Ring Timing
S-0-0009	Position of data record in MDT	CP2-W	Telegram Configuration
S-0-0015	Telegram type	CP2-W	Telegram Configuration
S-0-0089	MDT transmission starting time (t_2)	CP2-W	Ring Timing
S-0-0127	CP3 transition check	CP2-W	Phase switch

The parameter list S-0-0021 “IDN-list of invalid operation data for CP2” will only reflect parameters from this table.

13.3 Communication Class B (Extended Functions)

Communication Class B includes

- Communication Class A with the following basic communication-related functions (see clause 13.2):
    - Ring Configuration (Timing, Standard Telegram, Phase run-up)
    - Service Channel Protocol
    - Information & Diagnostics
    - Status Word (Real-time Channel)
    - Control Word (Real-time Channel)
- and the following extended communication functions:
    - Ring Configuration (Telegram 7)
    - Extended Information & Diagnostics
    - Real-time Control Bits
    - Real-time Status Bits

FG 1B	**Ring Configuration : Telegram Configuration**	

IDN	Description	Capability	Comments
S-0-0016	Configuration list of AT	W	
S-0-0024	Configuration list of MDT	W	
S-0-0185	Length of the configurable data record in the AT	R	
S-0-0186	Length of the configurable data record in the MDT	R	
S-0-0187	IDN-list of configurable data in the AT	R	
S-0-0188	IDN-list of configurable data in the MDT	R	

FG 2A	Information & Diagnostics		
IDN	**Description**	**Capability**	**Comments**
S-0-0097	Mask class 2 diagnostic	W	
S-0-0098	Mask class 3 diagnostic	W	

FG 12A	Real-time Control Bits		
IDN	**Description**	**Capability**	**Comments**
S-0-0300	Real-time control bit 1	R	
S-0-0301	Allocation of real-time control bit 1	W	
S-0-0302	Real-time control bit 2	R	
S-0-0303	Allocation of real-time control bit 2	W	

FG 12B	Real-time Status Bits		
IDN	**Description**	**Capability**	**Comments**
S-0-0304	Real-time status bit 1	R	
S-0-0305	Allocation of real-time status bit 1	W	
S-0-0306	Real-time status bit 2	R	
S-0-0307	Allocation of real-time status bit 2	W	

The following IDNs **have to** be written by the control unit in CP2. The control unit can not rely on defaults or previously stored parameters. The drive has to accept these parameters in CP 2. The control unit may or may not write additional parameters in CP2. The drive has to accept all other parameters in CP3, as well.

IDN	Name	Access	Comment
S-0-0001	Control unit cycle time (tNcyc)	CP2-W	Ring Timing
S-0-0002	Communication cycle time (tScyc)	CP2-W	Ring Timing
S-0-0006	AT transmission starting time (t1)	CP2-W	Ring Timing
S-0-0007	Feedback acquisition capture point (t4)	CP2-W	Ring Timing
S-0-0008	Command value valid time (t3)	CP2-W	Ring Timing
S-0-0009	Position of data record in MDT	CP2-W	Telegram Configuration
S-0-0015	Telegram type	CP2-W	Telegram Configuration
S-0-0016	Configuration list of AT	CP2-W	Ring Timing
S-0-0024	Configuration list of MDT	CP2-W	Ring Timing
S-0-0089	MDT transmission starting time (t2)	CP2-W	Ring Timing
S-0-0127	CP3 transition check	CP2-W	Phase switch

The parameter list S-0-0021 “IDN-list of invalid operation data for CP2” will only reflect parameters from this table.

13.4 Communication Class C (Additional Functions)

The communication class C contains

- Communication Class B which includes
    - Communication Class A with the following basic communication-related functions (see clause 13.2):
        - Ring Configuration (Timing, Standard Telegram, Phase run-up)
        - Service Channel Protocol

    - Information & Diagnostics
    - Status Word (Real-time Channel)
    - Control Word (Real-time Channel)
  - and the following extended communication functions:
    - Ring Configuration (Telegram 7)
    - Extended Information & Diagnostics
    - Real-time Control Bits
    - Real-time Status Bits
- and the following additional optional functions, such as :
- Automatic Baud Rate Recognition (FG 1D)
- Physical Order (FG 1E)
- Configurable Real-time Bits - Signal Control (FG 12C)
- Configurable Real-time Bits - Signal Status Word (FG 12D)
- Data Container - Multiplex Channel (FG 13A)
- Data Container - List Handling via Multiplex Channel (FG 13B)
- List Handling via Service Channel (FG 14)
- Expanded Service Channel
- Firmware up/download
- File transfer

13.5 Communication cycle times

For S-0-0002, the communication cycle time has to be preselected. The control unit cycle time should be an integer multiple of the communication cycle time. For good performance of the whole system, the cycle time should be as small as possible.

Three granularities are defined. In the absence of a granularity specification, the granularity 1 is assumed.

– granularity 1: 62µs, 125µs, 250µs, 500µs, 1ms to 65 ms (in 1 ms increments)
– granularity 2: 62µs, 125µs, 250µs, 500µs to 65 ms (in 500 µs increments)
– granularity 3: 62µs, 125µs, 250µs to 65 ms (in 250µs increments)

Implementation of the SERCOS interface should support granularity 1 to insure inter-operability. Granularities 2 and 3 should be regarded as optional enhancements.

14 Application function groups

14.1 General

The following functional sequences describe procedure commands and real-time bits and their application in more detail. The IDNs refer to parameter set 0 of the standardized data.

14.2 Scaling of operation data

Operation data can have different scalings depending on the functional capabilities of the drives and applications. The normative part of this specification uses SI-units.

The SERCOS interface differentiates between unscaled operation data and application-specific scaled data.

With an unscaled data format, it is up to the user to apply scaling to the operation data.

With application-specific scaling, the data is referred depending on rotational or linear load movements.

It is also possible to chose from scaling preferred values and scaling of arbitrary values by means of freely adjustable scaling parameters.

The type of scaling is defined by setting the scaling type definition bits of the scaling type parameters.

Scaling determines the weight of the operation data which is transferred between the control unit and the drives (and vice versa) using the SERCOS interface. The processing accuracy of the control unit and the drives is not affected by scaling.

14.2.1 Scaling of position data

IDN	Description
S-0-0076	Position data scaling type
S-0-0077	Linear position data scaling factor
S-0-0078	Linear position data scaling exponent
S-0-0079	Rotational position resolution
S-0-0103	Modulo value
S-0-0294	Divider modulo value

14.2.1.1 No scaling of position data

The position data acquired by the drive and the position data calculated by the control unit are transferred between the drives and the control unit (and vice versa) without scaling (see S-0-0076). It is up to the user to apply scaling to the position data.

14.2.1.2 Scaling of linear position data

Linear scaling is defined by the scaling type (see S-0-0076). Linear scaling parameters (S-0-0077 and S-0-0078) apply to all linear position data.

The weight of the LSB of linear position data is derived from the multiplication of the scaling factor and the scaling exponent (base 10).

$$\text{LSB weight} = \text{unit} * \text{factor} * 10^{\text{exponent}}$$

Preferred scaling of linear position data:

If preferred linear scaling (see S-0-0076) is used, the scaling factor (S-0-0077) is based on 1 and the scaling exponent (S-0-0078) is based on -7.

Scaling type (S-0-0076)	Unit	Scaling factor (S-0-0077)	Scaling exponent (S-0-0078)	Preferred Scaling
linear	**m**	**1**	**-7**	**0,1 µm**
linear (additional)	in	1	-6	0,000 001 in

14.2.1.3 Scaling of rotational position data

Rotational scaling is defined by the scaling type (see S-0-0076). Rotational position resolution (S-0-0079) applies to all rotational position data.

The weight of the LSB of rotational position data is defined by the rotational position resolution.

$$\text{LSB weight} = \frac{1\,\text{revolution}}{\text{Rotational position resolution}}$$

Preferred scaling of rotational positon data:

If preferred rotational scaling (see S-0-0076) is used, the rotational resolution is fixed on 3 600 000. Therefore, LSB weight for all rotational position data is fixed at 0,0001° (10^{-4} angular degrees).

Scaling type (S-0-0076)	Unit	Rotational position resolution (S-0-0079)	Preferred scaling
rotational	angular degree	3 600 000	0,0001°

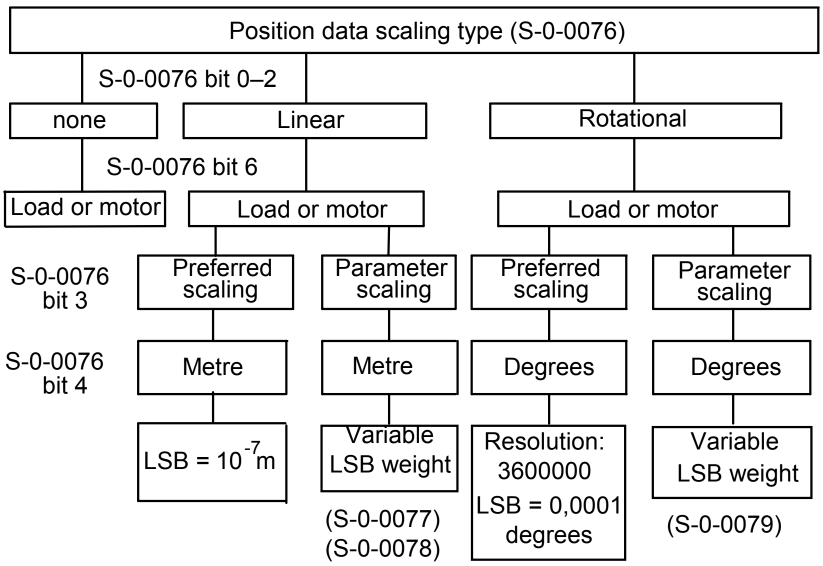


Figure 85 - Position data scaling type diagram

14.2.2 Scaling of velocity data

IDN	Description

S-0-0044	Velocity data scaling type
S-0-0045	Velocity data scaling factor
S-0-0046	Velocity data scaling exponent

14.2.2.1 No scaling of velocity data

The velocity data acquired by the drive and the velocity data computed by the control unit are transferred between the drives and the control unit (and vice versa) without scaling (see S-0-0044). It is up to the user to apply scaling to the velocity data.

14.2.2.2 Scaling of linear velocity data

The linear scaling is defined by the scaling type (see S-0-0044). The scaling parameters (S-0-0045 and S-0-0046) apply to all linear velocity data.

The weight of the LSB of linear velocity data is derived from the multiplication of the scaling factor and the scaling exponent (base 10).

$$\text{LSB weight} = \frac{\text{unit}}{\text{time unit}} * \text{factor} * 10^{\text{exponent}}$$

Preferred scaling of linear velocity data:

If preferred linear scaling (see S-0-0044) is used, the scaling factor (S-0-0045) is based on 1 and the scaling exponent (S-0-0046) is based on -6.

Scaling type (S-0-0044)	Unit	Scaling factor (S-0-0045)	Scaling exponent (S-0-0046)	Preferred Scaling
linear	**m/min**	**1**	**-6**	**0,001 mm/min**
linear (additional)	in/min	1	-5	0,000 01 in/min

14.2.2.3 Scaling of rotational velocity data

Rotational scaling is defined by the scaling type (see S-0-0044). The scaling parameters (S-0-0045 and S-0-0046) apply to all rotational velocity data.

The weight of the LSB of rotational velocity data is derived from the multiplication of the scaling factor and the scaling exponent (base 10).

$$\text{LSB weight} = \frac{\text{unit}}{\text{time unit}} * \text{factor} * 10^{\text{exponent}}$$

Preferred scaling of rotational velocity data:

Two preferred scaling units are defined for rotational velocity data. For both, the scaling factor (S-0-0045) is 1 and the scaling exponent (S-0-0046) depends on the time unit used.

Scaling type (S-0-0044)	Unit	Scaling factor (S-0-0045)	Scaling exponent (S-0-0046)	Preferred Scaling
rotational	**$\mathbf{min^{-1}}$ (RPM)**	**1**	**-4**	**0,000 1 $\mathbf{min^{-1}}$**
rotational	**$\mathbf{s^{-1}}$ (rev/s)**	**1**	**-6**	**0,000 001 $\mathbf{s^{-1}}$**

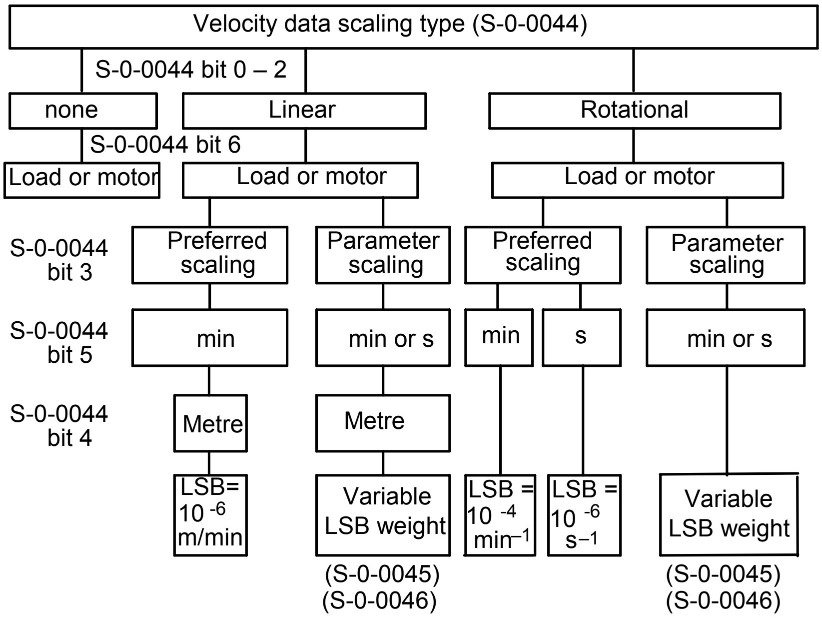


Figure 86 - Velocity data scaling type diagram

14.2.3 Scaling of torque/force data

IDN	Description
S-0-0086	Torque/force data scaling type
S-0-0093	Torque/force data scaling factor
S-0-0094	Torque/force data scaling exponent

14.2.3.1 Percentage scaling of torque/force data

The percentage scaling is defined by the scaling type parameter (S-0-0086). No further scaling parameters are required.

With percentage torque scaling, the LSB weight of the torque data is based on 0,1% of the continuous stall torque of the motor (see S-0-0111) or the rated torque of the motor (see S-0-0196).

14.2.3.2 Scaling of force data

The scaling of force data is defined by the scaling type (see S-0-0086). The scaling parameters (S-0-0093 and S-0-0094) apply to all force data.

The weight of the LSB of force data is derived from the multiplication of the scaling factor and the scaling exponent (base 10).

$$\text{LSB weight} = \text{unit} * \text{factor} * 10^{\text{exponent}}$$

Preferred scaling of force data:

If preferred scaling is used, the scaling factor (S-0-0093) is based on 1 and the scaling exponent (S-0-0094) is based on 0.

Scaling type (S-0-0086)	Unit	Scaling factor (S-0-0093)	Scaling exponent (S-0-0094)	Preferred Scaling
linear	**N**	**1**	**0**	**1 N**

linear (additional)	lbf	1	-1	0,1 lbf

Note: 1N = 0,22481 lbf

14.2.3.3 Scaling of torque data

The scaling of torque data is defined by the scaling type (see S-0-0086). The scaling parameters (S-0-0093 and S-0-0094) apply to all torque data.

The weight of the LSB of torque data is derived from the multiplication of the scaling-factor and the scaling exponent (base 10).

$$\text{LSB weight} = \text{unit} * \text{factor} * 10^{\text{exponent}}$$

Preferred scaling of torque data:

If preferred scaling is used, the scaling factor (S-0-0093) is based on 1 and the scaling exponent (S-0-0094) is based on -2.

Scaling type (S-0-0086)	Unit	Scaling factor (S-0-0093)	Scaling exponent (S-0-0094)	Preferred Scaling
rotational	**Nm**	**1**	**-2**	**0,01 Nm**
ratational (additional)	in lbf	1	-1	0,1 in lbf

Note: 1Nm = 8,851 in lbf

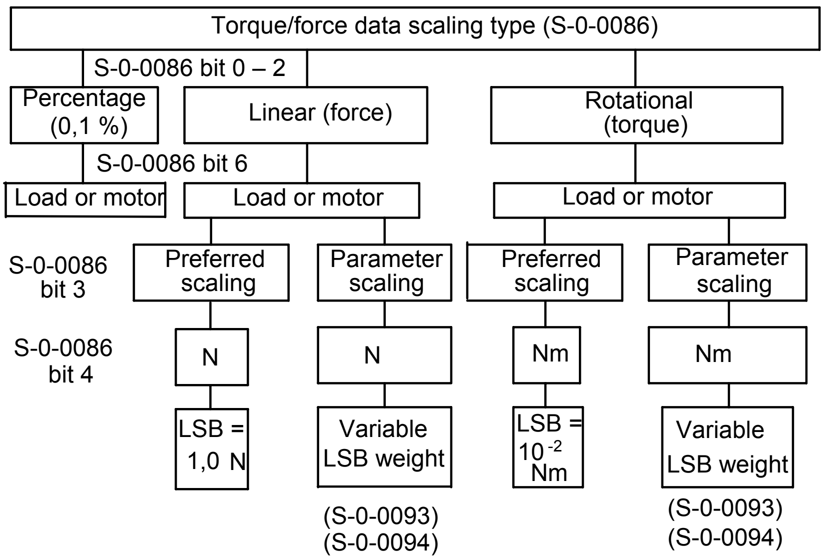


Figure 87 - Torque/force data scaling type diagram

14.2.4 Scaling of acceleration data and jerk data

IDN	Description
S-0-0160	Acceleration data scaling type
S-0-0161	Acceleration data scaling factor
S-0-0162	Acceleration data scaling exponent
S-0-0446	Ramp reference velocity

14.2.4.1 No scaling of acceleration data and jerk data

The acceleration/jerk data acquired by the drive and the acceleration/jerk data computed by the control unit are transferred between the drives and the control unit (and vice versa) without scaling (see S-0-0160). It is up to the user to apply scaling to the acceleration/jerk data.

14.2.4.2 Scaling of linear acceleration/jerk data

The linear scaling is defined by the scaling type (see S-0-0160). The scaling parameters (S-0-0161 and S-0-0162) apply to all linear acceleration data and jerk data.

The weight of the LSB of linear acceleration data and jerk data is derived from the multiplication of the scaling factor and the scaling exponent (base 10).

$$\text{LSB weight} = \frac{\text{unit}}{\text{time unit}^{2\text{ or }3}} * \text{factor} * 10^{\text{exponent}}$$

Preferred scaling of linear acceleration/jerk data:

Only one preferred unit is defined for linear acceleration data and jerk data (i.e., metric). The scaling factor (S-0-0161) is based on 1 and the scaling exponent (S-0-0162) is based on -6.

Scaling type (S-0-0160)	Unit	Scaling factor (S-0-0161)	Scaling exponent (S-0-0162)	Preferred Scaling
Linear (acceleration)	**m/s^2**	**1**	**-6**	**0,000 001 m/s^2**
Linear (jerk)	**m/s^3**	**1**	**-6**	**0,000 001 m/s^3**

14.2.4.3 Scaling of rotational acceleration/jerk data

Rotational scaling is defined by the scaling type (see IDN S-0-0160). The scaling parameters (S-0-0161 and S-0-0162) apply to all rotational acceleration/jerk data.

The weight of the LSB of rotational acceleration data and jerk data is derived from the multiplication of the scaling factor and the scaling exponent (base 10).

$$\text{LSB weight} = \frac{\text{unit}}{\text{time unit}^{2\text{ or }3}} * \text{factor} * 10^{\text{exponent}}$$

Preferred scaling of rotational acceleration/jerk data:

Only one preferred unit is defined for rotational acceleration/jerk data.

Scaling type (S-0-0160)	Unit	Scaling factor (S-0-0161)	Scaling exponent (S-0-0162)	Preferred Scaling
Rotational (acceleration)	**rad/s^2**	**1**	**-3**	**0,001 rad/s^2**
Rotational (jerk)	**rad/s^3**	**1**	**-3**	**0,001 rad/s^3**

14.2.4.4 Scaling of Ramp time

The scaling of ramp time data is defined by the scaling type (S-0-0160). The scaling parameters (S-0-0161 and S-0-0162) apply to all ramp time data.

The acceleration is calculated by the ramp time data related to the ramp reference velocity (S-0-0446).

The weight of the LSB of ramp time data is derived from the multiplication of the scaling factor and the scaling exponent (base 10).

$$\text{LSB weight} = \text{unit} * \text{factor} * 10^{\text{exponent}}$$

Preferred scaling of ramp time data:

If preferred scaling (see S-0-0160) is used, the scaling factor (S-0-0161) is based on 1 and the scaling exponent (S-0-0162) is based on -3.

Scaling type (S-0-0160)	Unit	Scaling factor (S-0-0161)	Scaling exponent (S-0-0162)	Preferred Scaling
ramp time	**s**	**1**	**-3**	**0,001 s**

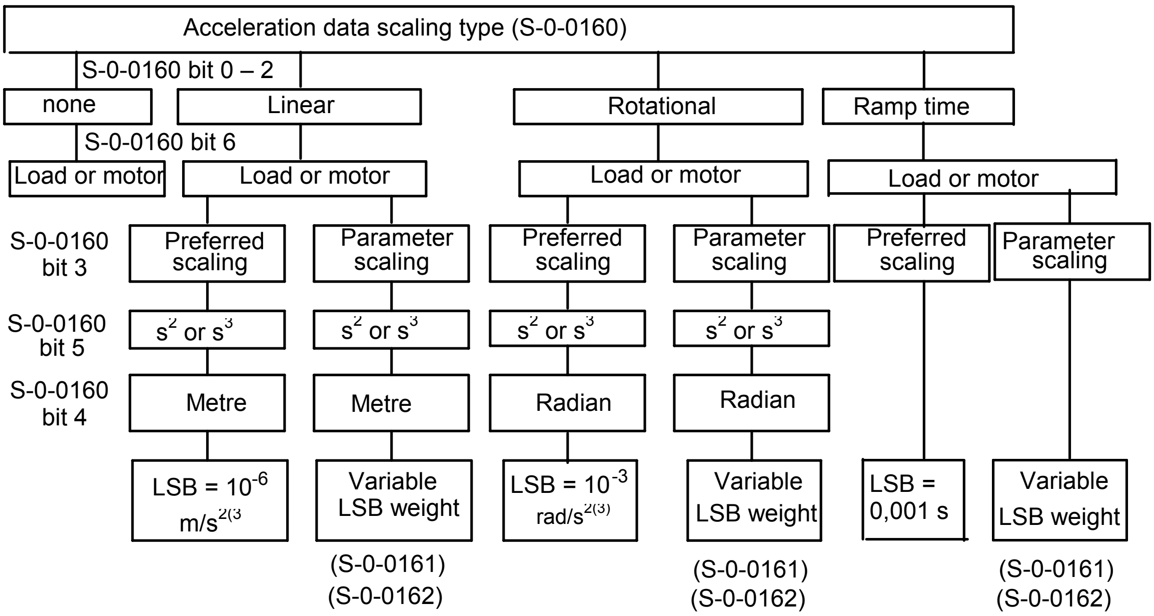


Figure 88 - Acceleration/jerk data scaling type diagram

14.2.5 Scaling of temperature data

IDN	Description
S-0-0208	Temperature data scaling type

14.3 Drive parameters

14.3.1 Velocity loop parameters

IDN	Description
S-0-0100	Velocity loop proportional gain
S-0-0101	Velocity loop integral action time
S-0-0102	Velocity loop differential time

14.3.1.1 Adaptation of the velocity loop

When using the adaptation parameters (S-0-0209, S-0-0210, S-0-0211, S-0-0212), the proportional gain (S-0-0100) and the integral action time (S-0-0101) in the velocity loop can be adapted within a programmable velocity range.

IDN	Description

S-0-0209	Lower adaptation limit
S-0-0210	Upper adaptation limit
S-0-0211	Adaptation proportional gain
S-0-0212	Adaptation integral action time

Example:

– Velocity loop proportional gain (S-0-0100): 50
– Lower adaptation limit (S-0-0209): 3 min^{-1}
– Upper adaptation limit (S-0-0210): 8 min^{-1}
– Adaptation proportional gain (S-0-0211): 150 %

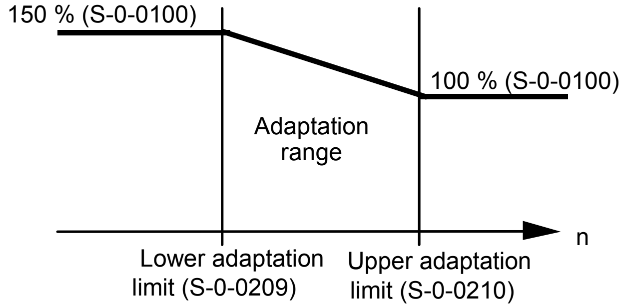


Figure 89 - Adaptation of the velocity loop proportional gain

Example:

– Velocity loop integral action time (S-0-0101): 2 ms
– Lower adaptation limit (S-0-0209): 3 min^{-1}
– Upper adaptation limit (S-0-0210): 8 min^{-1}
– Adaptation integral action time (S-0-0212): 75 %

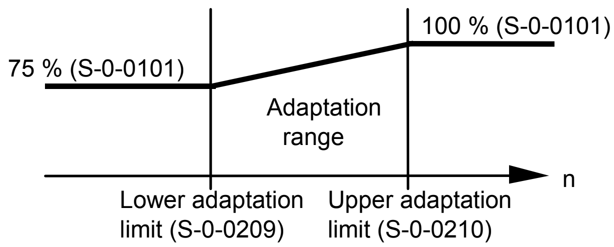


Figure 90 - Adaptation of the velocity loop integral action time

14.3.2 Position loop parameters

IDN	Description
S-0-0104	Position loop K_V–factor
S-0-0105	Position loop integral action time
S-0-0159	Monitoring window

14.3.3 Current loop parameters

Current loop parameters are divided into two groups:

– group 1 for torque/force-producing current;
– group 2 for flux-producing current.

IDN	Description
S-0-0106	Current loop proportional gain 1
S-0-0107	Current loop integral action time 1
S-0-0119	Current loop proportional gain 2
S-0-0120	Current loop integral action time 2

14.3.4 Drive limit values

IDN	Description
S-0-0109	Motor peak current
S-0-0110	Amplifier peak current
S-0-0111	Motor continuous stall current
S-0-0196	Motor rated current
S-0-0112	Amplifier rated current
S-0-0113	Maximum motor speed
S-0-0114	Load limit of the motor
S-0-0108	Feedrate override
S-0-0200	Amplifier warning temperature
S-0-0201	Motor warning temperature
S-0-0202	Cooling error warning temperature
S-0-0203	Amplifier shut-down temperature
S-0-0204	Motor shut-down temperature
S-0-0205	Cooling error shut-down temperature

14.3.5 Drive state machine parameters

IDN	Description
S-0-0206	Drive on delay time
S-0-0207	Drive off delay time
S-0-0273	Maximum drive off delay time
S-0-0295	Drive enable delay time

14.4 Mechanics

14.4.1 Feedback systems

IDN	Description
S-0-0116	Resolution of rotational feedback 1
S-0-0117	Resolution of rotational feedback 2
S-0-0118	Resolution of linear feedback
S-0-0165	Distance coded reference marks A
S-0-0166	Distance coded reference marks B
S-0-0167	Frequency limit of feedback 1
S-0-0168	Frequency limit of feedback 2

S-0-0115	Position feedback type parameter

14.4.2 Feed constant

IDN	Description
S-0-0123	Feed constant

14.4.3 Gear train

The gear ratio of a gear train is calculated by the drive from the ratio of input revolutions to output revolutions.

$$\text{Gear ratio} = \frac{\text{input revolutions}}{\text{output revolutions}}$$

IDN	Description
S-0-0121	Input revolutions of load gear
S-0-0122	Output revolutions of load gear

14.4.4 Polarities

These parameters are used to switch polarities of reported command values and feedback values for specific applications. Polarities are switched outside (i.e., on the input and output) of a closed loop system.

IDN	Description
S-0-0055	Position polarity parameter
S-0-0043	Velocity polarity parameter
S-0-0085	Torque polarity parameter

- **Position loop:** The motor shaft turns clockwise when there is a positive position command difference and no inversion is programmed.
- **Velocity loop:** The motor shaft turns clockwise when there is a positive velocity command difference and no inversion is programmed.
- **Torque loop:** The motor shaft turns clockwise when there is a positive torque command difference and no inversion is programmed.

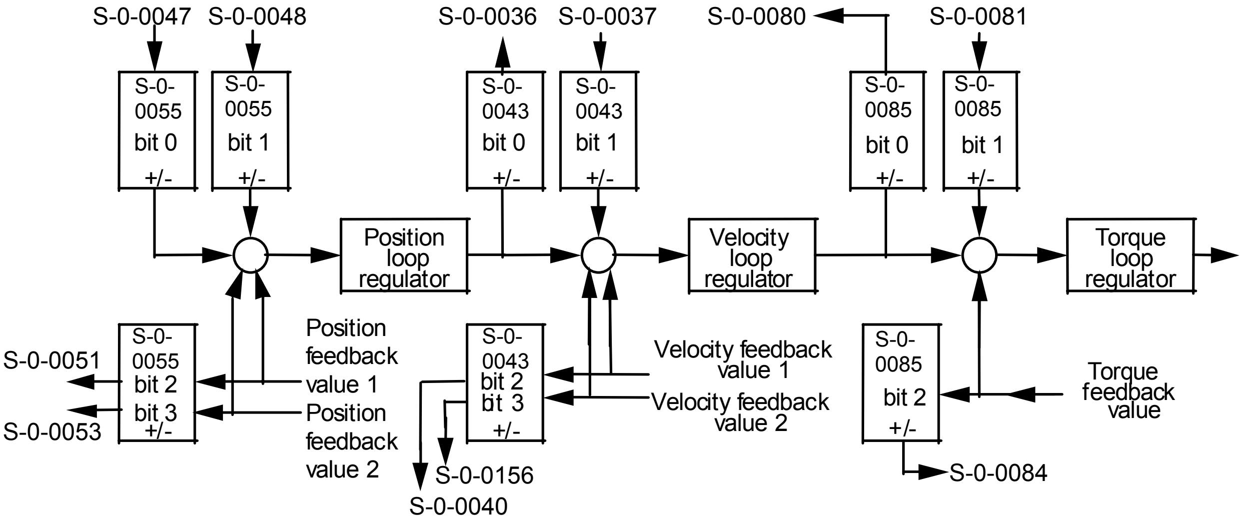


Figure 91 - Polarity parameter

14.4.5 Parameter sets and gear ratios

The number of parameters in a parameter set as well as the number of parameter sets for the drive are determined by the drive manufacturer. All data block numbers ranging from 0000 through 4095 can be defined in each parameter set as fixed IDNs (see clause 11.1.3 for the structure of IDNs.)

The standard and the product data range contain eight parameter sets each. Generally, the drive works with the IDNs of parameter set 0. With the switch parameter set procedure command (S-0-0216), some (or all) of the parameters of parameter set 0 can be switched (e.g., the adaptation of the regulator on the changed inertia).

IDN list S–0–0219 contains all these switchable parameters which are listed in the IDN-lists S–X–0219 (X = 1 … 7). The switchable parameters will be activated in the drive when a preselected parameter set (S-0-0217) is set by the switch parameter set procedure command (S-0-0216).

Since the parameter set number is contained in the structure of the IDN (see clause 11.1.3), the control unit has access to all IDNs via the service channel, independent of the actual parameter set. This enables the control unit to modify parameters in a parameter set which is off-line while another parameter set is running on-line. These modifications are accomplished through the service channel.

The switch parameter set procedure command (S-0-0216) is also valid for gear ratio switching. The demanded gear ratio is selected with S-0-0218 (only possible if the drive supports a gear changing function.)

IDN	Description
S-0-0219	IDN-list of parameter set
S-0-0216	Switch parameter set procedure command
S-0-0217	Parameter set preselection
S-0-0218	Gear ratio preselection
S-0-0254	Actual parameter set
S-0-0255	Actual gear ratio

14.4.6 Switching of parameter sets and gear ratio

The following sequence (see Figure 92) is valid for the switching of parameter sets and gear ratio:

write request for ‘parameter set preselection’ (S-0-0217) and/or ‘gear ratio preselection’ (S-0-0218);

set and enable procedure command ‘switch parameter set ‘ (S-0-0216);

the procedure command is acknowledged positively when ‘parameter set preselection’ (S-0-0217) ‘/Gear ratio preselection’ (S-0-0218) are equal to the ‘actual parameter set’ (S-0-0254)/ ‘actual gear ratio’ (S-0-0255).

cancel the procedure command.

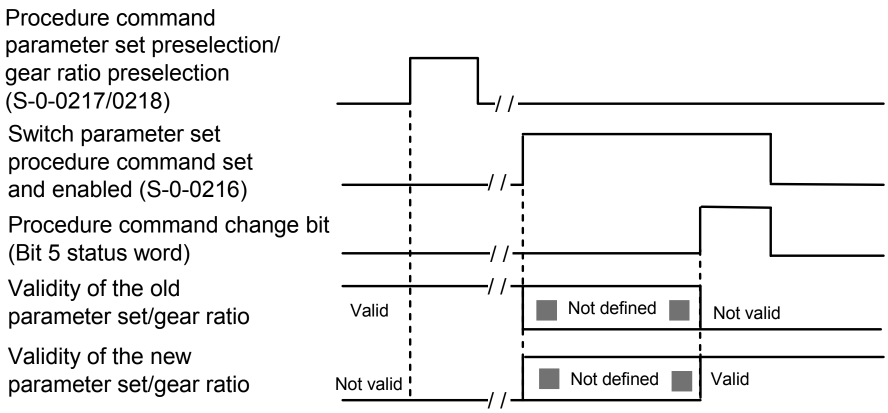


Figure 92 - Bit sequence for switching parameter sets and/or gear ratio

14.5 Drive operation modes

The drive operation mode is set by the control word in the MDT. The control word allows the system to choose between one primary mode of operation and up to seven secondary modes of operation. The response to the active mode appears in the status word of the AT.

The drive generates the actual operating mode (drive status, bit 8, 9, 10) independently of the following conditions:

- Drive OFF
- Drive not enabled
- Drive controlled functions (see drive status, bit 3)
- Error of C1D

Switching operation mode:

While switching the operation mode, the drive is given several communication cycles to acknowledge the switching in the status word. During the switching phase, the control unit needs to keep all cyclic command values current. After the drive acknowledges the switching in the status word, only the command values for the new operation mode need to be kept valid by the control unit.

Switching to an uninitialized operation mode results in an error message in the interface status (S-0-0014) generated by the drive.

The primary and secondary operation modes are individually defined in separate parameters. The drive modes of operation defined by these parameters become active when the operation mode is selected via bits 11, 9, and 8 in the control word of the MDT. If a drive supports secondary operation modes 4 through 7, it must also support bit 11 in the control word and bit 10 in the drive status word. The activated operation mode is indicated by bits 10, 9 and 8 of the drive status in the AT.

IDN	Description
S-0-0032	Primary operation mode
S-0-0033	Secondary operation mode 1

S-0-0034	Secondary operation mode 2
S-0-0035	Secondary operation mode 3
S-0-0284	Secondary operation mode 4
S-0-0285	Secondary operation mode 5
S-0-0286	Secondary operation mode 6
S-0-0287	Secondary operation mode 7
S-0-0292	List of supported operation modes
S-0-0520	Axis control word
S-0-0521	Axis status word

Table 44 - Structure of drive operation modes

1= manufacturer operation mode 0= SERCOS operation mode	reserved	0= without axis control word 1= with axis control word (S-0-0520)	0= without transition support 1= with transition support	Expanded operation modes	0= with following error 1= without following error	Basic operation modes	**Operation modes**
15	**14 - 10**	**9**	**8**	**7 - 4**	**3**	**2 1 0**	**Bit number**
1	xx xxx	x	x	xxxx	x	xxx	Operation mode (bits 14-0) defined by manufacturer
0	000 00	0	0	0000	x	000	No operation mode defined
0	000 00	0	0	0000	x	001	Torque/Force control
0	000 00	0	0	0000	x	010	Velocity control
0	000 00	0	0/1	0000	0/1	011	Position control using position feedback value 1
0	000 00	0	0/1	0000	0/1	100	Position control using position feedback value 2
0	000 00	0	0/1	0000	0/1	101	Position control using position feedback values 1 and 2
0	000 00	1	0	0000	x	101	Position control using axis control word
0	000 00	0	0	0000	0	110	Pressure control
0	000 00	0	0	0000	x	111	Operation mode without control loops
0	000 00	0	0/1	0001	0/1	011	Interpolation using position feedback value 1
0	000 00	0	0/1	0001	0/1	100	Interpolation using position feedback value 2
0	000 00	0	0/1	0001	0/1	101	Interpolation using position feedback values 1 and 2
0	000 00	1	0	0001	x	101	Interpolation using axis control word
0	000 00	0	0/1	0010	0/1	011	Positioning using position feedback value 1
0	000 00	0	0/1	0010	0/1	100	Positioning using position feedback value 2
0	000 00	0	0/1	0010	0/1	101	Positioning using position feedback values 1 and 2
0	000 00	1	0	0010	x	101	Positioning using axis control word
0	000 00	0	0/1	0011	0/1	011	Block mode using position feedback value 1
0	000 00	0	0/1	0011	0/1	100	Block mode using position feedback value 2

1= manufacturer operation mode 0= SERCOS operation mode	reserved	0= without axis control word 1= with axis control word (S-0-0520)	0= without transition support 1= with transition support	Expanded operation modes	0= with following error 1= without following error	Basic operation modes	**Operation modes**
15	**14 - 10**	**9**	**8**	**7 - 4**	**3**	**2 1 0**	**Bit number**
0	000 00	0	0/1	0011	0/1	101	Block mode using position feedback value 1 and 2
0	000 00	1	0	0011	x	101	Block mode using axis control word
0	000 00	0	0	0100	x	010	Synchronous Operation with velocity control
0	000 00	0	0/1	0100	0/1	011	Synchronous Operation with position control using position feedback value 1
0	000 00	0	0/1	0100	0/1	100	Synchronous Operation with position control using position feedback value 2
0	000 00	0	0/1	0100	0/1	101	Synchronous Operation with position control using position feedback values 1 and 2
0	000 00	1	0	0100	x	101	Synchronous Operation with position control using axis control word

Note: x = don't care

For operation modes, bits 0, 1, and 2 select the basic operation modes. Bits 4, 5, 6 and 7 select expanded operation modes. Additional functions are activated via bits 3, 8 and 9. If bit 9 is set to 1, then bit 3 is don't care and the additional axis control word (S-0-0520) and axis status word (S-0-0521) are activated.
If bit 15 is set to '1', then the coding of bits 0 through 14, as well as the operation modes, are defined by the drive supplier.

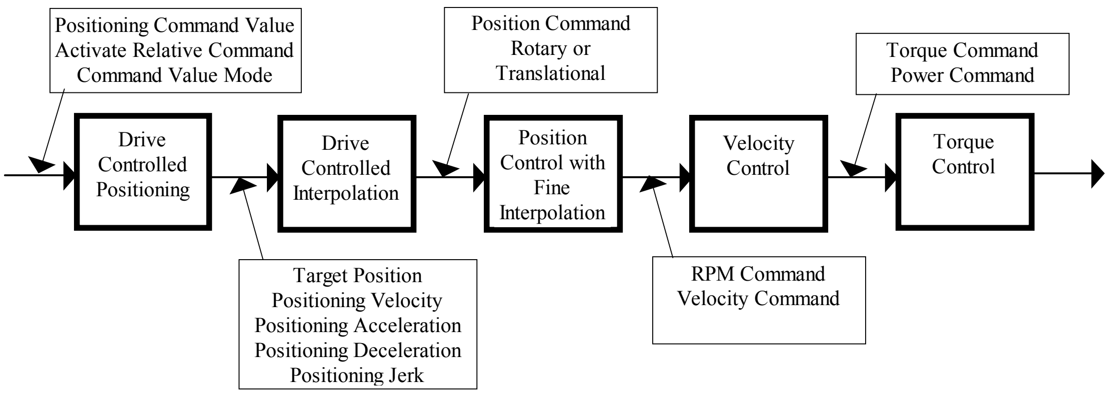


Figure 93 - Block Diagram of Operation Modes

14.5.1 Torque/Force control

14.5.2 Velocity control

14.5.3 Position control

14.5.4 Interpolation

The operation mode interpolation is the basis for all control modes in which the drive is to be positioned in a drive-controlled way. It can be adjusted, if the interpolation processes the target position in an absolute or a modular format. Relative position data cannot be processed by the interpolation. The structure is shown in figure 94.

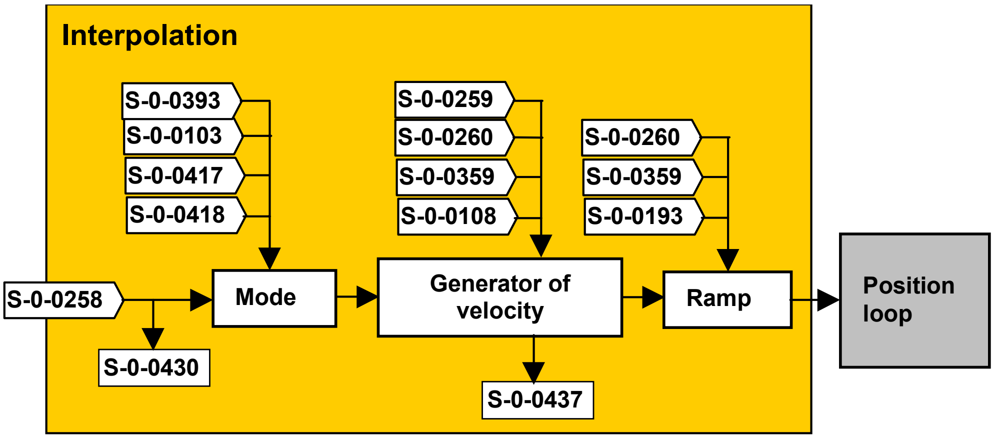


Figure 94 – Block diagram Interpolation

“Interpolation” variables and configuration settings are dictated using the following parameters:

IDN	Description
S-0-0103	Modulo value
S-0-0258	Target position
S-0-0393	Command value mode
S-0-0417	Positioning velocity threshold in modulo mode
S-0-0418	Target postion window in modulo mode
S-0-0430	Active target position
S-0-0108	Feedrate override
S-0-0259	Positioning velocity
S-0-0260	Positioning acceleration
S-0-0359	Positioning deceleration
S-0-0437	Positioning status
S-0-0193	Positioning jerk

14.5.4.1 Function description

The target position (S-0-0258) is automatically taken over by the drive into the active target position (S-0-0430) and preset for the interpolator. If the target position lies outside the axis limit value, the drive triggers the warning ‘target position outside axis limit value’. With that the control is able react correctly to the warning. If there is no reaction on the part of the control, then the drive will generate a Class 1 error, latest, when the axis limit values are exceeded.

Taking into account the positioning jerk, accelerations, slowing down and velocity, the drive moves towards the active target position. If the positioning speed is higher than the activated velocity limit value, the drive gives the warning ‘positioning velocity >nLimit’. The drive is not allowed to exceed the velocity limit value. By means of the positioning velocity and the federate override the control is able to change the velocity at any time.

The control can stop the interpolator in the drive with ‚drive Stopp’ (Bit 13, control word). In this case the drive reduces the positioning velocity in consideration of the bipolar acceleration (S-0-0372). If the interpolator doesn’t compute any new positioning commands (‘slowing down accomplished’), the drive will signal ‘interpolator stopped’. If the interpolator in the drive is restarted, the drive will speed up with the positioning acceleration up to the positioning velocity. The signal ‘interpolator stopped’ will then be deleted.

When the drive reaches the active target position, there will be generated two messages:

a) ‘target position hit’ when the positioning command hits the active target position.

b) ‘actual feedback value = active target position’ is set when the actual feedback value reaches the active target position within the positioning window.

14.5.4.2 Additional functions with modulo format

In the modulo format the positioning data are processed in a limited range of values. For this, the additional functions are needed.

The modulo value limits the range of values of the positioning data. If the positioning data exeed the modulo value, the control and the drives have to perform a modulo computation.

The moving direction of the drive is programmed in the command value mode. This informations are not sufficient for certain applications. Therefore, the velocity threshold positioning in modulo format and the target position window in modulo format are defined.

If the absolute value of the actual velocity is higher than the velocity threshold in modulo format, the last rotational direction is maintained, irrespective of the command value mode.

If the active target position lies within the target position window and the motion can be slowed down within the target position window, then always the shortest path is activated irrespective of the command value mode.

The interrelation of these parameters is demonstrated by the following 4 examples.

Example 1:

In example 1 the stated rules apply for the positive direction. The position data are processed in modulo format (endless rotating axes). Since the active target position lies outside of the target position window, the target position is always approached with a positive direction. Figure 95 shows exemplary the behaviour of the drive for 3 different starting velocities.

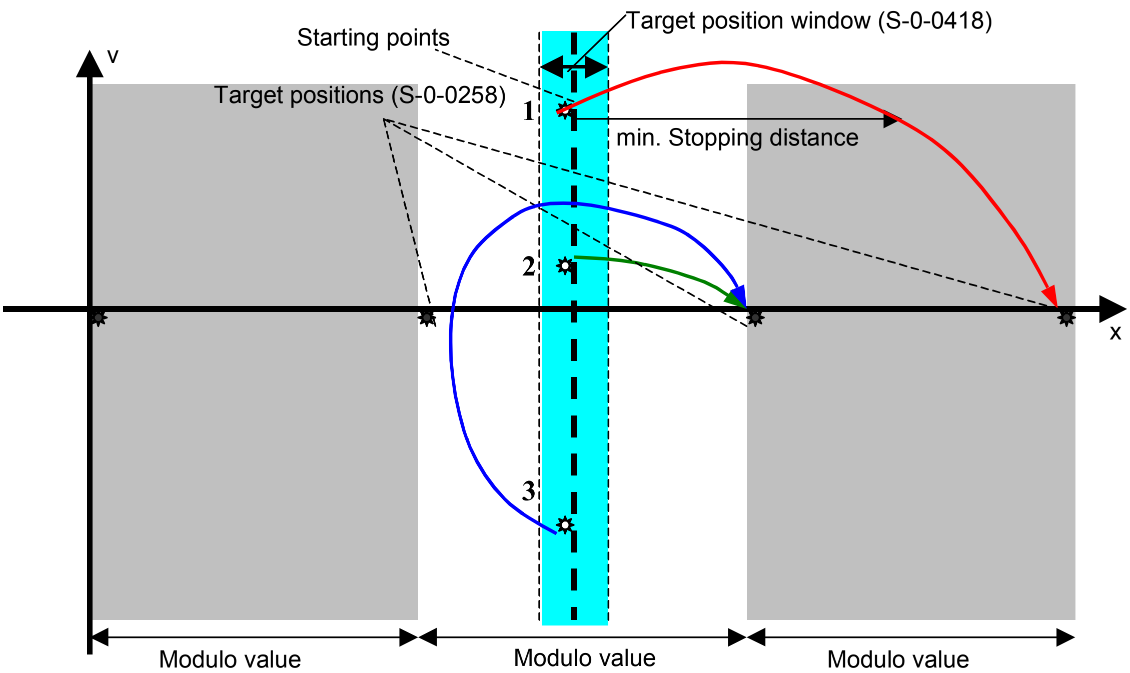


Figure 95 – Sequence of movements of example 1

For starting point 1 applies: active velocity positive and braking distance>distance between starting point and next target position:>drive moves to the next possible target position

For starting point 2 applies: active velocity positive and braking distance<distance between starting point and next target position:<drive move to the next possible target position

For starting point 3 applies: active velocity negative:>drive brakes at velocity = 0 and positions in positive direction on the next possible target position.

Example 2:

In example 2 the stated rues apply for the positive direction. The position data are processed in modulo format (endless rotating axes). Since the active target position lies within the target position window, the target position is approached with different directions. Figure 96 shows exemplary the behaviour of the drive for 4 different starting velocities.

The drive computes the braking distance at the start of the positioning motion and respectively the target position to be approached and the direction are defined.

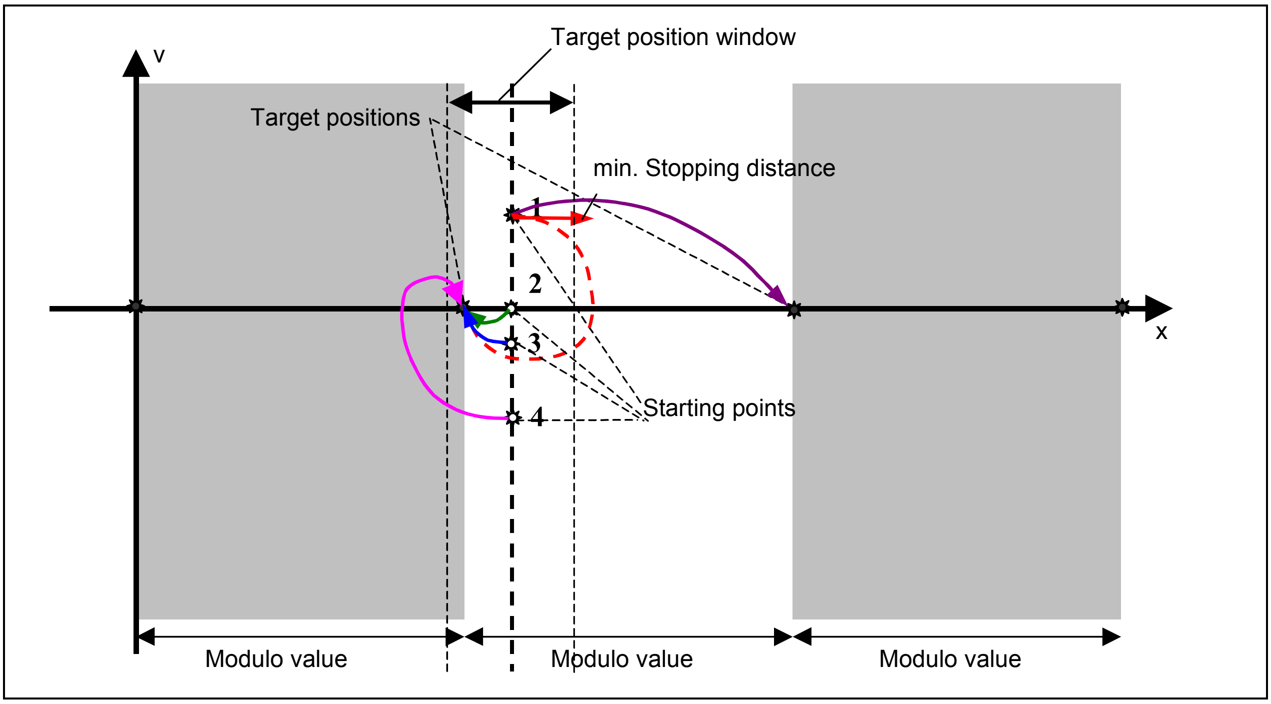


Figure 96 – Sequence of movements of example 2

For starting point 1 applies: active velocity positive and braking distance longer than the difference between starting point and next target position: >drive moves in positive direction to next possible target position. Decelerating and going back would result in a movement in negative direction bigger than the programmed target position window (red curve). Starting position + braking distance – target position >target position window: >positioning in negative direction is not allowed. Target position must be approached in positive direction.

For starting point 2 applies: active velocity = 0>drive approaches target position in negative direction. Starting position + braking distance – target position<target positioning window:>positioning on target position in negative direction.

For starting point 3 applies: active velocity negative and braking distance shorter than the difference between starting point and next target position>drive moves to target position in negative direction. Starting position + braking distance (negative) – target position >target position window:>positioning on target position in negative direction.

For starting point 4 applies: active velocity negative and braking distance longer than the difference between starting point and next target position>drive brakes at velocity =0 and positions in positive direction on the next possible target position. Starting position + braking distance (negative) – target position >target position window:>drive brakes at velocity =0 and positions in positive direction on the next possible target position.

Example 3:

In example 3 the stated rules apply for ‚shortest distance' in consideration of the velocity threshold positioning. The position data are processed in modulo format (endless rotating axes).

Figure 97 shows exemplary the behaviour of the drive for 4 different starting velocities.

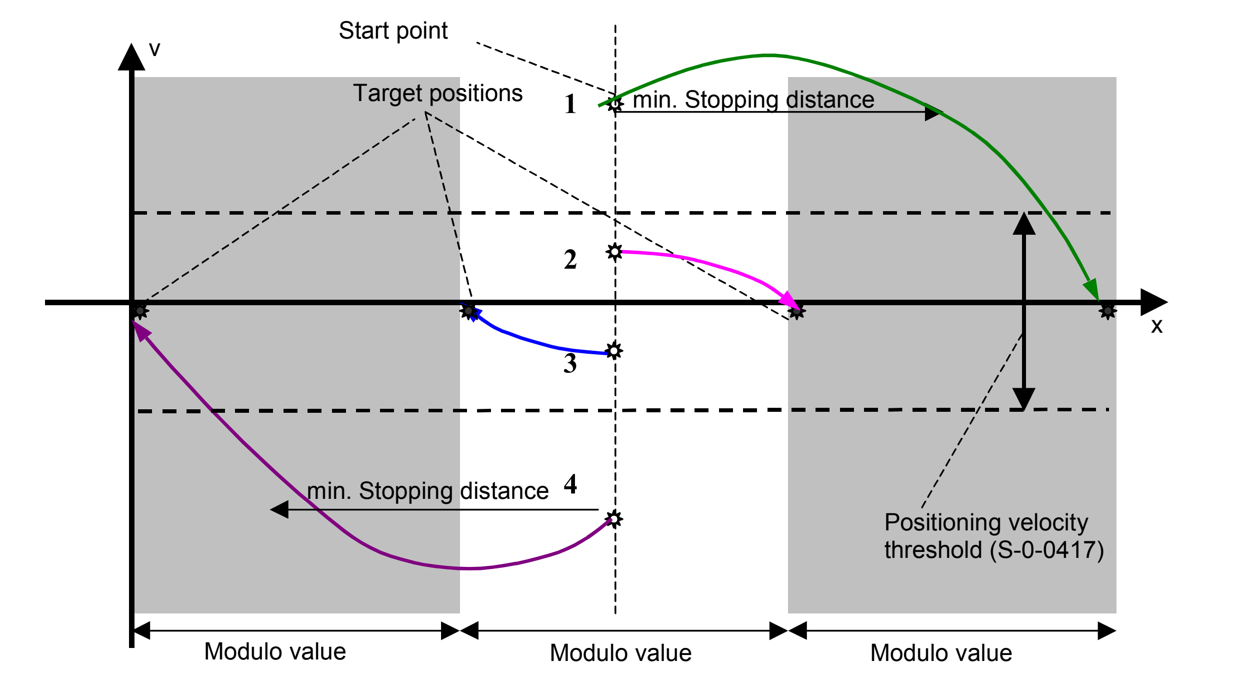


Figure 97 – Sequence of movements of example 3

For starting point 1 applies: active velocity positive and higher than ‘velocity threshold positioning in modulo format’. The braking distance is longer than the difference between starting point and next target position:>positioning in positive direction on target position.

For starting point 2 applies: active velocity positive and lower than ‘velocity threshold positioning in modulo format’. The braking distance is shorter than the difference between starting point and next target position : > positioning in positive direction on target position (shortest distance).

For starting point 3 applies: active velocity negative and lower than ‘velocity threshold positioning in modulo format’. The braking distance is shorter than the difference between starting point and next target position: >positioning in negative direction on target position (shortest distance).

For starting point 4 applies: active velocity negative and braking distance longer than the difference between starting point and next target position>positioning in negative direction on target position (shortest distance).

Example 4:

In example 4 the stated rules apply for ‚shortest distance’ in consideration of the velocity threshold positioning. The position data are processed in modulo format (endlessly rotating axes). Figure 98 shows exemplary the behaviour of the drive for 2 different starting velocities.

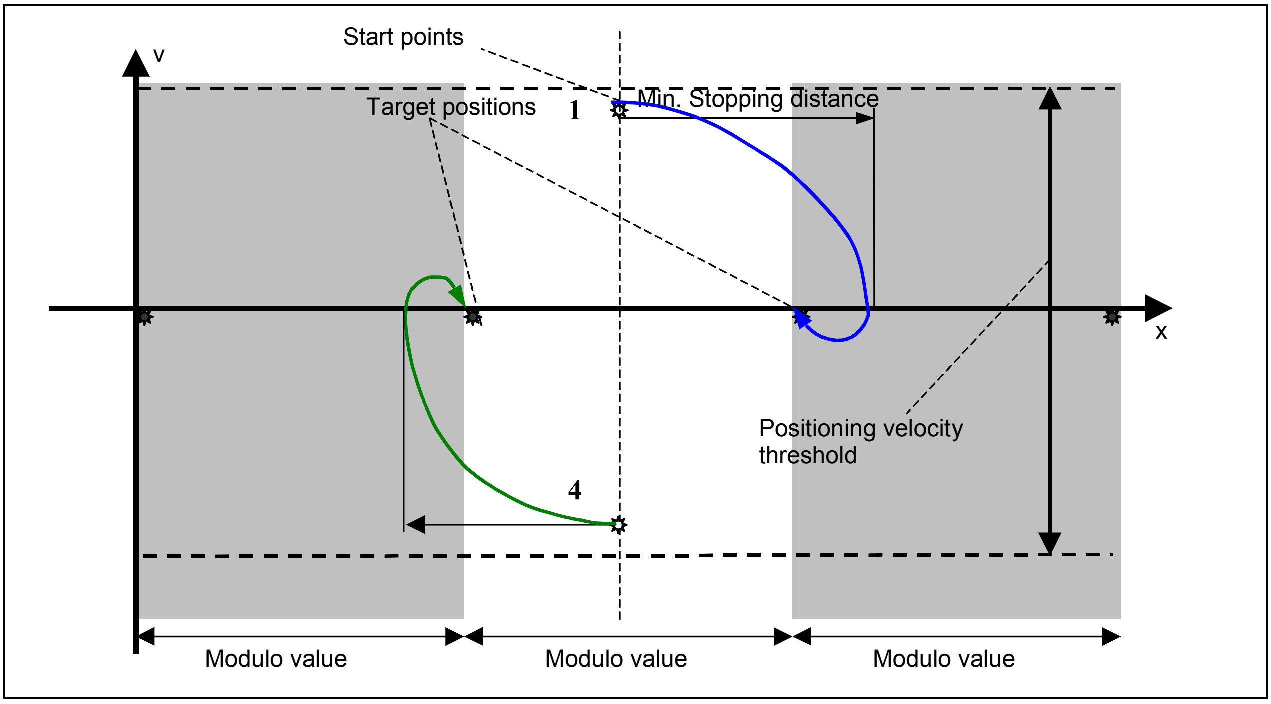


Figure 98 – Sequence of movements of example 4

For starting point 1 applies: active velocity positive and lower than "velocity threshold positioning in modulo format". The braking distance is longer than the difference between starting point and next target position:> drive brakes at velocity = 0, turns around and positions on next target position.

For starting point 4 applies: active velocity negative and lower than "velocity threshold positioning in modulo format". The braking distance is longer than the difference between starting point and next target position: > drive brakes at velocity = 0 , turns around and positions on next target position.

14.5.5 Positioning

The operation mode ‚positioning' includes interpolation, but allows the presetting of absolute and relative positioning data. The structure is shown in figure 99.

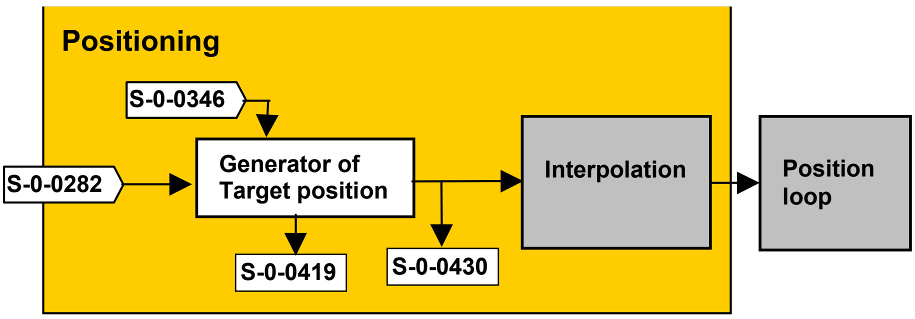


Figure 99 – Block diagram Positioning

“Positioning” using the interpolation parameters and the following additional parameters:

IDN	Description
S-0-0282	Positioning command value
S-0-0346	Positioning control word
S-0-0419	Positioning acknowledge

The adoption of the takes place at each edge of the positioning command value adoption, (S-0-0346, Bit 0). The positioning command value adoption is indicated by the drive in the positioning command value receipt, (S-0-0419, Bit 0). During the initialization the control and the drive set the positioning command value adoption on 0.

Depending on S-0-0346, Bit 3 with each adoption the positioning command value is either copied into the active target position (S-0-0430) (absolute positoning command value) or added up (relative positioning command value). A relative positioning command value can either be related to the actual value or the active target position (depending on S-0-0346, Bit 4).

In the operation mode positioning also a jog mode (endless travel) and stop is integrated through S-0-0346, Bit 1 and 2.

Depending on S-0-0346, Bit 5 the drive positions either on the active target position or it takes immediately over the new active target position. With this function the drive does no longer approach the target position assigned before. Bit 6 and 7 are extensions when Bit 5 is set on 0. See figure 100.

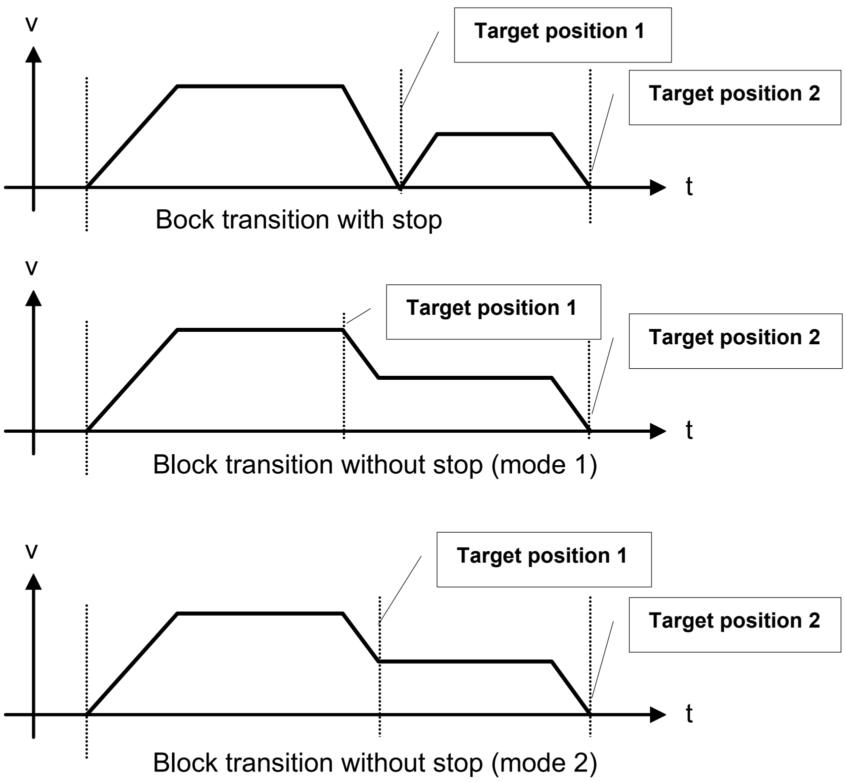


Figure 100 – Block transitions

14.6 Homing

The homing procedure can either be controlled by the control unit or by the drive. There are procedure commands available for both possibilities.

14.6.1 Drive controlled homing procedure command

The following conditions shall be valid:

- the position feedback is connected to the drive and the actual position acquisition is done by the drive;
- the home switch is connected directly to the drive or to the control unit.

Before the control unit starts the drive controlled homing procedure by setting and enabling the procedure command S-0-0148, the control unit shall allocate the necessary control and status signals to real-time bits via the service channel. The sequence is shown in Figure 101.

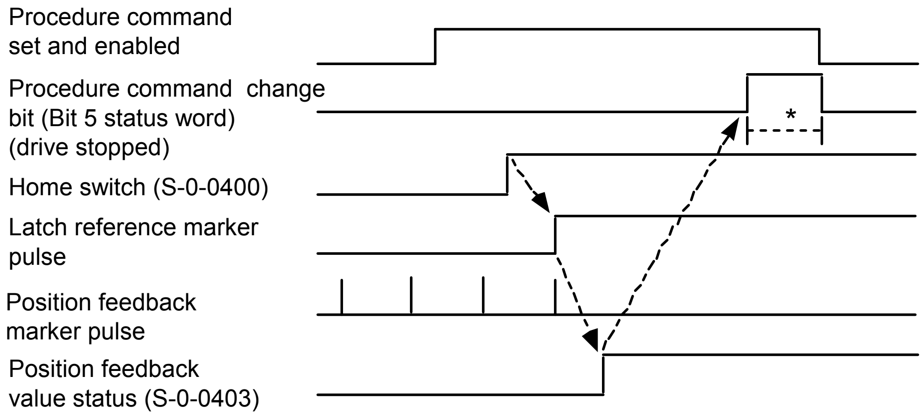


Figure 101 - Bit sequence for drive controlled homing

* During this period, the control unit has to read the position command value (S-0-0047) from the drive.

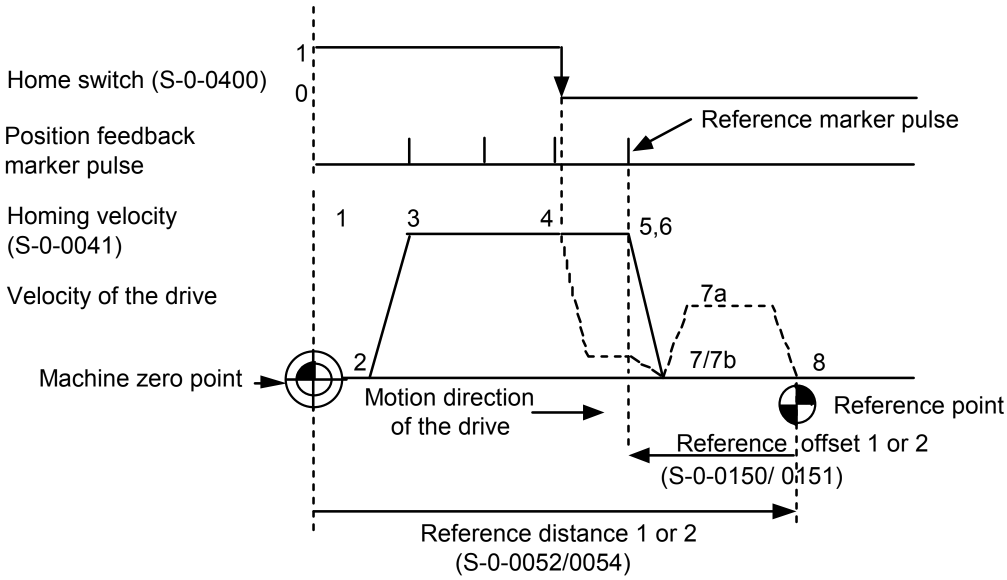


Figure 102 - Drive controlled homing diagram

NOTE 1:

1) The procedure command ‘drive controlled homing’ (S-0-0148) is set and enabled.

2) Start-point of the drive not yet referenced to the machine zero point. The drive switches into internal position control and resets the bit ‘position feedback value status’ (S-0-0403).

3) Taking the start direction into account which is determined by the homing parameter (S-0-0147) and the Homing acceleration (S-0-0042), the drive accelerates to the homing velocity (S-0-0041).

4) Recognizing the programmed signal change at the home switch (programmed by the homing parameter S-0-0147), the drive finds the next position feedback marker pulse of the feedback as the reference marker pulse. The drive may have an internal function for reducing the velocity after it has recognized the home switch signal change (dotted line in Figure 102).

5) The drive reduces the velocity to a standstill using the homing acceleration.

6) The recognition of the position feedback reference marker pulse in the drive leads to the setting of the position feedback value 1 or 2 (position feedback value 1 or 2 = reference distance 1 or 2 + reference offset 1 or 2 + distance to reference marker pulse). The signs of these position data have to be taken into account. As soon as the position feedback value 1 or 2 referenced to the machine zero point, is entered in the drive telegram, the drive sets the procedure command change bit (bit 5 in the status word, indicating that the drive controlled homing was executed properly).

The drive calculates a command value which equals the referenced position feedback value 1 or 2 and the control unit reads this position command value (S-0-0047) from the drive and sets its command value to this position.

7) Afterwards, the control unit cancels the procedure command and the drive follows the command values of the control unit.

Depending on control unit functionality, two cases can be distinguished:

a) the control unit automatically assigns a new position value to the drive in order to go through the reference offset 1 or 2 and to reach the reference point (dotted line in Figure 102);

b) the control unit does not assign new position command values (i.e., the axis stops near the position feedback reference marker pulse) and later the control unit starts from that point.

8) Reference point of the axis. The control unit continues with the same procedure for all other drives.

Note 2: The signs of the position data depend on the machine configuration.

14.6.2 Control unit controlled homing procedure command

For control unit controlled homing there are three procedure commands available:

– ‘control unit controlled homing’ (S-0-0146);
– ‘calculate displacement’ (S-0-0171);
– ‘displacement to the referenced system’ (S-0-0172).

These commands may also be used partially, if for example the control unit calculates the displacement and writes it to the drive.

14.6.2.1 Procedure command ‘control unit controlled homing’

For the correct operation of the procedure command (S-0-0146), the following assignments to real-time control and status bits have to be made:

– real-time control bit: homing enable (S-0-0407);
– real-time status bit: reference marker pulse registered (S-0-0408).

If the home switch is connected to the drive, the following additional allocation to the other real-time status bit is necessary:

– real-time status bit: home switch (S-0-0400).

These allocations to the other real-time status bit have to be made before the procedure command is started and may be checked by the drive.

For control unit controlled homing, three cases have to be distinguished:

Case 1: the home switch is connected to the control unit, the drive only evaluates the ‘homing enable’ signal.

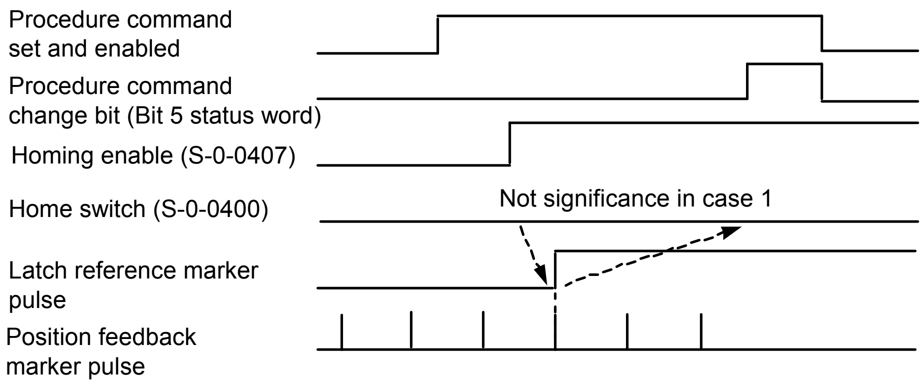


Figure 103 - Bit sequence for control unit controlled homing (case 1)

Case 2: the home switch is connected to the drive.

Case 2.1: The drive signals the home switch (S-0-0400) to the control unit via the real-time status bit 2.

The control unit sets the homing enable (S-0-0407) via the real-time control bit. The drive evaluates homing enable (S-0-0407) only.

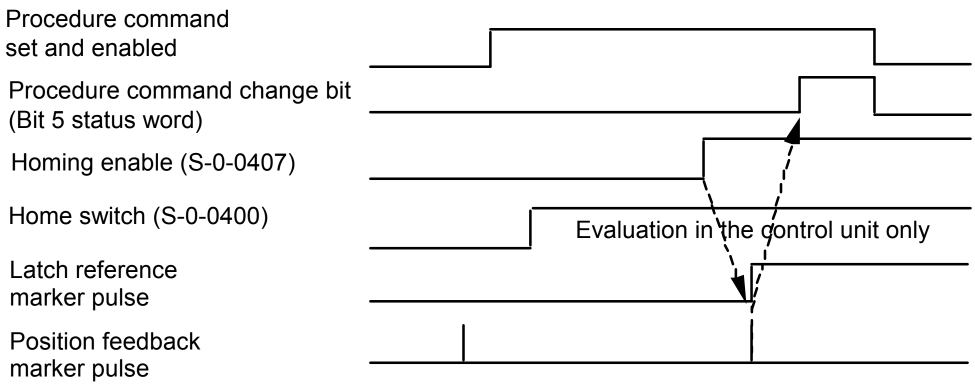


Figure 104 - Bit sequence for control unit controlled homing (case 2.1)

Case 2.2: The drive signals the home switch (S-0-0400) to the control unit via the real-time status bit 2.

The control unit sets the homing enable (S-0-0407) via the real-time control bit. The drive evaluates the homing enable (S-0-0407) and the home switch (S-0-0400).

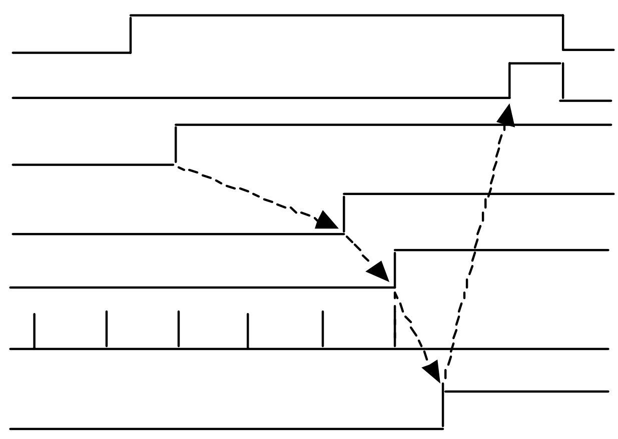


Figure 105 - Bit sequence for control unit controlled homing (case 2.2)

The programmed function is recognized by the drive by the homing parameter (S-0-0147).

14.6.2.2 Procedure command ‘calculate displacement’

To calculate the displacement between the old and the new feedback system (which is referenced to the machine zero point), two methods are applicable:

a) the drive calculates the displacement via the procedure command ‘calculate displacement’ (S-0-0171).

1) the control unit starts and enables the procedure command ‘calculate displacement’;
2) the drive calculates the distance from the machine zero point:
   i) for incremental feedback:
   distance from machine zero point = reference distance 1 or 2 (S-0-0052/0054) + reference offset 1 or 2 (S-0-0150/0151) (the signs depend on the machine configuration);
   ii) for distance-coded marker pulses:
   distance from machine zero point is calculated by means of marker position A (S-0-0173), marker position B (S-0-0174) and the absolute distance 1 or 2 (S-0-0177/0178);
3) the drive calculates the distance between the machine zero point and the zero point of the unreferenced drive by the following formula (observing the signs): displacement 1 or 2 = distance from machine zero point - marker position A (S-0-017 0173). The result is stored in the displacement parameter 1 or 2 (S-0-0175/0176) and is valid for incremental and distance-coded feedback systems;
4) the drive acknowledges the procedure command positively as soon as the displacement is calculated and stored;
5) the control unit reads the displacement parameter 1 or 2 from the drive to set the command value to the referenced system;
6) the control unit cancels the procedure command ‘calculate displacement’.

b) The control unit calculates the displacement:

1) the control unit reads the data out of the drive which are necessary for the calculation (see a);
2) the control unit calculates the displacement 1 or 2 = distance from machine zero point - marker position A (S-0-0173);
3) the control unit writes the displacement parameter 1 or 2 (S-0-0175/0176) to the drive.

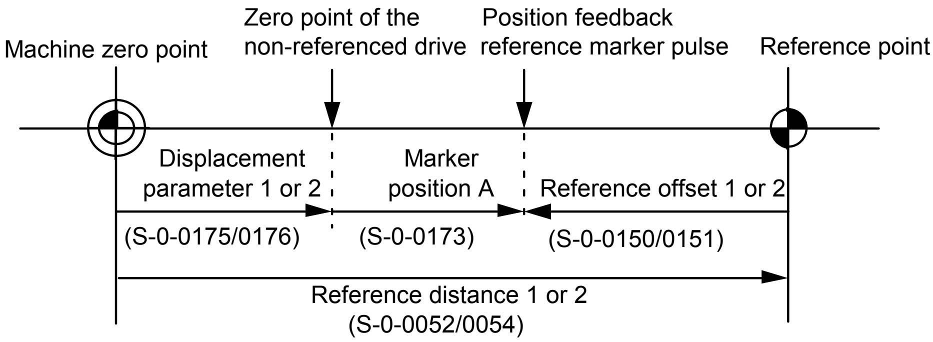


Figure 106 - Incremental feedback system

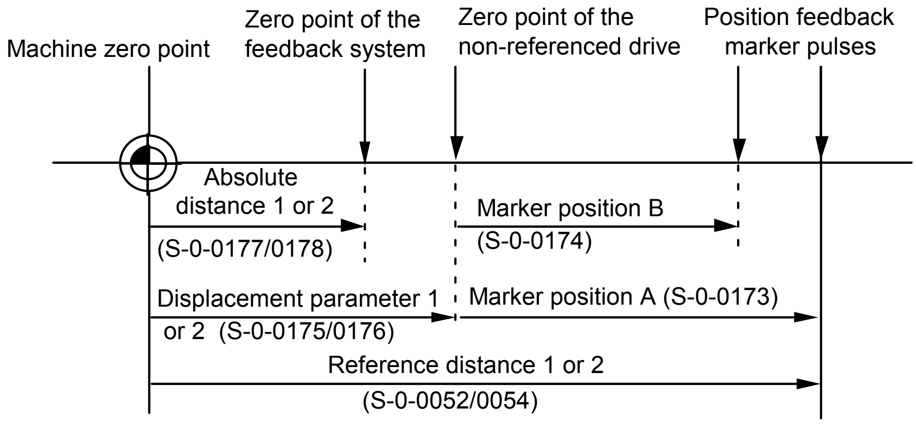


Figure 107 – Distance coded feedback system

NOTE – In Figure 106 and Figure 107, the signs of the position data depend on the machine configuration

14.6.2.3 Procedure command 'displacement to the referenced system'

For the correct operation of the procedure command 'displacement to the referenced system' (S-0-0172) the following assignments of real-time bits are necessary:

- real-time control bit: position command value status (S-0-0404);
- real-time status bit: position feedback value status (S-0-0403).

Simultaneous to the setting of the real-time control bit (position command value status) the position command values are switched to the referenced system. Simultaneous to entering the referenced feedback values 1 or 2 in the AT, the position feedback value status (S-0-0403) is set via the real-time status bit known in the control unit (the position feedback values are refered to the reference point). When both bits are set, the drive acknowledges the procedure command positively. The sequence (see Figure 108) in which the bits have to be set is not fixed.

Position command value status must be set by the control unit independently from the operation mode.

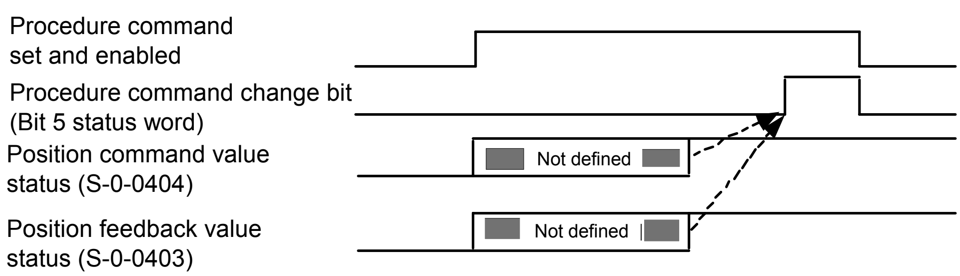


Figure 108 - Bit sequence to activate the displacement to the referenced system

14.6.3 Set absolute position

14.6.3.1 General

When using absolute position measuring systems, the position feedback shall be referenced to the axis system mechanics once during initial commissioning. To affect that, the current position value of an absolute feedback shall be set to a new value.

The reference for an absolute measuring system is established using the “Set Absolute Position” procedure command. An external feedback as well as the motor feedback can be referenced.

After powering up a drive with a referenced absolute feedback, the position feedback is immediately referenced to the axis mechanical position.

The drive shall clear the reference position, when it recognizes via the parameterization that the feedback, the motor, or the mechanics have been changed.

14.6.3.2 Functional description

The drive shall clear the reference when:

- a new “Set Absolute Position” procedure command is activated, or
- the motor is exchanged, or
- the absolute feedback is exchanged, or
- the axis’ mechanical components are changed

Set Absolute Position

This occurs, in that the Position feedback value 1 (motor feedback) is set to the Reference distance 1 and the Position feedback value 2 (external feedback) is set to the Reference distance 2.

Normally, the Set absolute position procedure command is executed when the axis is stopped, and enable is removed. For those cases where the axis shall move to a position and actively hold there in order to set absolute position, the procedure command can also be activated with the drive enabled. In this case, either the Drive-Halt bit must be cleared before initiating the Set absolute position procedure command or a Drive-controlled homing procedure command shall be executed while the Set absolute position procedure command is active.

“Set Absolute Position” variables and configuration settings are dictated using the following parameters:

IDN	Description
S-0-0052	Reference Distance 1
S-0-0054	Reference Distance 2
S-0-0447	Set Absolute Position Procedure Command
S-0-0448	Set Absolute Position Control Word
S-0-0147	Homing parameter
S-0-0148	Drive controlled homing procedure command
S-0-0051	Position feedback value 1
S-0-053	Position feedback value 2
S-0-0175	Displacement parameter 1
S-0-0176	Displacement parameter 2
S-0-0403	Position feedback value status
S-0-0013	Class 3 Diagnostic (bit 14)

Absolute feedback selection

When multiple absolute feedbacks are connected to the drive, the parameter "Set absolute position control word" (S-0-0448) is used to select the absolute feedback that should be set.

Possible Operating Modes for "Set Absolute Position"

The "Set Absolute Position" command can be activated in the following operating states (see Table 45):

Table 45 – Drive operating states

Case	Bit 15	Bit 14	Bit 3	Drive status
1)	0 x	x 0	x x	Drive ready, but not ON
2)	1	1	0	Drive ready to operate, 'enable drive' is set and active. Power stage is active Halt drive is active, drive ignores the command values
3)	1	1	1	Drive ready to operate, 'enable drive' is set and active. Power stage is active Drive follows the command values

Set Absolute Position Execution (see Figure 109)

With the start of the "Set absolute position" procedure command:

- The reference bit of the selected absolute feedback (S-0-0403) is cleared, and the position feedback value is stored.
- The difference between the position feedback value 1 or 2 and the Reference Distance 1 or 2 is calculated and stored in Displacement Parameter 1 or 2 (S-0-0175 or S-0-0176).
- The drive checks if the calculated displacement value can be transferred into the position feedback value 1 or 2. The transfer is dependent upon the drive status (see Table 45).
- The procedure command is positively acknowledged when the transfer successfully occurs.

Transfer of the calculated displacement value into Position Feedback 1 or 2 (S-0-0051/0053)

a) When the drive is ready but not ON or Halt-drive is active

Case 1) and 2) of Table 45.

The calculated displacement is immediately effective and is transferred by the drive into Position feedback 1 or 2 (S-0-0051/0053). The associated bit in Position feedback status is set to "1".

b) Drive is ready, and ON

Case 3) of Table 45.

When in case 3) the Set Absolute Position procedure command is activated, there are two possible ways to transfer the displacement value into Position feedback 1 or 2.

- Deactivate the drive enable:
  When the drive reaches the inactive state (case 1 of Table 45), Position feedback 1 or 2 (S-0-0051/S-0-0053) are set as in a) (above).
- Start the "Drive controlled homing" procedure command:
  The drive ignores the command value. The calculated displacement is transferred into Position feedback 1 or 2 (S-0-0051/S-0-0053) and then the associated bit in Position feedback status is set to "1". The drive acknowledges the "Drive controlled homing" procedure command as being completed. The control unit shall then set its position command value to the new position command value in the drive. After that, the control unit clears the "Drive controlled homing" procedure command. The drive will then begin following the command input again.

After transferring the reference value

The control unit shall clear the "Set absolute position" procedure command.

Verifying whether the position reference has been established

The relevant bit in Position feedback value status (S-0-0403) can be used to verify whether the feedback selected via Set absolute position control word (S-0-0448) is indeed referenced

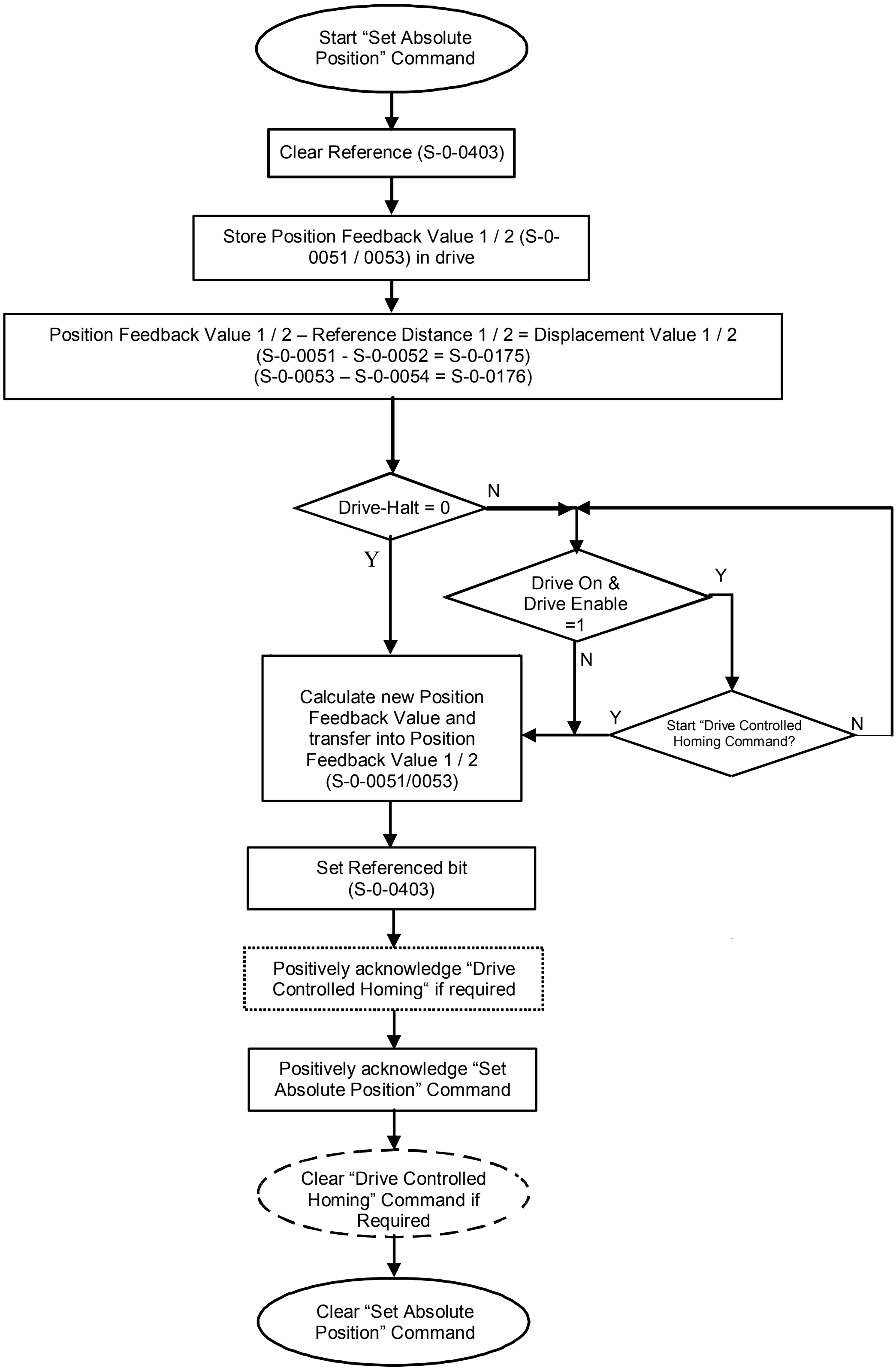


Figure 109 - Sequence of "Set Absolute Position" Procedure Command

14.7 Position spindle procedure command

The position spindle procedure command (S-0-0152) is used to position a spindle at an absolute angle position or to rotate a spindle at a relative offset (i.e., a defined angle).

The function is activated in the drive by setting and enabling the procedure command. The drive signals the activation by setting the procedure command acknowledgment (data status) to ‘procedure command set, enabled, and not yet executed’. An acknowledgment ‘procedure command executed’ is not set. This means that the procedure command change bit is only set in case of an error.

The mode of positioning the spindle is stored in the ‘spindle positioning parameter’ (S-0-0154). This parameter defines whether the spindle is driven into the position clockwise, counterclockwise or in the shortest way. Additionally it defines whether the positioning has to be executed absolutely or relatively.

14.7.1 Spindle Positioning when the function is started

14.7.1.1 Velocity feedback value > spindle positioning speed

When the procedure command ‘position spindle’ is activated and the velocity feedback value of the drive at that moment is greater than the spindle positioning speed (S-0-0222), the drive slows down to the spindle positioning speed and then it starts the positioning (see Figure 110).

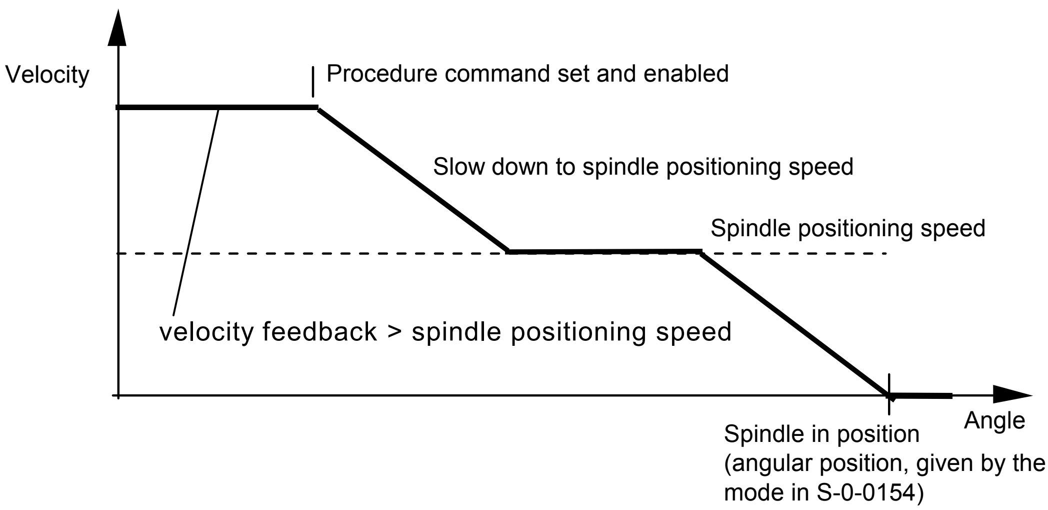


Figure 110 - Velocity diagram for spindle positioning (1)

14.7.1.2 Velocity feedback value ≤ spindle positioning speed

When the velocity feedback value is equal or less than the spindle positioning speed (S-0-0222) the drive switches into internal position control and positions the spindle to the absolute angle defined by IDN S-0-0153, taking the spindle positioning parameter (S-0-0154) into account (see Figure 111).

The covered distance is undefined because the start-point of the motion is not defined. Bit 2 of S-0-0154 can only be 0.

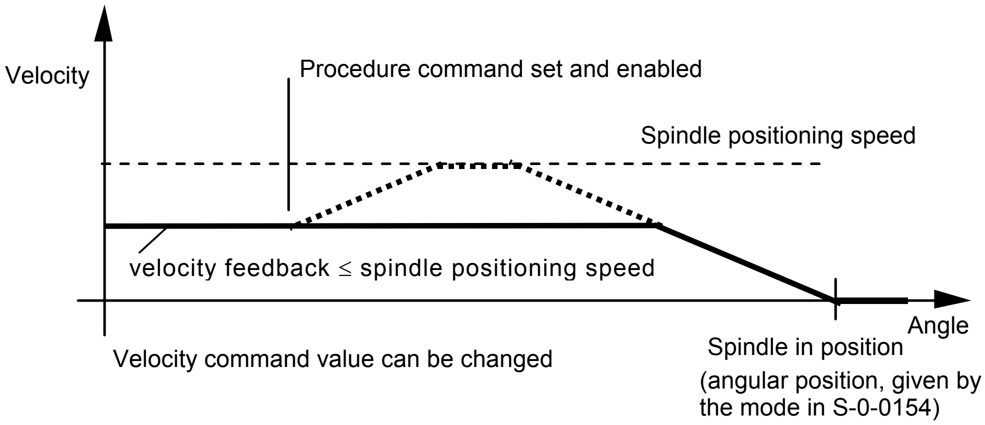


Figure 111 - Velocity diagram for spindle positioning (2)

14.7.1.3 Velocity feedback value = 0

When the procedure command 'position spindle' is activated while the drive is stopped, the drive positions the spindle to the absolute Spindle angle position (S-0-0153), taking the spindle positioning parameter (S-0-0154), the acceleration parameters and the maximum spindle positioning speed (S-0-0222) into account or it drives a relative spindle relative offset (S-0-0180) (also defined by the spindle positioning parameter). Sequence see Figure 112.

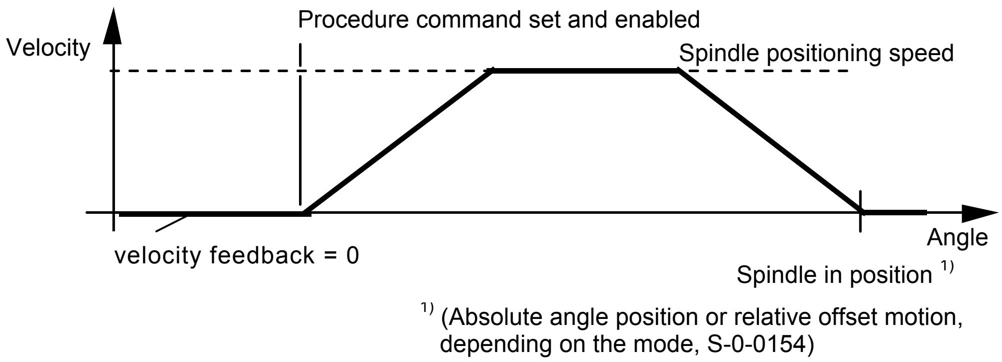


Figure 112 - Velocity diagram for spindle positioning (3)

14.7.2 New position values while the procedure command is active

While the procedure command 'position spindle' (S-0-0152) is activated by the control unit, the drive stays in internal position control and executes every new (absolute) spindle angle position (S-0-0153) respectively drives every new spindle relative offset (S-0-0180) as long as the positioning mode angle position/relative offset is not changed by writing the spindle positioning parameter (S-0-0154). The values of a spindle relative offset are accumulated each time a new relative offset value is written via IDN S-0-0180.

When a new spindle position is taken over and acknowledged by resetting the busy bit, the status 'in position' (S-0-0336) respectively in the C3D (S-0-0013) is valid for the new position (see Figure 113).

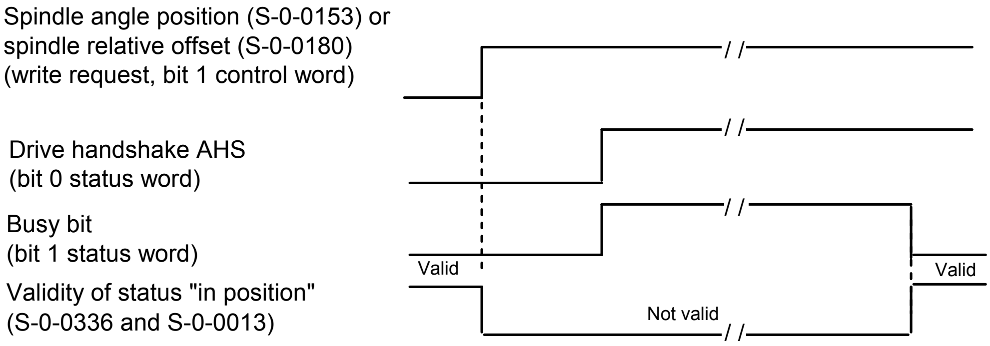


Figure 113 - Bit sequence while writing new position values (S-0-0153 or S-0-0180)

14.7.3 Switching the positioning mode angle position/relative offset while the procedure command is active

Switching of the positioning mode from angular with spindle angle positions (S-0-0153) to relative with values for spindle relative offset (S-0-0180) or vice versa while the procedure command ‘position spindle’ (S-0-0152) is active, is initiated by writing the spindle positioning parameter (S-0-0154) and is not valid before a new position value is written. The old ‘in position’ status is valid until the write request for a new position command value is given (see Figure 114).

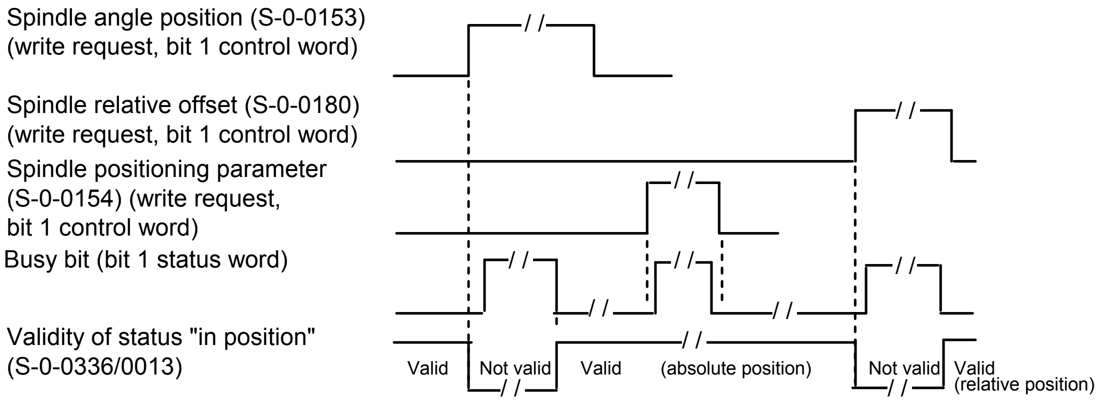


Figure 114 - Bit sequence for switching spindle positioning mode

14.8 Measurements

To activate the function ‘measuring via probe’, there is the procedure command ‘probing cycle’ (S-0-0170) available. With this procedure command, single probing is possible as well as multiple probing (using real-time bits).

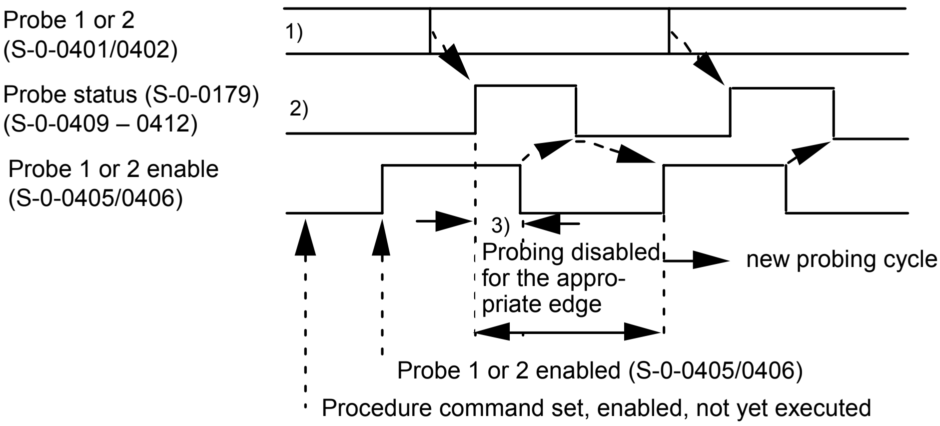
Setting and enabling the procedure command activates the function ‘measuring’ in the drive (see Figure 115). The drive signals this by setting the procedure command acknowledgement (data status) to ‘procedure command set, enabled, and not yet executed’. An acknowledgement ‘procedure command executed correctly’ is not set. That means that the procedure command change bit will be set only in the case of an error.

Using the ‘probe control parameter’ (S-0-0169), specific edges of probe 1 and 2 can be selected. The measuring is enabled using the signals ‘probe 1 or 2 enable’ (S-0-0405/0406).

With the appearance of a selected edge at the probe, the drive stores the position feedback value in the parameters S-0-0130 to S-0-0133 (probe value 1 or 2, positive or negative edge) which is assigned to the appropriate edge and sets the corresponding bit in the probe status (S-0-0179). The status bits in the probe status are separately addressable by IDNs S-0-0409 to S-0-

0412 (probe 1 or 2 latched) and therefore they can be allocated to real-time status bits for this measuring.

With the appearance of an active edge, the operation of an equivalent edge is disabled. This disabling is cancelled by resetting the procedure command 'probe 1 or 2 enable' (S-0-0405/0406). With the following setting of the procedure command 'probe 1 or 2 enable', the measuring is enabled again.



NOTES

1) Selection of probe 1 or 2 and the active edge via the probe control parameter IDN S-0-0169.

2) The active probe status 1 or 2, positive or negative edge, appears in IDN S-0-0179. These bits are assigned to IDN S-0-0409 to S-0-0412.

3) Within this period the probe value 1 or 2, positive or negative edge (IDN S-0-0130 to S-0-0133) is normally read.

Figure 115 - Bit sequence for measuring

14.9 Velocity window

IDN	Description
S-0-0036	Velocity command value
S-0-0040	Velocity feedback value 1
S-0-0156	Velocity feedback value 2
S-0-0157	Velocity window
S-0-0272	Velocity window percentage
S-0-0330	Status "$n_{feedback} = n_{command}$"

The velocity window" relates the current velocity to the velocity command value (S-0-0036). If the current velocity feedback value falls within the calculated velocity window, the drive sets the status "$n_{feedback} = n_{command}$" (see Figure 116).

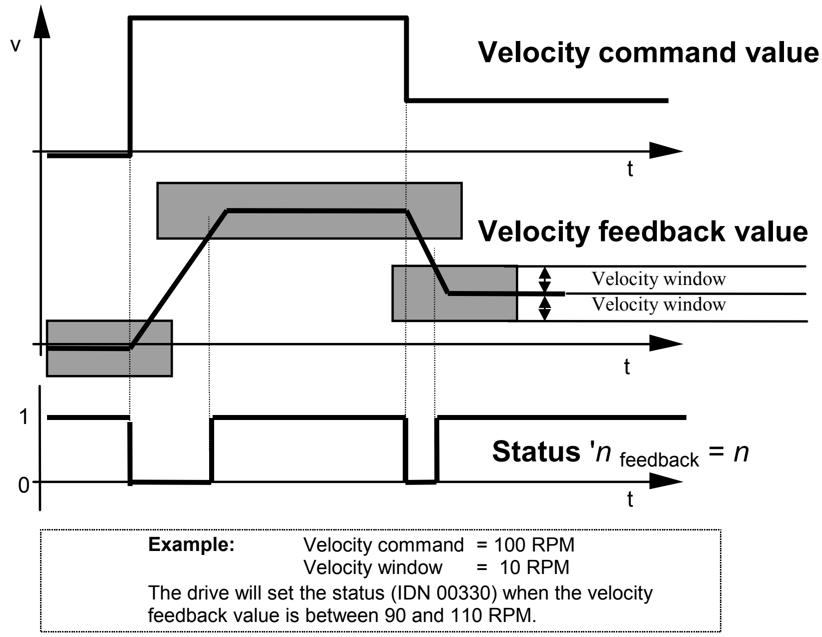


Figure 116 - Velocity Window

The velocity window percentage refers to a percentage of the “Velocity command value” (S-0-0036). If the current velocity feedback value is found to be within a window of the velocity command defined by this percentage, the drive will set the status "$n_{feedback} = n_{command}$" (see Figure 117).

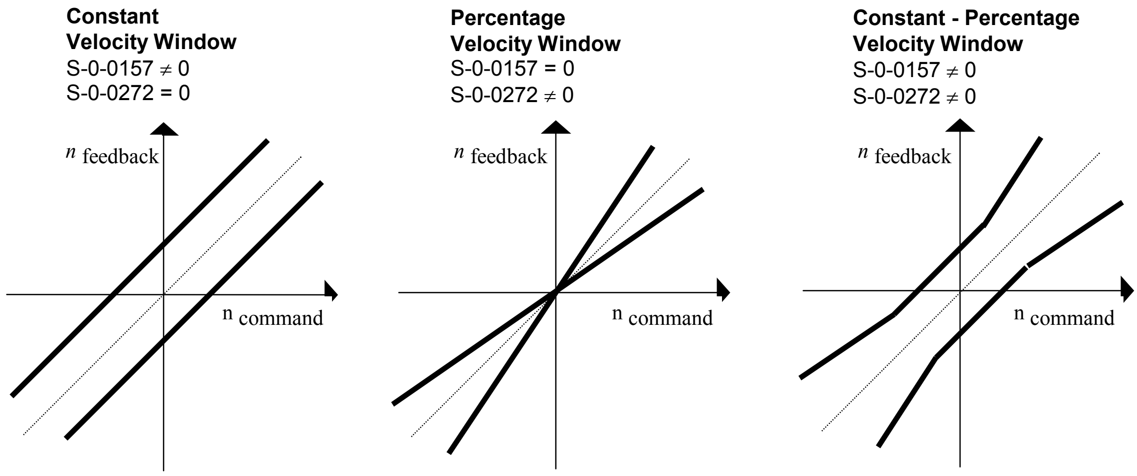


Figure 117 - $n_{feedback} = n_{command}$ Depiction

The IDN S-0-0330 allows the status '$n_{feedback} = n_{command}$' to be assigned to a real-time status bit (see S-0-0305). The status '$n_{feedback} = n_{command}$' is defined as a C3D bit (S-0-0013) and is set when the current velocity feedback value (S-0-0040 or S-0-0156) lies within the calculated command value for the velocity window (S-0-0157 and / or S-0-0272) which is based upon the velocity command value (S-0-0036).

Calculation of "$n_{feedback} = n_{command}$":

$$| n_{feedback} - n_{command} | \leq | n_{command} | \times \text{S-0-0272} + \text{S-0-0157}$$

14.10 Position switches

The position switches make it possible to generate a position switch flag at programmed positions refered on the position feedback value in the drive.

Two functions are specified,

Position switch mode is used at limited position ranges without modulo function.

Cam switch mode is used at limited position ranges and continuous moving axes. The cam switch mode includes the position switch mode and additional parameters.

The used IDNs are listed below.

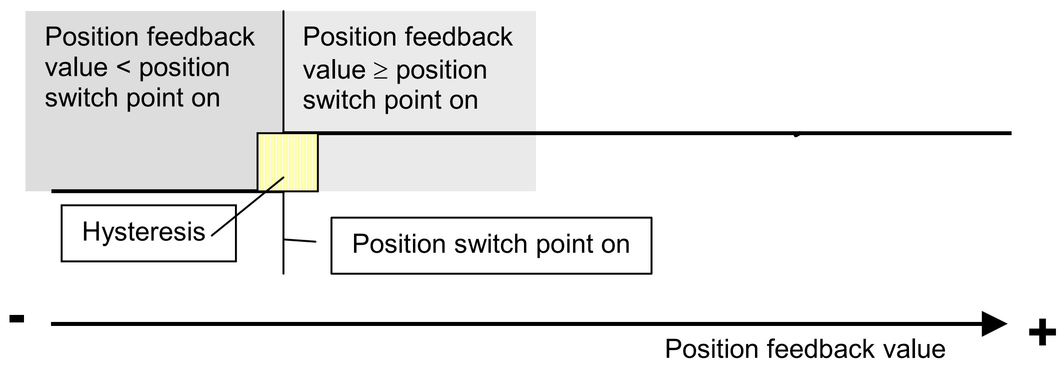
IDN	Description
	Position switch mode
S-0-0059	Postion switch flag
S-0-0060 to S-0-0075	Position switch point on 1 to 16
S-0-0477	Position switch hysteresis
	Cam switch mode (additional parameters)
S-0-0460 to S-0-0475	Position switch point off 1 to 16
S-0-0476	Position switch control

14.10.1 Position switch mode

The position switch mode consist of a **position switch point on** (S-0-0060 to S-0-0075) and a position switch flag (S-0-0059). If the position feedback value is less than the position switch point on, the appropriate position switch flag is set to 0. If the position feedback value is equal to or greater than the position switch point on, the appropriate position switch flag is set to 1. The sequence is shown in Figure 118.

The hysteresis (S-0-0477) has effect on all position switch points on (S-0-0060 to S-0-0075) and is taken into account, at which the flags (S-0-0059) switch on and off.

In the position switch mode, the function of the related bit is deactivated, if the corresponding bit (bit 0 to 15) in the position switch control is set to 0.



Position switch mode with absolute format

Figure 118 – Position switch mode

14.10.2 Cam switch mode

The cam switch mode consist of the position switch mode, the **position switch point off** and a position switch control (S-0-0476). If the position feedback value is less than the position switch point off, the appropriate position switch flag is set to 1. If the position feedback value is equal to or greater than the position switch point off, the appropriate position switch flag is set to 0. The sequence is shown in Figure 119.

The hysteresis (S-0-0477) has effect on all position switch points off (S-0-0460 to S-0-0475) and is taken into account, at which the flags (S-0-0059) switch on and off.

In cam switch mode, the function of the related bit is deactivated, if the the corresponding bit (bit 0 to 15) in the position switch control is set to 0.

The adjustings in the S-0-0476, bits 16-31 defines the position switch mode or cam switch mode. With cam switch mode the position switch points on (S 0-0060 to S 0-0075) and position switch points off (S 0-0460 to S 0-0475) are necessary.

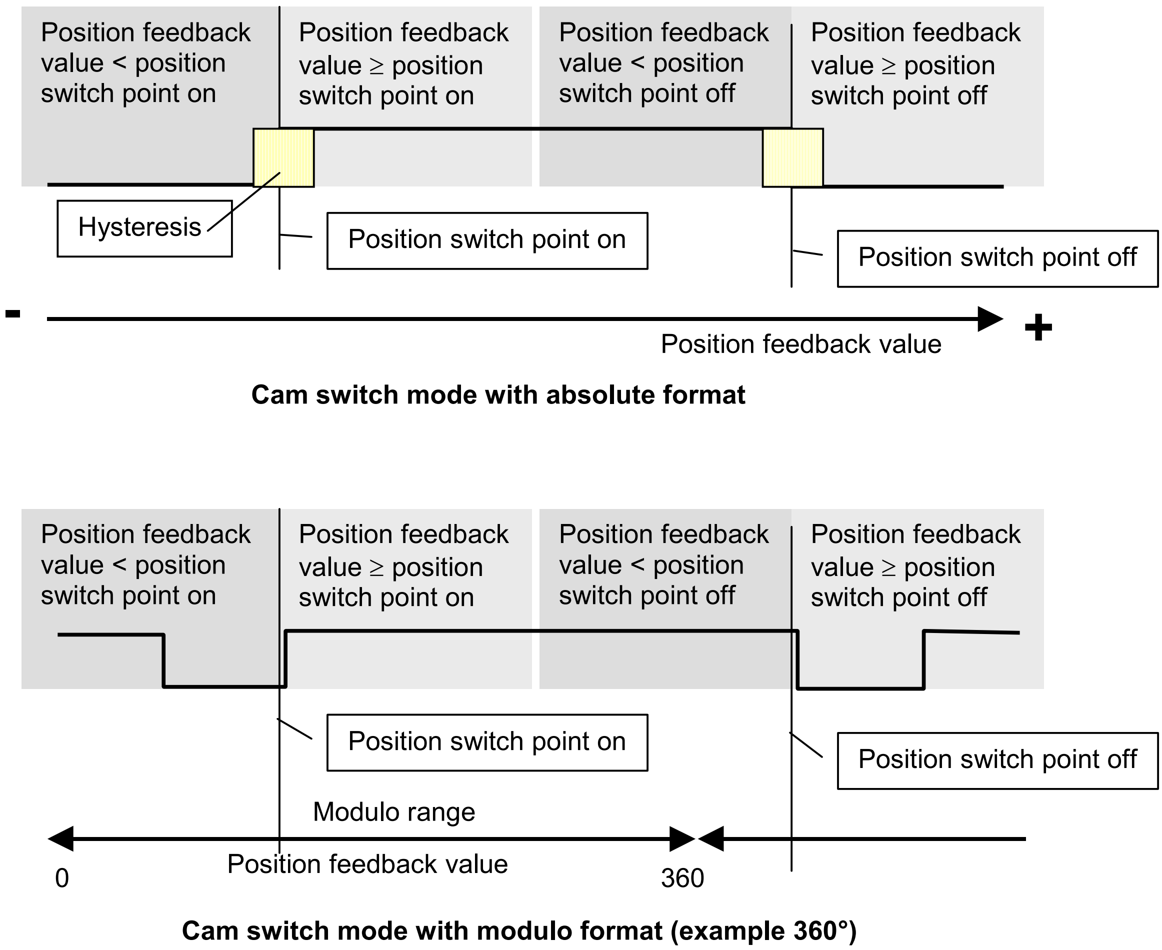


Figure 119 – Cam switch mode

14.11 Starting/stopping functions (State machine)

The following sequences (see Figure 120, Figure 121 and Figure 122) illustrate the use of the bits 13-15 in the control word (see Table 18) and the bits 14-15 in the status word (Table 19).

14.11.1 Start-up

a) Control voltage 'on':
1) power supplied to control unit and drive(s); initialization of control unit and drive(s);
2) establishing the communication (see clause 8).
b) As long as drive-internal computations are not finished, the drive sends the status 'not ready for power up' bits 14 and 15 = 0, status word.
c) The drive sends the status 'ready for main power on'; (bit 14 =1, bit 15 = 0, status word). No error in C1D, (S-0-0011).
d) The main power for the drive(s) is turned on.
e) Drive is ready and free of torque (bit 14 = 0, bit 15 = 1, status word). The master may set 'enable drive' and 'drive on'.
f) master issues 'enable drive' (bit 14 = 1, control word). The „drive enable delay time“ (S-0-0295) is started.
g) master issues 'drive on' (bit 15 = 1, control word).
h) "Drive enable delay time" (S-0-0295) is elapsed and 'drive on' is set (bit 15 = 1, control word) and torque is active. Drive signals 'ready to operate' (bit 14 = 1, status word) and the ‘drive on delay time’ (S-0-0206) is started.
i) The ‘drive on delay time’ (S-0-0206) is elapsed. The drive sets „status command value processing (bit 3 = 1, status word) and follows the command values of the control unit.

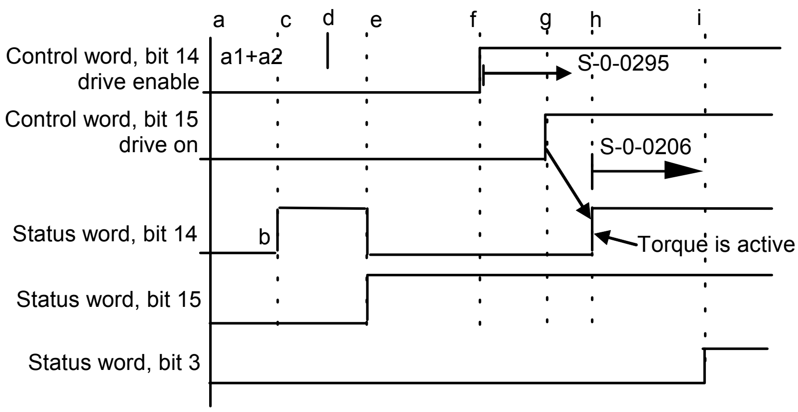


Figure 120 - Bit sequence during start-up

14.11.2 Shut-down

Case 1: Normal situation
a) The drive follows the command values of the control unit.
b) The master issues 'drive off' (bit 15 = 0, control word). The drive is halted in the best possible manner.
c) n_{min} is reached inside the maximum drive off delay time (S-0-0273) and „drive off delay time“ (S-0-0207) is started:
The drive is halted with torque until „drive off delay time“ (S-0-0207) is elapsed.
d) The drive disables torque and sends the status 'free of torque' (bit 14 = 0, status word).
e) The master resets bit 14 to ‘not enabled' (bit 14 = 0, control word).
f) Main power is turned off.
g) The drive sends the status 'ready for main power on' (bit 14 = 1, bit 15 = 0, status word).

Case 2: Error situation
a) The drive follows the command values of the control unit.
b) The master issues 'drive off' (bit 15 = 0, control word). The drive is halted in the best possible manner.
b1) n_{min} is not reached inside the maximum drive off delay time (S-0-0273). The break is locked if the maximum drive off delay time (S-0-0273) is elapsed. The drive disables the torque (bit 14 = 0, status word). Attention: The drive is halted with break only.
c1) Reaching n_{min} is no longer relevant.

e) The master resets bit 14 to ‘not enabled' (bit 14 = 0, control word).
f) Main power is turned off.
g) The drive sends the status 'ready for main power on' (bit 14 = 1, bit 15 = 0, status word).

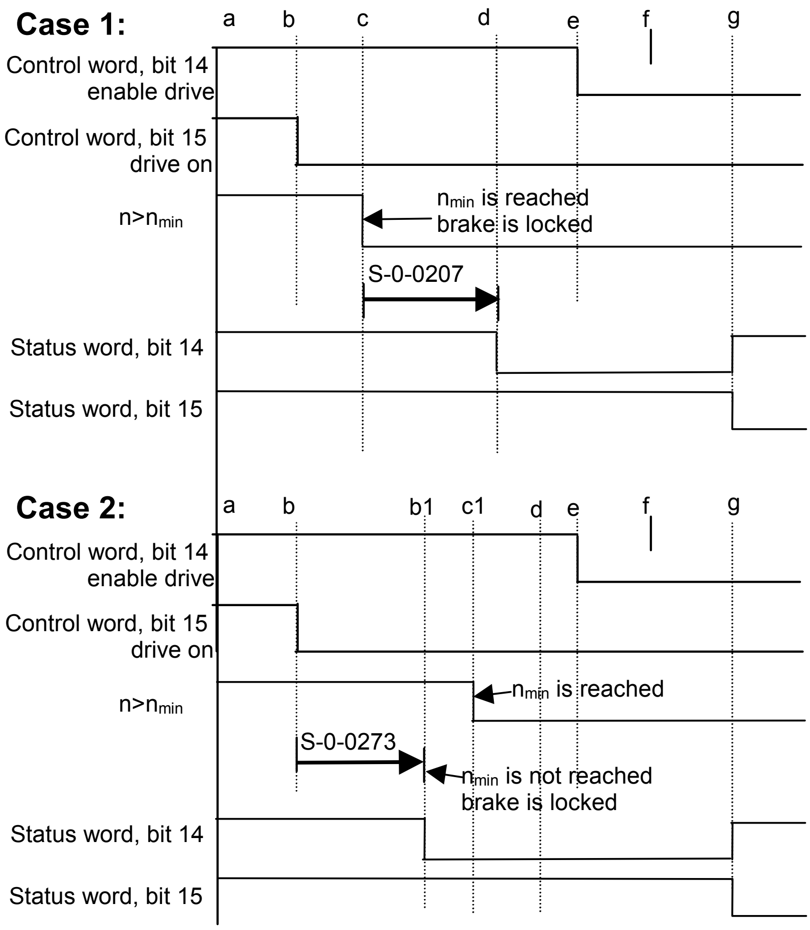


Figure 121 - Bit sequence during shut-down

14.11.3 Shut-down due to error

This is done by the drive when an error of C1D occurs.

a) The drive follows the command values of the control unit.
b) The drive has recognized an error and sends the status 'drive shut-down, error in C1D' (bit 13 = 1, status word) and ignores the cyclic command values (bit 3 = 0, status word). The drive is halted in the best possible manner. The actual status of the drive after shut-down is sent back to the control unit with the state of bits 14 and 15, status word.
c) The drive has stopped and disables the torque
d) Before turning on power again, the drive shut-down shall be cancelled via 'reset class 1 diagnostic' (S-0-0099). After this, bit 15 of the control word shall be in the 0 state.
e) master issues 'drive on' (bit 15 = 1, control word).

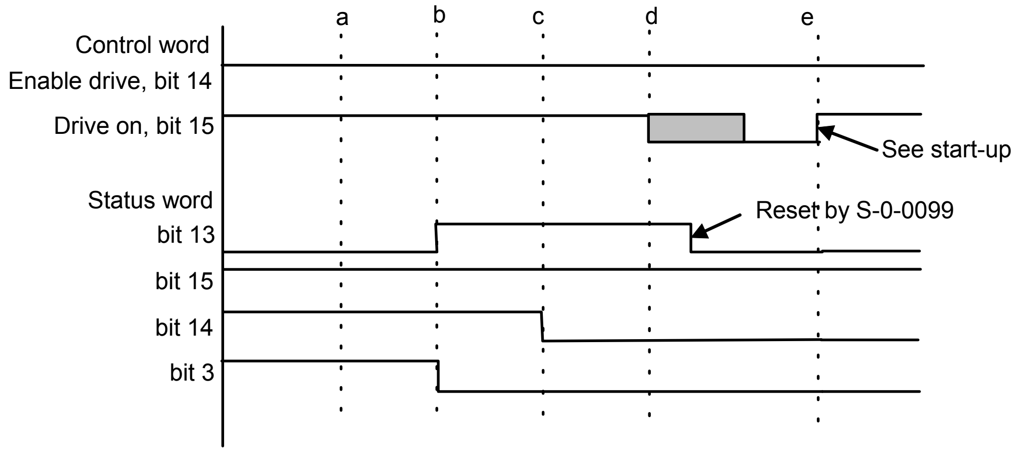


Figure 122 - Bit sequence for C1D error

14.12 Park axis procedure command

The following sequence (see Figure 123) is valid for the park axis procedure command (S-0-0139):

– the park axis procedure command (S-0-0139) is set and enabled by the control unit via the service channel;
– in the drive, the monitoring of the feedback system (e.g., position window) is shut-down;
– afterwards the position feedback value status is reset in the drive and the procedure command change bit is set by the drive. This is the indication to the control unit that the procedure command is executed;
– the drive is now able to perform other functions;
– the procedure command is cancelled. This reactivates monitoring.

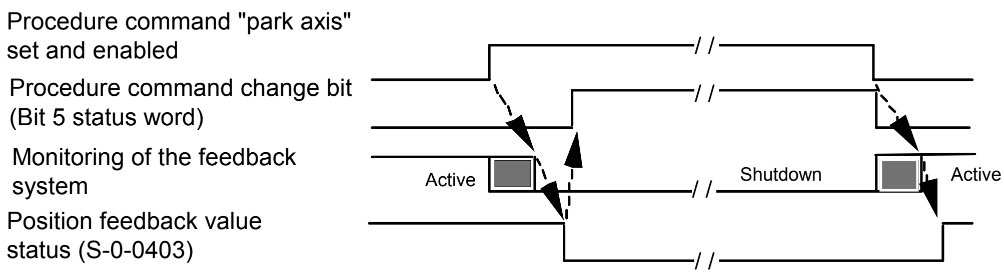


Figure 123 - Bit sequence for park axis

14.13 Positive stop drive procedure command

The following sequence (see Figure 124) is valid for the procedure command positive stop drive (S-0-0149):

– the procedure command positive stop drive (S-0-0149) is set and enabled by the control unit via the service channel;
– the drive turns off monitoring of the velocity (and position) control loop(s);
– when $T \geq T_{limit}$ and $n_{feedback} = 0$, the procedure command is executed;
– before the procedure command is cancelled, the control unit has to set the command value to the feedback value;
– as soon as the procedure command is cancelled, monitoring of the velocity (and position) becomes active again;
– while this procedure command is active, the control unit monitors $n_{feedback} = 0$.

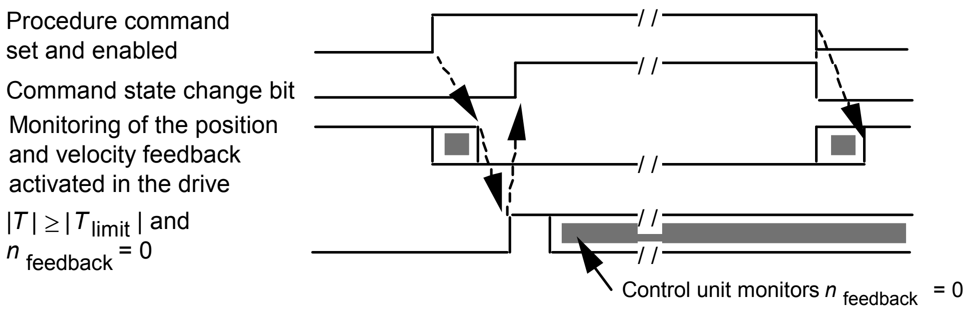


Figure 124 - Bit sequence for positive stop drive

14.14 Spindle parameters

IDN	Description
S-0-0190	Drive controlled gear engaging procedure command
S-0-0158	Power threshold (p_x)
S-0-0213	Engaging dither amplitude
S-0-0214	Average engaging speed
S-0-0215	Engaging dither period
S-0-0339	Status ‘n feedback ≤ minimum spindle speed’
S-0-0340	Status ‘n feedback ≥ maximum spindle speed’
S-0-0220	Minimum spindle speed
S-0-0221	Maximum spindle speed
S-0-0152	Position spindle procedure command
S-0-0154	Spindle positioning parameter
S-0-0222	Spindle positioning speed
S-0-0153	Spindle angle position
S-0-0180	Spindle relative offset

14.14.1 Spindle synchronous operation

IDN	Description
S-0-0223	Drive controlled synchronous operation procedure command
S-0-0224	Lead spindle address
S-0-0225	Synchronous operation parameter
S-0-0226	Lead spindle revolutions
S-0-0227	Synchronous spindle revolutions
S-0-0230	Synchronous position offset
S-0-0228	Synchronization position window
S-0-0308	Synchronization operation status
S-0-0229	Synchronization position error limit
S-0-0309	Synchronization error status
S-0-0183	Synchronization velocity window
S-0-0184	Synchronization velocity error limit

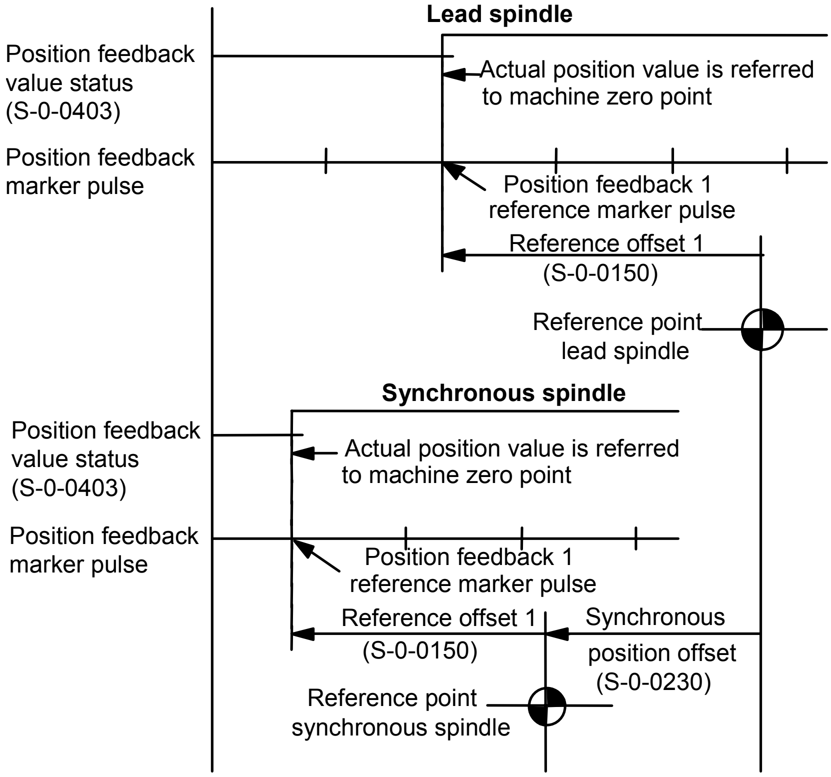


Figure 125 - Synchronous spindle operation diagram (example)

NOTES – The signs of the position data depend on the machine configuration.
Reference points are referred to the machine zero point.

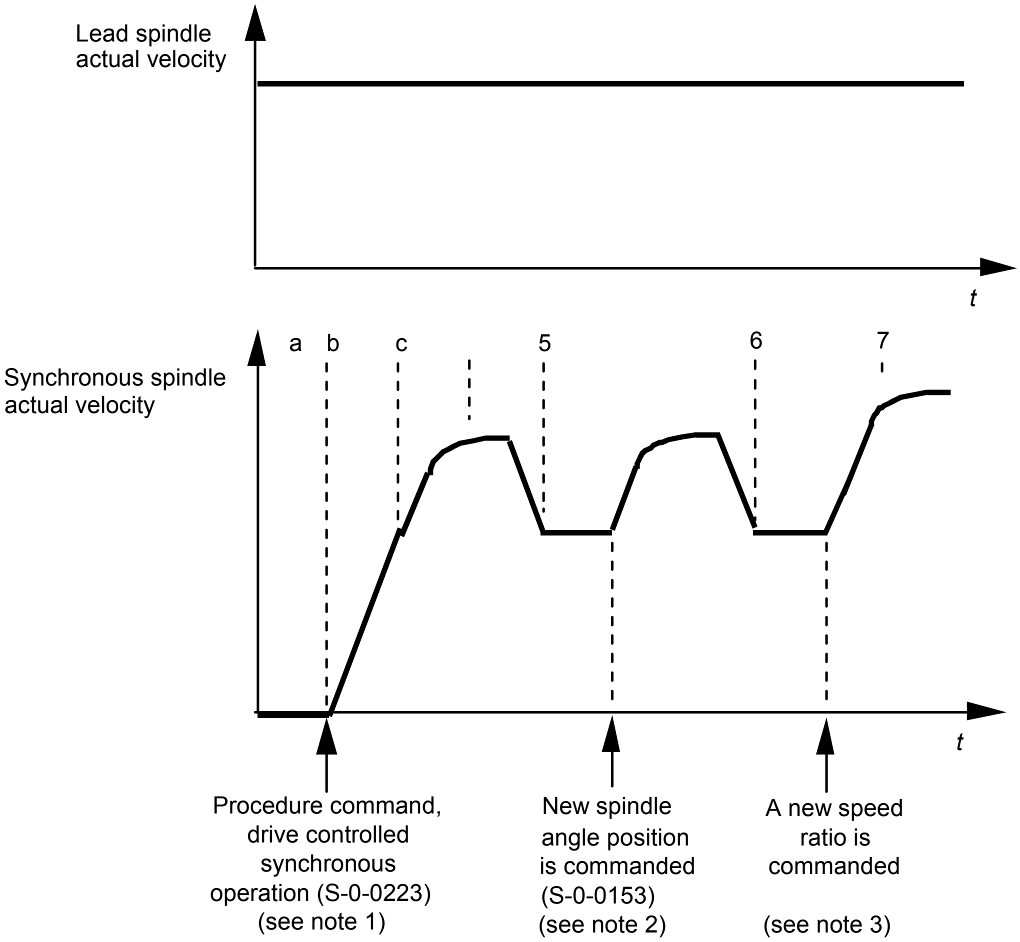
14.15 Drive controlled synchronous operation procedure command

A typical application of a synchronous spindle drive is a turning machine where the workpiece has to be transferred from the main spindle (lead spindle, address in S-0-0224) to the secondary spindle (= synchronous spindle) without requiring the main spindle to stop.

The synchronous operation parameter (S-0-0225) selects which kind of synchronous operation is to be executed.

14.15.1 Synchronization of the synchronous spindle to the lead spindle with a fixed angular offset

a) The synchronous spindle follows the command values of the control unit.
b) With the start of the drive controlled synchronous operation procedure command (S-0-0223), the command values for the synchronous spindle are derived from the velocity command value or the position command value of the lead spindle. This is done in the control unit. The MDT for the synchronized spindle contains the derived values.
c) The synchronous spindle accelerates to the synchronous speed. In order to reach the given angular offset (S-0-0230), the drive, which has to be synchronized, may exceed the synchronous velocity for a short time period.
d) The synchronization operation status (S-0-0308) is set when:
1) the velocity feedback value is within the synchronization velocity window (S-0-0183) during velocity synchronization, or
2) the position feedback value is within the synchronization position window (S-0-0228) during position synchronization.
e) The monitoring of the synchronization error limit (S-0-0184 for velocity or S-0-0229 for position) is activated when synchronization is achieved for the first time. When the feedback values (velocity or position) exceed the error limits, the synchronization error status (S-0-0309) is set.



Note 1: see 14.15.1 Note 2: see 14.15.2 Note 3: see 14.15.3

Figure 126 - Velocity diagram for lead and synchronous spindle

14.15.2 New synchronous position offset after synchronization

While in the angle synchronization mode (S-0-0225), and after the new spindle angle position (S-0-0153) is written, the synchronous spindle will exceed or reduce the synchronization speed for a short time period to achieve the desired angular position. In Figure 126, point 6, the desired angular position is achieved.

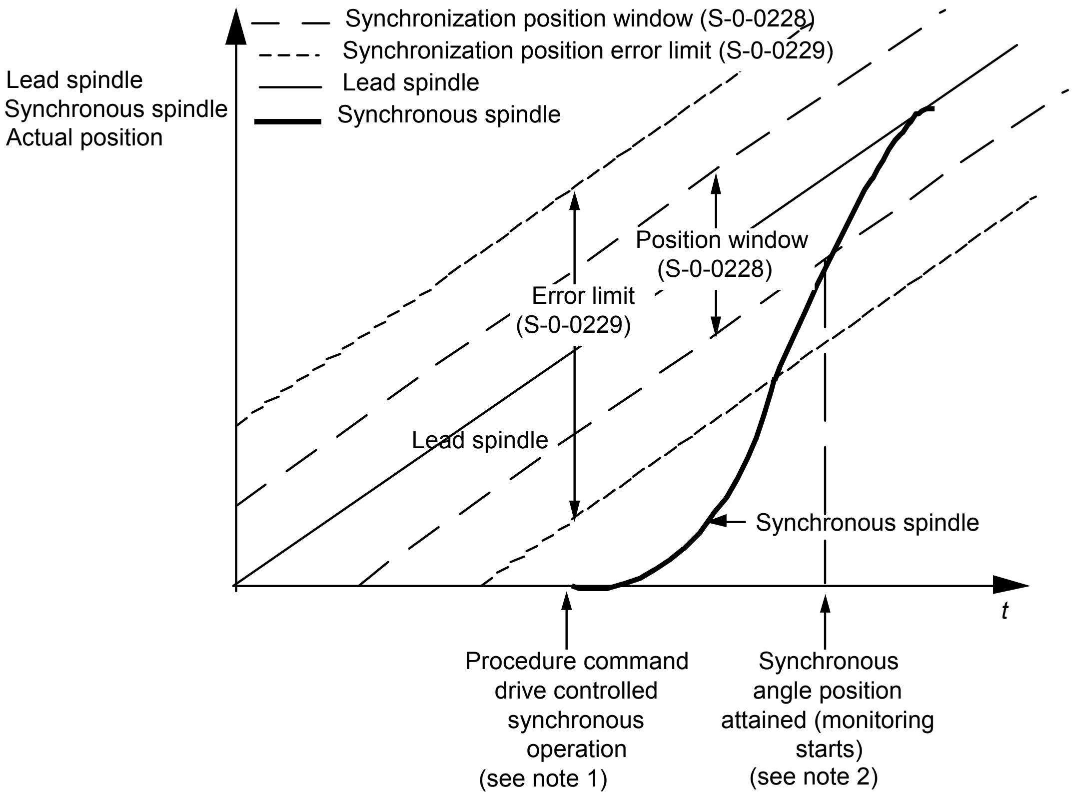
14.15.3 New speed ratio after synchronization

The control unit resets bit 2 of the synchronous operation parameter (S-0-0225) to 0 and permits a change of the ratio between lead spindle revolutions (S-0-0226) and synchronous spindle revolutions (S-0-0227). This has no effect upon the synchronous spindle at that time.

The control unit sets new values for the lead spindle revolutions (S-0-0226) and the synchronous spindle revolutions (S-0-0227) in the synchronous spindle in order to calculate a new speed ratio between lead spindle and synchronous spindle.

Setting in the synchronous operation parameter (S-0-0225) bit 2 = 1 causes the synchronous spindle to take the new speed ratio into account, and to accelerate the synchronous spindle to the new synchronous speed. In Figure 126, point 7, the desired speed is achieved.

While in the position synchronization mode, a new angular position can be reached by setting a new spindle angle position (S-0-0153).



Note 1: see Figure 126, point b   Note2: see Figure 126, point 5

Figure 127 - Position feedback diagram for lead and synchronous spindle

14.16 Drive controlled gear engaging procedure command

The following sequence (see Figure 128) is valid for the drive controlled gear engaging procedure command (S-0-0190):

– this procedure command (S-0-0190) is set and enabled by the control unit via the service channel;

- the drive ignores the command values from the control unit and decelerates (or accelerates) to the average engaging speed (S-0-0214);
- the average engaging speed is modulated by the engaging dither amplitude (S-0-0213), taking into account the engaging dither period (S-0-0215);
- as soon as these conditions are met, the drive signals that the procedure command has been executed (ready for gear change);
- the drive continues to dither at the average engaging speed (S-0-0214) until the control unit cancels the procedure command;
- the drive turns off the gear engaging function and the command values of the control unit are accepted by the drive again.

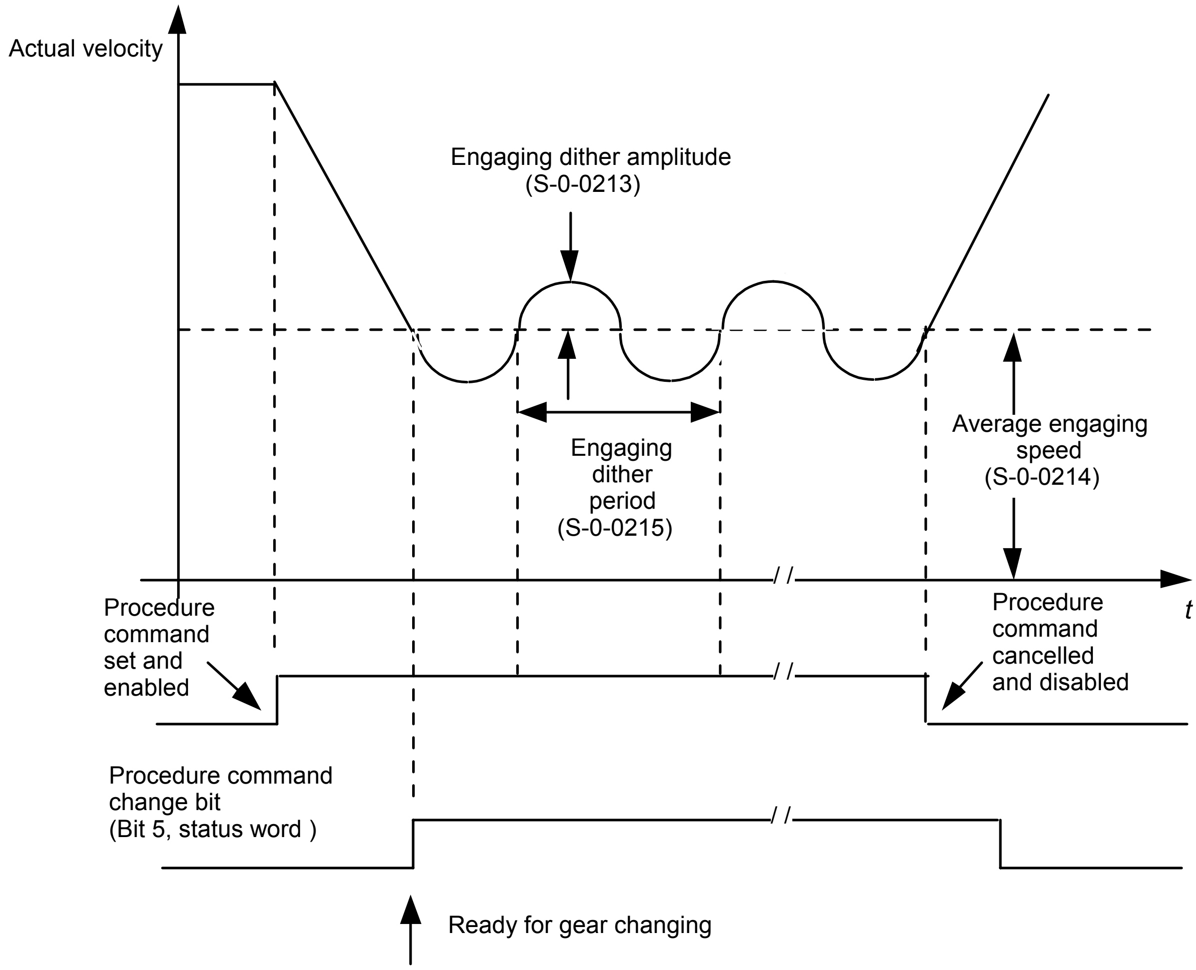


Figure 128 - Drive controlled gear engaging procedure command

14.17 Parameterization levels

not yet included

Annex A (normative) - Identification numbers in numerical order

The following is the list of IDNs in numerical order.

IDN	Name
S-0-0000	(reserved)
S-0-0001	Control unit cycle time (t_{Ncyc})
S-0-0002	Communication cycle time (t_{Scyc})
S-0-0003	Shortest AT transmission starting time (t_{1min})
S-0-0004	Transmit/receive transition time (t_{ATMT})
S-0-0005	Minimum feedback processing time (t_5)
S-0-0006	AT transmission starting time (t_1)
S-0-0007	Feedback acquisition capture point (t_4)
S-0-0008	Command value valid time (t_3)
S-0-0009	Position of data record in MDT
S-0-0010	Length of MDT
S-0-0011	Class 1 diagnostic
S-0-0012	Class 2 diagnostic
S-0-0013	Class 3 diagnostic

IDN	Name
S-0-0014	Interface status
S-0-0015	Telegram type
S-0-0016	Configuration list of AT
S-0-0017	IDN-list of all operation data
S-0-0018	IDN-list of operation data for CP2
S-0-0019	IDN-list of operation data for CP3
S-0-0020	IDN-list of operation data for CP4
S-0-0021	IDN-list of invalid operation data for CP2
S-0-0022	IDN-list of invalid operation data for CP3
S-0-0023	IDN-list of invalid operation data for CP4
S-0-0024	Configuration list of MDT
S-0-0025	IDN-list of all procedure commands
S-0-0026	Configuration list for signal status word
S-0-0027	Configuration list for signal control word
S-0-0028	MST error counter
S-0-0029	MDT error counter
S-0-0030	Manufacturer version
S-0-0031	Hardware version
S-0-0032	Primary operation mode
S-0-0033	Secondary operation mode 1
S-0-0034	Secondary operation mode 2
S-0-0035	Secondary operation mode 3
S-0-0036	Velocity command value
S-0-0037	Additive velocity command value
S-0-0038	Positive velocity limit value
S-0-0039	Negative velocity limit value
S-0-0040	Velocity feedback value 1
S-0-0041	Homing velocity
S-0-0042	Homing acceleration
S-0-0043	Velocity polarity parameter
S-0-0044	Velocity data scaling type
S-0-0045	Velocity data scaling factor
S-0-0046	Velocity data scaling exponent
S-0-0047	Position command value
S-0-0048	Additive position command value
S-0-0049	Positive position limit value
S-0-0050	Negative position limit value
S-0-0051	Position feedback value 1 (Motor feedback)
S-0-0052	Reference distance 1
S-0-0053	Position feedback value 2 (External feedback)
S-0-0054	Reference distance 2
S-0-0055	Position polarity parameter
S-0-0056	deleted
S-0-0057	Position window
S-0-0058	Reversal clearance
S-0-0059	Position switch flag parameter
S-0-0060	Position switch point on 1
S-0-0061	Position switch point on 2
S-0-0062	Position switch point on 3
S-0-0063	Position switch point on 4
S-0-0064	Position switch point on 5
S-0-0065	Position switch point on 6
S-0-0066	Position switch point on 7
S-0-0067	Position switch point on 8
S-0-0068	Position switch point on 9
S-0-0069	Position switch point on 10

IDN	**Name**
S-0-0070	Position switch point on 11
S-0-0071	Position switch point on 12
S-0-0072	Position switch point on 13
S-0-0073	Position switch point on 14
S-0-0074	Position switch point on 15
S-0-0075	Position switch point on16
S-0-0076	Position data scaling type
S-0-0077	Linear position data scaling factor
S-0-0078	Linear position data scaling exponent
S-0-0079	Rotational position resolution
S-0-0080	Torque command value
S-0-0081	Additive torque command value
S-0-0082	Positive torque limit value
S-0-0083	Negative torque limit value
S-0-0084	Torque feedback value
S-0-0085	Torque polarity parameter
S-0-0086	Torque/force data scaling type
S-0-0087	Transmit to transmit recovery time (t_{ATAT})
S-0-0088	Receive to receive recovery time (t_{MTSY})
S-0-0089	MDT transmission starting time (t_2)
S-0-0090	Command value proceeding time (t_{MTSG})
S-0-0091	Bipolar velocity limit value
S-0-0092	Bipolar torque limit value
S-0-0093	Torque/force data scaling factor
S-0-0094	Torque/force data scaling exponent
S-0-0095	Diagnostic message
S-0-0096	Slave arrangement (SLKN)
S-0-0097	Mask class 2 diagnostic
S-0-0098	Mask class 3 diagnostic
S-0-0099	Reset class 1 diagnostic
S-0-0100	Velocity loop proportional gain
S-0-0101	Velocity loop integral action time
S-0-0102	Velocity loop differential time
S-0-0103	Modulo value
S-0-0104	Position loop K_V-factor
S-0-0105	Position loop integral action time
S-0-0106	Current loop proportional gain 1
S-0-0107	Current loop integral action time 1
S-0-0108	Feedrate override
S-0-0109	Motor peak current
S-0-0110	Amplifier peak current
S-0-0111	Motor continuous stall current
S-0-0112	Amplifier rated current
S-0-0113	Maximum motor speed
S-0-0114	Load limit of the motor
S-0-0115	Position feedback 2 type
S-0-0116	Resolution of feedback 1
S-0-0117	Resolution of feedback 2
S-0-0118	Resolution of linear feedback
S-0-0119	Current loop proportional gain 2
S-0-0120	Current loop integral action time 2
S-0-0121	Input revolutions of load gear
S-0-0122	Output revolutions of load gear
S-0-0123	Feed constant
S-0-0124	Standstill window

IDN	Name
S-0-0125	Velocity threshold (n_x)
S-0-0126	Torque threshold (T_x)
S-0-0127	CP3 transition check
S-0-0128	CP4 transition check
S-0-0129	Manufacturer class 1 diagnostic
S-0-0130	Probe value 1 positive edge
S-0-0131	Probe value 1 negative edge
S-0-0132	Probe value 2 positive edge
S-0-0133	Probe value 2 negative edge
S-0-0134	Master control word
S-0-0135	Drive status word
S-0-0136	Positive acceleration limit value
S-0-0137	Negative acceleration limit value
S-0-0138	Bipolar acceleration limit value
S-0-0139	Park axis procedure command
S-0-0140	Controller type
S-0-0141	Motor type
S-0-0142	Application type
S-0-0143	SERCOS Interface version
S-0-0144	Signal status word
S-0-0145	Signal control word
S-0-0146	Control unit controlled homing procedure command
S-0-0147	Homing parameter
S-0-0148	Drive controlled homing procedure command
S-0-0149	Positive stop drive procedure command
S-0-0150	Reference offset 1
S-0-0151	Reference offset 2
S-0-0152	Position spindle procedure command
S-0-0153	Spindle angle position
S-0-0154	Spindle positioning parameter
S-0-0155	Friction torque compensation
S-0-0156	Velocity feedback value 2
S-0-0157	Velocity window
S-0-0158	Power threshold (P_x)
S-0-0159	Monitoring window
S-0-0160	Acceleration data scaling type
S-0-0161	Acceleration data scaling factor
S-0-0162	Acceleration data scaling exponent
S-0-0163	Weight counterbalance
S-0-0164	Acceleration feedback value 1
S-0-0165	Distance coded reference marks A
S-0-0166	Distance coded reference marks B
S-0-0167	Frequency limit of feedback 1
S-0-0168	Frequency limit of feedback 2
S-0-0169	Probe control parameter
S-0-0170	Probing cycle procedure command
S-0-0171	Calculate displacement procedure command
S-0-0172	Displacement to the referenced system procedure command
S-0-0173	Marker position A
S-0-0174	Marker position B
S-0-0175	Displacement parameter 1
S-0-0176	Displacement parameter 2
S-0-0177	Absolute distance 1
S-0-0178	Absolute distance 2
S-0-0179	Probe status

IDN	Name
S-0-0180	Spindle relative offset
S-0-0181	Manufacturer class 2 diagnostic
S-0-0182	Manufacturer class 3 diagnostic
S-0-0183	Synchronization velocity window
S-0-0184	Synchronization velocity error limit
S-0-0185	Length of the configurable data record in the AT
S-0-0186	Length of the configurable data record in the MDT
S-0-0187	IDN-list of configurable data in the AT
S-0-0188	IDN-list of configurable data in the MDT
S-0-0189	Following distance
S-0-0190	Drive controlled gear engaging procedure command
S-0-0191	Cancel reference point procedure command
S-0-0192	IDN-list of all backup operation data
S-0-0193	Positioning jerk
S-0-0194	Acceleration command value
S-0-0195	Acceleration feedback value 2
S-0-0196	Motor rated current
S-0-0197	Set coordinate system procedure command
S-0-0198	Initial coordinate value
S-0-0199	Shift coordinate system procedure command
S-0-0200	Amplifier warning temperature
S-0-0201	Motor warning temperature
S-0-0202	Cooling error warning temperature
S-0-0203	Amplifier shut-down temperature
S-0-0204	Motor shut-down temperature
S-0-0205	Cooling error shut-down temperature
S-0-0206	Drive on delay time
S-0-0207	Drive off delay time
S-0-0208	Temperature data scaling type
S-0-0209	Lower adaptation limit
S-0-0210	Upper adaptation limit
S-0-0211	Adaptation proportional gain
S-0-0212	Adaptation integral action time
S-0-0213	Engaging dither amplitude
S-0-0214	Average engaging speed
S-0-0215	Engaging dither period
S-0-0216	Switch parameter set procedure command
S-0-0217	Parameter set preselection
S-0-0218	Gear ratio preselection
S-0-0219	IDN-list of parameter set
S-0-0220	Minimum spindle speed
S-0-0221	Maximum spindle speed
S-0-0222	Spindle positioning speed
S-0-0223	Drive controlled synchronous operation procedure command
S-0-0224	Lead spindle address
S-0-0225	Synchronous operation parameter
S-0-0226	Lead spindle revolutions
S-0-0227	Synchronous spindle revolutions
S-0-0228	Synchronization position window
S-0-0229	Synchronization position error limit
S-0-0230	Synchronous position offset
S-0-0231	deleted
S-0-0232	deleted
S-0-0233	deleted
S-0-0234	deleted
S-0-0235	deleted
S-0-0236	deleted

IDN	Name
S-0-0237	deleted
S-0-0238	deleted
S-0-0239	deleted
S-0-0240	deleted
S-0-0241	deleted
S-0-0242	deleted
S-0-0243	deleted
S-0-0244	deleted
S-0-0245	deleted
S-0-0246	deleted
S-0-0247	deleted
S-0-0248	deleted
S-0-0249	deleted
S-0-0250	deleted
S-0-0251	deleted
S-0-0252	deleted
S-0-0253	deleted
S-0-0254	Actual parameter set
S-0-0255	Actual gear ratio
S-0-0256	Multiplication factor 1
S-0-0257	Multiplication factor 2
S-0-0258	Target position
S-0-0259	Positioning velocity
S-0-0260	Positioning acceleration
S-0-0261	Coarse position window
S-0-0262	Load defaults procedure command
S-0-0263	Load working memory procedure command
S-0-0264	Backup working memory procedure command
S-0-0265	Language selection
S-0-0266	List of available languages
S-0-0267	Password
S-0-0268	Angular setting
S-0-0269	Storage mode
S-0-0270	IDN-list of selected backup operation data
S-0-0271	Drive ID
S-0-0272	Velocity window percentage
S-0-0273	Maximum Drive off delay time
S-0-0274	Received drive addresses
S-0-0275	Coordinate offset value
S-0-0276	Return to Module range procedure command
S-0-0277	Position feedback 1 type
S-0-0278	Maximum travel range
S-0-0279	IDN-list of password protected data
S-0-0280	Underflow threshold
S-0-0281	Overflow threshold
S-0-0282	Positioning command value
S-0-0283	Current coordinate offset
S-0-0284	Secondary operation mode 4
S-0-0285	Secondary operation mode 5
S-0-0286	Secondary operation mode 6
S-0-0287	Secondary operation mode 7
S-0-0288	IDN list of data programmable in CP2 only
S-0-0289	IDN list of data programmable in CP3 only
S-0-0290	Device type (see I/O-Function)
S-0-0291	deleted (I/O Base (see I/O-Function))
S-0-0292	List of supported operation modes

IDN	**Name**
S-0-0293	Selectively backup working memory procedure command
S-0-0294	Divider modulo value
S-0-0295	Drive enable delay time
S-0-0296	Velocity feed forward gain
S-0-0297	Homing distance
S-0-0298	Suggest home switch distance
S-0-0299	Home switch offset 1
S-0-0300	Real-time control bit 1
S-0-0301	Allocation of real-time control bit 1
S-0-0302	Real-time control bit 2
S-0-0303	Allocation of real-time control bit 2
S-0-0304	Real-time status bit 1
S-0-0305	Allocation of real-time status bit 1
S-0-0306	Real-time status bit 2
S-0-0307	Allocation of real-time status bit 2
S-0-0308	Synchronization operation status
S-0-0309	Synchronization error status
S-0-0310	Overload warning
S-0-0311	Amplifier overtemperature warning
S-0-0312	Motor overtemperature warning
S-0-0313	Cooling error warning
S-0-0314	(reserved for class 2 diagnostic)
S-0-0315	Positioning velocity $\geq n_{\text{Limit}}$
S-0-0316	(reserved for class 2 diagnostic)
S-0-0317	(reserved for class 2 diagnostic)
S-0-0318	(reserved for class 2 diagnostic)
S-0-0319	(reserved for class 2 diagnostic)
S-0-0320	(reserved for class 2 diagnostic)
S-0-0321	(reserved for class 2 diagnostic)
S-0-0322	(reserved for class 2 diagnostic)
S-0-0323	Target position outside of travel range
S-0-0324	(reserved for class 2 diagnostic)
S-0-0325	(reserved for class 2 diagnostic)
S-0-0326	Parameter checksum (for S-0-0327)
S-0-0327	IDN list of checksum parameter
S-0-0328	Bit number allocation list for signal status word
S-0-0329	Bit number allocation list for signal control word
S-0-0330	Status "$n_{\text{feedback}} = n_{\text{command}}$"
S-0-0331	Status "$n_{\text{feedback}} = 0$"
S-0-0332	Status "$n_{\text{feedback}} < n_{\text{x}}$"
S-0-0333	Status "$T \geq T_{\text{x}}$"
S-0-0334	Status "$T \geq T_{\text{limit}}$"
S-0-0335	Status "$n_{\text{command}} > n_{\text{limit}}$"
S-0-0336	Status "In position"
S-0-0337	Status "$P \geq P_{\text{x}}$"
S-0-0338	Status “Position feedback = active target position”
S-0-0339	Status "$n_{\text{feedback}} \leq$ Minimum spindle speed"
S-0-0340	Status " $n_{\text{feedback}} \geq$ Maximum spindle speed"
S-0-0341	Status “In coarse position”
S-0-0342	Status “Target position attained”
S-0-0343	Status “Interpolator halted”
S-0-0344	(reserved for class 3 diagnostic)
S-0-0345	(reserved for class 3 diagnostic)
S-0-0346	Positioning control word
S-0-0347	Velocity error

IDN	**Name**
S-0-0348	Acceleration feed forward gain
S-0-0349	Bipolar jerk limit
S-0-0350	deleted
S-0-0351	deleted
S-0-0352	deleted
S-0-0353	deleted
S-0-0354	deleted
S-0-0355	deleted
S-0-0356	Distance home switch - marker pulse
S-0-0357	Marker pulse distance
S-0-0358	Home switch offset 2
S-0-0359	Positioning deceleration
S-0-0360	MDT data container A1
S-0-0361	MDT data container B1
S-0-0362	MDT data container A list index
S-0-0363	MDT data container B list index
S-0-0364	AT data container A1
S-0-0365	AT data container B1
S-0-0366	AT data container A list index
S-0-0367	AT data container B list index
S-0-0368	Data container A pointer
S-0-0369	Data container B pointer
S-0-0370	MDT data container A/B configuration list
S-0-0371	AT data container A/B configuration list
S-0-0372	Drive Halt acceleration bipolar
S-0-0373	Service channel error list
S-0-0374	Procedure command error list
S-0-0375	Diagnostic numbers list
S-0-0376	Baud rate
S-0-0377	Velocity feedback monitoring window
S-0-0378	Absolute encoder range 1
S-0-0379	Absolute encoder range 2
S-0-0380	DC bus voltage
S-0-0381	DC bus current
S-0-0382	DC bus power
S-0-0383	Motor temperature
S-0-0384	Amplifier temperature
S-0-0385	Active power
S-0-0386	Active position feedback value
S-0-0387	Power overload
S-0-0388	Braking current limit
S-0-0389	Effective current
S-0-0390	Diagnostic number
S-0-0391	Position feedback monitoring window
S-0-0392	Velocity feedback filter
S-0-0393	Command value mode
S-0-0394	List IDN
S-0-0395	List index
S-0-0396	Number of list elements
S-0-0397	List segment
S-0-0398	IDN-List of configurable data in signal status word
S-0-0399	IDN-List of configurable data in signal control word
S-0-0400	Home switch
S-0-0401	Probe 1
S-0-0402	Probe 2
S-0-0403	Position feedback value status

IDN	Name
S-0-0404	Position command value status
S-0-0405	Probe 1 enable
S-0-0406	Probe 2 enable
S-0-0407	Homing enable
S-0-0408	Reference marker pulse registered
S-0-0409	Probe 1 positive latched (Counter)
S-0-0410	Probe 1 negative latched (Counter)
S-0-0411	Probe 2 positive latched (Counter)
S-0-0412	Probe 2 negative latched (Counter)
S-0-0413	Bit number allocation of real-time control bit 1
S-0-0414	Bit number allocation of real-time control bit 2
S-0-0415	Bit number allocation of real-time status bit 1
S-0-0416	Bit number allocation of real-time status bit 2
S-0-0417	Positioning velocity threshold in modulo mode
S-0-0418	Target postion window in modulo mode
S-0-0419	Positioning acknowledge
S-0-0420	Activate parameterization level 1 procedure command (PL1)
S-0-0421	Activate parameterization level 2 procedure command (PL2)
S-0-0422	Exit parameterization level procedure command
S-0-0423	IDN-list of invalid data for parameterization levels
S-0-0424	Status parameterization level
S-0-0425	Control word parameterization level
S-0-0426	Measuring data allocation 1
S-0-0427	Measuring data allocation 2
S-0-0428	IDN list of configurable measuring data
S-0-0429	Emergency stop deceleration
S-0-0430	Active target position
S-0-0431	Spindle positioning acceleration bipolar
S-0-0432	Serial number drive control
S-0-0433	Serial number power stage
S-0-0434	Serial number motor
S-0-0435	Operational hours drive control
S-0-0436	Operational hours power stage
S-0-0437	Positioning status
S-0-0438	Vendor name
S-0-0439	Vendor code
S-0-0440	IDN groups control
S-0-0441	IDN groups list
S-0-0442	List of supported group codes
S-0-0443	Name of selected IDN group
S-0-0444	IDN-list of configurable data in the AT data container
S-0-0445	IDN-list of configurable data in the MDT data container
S-0-0446	Ramp reference velocity
S-0-0447	Set absolute position procedure command
S-0-0448	Set absolute position control word
S-0-0449	Profile Identification)
S-0-0450	MDT Data container A2
S-0-0451	MDT Data container A3
S-0-0452	MDT Data container A4
S-0-0453	MDT Data container A5
S-0-0454	MDT Data container A6
S-0-0455	MDT Data container A7
S-0-0456	MDT Data container A8
S-0-0457	MDT Data container A9
S-0-0458	MDT Data container A10
S-0-0459	MDT data container B2

IDN	Name
S-0-0460	Position switch point off 1
S-0-0461	Position switch point off 2
S-0-0462	Position switch point off 3
S-0-0463	Position switch point off 4
S-0-0464	Position switch point off 5
S-0-0465	Position switch point off 6
S-0-0466	Position switch point off 7
S-0-0467	Position switch point off 8
S-0-0468	Position switch point off 9
S-0-0469	Position switch point off 10
S-0-0470	Position switch point off 11
S-0-0471	Position switch point off 12
S-0-0472	Position switch point off 13
S-0-0473	Position switch point off 14
S-0-0474	Position switch point off 15
S-0-0475	Position switch point off 16
S-0-0476	Position switch control
S-0-0477	Position switch hysteresis
S-0-0478	Limit switch status
S-0-0479	Device ID
S-0-0480	AT data container A2
S-0-0481	AT data container A3
S-0-0482	AT data container A4
S-0-0483	AT data container A5
S-0-0484	AT data container A6
S-0-0485	AT data container A7
S-0-0486	AT data container A8
S-0-0487	AT data container A9
S-0-0488	AT data container A10
S-0-0489	AT data container B2
S-0-0490	MDT data container A2 configuration list
S-0-0491	MDT data container A3 configuration list
S-0-0492	MDT data container A4 configuration list
S-0-0493	MDT data container A5 configuration list
S-0-0494	MDT data container A6 configuration list
S-0-0495	MDT data container A7 configuration list
S-0-0496	MDT data container A8 configuration list
S-0-0497	MDT data container A9 configuration list
S-0-0498	MDT data container A10 configuration list
S-0-0499	Device name
S-0-0500	AT data container A2 configuration list
S-0-0501	AT data container A3 configuration list
S-0-0502	AT data container A4 configuration list
S-0-0503	AT data container A5 configuration list
S-0-0504	AT data container A6 configuration list
S-0-0505	AT data container A7 configuration list
S-0-0506	AT data container A8 configuration list
S-0-0507	AT data container A9 configuration list
S-0-0508	AT data container A10 configuration list
S-0-0509	Extended probe control
S-0-0510	Difference value probe 1
S-0-0511	Difference value probe 2
S-0-0512	Minimum position probe 1
S-0-0513	Maximum position probe 1
S-0-0514	Minimum position probe 2
S-0-0515	Maximum position probe 2
S-0-0516	Marker losses probe 1

IDN	Name
S-0-0517	Marker losses probe 2
S-0-0518	Maximum marker losses probe 1
S-0-0519	Maximum marker losses probe 2
S-0-0520	Axis control word
S-0-0521	Axis status word
S-0-0522	Difference value 1 latched
S-0-0523	Difference value 2 latched
S-0-0524	Measuring data additional allocation 1
S-0-0525	Measuring data additional allocation 2
S-0-0526	Additional probe value 1 positive edge
S-0-0527	Additional probe value 1 negative edge
S-0-0528	Additional probe value 2 positive edge
S-0-0529	Additional probe value 2 negative edge
S-0-0530	Clamping torque (for homing with pos. stop)
S-0-0531	Checksum for backup operation data (S-0-0192)
S-0-0532	Limit switch control word
S-0-0800	reserved for hydraulic (16 bit IDN)
to	...
S-0-0899	reserved for hydraulic
S-0-1000	reserved for SERCOS III (16 bit IDN)
to	...
S-0-1199	reserved for SERCOS III
S-0-1200	reserved for C2C (16 bit IDN)
to	...
S-0-1299	reserved for C2C
S-0-1300	reserved for subdevice, slave, (32 bit IDN)
to	...
S-0-1399	reserved for subdevice, slave,
S-0-1400	reserved for drive (32 bit IDN)
to	...
S-0-1499	reserved for drive
S-0-1500	reserved for IO (32 bit IDN)
to	...
S-0-1599	reserved for IO
	all other S-IDNs are reserved

Annex B (normative) - Identification numbers in alphabetical order

The following is the list of IDNs in alphabetical order.

Annex C (normative) - Description of IDNs

The description of IDNs is given in the following format:

IDN S-0-nnnn	Name (abbreviation)		
	Function/description		
	Length (bytes) Display format	Minimum input value Maximum input value (The input values are indicated only, if a limitation is specified.)	Scaling/resolution	Unit

Where additional information is required for a particular description, it is provided after that block.

S-0-0001	Control unit cycle time (t_{Ncyc})			
	The control unit cycle time defines the cyclic intervals during which the control unit makes new command values available. The control unit cycle time shall be transferred from the master to the slave during CP2 and becomes active in the slave during CP3. The control unit cycle time should be an integer multiple of the communication cycle time. $t_{Ncyc} = t_{Scyc} * n$ [n =1,2,3,4...] Min/max input value are mandatory.			
	2 unsigned decimal	Min. ≥ 62 Max. ≤ 65 000	1	µs

S-0-0002	Communication cycle time (t_{Scyc})			
	The communication cycle time of the interface defines the intervals during which the cyclic data are transferred. The communication cycle time is defined as 62 µs, 125 µs, 250 µs, ..., up to 65000 µs in steps of 250 µs. The communication cycle time shall be transferred from the master to the slave during CP2 and becomes active in both during CP3. Min/max input value are mandatory.			
	2 unsigned decimal	Min. ≥ 62 Max. ≤ 65 000	1	µs

S-0-0003	Shortest AT transmission starting time (t_{1min})			
	Indicates the time requirement of the slaves between the end of the reception of the MST and the start of transmission of the AT. This time interval, required by the slave, depends on the selected telegram type. The time t_{1min} is read by the master during CP2 in order to calculate the time of transfer of AT transmission starting time, t_1 (S-0-0006).			
	2 unsigned decimal		1	µs

S-0-0004	Transmit/receive transition time (t_{ATMT})			
	The time required by the slave to switch from transmitting the AT to receiving the MDT. The transition time for transmit/receive is read by the master during CP2 in order to calculate correctly the MDT transmission starting time t_2 (S-0-0089).			
	2 unsigned decimal		1	µs

S-0-0005	Minimum feedback processing time (t_5)
	The time required by a drive between the start of feedback acquisition and the end of the next MST. This value is declared by the drive such that feedback values are transferred to the control unit during the next drive telegram. The master reads this value during CP2 in order to synchronize the measurement times of the feedback acquisition capture point, t_4 (S-0-0007) appropriately for all drives.

	2 unsigned decimal		1	µs

S-0-0006	AT transmission starting time (t_1)			
	The AT transmission starting time determines when the slave sends its AT during CP3 and CP4, following the MST. This parameter is transferred by the master to the slave during CP2. The time of transfer of the AT shall be set greater than or equal to the shortest AT transmission starting time (S-0-0003). $t_1 \geq t_{1min}$			
	2 unsigned decimal	Min. $\geq t_{1min}$ Max. $\leq t_{Scyc}$	1	µs

S-0-0007	Feedback acquisition capture point (t_4)			
	The acquisition capture point of the feedback is determined by the master after the MST. In this way the master declares a default acquisition capture point for the feedback for all drives that work in coordination with each other. This ensures synchronized data acquisition of the feedback for the appropriate drives. The master sets the acquisition capture point of the feedback to be less than or equal to the difference between the communication cycle time (S-0-0002) and the requested minimum feedback processing time (S-0-0005). $t_4 \leq t_{Scyc}$-t_5 The drive enables the acquisition capture point of the feedback during CP3.			
	2 unsigned decimal	Min $\geq$ 0 µs Max $\leq t_{Scyc}$	1	µs

S-0-0008	Command value valid time (t_3)			
	t_3 determines the time at which the drive is allowed to access the new command values after the completion of a MST. In this way the master provides the command value valid time for command values among all coordinated drives. The drive activates the command value valid time during CP3.			
	2 unsigned decimal	Min. $\geq$ 0 µs Max. $\leq t_{Scyc}$	1	µs

S-0-0009	Position of data record in MDT			
	The position of a data record of the drive in a MDT, expressed as a byte position. It starts with 0x0001 for the initial data byte after the address field within the MDT. Every drive is informed by the master during CP2 of the beginning address of the data record of the drive in the MDT. The position of a data record in the MDT becomes active during CP3 in the master and slave.			
	2 unsigned decimal	Min. ≥ 1 (one drive) Max. ≤ 65 531	1	Byte

S-0-0010	Length of MDT			
	The length of the MDT, expressed in bytes, includes data records for all drives. Every drive is informed by the master during CP2 of the length of the MDT. It becomes active in the master and slave during CP3			
	2 unsigned decimal	Min. ≥ 4 (one drive) Max. ≤ 65 534 (number of bytes of 254 drives)	1 General structure of the MDT: (see Figure 32)	Byte

S-0-0011	Class 1 diagnostic (C1D)
	Drive shut-down error A drive error situation of C1D leads to the following: a) A best case deceleration followed by torque release at n_{min}. b) The drive shut-down error bit for C1D is set to '1' in the drive status (bit 13). The error bit is reset to '0' by the drive only when no errors of C1D exists and after the command 'reset class 1 diagnostic' (S-0-0099) has been received by the drive via the service channel.

	2 binary	Structure of C1D: Bit 0: overload shut-down (see S-0-0114) Bit 1: amplifier overtemperature shut-down (see S-0-0203) Bit 2: motor overtemperature shut-down (see S-0-0204) Bit 3: cooling error shut-down (see S-0-0205) Bit 4: control voltage error Bit 5: feedback error Bit 6: error in the „commutation“ system Bit 7: overcurrent error Bit 8: overvoltage error Bit 9: undervoltage error Bit 10: power supply phase error Bit 11: excessive position deviation (see S-0-0159) Bit 12: communication error (see S-0-0014) Bit 13: overtravel limit is exceeded (shut-down) (see S-0-0049, S-0-0050) Bit 14: reserved (for I/O-Zustandsklasse, see I/O specification) Bit 15: manufacturer-specific error (see S-0-0129) Bit = 0 no error Bit = 1 error

S-0-0012	Class 2 diagnostic (C2D)	
	Shut-down warning (warning) When a warning is activated or canceled in the C2D, this sets the change bit for C2D in the drive status (bit 12) to a binary ‘1’. When the C2D is read via the service channel, the C2D change bit is canceled and reset to ‘0’. The mask associated with C2D can mask the effects on the change bit of the drive status when a warning condition changes (see S-0-0097). (Bits defined by C2D are also defined by IDNs.)	
	2 binary	Structure of C2D: Bit 0: overload warning (see S-0-0310) Bit 1: amplifier overtemperature warning (see S-0-0311) Bit 2: motor overtemperature warning (see S-0-0312) Bit 3: cooling error warning (see S-0-0313) Bit 4: reserved Bit 5: Positioning velocity $\geq n_{Limit}$ (S-0-0315) Bit 6: reserved Bit 7: reserved Bit 8: reserved Bit 9: Undervoltage warning (bus voltage) Bit 10: reserved Bit 11: excessive velocity deviation (S-0-0377) Bit 12: Communication warning Bit 13: Target position outside of travel range (S-0-0323) Bit 14: reserved (for I/O-Warnung, see I/O specification) Bit 15: manufacturer-specific warning (see S-0-0181) Bit = 0 no (shut-down) warning Bit = 1 (shut-down) warning

S-0-0013	Class 3 diagnostic (C3D)	
	Drive operation status flags. When a condition changes in the drive, the corresponding bit changes in the C3D, this sets the change bit for C3D in the drive status (bit 11) to a binary '1'. When the C3D is read via the service channel, the C3D change bit is reset to '0'. The mask associated with C3D can mask the effects on the change bit of the drive status when an operating condition changes (see S-0-0098). (Bits defined by C3D are also defined by IDNs.)	
	2 binary	Structure of C3D: Bit 0: $n_{feedback} = n_{command}$ (see S-0-0330) Bit 1: $n_{feedback} = 0$ (see S-0-0331) Bit 2: $\lvert n_{feedback} \rvert < \lvert n_x \rvert$ (see S-0-0332) Bit 3: $\lvert T \rvert \geq \lvert T_x \rvert$ (see S-0-0333) Bit 4: $\lvert T \rvert \geq \lvert T_{limit} \rvert$ (see S-0-0334) Bit 5: $\lvert n_{command} \rvert > \lvert n_{limit} \rvert$ (see S-0-0335) Bit 6: in position (see S-0-0336) Bit 7: $\lvert P \rvert \geq \lvert P_x \rvert$ (see S-0-0337) Bit 8: Position feedback = Active target position |(S-0-0430 – S-0-0051/0053)| < S-0-0057 (see S-0-0338) Bit 9: $\lvert n_{feedback} \rvert \leq$ minimum spindle speed (see S-0-0339) Bit 10: $\lvert n_{feedback} \rvert \geq$ maximum spindle speed (see S-0-0340) Bit 11: In coarse position (see S-0-0341) Bit 12: Target position attained (see S-0-0342) Bit 13: Interpolator halted (see S-0-0343) Bit 14: Position feedback value status (S-0-0403, bit 0) Bit 15: manufacturer-specific operation status (see S-0-0182) Bit = 0 condition does not exist Bit = 1 condition exists

S-0-0014	Interface status	
	A communication error is set in C1D (see S-0-0011) if the interface status is set by an error. The setting of bits 2–0 does not signify an error. If there are no communication errors present, the actual communication phase is contained in the interface status. If a communication error has occurred, the error and the CP at the time of the error will be stored. The drive cancels a communication error and resets to '0' only if the error at the interface has been eliminated and on receiving the command 'reset class 1 diagnostic' (see S-0-0099) via the service channel.	
	2 binary	Structure of interface status: Bit 2-0: communication phase Bit 3: MST failure Bit 4: MDT failure Bit 5: invalid phase (phase > 6) Bit 6: error during phase upshift (invalid sequence) Bit 7: error during phase downshift (not to phase 0) Bit 8: phase switching without ready acknowledge Bit 9: switching to uninitialized operation mode Bit 10: drives with the same address in the ring Bit 11: IPO-SYNC error Bit 12: S III reserved Bit 13: S III reserved Bit 14: FIBBR (SERCON816) Bit 15: reserved Bit = 0 no error Bit = 1 error (for bits 3-15)

S-0-0015	Telegram type
	The telegram type allows selection between standard telegrams and application telegrams (bits 2-0). The position feedback 1 or 2 is programmed in bit 3. The extension of the service channel is programmed in the telegram type in bit 8 - 11. The extended service channel is only active in CP3 and CP4. In CP2 the service channel stays unchanged (2 bytes).

	2 binary	Structure of telegram type parameter: Bits 4–0: 0 0000 – Standard telegram – 0 0 0001 – Standard telegram – 1 0 0010 – Standard telegram – 2 x x011 – Standard telegram – 3 x x100 – Standard telegram – 4 x x101 – Standard telegram – 5 0 0110 – Standard telegram – 6 0 0111 – Application telegram (see S-0-0016, S-0-0024) Bit 3: 0 – Position feedback value 1 (motor feedback) 1 – Position feedback value 2 (external feedback) Bit 4: 0 - configured position feedback value 1 - active position feedback value Bits 7-5: (reserved) Bits 9-8: Length of MDT service channel 00 - 2 bytes, Master service INFO (Standard, CP2/3/4) 01 - 4 bytes, Master service INFO (CP3/4) 10 - 6 bytes, Master service INFO (CP3/4) 11 - 8 bytes, Master service INFO (CP3/4) Bits 11-10: Length of AT service channel 00 - 2 bytes, Drive service INFO (Standard, CP2/3/4) 01 - 4 bytes, Drive service INFO (CP3/4) 10 - 6 bytes, Drive service INFO (CP3/4) 11 - 8 bytes, Drive service INFO (CP3/4) Bits 15-12: (reserved)

S-0-0016	Configuration list of AT	
	This IDN list contains the IDNs whose operation data will be transmitted cyclically in the AT in an application telegram. The drive needs to support this list only if it allows the application telegram in its telegram type parameter (see S-0-0015). Only operation data which are present in the "IDN list of configurable data in the AT" (S-0-0187) are allowed as cyclic data.	
	2, variable IDN	Structure of the configuration list of AT: (see Figure 69)

S-0-0017	IDN-list of all operation data	
	All IDNs of all operation data, procedure commands, parameters etc. of a given drive are stored in this IDN-list.	
	2, variable IDN	(See Figure 69)

S-0-0018	IDN-list of operation data for CP2	
	IDNs of all operation data needed for CP2 are stored in this IDN-list and must be transferred during CP2. Processing this list is required before switching to CP3.	
	2, variable IDN	(See Figure 69)

S-0-0019	IDN-list of operation data for CP3	
	IDNs of all operation data needed for CP3 are stored in this IDN-list and must be transferred during CP3. Processing this list is required before switching to CP4.	
	2, variable IDN	(See Figure 69)

S-0-0020	IDN-list of operation data for CP4
	IDNs of all operational data which can be changed during CP4 are stored in this IDN-list.

	2, variable IDN	(See Figure 69)

S-0-0021	IDN-list of invalid operation data for CP2	
	IDNs which are in the list "IDN-list of operation data for CP2" (S-0-0018) and which are considered invalid by the drive prior to switchover from CP2 to CP3 are stored in this IDN-list (see S-0-0127). Case 1: procedure command S-0-0127 is performed correctly; the IDN-list (S-0-0021) contains no IDNs. Case 2: procedure command S-0-0127 results in an error; the IDN-list (S-0-0021) contains all IDNs of invalid operation data.	
	2, variable IDN	(See Figure 69)

S-0-0022	IDN-list of invalid operation data for CP3	
	IDNs which are in the list "IDN-list of operation data for CP3" (S-0-0019) and which are considered invalid by the drive prior to switchover from CP3 to CP4 are stored in this IDN-list (see S-0-0128). Case 1: procedure command S-0-0128 is performed correctly; the IDN-list (S-0-0022) contains no IDNs. Case 2: procedure command S-0-0128 results in an error; the IDN-list (S-0-0022) contains all IDNs of invalid operation data.	
	2, variable IDN	(See Figure 69)

S-0-0023	IDN-list of invalid operation data for CP4	
	IDNs of all drive data which are considered invalid by the drive are stored in this IDN-list following switchover to CP4.	
	2, variable IDN	(See Figure 69)

S-0-0024	Configuration list of MDT	
	This IDN list contains the IDNs whose operation data will be transmitted cyclically in the MDT in an application telegram. The drive needs to support this list only when it allows the application telegram in its telegram type parameter (see S-0-0015). Only operation data which are present in the "IDN-list of configurable data in the MDT" (S-0-0188) are allowed as cyclic data.	
	2, variable IDN	Structure of the configuration list of MDT: (see Figure 69)

S-0-0025	IDN-list of all procedure commands	
	All IDNs of all drive procedure commands are stored in this IDN-list.	
	2, variable IDN	(See Figure 69)

S-0-0026	Configuration list for signal status word	
	All IDNs of bits which are part of the signal status word (see S-0-0144) are found in the data of the configuration list. The sequence of the IDNs in the configuration list determines the bit numbering scheme in the signal status word. The initial IDN of the configuration list defines bit 0. The last IDN defines bit 15 of the signal status word (see S-0-0328). If the S-0-0328 of the drive isn't supported, the bit 0 of the IDN is configured automatically.	
	2, variable IDN	Structure of configuration list: (See Figure 69)

S-0-0027	Configuration list for signal control word:

	All IDNs of bits which are part of the signal control word (see S-0-0145) are found in the data of the configuration list. The sequence of IDNs in the configuration list determines the bit numbering scheme in the signal control word. The initial IDN of the configuration list defines bit 0. The last IDN defines bit 15 of the signal control word (see S-0-0329). If the S-0-0329 of the drive isn't supported, the bit 0 of the IDN is configured automatically.	
	2, variable IDN	Structure of configuration list: (See Figure 69)

S-0-0028	MST error counter			
	The MST error counter counts all invalid MST's in communication phases 3 and 4. (Refer also to error handling in clause 9). In cases where more than two consecutive MSTs are invalid, the invalid MSTs over two are not counted. The MST error counter counts to a maximum of $2^{16} - 1$. This means that if a value of 65 535 is set in the counter, there may have been a noisy transmission over a long period of time.			
	2	Min. ≥ 0 Max. ≤ 65 535	1	

S-0-0029	MDT error counter			
	The MDT error counter counts all invalid MDTs in communication phase 4. (Refer also to error handling in clause 9). In cases where more than two consecutive MDTs are invalid, the invalid MDTs over two are not counted. The MDT error counter counts to a maximum of $2^{16} - 1$. This means that if a value of 65 535 is set in the counter, there may have been a noisy transmission over a long period of time.			
	2	Min. ≥ 0 Max. ≤ 65 535	1	

S-0-0030	Manufacturer version	
	The operation data of the manufacturer version contains the actual firmware version and additional information of the device. The structure of the manufacturer version is not specified. Used for diagnosis, not used for evaluation in the master.	
	1, variable text	Structure of manufacturer version: (see Figure 69). Refer to operation data with variable length and data type characters.

S-0-0031	Hardware version	
	The operation data of the hardware version contains the actual hardware version and additional information of the device. The structure of the hardware version is not specified. Used for diagnosis, not used for evaluation in the master.	
	1, variable text	Structure of hardware version: (see Figure 69). Refer to operation data with variable length and data type characters.

S-0-0032 S-0-0033 S-0-0034 S-0-0035	Primary operation mode Secondary operation mode 1 Secondary operation mode 2 Secondary operation mode 3	
	The drive modes of operation defined by these parameters become active when the operation mode is selected via bits 9 and 8 in the control word of the MDT. The activated operation mode is indicated by bits 9 and 8 of the drive status in the AT.	
	2 binary	Structure of operation modes: (see Table 44)

S-0-0036	Velocity command value		
	In the velocity control operating mode in the drive, the control unit transfers the velocity command values to the drive in the time pattern of the control unit cycle time.		
	4 signed decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0037	Additive velocity command value
	The additive velocity command value is an additional velocity offset which is to be added to the velocity command value.

	4 signed decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0038	Positive velocity limit value		
	The positive velocity limit value describes the maximum allowable velocity in the positive direction. If the velocity limit value is exceeded, the drive responds by setting the status '$n_{command} > n_{limit}$' in C3D (see S-0-0013).		
	4 signed decimal	Min. ≥ 0	Scaling of velocity data (see clause 14.2.2)

S-0-0039	Negative velocity limit value		
	The negative velocity limit value describes the maximum allowable velocity in the negative direction. If the velocity limit value is exceeded, the drive responds by setting the status '$n_{command} > n_{limit}$' in C3D (see S-0-0013).		
	4 signed decimal	Max. ≤ 0	Scaling of velocity data (see clause 14.2.2)

S-0-0040	Velocity feedback value 1		
	The velocity feedback value 1 is transferred from the drive to the control unit in order to allow the control unit to periodically display the velocity. The velocity feedback value 1 refers to the motor encoder.		
	4 signed decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0041	Homing velocity		
	The homing velocity is used during the procedure command 'drive controlled homing' (S-0-0148) when activated. The drive performs its own homing control.		
	4 signed decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0042	Homing acceleration		
	The homing acceleration is needed by the drive if the procedure command 'drive controlled homing' (S-0-0148) is activated.		
	4 unsigned decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0043	Velocity polarity parameter	
	This parameter is used to switch polarities of velocity data for specific applications. Polarities are not switched internally but externally (on the input and output) of a closed loop system. The motor shaft turns clockwise when there is a positive velocity command difference and no inversion is programmed.	
	2 binary	Structure of velocity polarity parameter (see Figure 91): Bit 0 – Velocity command value = 0 – non-inverted = 1 – inverted Bit 1 – Additive velocity command value = 0 – non-inverted = 1 – inverted Bit 2 – Velocity feedback value 1 = 0 – non-inverted = 1 – inverted Bit 3 - Velocity feedback value 2 = 0 - non inverted = 1 - inverted Bits 15-4 (reserved)

S-0-0044	Velocity data scaling type
	A variety of scaling methods can be selected by means of the scaling type parameter. Bit 5 is set to 'minute' for preferred data (see also Figure 86)

	2 binary	Structure of velocity data scaling type: Bits 2–0: Scaling method 000 – no scaling 001 – linear scaling 010 – rotational scaling Bit 3: 0 – preferred scaling 1 – parameter scaling Bit 4: Units for linear scaling 0 – metres [m]) (1 – inches [in]) additional Bit 4: Units for rotational scaling 0 – revolutions [Rev] 1 – (reserved) Bit 5: Time units 0 – minutes [min] 1 – seconds [s] Bit 6: Data reference 0 – at the motor shaft 1– at the load (all other bits are reserved)

S-0-0045	Velocity data scaling factor		
	This parameter defines the scaling factor for all velocity data in a drive.		
	2 unsigned decimal	Min. ≥ 1 Max. ≤ $+2^{16} - 1$	Structure of the scaling factor: Bits 15-0: factor

S-0-0046	Velocity data scaling exponent		
	This parameter defines the scaling exponent for all velocity data in a drive.		
	2 signed decimal		Structure of the scaling exponent: Bit 15: Sign of the exponent 0 – positive 1 – negative Bits 14-0: Exponent

S-0-0047	Position command value		
	During the position control drive operation mode, the position command values are transferred from the control unit to the drive according to the time pattern of the control unit cycle.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0048	Additive position command value		
	This IDN is used if an additional position offset is required during position control operation mode in the drive. The additive position command value is added to the position command value (S-0-0047), when the bit "IPOSYNC" toggles (control word, bit 10).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0049	Positive position limit value		
	The positive position limit value describes the maximum allowed distance in the positive direction. The positive position limit value is only enabled when all position data are based on the machine zero point. Position polarity parameter (see S-0-0055) can be used to disable the position limit values. When the positive position limit value is exceeded, the drive sets an error bit in C1D (S-0-0011).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0050	Negative position limit value

	The negative position limit value describes the maximum allowed distance in the negative direction. The negative position limit value is only enabled when all position data are based on the machine zero point. Position polarity parameter (see S-0-0055) can be used to disable the position limit values. When the negative position limit value is exceeded, the drive sets an error bit in C1D (S-0-0011).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0051	Position feedback value 1 (motor feedback)		
	The position feedback value 1 is transferred from the drive to the control unit so that it is possible for the control unit to perform block stepping and display position information if necessary.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0052	Reference distance 1		
	This parameter describes the distance between the machine zero point and the reference point related to the motor feedback. After the homing procedure, the position feedback value 1 is calculated by: – reference distance 1; – reference offset 1 (S-0-0150); – marker position A/B (S-0-0173/00174). For absolute homing the reference distance 1 is the absolute position of the axis upon completion of the homing sequence with procedure command S-0-0447.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0053	Position feedback value 2 (external feedback)		
	The position feedback value 2 is transferred from the drive to the control unit so that it is possible for the control unit to perform block stepping and display position information if necessary.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0054	Reference distance 2		
	This parameter describes the distance between the machine zero point and the reference point related to the external feedback. After the homing procedure, the position feedback value 2 is calculated by: – reference distance 2; – reference offset 2 (S-0-0151); – marker position A/B (S-0-0173/00174). For absolute homing the reference distance 2 is the absolute position of the axis upon completion of the homing sequence with procedure command S-0-0447.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0055	Position polarity parameters	
	This parameter is used to switch polarities of reported position data for specific applications. Polarities are switched outside (i.e., on the input and output) of a closed loop system. The motor shaft turns clockwise (as viewed from the output shaft) when there is a positive position command difference and no inversion is programmed.	
	2 binary	Structure of the Position polarity parameter (see Figure 91): Bit 0 Position command value 0 – Non-inverted 1 – Inverted Bit 1 Additive position command value 0 – Non-inverted 1 – Inverted Bit 2 Position feedback value 1 0 – Non-inverted 1 – Inverted Bit 3 Position feedback value 2 0 – Non-inverted 1 – Inverted Bit 4 Position limit values 0 – disabled 1 – enabled Bit 5: Underflow / Overflow threshold (S-0-0280, S-0-0281) 0 – disabled 1 – enabled Bits 15-6 (reserved)

S-0-0056	deleted			

S-0-0057	Position window		
	When the difference between the accumulated position command value and the position feedback value is within the range of the position window, then the drive sets the status “in position” (S-0-0336). When needed, the status 'in position' is assigned to a real-time status bit within the drive status and then transferred to the control unit (see S-0-0305).		
	4 unsigned decimal	Min. ≥ 0	Scaling of position data (see clause 14.2.1)

S-0-0058	Reversal clearance		
	The reversal clearance describes the amount of backlash between motor and load during reversal, relative to the position data.		
	4 unsigned decimal	Min. ≥ 0	Scaling of position data (see clause 14.2.1)

S-0-0059	Position switch flag parameter
	Bit 0 = position switch point on/off 1 (S-0-0060 and/or S-0-0460) up to Bit 15 = position switch point on/off 16 (S-0-0075 and/or S-0-0475) Refer to position switches (S-0-0060 to S-0-0075 and S-0-0460 to S-0-0475). In the position switch mode, the function of the related bit is deactivated, if the corresponding bit (bit 0 to 15) in the position switch control is set to 0. In cam switch mode, the function of the related bit is deactivated, if the corresponding bit (bit 16 to 32) in the position switch control is set to 0. In cam switch mode the position overflow must be taken into account at modulo format.

	2 binary	Structure of the position switch flag parameter: Bit (n) (n = 0, ...15) = 0 Position feedback value < position switch point on (n+1) S-0-0060 to S-0-0075 = 1 Position feedback value ≥ position switch point on (n+1) S-0-0060 to S-0-0075 = 1 Position feedback value < position switch point off (n+1) S-0-0460 to S-0-0475 = 0 Position feedback value ≥ position switch point off (n+1) S-0-0460 to S-0-0475

S-0-0060 to S-0-0075	Position switches (position switch points on 1-16)		
	The position switches consist of a “position switch point on” and a position switch flag (S-0-0059). If the position feedback value is less than the “position switch point on”, the appropriate position switch flag is set to 0. If the position feedback value is equal to or greater than the “position switch point on”, the appropriate position switch flag is set to 1.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0076	Position data scaling type	
	A variety of scaling methods can be selected by means of the scaling type parameter (see also Figure 85).	
	2 binary	Structure of position data scaling type: Bits 2–0: Scaling method 000 – no scaling 001 – linear scaling 010 – rotational scaling Bit 3: 0 – preferred scaling 1 – parameter scaling Bit 4: Units for linear scaling 0 – metres [m] (1 – inches [in]) additional Bit 4: Units for rotational scaling 0 – degrees 1 – (reserved) Bit 5: (reserved) Bit 6: Data reference 0 – at the motor shaft 1 – at the load Bit 7: Processing format 0 – absolute format 1 – modulo format (see S-0-0103) (all other bits are reserved)

S-0-0077	Linear position data scaling factor		
	This parameter defines the scaling factor for all position data in a drive.		
	2 unsigned decimal	Min. ≥1	

S-0-0078	Linear position data scaling exponent		
	This parameter defines the scaling exponent for all position data in a drive.		
	2 signed decimal		Structure of the scaling exponent: Bit 15: Sign of the exponent 0 – positive 1 – negative Bits 14–0: Exponent

S-0-0079	Rotational position resolution		
	This parameter defines the rotational position resolution for all position data in a drive.		
	4 unsigned decimal	Min. ≥ 1	

S-0-0080	Torque command value		
	During the torque control operation mode of the drive, torque command values are transferred from the control unit to the drive.		
	2 signed decimal		Scaling of torque/force data (see clause 14.2.3)

S-0-0081	Additive torque command value		
	This is an additional function for torque control in the drive. The additive torque command value is added to the torque command value, (S-0-0080), in the drive.		
	2 signed decimal		Scaling of torque/force data (see clause 14.2.3)

S-0-0082	Positive torque limit value		
	The positive torque limit value limits the maximum torque in the positive direction. If the torque limit value is exceeded, the drive sets the status '$T \geq T_{limit}$' in C3D (S-0-0013).		
	2 unsigned decimal		Scaling of torque/force data (see clause 14.2.3)

S-0-0083	Negative torque limit value		
	The negative torque limit value limits the maximum torque in the negative direction. If the torque limit value is exceeded, the drive sets the status '$T \geq T_{limit}$' in C3D (S-0-0013).		
	2 unsigned decimal		Scaling of torque/force data (see clause 14.2.3)

S-0-0084	Torque feedback value		
	The torque feedback value is transferred from the drive to the control unit.		
	2 signed decimal		Scaling of torque/force data (see clause 14.2.3)

S-0-0085	Torque polarity parameter	
	This parameter is used to switch polarities of reported torque data for specific applications. Polarities are not switched internally but externally (on the input and output) of a closed loop system. The motor shaft turns clockwise when there is a positive torque command difference and no inversion.	
	2 binary	Structure of torque polarity parameter (see Figure 91): Bit 0 – Torque command value = 0 – non-inverted = 1 – inverted Bit 1 – Additive torque command value = 0 – non-inverted = 1 – inverted Bit 2 – Torque feedback value = 0 – non-inverted = 1 – inverted Bits 15-3 (reserved)

S-0-0086	Torque/force data scaling type
	A variety of scaling methods can be selected by means of this scaling type parameter (see also Figure 87).

	2 binary	Structure of torque/force data scaling type: Bits 2–0: Scaling method 000 – percentage scaling 001 – linear scaling (force) 010 – rotational scaling (torque) Bit 3: 0 – preferred scaling 1 – parameter scaling Bit 4: Units for force 0 – newton [N] (1 – pound force [lbf]) additional Bit 4: Units for torque 0 – newton metre [Nm] (1 – inch pound force [in lbf]) additional Bit 5: (reserved) Bit 6: Data reference 0 – at the motor shaft 1 – at the load) (all other bits are reserved)

S-0-0087	Transmit to transmit recovery time (t_{ATAT})			
	The time required between two ATs when sent by the same slave. This parameter is not used for slaves with a single drive. The transmit to transmit recovery time is read by the master during CP2 in order to correctly calculate the AT transmission starting time t_1 (S-0-0006).			
	2 unsigned decimal		1	µs

S-0-0088	Receive to receive recovery time (t_{MTSY})			
	Recovery time of the slave after reception of a MDT to switch over to receive the next MST. The master reads this time during CP2 to ensure that the interval will be sufficient between the end of the MDT and the beginning of the MST.			
	2 unsigned decimal		1	µs

S-0-0089	MDT transmission starting time (t_2)			
	The MDT transmission starting time determines when the master shall send its MDT during CP3 and CP4, following the MST. This parameter is transferred by the master to the slave during CP2 and becomes active during CP3.			
	2 unsigned decimal	Min. ≥ 0 µs Max. $\leq t_{Scyc}$	1	µs

S-0-0090	Command value proceeding time (t_{MTSG})			
	The time required by the slave to make command values available for a drive after receipt of a MDT. This time is read by the master during CP2 in order to correctly calculate the command value valid time t_3 (S-0-0008). The command value proceeding time depends on the telegram type.			
	2 unsigned decimal		1	µs

S-0-0091	Bipolar velocity limit value		
	The bipolar velocity limit value describes the maximum allowable velocity in both directions. If the velocity limit value is exceeded, the drive responds by setting the status '$n_{command} > n_{limit}$' in C3D (see S-0-0013).		
	4 unsigned decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0092	Bipolar torque limit value

	The bipolar torque limit value limits the maximum torque symmetrically in both directions. If the torque limit value is exceeded, the drive sets the status '$T \geq T_{limit}$' in C3D (S-0-0013).		
	2 unsigned decimal		Scaling of torque/force data (see clause 14.2.3)

S-0-0093	Torque/force data scaling factor		
	This parameter defines the scaling factor for all torque/force data in a drive.		
	2 unsigned decimal	Min. ≥ 1	

S-0-0094	Torque/force data scaling exponent		
	This parameter defines the scaling exponent for all torque/force data in a drive.		
	2 signed decimal		Structure of the torque/force data scaling exponent: Bit 15: Sign of the exponent 0 – positive 1 – negative Bits 14-0: Exponent

S-0-0095	Diagnostic message	
	The currently relevant operating status is being monitored with diagnostic messages. The diagnostic messages are generated by the drive as a text and stored in the operation data of this IDN.	
	1, variable text	Structure of diagnostic message: (see Figure 69) Refer to operation data of variable length and data type characters.

S-0-0096	Slave arrangement (SLKN)	
	During initialization, the master needs to recognize which physical slaves and their associated drives are present in order to optimize the automatic timeslot computation. The master can request this information from the drives during CP2. By this entry the master recognizes other drives which belong to the same physical slave. Valid drive addresses are all decimal values from 1 to 254, in accordance with hexadecimal values 0x0001 through 0x00FE .	
	2 hex	Structure of SLKN: Bit 15-8: high byte: intrinsic drive address the drive enters its own address here Bit 7-0: low byte: next drive address The next higher drive address of the drive serviced by the slave is entered in ascending order here. If the actual drive on the physical slave is one with the highest address, then the slave enters the lowest available drive address here. If the slave services only one drive, then the 'intrinsic drive address' is entered here. Example: slave with three drives (drive addresses 3, 5, 8) SLKN drive 3: 03 | 05 SLKN drive 5: 05 | 08 SLKN drive 8: 08 | 03

S-0-0097	Mask class 2 diagnostic
	Using this mask, warnings in class 2 diagnostic can be masked with respect to their effect on the change bit in drive status. When changing masked warnings, the change bit for class 2 diagnostic is not set in the drive status. The mask does not affect the operation data of class 2 diagnostic (see S-0-0012).

	2 binary	Structure of Mask C2D: Bits 15 – 0: all 0s – masked warning all 1s – unmasked warning

S-0-0098	Mask class 3 diagnostic	
	Using this mask, condition flags in C3D can be masked with respect to their effect on the change bit in drive status. When masked condition flags change, the change bit for C3D is not set in the drive status. The mask does not affect the operation data of C3D (see S-0-0013).	
	2 binary	Structure of Mask C3D: Bits 15 – 0: all 0s – masked condition flag all 1s – unmasked condition flag

S-0-0099	Reset class 1 diagnostic	
	When this procedure command is received by the drive via the service channel and no error exists, C1D, the interface status, the manufacturer's C1D, the drive shut-down error (drive status, bit 13), and the drive shut-down mechanism in the drive are all reset (see S-0-0011, S-0-0014, and S-0-0129). The drive acknowledges the procedure command positively, even if an error can not be deleted or no error in the drive is existing.	
	2 binary	Structure of reset class 1 diagnostic: (see Table 23) Structure of procedure command acknowledgment (see Table 24)

S-0-0100	Velocity loop proportional gain		
	The operational characteristic of the velocity loop proportional gain is defined by the drive manufacturer. The 4 byte data length is preferred for new implementations.		
	2 or 4 unsigned decimal (attribute has to be checked by the control unit.)		(Scaling and unit defined by the drive manufacturer)

S-0-0101	Velocity loop integral action time			
	The operational characteristic of the velocity loop integral action time is defined by the drive manufacturer. With the maximum value of $2^{16} - 1$, the integrator in the velocity loop regulator is switched off.			
	2 unsigned decimal		0,1	ms

S-0-0102	Velocity loop differential time			
	The operational characteristic of the velocity loop differential time is defined by the drive manufacturer.			
	2 unsigned decimal		0,1	ms

<table>
<tr><td rowspan="3">S-0-0103</td><td colspan="3">Modulo value</td></tr>
<tr><td colspan="3">If the Modulo format is selected in the position data scaling factor (S-0-0076), the Modulo value defines the range that the drive & control must implement. When extrapolation is used for missing commands (MDTs), the position command difference between two consecutive cycles may not exceed half the Modulo value.
$\frac{\text{IDN 00103}}{2}$ = Maximum position command difference
If extrapolation is not used for missing commands (MDT's), the position command difference between two consecutive cycles may not exceed one fourth the Modulo value.
$\frac{\text{IDN 00103}}{4}$ = Maximum position command difference
This reduces the maximum possible velocity due to the position command difference. The spindle angle position in addition always is related on the physical modulo value to reach short positioning times. To compensate this disadvantage, the divider modulo value (S-0-0294) is programmed.

<u>Example 1:</u>
NC cycle time = 4 ms
Modulo value = 360°
Divider modulo value = 1
→ Vmax = (360°/2) / 4ms = 45000°/s (7500 rpm)

<u>Example 2:</u>
NC cycle time = 4 ms
Modulo value = 1080° (3*360°)
Divider modulo value = 3
→ Vmax = (1080°/2) / 4ms = 135000°/s (22500 rpm)</td></tr>
<tr><td>4
unsigned decimal</td><td>Min. ≥ 1</td><td>Scaling of position data (see clause 14.2.1)</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0104</td><td colspan="4">Position loop K_V -factor</td></tr>
<tr><td colspan="4">The K_V-factor determines the gain of the position loop regulator throughout the entire velocity range.</td></tr>
<tr><td>2
unsigned decimal</td><td></td><td>0,01</td><td>(m/min)/mm</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0105</td><td colspan="4">Position loop integral action time</td></tr>
<tr><td colspan="4">The method of operation of the position loop integral action time is defined by the manufacturer.</td></tr>
<tr><td>2
unsigned decimal</td><td></td><td>0,1</td><td>ms</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0106</td><td colspan="3">Current loop proportional gain 1</td></tr>
<tr><td colspan="3">The current loop proportional gain 1 influences the torque/force-producing current. The mode of operation is determined by the drive manufacturer.
The 4 byte data length is preferred for new implementations.</td></tr>
<tr><td>2 or 4
unsigned decimal
(attribute has to be checked by the control unit.)</td><td></td><td>(Scaling and unit defined by the drive manufacturer)</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0107</td><td colspan="4">Current loop integral action time 1</td></tr>
<tr><td colspan="4">The current integral action time 1 influences the torque/force-producing current. The mode of operation is determined by the drive manufacturer.</td></tr>
<tr><td>2
unsigned decimal</td><td></td><td>1</td><td>µs</td></tr>
</table>

S-0-0108	Feedrate override			
	The feedrate override is activated only with drive controlled procedure commands. In such a case, the velocity command value is calculated internally by the drive. The feedrate override has multiplying effects on the velocity command value.			
	2 unsigned decimal		0,01	%

S-0-0109	Motor peak current			
	If the motor peak current is less than that of the amplifier, the amplifier is automatically limited to the level of the motor peak current.			
	4 unsigned decimal		0,001	A

S-0-0110	Amplifier peak current			
	The amplifier peak current is limited by the hardware, which means that the current for the maximum attainable torque limit value is fixed as well.			
	4 unsigned decimal		0,001	A

S-0-0111	Motor continuous stall current			
	The motor continuous stall current is the current at which the motor produces the continuous standstill torque according to the motor spec sheet. For all motors except for asynchronous motors, this parameter is used as a reference for all torque data and for determining motor-related current values.			
	4 unsigned decimal		0,001	A

S-0-0112	Amplifier rated current			
	The amplifier rated current is equal to the allowable continuous current of the drive unit.			
	4 unsigned decimal		0,001	A

S-0-0113	Maximum motor speed			
	The maximum motor speed is listed in the motor spec sheet provided by the manufacturer.			
	4 unsigned decimal		10^{-4}	min^{-1}

S-0-0114	Load limit of the motor			
	When the load limit is exceeded, the drive sets the overload warning bit in C2D (see S-0-0310). After a time period specified by the manufacturer, the overload shut-down bit is set in C1D (S-0-0011).			
	2 unsigned decimal		1	%

S-0-0115	Position feedback 2 type
	The position feedback 2 type parameter refers only to an external feedback. This parameter is programmed to define the corresponding conditions which apply to the external feedback (see also S-0-0277).

	2 binary	Structure of Position Feedback 2 Type Bit 0: Feedback type 0 – rotational feedback (S-0-0117) 1 – linear feedback (S-0-0118) Bit 1: Distance coded feedback 0 – no distance coded reference marks 1 – distance coded reference marks (S-0-0165, S-0-0166) Bit 2: Feedback resolution (S-0-0118) 0 – resolution = metric 1 – resolution = inches Bit 3: Direction polarity 0 – not inverted 1 – inverted Bit 4: Marker pulse quantity 0 – only one reference marker pulse 1 – multiple cyclic reference marker pulses Bit 5: Structure of distance coded feedback 0 – counting positive with positive direction 1 – counting negative with positive direction Bit 6: Type of measuring system 0 - relative (incremental) measuring system 1 - absolute measuring system Bit 7: Usage 0 - absolute measurements with an absolute measuring system 1 - relative (incremental) measurements with an absolute measuring system Bits 15-8 (reserved)

S-0-0116	Resolution of feedback 1		
	The resolution parameter of feedback 1 (motor feedback) contains, for a rotary feedback, the cycles per revolution of the motor (see also S-0-0256). For a linear feedback the grid constant is entered.		
	4 unsigned decimal		1 [cycles/motor revolution] or µm

S-0-0117	Resolution of feedback 2		
	The resolution parameter of feedback 2 (external feedback) contains, for a rotary feedback, the cycles per revolution (see also S-0-0257). For a linear feedback the grid constant is entered.		
	4 unsigned decimal		1 [cycles/revolution] or µm

S-0-0118	Resolution of linear feedback		
	The resolution of linear feedback is calculated on the basis of: – the grid constant for the linear scale, and – the external multiplier of the digitization unit. $\text{Linear feedback resolution} = \frac{\text{grid constant}}{\text{external multiplier}}$ If there is no external multiplier (i.e., the multiplication is done in the amplifier), the external multiplier is to be set to 1 and the linear feedback resolution equals the grid constant. Example 1: Grid constant = 0,01 mm external multiplier = 5 ==> Linear feedback resolution = 0,002 mm Example 2: Grid constant = 0,01 mm external multiplier = 1 ==> Linear feedback resolution = 0,01 mm		
	4 unsigned decimal		(Scaling and unit defined by the drive manufacturer, see S-0-0115)

S-0-0119	Current loop proportional gain 2
	The current loop proportional gain 2 influences the flux producing current. The mode of operation is determined by the drive manufacturer. The 4 byte data length is preferred for new implementations.

	2 or 4 unsigned decimal (attribute has to be checked by the control unit.)		(Scaling and unit defined by the drive manufacturer)

S-0-0120	Current loop integral action time 2			
	The current loop integral action time 2 influences the flux–producing current. The mode of operation is determined by the drive manufacturer.			
	2 unsigned decimal		1	µs

S-0-0121	Input revolutions of load gear		
	Input revolution values must be entered as integers.		
	4 unsigned decimal		1 [input revolution]

S-0-0122	Output revolutions of load gear		
	Output revolution values must be entered as integers.		
	4 unsigned decimal		1 [output revolution]

S-0-0123	Feed constant		
	The feed constant describes the machine element which converts a rotational motion into a linear motion. The feed constant indicates the linear distance during one revolution of the feed spindle.		
	4 unsigned decimal		(Scaling and unit defined by the drive manufacturer)

S-0-0124	Standstill window		
	The standstill window describes the amount of the deviation of the velocity from 0. If the velocity feedback value is within the standstill window the drive sets the status $n_{feedback} = 0$ (S-0-0331).		
	4 unsigned decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0125	Velocity threshold (n_x)		
	If the velocity feedback value falls below the velocity threshold n_x, the drive sets the status '$n_{feedback} < n_x$' (S-0-0332) in C3D.		
	4 unsigned decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0126	Torque threshold (T_x)		
	If the torque feedback value exceeds the torque threshold T_x, the drive sets the status '$T \geq T_x$' in C3D (S-0-0333).		
	2 unsigned decimal		Scaling of torque/force data (see clause 14.2.3)

S-0-0127	CP3 transition check	
	The master uses this procedure command to instruct the slave to check that all necessary parameters have been transferred for CP3. Otherwise, this procedure command results in an error (see S-0-0021). After the procedure command is performed correctly, the control unit has to cancel the procedure command. The control unit can then activate CP3 in the MST.	
	2 binary	Structure of procedure command control (see Table 23) Structure of procedure command acknowledgment (see Table 24)

S-0-0128	CP4 transition check		
	The master uses this procedure command to instruct the slave to check that all necessary parameters have been transferred for CP4. Otherwise, this procedure command results in an error. (see S-0-0022). After the procedure command is performed correctly, the control unit has to cancel the procedure command. The control unit can then activate CP4 in the MST.		
	2 binary	Structure of procedure command control (see Table 23) Structure of procedure command acknowledgment (see Table 24)	

S-0-0129	Manufacturer class 1 diagnostic		
	The drive manufacturer can define additional shut-down errors in manufacturer class 1 diagnostic. If an error is set in the manufacturer class 1 diagnostic, the manufacturer-specific error bit in class 1 diagnostic (see S-0-0011) is set as well. The drive cancels the manufacturer-specific error and resets to '0' only if the error in manufacturer class 1 diagnostic has been eliminated upon receiving the command 'reset class 1 diagnostic' (see S-0-0099) via the service channel.		
	2 binary	Structure of manufacturer Class 1 diagnostic: Bits 15 – 0: all 0s – no error all 1s – error	

S-0-0130	Probe value 1 positive edge		
	If an external feedback is present, the drive stores position feedback value 2 in the measuring cycle in this parameter following the positive edge of the input signal of probe 1 (see S-0-0401). If no external feedback is present, position feedback value 1 is stored. This allows the control unit to read 'probe value 1 positive edge' at a later time.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0131	Probe value 1 negative edge		
	If an external feedback is present, the drive stores position feedback value 2 in the measuring cycle in this parameter following the negative edge of the input signal of probe 1 (see S-0-0401). If no external feedback is present, position feedback value 1 is stored. This allows the control unit to read 'probe value 1 negative edge' at a later time.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0132	Probe value 2 positive edge		
	If an external feedback is present, the drive stores position feedback value 2 in the measuring cycle in this parameter following the positive edge of the input signal of probe 2 (see S-0-0402). If no external feedback is present, position feedback value 1 is stored. This allows the control unit to read 'probe value 2 positive edge' at a later time.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0133	Probe value 2 negative edge		
	If an external feedback is present, the drive stores position feedback value 2 in the measuring cycle in this parameter following the negative edge of the input signal of probe 2 (see S-0-0402). If no external feedback is present, position feedback value 1 is stored. This allows the control unit to read 'probe value 2 negative edge' at a later time.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0134	Master control word		
	Enables the display of the master control word on the control unit screen, via the service channel. (This can be useful during start-up and error recovery.)		
	2 binary	Structure of master control word: Refer to Table 18.	

S-0-0135	Drive status word	
	Enables the display of the drive status word on the control unit screen, via the service channel. (This can be useful during start-up and error recovery.)	
	2 binary	Structure of drive status word: Refer to Table 19

S-0-0136	Positive acceleration limit value		
	The positive acceleration parameter limits the maximum acceleration ability of the drive to the programmed value. If the velocity increases it is said to be a positive acceleration.		
	4 unsigned decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0137	Negative acceleration limit value		
	The negative acceleration parameter limits the maximum acceleration ability of the drive to the programmed value. If the velocity decreases it is said to be a negative acceleration.		
	4 unsigned decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0138	Bipolar acceleration limit value		
	The bipolar acceleration parameter limits the maximum acceleration ability of the drive symmetrically to the programmed value in both directions.		
	4 unsigned decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0139	Park axis procedure command	
	Setting and enabling the park axis procedure command causes all monitors associated with the feedback sensing system to shut down. This affects the position control, the transducer monitoring circuit (feedback hardware), and the monitoring of the position window (S-0-0057). While the command is active, the drive does not report a C1D error (S-0-0011). The position feedback value status (S-0-0403) is reset by the drive. The command is positively acknowledged when the monitoring system mentioned above is turned off. When the set command is cancelled, all monitors mentioned above are turned on again. In order to relate the position feedback values again to the reference point again, the control unit shall start a homing procedure.	
	2 binary	Structure of Park axis procedure command: see Table 23. Structure of Command acknowledgment: see Table 24.

S-0-0140	Controller type	
	The operation data of the controller type contains the manufacturer controller type. Used for diagnosis, not used for evaluation in the master.	
	1, variable text	Structure of controller type: (see Figure 69) Refer to operation data with variable length and data type characters.

S-0-0141	Motor type	
	The operation data of the motor type contains the manufacturer motor type. Used for diagnosis, not used for evaluation in the master.	
	1, variable text	Structure of motor type: (see Figure 69) Refer to operation data with variable length and data type characters.

S-0-0142	Application type	
	The operation data of the application type contains the type of the drive application (e.g., main spindle drive, round axis, X axis, etc.) The user can program this parameter if desired.	
	1, variable text	Structure of application type: (see Figure 69). Refer to operation data with variable length and data type characters.

<table>
<tr><td rowspan="3">S-0-0143</td><td colspan="2">SERCOS interface version</td></tr>
<tr><td colspan="2">The operation data contains the version of the SERCOS interface specification. A version number is linked to every update. If only one of the changed or new functions of the drive is supported, then the corresponding version number must be shown. Only changes or modifications of the basic functions of SERCOS interface influence the version number.
Basic functions:
• Data block structure
• Service channel functions (Error messages, sequence, length, ...)
• Structure of control word and status word
• Error handling
• Phase switching sequence
• Telegram structure
• Topology
• Physical layer
• Procedure command sequence</td></tr>
<tr><td>1, variable
text</td><td>Structure of SERCOS interface version
V01.01 - Specification 1990 (old standard telegrams)
V01.02 - IEC 61491 / EN 61491 (1st edition)
V01.03 - Update 98.1
V02.01 - Specification SERCOS16:2002
V02.03 – Specification SERCOS16 V2.3 (2003)</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0144</td><td colspan="2">Signal status word</td></tr>
<tr><td colspan="2">Signals can be transmitted in real-time from the drives to the control unit by means of the signal status word. For this purpose, the signal status word needs to be integrated in the AT as cyclic data. Bits in the signal status word are definable by means of the configuration list of the signal status word (see S-0-0026).</td></tr>
<tr><td>2
binary</td><td>Structure of signal status word:
Bits 15 – 0 are defined in configuration list S-0-0026</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0145</td><td colspan="2">Signal control word</td></tr>
<tr><td colspan="2">Signals can be transmitted in real-time from the control unit to the drives by means of the signal control word. For this purpose, the signal control word needs to be integrated in the MDT as cyclic data. Bits in the signal control word are definable by means of the configuration list of the signal control word (see S-0-0027).</td></tr>
<tr><td>2
binary</td><td>Structure of signal control word:
Bits 15 – 0 are defined in configuration list S-0-0027</td></tr>
</table>

<table>
<tr><td rowspan="2">S-0-0146</td><td>Control unit controlled homing procedure command</td></tr>
<tr><td>When the master sets and enables the control unit controlled homing procedure command, the drive has to react on the programmed or assigned signals (homing enable S-0-0407, home switch S-0-0400, reference marker pulse of the feedback system).
When it reaches the appropriate marker pulse of the feedback system, the drive has to store the position feedback value in the corresponding marker position (S-0-0173 and S-0-0174). Furthermore, the drive has to set the signal "reference marker pulse registered" (S-0-0408). Afterwards, the drive acknowledges the procedure command as performed correctly.
When an error of C1D occurs, the procedure command results in an error in the procedure command acknowledgment.
For more details see clause 14.6</td></tr>
</table>

	2 binary	Structure of the control unit controlled homing procedure command: see Table 23. Structure of procedure command acknowledgment: see Table 24.

S-0-0147	Homing parameter	
	This parameter is used to align sequences during the Homing procedure with the installation of the machine, the control unit or the drive. For the drive controlled homing procedure command, only bit 0, bit 1, bit 2, bit 3, bit 5, bit 6, bit 7 and bit 8 apply. For the control unit controlled homing procedure command, only bit 1, bit 2, bit 3, and bit 4 apply.	
	2 binary	Structure of homing parameter: Bit 0: Homing direction 0 – positive: increasing position values 1 – negative: decreasing position values Bit 1: Position feedback marker pulse 0 – first marker pulse after the positive edge of the home switch (S-0-0400) 1 – first marker pulse after the negative edge of the home switch (S-0-0400) Bit 2: Home switch (S-0-0400) 0 – connected to the control unit 1 – connected to the drive Bit 3: Homing 0 – using motor feedback 1 – using external feedback Bit 4: Interpretation in the drive 0 – home switch and homing enable (S-0-0407) 1 – homing enable only Bit 5: Evaluation of home switch 0 – home switch is evaluated 1 – home switch is not evaluated Bit 6 Evaluation of position feedback marker pulse 0 – marker pulse is evaluated 1 – marker pulse is not evaluated Bit 7: Position after drive controlled homing 0 - drive is positioned at an arbitrary position 1 - drive is positioned at the Reference position (S-0-0052, S-0-0054) Bit 8: Drive controlled homing with homing distance 0 - Homing distance is not selected 1 - Homing distance is selected (S-0-0297) Bit 9: Homing with Limit switch 0 – without limit switch 1 – with limit switch (bit 5 = 1, bit 10 = 0) Bit 10: Homing with Positive Stop 0 – without positive stop 1 – with positive stop (bit 5 = 1, bit 9 = 0, see S-0-0530 Clamping torque Bits 15-11: (reserved)

S-0-0148	Drive controlled homing procedure command	
	When the Master sets and enables the Drive Controlled homing procedure command, the drive automatically activates the drive internal position control and accelerates to the homing velocity (S-0-0041) taking the Homing acceleration (S-0-0042) into account. The drive resets the bit "position feedback value status" (S-0-0403). Further options for the homing procedure are programmed in the "homing parameter" (S-0-0147). All changes of the cyclic command values are ignored as long as the procedure command is activated. After passing over the reference marker pulse, the drive decelerates to standstill, taking the homing acceleration into account, or travels to the reference position. The procedure command "drive controlled homing" is successfully completed when the drive has stopped and the position feedback value is referred to the reference point of the machine. The drive announces this by setting the bit "position feedback value status" (S-0-0403). The drive internally calculates the commanded position value (S-0-0047) relationship to the reference mark and adjusts S-0-0047 accordingly. The control unit must then either read the "position command value" (S-0-0047) of the drive via the service channel and resets it's position command value to this position command value, or the control sets its position command off the reference distance (S-0-0052, S-0-0054), (S-0-0147 must be set to 1). Afterwards, the procedure command is canceled by the control unit and the drive once again follows the command values of the control unit. An interrupt of this procedure command will result in the position feedback value not being referenced to the position feedback reference mark. Also the 'position feedback status value' bit will not be set. When an error of C1D occurs, the procedure command results in an error in the procedure command acknowledgment. For more details see clause 14.6.	
	2 binary	Structure of the drive controlled homing procedure command: see Table 23) Structure of command acknowledgment: see Table 24.

S-0-0149	Positive drive stop procedure command	
	The positive drive stop procedure command results in all feedback monitors being shut off which otherwise would result in a C1D shut-down error due to drive locking during the positive stop. Shutting off the feedback monitoring system applies to all drive operation modes. The sequence of the positive stop drive procedure command is identical in both operation modes; velocity control and position control. The command is positively acknowledged as soon as: – monitoring of the feedback system is turned off; – $\lvert T \rvert \geq \lvert T_{\text{limit}} \rvert$; and – n_{feedback} = 0 is true.	
	2 binary	Structure of the positive drive stop procedure command: see Table 23. Structure of command acknowledgment: see Table 24.

S-0-0150	Reference offset 1		
	This parameter describes the distance between the reference marker pulse of position feedback 1 and the reference point. For more details see clause 14.6.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0151	Reference offset 2		
	This parameter describes the distance between the reference marker pulse of position feedback 2 and the reference point. For more details see clause 14.6.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0152	Position spindle procedure command	
	This procedure command automatically switches the drive to internal position loop control, below the spindle positioning speed (S-0-0222), and references the spindle, if necessary. While this command is active, all changes to cyclic command values are ignored. Additionally, depending on the Spindle position parameter (S-0-0154), the drive positions the spindle absolute to the programmed angle position (S-0-0153) or rotates the spindle relative (incrementally) (S-0-0180). When the drive interpolator reaches the selected command value, the drive sets the status ‘Target position attained’(S-0-0342). The status ‘In coarse position’ (S-0-0341) or ‘In Position’ (S-0-0336) are updated by the drive. While this procedure command is active, the drive maintains the position control and adjusts to every new command value (S-0-0153 or S-0-0180) which is transferred through the service channel. When the control unit cancels this command, the drive switches over to the mode of operation set in the control word. Refer to the Spindle position diagram (see Figure 110, Figure 111, Figure 112). clause 14.7 describes more functions.	
	2 binary	Structure of position spindle procedure command: see Table 23. Structure of procedure command acknowledgment: see Table 24.

S-0-0153	Spindle angle position		
	This parameter is the absolute spindle angle position relative to the reference point. The parameter is enabled only in connection with the position spindle procedure command (see S-0-0152) or the drive-controlled synchronous operation procedure command (see S-0-0223).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0154	Spindle positioning parameter

	When the velocity command value is equal to zero and the position spindle procedure command is active, the turning direction for reaching the spindle angle position can be given here. If the velocity command value is not equal to zero, the current turning direction is maintained in order to reach the spindle angle position.	
	2 binary	Structure of spindle position parameter: Bit 0-1: 00 – rotate clockwise 01 – rotate counter-clockwise 10 – take shortest path 11 – last active rotational direction Bit 2: 0 - spindle angle position (S-0-0153) 1 - spindle relative offset (S-0-0180) Bit 3: 0 – motor feedback 1 – external feedback Bit 4: **0** – a not referenced spindle activates once the homing. At every further start of the position spindle procedure command the spindle is positioning on the spindle angle position only (S-0-0153). **1** - at every start of the position spindle procedure command the spindle activates the homing (with home switch or encoder reference) after this the spindle is positioning on the spindle angle position.) Bits 15-5: (reserved)

S-0-0155	Friction torque compensation		
	The friction torque compensation is overlaid additively to the torque command value. During addition, the friction torque compensation and torque command value need to have the same sign. The inclusion of friction torque compensation helps compensate for the frictional grip during acceleration from standstill, and during reversals.		
	2 unsigned decimal		Scaling of torque/force data (see clause 14.2.3)

S-0-0156	Velocity feedback value 2		
	The velocity feedback value 2 is transferred from the drive to the control unit in order to allow the control unit to periodically display the velocity. The velocity feedback value 2 refers to the external encoder.		
	4 signed decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0157	Velocity window		
	The velocity window" relates the current velocity to the sum of the velocity command values. If the current velocity feedback value falls within the calculated velocity window, the drive sets the status '$n_{feedback} = n_{command}$' (S-0-0330). See clause 14.9.		
	4 unsigned decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0158	Power threshold (P_X)			
	The power threshold (P_X) parameter determines at which power level the drive generates the status '$P \geq P_X$' (see S-0-0337).			
	4 unsigned decimal		1	W

S-0-0159	Monitoring window		
	By means of the monitoring window, the maximum position deviation, as referenced to the active position feedback value, can be defined for the position feedback value. When the position error value exceeds the maximum value of the monitoring window, the drive sets an error for excessive position deviation in C1D (S-0-0011).		
	4 unsigned decimal		Scaling of position data (see clause 14.2.1)

S-0-0160	Acceleration data scaling type
	A variety of scaling methods can be selected by means of the acceleration data scaling type parameter (see also Figure 88)

	2 binary	Structure of the acceleration data scaling type: Bits 2–0: Scaling method 000 – no scaling 001 – linear scaling 010 – rotational scaling 011 – ramp time (see S-0-0446) Ramp reference velocity Bit 3: 0 – preferred scaling 1 – parameter scaling Bit 4: Units for linear scaling 0 – metres [m] (1 – inches [in]) additional Bit 4: Units for rotational scaling 0 – radian [rad] 1 – (reserved) Bit 5: Time units 0 – seconds [s] 1 – (reserved) Bit 6: Data reference 0 – at the motor shaft 1 – at the load (all other bits are reserved))				
	Bit	6	5	4	3	2-0
	no scaling	0	0	0	0	000
	linear	0/1	0	0/1	0/1	001
	rotational	0/1	0	0	0/1	010
	ramp time	0/1	0	0	0/1	011

S-0-0161	Acceleration data scaling factor		
	This parameter defines the scaling factor for all acceleration data in a drive.		
	2 unsigned decimal	Min. ≥ 1	

S-0-0162	Acceleration data scaling exponent		
	This parameter defines the scaling exponent for all acceleration data in a drive.		
	2 signed decimal		Structure of the scaling exponent: Bit 15: Sign of the exponent 0 – positive 1 – negative Bits 14-0: Exponent

S-0-0163	Weight counterbalance		
	This parameter is used to program the counterbalance (torque) of vertically positioned (hanging) axes in the positive or negative effective direction.		
	2 signed decimal		Scaling of torque/force data (see clause 14.2.3)

S-0-0164	Acceleration feedback value 1		
	The acceleration feedback value 1 is the velocity change refered to the motor encoder. Velocity increase is described as positive acceleration. Velocity decrease is described as negative acceleration.		
	4 signed decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0165	Distance-coded reference marks A		
	When a measuring system with distance-coded reference marks is being used, this parameter contains the larger periodic distance between two of the reference marks.		
	4 unsigned decimal		(Scaling and unit defined by the drive manufacturer)

<table>
<tr><td rowspan="3">S-0-0166</td><td colspan="3">Distance-coded reference marks B</td></tr>
<tr><td colspan="3">When a measuring system with distance-coded reference marks is being used, this parameter contains the smaller periodic distance between two of the reference marks.</td></tr>
<tr><td>4
unsigned decimal</td><td></td><td>(Scaling and unit defined by the drive manufacturer)</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0167
S-0-0168</td><td colspan="4">Frequency limit of feedback 1
Frequency limit of feedback 2</td></tr>
<tr><td colspan="4">The frequency limit of feedback 1 is the maximum frequency of the motor feedback signal, i.e., the maximum working frequency which the electronics can output in pulses per second.
The frequency limit of feedback 2 is the maximum frequency of the external feedback signal, i.e., the maximum working frequency which the electronics can output in pulses per second.
If these frequencies were exceeded, the drive would loose its reference to the machine zero point and bit 0 of the position feedback value status (S-0-0403) would be reset.</td></tr>
<tr><td>4
unsigned decimal</td><td></td><td>1</td><td>Hz</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0169</td><td colspan="2">Probe control parameter</td></tr>
<tr><td colspan="2">This parameter fixes which probes and which edges are activated for the probing cycle procedure command.
For more details see clause 14.8.</td></tr>
<tr><td>2
binary</td><td>Structure of probe control parameter:
Bit 0: Probe 1 positive edge
0 – positive edge is not active
1 – positive edge is active
Bit 1: Probe 1 negative edge
0 – negative edge is not active
1 – negative edge is active
Bit 2: Probe 2 positive edge
0 – positive edge is not active
1 – positive edge is active
Bit 3: Probe 2 negative edge
0 – negative edge is not active
1 – negative edge is active
(all other bits are reserved)</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0170</td><td colspan="2">Probing cycle procedure command</td></tr>
<tr><td colspan="2">When the master sets and enables the probing cycle procedure command, the drive reacts on the following parameters:
– probe 1/2 enable (S-0-0405, S-0-0406); and
– probe 1/2 (S-0-0401, S-0-0402) as programmed in the probe control parameter (S-0-0169).
While the procedure command is activated, the control unit can start multiple measurements.
If the control unit does not want any more measurements, the control unit cancels the procedure command.
For more details see clause 14.8.</td></tr>
<tr><td>2
binary</td><td>Structure of probing cycle procedure command: see Table 23.
Structure of command acknowledgment: see Table 24.</td></tr>
</table>

<table>
<tr><td>S-0-0171</td><td>Calculate displacement procedure command</td></tr>
</table>

	When the master sets and enables the procedure command "calculate displacement" the drive takes the parameters: – reference distance 1/2 (S-0-0052/S-0-0054); – reference Offset 1/2 (S-0-0150/S-0-0151); – marker position A and marker position B (S-0-0173/S-0-0174); into account to calculate the displacement between the old and the new (referenced) command/feedback system. The calculated displacement is stored in the parameters – displacement parameter 1 (S-0-0175, motor feedback); – displacement parameter 2 (S-0-0176, external feedback). The feedback system for which the displacement has to be calculated is selected in the homing parameter (S-0-0147, bit 3). When the drive recognizes the displacement as invalid, the procedure command results in an error in the procedure command acknowledgment. For more details see clause 14.6.		
	2 binary	Structure of the calculated displacement procedure command: see Table 23. Structure of command acknowledgment: see Table 24.	

S-0-0172	Displacement to the referenced system procedure command		
	When the master sets and enables the procedure command "displacement to the referenced system", the drive switches to the referenced position feedback system and marks this by simultaneously setting the bit "position feedback value status" (S-0-0403). To inform the control unit about the switching in real-time, the bit "position feedback value status" has to be assigned to a real-time status bit. While the procedure command is activated, the control unit switches to the referenced command value system and marks this by simultaneously setting the bit "position command value status" (S-0-0404). To inform the drive about the switching in real-time, the bit "position command value status" has to be assigned to a real-time control bit. The bit "position command value status" has to be set by the control unit independent from the operation mode. The procedure command is completed by the drive as soon as the bits "position feedback value status" and "position command value status" are set to 1. There is no fixed sequence to set the bits. For more details see clause 14.6.		
	2 binary	Structure of the displacement to the referenced system procedure command: see Table 23. Structure of command acknowledgment: see Table 24.	

S-0-0173	Marker position A		
	When the drive recognizes the reference marker pulse of position feedback 1/2 during homing, it stores the instantaneous unreferenced position feedback value 1/2 in the parameter marker position A. There are groups of two reference marker pulses with a distance coded feedback system. When the drive recognizes the first reference marker pulse of distance coded position feedback 1/2 during homing, it stores the instantaneous unreferenced position feedback value 1/2 in the parameter marker position A.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0174	Marker position B
	The marker position B is used additionally for distance coded feedback to be able to calculate the absolute position referred to the zero point of the feedback system. There are groups of two reference marker pulses with a distance coded feedback system. When the drive recognizes the second reference marker pulse of distance coded position feedback 1/2 during homing, it stores the instantaneous unreferenced position feedback value 1/2 in the parameter marker position B.

	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0175	Displacement parameter 1		
	When the procedure command "calculate displacement" (S-0-0171) or “Set absolute position” (S-0-0447) is active, the drive calculates the difference between the old position feedback value and the new position feedback value. The drive stores the difference as the "displacement Parameter 1" if motor feedback is selected. For more details see clause 14.6.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0176	Displacement parameter 2		
	When the procedure command "calculate displacement" (S-0-0171) or “Set absolute position” (S-0-0447) is active, the drive calculates the difference between the old position feedback value and the new position feedback value. The drive stores the difference as the "displacement parameter 2" if external feedback is selected. For more details see clause 14.6.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0177	Absolute distance 1		
	This parameter describes the distance between the machine zero point and the zero point of an absolute feedback system on the motor.		
	4 signed decimal		(Scaling and unit defined by the drive manufacturer)

S-0-0178	Absolute distance 2		
	This parameter describes the distance between the machine zero point and the zero point of an absolute feedback system on the machine (external feedback system).		
	4 signed decimal		(Scaling and unit defined by the drive manufacturer)

S-0-0179	Probe status	
	If the drive stores one or more measurement values while the procedure command "probing cycle" (S-0-0170) is activated, it simultaneously sets the assigned bit in the probe status. If probe 1 enable (S-0-0405) is reset by the control unit, the drive resets bit 0 and bit 1 of probe status. If probe 2 enable (S-0-0406) is reset by the control unit, the drive resets bit 2 and bit 3 of probe status. The drive resets all bits of the probe status when the control unit cancels the "probing cycle procedure command" (S-0-0170).	
	2 binary	Structure of probe status: Bit 0: Probe 1 positive latched (see S-0-0409) 0 – not latched 1 – latched Bit 1: Probe 1 negative latched (see S-0-0410) 0 – not latched 1 – latched Bit 2: Probe 2 positive latched (see S-0-0411) 0 – not latched 1 – latched Bit 3: Probe 2 negative latched (see S-0-0412) 0 – not latched 1 – latched (all other bits are reserved)

S-0-0180	Spindle relative offset

	The parameter is enabled only in connection with the position spindle procedure command (see S-0-0152). The spindle relative offset is added to the absolute position value while being processed. This parameter is used to drive the spindle of a certain number of revolutions.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0181	Manufacturer class 2 diagnostic	
	The drive manufacturer can define additional shut-down warnings in manufacturer class 2 diagnostics. If a warning is set or reset in the manufacturer class 2 diagnostic, the manufacturer-specific warning bit in class 2 diagnostic (see S-0-0012) is set as well. When the manufacturer class 2 diagnostic is read via the service channel, the manufacturer specific warning bit in class 2 diagnostic is reset to 0, but the change bit for C2D (bit 12) in the drive status is not changed.	
	2 binary	Structure of manufacturer C2D: Bits 15 – 0: all 0s – no warning all 1s – warning occurred

S-0-0182	Manufacturer class 3 diagnostic	
	The drive manufacturer can define additional operation status conditions in the manufacturer class 3 diagnostic. If an operation status is set or reset in the manufacturer class 3 diagnostic, the manufacturer-specific operation status bit in class 3 diagnostic (see S-0-0013) is set as well. When the manufacturer class 3 diagnostic is read via the service channel, the manufacturer specific operation status bit in class 3 diagnostic is reset to 0, but the change bit for C3D (bit 11) in the drive status is not changed.	
	2 binary	Structure of manufacturer C3D: Bits 15 – 0: all 0s – no conditions exist any bit(s) set – operation condition(s) exist

S-0-0183	Synchronization velocity window		
	If during velocity synchronous operation the difference between the synchronous velocity command value of the lead spindle and the velocity feedback value of the synchronous spindle falls within the synchronization window, the drive sets the synchronization operation status (see S-0-0308). When necessary, the synchronization operation status can be assigned to a real-time status bit in the drive status word and transferred to the control unit.		
	4 signed decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0184	Synchronization velocity error limit		
	If during velocity synchronous operation the difference between the synchronous velocity command value of the lead spindle and the velocity feedback value of the synchronous spindle becomes greater than the synchronization velocity error limit value, the drive sets the synchronization error status (see S-0-0309). When necessary, the synchronization error status can be assigned to a real-time status bit in the drive status word and transferred to the control unit.		
	4 signed decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0185	Length of the configurable data record in the AT			
	The drive indicates the maximum length in bytes which can be processed in the configurable data record of the AT in the operation data of this IDN. The drive needs to support this IDN only if it allows the application telegram in its telegram type parameter (see S-0-0015).			
	2 unsigned decimal		1	Byte

S-0-0186	Length of the configurable data record in the MDT
	The drive indicates the maximum length in bytes which can be processed in the configurable data record of the MDT in the operation data of this IDN. The drive needs to support this IDN only if it allows the application telegram in its telegram type parameter (see S-0-0015).

	2 unsigned decimal		1	Byte

S-0-0187	IDN-list of configurable data in the AT	
	This list consists of the IDNs of operation data which can be processed by the drive cyclically as feedback values. The drive needs to support this list only if it allows the application telegram in its telegram type parameter (see S-0-0015).	
	2, variable IDN	Structure of the IDN-list of configurable data in the AT: (see Figure 69).

S-0-0188	IDN-list of configurable data in the MDT	
	This list consists of the IDNs of operation data which can be processed by the drive cyclically as command values. The drive needs to support this list only if it allows the application telegram in its telegram type parameter (see S-0-0015).	
	2, variable IDN	Structure of the IDN-list of configurable data in the MDT: (see Figure 69)

S-0-0189	Following distance		
	The drive uses the operation data of this IDN to store the distance between position command value and the appropriate position feedback value 1/2. Calculation of the following distance: following distance = position command value – position feedback value 1/2		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0190	Drive controlled gear engaging procedure command	
	When the drive controlled gear engaging procedure command is activated, the drive ignores the cyclic command values and turns in the average engaging speed (S-0-0214). With this procedure command, the "gear engaging function" is activated in the drive using the parameters – engaging dither amplitude (S-0-0213) – average engaging speed (S-0-0214) – engaging dither period (S-0-0215) in order to improve the gear shifting. When the relevant actual values fulfil the conditions of the gear engaging function, the drive signals the procedure command as performed correctly. When the master cancels the procedure command, the drive turns off the gear engaging function and the cyclic command values are valid in the drive again. For more details see 14.16.	
	2 binary	Structure of the drive controlled gear engaging procedure command: see Table 23. Structure of command acknowledgment (see data status): see Table 24.

S-0-0191	Cancel reference point procedure command	
	When the master sets and enables the procedure command "cancel reference point" the drive resets the bit "position feedback value status" (S-0-0403). The procedure command is completed successfully by the drive as soon as the bit "position feedback value status" is reset to 0.	
	2 binary	Structure of the cancel reference point procedure command: see Table 23. Structure of command acknowledgment: see Table 24.

S-0-0192	IDN-list of all backup operation data	
	The IDN-list stores IDNs of all drive data that have to be loaded in the drive in order to guarantee correct operation. The master uses this list to generate a backup copy of the drive parameters (e.g., on a floppy disk).	
	2, variable IDN	Structure of the IDN-list of backup operation data (see Figure 69).

S-0-0193	Positioning jerk		
	"Positioning jerk" is the maximum rate of change of acceleration in the operation modes "Interpolation" and "Positioning". Programming a value of zero will cause jerk limiting to be deactivated.		
	4 signed decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0194	Acceleration command value		
	The acceleration command value can be transferred on demand by the control unit as cyclic data or via the service channel.		
	4 signed decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0195	Acceleration feedback value 2		
	The acceleration feedback value 2 is the velocity change refered to the external encoder. Velocity increase is described as positive acceleration. Velocity decrease is described as negative acceleration.		
	4 signed decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0196	Motor rated current			
	The motor rated current is the current at which the motor produces the rated torque according to the motor spec sheet. For all asynchronous motors, this parameter is used as a reference for all torque data and for determining motor related current values.			
	4 unsigned decimal	Min. ≥ 0	0,001	A

S-0-0197	Set coordinate system procedure command	
	After activation of the “Set coordinate system procedure command”, the drive ignores the position command value and instead transfers the programmed “Initial coordinate value” (S-0-0198) into the drive-internal position command. Additionally, the drive re-calculates all absolute values (feedbacks, position limits, etc.), relating them to the “Initial coordinate value”. The position feedback value status (S-0-0403) and position command value status (S-0-0404) are not affected by this procedure command. This procedure command is successfully completed by the drive when all necessary calculations are completed, the “Current coordinate offset” (S-0-0283) is calculated, and the drive has based its coordinate system on the “Initial coordinate value” (S-0-0198). Before the control clears the command, it must also adjust its coordinate system to the same value the drive used. After clearing of the procedure command, the drive will once again act upon the position command. The procedure command will terminate with a fault, when the drive detects an error during the command specific calculations.	
	2 binary	Structure of the procedure command: (see Table 23) Structure of command acknowledgment: (see Table 24)

S-0-0198	Initial coordinate value		
	The drives coordinate system will be set to the value programmed as the initial coordinate value during the Set coordinate system procedure command (S-0-0197)		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0199	Shift coordinate system procedure command

	After activation of the "Shift coordinate system procedure command", the drive ignores the position command value and instead adds the programmed "Coordinate offset value" (S-0-0275) to the drive-internal position command. Additionally, the drive re-calculates all absolute values (feedbacks, position limits, etc.), relating them to the "Coordinate offset value". The position feedback value status (S-0-0403) and position command value status (S-0-0404) are not affected by this procedure command. This procedure command is successfully completed by the drive when all necessary calculations are completed, the "Current coordinate offset" (S-0-0283) is calculated, and the drive has adjusted its coordinate system based upon the "Coordinate offset value". Before the control clears the procedure command, it must also adjust its coordinate system to the same value the drive used. After clearing of the procedure command, the drive will again act upon the position command. The procedure command will terminate with a fault, when the drive detects an error during the command specific calculations.	
	2 binary	Structure of the procedure command: (see Table 23) Structure of command acknowledgment: (see Table 24)

S-0-0200	Amplifier warning temperature		
	When the amplifier temperature exceeds the amplifier warning temperature value, the drive sets the warning bit for amplifier overtemperature in C2D (S-0-0012).		
	2 unsigned decimal	Min. ≥ 0	Scaling type, S-0-0208

S-0-0201	Motor warning temperature		
	When the motor temperature exceeds the motor warning temperature value, the drive sets the warning bit for motor overtemperature in C2D (S-0-0012).		
	2 unsigned decimal	Min. ≥ 0	Scaling type, S-0-0208

S-0-0202	Cooling error warning temperature		
	When an error occurs in the cooling system (e.g., the temperature inside the circuitry housing exceeds the cooling error warning temperature value), the drive sets the warning bit for cooling error in C2D (S-0-0012).		
	2 unsigned decimal		Scaling type, S-0-0208

S-0-0203	Amplifier shut-down temperature		
	When the amplifier temperature exceeds the amplifier shut-down temperature value, the drive sets the bit for amplifier overtemperature shut-down in C1D (S-0-0011).		
	2 unsigned decimal		Scaling type, S-0-0208

S-0-0204	Motor shut-down temperature		
	When the motor temperature exceeds the motor shut-down temperature value, the drive sets the bit for motor overtemperature shut-down in C1D (S-0-0011).		
	2 unsigned decimal		Scaling type, S-0-0208

S-0-0205	Cooling error shut-down temperature		
	When an error occurs in the cooling system (e.g., the temperature inside the circuitry housing exceeds the cooling error shut-down temperature value), the drive sets the bit for cooling error shut-down in C1D (S-0-0011).		
	2 unsigned decimal		Scaling type, S-0-0208

S-0-0206	Drive on delay time			
	After torque is activated (bit 14, drive status is set) "drive on delay time" is started. The drive follows the command values after the "drive on delay time" has elapsed.			
	2 unsigned decimal		0,1	ms

S-0-0207	Drive off delay time			
	After "drive off" (bit 15 of the master control word) is reset and n_{min} is reached, the drive off delay time is started and the locking of the brake is initiated. The torque remains activated in the drive until this drive off delay time is elapsed. Example: Used as break delay time (clamping or release).			
	2 unsigned decimal		0,1	ms

S-0-0208	Temperature data scaling type	
	This scaling type parameter determines whether temperature is used in units of °C or F. Temperature scaling is 0,1 °C or 0,1 F. The data length of temperature data is fixed to two bytes.	
	2 binary	Structure of temperature data scaling type: Bit 0: 0 – entry in 0,1 °C 1 – entry in 0,1 F (all other bits are reserved)

S-0-0209	Lower adaptation limit		
	Below the lower adaptation limit, the proportional gain adaptation (S-0-0211) and the integral action time adaptation (S-0-0212) are enabled. Above the lower adaptation limit, the adaptation of proportional gain and the integral action time change linearly from the lower level to the values at the upper adaptation limit, as defined for the velocity loop proportional gain (S-0-0100) and the velocity loop integral action time (S-0-0101).		
	4 unsigned decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0210	Upper adaptation limit		
	Above the upper adaptation limit, the velocity loop proportional gain (S-0-0100) and the velocity loop integral action time (see S-0-0101) are enabled. Below the upper adaptation limit, the proportional gain and the integral action time velocity loops change linearly from the higher level to the values at the lower adaptation limit as defined for the proportional gain adaptation (S-0-0211) and the integral action time adaptation (S-0-0212).		
	4 unsigned decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0211	Adaptation proportional gain			
	Adaptation proportional gain determines the percentage value below the lower adaptation limit, dependent on the velocity loop proportional gain (S-0-0100). Above the upper adaptation limit, adaptation proportional gain is not enabled. Between the upper and lower adaptation limits, the velocity loop proportional gain changes linearly, dependent on the adaptation proportional gain and the actual velocity (example: see Figure 89).			
	2 unsigned decimal		0,1	%

S-0-0212	Adaptation integral action time			
	Adaptation integral action time determines the percentage value below the lower adaptation limit, dependent on the velocity loop integral action time (S-0-0101). Above the upper adaptation limit, adaptation integral action time is not enabled. Between the lower and upper adaptation limits, the velocity loop integral action time changes linearly, dependent on the adaptation integral action time and the actual velocity (example: see Figure 90).			
	2 unsigned decimal		0,1	%

S-0-0213	Engaging dither amplitude			
	The engaging dither amplitude defines the maximum speed of the drive in both directions during the drive controlled gear engaging procedure command. Data reference is the motor shaft.			
	4 unsigned decimal		10^{-4}	min^{-1}

S-0-0214	Average engaging speed			
	During the drive controlled gear engaging procedure command, the drive adds the programmed average engaging speed to the engaging dither amplitude. Data reference is the motor shaft.			
	4 unsigned decimal		10^{-4}	min^{-1}

S-0-0215	Engaging dither period			
	During the drive controlled gear engaging procedure command, the drive oscillates at its programmed engaging dither amplitude, average engaging speed, and engaging dither period.			
	2 unsigned decimal		0,1	ms

S-0-0216	Switch parameter set procedure command	
	This procedure command allows the system to switch parameter sets and/or gear ratio. The drive switches to the parameter set which is programmed in the parameter set preselection (S-0-0217). If a gear ratio has also been programmed in the gear ratio preselection (S-0-0218), the gear ratio is switched as well.	
	2 binary	Structure of the cancel reference point procedure command: see Table 23. Structure of command acknowledgment: see Table 24.

S-0-0217	Parameter set preselection	
	The parameter set of the drive is selected by means of the parameter set preselection. The switch parameter set procedure command (see S-0-0216) is used to switch parameter sets. If the drive has no switchable parameter sets, it will only accept parameter set 0. Therefore, parameter set 0 must be available in every drive and will be activated during initialization.	
	2 binary, hex or dec	Structure of parameter set preselection: Bit 2 – 0: 0 0 0 – parameter set 0 0 0 1 – parameter set 1 0 1 0 – parameter set 2 0 1 1 – parameter set 3 1 0 0 – parameter set 4 1 0 1 – parameter set 5 1 1 0 – parameter set 6 1 1 1 – parameter set 7 (all other bits are reserved)

S-0-0218	Gear ratio preselection	
	The gear ratio preselection selects the gear ratio of the drive. The switch parameter set procedure command (see S-0-0216) is used to switch the gear ratio. If the drive switches to another gear ratio, additional parameters (see S-0-0217, S-0-0219) can be activated.	
	2 binary, hex or dec	Structure of the gear ratio preselection: Bit 2 – 0: 0 0 0 – gear ratio 0 0 0 1 – gear ratio 1 0 1 0 – gear ratio 2 0 1 1 – gear ratio 3 1 0 0 – gear ratio 4 1 0 1 – gear ratio 5 1 1 0 – gear ratio 6 1 1 1 – gear ratio 7 (all other bits are reserved)

S-0-0219	IDN–list of parameter set

	IDN-list of S-0-0219 contains all IDNs of parameter set 0 which are also supported in the parameter sets 1 – 7. IDN-list S-X-0219 (X =1..7) contains all the IDNs of operation data which are changed automatically when parameter set X is activated. An IDN-list S–X –0219 (X = 1…7) can contain only parameters of parameter set 0.			
	2, variable IDN	Structure of the IDN-list: Refer to operation data with variable length. (see Figure 69)		

S-0-0220	Minimum spindle speed			
	When the speed falls below minimum spindle speed, the drive can shift to another gear (see also S-0-0216).			
	4 unsigned decimal		10^{-4}	min^{-1}

S-0-0221	Maximum spindle speed			
	The maximum spindle speed indicates the limiting speed for the actual gear.			
	4 unsigned decimal		10^{-4}	min^{-1}

S-0-0222	Spindle positioning speed			
	When the position spindle procedure command (see S-0-0152) is received, the drive accelerates or decelerates to the spindle positioning speed, depending upon the current speed.			
	4 unsigned decimal		10^{-4}	min^{-1}

S-0-0223	Drive controlled synchronous operation procedure command	
	When the master activates the drive controlled synchronous operation procedure command, the synchronous spindle is synchronized on the lead spindle as programmed in the synchronous operation parameter (S-0-0225). The synchronous operation is cancelled by disabling the procedure command. The command is executed correctly when synchronized operation status (S-0-0308) has been reached. If the synchronous spindle generates an error of C1D, the procedure command results in an error in the procedure command acknowledgment. If the lead spindle generates errors of C1D, synchronized operation continues. The master transfers the drive controlled synchronous operation procedure command only to the synchronous spindle. Synchronization between lead and synchronous spindle must be maintained during speed changes.	
	2 binary	Structure of the drive controlled synchronous operation procedure command: see Table 23. Structure of the procedure command acknowledgment: see Table 24.

S-0-0224	Lead spindle address			
	This parameter contains the drive address of the lead spindle responsible for synchronous operation. Command values are taken from this address during the synchronous operation command.			
	2 unsigned decimal	Min.: ≥ 1 Max.: ≤ 254	1	

S-0-0225	Synchronous operation parameter
	This parameter contains the control commands for the synchronous operation function.

	2 binary	Structure of the synchronous operation parameter: Bit 0–1: **00** – velocity synchronous mode: For the synchronization only the parameters • synchronization velocity window (S-0-0183) and • synchronization velocity error limit (S-0-0184) are necessary. **01** – (reserved) **10** – relative angle synchronous mode without regard to a reference point and synchronous position offset (S-0-0230). **11** – absolute angle-synchronous mode with regard to a reference point and position-dependent parameter of the synchronous spindle: • synchronous position offset (S-0-0230) • spindle angle position (S-0-0153) Bit 2: **0** – changing speed ratio from lead spindle revolutions (S-0-0226) to synchronous spindle revolutions (S-0-0227). **1** – changing of the speed ratio is complete and the synchronous spindle accepts the ratio. Therefore, new parameters can be issued during the active synchronous operation function. (all other bits are reserved)

S-0-0226	Lead spindle revolutions		
	The speed ratio between the lead spindle and the synchronous spindle is calculated from the revolution ratio between the lead spindle and the synchronous spindle. Speed ratio = Lead spindle revolutions shall be entered as integers.		
	4 signed decimal		1 [lead spindle revolution]

S-0-0227	Synchronous spindle revolutions		
	Refer to lead spindle revolutions (S-0-0226) for speed ratio. Synchronous spindle revolutions shall be entered as integers.		
	4 signed decimal		1 [synchronous spindle revolution]

S-0-0228	Synchronization position window		
	If during synchronization the difference between the synchronous position command value of the lead spindle and the position feedback value of the synchronous spindle falls within the synchronization window, the drive sets the status for synchronization (see S-0-0308). When necessary, the synchronization operation status can be assigned to a real-time status bit in the drive status word and transferred to the control unit.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0229	Synchronization position error limit		
	If during synchronization the difference between the synchronous position command value of the lead spindle and the position feedback value of the synchronous spindle becomes greater than the synchronization error limit value, the drive sets the synchronization error status (see S-0-0309). When necessary, the synchronization error status can be assigned to a real-time status bit in the drive status word and transferred to the control unit.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0230	Synchronous position offset		
	This parameter describes the offset angle between the reference points for lead and synchronous spindle.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0231	deleted			

S-0-0232	deleted			

S-0-0233	deleted			

S-0-0234	deleted			

S-0-0235	deleted			

S-0-0236	deleted			

S-0-0237	deleted			

S-0-0238	deleted			

S-0-0239	deleted			

S-0-0240	deleted			

S-0-0241	deleted

S-0-0242	deleted		

S-0-0243	deleted		

S-0-0244	deleted		

S-0-0245	deleted		

S-0-0246	deleted		

S-0-0247	deleted		

S-0-0248	deleted		

S-0-0249	deleted		

S-0-0250	deleted		

S-0-0251	deleted		

S-0-0252	deleted		

S-0-0253	deleted		

S-0-0254	Actual parameter set	
	This parameter stores the current active parameter set in the drive. If a parameter set is to be switched, it is important that the next consecutive parameter set be updated and correct, and preselected in the parameter set preselection (S-0-0217). Parameter set 0 must be active in every drive before and during initialization.	
	2 binary, hex or dec	Structure of the actual parameter set: Bit 2 – 0: 0 0 0 – parameter set 0 active 0 0 1 – parameter set 1 active 0 1 0 – parameter set 2 active 0 1 1 – parameter set 3 active 1 0 0 – parameter set 4 active 1 0 1 – parameter set 5 active 1 1 0 – parameter set 6 active 1 1 1 – parameter set 7 active (all other bits are reserved)

S-0-0255	Actual gear ratio	
	This parameter stores the current active gear ratio in the drive. If the gear ratio is to be switched, it is important that the next consecutive gear ratio is updated and correct and it must be preselected in the gear ratio preselection (S-0-0218).	
	2 binary, hex or dec	Structure of the actual gear ratio: Bit 2 – 0: 0 0 0 – gear ratio 0 active 0 0 1 – gear ratio 1 active 0 1 0 – gear ratio 2 active 0 1 1 – gear ratio 3 active 1 0 0 – gear ratio 4 active 1 0 1 – gear ratio 5 active 1 1 0 – gear ratio 6 active 1 1 1 – gear ratio 7 active (all other bits are reserved)

S-0-0256	Multiplication factor 1			
	“Multiplication Factor 1” defines the factor that the motor feedback signal is multiplied by in the drive (see S-0-0116). Multiplication factor 1 can also be determined by the drive, taking the “Maximum travel range” (S-0-0278) into account. The drive-internal resolution for the motor encoder is determined from the resolution of feedback 1 (S-0-0116) and multiplication factor 1.			
	4 unsigned decimal		1	

S-0-0257	Multiplication factor 2			
	“Multiplication Factor 2” defines the factor that the EXTERNAL feedback signal is multiplied by in the drive (see S-0-0117). Multiplication factor 2 can also be determined by the drive, taking the “Maximum travel range” (S-0-0278) into account. The drive-internal resolution for the external encoder is determined from the resolution of feedback 2 (S-0-0117) and multiplication factor 2.			
	4 unsigned decimal		1	

S-0-0258	Target position		
	In the “Interpolation”, the control sends the “Target position” as a command to the drive. The drive travels to the target position, taking into account the positioning velocity (S-0-0259), positioning acceleration (S-0-0260), and positioning jerk (S-0-0193).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0259	Positioning velocity		
	The “positioning velocity” is used in the operation modes “Interpolation” and "Positioning"as the velocity to travel to the “Active target position” (S-0-0430).		
	4 signed decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0260	Positioning acceleration		
	The “positioning acceleration” is used in the operation modes “Interpolation” and "Positioning" as the rate to accelerate to and decelerate from the positioning velocity (S-0-0259). If the drive supports the positioning deceleration (S-0-0359), then a separate deceleration can be adjusted.		
	4 signed decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0261	Coarse position window		
	When the difference between the accumulated position command value and the position feedback value is within the range of the “coarse position window”, then the drive sets the status “In coarse position” (S-0-0341). When needed, the status 'in coarse position' is assigned to a real-time status bit within the drive status and then transferred to the control unit (see S-0-0305).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0262	Load defaults procedure command	
	When the master sets and enables the “load defaults” procedure command, the default parameters (basic parameter set) will be activated. The scope and contents of the default parameters (for example limit values, velocity loop settings, etc.) are determined by the drive supplier. The default parameters are not optimized for the respective application, rather they permit a problem free inter-operation between the amplifier and motor. NOTE! This parameter may cause optimized parameters to be overwritten, and the control-registered “Drive ID” (S-0-0271) to be erased.	
	2 binary	Structure of the procedure command: (see Table 23) Structure of command acknowledgment: (see Table 24)

S-0-0263	Load working memory procedure command	
	When the master sets and enables the “Load working memory” procedure command, all data necessary for operation (see “IDN-list of all backup operation data“ S-0-0192) will be loaded from the drive’s non-volatile memory into its “active memory”. After power on, the drive automatically transfers the data from non-volatile memory into the active memory. NOTE! This procedure command will cause active parameters to be overwritten.	
	2 binary	Structure of the procedure command: (see Table 23) Structure of command acknowledgment: (see Table 24)

S-0-0264	Backup working memory procedure command

	When the master sets and enables the "Backup working memory" procedure command, all data necessary for operation (see "IDN-list of all backup operation data" S-0-0192) will be loaded from the drive's "active memory" into its non-volatile memory. NOTE! This procedure command will cause previously saved parameters to be overwritten.	
	2 binary	Structure of the cancel reference point procedure command: see Table 23. Structure of command acknowledgment: see Table 24.

S-0-0265	Language selection	
	This parameter can be used to select one of the languages available in the drive (see S-0-0266). By changing the language selection, text from the drive such as - NAME (Data block element 2) - UNITS (Data block element 4) and - Diagnostic (S-0-0095) will be displayed in the new language.	
	2 binary	Structure of the language selection: Language Codes Bit 4-0: 00000 - German 00001 - English 00010 - French 00011 - Spanish 00100 - Italian 00101 - Portuguese 00110 - Polish 00111 - Hungarian 01000 - Russian (individual character set) 01001 - Swedish 01010 - Danish 01011- Norwegian Bit 7-5: reserved Bit 11-8: 0000 - SERCOS interface character set (see annex E) Bit 15-12: reserved

S-0-0266	List of available languages	
	This list contains codes for all languages currently available in the drive for language selection (See S-0-0265). This list is required if the drive cannot manage or save all languages in his memory simultaneously.	
	2, variable unsigned decimal (Language Codes see S-0-0265)	Structure of the list: (see Figure 69)

S-0-0267	Password

SERCOS interface supports passwords that can be used to write protect selected parameters stored in the drive. S-0-0267 is used to modify passwords, as well as enable and disable write protection.

A password must be between 3 and 10 ASCII characters long. Acceptable characters include the 26 character alphabet, both upper and lower case (A-Z, a-z). Character recognition is case sensitive. The numeric characters 0-9 are also acceptable. The password is stored in non-volatile drive memory.

If a control or operator interface attempts to modify a password listed in the ”IDN list of password protected data” (S-0-0279), The drive will generate the following error message in the Service Channel (see Table 22)
Error Code: 0x7009 “Operation data is password write-protected”.

Reading the current password:
Passwords cannot be read. If an attempt is made to read S-0-0267 over the service channel, the drive will not send the password. A string of 10 asterisk characters (ASCII code $2A_H$=*) will be sent instead (“**********”)

Modifying the password
To modify the password, the currently active password, the new password, and a second verification of the new password are transmitted via the service channel to the drive. A space (ASCII 20_H) character is used to delimit the passwords The new parameter and the verification copy must match for the drive to accept the change. Modifying the password will cause write-protection to be activated.

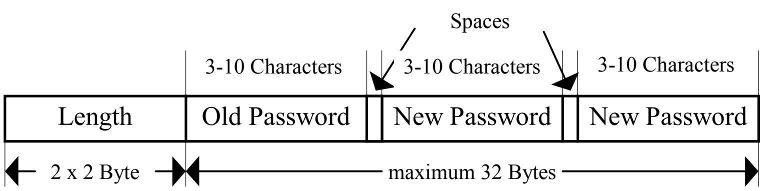
Activating password write protection
Password write-protection will be activated:
1. by cycling (removing and reapplying) power to the drive
2. by attempting to send S-0-0267 to the drive with anything other than the current password

Activating password write protection does not change bits 28, 29 or 39 in the attribute, and affects all parameters specified by the drive supplier or user in the ”IDN list of password protected data” (S-0-0279).

Deactivating password write-protection
Sending S-0-0267 to the drive with the currently active password will deactivate write-protection. Parameters affected by password write protection may then be altered.

With every write access that does not change the password, deactivate password write-protection, or activates password write protection, the drive returns the error message “Invalid data” (Element 7, 0111, code 1000) via the service channel. In the case of an unknown password, a supplier designed master password must be available to deactivate password write protection. This password must always be available as a “current password”, in addition to the user specified password. The drive supplier must provide this or another password in documentation shipped with the drive, so that the user is able to set up their own password..

1, variable text	Structure of the parameter (see Figure 69) See operation data with variable length and ASCII character data type. Data length: Maximum 32 characters.



S-0-0268	Angular setting		
	This parameter describes an absolute angular setting related to the reference point of the synchronous spindle. This parameter allows the synchronous spindle to be rotated a specific amount in relation to the lead spindle. Situations such as arrangements where the tool change spindle orientation is different than the spindle transfer position can make use of this parameter.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0269	Storage mode

	The storage mode parameter setting determines whether data received over the service channel is stored temporarily (e.g., in RAM), or permanently (e.g., EEPROM). Which data (IDN numbers) are affected by the storage mode setting are to be defined by the drive supplier in the drive documentation. Only bit 0 is defined in the operation data.	
	2 binary	Structure of Storage mode: Bit 0: 0 - Data stored permanently 1 - Data stored temporarily

S-0-0270	IDN list of selected backup operation data	
	This IDN is used to define a subset of a drive's entire parameter set that should be backed up into the drive's non-volatile memory. The command procedure "Selectively backup working memory procedure command" (S-0-0293), will only store the operation data of these IDN numbers into non-volatile memory.	
	2, variable IDN	Structure of IDN lists: (see Figure 69)

S-0-0271	Drive ID			
	This IDN is provided by the drive for the control's use. The parameter must be stored by the drive in non-volatile memory. Controls can use this parameter to store a unique ID in each drive. By comparing the value of this IDN in each drive with a control-stored list, the control can determine if a drive or its software has been exchanged. If the two values are not equal, the control can generate a diagnostic intended for startup personnel with recommendations for recovery. The load defaults procedure command (S-0-0262) erases the Drive ID, setting all bits to 0.			
	4 unsigned decimal		1	

S-0-0272	Velocity window percentage			
	The velocity window percentage refers to a percentage of the "Velocity command value" (S-0-0036). See S-0-0330 for additional information. If the velocity feedback value (S-0-0040) is found to be within a window of the velocity command defined by this percentage, the drive will set the status '*n* feedback = *n* command' (S-0-0330).			
	2 unsigned decimal		0,01	%

S-0-0273	Maximum drive off delay time			
	After "drive off" (bit 15, control word) is reset, the „maximum drive off delay time" is started. After the „maximum drive off delay time" is elapsed, the locking of the brake is initiated and the torque is disabled.			
	2 unsigned decimal		0,1	ms

S-0-0274	Received drive addresses	
	If a drive supports the recognition of the physical ring order, then the received drive addresses are stored in this parameter.	
	2, variable unsigned decimal (ADR)	Structure of Received drive addresses: Bit 7-0: received drive address Bit 15-8: set to "0"

S-0-0275	Coordinate offset value
	Using the Shift coordinate system procedure command (S-0-0199), the coordinate system of the drive is shifted by coordinate offset value

	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0276	Return to Modulo range procedure command	
	Activating the command “Return to Modulo range procedure command” causes positive and negative commanded and actual positions, as well as angular values, to be recalculated, based upon the Modulo value (S-0-0103), into a positive command and actual positions. While the command is active, the drive will ignore cyclic command values. The bits “Position feedback value status” (S-0-0403) and “Position command value status” (S-0-0404) are not affected by this command This command is successfully completed by the drive when all necessary calculations are completed. Before the control clears the command, it must also adjust it’s position command to the value the drive calculates After clearing of the command, the drive will again act upon the command for the selected operation mode. The command will terminate with a fault, when the drive detects an error during the command specific calculations. This command is only effective in the drive, when the parameter “Position data scaling type” (S-0-0076) is programmed for absolute format.	
	2 binary	Structure of the procedure command: (see Table 23) Structure of command acknowledgment: (see Table 24)

S-0-0277	Position feedback 1 type	
	The position feedback 1 type parameter refers only to a motor feedback. This parameter is programmed to define the corresponding conditions which apply to the motor feedback (see also S-0-0115).	
	2 binary	Structure of Position Feedback 1 Type Bit 0: Feedback type 0 – rotational feedback (S-0-0117) 1 – linear feedback (S-0-0118) Bit 1: Distance coded feedback 0 – no distance coded reference marks 1 – distance coded reference marks (S-0-0165, S-0-0166) Bit 2: Feedback resolution (S-0-0118) 0 – resolution = metric 1 – resolution = inches Bit 3: Direction polarity 0 – not inverted 1 – inverted Bit 4: marker pulse quantity 0 – only one reference marker pulse 1 – multiple cyclic reference marker pulses Bit 5: Structure of distance coded feedback 0 – counting positive with positive direction 1 – counting negative with positive direction Bit 6: Type of measuring system 0 - relative (incremental) measuring system 1 - absolute measuring system Bit 7: Usage 0 - absolute measurements with an absolute measuring system 1 - relative (incremental) measurements with an absolute measuring system Bits 15-8 (reserved)

S-0-0278	Maximum travel range

	Via this parameter the valid range of position data is defined. For Modulo axes, at the minimum the Modulo value (S-0-0103) must be programmed. Using the gear ratio, the feed constant, and the motor feedback resolution, the drive calculates Multiplication factor 1 (S-0-0256). Using the gear ratio, the feed constant, and the external feedback resolution, the drive calculates Multiplication factor 2 (S-0-0257).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0279	IDN list of password protected data	
	The user can enter into this IDN list the IDN numbers whose operation data should be write-protected via the Password (S-0-0267).	
	2, variable IDN	Structure of the list: (see Figure 69)

S-0-0280 S-0-0281	Underflow threshold Overflow threshold		
	The underflow and overflow parameters are only required when Position, Drive controlled interpolation, or Block modes are used with an endless turning axis. When the underflow or overflow values are reached or exceeded, the drive conducts an automatic correction calculation on both the actual and commanded position systems. Underflow and Overflow thresholds are activated in the Position polarity parameter (S-0-0055) when the Position data scaling type parameter (S-0-0076) is set for absolute format. The difference between “old” and “new” position commands may not be more than one-half the difference between the underflow and overflow thresholds. $\frac{\text{IDN 00281 - IDN 00280}}{2}$ = Maximum position command difference		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0282	Positioning command value		
	The positioning command value is sent to the drive as a relative (incremental) or absolute position command when in "Positioning" operation mode. Toggling bit 0 of “Positioning control word” (S-0-0346) will cause the drive to add or copy the positioning command value to the “Active target position” (S-0-0430), and move to that new position taking into account the positioning velocity (S-0-0259), positioning acceleration (S-0-0260), and positioning jerk (S-0-0193).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0283	Current coordinate offset		
	Via the “Set coordinate system procedure command” (S-0-0197) and the “Shift coordinate system procedure command” (S-0-0199), the drive calculates the offset from the current system to the new coordinate system (referenced to the machine reference point). The control is then always able to reference the absolute position to the machine reference point, even when the coordinate system has been shifted several times.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0284	Secondary operation mode 4
S-0-0285	Secondary operation mode 5
S-0-0286	Secondary operation mode 6
S-0-0287	Secondary operation mode 7

	The drive modes of operation defined by this parameter become active when the operation mode is selected via bits 11, 9, and 8 in the control word of the MDT. If a drive supports secondary operation modes 4 through 7, it must also support bit 11 in the control word and bit 10 in the drive status word. The activated operation mode is indicated by bits 10, 9 and 8 of the drive status in the AT.	
	2 binary	Structure of operation modes: (see Table 44)

S-0-0288	**This IDN is deleted** IDN list of data programmable in CP2 only	
	In this IDN list, the drive indicates all IDN numbers that are programmable in CP2. The order in which the IDNs are entered into the data of this parameter has significance. Using this IDN list, the control or operator interface can extract the parameters for CP2 from a data file in the order they are listed here, and send them to the drive. This handles situations for example where one IDN's limits are dependent upon another IDN's value. The drive need only support this IDN list when not all parameters are programmable in CP2.	
	2, variable IDN	Structure of the list: (see Figure 69)

S-0-0289	**This IDN is deleted** IDN list of data programmable in CP3 only	
	In this IDN list, the drive indicates all IDN numbers that are programmable in CP3. The order in which the IDNs are entered into the data of this parameter has significance. Using this IDN list, the control or operator interface can extract the parameters for CP3 from a data file in the order they are listed here, and send them to the drive. This handles situations for example where one IDN's limits are dependent upon another IDN's value. The drive need only support this IDN list when not all parameters are programmable in CP2.	
	2, variable IDN	Structure of the list: (see Figure 69)

S-0-0290	Device type	
	See specification of I/O-Functions	

S-0-0291	I/O Base	
	See specification of I/O-Functions	

S-0-0292	List of supported operation modes	
	In this list, the drive enters the codes (see Table 44) for all operation modes it supports. Hereby not only the SERCOS interface specified operation modes supported, but also supplier designated coding of operation modes. Using this list, the control as well as the operator interface can determine what operation modes the drive supports	
	2, variable binary or hex (codes)	Structure of the list: (see Figure 69)

S-0-0293	Selectively backup working memory procedure command
	When the master sets and enables the "Selectively backup working memory" procedure command, all data programmed in the "IDN list of selected backup operation data" S-0-0270) will be loaded from the drive's "active memory" into its non-volatile memory. NOTE! This command will cause previously saved parameters to be overwritten.

	2 binary	Structure of the cancel reference point procedure command: see Table 23. Structure of command acknowledgment: see Table 24.

S-0-0294	Divider modulo value			
	If the physical modulo value isn't programmed in the modulo value (S-0-0103), a factor can be entered in this parameter to adapt the modulo value on the physical modulo value. If the modulo value corresponds to the physical modulo value, then the factor must be programmed on the value 1.			
	2 unsigned decimal	Min: ≥ 1	1	

S-0-0295	Drive enable delay time			
	When "drive enable" is set (bits 14, control word) the "drive enable delay time" is started. Motor current (torque) will first be activated after this time delay. The enable delay is required at use of a contactor in the motor cable.			
	2 unsigned decimal		0,1	ms

S-0-0296	Velocity feed forward gain		
	Velocity feed forward is effective in the operation mode “Position control without following error (lag-less)”, and serves to reduce the velocity-dependent following distance.		
	2 or 4 unsigned decimal (attribute has to be checked by the control unit.)		(Scaling and unit defined by the drive manufacturer)

S-0-0297	Homing distance		
	The homing distance is necessary to also use the "drive controlled homing procedure command" (S-0-0148) (e.g. distance coded measurement systems) on mechanical coupled axes (e.g. gantry axes). The procedure command must be synchronized via the drive start / stop bit. The function is selected via bit 8 in the homing parameter (S-0-0147). Remark: On distance coded measurement systems the homing distance must be chosen long enough, that the drive can surely recognise two distance coded reference marks (S-0-0165, S-0-0166). After activation of "drive controlled homing procedure command ", the drive travels the homing distance. At the first reference mark the actual feedback value is saved into the marker position A (S-0-0173), at the second reference mark the actual feedback value is saved into the marker position B (S-0-0174).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0298	Suggest home switch distance		
	There is an optimum distance between the marker pulse of a feedback and the home switch. To assist setup personnel in adjusting this during the first commissioning, this parameter displays the distance between the home switch and the ideal point. The home switch must be either mechanically or electronically shifted by this value. For electronic shifting, this value is entered into the parameter "home switch offset 1 or 2" (S-0-0299 or S-0-0358).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0299	Home switch offset 1

	With digital drives, it is no longer technically possible to mechanically rotate the feedback system on the motor in order to shift the relationship between the marker pulse and home switch. With milled switch dog rails neither can the home switch dog be shifted. Based on these conditions, the home switch offset 1 parameter is programmed during startup so that the home position is unambiguous. The required offset between the home switch and marker pulse is provided by the drive with the aid of the programmed home switch offset 1. The "suggest home switch distance" (S-0-0298) can be transferred into this parameter.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0300	Real-time control bit 1	
	This parameter defines an IDN for the real-time control bit 1 of the control word. In this way the real-time control bit 1 can be assigned to certain functions by its IDN. Only bit 0 is defined for the operation data.	
	2 binary	Structure of real-time control bit 1: Bit 0 = 0: bit reset 1: bit set

S-0-0301	Allocation of real-time control bit 1			
	In order to assign a signal to the real-time control bit 1, the IDN of the signal is written to the operation data allocation for real-time control bit 1. After the allocation of IDN and bit number (see S-0-0413), the assigned signal appears in the real-time control bit 1. If the S-0-0413 of the drive isn't supported, the bit 0 of the IDN is configured automatically.			
	2 IDN			

S-0-0302	Real-time control bit 2	
	This parameter defines an IDN for the real-time control bit 2 of the control word. In this way the real-time control bit 2 can be assigned to certain functions by its IDN. Only bit 0 is defined for the operation data.	
	2 binary	Structure of real-time control bit 2: Bit 0 = 0: bit reset 1: bit set

S-0-0303	Allocation of real-time control bit 2			
	In order to assign a signal to the real-time control bit 2, the IDN of the signal is written to the operation data allocation for real-time control bit 2. After the allocation of IDN and bit number (see S-0-0414), the assigned signal appears in the real-time control bit 2. If the S-0-0414 of the drive isn't supported, the bit 0 of the IDN is configured automatically.			
	2 IDN			

S-0-0304	Real-time status bit 1	
	This parameter defines an IDN for the real-time status bit 1 of the drive status. In this way the real-time status bit 1 can be assigned to certain functions by its IDN. Only bit 0 is defined for the operation data.	
	2 binary	Structure of real-time status bit 1: Bit 0 = 0: bit reset 1: bit set

S-0-0305	Allocation of real-time status bit 1			
	In order to assign a signal to the real-time status bit 1, the IDN of the signal is written to the operation data allocation for real-time status bit 1. After the allocation of IDN and bit number (see S-0-0415), the assigned signal appears in the real-time status bit 1. If the S-0-0415 of the drive isn't supported, the bit 0 of the IDN is configured automatically.			
	2 IDN			

S-0-0306	Real-time status bit 2	
	This parameter defines an IDN for the real-time status bit 2 of the drive status. In this way the real-time status bit 2 can be assigned to certain functions by its IDN. Only bit 0 is defined for the operation data.	
	2 binary	Structure of real-time status bit 2: Bit 0 = 0: bit reset 1: bit set

S-0-0307	Allocation of real-time status bit 2			
	In order to assign a signal to the real-time status bit 2, the IDN of the signal is written to the operation data allocation for real-time status bit 2. After the allocation of IDN and bit number (see S-0-0416), the assigned signal appears in the real-time status bit 2. If the S-0-0416 of the drive isn't supported, the bit 0 of the IDN is configured automatically.			
	2 IDN			

S-0-0308	Synchronization operation status	
	This parameter defines an IDN for the synchronization operation status. Therefore, the synchronization operation status can be assigned to a real-time status bit (see S-0-0305). Case 1, Angle synchronous mode: The synchronization operation status is set when the difference between the synchronous position command value of the lead spindle and the position feedback value of the synchronous spindle is within the value range of the synchronization position window (S-0-0228). Case 2, Velocity synchronous mode: The synchronization operation status is also set when the difference between the synchronous velocity command value of the lead spindle and the velocity feedback value of the synchronous spindle is within the value range of the synchronization velocity window (S-0-0183). Only bit 0 is defined within the operation data.	
	2 binary	Structure of the synchronization operation status: Bit 0: 0 – not synchronized 1 – synchronized (all other bits 0)

S-0-0309	Synchronization error status	
	This parameter defines an IDN for the synchronization error status. Therefore, the synchronization error status can be assigned to a real-time status bit (see S-0-0305). Case 1, Angle synchronous mode: The synchronization error status is set when the difference between the synchronous position command value of the lead spindle and the position feedback value of the synchronous spindle falls outside the value range of the the synchronization position error limit value (S-0-0229). Case 2, Velocity synchronous mode: The synchronization error status is also set when the difference between the synchronous velocity command value of the lead spindle and the velocity feedback value of the synchronous spindle falls outside the value range of the the synchronization velocity error limit value (S-0-0184). Only bit 0 is defined within the operation data.	
	2 binary	Structure of the synchronization error status: Bit 0: 0 – synchronization error limit not exceeded 1 – synchronization error limit exceeded (all other bits 0)

S-0-0310	Overload warning	
	This parameter is used to define an IDN for the overload warning. This allows the overload warning to be assigned, for instance, to a real-time status bit (see S-0-0305). The overload warning is defined as a C2D bit (S-0-0012) and is set appropriately according to the overload limit value (see S-0-0114). Bit 0 is defined for operation data only.	
	2 binary	Structure of overload warning: Bit 0 = 0: no overload warning 1: overload warning

S-0-0311	Amplifier overtemperature warning

	This parameter is used to define an IDN for the amplifier overtemperature warning. This allows the amplifier overtemperature warning to be assigned, for instance, to a real-time status bit (see S-0-0305). The amplifier overtemperature warning is defined as a C2D bit (S-0-0012) and is set appropriately according to the amplifier temperature warning (see S-0-0200). Bit 0 is defined for operation data only.	
	2 binary	Structure of amplifier overtemperature warning: Bit 0 = 0: no amplifier overtemperature warning 1: amplifier overtemperature warning

S-0-0312	Motor overtemperature warning	
	This parameter is used to define an IDN for the motor overtemperature warning. This allows the motor overtemperature warning to be assigned, for instance, to a real-time status bit (see S-0-0305). The motor overtemperature warning is defined as a C2D bit (S-0-0012) and is set appropriately according to the motor temperature warning (see S-0-0201). Bit 0 is defined for operation data only.	
	2 binary	Structure of motor overtemperature warning: Bit 0 = 0: no motor overtemperature warning 1: motor overtemperature warning

S-0-0313	Cooling error warning	
	This parameter is used to define an IDN for the cooling error warning. This allows the cooling error warning to be assigned, for instance, to a real-time status bit (see S-0-0305). The cooling error warning is defined as a C2D bit (S-0-0012) and is set appropriately according to the cooling error warning temperature (see S-0-0202). Bit 0 is defined for operation data only.	
	2 binary	Cooling error warning: Bit 0 = 0: no cooling error warning 1: cooling error warning

S-0-0314	reserved	

S-0-0315	Positioning velocity ≥ n_{Limit}	
	This parameter is used to define an IDN for the positioning velocity > n_{Limit} warning. This allows the warning to be assigned, for instance, to a real-time status bit (for example S-0-0305). The positioning velocity > n_{Limit} warning is defined as a C2D bit (S-0-0012) and is set appropriately when the positioning velocity (S-0-0259) is outside the active velocity limit values (S-0-0038, S-0-0039, S-0-0091). Bit 0 is defined for operation data only.	
	2 binary	Structure of the warning positioning velocity > n_{Limit}: Bit 0: 0 - positioning velocity ≤ n_{Limit} 1 - positioning velocity > n_{Limit}

S-0-0316 to S-0-0322	reserved	

S-0-0323	Target position outside of travel range
	This parameter is used to define an IDN for the target position outside of travel range warning. This allows the warning to be assigned, for instance, to a real-time status bit (for example S-0-0305). The target position outside of travel range warning is defined as a C2D bit (S-0-0012) and is set appropriately when the active target position (S-0-0430) is outside the position limit values (positive or negative, S-0-0049, S-0-0050) NOTE: If the actual position exceeds a position limit value, the C1D bit “overtravel limit is exceeded (shut-down)” (drive status, bit 13) is set. Bit 0 is defined for operation data only.

	2 binary	Structure of the warning target position outside of travel range Bit 0: 0 - target position within position limit values 1 - target position outside of position limit values

S-0-0324	reserved	

S-0-0325	reserved	

S-0-0326	Parameter checksum		
	After being switched on, the control unit is able to find out by comparing, whether the parameters or firmware have changed in the drive. The drive calculates the drive's checksum, when the IDN is read via the service channel. For the calculation of the checksum, the parameters which are saved in S-0-0327 are used. If S-0-0327 is not supported by the drive, the IDN list S-0-0192 is taken for the checksum.		
	4 unsigned decimal		1

S-0-0327	IDN list of checksum parameter	
	This IDN-list contains all ident numbers for the calculation of the parameter checksum. See S-0-0326.	
	2, variable IDN	Structure of the list: (see Figure 69)

S-0-0328	Bit number allocation list for signal status word	
	In this configuration list the bit numbers of the operation data are programmed, which are copied into the signal status word (S-0-0144). The sequence of the bit numbers in the configuration list sets the numerical order in the signal status word. The first bit number in the configuration list sets bit 0, the last bit number sets bit 15 into the signal status word. Maximum 16 bit number can be taken into this list. (see also S-0-0026).	
	2, variable unsigned decimal (bit number)	Structure of the list: (see Figure 69) Maximum input ≤ 63

S-0-0329	Bit number allocation list for signal control word	
	In this configuration list the bit numbers of the operation data are programmed, which are contained in the signal control word (S-0-0145). The sequence of the bit numbers in the configuration list sets the numerical order in the signal control word. The first bit number in the configuration list sets bit 0, the last bit number sets bit 15 in the signal control word. Maximum 16 bit number can be taken into this list. (see also S-0-0027).	
	2, variable unsigned decimal (bit number)	Structure of the list: (see Figure 69) Maximum input ≤ 63

S-0-0330	Status '$n_{feedback} = n_{command}$'

	This parameter is used to define an IDN for the status '$n_{\text{feedback}} = n_{\text{command}}$' This allows the status '$n_{\text{feedback}} = n_{\text{command}}$' to be assigned to a real-time status bit (see S-0-0305). The status '$n_{\text{feedback}} = n_{\text{command}}$' is defined as a C3D bit (S-0-0013) and is set when the velocity feedback value (S-0-0040) lies within the calculated command value for the velocity window (S-0-0157 and / or S-0-0272) which is based upon the velocity command values (see S-0-0036, S-0-0037, etc.). Bit 0 is defined for operation data only. Calculation of $n_{\text{feedback}} = n_{\text{command}}$': $\| n_{\text{feedback}} - n_{\text{command}} \| \leq \| n_{\text{command}} \|$ * S-0-0272 + S-0-0157	
	2 binary	Structure of status '$n_{\text{feedback}} = n_{\text{command}}$' Bit 0 = 0: $n_{\text{feedback}} \neq n_{\text{command}}$ 1: $n_{\text{feedback}} = n_{\text{command}}$

S-0-0331	Status '$n_{\text{feedback}} = 0$'	
	This parameter is used to define an IDN for the status '$n_{\text{feedback}} = 0$'. This allows the status '$n_{\text{feedback}} = 0$' to be assigned to a real-time status bit (see S-0-0305). The status '$n_{\text{feedback}} = 0$' is defined as a C3D bit (S-0-0013) and is set when the velocity feedback value (S-0-0040) is within the standstill window (see S-0-0124). Bit 0 is defined for operation data only.	
	2 binary	Structure of status '$n_{\text{feedback}} = 0$': Bit 0 = 0: $n_{\text{feedback}} \neq 0$ 1: $n_{\text{feedback}} = 0$

S-0-0332	Status '$n_{\text{feedback}} < n_x$'	
	This parameter is used to define an IDN for the status '$n_{\text{feedback}} < n_x$'. This allows the status '$n_{\text{feedback}} < n_x$' to be assigned to a real-time status bit (see S-0-0305). The status '$n_{\text{feedback}} < n_x$' is defined as a C3D bit (S-0-0013) and is set when the velocity feedback value (see S-0-0040) is smaller than the velocity threshold n_x (see S-0-0125). Bit 0 is defined for operation data only.	
	2 binary	Structure of status $n_{\text{feedback}} < n_x$: Bit 0 = 0: $\|n_{\text{feedback}}\| \geq \|n_x\|$ 1: $\|n_{\text{feedback}}\| < \|n_x\|$

S-0-0333	Status '$T \geq T_x$'	
	This parameter is used to define an IDN for the status '$T \geq T_x$' This allows the status '$T \geq T_x$' to be assigned to a real-time status bit (see S-0-0305). The status '$T \geq T_x$' is defined as a C3D bit (S-0-0013) and is set when the torque feedback value (see S-0-0084) is greater than the torque threshold value T_x (see S-0-0126). Bit 0 is defined for operation data only.	
	2 binary	Structure of Status '$T \geq T_x$': Bit 0 = 0: $\|T\| < \|T_x\|$ 1: $\|T\| \geq \|T_x\|$

S-0-0334	Status '$T \geq T_{\text{limit}}$ '	
	This parameter is used to define an IDN for the status '$T \geq T_{\text{limit}}$.' This allows the status '$T \geq T_{\text{limit}}$' to be assigned to a real-time status bit (see S-0-0305). The status '$T \geq T_{\text{limit}}$' is defined as a C3D bit (S-0-0013) and is set when the torque feedback value (see S-0-0084) lies beyond the programmed torque limits (see S-0-0082, S-0-0083, S-0-0092). Bit 0 is defined for operation data only.	

	2 binary	Structure of status '$T \geq T_{limit}$': Bit 0 = 0: $\lvert T \rvert < \lvert T_{limit} \rvert$ 1: $\lvert T \rvert \geq \lvert T_{limit} \rvert$

S-0-0335	Status '$n_{command} > n_{limit}$'	
	This parameter is used to define an IDN for the status $n_{command} > n_{limit}$'.' This allows the status $n_{command} > n_{limit}$' to be assigned to a real-time status bit (see S-0-0305). The status $n_{command} > n_{limit}$' is defined as a C3D bit (S-0-0013) and is set when the sum of velocity command values (see S-0-0036, S-0-0037, etc.) is greater than the velocity limit value (see S-0-0038, S-0-0039, S-0-0091). Bit 0 is defined for operation data only.	
	2 binary	Structure of status $n_{command} > n_{limit}$': Bit 0 = 0: $\lvert n_{command} \rvert \leq \lvert n_{limit} \rvert$ 1: $\lvert n_{command} \rvert > \lvert n_{limit} \rvert$

S-0-0336	Status 'In position'	
	This parameter is used to define an IDN for the status 'in position' to be assigned to a real-time status bit (see IDN 305). The status 'in position' is defined as a C3D bit (S-0-0013) and is set when the position feedback value falls within the position window (see S-0-0057) relative to the position command value (see S-0-0047). Bit 0 is defined for operation data only.	
	2 binary	Structure of status 'in position': Bit 0 = 0: outside of position window 1: within position window

S-0-0337	Status '$P \geq P_X$'	
	This parameter is used to define an IDN for the status '$P \geq P_X$.' This allows the status '$P \geq P_X$' to be assigned to a real-time status bit (see S-0-0305). The status '$P \geq P_X$' is defined as a C3D bit (S-0-0013) and is set when the actual supplied power exceeds the power threshold P_X (see S-0-0158). Bit 0 is defined for operation data only.	
	2 binary	Structure of status '$P \geq P_X$': Bit 0 = 0: $\lvert P \rvert < \lvert P_X \rvert$ 1: $\lvert P \rvert \geq \lvert P_X \rvert$

S-0-0338	Status “Position feedback = active target position	
	This parameter is used to define an IDN for the status „position feedback = active target position“. This allows the status „position feedback = active target position“ to be assigned to a real-time status bit (see S-0-0305). The status „position feedback = active target position“ is defined as a C3D bit (S-0-0013) and is set when position feedback value falls within the position window (see S-0-0057) relative to the active target position (see S-0-0430). Bit 0 is defined for operation data only.	
	2 binary	Structure of Postion feedback = active target position Bit 0 = 0 – Position feedback outside position window 1– |(S-0-0430 – S-0-0386)| < S-0-0057

S-0-0339	Status '$n_{feedback} \leq$ minimum spindle speed'

	This parameter is used to define an IDN for the status '$n_{feedback}$ ≤ minimum spindle speed'. This allows the status '$n_{feedback}$ ≤ minimum spindle speed' to be assigned to a real-time status bit (see S-0-0305). The status '$n_{feedback}$ ≤ minimum spindle speed' is defined as a C3D bit (S-0-0013) and is set when the velocity feedback value (S-0-0040) is lower than or equal to the programmed minimum spindle speed (S-0-0220). Bit 0 is defined for operation data only.	
	2 binary	Structure of '$n_{feedback}$ ≤ minimum spindle speed': Bit 0 = 0 – $\|n_{feedback}$ > minimum spindle speed 1– $\| n_{feedback}\|$ ≤ minimum spindle speed

S-0-0340	Status '$n_{feedback}$ ≥ maximum spindle speed'	
	This parameter is used to define an IDN for the status '$n_{feedback}$ ≥ maximum spindle speed'. This allows the status '$n_{feedback}$ ≥ maximum spindle speed' to be assigned to a real–time status bit (see S-0-0305). The status '$n_{feedback}$ ≥ maximum spindle speed' is defined as a C3D bit (S-0-0013) and is set when the velocity feedback value (S-0-0040) is greater than or equal to the programmed maximum spindle speed (S-0-0221). Bit 0 is defined for operation data only.	
	2 binary	Structure of '$n_{feedback}$ ≥ maximum spindle speed': Bit 0 = 0 – $\|n_{feedback}\|$ < maximum spindle speed 1 – $\|n_{feedback}\|$ ≥ maximum spindle speed

S-0-0341	Status “In Coarse position”	
	This parameter is used to define an IDN for the ‘in coarse position’ status. This allows the status to be assigned, for instance, to a real-time status bit (for example S-0-0305). The status 'in coarse position' is defined as a C3D bit (S-0-0013) and is set when the position feedback value falls within the coarse position window (see S-0-0261) relative to the position command value (see S-0-0047). Bit 0 is defined for operation data only.	
	2 binary	Structure of status 'in position': Bit 0 = 0: outside of coarse position window 1: within coarse position window

S-0-0342	Status “Target position attained”	
	This parameter is used to define an IDN for the 'target position attained' status. This allows the status to be assigned, for instance, to a real-time status bit (for example S-0-0305). The status 'target position attained' is defined as a C3D bit (S-0-0013) and is set when the position command of the drive interpolator (S-0-0047) is equal to the Active target position (S-0-0430) Bit 0 is defined for operation data only.	
	2 binary	Structure of status 'target position attained': Bit 0 = 0: target position not reached 1: target position reached (position command = active target position)

S-0-0343	Status “Interpolator halted”	
	This parameter is used to define an IDN for the 'interpolator halted' status. This allows the status to be assigned, for instance, to a real-time status bit (for example S-0-0305). The status 'interpolator halted' is defined as a C3D bit (S-0-0013) and is set when the drive interpolator (IPO) has not yet attained the Active target position (S-0-0430), but the position command is not changing. The control can stop the interpolator with bit 13 in the control word. Bit 0 is defined for operation data only.	

	2 binary	Structure of status 'interpolator halted': Bit 0 = 0: interpolator not halted 1: interpolator halted (target position not attained, position command not changing)

S-0-0344	Reserved	

S-0-0345	Reserved	

S-0-0346	Positioning control word	
	This parameter is used in the operation mode Positioning only to implement positioning functions.	
	2 binary	Positioning control word structure: Bit 0: Takeover of positioning command value with every changing edge (toggle). The bit shall be inverted by the control unit to take on the next positioning command value: 0 /1: Takeover of positioning command value Bit 2-1: **00 – Positioning**: the positioning starts after takeover of positioning command value (bit 0). The positioning is interrupted by changing the Bit 1 and 2 from 00 to xx. The positioning is restarted with Bit 0. A still available remains distance is deleted (see bit 4). **01 – Jogging +**: Continuous movement in positive direction with the current positioning parameters (S-0-0259/0260/0359). **10 – Jogging -:** Continuous movement in negative direction with the current positioning parameters (S-0-0259/0260/0359). **11 – Positioning Halt:** Stop with positioning deceleration (S-0-0359) Bit 3: 0 – Positioning command value is an absolute position value 1 – Positioning command value is a relative position value Bit 4: **Reference of relative positioning command value** (bit 3 = 1) This bit controls the behave of the positioning command value. The positioning command value is referred to **0 – the active target position:** the positioning command value is added to the active target position. **1 – current position feedback value: :** the positioning command value is added to the current position feedback value. Bit 7-5: **Block transitions:** **xx0 – Active target position remains stored:** the following functions for the block transitions are defined: (bit 6 and 7 are active) **000 – Block transition with halt**: Drive always positions on active target position, before positioning to next active target position (Target position - Actual value < Positioning window) **010 – Block transition withouf halt (Mode 1)** The target position of the start block is passed with the velocity of the start block. When the target position of the start block is reached the acceleration of the following block is activated. **100 – Block transition without halt (Mode 2)** The target position of the start block is passed with the velocity of the following block. Required accelerations or decelerations are already activated during start block. The target position of the following block is activated only, when reaching the target position of the start block. **yy1 – Active target position is overwritten:** On acceptance the drive overwrites immediately the active target position and positions to the new active target position. The drive does not move to the previous target position. Bit 6 and 7 are inactive. Bit 15-8: (reserved)

S-0-0347	Velocity error		
	The actual difference between the commanded velocity and actual velocity is placed in this parameter.		
	4 signed decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0348	Acceleration feed forward gain		
	Acceleration feed forward is effective in the operation mode "Position control without following distance (lag-less)", and serves to reduce acceleration / deceleration-dependent following distance.		
	2 or 4 unsigned decimal (attribute has to be checked by the control unit.)		(Scaling and unit defined by the drive manufacturer)

S-0-0349	Bipolar jerk limit		
	"Bipolar jerk" limits the maximum rate of change of acceleration. Programming a value of zero will cause jerk limiting to be deactivated.		
	4 unsigned decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0350 to S-0-0355	deleted	

S-0-0356	Distance home switch - marker puls		
	For the relative position of the home switch to the marker pulse of the encoder exists an optimal distance. In order to make the commissioning easy for the user, the distance from the home switch to the marker pulse is measured by the drive and shown in this parameter. Then the user has to calculate a value following the indications of the drive manufacturer and set this value in the home switch offset 1 / 2 (S-0-0299, S-0-0358), or shift mechanically the home switch corresponding to the calculated value .		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0357	Marker pulse distance		
	In order to calculate in the drive the optimal distance between marker pulse and home switch, the distance between two marker pulses is set in this parameter.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0358	Home switch offset 2		
	With digital drives, it is no longer technically possible to mechanically shift the external feedback system in order to shift the relationship between the marker pulse and home switch. With milled switch dog rails neither can the home switch dog be shifted. Based on these conditions, the home switch offset 2 parameter is programmed during startup so that the home position is unambiguous. The required offset between the home switch and marker pulse is provided by the drive with the aid of the programmed home switch offset 2. The "suggest home switch distance" (S-0-0298) can be transferred into this parameter.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0359	Positioning deceleration		
	With the "positioning deceleration" the positioning velocity (S-0-0259) is reduced during stop function in the operation modes "Interpolation" and "Positioning".		
	4 signed decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0360 S-0-0361	MDT data container A1 MDT data container B1		
	Two data containers (4 bytes long) are defined for the MDT, A1 and B, serving as placeholders in the MDT. The contents of the data containers can be dynamically changed by the control as necessary, or based upon the operation mode. Additionally, a data container pointer is required for each of the containers (S-0-0364 and S-0-0365), as well as a configuration list for the MDT container (S-0-0370). If the configured operation data is only 2 bytes long, it is placed in the low word of the MDT data container. The high word is not used. In configuring data container operation data, the control can select between a minimum requirement and maximum requirement. Minimum required data block (access via service channel): The configured operation data is represented in the data container in hexadecimal, without the units. Attribute: ‘Data type and display format’ are set hexadecimal (bits 22-20 = 011) Units: Not present Maximum required data block (access via service channel): The configured operation data is represented in the data container not with the data block of the data container itself, rather the configured operation data’s data block. In this case the operation data will be displayed with the IDN of the data container exactly the same as it would be with its own IDN.		
	4		1, or the scaling of the configured data

S-0-0362 S-0-0363	MDT data container A list index MDT data container B list index	
	If in the MDT-data container A or B an IDN with a variable length is configured, the corresponding data element of this list will be addressed via the list index. The list index of the MDT data container consists of a 16 bit address. Via index 65535 the data container can be defined not valid by the control. The control sets the addressed list element into the MDT data container. The list index of MDT data container can be configured in the cyclic data of the MDT. Thereby, a switching of the list elements in the data container during a communication cycle is possible. During writing on the MDT data container with the list index the length of a list cannot be changed. The list index of MDT data container can also be configured into the cyclic data of the ATs. In this way an acknowledgement of the MDT data container is possible. The drive reads the list index of MDT data container from the MDT and acknowledges it in the AT. If the list index is situated outside of the list, the list index of MDT will be set in the AT (acknowledgement) on value 65535 and the pointer of data container in AT (acknowledgement) on value 255. All data in the MDT data container will be ignored.	
	2 unsigned decimal	MDT data container A list index structure: Bits 15-0: 0 - 65534 - index of the configured list 65535 - MDT data container A not valid MDT data container B list index structure: Bits 15-0: 0 - 65534 - index of the configured list 65535 - MDT data container B not valid

<table>
<tr><td>S-0-0364
S-0-0365</td><td colspan="3">AT data container A1
AT data container B1</td></tr>
<tr><td></td><td colspan="3">2 data containers (4 bytes long) are defined for the AT, A and B, serving as placeholders in the AT. The contents of the data containers can be dynamically changed by the control as necessary, or based upon the operation mode. Additionally, a data container pointer is required for each of the containers (S-0-0368 and S-0-0369), as well as a configuration list for the AT container (S-0-0371). If the configured operation data is only 2 bytes long, it is placed in the low word of the AT data container. The high word is not used.

In configuring data container operation data, the drive can select between a minimum requirement and maximum requirement.

Minimum required data block (access via service channel)

The configured operation data is represented in the data container in hexadecimal, without the units.

Attribute: ‘Data type and display format’ are set hexadecimal (bits 22-20 = 011)

Units: Not present

Maximum required data block (access via service channel)

The configured operation data is represented in the data container not with the data block of the data container itself, rather the configured operation data’s data block. In this case the operation data will be displayed with the IDN of the data container exactly the same as it would be with its own IDN.</td></tr>
<tr><td></td><td>4</td><td></td><td>1, or

the scaling of the configured data</td></tr>
</table>

<table>
<tr><td>S-0-0366
S-0-0367</td><td colspan="2">AT data container A list index
AT data container B list index</td></tr>
<tr><td></td><td colspan="2">If in the AT-data container A or B an IDN with a variable length is configured, the corresponding data element of this list will be addressed via the list index.

The list index of the AT data container consists of a 16 bit address. Via index 65535 the data container can be defined not valid by the control.

The drive sets the addressed list element into the AT data container.

The list index of AT data container can be configured in the cyclic data of the MDT. Thereby, a switching of the list elements in the data container during a communication cycle is possible. Through the AT data container, data can be read only within the configured IDN list.

The list index of AT data container can also be configured into the cyclic data of the ATs. In this way an acknowledgement of the AT data container is possible. The drive reads the list index of AT data container from the MDT and acknowledges it in the AT.

If the list index is situated outside of the list, the list index of AT will be set in the AT (acknowledgement) on value 65535 and the pointer of data container in AT (acknowledgement) on value 255. All data in the AT data container will be ignored.</td></tr>
<tr><td></td><td>2

unsigned decimal</td><td>AT data container A list index structure:

Bits 15-0: 0 - 65534 - index of the configured list
65535 - AT data container A not valid

AT data container B list index structure:

Bits 15-0: 0 - 65534 - index of the configured list
65535 - AT data container B not valid</td></tr>
</table>

S-0-0368	Data container A pointer
S-0-0369	Data container B pointer

	The data container pointers contain an 8-bit pointer, that defines what operation data should be placed in the MDT and AT data container. The pointer is the offset, within the data container configuration list (S-0-0370 or S-0-0371). Herewith inside the configuration list an IDN is addressed for the MDT data container or AT data container. With value 255 the control can declare the data containers for not valid. The control sets the addressed operation data into the MDT data container. The drive sets the addressed operation data into the AT data container. The IDN "Data container A pointer and B pointer" (S-0-0368, S-0-0369) can be configured in the cyclic data of the MDT. Thereby, a switching of the operation data in the data containers within a communication cycle is possible. The IDN "Data container A pointer and B pointer" (S-0-0368, S-0-0369) can also be configured in the cyclic data of the AT. In this case the addressing (acknowledgement) according to the contents of the data container will be transmitted. The drive generates the acknowledgement by copying the pointer of MDT to the pointer of AT. If the pointer of the data container is situated outside of the configuration list for the MDT or AT data container or the data does not fit in the data container, the contents of the data container are not valid. The drive sets the pointer (acknowledgement) in the AT on 255. The data in MDT or AT data container will be ignored.	
	2 binary or hexadecimal	Data container A pointer structure: Bits 7-0: 0 - 254 - address for MDT data container A 255 - MDT data container not valid Bits 15-8: 0 - 254 - address for AT data container A 255 - AT data container A not valid Data container B pointer structure: Bits 7-0: 0 - 254 - address for MDT data container B 255 - MDT data container B not valid Bits 15-8: 0 - 254 - address for AT data container B 255 - AT data container B not valid

S-0-0370	MDT data container A/B configuration list	
	The control enters into the MDT data container configuration list the IDN numbers for the operation data that are to be sent via the MDT data container (A and B of standard data container, or A1 of extended data container) as needed from the control to the drive. This IDN list is generated either from S-0-0188 or S-0-0445.	
	2, variable IDN	Structure of IDN lists: (see Figure 69)

S-0-0371	AT data container A/B configuration list	
	The control enters into the AT data container configuration list the IDN numbers for the operation data that are to be sent via the AT data container (A and B of standard data container, or A1 of extended data container) as needed from the drive to the control. This IDN list is generated either from S-0-0187 or S-0-0444.	
	2, variable IDN	Structure of IDN lists: (see Figure 69)

S-0-0372	Drive Halt acceleration bipolar		
	This parameter is only activated if no internal drive interpolator is active and “Drive Halt” (control word, bit13) is changed by the control unit. See control word, Table 18 .		
	4 signed decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0373	Service channel error list

	With every service channel error, the drive records the IDN and the specific error code into this list. The list is organized as a ring buffer. When the list is read via the service channel, the drive will position the last error recorded as the first element of the list. The display format of the list elements is hexadecimal.	
	4, variable hexadecimal (error codes)	Structure of lists: (see Figure 69) Bit 31-16: error code (see Table 22) Bit 15-0: IDN

S-0-0374	Procedure command error list	
	With every procedure command error, the drive records the IDN and a manufacturer specific error code into this list. The list is organized as a ring buffer. When the list is read via the service channel, the drive will position the last error recorded as the first element of the list. The display format of the list elements is hexadecimal.	
	4, variable hexadecimal (error codes)	Structure of lists: (see Figure 69) Bit 31-16: manufacturer specific error code (see Table 22) Bit 15-0: IDN

S-0-0375	Diagnostic numbers list	
	The drive records every change of the diagnostic number into this list. The list is organized as a ring buffer. When the list is read via the service channel, the drive will position the last diagnostic recorded as the first element of the list.	
	4, variable hexadecimal (diagnostic numbers)	Structure of lists: (see Figure 69)

S-0-0376	Baud rate	
	The drive places the supported transmission rates in this parameter. The transmission rate of 2 Mbit/s shall always be supported.	
	2 binary	Baud rate structure: Bit 0: 1 - 2 Mbit/s available Bit 1: 0 - 4 Mbit/s not available 1 - 4 Mbit/s available Bit 2: 0 - 8 Mbit/s not available 1 - 8 Mbit/s available Bit 3: 0 - 16 Mbit/s not available 1 - 16 Mbit/s available (Bits 7-4: reserved) Bit 8: 0 - automatic baudrate recognition is not supported 1 - automatic baudrate recognition is supported (Bits 15-9: reserved)

S-0-0377	Velocity feedback monitoring window		
	With help of the "Velocity feedback monitoring window" the maximum velocity deviation between velocity feedback value 1 (S-0-0040) and velocity feedback value 2 (S-0-0156) can be monitored. If the velocity deviation exceeds the monitoring window, the drive will generate either a warning (excessive velocity deviation) in class 2 diagnostics (S-0-0012) or an error in class 1 diagnostics (S-0-0011). With this function a lack in the mechanics can be monitored. With the value "0" the monitoring is switched off.		
	4 unsigned decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0378	Absolute encoder range 1

	If the motor encoder is an absolute measuring system, then the absolute range with consideration of the mechanics and programming will be displayed or entered in this parameter.			
	4 unsigned decimal		Scaling of position data (see clause 14.2.1)	

S-0-0379	Absolute encoder range 2			
	If the external encoder is an absolute measuring system, then the absolute range with consideration of the mechanics and programming will be displayed or entered in this parameter.			
	4 unsigned decimal		Scaling of position data (see clause 14.2.1)	

S-0-0380	DC bus voltage			
	The drive's DC (intermediate) bus voltage value is placed in this parameter.			
	2 unsigned decimal		1	V

S-0-0381	DC bus current			
	The drive places the measured (actual) DC (intermediate) bus current in this parameter.			
	4 signed decimal		0,001	A

S-0-0382	DC bus power			
	The drive places the measured (actual) DC (intermediate) bus power in this parameter.			
	4 signed decimal		1	W

S-0-0383	Motor temperature			
	The drive places the measured (actual) motor temperature in this parameter.			
	2 unsigned decimal		Scaling type, S-0-0208	

S-0-0384	Amplifier temperature			
	The drive places the measured (actual) amplifier temperature (output stage) in this parameter.			
	2 unsigned decimal		Scaling type, S-0-0208	

S-0-0385	Active power			
	The drive places the calculated active power of the motor in this parameter.			
	4 signed decimal		1	W

S-0-0386	Active position feedback value			
	The "Active position feedback value" is necessary, when the drive changes in the operation modes between position feedback value 1 and 2 automatically. The position feedback value which is activated by the operation mode is written in this IDN. To use this function, the control unit has to configure S-0-0386 in the AT.			
	4 signed decimal		Scaling of position data (see clause 14.2.1)	

S-0-0387	Power overload

	The drive places the calculated power overload in this parameter.			
	2 unsigned decimal		0,01	%

S-0-0388	Braking current limit			
	With this parameter, the user can reduce the braking current limit during deceleration phase (active braking).			
	4 signed decimal		0,001	A

S-0-0389	Effective current			
	The drive places the measured (actual) or calculated effective current (Root Mean Square) in this parameter.			
	4 signed decimal		0,001	A

S-0-0390	Diagnostic number			
	For every diagnostic, the drive stores a manufacturer specific code in the diagnostic number parameter. Using this, the operator interface has the ability to display diagnostic message text in languages not supported by the drive.			
	4 hexadecimal		1	

S-0-0391	Position feedback monitoring window		
	Using the position feedback monitoring window, the maximum permissible position error between actual position 1 and actual position 2 can be defined. If the position difference between these two feedback devices exceeds the limit in this parameter, the drive generates an error for excessive actual position difference in C1D (S-0-0011). Entering the value ‘0’ disables the monitoring.		
	4 unsigned decimal		Scaling of position data (see clause 14.2.1)

S-0-0392	Velocity feedback filter			
	The time constant for the velocity feedback filter is entered into this parameter. If the filter time constant is 0, the filter is inactive.			
	2 unsigned decimal		1	µs

S-0-0393	Command value mode	
	When the Modulo function is active, the interpretation of position commands is dependent upon the command value mode setting. In operation modes "Interpolation" and "Positioning" active only.	
	2 binary	Command value mode structure: Bit 1-0: Direction with modulo function 00 – clockwise, positive direction 01 - counter-clockwise, negative direction 10 - shortest path 11 - reserved Bit 15-2: (reserved)

S-0-0394	List IDN

	The identification number of an operation data with variable length must be set into the List IDN. After this, access to the list elements of the operation data via "List index" (S-0-0395) and "number of list elements" (S-0-0396) is possible.			
	2 IDN		1	

S-0-0395	List index			
	The list index specifies the starting address inside the list. With list index = 0, the first list element is accessed after the lengths indication. The list index is always programed according to the list elements. List index = 0 ➔ 1. List element (1, 2, 4 or 8 byte long) List index = 1 ➔ 2. List element (1, 2, 4 or 8 byte long) etc.			
	2 unsigned decimal		1	

S-0-0396	Number of list elements			
	The IDN specifies, how many list elements beginning at the list index are written or read via the list segment.			
	2 unsigned decimal		1	

S-0-0397	List segment		
	In the list segment the data are transmitted, which are selected by list IDN, list index and number of list elements. In order to show the list segment, the drive can choose between minimal requirement and maximal requirement. **Minimal requirement of list segment:** Herewith the list segment is shown hexadecimal and without unit. Attribute: Data type and display format are set on hexadecimal (Bit 22-20 = 011). Unit: not present **Maximal requiremet of lists segment:** Herewith the list segment is shown with the data block of the programmed list. In this way the values in the list segment is shown exactly as with his own identification number.		
	1, 2, 4 or 8 like configured data		1 or scaling like configured data

S-0-0398	IDN list of configurable data in the signal status word	
	This IDN list contains ident numbers, whose operation data (bits) are configurable in the signal status word. If one of the ident numbers in this list contains several bits, the bits have to be configurable by S-0-0328.	
	2, variable IDN	Structure of IDN lists: (see Figure 69)

S-0-0399	IDN list of configurable data in the signal control word	
	This IDN list contains ident numbers, whose operation data (bits) are configurable in the signal control word. If one of the ident numbers in this list contains several bits, the bits have to be configurable by S-0-0329.	
	2, variable IDN	Structure of IDN lists: (see Figure 69)

S-0-0400	Home switch	
	This parameter is used to assign an IDN to the home switch (external signal). This allows the home switch to be allocated to a real-time status bit (see S-0-0305). If the procedure command "control unit controlled homing" (S-0-0146) is active, the "home switch" is only valid if the signal "homing enable" (S-0-0407) is set. Bit 0 is defined for operation data only.	
	2 binary	Structure of home switch: Bit 0 = 0: inactive switch 1: active switch

S-0-0401	Probe 1	
	This parameter is used to assign an IDN to probe 1 (external signal). This allows probe 1 to be assigned to a real-time status bit (see S-0-0305). Additional parameters are S-0-0130 and S-0-0131. The signal "probe 1" is checked and updated by the drive only if the procedure command "probing cycle" (S-0-0170) is active and the signal "probe 1 enable" (S-0-0405) is set. Bit 0 is defined for operation data only.	
	2 binary	Structure of probe 1: Bit 0 = 0: inactive probe 1: active probe

S-0-0402	Probe 2	
	This parameter is used to assign an IDN to probe 2 (external signal). This allows probe 2 to be assigned to a real-time status bit (see S-0-0305). Additional parameters are S-0-0132 and S-0-0133. The signal "probe 2" is checked and updated by the drive only if the procedure command "probing Cycle" (S-0-0170) is active and the signal "probe 2 enable" (S-0-0406) is set. Bit 0 is defined for operation data only.	
	2 binary	Structure of probe 2: Bit 0 = 0: inactive probe 1: active probe

S-0-0403	Position feedback value status	
	When the drive switches the position feedback values to the coordinates referred to the machine zero point the drive sets bit 0 of this parameter in order to inform the control unit that all actual position values are based on the zero point of the machine. Bit 0 is reset when either the procedure command "displacement to the referenced system" (S-0-0172) or the procedure command "drive controlled homing procedure" (S-0-0148) or the procedure command "cancel reference point" (S-0-0191) or “set absolute position procedure command” (S-0-0447) is started or when the drive loses its reference to the zero point of the machine. The position feedback value status can be assigned to a real-time status bit and therefore it can be permanently signalled to the control unit in the drive status word (see S-0-0305). Bit 0 is mapped to CD3 (S-0-0013) bit 14 for an immediate real time reference in the control unit.	
	2 binary	Structure of position feedback value status: Bit 0: Status of activated position feedback value (see S-0-0013, Bit 14) 0: not referenced to machine zero point 1: referenced to machine zero point Bit 1: Status of position feedback value 1 0: not referenced to machine zero point 1: referenced to machine zero point Bit 2: Status of position feedback value 2 0: not referenced to machine zero point 1: referenced to machine zero point Bit 15-3: (reserved)

S-0-0404	Position command value status	
	When the position command values are switched to the coordinates referred to the machine zero point the control unit sets bit 0 of this parameter. This signals to the drive that all position command values are based on the zero point of the machine. Simultaneously the control unit transfers the new position command values in the cyclic data. Bit 0 is reset when the procedure command "displacement to the referenced system" (S-0-0172) is started. The position command value status can be assigned to a real-time control bit and therefore it can be permanently signalled to the drive in the control word (see S-0-0301). Bit 0 is defined for operation data only.	
	2 binary	Structure of position command value status: Bit 0 = 0: position command value not referenced to machine zero point 1: position command value referenced to machine zero point

S-0-0405	Probe 1 enable	
	This parameter is used to assign an IDN to probe 1 enable. This allows the status "probe 1 enable" to be assigned to a real-time control bit (see S-0-0301). Probe 1 enable is checked by the drive only as long as the procedure command "probing cycle" (S-0-0170) is active. For a new probing cycle with the same edge of probe 1 the control unit has to reset probe 1 enable to "0" and set it to "1" (see clause 14.8). Bit 0 is defined for operation data only. (For more details see S-0-0179.)	
	2 binary	Structure of probe 1 enable: Bit 0 = 0: probe 1 not enabled 1: probe 1 enabled

S-0-0406	Probe 2 enable	
	This parameter is used to assign an IDN to probe 2 enable. This allows the status "probe 2 enable" to be assigned to a real-time control bit (see S-0-0301). Probe 2 enable is checked by the drive only as long as the procedure command "probing cycle" (S-0-0170) is active. For a new probing cycle with the same edge of probe 2 the control unit has to reset probe 2 enable to "0" and set it to "1" (see clause 14.8). Bit 0 is defined for operation data only. (For more details see S-0-0179.)	
	2 binary	Structure of probe 2 enable: Bit 0 = 0: probe 2 not enabled 1: probe 2 enabled

S-0-0407	Homing enable	
	This parameter is used to assign an IDN to the status homing enable. This allows the status "homing enable" to be assigned to a real-time control bit (see S-0-0301). The drive interprets the homing enable only while the procedure command "control unit controlled homing" (S-0-0146) is active. Bit 0 is defined for operation data only.	
	2 binary	Structure of homing enable: Bit 0 = 0: homing not enabled 1: homing enabled

S-0-0408	Reference marker pulse registered	
	This parameter is used to assign an IDN to reference marker pulse registered. This allows the status "reference marker pulse registered" to be assigned to a real-time status bit (see S-0-0305). The drive sets this bit to 1 if the procedure command "control unit controlled homing" (S-0-0146) is active, if the homing is enabled (S-0-0407) and the marker pulse of the feedback (external signal) is registered. Simultaneously the drive stores the not referenced position feedback value in the related marker position (S-0-0173 or S-0-0174). The drive resets this bit to 0 when the control unit activates the procedure command “control unit controlled homing” (S-0-0146). While the procedure command (S-0-0146) is active, the ”reference marker pulse registered” is valid. The procedure command ”drive controlled homing” (S-0-0148) has no effect on this bit (S-0-0408). Bit 0 is defined for operation data only.	
	2 binary	Structure of reference marker pulse registered: Bit 0 = 0: reference marker pulse not registered 1: reference marker pulse registered

S-0-0409	Probe 1 positive latched	
	This parameter is used to assign an IDN to probe 1 positive latched. This allows the status "probe 1 positive latched" to be assigned to a real-time status bit (see S-0-0305). Bit 0 of this parameter is set by the drive only if the procedure command "probing cycle" (S-0-0170) is active, the signal "probe 1 enable" (S-0-0405) is set to 1 and the positive edge of "probe 1" (S-0-0401) is registered. Simultaneously the drive stores the position feedback value in "probe 1 positive edge" (S-0-0130) (see clause 14.8). The drive resets this bit when the control unit cancels the procedure command "probing cycle" or when probe 1 enable is reset to 0. Bit 0 is defined for operation data only. (For more details see S-0-0179.) With single measuring only bit 0 is valid. With continuous measuring the value is a 16 bit counter.	
	2 binary or unsigned decimal	Structure of probe 1 positive latched: Bit 0 = 0: probe 1 positive not latched 1: probe 1 positive latched

<table>
<tr><td rowspan="3">S-0-0410</td><td colspan="2">Probe 1 negative latched</td></tr>
<tr><td colspan="2">This parameter is used to assign an IDN to probe 1 negative latched. This allows the status "probe 1 negative latched" to be assigned a real-time status bit (see S-0-0305). Bit 0 of this parameter is set by the drive only if the procedure command "probing cycle" (S-0-0170) is active, the signal "probe 1 enable" (S-0-0405) is set to 1 and the negative edge of "probe 1" (S-0-0401) is registered. Simultaneously the drive stores the position feedback value in "probe 1 negative edge" (S-0-0131) (see clause 14.8). The drive resets this bit when the control unit cancels the procedure command "probing cycle" or when probe 1 enable is reset to 0. Bit 0 is defined for operation data only. (For more details see S-0-0179.)

With single measuring only bit 0 is valid.

With continuous measuring the value is a 16 bit counter.</td></tr>
<tr><td>2
binary or
unsigned
decimal</td><td>Structure of probe 1 negative latched:
Bit 0 = 0: probe 1 negative not latched
1: probe 1 negative latched</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0411</td><td colspan="2">Probe 2 positive latched</td></tr>
<tr><td colspan="2">This parameter is used to assign an IDN to probe 2 positive latched. This allows the status "probe 2 positive latched" to be assigned to a real-time status bit (see S-0-0305). Bit 0 of this parameter is set by the drive only if the procedure command "probing cycle" (S-0-0170) is active, the signal "probe 2 enable" (S-0-0406) is set to 1 and the positive edge of "probe 2" (S-0-0402) is registered. Simultaneously the drive stores the position feedback value in "probe 2 positive edge" (S-0-0132) (see clause 14.8). The drive resets this bit when the control unit cancels the procedure command "probing cycle" or when probe 2 enable is reset to 0. Bit 0 is defined for operation data only. (For more details see S-0-0179.)

With single measuring only bit 0 is valid.

With continuous measuring the value is a 16 bit counter.</td></tr>
<tr><td>2
binary or
unsigned
decimal</td><td>Structure of probe 2 positive latched:
Bit 0 = 0: probe 2 positive not latched
1: probe 2 positive latched</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0412</td><td colspan="2">Probe 2 negative latched</td></tr>
<tr><td colspan="2">This parameter is used to assign an IDN to probe 2 negative latched. This allows the status "probe 2 negative latched" to be assigned to a real-time status bit (see S-0-0305). Bit 0 of this parameter is set by the drive only if the procedure command "probing cycle" (S-0-0170) is active, the signal "probe 2 enable" (S-0-0406) is set to 1 and the negative edge of "probe 2" (S-0-0402) is registered. Simultaneously the drive stores the position feedback value in "probe 2 negative edge" (S-0-0133) (see clause 14.8). The drive resets this bit when the control unit cancels the procedure command "probing cycle" or when probe 2 enable is reset to 0. Bit 0 is defined for operation data only. (For more details see S-0-0179.)

With single measuring only bit 0 is valid.

With continuous measuring the value is a 16 bit counter.</td></tr>
<tr><td>2
binary or
unsigned
decimal</td><td>Structure of probe 2 negative latched:
Bit 0 = 0: probe 2 negative not latched
1: probe 2 negative latched</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0413</td><td colspan="4">Bit number allocation of real-time control bit 1</td></tr>
<tr><td colspan="4">This ident nummer contains the bit number of the operation data assigned in the S-0-0301. The bit assigned by S-0-0301 and bit number (S-0-0413) is copied into the real- time control bit 1.</td></tr>
<tr><td>2
unsigned decimal
(bit number)</td><td>Min. ≥ 0
Max. ≤ 63</td><td></td><td></td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0414</td><td colspan="4">Bit number allocation of real-time control bit 2</td></tr>
<tr><td colspan="4">This ident nummer contains the bit number of the operation data assigned in the S-0-0303. The bit assigned by S-0-0303 and bit number (S-0-0414) is copied into the real- time control bit 2.</td></tr>
<tr><td>2
unsigned decimal
(bit number)</td><td>Min. ≥ 0
Max. ≤ 63</td><td></td><td></td></tr>
</table>

S-0-0415	Bit number allocation of real-time status bit 1			
	This ident nummer contains the bit number of the operation data assigned in the S-0-0305. The bit assigned by S-0-0305 and bit number (S-0-0415) is copied into the real- time status bit 1.			
	2 unsigned decimal (bit number)	Min. ≥ 0 Max. ≤ 63		

S-0-0416	Bit number allocation of real-time status bit 2			
	This ident nummer contains the bit number of the operation data assigned in the S-0-0307. The bit assigned by S-0-0307 and bit number (S-0-0416) is copied into the real- time status bit 2.			
	2 unsigned decimal (bit number)	Min. ≥ 0 Max. ≤ 63		

S-0-0417	Positioning velocity threshold in modulo mode		
	At modulo mode and specified value mode “shortest way” the last direction of rotation will be kept, if the amount of the current actual velocity is greater than the “velocity threshold positioning in modulo format”. The „positioning velocity threshold in modulo mode“ has to be greater programmed than the noise level of the velocity actual value. If the worth 0 is programmed, this paramenter is not active and it always value the rotation direction which has been fixed in the specified value mode.		
	4 unsigned decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0418	Target position window in modulo mode		
	At modulo mode and **specified value mode „only positive / negative motion direction**“ it will be positioned the modulo shortest way, if the active target position is within this target positioning window and further on the motion can be braked within the target positioning window. It is possible to adjust with **the parameter S-0-0418 target positioning window** in modulo format, from which distance of actual position to target position + stopping distance but shortest way can be proceeded. If the worth 0 is programmed, this parameter is not active and it is always value the rotation direction fixed in the specified value mode.		
	4 unsigned decimal		Scaling of position data (see clause 14.2.1)

S-0-0419	Positioning acknowledge	
	The drive acknowleges the take-over of the positioning command value, by copying bit 0 of S-0-0346 to bit 0 of S-0-0419. This bit is set to 0, if the operation mode is activated or the control unit sets in the positioning control word (S-0-0346) bit 0 to 0.	
	2 binary	Positioning acknowledge structure: Bit 0 = 0/1: the drive has taken on the positioning command value related on positioning control word, bit 0. Bit 15-1: (reserved)

S-0-0420	Activate parameterization level 1 procedure command (PL1)

	The master can activate this procedure command in CP2 to CP4. In CP4 the procedure command is accepted by the drive only, if the torque is disabled (control word, bit 14=0 and/or bit 15=0), otherwise the drive generates an error message via the service channel (error code 0x7012). The PL1 is not cancelled automatically in CP0. PL1 is only cancelled in CP4 with the procedure command „Exit PL1“ (S-0-0422)“. Activating the PL1 procedure command causes all monitors associated with the feedback sensing system to shut down. This affects the position control, the transducer monitoring circuit (feedback hardware), and the monitoring of the position window (S-0-0057). While the command is active, the drive does not report a C1D error (S-0-0011). The position feedback value status (S-0-0403) is reset by the drive. The command is positively acknowledged when the monitoring system mentioned above is turned off. During PL1 the control unit can change all parameters except the communication parameters. When the “Exit parameterization level procedure command (S-0-0422)” is activated, all parameters are checked and all monitors mentioned above are turned on again. In order to relate the position feedback values to the reference point again, the control unit shall start a homing procedure.	
	2 binary	Structure of the procedure command: (see Table 23) Structure of command acknowledgment: (see Table 24)

S-0-0421	Activate parameterization level 2 procedure command (PL2)	
	The master can activate this procedure command in CP4 only. In CP4 the procedure command is accepted by the drive only, if the torque is disabled (control word, bit 14=0 and/or bit 15=0), otherwise the drive generates an error message via the service channel (error code 0x7012). The PL1 is cancelled automatically in CP0 or with the procedure command „Exit PL1“ (S-0-0422)“. The position feedback value status (S-0-0403) is not changed by the drive. The command is positively acknowledged when the drive has activated PL2. During PL2 the control unit can change parameters except the communication parameters and reference related parameters. When the “Exit parameterization level procedure command (S-0-0422)” is activated, all related parameters are checked.	
	2 binary	Structure of the procedure command: (see Table 23) Structure of command acknowledgment: (see Table 24)

S-0-0422	Exit parameterization level procedure command	
	The parameterization levels 1 and 2 are cancelled if the drive activates this procedure commend. When leaving PL1 the command is positively acknowledged if the corresponding parameters are checked without errors and the monitoring is switched on again (see S-0-0420). When leaving PL2 the command is positively acknowledged if the corresponding parameters are checked without errors (see S-0-0421). The command is negatively acknowledged if at the checks a fault has appeared. The IDNs which have caused an error are stored in the IDN-list (S 0-0423).	
	2 binary	Structure of the procedure command: (see Table 23) Structure of command acknowledgment: (see Table 24)

S-0-0423	IDN-list of invalid data for parameterization levels	
	IDNs which are considered invalid by the drive prior to exit parameterization level 1 or 2 (see S-0-0422) are stored in this IDN-list. Case 1: procedure command S-0-0422 is performed correctly; the IDN-list (S-0-0423) contains no IDNs. Case 2: procedure command S-0-0422 results in an error; the IDN-list (S-0-0423) contains all IDNs of invalid operation data.	
	2, variable IDN	Structure of IDN lists: (see Figure 69)

S-0-0424	Status parameterization level

	In this parameter the drive shows the active parameter level.	
	2, binary	Structure of Status parameterization level Bit 1-0: Parameterization level 00 – Operation mode 01 – Parameterization level 1 10 – Parameterization level 2 Bit 15-2: reserved

S-0-0425	Control word parameterization level	

S-0-0429	Emergency stop deceleration		
	When the control unit activates „Drive OFF“ (control word, bit 15 = 0, bit 14 = 1) the drive decelerates as best as possible limited by the „emergency stop deceleration“, followed by disabling of the torque at n_{min}. See Table 18, control word.		
	4 signed decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0430	Active target position		
	At the operating mode interpolation, the drive writes the target position (S-0-0258) into the active target position. At the operating mode positioning, the drive writes the positioning command value (S-0-0282) either into the target position (absolute position data) or the positioning command value is added (relative position data) to the active target position. See control word positioning (S-0-0346). Active target position is only an intermediate memory in the drive, therefore cannot be configured in the MDT and is readable only over the service channel.		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0431	Spindle positioning acceleration bipolar		
	When the position spindle procedure command (see S-0-0152) is received, the drive accelerates or decelerates to the spindle positioning speed (S-0-0222), depending on the spindle positioning acceleration bipolar.		
	4 signed decimal		Scaling of acceleration data (see clause 14.2.4)

S-0-0432	Serial number drive control	
	This IDN contains the serial number of the drive control.	
	1, variable text	Structure of diagnostic message: (see Figure 69) Refer to operation data of variable length and data type characters.

S-0-0433	Serial number power stage	
	This IDN contains the serial number of the power stage.	
	1, variable text	Structure of diagnostic message: (see Figure 69) Refer to operation data of variable length and data type characters.

S-0-0434	Serial number motor	
	This IDN contains the serial number of the motor.	
	1, variable text	Structure of diagnostic message: (see Figure 69) Refer to operation data of variable length and data type characters.

S-0-0435	Operational hours drive control		
	This IDN contains the operational hours of the drive control.		
	4 unsigned decimal		(Scaling and unit defined by the drive manufacturer)

S-0-0436	Operational hours power stage		
	This IDN contains the operational hours of the power stage.		
	4 unsigned decimal		(Scaling and unit defined by the drive manufacturer)

S-0-0437	Positioning status	
	In this parameter all status messages of the operation modes "interpolation" and "positioning" are combined. Bit 1 is supported in operation mode interpolation only. Bits 2 and 12 are supported in operation mode positioning only.	
	2 binary	Positioning status structure: Bit 0: Status 'target position attained' (see S-0-0342) drive internal position command = active target position 0 - target position not reached 1 - target position reached Bit 1: Status Postion feedback = target position (Interpolation only) |(S-0-0258 – S-0-0386)| < S-0-0057 0 – Position feedback outside position window 1 – Position feedback within position window Bit 2: Status Postion feedback = active target position (Positioning only) (see S-0-0338) |(S-0-0430 – S-0-0386)| < S-0-0057 0 – Position feedback outside position window 1 – Position feedback within position window Bit 3: Status 'interpolator halted' (see S-0-0343) the control unit can stop the drive interpolator with bit 13 of control word. 0 - interpolator not halted 1 - interpolator halted (target position not attained) Bit 4: constant interpoaltion velocity 0 – no constant velocity 1 – constant velocity Bit 5: drive accelerates 0 – drive doesn't accelerate 1 – drive accelerates Bit 6: drive decelerates 0 – drive doesn't decelerate 1 – drive decelerates Bit 11 – 7: (reserved) Bit 12: Jog mode (Positioning only) 0 – jog mode is inactive 1 – jog mode is active (S-0-0346, bit 2 and 1 are set to "01" or "10") Bit 13: Warning positioning velocity > n_{Limit}: (S-0-0315) 0 - positioning velocity ≤ n_{Limit} 1 - positioning velocity > n_{Limit} Bit 14: Warning target position outside of travel range (see S-0-0323) 0 - target position within position limit values 1 - target position outside of position limit values) Bit 15: (reserved)

S-0-0438	Vendor name	
	This IDN contains the vendor name of the device.	
	1, variable text	Structure: (see Figure 69) Refer to operation data of variable length and data type characters.

S-0-0439	Vendor code		
	This IDN contains the vendor code of the device. The Vendor code is allocated by SERCOS International on request.		
	4 unsigned decimal		1

S-0-0440??			

S-0-0441??			

S-0-0442??			

S-0-0443??			

S-0-0444	IDN-list of configurable data in the AT data container	
	This list consists the IDNs of operation data which can be processed by the drive in the AT data containers.	
	2, variable IDN	Structure of the IDN-list: (Figure 69).

S-0-0445	IDN-list of configurable data in the MDT data container	
	This list consists the IDNs of operation data which can be processed by the drive in the MDT data containers.	
	2, variable IDN	Structure of the IDN-list: (see Figure 69)

S-0-0446	Ramp reference velocity		
	With acceleration scaling “ramp time” the acceleration is programmed as time. The parameter “ramp reference veolcity” serves as a reference value for the acceleration calculation (see clause 14.2.4.4). acceleration parameter [time] = ramp reference velocity / acceleration		
	4 unsigned decimal		Scaling of velocity data (see clause 14.2.2)

S-0-0447	Set absolute position procedure command

	After activation of the “Set absolute position procedure command” the drive ignores the position command value and the difference between the position feedback value 1 or 2 and the Reference Distance 1 or 2 is calculated and stored in Displacement Parameter 1 or 2 (S-0-0175 or S-0-0176). The position feedback value status (IDN 00403) reflects that homing has been completed once. The status of the position feedback is mapped to CD3 (IDN 00013, bit 14). The drive checks whether it can immediately transfer the displacement value or not. How the absolute reference is set and maintained within the drive is a function of the drive. See “Set Absolute Position” description. The procedure command will terminate with a fault, when the drive detects an error during the procedure command specific calculations.	
	2 binary	Structure of the procedure command: (see Table 23, clause 7.5) Structure of command acknowledgment: (see Table 24, clause 7.5)

S-0-0448	Set absolute position control word	
	The control word specifies which encoder is referenced by the set absolute position procedure command. Encoder 1, encoder 2 or both. A drive may or may not support setting the absolute position while it is enabled. The control unit can verify if the drive supports set absolute position with or without the drive enabled. In the case that bit 2 is set to “1” by the control unit, and the drive responses with an error, it does not support set absolute position while enabled.	
	2 binary	Bit 0: encoder 1 (motor encoder) 0 – not selected 1 – selected for absolute homing Bit 1: encoder 2 (external encoder) 0 – not selected 1 – selected for absolute homing Bit 2: absolute homing mode in the drive 0 – the control unit requests the drive to support absolute homing “**without** drive enabled” 1 – the control unit requests the drive to support absolute homing “**with** drive enabled” Bit 3-15: reserved

S-0-0449	Profile Identification		

S-0-0450	MDT data container A2
S-0-0451	MDT data container A3
S-0-0452	MDT data container A4
S-0-0453	MDT data container A5
S-0-0454	MDT data container A6
S-0-0455	MDT data container A7
S-0-0456	MDT data container A8
S-0-0457	MDT data container A9
S-0-0458	MDT data container A10

<table>
<tr><td rowspan="2"></td><td colspan="3">For the extended data container function eight data containers (4 bytes long, A1 – A8) and two (8 bytes long, A9 – A10) are defined for the MDT, serving as placeholders in the MDT. The contents of the data containers can be dynamically changed by the control unit as necessary, or based upon the operation mode. Additionally, a data container pointer (S-0-0368) is required for all containers (S-0-0360, S-0450 to S-0-0458), as well as a configuration list (S-0-0370, S-0-0490 to S-0-0498) for each of the MDT container. If the configured operation data is only 2 or 4 bytes long, it is placed in the lower part of the MDT data container. The higher part is not used.

In configuring data container operation data, the control unit can select between a minimum requirement and maximum requirement.

Minimum required data block (access via service channel):

The configured operation data is represented in the data container in hexadecimal, without the units.

Attribute: ‘Data type and display format’ are set hexadecimal (bits 22-20 = 011)

Units: Not present

Maximum required data block (access via service channel):

The configured operation data is represented in the data container not with the data block of the data container itself, rather the configured operation data’s data block. In this case the operation data will be displayed with the IDN of the data container exactly the same as it would be with its own IDN.</td></tr>
<tr><td>4 (S-0-0450 to S-0-0456)

8 (S-0-0457, S-0-0458)</td><td></td><td>1, or

the scaling of the configured data</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0459</td><td colspan="3">MDT data container B2</td></tr>
<tr><td colspan="3">For the standard data container function two data containers (8 bytes long, A9 and B2) are defined for the MDT, serving as placeholders in the MDT. The contents of the data containers can be dynamically changed by the control as necessary, or based upon the operation mode. Additionally, a data container pointer (S-0-0368 and S-0-0369) is required for each of the containers (S-0-0360 and S-0-0361), as well as a configuration list for the MDT container (S-0-0370). If the configured operation data is only 2 or 4 bytes long, it is placed in the low part of the MDT data container. The high part is not used.

In configuring data container operation data, the control can select between a minimum requirement and maximum requirement.

Minimum required data block (access via service channel):

The configured operation data is represented in the data container in hexadecimal, without the units.

Attribute: ‘Data type and display format’ are set hexadecimal (bits 22-20 = 011)

Units: Not present

Maximum required data block (access via service channel):

The configured operation data is represented in the data container not with the data block of the data container itself, rather the configured operation data’s data block. In this case the operation data will be displayed with the IDN of the data container exactly the same as it would be with its own IDN.</td></tr>
<tr><td>8</td><td></td><td>1, or

the scaling of the configured data</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0460 to

S-0-0475</td><td colspan="3">Position switches (position switch points off 1-16)</td></tr>
<tr><td colspan="3">The position switches consist of a “position switch point off” and a position switch flag (S-0-0059). If the position feedback value is less than the “position switch point off”, the appropriate position switch flag is set to 1. If the position feedback value is equal to or greater than the “position switch point off”, the appropriate position switch flag is set to 0.</td></tr>
<tr><td>4
signed decimal</td><td></td><td>Scaling of position data (see clause 14.2.1)</td></tr>
</table>

S-0-0476	Position switch control

	The positioning switches will be activated in the control parameter of the bits 0-15. The drive has only treat the positioning switches, which are activated in the bits 0 to 15. The adjustments in the bits 16-31 state, if the matter is of positioning switches or of cam switches. For a cam switch it is necessary to have the “positioning on” (S-0-0060 to S-0-0075) and the “positioning off” (S-0-0460 to S-0-0475).	
	4 binary	Structure of the position switch control: Bit 0: Position switch flag 1 (S-0-0060, S-0-0460) 0 – disabled 1 – enabled up to Bit 15: Position switch flag 16 (S-0-0075, S-0-0475) 0 – disabled 1 – enabled Bit 16: Cam switch 1 (S-0-0060 and S-0-0460) 0 – no cam switch -> only S-0-0060 is active 1 – cam switch enabled -> S-0-0060 and S-0-0460 are active up to Bit 31: Cam switch 16 (S-0-0075 and S-0-0475) 0 – no cam switch -> only S-0-0075 is active 1 – cam switch enabled -> S-0-0075 and S-0-0475 are active

S-0-0477	Position switch hysteresis		
	The hysteresis is active to all positioning switches (S-0060 to S-0-0075 and S-0-0460 to S-0-0475) and will be considered at the switching on and off of the flags (S-0-0059).		
	4 signed decimal		Scaling of position data (see clause 14.2.1)

S-0-0478	Limit switch status	
	This parameter shows the input level of the limit switches and can be used for diagnostics.	
	2 binary	Structure of the limit switch status: Bit 0: Limit switch positive direction 0 – low level (no voltage, e.g. 0V) 1 – high level (voltage, e.g. +24V) Bit 1: Limit switch negative direction 0 – low level (no voltage, e.g. 0V) 1 – high level (voltage, e.g. +24V) Bit 15-2: reserved

S-0-0479	Vendor device ID	
	The vendor device ID is a unique device ID specified by the vendor and identifies the component name.	
	4 unsigned decimal	Stucture: 0000 = not a SERCOS member 0001 … 9999

S-0-0480 S-0-0481 S-0-0482 S-0-0483 S-0-0484 S-0-0485 S-0-0486 S-0-0487 S-0-0488	AT data container A2 AT data container A3 AT data container A4 AT data container A5 AT data container A6 AT data container A7 AT data container A8 AT data container A9 AT data container A10		
	For the extended data container function eight data containers (4 bytes long, A1 – A8) and two (8 bytes long, A9 – A10) are defined for the AT, serving as placeholders in the AT. The contents of the data containers can be dynamically changed by the control unit as necessary, or based upon the operation mode. Additionally, a data container pointer (S-0-0368) is required for all containers (S-0-0364, S-0480 to S-0-0488), as well as a configuration list (S-0-0371, S-0-0500 to S-0-0508) for each of the AT container. If the configured operation data is only 2 or 4 bytes long, it is placed in the lower part of the AT data container. The higher part is not used. In configuring data container operation data, the control unit can select between a minimum requirement and maximum requirement. Minimum required data block (access via service channel): The configured operation data is represented in the data container in hexadecimal, without the units. Attribute: ‘Data type and display format’ are set hexadecimal (bits 22-20 = 011) Units: Not present Maximum required data block (access via service channel): The configured operation data is represented in the data container not with the data block of the data container itself, rather the configured operation data’s data block. In this case the operation data will be displayed with the IDN of the data container exactly the same as it would be with its own IDN.		
	4 (S-0-0480 to S-0-0486) 8 (S-0-0487, S-0-0488)		1, or the scaling of the configured data

S-0-0489	AT data container B2		
	For the standard data container function two data containers (8 bytes long, A9 and B2) are defined for the AT, serving as placeholders in the AT. The contents of the data containers can be dynamically changed by the control as necessary, or based upon the operation mode. Additionally, a data container pointer (S-0-0368 and S-0-0369) is required for each of the containers, as well as a configuration list for the AT container (S-0-0371). If the configured operation data is only 2 or 4 bytes long, it is placed in the low part of the AT data container. The high part is not used. In configuring data container operation data, the control can select between a minimum requirement and maximum requirement. Minimum required data block (access via service channel): The configured operation data is represented in the data container in hexadecimal, without the units. Attribute: ‘Data type and display format’ are set hexadecimal (bits 22-20 = 011) Units: not present Maximum required data block (access via service channel): The configured operation data is represented in the data container not with the data block of the data container itself, rather the configured operation data’s data block. In this case the operation data will be displayed with the IDN of the data container exactly the same as it would be with its own IDN.		
	8		1, or the scaling of the configured data

S-0-0490 S-0-0491 S-0-0492 S-0-0493 S-0-0494 S-0-0495 S-0-0496 S-0-0497 S-0-0498	MDT data container A2 configuration list MDT data container A3 configuration list MDT data container A4 configuration list MDT data container A5 configuration list MDT data container A6 configuration list MDT data container A7 configuration list MDT data container A8 configuration list MDT data container A9 configuration list MDT data container A10 configuration list	
	The control enters into the MDT data container configuration list the IDN numbers for the operation data that are to be sent via the MDT data container (A1 to A10 of extended data container) as needed from the control to the drive. This IDN list is generated either from S-0-0188 or S-0-0445.	
	2, variable IDN	Structure of IDN lists: (see Figure 69)

S-0-0499	Vendor device name		

S-0-0500 S-0-0501 S-0-0502 S-0-0503 S-0-0504 S-0-0505 S-0-0506 S-0-0507 S-0-0508	AT data container 2 configuration list AT data container 3 configuration list AT data container 4 configuration list AT data container 5 configuration list AT data container 6 configuration list AT data container 7 configuration list AT data container 8 configuration list AT data container 9 configuration list AT data container 10 configuration list	
	The control enters into the AT data container configuration list the IDN numbers for the operation data that are to be sent via the AT data container (A1 to A10 of extended data container) as needed from the drive to the control. This IDN list is generated either from S-0-0187 or S-0-0444.	
	2, variable IDN	Structure of IDN lists: (see Figure 69)

S-0-0520	Axis control word	
	The axis control word is active, if bit 9 in the operation mode is set to 1 (see Table 44).	
	2 binary	Structure of the axis control word: Bit 0: Position control with feedback 1 or 2 0 – with feedback 1 (motor encoder) 1 – with feedback 2 (external encoder) Bit 1: Hybrid position control 0 – Bit 0 defines the activated feedback 1 – Position control with feedback 1 and 2 (hybrid) Bit 2: Postion control with or without following distance 0 – with following distance 1 – without following distance Bit 15-3: reserved

<table>
<tr><td rowspan="3">S-0-0521</td><td colspan="2">Axis status word</td></tr>
<tr><td colspan="2">The axis status word is active, if bit 9 in the operation mode is set to 1 (see Table 44).</td></tr>
<tr><td>2
binary</td><td>Structure of the axis status word:

Bit 0: Position control with feedback 1 or 2
0 – with feedback 1 (motor encoder)
1 – with feedback 2 (external encoder)
Bit 1: Hybrid position control
0 – Bit 0 defines the activated feedback
1 – Position control with feedback 1 and 2 (hybrid)
Bit 2: Postion control with or without following distance
0 – with following distance
1 – without following distance

Bit 15-3: reserved</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0530</td><td colspan="3">Clamping torque</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>2</td><td></td><td>Scaling of torque data (see clause 14.2.3)</td></tr>
</table>

<table>
<tr><td rowspan="3">S-0-0532</td><td colspan="2">Limit switch control word</td></tr>
<tr><td colspan="2">The configuration of the limit switches is programmable.</td></tr>
<tr><td>2
binary</td><td>Structure of the limit switch control word:

Bit 0: Invertion
0 – both limit switches are not inverted
1 – both limit switches are inverted
Bit 1: Activation
0 – both limit switches are disabled
1 – both limit switches are enabled
Bit 2: Error reaction
0 – activation of limit switch leads to an error (C1D)
1 – activation of limit switch leads to a warning (C2D)

Bit 15-3: reserved</td></tr>
</table>

Annex E (normative) - Coded character set

The base coded character set is based on the G0 set of ISO/IEC 646. It is extended with the DOS character set.

				b7	0	0	0	0	1	1	1	1
				b6	0	0	1	1	0	0	1	1
				b5	0	1	0	1	0	1	0	1
b4	b3	b2	b1		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0	0	0	0	**0**			SP	0	@	P	`	p
0	0	0	1	**1**			!	1	A	Q	a	q
0	0	1	0	**2**			“	2	B	R	b	r
0	0	1	1	**3**			#	3	C	S	c	s
0	1	0	0	**4**			$	4	D	T	d	t
0	1	0	1	**5**			%	5	E	U	e	u
0	1	1	0	**6**			&	6	F	V	f	v
0	1	1	1	**7**			‘	7	G	W	g	w
1	0	0	0	**8**			(	8	H	X	h	x
1	0	0	1	**9**			)	9	I	Y	i	y
1	0	1	0	**10**			*	:	J	Z	j	z
1	0	1	1	**11**			+	;	K	[	k	{
1	1	0	0	**12**			,	<	L	\	l	|
1	1	0	1	**13**			–	=	M	]	m	}
1	1	1	0	**14**			.	>	N	^	n	~
1	1	1	1	**15**			/	?	O	_	o	DEL

Annex F (informative) - Functional principles of the repeater circuit

Figure F.1 shows an example of an implementation of the signal-regeneration function from the repeater circuit. The primary task of this circuit consists of retrieving the clock RCLK from the NRZI-coded input signal IN. This may be accomplished e.g., by means of a digital phase-locked loop (DPLL). In addition, by sampling the input signal IN at appropriate times, a regenerated received signal RxD can be generated. The NRZI-coded signal is especially useful in the ring structure.

The circuit consists of eight flip-flops and a combinational logic PLA. The flip-flops are driven by a common clock CX. This clock signal is generated by a crystal oscillator having 16 times the frequency of the data rate, which is 32 MHz at 2 Mbit/s transmission rate.

It is also possible to implement DPLLs having different sampling rates. Note, though, that in order to match the following condition, a sampling rate of at least 12 times is needed:

$$0 \le t_{\mathrm{cadreal}} \le \frac{t_{\mathrm{Bitnom}}}{11}$$

Flip-flop 1 is used to initially synchronize the input signal. Flip-flop 2 is used for edge detection; it is always the case that when IN1 = 1 and IN2 = 0, a positive edge has been found. Flip-flops 5-8 in conjunction with the combinatorial logic are used to implement a finite-state machine.

The status diagram of figure F.2 illustrates the behaviour of the DPLL. States Z = 0 through Z = 15 in figure F.2 correspond to the binary values which are given by the output signals of the flip-flops 5-8.

In figure F.2, the following conditions means:

E : event: light-on edge detected;
E* : event: no light-on edge detected.

Depending on the status number (Z = 0...15) in which E or E* is detected, the DPLL reacts by repeating or skipping a status. Where E is found to be in the state Z = 0, the DPLL does not repeat or skip (i.e., the DPLL is synchronized). Input signals are not sampled at the theoretical mean of the bit cell but in their shifted position. This enables the system to operate even with relatively strong distorted signals. During the transition from Z = 3 to Z = 4, RCLK = 1 is set. During the transition from Z = 10 or Z = 11 to Z = 12 and from Z = 11 to Z = 13, RCLK = 0 is set and the output signal RxD is set equal to the synchronized input signal IN1.

Figure F.3 illustrates the timing of various signals.

In general, the signal becomes distorted mainly by electrical-to-optical conversion and vice versa. In figure F.3, it is shown what the signal IN1 looks like ideally, and what its typical shape is during minimum and maximum transmission power. The assumption is made that a series of NRZI-coded zeros is transferred. This corresponds to a rectangular signal with the period 2 x t_{BIT}.

Increasing transmission power eventually overdrives the receiver. The electrical signal level corresponding to the optical "light-on" remains at the receiver output longer than the generating electrical signal at the transmitter's input. Since the signal IN1 is not symmetric, it is useful to synchronize the phase lock loop on one signal edge only. For this purpose, the light-on edge seems to be more stable. Depending on the physical circumstances (i.e., inverted or non-inverted receiver) either the positive or the negative edge can be used as the input signal of the DPLL.

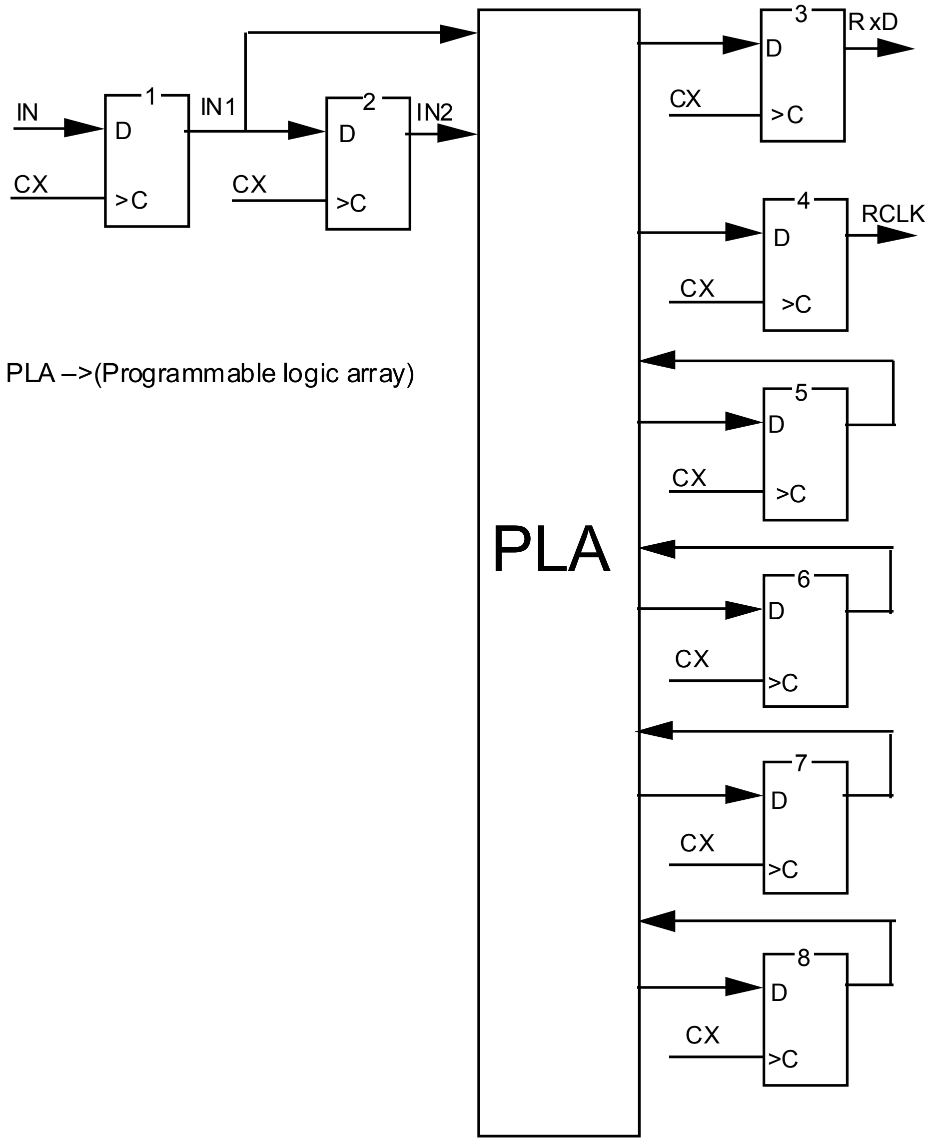


Figure F. 1 – Example of an implemented DPLL

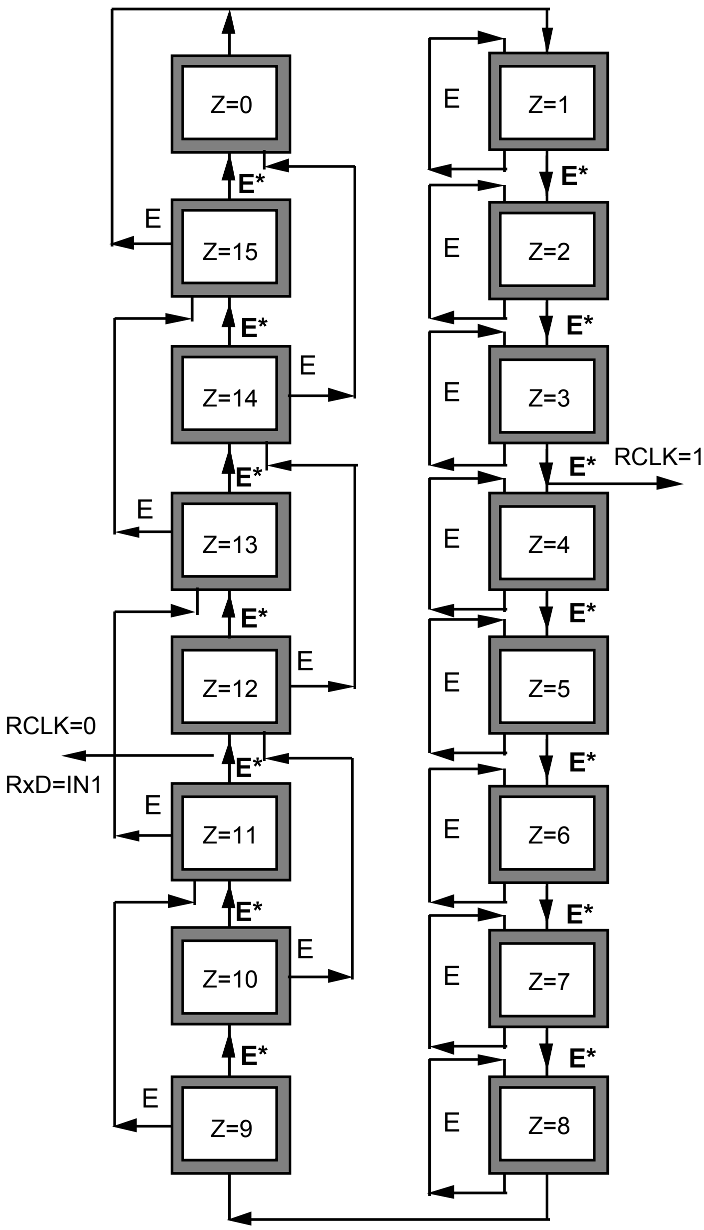


Figure F. 2 – DPLL status diagram

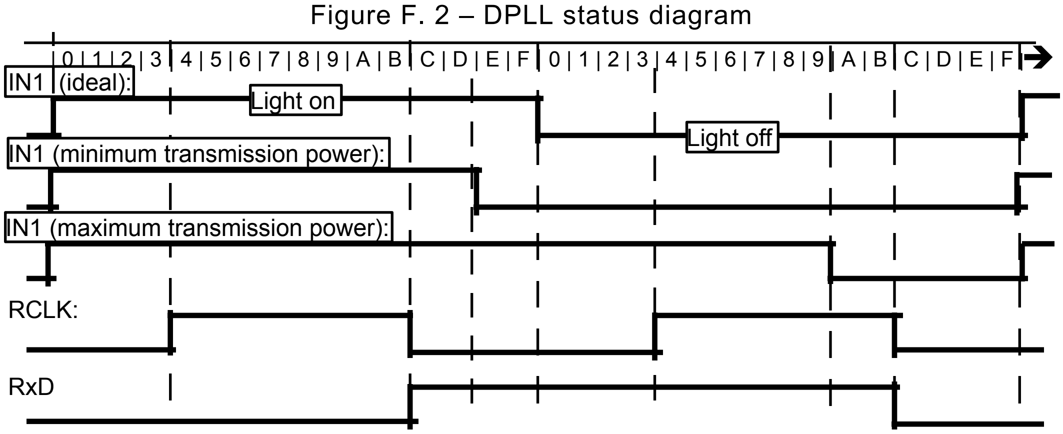


Figure F. 3 – DPLL timing

Annex G (informative) - Attenuation on the transmission line

This annex shows which factors contribute to the attenuation along the transmission line.

Two levels of maximum allowable attenuation along the line are specified. A transmitter can be switched to drive a transmission line with "low attenuation" or "high attenuation". This reduces the effects of the large attenuation range (0 .. 7,4 dB).

The following factors contribute to attenuation:

– the fibre optic cable;
– possible additional couplings (e.g., wall breakthroughs).

The additional variable couplings do not include inserted attenuation due to F-SMA plug connectors on the transmitter output and receiver input.

The transmission "low attenuation" should be selected for a short transmission line without additional couplings (e.g., 2 dB attenuation along the line) whereas "high attenuation" is selected for a long transmission line with additional couplings (e.g., 7 dB attenuation along the line). When designing the line, care shall be taken that the maximum attenuation along the line does not exceed the power levels as defined by high and low attenuation, i.e., the level of the transmission power shall eventually be adapted to the expected attenuation along the line.

Attenuation due to the couplings is often specified by technical data for the plugs. Attenuation due to the fibre optic cable cannot be determined so simply. The reason is that the specific attenuation of the fibre optic cable is not constant in the range of the specified wavelength range. For instance, a cable with a specified attenuation of 220 dB/km may in fact have this rating for only a narrow range of wavelengths, around 650 nm. This specific attenuation rating can easily increase to a value in excess of 350 dB/km (at wavelengths of approximately 635 nm and approximately 680 nm).

Consider that the wavelength radiated by the transmitting diode shifts to longer wavelengths at increasing temperatures (λp and $\Delta\lambda$ increase), significant portions of the emitted light become attenuated by the fibre optic cable.

In order to determine the exact attenuation due to the fibre optic cable, the product of attenuation and radiated light power has to be integrated over the wavelength.

A 30 m long fibre optic cable with a typical attenuation rating of 220 dB/km may have an attenuation interval of 6 dB to 9 dB over the entire temperature range of 0 °C to +55 °C (due to shifted wavelength).

Another uncertainty factor contributing to attenuation along the line is assembly. A cleanly mounted and polished plug has a very low inserted attenuation, compared to a poorly installed plug.

Annex H (informative) - Determination of the transmission timeslots

Timeslots can be determined using IDNs as follows.

IDN	Description	
S-0-0002	Communication cycle time	t_{Scyc}
S-0-0003	Shortest AT transmission starting time	t_{1min}
S-0-0004	Transmit/receive transition time	t_{ATMT}
S-0-0087	Transmit to transmit recovery time	t_{ATAT}
S-0-0088	Receive to receive recovery time	t_{MTSY}
S-0-0006	AT transmission starting time	t_1
S-0-0089	MDT transmission starting time	t_2
S-0-0090	Command value proceeding time	t_{MTSG}
S-0-0005	Minimum feedback processing time	t_5
S-0-0008	Command value valid time	t_3
S-0-0007	Feedback acquisition capture point	t_4

The jitter has to be considerated differently in dependence to the transmission rate.

Jitter MST, MDT, AT	Transmission rate 2 Mbit/s and 4 Mbit/s	Transmission rate 8 Mbit/s and 16 Mbit/s
J_{tScyc}, J_{t2}, J_{t1}	min {5 µs; 0,005 * t_{Scyc}} + 4 * t_{BIT}	1 µs

H.1 Determination of AT transmission starting time t_1

During CP2 the control unit requests the parameter t_{1min} from all drives. The drive which has the smallest t_{1min} is placed as the first drive (m =1). The following is true:

$$t_{1.1} = t_{1min.1}$$

The control unit shall make sure that it is ready to receive an AT already at $t_{1min.1} - J_{t1}$ after the end of the MST. Otherwise, a time interval greater than $t_{1.1}$ shall be determined. After the timeslot for the first drive has been determined, the control unit can assign the timeslot for the next drive (m = 2). This is determined from the following (see figure H.1):

$$t_{1.m+1} \geq t_{1.m} + \text{DAT.m} + t_{ATNT.m} + 2 * J_{t1}$$

In this case, $t_{ATNT.m}$ is the minimum time interval which drive m requires up to the next telegram and DAT.m is the maximum time interval of the AT.m (see below).

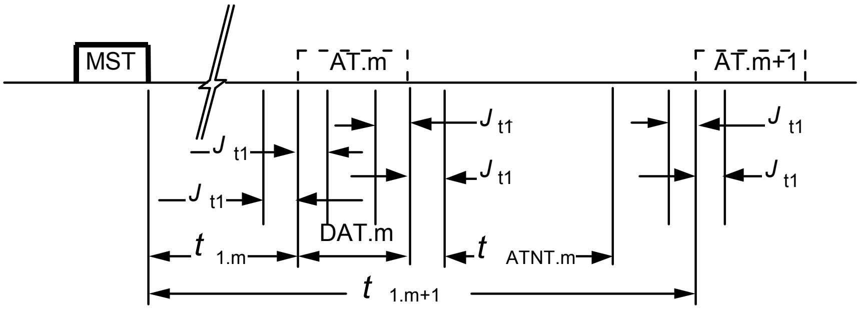


Figure H. 1 – Determination of the AT transmission starting time

The control unit shall have to make sure the t_{1min} of a drive is shorter than the calculated t_1, taking into consideration the time the control unit itself requires between two ATs. Where necessary, a greater time interval of $t_{1.m+1}$ shall be determined. For slaves with several drives, the time interval for two ATs from the same slave shall be at least $t_{ATNT} \geq t_{ATAT}$, and for ATs from different slaves, at least $t_{ATNT} \geq t_{ATRP}$. In order to select a shorter interval, the control unit shall know which drives are connected to a common slave. This can be accomplished via the slave identification parameter (SLKN, see S-0-0096).

H.2 Determination of MDT transmission starting time t_2

After the control unit has calculated the timeslots for all drive telegrams in this manner, the timeslot for the MDT can be determined as follows (see figure H.2):

$$t_2 \geq t_{1.M} + \text{DAT.M} + t_{ATMT.M} + J_{t1} + J_{t2}$$

The control unit is forced, however, to incorporate its own restrictions as well.

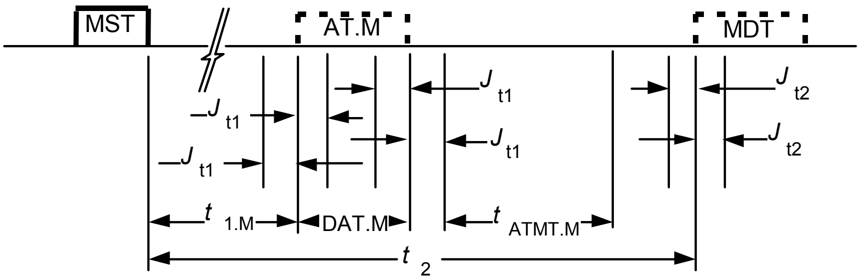


Figure H. 2 – Determination of the MDT transmission starting time

The timeslot shall be chosen in a way so that the maximum time which a drive requires between the MDT and the MST, t_{MTSY}, is not exceeded.

Therefore:

$$t_2 \leq t_{Scyc} - \text{DMDT} - \text{DMST} - \max\{t_{MTSY(m)}\} - J_{t2} - J_{tScyc}$$

where
DMDT is the maximum duration of the MDT;
DMST is the maximum duration of the MST.

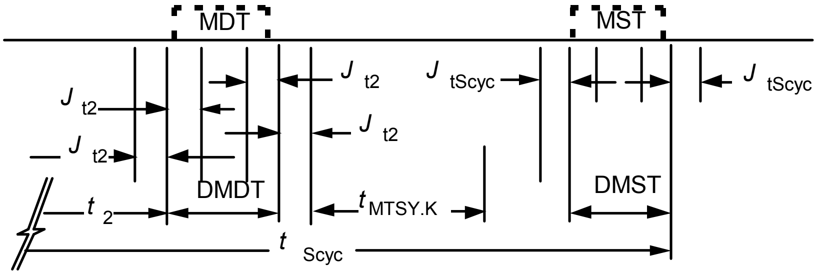


Figure H. 3 – Evaluation of t_{MTSY}

Where it is not possible to satisfy all of the conditions mentioned above, then either the t_{Scyc} shall be increased or the slaves shall be distributed over multiple rings.

H.3 Maximum duration of the telegrams

The maximum duration of single telegrams can be determined as follows:

H.3.1 *Duration of the MST (DMST)*

The exact structure of the MST is described in clause 7.3.1. The length of the data field is only one byte long. The time duration of the MST is calculated by:

$$DMST = (2 * 8 + 4 * 9{,}6) * t_{Bit} \quad (t_{Bit} = \frac{1}{\text{transmission rate}})$$

The term 2 * 8 represents the BOF and EOF sequences. The remaining four bytes, (for ADR field, INFO field and FCS field) can have a maximum length of 9,6 as a result of bit stuffing.

Example:
transmission rate = 2 Mbit/s
DMST = 27,2 µs

H.3.2 *Duration of the AT (DAT)*

The exact structure of the AT is described in clause 7.3.3. The duration of the AT is calculated by:

$$DAT = (2 * 8 + (5 + NBYSC + NBYVA) * 9.6) * t_{Bit} \quad (t_{Bit} = \frac{1}{\text{transmission rate}})$$

Where NBYVA is the number of bytes of the configurable data record in the AT.
Where NBYSC is the number of bytes (2, 4, 6 or 8 bytes) of the service channel.
Example:
NBYVA = 6, NBYSC = 2,
transmission rate = 2 Mbit/s
DAT = (2 * 8 + (13 * 9,6)) * 0,5 µs = 70,4 µs

H.3.3 *Duration of the MDT (DMDT)*

The exact structure of the MDT is described in clause 7.3.2. The duration of the MDT is calculated by:

$$DMDT = \left(2 * 8 + 3 * 9{,}6 + 2 * 9{,}6 * M + 9{,}6 * \sum_{m=1}^{m=M} NBYVM(m)\right) * t_{Bit}$$

where
M is the number of drives in a ring, and
NBYVM(m) is the number of bytes of the configurable data records and the number of bytes of the service channels for the respective drives in the MDT.

H.4 Determination of command value valid time (t_3)

After the control has calculated the transmission starting times of all telegrams, it has to find out the command value valid time (t_3). For all drives working together in coordination the control has to provide the same command value valid time. For the calculation the longest time t_{MTSG} a drive needs has to be taken.
The command value valid time has to fill the following conditions:

$$t_3 \geq t_2 + DMDT + \max\{t_{MTSG}(m)\} + J_{t2} + J_{tScyc}$$

$$t_3 \leq t_2 + DMDT - J_{t2} - J_{tScyc}$$

$$t_3 \leq t_{Scyc}$$

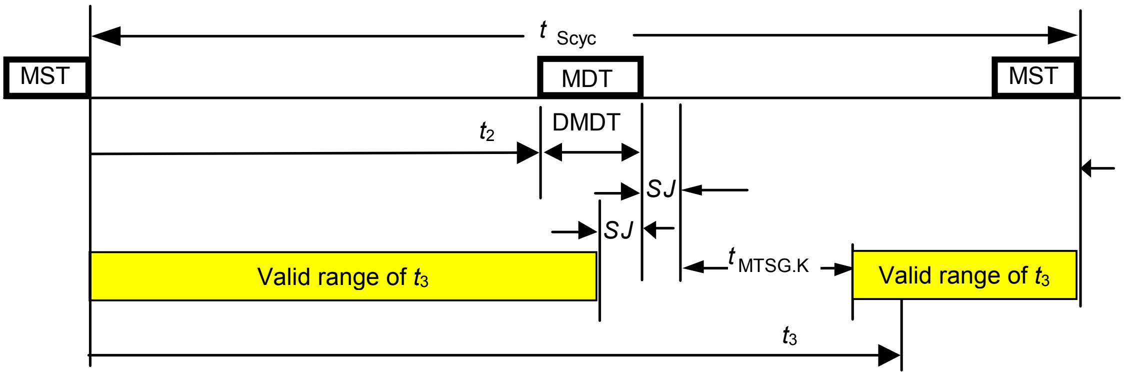


Figure H. 4 - Determination of command value valid time

H.5 Determination of feedback acquisition capture point (t_4)

After the control has found the command value valid time, it has to provide the same feedback acquisition capture point (t_4) for all drives working in coordination on the ring to ensure that they are synchronized. The maximum time required by a drive (t_5) must be calculated.
The synchronization time has to fill the following conditions:

$$0 \leq t_4 \leq t_{Scyc} - \max\{t_{5(m)}\} - 2 * J_{tScyc}$$

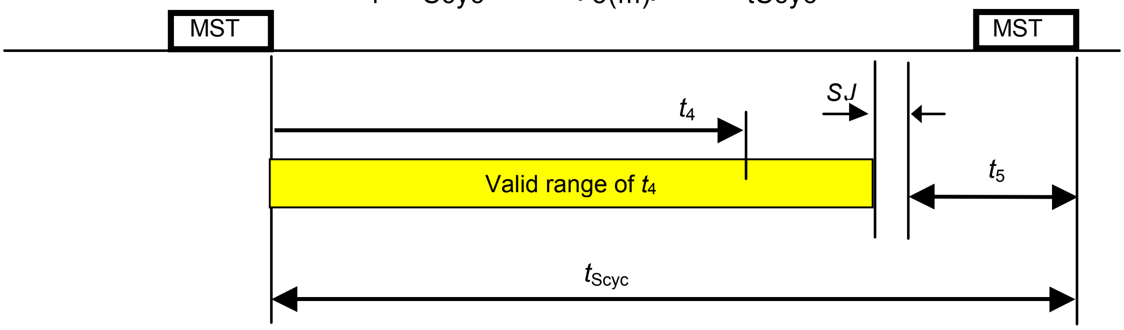


Figure H. 5 - Determination of feedback acquisition capture point

H.6 Dependences of the times t_3 and t_4

Due to the processing of the command values and feedback values definite dependences consist in the drive between the times t_3 and t_4. The manufacturer should document this in the drive manual.

Annex I (informative) - Processing operation data

The following is an example showing the processing of operation data. The example shows the drive's service INFO fields in the AT and the MDT and their related control or status bits of sequential interface cycles.

Figure I.1 explains the significance of individual bits.

Service channel in the AT

Drive status		Drive service INFO	
. . . .	. . . . . 2 1 0		
MSB	LSB	MSB	LSB

2 – error bit
1 – busy bit
0 – drive handshake bit (AHS)

Service channel in the MDT

Master control		Master service INFO	
. . . .	. . . 5 4 3 2 1 0	. . . .	. . . .
MSB	LSB	MSB	LSB

5-3 – data block element
2 – current/last transmission
1 – read/write
0 – master handshake bit (MHS)

Figure I. 1 – Explanation for processing operation data examples

In figure I.2, several additional 'wait cycles' have been included in the sequence of the communication cycles. The frequency of the 'wait cycles' depends on the status of the service channel and the processing speeds of the master and the drive. Any service channel activities by a drive or the master are always indicated in the AT status and MDT control fields.

The IDNs used in the example are chosen arbitrarily. For simplification, IDNs are written decimally.

IDN (decimal)	IDN (hexadecimal)	IDN
54321	0xD431	P-5-1073
12345	0x3039	S-3-0057

The example starts with cycle 01, which opens the service channel to operation data having the IDN 54321 0xD431. Since the MSB has been set in this IDN, it must be a manufacturer-defined operation data. The drive responds in cycle 03 with the data status of the data block of this IDN.

In order to process and display the attribute for this operation data, the master proceeds to read cycles 03 to 06 in two steps. Cycle 07, in this example, is a wait cycle, since the master has not given instructions for a new step.

During cycles 08 to 15, the master reads the name of operation data through IDN 54321. In cycle 11, the master is informed that the name consists of 6 ASCII characters. In cycle 12, the master is informed that the drive has a data length available for 60 characters for the name. During the cycles 13 through 15, the master reads the name 'P-GAIN' in three steps. During cycles 17 through 22, the master attempts, through the action write name, to change this name to 'P-GAIN Y-AXIS'. In cycle 17, the master informs the drive of the new text length of 14 ASCII characters. It is assumed in this example that the drive has enough memory for this name change, but is unable at this time to change the name. Thus, the drive responds with the error code 'error group 2, error type 5' (name currently write-protected) during cycle 23.

Starting with cycle 25, the master reads the unit for operation data IDN 54321. In cycle 28, the master is informed of the text length of the programmed text. In this example, the text length is assumed to be zero ASCII characters, that is, the data is a dimensionless number without units. A maximum text length of 12 ASCII-characters is reported by the drive (cycle 30).

During the cycles 32 to 35, the 4-byte long data of IDN 54321 is read in two steps.

Beginning with cycle 36, the service channel is opened briefly for operation data of IDN 12345, 0x3039 and, in this example, the 2-byte long data is written in one step.

In cycle 40, the service channel is made available again for operation data IDN 54321. More data processing takes place in cycles 41 through 43, through reading the maximum input value in two steps.

Cycles 44 through 46 are used, in this example, to write the changed data of operation data IDN 54321 back to the drive in two steps.

The service channel is closed again with cycle 48.

00	Wait for a new step	.....	...000	Undefined	No new step	.....	000000	Undefined	
01	Wait for a new step	....	...000		Write IDN Open service channel for IDN 54321	....	..001111	0xD4	0x31
02	Acknowledge transfer Step is being processed	....	...011	Undefined	Waiting for acknowledgement	....	..001111	0xD4	0x31
03	Acknowledge step Send data status	....	...001	Data status	Read attribute Read attribute LOW word	....	..011000	Undefined	
04	Transfer acknowledged Step acknowledged Send attribute LOW word	....	...000	Attribute LOW word	No new step	....	..011000	Undefined	
05	Waiting for a new step	....	... 000	Attribute LOW word	Read attribute HIGH word	....	..011101	Undefined	
06	Transfer acknowledged Step acknowledged Send attribute HIGH word	....	...001	Attribute HIGH word	No new step	....	..011101	Undefined	
07	Waiting for a new step	....	...001	Attribute HIGH word	No new step	....	..011101	Undefined	
08	Waiting for a new step	....	...001	Attribute HIGH word	Read name Read length of programmed text	....	..010000	Undefined	
09	Transfer not yet acknowledged	....	...001	Attribute HIGH word	Waiting for transfer handshake	....	..010000	Undefined	
10	Transfer acknowledged Step is being processed	....	...010	Attribute HIGH word	Waiting for acknowledgement	....	..010000	Undefined	

Step acknowledged
Send length of programmed text

Read maximum text length

11	……..	…000	0x00	0x06		……..	..010001	Undefined	

Transfer acknowledged
Step acknowledged
Send maximum text length

Read initial two characters

12	……..	…001	0x00	0x3C		……..	..010000	Undefined	

Transfer acknowledged
Step acknowledged
Send initial two characters

Read next two characters

13	……..	…000	”-”	”P”		……..	..010001	Undefined	

NOTE - The characters are coded as shown in annex E.

Transfer acknowledged
Step acknowledged
Send next two characters

Read last two characters

14	……..	…001	”A”	”G”		……..	..010100	Undefined	

NOTE - The characters are coded as shown in annex E.

Transfer acknowledged
Step acknowledged
Send last two characters

No new step

15	……..	…000	”N”	”I”		……..	..010100	Undefined	

NOTE - The characters are coded as shown in annex E.

Waiting for new step

No new step

16	……..	…000	”N”	”I”		……..	..010100	Undefined	

NOTE - The characters are coded as shown in annex E.

Waiting for new step

Write name
Write length of programmed text

17	……..	…000	”N”	”T”		……..	..010011	0x00	0x0E

NOTE - The characters are coded as shown in annex E.

Transfer not yet acknowledged

Waiting for transfer handshake

18	……..	…000	”N”	”T”		……..	..010011	0x00	0x0E

NOTE - The characters are coded as shown in annex E.

Transfer acknowledged
Step is being processed

Waiting for acknowledgement

19	……..	… 011	Undefined		……..	..010011	0x00	0x0E

Step acknowledged

Write dummy bytes for maximum text length

20	……..	…001	Undefined		……..	..010010	Undefined

Transfer acknowledged
Step acknowledged

Write initial two characters

21	……..	…000	Undefined		……..	..010011	“-”	“P”

Transfer acknowledged
Step is being processed

Waiting for acknowledgement

22		……..	…011	Undefined			……..	..010011	"-"	"P"
23	Step acknowledged Error message	……..	…101	0010 …. …. 0101		Error handling No new step	……..	..010011	"-"	"P"
24	Waiting for new step	……..	…101	0010 …. ….0101		No new step	……..	..010011	"-"	"P"
25	Waiting for new step	……..	…101	0010 …. ….0101		Read unit Read length of programmed text	……..	..100000	Undefined	
26	Transfer not yet acknowledged	……..	…101	0010 …. ….0101		Waiting for transfer handshake	……..	..100000	Undefined	
27	Transfer acknowledged Step is being processed	……..	…010	Undefined		Waiting for acknowledgement	……..	..100000	Undefined	
28	Step acknowledgement Send length of programmed text	……..	…000	0x00	0x00	No new step	……..	..100000	Undefined	
29	Waiting for new step	……..	…000	0x00	0x00	Read maximum text length	……..	..100101	Undefined	
30	Transfer acknowledged Step acknowledged Send maximum length text	……..	…001	0x00	0x0C	No new step	……..	..100101	Undefined	
31	Waiting for new step	……..	…001	0x00	0x0C	No new step	……..	..100101	Undefined	
32	Waiting for new step	……..	…001	0x00	0x0C	Read data Read LOW word data	……..	..111000	Undefined	
33	Transfer not yet acknowledged	……..	…001	0x00	0x0C	Waiting for transfer handshake	……..	..111000	Undefined	
34	Transfer acknowledged Step acknowledged Send LOW word data	……..	…000	LOW word data		Read HIGH word data	……..	..111101	Undefined	

Transfer acknowledged
Step acknowledged
Send HIGH word data

No new step

35

……..	…001	HIGH word data

……..	..111101	Undefined

Waiting for new step

Write IDN
Open service channel for IDN 12345

36

……..	…001	HIGH word data

……..	..001110	0x30	0x39

Transfer acknowledged
Step is being processed

Waiting for acknowledgement

37

……..	…010	Undefined

……..	..001110	0x30	0x39

Transfer acknowledged
Send data status

Write operation data

38

……..	…000	Data status

……..	..111111	Operation data

Transfer acknowledged
Step acknowledged
Data received

No new step

39

……..	…001	Undefined

……..	..111111	Undefined

Waiting for new step

Write IDN
Open service channel for IDN 54321

40

……..	…001	Undefined

……..	..001110	0xD4	0x31

Transfer acknowledged
Step acknowledged
Send data status

Read maximum input value
Read maximum input value LOW word

41

……..	…000	Data status

……..	..110001	Undefined

Transfer acknowledged
Step acknowledged
Send maximum value LOW word

Read maximum input value HIGH word

42

……..	…001	Maximum value LOW word

……..	..110100	Undefined

Transfer acknowledged
Step acknowledged
Send maximum value of HIGH word

No new step

43

……..	…000	Maximum value HIGH word

……..	..110100	Undefined

Waiting for new step

Write operation data
Writing LOW word operation data

44

……..	…000	Maximum value HIGH word

……..	..111011	LOW word data

Transfer acknowledged
Step acknowledged

Writing HIGH word operation data

45

……..	…001	Undefined

……..	..111110	HIGH word data

Transfer acknowledged
Step acknowledged

No new step

46

……..	…000	Undefined

……..	..111110	HIGH word data

Waiting for new step

No new step

47	……..	…000	Undefined	……..	..111110	Undefined
	Waiting for new step			Write end Close service channel		
48	……..	…000	Undefined	……..	..000111	Undefined
	Transfer acknowledged Step acknowledged			No new step		
49	……..	…001	Undefined	……..	..000111	Undefined
	Waiting for new step			No new step		
50	……..	…001	Undefined	……..	..000111	Undefined

Figure I. 2 – Examples for processing operation data

Annex J (informative) - Procedure command execution

This annex gives an example of the execution of procedure commands via the service channel. The example shows the drive's service INFO fields in the AT and the MDT and their related status or control bits of individual communication cycles. Figure J.1 explains once more the significance of individual bits.

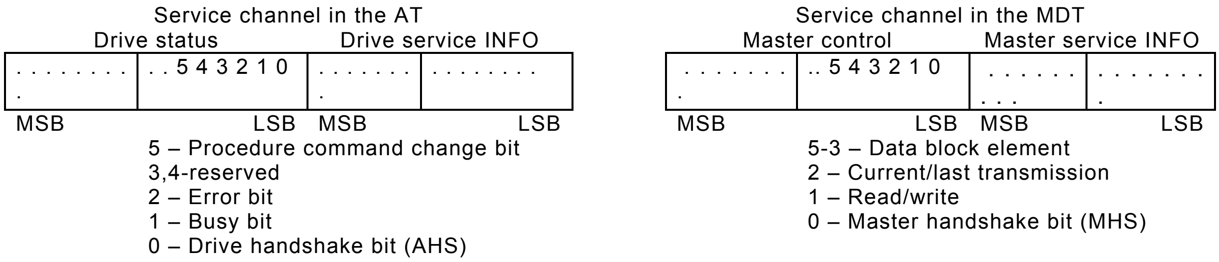


Figure J. 1 – Explanation for procedure command execution examples

In the following example, figure J.2, several interface cycles are shown as they are needed during procedure command execution, in this example during initialization of the interface. While the processing of the procedure commands is active the service channel is available for other activities such as the transfer of operation data.

Service channel activities of the drive or master are shown above the fields representing the AT and the MDT. Also shown are the effects of the transport mechanism on the control and status bits of the service channel. However, these effects have already been described in detail in annex I. In this example, the effects of the transport of procedure commands will be illustrated.

Any transport of the remaining elements of the data block of a procedure command (such as name or attribute) have also been omitted. These elements correspond to the processing of operation data as shown in annex I.

The example starts with CP2. The master has transferred all operation data which are required for switching to CP3. It starts with cycle a1 where the service channel is opened for the procedure command ‘CP3 transition check’, using S-0-0127 0x007F. In cycle a3 the drive responds with the data status of the data block corresponding to this IDN, that is, the command acknowledgment. During this cycle, the master sends the procedure command ‘set and enable procedure command execution’. This command is accepted by the drive during the subsequent cycle so that the master writes the S-0-0127 to the drive to get the procedure command acknowledgement. In cycle a5, the drive sends the procedure command acknowledcgement, that the procedure command is not yet executed. In both cases a3 and a5 the drive acknowledges the procedure command and the step in the same cycle.

During the b cycles, the master checks the status of procedure command S-0-0127. The procedure command acknowledgment indicates that the procedure command has been set and enabled in the drive and is still being processed.

During cycle c1, the drive has finished the procedure command and is setting the procedure command change bit in the status.

During cycle d1, the master opens the service channel again for procedure command S-0-0127 and is informed by the procedure command acknowledgment in cycle d2, that the drive has executed the procedure command properly and is now ready for switching to CP3. The master concludes this procedure command properly in cycle d3 through the procedure command control ‘cancel procedure command’. Next, the drive cancels the procedure command change bit and acknowledges the step in cycle d4.

During the next cycles in this example, it is assumed that the master succeeds in switching the interface to CP3 and performs all activities which are required to switch to CP4.

In cycle e1, the service channel is opened for the procedure command CP4 transition check, using S-0-0128 0x0080. The master starts this procedure command in cycle e3 with the procedure command control, ‘set and enable command execution’.

During the f cycles, the master requests an interruption of the procedure command execution. The master writes the appropriate IDN and is informed through the procedure command acknowledgement, that the procedure command is not yet executed. Following the procedure command control ‘interrupt procedure command execution’ in cycle f2, the drive stops the execution during cycle f3. Thereupon the drive updates its procedure command acknowledgement internal only and acknowledges the step in cycle f3.

During the g cycles, the master requests to restart the procedure command. During the procedure command acknowledgement of cycle g2, the master is informed that the procedure command has been set but not yet finished, since it was interrupted by the master. The procedure command S-0-0128 is restarted after the procedure command control ‘enable procedure command’ and the subsequent acceptance by the drive in cycle g3.

Next, the procedure command change bit is set in the status word in cycle h1.

The master checks for a conclusion of the procedure command by sending S-0-0128 in cycle i1 and reading the procedure command acknowledgement in cycle i2. This time, the master receives a negative procedure command acknowledgement (error bit is set), that is, the drive is not ready for switching to CP4 (e.g., missing operation data). This procedure command shall also be cancelled properly by the master with the procedure command control ‘cancel procedure command’, in cycle i2. Following this step, the drive cancels the procedure command change bit and updates its procedure command acknowledgement internal only. The drive sends the step acknowledgement in cycle i3.

After eliminating the cause which prevented the drive from switching (in this case, by transferring the missing operation data), the master sends and starts procedure command S-0-0128 again during the k cycles.

After setting the command change bit in cycle l1, the drive issues a positive procedure command acknowledgement during the m cycles and the master cancels the procedure command properly. The drive cancels the command change bit again and updates the command acknowledgement internal only.

In this example, the initialization process is finished when the master switches the interface to CP4.

This example illustrates how procedure commands which were transferred during initialization cause autonomous functional processes in the drives and the master.

Cycle	Drive			Master			
				No new step			
a0				……..	..000000	Undefined	
	Waiting for a new step			Write new IDN Open service channel for procedure command S-0-0127			
a1	……..	..000000	Undefined	……..	..001111	0x00	0x7F
	Transfer acknowledged Step being processed			Waiting for acknowledgement			
a2	……..	..000011	Undefined	……..	..001111	0x00	0x7F
	Step acknowledged Send procedure command acknowledgement			Send procedure command control Set and enable procedure command			

a3	……..	..000001	00000000	00000000		……..	..111110	00000000	00000011

Transfer acknowledged
Step acknowledged

Write IDN
Open service channel for procedure command S-0-0127

a4	……..	..000000	Undefined			……..	..001111	0x00	0x7F

Transfer acknowledged
Send procedure command acknowledgement
Step acknowledged

a5	……..	..000001	00000000	00000111

Waiting for a new step

Write IDN
Open service channel for procedure command S-0-0127

b1	……..	..000000	Undefined			……..	..001111	0x00	0x7F

Transfer acknowledged
Step acknowledged
Send procedure command acknowledgement

No new step

b2	……..	..000001	00000000	00000111		……..	..001111	0x00	0x7F

Procedure command change bit is set

c1	……..	..1xxxxx	Undefined	

NOTE - x = undefined

Waiting for a new step

Write IDN
Open service channel for procedure command S-0-0127

d1	……..	..100000	Undefined			……..	..001111	0x00	0x7F

Transfer acknowledged
Step acknowledged
Send procedure command acknowledgement

No new step

d2	……..	..100001	00000000	00000011		……..	..001111	0x00	0x7F

Waiting for a new step

Send procedure command control
Cancel procedure command

d3	……..	..100001	00000000	00000011		……..	..111110	00000000	00000000

Transfer acknowledged
Cancel procedure command change bit
Step acknowledged

d4	……..	..000000	Undefined	

Waiting for a new step

WriteIDN
Open service channel for procedure command S-0-0128

e1	……..	..000000	Undefined			……..	..001111	0x00	0x80

e2

Transfer acknowledged
Step is being processed

....	..000011	Undefined

Waiting for acknowledgement

....	..001111	0x00	0x80

e3

Step acknowledged
Send procedure command acknowledgement

....	..000001	00000000	00000000

Send procedure command control
Set and enable procedure command

....	..111110	00000000	00000011

e4

Transfer acknowledged
Step acknowledged

....	..000000	Undefined

f1

Waiting for a new step

....	..000001	Undefined

Write IDN
Open service channel for procedure command
S-0-0128

....	..001110	0x00	0x80

f2

Transfer acknowledged
Step acknowledged
Send procedure command acknowledgement

....	..000000	00000000	00000111

Send procedure command control
Interrupt procedure command execution

....	..111111	00000000	00000001

f3

Transfer acknowledged
Step acknowledged

....	..000001	Undefined

g1

Waiting for a new step

....	..000000	Undefined

Write IDN
Open service channel for procedure command
S-0-0128

....	..001111	0x00	0x80

g2

Transfer acknowledged
Step acknowledged
Send procedure command acknowledgement

....	..000001	00000000	00000101

Send procedure command control
Enable procedure command again

....	..111110	00000000	00000011

g3

Transfer acknowledged
Step is being processed

....	..000010	Undefined

Waiting for acknowledgement

....	..111110	00000000	00000011

h1

Procedure command change bit is set

....	..1xxxxx	Undefined

NOTE - x = undefined

i1

Waiting for a new step

....	..100000	Undefined

Write IDN
Open service channel for procedure command
S-0-0128

....	..001111	0x00	0x80

i2

Transfer acknowledged
Step acknowledged
Send procedure command acknowledgement

……..	..100001	00000000	00001111

Send procedure command control
Cancel procedure command

……..	..111110	00000000	00000000

i3

Transfer acknowledged
Cancel procedure command change bit
Step acknowledged

……..	..000000	Undefined

k1

Waiting for a new step

……..	..000001	Undefined

Write IDN
Open service channel for procedure command
S-0-0128

……..	..001110	0x00	0x80

k2

Transfer acknowledged
Step acknowledged
Send procedure command acknowledgement

……..	..000000	00000000	00000000

Send procedure command control
Set and enable procedure command

……..	..111111	00000000	00000011

k3

Transfer acknowledged
Step acknowledged

……..	..000001	Undefined

No new step

……..	..111110	00000000	00000011

l1

Procedure command change bit is set

……..	..1xxxxx	Undefined

NOTE - x = undefined

m1

Waiting for a new step

……..	..100001	Undefined

Write IDN
Open service channel for procedure command
S-0-0128

……..	..001110	0x00	0x80

m2

Transfer acknowledged
Step acknowledged
Send procedure command acknowledgement

……..	..100000	00000000	00000011

Send procedure command control
Cancel procedure command

……..	..111111	00000000	00000000

m3

Transfer acknowledged
Cancel procedure command change bit
Step acknowledged

……..	..000001	Undefined

Figure J. 2 – Examples of procedure command executions