SIEB & MEYER

Drive System SD2

SERVOLINK 4 Bus System Description

D-00000138.3
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1 SERVOLINK 4 Bus System

SERVOLINK 4 is a bus system for connecting drive amplifiers and a control computer in a network. The bus is realized as a ring structure. Data transmission is serial and cyclical. The data are transmitted via optical fiber connectors (TOSLINK) and RS422 interfaces. The drive amplifiers provide both types of connectors and both connectors can be used at the same time. FPGA solutions are provided for connection at the master and the slave. For the master additional equipment is available: the gateway 036215Xy. The interface to the controller behaves like a dual port memory (DPRAM). For every drive it provides 16 bytes reference data and 16 bytes actual data. The contents depend on the operating mode. The data blocks are checked with a CRC check (cyclic redundancy check). Every drive exchanges the received reference data with the actual data. This makes sure that the transmission time is not extended by the transmission of the actual values.

1.1 Structure

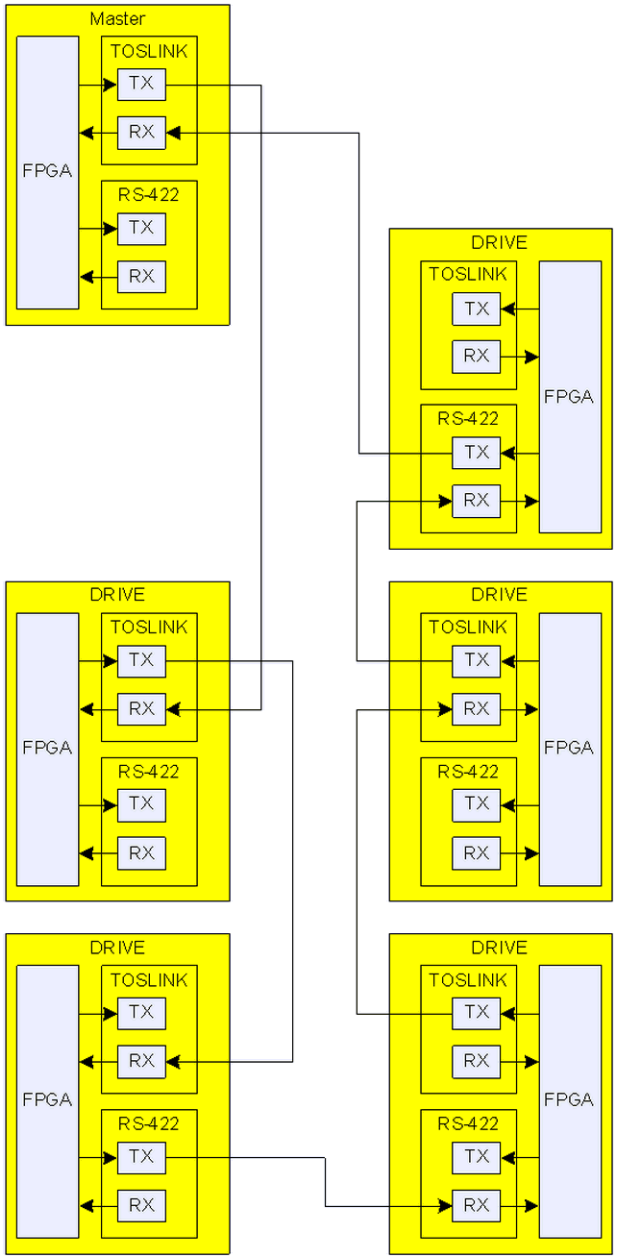

Fig. 1: Mixed operation with Toslink and RS422

1.2 Transmission Format

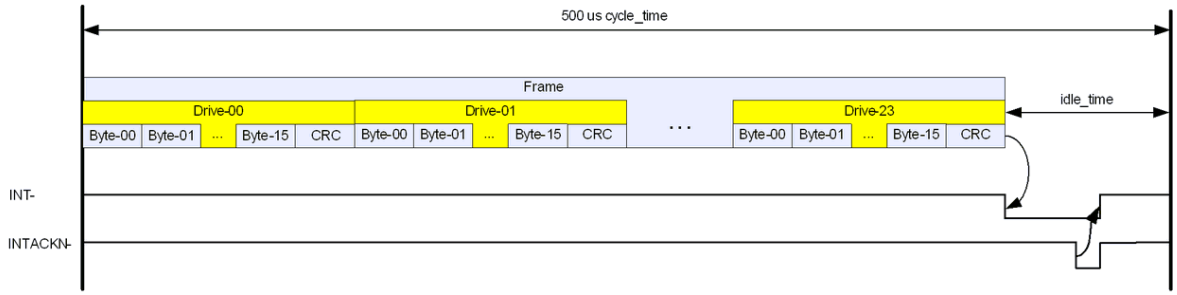

Fig. 2: SERVOLINK 4 transmission format

Transmission time

t_{bit} = 84 ns

$t_{frame} = t_{bit} \times n_{drives} ((n_{byte} + n_{delay} + 1_{CRC}) \times 10_{bits}) = 84\ ns \times 24 \times ((16 + 2 + 1) \times 10) = 380\ \mu s$

$t_{idle} = t_{cycle} - t_{frame} = 500\ \mu s - 380\ \mu s = 120\ \mu s$

CRC:

$1 + x^1 + x^2 + x^8$

1.3 Interrupt

By default the FPGA triggers an interrupt at the end of a data frame. In the interrupt routine the actual values are read and the new reference values are written to the FPGA. If this process is not executed until the next cycle start, zero data are automatically transmitted to the drives. The interrupt is reset by reading an address in the FPGA.

1.4 FPGA Interface

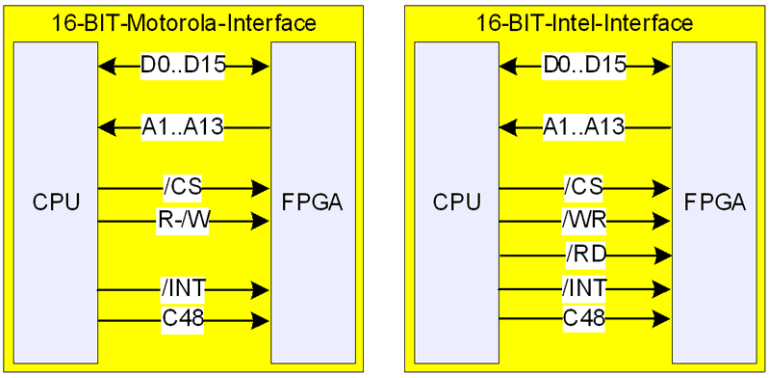

Fig. 3: FPGA interface

1.5 RAM Interface

Address	Name	Meaning
0x0000 … 0x017f	ACTUALVALUES	Actual data of the drive
0x0200 … 0x037f	SETPOINTVALUES	Reference data of the drive
0x0400 … 0x0402	CRCSTATE	CRC status, 0xffffff → OK
0x0404	DATAEXCHANGE	Bit = 0 → idle operation Bit = 1 → data exchange
0x0406	INTACKN	Interrupt acknowledgement
0x0408	CONFIG	Configuration Bit-0 = 1 → interrupt ON
0x040a	SELECT	Medium selection Bit-0 = 0 → RS422 Bit-0 = 1 → TOSLINK
0x040c	DRIVEIN	Receipt position
0x040e	DRIVEOUT	Transmission position
0x0410	INTPOSITION	Interrupt position
0x0412	ZEROCNT	16 bit zero data counter
0x1000	VERSION	Version code
0x1002	TESTWORD	Test word (0xaaaa)

ACTUAL VALUES

Actual data of the drive: 24 drives × 16 bytes per drive

SETPOINT VALUES

Reference data of the drive: 24 drives × 16 bytes per drive

CRC-STATE

One CRC bit per drive. Bit-0 for drive-0, bit-1 for drive -1, etc.

Bit = 0 → invalid data, bit = 1 → valid data

When a new cycle is started all bits are reset to 0. The CRC bit is set after a the data package was received without errors.

DATA EXCHANGE

Bit-0 = 0 → SERVOLINK 4 is in the idle operation phase. Bit-0 = 1 → SERVOLINK 4 is in the transmission phase.

INTACKN

An access to this register acknowledges the interrupt. If the interrupt is not sent until the next cycle starts, zero data will be sent.

CONFIG

Bit-0 = 0 → interrupt disabled, bit-0 = 1 → interrupt enabled

SELECT

Bit-0 = 0 → RS422 interface, bit-0 = 1 → TOSLINK interface.

DRIVE-IN POSITION

The register indicates the drive number of the data package that is currently being received.

DRIVE-OUT POSITION

The register indicates the drive number of the data package that is currently being sent.

INTPOSITION (programmable interrupt position)

This register is used for setting the interrupt position. The position is indicated in bit times. The position can be between 160 and 5999. Please consider a delay of up to 20 µs for each module.

ZEROCNT

The counter is increased after every transmission process of a zero data cycle.

VERSION

Version code of the VHDL program, e.g. 0x10001

TESTWORD

Test register. The value is 0xaaaa.

2 Telegrams

The SERVOLINK 4 telegrams are divided into a process data channel and a service data channel. The data in the process data channel are updated and transmitted in every cycle. These data are the control and the status word. The additional area is used differently according to the current operating mode and described in separate sections below.

The service data channel is used to transmit not time-critical or larger data areas. The data transmission is serial.

2.1 Velocity Mode 1 (Mode 2)

The operating mode “Velocity mode 1” offers the following features:

- easy definition of the reference speed value
- easy definition of the current/maximum torque limitation
- internal ramp generation for
  - reference speed value with linear acceleration and deceleration ramp
  - reference speed value with S-curve acceleration and deceleration ramp
  - limitation of the current/maximum torque
- status functions for
  - speed zero
  - speed ramp has reached the target value
  - speed controller is in the current/torque limitation
  - current/torque limitation ramp has reached the target value
  - device status
- quick stop function (configurable via parameter setting)
  - deceleration with maximum torque/current
  - deceleration with deceleration ramp (configurable via parameter setting)
  - deceleration with defined down-ramping of the torque or current
- device control according to drive profile DS402
- speed and torque control possible

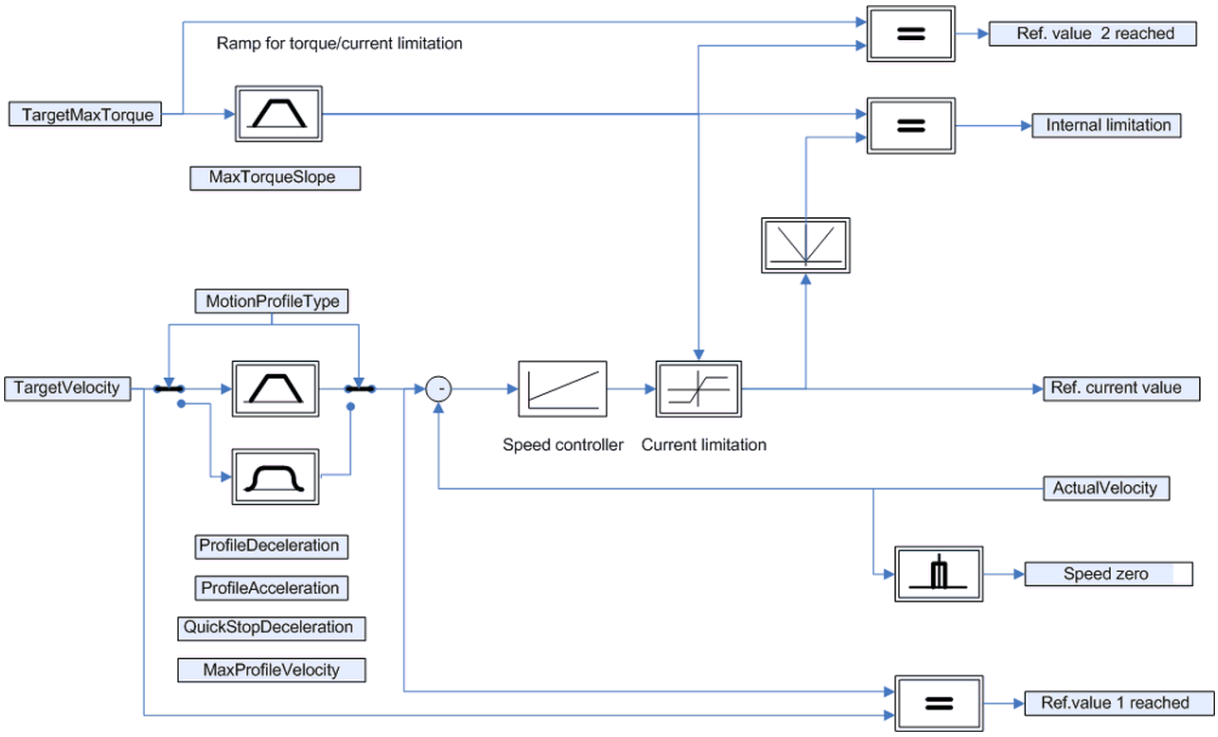

Fig. 4: Operating mode “Velocity mode 1”

2.1.1 Reference Value Telegram

The reference value telegram for controlling the drive consists of 16 byte user data structured as follows:

Byte	Value	Name	Bit	Description
0	2	ControlWord	0	Switch on(1)
			1	Enable voltage(1)
			2	Quick stop(1)
			3	Enable operation(1)
			4	Reserved
			5	Reserved
			6	Reserved
			7	Fault reset(1)
			8	Reserved
			9	Reserved
			10	Reserved
			11	Reserved
			12	Reserved
			13	Reserved
			14	Reference value telegram ID / 0(2)
			15	Reference value telegram ID / 1(2)
2	2	Res.		Reserved
4	2	SPG_TARGET_VELOCITY_VL		Target speed/velocity VL 16 bit 0x3fff = 100 % = Vscaling
6	2	SPG_TARGET_TORQUE_LIMIT		Torque/current limitation 0x3fff = peak current of the drive amplifier Only for drive function SERVO, otherwise reserved
8	1	Res.		Reserved
9	7	ServiceChannel		See page 17

(1) The function of each bit is described in greater detail in the manual “Drive System SD2 – Device Control”.
(2) The telegram ID has fix values for SERVOLINK 4: bit 14 is always 0 and bit 15 is always 1.

2.1.2 Actual Value Telegram

The actual value telegram of the drive consists of 16 byte user data structured as follows:

Byte	Value	Name	Bit	Description
0	2	StatusWord	0	Ready to switch on[1]
			1	Switched on[1]
			2	Operation enabled[1]
			3	Error[1]
			4	Enable voltage[1]
			5	Quick stop[1]
			6	Switch on disabled[1]
			7	Warning[1]
			8	Status of digital input 4 / measuring system contact[2]
			9	Remote[1]
			10	Reference value reached[1]
			11	Internal limit active[1]
			12	Speed 0[1]
			13	SERVOLINK toggle bit[3]
			14	Actual value telegram ID / 1[4]
			15	Actual value telegram ID / 0[4]
2	4	PCTRL_POSITION_ACTUAL_VALUE		Current position of position controller 32 bits, resolution 0.1 µm
2[5]	2	PCTRL_POSITION_ACTUAL_VALUE		Current position of position controller 16 bits, resolution 0.1 µm
4[5]	2	ICTR_ACTIVE_CURRENT		Active current (0x3FFF ≙ peak current of output stage)
6	2	VCTRL_VELOCITY_ACTUAL_VALUE		Actual speed 0x3fff = 100% = Vscaling
8	2	ICTRL_IQ_REFERENCE		Current reference value 0x3fff = peak current of the drive amplifier
10	6	ServiceData Channel		See page 17

[1] The function of each bit is described in greater detail in the manual “Drive System SD2 – Device Control”.

[2] The function of this bit is described in greater detail in the document “TIE_SD2_DeviceControl_DepthMeasuring.pdf”.

[3] This bit is toggled with each update of the actual values.

[4] The telegram ID has fix values for SERVOLINK 4: bit 14 is always 1 and bit 15 is always 0.

[5] With drive function UF/HSPAM the actual position value is not transmitted as a 32-bit value but as a 16-bit position value and the actual active current.

2.2 Profile Velocity Mode (PV, Mode 3)

The operating mode “Profiled Velocity Mode” offers the following features:

- speed setting via SERVOLINK 4,
  positioning profile is generated in higher-ranking control.
- SERVOLINK 4 baud rate 2 kHz (default) or 4 kHz

- The data rate of the reference speed values can be 250 Hz, 500 Hz, 1000 Hz, 2000 Hz or 4000 Hz.
- internal fine interpolation of the reference speed values for reducing reference value jumps resulting from the data rate of the set values
- direct setting of a current feed forward value in the cyclic reference value telegram
- automatic conversion or scaling of the position measuring systems in 100 nm
- calculation of a current feed forward with 4 kHz in the drive amplifier
- monitoring of the speed error in the drive amplifier
- monitoring of the set positioning profile regarding maximum speed and maximum acceleration
- device control according to drive profile DS402
- additional torque/force limitation

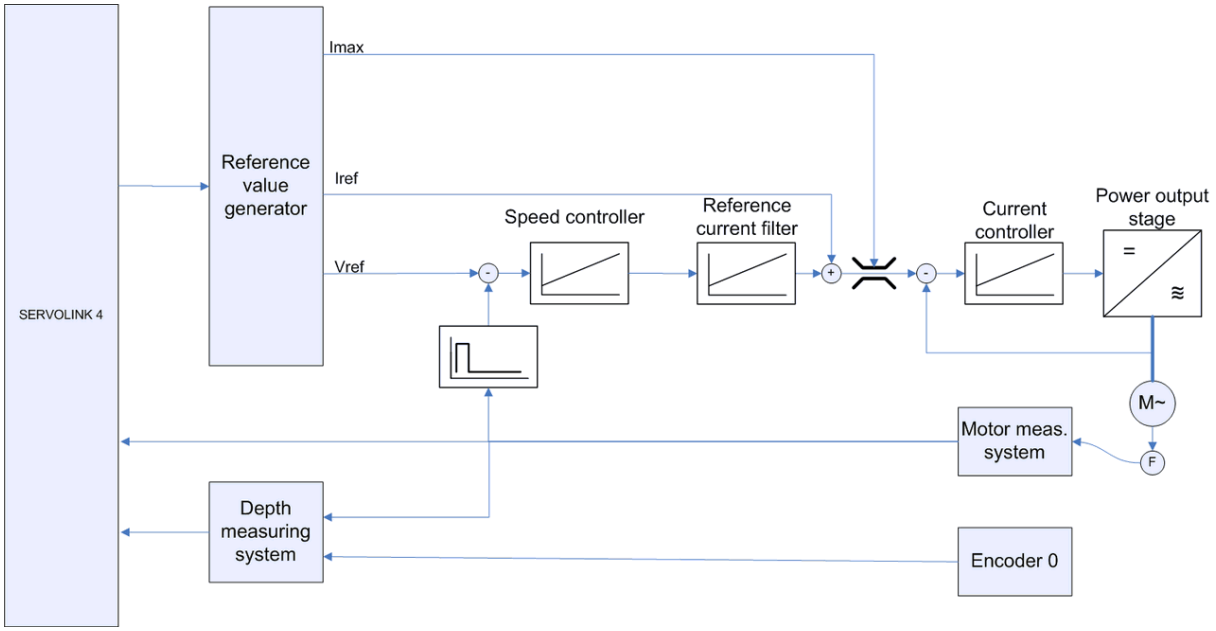

Fig. 5: Operating mode “Profile Velocity Mode”

2.2.1 Reference Value Telegram

The reference value telegram for controlling the drive consists of 16 byte user data structured as follows:

Byte	Value	Name	Bit	Description
0	2	ControlWord	0	Switch on(1)
			1	Enable voltage(1)
			2	Quick stop(1)
			3	Enable operation(1)
			4	Reserved
			5	Reserved
			6	Reserved
			7	Fault reset(1)
			8	Reserved
			9	Reserved
			10	Reserved
			11	Reserved
			12	Reset delta Z function(2)
			13	Reserved
			14	Reference value telegram ID / 0(3)
			15	Reference value telegram ID / 1(3)
2	2	Res.		Reserved
4	2	SPG_TARGET_VELOCITY_VL		Target speed 32 bits [0.1u/500µs*65536]
6	2	SPG_TARGET_TORQUE_LIMIT		Current feed forward 0x3fff = peak current of the drive amplifier
8	1	Res.		Reserved
9	7	ServiceChannel		See page 17

(1) The function of each bit is described in greater detail in the manual “Drive System SD2 – Device Control”.

(2) The function of this bit is described in greater detail in the document “TIE_SD2_DeviceControl_DepthMeasuring.pdf”.

(3) The telegram ID has fix values for SERVOLINK 4: bit 14 is always 0 and bit 15 is always 1.

2.2.2 Actual Value Telegram

The actual value telegram of the drive consists of 16 byte user data structured as follows:

Byte	Value	Name	Bit	Description
0	2	StatusWord	0	Ready to switch on(1)
			1	Switched on(1)
			2	Operation enabled(1)
			3	Error(1)
			4	Enable voltage(1)
			5	Quick stop(1)
			6	Switch on disabled(1)
			7	Warning(1)
			8	Status of digital input 4 / measuring system contact(2)
			9	Remote(1)
			10	Reference value reached(1)
			11	Internal limit active(1)
			12	Speed 0(1)
			13	SERVOLINK toggle bit(3)
			14	Actual value telegram ID / 1(4)
			15	Actual value telegram ID / 0(4)
2	4	PCTRL_POSITION_ACTUAL_VALUE		Current position of position controller 32 bits, resolution 0.1 µm
6	2	DELTAZ_POSITION_ACTUAL_VALUE		Actual delta Z-position, 16 bits, resolution 0.1 µm
8	2	ICTRL_IQ_REFERENCE		Actual current 0x3fff = peak current of the drive amplifier
10	6	ServiceData Channel		See page 17

(1) The function of each bit is described in greater detail in the manual “Drive System SD2 – Device Control”.

(2) The function of this bit is described in greater detail in the document “TIE_SD2_DeviceControl_DepthMeasuring.pdf”.

(3) This bit is toggled with each update of the actual values.

(4) The telegram ID has fix values for SERVOLINK 4: bit 14 is always 1 and bit 15 is always 0.

2.3 Interpolated Position Control (Mode 7)

The operating mode “Interpolated position control” offers the following features:

- cyclic position value setting via SERVOLINK 4
  positioning profile is generated in higher-ranking control.
- SERVOLINK 4 transmission rate: 2 kHz (default) or 4 kHz
- The data rate of the reference speed values can be a multiple of 4 kHz.
- internal calculation of the reference speed values from the reference position values with fine interpolation
- position control with 4 kHz in drive amplifier
- automatic conversion or scaling of the position measuring systems in 100 nm

- calculation of a current feed forward with 4 kHz in the drive amplifier
- monitoring of the set positioning profile regarding maximum speed and maximum acceleration
- tracking error monitoring in the drive amplifier
- Device Control Acc. to Drive Profile DS402
- additional torque/force limitation

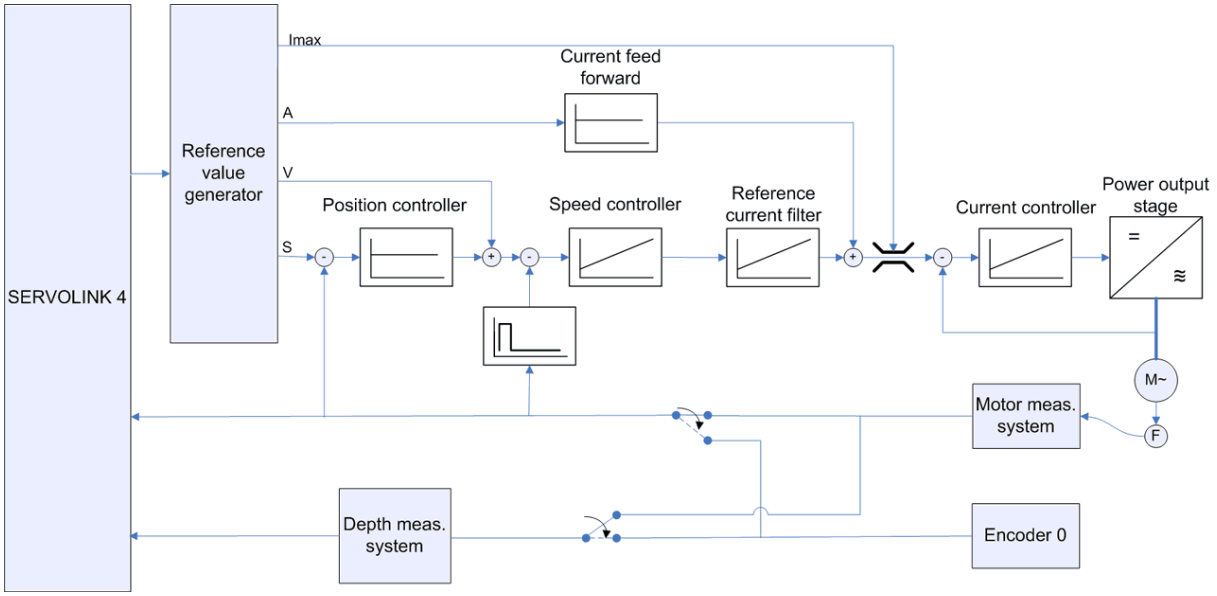

Fig. 6: Operating mode “Interpolated position control”

2.3.1 Reference Value Telegram

The reference value telegram for controlling the drive consists of 16 byte user data structured as follows:

Byte	Value	Name	Bit	Description
0	2	ControlWord	0	Switch on(1)
			1	Enable voltage(1)
			2	Quick stop(1)
			3	Enable operation(1)
			4	Enable IP mode(2)
			5	Reserved(2)
			6	Reserved(2)
			7	Fault reset(1)
			8	Hold bit (always 1)(2)
			9	Interpolated position control(3)
			10	Velocity mode 1(3)
			11	Profile velocity mode (PV)(3)
			12	Reset delta Z function(4)
			13	Reserved
			14	Reference value telegram ID / 0(5)
			15	Reference value telegram ID / 1(5)
2	6	INTERPOLATION_DATA		Target position (format 0.1µ*65536)

Byte	Value	Name	Bit	Description
8	1	INTERPOLATION_CONTROLWORD		See manual “Drive System SD2 – Device Control”
9	7	ServiceChannel		See page 17

(1) The function of each bit is described in greater detail in the manual “Drive System SD2 – Device Control”.
(2) The bits 4, 5, 6 and 8 are control bits specific to the operating mode.
(3) The bits 9, 10 and 11 determine the operating mode.
(4) The function of this bit is described in greater detail in the document “TIE_SD2_DeviceControl_DepthMeasuring.pdf”.
(5) The telegram ID has fix values for SERVOLINK 4: bit 14 is always 0 and bit 15 is always 1.

2.3.2 Actual Value Telegram

The actual value telegram of the drive consists of 16 byte user data structured as follows:

Byte	Value	Name	Bit	Description
0	2	StatusWord	0	Ready to switch on(1)
			1	Switched on(1)
			2	Operation enabled(1)
			3	Error(1)
			4	Enable voltage(1)
			5	Quick stop(1)
			6	Switch on disabled(1)
			7	Warning(1)
			8	Status of digital input 4 / measuring system contact(2)
			9	Remote(1)
			10	Reference value reached(1)
			11	Internal limit active(1)
			12	Interpolation active(1)
			13	SERVOLINK toggle bit(3)
			14	Actual value telegram ID / 1(4)
			15	Actual value telegram ID / 0(4)
2	4	PCTRL_POSITION__ACTUAL_VALUE		Current position of position controller 32 bits, resolution 0.1 µm
6	2	DELTAZ_POSITION_ACTUAL_VALUE		Actual delta Z-position, 16 bits, resolution 0.1 µm
8	2	ICTRL_IQ_REFERENCE		Current reference value 0x3fff = peak current of the drive amplifier
10	6	ServiceData Channel		See page 17

(1) The function of each bit is described in greater detail in the manual “Drive System SD2 – Device Control”.
(2) The function of this bit is described in greater detail in the document “TIE_SD2_DeviceControl_DepthMeasuring.pdf”.
(3) This bit is toggled with each update of the actual values.
(4) The telegram ID has fix values for SERVOLINK 4: bit 14 is always 1 and bit 15 is always 0.

3 Service Data Channel

The service data channel allows reading and writing any data object. The contents are transmitted sequentially via the cyclical data channel. Large data structures and complete programs can also be transmitted via the cyclical data channel. Contrary to the objects in the process data channel these data are not transmitted cyclically, but only if required.

3.1 Mapping in the Telegram

3.1.1 Reference Value Telegram

The reference value telegram for controlling the drive consists of 16 byte user data. The bytes 9 to 15 are used for the service data channel:

Byte	Value	Name	Bit	Description
0	9	CyclicDataChannel		Process data channel
9	1	ServiceControl	0	ServiceValidToggle
			1	ServiceFunction bit 0
			2	ServiceFunction bit 1
			3	ServiceLastValidByteIndex bit 0
			4	ServiceLastValidByteIndex bit 1
			5	Reserved S&M
			6	Reserved S&M
			7	Reserved S&M
10	2	ServiceIndex		Object number
12	4	ServiceValue		Object value

Control bits “ValidToggle”

Comparing the bit “ServiceValidToggle” of the reference value telegram to the bit “ServiceDoneToggle” of the actual value telegram determines whether a service inquiry is still active or the result is already available. If the bits have the same value the result can be read from the actual value telegram. If the values are different, the inquiry is not finished yet. The master toggles the bit “ServiceValidToggle” for every service inquiry. The bit “ServiceDoneToggle” is toggled after each execution by the slave. The bit “ServiceValidToggle” can only be toggled when it has the same value as the bit “ServiceDoneToggle”. This process is shown in figure 7 “Process of reading and writing objects”, page 21.

Control bits “ServiceFunction0/1”

The desired function is selected via the bits “ServiceFunction0” and “ServiceFunction1”:

Value	Meaning
0	Read object
1	Set array index
2	Write object
3	Reserved

Control bits “ServiceLastValidByteIndex0/1”

The bits “ServiceLastValidByteIndex0/1” indicate the number of valid data bytes in the last data word:

Value	Meaning
0	1 byte valid
1	2 bytes valid
2	3 bytes valid
3	4 bytes valid

Index

The index describes the selected object number.

Value (write)

The bytes 12 to 15 transmit the object value.

3.2 Actual Value Telegram

The actual value telegram for controlling the drive consists of 16 byte user data. The bytes 10 to 13 and 15 are used for the service data channel:

Byte	Value	Name	Bit	Description
0	10	CyclicDataChannel		Process data channel
10	4	ServiceValue		Return data
14	1	Reserved		Reserved
15	1	ServiceState	0	ServiceDoneToggle
			1	ServiceFault
			2	Reserved S&M
			3	Reserved S&M
			4	Reserved S&M
			5	Reserved S&M
			6	Reserved S&M
			7	Reserved S&M

Status bit “ServiceDoneToggle”

The bit “ServiceDoneToggle” acknowledges the acceptance of a data word (see figure 7 “Process of reading and writing objects”, page 21).

Status bit “ServiceFault”

The bit “ServiceFault” indicates the successful or unsuccessful transmission of the object data (0 = successful,1 = not successful). The status of the bit is valid when “ServiceValidToggle” and “ServiceDoneToggle” have the same value. During a running service inquiry (ServiceValidToggle ≠ ServiceDoneToggle) the status is not defined. If a service inquiry is processed successfully, this bit is cleared.

Value (read)

The bytes 10 to 13 transmit the object value.

3.3 Access to the Drive Objects

3.3.1 Acyclic Service Data

The master controls the access to the service data channel via the signal ServiceValidToggle. The drive signals the status of the execution via the signal “ServiceDoneToggle”. If no service command is executed both signals “ServiceValidToggle” and “ServiceDoneToggle” have the same level. A new service command is started by the master by toggling the signal “ServiceValidToggle”. When the execution of a service command by the drive is finished, it is signaled to the control by toggling the signal “ServiceDoneToggle”.

The following accesses are available:

- Reading an object:
  The read access is controlled in the reference telegram of the service data channel via 'ServiceFunction = 0' (byte 17). Via “ServiceIndex” (low/high) the corresponding object is selected. The result of the reading access is returned in the actual value telegram of the service data channel via “ServiceReturn”.
  Via array index 0…3 a subindex can be transmitted.
- Setting an array index:
  The setting of an array index is controlled in the reference value telegram of the service data channel 'ServiceFunction== 1' (byte 17). Via “ServiceIndex” (low/high) the corresponding object is selected. Via array index 0…3 the array index is transmitted.
- Writing an object:
  The write access is controlled in the reference value of the service data channel via 'ServiceFunction = 2'. Via “ServiceIndex” (low/high) the corresponding object is selected. “ServiceData” contains the corresponding value. Via “ServiceLastValidByteIndex” the number of valid bytes (minus 1) in this telegram must be defined.

Writing of arrays

There are max. 32 bit user data available in the acyclic service data channel. For this reason only objects with a maximum size of 32 bit can be written.

If objects of a larger size shall be written, e.g. arrays, an additional mechanism is necessary. In order to write arrays the corresponding array index must be addressed at first. The array index is addressed in the reference telegram of the service data channel via 'ServiceFunction=1' (Set Array Index). The drive acknowledges the telegram by returning the received array index in the actual value telegram and with a ServiceToggle. In the following reference value telegram 1 to 4 bytes can be written into the array via the command 'ServiceFunction=2' (write object). The array index saved in the device is automatically increased by the number of written bytes. Thus it is possible to write the array consecutively with a new command 'ServiceFunction=2' (Write Object) in one of the following telegrams. Since there is only one variable available in the drive to save the actual array index, a nested access to two arrays is not possible e.g. write array A, write array B, write array A etc.

Reading of arrays

During reading of array objects the array index is transmitted in each reference value telegram. For this reason setting an array index is not necessary. The variable saved in the drive is not increased by read access. Therefore the read access to an array does not interrupt the incremental writing of the array.

Error during object access

When the access to a drive object is faulty (index is not valid, range of values is exceeded, object is not writable etc.), this error is indicated in the actual value telegram via the signal “ServiceFault”. In addition the detailed error number is returned via “ServiceReturn”.

3.3.2 Overview of Access Functions

Reference Value Telegram	Byte	Read object (0)	Write object (2)	Set array index (1)
ServiceControl	9	Service control	Service control	Service control
ServiceIndex	10	Index LOW-byte	Index LOW-byte	Not assigned
	11	Index HIGH-byte	Index HIGH-byte	Not assigned
ServiceValue	12	Array index 0	Byte 0	Array index 0
	13	Array index 1	Byte 1	Array index 1
	14	Array index 2	Byte 2	Array index 2
	15	Array index 3	Byte 3	Array index 3

Actual Value Telegram	Byte	Read object (0)	Write object (2)	Set array index (1)
ServiceReturn	10	Byte 0 / error code	Array index 0 / error code	Array index 0
	11	Byte 1 / sine code	Array index 1 / error code	Array index 1
	12	Byte 2	Array index 2	Array index 2
	13	Byte 3	Array index 3	Array index 3
ServiceValue	14	-	-	-
	15	Service status	Service status	Service status

3.3.3 Reading and Writing of Uncomplex Objects

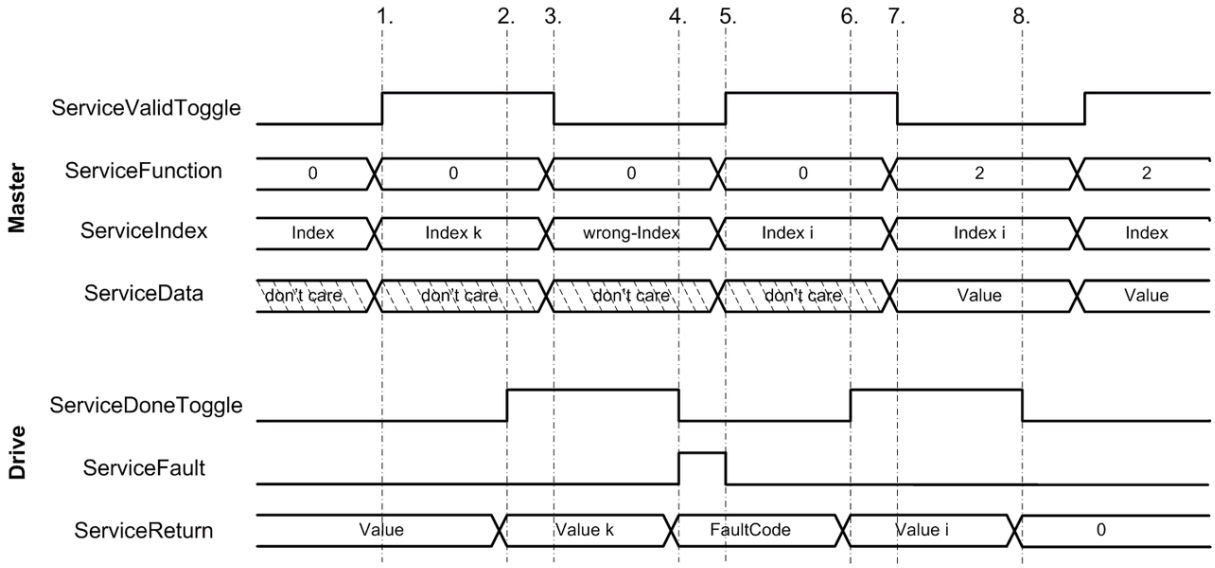

Fig. 7: Process of reading and writing objects

1. Start of reading the object with index 'k'.
2. Read-out of object with index 'k' finished without error.
3. Start of reading an object with wrong index.
4. Read-out of object with wrong index finished with error.
5. Start of reading the object with index 'i'.
6. Read-out of object with index 'i' finished without error.
7. Start of writing the object with index 'i'.
8. Writing of object with index 'i' finished without error.

3.3.4 Reading and Writing of Array Objects

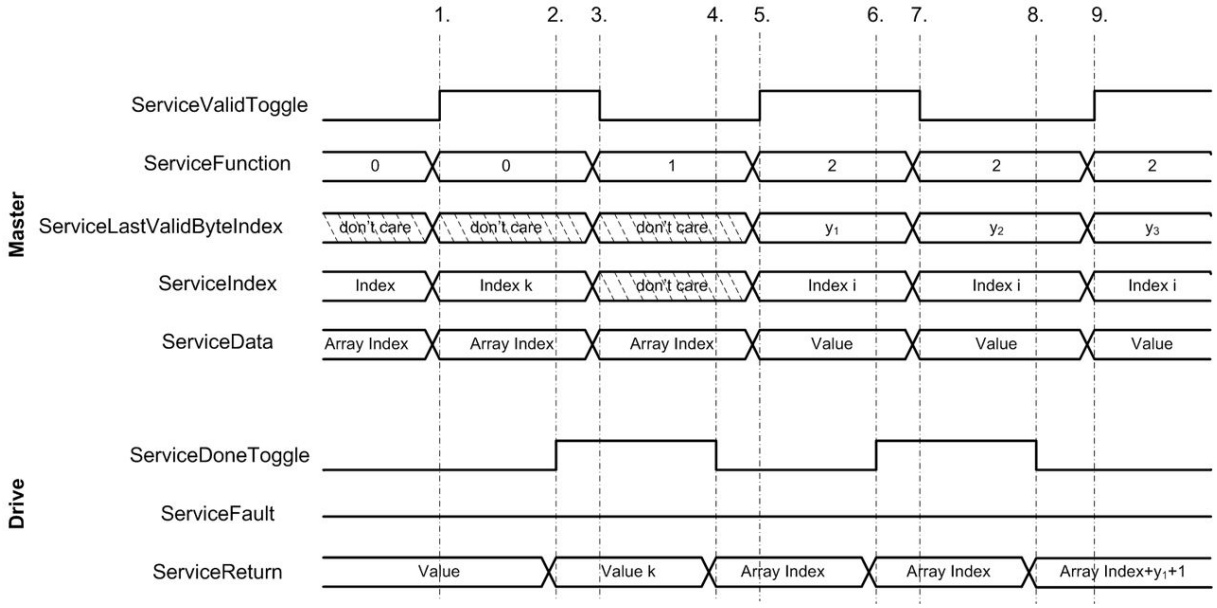

Fig. 8: Process of reading and writing arrays

1. Start of reading the array object 'k' at the array position "Array Index".
2. Read-out of array object 'k' finished without error.
3. Setting the array position for the subsequent writing of an array.
4. Acknowledgment from the drive by returning the array index for checkup.
5. Writing of y_1+1 bytes at array position "Array Index" in the array 'i'.
6. Acknowledgment from the drive by returning the actual array index for checkup.
7. Writing of auto incremental y_2+1 bytes in the array 'i'.
8. Acknowledgment from the drive by returning the actual array index for checkup.
9. Writing of auto incremental y_3+1 bytes in the array 'i'.

3.3.5 Access to Array/String Objects

Reference value index	Byte	Read array object	Write array object	Array object incremental writing
ServiceIndex	0	Index LOW-byte	Index LOW-byte	Index LOW-byte
	1	Index HIGH-byte	Index HIGH-byte	Index HIGH-byte
ServiceValue	0	Array index LOW-byte	Array index LOW-byte	Data
	1	Array index HIGH-byte	Array index HIGH-byte	Data
	2	Not assigned	Data	Data
	3	Not assigned	Data	Data

Actual value index	Byte	Read array object	Write array object	Array object incremental writing
ServiceReturn	0	Data / error code	Error code	Error code
	1	Data / error code	Error code	Error code
	2	Data	Not assigned	Array index LOW-byte
	3	Data	Not assigned	Array index HIGH-byte

In order to read an array via the service channel the meaning of ServiceValue is adapted in the reference value telegram by using the 2 higher-ranking bytes as index pointer to a word of the array. Generally, data are transmitted the same way as for objects. The result in the actual value telegram are 4 bytes, beginning with the transmitted array index. This allows reading an array step by step. In case of a error during the access the ServiceFault bit is set and the error code is transmitted in the 2 higher-ranking bits of the actual value telegram.

The write process of an array works the same way as the read process. The process also uses the 2 higher-ranking bytes of the ServiceValue as index pointer. The 2 lower-ranking bytes contain the data to be written, beginning at the indicated index. The higher-ranking bytes of the actual value telegram are used for transmitting the error code in case of ServiceFault. Since the bandwidth of the write channel only is 16 bits per telegram, the auto-incremental mode can be used. For this purpose the ServiceAutoIncrement bit needs to be set. If the bit is set, 4 bytes can be transmitted via ServiceValue.

3.3.6 Error Codes of the Service Data Channel

Error code	Description
0x00	No error
0x81 or 0x01	Toggle bit not alternated
0x86 or 0x06	CRC error
0x87 or 0x07	No free memory
0x88 or 0x08	Unsupported access to an object
0x89 or 0x09	Attempt to read a write-only object
0x8A or 0x0A	Attempt to write in a read-only object
0x8B or 0x0B	Object does not exist in the object dictionary!
0x8C or 0x0C	Reserved
0x8D or 0x0D	Reserved
0x8E or 0x0E	General parameter incompatibility reason
0x8F or 0x0F	General internal incompatibility in the device
0x90 or 0x10	Access failed due to hardware error
0x91 or 0x11	Data type not correct, length of the service parameter not correct
0x92 or 0x12	Data type not correct, length of the service parameter too long
0x93 or 0x13	Data type not correct, length of the service parameter too short
0x94 or 0x14	Subindex does not exist
0x95 or 0x15	Value range of the parameter exceeded (only for write access)
0x96 or 0x16	Value of the written parameter too high
0x97 or 0x17	Value of the written parameter too low
0x98 or 0x18	Maximum value is less than minimum value
0x99 or 0x19	General error
0x9A or 0x1A	Data can not be transmitted or saved in the application.
0x9B or 0x1B	Data can not be transmitted or saved in the application due to the status of the control.
0x9C or 0x1C	Data can not be transmitted or saved in the application due to the reset device.
0x9D or 0x1D	Dynamic generation of the object dictionary not possible or no object dictionary existing
0x9E or 0x1E	Read access denied
0x9F or 0x1F	Write access denied