TSP10-PBE Field bus appendix

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Previous issues:

Issue	Remarks
2015-03-05	First edition
2016-01-15	Additions to the command and status word from revision 64

TSP10-PBE - Compact stepper motor drive

1 Profibus settings

The TSP10-PBE is a modular station with 2 modules. The profibus ID is 0EE7h. The output module and the input module both have 6 configurable words. The stepping motor control may be operated in velocity or positioning mode. The profibus master is able to initiate operations of the driving mechanism by setting control bits in the command word.
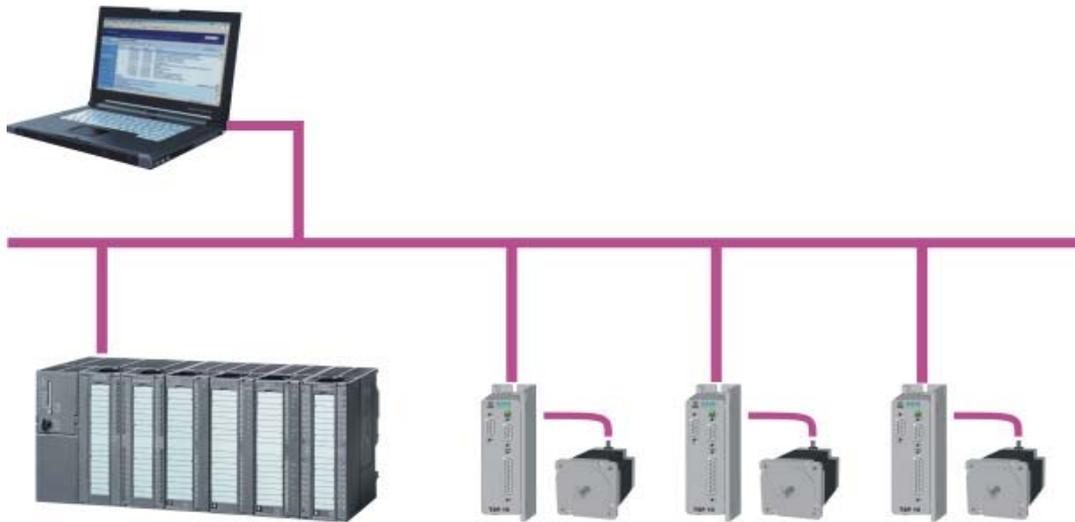
The control can any time request the current state and position by reading the input bytes.
The output words 5 and 6 contain the absolute target position, which is reached with the next positioning profile. This allows performing a precise decentralised relocation without burdening the master. Please, request a sample project of an S7 control by email (info@ahs-antriebstechnik.de).

In this appendix you may read about the add-ins of the TSP10-PBE and the differences from the basic device TSP10-BA. The general functions of the device are described in the TSP10 manual (http://www.ahs-antriebstechnik.de/downloads2-gb.html).

1.1 Connector configuration

Connect the profibus to the additional 9-pin Sub-D connector X5 on the left, next to the serial interface X1 jack. All signals of this interface are opto-isolated. Baud rates up to 12 Mbaud are supported.

The D-sub receptacle X6 below the profibus connector is used for the encoder feedback and has the following pin assignment:

Signal	TSP10 X6 pin	AE30 wire colors	M21 wire colors	DFS wire colors
+5V	1	red	red	red
A	2	purple	green	white
B	3	yellow	orange	pink
Index	4	green	white	purple
GND	6	black	black	blue
/A	7	brown	red/black	brown
/B	8	orange	white/black	black
/Index	9	blue	blue	yellow
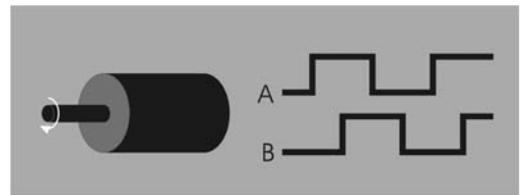
The inputs for limit, reference and stop switches of the TSP10-PBE are defined as follows:

GND-DE	reference potential	X2 pin 1
DE2	lower limit switch	X2 pin 10
DE3	upper limit switch	X2 pin 11
DE4	reference switch	X2 pin 12
DE5	stop switch	X2 pin 13

If the parameter Motor Rotational Direction is set to Reverse Rotational Direction, then the function of the pins DE2 and DE3 are swapped.

The inputs are opto-isolated and designed for 24 V or 5 V (see ordering code). The inputs may be disabled via the parameter data (see chapter 1.3). The level of all inputs is shown in one configurable profibus word.

1.2 Profibus-address

The two rotary switches of the TSP10-PBE determine the profibus address. Set motor current and step size via the parameter data (see 1.3).

Set the address in hex values. For any address up to 15, keep the left rotary switch on zero. For higher addresses, multiply the left rotary switch setting by 16 and add to the value on the right.

1.3 Parameter data

Set the parameters for motor current, micro step factor, limit switch, homing, smoothing and idle current reduction via the Profibus user parameter data. The default is set in the GSD file. Excerpts from the GSD file are shown *in italics*.

Parameter	Value
Limit switches	Limit switches are connected.
Smoothing	Smoothing enabled
Idle current reduction	After 100 ms
Motor rotational direction	Default rotational direction
Stop switch	High level to stop
Idle current [%]	50
Motor current [mA rms]	100
Micro step factor n*200/rev.	20
Homing	Actual position
DA1	Ready
DA2	Enabled
DA3	Target reached
DA4	Error
Enabled output	Enabled

User prm data:

001	002	003	004	005	006	007	008	009	010	011	012	013	014	015
00	00	00	00	8D	32	00	64	14	23	01	02	03	04	02

In the following figure you can see the default parameter settings of the input module.

| Common | Parameter assignment | Tag(s) |

Modul data

Parameter	Value
Encoder [lines/rev.]	0
Input word 1	Actual velocity
Input word 2	Status word
Input word 3	Actual position bit0-15
Input word 4	Actual position bit16-31
Input word 5	Encoder counter bit0-15
Input word 6	Inputs logic level

1.3.1 Micro step factor (step size)

Select the micro step factor (byte 9) anywhere between 1 and 128 (200 and 25600 steps per turn) are available. Higher resolution provides steadier operation at low speed.

```
ExtUserPrmData    = 1 "micro step factor n*200 /revolution"
Unsigned8 20 1-128
EndExtUserPrmData
```

Example:

A drive rotates a spindle that generates per revolution 4 mm feed. The total distance is 700 mm (175 revolutions). With a selected micro step factor of n = 20 the micro step resolution is 4000 steps per revolution. The target position can then be specified in µm (micrometers). The end position would be 700,000.

1.3.2 Limit switch

If the limit switches (X2 pin 10 and 11) are not used, set the parameter (byte 4 bits 0) at zero, so that the motor is able to move. The limit switches serve as openers and, when open, prevent any motion of the motor.

```
PrmText            = 2
Text(0)=" Limit switches not connected!"
Text(1)=" Limit switches are connected."
EndPrmText
```

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1.3.3 Smoothing

You achieve smooth running of the motor by enabling the function Smoothing (byte 4 bit 1).

```
PrmText            = 3
Text(0)="without Smoothing"
Text(1)="with Smoothing"
EndPrmText
ExtUserPrmData    = 3 "Smoothing"
Bit (1) 0 0-1
Prm Text Ref      = 3
```

1.3.4 Motor rotational direction

The motor shaft default movement is clockwise. If the Reverse Rotational Direction is chosen, then the limit switch functions of DE2 and DE3 are swapped.

```
PrmText            = 8
Text(0)            = "Default rotational direction"
Text(1)            = "Reverse rotational direction"
EndPrmText
ExtUserPrmData         = 8 "Motor rotational direction"
Bit(6) 0 0-1
Prm_Text_Ref      = 8
EndExtUserPrmData
```

1.3.5 Stop switch

The polarity of the stop switch is parameterizable.

```
PrmText            = 9
Text(0)            = "Low level to stop"
Text(1)            = "High level to stop"
EndPrmText
ExtUserPrmData     = 9 "Stop switch"
Bit(7) 1 0-1
Prm_Text_Ref      = 9
EndExtUserPrmData
```

1.3.6 Motor current

The motor current may be modified between 100 and 7000mA (byte 6 and 7). The value set may never exceed the permissible motor current, not even briefly.

```
ExtUserPrmData    = 6 "Motor current [mA rms]"
Unsigned16 100 100-7000
EndExtUserPrmData
```

1.3.7 Idle current reduction

The holding time until the idle current is reduced may be set in 8 steps (byte 4 bits 2-5). The motor current is dictated as a percentage of the set value (byte 5) so that the heating of the motor will be reduced.

```
PrmText            = 4
Text(0)="No idle current reduction"
Text(1)="After 25 ms"
Text(2)="After 50 ms"
Text(3)="After 100 ms"
Text(4)="After 250 ms"
Text(5)="After 500 ms"
Text(6)="After 1 second"
Text(7)="After 2 second"
EndPrmText
ExtUserPrmData    = 4 "idle current reduction"
BitArea (2-5) 3 0-7
Prm Text Ref      = 4
EndExtUserPrmData
ExtUserPrmData    = 5 "reduced idle current [%]"
Unsigned8 50 0-100
EndExtUserPrmData
```

1.3.8 Homing

Using the homing method you can set over byte 10.

```
PrmText            = 5
Text(35)="Current position"
Text(17)="Lower limit switch"
Text(18)="Upper limit switch"
Text(24)="Lower reference switch (Fahrtr. +)"
Text(29)="Lower reference switch (Fahrtr. -)"
Text(25)="Upper reference switch (Fahrtr. +)"
Text(28)="Upper reference switch (Fahrtr. -)"
Text(250)="Lower mechanical limit"
Text(251)="Upper mechanical limit"
EndPrmText
ExtUserPrmData    = 7 "Homing"
Unsigned8 35 17-251
Prm Text Ref      = 5
EndExtUserPrmData
```

1.3.9 Digital outputs

Every digital output can be configured with an internal function or controlled over the profibus command word.

```
PrmText              = 12
Text(0)              = "Not used"
Text(1)              = "Ready"
Text(2)              = "Enabled"
Text(3)              = "Target reached"
Text(4)              = "Error"
Text(100)            = "Profibus command word"
 EndPrmText
ExtUserPrmData       = 24 "DA1"
Unsigned8 1 0-100
Prm_Text_Ref         = 12
EndExtUserPrmData
ExtUserPrmData       = 25 "DA2"
Unsigned8 2 0-100
Prm_Text_Ref         = 12
EndExtUserPrmData
ExtUserPrmData       = 26 "DA3"
Unsigned8 3 0-100
Prm_Text_Ref         = 12
EndExtUserPrmData
ExtUserPrmData       = 27 "DA4"
Unsigned8 4 0-100
Prm_Text_Ref         = 12
EndExtUserPrmData
 ExtUserPrmData      = 28 "Enabled output"
 Unsigned8 2 0-100
Prm_Text_Ref         = 12
EndExtUserPrmData
```

1.3.10 Encoder

```
ExtUserPrmData       = 10 "Encoder [lines/rev.]"
 Signed16 0 -10000-10000
EndExtUserPrmData
```

The settings for this parameter are:

0:	the unchanged impulse counter (raw data)
1:	the impulse counter value can be set to zero with command word bit 1
500-10000:	the impulse counter value is converted equal to the configured micro step factor and can be set to zero with command bit 1

1.3.11 Input word 1-6

The configuration of the input words are set with this parameter.

```
PrmText             = 10
Text(0)             = "Not used"
Text(1)             = "Actual velocity"
Text(2)             = "Status word"
Text(3)             = "Actual position bit0-15"
Text(4)             = "Actual position bit16-31"
Text(5)             = "Encoder counter bit0-15"
Text(6)             = "Encoder counter bit16-31"
Text(7)             = "Encoder velocity"
Text(8)             = "Inputs logic level"
 EndPrmText
ExtUserPrmData      = 12 "Input word 1"
 Unsigned8 1 0-8
Prm_Text_Ref        = 10
EndExtUserPrmData
```

1.3.12 Output word 1-6

The default configuration of the output words can be changed with this parameter.

```
; Module 1 with 6 parameterizable output words
PrmText             = 11
Text(0)         = "Not used"
Text(1)         = "Velocity"
Text(2)         = "Start velocity"
Text(3)         = "Acceleration time [ms]"
Text(4)         = "Command word"
Text(5)         = "Target position bit0-15"
Text(6)         = "Target position bit16-31"
EndPrmText
ExtUserPrmData              = 18 "Output word 1"
Unsigned8 1 0-8
Prm_Text_Ref       = 11
EndExtUserPrmData
ExtUserPrmData              = 19 "Output word 2"
Unsigned8 2 0-8
Prm_Text_Ref       = 11
EndExtUserPrmData
ExtUserPrmData              = 20 "Output word 3"
Unsigned8 3 0-8
Prm_Text_Ref       = 11
EndExtUserPrmData
ExtUserPrmData              = 21 "Output word 4"
Unsigned8 4 0-8
Prm_Text_Ref       = 11
EndExtUserPrmData
ExtUserPrmData              = 22 "Output word 5"
Unsigned8 5 0-8
Prm_Text_Ref       = 11
EndExtUserPrmData
ExtUserPrmData              = 23 "Output word 6"
Unsigned8 6 0-8
Prm_Text_Ref       = 11
EndExtUserPrmData
```

1.4 Diagnostic data

The revision number (last number) of the firmware as a 16-bit value is transmitted as status information in the user-specific diagnostics (EXT_DIAG).

For e.g.: Firmware 2.1.60   User diagnostics:
                               Byte 1: 3 (Length)
                               Byte 2: 0 (High-Byte)
                               Byte 3: 60 (Low-Byte)

2   Module 1 (Output words)

The following table lists the individual output words of the TSP10-PBE control. Elements used only for positioning have a green background. Values used in the velocity mode are highlighted in orange.

Module 1 — 6 Output words																	
1	**Velocity**	Profile velocity in rpm															
2	**Initial velocity**	Start velocity of the acceleration ramp rpm															
3	**Acceleration time**	Time of acceleration in ms															
4	**Command word**			A	4	3	2	1	H	E	D	S	V	a	R	I
5	**Target position**	Low word															
6	**(32 bits integer)**	High word															

Byte-Order is Big Endian. The higher order byte has to be sent first.

2.1 Command word

Bit		Meaning	Description
0	I	Sync Encoder	↑ = Set current position at encoder postion
1	R	Counter Reset	1 = Set current position at 0
2	a	Acceleration	0 = no ramp (jump) 1 = linear velocity change
3	V	Velocity mode	0 = Positioning 1 = Velocity mode
4	S	Start motor	0 = Stop motor 1 = Start positioning
5	D	Direction	0 = forward 1 = backward
6	E	Enable	0 = Motor is without current 1 = Holding torque or torque active
7	H	Homing	0 = Standard mode 1 = Homing
8	1	DA1	Logic level of the digital output, if configured
9	2	DA2	Logic level of the digital output, if configured
10	3	DA3	Logic level of the digital output, if configured
11	4	DA4	Logic level of the digital output, if configured
12	A	Activ	Logic level of the digital output, if configured

The positioning mode always applies a ramp, the sense of rotation (direction) is a function of set and current position.

2.2 Velocity and start velocity

The first output word contains the maximal velocity of the profile. If the motor should start with an initial velocity, then this can be configured in the second output word.

2.3 Acceleration

The third word contains the acceleration time in ms. The acceleration value can be calculated by dividing the maximal profile velocity with the acceleration time. In velocity mode instead of the profile velocity a constant value of 100 rpm is used to calculate the acceleration value. The acceleration time is set to 1 second, if the value of the word is zero.
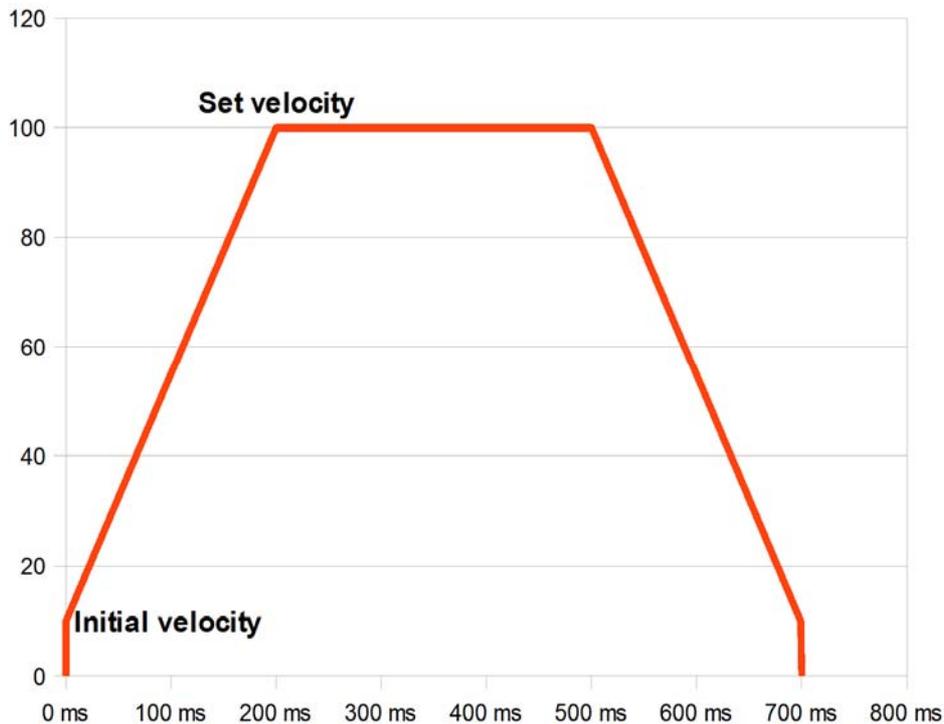

Fig. 1: Velocity profile of a positioning

Acceleration time = 200 ms

2.4 Target position

The output words 5 and 6 contain the target position for the profile. It has 32 bits integer to permit high resolution and absolute positioning even across a great distance.

The reference point basically serves to align in absolute positioning. This is the position 0 (zero). That value was defined to provide a sufficient value range for positioning left or right of the reference point. You can easily convert the position value into the user's number format. The preferred 32-bit value is a reasonable starting point to convert into different customised number formats. Analogue input devices in the realm of PROFIBUS-DP and other field bus systems apply the same principle.

In the default configuration the actual velocity of the motor is shown in the first input word. As mentioned before, the counter is set to 0 (zero) and the counter status in the status word is set to 'Referenced' as soon as the reference point has been reached by travelling. The position is undefined when the device is powered on, hence, the counter is then set to 0 (zero), allowing the user to travel either way. The control requests the actual counter reading to identify the current position of the driving mechanism and process it in the application software.

The control does not need to request the actual counter reading for positioning, the Busy message in the status word meets the same requirement. For each step, the module compares the current position and the target position to terminate the travel command as soon as both values agree.

Once the Stepper has reached the target position, the application software preselects a new target position. Before the Stepper starts again, though, the motor start bit of the command byte, which may have been left enabled by the preceding run, has to be disabled and re-enabled.

Note as well that the stepper automatically sets the direction in the positioning mode. Hence, the corresponding command bit is disabled. The direction chosen by the stepper always results from a match of current and target position.

The stop conditions (stop, limit, emergency shutdown switch) are constantly checked while travelling. They enjoy higher priority, of course, i. e. if the given position value is not reached yet and the corresponding switch is pressed, then the motor is shut down at once.

If there is any limit switch or alarm stop or if reaching the target position triggers a stop, the motor will restart only after the motor start bit was disabled and re-enabled.

2.5 Homing

The homing is a specific feature among the commands of the stepper motor controller. It is always started by setting the command bit 7. It gives different methods to making the homing run. The homing methods are listed in the parameter data. You can set the Homing velocity and acceleration as described in chapter 2.2 and 2.3.

After the successful homing, the drive is exactly on the reference point and the position counter get up 0 (zero). In the status word, it is indicated that the data of the position counter is valid. An additional homing is not running before with "counter reset" the status bit is deleted.

Now the controller is ready to accept absolute position commands. The control may initiate the homing any time. The homing is interrupted by the emergency shutdown, the stop switch or when the second limit switch is reached, because the reference switch was not found in that case. Emergency stop and reaching the lower limit switch trigger the alarm status while a response of the stop switch during the homing merely stops the driving mechanism, terminating the homing. The control can read all states from the status bytes and initiate corresponding procedures.

Example: **upper reference switch (positive direction)**, slide between reference point and upper limit switch:
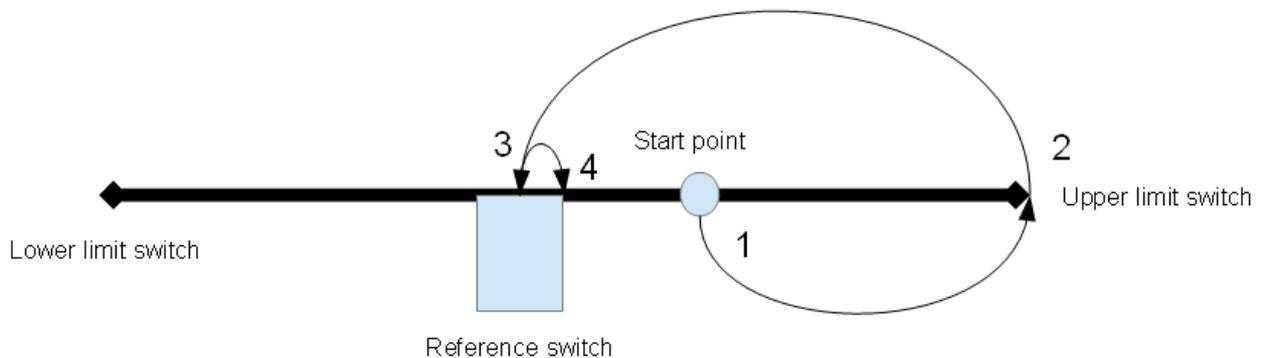
Output words:

Velocity	0x64
Command word	0x00C0
Target position	Any

After the command was given, the following configuration of the profibus input words:

Current velocity	0x64
Status word	0x1000

1	Start: Position counter increments, velocity as set.
2	Upper limit switch responds. Direction inverts, position counter decrements. Velocity as set. Reference point is below the start position.
3	Reference switch responds. Direction inverts. Position counter value increments. Reference switch is met from above, back to edge of the reference switch.
4	Reference point is verified by leaving and triggering the reference switch again. Set position counter at 0 (zero). Motor has arrived at the reference point.

3 Module 2 (Input words)

Module 2 6 Input words																			
1	**Current velocity**	Actual motor velocity in rpm																	
2	**Status word**		E	U	C	A				B	I	V	D	↑	R	↓	S		
3	**Current position (32 bits integer)**	Low word																	
4		High word																	
5	**Encoder position**	Encoder position (low word)																	
	Encoder position	Encoder position (high word)																	
	Encoder velocity	Encoder velocity in rpm																	
6	**Logic level of the digital inputs DE1 – DE10 and Enable**						F	10	9	8	7	6	5	4	3	2	1		

The numbering shows the default configuration.
Byte-Order is Big Endian. The higher order byte has to be sent first.

3.1 Status word

To monitor the state of the stepper motor controller in the control, read the status word of the controller. The following table tells which positions of the status word may be evaluated.

Bit		Meaning	Description
0	S	Stop switch	0 = Stop switch not enabled 1 = Stop switch triggered
1	↓	Lower limit switch	1 = Lower limit switch enabled
2	R	Reference switch	1 = Reference switch enabled
3	↑	Upper limit switch	1 = Upper limit switch enabled
4	D	Direction of travel	0 = forward (incrementing current position) 1 = backward
5	V	Final velocity	0 = not reached 1 = reached
6	I	In position	0 = deviation of the encoder value 1 = encoder value near current position
7	B	Busy	0 = Travel command terminated 1 = Travel command enabled
8			
9			
10			
11	A	Emergency shutdown/alarm	1 = Alarm or emergency stop enabled
12	C	Counter status	1 = Counter reading is referenced
13	U	Bus voltage	DC bus voltage ok
14	E	Error	1 = Error

3.2 Current position and velocity

The values of the current position and velocity share the format of the specified values in the output words.

3.3 Emergency shutdown

The stepping motor control provides an option to trigger an emergency shutdown if any hazard or error has occurred. If an emergency shutdown occurred, the driving mechanism is stopped immediately and does not accept any further commands. The PROFIBUS DP is not interrupted, though, so that the other PROFIBUS DP members may continue to work.

The emergency shutdown function has no special input but is triggered by the simultaneous activation of both limit switches. Since the limit switches are basically designed as openers - to exclude malfunctions from broken wires -, the wiring of the emergency shutdown function should be designed in such a way that the inputs DE2 and DE3 are isolated from the 24 V level as soon as the emergency shutdown switch is pressed.

3.4 Alarm status

The alarm status is triggered by the following events:

1. At the homing to the reference switch was the second limit switch activated.
2. Over current
3. Over temperature

No commands are processed while the alarm status applies. The stepper blocks all command information. However, status information and position messages are still forwarded. The status information includes the "Alarm" message.

An option to cancel the alarm status without shutdown has been implemented by introducing a **pseudo-code** for the velocity output word. This is code **0xAA55**. That code does not occur in standard operation because the highest velocity is represented by 3000. If the stepper reads the pseudo-code it checks **once more** whether the conditions of the alarm status are still applying. If they aren't, the stepper cancels the alarm status and returns to standard operation **after terminating** the pseudo-code. Make sure that the pseudo-code output 0xAA55 **is really terminated**, because the standard operation will resume only then.