

Encoder programming with EPROG

Operating manual for parameterizing software

Please keep for further use !

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"< >" refers to keys on your computer keyboard (e.g. <RETURN>).

Note

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1 Instructions for configuration and commissioning

1.1 Safety Information

This operating manual contains information that you must comply with to ensure your personal safety and to avoid damage to property. The information is emphasized by warning triangles, which have different appearances to match the level of danger:



Warning

Means that if the appropriate safety measures are ignored, death, severe injury or considerable damage to property can occur.



Caution

Means that if the appropriate safety measures are ignored, slight injury or damage to property can occur.

Commissioning and operation of a unit may be carried out by qualified personnel only. Qualified personnel in the sense of the safety instructions contained in this operating manual are persons who are authorized to commission, connect to ground and to mark units, systems and electric circuits according to the standards of safety technology.

1.2 Instructions for configuration and installation

In most cases, the product will be used as a component which is part of larger systems. For this reason, these instructions are meant to give guidelines for safe integration of the product into its environment.



Warning

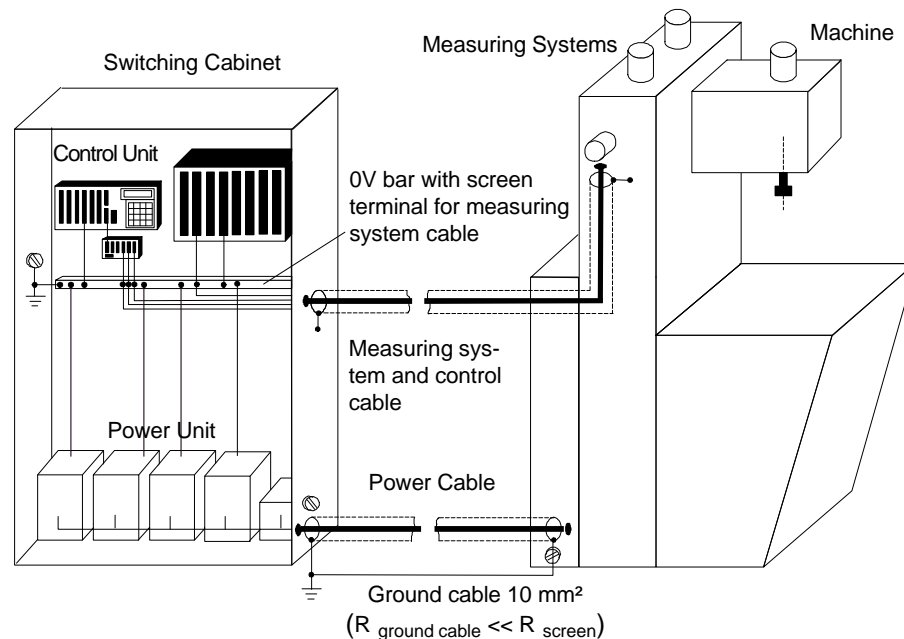
- The specific safety regulations and regulations for accident prevention must be complied with.
- The EN (European Standards), VDE (Association of German Electricians) and DIN standards applying to your plant must be complied with.

1.3 Shielding

The use of electronic-sensor active systems in modern machines requires a concept for interference suppression and cabling which must be implemented correctly and consistently.

A plant containing electronic measuring systems as well as the cassette may only run smoothly if these requirements are met.

Recommendation for shield cabling



1.4 Configuring instructions

- Route (screened) lines connecting to the encoder either a long way from or completely physically separated from energy lines that carry disturbances.
- Use only completely screened lines for data transfer and ensure they are well earthed. In the case of differential data transfer, (RS422, RS485 etc.), you must additionally use twisted-pair lines.
- Use cables with a minimum cross-section of 0.22 mm² for data transfer.
- Use a ground cable with a minimum cross-section of 10 mm² to avoid equipotential bonding via the screen. In this context, you should ensure that the ground cable's resistance must be much lower than the screen's resistance.
- Wire the screen continuously keeping a large area in contact with special screen connecting terminals.
- Avoid crossing cables. If this is not possible, the cables should only cross at right-angles.

1.5 Commissioning instructions

- Cabling at the mating connector or in the control cabinet may be carried out in dead condition only.
- Before commissioning the plant, check all connections between the mating connector and the control cabinet.
- Plug in or unplug mating connectors of signal or supply lines in dead condition only.
- Do not make mechanical or electrical modifications to the axis cassette or the measuring systems.
- Carry out commissioning according to the safety instructions.

2 Encoder concept

CE means Compact Encoder. It is a programmable absolute optoelectronic path-measuring system.

The rotating measuring shaft of the absolute encoder carries a disc on which circular tracks with transparent and non-transparent fields are to be found. There can be satellite discs for measuring the rotations connected with the central disc by a reducing gear. The code discs are scanned by light barriers and thus their position is converted into digital electric signals.

Absolute means that the position data provided by the absolute encoder indicate the position of the measuring shaft immediately and without further notice. Different from this, an incremental encoder transmits pulses when positions change which must be collected in a counter by the user. The disadvantage is that a home position must be driven to when starting the machine where the counter is reset to zero. Moreover, disturbing pulses are permanently stored in the counter, which is why home return must be repeated frequently.

The light barrier signals are processed by a microprocessor. It serves for adjusting zero point, resolution and measuring range. Moreover, it provides additional functions such as self-regulation, standstill and rotational direction recognition, overspeed monitor, limit switch and dynamic camshaft gear.

The encoder can provide the following interfaces for transmitting output data to the user: SSI, ISI, parallel using up to 32 outputs, Profibus and switching outputs for the additional functions.

With moving encoder, the output data lag behind the position. This is mainly caused by the processing time or cycle time of the microprocessor program in the encoder. The cycle time depends on the selected interfaces and options. Some typical cycle times are listed for orientation in a table in the appendix (see chapter 6.2.2 Times).

As the cycle of the encoder is not synchronized with the data transfer to the connected control system, the ages of the transferred output data fluctuate irregularly between single and double cycle period. This does generally not lead to problems, as this cycle period is normally considerably shorter than the cycle of the connected control system. For the rarely occurring cases of the synchronization being necessary for very fast control, there are special types available.

Programming the encoder is executed serially via a bifilar RS485 interface, which allows high immunity to interfering and cable lengths up to 1,000 m. As operator device and for filing data, an IBM-compatible PC with the program **EPROG** is used. It is connected to the encoder via one of its V24 interfaces with a so-called PC adapter. The latter contains a potential segregation and the conversion from V24 to RS485.

The encoder can optionally be programmed or adjusted with the handy terminal PT100 if it has been prepared to it by EPROG. In this case, however, some adjusting options are not available, and for filing the programs, **EPROG** must be used again. A position indicator can be connected instead of the PT100. The slave indicator TA has 8 decades, the slave indicator TAMINI 6 decades. If a negative sign must be displayed, one decade is dropped.

3 Program EPROG

EPROG is a PC program for serial programming of position measuring devices. An IBM-compatible PC is required. The processor must be at least a 10 MHz 8088 processor or a 6 MHz 8086 processor and the operating system must be MS-DOS 3.0 or above. The program also runs in the DOS box of Windows 3.1 or higher, then however at least a 486DX2/66 processor must be used.

Data interchange between the PC and the measuring device is via one of the serial V.24 interfaces at 115 kbps. It is necessary to plug on the PC adapter which is responsible for electrical isolation and converting the signal to RS485 whereby the range is expanded to up to 800 m.

3.1 Dialog

The dialog is primarily used for viewing and changing the programming of the connected device. It is shown on the left of the EPROG window.

3.1.1 Lines

The dialog consists of lines which are shown one below the other. There is one line for each value to be displayed. On the left-hand side, the designation of the value is given and on the right-hand side the value itself, for example *Steps per rev.* and *4096*.

There are five different types of dialog lines:

- 1.) Title lines which do not have a value and whose designation is only used as a title, for example for a section.
- 2.) Lines for integer values from -2^{31} to $+2^{31}-1$
- 3.) Lines for floating point values in IEEE format with 64 bits.
- 4.) Lines for text values
- 5.) Lines for selection lists. The selection list consists of several predefined texts, for example *Yes* and *No*. One of these is shown as a value or as selected.

Some of the dialog lines are only used to display actual values such as velocity or speed or a bit pattern which is to be written to an interface. They cannot be changed.

Dialog lines that are not needed become invisible. If an interface that is not needed is disconnected, for example, the associated subordinate dialog lines disappear until the interface is connected again. The main application is switching between *standard* and *extended options* which usually appears in the first line. It deactivates lines with settings that are rarely needed and assigns standard values to them.

3.1.2 Sections

Dialog lines that belong together are grouped together to individual sections which are mostly separated by blank lines. The first line gives the section a title, for example *Device*. The following subordinate lines are indented once or twice and become invisible when you switch on the EPROG overview. Exception: When you enter *cams*, the title lines of the paths remain visible although they are subordinate in the *Cams* section.

Often, the purpose of the line containing the title is to deactivate the subordinate lines of a section when they are not required. Example: The value of the title line of the *SSI* section is a selection list containing the texts *Yes* and *No*. If *No* is selected, the *SSI* output is switched off and the indented lines containing *SSI code*, *SSI bit number* etc. disappear. If *Yes* is selected, they reappear.

An device for position measurement usually has the following sections:

- 1.) *Options* to choose between standard and extended options
- 2.) *Device* to display the device type, manufacturer, program name, version and date, serial number and date of manufacture
- 3.) *Equipment* to display the integrated interfaces
- 4.) *Axis name* to enter a freely selectable designation for the place of use
- 5.) *Measured distance* or *Position* to program the resolution, the measuring range, the counting direction and the initial value
- 6.) *Preset inputs* to program the selector values, the starting edge and the response time
- 7.) *Signal bits* to program the speed monitor and the limit switches
- 8.) *Cams* to program the device as a cam controller if this is possible with the device
- 9.) One section for each available interface for data output, for example *SSI*, *ISI*, *Parallel interface*, *Profibus DP*, *Switching outputs* etc.
- 10.) *Actual values* to display the position, the velocity, errors that occurred and bit patterns that were read out. Here, the position is the only value that can be changed so that it is possible to carry out adjustment. After adjustment, press < F5 > to permanently store the new zero point as described below in the *Saving* section.

3.1.3 Paging

A line marking in the form of a luminous bar appears on the screen. It can be moved upward or downward line-by-line by means of the < up arrow > and < down arrow > keys. If the value of a line can be changed, it is enclosed in square brackets when the luminous bar arrives at that line.

Usually, the dialog is so comprehensive that not all the lines fit on the screen. Therefore, you can use the page up < PgUp > and page down < PgDn > keys to scroll one screen page forward or backward. If you press the < Ctrl > and < page up > keys at the same time, you jump to the first line; if you press the < Ctrl > and < page down > keys, you jump to the last one.

For a better overview, you can switch from 25 lines to 50 lines per screen page using the < Ctrl > and < F6 > keys.

The < F2 > key switches on the overview, that means all the indented and subordinate lines disappear so that only the first lines of the sections are visible. Now you can quickly move the luminous bar to the beginning of the desired section and then press < F2 > to switch back to the complete view.

Entry

To change the value of a line, you must first mark the line by means of the luminous bar. The entry is carried out in different ways depending on the type of the value and is terminated by pressing the

< Return > key or paging to a new line. If the device is connected, the new target value is transferred to the device immediately afterward. The device corrects it if necessary and enters it as the new actual value. Moreover, it adjusts dependent values and issues an error message in the event of an error.

Once the device has completed these operations, the EPROG program reads in the actual values of all dialog lines one after the other and displays the error message if an one is present. In addition, the program activates or deactivates dialog lines which are now to become visible or invisible.

If the device is not connected or if *file access* is switched on instead of *device access*, the entries are accepted without any kind of checking or evaluation. Therefore, you should only make entries if device access is switched on and the device is connected. File access should only be used for printing, saving as, loading from or viewing of EPROG files.

Depending on the value type, entries are made as described below:

In the case of a selection list, press the < left arrow > or less than < < > key to move to the previous selection text and the < right arrow > or greater than < > > key to move to the following one. Press the < Home > key to switch to the first selection text and the < End > key to switch to the last one. The new value is sent to the device after a one-second pause or immediately after the data entry described above.

Press the less than < < > key to decrease a digit by 1 and the greater than < > > key to increase it by 1. The new value is sent to the device after a one-second pause or immediately after the data entry described above.

If you want to enter a completely new digit or text value, you simply start typing in the corresponding characters. Then the old value disappears and the cursor appears on the screen. If you only want to change such a value, first press a key to move the cursor to the desired position. The < Home > key moves it to the first character, the < End > key moves it behind the last character, the < left arrow > and < right arrow > keys move it one character to the left or one character to the right.

The < Ins > key changes between insert and overwrite. In insert mode, the insertion point appears as an underscore; in overwrite mode, the insertion point has the shape of a rectangle. The < Del > key deletes the character at the insertion point, the < Backspace > key (above the < Return > key) deletes the character ahead of it.

The key combination < Ctrl > + < Y > deletes all characters, the < Ctrl > + < U > (undo) keys retrieve the old value, however without canceling the entry.

Press the < Escape > key to cancel the entry, press the < Return > key or page to a new line to terminate it.

3.1.4 Saving

Once a new value has been entered and the device has evaluated it, it is immediately valid there. However, it is **not yet permanently** stored. To do this, press the < F5 > key with device access being switched on to program the device's characteristic value memory. It is best to do this after all the necessary entries have been made.

If you want to reject the entries, press the < F6 > key to reset the device. Then the old status of the characteristic value memory will be read. However, if you pressed the < F5 > key before, the old status has already been overwritten and can no longer be retrieved.

With file access being switched on, the dialog data can also be saved in an EPROG file.

If the data has not yet been saved and you try to leave the program or load a new EPROG file, an error message will be issued.

3.2 Data Transmission

The complete dialog for device programming comes from the device itself. The EPROG program is only used for display, entry and data saving in files. The correction of entries and adjustment of dependent values can only be carried out by the device itself; the same applies to the deactivation of dialog lines that are not needed.

3.2.1 Device access

This is the EPROG program's normal operating mode. In this mode, it is permanently connected to the device via the serial interface. If the connection is interrupted, it continuously tries to establish the connection again.

When the connection is established again, the program first checks whether the device dialog corresponds to the dialog stored by EPROG, since the device could have been replaced in the meantime.

If the dialog structures are different and therefore incompatible, the stored dialog is rejected and the dialog from the device is loaded. If the structure only differs in values that can be changed, the EPROG program provides the option of permanently programming the stored values to the device. If this is done, the position is also adjusted again so that it corresponds to the stored value. It is **not** necessary to additionally program the device by pressing the < F5 > key afterward.

3.2.2 File access

File access mode is used to print the dialog and to *save as* or *load from* EPROG files. In this mode, the connection to the device is interrupted so that loaded EPROG files can be viewed even if their dialog differs from that of the device.

It is possible to enter new values. However, they are only checked and evaluated when the connection to the device is established again. Therefore, you should not make entries until the connection has been established.

On switching from *file access* to *device access*, the connection is established again and reprogramming of the device as described above may be offered as an option. In this way, data can be loaded from EPROG files and transferred to the device.

3.3 Status Display

The status display appears in the top right corner of the EPROG window. It indicates

- 1.) whether *device access* or *file access* is switched on.
- 2.) whether the dialog data has only been changed or whether it has already been stored.
- 3.) the number of the serial interface on which the PC adapter was found.
- 4.) whether the device is connected.

During file access, the connection to the device is interrupted and displays 3 and 4 disappear.

3.4 Keyboard Commands

3.4.1 Paging

< Up/down arrow >	Paging one line upward/downward, terminating entry
< Page up/down >	Paging one page upward/downward, terminating entry
< Ctrl > + < page up/down >	Moving to first/last line, terminating entry
< Ctrl > + < Home/End >	Moving to first/last line, terminating entry

3.4.2 Dialog line with selection list

< </> >	Moving to previous/following selection text
< Left/right arrow >	Moving to previous/following selection text
< Home/End >	Moving to first/last selection text

3.4.3 Dialog line with digit

< </> >	Decreasing/increasing by 1
---------	----------------------------

3.4.4 Digit or text entry

< Left/right arrow >	Moving one character to the left/right, starting entry
< Home/End >	Moving to first/moving behind last character, starting entry
< Ins >	Switching between insert/overwrite mode
< Del >	Deleting character at insertion point
< Backspace >	Deleting character ahead of insertion point
< Ctrl > + < Y >	Deleting all characters
< Ctrl > + < U >	Retrieving old value (undo)
< Escape >	Canceling entry
< Return >	Terminating entry

3.4.5 General

< Escape >	Canceling procedure or program end
< F2 >	<i>Overview</i> on/off: activation and deactivation of subordinate dialog lines
< F3 >	Program end
< Alt > + < F4 >	Program end
< Ctrl > + < F4 >	Searching the serial interfaces for PC adapter and switching the device on/off
< Ctrl > + < F5 >	Choosing colour of background
< Ctrl > + < F6 >	Switching between 25 and 50 lines per screen page
< Ctrl > + < F7 >	Selecting language
< Ctrl > + < F8 >	Creating files with templates for translations of system and device texts to enable users to add languages of their own

3.4.6 Device access

< F5 >	<i>Programming the device</i> : permanently storing entered values in the device's characteristic value memory
< F6 >	<i>Resetting device</i> : rejecting entered values and reading the device's characteristic value memory
< F8 >	Switching to file access

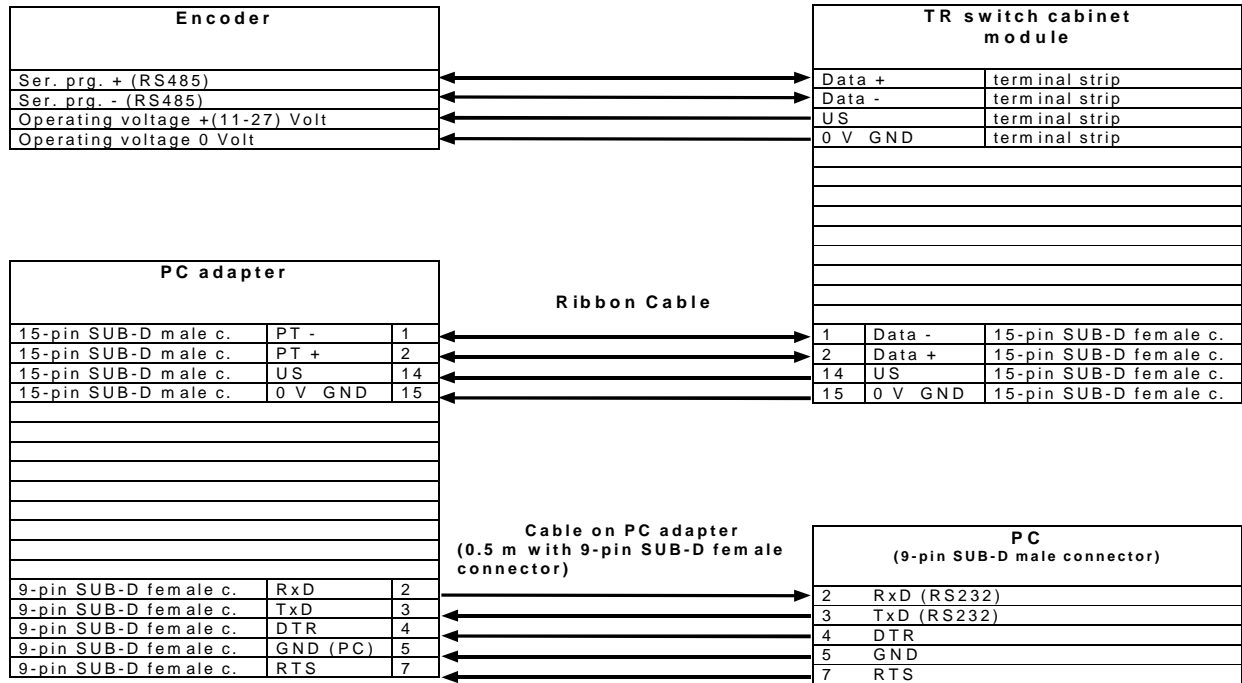
3.4.7 File access

< F4 >	Printing dialog data to interface or file
< F5 >	Storing dialog data in file
< F6 >	Loading dialog data from file
< F8 >	Switching to device access

4 Cabling the unit

4.1 Cabling for programming with EPROG

Please observe the notes of the pin assignment in the appendix!

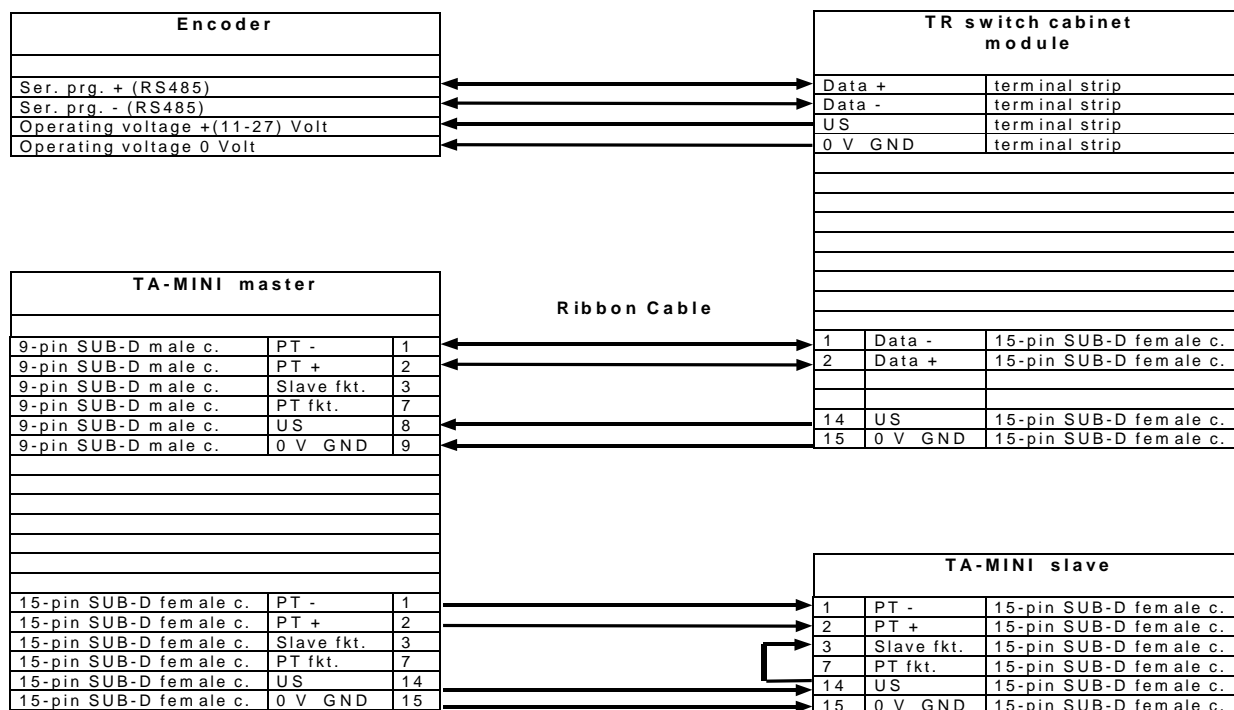


Notes:

The PC adapter is available quoting reference number 490-00301.

The switch cabinet module is available quoting reference number 490-00101.

4.2 Cabling for position indication with TA resp. with TA-Mini



Note:

The switch cabinet module is available quoting reference number 490-00101.

5 Programming with EPROG

The EPROG PC program calls the input screen form from the connected device, displays it together with the actual values and transmits new entries back to the device where they are corrected, if applicable, and stored. The input screen form is also called a dialog. It has a line structure and is divided into sections.

In the following, the individual sections of the CE dialog are explained. The name of each section corresponds to the entry in the title bar. Dialog lines can display four different kinds of values: integers, floating-point numbers, selections or text. Dialog lines with rarely required settings are only visible if *extended options* instead of *standard options* is selected in the first line.

The description refers to the programs *C6HPC*, *C6HPCBN*, *C6HPCIJ*, *C6HPCPT* and *C6HPCNO*. Depending on the program type and the equipment, some of the following dialog lines and settings are not available.

5.1 *Device* section

Here, you will find the description of the device: the manufacturer, the program name and date, the serial number and the production date.

5.2 *Equipment* section

Here, the equipment of the unit with interfaces and further type specific special options as well as the limits for resolution and measuring range are displayed. This is preset at the factory and cannot be changed afterwards without modification.

The dynamic camshaft gear can be used if the necessary additional memory is available.

There can be 3 interfaces available and used at the same time: SSI, a 2nd interface and ISI. As 2nd interface is possible: parallel with 32, 24 or 12 outputs, 8 switch outputs and Profibus.

In the line *Main disc* the resolution is indicated as step number per revolution, in the line *Satellites* the measuring range is indicated as number of revolutions.

5.3 *Axis name* section

Here you can enter any text you like to describe the axis.

5.4 *Stroke* section

During a measurement, a physical measured quantity is converted to a measured value. Since absolute encoders are trajectory measurement systems, the measured quantity is an angle for rotating absolute encoders. In the following, it is indicated by *revolutions*. The measured value is shown in *steps*.

To evaluate the measurement, the measuring range and the ratio between the physical measured quantity and the measured value must be known. This ratio is also called the resolution and limits measurement accuracy.

The resolution corresponds to the precision if the shaft couplings that the user mounted are not eccentric and he or she does overload the shaft radially and/or axially.

To adapt the device to the application, you can program a reduced measuring range and/or resolution. It is even possible to extend the measuring range from 4096 revolutions to up to 256000 revolutions. This is described in the *Integer stroke* section.

The measuring range is entered as the stroke in revolutions; the resolution results from the Stroke in steps or Steps per revolution entries.

Due to their construction, rotating absolute encoders jump back to the initial value when the upper limit of the measuring range is exceeded and to the final value when the value falls below the lower limit of the measuring range.

The following applies: Final value = initial value + stroke in steps - 1

In the *Stroke* line, you can choose from the following four types for programming the measuring range and resolution:

5.4.1 *Stroke, 1 rev.*

The stroke is one revolution long. If no satellites are available, there are no other options.

5.4.2 *Power of 2 stroke*

With the power of 2 stroke, the length in revolutions must be a second power of the group of 2^0 , 2^1 , 2^2 etc. to 2^{12} (or 1, 2, 4 to 4096). The number of revolutions and the steps per revolution are entered in the subsequent lines.

If the number of steps per revolution is not an integer, but a decimal fraction with decimal places, you must choose *Fraction stroke* and convert the entry as described there (see below).

Example: You want to program 7031,1234 steps per revolution. Choosing 4096 revolutions gives you the most precise result while avoiding the danger of a zero-point shift during zero-current travel. Set the denominator of the stroke in revolutions to 1 and the stroke in steps to $7031,1234 \cdot 4096$. The rounded result will be 28799481.

5.4.3 *Integer stroke*

With the integer stroke, the length in revolutions is an integer between 1 and 256000. A second power as the measuring range can, for example, be unfavorable for rotating applications or decimal codes. Apart from that, programming is carried out as in *Power of 2 stroke*.

To extend the encoder's measuring range of 4096 revolutions, revolution bits 2^{12} to 2^{17} which cannot be measured are incremented and decremented using the carries of bits 2^8 to 2^{11} and permanently stored every 2^8 revolutions in a FRAM. In this connection, a delay of up to 1600 revolutions may occur without leading to the loss of a carry. If the encoder's extended measuring range of 2^{18} revolutions cannot be divided by the programmed measuring range without a remainder, the zero point must be displaced by this remainder and stored in the FRAM whenever the upper or lower limit of the measuring range is exceeded.

This means that with an integer stroke you must not operate the system at more than 1600 revolutions if the encoder is switched off to avoid having to make a readjustment after switching on again. This restriction does not apply if the stroke in revolutions is a second power of 2^0 to 2^{12} .

The data preservation and endurance of FRAM is described in more detail below in the *Preset inputs* section.

5.4.4 *Fraction* stroke

With the fraction stroke, the length in revolutions is a fraction. You enter the numerator and the denominator in the subsequent lines as well as how many steps long the stroke is to be. The numerator must be between 1 and 256000, the denominator between 1 and 2^{14} (or 16384). In addition, the fraction must not be smaller than $\frac{1}{2}$. Zero-current travel is the same as with *Integer stroke*.

You cannot enter the number of steps per revolution directly. The value, which can also have decimal places, must be multiplied by the stroke in revolutions, rounded up to the next integer and entered under stroke in steps.

5.4.5 Counting direction

Here, you must enter whether the position values are to be increased or decreased if the encoder is turned clockwise looking towards the shaft.

5.4.6 Initial value

In the *Initial value* line, you specify the type of initial value. If you do not want it to be zero, the following options are available:

Symmetrical sign means that half the measuring range is negative. Thus, the initial value is the negative half of the stroke in steps.

Entry means that you can enter any negative or positive number as the initial value.

5.5 *Preset inputs* section

Here, you specify the selector values of the preset inputs, the starting edge, and the response time.

When the three preset inputs are connected to the starting edge, they trigger a zero displacement or adjustment. As a result, the position the device measured during the starting edge afterwards corresponds to the selector value. To suppress interference, however, the preset is only carried out if the preset signal is present without interruption during the entire response time. The starting edge and response time are measured with an accuracy of two milliseconds.

When the response time has elapsed, up to 50 milliseconds more will pass before the preset adjustment is finished and affects the position. This period of time is needed for storing and recalling the newly set zero point with checksum.

With extended options, the response time can be set between 10 and 255 milliseconds. With standard options, this line is invisible and the response time is 50 milliseconds.

If you do not need the preset inputs, you should inhibit them in the section's first line to suppress interference. All the rest of the section will then become invisible. However, adjustment by means of EPROG in the *Actual values* section is still possible.

If the Profibus transmission is set with 24 inputs and 8 outputs, the output bits 2^1 and 2^2 will replace the 2nd and the 3rd preset input. These function can thus be started via the Profibus.

The zero point adjusted by means of a preset is stored in a FRAM with 100 million guaranteed write cycles. This means that it is possible to carry out a preset adjustment every three seconds for 10 years with the last zero point being subsequently retained for at least another 10 years. Two copies of the zero point are stored with checksums which makes it very unlikely that a failure to store that may have occurred will be undetected.

Slip drives with initiators at the end points of the travel path are a sensible application. For rotating applications with known reduction ratio, you should rather use the gearing programming in the *Stroke* section, since it works without loss of accuracy even at high traversing speeds.

5.6 *PT/TA* section

This section is only visible with extended options. Shall serial programming of the encoder with the handy terminal PT100 be possible or a slave indicator be connected, the suitable of the 5 possible types of PT100 must be set in the first line. Otherwise, the PT100 data exchange should be disabled as in other respects restrictions may result.

5.6.1.1 General restrictions for PT100 operation

Only one single interface is allowed. The stroke must always be indicated as gear. It may at most amount to $31 \cdot 4096 = 126976$ revolutions and $2^{24} = 16777216$ steps. The denominator of the revolutions may not exceed 99. The initial value may not be smaller than $-2^{23} = -8388608$. It must be so small that the final value stays below 2^{24} . The counting direction input cannot be switched off. The response time for the preset inputs is always 50 ms with the preset starting edge always rising. the 3rd preset input is dropped. the maximum velocity is always 6000 rpm. The signal bits "Upward" and "Downward" as well as the switch outputs are dropped.

5.6.1.2 Type specific restrictions for PT100 operation

- PT100 SSI: Only SSI is allowed as an interface. The camshaft gear is dropped. As for the pine-tree format, signal bits may not come before the 24th SSI bit. After the SSI position data, at most 6 signal bits can come. 2 signal bits are transmitted as switch outputs.
- PT100 ISI: Only ISI is allowed as an interface. The camshaft gear is dropped. The response time for the loading input is always 50 ms with the load starting edge always descending.
- PT100 Parallel: Only parallel with 24 or 32 outputs is allowed as an interface. The camshaft gear is dropped. Only the first 24 outputs can be used.
- PT100 18 cams: Only parallel with 24 or 32 outputs is allowed as an interface whereby only cams can be output. There are exactly 18 paths with 1 cam each allowed.
- The dynamic cams or lead times are dropped. The initial value must always be 0. The limit switch, inverting data, bus, latch, parallel 2⁰ trigger and all signal bits are dropped.
- PT100 29 cams: The encoder must be equipped with a main disc performing 2,048 steps per revolution.
- Only parallel with 24 or 32 outputs is allowed as an interface whereby only cams can be output. There are exactly 29 paths with 1 cam each allowed. The stroke is always 1 revolution with 360 steps.
- The dynamic cams or lead times are dropped. The initial value must always be 0. The limit switch, inverting data, bus, latch and parallel 2⁰ trigger and all signal bits are dropped except the following: The 30th and the 31st parallel output are always assigned with the signal bits "1=Moving" und "0=Error".
- The 1st path serves as blue cam. That is, on wiring the 3rd preset input, the cam is displaced in a way that its switch-off point coincides with the current position.
- Switch-on and switch-off points of the cams may coincide, by which the cam always stays at 0.

5.7 *Signal bits* section

This section is visible with extended options only. Here, you specify the allowed maximum speed of the speed monitor and the switch-on and switch-off points of the four limit switches.

The maximum speed must be between 30 and 6000 revolutions per minute. With standard options, the maximum value is used.

The position and number of the relevant signal bits are later set in the appropriate sections for every interface (see below for further explanations).

5.8 *Cams* section

The cams can be output instead of the position via all interfaces except ISI and switch outputs. There are 32 paths with 4 cams per path possible.

The camshaft gear can be completely switched off if you select *No* in the title line.

5.8.1 *Stroke*

If *Cams* is selected in the *Stroke* line, a subsection is displayed where you can enter a stroke for calculation of the respective cam position. The stroke is shown in the *Actual values* section below the normal position. The subsection contains the *Measuring length in revolutions*, *Number of steps per revolution* and *Origin* lines.

You can only adjust the cam position indirectly via the normal position. The zero point of the normal position is also cam position 0. However, this does not apply the other way around, e.g. if the normal measuring range is 1024 revolutions and that of the cams is one revolution.

If you select *Position* in the *Stroke* line, the normal position is used as the cam position. Since for reasons of speed, the camshaft gear only works with 16 bits, this is possible only if the stroke is a maximum of 65536 steps.

You should set the cam measuring range and resolution before entering the initial and final points of the cams, i.e. the switching points. In this way, you determine which value range is permitted for the switching points. The initial value can always be modified later, since the switching points are then adapted such that the cam pattern does not change.

In the *Grid* line, you can set a grid for the switching points. In this way, the switching points and the cam position can be displayed with a resolution which is higher than that with cam output. The wider the grid, the faster the camshaft gear, because the position values which lie between the grid points need not be processed. When the grid is altered, the switching points present are shifted to the nearest grid point. The grid is at least one step in size. If you cannot see this line, it is exactly one step in size.

Notes:

If the encoder does not move too fast, in each cycle the camshaft gear moves one grid point towards the new position. This guarantees that each switching point or cam appears for at least one cycle in the output data. If the camshaft gear lags behind the position by more than four grid points, the system issues the error *Cam speed*, sets the error bits and outputs and carries out four steps per cycle. As a result, cams which do not exceed four grids can disappear. However, the remainder of the cams are output correctly up to the point where the speed is twice as high as it was when the cam speed error occurred for the first time. If the speed is increased further, the position overtakes the camshaft gear, thus rendering the cams completely useless.

You should avoid at all costs operating the camshaft gear while the *Cam speed* error is present. To remedy this, you must either reduce the cam resolution or increase the size of the grid. You can calculate permissible values using the required maximum speed from the table in the technical data in the appendix.

For example: You want a maximum speed of 1500 RPM or 25 revs/sec. Take a cycle time of 312.5 μ s from the table. In one second, the camshaft gear can thus run $1000000\mu\text{s}/312.5\mu\text{s} = 3200$ grid points. As a result, a maximum of $3200/25 = 128$ grid points may be dropped for each of the 25 revs/sec. If 1 grid point = 1 step, the cam resolution may not be more than 128 steps per revolution. If, in addition, a cam resolution of 4096 steps per revolution is required, you must enter a grid that is at least $4096/128 = 32$ steps in size.

After a preset adjustment or reprogramming of the encoder, which can result in a change in the position, the system may briefly issue the *Cam speed* error.

5.8.2 Advance times

If extended options are selected, dynamic cams can be programmed with four different advance times. At the beginning, the advance times are programmed between 0 and 70 milliseconds. For each track, you can specify the number of the relevant advance time for all of its switch-on and switch-off points. The switching points are then issued by the respective time earlier than they are actually reached, i.e. they are advanced by a distance which is dependent on the speed. The purpose is to compensate for the response times at switching on and switching off of actuators or tools independently of the speed.

5.8.3 Displacement

If you specify a positive or negative number in the *Displacement* line, all cams are displaced accordingly and the displacement is set to 0 again. The cams can also be shifted beyond the initial or final value without this leading to a changed cam pattern.

5.8.4 Tracks

In the *Tracks* line, you specify the desired number of tracks between 1 and 80. For each track, a subsection of its own appears. In the case of dynamic cams, the advance times for the switch-on and switch-off point are selected first. Then you specify the desired number of cams between 1 and 4. The corresponding number of lines for the switch-on and switch-off points appear.

During entry of the switching points, overlapping cams and cams of zero length are automatically corrected, starting with the first line. The cams can exceed the upper and lower limit of the stroke, i.e. the switch-on point can also be greater than the switch-off point. Only cams of zero length, i.e. with the same switch-on and switch-off point or overlapping cams are not allowed.

5.9 SSI section

Functioning of the interface is described in the glossary section of the same name. The allowed line lengths and SSI clock frequencies are described in technical data in the appendix.

5.9.1 Interface

In the *26-bits + repeat* line you select whether with longer clock pulse bundles the data bits are to be repeated every 26 clock pulses or whether 0 bits are to be transmitted after the last data bit. Application: simple detection of transmission errors.

In the *Tree format* line you can select the so-called pine-tree format with 0, 12 or 16 revolution bits if the type of data is called position. The number of steps per rotation must be a power of 2; the initial value must be 0, and you must select binary code or Gray code. The revolution bits will then be right-justified in the 12 or 16 SSI most significant bits, followed by the central disk bits. Only if the stroke is one revolution can you set the tree format to 0 bits.

Since data transfer is synchronized by the start of the clock pulse bundle, you can easily use multi-step codes like binary code, for example.

5.9.2 Data and signal bits

The total number of data and signal bits may not exceed 26 if SSI with 26-bit repeat is selected. Otherwise, the maximum value is 32.

5.9.3 Data bits

In the *Data type* line, you choose whether position values or cams are to be output via the SSI interface. It is not possible to do both at the same time. In the case of cams, you need to program the cams appropriately in the previous *Cam tracks* section.

In the *Data bits* line, you specify the number of bits reserved for the position or the cams. They start at input bit 2^0 .

In the case of position values, you specify in the *Code* line whether binary code, Gray code, clipped Gray code, BCD code, excess-three code, or clipped excess-three code is to be used. If the number of data bits reserved for the position is not sufficient for BCD or excess-three code, the system automatically switches to binary code or Gray code. If it is still not sufficient, the relevant error message is issued. Then, you must either reserve more data bits or decrease either the initial value, the measuring range, or the resolution in the *Stroke* section described above.

If a negative initial value was selected in the *Stroke* section, you must specify in the *Negative values* line whether this value is to be represented as an absolute value and sign or as a complement. The complement representation allows the user easier calculating methods in adding and subtraction.

With negative numbers, the most significant position bit, which is used as the sign, is set in both forms of representation. Therefore, negative initial values mostly require an additional data bit. The following table compares the complement representation and signed representation for binary and BCD code with 16 bits:

Value	Binary+Compl.	Binary+Sign	BCD+Compl.	BCD+Sign
2	0x0002	0x0002	0x0002	0x0002
1	0x0001	0x0001	0x0001	0x0001
0	0x0000	0x0000	0x0000	0x0000
-1	0xFFFF	0x8001	0x9999	0x8001
-2	0xFFFE	0x8002	0x9998	0x8002
-3	0xFFFD	0x8003	0x9997	0x8003

5.9.4 Signal bits

The data bit with the lowest value can be followed by up to 8 signal bits. You specify the desired number in the *Signal bits* line. Then, two subordinate lines are displayed for every signal bit where you can select the type of signal and invert it if required. The following signal types are available:

5.9.4.1 Upward movement, downward movement

This is a combination of direction indicator and zero-speed switch. The signal bit is set when the position moves in the corresponding direction and is deleted once it has remained unchanged for 50 milliseconds.

To suppress vibrations, the movement detection has a hysteresis. With HE, the hysteresis is one step referred to the resolution of the central disk. After a reversal of the direction of movement, at least a distance corresponding to the hysteresis must be traveled before a movement or change in the direction of movement is signaled. The hysteresis also applies to the *Previous upward movement* and *Ongoing movement* signals explained below:

5.9.4.2 Previous upward movement

The signal bit is set when *Upward movement* is set and it is deleted when *Downward movement* is set.

5.9.4.3 Ongoing movement

The signal bit is set while either *Upward movement* or *Downward movement* is set.

5.9.4.4 Static and dynamic error (watchdog)

As long as the position data can be measured and transmitted without errors, the signal bit *Static error* is deleted and the signal bit *Dynamic error* supplies a square-wave frequency of 250 Hz. In the case of an error, the *Static error* is set and the *Dynamic error* stays at any level.

You should use the dynamic error instead of the static one if possible, since the dynamic error is very likely to also detect faulty program execution in the device.

In the case of an error, the cause of the error is displayed in plain text in the *Actual values* section. The description of this section contains a list of possible errors and their remedies (see below). *Overspeed* is also indicated as an error there; however, it does not trigger static and dynamic error.

5.9.4.5 Maximum speed

The signal bit is set when the maximum speed set in the *Signal bits* section above is exceeded. This signal type is available with extended options only.

5.9.4.6 1st to 4th limit switch

The signal bit of a limit switch is set while the position is on or above the switch-on point and below the switch-off point. The switching points are entered in the *Signal bits* section above.

The switch-off point must be greater than the switch-on point. If the opposite case is required, you must reverse the two switching points and invert the signal bit.

This signal type is available with extended options only.

5.9.4.7 Even parity, even error parity

You receive uneven parities by inverting the bit pattern.

If no encoder error is present, the error parity corresponds exactly to the normal parity. In the case of an error, it is inverted. Its purpose is to make additional transmitting of the encoder error unnecessary.

If for SSI a signal bit *Parity* or *Parity error* is desired, it must be at the last digit. It is calculated from all previous bits. Therefore, only one single parity bit is possible. For other interfaces see section "Data and signal bits".

5.10 *ISI* section

Functioning of the interface is described in the glossary section of the same name.

You make these settings for the load input in lines *Load start edge* and *Response time*. In line *Highest frequency*, you enter the highest frequency that the incremental counter connected to the encoder can still acquire.

At some encoders the ISI outputs can be made tristate via a bus input. Then the line *Tristate* appears. There you must normally select *Never*.

At some encoders the ISI outputs can be locked against upward and downward movement after the loading procedure. The point is to hide a slight backward movement from the control system at gears with much floating after the axis has stopped. These encoders display the *Count direction* line. There you must normally select *Upward & downward*.

Notes:

Since the incremental counter does not get a valid position during loading, you should only position or regulate the axis when the encoder has switched the loading input to 0 thus indicating the end of loading. Traversing the axis during the loading process does not, however, distort the position value loaded in the incremental counter.

After completing loading, the encoder behaves like a normal incremental encoder. This means that when it runs over the start or the end value, the incremental encoder continues to run in the direction of traversing. Since the absolute position jumps to the opposite limit value, it no longer matches the reading of the incremental encoder.

To suppress disturbing pulses that are stored in the incremental counter, loading should be repeated at regular intervals, e.g. when the axis in question is idle.

Negative position values can also be loaded in the incremental counter, e.g. if the start value is negative. If the signs of the displayed absolute position and the incremental counter reading are different, you must reverse lines K1 and K2.

If the encoder does not issue any pulses when traversing the axis, it is probably waiting for the load start edge. You can remedy this by reprogramming the edge direction.

If the connected incremental counter frequently contains faulty values, you should reduce the maximum frequency that is programmed in the axis cassette. Apart from this, the system must have good interference suppression characteristics. The incremental signals should be transferred differentially with TTL levels via twisted-pair wires. All the cables, particularly the power cables on frequency converters, must be fitted with screens grounded on both ends (see wiring notes at the beginning). With persistent disturbances use SSI by preference.

5.11 Section *Digital outputs*

Different from the parallel interface, the up to 8 switch outputs cannot output position data, cams or parities. However, limit switches are possible with extended options.

The inputs for inversion, latch and bus do not effect the switch outputs. By that they can always indicate the latest state of signal bits such as limit switch or error, even if the outputs of the parallel interface are momentarily inverted, frozen or tristate.

The switch outputs can also be present with disconnected or missing parallel interface. However, you must check by means of the pin assignment which ones are actually connected at the pin.

Programming the signal bits is done in the same way as described in section SSI above, yet with the parities being dropped.

If the encoder has a parallel interface with 32 outputs, the last 8 can be turned into switch outputs by selecting *Output 25 - 32* instead of *No* in the *Digital outputs* line.

5.12 *Parallel interface* section

Functioning of the interface is described in the glossary section of the same name.

5.12.1 Interface

5.12.1.1 Inverting function

In the *Inverted* line, it is indicated when the data bits are output invertedly. *No* means never, *Yes* means always. *OV=No* means that the data bits are output normally with 0 V at the inverting input but invertedly with US level. *OV=Yes* is the opposite case. The user can check by short inverting if the inputs, the encoder outputs and the cable are all right.

5.12.1.2 Bus function

In the *Tristate* line, the bus function is set. *OV=No* means that the data outputs at the bus input are switched on with 0 V but switched off or tristate with US level. *OV=Yes* is the opposite case. If *never* is selected, the data outputs never are tristate, i. e. there is no bus function.

For safe data transfer we recommend to freeze the data outputs on switching them on. The bus and the latch input must then be connected with each other and programmed the other way round, e. g. *OV=No* for the bus function and *OV=Yes* for the latch function.

5.12.1.3 Latch function

In line *Latch*, you set the latch function. *OV=No* means that at 0 V at the latch input the data outputs always state the latest values; with a US level, the outputs are frozen or latched and can be read continuously by the user. With *OV=Yes*, the opposite applies. If *never* is selected, the data outputs never are frozen, i.e. there is no latch function.

The latch function is important when using multi-step codes, i.e. if several data bits can change at the transition to the next position. If the user reads the data bits during one of these transitions instead of freezing them, a situation can arise in which the user only obtains the new status for a few of the data bits. This can lead to nonsensical position values. With binary code, for example, the transition from 0x1FF to 0x200 often results in a faulty read out of 0x2FF or 0x100, depending on the direction. With decimal codes, pseudo tetrads can occur, i.e. illegal bit combinations.

If you use long cables, the capacity between the lines can result in crosstalk. This means that when a parallel encoder switches other wires may take the same level. This can be remedied by freezing the data before reading it.

The response time for freezing data is 20 μ s; the time for unfreezing or refreshing is 100 μ s. The delay times on the user's side for the latch output and the input filters must be added to the response time for freezing. If these amount to e.g. 200 μ s altogether, the latch input must be switched to freezing at least 220 μ s before reading the data.

5.12.1.4 Dynamic strobe

If you expects a strobe signal indicating the validity of data, you can help yourself by taking a slight detour as follows: Program a switch output of the encoder as a dynamic error so that it transmits a symmetric rectangular signal with a period of 4 milliseconds in normal operation. This is led to the latch input of the encoder and to the strobe input of the user. If the latch function is set to *OV=No*, 0 V means invalid data and US level means valid data with the strobe signal. For *OV=Yes* it is the other way round.

Mind that for the strobe output of the encoder a switch output is used instead of a signal bit of the parallel output, as otherwise it is frozen as well.

5.12.1.5 2^0 strobe

Some control systems avoid reading the position data during the transitions by taking over this short time after a level change on the 2^0 bit and thereby using a binary or BCD code.

This however creates the problem that sometimes data bits can change without the 2^0 bit changing the level. This can occur after switching on, after a preset adjustment or with processes at such a high velocity that the encoder must skip position values on outputting data. The control system then operates with old or even invalid position values.

If such a control system is used, the 2^0 strobe should be switched on. The encoder then switches the 2^0 bit after switching on and with every data output if any data bit has changed.

The 2^0 strobe is only possible when latch and bus function are disabled, when binary or BCD code have been selected and when no signal bit *dynamic error* is used.

5.12.1.6 Continuous progressive codes

You can use continuous progressive codes for parallel data transfer for reading without synchronization by latch or strobe signals. You must select clipped codes, i.e. shifted Gray code or shifted Gray excess-three code, so that also the transition from initial to final value turns out continuously.

When using shifted Gray code, the used value range i.e. the measured length in steps is rounded up to the next bigger 2-potency. The value range is then laid centrically into this 2-potency by adding half the difference between 2-potency and value range before data output. After decoding on the user's side, this value must be subtracted again to obtain the actual position.

Example: For the shifted Gray code with 360 steps, half the difference is $(2^9-360)/2=(512-360)/2=76$.

For the shifted Gray excess-three code, you round up to the next 10-potency.

Example: For the shifted Gray excess-three code with 720 steps, half the difference is $(10^3-720)/2=(1000-720)/2=140$.

Shifted code is only possible with the initial value being 0.

5.12.2 Data and signal bits

Selection of data and signal bits is made in the same way as described in section SSI above, but with the following variations:

Up to 8 signal bits can follow the data bit of maximum value. If signal bits have already been selected for SSI, their number is subtracted from the maximum value 8.

The parity is calculated from the data bits only, i.e. either cams or position with sign if existing. All other bits are not considered. Several parities can be output.

The total number of data and signal bits may not exceed the number of outputs specified in the equipment of 12, 24 or 32. If the last 8 parallel outputs have been turned into switch outputs in section switch outputs, the maximum number of data and signal bits is reduced by 8 again. In addition, you must check by means of the pin assignment how many outputs are actually connected to the pin.

If the last 8 parallel outputs have been turned into switch outputs, the inputs for inverting, latch and bus have no more effect on them. Programming them is done in the previous section *Digital outputs*.

5.13 Profibus DP section

Functioning of the interface is described in the glossary section of the same name.

Chapters 4 and 5 of the manual entitled Distributed Peripheral System ET22 contain supplementary information about additional line lengths and installation of the Profibus. You can obtain this manual from Siemens quoting reference number EWA 4NEB 780 6000-01.

5.13.1 Interface

The Profibus interface is equipped with component LSPM2. The LSPM2 automatically adapts to the baud rate in use. As standard, it is possible to use all the baud rates from 9.6 kbps to 1.5 Mbps; 3 to 12 Mbps are available as an option.

Through the window in the encoder cover you can see a green LED "NORMOPER" and a red LED "DIAERROR". On removing the cover, there are two BCD switches and two DIP switches besides the terminals accessible. The BCD switches allow to set the station address for the Profibus, the DIP switches allow to set the terminator or the bus moving load. If the station is the last one on the bus line, these switches must be set to ON; in all other cases, they must be set to OFF.

If you choose $32 I$ in the *Inputs/Outputs* line, from the point of view of the PLC, the station has 0 output bytes and four consistent input bytes. When configuring the Siemens Profibus IM308 module, you must specify values 000 and 147.

If you choose the value $8 O. + 24 I$, the station has one output byte and three consistent input bytes and you must enter the values 160 and 146 for configuration of the IM308. The purpose of this setting is to trigger the second and third electrical preset by means of bits 2^1 and 2^2 via the Profibus. Then the corresponding inputs no longer have an effect. In this context, the preset function must be enabled and the selector values, starting edge, and response time set appropriately in the previous *Preset inputs* section.

In the case of a general error, diagnosis bit 2^7 is set; in the case of overspeed, diagnosis bit 2^6 is set. If the red DIAERROR LED lights up, at least one diagnosis bit is set. If the green NORMOPER LED lights up, the station is being addressed via the Profibus. This is also displayed by EPROG in the Actual values section.

Since data transfer is synchronized by the Profibus telegram, you can use multistep codes such as the binary code without problems. However, if the Profibus connection on the user's side has problems in consistent reading, you can avoid this by using clipped continuous progressive codes.

Notes:

Detailed notes about connecting to a Profibus connection IM308 by Siemens are available quoting reference number TR-ECE-TI-GB-0009.

Quoting reference number 490-00405 there is a floppy disk available, containing the type files for the configuration program COM-ET-200 by Siemens. The above-mentioned notes are also included as a WINWORD 6.0 file. These files can be downloaded gratuitously from the TR mailbox.

Only the terminals DataA und DataB must be connected for the Profibus. These are existing twice in the cover for the lines to the previous and to the subsequent station. The terminals M5V2 must remain open.

5.13.2 Data and signal bits

Selection of data and signal bits is made in the same way as described in section SSI above, but with the following variations:

Up to 8 signal bits can follow the data bit of maximum value. If signal bits have already been selected for SSI, their number is subtracted from the maximum value 8.

The parity is calculated from the data bits only, i.e. either cams or position with sign if existing. All other bits are not considered. Several parities can be output. Depending on the setting of *Inputs/Outputs*, the total number of data and signal bits may not exceed 24 or 32.

5.14 Section *Analog outputs*

The analog output is potentially separated from the supply terminals of the encoder. The load must be connected between analog+ and analog-. If the analog output is used as a voltage output, the load must be at least 500 Ohm. If the analog output is used as a power output, the load may not exceed 500 Ohm. As a result, the maximum values for output voltage resp. power amount to 10 V and 20 mA.

The first line *Analog outputs* indicates how many of the existing analog outputs shall be used. 0 disconnects them completely.

A separate section appears for each analog output. The line *X. Analog output* indicates whether voltage (-10...+10 V) or power (0...20 mA) shall be output. Then the analog units used are millivolts "mV" resp. microampere "µA".

In line *Data type*, you select as input quantity to which the analog signal shall correspond, either position or velocity. In the lines *Initial value* and *Final value*, you set the ranges for the input quantity and the analog output signal. The volume of the ranges is the difference between the limit values, i.e. between the final and the initial values.

If the input quantity is in its range, the analog signal moves in a linear way from the initial to the final value. If the input quantity exceeds its range, the analog signal stays at the corresponding limit value.

The final value for the input quantity and the analog signal may not be smaller than the initial value.

Adjustment to the various analog interfaces is made by suitable selection of the analog initial and final values, e.g. 4000...20000 µA for 4...20 mA, -5000...5000 mV for -5...+5 V or 0...10000 mV for 0...10 V.

The resolution of the analog output normally is 14 bit for the whole output range of 20 V or 20 mA, which results in steps of 1.2 mV or µA.

This resolution, however, is only utilized in the largest possible range of the analog signal if the range of the input quantity is selected at least 2^{14} steps large. On reducing the analog range, this value is diminished linearly.

1st example: The input range shall be 20 steps large, the output range 20 V. The output voltage then runs in steps of 1 V from the initial to the final value.

2nd example: The input range shall be 20 steps large, the output range 10 mV. Then the output voltage should run in steps of 0.5 mV from the initial to the final value. Actually, the next smaller possible step is then output so that the steps are 1.2 mV.

3rd example: The input range shall be 0 steps large, i.e. its initial and final value shall be equal. The output voltage then jumps from the analog initial value to the analog final value.

5.14.1 Latch function

In line *Latch*, you set the latch function. *OV=No* means that the analog output always indicates the latest value with 0 V at the latch input, but is frozen or latched with US level and can be read stably by the user. *OV=Yes* is the opposite case. If *Never* is selected, the analog output is never frozen, i.e. there is no latch function.

The response time of the latch input for freezing the analog output is 20 μ s, for unfreezing or refreshing 100 μ s. The delay times on the user's side for the latch output and the input filters must be added to the response time for freezing. If these amount to e.g. 200 μ s, the latch input must be switched to freezing at least 220 μ s before reading the data.

5.14.2 Inversion function

Line *Inverted* specifies in which cases the analog signal is output invertedly. *OV=No* means that the analog signal is output normally with 0 V at the inversion input, but invertedly with US level. *OV=Yes* is the opposite case. If *Never* is selected, the inversion input is switched off. The user can check by quick inversion if the inputs, encoder outputs and the cable are all right.

Note

The inversion function is available with voltage output only.

5.15 *Actual values* section

5.15.1 Position

The currently output position is displayed here. An adjustment can be carried out by entering a new value, which must, however, be stored afterwards (see chapter "Program EPROG" up to page 11).

If cams are available, the cam position is additionally displayed, since the cam measuring range and resolution may differ from the normal position calculation. However, the cam position can only indirectly be adjusted via the normal position. At the zero point of the normal position, the cam position is 0 too. However, this does not apply the other way round, for example if the normal measuring range is 1024 revolutions and the one for the cams is one revolution.

5.15.2 Velocity

The velocity is displayed here: for rotating encoders in RPM, for linear encoders in mm/sec.

5.15.3 Errors

If proper measurement and transmission of the position data are at risk or impossible, the cause is displayed here. A list of possible errors and measures to remove them is given below. Unless specified otherwise, the error need **not** be acknowledged or deleted, but must simply be **removed**. Then the error message will automatically disappear and the *Error* signal bit will be deleted. Apart from *overspeed*, all the errors listed here lead to setting of the *Error* signal bit and the fall of the Ready-for-operation relay. This state has a signal bit of its own.

5.15.3.1 Components

The self-diagnosis which is carried out at start-up has identified defective components. The device must be replaced.

5.15.3.2 Central disk

The rotating encoder abruptly changed its direction of travel. This can be caused by loose contacts in the encoder cable, wrong programming of the encoder resolution (see rating plate), very strong vibrations, electrical interference, excess axial and radial forces on the shaft, or scanning problems. You can first delete the error by resetting the encoder by means of EPROG (see chapter "Program EPROG" up to page 11) or by switching the encoder off and then on again.

Insulating flanges and couplings made of plastic as well as cables with twisted-pair cores for clock pulse, data, and supply are measures against electrical interference. The cable shields should be grounded **on both sides**. Only if the machine ground is heavily contaminated with interference towards the control cabinet ground should the shield be grounded **in the control cabinet only**. Plastic couplings prevent mechanical strain of the shaft. Vibrations and impact stress, for example at presses, are dampened by means of "shock modules". If the error continues to occur despite these measures, the encoder must be replaced.

5.15.3.3 Satellite

The rotating encoder made a very large step change. This can be caused by loose contacts in the encoder cable, wrong programming of the encoder measuring range (see rating plate), electrical interference or scanning problems. For measures, refer to central disk error (see above).

5.15.3.4 FRAM checksum

The checksum for the characteristic values stored in FRAM is not correct. If the error cannot be removed by programming the device by means of EPROG (see chapter "Program EPROG" up to page 11), the FRAM is defective and the device must be replaced.

5.15.3.5 Cam speed

The speed is so high that the cams' switching points can no longer be processed in time. It is normal that this error occurs for a short period of time after an adjustment or preset. If this error message is issued continuously, the speed must be reduced and the cam output must be increased. To do so, switch off interfaces and options such as limit switches which are not used. Should this not work, the cam resolution must be reduced or the cam grid must be made wider (see above section Cams).

5.15.3.6 Warm restart

The device continuously checks the settings of its ports and the contents of its RAM. If it detects unreasonable or invalid states, it assumes that electrical interference is present and carries out a warm restart for re-initialization. If this occurs frequently, the device's interference must be suppressed as described above in *Central disk error*.

5.15.3.7 Overspeed

The speed monitor has detected that the maximum speed programmed in the *Signal bits* section has been exceeded. Action: reduce speed or increase speed limit. This is the only error that does not lead to setting of the *Error* signal bit, but only to setting of the *Overspeed* signal bit.

5.15.3.8 Analog outputs

The analog outputs are lined up digitally in the factory and the correction values are stored in EEPROM. On switching on, the encoder checks if the correction values are in the acceptable range. Otherwise, the error message "Analog outputs" appears. This is a manufacturing error. The unit must be replaced.

5.15.4 Interfaces

For every active interface, the currently output bit pattern is displayed here by means of 0 and 1. If a short circuit is detected on a bit, a normal comma or an inverted comma appears depending on whether the nominal value is 0 or 1. However, this diagnosis is not possible with all bits.

With the SSI bit pattern, 32 bits are displayed with simple transmission while only 26 bits are displayed with multiple transmission. The display is left-justified as is the transmission, i.e. the data occupies the more significant bits and the less significant bits are padded with zeroes.

At the parallel interface, the latch function has also an effect on the displayed bits. If the outputs are frozen, the display remains as well even if the encoder is moving.

With the Profibus interface, you can additionally see whether the station is currently being addressed via the bus.

6 Appendix

6.1 Dimensioned drawing, pin assignment, available options

See specification sheet of the respective encoder.

6.2 Technical data

6.2.1 Power supply

Because of the filter capacitors of the devices, you need not take into consideration the residual ripple of the supply voltage while the voltage remains within the allowed range.

With devices containing switching power supplies, the input power is hardly dependent on the supply voltage, i.e. the higher the supply voltage, the more the input current increases until the switching power supply switches off. As follows, the supply voltage with the highest current consumption and the current consumption at the highest supply voltage are specified, together with the current consumption at the lowest acceptable operating voltage. Possibly existing parallel outputs are unloaded in this case. the current consumption increases depending on the load.

The listed guaranteed maximum values for current consumption are 120% of typical values.

At power-on of the supply voltage, the charging current for the filter capacitors of the devices (maximum of 300 microfarad per device) must be provided in addition to the specified maximum input current.

With long cables the ohm voltage drop on the up-and-down-line must be taken into account. Example: With 500 m of copper strand of 0.5 mm², resistance is 18 Ω. At 280 mA, the supply voltage of the encoder decreases by $2 \cdot 18 \Omega \cdot 0.28 \text{ A} = 10.1 \text{ V}$. Thus, a minimum of $11 + 10.1 \text{ V} = 21.1 \text{ V}$ must be supplied.

Supply voltage:	11-27 V
Temperature range:	0...+60° C standard, -20...+70° C on request

6.2.1.1 CE65 SSI

Input current at 8V:	max. of 280 mA
Input current at 11V:	max. of 190 mA
Input current at 27V:	max. of 120 mA

6.2.1.2 CE65 SSI+parallel 32xUS level

Input current at 8V:	max. of 280 mA
Input current at 11V:	max. of 220 mA
Input current at 27V:	max. of 150 mA

6.2.1.3 CE65 SSI+ISI

Input current at 8V:	max. of 410 mA
Input current at 11V:	max. of 280 mA
Input current at 27V:	max. of 160 mA

6.2.1.4 CE65 SSI+Profibus

Input current at 8V:	max. of 460 mA
Input current at 11V:	max. of 330 mA
Input current at 27V:	max. of 160 mA

6.2.1.5 CE65 SSI+analog output

Input current at 8V:	max. of 410 mA with 500 Ω load
Input current at 11V:	max. of 310 mA with 500 Ω load
Input current at 27V:	max. of 160 mA with 500 Ω load

6.2.2 Times

Average cycle time (1 interface, no options)	300 μs
Maximum cycle time (all interfaces and options)	500 μs
Freeze parallel/analog outputs (activate latch)	20 μs
Unfreeze parallel/analog outputs (deactivate latch)	100 μs
Period from dynamic error output (symmetrical rectangle)	4000 μs

6.2.3 Clock frequency for SSI output

6.2.3.1 SSI clock frequency and monoflop time

The system routes the clock pulses to a retriggerable monoflop and detects the start and end of the bundle of clock pulses. For this to function safely, the clock frequency must be at least 2/monoflop period and the space between the bundles of clock pulses must be at least 2*monoflop period.

Monoflop period	21 μs
Minimum frequency for SSI clock pulse	95 kHz
Minimum space between SSI bundles of clock pulses	42 μs

6.2.3.2 SSI clock frequency and line lengths

The listed guaranteed maximum values for the SSI clock frequency are 75% of typical maximum values. They are applicable with a symmetrical clock pulse signal. With a non-symmetrical clock pulse, the maximum frequencies or the line lengths are reduced.

The following assumptions are made: a cable is used comprising twisted-pair wires with a common sheath and a cross-section of at least 0.25 mm²; an RS422 or an RS485 cable transmitter is used as the clock pulse transmitter and fast optocouplers, with an amplifier like a 6N137, for example, are used as the data receiver. It is not advisable to use RS422 cable receivers instead of the optocouplers. It is true that this can slightly increase the clock pulse frequencies; however, due to the lack of potential separation, the signals are more susceptible to disturbances. In addition, reversing the polarity of the encoder can damage it and the connected electronics.

If the clock pulse lines to the encoder are mixed up, data is delayed by half a clock pulse period. The MSB arrives on the second or third clock edge. You must set optimum clock pulse polarity so that the system shifts and reads the data on the same clock pulse edge. If different edges are used for this, the connected electronics has only half a clock pulse period instead of a full one to read a data bit and the allowed clock pulse frequency is halved.

Line length up to	Maximum allowed SSI clock pulse frequency
12.5 m	819 kHz
25 m	756 kHz
50 m	578 kHz
100 m	364 kHz
200 m	228 kHz
300 m	163 kHz
400 m	127 kHz
500 m	105 kHz

6.2.3.3 Optimum SSI clock pulse polarity

To find out the optimum SSI clock pulse polarity, you must first find out whether the system reads the SSI data bits on the first, the third and the other odd-numbered clock pulse edges or on the even-numbered edges. For this, you connect the AK with a short cable.

Turn the encoder one rotation, make a note of the change in the received position value that this produces, reverse the polarity of the clock pulse and repeat the procedure. If, while doing this, you find out that a change is only half as great as the other one, the system is reading the odd-numbered clock pulse edges. In this case, use the polarity with the smallest change.

If there is no difference between the changes, you must carry out oscillograph inspection of the clock pulse and the data together. Trigger on the pulse and notice the polarity on which the data comes half a clock pulse earlier. In this case, the data edges coincide with the even-numbered clock pulse edges and polarity is optimized.

6.2.4 Instructions for cabling

For SSI and RS485 signals, you should choose leads of at least 0.25 mm², for supply at least 0.5 mm². This is especially true for cables of more than 100 m in length. You should use twisted pair leads for this purpose. It is recommended to use shielded cables which are grounded on both sides to protective earth or to frame ground.

Chapters 4 and 5 of the manual entitled Distributed Peripheral System ET22 contain supplementary information about additional line lengths and installation of the Profibus. You can obtain this manual from Siemens quoting reference number EWA 4NEB 780 6000-01.

6.3 Accessories

TR-ECE-TI-D-0009	Description (German): Instructions for Siemens IM308 Profibus interface module
TR-ECE-TI-GB-0009	Description (English): Information on the Siemens IM308 Profibus interface module
490-00301	Equipment: PC Adaptor
490-00404	3.5" floppy disk: EPROG program
490-00405	3.5" floppy disk: Profibus support files for Siemens COM-ET-200
490-00101	TR-PT-6: control box module for PT-100 connection
485-00001	TA-MINI: 6-digit display for actual data

6.4 Glossary

Explanation of technical terms

6.4.1 Absolute encoder

A device for position measurement. The supplied measured value contains the complete position as an analog or digital value.

By contrast with an absolute encoder, an incremental encoder signals changes in position only by counting-pulses with information on the direction of rotation which must be detected by means of an incremental counter. After switch-on, a reference point must first be approached and the incremental counter set to zero. An additional disadvantage is that glitches are also permanently stored in the incremental counter and they can only be removed by carrying out a further reference run.

6.4.2 FRAM

Ferroelectric RAM: data memory which does not require a power supply unit for data retention. One hundred million write cycles are guaranteed. This means that it is possible to write into the same location every three seconds for ten years with the last written value being subsequently retained for at least another ten years. Data transfer is serial and must be started with a code word. This makes it very unlikely that the stored data is overwritten as a result of disturbances.

Storage-battery or battery-backed RAMs and EEPROMs are also commonly used for permanent data storage. The disadvantage of battery-backed RAMs is that the storage batteries or batteries quickly discharge at high temperatures which results in a loss of data. Moreover, electrical interference can easily trigger undesired write operations. The disadvantage of EEPROMs is that only several thousand write operations can be carried out.

6.4.3 Incremental encoder

Refer to absolute encoder.

6.4.4 ISI

Incremental serial interface for absolute encoders. It enables absolute encoders to operate in control systems designed for incremental encoders. Changes in position are transferred by means of two common incremental tracks. The sign of the 90° phase displacement indicates the direction of travel. However, it is not necessary to approach reference points.

The load input of the encoder is assigned with the reverse load starting edge instead. The encoder then sends no more pulses and switches its load output to 1. Now you can set the connected incremental counter to zero and give the load starting edge itself on the load input. Then the encoder outputs so many incremental pulses that the incremental counter counts up to the encoder's position. If this is achieved, it switches its load output back to 0 and is ready for further loading procedures.

6.4.5 Interface

Connection for data transfer

6.4.6 LA

Linear absolute encoder for length measurements.

The principle of measurement is based on the Wiedemann effect. A current surge is sent through a magnetostrictive tube. Magnetostrictive means that the material contracts in the direction of the magnetic lines of force during magnetization. During the current surge, the tube diameter is reduced because the magnetic lines of force run around the tube's axis in a circle. A bar magnet whose magnetic lines of force point in the direction of the axis is held to the tube. During the current surge, this additionally results in a twist at the location of the magnet which is propagated to the measuring head as an ultrasonic pulse at the tube material's sound velocity and which is registered there by means of a receiver coil. The position of the magnet can be determined from the propagation time required for this.

Due to the required propagation time of the ultrasonic pulse, a measurement takes approximately 1400 microseconds per meter of measured length.

6.4.7 LSPM2

A Siemens component for a Profibus slave connection.

6.4.8 Luenberg observer

A filter for determination of the state variables that cannot be measured directly from the ones that can be measured directly if the model of the system is known. Application with encoders and axis cassettes: determination of velocity from position, plausibility checking of position measurement, estimation of position if no measured values are available. It is assumed that the system is an unaccelerated mass.

6.4.9 Parallel interface

Each data bit to be transferred has a data line of its own. If a single-step code is used, no synchronization between the data source and the data receiver is necessary for data transfer. If a multistep code is used, the data receiver can freeze the source by connecting the latch input and can accept the data after a transient recovery period.

6.4.10 Profibus DP

Serial high-speed bus for automation purposes.

6.4.11 Rotating absolute encoder

An absolute encoder for the measurement of angles and revolutions on an optoelectronic basis. A code disk with annular tracks on which transparent and non-transparent fields alternate with one another is located on the encoder shaft. The tracks form a single-step code. Additionally, there are compensation tracks to compensate for mechanical inaccuracies. They are converted to electrical digital signals by means of light barriers.

Apart from the central disk, further code disks are available for revolution measurement. These disks are connected to the shaft via a reduction gearing and are called satellites.

6.4.12 Satellite

A code disk with reduction gearing for measuring the number of revolutions with rotating absolute encoders.

6.4.13 SSI

Synchronous serial interface for absolute encoders. The data source receives a clock pulse bundle from the data receiver whose number of pulses corresponds to the number of data bits. On the bundle's first negative edge, the data is loaded into the shift register. On the following positive edges, the data bits appear on the data line one after the other, starting with the most significant bit.

The last data bit is followed by zero bits only. During the break between the bundles, high bits are transferred. The break is identified by means of a retriggerable monoflop. A new bundle may not start until this has taken place.

Since the data transfer is synchronized by the start of the bundle, it is not necessary to use single-step codes such as Gray code.

The clock pulses and data are differentially transmitted by means of cable transmitters with TTL levels and received by means of optocouplers to protect them from damage resulting from interference, potential differences, or polarity reversal.

Parity bits or checksums can be added to detect faulty transmissions. The simplest measure is to read in the values twice with the data bits being repeated after 13 or 26 clock pulses of a bundle. However, this has the disadvantage of considerably increasing transmission times.