Inline terminal for incremental encoders

R911170488
Edition 03

Data sheet R-IB IL INC-IN-PAC

Input for incremental encoders
3 digital 24 V DC inputs

11 / 2025

1 Description

The terminal is designed for use within an Inline station.
The terminal is used for detecting positions, lengths, or angular positions with incremental encoders. Both symmetrical (RS-422) and asymmetrical (5 V DC to 24 V DC) encoders with rectangular signals can be connected to the terminal block. Rotary transducers or length measurement systems can be read in with or without a Z pulse.
To increase operational safety, all encoder inputs are monitored for broken cables. Using a special operating mode, the terminal supports distance-coded incremental encoders, with which the reference run can be reduced to very short distances.
In addition to the input for the encoder signals, the terminal also has three digital 24 V DC inputs, one input for the home position switch, and two inputs for limit position switches. Thus 2 or 3-conductor sensors can be connected. Input E3 can also be used as an "open collector" output.
The terminal block records the position values using a counter, which counts up or down depending on the phase relationof the A and B signals.

Features

- Supports incremental encoders with symmetrical signals in accordance with EIA standard RS-422 (line driver)
- Supports incremental encoder with asymmetrical signals (push-pull)
- Supplies encoder with 5 V or 24 V voltage
- Three digital inputs for connecting two limit switches or a home position switch
- Maximum input frequency: 300 kHz
- 25-bit actual position value
- Precise evaluation via 1x, 2x, or 4x sampling
- Direction of rotation indicator via LED

This data sheet is only valid in association with the “Automation terminals of the Inline product range” application description (DOK-CONTRL-ILSYSINS***-AW..-EN-P, MNR R911317021).

Make sure you always use the latest documentation.
It can be downloaded under www.boschrexroth.com/electrics.

2 Table of contents

3 Ordering data

Description	Type	MNR	Pcs./Pkt.
Inline terminal for incremental encoders, complete with accessories (connectors and labeling fields)	R-IB IL INC-IN-PAC	R911308491	1

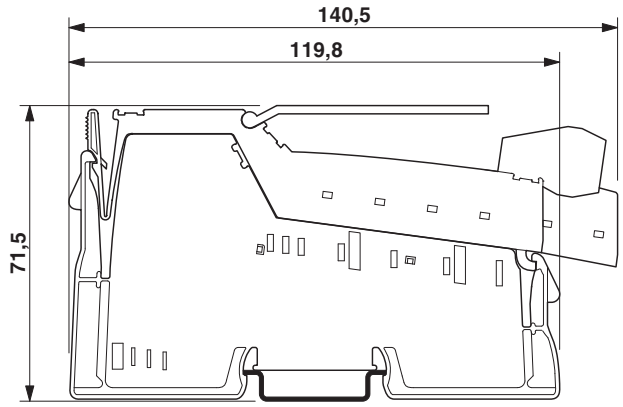
Documentation	Type	MNR	Pcs./Pkt.
Application description Automation terminals of the Inline product range	DOK-CONTRL-ILSYSINS***-AW..-EN-P	R911317021	1

Additional ordering data

For additional ordering data (accessories), please refer to the product catalog at www.boschrexroth.com/electrics.

4 Technical data

Dimensions (nominal sizes in mm)



General data	
Color	Housing: light gray (RAL 7035)
Weight	143 g (with connectors)
Operating mode	Process data mode with two words
Ambient temperature (operation)	-25 °C ... 55 °C
Ambient temperature (storage/transport)	-25 °C ... 85 °C
Permissible humidity (operation)	10 % ... 95 % (non-condensing)
Permissible humidity (storage/transport)	10 % ... 95 % (non-condensing)
Air pressure (operation)	70 kPa ... 106 kPa (up to 3000 m above sea level)
Air pressure (storage/transport)	70 kPa ... 106 kPa (up to 3000 m above sea level)
Degree of protection	IP20
Protection class	III (IEC 61140, EN 61140, VDE 0140-1)
Overvoltage category	II (IEC 60664-1, EN 60664-1)
Degree of pollution	2 (IEC 60664-1, EN 60664-1)

Connection data: Inline connector	
Connection method	Spring-cage connection
Conductor cross-section, rigid	0.08 mm² ... 1.5 mm²
Conductor cross-section, flexible	0.08 mm² ... 1.5 mm²
Conductor cross-section [AWG]	28 ... 16
Stripping length	8 mm

Interface: Inline local bus	
Number of interfaces	2
Connection method	Inline data jumper
Transmission speed	500 kbps
Transmission physics	Copper
Communications power (U_L) (500 kbps)	
Supply voltage	7.5 V DC (via voltage jumper)
Current consumption	max. 70 mA
Main circuit supply (U_M)	
Supply voltage	24 V DC (via voltage jumper)
Supply voltage range	19.2 V DC ... 30 V DC (including all tolerances, including ripple)
Current consumption	typ. 340 mA max. 1 A
Power dissipation	
Maximum power dissipation for nominal condition	1.4 W
Incremental encoder input	
Number of inputs	1 (Symmetrical or asymmetrical)
Connection method	Spring-cage connection
Encoder signals	symmetrical encoders according to EIA-422 and asymmetrical encoders
Permissible cable length	max. 30 m (shielded cable, to ensure conformance with EMC Directive)
Encoder types	
Symmetrical incremental encoders	
Number	max. 1 (A, /A, B, /B, Z, /Z)
Signal voltage level	Differential signal (signal – inverted signal) ±0.5 V, minimum; ±6 V, maximum
Input frequency	max. 300 kHz
Encoder supply voltage	5 V DC, 24 V DC
Common mode voltage range signal - ground	-10 V DC ... 13.2 V DC
Asymmetrical incremental encoder	
Number	max. 1 (A, B, (Z))
Signal voltage level	Low ≤ 2.5 V, high ≥ 3.5 V (up to 27 V, maximum)
Input frequency	max. 300 kHz
Encoder supply voltage	5 V DC, 24 V DC
Encoder supply	
5 V encoder supply	
Number	1
Nominal output voltage	5 V DC
Voltage range	4.75 V DC ... 5.25 V DC
Current carrying capacity	max. 250 mA
Short-circuit protection	Electrical and thermal

Encoder supply	
24 V encoder supply	
Number	1
Nominal output voltage	24 V DC
Voltage range	19.2 V DC ... 30 V DC
Current carrying capacity	max. 250 mA
Short-circuit protection	Electronic and thermal

Digital inputs	
Number of inputs	3
Connection method	Spring-cage connection
Connection technology	3-conductor
Description of the input	EN 61131-2 type 1
Nominal input voltage	24 V DC
Nominal input voltage range	-30 V DC ... 30 V DC
Nominal input current	typ. 2.7 mA
Input voltage range "0" signal	-3 V DC ... 5 V DC
Input voltage range "1" signal	15 V DC ... 30 V DC
Signal delay	max. 1 ms
Cable length	max. 30 m

Digital outputs	
Number of outputs	1 (NPN, double assignment of input E3)
Connection method	Spring-cage connection
Connection technology	2-conductor
Nominal current I_N	0.5 A

Programming data (INTERBUS, local bus)	
ID code (hex)	7F
ID code (dec.)	127
Length code (hex)	02
Length code (dec)	02
Process data channel	32 bit
Input address area	4 Byte
Output address area	4 Byte
Parameter channel (PCP)	0 Byte
Register length (bus)	4 Byte

For the programming data/configuration data for other bus systems, refer to the corresponding electronic device data sheet (e.g., GSD, EDS).

Configuration and parameter data in a PROFIBUS system	
Required parameter data	1 Byte
Required configuration data	5 Byte

Electrical isolation/isolation of the voltage areas	
Test section	**Test voltage**
7.5 V supply (bus logics)/24 V supply (I/O)	500 V AC, 50 Hz, 1 min
24 V supply (I/O) / functional ground	500 V AC, 50 Hz, 1 min
7.5 V supply (bus logic)/functional ground	500 V AC, 50 Hz, 500 min

Electrical isolation of the logic level from the serial interface is ensured by the DC/DC converter.

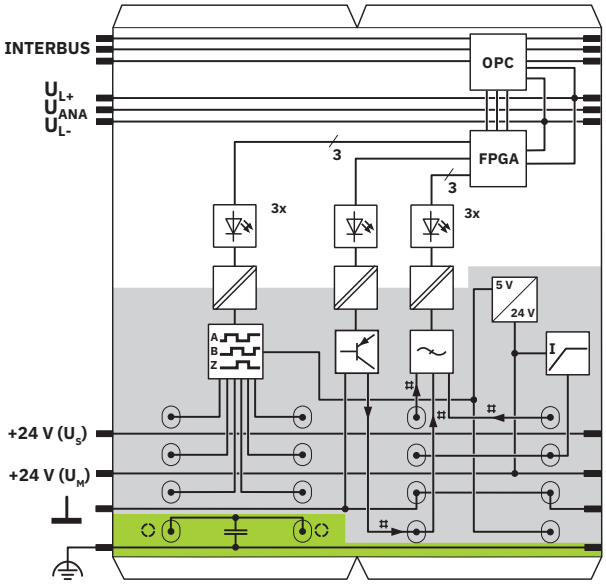
Conformance with EMC Directive 2014/30/EU	
Immunity test in accordance with EN IEC 61000-6-2	
Electrostatic discharge (ESD) IEC 61000-4-2	Criterion B, ±6 kV contact discharge, ±8 kV air discharge
Electromagnetic fields IEC 61000-4-3	Criterion B, field strength: 10 V/m
Fast transients (burst) IEC 61000-4-4	Criterion B, ±2 kV
Conducted interference IEC 61000-4-6	Criterion A, Test voltage 10 V
Noise emission test in accordance with EN IEC 61000-6-4	Class A

Approvals

For the current approvals, please visit www.boschrexroth.com/electrics.

5 Internal circuit diagram

Fig. 1 Internal wiring of the terminal points



Key:

OPC — Protocol chip (Bus logic including voltage conditioning)

FPGA — FPGA

LED

Electrical isolation for data or power supply

Power supply unit

Transistor

Filter

Encoder supply with short-circuit protection

Input

Coupling capacitor

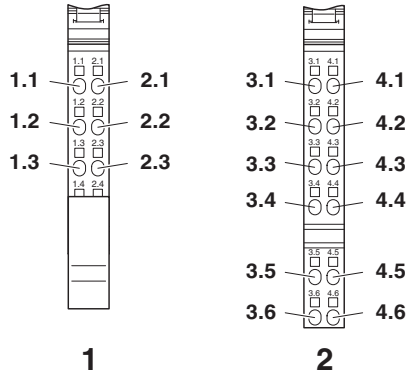
Output

Electrically isolated areas

For an explanation of the other symbols used, please refer to the “Automation terminals of the Inline product range” application description (DOK-CONTRL-ILSYSINS***-AW..-EN-P, MNR R911317021).

6 Terminal point assignment

Fig. 2 Terminal point assignment



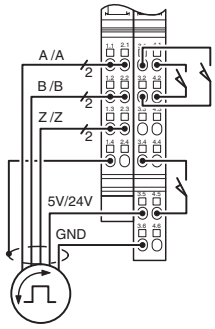
Connector 1			
Terminal point	**Assignment**	**Description**	
		Symmetrical encoder	**Asymmetrical encoders**
1.1	A	Track A	Track A
2.1	/A	Track A inverted	-
1.2	B	Track B	Track B
2.2	/B	Track B inverted	-
1.3	Z	Z-pulse	Z-pulse
2.3	/Z	Z-pulse inverted	-
1.4, 2.4	Shield	Encoder cable shield	

Connector 2		
Terminal point	**Assignment**	**Description**
3.1	E1	Input of limit switch 1
4.1	E2	Input of limit switch 2
3.2, 4.2	24 V	24 V supply for encoder and limit switch
3.3, 4.3	GND	GND (0 V) of supply for encoder and limit switch
3.4	E3	Input for home position switch or NPN output
4.4	5 V	5 V encoder/limit switch supply
3.5, 4.5	24 V	24 V supply for encoder and limit switch
3.6, 4.6	GND	GND (0 V) of supply for encoder and limit switch

7 Connection examples

7.1 Symmetrical encoders

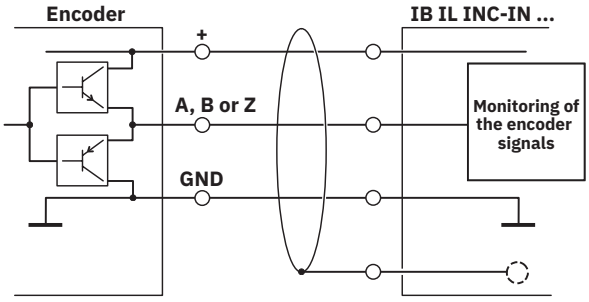
Fig. 3 Quadrature encoder with 24 V supply



7.2 Asymmetrical encoders with push/pull outputs

Recommended:
Use encoders with push/pull outputs for error-free operation.
This is particularly true if the encoder or the cables to the encoder are in an area with electromagnetic interference.

Fig. 4 Connection of asymmetrical encoders with push/pull outputs



7.3 Asymmetrical encoders with NPN and OC outputs

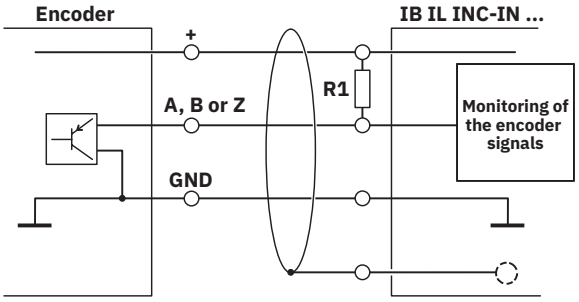
When using encoders with NPN and open-collector (OC) outputs:

Apply every encoder signal with a pull-up resistor (R1) to “+”.

Size the resistor in line with the maximum permissible collector/emitter current of the encoder.

Consider the resulting power dissipation when selecting resistor R1.

Fig. 5 Connection of asymmetrical encoders with NPN and OC outputs



8 Connection notes

Encoder

If a symmetrical encoder without Z signal is used, input Z must be jumpered to 0 V (GND) and input /Z to +5 V.

If an asymmetrical encoder without Z signal is used, input Z must be jumpered to 0 V (GND) and input /Z remains open.

Observe the connection instructions of the encoder manufacturer.

Shielding

Always connect the encoder using shielded, twisted pair cables.

Unshielded cables may lead to erroneous results in environments subject to heavy noise.

Connect the shield on the side of the Inline terminal to the functional ground (FE) capacitively via the shield plug.

On the encoder side, connect the shield to the grounded encoder housing.

If there is no shield connection on the encoder, you can connect the shield directly to the functional ground in the control cabinet via an additional shield clamp.

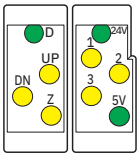
For information on shielding, please refer to the “Automation terminals of the Inline product range” application description (DOK-CONTRL-ILSYSINS***-AW..-EN-P, MNR R911317021).

Strain relief

Do not use the shield contact as a strain relief. Carry out the shielding and the strain relief separately.

9 Local diagnostic and status indicators

Fig. 6 Local diagnostic and status indicators



Designation	Color	Meaning
D	Green	Diagnostics (bus and logic voltage)
	On	Data transmission active within the station
	Flashing slowly (0.5 Hz)	Communications power present, Data transmission not active within the station
	Flashing medium (2 Hz)	Communications voltage present, I/O error present
	Flashing medium (2 Hz) and LED Z on	No bridge was inserted when using an encoder without Z signal Observe the connection notes for encoders without Z-signal.
	Flashing quickly (4 Hz)	Communications power present, Error at the interface between the previous and flashing module (the modules after the flashing module cannot be addressed)
	Off	Communications voltage not present
UP	Yellow	Positive direction of rotation (UP)
	ON and DN LED OFF	Terminal block counting upwards
	OFF and DN LED OFF	Standstill
DN	Yellow	Negative direction of rotation (DN)
	ON and UP LED OFF	Terminal block counting downwards
	OFF and UP LED OFF	Standstill
Z	Yellow	Z signal
	On	Z signal present
	Off	Z signal not active
	Flashing and LED D on	Encoder has reached the Z signal and left it again
	Lighting up and LED D on	Encoder is on the Z signal
		The encoder speed is so high that the human eye interprets the rapidly flashing LED Z as permanently illuminated
24 V	Green	24 V encoder supply
	On	Encoder supply present
	Off	Encoder supply not present
1, 2, 3	Yellow	Inputs
	On	Input is set
	Off	Input is not set
5 V	Green	5 V encoder supply
	On	Encoder supply present
	Off	Encoder supply not present

For more detailed information on diagnostics, please refer to the “Automation terminals of the Inline product range” application description (DOK-CONTRL-ILSYSINS***-AW..-EN-P, MNR R911317021).

Function identification

Orange

10 Function description

10.1 Position detection

After switching on the terminal, write the control bits for the encoder type and the evaluation to the terminal block via the process data output word OUT[0].

The terminal block then starts position detection. It starts with a random value in the positioning counter.
As long as the operating mode 0 (“Read actual position value”) is not quit, the actual position value only provides relative position values (not homed).

The control bits for the encoder type and evaluation must remain set as long as position detection is carried out. Changing the evaluation also requires new homing.

The terminal can only output an absolute position value if homing has been carried out on the terminal previously.
For this, use the homing function to set the positioning counter at a specific point on an axis to the reference point value determined by the process data output word OUT[0].

There are two options for homing:

- Setting the reference point via the local bus (operating mode 1).
  During this process, the axis remains as still as possible or moves so slowly that the time delay, with which the signals are transmitted via the local bus, does not cause any major deviations.
- Dynamic homing by means of reference point approach (operating modes 2 to 6).
  In many applications, this results in a higher level of precision.
  The terminal responds directly to the connected limit switch or home position switch signals or the Z signal (index pulse from the encoder) with a hardware circuit.

Homing function sequence

1. Starting homing
   Write the reference point value to OUT[0] and OUT[1].
   Start homing by writing one of the control codes for operating modes 1 to 5 to OUT[0].
   If the terminal was already homed, the message code switches to “Device is not homed”.
2. Wait for acknowledgment (status bit A)
   The time it takes to receive acknowledgment varies depending on the homing mode.
   In operating mode 1, the acknowledgment bit (status bit Q) appears immediately.
   For operating modes 2 to 6, the duration depends on the following factors:
   - Distance to reference point
   - Speed at which the axis is moved during homing.

   The acknowledgement bit “Homed” is present until an error occurs or a new homing process is initialized.
3. Reading adjustment value (only for homing versions in operating modes 4 and 5)
   In modes 4 and 5, the delta value (adjustment value) can be read in the “Actual position value” data field. This indicates the distance between the position of the home position switch edge and the position of the Z pulse.
   This value stays in the “Actual position value” data field until the switch is made to operating mode 0 “Read actual position value".
   Internally, the positioning counter starts position detection beginning from the Z pulse position.
4. Switching back to “Read actual position value”
   In OUT[0], select operating mode 0 (“Read actual position value”).
   From the “Actual position value” data field in IN[0] and IN[1], you can read the respective position (value range 0 to 2^{25} - 1).

10.2 Homing function for distance-coded linear encoders

In addition to the counting tracks, distance-coded linear encoders have a reference mark track with different pitch periods. This results in fields of different sizes between two reference marks. Each field only appears once in the linear system.

In order to detect the absolute position in the system only two reference marks must be overrun.

The sequence is as follows (see following figures):
The slide position is unknown; the slide is moved in any direction with the set operating mode 6.
When the slide reaches the first reference mark (Z), the internal counter is set to 0 and the incoming increments of the counting track are added.

When the slide reaches the second reference mark, the counter value determined between the two reference marks is output and the internal counter is set to 0 again. At the same time, the message code “Acknowledgement, device homed” is output.

The output counter value corresponds to the increments of the overrun field and is displayed until the switch is made to operating mode 0 “000bin” (read position actual value). After the operating mode is switched, the counter value is displayed beginning from the second reference mark. The position corresponds to the position before or after the determined field depending on the counting and positioning directions.

Fig. 7 Example 1: Positioning in positive counting direction

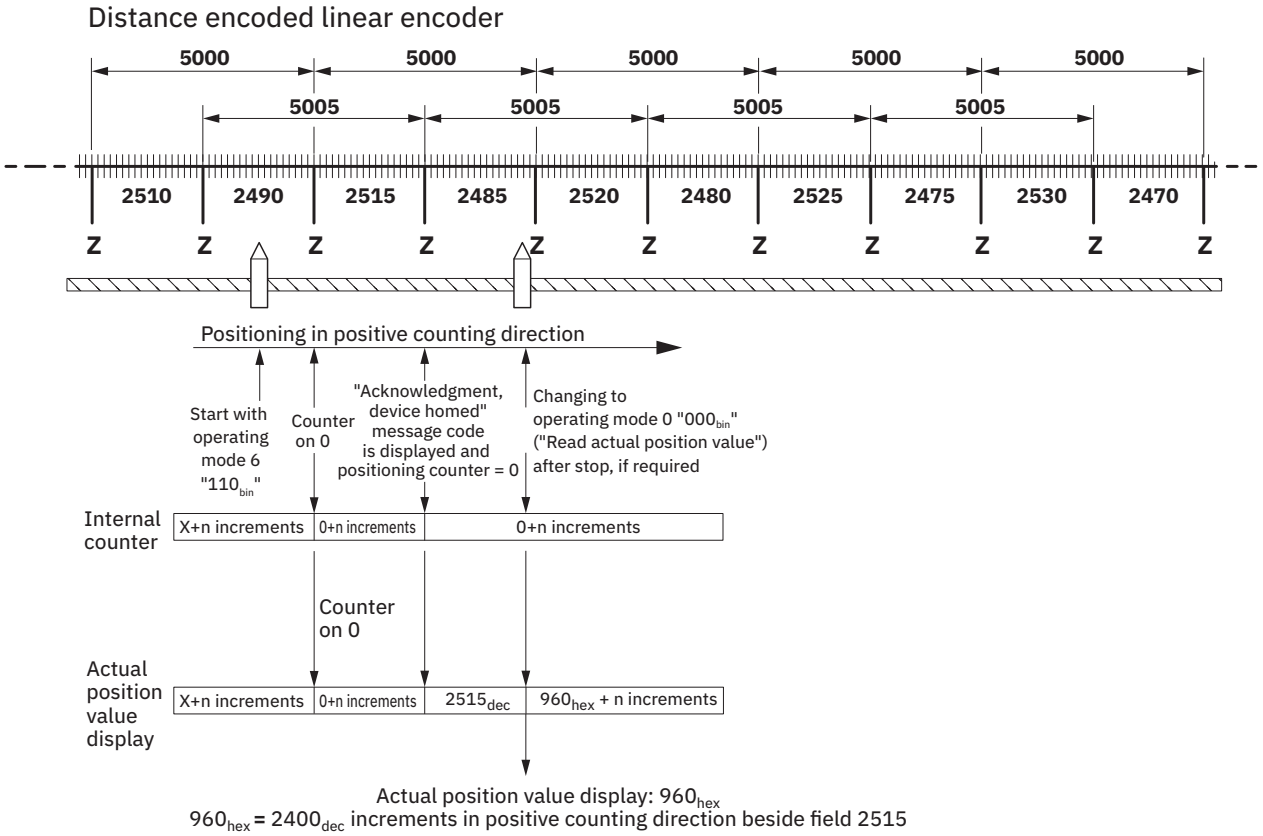
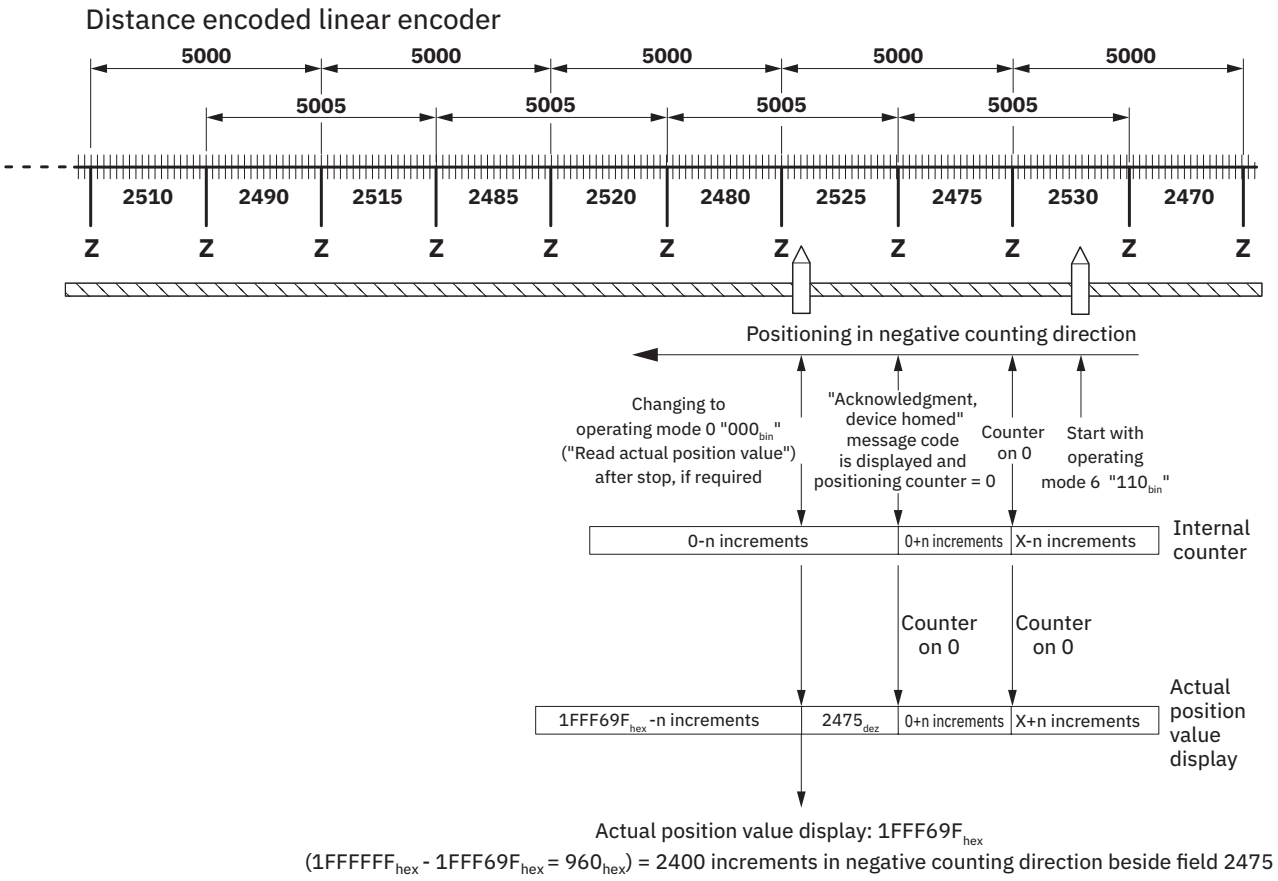


Fig. 8 Example 2: Positioning in negative counting direction



Actual position value display: $1FFF69F_{hex}$

($1FFFFFF_{hex}$ - $1FFF69F_{hex}$ = 960_{hex}) = 2400 increments in negative counting direction beside field 2475

10.3 I/O error

The terminal has the following monitoring mechanisms that trigger an I/O error message:

- Monitoring of the encoder power supply (5 V or 24 V)

  If the encoder supply fails or is overloaded, an I/O error is triggered and a corresponding error code is generated.
- Monitoring of encoder signals

  The differential signal of a symmetrical encoder must exceed 0.5 V.
  An asymmetrical encoder must actively pull the inputs, which are biased to 3 V with resistors, either under 2.5 V (low level) or above 3.5 V (high level).
  If these conditions are not met, an I/O error is triggered and a corresponding error code is generated.

  Possible error causes:
  - No encoder connected
  - An asymmetrical encoder was not parameterized as an asymmetrical encoder
  - Wire break in an encoder cable
  - No bridge was inserted when using an encoder without Z signal, see section “Connection notes”

11 Process data

The terminal uses two words of IN process data and two words of OUT process data.

11.1 OUT process data

The process data output words transmit the output values in each cycle.

(Word.bit) view	Word	0															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.Bit) view	Byte	0								1							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Assignment		Operating mode			Evaluation and encoder type			AS		Reference point value for homing function							

(Word.bit) view	Word	1															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.Bit) view	Byte	2								3							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Assignment		Reference point value for homing function															

Operating mode	See “Operating mode” table
Evaluation and encoder type	See “Evaluation and encoder type” table
AS	Set the output bit (activates the open collector output of E3). Terminal point E3 can be used as a 24 V input or as an output with negative logic. When OB = 1, the output connects terminal point E3 to GND.
Reference point value for homing function	This value is applied to the position counter during homing. From this point onwards, the reference point value forms the output value for position detection (value range 0 ... 2^{25} - 1).

NOTE **Misinterpretation of values when the data consistency is violated**

Ensure data consistency of two words to prevent the possibility of the values being misinterpreted.

Operating mode				
Operating mode	**Bit**			**Description**
	15	**14**	**13**	
0	0	0	0	Read actual position value
				The positioning counter is continuously displayed in the actual position value (process data input words 0 and 1).
1	0	0	1	Setting the counter to the reference point value (homing at standstill)
				The reference point value is loaded to the positioning counter and the counter immediately starts to count the incoming pulses.
				The message code “Acknowledgment, device homed” appears.
				You exit the homing function by switching to operating mode 0 (Read actual position value).
2	0	1	0	Homing on the next rising edge of input E1, E2, or E3* without Z
				The reference point value is loaded into the counting register with a rising edge of one of the inputs.
				The message code “Acknowledgment, device homed” appears.
				You exit the homing function by switching to operating mode 0 (Read actual position value).

Operating mode				
Operating mode	**Bit**			**Description**
	15	**14**	**13**	
3	0	1	1	Homing on the next falling edge of input E1, E2, or E3* without Z
				The reference point value is loaded into the counting register with a falling edge of one of the inputs.
				The message code “Acknowledgment, device homed” appears.
				You exit the homing function by switching to operating mode 0 (Read actual position value).
4	1	0	0	Homing on Z after rising edge of input E1, E2, or E3*
				The delta counting register is set to 0 with a rising edge of one of the inputs.
				The position value gives a positive count value, which indicates the difference between the input edge and the next rising edge of Z (adjustment value). When Z is reached, the message code “Acknowledgement, device homed” appears and the reference point value is loaded into the counting register. The delta value is displayed until the operating mode is changed to “Read actual position value”.
				You exit the homing function by switching to operating mode 0 (Read actual position value).
5	1	0	1	Homing on Z after falling edge of input E1, E2, or E3*
				The delta counting register is set to 0 with a falling edge of one of the inputs.
				The position value gives a positive count value, which indicates the difference between the input edge and the next rising edge of Z (adjustment value). When Z is reached, the message code “Acknowledgement, device homed” appears and the reference point value is loaded into the counting register. The delta value is displayed until the operating mode is changed to “Read actual position value”.
				You exit the homing function by switching to operating mode 0 (Read actual position value).
6	1	1	0	Homing of distance-coded incremental encoders
				The delta counting register is set to 0 with the first rising edge of the Z signal. The position value gives a positive count value, which indicates the delta between the two Z signals, with the second rising edge of the Z signal. When the second Z signal is reached, the message code “Acknowledgement, device homed” appears and the reference point value is loaded into the counting register. The delta value is displayed until the operating mode is changed to “Read actual position value”.
				You exit the homing function by switching to operating mode 0 (Read actual position value).
7	1	1	1	Test mode
				The delta counting register is set to 0 with a rising edge of the Z signal. The delta counting register is reset to 0 with a second rising edge of Z. The position value gives a positive count value, which indicates the delta between the last two Z signals.

* Terminal point E3 can be used as a 24 V input or as an output with negative logic.
When output bit OUT[0], bit 9 = 1 is set, the output connects terminal output E3 to GND.
When output bit OUT[0], bit 9 = 0 is set, E3 can be used as an input.
Application example: In an incremental length measuring system (ELGO Electric, Rielasingen), a 0 V enable signal is required for the Z index pulse.

The difference between the limit switch and the first Z edge is always specified as a positive value, even if the direction of rotation or the traversing direction is negative.

NOTE **Misinterpretation of the input edges of E3**

Inputs E1 to E3 are active simultaneously for the homing function in modes 2 to 5. If you use E3 as an open collector output, note the following:
To ensure that the input edges of E3 are correctly interpreted during homing, do not change the output OUT[0], bit 9 after activating one of the homing modes 2 to 5.

Evaluation and encoder type				
Bit			**Description**	
12	**11**	**10**	**Evaluation**	**Encoder type**
0	0	0	No evaluation (no function)	
0	0	1	2-sample	Symmetrical encoder
0	1	0	4-sample	
0	1	1	1x	
1	0	0	No evaluation (no function)	
1	0	1	2-sample	Asymmetrical encoders
1	1	0	4-sample	
1	1	1	1x	

11.2 IN process data

The input process data contains the status and the actual position value.

(Word.bit) view	Word	0															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.Bit) view	Byte	0								1							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Assignment		Error/message code				E3	E2	E1	Actual position value								

(Word.bit) view	Word	1															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.Bit) view	Byte	2								3							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Assignment		Actual position value															

Error/message code	See “Error/message code” table
E3, E2, E1	Status of the corresponding input
Actual position value	Contents of the positioning counter (25 bits)

NOTE **Misinterpretation of values when the data consistency is violated**

Ensure data consistency of two words to prevent the possibility of the values being misinterpreted.

Error/message code				
Bit				Description
15	14	13	12	
0	0	0	0	No error, device not (yet) homed
0	0	0	1	Acknowledgment, device homed
0	0	1	0	Test mode is activated
0	1	0	0	Homing initiated several times The set operating mode 1 to 6 for a homing function was changed before the terminal output the acknowledgement “Device homed”.
1	0	0	0	Actual position value invalid (power supply)
1	0	1	0	Position actual value invalid (encoder error) Possible causes include: - Asymmetrical encoder was parameterized as symmetrical - No bridge was inserted when using an encoder with Z signal
1	1	0	0	Homing not possible, as evaluation not set
1	1	1	0	Actual position value invalid as evaluation was changed during operation

After successful homing, status bit 12 (IN[0]) “Acknowledgement, device homed” is set. It is present until an error occurs or a new homing process is initialized.

DOK-CONTRL-ILINC*IN***-KB03-EN-P

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