Interfaces
of HEIDENHAIN Encoders

09/2019
As the defined junctions between encoders and subsequent electronics, interfaces ensure the reliable exchange of information.

HEIDENHAIN offers encoders with interfaces for many common subsequent electronics. The interface possible in each individual case depends on, among other things, the measuring method used by the encoder.

**Measurement methods**

With the **incremental measuring method**, the position information is obtained **by counting** the individual increments (measuring steps) starting from some point of origin. Since an absolute reference point is necessary for determining the positions, a reference-mark signal is output as well. As a general rule, encoders that operate with the incremental measuring method provide **incremental signals**. Some incremental encoders with integrated interface electronics have a counting function: once the reference mark is traversed, an absolute position value is generated and transmitted via a serial interface.

With the **absolute measuring method** the absolute position information is acquired directly **from the grating of the measuring standard**. The position value is available from the encoder immediately upon switch-on and can be requested at any time by the subsequent electronics.

Encoders that use the absolute measuring method output **position values**. Some interfaces provide incremental signals as well.

Since absolute encoders do not require a reference run, they are particularly advantageous in concatenated manufacturing systems, transfer lines, and multi-axis machines. They are also highly immune to EMC interference.

**Interface electronics**

Interface electronics from HEIDENHAIN adapt the encoder signals to the interface of the subsequent electronics. They are used when the subsequent electronics cannot directly process the output signals from HEIDENHAIN encoders or when additional interpolation of the signals is necessary.

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This brochure supersedes all previous editions, which thereby become invalid. The basis for ordering from HEIDENHAIN is always the brochure edition valid when the order is made.

Standards (ISO, EN, etc.) apply only where explicitly stated in the brochure.

**Further information:**
- Interface Electronics product overview
- Cables and Connectors brochure
## Position values

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<td>Proprietary interface</td>
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<td></td>
<td></td>
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<td>Proprietary interface</td>
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## Incremental signals

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<th>14</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>$11\text{µA}_{\text{pp}}$</td>
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<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Square-wave signals</td>
<td>TTL</td>
<td>RS-422, typically 5 V</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HTL</td>
<td>Typically 10 V to 30 V</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HTLs</td>
<td>Typically 10 V to 30 V, without inverted signals</td>
<td>21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Other signals

| Commutation signals    | Block commutation     | 23                         |                             |                             |   |
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| Interface electronics   | 28                         |                             |                             |                             |   |
| Diagnostic and testing equipment | 30                        |                             |                             |                             |   |
| General electrical information | 34                        |                             |                             |                             |   |
The EnDat interface is a digital, bidirectional interface for encoders. It is capable of outputting position values, reading and updating information stored in the encoder, and storing new information in the encoder. Thanks to the interface's serial transmission method, only four signal lines are required. The data are transmitted in synchronism with the clock signal from the subsequent electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected via mode commands sent to the encoder by the subsequent electronics. Some functions are available only in conjunction with EnDat 2.2 mode commands.

History and compatibility
The EnDat 2.1 interface, which has been available since the mid-1990s, has since been upgraded to EnDat 2.2 (recommended for new applications). In terms of its communication, command sets, and time conditions, EnDat 2.2 is compatible with EnDat 2.1 but also offers significant advantages. For example, EnDat 2.2 permits the transfer of additional data (sensor values, diagnostics, etc.) along with the position value without initiating a separate request. This allows the interface to support additional types of encoders (e.g., encoders with buffer battery backup, incremental encoders). The interface protocol has also been expanded, and the time conditions (clock frequency, calculation time, recovery time) have been optimized.

Supported encoder types
The following encoder types are currently supported with the EnDat 2.2 interface (readable from the memory area of the encoder):
- Incremental linear encoders
- Absolute linear encoders
- Incremental, singleturn rotational encoders
- Absolute, singleturn rotational encoders
- Multiturn rotary encoders
- Multiturn rotary encoders with buffer battery backup
For the various encoder types, some parameters must be interpreted differently (see the EnDat specifications), or EnDat additional data must be processed (e.g., incremental encoders or encoders with buffer battery backup).

### Interface

<table>
<thead>
<tr>
<th>Data transmitted</th>
<th>EnDat serial bidirectional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position values, parameters, and additional data</td>
<td>Position values, parameters, and additional data</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data input</th>
<th>Differential line receiver in compliance with EIA standard RS-485 for the signals CLOCK, CLOCK, DATA, and DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data output</td>
<td>Differential line driver in compliance with EIA standard RS-485 for DATA and DATA signals</td>
</tr>
<tr>
<td>Position values</td>
<td>Ascending during movement in the direction of the arrow (see mating dimensions of the encoders)</td>
</tr>
<tr>
<td>Incremental signals</td>
<td>Depends on the encoder 1 VPP, TTL, HTL (see respective Incremental signals)</td>
</tr>
</tbody>
</table>

### Ordering designations
The ordering designations define the core specifications and provide the following information:
- Typification of the encoder
- Command set
- Availability of incremental signals
- Maximum clock frequency
- The second position in the ordering designation identifies the interface generation. With encoders of the current generation, the ordering designation can be read from the encoder memory.

### Incremental signals
Some encoders also provide incremental signals. These signals are primarily used for increasing the resolution of the position value or for servicing a second subsequent electronics unit. Current generations of encoders have a high internal resolution and therefore no longer need to provide incremental signals. The ordering designation indicates whether an encoder outputs incremental signals:
- EnDat01 1 VPP incremental signals
- EnDatH HTL incremental signals
- EnDatT TTL incremental signals
- EnDat21 Without incremental signals
- EnDat02 With 1 VPP incremental signals
- EnDat22 Without incremental signals

#### Note on EnDat01/02:
The signal period is stored in the encoder memory

#### Note on EnDatH/EnDatT:
The interpolation factor with which the internal incremental signals are output is indicated by a single letter added to the ordering designation:
- a 2-fold interpolation
- b Without interpolation
- c 0.5-fold interpolation (incremental signals/2)

### Supply voltage
The typical supply voltage of the encoders depends on the interface:

<table>
<thead>
<tr>
<th>EnDat01</th>
<th>5 V ±0.25 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnDat21</td>
<td>5 V ±0.25 V</td>
</tr>
<tr>
<td>EnDat02</td>
<td>3.6 V to 5.25 V or 14 V</td>
</tr>
<tr>
<td>EnDat22</td>
<td>10 V to 30 V</td>
</tr>
<tr>
<td>EnDatH</td>
<td>4.75 V to 30 V</td>
</tr>
</tbody>
</table>

Exceptions are documented in the specifications.

### Command set
The command set describes the available mode commands, which define the information exchange between the encoder and the subsequent electronics. The EnDat 2.2 command set includes all EnDat 2.1 mode commands. In addition, EnDat 2.2 permits further mode commands for the selection of additional data and enables memory accesses even in a closed control loop. When a mode command from the EnDat 2.2 command set is sent to an encoder that supports only the EnDat 2.1 command set, an error message is triggered. The specific command set supported is identified in the encoder's memory area:
- EnDat01/21/H/T Command set 2.1 or 2.2
- EnDat02/22 Command set 2.2
Clock frequency

The clock frequency is variable between 100 kHz and 2 MHz depending on the cable length (max. 150 m). With propagation-delay compensation in the subsequent electronics, clock frequencies of up to 16 MHz or cable lengths of up to 100 m are possible. For EnDat encoders with the ordering designation EnDat22, the maximum clock frequency is stored in the encoder memory. For all other encoders, the maximum clock frequency is 2 MHz. Propagation-delay compensation is intended only for the ordering designations EnDat21 and EnDat22; for EnDat02, see the note below.

| EnDat01 | ≤ 2 MHz (see "without propagation-delay compensation" in diagram) |
| EnDatT  | ≤ 2 MHz |
| EnDatH  | ≤ 2 MHz |
| EnDat21 | ≤ 2 MHz or ≤ 8 MHz or 16 MHz (see note) |
| EnDat22 | ≤ 8 MHz or 16 MHz |

In conjunction with large cable lengths, transmission frequencies of up to 16 MHz place high technological demands on the cable. For reasons concerning the transmission technology, the adapter cable connected directly to the encoder must not be longer than 20 m. Greater cable lengths can be realized with an adapter cable no longer than 6 m and an extension cable. As a rule, the entire transmission path must be designed for the respective clock frequency.

Note on EnDat02

EnDat02 encoders may have a pluggable cable assembly. In choosing the version of the adapter cable, the customer decides whether the encoder will be operated with or without incremental signals. This also influences the maximum possible clock frequency. For adapter cables with incremental signals, the clock frequency is limited to 2 MHz; see also EnDat01. For adapter cables without incremental signals, the clock frequency can be up to 16 MHz. The exact values are stored in the encoder memory.

Position values

The position value can be transmitted with or without additional data. At the earliest, the position value is transmitted to the subsequent electronics after the calculation time t_cal has elapsed. The calculation time is determined for the encoder’s highest permitted clock frequency, but for no more than 8 MHz.

For the position value, only the required number of bits is transferred. The number of bits thus depends on the respective encoder and can be read from the encoder for automatic parameterization.

Typical operating modes

Operating mode EnDat 2.1: This mode is for encoders that provide additional incremental signals. For generation of the position value, the absolute position is read once simultaneously with the incremental position, and both are used in the calculation of the position value. The subsequent generation of the position value in the control loop is based on the incremental signals. Only EnDat 2.1 mode commands are used.

Operating mode EnDat 2.2: This mode is for purely serial encoders. For position value generation, the position value is read from the encoder during each control cycle. EnDat 2.2 mode commands are typically used to read the position value. EnDat 2.1 mode commands are typically used to read and write parameters after switch-on.

In the closed control loop, the EnDat 2.2 interface allows additional data to be requested along with the position, and it permits the execution of functions (e.g., read/write parameters, reset error messages).

Additional data

Depending on the type of transmission (selection via MRS code), one or two items of additional data can be appended to the position value. The types of additional data supported by the respective encoder are saved in the encoder’s parameters. Additional data encompasses the following:

- Status information, addresses, and data
  - WRN – warnings
  - RM – reference mark
  - Busy – parameter request

Additional data 1

- Diagnostics
- Memory parameters
- MRS-code acknowledgment
- Test values
- Temperature
- Additional sensors

Additional data 2

- Commutation
- Acceleration
- Limit position signals
- Asynchronous position value
- Operating status error sources
- Timestamp
Memory areas
The encoder provides multiple memory areas for parameters. These memory areas can be read by the subsequent electronics, and some areas can be written to by the encoder manufacturer, the OEM, or the end user. The parameter data are stored in permanent memory. This memory allows only a limited number of write accesses and is not designed for the cyclic storage of data. Certain storage areas can be write-protected (resettable only by the encoder manufacturer).

Parameters are stored in various memory areas, e.g.:
- Encoder-specific information
- Information from the OEM (e.g., electronic ID label of the motor)
- Operating parameters (datum shift, instruction, etc.)
- Operating status (alarms or warnings)

Monitoring and diagnostic functions of the EnDat interface enable a detailed inspection of the encoder. These include the following:
- Error messages
- Warnings
- Online diagnostics based on valuation numbers (EnDat 2.2)
- Mounting interface

Basics of functional safety
EnDat 2.2 can support the use of encoders in safety-related applications. To this end, the following standards are taken as a basis: DIN EN ISO 13849-1 (successor to EN 954-1), as well as EN 61508 and EN 61800-5-2. In these standards, safety-related systems are assessed based on criteria such as the failure probabilities of integrated components and subsystems. The modular approach helps manufacturers of safety-related systems in implementing their complete systems by allowing them to build upon already qualified subsystems.

Further information:
See “Functional Safety” at www.endat.de

Input circuit of the subsequent electronics
Dimensioning
IC1 = RS-485 differential line receiver and driver
Z0 = 120 Ω
## Proprietary serial interfaces

<table>
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<tr>
<th>Control manufacturer</th>
<th>Interface</th>
<th>Designation in brochure</th>
<th>Ordering designation</th>
<th>Code letter</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
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<td>Siemens</td>
<td>Siemens</td>
<td>DRIVE-CLiQ</td>
<td>DQ01</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>Fanuc</td>
<td>Fanuc α</td>
<td>Fanuc02</td>
<td>F</td>
<td>Normal and high speed, two-pair transmission</td>
<td></td>
</tr>
<tr>
<td>Fanuc</td>
<td>Fanuc αβ</td>
<td>Fanuc06</td>
<td></td>
<td>High-speed, one-pair transmission, includes the α interface (normal and high speed, two-pair transmission)</td>
<td></td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>Mitsubishi high speed interface</td>
<td>Mitsui01, Miti02-4, Miti02-2, Miti03-4, Miti03-2</td>
<td>M</td>
<td>Two-pair transmission \ Generation 1, two-pair transmission \ Generation 1, one-pair transmission \ Generation 2, two-pair transmission \ Generation 2, one-pair transmission</td>
<td></td>
</tr>
<tr>
<td>Yaskawa</td>
<td>Yaskawa Serial Interface</td>
<td>YEC02, YEC07</td>
<td>Y</td>
<td>–</td>
<td>Compatible with YEC02</td>
</tr>
<tr>
<td>Panasonic</td>
<td>Panasonic Serial Interface</td>
<td>Panasonic01, Panasonic02</td>
<td>P</td>
<td>–</td>
<td>Compatible with Panasonic01</td>
</tr>
</tbody>
</table>

1) For more information on the combination of an encoder and control, please contact the control manufacturer
2) The code letter is an add-on to the model designation of HEIDENHAIN encoders, such as “LC 495 S.”
PROFIBUS DP

PROFIBUS is a non-proprietary, open fieldbus that complies with the international standard EN 50170. The connection of sensors through fieldbus systems minimizes cabling and reduces the number of lines between the encoder and the subsequent electronics.

Topology and bus assignment

The PROFIBUS DP has a linear topology. Transfer rates of up to 12 Mbit/s are possible. Both single-master and multi-master systems can be implemented. Each master can serve only its own slaves (polling). The slaves are polled cyclically by the master. Slaves can be sensors such as absolute rotary encoders and linear encoders, or they can also be control devices such as variable-frequency drives.

Physical-layer characteristics

The electrical characteristics of PROFIBUS DP comply with the RS-485 standard. The bus connection is a shielded, twisted-pair cable with active bus terminations at both ends.

Commissioning

The data of the connectable HEIDENHAIN encoders required for system configuration are available for each encoder in the form of electronic device data sheets, commonly referred to as general station description files (GSD). These general station description files completely and unambiguously describe the characteristics of a device in a precisely defined format, thereby enabling the convenient and application-friendly integration of the devices into the bus system.

Configuration

PROFIBUS DP devices can be configured and parameterized in accordance with the requirements of the user. These settings are saved in the master once they have been selected in the configuration tool with the help of the GSD file. As a result, the PROFIBUS devices are configured upon every network start-up. This simplifies device replacement by eliminating the need for editing or re-entry of the configuration data.

There are two GSD files to choose from:
- GSD file for the DP-V0 profile
- GSD file for the DP-V1 and DP-V2 profiles

Bus topology of PROFIBUS DP
PROFIBUS DP profile
The PNO (PROFIBUS user organization) has defined standardized, non-proprietary profiles for the connection of absolute encoders to the PROFIBUS DP fieldbus. High flexibility and simple configuration are thereby ensured for all equipment using these standardized profiles.

DP-V0 profile
This profile can be requested from the PNO in Karlsruhe, Germany (ordering number: 3.062). There are two classes defined in this profile: class 1 is equivalent to the minimum range of functions, and class 2 contains additional functions, some of which are optional.

DP-V1 and DP-V2 profile
This profile can be obtained from the PNO in Karlsruhe, Germany (ordering number: 3.162). This profile likewise distinguishes between two device classes:
• Class 3 with the basic functions and
• Class 4 with the full range of scaling and preset functions.

In addition to the mandatory functions of classes 3 and 4, optional functions are defined as well.

Supported functions
Of particular importance in decentralized fieldbus systems are diagnostic functions (e.g., warnings and alarms) and the electronic ID label, which contains information about the encoder model, resolution, and measuring range. Yet programming functions are possible as well, such as reversal of counting direction, preset/datum shift, and changing the resolution (scaling). The operating time and the speed of the encoder can also be recorded.

Encoders with PROFIBUS DP
Absolute encoders with an integrated PROFIBUS DP interface are connected directly to the PROFIBUS fieldbus. The rear side of these encoders is equipped with LEDs for indicating the operating status, supply voltage, and bus status.

The coding switches for addressing (0 to 99) and for activating the terminating resistor are easily accessible under the bus cover. The terminating resistor must be activated if the rotary encoder is the final participant on the PROFIBUS DP fieldbus and if the external terminating resistor is not in use.

### Functions of the DP-V0 classes

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Class</th>
<th>Rotational encoders</th>
<th>Linear encoders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>≤ 16 bits</td>
<td>≤ 31 bits</td>
</tr>
<tr>
<td>Pos. value in pure binary code</td>
<td>1,2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Data word length</td>
<td>1,2</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>Scaling function</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Total resolution</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reversal of counting direction</td>
<td>1,2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Preset (output data:</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>16 bits or 32 bits)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnostic functions</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Warnings and alarms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating time recording</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Speed</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Profile version</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Serial number</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

1) With a data word width > 31 bits, only the upper 31 bits are transferred
2) Requires a 32-bit configuration of the output data and a 32+16-bit configuration of the input data

### Functions of the DP-V1 and DP-V2 classes

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Class</th>
<th>Rotational encoders</th>
<th>Linear encoders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>≤ 32 bits</td>
<td>&gt; 32 bits</td>
</tr>
<tr>
<td>Telegram</td>
<td>3,4</td>
<td>81-84</td>
<td>84</td>
</tr>
<tr>
<td>Scaling function</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reversal of counting direction</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Preset / datum shift</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Acyclic parameters</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Channel-dependent diagnosis</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>via alarm channel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating time recording</td>
<td>3,4</td>
<td>✓ 1)</td>
<td>✓ 1)</td>
</tr>
<tr>
<td>Speed</td>
<td>3,4</td>
<td>✓ 1)</td>
<td>✓ 1)</td>
</tr>
<tr>
<td>Profile version</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Serial number</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

1) Not supported by DP-V2
PROFINET IO

PROFINET IO is the open Industrial Ethernet standard for industrial communication. It builds on the field-proven functional model of PROFIBUS DP but employs fast Ethernet technology as its physical transmission medium, thereby tailoring it to the fast transmission of I/O data. At the same time, this standard provides the option of transmitting demand data, parameters, and IT functions.

PROFINET enables the connection of decentralized field devices to a controller. It also describes parameterization, diagnostics, and the exchange of data between the controller and field devices. The PROFINET design is modular. Cascading functions can be selected by the user himself. In order for the high speed requirements to be met, these functions primarily differ in terms of their data exchange type.

Topology and bus assignment

A PROFINET IO system is made up of the following elements:

• IO controller (control/PLC; controls the automation task)
• IO device (decentralized field device such as a rotary encoder)
• IO supervisor (development or diagnostic tool such as a PC or programming device)

PROFINET IO follows the provider-consumer model, which supports communication between Ethernet peers. This has the advantage that the provider transmits its data without any prompting by the communication partner.

Physical-layer characteristics

HEIDENHAIN encoders are connected to PROFINET in accordance with 100BASE-TX (IEEE 802.3, Clause 25) over one shielded, twisted wire pair in each direction. The data transfer rate is 100 Mbit/s (Fast Ethernet).

PROFINET profile

HEIDENHAIN encoders generally satisfy the definition as per Profile 3.162, Version 4.1. This device profile describes the functionality of the rotary encoder. Class 4 functions are supported (full scaling and preset functionality). More information about PROFINET can be obtained from the PROFIBUS user organization (PNO).

<table>
<thead>
<tr>
<th>Supported functions (Profile 3.162, V4.1)</th>
<th>Class</th>
<th>Rotary encoders Singleturn</th>
<th>Multiturn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position value</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Isochronous mode</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Functions of class 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scaling function</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Measuring units per revolution</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Total measuring range</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cyclic operation (binary scaling)</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Acyclic operation</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Preset</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Code sequence</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Preset control G1_XIST1</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Compatibility mode (encoder profile V3.1)</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Operating time</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Speed</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Profile version</td>
<td>3,4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Continuous storage of the offset value</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Identification &amp; maintenance (I &amp; M)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External firmware upgrade</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Commissioning

In order for an encoder with PROFINET interface to be put into operation, a general station description (GSD) must be downloaded and imported to the configuration software. The GSD file contains the execution parameters required for a PROFINET IO device.

Configuration

Profiles are predefined configurations of the functions and performance characteristics available from PROFINET for use in certain devices or applications, such as in rotary encoders. They are defined and published by the workgroups of PROFIBUS & PROFINET International (PI).

Profiles are important for openness, interoperability, and exchangeability, assuring the end user that similar devices from different manufacturers operate in a standardized manner.

Encoders with PROFINET

Absolute encoders with an integrated PROFINET interface are incorporated directly into the network. Addresses are assigned automatically via a protocol integrated into the PROFINET network. Within a network, a PROFINET IO field device is addressed via its physical device MAC address.

The rear side of the encoders features two double-color LEDs for bus and device diagnostics.

A terminating resistor for the final participant is not needed.
Starting with the most significant bit (MSB), the **absolute position value** is transmitted over the data lines (DATA) in synchronism with a clock signal (CLOCK) provided by the control. The SSI standard data word length for singleturn encoders is 13 bits, and for multiturn encoders 25 bits. In addition to the absolute position values, **incremental signals** can be transmitted as well. For a signal description, see *Incremental signals*.

The following **functions** can be activated via the programming inputs of the interface through application of the supply voltage \( U_P \):

- **Direction of rotation**
  The continuous application of a HIGH level on PIN 2 \( (t_{min} > 1 \text{ ms}) \) reverses the direction of rotation for ascending position values.

- **Zeroing** (setting to zero)
  Application of a positive edge \( (t_{min} > 12 \text{ ms}) \) to pin 5 sets the current position value to zero.

**Warning**: The programming inputs must always be terminated with a resistor (see *Input circuit of the subsequent electronics*).

### Interface SSI serial

<table>
<thead>
<tr>
<th>Data transmitted</th>
<th>Absolute position values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data input</td>
<td>Differential line receiver in compliance with EIA standard RS-485 for CLOCK and CLOCK signals</td>
</tr>
<tr>
<td>Data output</td>
<td>Differential line driver in compliance with EIA standard RS-485 for DATA and DATA signals</td>
</tr>
<tr>
<td>Code</td>
<td>Gray code</td>
</tr>
<tr>
<td>Ascending position values</td>
<td>With clockwise rotation as viewed from the flange side (switchable via interface)</td>
</tr>
<tr>
<td>Incremental signals</td>
<td>Depends on the encoder</td>
</tr>
</tbody>
</table>
  - \(~ 1 \text{ V}_{PP}, \text{TTL}, \text{HTL} \) (see respective *Incremental signals* )

**Programming inputs**

<table>
<thead>
<tr>
<th>Inactive</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW (&lt;0.25 \cdot U_P)</td>
<td>HIGH (&gt;0.6 \cdot U_P)</td>
</tr>
</tbody>
</table>

### Connecting cable

- **Cable length**
  - HEIDENHAIN shielded cables; e.g., PUR \([(4 \times 0.14 \text{ mm}^2) + 4(2 \times 0.14 \text{ mm}^2) + (4 \times 0.5 \text{ mm}^2)]\)
  - Max. 100 m
  - 6 ns/m

**Control cycle for a complete data format**

When not transmitting, the clock and data lines are held at HIGH level. The internally and cyclically generated position value is stored on the first falling clock edge. The data are transmitted on the first rising clock edge.

After transmission of a complete data word, the data output line remains at LOW level until the encoder is ready for a new measured-value request \( (t_2) \). Encoders with the SSI 39r1 or SSI 41r1 interfaces additionally require a subsequent clock pause \( (t_3) \). If another data-output request (CLOCK) is received within this time \( (t_2 + t_3) \), then the same data will be output again.

If the data output is interrupted \( (\text{CLOCK} = \text{HIGH} \text{ for } t \geq t_2) \), then a new position value will be stored on the next falling clock edge. The data are read in by the subsequent electronics on the next rising clock edge.
Incremental signals
Some encoders also provide incremental signals. These signals are primarily used to increase the resolution of the position value or to service a second subsequent electronics unit. The signals are almost always 1 Vpp incremental signals. Exceptions are identifiable based on the ordering designation:
- SSI41H  With HTL incremental signals
- SSI41T  With TTL incremental signals

Input circuit of the subsequent electronics

Dimensioning
IC₁ = Differential line receiver and driver
e.g.,  SN 65 LBC 176
     LT 485

Z₀ = 120  Ω
C₃ = 330 pF (for improved noise immunity)

Data transmission
Encoder
Subsequent electronics

Incremental signals
e.g., 1 Vpp

Programming via connecting element
(for availability, see the encoder documentation)

Zeroing
Direction of rotation

3.9  kΩ
3.9  kΩ
**Incremental signals**

HEIDENHAIN encoders with the ~1 Vpp interface provide voltage signals that are highly interpolatable.

The sinusoidal incremental signals A and B are phase-shifted by 90° elec. and have a typical amplitude of 1 Vpp. The illustrated sequence of output signals—with B lagging A—applies to the direction of motion shown in the dimension drawing.

The reference mark signal R has a usable component G of approx. 0.5 V. Adjacent to the reference mark, the output signal can drop by up to 1.7 V to a quiescent value H. The subsequent electronics must not be allowed to overdrive on account of this. Even at the low quiescent level, signal peaks with amplitude G can appear.

The signal amplitude is valid when the supply voltage stated in the specifications is applied at the encoder. The signal amplitude is based on a differential measurement between the associated outputs at the 120 ohm terminating resistor. The signal amplitude decreases when the frequency increases. The cutoff frequency is the frequency up to which a certain percentage of the original signal amplitude is maintained:

- –3 dB ≥ 70 % of the signal amplitude
- –6 dB ≥ 50 % of the signal amplitude

The parameters in the signal description apply to motion at up to 20 % of the –3 dB cutoff frequency.

**Interpolation/resolution/measuring step**

The output signals of the 1 Vpp interface are usually interpolated in the subsequent electronics for the purpose of attaining sufficiently high resolutions. For speed control, interpolation factors of greater than 1000 are normally used for providing usable data even at low shaft speeds or traversing speeds.

Measuring steps for position measurement are recommended in the specifications. Other resolutions are also possible for special applications.

---

**Interface**

<table>
<thead>
<tr>
<th>1 Vpp sinusoidal voltage signals</th>
</tr>
</thead>
</table>

**Incremental signals**

- Two nearly sinusoidal signals A and B
  - Signal amplitude M: 0.6 to 1.2 Vpp, typ. 1 Vpp
  - Asymmetry |P – N|/2M: ≤ 0.065 (equivalent to 15°)
  - Amplitude ratio M_A/M_B: 0.8 to 1.25
  - Phase angle |φ1 + φ2|/2: 90° ± 10° elec.

**Reference mark signal**

- One or more signal peaks R
  - Usable component G: ≥ 0.2 V
  - Quiescent value H: ≤ 1.7 V
  - Signal-to-noise ratio E, F: 0.04 V to 0.68 V
  - Zero crossovers K, L: 180° ± 90° elec.

**Connecting cable**

- HEIDENHAIN shielded cables; e.g., PUR [4(2 x 0.14 mm²) + (4 x 0.5 mm²)]
- Max. 150 m
- 6 ns/m

These values can be used for the dimensioning of the subsequent electronics. Any encoder tolerances that are subject to constraints are listed in the specifications. For encoders without an integral bearing, reduced tolerances are recommended for commissioning (see mounting instructions).
**Short-circuit stability**
The shorting of outputs is not a permissible operating condition. Excepted from this are encoders with a supply voltage of DC 5 V ±5 %, which do not fail if an output briefly shorts to 0 V or U_R:

<table>
<thead>
<tr>
<th>Condition</th>
<th>20 °C</th>
<th>125 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short circuit at</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One output</td>
<td>&lt; 3 min</td>
<td>&lt; 1 min</td>
</tr>
<tr>
<td>All outputs</td>
<td>&lt; 20 s</td>
<td>&lt; 5 s</td>
</tr>
</tbody>
</table>

**Monitoring of the incremental signals**
The following sensitivity levels are recommended for monitoring the signal amplitude M:
- Lower threshold: 0.30 V_{PP}
- Upper threshold: 1.35 V_{PP}

The amplitude of the incremental signals can be monitored based on the resulting length of the position indicator, for example. The oscilloscope shows the output signals A and B as a Lissajous figure in the XY graph. Ideal sinusoidal signals produce a circle with a diameter M. In this case, the position indicator r (shown) is equivalent to \( \frac{1}{2}M \). The following formula applies:

\[
r = \sqrt{A^2 + B^2}
\]

where \(0.3 \text{ V} < 2r < 1.35 \text{ V}\).

**Input circuit of the subsequent electronics**

**Dimensioning**
Operational amplifier (e.g., MC 34074)
- \( Z_0 = 120 \text{ } \Omega \)
- \( R_1 = 10 \text{ } k\Omega \) and \( C_1 = 100 \text{ } \text{pF} \)
- \( R_2 = 34.8 \text{ } k\Omega \) and \( C_2 = 10 \text{ } \text{pF} \)
- \( U_B = \pm 15 \text{ V} \)
- \( U_1 \approx U_0 \)

-3 dB cutoff frequency of the circuit
\approx 450 \text{ } \text{kHz}
\approx 50 \text{ } \text{kHz} \text{ with } C_1 = 1000 \text{ } \text{pF} \text{ and } C_2 = 82 \text{ } \text{pF}

The circuit variant for 50 kHz does reduce the bandwidth of the circuit but also improves its immunity to interference.

**Output signals of the circuit**
\( U_a = \text{typ. } 3.48 \text{ } V_{PP} \)
Gain: 3.48-fold
Input circuit of the subsequent electronics for high signal frequencies

For high-accuracy encoders with a high signal frequency, a special input circuit is necessary.

-3 dB cutoff frequency of the circuit

Various circuit variants are possible for the input circuit, thereby allowing various cutoff frequencies to be implemented. Depending on the application and the encoder being used, the receiver circuit may need to be adapted in order to achieve maximum performance from the overall system.

Output signals of the circuit

The input circuit has been optimized for a downstream A/D converter with an input range of 2 VPP. This yields a signal gain factor of 1.21, resulting in an output voltage $U_a = 1.21 V_{PP}$ for the A and B signals. The signal gain factor for the R signal is 0.58.

<table>
<thead>
<tr>
<th>Cutoff frequency -3 dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 kHz</td>
</tr>
<tr>
<td><strong>Signal</strong></td>
</tr>
<tr>
<td>$U_a$</td>
</tr>
<tr>
<td>$U_p$</td>
</tr>
<tr>
<td>$U_n$</td>
</tr>
<tr>
<td>$Z_0^*$</td>
</tr>
<tr>
<td>$R_0^*$</td>
</tr>
<tr>
<td>$R_1$</td>
</tr>
<tr>
<td>$R_2$</td>
</tr>
<tr>
<td>$R_3$</td>
</tr>
<tr>
<td>$C_0$</td>
</tr>
<tr>
<td>$C_1$</td>
</tr>
<tr>
<td>OP1</td>
</tr>
</tbody>
</table>

* The resulting effective terminating resistance of the circuit is ~120 Ω for A, B, and R
HEIDENHAIN encoders with the \(11 \, \mu\text{A}_{\text{PP}}\) interface provide current signals. These encoders are intended for connection to ND position display units or EXE pulse-shaping electronics from HEIDENHAIN.

The sinusoidal incremental signals \(I_1\) and \(I_2\) are phase-shifted by 90° elec. and typically have a signal level of 11 \(\mu\text{A}_{\text{PP}}\). The illustrated sequence of output signals—with \(I_2\) lagging \(I_1\)—applies to the direction of motion indicated in the dimension drawing (or to plunger retraction in the case of length gauges).

The reference mark signal \(I_0\) has a usable component \(G\) of approx. 5.5 \(\mu\text{A}\).

The signal amplitude is valid when the supply voltage stated in the specifications is applied at the encoder. It is based on a differential measurement between the associated outputs. The signal amplitude decreases when the frequency increases.

The cutoff frequency is the frequency up to which a certain percentage of the original signal amplitude is maintained:

- 3 dB cutoff frequency: 70% of the signal amplitude
- 6 dB cutoff frequency: 50% of the signal amplitude

Interpolation/resolution/measuring step

The output signals of the 11 \(\mu\text{A}_{\text{PP}}\) interface are usually interpolated in the subsequent electronics (ND position displays or EXE pulse-shaping electronics from HEIDENHAIN) in order to attain sufficiently high resolutions.
HEIDENHAIN encoders with the TTL interface contain electronics that digitalize sinusoidal scanning signals either with or without interpolation.

The incremental signals are output as the square-wave pulse trains $U_{a1}$ and $U_{a2}$, phase-shifted by 90° elec. The reference mark signal consists of one or more reference pulses $U_{a0}$, which are gated with the incremental signals. In addition, the integrated electronics generate the inverted signals $U_{\bar{a}1}$, $U_{\bar{a}2}$, and $U_{\bar{a}0}$ for noise-immune transmission. The illustrated sequence of output signals—with $U_{a2}$ lagging $U_{a1}$—applies to the direction of motion shown in the dimension drawing.

The fault-detection signal $U_{aS}$ indicates malfunctions such as breakage of the power lines or failure of the light source. In automated manufacturing, for example, it can be used for machine switch-off.

The distance between two successive edges of the incremental signals $U_{a1}$ and $U_{a2}$ through 1-fold, 2-fold, or 4-fold evaluation is one measuring step.

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum edge separation $a$ stated in the specifications is valid for the input circuit shown in conjunction with a cable length of 1 m, and is based on a measurement at the output of the differential line receiver.

### Interface

<table>
<thead>
<tr>
<th>Incremental signals</th>
<th>TTL square-wave signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two TTL square-wave signals $U_{a1}$, $U_{a2}$, and their inverted signals $U_{\bar{a}1}$, $U_{\bar{a}2}$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reference mark signal</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse width</td>
<td></td>
</tr>
<tr>
<td>Delay time</td>
<td></td>
</tr>
<tr>
<td>One or more TTL square-wave pulses $U_{a0}$ and their inverted pulses $U_{\bar{a}0}$</td>
<td></td>
</tr>
<tr>
<td>90° elec. (other widths upon request)</td>
<td></td>
</tr>
<tr>
<td>$</td>
<td>t_d</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fault-detection signal</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse width</td>
<td></td>
</tr>
<tr>
<td>One TTL square-wave pulse $U_{aS}$</td>
<td></td>
</tr>
<tr>
<td>Fault detection: LOW (upon request: high-impedance $U_{a1}/U_{a2}$)</td>
<td></td>
</tr>
<tr>
<td>Proper functioning: HIGH</td>
<td></td>
</tr>
<tr>
<td>$t_S \geq 20$ ms</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signal amplitude</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Differential line driver as per EIA standard RS-422</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Permissible load</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z_0 \geq 100$Ω</td>
<td>Between associated outputs</td>
</tr>
<tr>
<td>$I_L \leq 20$mA</td>
<td>Max. load per output</td>
</tr>
<tr>
<td>$C_{load} \leq 1000$ pF</td>
<td>To 0 V</td>
</tr>
<tr>
<td>Outputs are protected against a short to 0 V</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Switching times</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(10% to 90%)</td>
<td></td>
</tr>
<tr>
<td>$t_{on} = 30$ ns (typ. 10 ns)</td>
<td></td>
</tr>
<tr>
<td>with 1 m cable and specified input circuit</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Connecting cable</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HEIDENHAIN shielded cables;</td>
<td></td>
</tr>
<tr>
<td>e.g., PUR [4(2 × 0.14 mm²) + 4(0.5 mm²)]</td>
<td></td>
</tr>
<tr>
<td>Max. 100 m ($U_{aS}$ max. 50 m)</td>
<td></td>
</tr>
<tr>
<td>Typ. 6 ns/m</td>
<td></td>
</tr>
</tbody>
</table>

---

**Note:**

Not all encoders output a reference-mark signal, fault-detection signal, and inverted signals. Please see the pin layout for this.

---

![Diagram](image.png)

The inverted signals $U_{\bar{a}1}$, $U_{\bar{a}0}$, and $U_{\bar{a}2}$ are not shown.
Clocked output signals are typical of encoders and interpolation electronics with 5-fold interpolation (or higher). The edge separation \( a \) of these signals is derived from an internal clock source. At the same time, the clock frequency determines the permissible input frequency of the incremental signals (1 Vpp or 11 µAPP) and thus the resulting maximum permissible shaft speed or traversing speed:

\[
a_{\text{nom}} = \frac{1}{4 \cdot \text{IPF} \cdot f_{\text{enom}}}
\]

- \( a_{\text{nom}} \) : Nominal edge separation
- \( \text{IPF} \) : Interpolation factor
- \( f_{\text{enom}} \) : Nominal input frequency

The tolerances of the internal clock source have an influence on the edge separation \( a \) of the output signal and the input frequency \( f_e \), thereby influencing the traversing speed or shaft speed.

For the stated edge separation, these tolerances are already taken into account at 5 %; in each case, it is not the nominal edge separation that is stated, but rather the minimum edge separation \( a_{\text{min}} \).

For the maximum permissible input frequency, however, a tolerance of at least 5 % must be taken into account. This means that the maximum permissible traversing speed or shaft speed is also reduced accordingly.

As a rule, encoders and interpolation electronics without interpolation have unlocked output signals. The minimum edge separation \( a_{\text{min}} \) at the maximum permissible input frequency is stated in the specifications. If the input frequency is reduced, then the edge separation correspondingly increases.

Cable-dependent differences in the propagation time additionally reduce the edge separation by 0.2 ns per meter of cable. In order to avoid counting errors, a safety margin of 10 % must be taken into account. The subsequent electronics must also be designed to process 90 % of the resulting edge separation.

Please note:
The maximum permissible shaft speed or traversing speed must not be exceeded—even temporarily—because this will cause irreversible counting errors.

---

### Example calculation 1

**LIDA 400 linear encoder**

Requirements: display step: 0.5 µm; traversing speed: 1 m/s; output signals: TTL; cable length to subsequent electronics: 25 m.

What is the minimum edge separation that the subsequent electronics must be able to process?

- **Selection of the interpolation factor**
  
  \[ \text{IPF} = 10 \text{-fold} \]

- **Evaluation in the subsequent electronics**
  
  \[ f_{\text{enom}} = 4 \text{-fold} \]

- **Interpolation**
  
  \[ f_{\text{enom}} = 40 \text{-fold subdivision} \]

**Selection of the edge separation**

- **Traversing speed**
  
  \[ 60 \text{ m/min (equivalent to 1 m/s)} \]

- **Tolerance value**: 5 %
  
  \[ 63 \text{ m/min} \]

**Select in the specifications**

- **Next LIDA 400 version**
  
  \[ 120 \text{ m/min (from the specifications)} \]

**Minimum edge separation**

\[ 0.22 \mu\text{s} \] (from the specifications)

**Determining the edge separation that the subsequent electronics must process**

\[ \text{Permissible edge separation of the subsequent electronics} = 0.5 \mu\text{s} \] (input frequency: 2 MHz).

**What shaft speed is possible?**

- **Selecting the input frequency**
  
  With the IBV 102, the input frequencies and thus the edge separation \( a \) are adjustable as per the Production Information document.

- **Next suitable edge separation**
  
  \[ 0.585 \mu\text{s} \]

**Calculating the permissible shaft speed**

- **Input frequency at 100-fold interpolation**
  
  \[ 4 \text{ kHz} \]

- **Tolerance value**: 5 %
  
  \[ 3.8 \text{ kHz} \]

- **With the 32 768 lines of the ERA 4000, the following applies:**

  **Maximum permissible shaft speed**

  \[ 6.95 \text{ rpm} \]
The permissible cable length for transmission of the TTL square-wave signals to the subsequent electronics is dependent on the edge separation $a$. The maximum cable length is 100 m, or 50 m for the fault detection signal. The required supply voltage must be applied at the encoder (see the specifications). Over the sense lines, the voltage at the encoder can be monitored and adjusted as needed by a suitable regulating device (remote sense power supply).

Greater cable lengths can be provided upon consultation with HEIDENHAIN.

### Input circuit of the subsequent electronics

**Dimensioning**

IC$_1$ = Recommended differential line receiver:
- DS 26 C 32 AT
- Only for $a > 0.1$ µs:
  - AM 26 LS 32
  - MC 3486
  - SN 75 ALS 193

$R_1 = 4.7$ kΩ
$R_2 = 1.8$ kΩ
$Z_0 = 120$ Ω
$C_1 = 220$ pF (serves to improve noise immunity)
The current consumption of encoders with HTL output signals is dependent on the output frequency and the cable length to the subsequent electronics.
Input circuit of the subsequent electronics
HTL

Incremental signals
Reference mark signal
Fault-detection signal

Encoder

Subsequent electronics

HTLs
The block commutation signals U, V, and W are obtained from three separate tracks. They are transmitted as square-wave signals in TTL levels.

### Commutation signals
(values in mechanical degrees)

#### Interface
TTL square-wave signals

#### Commutation signals
- **Width**
- **Signal level**

#### Incremental signals
See Incremental signals TTL

#### Connecting cable
- **Cable length**: Max. 100 m
- **Propagation time**: 6 ns/m

#### HEIDENHAIN shielded cables; e.g., PUR [6(2 x 0.14 mm²) + (4 x 0.5 mm²)]

### Diagrams
- **C01 U_a0**:
  - U, V, W
  - Yₛ = 30° ± 2° (n = 1–6)
  - 180° (≡ T)
  - 2x T = 360°

- **C02 U_a0**:
  - U, V, W
  - Y₄ = 20° ± 2° (n = 1–6)
  - 120° (≡ T)
  - 3x T = 360°

- **C03 U_a0**:
  - U, V, W
  - Y₄ = 15° ± 2° (n = 1–6)
  - 90° (≡ T)
  - 4x T = 360°
The **commutation signals C and D** are obtained from the Z1 track and are equivalent to one sine or cosine period per revolution. They have a signal amplitude of typically $1 \text{ V}_{\text{PP}}$ at $1 \text{k}\Omega$.

The input circuit of the subsequent electronics is the same as that of the $\sim 1 \text{ V}_{\text{PP}}$ interface. However, the required terminating impedance $Z_0$ is $1 \text{k}\Omega$ instead of $120 \Omega$.

### Commutation signals

<table>
<thead>
<tr>
<th>Interface</th>
<th>$\sim 1 \text{ V}_{\text{PP}}$ sinusoidal voltage signals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commutation signals</strong></td>
<td>Two nearly sinusoidal signals C and D</td>
</tr>
<tr>
<td>For signal levels, see Incremental signals $\sim 1 \text{ V}_{\text{PP}}$</td>
<td></td>
</tr>
<tr>
<td><strong>Incremental signals</strong></td>
<td>See Incremental signals $\sim 1 \text{ V}_{\text{PP}}$</td>
</tr>
<tr>
<td><strong>Connecting cable</strong></td>
<td>HEIDENHAIN shielded cables; e.g., PUR $(4(2 \times 0.14 \text{ mm}^2) + (4 \times 0.14 \text{ mm}^2) + (4 \times 0.5 \text{ mm}^2))$</td>
</tr>
<tr>
<td>Cable length</td>
<td>Max. 150 m</td>
</tr>
<tr>
<td>Propagation time</td>
<td>6 ns/m</td>
</tr>
</tbody>
</table>

### Electronic commutation with Z1 track

- **One revolution**
- **Z1 track**
- **Incremental signals**
- **Reference mark signal**
- **Absolute position value**
  - **Coarse commutation**
  - **Exact commutation**
- **Analog switch**
- **A/D converter**
- **EEPROM and counter**
- **Multiplexer**
- **Subdivision electronics**
- **Output of position value**
Other signals
Limit switches

Encoders with limit switches, such as the LIDA 400, are equipped with two limit switches that permit limit-position detection or the creation of a homing track. The limit switches are activated by differing adhesive magnets, thereby permitting precise switching of the right or left limit switches. The magnets can be configured in series for the creation of homing tracks.

The signals from the limit switches are output over separate lines and are thus directly available.

<table>
<thead>
<tr>
<th>LIDA 4xx</th>
<th>Output signals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH/LOW level for each TTL square-wave pulse for limit switches L1 and L2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIDA 4xx</th>
<th>Signal amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Collector stage with load resistance of 10 kΩ against 5 V</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIDA 4xx</th>
<th>Permissible load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I_{L \downarrow} ≤ 4 mA</td>
</tr>
<tr>
<td></td>
<td>I_{L \uparrow} ≤ 4 mA</td>
</tr>
</tbody>
</table>

| Switching | Rise time |
|          | (10 % to 90 %) |
|          | t_{+} ≤ 10 µs |
|          | t_{-} ≤ 3 µs |

<table>
<thead>
<tr>
<th>Permissible cable length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. 20 m</td>
</tr>
</tbody>
</table>

---

**Input circuit of the subsequent electronics**

**Dimensioning**

IC₃ (e.g., 74AC14)

R₃ = 1.5 kΩ
Position detection

In addition to having an incremental graduation, encoders with position detection, such as the LIF 4x1/LIP 60x1, feature a homing track and limit switches for limit position detection.

The signals are output in TTL levels over the separate lines H and L, and are therefore directly available.

With the LIP 60x1, fine adjustment of the limit/homing position can also be performed with the PWM 21.

LIF 4x1/LIP 60x1

<table>
<thead>
<tr>
<th>Output signals</th>
<th>One TTL pulse each for homing track H and limit switch L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal amplitude</td>
<td>TTL</td>
</tr>
<tr>
<td></td>
<td>$U_H \geq 3.8, \text{V}$ at $-I_H = 8, \text{mA}$</td>
</tr>
<tr>
<td></td>
<td>$U_L \leq 0.45, \text{V}$ at $I_L = 8, \text{mA}$</td>
</tr>
<tr>
<td>Permissible load</td>
<td>$R \geq 680, \Omega$</td>
</tr>
<tr>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Permissible cable length</td>
<td>Max. 10 m; for LIP 60x1 during adjustment with PWM 21: max. 3 m</td>
</tr>
</tbody>
</table>

LIP 60x1

Tolerancing ISO 8015
ISO 2768 - m H
≤ 6 mm: ±0.2 mm

= Reference mark position
= Beginning of measuring length ML
= Limit mark, adjustable
= Switch for homing track
Ho = Trigger point for homing
LIF 4x1

mm

Tolerancing ISO 8015
ISO 2768 - m H
≤ 6 mm: ±0.2 mm

⊙ = Reference mark position
Ⓢ = Beginning of measuring length ML
ⓡ = Limit mark, adjustable
Ⓗ = Switch for homing track
Ho = Trigger point for homing

Input circuit of the subsequent electronics

Dimensioning
IC3 (e.g., 74AC14)
R3 = 4.7 kΩ

Limit switches
Homing track
LIF 400

Var. 01 X₁ = 2 mm
Var. 02 X₂ = 14 mm
Var. 03 X₃ = 22 mm
Interface electronics from HEIDENHAIN adapt the encoder signals to the interface of the subsequent electronics. They are used when the subsequent electronics cannot directly process the output signals from HEIDENHAIN encoders or when additional interpolation of the signals is necessary.

**Input signals of the interface electronics**

HEIDENHAIN interface electronics can be connected to encoders with 1 Vpp sinusoidal signals (voltage signals) or 11 µAmp sinusoidal signals (current signals). Encoders with the EnDat or SSI serial interfaces can also be connected to various interface electronics.

**Output signals of the interface electronics**

The interface electronics are available with the following interfaces to the subsequent electronics:
- TTL square-wave pulse trains
- EnDat 2.2
- DRIVE-CLiQ
- Fanuc Serial Interface
- Mitsubishi high speed interface
- Yaskawa Serial Interface
- PROFIBUS

**Interpolation of the sinusoidal input signals**

The interface electronics perform signal conversion and interpolate the sinusoidal encoder signals. This permits finer measuring steps and thus higher control quality and superior positioning behavior.

**Position value generation**

Various interface electronics feature an integrated counting function. Beginning from the last set reference point, an absolute position value is generated and output to the subsequent electronics when the reference mark is traversed.
<table>
<thead>
<tr>
<th>Outputs</th>
<th>Inputs</th>
<th>Design – IP rating</th>
<th>Interpolation or subdivision</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTL</td>
<td>1</td>
<td>1 Vpp</td>
<td>1</td>
<td>Box design – IP65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5/10-fold</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20/25/50/100-fold</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Without interpolation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25/50/100/200/400-fold</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plug design – IP40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5/10-fold</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20/25/50/100-fold</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 µApp</td>
<td>1</td>
<td>Box design – IP65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5/10-fold</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20/25/50/100-fold</td>
</tr>
<tr>
<td>TTL/</td>
<td>2</td>
<td>1 Vpp</td>
<td>1</td>
<td>Box design – IP65</td>
</tr>
<tr>
<td>(adjustable)</td>
<td></td>
<td></td>
<td></td>
<td>2-fold</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5/10-fold</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5/10-fold and 20/25/50/100-fold</td>
</tr>
<tr>
<td>EnDat 2.2</td>
<td>1</td>
<td>1 Vpp</td>
<td>1</td>
<td>Box design – IP65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plug design – IP40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
</tr>
<tr>
<td>DRIVE-CLIQ</td>
<td>1</td>
<td>EnDat 2.2</td>
<td>1</td>
<td>Box design – IP65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cable design – IP65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Fanuc Serial Interface</td>
<td>1</td>
<td>1 Vpp</td>
<td>1</td>
<td>Box design – IP65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plug design – IP40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
</tr>
<tr>
<td>Mitsubishi high speed interface</td>
<td>1</td>
<td>1 Vpp</td>
<td>1</td>
<td>Box design – IP65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plug design – IP40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
</tr>
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<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 16384-fold subdivision</td>
</tr>
<tr>
<td>Yaskawa Serial Interface</td>
<td>1</td>
<td>EnDat 2.2</td>
<td>1</td>
<td>Plug design – IP40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>PROFIBUS DP</td>
<td>1</td>
<td>EnDat 2.2</td>
<td>1</td>
<td>Top-hat rail design</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>PROFINET IO</td>
<td>1</td>
<td>EnDat 2.2</td>
<td>1</td>
<td>Top-hat rail design</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
</tbody>
</table>

1) Switchable
HEIDENHAIN encoders provide all of the information necessary for commissioning, monitoring, and diagnostics. The type of information available depends on whether the encoder is incremental or absolute and on which interface is in use.

Incremental encoders primarily have 1 Vpp, TTL, or HTL interfaces. TTL and HTL encoders monitor their signal amplitudes internally and generate a purely digital fault detection signal. With 1 Vpp signals, an analysis of the output signals is possible only with external testing devices or through the use of computation resources in the subsequent electronics (analog diagnostic interface).

Absolute encoders employ serial data transmission. Depending on the interface, additional 1 Vpp incremental signals can be output. The signals are comprehensively monitored within the encoder. The result from monitoring (particularly in the case of valuation numbers) can be transmitted to the subsequent electronics along with the position values via the serial interface (digital diagnostics interface). The following information is available:

- Error message: position value is not reliable
- Warning: an internal functional limit of the encoder has been reached
- Valuation numbers:
  - Detailed information about the encoder’s functional reserve
  - Identical scaling for all HEIDENHAIN encoders
  - Cyclic reading is possible

The subsequent electronics are able to evaluate the current status of the encoder with little resource expenditure, including in closed-loop operation.

For the analysis of these encoders, HEIDENHAIN offers the suitable PWM inspection devices and PWT testing devices. Depending on how these devices are integrated, a distinction is made between two types of diagnostics:

- Encoder diagnostics: The encoder is connected directly to the testing or inspection device, thereby enabling a detailed analysis of the encoder functions.
- Monitoring mode: The PWM inspection device is inserted into the closed control loop (via suitable testing adapters if needed). This enables real-time diagnosis of the machine or equipment during operation. The available functions depend on the interface.
<table>
<thead>
<tr>
<th>Interface</th>
<th>Output signals</th>
<th>PWM 21 Encoder diagnostics</th>
<th>Monitoring mode</th>
<th>PWT 101 Encoder diagnostics</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnDat 2.1</td>
<td>Position value</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Incremental signals</td>
<td>Yes</td>
<td>Yes 1)</td>
<td>Yes</td>
</tr>
<tr>
<td>EnDat 2.2</td>
<td>Position value</td>
<td>Yes</td>
<td>Yes 1)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Valuation numbers</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>DRIVE-CLiQ</td>
<td>Position value</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Valuation numbers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fanuc</td>
<td>Position value</td>
<td>Yes</td>
<td>Yes 1)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Valuation numbers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>Position value</td>
<td>Yes 1)</td>
<td>Yes 1) 5)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Valuation numbers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Panasonic</td>
<td>Position value</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Valuation numbers</td>
<td>Yes</td>
<td>Yes 1)</td>
<td>Yes</td>
</tr>
<tr>
<td>Yaskawa</td>
<td>Position value</td>
<td>Yes 1)</td>
<td>Yes 1)</td>
<td>Yes 8)</td>
</tr>
<tr>
<td></td>
<td>Valuation numbers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SSI</td>
<td>Position value</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Incremental signals</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1 VPP</td>
<td>Incremental signals</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>11 µApp</td>
<td>Incremental signals</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>TTL</td>
<td>Incremental signals</td>
<td>Yes 4)</td>
<td>Yes</td>
<td>Yes 4)</td>
</tr>
<tr>
<td></td>
<td>Scanning signals</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>HTL</td>
<td>Incremental signals</td>
<td>Yes 2)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Commutation</td>
<td>Block commutation</td>
<td>Yes 2)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Sinusoidal commutation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1) Information must be requested and transferred by the control
2) Via appropriate signal adapter
3) Only for encoders with block commutation (see encoder documentation)
4) If supported by the encoder (PWT function)
5) Not usable for encoders with the Mitsu01 ordering designation
6) Not available for EIB 3391Y
7) Function not available yet
8) Two-pair transmission is required (for more information, see the documentation for the PWT 100/PWT 101)
PWT 101
The PWT 101 is a testing device for the functional testing and adjustment of incremental and absolute HEIDENHAIN encoders. Thanks to its compact dimensions and rugged design, the PWT 101 is ideal for portable use.

**Encoder input**
- EnDat
- Fanuc Serial Interface
- Mitsubishi high speed interface
- Panasonic Serial Interface
- Yaskawa Serial Interface
- 1 Vpp
- 11 µAPP
- TTL

**Display**
- 4.3-inch color flat-panel display (touchscreen)

**Supply voltage**
- DC 24 V
- Power consumption: max. 15 W

**Operating temperature**
- 0 °C to 40 °C

**Protection class**
- EN 60529 IP20

**Dimensions**
- Approx. 145 mm x 85 mm x 35 mm
The PWM 21 phase-angle measuring unit, together with the ATS adjusting and testing software, serves as an adjusting and testing package for the diagnosis and adjustment of HEIDENHAIN encoders.

For more information, please refer to the PWM 21/ATS Software Product Information document.

**PWM 21**

| Encoder input       | • EnDat 2.1 or EnDat 2.2 (absolute value with or without incremental signals)  
|                     | • DRIVE-CLiQ  
|                     | • Fanuc Serial Interface  
|                     | • Mitsubishi high speed interface  
|                     | • Yaskawa Serial Interface  
|                     | • Panasonic serial interface  
|                     | • SSI  
|                     | • 1 Vpp/TTL/11 µAPP  
|                     | • HTL (via signal adapter)  |
| Interface           | USB 2.0  
| Supply voltage      | AC 100 V to 240 V or DC 24 V  
| Dimensions          | 258 mm × 154 mm × 55 mm  

**ATS**

| Languages           | Choice between German and English  
| Functions           | • Position display  
|                     | • Connection dialog  
|                     | • Diagnostics  
|                     | • Mounting wizard for EB/ECI/EOI, LIP 200, LIC 4000, and others  
|                     | • Additional functions (if supported by the encoder)  
|                     | • Memory contents  
| System requirements | PC (dual-core processor > 2 GHz)  
| and recommendations | RAM > 2 GB  
|                      | Operating systems: Windows 7, 8, and 10 (32-bit/64-bit)  
|                      | 500 MB of free hard drive space  

DRIVE-CLiQ is a registered trademark of Siemens AG.
General electrical information

Scope
The general electrical information applies to encoders from HEIDENHAIN as well as to cables. Any supplementary information is provided in the specifications.

Supply voltage
Connect HEIDENHAIN encoders only to subsequent electronics whose supply voltage comes from PELV systems (for a definition, see EN 50178).

HEIDENHAIN encoders meet the requirements of the IEC 61010-1 standard if power is supplied from a secondary circuit with limited energy as per IEC 61010-1, Section 9.4, or with limited power as per IEC 60950, Section 2.5, or from a Class 2 secondary circuit as per UL1310.

A stabilized DC voltage \( U_P \) is required for powering the encoders. Information on voltage and current consumption or power consumption can be obtained from the respective specifications. Regarding the ripple voltage of the DC power, the following parameters apply:

- High-frequency interference
  \[ U_{PP} < 250 \text{ mV with } \frac{dU}{dt} > 5 \text{ V/µs} \]
- Low-frequency fundamental ripple
  \[ U_{PP} < 100 \text{ mV} \]

However, the limits of the supply voltage must not be violated by the ripple content.

The required supply voltage depends on the encoder interface. A distinction is made between encoders without an extended supply voltage range (e.g., DC 5.0 V ±0.25 V) and those with an extended supply voltage range (e.g., DC 3.6 V to 14 V).

Encoders with extended supply voltage range
For encoders with an extended supply voltage range, the relationship between the current consumption and the supply voltage is non-linear. However, the power consumption of the encoder exhibits a nearly linear curve (see Power consumption and current consumption graph).

For this reason, the specifications provide the maximum power consumption at the minimum and maximum supply voltage. The maximum power consumption takes the following factors into account:

- The recommended receiver circuit
- A cable length of 1 m
- The effects of aging and temperature
- Proper use of the encoder with respect to the clock frequency and cycle time

For the sake of comparison and for inspection purposes, the typical current consumption and power consumption at typical ambient and operating conditions without load (only supply voltage connected) are specified for the typical supply voltage or rated voltage.

This information is non-binding and subject to change without notice. For dimensioning of the power supply, the maximum power consumption is to be used.

---

1) In place of IEC 61010-1, Section 9.4, the corresponding sections of the following standards can be used: DIN EN 61010-1, EN 61010-1, UL 61010-1, and CAN/CSA-C22.2 No. 61010-1. In place of IEC 60950-1, Section 2.5, the corresponding sections of the following standards can be used: DIN EN 60950-1, EN 60950-1, UL 60950-1, and CAN/CSA-C22.2 No. 60950-1.
The voltage values must be maintained at the encoder. The voltage applied at the encoder can be monitored and regulated over the sense lines, if available. If no variable power pack is available, then the sense lines should be switched in parallel with the respective supply lines in order to reduce the voltage drop (see Cable lengths in the Cables and Connectors brochure).

Switch-on/off behavior of the encoders
Valid output signals are available after the switch-on time $t_{SOT}$. During the time $t_{SOT}$, the output signals reach the maximum voltage values stated in the table. The duration of switch-on time $t_{SOT}$ depends on the interface.

<table>
<thead>
<tr>
<th>Interface</th>
<th>Switch-on time</th>
<th>Maximum voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Vpp</td>
<td>1.3 s</td>
<td>5.5 V</td>
</tr>
<tr>
<td>11 µApp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HTL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EnDat</td>
<td></td>
<td>5.5 V</td>
</tr>
<tr>
<td>SSI</td>
<td></td>
<td>$U_{P\text{max}}$</td>
</tr>
<tr>
<td>PROFIBUS DP</td>
<td>2 s</td>
<td>5.5 V</td>
</tr>
<tr>
<td>PROFINET</td>
<td>10 s</td>
<td>$U_{P\text{max}}$</td>
</tr>
</tbody>
</table>

If the power supply is switched off, or if the supply voltage falls below $U_{\text{min}}$, then the output signals are invalid as well. Furthermore, the interface-specific switch-on/off characteristics must be taken into account. If the encoder is operated via interposed interface electronics, then the switch-on/off behavior of the interface electronics must be considered as well.

Other proprietary interfaces supported by HEIDENHAIN are not dealt with here.

Design information regarding the power pack of the subsequent electronics

Selection of the power supply of the subsequent electronics
Select a power supply that is as close as possible to the upper tolerance limit. Consider the voltage drop $\Delta U$ resulting from the cable length. The power supply should lie within the upper tolerance range, particularly in the case of encoders with a supply voltage of DC 5 V ±0.25 V and DC 5 V ±0.5 V. For encoders with a supply voltage of DC 3.6 V to 14 V and functional safety, a supply voltage of DC 12 V is recommended.

Power output of the subsequent electronics
For encoders with an extended supply voltage range, the maximum power consumption stated in the specifications must be taken into account. Particularly in the case of encoders with a supply voltage of DC 5 V, be sure to note that the power for the current consumption is indicated without load. Therefore, keep in mind that the current consumption values will be higher depending on the design of the receiver circuit. The voltage drops in the adapter cables and connecting cables must be taken into account as well (for the calculations, see Power supply in the Cables and Connectors brochure).

Maximum current consumption at the moment of switch-on
The increased current consumption must be considered for the dimensioning of the power pack. HEIDENHAIN therefore recommends that the power pack be equipped with a current limit. The recommended value for the limit is 400 mA, but at least 1.2 times the value of the maximum current consumption of the encoder in steady state.

When dimensioning the current monitor with switch-off (especially trigger threshold and trigger speed), ensure that the increased current consumption can be tolerated at the moment of switch-on.
Scope

For HEIDENHAIN encoders with a proprietary interface, the general electrical information is applicable along with the sections below. For supplementary information, see the specifications.

Encoders with the DRIVE-CLiQ interface

Power supply

Encoders with the DRIVE-CLiQ interface are designed for a rated voltage of DC 24 V. The manufacturer of the subsequent electronics specifies DC 20.4 V to 28.8 V as the tolerance for the supply voltage.

HEIDENHAIN encoders with the DRIVE-CLiQ interface permit a larger voltage range (see the specifications). Operation at up to DC 36.0 V is briefly permissible. In the range of DC 28.8 V to 36.0 V, higher power consumption is to be expected.

Switch-on/off behavior

HEIDENHAIN encoders with the DRIVE-CLiQ interface are designed for the switch-on/switch-off behavior shown to the right.

- Operation
- Switch-off
- Off
- Switch-on
- Start-up
- Ready for operation

36 V (without limiting functional safety) Typically 15 s
28.8 V
Up min.

Depiction of the switch-on and switch-off conditions

Electrically permissible shaft speed or traversing speed

The maximum permissible shaft speed or traversing speed of an encoder is derived from:
- the mechanically permissible shaft speed or traversing speed and
- the electrically permissible shaft speed or traversing speed.

In the case of incremental encoders with sinusoidal output signals, the electrically permissible shaft speed or traversing speed is limited by the –3dB/–6dB cutoff frequency or the permissible input frequency of the subsequent electronics.

For incremental encoders with square-wave signals, the electrically permissible shaft speed or traversing speed is limited by:
- the maximum permissible scanning/output frequency \( f_{\text{max}} \) of the encoder and
- the minimum permissible edge separation \( a \) for the subsequent electronics.

For angle or rotary encoders

\[
\eta_{\text{max}} = \frac{f_{\text{max}}}{z} \cdot 60 \cdot 10^3
\]

For linear encoders

\[
v_{\text{max}} = f_{\text{max}} \cdot SP \cdot 60 \cdot 10^{-3}
\]

Where:
- \( \eta_{\text{max}} \) Electrically permissible speed in rpm
- \( v_{\text{max}} \) Electrically permissible traversing speed in m/min
- \( f_{\text{max}} \) Maximum scanning/output frequency of the encoder or input frequency of the subsequent electronics in kHz
- \( z \) Signal periods of the angle encoder or rotary encoder per 360°
- \( SP \) Signal period of the linear encoder in µm
Electrical safety
HEIDENHAIN encoders must be powered through PELV systems (for a definition, see EN 50178). The housings of HEIDENHAIN encoders are insulated from internal circuits. The impulse withstand voltage of the insulation is 500 V in accordance with EN 60664-1. In addition, contamination level 2 must be complied with in the micro-environment (see EN 60664-1).

Electromagnetic compatibility
Sources of electrical interference
Electrical interference is primarily caused by capacitive or inductive couplings. Interference can arise over wires and at input and output terminals on devices.
Typical sources of electrical interference include the following:
• Strong magnetic fields from transformers, brakes, and electric motors
• Relays, contactors, and solenoid valves
• High-frequency equipment, pulse devices, and stray magnetic fields from switching power supplies
• Power cables and supply lines to the encoders

Noise immunity (EN 61000-6-2)
Specifically, the following standards:
- ESD EN 61000-4-2
- Electromagnetic fields EN 61000-4-3
- Burst EN 61000-4-4
- Surge EN 61000-4-5
- Conducted disturbances EN 61000-4-6
- Power frequency magnetic fields EN 61000-4-8
- Voltage dips, short interruptions EN 61000-4-11

Noise emission (EN 61000-6-4)

Measures
The EMC Directive requires the attainment of interference-free operation without the need for EMC expertise. The following measures serve to ensure this level of interference-free operation (please consult with HEIDENHAIN as needed):

- Properly install or mount HEIDENHAIN encoders in accordance with the mounting instructions
- Use only original HEIDENHAIN cables. Comply with the maximum permissible cable lengths for the respective interface. For usage that deviates from standard usage (assignment of signals and connectors), the manufacturer of the complete system must ensure conformity
- Do not install signal cables in the direct vicinity of sources of interference (inductive consumers such as contactors, motors, frequency inverters, solenoids, etc.)
  - Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are routed in metal ducts, by a grounded partition
  - A minimum clearance of 200 mm from storage reactors in switching power supplies is required
- Prevent accidental contact between the shield (e.g., connector) and other metal parts
- For cables with an internal shield and external shield, connect the internal shield to 0 V on the subsequent electronics (exception: the hybrid motor cable from HEIDENHAIN; see the documentation on the hybrid motor cable). Do not connect the internal shield with the external shield
- Use connecting elements (e.g., connectors or terminal boxes) with metal housings. These connecting elements may be used only for the signals and supply voltage of the connected encoder (exception: the hybrid motor cable from HEIDENHAIN)
- Connect the encoder housing, connecting elements, and subsequent electronics with each other by means of the cable shield. Connect the shield over a large area around the complete circumference (360°). For encoders with more than one electrical connection, refer to the documentation of the respective product
- Install encoders and interface electronics with exposed electronics or a plastic housing in an enclosed metal housing. If other signals and sources of interference will pass through the housing, then EMC expertise is required, and the manufacturer of the complete system must ensure conformity
- Connect the (external) shield with functional earth in accordance with the mounting instructions
- For devices and cable assemblies with plastic connectors or connectors without a large-area shield connection, connect the (external) shield with functional earth over a large area just a short distance before the connector (shield clamp; see figure). There must be no source of interference in the immediate vicinity
- For encoders that optionally enable the connection of an external sensor (e.g., a temperature sensor), conformity with the EMC Directive applies only to operation without an external sensor. For operation with an external sensor (e.g., temperature sensor), EMC expertise is required for interference-free operation, and the manufacturer of the complete system must ensure conformity
  - In most applications, interference-free operation is possible because the disturbances acting on the sensor are low
  - In addition, the requirements for the electrical isolation of the sensor must be considered, because electrical hazards can arise in such systems
- If compensating currents are to be expected within the complete system, then a separate equipotential bonding conductor must be provided. The shield is not meant to serve as an equipotential bonding conductor
- For HEIDENHAIN encoders, provide high-frequency, low-resistance grounding (see the EMC chapter in EN 60204-01)
Related documents

Length measurement

Brochure
*Linear Encoders*
*For Numerically Controlled Machine Tools*

Contents:
- Absolute linear encoders
  - LC
- Incremental linear encoders
  - LB, LF, LS

Brochure
*Exposed Linear Encoders*

Contents:
- Absolute linear encoders
  - LIC
- Incremental linear encoders
  - LIP, PP, LIF, LIDA

Brochure
*Length Gauges*

Contents:
- HEIDENHAIN-ACANTO
- HEIDENHAIN-SPECTO
- HEIDENHAIN-METRO
- HEIDENHAIN-CERTO

Angle measurement

Brochure
*Rotary Encoders*

Contents:
- Absolute rotary encoders
  - ECN, EQN, ROC, ROQ
- Incremental rotary encoders
  - ERN, ROD

Brochure
*Encoders for Servo Drives*

Contents:
- Rotary encoders
- Angle encoders
- Linear encoders

Brochure
*Angle Encoders with Integral Bearing*

Contents:
- Absolute angle encoders
  - RCN, ECN
- Incremental angle encoders
  - RON, RPN, ROD

Brochure
*Modular Angle Encoders*
*With Optical Scanning*

Contents:
- Incremental angle encoders
  - ERP, ERO, ERA

Brochure
*Angle Encoder Modules*

Contents:
- Angle Encoder Modules
  - MRP 2000/MRP 5000/MRP 8000
- Angle encoder modules
  - with integrated torque motor
  - SRP 5000, AccurET
Measured value acquisition and display

Brochure
*Evaluation Electronics*
For Metrology Applications

Contents:
ND, QUADRA-CHEK, MSE, EIB, IK

Brochure
*Digital Readouts/Linear Encoders*
For Manually Operated Machine Tools

Contents:
Digital readouts
ND, POSITIP
Linear encoders
LS

Setup and measurement

Brochure
*Measuring Devices For Machine Tool Inspection and Acceptance Testing*

Contents:
Incremental linear encoders
KGM, VM

Connecting encoders and touch probes

Brochure
*Cables and Connectors*

Contents:
Technical characteristics, cable overviews, and cable lists