Interfaces of HEIDENHAIN Encoders
Interfaces

As the defined link between encoders and downstream electronics, interfaces ensure the reliable exchange of information.

HEIDENHAIN offers encoders with interfaces for many common downstream electronics. The specific interface that can be used depends on the encoder's method of measurement and other factors.

Methods of measurement

In the incremental measuring method, the position information is obtained by counting the individual increments (measuring steps) starting from a selected point of origin. An absolute reference point is needed for determining the position, so a reference-mark signal is output as well. Incremental encoders generally output incremental signals. Some incremental encoders with integrated signal converters have a counting function: once the reference mark is traversed, an absolute position value is generated and transmitted via a serial interface.

In 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 downstream electronics.

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

Signal converters

Signal converters from HEIDENHAIN let you flexibly adapt your encoder signal interfaces to the requirements of your application. Depending on the application, additional signals (such as temperature-sensor signals) may be processed and transmitted to the downstream electronics.

Serial data transmission

Serial interfaces

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Further information

- www.heidenhain.com/products/signal-converters
- Brochure: Cables and Connectors

Further information:
- Signal converters
- Testing and inspection devices, and diagnostics
- Measuring principles
- General electrical information
- Cable lengths

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 placed. Standards (ISO, EN, etc.) apply only where explicitly stated in the brochure.
EnDat 3 carries forward the features and benefits of EnDat into the future of digital manufacturing. To achieve this feat, EnDat 3 relies on a new architecture that builds upon proven technology, ensuring optimal continuity and compatibility with predecessor interfaces.

**EnDat 3 characteristics:**
- Hybrid cable transmission
- Bus topologies
- Sensors: versatile data contents and sensor box
- Functional safety: black-channel communication
- Higher data bandwidth
- Definable send lists
- System installation: introduction of access levels

**Ordering designations**
The ordering designation defines key communication characteristics:

- Request-response procedures in half-duplex mode
- RS-485: 4-wire or 2-wire
- 12.5 Mbit/s (25 Mbit/s)
- For 12.5 Mbit/s: max. 100 m / for 25 Mbit/s: max. 40 m
- Typically 10 µs (the parameter XEL-timeHPF.out indicates the duration between position value generation (stored via latch) and transmission of the complete HPF, without cable effects)
- Typically > 25 µs
- Daisy chain
- Designed for up to SIL 3, black-channel communication

**Functions**
- For condition monitoring and predictive maintenance
- Automated configuration and storage of operating status data
- User authentication (e.g., for datum shift, OEM memory)

**Supported communication types**
- E30-R2
- E30-R4
- E30-RI
- EnDat 3: communication modulated onto power supply wires
- EnDat 3: communication + separate power supply wires (4 wires)
- EnDat 3: bus operation
- Sensor box integration

**Foreground communication**
Foreground communication is for data that must be available in the communication cycle (e.g., controller cycle).

Requests and responses are organized into frames with a defined length. Each request and response begins with a preamble (PRE) and ends with a postamble (POST). The REQ request frame controls communication with the encoder or triggers certain actions within it (e.g., clearing of error messages), thereby determining the contents of the response. Irrespective of the REQ frame contents, the response frame is chronologically divided into high-priority data and low-priority data.

A response contains the following elements:
- One HPF (High Priority Frame)
  - The HPF typically contains the encoder position. Depending on the encoder, other information can be specified for transmission in the HPF as well.
  - One LPH (Low Priority Header)
  - The LPH carries status information about the subsequent data contents. It also contains information about the send list and the number of transmitted LPFs.

The send list specifies the chronological sequence of LPFs within the individual communication cycles.

- Up to 15 optional LPFs (Low Priority Frames)
- LPFs can carry additional data, such as diagnostic values, sensor information, or redundant information for functional safety.

**Background communication**
Some tasks, such as reading from and writing to the encoder memory, have low timing demands. For these kinds of tasks, EnDat 3 defines a background channel. 

Background communication is embedded in the foreground communication and uses its frames as transport carriers (REQ, LPH, LPT). The background channel thus makes it possible to read and write to the encoder memory in the controller cycle.

**Bus operation**
Along with point-to-point mode, EnDat 3 also offers bus operation for special applications. In bus operation, a bus Request Frame is added in front of the Request Frame, thus allowing multiple participants to send responses in a single communication cycle.

Further information:
- www.endat.de

![Diagram](image-url)
Functional safety

EnDat supports the use of encoders in safety-related applications in accordance with the following standards: DIN EN ISO 13849-1 (successor to EN 954-1), as well as EN 61508 and EN 61800-9-2. In these standards, safety-related systems are assessed based on the failure probabilities of integrated components and sub-systems, along with other criteria. This modular approach helps manufacturers implement their complete systems by allowing them to build upon previously qualified subsystems.

The functional safety provided with EnDat 3 encoders for applications up to SIL 3 is based on the following factors:

- Position value
  - Two independent position values: Pos1 (high resolution) and Pos2 (low resolution, if applicable)
  - Comparison of Pos1 and Pos2 by the safe control unit
- Forced dynamic sampling
- Cyclic testing of the monitoring function in the encoder
- Error messages
  - Monitoring of error bits F1 and F2
  - Due to the black channel, a safe EnDat master is not required and is thus not part of the safety chain
  - Separation of communication to the motion controller and safe control unit (e.g., separate error messages)

In summary: Convenient implementation is possible thanks to the black-channel approach combined with standardized position data formats and the option of moving forced dynamic sampling to the encoder.

Diagnostics

EnDat enables extensive encoder monitoring and diagnostics without an additional line. Its diagnostics generate valuation numbers, error messages, and warnings, and are a key ingredient in attaining high availability in the complete system.

The important factors:

- Machine utilization planning
- Support for the on-site service technician
- Easy evaluation of the encoder’s function reserve
- Simplified troubleshooting for repairs
- Creation of informative quality statistics

For an analysis of encoder functionality, valuation numbers can be read cyclically from the encoder. Valuation numbers provide information about the current status of the encoder and its function reserve. Their identical scaling for all HEIDENHAIN encoders enables consistent analysis. The function reserves, combined with other sensor data, serve as the basis for condition monitoring and predictive maintenance in the highlevel downstream electronics.

System information

EnDat provides information about the encoder and the system in the form of an electronic ID label:

- Encoder parameters, which are all of the parameters needed for initial encoder configuration, are stored in the encoder.
- System parameters can be stored in the encoder’s memory by the OEM or plant builder, and accessible areas can be password-protected.
- System or process status data, referred to as operating status data, can be stored in the encoder during normal operation; the encoder can even collect operating status data on its own.

Access control

Memory areas can be protected by various levels of user authentication. The available access levels are OEM1, OEM2, and User. Authentication is performed with a 32-bit password. As shipped, the encoder’s OEM1, OEM2, and User areas are vacant and protectable by separate passwords.

Singletum and multilum information can also be separately configured and protected.

Typical implementation:

- OEM1 (motor manufacturer): singletum is set, and OEM1 memory is written to. A password is defined; the OEM1 area is protected.
- OEM2 (machine manufacturer): multilum is set, and OEM2 memory is written to. A separate password is defined; the OEM2 area is protected.
- User (customer): the User memory can be written to. A separate password is defined; the User area is protected.

Encoders with the purely serial EnDat interface predominantly use 8-pin M12 and 9-pin M23 connecting elements. This widespread connector technology offers the following benefits:

- Cost-effective connection technology
- Smaller connector dimensions and thinner connecting cables

Through its larger number of wires, EnDat 3 offers further options for miniaturizing the connection technology and adapting it to the application requirements.

2-wire technology

In the 2-wire variant, the master powers the encoder with one wire pair and uses a second wire pair to communicate with the encoder.

Cables

High transmission frequencies over long cable lengths place rigorous technological demands on the cable. Specifically designed for this purpose, HEIDENHAIN cables are qualified to handle this type of application. We therefore recommend using HEIDENHAIN cables.

4-wire technology

The 4-wire variant offers the greatest flexibility. The master can supply power to the encoder and conduct communication at the same time. Communication is possible over a daisy-chain bus or point-to-point connection.

4-wire bus in daisy-chain mode

This variant allows encoders to be operated on a daisy-chain bus. Unlike the 4-wire variant, the 4-wire daisy-chain bus variant requires an additional transceiver branch inside the encoder. This additional transceiver branch establishes the data connection to the next encoder on the bus. The 4-wire daisy-chain bus variant also supports the 4-wire variant.

Sensor box

With the 4-wire variant, a sensor box can be inserted.

Power supply

The supply voltage and power consumption are stated in each encoder’s specifications. For encoders with the EnDat 3 interface, a supply voltage of 12 V (±5%) is recommended.
The EnDat interface is a digital bidirectional interface for encoders. It can output position values, read and update information stored in the encoder, and store new information in the encoder. Thanks to the interface’s serial transmission method, only four signal lines are required. The data are transmitted synchronously to the clock signal provided by the downstream electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected via mode commands sent to the encoder by the downstream 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, diagnostic data, 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 timing factors (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 encoders  
- Multiturn rotary encoders with buffer battery backup

For the various encoder types, some parameters must be interpreted differently (see the EnDat specifications). If additional data must be processed (e.g., incremental encoders or encoders with buffer battery backup), the following types are currently supported with the EnDat 2.2 interface:

- **Absolute, singleturn rotational encoders**
- **Incremental, singleturn rotational encoders**

### Ordering designations

The ordering designations define the key specifications and provide the following information:

- Typical power supply range
- Command set
- Availability of incremental signals
- Maximum clock frequency

The second position in the ordering designation identifies the interface generation. For current-generation encoders, 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 supplying data to a second downstream device. Current generation 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** With 1 Vpp incremental signals
- **EnDat1H** With HTL incremental signals
- **EnDatT** With TTL incremental signals
- **EnDat21** Without incremental signals
- **EnDat22** With 1 Vpp incremental signals
- **EnDat22** Without incremental signals

### Supply voltage

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

- **EnDat01** 5 V ±0.25 V
- **EnDat21** 5 V ±0.25 V or 14 V
- **EnDat22** 3.8 V to 5.25 V or 14 V
- **EnDatH** 10 V to 30 V
- **EnDatT** 4.75 V to 30 V

### 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 downstream electronics. The ordering designation indicates whether an encoder outputs incremental signals. 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 access in a closed control loop. When a mode command from the downstream electronics is received, the encoder must be able to respond (see note).

### Additional data

The supported command set is stored in the encoder’s memory area. The typical supply voltage of the encoders depends on the interface:

- **EnDat01** 5 V ±0.25 V
- **EnDat21** 5 V ±0.25 V or 14 V
- **EnDat22** 3.8 V to 5.25 V or 14 V
- **EnDatH** 10 V to 30 V
- **EnDatT** 4.75 V to 30 V

### Clock frequency

The clock frequency is variable between 100 kHz and 2 MHz depending on the cable length (maximum: 150 m). With propagation-time compensation in the downstream electronics, clock frequencies of up to 16 MHz or cable lengths of up to 100 m are possible. In the case of EnDat encoders with the ordering designations EnDat02 or EnDat22, the maximum clock frequency is stored in the encoder memory. For all other encoders, the maximum clock frequency is 2 MHz. Propagation-time compensation is provided only upon the ordering designations EnDat21 and EnDat22; for EnDat01, see the note below.

### 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**
  - **WIR:** warnings
  - **RM:** reference mark
  - **Busy:** parameter request
- **Additional data 1**
  - **Diagnostics**
  - **Position value 2**
  - **Memory parameters**
  - **MRS-code acknowledgment**
  - **Test values**
  - **Temperature**
  - **Additional sensors**
- **Additional data 2**
  - **Commutation**
  - **Acceleration**
  - **Limit position signals**
  - **Asynchronous position source**
  - **Operating status error sources**
  - **Timestamp**

### Additional notes:

- **Position values:**
  - The position value can be transmitted with or without additional data. At the earliest, the position value is transmitted to the downstream electronics after the calculation time $t_{cal}$ has elapsed, or after 14.5 clock pulses. 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 given 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).
**Company-specific serial interfaces**

**Memory areas**
The encoder provides multiple memory areas for parameters. These memory areas can be read by the downstream 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 for easily determining the function reserves of an encoder
- Parameters for mounting the encoder

**System information**
EnDat provides information about the encoder and the system in the form of an electronic ID label:
- Encoder parameters, which are all of the parameters needed for initial encoder configuration, are stored in the encoder.
- System parameters can be stored in the encoder’s memory by the OEM or plant builder.
- System or process status data, referred to as operating status data, can be stored in the encoder during closed loop operation.

**Basics of functional safety**
EnDat 2.2 strictly supports the use of encoders in safety-related applications. The basis for these are the standards DIN EN ISO 13849-1 (successor to EN 954-1), as well as EN 61508 and EN 61800-5-2. These standards, safety-related systems are assessed based on criteria such as the failure probabilities of integrated components and subsystems. This modular approach helps manufacturers implement their complete systems by allowing them to build upon previously qualified subsystems.

**Input circuit design of the downstream electronics**

### Dimensioning

\[ Z_0 = 120 \, \Omega \]

Further information:
FAQ: RS-485 transceiver at www.endat.de

**Data transmission**

- **Incremental signals**: Depends on the encoder (e.g., 1 Vpp)
- **Absolute position value**

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

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**Control manufacturer**

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<th>Ordering designation</th>
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<td>DRIVE-CLiQ</td>
<td>DQ01</td>
<td>S</td>
<td>Normal and high speed, two-pair transmission</td>
</tr>
<tr>
<td>Fanuc</td>
<td>Fanuc Serial Interface α</td>
<td>Fanuc α</td>
<td>Fanuc02</td>
<td>F</td>
<td>High-speed, one-pair transmission includes the α interface (normal and high speed, two-pair transmission)</td>
</tr>
<tr>
<td></td>
<td>Fanuc Serial Interface αi</td>
<td>Fanuc αi</td>
<td>Fanuc05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>Mitsubishi high speed interface</td>
<td>Mitsubishi</td>
<td>Mitsu01, Mitsu02-4, Mitsu02-2, Mitsu02-4, Mitsu02-2</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>
</tr>
<tr>
<td>Yaskawa</td>
<td>Yaskawa serial interface</td>
<td>Yaskawa</td>
<td>YEC02, YEC07</td>
<td>Y</td>
<td>Compatible with YEC02</td>
</tr>
<tr>
<td>Panasonic</td>
<td>Panasonic Serial Interface</td>
<td>Panasonic</td>
<td>Pana01, Pana02</td>
<td>F</td>
<td>Compatible with Pana01</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 in “LC 495 S.”
The PNO (PROFIBUS user organization) has defined standard, non-proprietary profiles for the connection of absolute encoders to PROFIBUS DP. 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 profiles**
The profiles can be requested from the PNO in Karlsruhe, Germany (ordering number: 3.162). These profiles likewise distinguish between two device classes:
- Class 3, with the basic functions, and
- Class 4, with the full scaling and preset functionality.

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.

Also possible are programming functions, 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>
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<th>Characteristic</th>
<th>Class</th>
<th>Rotational encoders</th>
<th>Linear encoders</th>
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<tbody>
<tr>
<td>Data word width</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>Measuring steps/rev.</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: 16 bits or 32 bits)</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Diagnostic functions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warnings and alarms</td>
<td>2</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>Data word width</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>64</td>
</tr>
<tr>
<td>Scaling function</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
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<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>Acrylic parameters</td>
<td>3, 4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Channel-dependent diagnosis via alarm channel</td>
<td>3, 4</td>
<td>✓ ✓</td>
<td>–</td>
</tr>
<tr>
<td>Operating time recording</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>Serial number</td>
<td>3, 4</td>
<td>✓ ✓</td>
<td>–</td>
</tr>
</tbody>
</table>

1) Not supported by DP-V2
PROFINET IO serial interface

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 uses fast Ethernet technology as its physical transmission medium, making it well adapted to the fast transmission of I/O data. This standard also 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 consists of:
- 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. One advantage is 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 definitions as per Profile 3.162, Version 4.2. 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).

Initial setup

In order for an encoder with the PROFINET interface to be put into operation, a general station description (GSD) file must be downloaded and imported into 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 or gateway with PROFINET

The encoders with integrated PROFINET interface or the gateway are incorporated directly into the network. Addresses are automatically assigned via a protocol integrated into PROFINET. A PROFINET IO field device is addressed within a network via its physical device MAC address. The encoders feature two dual-color LEDs for bus and device diagnostics.

A terminating resistor for the final participant is not needed.

Supported functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Class</th>
<th>Rotary encoders</th>
<th>Linear encoders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position value</td>
<td>3, 4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Isochronous mode</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Functions of Class 4</td>
<td>4</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</td>
<td>3, 4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(encoder profile V.3.1)</td>
<td></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>Permanent 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>
Starting with the Most Significant Bit (MSB), the relative position value is transmitted over the data lines (DATA) at a clock speed provided by the control (CLOCK). 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. For a signal description, see Incremental signals.

### Functions

- **Direction of rotation**
  - The continuous application of a HIGH level on PIN 2 (tmin > 1 ms) reverses the direction of rotation for ascending position values.

- **Zeroing (setting to zero)**
  - Application of a positive edge (tmin > 12 ms) to PIN 5 sets the current position value to zero (encoder must be at a standstill).

### Incremental signals

Some encoders also provide incremental signals. These signals are primarily used for increasing the resolution of the position value or for providing data to a second downstream device. They are almost always 1 Vpp signals. Exceptions are identifiable based on the ordering designation:

- SSI41H With HTL incremental signals
- SSI41T With TTL incremental signals

### Input circuit design of the downstream 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**

- t1 = 0.4 µs (without cable)  
- t2 = 17 µs to 20 µs  
- t3 ≥ 5 µs  
- t4 ≤ 0.4 µs  
- n = Data word length  
- t1 = 13 bits for ECN/ROC  
- t2 = 25 bits for EQN/ROQ

**CLOCK and DATA not shown**

**Permissible clock frequency as a function of cable length**

- Clock frequency in Hz vs. Cable length in m

---

**Input circuit design of the downstream electronics**

**Data transmission**

- Encoder  
  - Downstream electronics

**Incremental signals**

- e.g., 1 Vpp

**Programming via connecting element**

- For availability, see the encoder documentation

---

**Warning:**

The programming inputs must always be terminated with a resistor (see Input circuit design of the downstream electronics).
Incremental signals

HEIDENHAIN encoders with ~ 1 Vpp
interface provide voltage signals that can be highly interpolated.

The sinusoidal incremental signals A and B are phase-shifted by 90° elec. and have amplitudes of typically 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. Next to the amplitude, the waveform is valid when the reference mark signal is within ±0.2 V.

In the dimension drawing, A, B, and R are measured with an oscilloscope in differential mode.

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 downstream electronics in order to attain sufficiently high resolutions. For speed control, interpolation factors of greater than 1000 are normally used in order to provide 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.

<table>
<thead>
<tr>
<th>Interface</th>
<th>~ 1 Vpp sinusoidal voltage signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental signals</td>
<td>Two nearly sinusoidal signals A and B</td>
</tr>
<tr>
<td>Signal amplitude M:</td>
<td>0.6 to 1.2 Vpp; typ. 1 Vpp</td>
</tr>
<tr>
<td>Asymmetry</td>
<td>≤ 0.065 (equivalent to 15°)</td>
</tr>
<tr>
<td>Amplitude ratio M0/MN:</td>
<td>0.8 to 1.25</td>
</tr>
<tr>
<td>Phase angle</td>
<td></td>
</tr>
<tr>
<td>Reference mark signal</td>
<td>One or more signal peaks R</td>
</tr>
<tr>
<td>Usable component G:</td>
<td>≥ 0.2 V</td>
</tr>
<tr>
<td>Quiescent value H:</td>
<td>≤ 1.7 V</td>
</tr>
<tr>
<td>Signal-to-noise ratio E, F:</td>
<td>0.04 V to 0.68 V</td>
</tr>
<tr>
<td>Zero crossovers K, L:</td>
<td>180° ± 90° elec.</td>
</tr>
<tr>
<td>Connecting cable</td>
<td>HEIDENHAIN shielded cables;</td>
</tr>
<tr>
<td>Cable length</td>
<td>e.g., PUR [4(2 x 0.14 mm²) + (4 x 0.5 mm²)]</td>
</tr>
<tr>
<td>Signal propagation time</td>
<td>Max. 150 m</td>
</tr>
</tbody>
</table>

These values can be used for the dimensioning of the downstream electronics. Encoder tolerances that are subject to constraints are listed in the specifications. For encoders without an integral bearing, reduced tolerances are recommended for initial setup (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 U0.

<table>
<thead>
<tr>
<th>Short circuit at</th>
<th>30°C</th>
<th>125°C</th>
</tr>
</thead>
<tbody>
<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 Vpp
- Upper threshold: 1.35 Vpp

The amplitude of the incremental signals can be monitored based on the length of the position indicator arrow: the A and B output signals are shown as a Lissajous figure in the XY representation of the oscilloscope. Ideal sinusoidal signals produce a circle with a diameter M. In this case, the position indicator R shown is equivalent to 1/16M. The following formula applies:

\[ r = \frac{(A^2 + B^2)}{2} \]  

Where: 0.3 V < 2r < 1.35 V

Input circuit design of the downstream electronics

Dimensioning

Operational amplifier (e.g., MC 34074)
- \( Z_0 = 120 \, \Omega \)
- \( R_1 = 10 \, \Omega \) and \( C_1 = 100 \, \mu F \)
- \( R_2 = 34.8 \, \Omega \) and \( C_2 = 10 \, \mu F \)
- \( U_0 = \pm 15 \, V \)
- \( U_1 = U_0 \)

-3 dB cutoff frequency of the circuit
- 450 kHz
- 50 kHz with \( C_1 = 1000 \, \mu F \) and \( C_2 = 82 \, \mu F \)

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
- \( U_0 = \) typ. 3.48 Vpp
- Gain: 3.48-fold
Input circuit design of the downstream 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 Vpp for the A and B signals. The signal gain factor for the R signal is 0.58.

Cutoff frequency

<table>
<thead>
<tr>
<th>Cutoff frequency</th>
<th>500 kHz</th>
<th>2.5 MHz</th>
<th>5 MHz</th>
<th>10 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal</td>
<td>A, B, R</td>
<td>A, B, R</td>
<td>A, B, R</td>
<td>A, B, R</td>
</tr>
<tr>
<td>U_a</td>
<td>0 V</td>
<td>0 V</td>
<td>0 V</td>
<td>0 V</td>
</tr>
<tr>
<td>U_p</td>
<td>±5 V</td>
<td>±5 V</td>
<td>±5 V</td>
<td>±5 V</td>
</tr>
<tr>
<td>U_n</td>
<td>0 V</td>
<td>0 V</td>
<td>0 V</td>
<td>0 V or –5 V</td>
</tr>
<tr>
<td>Z_o</td>
<td>127 Ω</td>
<td>59.0 Ω</td>
<td>133 Ω</td>
<td>59.0 Ω</td>
</tr>
<tr>
<td>R_0</td>
<td>0 Ω</td>
<td>31.6 Ω</td>
<td>0 Ω</td>
<td>31.6 Ω</td>
</tr>
<tr>
<td>R_1</td>
<td>1.21 kΩ</td>
<td>681 Ω</td>
<td>681 Ω</td>
<td>681 Ω</td>
</tr>
<tr>
<td>R_2</td>
<td>1.47 kΩ</td>
<td>625 Ω</td>
<td>625 Ω</td>
<td>625 Ω</td>
</tr>
<tr>
<td>R_3</td>
<td>1.82 kΩ</td>
<td>464 Ω</td>
<td>464 Ω</td>
<td>464 Ω</td>
</tr>
<tr>
<td>C_0</td>
<td>220 pF</td>
<td>47 pF</td>
<td>22 pF</td>
<td>10 pF</td>
</tr>
<tr>
<td>C_1</td>
<td>68 pF</td>
<td>47 pF</td>
<td>22 pF</td>
<td>10 pF</td>
</tr>
</tbody>
</table>

Incremental signals

Reference mark signal

Heidenhain encoders with 11 µAPP interface provide current signals. These encoders are intended for connection to ND digital readouts or EXE signal converters from Heidenhain.

The sinusoidal incremental signals I_1 and I_2 are phase-shifted by 90° elec. and have signal levels of typically 11 µAPP.

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 µA.

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 µAPP interface are usually interpolated in the downstream electronics (ND digital readouts or EXE signal converters from Heidenhain) in order to attain sufficiently high resolutions.
HEIDENHAIN encoders with the TTL square-wave signals interface contain electronics that digitize sinusoidal scanning signals either with or without interpolation.

The incremental signals are transmitted as the square-wave pulse trains Ua1 and Ua0, phase-shifted by 90° elec. The reference mark signal consists of one or more reference pulses Ua2, which are gated with the incremental signals. In addition, the integrated electronics produce their inverted signals Ua1 and Ua0 for noise-proof transmission. The illustrated sequence of output signals—with Ua0 latching Ua1—applies to the direction of motion shown in the dimension drawing.

The fault-detection signal Ua2 indicates malfunctions such as breakage of the power lines or failure of the light source.

The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

HEIDENHAIN encoders with the TTL square-wave signals interface contain electronics that digitize sinusoidal scanning signals either with or without interpolation.

The incremental signals are transmitted as the square-wave pulse trains Ua1 and Ua2, phase-shifted by 90° elec. The reference mark signal consists of one or more reference pulses Ua2, which are gated with the incremental signals. In addition, the integrated electronics produce their inverted signals Ua1 and Ua0 for noise-proof transmission. The illustrated sequence of output signals—with Ua0 latching Ua1—applies to the direction of motion shown in the dimension drawing.

The fault-detection signal Ua2 indicates malfunctions such as breakage of the power lines or failure of the light source.

The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

The fault-detection signal Ua2 indicates malfunctions such as breakage of the power lines or failure of the light source.

The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

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The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

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The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

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The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

The fault-detection signal Ua2 indicates malfunctions such as breakage of the power lines or failure of the light source.

The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

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The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

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The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

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The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

The fault-detection signal Ua2 indicates malfunctions such as breakage of the power lines or failure of the light source.

The maximum permissible traversing speed or shaft speed.

The downstream 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. For the evaluation of the reference mark signal, the level of the reference mark signal is usually checked when signals Ua1 and Ua2 are at HIGH level and are gated with the edge change at Ua1 or Ua2.

The fault-detection signal Ua2 indicates malfunctions such as breakage of the power lines or failure of the light source.

The maximum permissible traversing speed or shaft speed.
The permissible cable length for the transmission of the TTL square-wave signals to the downstream electronics depends 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).

### Permissible cable length as a function of the edge separation

<table>
<thead>
<tr>
<th>Without $U_{a0}$</th>
<th>With $U_{a0}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable length</td>
<td>Edge separation</td>
</tr>
<tr>
<td>75</td>
<td>0.7</td>
</tr>
<tr>
<td>70</td>
<td>0.8</td>
</tr>
<tr>
<td>65</td>
<td>0.9</td>
</tr>
<tr>
<td>60</td>
<td>1.0</td>
</tr>
<tr>
<td>55</td>
<td>1.1</td>
</tr>
<tr>
<td>50</td>
<td>1.2</td>
</tr>
</tbody>
</table>

### Input circuit design of the downstream electronics

#### Dimensioning

**Dimensioning IC1 = Recommended differential line receiver:**
- DS 26 C 32 AT
- Only for $a > 0.1 \mu s$
- AM 26 LS 32
- MC 3486
- SN 75 ALS 193

- $R_1 = 4.7 \text{ k} \Omega$
- $R_2 = 1.8 \text{ k} \Omega$
- $Z_0 = 120 \Omega$
- $C_1 = 220 \text{ pF}$ (serves to improve noise immunity)

### Incremental signals

<table>
<thead>
<tr>
<th>Encoder</th>
<th>Downstream electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_a1$</td>
<td>$U_{a2}$</td>
</tr>
<tr>
<td>$U_{a2}$</td>
<td>$U_{a1}$</td>
</tr>
</tbody>
</table>

### Reference mark signal

- **Pulse width**
- **Delay time**

### Fault-detection signal

- **Pulse width**
- **Delay time**

### Connectors

- HEIDENHAIN shielded cables; e.g., PUR [4(2 × 0.14 mm²) + (4 × 0.5 mm²)]
- Max. 300 m (HTLs max. 100 m)
- 8 mm²

The permissible cable length for incremental encoders with HTL signals is dependent on the output frequency, the supply voltage being applied, and the operating temperature of the encoder.

### Current consumption

The current consumption of encoders with HTL output signals depends on the output frequency and the cable length to the downstream electronics.

### Interface

<table>
<thead>
<tr>
<th>Interface</th>
<th>HTL</th>
<th>HTLs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental signals</td>
<td>Two HTL square-wave signals $U_{a1}$, $U_{a2}$ and their inverted signals $U_{a1}^\prime$, $U_{a2}^\prime$</td>
<td></td>
</tr>
<tr>
<td>Reference mark signal</td>
<td>One or more HTL square-wave signals $U_{a0}$ and their inverse pulses $U_{a0}^\prime$ (HTLs without $U_{a0}$)</td>
<td></td>
</tr>
<tr>
<td>Signal level</td>
<td>$U_H &gt; 21 \text{ V}$ at $-I_L = 20 \text{ mA}$</td>
<td>$U_H = 24 \text{ V}$, without cable</td>
</tr>
<tr>
<td>Permissible load</td>
<td>$</td>
<td>I_L</td>
</tr>
<tr>
<td>Switching times</td>
<td>$</td>
<td>t_2/2</td>
</tr>
<tr>
<td>Connecting cable</td>
<td>HEIDENHAIN shielded cables; e.g., PUR [4(2 × 0.14 mm²) + (4 × 0.5 mm²)]</td>
<td>Max. 300 m (HTLs max. 100 m)</td>
</tr>
<tr>
<td>Cable length</td>
<td>8 mm²</td>
<td></td>
</tr>
</tbody>
</table>
Other signals

Commutation signals for block commutation

Input circuit design of the downstream electronics HTL

![Diagram of HTL input circuit design](image)

**HTLs**

![Diagram of HTLs](image)

**Other signals**

Commutation signals for block commutation

<table>
<thead>
<tr>
<th>Interface</th>
<th>TTL square-wave signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commutation signals</td>
<td>Three square-wave signals U, V, W and their inverted signals U, V, W</td>
</tr>
<tr>
<td>Width</td>
<td>2x180° mech., 3x120° mech., or 4x90° mech. (others upon request)</td>
</tr>
<tr>
<td>Signal level</td>
<td>See Incremental signals TTL</td>
</tr>
<tr>
<td>Incremental signals</td>
<td>See Incremental signals TTL</td>
</tr>
<tr>
<td>Connecting cable</td>
<td>HEIDENHAIN shielded cables; e.g., PUR [6(2 x 0.14 mm²) + (4 x 0.5 mm²)]</td>
</tr>
<tr>
<td>Cable length</td>
<td>Max. 100 m</td>
</tr>
<tr>
<td>Signal propagation time</td>
<td>6 ns/m</td>
</tr>
</tbody>
</table>

**Commutation signals**

(values in mechanical degrees)

- **C01 U>0**
  - $Y_1 = 30°$ + $2°$ per $T_1$
  - $180°$ + $T_1$
  - $2x$ T $360°$

- **C02 U>0**
  - $Y_1 = 20°$ + $2°$ per $T_1$
  - $120°$ + $T_1$
  - $3x$ T $360°$

- **C03 U>0**
  - $Y_1 = 15°$ + $2°$ per $T_1$
  - $90°$ + $T_1$
  - $4x$ T $360°$
Commutation signals for sine commutation

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 $\sim 1\,\text{Vpp}$ at 1 kΩ. The input circuit design of the downstream electronics is the same as for the $\sim 1\,\text{Vpp}$ interface. The required terminating resistance $Z_0$, however, is 1 kΩ instead of 120 Ω.

**Interface**

<table>
<thead>
<tr>
<th>Interface</th>
<th>$\sim 1,\text{Vpp}$ sinusoidal voltage signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commutation signals</td>
<td>Two nearly sinusoidal signals C and D</td>
</tr>
<tr>
<td>For the signal level, see Incremental signals $\sim 1,\text{Vpp}$</td>
<td></td>
</tr>
<tr>
<td>Incremental signals</td>
<td>See Incremental signals $\sim 1,\text{Vpp}$</td>
</tr>
<tr>
<td>Connecting cable</td>
<td>HEIDENHAIN shielded cables; e.g., PUR [4(2 x 0.14 mm²) + (4 x 0.14 mm²) + (4 x 0.5 mm²)]</td>
</tr>
<tr>
<td>Max. 150 m</td>
<td>6 ns/m</td>
</tr>
</tbody>
</table>

**Limit switches**

Encoders with limit switches, such as LIDA 400, are equipped with two limit switches that make limit-position detection and the formation of homing tracks possible. 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.

**Electronic commutation with Z1 track**

- **One revolution**
- **Z1 track**
- **Incremental signals**
- **Reference mark signal**

**Limit switches**

- **Output signals**
  - HIGH/LOW level for each 1 TTL square-wave pulse for limit switches L1 and L2

- **Signal amplitude**
  - Collector stage with load resistance of 10 kΩ against 5 V

- **Permissible load**
  - $I_{\text{LH}} \leq 4\,\text{mA}$
  - $I_{\text{LH}} \leq 4\,\text{mA}$

- **Switching times**
  - Rise time $t_+ \leq 10\,\mu\text{s}$
  - Fall time $t_- \leq 3\,\mu\text{s}$

- **Permissible cable length**
  - Max. 20 m

**Input circuit design of the downstream electronics**

- **Dimensioning**
  - $IC_3$ (e.g., 74AC14)
  - $R_3 = 1.5\,\text{kΩ}$

LIDA 400 limit switches
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>R3</td>
<td>3.9 V at ( -I_H = 8 \text{ mA} )</td>
</tr>
<tr>
<td>U3</td>
<td>0.45 V at ( I_L = 8 \text{ mA} )</td>
</tr>
<tr>
<td>Permissible load</td>
<td>( R \geq 680 \Omega )</td>
</tr>
<tr>
<td>( I_L )</td>
<td>( \leq 8 \text{ mA} )</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**

- Reference mark position
- Beginning of measuring length ML
- Limit mark, adjustable
- Switch for homing track
- Trigger point for homing

---

**Input circuit design of the downstream electronics**

- Dimensioning: IC\(3\) (e.g., 74AC14)
- \( R_3 = 4.7 \text{ k}\Omega \)

---

**Limit switches**

- Homing track
- LIF 400
- LIP 6000

---

**Tolerancing ISO 8016**

- ISO 2798: \( ± 0.5 \) mm
- LIP 6000: \( ± 0.2 \) mm
Further information
Signal converters

Signal converters from HEIDENHAIN enable the flexible adaptation of interfaces for encoder signals to the requirements of your application. Depending on the application, additional signals (such as temperature-sensor signals) may be processed and transmitted to the downstream electronics.

Input signals of the signal converters
HEIDENHAIN signal converters 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 interface can be connected to various signal converters as well.

Output signals of the signal converters
The signal converters are available with the following interfaces to the downstream electronics:
- TTL square-wave pulse trains
- EnDat 2.2
- DRIVE-CLIQ
- Mitsubishi high speed interface
- Yaskawa Serial Interface
- PROFIBUS

Interpolation of the sinusoidal input signals
In addition to performing signal conversion, the signal converter also interpolates the sinusoidal encoder signals. This permits finer measuring steps, resulting in higher control quality and superior positioning behavior.

Generation of a position value
Various signal converters feature an integrated counter function. Starting from the last set reference point, an absolute position value is generated and output to the downstream electronics when the reference mark is crossed.

### Outputs

<table>
<thead>
<tr>
<th>Interface</th>
<th>Quantity</th>
<th>Design - IP rating</th>
<th>Interpolation or subdivision</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLJTL</td>
<td>1</td>
<td>Box design – IP65</td>
<td>5/10-fold</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Plug design – IP65</td>
<td>20/25/50/100-fold</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Without interpolation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Plug design – IP40</td>
<td>5/10-fold</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Box design – IP65</td>
<td>20/25/50/100-fold</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>EXE 101</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>EXE 102</td>
<td></td>
</tr>
<tr>
<td>FLJTL/</td>
<td>2</td>
<td>Box design – IP65</td>
<td>2-fold</td>
</tr>
<tr>
<td>(∼ 1 Vpp)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(∼ 11 µAmp)</td>
<td>1</td>
<td>Box design – IP65</td>
<td>5/10-fold</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Box design – IP65</td>
<td>5/10-fold and 20/25/50/100-fold</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>EnDat 2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Cable design – IP65</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Box design – IP65</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Fanuc Serial Interface</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Plug design – IP40</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Box design – IP65</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Box design – IP65</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Mitsubishi high speed interface</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Plug design – IP40</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Box design – IP65</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Yaskawa Serial Interface</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Plug design – IP40</td>
<td>≤16 384-fold subdivision</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PROFIBUS DP</td>
<td>PROFIBUS gateway</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PROFINET ID</td>
<td>PROFINET gateway</td>
</tr>
</tbody>
</table>

1) Switchable

### Inputs

<table>
<thead>
<tr>
<th>Interface</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

### Design – IP rating

- Box design – IP65
- EXE 101
- EN 192
- EIB 392
- EIB 1912
- EIB 392M
- EIB 392M
- PROFIBUS gateway
- PROFINET gateway

- 5/10-fold
- 20/25/50/100-fold
- Without interpolation
- ≤16 384-fold subdivision
- ≥16 384-fold subdivision
- Top-hat rail design
- Plug design – IP40
- Top-hat rail design
HEIDENHAIN encoders provide all of the information needed for initial setup, monitoring, and diagnostics. The type of information available depends on whether the encoder is incremental or absolute and on which interface is being used.

Incremental encoders have 1 Vpp, TTL, or HTL interfaces. TTL and HTL encoders monitor their signal amplitudes internally and generate a simple 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 downstream electronics (analog diagnostics interface).

Absolute encoders use serial data transmission. Depending on the interface, additional 1 Vpp incremental signals can be output. The signals are extensively monitored within the encoder. The monitoring results (particularly valuation numbers) can be transmitted to the downstream 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 function reserve
  - Identical scaling for all HEIDENHAIN encoders
  - Cyclic reading capability

This enables the downstream electronics to evaluate the current status of the encoder with little effort, even in closed loop mode.

For the analysis of these encoders, HEIDENHAIN offers the appropriate PWM inspection devices and PWT testing devices. Based 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 encoder functions.
- **Monitoring mode:** the PWM inspection device is inserted into the closed control loop (via suitable testing adapters as needed). This enables real-time diagnosis of the machine or equipment during operation. The available functions depend on the interface.

### Overview

<table>
<thead>
<tr>
<th>Interface</th>
<th>Output signals (selection)</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 (with incremental signals)</td>
<td>Position value, Incremental signals</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>EnDat 2.2 (without incremental signals)</td>
<td>Position value, Valuation numbers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>DRIVE-CLIQ</td>
<td>Position value, Valuation numbers</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Fanuc</td>
<td>Position value, Valuation numbers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>Position value, Valuation numbers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Panasonic</td>
<td>Position value, Valuation numbers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Yaskawa</td>
<td>Position value, Valuation numbers</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>SSI</td>
<td>Position value, Incremental signals</td>
<td>Yes</td>
<td>No</td>
<td>No</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, Scanning signals</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>HTL</td>
<td>Incremental signals</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Commutation</td>
<td>Block commutation, Sinusoidal commutation</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1) Information must be requested and transferred by the control
2) Via the appropriate signal adapter
3) Only for encoders with block commutation (see encoder documentation)
4) If supported by the encoder (PWT function)
5) Not available for encoders with the ordering designation Mitsu01
6) Not available for the EIB 0591Y
7) Function not yet available
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 and rugged design, the PWT 101 is ideal for portable use.

**Encoder input**
- EnDat 2.1 or EnDat 2.2 (with or without incremental signals)
- Fanuc Serial Interface
- Mitsubishi high-speed interface
- Panasonic Serial Interface
- Yaskawa Serial Interface
- 1 Vpp
- 11 µAPP
- TTL

**Display**
4.3-inch touchscreen

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

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

**Protection**
EN 60529 IP20

**Dimensions**
Approx. 145 mm x 85 mm x 35 mm

**PWM 21**
The PWM 21 phase angle measuring unit, in conjunction with the included ATS adjustment and testing software, provides an adjustment and testing package for the diagnosis and adjustment of HEIDENHAIN encoders.

**Encoder input**
- EnDat 2.1 or EnDat 2.2 (with or without incremental signals)
- EnDat 3 (signal adapter may be needed)
- 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**
- German, English, French, Italian, Spanish, Korean, Chinese (simplified), Chinese (traditional)

**System requirements and recommendations**
- PC (dual-core processor > 2 GHz)
- RAM > 2 GB
- Operating system: Windows 7, 8, and 10 (32-bit/64-bit)
- 500 MB of free hard drive space

**Mounting wizard**
The PWM 21, together with the adjusting and testing software (ATS), is recommended for the mounting of exposed or multi-section linear encoders or modular angle encoders. If supported by the encoder interface, the PWT 101 can be used as well to a limited extent.

**Suitability of PWT 101**

<table>
<thead>
<tr>
<th>Encoders</th>
<th>Suitable</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIC 21xx, LIC 31xx, LIF 4xx, LIF 1xx, LiDA 4xx, LiDA 2xx, ERM 2xx</td>
<td>✔</td>
</tr>
<tr>
<td>LIC 41xx, LIP 3xx, LB 3xx, LC 2xx, PP 281, ECA 4xx, ECM 24xx, ERA 4xx, ERA 7xx, ERA 8xx, ERP 880</td>
<td>Limited suitability: for optimal mounting quality, please use the PWM 21 with the ATS adjusting and testing software</td>
</tr>
</tbody>
</table>

*Please read the notes in the encoder documentation.*
Measuring principles

Incremental measuring method
With the incremental measuring method, the position information consists of a periodic grading structure. The position information is obtained by counting the individual increments (measuring steps) from a chosen datum. The shaft speed or traversing speed is mathematically derived based on the change in position over time. Since an absolute position is needed in order to determine the absolute reference, the measuring standards feature an additional track that bears one or more reference marks. The measuring standard's absolute position, as defined by the reference mark, is assigned to exactly one measuring step or signal period. As a result, the reference mark must be scanned in order to establish an absolute reference or in order to find the most recently selected datum. In suboptimal cases, this may require machine movements over large sections of the measuring range. To make this easier, many HEIDENHAIN encoders feature distance-coded reference marks: the reference mark track contains multiple reference marks at different defined distances. After two neighboring reference marks have been crossed without a change in direction, the downstream electronics can determine the absolute reference in less distance travelled. Scale drums or encoders with distance-coded reference marks are designated with the letter “C” at the end of the model designation (e.g., for the TTR ERM 2200C and ERA 4200C angle encoders, and the LS 487C linear encoder). With distance-coded reference marks, the absolute position is calculated by counting the increments between two reference marks and using the formulas shown below.

Absolute measuring method
In the absolute measuring method, the position value is available immediately upon encoder switch-on and can be requested by the downstream electronics at any time. There is therefore no need to search for the reference position by jogging the axes. This absolute position information is read from the measuring standard, which features a serial code structure. To obtain the position value, a separate incremental track is interpolated.

Linear encoders:

\[ \alpha_2 = (\text{abs } A - \text{sgn } A - 1) \times \frac{1}{2} + (\text{sgn } A - \text{sgn } D) \times \frac{\text{abs } MRR}{2} \]

and:

\[ A = 2 \times \text{abs } MRR \times N \]

Definitions:

\( \alpha_2 \) = Absolute angular position of the first reference mark traversed relative to the zero position in degrees
\( \text{abs } A \) = Absolute value
\( \text{sgn } A \) = Algebraic sign function ("+1" or "-1")
\( MRR \) = Measured value between the traversed reference marks in degrees
\( N \) = Nominal increment between two fixed reference marks (see tables)
\( \text{GP} \) = Graduation period \((360°/\text{Line count})\)
\( \text{D} \) = Direction of rotation (+1 or -1). The rotation as per mating dimensions result in "+1" or "-1".

\[ P_1 = (\text{abs } R - \text{sgn } R - 1) \times \frac{1}{2} + (\text{sgn } R - \text{sgn } D) \times \frac{\text{abs } MRR}{2} \]

and:

\[ R = 2 \times \text{abs } MRR \times N \]

Definitions:

\( P_1 \) = Position of the first traversed reference mark in signal periods
\( \text{abs } R \) = Absolute value
\( \text{sgn } R \) = Algebraic sign function ("+1" or "-1")
\( MRR \) = Number of signal periods between the traversed reference marks
\( N \) = Nominal increment between two fixed reference marks in signal periods (see table below)
\( \text{D} \) = Direction of travel (+1 or -1). Traverse of scanning unit to the right (when properly installed) equals +1

Absolute measuring method
The General electrical information applies to HEIDENHAIN encoders, signal converters, and cables. For any deviation, see the specifications. Throughout the General electrical information chapter, the term “encoders” refers to HEIDENHAIN encoders and HEIDENHAIN signal converters.

Scope
The General electrical information applies to HEIDENHAIN encoders, signal converters, and cables. For any deviation, see the specifications. Throughout the General electrical information chapter, the term “encoders” refers to HEIDENHAIN encoders and HEIDENHAIN signal converters.

Power supply
Connect HEIDENHAIN encoders only to downstream electronics whose supply voltage comes from PELV systems (for a definition of terminology, see EN 60204-1).

Encoders meet the requirements of the IEC 61010-1 standard if power is supplied from a secondary circuit with limited energy (low voltage, limited energy) as per IEC 61010-1 (IEC 61010-1 Ed. 4, Section 8.4, or from a Class 2 secondary circuit as per UL1310). When indicated in the certificate, encoders that are certified for functional safety also meet the requirements of the IEC 61800-5-3 standard if power is supplied from a secondary circuit with the relevant DVC A voltage class.

A stabilized DC voltage \( U_{\text{IN}} \) 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 signal \( U_{\text{IN}} < 250 \text{ mV with } \text{dU/dt} > 5 \text{ V/µs} \)
- Low-frequency fundamental ripple \( U_{\text{IN}} < 100 \text{ mV} \)

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

The voltage values must be complied with at the encoder. For encoders with an integrated cable assembly, the voltage drop in this cable assembly must be taken into account. Further information (e.g., the cross section of the supply wires) must be taken from the encoder documentation as needed. The voltage applied to the encoder can be monitored and adjusted via the sense lines, if present. If a variable power supply unit is not available, then the voltage drop can be reduced by connecting the sense lines in parallel with the corresponding supply wires.

When designing the power supply, use the maximum current or power consumption according to the specifications. For the sake of correlation 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.

General electrical information

Current consumption and power consumption as a function of the supply voltage (example)

Influence of the cable length on the power output of the downstream electronics (example)

<table>
<thead>
<tr>
<th>Supplier</th>
<th>3 m</th>
<th>3 m</th>
<th>3 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder 1</td>
<td>20 m</td>
<td>20 m</td>
<td>20 m</td>
</tr>
<tr>
<td>Encoder 2</td>
<td>3 m</td>
<td>17 m</td>
<td>20 m</td>
</tr>
<tr>
<td>Encoder 3</td>
<td>4 m</td>
<td>47 m</td>
<td>50 m</td>
</tr>
<tr>
<td>Encoder 4</td>
<td>5 m</td>
<td>92 m</td>
<td>100 m</td>
</tr>
</tbody>
</table>

The voltage \( U_{\text{IN}} \) actually applied at the encoder is to be considered when calculating the current consumption and power consumption of the encoder. This voltage consists of the supply voltage \( U_{\text{IN}} \) provided by the downstream electronics minus the voltage drop \( \Delta U \) on the supply wires.

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 an extended supply voltage range
For encoders with an extended supply voltage range, the relationship between the current consumption and the supply voltage is nonlinear. 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
- Age and temperature influences
- Proper use of the encoder with respect to the clock frequency and cycle time

For encoders with an extended supply voltage range, the calculation of the voltage drop \( \Delta U \) on the supply wires must take the non-linear current consumption into account. This occurs in three steps:

**Step 1: Resistance of the supply wires**

The resistance of the supply wires (adapter cable and connecting cable) can be calculated with the following formula:

\[
R_L = \frac{1.05 \cdot L_c}{56 \cdot \sigma} \text{ in } \Omega
\]

**Step 2: Coefficients for calculation of the voltage drop**

\[
b = R_L \left( \frac{P_{\text{Max}} - P_{\text{Min}}}{U_E - U_P} \right) + \frac{U_E}{I_M}
\]

\[
c = R_L \left( \frac{P_{\text{Max}} - P_{\text{Min}}}{U_E - U_P} \right) \frac{I_M}{U_E - U_{\text{Min}}}
\]

**Step 3: Voltage drop based on the coefficients \( b \) and \( c \)**

\[
\Delta U = 0.5 \cdot b \cdot \Delta I + c \cdot \Delta I^2
\]

Encoders without an extended supply voltage range

For encoders without an extended supply voltage range (typical supply voltage: DC 5 V), the voltage drop \( \Delta U \) on the supply wires is calculated as follows:

\[
\Delta U = 2 \cdot \frac{1.05 \cdot L_c}{56 \cdot \sigma} \cdot I_M \cdot 10^{-3}
\]

If the value for the voltage drop \( \Delta U \) is known, then the following parameters can be calculated for the encoder and downstream electronics: voltage at the encoder, current consumption of the encoder, power consumption of the encoder, and the power to be provided by the downstream electronics.

Voltage at the encoder:

\[
U_E = U_{\text{Min}} - \Delta U
\]

Current consumption of the encoder:

\[
I_M = \frac{U_E - U_{\text{Min}}}{R_L}
\]

Power consumption of the encoder:

\[
P_M = U_E \cdot I_M
\]

Power output of the downstream electronics:

\[
P_E = U_P \cdot I_M
\]

Definitions:

- \( U_E \): Voltage at the encoder in V
- \( I_M \): Current consumption of the encoder in mA
- \( P_M \): Power consumption of the encoder in W
- \( U_P \): Supply voltage at the downstream electronics in V
- \( P_E \): Power output of the downstream electronics in W
- \( \Delta U \): Voltage drop over the cable in V
- \( L_c \): Cable length in meters
- \( \sigma \): Electrical conductivity of copper in \( \Omega \cdot \text{mm}^2 / \text{m} \)
- \( R_L \): Resistance of the supply wires (for 56 Electrical conductivity of copper in \( \Omega \cdot \text{mm}^2 / \text{m} \))
- \( \rho \): Length factor due to twisted wires
- \( L_f \): Cross section of the supply wires in mm² (see cables)

**Cable lengths**

**Maximum cable lengths**

The cable lengths in the specifications apply only to HEIDENHAIN cables and the recommended input circuit designs for the downstream electronics. The maximum attainable cable length is limited by the following key factors:

- Compliance with the supply voltage at the encoder
- Restrictions arising from the transmission technology (e.g., protocol design for purely serial interfaces and manufacturer specifications for proprietary interfaces)

Please note: These restrictions must be checked independently from each other and complied with.

The maximum overall length of the pre-assembled cables is provided in the table below.

<table>
<thead>
<tr>
<th>Cable Length</th>
<th>Power Supply Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnDat 3</td>
<td>100 m</td>
</tr>
<tr>
<td>HVAC 2</td>
<td>100 m</td>
</tr>
<tr>
<td>EnDat 2.2</td>
<td>100 m</td>
</tr>
<tr>
<td>HVAC 6</td>
<td>100 m</td>
</tr>
<tr>
<td>DRIVE-CtIo</td>
<td>100 m</td>
</tr>
<tr>
<td>Fanuc, Mitsubishi, Yamaha</td>
<td>30 m²</td>
</tr>
<tr>
<td>EnDat 2.1</td>
<td>150 m</td>
</tr>
<tr>
<td>SSI</td>
<td>100 m</td>
</tr>
<tr>
<td>1 Vpp</td>
<td>150 m</td>
</tr>
<tr>
<td>11 μAPP</td>
<td>30 m</td>
</tr>
<tr>
<td>TTL</td>
<td>100 m</td>
</tr>
</tbody>
</table>

**Compliance with the supply voltage at the encoder**

This voltage drop may cause the supply voltage to fall below its minimum permissible level, particularly in the case of long cable lengths and encoders with high current requirements, such as absolute linear and angle encoders. The highest possible supply voltage \( U_e \) should therefore be selected in the downstream electronics. The voltage drop can be mitigated through the following measures:

- Keep thin cables with small wire cross-sections as short as possible
- For large cable lengths, select a wider wire cross-section
- For downstream electronics without a variable power supply unit, connect the sense lines in parallel with the supply lines. This doubles the available cross-section

**Data transfer technology**

The transmission characteristics of the pre-assembled cables, protocol properties of the interfaces, and other specifications impose limitations on the design of the cable lengths.

Purely serial interfaces with transmission frequencies of up to 16 MHz, in combination with large cable lengths, place high technological demands on the cable. Thanks to a design that is specially adapted to these applications, HEIDENHAIN cables are highly suitable for meeting these requirements.

For this reason, HEIDENHAIN recommends using original HEIDENHAIN cables.

An adapter cable connected directly to the encoder is limited in terms of its length. To implement larger cable lengths, an adapter cable and an additional connecting cable with a larger cross section can be used.

---

**Cable Lengths**

**Cable lengths for purely serial interfaces**

<table>
<thead>
<tr>
<th>Encoder</th>
<th>Fanuc, Mitsubishi, Panasonic, Yaskawa</th>
<th>HEIDENHAIN</th>
<th>SSI</th>
<th>1 Vpp</th>
<th>11 μAPP</th>
<th>TTL</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12</td>
<td>[Diagram showing cable lengths]</td>
<td>[Narrative explaining the diagram]</td>
<td>[Table detailing cable lengths]</td>
<td>[Note: Lengths of up to 50 m are possible depending on the encoder]</td>
<td>Please consider the specifications of the given encoder.</td>
<td></td>
</tr>
</tbody>
</table>
A major factor influencing the attainable maximum cable length is the supply voltage of the downstream electronics. At a supply voltage of DC 12 V (±10%), overall lengths of 100 m can be realized with HEIDENHAIN connecting cables for the encoders in the table. The value selected for the table, 4.9 V, represents the lower limit of the supply voltage of commercially available downstream electronics. The table shows examples of adapter cable length combinations (Ø 4.5 mm) for various encoders and the resulting maximum cable lengths of the connecting cable. The values in the table apply to a parallel connection of the sense connecting cables for the encoders in the encoder motor housing.

**Note:** Depending on the encoder, other length limitations may apply. For more information, see the brochure and Product Information document of the encoder in question.

### Encoder Power consumption at Up = 3.6 V or 14 V

<table>
<thead>
<tr>
<th>Encoder</th>
<th>Power consumption at Up = 3.6 V or 14 V</th>
<th>Adapter cable Ø 4.5 mm Ap = 2 x 0.16 mm²</th>
<th>Additional connecting cable</th>
<th>Pre-assembled cable Ø 6 mm Ap = 2 x 0.16 mm²</th>
<th>Pre-assembled cable Ø 8 mm Ap = 2 x 0.35 mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>LC/RCN/ROC</td>
<td>3.6 V ≤ 1100 mW 14 V ≤ 1300 mW</td>
<td>20 m 6 m 1 m</td>
<td>15 m 29 m 34 m</td>
<td>35 m 66 m 77 m</td>
<td></td>
</tr>
<tr>
<td>ECN 1325</td>
<td>3.6 V ≤ 600 mW 14 V ≤ 700 mW</td>
<td>0.5 m Output cable inside the motor housing</td>
<td>85 m</td>
<td>99 m</td>
<td></td>
</tr>
<tr>
<td>EGN 1337</td>
<td>3.6 V ≤ 700 mW 14 V ≤ 800 mW</td>
<td>0.5 m</td>
<td>55 m</td>
<td>99 m</td>
<td></td>
</tr>
<tr>
<td>AK LIC 41x</td>
<td>3.6 V ≤ 950 mW 14 V ≤ 1050 mW</td>
<td>3 m 1 m Output cable on the encoder</td>
<td>37 m 39 m</td>
<td>85 m 89 m</td>
<td></td>
</tr>
</tbody>
</table>

Maximum cable length for purely serial interfaces (determined based on a supply voltage of DC 4.9 V)

### Switch-on/off behavior of the encoders

Valid output signals are available after the switch-on time tSOT. During the time tSOT, the output signals reach the maximum voltage values stated in the table. The duration of the switch-on time tSOT depends on the interface.

#### Interfaces

<table>
<thead>
<tr>
<th>Interface</th>
<th>Switch-on time (s)</th>
<th>Maximum voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTP</td>
<td>1.3</td>
<td>5.5 V</td>
</tr>
<tr>
<td>TCP</td>
<td>1.1</td>
<td>5.5 V</td>
</tr>
<tr>
<td>TTL</td>
<td></td>
<td>5.5 V</td>
</tr>
<tr>
<td>HTL</td>
<td></td>
<td>5.5 V</td>
</tr>
<tr>
<td>EnDat</td>
<td>2.5</td>
<td>5.5 V</td>
</tr>
<tr>
<td>PROFINET</td>
<td>10 s</td>
<td>5.5 V</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. Furthermore, the interface-specific switch-on/off characteristics must be taken into account. If the HEIDENHAIN encoder is operated through an interposing HEIDENHAIN signal converter, then the signal converter's switch-on and switch-off conditions must also be taken into consideration.

### Design information regarding the power pack of the downstream electronics

#### Selecting the power supply of the downstream electronics

Select a power supply that is as close as possible to the upper tolerance limit. Consider the voltage drop AU resulting on the interface version of the encoder (see encoder data in the respective brochure; maximum value = 100 mV).

The stated power consumption values apply only to the current edition of the Interfaces of HEIDENHAIN Encoders brochure. For the currently valid power consumption values, please refer to the specifications in the relevant product brochure.

Please also consider the information of the downstream electronics manufacturer regarding the supply voltage for the encoder and the maximum permissible cable lengths.

#### Power output of the downstream 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. Losses in the adapter and connecting cables must also be taken into account.

#### 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 should be considered for the dimensioning.

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.
Data age

Due to signal propagation times, deviations from the current physical position of the encoder may arise:
- in the encoder (for serial interfaces) and
- in the downstream electronics (for incremental interfaces).

The sum of the different signal propagation times is referred to as the data age. It causes a speed-dependent deviation of the determined position from the current physical position of the encoder.

Data age is determined by the signal propagation times in the analog and digital singal processing path of the encoder and the downstream electronics, as well as the propagation times in the transmission path. Due to the characteristics of the interface, the data age can be positive or negative.

For more information, refer to the encoder’s specifications as needed (please consult with HEIDENHAIN as needed).

Electrically permissible shaft speed or traversing speed

The maximum permissible shaft speed or traversing speed of an encoder is derived from:
- the electrically 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 downstream 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 of the encoder and
- the minimum permissible edge separation for the downstream electronics.

For angle or rotary encoders

\[ n_{\text{max}} = \frac{f_{\text{max}}}{2} \cdot 60 \cdot 10^{-3} \]

For linear encoders

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

Definitions:
- \( n_{\text{max}} \): Electrically permissible shaft speed in rpm
- \( v_{\text{max}} \): Electrically permissible traversing speed in m/min
- \( f_{\text{max}} \): Maximum scanning frequency / output frequency of the encoder or the input frequency of the downstream electronics in kHz
- \( \text{SP} \): Signal periods of the linear encoder in µm

Scope

As a supplement to the General electrical information, the following sections apply to HEIDENHAIN encoders with a proprietary interface. For any deviating information, see the specifications.

Encoders with the DRIVE-CLiQ interface

Power supply

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

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

Encoders with the DRIVE-CLiQ interface are designed for the switch-on/switch-off behavior shown in the upperright diagram.

Cable lengths

The cable lengths indicated in the specifications apply only in the case of HEIDENHAIN cables and the recommended input circuit designs for the downstream electronics.

The DRIVE-CLiQ interface permits a maximum cable length of 100 m, but this value is reduced by a number of factors:
- Number of dividing points with DRIVE-CLiQ couplings
- Length factor of the adapter or connecting cable
- Plugable adapter cable at the encoder
- Length of the HEIDENHAIN adapter cable with compensation factor

The maximum permissible cable length for DRIVE-CLiQ is determined as follows:

\[ n_{\text{MG}} \cdot 5 \text{ m} + \frac{4}{3} \cdot L_{\text{AD}} + \sum k_i \cdot L_i + n_{\text{NC}} \cdot 5 \text{ m} \leq 100 \text{ m} \]

Definitions:
- \( n_{\text{MG}} \): Influence of the encoder via a connectable adapter cable, for example: \( n_{\text{MG}} = 1 \)
- \( k_i \): Length compensation factor for HEIDENHAIN adapter cables
- \( L_{\text{AD}} \): Length of the HEIDENHAIN adapter cable in m
- \( L_i \): Overall length of the signal line i in m
- \( n_{\text{NC}} \): Number of dividing points

Encoders with the DRIVE-CLiQ interface that are connected via an output cable (AGK) have an additional length limitation. Due to the transmission characteristics of the output cables, a 40 m limit applies to the formula for calculating the maximum permissible cable length. This limit applies to all output cables that have the designation “DO01” in the “Use with” column of the cable overview list.

Note:
Depending on the encoder, further length restrictions may apply. For more information, see the brochure or Product Information document of the given encoder.

DRIVE-CLiQ is a registered trademark of Siemens AG.
Electrical safety

HEIDENHAIN encoders must be supplied from PELV systems (for an explanation of terminology, see EN 60204-1); they are certified in accordance with IEC 61010-1, UL 61010-1, and CAN/CSA-C22.2 No. 61010-1.

When indicated in the certificate, encoders that are certified for functional safety also meet the requirements of the IEC 61800-5-2 standard if power is supplied from a secondary circuit with the relevant DVC A voltage class.

The housing of the encoders does not provide protection from the ingress of outside contamination and liquids by means of a cover.

Electromagnetic compatibility

Sources of electrical interference

Electrical interference is primarily caused by capacitive or inductive couplings. Inductive couplings can arise on lines, as well as at device inputs and outputs. 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 abovementioned devices
- Strong magnetic fields from transformers, brakes, and electric motors

Conformity

If the measures listed below are complied with, then HEIDENHAIN encoders fulfill EMC Directive 2014/30/EU with regard to the generic standards for the given area of application:

- **Immunity**
  - 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
- **Emission**

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 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 cables in the immediate vicinity of interference sources (inductive consumers such as contactors, motors, frequency inverters, solenoid valves, etc.)
  - Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are 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 downstream 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 downstream electronics with each other by means of the cable shield. Connect the shield over a large area just a short distance with the (external) shield with functional earth (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) strong EMC expertise is required for interference-free operation, and the manufacturer of the overall system must ensure conformity:
  - Interference-free operation is possible in most applications because the disturbances acting on the sensor are low.
  - In addition, the requirements for the electrical insulation of the sensor must be considered because electrical hazards can arise from 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 encoders, provide high-frequency, low-resistance grounding (see the EMC chapter in EN 60204-01).

Minimum clearance from sources of interference

- Minimum clearance from sources of interference: 100 mm
- Minimum clearance from terminals: 100 mm
- Minimum clearance from plastic housing in an enclosed metal housing: 200 mm

Shield clamp as substitute
<table>
<thead>
<tr>
<th>Country</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE</td>
<td>HEIDENHAIN Vertrieb Deutschland 83301 Traunreut, Deutschland 08669 31-312 E-Mail: <a href="mailto:hdl@heidenhain.de">hdl@heidenhain.de</a></td>
</tr>
<tr>
<td>DK</td>
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</tr>
<tr>
<td>ES</td>
<td>FARRESA ELECTRONICA S.A. 08028 Barcelona, Spain <a href="http://www.farresa.es">www.farresa.es</a></td>
</tr>
<tr>
<td>FI</td>
<td>HEIDENHAIN Scandinavia AB 01404 Vantaa, Finland <a href="http://www.heidenhain.fi">www.heidenhain.fi</a></td>
</tr>
<tr>
<td>FR</td>
<td>HEIDENHAIN FRANCE s.r.l. 92310 Sèvres, France <a href="http://www.heidenhain.fr">www.heidenhain.fr</a></td>
</tr>
<tr>
<td>GB</td>
<td>HEIDENHAIN (G.B.) Limited Burgess Hill RH15 9BD, United Kingdom <a href="http://www.heidenhain.co.uk">www.heidenhain.co.uk</a></td>
</tr>
<tr>
<td>GR</td>
<td>MB Militon Vassilis 17841 Athens, Greece <a href="http://www.heidenhain.gr">www.heidenhain.gr</a></td>
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<td>Croatia → SL</td>
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<td>HU</td>
<td>HEIDENHAIN Kereskedelmi Képvisellet 1239 Budapest, Hungary <a href="http://www.heidenhain.hu">www.heidenhain.hu</a></td>
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<tr>
<td>ID</td>
<td>PT Servitama Era Toolsindo Jakarta 10350, Indonesia E-Mail: <a href="mailto:ptset@group.gts.co.id">ptset@group.gts.co.id</a></td>
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<tr>
<td>IL</td>
<td>NEUMO VARGUS MARKETING LTD. Holon, 5885948, Israel E-Mail: <a href="mailto:neumo@neumo-vargus.co.il">neumo@neumo-vargus.co.il</a></td>
</tr>
<tr>
<td>IN</td>
<td>HEIDENHAIN Optics &amp; Electronics India Private Limited Chetpet, Chennai 600 031, India <a href="http://www.heidenhain.in">www.heidenhain.in</a></td>
</tr>
<tr>
<td>IT</td>
<td>HEIDENHAIN ITALIANA S.r.l. 20128 Milano, Italy <a href="http://www.heidenhain.it">www.heidenhain.it</a></td>
</tr>
<tr>
<td>JP</td>
<td>HEIDENHAIN K.K. Tokyo 102-0083, Japan <a href="http://www.heidenhain.co.jp">www.heidenhain.co.jp</a></td>
</tr>
<tr>
<td>KR</td>
<td>HEIDENHAIN Korea Ltd. Anyang-si, Gyeonggi-do, 14087 South Korea <a href="http://www.heidenhain.co.kr">www.heidenhain.co.kr</a></td>
</tr>
<tr>
<td>MX</td>
<td>HEIDENHAIN CORPORATION MEXICO 20290 Aguascalientes, AGS., Mexico E-Mail: <a href="mailto:info@heidenhain.com">info@heidenhain.com</a></td>
</tr>
<tr>
<td>MY</td>
<td>ISOSERVE SDN. BHD. 43200 Balokong, Selangor E-Mail: <a href="mailto:sales@isoserve.com.my">sales@isoserve.com.my</a></td>
</tr>
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<td>NL</td>
<td>HEIDENHAIN NEDERLAND B.V. 6716 BM Ede, Netherlands <a href="http://www.heidenhain.nl">www.heidenhain.nl</a></td>
</tr>
<tr>
<td>NO</td>
<td>HEIDENHAIN Scandinavia AB 7300 Orkanger, Norway <a href="http://www.heidenhain.no">www.heidenhain.no</a></td>
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