



**HEIDENHAIN**

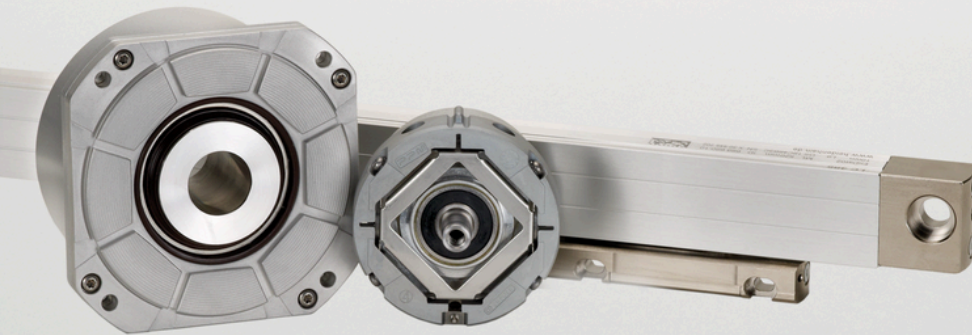


**Functional  
Safety**

# EnDat 3

## EnDat 3

Implementation Guide



English (en)  
10/2019

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# 1 Fundamentals

The EnDat 3 interface is typically implemented in several stages:

- Implementation of the physical layer: selection of transceiver, power supply, etc.
- Integration of the EnDat 3 Master



It is recommended that the FPGA code from HEIDENHAIN be used

- Software implementation:
  - Basic communication: simple foreground communication
  - Integration of background communication (e. g. memory accesses)
  - Integration of encoder functions (e. g. diagnostics, sensors)
  - Integration of encoder profiles (e. g. rotational, linear, backup battery)

HEIDENHAIN provides a variety of aids and documents for the individual implementation stages.

## 2 Document target groups

### 2.1 Hardware development

#### Physical layer

- EnDat 3 Hardware Specification
- EnDat 3 Interface Specification, in particular the chapters "Fundamentals", "Physical layer," and "Data link and transport layer"
- Electrical safety and electromagnetic compatibility

#### Digital design

- EnDat 3 Master Instructions



It is recommended that the EnDat 3 Master from HEIDENHAIN be used. Using the recommended EnDat 3 Master ensures that the requirements of the EnDat 3 Interface Specification are adhered to. In addition, the EnDat 3 Master from HEIDENHAIN handles the synchronization of the foreground and background communication.



For a detailed description, please refer to the "Physical layer" chapter of the "EnDat 3 Interface Specification".

### 2.2 Software development

- EnDat 3 Master Instructions
- EnDat 3 Interface Specification
- EnDat 3 Application Notes
- EnDat 3 Evaluation Board
  - Test of the EnDat 3 Features
  - Adopting the example programs from HEIDENHAIN in customer applications



When using bus operation, refer to the "Bus operation" chapter of the EnDat 3 Interface Specification. In this case, consultation with HEIDENHAIN is required.

### 2.3 Applications with functional safety



For functionally safe applications, also refer to: EnDat 3 Application Conditions for Functional Safety

### 3 About these instructions

The EnDat 3 Implementation Guide provides an overview of which documents and document contents are intended for which readers.



For more information, please refer to **[www.endat.de](http://www.endat.de)**  
Implementation ► EnDat 3



For individual advice on optimal implementation of the EnDat interface, please consult with your HEIDENHAIN contact person.

## 4 Notes on reading this document

### Associated documents

The table below lists the documentation components in their order of priority for reading.

Documentation	Description
EnDat 3 Technical Information	The Technical Information document gives an overview of the interface. It is not an interface specification.
EnDat 3 Guideline for Implementation	The Guideline for Implementation provides an overview of which documents or document contents are intended for which readers and which aids are available for implementation.
EnDat 3 Interface Specification	The Interface Specification specifies the EnDat 3 interface in the physical layer, the data link layer, the transport layer, and the application layer.
EnDat 3 Hardware Specification	The Hardware Specification specifies the hardware requirements to be fulfilled by the subsequent electronics for EnDat 3 encoders.
EnDat 3 Application Conditions for Functional Safety	The Application Conditions for Functional Safety describe the measures and mechanisms necessary in order to operate EnDat 3 encoders in a functionally safe manner.
EnDat 3 Master Instructions	The Master Instructions describe the EnDat 3 master provided by HEIDENHAIN, along with the associated test bench and behavior model of the EnDat 3 encoder.
EnDat 3 Application Notes	The Application Notes describe the functionalities, processes, mechanisms, encoder functions, and other topics from the application's point of view.
Electrical Safety and Electromagnetic Compatibility	Information about the electrical safety and electromagnetic compatibility can be found in the corresponding section of the "Interfaces of HEIDENHAIN Encoders" brochure. Also, the documentation of the respective encoder must be noted.

**Further information on the pertinent documentation**

The documents listed among the pertinent documentation must be requested from HEIDENHAIN.

The contact form is available at **www.endat.de** under Implementation ► EnDat 3



If you have any questions, please contact your HEIDENHAIN contact person.

**Would you like to see any changes, or have you found any errors?**

We are continuously striving to improve our documentation for you. Please help us by sending your requests to the following e-mail address:

**userdoc@heidenhain.de**

## 5 Overview of encoder characteristics

The extensive HEIDENHAIN product program of linear, angle and rotary encoders covers applications in the fields of machine tools, the electronics industry and automation technology.

The requirements arising within these applications and industries are reflected by the different characteristics of the various encoder models. These characteristics are modeled by the EnDat 3 interface and are reflected in the memory contents or functions of the encoder.



For more information, please refer to **[www.endat.de](http://www.endat.de)**  
Implementation ► EnDat 3



## 6 Aids for hardware and software

### 6.1 EnDat 3 Master

The EnDat 3 Master handles the communication with EnDat 3 encoders from HEIDENHAIN. This makes it easy to transfer the information transmitted via the EnDat 3 interface to the higher-level application. Due to the high transmission frequencies, an FPGA or ASIC is usually used. For integration into an FPGA or ASIC, HEIDENHAIN provides an EnDat 3 Master as VHDL code.

The EnDat 3 Master supports the EnDat 3 foreground and background communication and also handles the synchronization of the two communication paths. In addition, the Master from HEIDENHAIN is optimized for high transmission safety. This is especially important if there is a high EMC load, for example in hybrid-cable applications.

The following graphic shows the block diagram for the EnDat 3 Master from HEIDENHAIN:

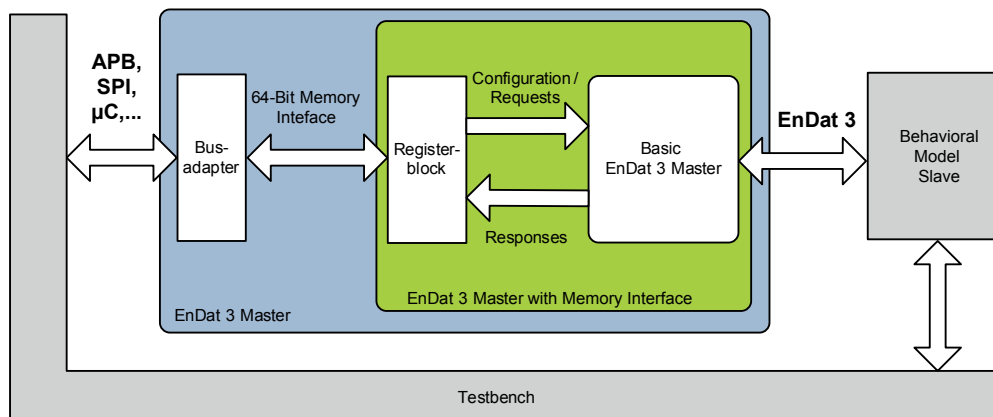


Figure 1: Overview of EnDat 3 Master

The part highlighted in blue is recommended for the integration of the EnDat Master. If the bus interface needs to fulfill special requirements, for example, it is also possible to use only the green area. HEIDENHAIN does not support independent user implementations or changes to the green parts made by the customer.

Together with the behavioral model of the slave, the test bench permits a comprehensive verification of the EnDat Master in the customer's application.



For a detailed documentation of the EnDat Master from HEIDENHAIN, please refer to your HEIDENHAIN contact person.

## 6.2 EnDat 3 Evaluation Board

The EnDat 3 Evaluation Board Software (in the following referred to as "software"), combined with an EnDat 3 Evaluation Board permits comprehensive testing of the EnDat 3 interface. The EnDat 3 Evaluation Board can be used as EnDat 3 Master for this purpose and thus enables direct communication with the encoder, or communication with an external API (such as the example programs, see below), in combination with the software.

However, the EnDat 3 Evaluation Board can also be switched in between an external master (in the subsequent electronics) and a slave. This makes it possible to record or manipulate the EnDat 3 communication. Depending on the configuration, this is referred to as internal or external master within the software.

The master on the EnDat 3 Evaluation Board is equivalent to the master HEIDENHAIN provides as a VHDL code. This means that the registers of the master in the example programs and in the customer's application can be controlled in the same way. For this purpose, the software enables direct reading and writing of the registers of the EnDat 3 Master. From the point of view of the user, using an external API results in the same structure of the application software, regardless of whether the EnDat 3 Evaluation Board or the customer's own hardware is used. The customer's application can thus be tested easily with the EnDat 3 Evaluation Board and then be ported to the customer's own, final hardware.



The software can be used to configure a send list even without the need to connect the evaluation board.



For more information, please refer to [www.endat.de](http://www.endat.de)  
Implementation ► EnDat 3



Figure 2: EnDat 3 Evaluation Board

### 6.3 Example programs

Example programs are available for testing the EnDat 3 communication. These can be found in the EnDat 3 Application Note. The programs should be tested together with the EnDat 3 Evaluation Board. However, these programs can also be ported relatively easily to a customer's own hardware, since they are based on the use of the EnDat 3 Master (and therefore on the same register control) from HEIDENHAIN.

The example programs are based on each other and illustrate the further steps on the path from a rudimentary implementation to the full performance range of EnDat 3.

Together with the EnDat 3 Evaluation Board, the EnDat Master, and the example programs from HEIDENHAIN, a comprehensive test and evaluation environment is obtained, which can also be used in the customer's application in exactly the same way.

### 6.4 The PWM 21 and ATS software

HEIDENHAIN encoders provide all of the information needed for commissioning, monitoring, and diagnostics.

For analysis of its encoders, HEIDENHAIN offers the PWM inspection devices and the PWT testing devices. The PWM inspection devices are universally deployable, feature low measuring tolerances, and can be calibrated.



As of the third quarter of 2020, the PWM 21 together with the ATS software will make it possible to analyze an EnDat 3 encoder if servicing is needed.



Figure 3: The PWM 21 and ATS software



For further information, please refer to: [www.heidenhain.de](http://www.heidenhain.de)  
Documentation ► Brochures ► Measuring and test equipment

## 7 Common implementation of EnDat 2.2 and EnDat 3

EnDat 3 includes the proven functional principles of EnDat 2.2, which were developed further for this purpose. The principles of communication differ significantly, however. With EnDat 3, special emphasis is placed on simple implementation and relief of the superordinate application.

At the same time, EnDat 3 is an interface that supports many different encoder models and functions with different access levels. This is complemented by comprehensive sensor handling.

The implementation effort therefore depends very much on the following questions, in a similar way as with EnDat 2.2:

- Which encoder models are to be supported, in particular BBMT and incremental?
- Which functions are to be supported?
- What is the scope of the sensor handling?
- Is functional safety supported?
- Is bus operation supported?

The example programs also include corresponding implementation options and have many similarities with the EnDat 2.2 implementation. As far as its basic structure is concerned, an existing EnDat 2.2 implementation can be used as a framework for the implementation of EnDat 3.

The implementation of EnDat 2.2 and EnDat 3 requires different EnDat Masters at the hardware level. There is currently no combined master permitting EnDat 2.2 and EnDat 3. Therefore, separate FPGA blocks must be implemented.

For a shared hardware layer of EnDat 2.2 and EnDat 3, the required 4-wire configuration according to the EnDat 3 Hardware Specification should be used.

## 8 References

### References

<b>Title</b>	<b>Document no.</b>
EnDat 3 Interface Specification	3000001-xx
EnDat 3 Hardware Specification	3000002-xx
EnDat 3 Application Conditions for Functional Safety	3000003-xx
EnDat 3 Master Instructions	3000004-xx
EnDat 3 Evaluation Board Product Information document	1300827-xx

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