



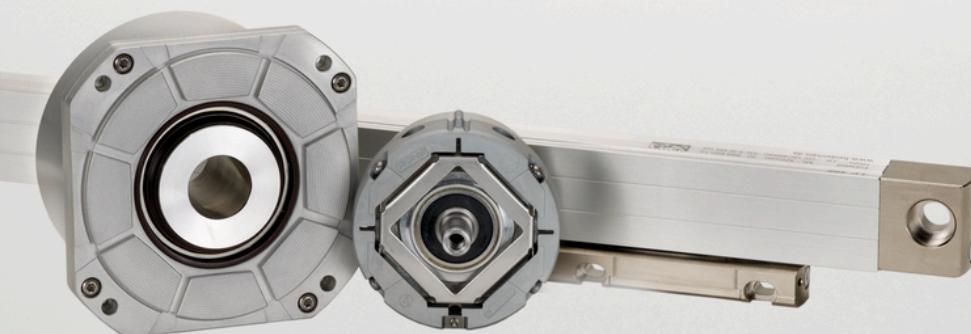
HEIDENHAIN



**Functional
Safety**

EnDat 2.2

EnDat 2.2
Implementation Guide



Contents

1 Fundamentals.....	3
2 Document target groups.....	4
2.1 Hardware development.....	4
2.2 Software development.....	4
2.3 Functionally safe applications.....	5
3 About these instructions.....	6
4 Notes on reading the documentation.....	7
5 FAQ.....	9
6 Overview of encoder characteristics.....	10
7 Aids for hardware and software.....	11
7.1 EnDat 2.2 Master.....	11
7.1.1 Overview.....	11
7.1.2 Versions from HEIDENHAIN.....	11
7.2 Example Programs.....	12
7.3 PWM 20 and EnDat 2.2 Demotool software.....	13
7.4 The PWM 21 and ATS software.....	14
8 References.....	15

1 Fundamentals

The EnDat 2.2 interface is typically implemented in four stages:

- Stage 1: Implementation of the physical layer: timing, "bits and bytes," etc.
- Stage 2: Communication on the basis of mode commands
- Stage 3: Implementation of complex processes, such as a memory access
- Stage 4: Integration of EnDat 2.2 communication into the controller structure, taking the various encoder profiles into account (absolute, incremental, linear, rotatory, etc.)

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



For the implementation of Stage 2, HEIDENHAIN recommends that you use one of the available EnDat masters.

Further information: "EnDat 2.2 Master", Page 11



For more information, please refer to **www.endat.de** under Implementation ► EnDat 2.2



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

2 Document target groups

2.1 Hardware development

Development of the hardware largely corresponds to Stage 1 of the implementation.

Physical layer

- EnDat 2.2 Interface Specification
- Electrical safety and electromagnetic compatibility

Digital design

- EnDat 2.2 Interface Specification

The EnDat 2.2 Interface Specification contains an exact description of timing and the "bits and bytes." The interface can be completely implemented with the help of the EnDat 2.2 Interface Specification.



HEIDENHAIN recommends that you use one of the solutions described in the chapter "EnDat 2.2 Master".

Further information: "EnDat 2.2 Master", Page 11

Using one of these solutions reduces the time to market and ensures error-free communication.

It also minimizes the effort needed for testing.

2.2 Software development

Software development largely corresponds to Stages 2 through 4 of the implementation.

- EnDat 2.2 Master Manual
- EnDat 2.2 Interface Specification
- EnDat 2.2 Application Notes
- PWM 20 with the EnDat Demotool software

Stage 2: Communication on the basis of mode commands

The communication between the control and the EnDat encoder is based on mode commands. In Stage 2 of the implementation, the mode commands are used in order to establish basic communication with the encoder.

HEIDENHAIN makes the Demotool software available, which makes it possible to send individual mode commands to the encoder. The customer can very easily add a "low-level" application software to test the mode commands together with the EnDat 2.2 Master Softmacro. Communication is based on simple register accesses.

Stage 3: Implementation of complex processes, such as a memory access

Stage 3 of the implementation requires processes that encompass the sending of multiple mode commands. With these processes, more complex tasks, such as a memory access, are handled. For this purpose, the annex of the EnDat 2.2 Interface Specification includes flowcharts that explain the required steps in detail.

Stage 4: Integration of EnDat 2.2 communication into the controller structure

In the final stage of the implementation, the processes must be integrated into the controller structure, taking the various encoder profiles into consideration (absolute, incremental, linear, rotatory, etc.).



For more information, please refer to the "How to get started" chapter in the EnDat 2.2 Application Notes

2.3 Functionally safe applications



For functionally safe applications, additional documents must be taken into consideration.

Further information: "Notes on reading the documentation", Page 7



Regarding the EnDat 2.2 Master, in functionally safe applications, both the EnDat 2.2 Master Safe and the non-functionally safe versions can be used, of which the EnDat 2.2 Master Basic is specifically designed for this.



For more information, please refer to **www.endat.de** under
Implementation ► EnDat 2.2

3 About these instructions

The EnDat 2.2 Implementation Guide provides an overview of which documents and document content are intended for which readers.



For more information, please refer to **www.endat.de** under
Implementation ► EnDat 2.2



For individual advice on optimal implementation of the EnDat 2.2 interface, please consult
with your HEIDENHAIN contact person.

4**Notes on reading the documentation****Pertinent documentation**

The table below lists the various parts of the documentation in their order of reading priority.

Documentation	Description
EnDat 2.2 Technical Information	This Technical Information document provides an overview of the interface. It is not an interface specification.
EnDat 2.2 Implementation Guide	The Implementation Guide provides an overview of which documents and document content are intended for which readers, and which aids are available for implementation.
EnDat 2.2 Interface Specification	The Interface Specification contains detailed and complete information regarding the physical interface, timing, and transmitted data contents. This information is required for implementation of the EnDat 2.2 interface.
EnDat 2.2 Master Instructions	The Master Instructions describe the EnDat 2.2 Master provided by HEIDENHAIN.
EnDat 2.2 Application Notes	The Application Notes describe the functionalities, processes, mechanisms, encoder functions, and other topics from the perspective of the application.
Electrical safety and electromagnetic compatibility	Information about electrical safety and electromagnetic compatibility can be found in the corresponding section of the "Interfaces of HEIDENHAIN Encoders" brochure. The documentation for the respective encoder must be observed as well.
EnDat Seminar	The EnDat Seminar provides detailed information surrounding the various aspects of the EnDat 2.2 interface, such as the EnDat 2.2 interface specification, information on cables and connecting elements, information about the EnDat Master, practical exercises for communicating with EnDat encoders via mode commands, and information on online diagnostics, zero point shift, etc.
Functional safety	Documents for the implementation of functional safety with the EnDat 2.2 interface: Catalog of measures, requirements for position value comparison, supplementary catalogue of measures for SIL 3, use of a non-functionally-safe EnDat 2.2 Master, etc.

Further information on the pertinent documentation

For more information, please refer to **www.endat.de** under
Implementation ► EnDat 2.2



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

FAQ

The FAQ (Frequently Asked Questions) are a collection of frequently asked questions and their answers regarding specific topics.



For more information, please refer to **www.endat.de** under
Implementation ► EnDat 2.2

6

Overview of encoder characteristics

The extensive HEIDENHAIN product portfolio of linear, encoders, angle encoders, 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 types. These characteristics are modelled by the EnDat 2.2 interface and are reflected in the memory contents or functions of the encoder.



For more information, please refer to www.endat.de under
Implementation ► EnDat 2.2

7 Aids for hardware and software

7.1 EnDat 2.2 Master

7.1.1 Overview

The EnDat 2.2 Master handles the communication with EnDat 2.2 encoders from HEIDENHAIN. This makes it easy to transfer the information transmitted via the EnDat 2.2 interface to the higher-level application. The EnDat 2.2 Master can be integrated by means of a microcontroller (μ C), an FPGA (Field Programmable Gate Array), or an ASIC.

The solutions with a μ C are used when the desired clock frequencies are relatively low. For integration into a μ C, HEIDENHAIN offers example code for implementation of the EnDat 2.1 mode commands. There are now also μ C-based solutions with an integrated EnDat 2.2 Master (e.g., from Texas Instruments, Renesas, or Hilscher).

Integration into an FPGA or ASIC is usually opted for when high transmission frequencies are desired with purely serial data transmission. Different versions are available for integration into an FPGA or ASIC.

7.1.2 Versions from HEIDENHAIN

EnDat 2.2 Master Basic

For implementation of the EnDat 2.2 interface into the subsequent electronics, an FPGA or ASIC is sufficient as a master. This is due to the purely serial data transmission. To facilitate integration of the EnDat 2.2 Master into the subsequent electronics, an EnDat 2.2 Master Softmacro ("EnDat 2.2 Master Basic") has been developed that exhibits the following key characteristics:

- Encapsulated, HEIDENHAIN-tested code block
- The implementation of the code block is secured through test vectors
- Designed for a short time to market
- All EnDat 2.2 encoders from HEIDENHAIN are supported

EnDat 2.2 Master Reduced

- Only the pure EnDat functionality (EnDat protocol machine) is integrated
- All EnDat encoders from HEIDENHAIN are supported
- Time to market: unfavorable compared with the EnDat 2.2 Master Basic, because more extensive testing is required
- There is no microcontroller interface or further support for convenient handling of the code
- Due to the limited functionality, the code size is smaller compared with that of the EnDat 2.2 Master Basic
- The code was tested only in an example application
- Concise documentation is available

EnDat 2.2 Master Mini

- Specially designed for the FPGA Lattice MachXO2-1200 in order to take advantage of the special features of this FPGA
- Based on the EnDat 2.2 Master Reduced with an additional register interface and SPI interface
- Time-to-market: optimal, since, in the simplest case, the programming file provided with shipment is used

EnDat 2.2 Master Light

- VHDL example code, which covers only a part of the EnDat 2.2 functionality
- Only absolute EnDat 2.2 encoders are supported; no incremental encoders or encoders with battery buffer backup are supported
- Time-to-market: unfavorable compared with the EnDat 2.2 Master Basic, because more extensive testing is required
- In purely serial operation, only the position is transferred without any EnDat 2.2 additional data. Thus, only a part of the functionality of the EnDat 2.2 interface is modelled
- There is no further support regarding the convenient handling of the code, nor is there a micro-controller interface
- The code size is considerably smaller than of the Basic and Reduced variants
- The code was tested only in an example application
- Concise documentation is available (in English only)

7.2 Example Programs

EnDat 2.2 Master

For the EnDat 2.2 Master Basic or Safe from HEIDENHAIN, example programs for driving the master are included in delivery.

EnDat 2.2 Master based on a µC

For integration into a µC, HEIDENHAIN offers example code for the implementation of the EnDat 2.1 mode commands.

EIB 700

The EIB 700 series are external evaluation electronics for precise position measurement, especially for inspection stations and multipoint inspection apparatuses, as well as for mobile data acquisition, such as during machine calibration. For the sake of processing measured values on a PC, the items supplied include driver software for Windows, Linux and LabVIEW, as well as example programs and the EIB application software. The driver software enables customers to easily program their own applications. For the EIB 700, an example program is available that demonstrates how various EnDat 2.2 features can be implemented from the perspective of the subsequent electronics.

EnDat 2.2 Application Note

The EnDat 2.2 Application Note contains implementation examples that show how communication with the encoder is established and how certain features are implemented.

7.3 PWM 20 and EnDat 2.2 Demotool software

The communication between the encoder and the subsequent electronics via the EnDat 2.2 interface is based on mode commands sent to the encoder by the subsequent electronics. The mode commands determine the specific data content to be transmitted, such as the position value, parameters, diagnostics, etc.

The Demotool software can run on the PWM 20 and enables easy communication with the encoder based on the mode commands:

- Display of the values returned by the encoder (position data and additional data)
- Entry of the parameters to be transmitted to the encoder for each mode command
- Display of communication error conditions
- Adjustment of the transmission frequency
- The communication is recorded on a log page for later analysis
- EnDat 2.1 and EnDat 2.2 mode commands are supported

These features support the design process in the following manner:

- In the first step, communication can be tested with mode commands outside of the control loop
- Utilization as a reference in the course of integration of the EnDat 2.2 Master within the control loop
- Servicing of encoders by means of the ATS software and the PWM 20



For further information, please refer visit:www.heidenhain.de

Documentation ► Brochures ► Measuring and test equipment



Figure 1: The PWM 20 with the EnDat 2.2 Demotool software

7.4 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. In conjunction with the ATS software, the PWM 21 enables an analysis of an EnDat 2.2 encoder in the event of servicing.



Figure 2: The PWM 21 and ATS software



For further information, please refer visit:www.heidenhain.de
Documentation ► Brochures ► Measuring and test equipment

8 References

References	
Title	Document no.
EnDat 2.2 Interface Specification	297403-xx
EnDat 2.2 Application Notes	722024-xx
EnDat 2.2 Application Conditions for Functional Safety	533095-xx
Safety with EnDat 2.2 and Non-Safe EnDat Master	1128897-xx

HEIDENHAIN

DR. JOHANNES HEIDENHAIN GmbH

Dr.-Johannes-Heidenhain-Straße 5

83301 Traunreut, Germany

 +49 8669 31-0

 +49 8669 32-5061

E-mail: info@heidenhain.de

Technical support  +49 8669 32-1000

Measuring systems  +49 8669 31-3104

E-mail: service.ms-support@heidenhain.de

NC support  +49 8669 31-3101

E-mail: service.nc-support@heidenhain.de

NC programming  +49 8669 31-3103

E-mail: service.nc-pgm@heidenhain.de

PLC programming  +49 8669 31-3102

E-mail: service.plc@heidenhain.de

APP programming  +49 8669 31-3106

E-mail: service.app@heidenhain.de

www.heidenhain.de

