Technical product description EMD3P

Powering Business Worldwide

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1 Scope of the document

1.1 Purpose of the document

This technical product description specifies the technical and configurable features as well as the product variants of the EMD3P.

1.2 Legal Notice

1.3 Referenced documents

Table 2 Referenced documents

Reference	Document Title/Description	Version / Date	Creator
/MBSpec/	Modbus specification of the EMD3P File: Modbus_Specification_EMD3P FW X.XX Rev. Y.pdf	0014	Eaton Industries (Austria) GmbH
/mDNSSpec/	Multicast DNS RFC6762 ISSN: 2070-1721	February 2013	S. Cheshire M. Krochmal Apple Inc.
/YMOD/	XMODEM/YMODEM PROTOCOL REFERENCE	14.10.1988	Chuck Forsberg

1.4 Abbreviations used

Table 3 Abbreviations

Abbreviation	Designation
HTTP	Hypertext Transfer Protocol
PAP	Program schedule
RTU	Remote Terminal Unit
TCP	Transmission Control Protocol
TE	Dividing unit
URL	Uniform Resource Locator

2 Hardware functions

2.1 LED states

2.1.1 "STATUS" LED

- Green permanent light: The EMD3P is switched on.
- Flashing green slowly: EMD3P is in update mode and the web interface is active.
- Flashing orange quickly: The firmware update is in progress.
- Continuous red light: A critical error has occurred.
- Flashing orange twice: The action of restoring the factory settings via the reset button has been detected.

2.1.2 LED "NETWORK"

- Off: No connection.
- Green permanent light: The Ethernet link is active.
- Flashing green: Communication is taking place via Modbus TCP.
- Flashing red: A communication error has occurred with Modbus TCP.

2.1.3 LED "SERIAL BUS"

- Off: There is no activity on the interface.
- Flashing green quickly: There is regular data communication.
- Flashing red: A communication error has occurred with Modbus RTU.

2.1.4 Identification of the device

To identify a Modbus device, it is possible to identify it using the LEDs. The setting of this method is described in chapter 3.1.7. After entering the necessary parameters, the device can be identified by the flashing of all installed LEDs.

2.2 Reset button functions

The functions of the reset button are described in the following chapters. The reset button can also be used to start the bootloader, see chapter 7.1.

2.2.1 Restart

Press and hold the RESET button with a pointed object for longer than 10 seconds. The device will then restart.

2.2.2 Reset to factory settings

Press and hold the RESET button with a pointed object briefly (<0.5 seconds) and then a second time between 3 and 5 seconds within 1 second to reset the device to factory settings. If the entry is successful, the status LED flashes orange twice. If an incorrect entry is made, you must wait 2 seconds before attempting to make a new entry.

For more information on resetting to factory settings, see chapter 3.3.

3 Device setting

3.1 Settings via Modbus

3.1 Settings via Modbus

The following sub-chapters describe the configurable values via Modbus.

If an entry is made outside the value range, the EMD3P returns the Modbus exception code 0x03 Illegal Data Value.

3.1.1 Measuring interval

The measuring interval can be set via Modbus register 256 (0x0100). The value to be set represents the interval as follows.

Table 4: Configuration of measuring interval

Value	Measuring interval
1	100 ms
2	200 ms
3	500 ms
4	1000 ms

3.1.2 Modbus RTU Baud rate

The Modbus RTU baud rate can be set via Modbus register 258 (0x0102). The value to be set represents the baud rates as follows.

Table 5: Configuration Modbus RTU Baud rate

Value	Measuring interval
0	9600 Bd
1	14400 Bd
2	19200 Bd
3	38400 Bd
4	57600 Bd
5	115200 Bd

3.1.3 Network parameters

For information on the network configuration, see chapter 6.1.

3.1.4 Read Only Flag

The Read Only flag is a parameter that can be set once and prevents further configuration. It can be activated by writing the value “1” to Modbus register 268 (0x010C).

⚠ ATTENTION: READ ONLY FLAG

Once the Read Only flag has been activated, only Modbus read access (Function Code 0x3) to the configuration registers is possible. A write access leads to the Modbus exception code 0x03 Illegal Data Value.

To deactivate the Read Only flag, the device must be reset to factory settings. For further information, see 3.3.

3.1.5 Phase assignment

For phase assignment, the current and voltage inputs can be assigned via Modbus register 269 (0x010D). The value to be set represents an assignment according to Table 4.

Table 6: Assignment of current/voltage inputs

Value	V1	V2	V3
0	I1	I2	I3
1	I1	I3	I2
2	I2	I1	I3
3	I2	I3	I1
4	I3	I1	I2
5	I3	I2	I1

3.1.6 Phase polarity

In addition to the assignment of the current/voltage inputs, the individual phase polarity can also be defined using Modbus register 270 (0x010E). The value to be set represents an assignment according to Table 5.

Table 7: Phase polarity
(0 for normal polarity, 1 for inverse polarity)

Value	L1	L2	L3
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

3.1.7 Modbus identification

To identify a Modbus device, an optical test is carried out via the installed LEDs. Registers 61613 (0xF0AD) and 61614 (0xFOAE) are provided to configure this test, with the former setting the flashing frequency and the latter the duration of the identification test.

Values between 100 and 10000 mHz are possible as flashing frequency, and up to 600 seconds are permissible as duration.

Setting the time duration leads directly to the execution of the test.

3.2 Factory setting

After delivery or after a successful reset to factory settings, the EMD3P is configured as follows.

Table 8: Configuration Factory setting

Parameters	Value
Current transformer profile	Depending on product variant
Measuring interval	200ms
Network configuration	DHCP enabled
ModBus TCP Unit ID	1
Modbus RTU Baud rate	115200
Modbus RTU Parity	Even
Modbus RTU Stop Bit	1
Modbus RTU Server ID	Consecutive; printed on side label & add. label
Read Only Flag	Not active
Phase assignment	V1I1 V2I2 V3I3
Phase polarity	Polarity not reversed

As the Read Only flag is reset, the user can reconfigure it. For more information on the read only flag, see chapter 3.1.4.

For the required key combination for resetting to factory settings, see chapter 2.2.2.

4 Data acquisition

After the device is supplied with power, the measured values are available after 5s at the latest. A restart via Modbus or push-button does not lead to this delay.

4.1 Measured values

To identify a Modbus device, an optical test is carried out via the installed LEDs.

The following data is calculated by the EMD3P and can be queried via Modbus. For the supported measuring intervals, see chapter 3.1.1. The energy values are recorded as a balance.

- Total active power
- Total reactive power
- Total apparent power
- Total imported energy
- Total exported energy
- Total inductive energy
- Total capacitive energy
- Total imported apparent energy
- Total exported apparent energy
- Total power factor
- Frequency
- Voltages between the phases

The following measured values are determined for each of the three phases.

- RMS Current
- RMS Voltage
- Active power
- Reactive power
- Apparent power
- Imported energy
- Exported energy
- Inductive energy
- Capacitive energy
- Imported apparent energy
- Exported apparent energy
- Power factor

4.2 Brownout detection

The EMD3P saves the energy values as soon as a low supply voltage is detected.

4.3 Fault memory

Critical system errors and warnings are saved persistently in the EMD3P for servicing. These can be read out by Eaton Industries (Austria) GmbH in the event of a service case.

5 Modbus interfaces

The functionality, the operating modes and the Modbus register specification are described below. A detailed description of the Modbus protocol and its functionality can be found in the Modbus specification (see www.modbus.org). Modbus TCP is part of the IEC 61158 standard.

The Modbus data interface can be used in the following operating modes:

- Modbus RTU Server
- Modbus TCP Server

Parallel operation of Modbus TCP and Modbus RTU is not supported.

For information on the OBIS key figure system and a Modbus register overview, see /MBSpec/.

5.1 Modbus RTU

As a Modbus RTU server, the EMD3P provides its Modbus registers via Modbus RTU. For this purpose, the EMD3P has an RS-485 interface, which is connected to the outside via two sockets connected in the same way.

Figure 0: Modbus connection

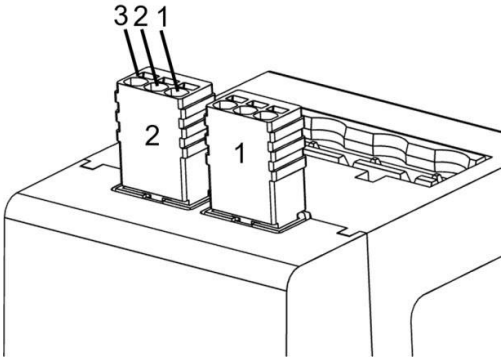


Table 9: RS-485 connection diagram

Pin	Labeling	Description
1	GND	Ground
2	A	RS485 A
3	B	RS485 B

Details on the connection to the RS-485 sockets and the polarity reversal of the interface can be found in the installation instructions.

The parity and the number of stop bits can be configured during production depending on the device.

5.1.1 Scheduling

Depending on the cable length and the number of devices on the bus, it is advisable to terminate the bus at both ends with a 120 Ohm resistor. Termination reduces reflections in the connection. This may be essential for the reliability of the application and to avoid transmission errors.

5.1.2 Idle-line failsafe

The developer of an RS-485 system must ensure that a defined level is always present on the bus. This also applies if all drivers are in the passive state.

To operate the EMD3P on a bus, the idle line failsafe must be ensured by the remote station or externally.

5.2 Modbus TCP

The Modbus TCP function is provided by the EMD3P on port 502.

The client must send the unit ID of the EMD3P with read/write commands.

The unit ID can be configured during production and may differ from the Modbus RTU unit ID. A maximum of 4 simultaneous Modbus TCP connections are supported.

6 Network

6.1 Network configuration

The network configuration is carried out via Modbus TCP/RTU.

The following parameters can be set via the specified Modbus registers.

Table 10: Network configuration via Modbus

Modbus register		Parameters	Values
Dec.	Hex.		
259 - 262	x103 - x106	Static IP address	One register for each octet of the static IP. Example IP address: 192.168.1.55 Register 259: 192 Register 260: 168 Register 261: 1 Register 262: 55
263 - 266	x107 - x10A	Subnet mask	One register for each octet of the subnet mask. s. Example: Static IP address
267	x10B	DHCP	DHCP active/not active 0: DHCP not active 1: DHCP active

Network configuration is not possible if the Read Only flag is active. For further information, see 3.1.4.

The settings only become active after the device is restarted. To restart the device, the reset button can be pressed or the value “1” can be written to Modbus register 61615 (0xF0AF).

6.2 mDNS

Every EMD3P supports mDNS for network discovery. For the mDNS specification see /mDNSSpec/

The EMD3P offers the service types _mbap._tcp and _http._tcp in the application. _http._tcp is only active if the configuration web server is switched on. Both mDNS services can be found under the instance name Product name-Serial number. Furthermore, both offer a generic part in the attached text field for unique identification of the device.

The structure is as follows:

```
manufacturer=<manufacturer> type=”Energy Meter”
model=<product name> mac=<MAC>
software=<SW Version> serial=<serial number> txtvers=1
```

As additional information, the unit ID for EMD3P is attached to _mbap._tcp in the following form:

```
unitid=<unit ID>
```

The service type _http._tcp is supported in the bootloader; this also implements the generic text and can be found under the instance name product name-serial number.

The service type _http._tcp is accompanied by a line in the text field of the mDNS service to identify the purpose. For the application, this results in the line:

```
function=configuration
```

For the bootloader, the line attached.

```
function=update
```

6.3 TCP Keepalive

A TCP keepalive mechanism is implemented, which is used to recognize and close connections that are not properly closed.

If a connection is inactive for 10 minutes, the EMD3P sends a keep-alive packet to the remote station by default. If the connection is intact and the remote station is reachable, the keep-alive packet is acknowledged and the timer is reset. If the remote station cannot be reached or the connection is not intact, the EMD3P sends another keep-alive packet up to 4 times. If the remote station does not respond to any of the packets, the connection is closed by the EMD3P. The TCP keep-alive can be adjusted via the production data. The time between the last activity and the start of the mechanism as well as the interval between two TCP keep-alive packets and their frequency can be set. Time settings are specified in seconds.

7 Update

Depending on the model variant, either an update via web server front end or HTTP, or via RS485 is supported.

For devices with a LAN interface and an RS485 interface, only the update via web server front end or http is supported.

Regardless of the update path, the name of the update file must be “EMD3P.UP” and the file size must be exactly 552 kB or 565248 bytes.

7.1 Start bootloader

Press and hold the RESET button for approx. 15 seconds until the device restarts and the Status LED flashes green.

An alternative option is to write the value 0xA0B1 to the bootloader register via Modbus TCP/RTU. If writing is successful, the status LED flashes green.

7.2 Update via web server frontend

An update via the web server is only supported for devices with a LAN interface. The bootloader version is displayed in the bottom left-hand corner.

The functions described in this chapter were tested with the following browsers:

- Google Chrome - Version 114.0.5735.110
- Microsoft Edge - Version 114.0.1823.51

.7.2.1 Perform update

If the EMD3P is in the bootloader, a web server opens which can be accessed via the IP address of the device (see Figure 1).

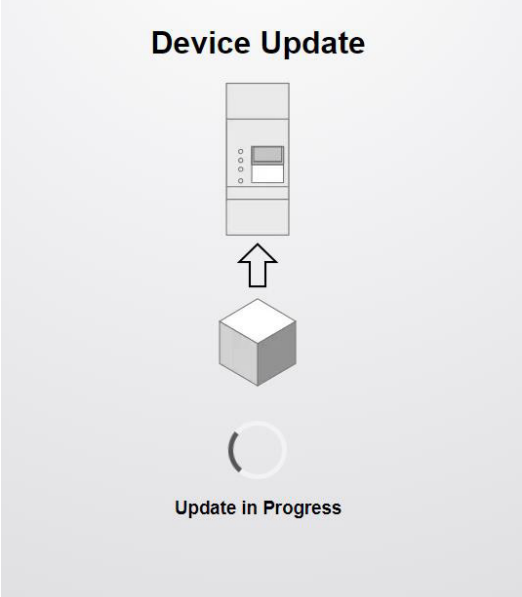
Figure 1: Web server of the EMD3P

The update file can be selected using the “Select file” button. Only files with the name “EMD3P.UP” are accepted.

The update process is started with the “Upload” button. If authorization is activated, the password must be entered in a separate field. For further information, see chapter 0.

During the update, the status LED of the EMD3P flashes orange quickly and the web server displays “Update in progress” (see Figure 2).

Figure 2: Web server during the update process

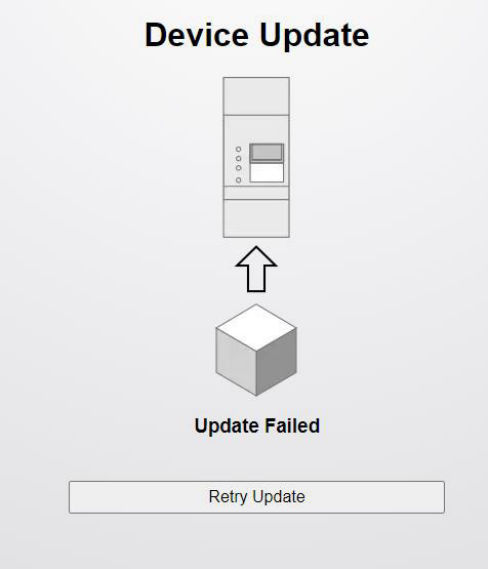


If the update is successful, the web server displays “Update successful” (see Figure 3) and the EMD3P restarts automatically. The website can now be closed.

Figure 3: Web server update successful

If the update fails, the web server displays “Update Failed” (see Figure 4) is displayed. By pressing the “Retry Update” button, the start page (see Figure 1) is called up and the update process can be restarted.

Figure 4 Web server update error



7.2.2 Authorization

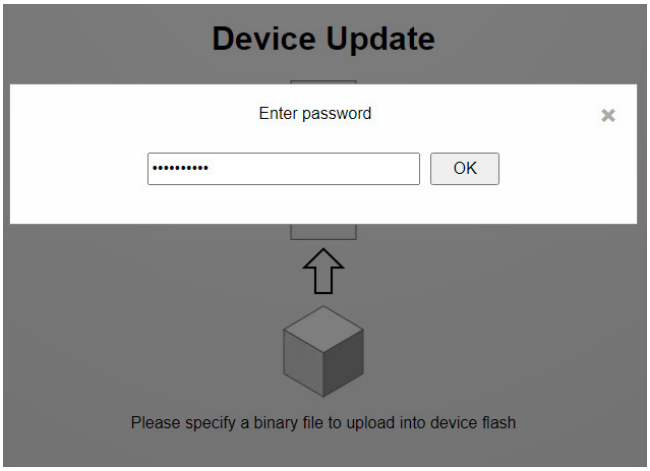
At the time of production, it is possible to activate the authorization function via the customer- specific production data. As soon as this is active, the user or remote station must transmit a password in order to be able to carry out an update.

A randomly generated, 10-digit password consisting of upper and lower case letters, numbers and special characters is created for each device during production and printed on the device-specific insert label.

The serial number of the respective device is appended to the generated password as a salt. This character string is used to calculate a SHA256 hash, which is written to the memory of the EMD3P. No password is stored in the device itself.

The input field for entering the password is shown in Figure 5 is shown.

Figure 5 Password input update



As soon as a password is transmitted to the EMD3P, the device calculates the hash of the transmitted password and compares the result with the value stored in the memory. If they match, the update is carried out as described in chapter 7.2.1 is carried out. If the password is not correct, the user is prompted to enter the password again (see Figure 6).

Figure 6 Invalid password

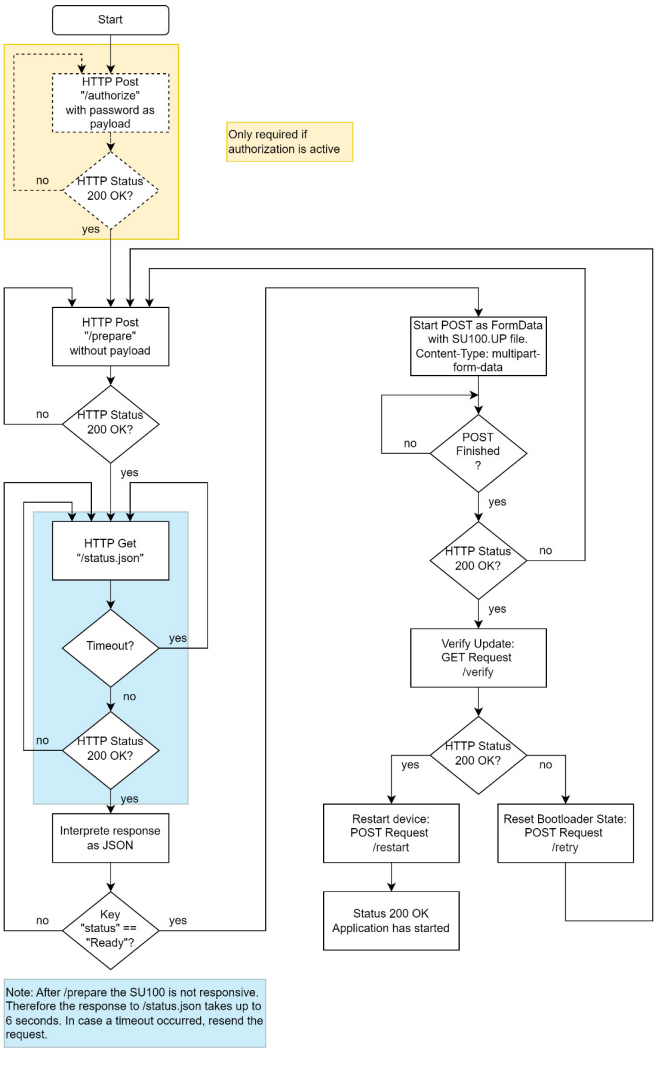
7.3 Update via HTTP interface

The bootloader of the EMD3P offers an HTTP interface, which enables the implementation of an own remote station.

7.3.1 Program schedule

The following illustration shows the PAP of the update process.

Figure 7 Update procedure



7.3.2 Description

The update process is described in brief below.

- If a valid application is available, it is started after the EMD3P is supplied with power. In this case, the bootloader must be started either via Modbus (see /ModbusSpec/) or by pressing a button (see chapter 7.1) must be activated.
- If no valid application is available, the EMD3P is in the bootloader. The status LED flashes green and the web server is available.
- To ensure that the web server is accessible, a GET request to /status.json can be executed at any time.
- If the authorization function is activated, a POST request / authorize with the password as plain text must be carried out in order to activate the routes /prepare /update and / verify. If authorization is active and no password has been transmitted, all accesses to the routes are answered with 400 Bad Request.
- Before transferring the update file, a POST request must be executed on /prepare. This request deletes the existing application and prepares the internal memory. The request is acknowledged directly with an HTTP response. The actual process can take up to 6 seconds on the part of EMD3P.
- The EMD3P is not accessible during this time. If a GET request to /status.json fails, it must be repeated.
- After /prepare has been successfully executed, the current status must be verified with a GET request to /status.json. This must be "Ready".
- The update file is transferred with the POST request on / update. The file should be transferred using the FormData interface. The name of the update file must be "EMD3P.UP".
- If the transfer is successful, the correctness of the update can be checked with a GET request on /verify.
- To exit the bootloader, a POST request to /restart must be executed. The EMD3P then starts the application.
- If an update fails, a POST request to /retry must be executed before the update process can be restarted
- If a POST request is executed during an active update process, it always returns 400 Bad Request as HTTP response. GET requests can also be executed during an update process.
- If a GET request is executed on /verify without an update having been carried out beforehand, this always returns a 400 Bad Request as the HTTP response.
- If a POST request is executed on /update without a POST request having previously been executed on /prepare, this always returns a 400 Bad Request as the HTTP response.

7.3.3 Available URLs

The following sections describe the available URLs that are required for the update process.

A description of the HTML files provided by the web server is not described, as these are not relevant for the creation of a client.

If an unavailable URL is called up, the HTTP status code 404 is returned

GET methods

The following sections describe the GET methods that are supported by the bootloader of the EMD3P.

/verify

The /verify method can be used to query the success status of a completed update.

Note: The response code 400 is always returned if the URL is called without an update having been carried out in advance

Table 11: /verify

Format	Return values	Description
HTTP Response Code	HTTP Code 200 - Status OK	The update has been successful. To switch to the new application, the EMD3P must be restarted.
	HTTP Code 400 - Bad Request	The update has failed. To perform the update again, the /prepare method must be executed.

/status.json

The method status.json is used to query the internal status of the bootloader.

Table 12: /status.json

Format	Return values	Description
JSON "status" key	HTTP Code 200 - Status OK	The update has been successful. To switch to the new application, the EMD3P must be restarted.
	HTTP Code 400 - Bad Request	The update has failed. To perform the update again, the /prepare method must be executed.

/version.json

The /version.json method is used to query the version of the bootloader.

Table 13: /version.json

Format	Return values	Description
JSON "version" key	"vA.B.C"	A - Major Version B - Minor Version C - Patch version

POST methods

The following chapters describe the POST methods that are supported by the bootloader of the EMD3P. No payload is required for all methods. The evaluation should be carried out using the HTTP response code.

/prepare

The EMD3P is prepared for an update using the /prepare method. The process can take up to 6 seconds, which must be taken into account during implementation. The EMD3P switches to the "Prepare" state after the request has been received. No HTTP requests can be processed in this state.

After the /prepare method, the status must be queried using GET /status.json.

⚠ ATTENTION: NOTE ON THE /PREPARE METHOD

After the /prepare method has been successfully executed, the existing EMD3P application is deleted. The device is then not ready for operation. To restore the operating status, a valid update must be carried out.

Table 14: /prepare

Return values	Description
HTTP Code 200 - Status OK	The EMD3P switches to the "Prepare" status. In this status, the EMD3P cannot process any further HTTP requests until the "Ready" or "Error" status is active.
HTTP Code 400 - Bad Request	An update file is currently being transferred

/upload

The /upload method is used to transfer the update file data. It is recommended to use the FormData interface for this.

The EMD3P checks the file name after receiving the first packet. This must always be "EMD3P.UP".

Table 15 /upload

Return values	Description
HTTP Code 200 - Status OK	The EMD3P switches to the "Prepare" status. In this status, the EMD3P cannot process any further HTTP requests until the "Ready" or "Error" status is active.
HTTP Code 400 - Bad Request	The following options are available: - An update file is already being transferred - The EMD3Ps are not in the "Ready" state - The HTTP "Content-Disposition" header does not contain "filename=EMD3P.UP"

/restart

The /restart method is used to restart the EMD3P.

Table 16: /prepare

Return values	Description
HTTP Code 200 - Status OK	The EMD3P restarts. If a valid application is available, it is executed. If the application is invalid or does not exist, the EMD3P remains in the bootloader.
HTTP Code 400 - Bad Request	An update file is currently being transferred.

/retry

The /retry method resets the internal state of the EMD3P bootloader.

Table 17: /retry

Return values	Description
HTTP Code 200 - Status OK	The EMD3P switches to the "Idle" state.
HTTP Code 400 - Bad Request	An update file is currently being transferred.

/authorize

The /authorize method transfers the password that is used to unlock the methods required for an update. The password is transferred as plain text.

Table 18: /authorize

Return values	Description
HTTP Code 200 - Status OK	The transmitted password is correct.
HTTP Code 400 - Bad Request	The transmitted password is not correct.

7.4 Update via RS485

The applications are transmitted via the YMODEM protocol. Packet sizes of 128 bytes and 1024 bytes are supported.

For more information on the YMODEM protocol, see /YMOD/.

7.4.1 Procedure

1. Activating the bootloader

The bootloader of the device must be activated. See chapter 7.1.

2. Ready to receive

The device is ready to receive as soon as the character "C" or the value 0x43 is sent every second via the RS485 interface. In this state, the status LED flashes green.

3. Transfer of the update

During transmission, the status LED flashes orange and the "SERIAL BUS" LED flashes green to indicate activity on the RS485 bus.

The update data is transmitted in encrypted form and decrypted and processed by the EMD3P.

⚠ ATTENTION: NOTE ON ABORT/FAILURE DURING AN UPDATE

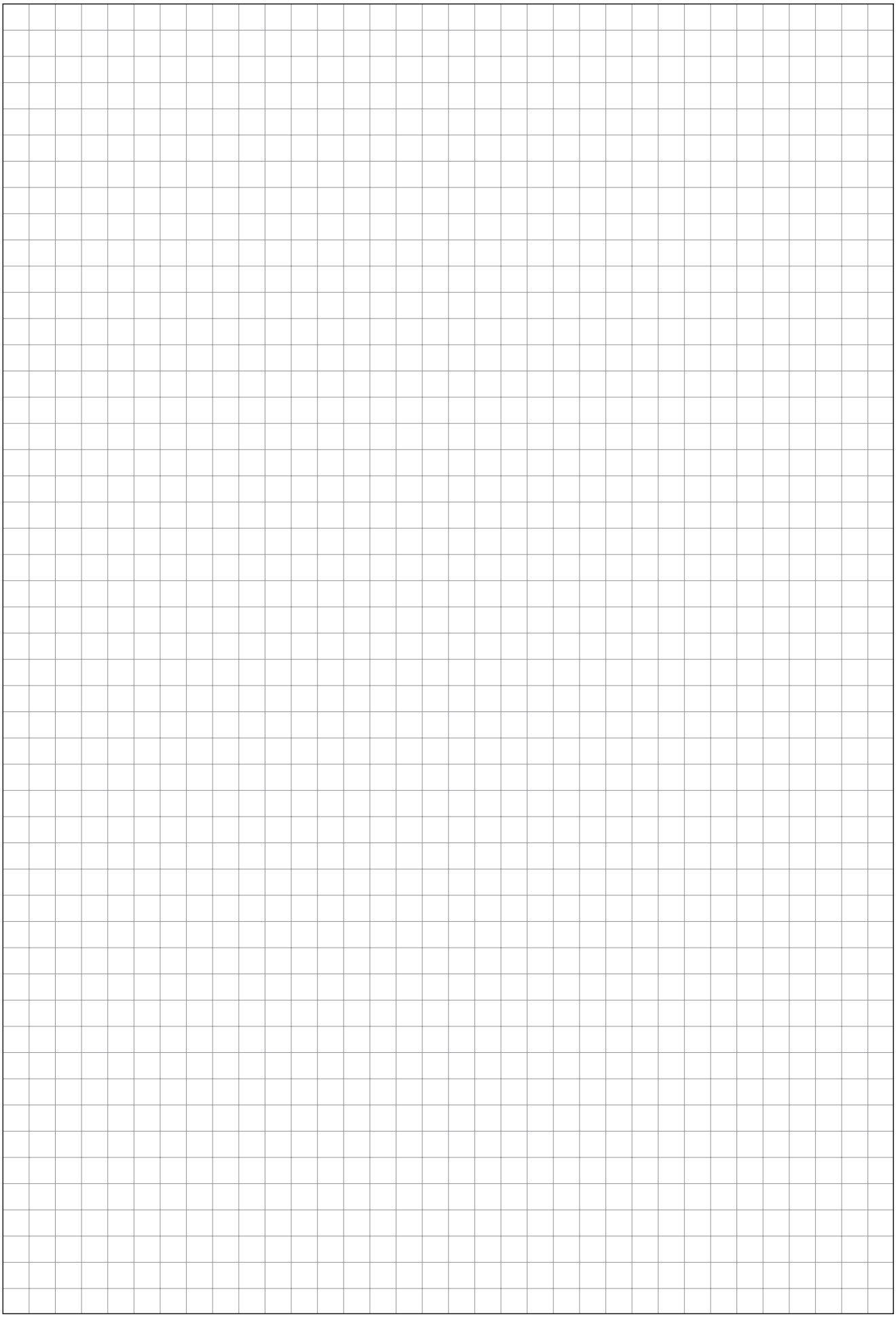
After the first data packet has been transmitted, the application is deleted. If the update is interrupted or fails, the EMD3P only starts the bootloader. A successful update must be carried out to restore the functionality.

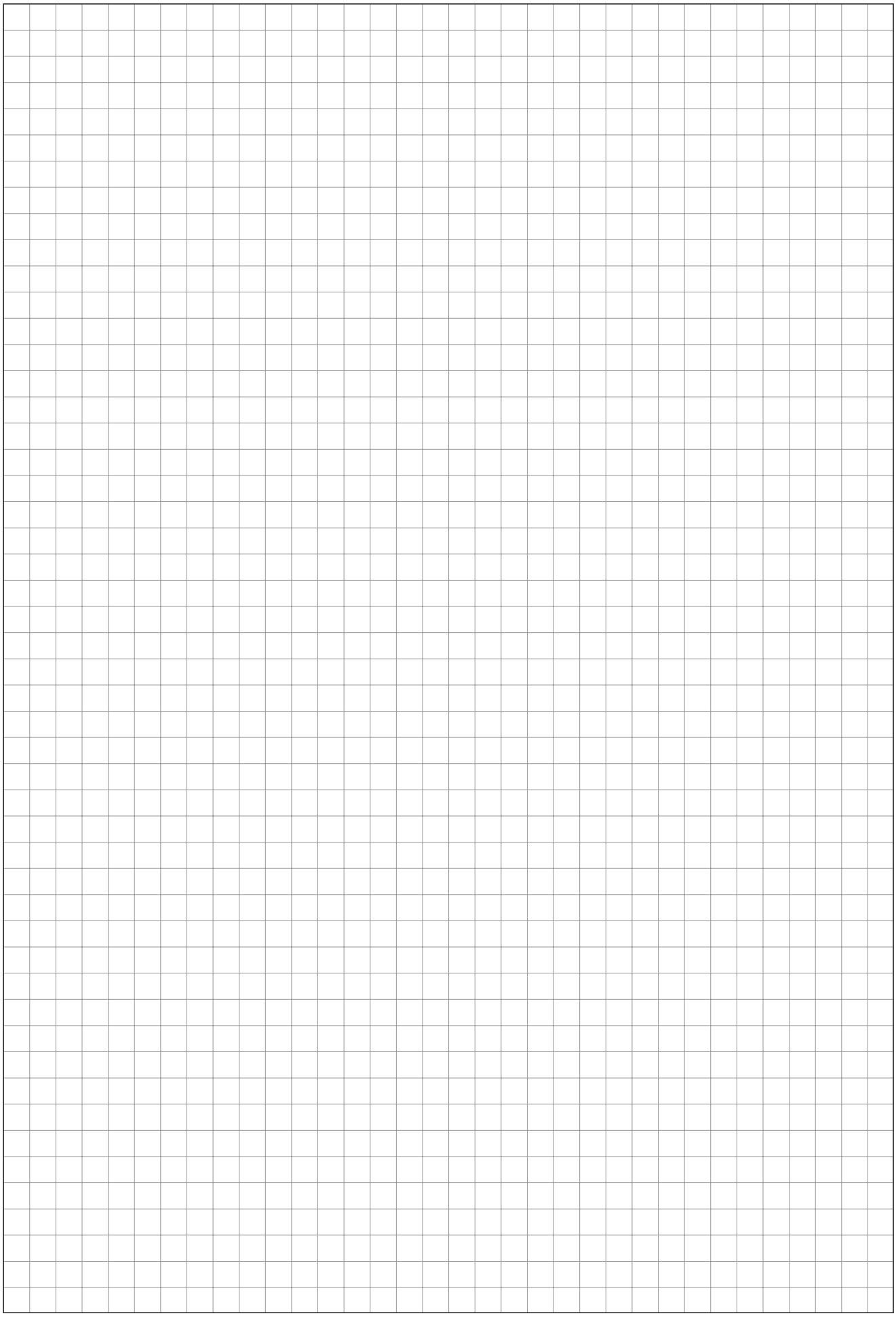
4. Completion

If the update is successful, the application is started automatically and the status LED lights up permanently green, or red in the event of an error.

If the application is in an error state, this is not due to a failed update. As soon as the application starts, the update was successful in any case.

If the update fails, the EMD3P is still in the bootloader (status LED flashes green) and transmits the character "C" or the value 0x43 every second.





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