Manual Professional II Lora

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1491	V1.0	01.07.2021	fbo, met	EMU Electronic AG	Creation of Document
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LoRa Interface

This document is a follow up for the EMU Professional II documentation (Doc.Ref 1451).

- The EMU Professional II Lora is compatible to LoraWAN ⩾ 1.0.3 (Class C).
- The EMU Professional II Lora permanently saves the needed parameters for Lora and its configuration on the Lora-module.
- A re-parametrization is only possible via the meter display or via a Lora downlink message.
- The EMU Professional II Lora autonomously synchronizes its internal clock at least once per day via a regularly scheduled DeviceTimeReq.
- The EMU Professional II Lora determines and optimizes its own transmit parameters (data rate, SF-factor etc.).
- The default meter uses an internal antenna for communication. A meter with an external antenna is only available through special request.

Note: Operation of the EMU Professional II Lora with a SMA-connector is only allowed with an attached antenna!

Note: per default the external antenna is deactivated!

Danger: An improperly installed antenna may damage the EMU Professional II Lora!

IT Environment

The Client is responsible for a functioning Lora net-infrastructure (Gateway, Network and Application server).EMU Electronic AG can support the client in installing the chosen solution if requested. The Lora interface can be used with the common gateways like devices from Kerlink or Laird.

Lora-Server

At the time of printing the EMU Professional II Lora has been successfully tested with TheThingsNetwork and Chirpstack. Relevant en- and decoders for both platforms are provided.

https://github.com/emuag/professional_II_lora

Hardware

The Lora interface of the EMU Professional II LoRa is based on the Lora transmission standard. This means the meter can reliably transmit data over large distances in environments without permanent communication. To ensure a stable and high-performance link to the Lora gateway the meter constantly adapts the optimal transmit and receive parameters independently. For a easier integration into the network you can check the status of the network connection on the display.

- Frequency: EU 863-870MHz
- Type: Class C Device
    - Two-way communication.
    - The Lora interface is available anytime for downlink messages (Class C).
    - The interface transmits with a signal strength of 14dbm.

Note: In case the EMU Professional II Lora is connected to a Lora network without Class-C support the meter acts as a Class-A device.

Note: The EMU Professional II Lora operates with an adaptive data rate. Use as a roaming device should be carefully clarified beforehand.

Note on Installation

Make sure to disconnect all current and voltage connections before installation of the external antenna!

Make sure that the SMA connector is fitted correctly. The maximum torque for the union nut must not exceed 1Nm.

You can activate the external antenna in the settings.

Note: For further documentation please consult the document “User Manual Professional II” Doc.-Ref: 1451

Start of Operation

Every meter is shipped with:

- Join-Modus: OTAA
- DeviceEUI (starting with 10-2C-EF)
- Appkey
- App-EUI (10 2C EF 00 00 00 00 00)

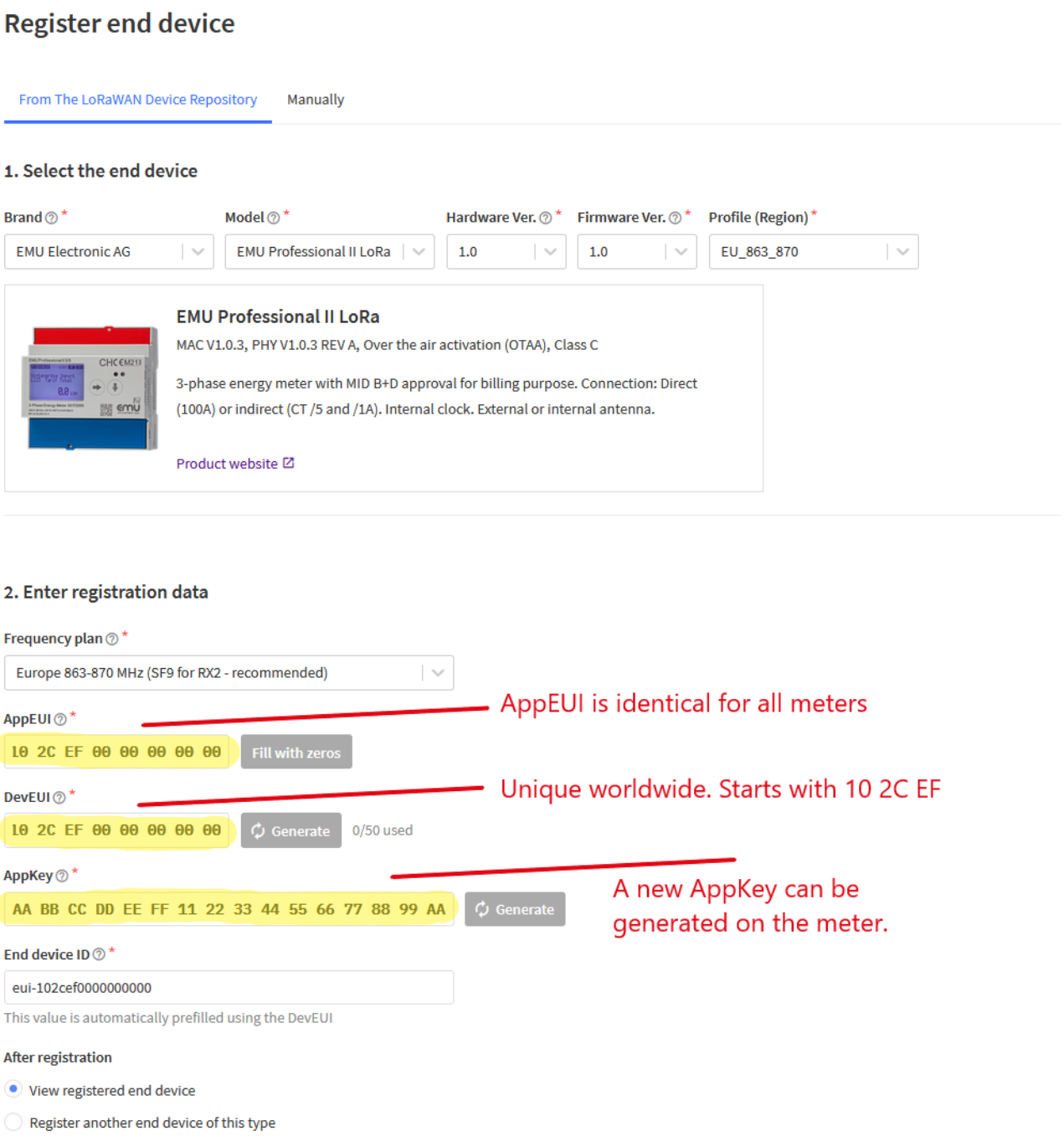
The Dev-EUI and the App-Key can be read out on the display, the App-EUI is always 10 2C EF 00 00 00 00 00

- Make sure that the meter is connected correctly (Phase and line sequence, direction of flow of energy).
- Make sure that the current and voltage transformer ratios of the converter counter are configured correctly.
- The EMU Professional II Lora is designed for fast detection of potential problems in connection range or throughput.
- Repositioning of the Lora gateway is possible after the installation of the EMU Professional II Lora. As long as the recommended distances are adhered to, the meter continues to communicate with the Lora server.
- Operation of the meter with a SMA-connector is only allowed with an attached antenna.

Example-Integration in The Things Network

The EMU Professional II Lora is available for selection on “The Things Network” as a predefined meter.

The AppEUI you need to provide is always 10 2C EF 00 00 00 00 00, the DevEUI and AppKey are individual for each meter.



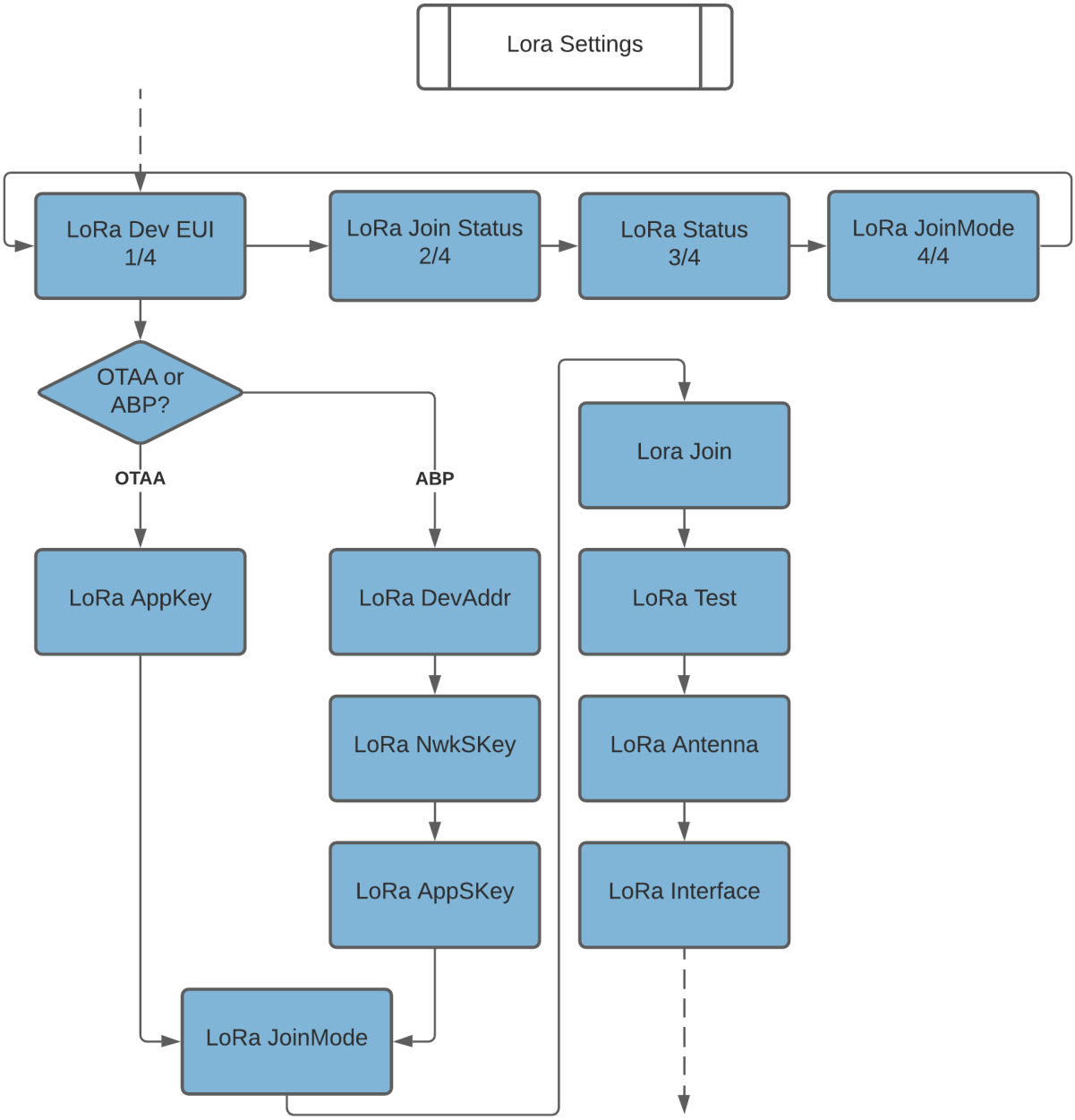
Service

The LoRa interface is designed to monitor its connection to a Lora network. If the connection is severed an automatic Re-Join is done. This monitoring happens at least once every 24 hours. This also allows for easy migration to a new Lora network. If needed you can order the meter to do time based Re-Joins via a downlink.

Operation

The following sub menus explain the settings for the EMU Professional II Lora.

Note: For further documentation please consult the document “User Manual Professional II” Doc.-Ref: 1451



LoRa DevEUI

A long press of the “Arrow Down” button changes the subpage.

LoRa DevEUI 1/4

This page shows the DevEUI of the Lora module. The DevEUI is 64bit, hex-coded.

LoRa JoinStatus 2/4

Joined: If the meter is connected to a Lora network.

Lst. Uplink: ACK/NACK (with or without acknowledge)

Timestamp of the last Uplink

LoRa Status 3/4

RSSI: The received field strength

SNR: Signal to noise ratio

SPF: Spreading factor BW: Bandwidth

LoRa JoinMode 4/4

OTAA or ABP

Lst. Downlink: ACK/NACK (with or without acknowledge)

Timestamp of last Downlink

LoRa AppKey (only with OTAA)

A short press of the SRVC button shows the current AppKey. Using the “Arrow right” button you can generate a new AppKey.

A second short press (<2s) of the SRVC button exits the edit mode **without changing** the AppKey.

A second long press (>2s) of the SRVC button finalizes the generation of the new AppKey and exits the edit mode automatically. The successful generation of a new AppKey is receipted with a short flashing of the display backlight.

The newly created AppKey can now be read out by a short press of the SRVC button.

LoRa DevAddr (only with ABP)

A short press of the SRVC button shows the current DevAddr. Using the “Arrow right” button you can generate a new DevAddr.

A second short press (<2s) of the SRVC button exits the edit mode **without changing** the DevAddr.

A second long press (>2s) of the SRVC button finalizes the generation of the new DevAddr and exits the edit mode automatically. The successful generation of a new DevAddr is receipted with a short flashing of the display backlight.

The newly created DevAddr can now be read out by a short press of the SRVC button.

LoRa NwkSKey (only with ABP)

A short press of the SRVC button shows the current NwkSKey. Using the “Arrow right” button you can generate a new NwkSKey.

A second short press (<2s) of the SRVC button exits the edit mode **without changing** the NwkSKey.

A second long press (>2s) of the SRVC button finalizes the generation of the new NwkSKey and exits the edit mode automatically. The successful generation of a new NwkSKey is receipted with a short flashing of the display backlight.

The newly created NwkSKey can now be read out by a short press of the SRVC button.

LoRa AppSKey (only with ABP)

A short press of the SRVC button shows the current AppSKey. Using the “Arrow right” button you can generate a new AppSKey.

A second short press (<2s) of the SRVC button exits the edit mode **without changing** the AppSKey.

A second long press (>2s) of the SRVC button finalizes the generation of the new AppSKey and exits the edit mode automatically. The successful generation of a new AppSKey is receipted with a short flashing of the display backlight.

The newly created AppSKey can now be read out by a short press of the SRVC button.

LoRa JoinMode (Available with OTAA and ABP)

A short press of the SRVC button lets you adjust the parameter. Using the “Arrow right” lets you select the desired JoinMode.

A second short press (<2s) of the SRVC button exits the edit mode **without changing** the JoinMode.

A second long press (>2s) of the SRVC button finalizes the new JoinMode and exits the edit mode automatically. The successful save is receipted with a short flashing of the display backlight.

Note: After a successful change of the JoinMode you need to provide your LoRa server with the new keys.

OTAA Over the Air Activation

The Lora interface of the EMU Professional II LoRa can use OTAA. The communication module arranges encryption with the Lora network server and joins the network. There can only exist one 1:1 connection between meter and Lora network. This mode of communication offers increased security against third party involvement.

LoRa Join

A short press of the SRVC button lets you adjust the parameter. Using the “Arrow right” lets you select “reboot”.

A second short press (<2s) of the SRVC button exits the edit mode **without changing** anything.

A second long press (>2s) of the SRVC button starts the (Re-)Join and exits the edit mode automatically. The successful save is receipted with a short flashing of the display backlight.

LoRa Test

Send an immediate uplink message with the configuration of slot 1 to the LoRa network.

A short press of the SRVC button lets you adjust the parameter. Using the “Arrow right” initiates the uplink.

A second short press (<2s) of the SRVC button exits the edit mode **without changing** anything.

A second long press (>2s) of the SRVC button starts the uplink and exits the edit mode automatically. The successful send is receipted with a short flashing of the display backlight.

Note: This uplink can only be sent if slot 1 is marked as active.

Note: This uplink can only be sent if no duty cycle restrictions apply.

LoRa Antenna

Allows for easy switching between internal and external antenna.

A short press of the SRVC button lets you adjust the parameter. Using the “Arrow right” selects the antenna.

A second short press (<2s) of the SRVC button exits the edit mode **without changing** the antenna configuration.

A second long press (>2s) of the SRVC button saves the selection and exits the edit mode automatically. The successful save is receipted with a short flashing of the display backlight.

 *DANGER: Make sure the meter is voltage free for the installation of the external antenna. The meter may be damaged from non-observance of installation instructions. Keep to the instructions!*

 *DANGER: The antenna must be attached before changing this setting!*

LoRa interface

Allows for a soft reset (Soft-Reset) of the LoRa module or the reset to factory settings (Factory RESET).

A short press of the SRVC button lets you adjust the parameter. Using the “Arrow right” lets you select the reset.

A second short press (<2s) of the SRVC button exits the edit mode **without changing** anything.

A second long press (>2s) of the SRVC button finalizes the reset and exits the edit mode automatically. The successful reset is receipted with a short flashing of the display backlight.

 *Note: A reset of the LoRa module does not change or impair any measurements, meter readings or other measurement relevant processes of the EMU Professional II LoRa.*

Join Request

As long as no Join request has occured the EMU Professional II Lora regularly tries to connect to a Lora network. These Join requests occur randomly in a ± 10 min time period to counteract bandwidth problems if multiple meters are in the same network.

 *Note: The up- and downlink counter is reset to 0 after a restart of the EMU Professional II Lora.*

Test if Lora Module is still connected to Lora Network

The EMU Professional II Lora checks its connection to the Lora network at least once per day. You are able to configure the data packages to request an ACK on each uplink transmission. If this option is set the meter can react much faster to a disconnect.

If the EMU Professional II Lora

- receives no ACK on its uplink messages within 24 hours,
- or the connection check (once every 24 hours) for the continued connection to the Lora network fails,

it automatically starts a new (Re-)Join process.

This check for continued connection to the Lora network can also be done via the time synchronization (DeviceTimeReq) or an uplink message to a dedicated fPort with an ACK.

Downlink Messages

The EMU Professional II Lora may acknowledge every received downlink transmission.

Configuration of Measurement Sending

- You can configure which measurement registers should be sent in what interval via a downlink message.
- Only measurements from the data logger and logbook are available for read out.
- There are 10 “Slots” available for this configuration which are represented by the fPorts 1-10.
- Only 10 measurements can be saved per Slot.
- Lower Slots have a higher priority.
- Per default the following measurement registers are transmitted:
    - See Default-Uplink
- You are able to configure in what interval the data is transmitted. The interval can be set from 1 minutes to a maximum of 67’500 minutes (45 days).
- Do you want your Lora network to send an ACK for every received transmission by the meter: Yes/No?
    - If Yes: Should the network not acknowledge the package, the meter will send the package again.
- Select if this profile is active or not.
-

Note: If you only change the transmission interval the downlink message will only contain the 2 interval bytes as well as the flags for ACK and active without further register data.

Note: If the Airtime of the meter does not accomodate a too large transmission, the transmission will only be sent partially or not at all.

Description of Downlink Message

The Bit-Order is LSB, the Byte-Order is Little-Endian.

Configuration of which registers are sent.

Length in Bytes: 4 Bytes - 13 Bytes fPort: 1-10

Byte	Description	Example
0-1	Time interval in minutes	0x01 0x00 - 0xFF 0xFF
2	Configurations-Flags	
3-12	ID’s of registers in transmission	0x03…
	CRC-8	see definition

Configuration Flag Byte

Byte	Bit	Description
00000000	1	Settings are unchanged
00000000	2	No ACK expected after upload
00000010	2	ACK expected for each upload
00000100	3	Do a (Re-)Join after ca. 60 minutes to an existing/new network
00000000	3	not defined
00001000	4	Port deactivated

Byte	Bit	Description
00000000	4	Port activated
00010000	5	not defined
00000000	5	not defined
00100000	6	not defined
00000000	6	not defined
01000000	7	not defined
00000000	7	not defined

For a list of possible register ID's consult the Measurement-Register

Note: If only Byte 0 + 1 + config-Byte + CRC-8 are sent, the transmission interval and the configuration flags are changed accordingly. The measurement registers are not changed.

Example for 1 minute interval adjustment

```
var data =[0x01, 0x00, 0x08, 0x53];

0x01 0x00 -> 1 Minute interval.
0x08      -> No ACK, no re-join, port is active.
0x53      -> CRC-8 checksum
```

Example for register transmission

This example shows the needed data downlink for an uplink of the energy registers "Active & Reactive Energy Import & Export Tarif 1&2" each minute.

```
var data = [0x01, 0x00, 0x0A, 0x01, 0x03, 0x04, 0x05, 0x06, 0x07, 0x08, 0x09, 0x0A, 0x83]

0x01 0x00 -> 1 Minute interval
0x0A      -> ACK, no re-join, port is active.
0x01      -> Timestamp
0x03 - 0x0A -> Register chosen for uplink.
0x83      -> CRC-8 Checksum
```

Uplink Message

The following messages can be sent by the EMU Professional II Lora:

- Join / Rejoin request
- Time synchronization
- Monitor network affiliation
- Sending of measurement registers

Join / Rejoin

The EMU Professional II Lora performs a Join / Rejoin with a Lora network.

DeviceTimeReq / Time Synchronization

While operating normally the EMU Professional II Lora regularly(min. once every 24h, max. once per hour) tries to get the current time and date. The meter adjusts its internal clock according to the following criteria:

- If the old and new time differ less than 2 seconds the meter accepts the new time as a time synchronization and sets the new time.
- If the difference is more than 2 seconds the meter will ask the current time at least 3 more times to make sure the new time is correct.

After start up or if the internal buffer for the RTC is used up the meter verifies the time with at least 3 Device-TimeReq requests. These 3 time requests happen in a 3 minute time frame.

Note: The operator of the Lora infrastructure must ensure that the meter can synchronize its time regularly for proper operation of the EMU Professional II Lora LP. For this the optimal solution is the Lora DeviceTimeReq command.

Sending of Measurements

- The EMU Professional II Lora sends all requested measurement register directly from its data logger via Lora without any changes to the data.
- The requested measurements are read from the data logger at the due date.
- The transmission must therefore begin and end in the transmission interval.

Example of a transmission interval of 15 minutes:

- 09:00:02am: The Lora communication module reads out the latest data logger entry. The values stored there are from 09:00:00am.
- 09:00:03am - 09:14:59am: The meter tries to transmit the data via the Lora network.
- 09:15:02am: The Lora communication module reads out the latest data logger entry. The values stored there are from 09:15:00am.

Note: Be aware that, if you operate multiple meters in the same Lora network, transmissions by these meters may collide.

Note: If the EMU Professional II Lora cannot transmit its packages due to network conditions such as SF too high or data rate too slow, the meter only transmits one package of data. All further measurement registers will not be transmitted at a later time. Please make sure to configure your meter and Lora network to allow for the full transmission of data.

Structure of Uplink Packages

The bit order is LSB, the byte order is Little-Endian. The four first bytes are always the timestamp from the data logger.

First Telegram after Join with a Lora Server

fPort: 100 Length: 29

Structure:

Byte	Description
0-3	current system time
4	Type
5-8	Serial number
9	Type
10	Meter type
11	Type
12-13	Current transformer primary
14	Type
15-16	Current transformer secondary
17	Type
18-19	Voltage transformer primary
20	Type
21-22	Voltage transformer secondary
23	Type
24-27	MID year of certification (BCD)
28	CRC 8-bit

Package Example:

```
#System time
#Serial number 22150405
#Meter type Converter Counter -> 2
#Current transformer ratio 5:5
#Voltage transformer ratio 100:100
#Mid year of certification 2022
CRC should be 0x65

var data = [0x68, 0x9b, 0xa8, 0x62,          // Systemtime 0x62A89B68
                                             // -> 1655217000
                                             //->Thuesday, 14. Juni 2022
                                             // 16:30:00 GMT+02:00 DST
            0xf1, 0x05, 0x04, 0x15, 0x22,    // Serial number 0x22150405
                                             //-> 22150405
            0xf7, 0x02,                      // Meter type 0x02 -> 2
            0xf3, 0x05, 0x00,                // Current transformer primary 0x0005
                                             //-> 5
            0xf4, 0x05, 0x00,                // Current transformer secondary 0x0005
                                             //-> 5
            0xf5, 0x64, 0x00,                // Voltage transformer primary 0x0064
                                             //-> 100
            0xf6, 0x64, 0x00,                // Voltage transformer secondary 0x0064
                                            //-> 100
            0xf8, 0x02, 0x00, 0x02, 0x02,    // MID year, BCD -> 2022
            0x65]                            // CRC-8 Checksum
```

Default-Uplink

After first start up or after resetting to factory settings the meter will send the following telegram:

fPort: 1 Length: 27 Interval: every 15 minutes the most current entry from the meter’s data logger.

Structure:

Byte	Description	
0-3	Time stamp	
4	Typ	0x03
5-8	Active energy import L123 T1	
9	Typ	0x04
10-13	Active energy import L123 T2	
14	Typ	0x05
15-18	Active energy export L123 T1	
19	Typ	0x06
20-23	Active energy export L123 T2	
24	Typ	0xFF
25	Error code	
26	CRC 8-bit	

The fPorts 1-10 can be changed individually as described in Downlink Messages.

Measurement-Registers

The energy measurements and technical information is read out of the data logger of the EMU Professional II Lora. These measurements are stored at the end of a measurement period (15 minutes).

Note: Changes to the configuration of the EMU Professional II Lora, e.g. current transformer ratio, are updated at the end of a measurement period in the data logger.

ID	Type	Description	Unit	Resolution
0x00	uInt32	Index	Index	
0x01	uInt32	Time stamp	Time	Epoch
0x02	uInt32	Original time stamp of the entry	Time	Epoch
0x03	uInt32	Active energy import L123 T1	Wh	1 Wh
0x04	uInt32	Active energy import L123 T2	Wh	1 Wh
0x05	uInt32	Active energy export L123 T1	Wh	1 Wh
0x06	uInt32	Active energy export L123 T2	Wh	1 Wh
0x07	uInt32	Reactive energy import L123 T1	varh	1 varh
0x08	uInt32	Reactive energy import L123 T2	varh	1 varh
0x09	uInt32	Reactive energy export L123 T1	varh	1 varh
0x0A	uInt32	Reactive energy export L123 T2	DL	varh
0x0B	Int32	Active power L123	W	1 W
0x0C	Int32	Active power L1	W	1 W
0x0D	Int32	Active power L2	W	1 W
0x0E	Int32	Active power L3	W	1 W
0x0F	Int32	Current L123	mA	1 mA
0x10	Int32	Current L1	mA	1 mA
0x11	Int32	Current L2	mA	1 mA
0x12	Int32	Current L3	mA	1 mA
0x13	Int32	Current L4 (neutral phase, only on CT meters)	mA	1 mA
0x14	Int32	Voltage L1-N	V	100 mV
0x15	Int32	Voltage L2-N	V	100 mV
0x16	Int32	Voltage L3-N	V	100 mV
0x17	Int8	Power factor L1	-1..1	0.01
0x18	Int8	Power factor L2	-1..1	0.01
0x19	Int8	Power factor L3	-1..1	0.01
0x1A	Int16	Frequency	Hz	0.1 Hz
0x1B	Int32	Average Power	W	1 W
0x1C	uInt32	Active energy import L123 T1	kWh	1 kWh
0x1D	uInt32	Active energy import L123 T2	kWh	1 kWh
0x1E	uInt32	Active energy export L123 T1	kWh	1 kWh
0x1F	uInt32	Active energy export L123 T2	kWh	1 kWh
0x20	uInt32	Reactive energy import L123 T1	kvarh	1 kvarh
0x21	uInt32	Reactive energy import L123 T2	kvarh	1 kvarh
0x22	uInt32	Reactive energy export L123 T1	kvarh	1 kvarh
0x23	uInt32	Reactive energy export L123 T2	kvarh	1 kvarh
0x24	uInt64	Active energy import L123 T1	Wh	1 Wh
0x25	uInt64	Active energy import L123 T2	Wh	1 Wh
0x26	uInt64	Active energy export L123 T1	Wh	1 Wh
0x27	uInt64	Active energy export L123 T2	Wh	1 Wh
0x28	uInt64	Reactive energy import L123 T1	varh	1 varh
0x29	uInt64	Reactive energy import L123 T2	varh	1 varh
0x2A	uInt64	Reactive energy export L123 T1	varh	1 varh
0x2B	uInt64	Reactive energy export L123 T2	varh	1 varh
0xF0	uInt8	Error code		
0xF1	uInt32 Hex	Serial number		
0xF2	uInt32 Hex	Factory number		
0xF3	uInt16	Current transformer primary		
0xF4	uInt16	Current transformer secondary		

ID	Type	Description	Unit	Resolution
0xF5	uInt16	Voltage transformer primary		
0xF6	uInt16	Voltage transformer secondary		
0xF7	uInt8	Meter type		
0xF8	uInt32	MID year of certification		BCD
0xF9	uInt32	Year of manufacture		BCD
0xFA	uInt32	Firmware version		ASCII
0xFB	uInt32	MID Mess-version		ASCII
0xFC	uInt32	Manufacturer		ASCII
0xFD	uInt32	Hardware index		ASCII
0xFE	uInt32	Current system time	Time	Epoch

For possible values of the error code please consult the chapter Status Codes

Status Codes

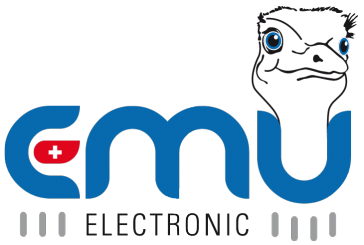
Bit Order	Description
0	Time set
1	Current transformer ratio adjusted
2	Voltage transformer ratio adjusted
3	Impulse Length adjusted
4	Impulse Ratio adjusted
5	Voltage Interruption
6	Time not valid or not synchronized
7	Logbook full

CRC-8 Prüfsumme

The checksum is based on the following polynom: x^8 + x^2 + x^1 + x^0 (CRC-8-CCITT)

Example implementation in Javascript:

```
function crc8_encode(data) {
    var xorOut = 0x0000;
    var table = [
        0x00, 0x07, 0x0E, 0x09, 0x1C, 0x1B,
        0x12, 0x15, 0x38, 0x3F, 0x36, 0x31,
        0x24, 0x23, 0x2A, 0x2D, 0x70, 0x77,
        0x7E, 0x79, 0x6C, 0x6B, 0x62, 0x65,
        0x48, 0x4F, 0x46, 0x41, 0x54, 0x53,
        0x5A, 0x5D, 0xE0, 0xE7, 0xEE, 0xE9,
        0xFC, 0xFB, 0xF2, 0xF5, 0xD8, 0xDF,
        0xD6, 0xD1, 0xC4, 0xC3, 0xCA, 0xCD,
        0x90, 0x97, 0x9E, 0x99, 0x8C, 0x8B,
        0x82, 0x85, 0xA8, 0xAF, 0xA6, 0xA1,
        0xB4, 0xB3, 0xBA, 0xBD, 0xC7, 0xC0,
        0xC9, 0xCE, 0xDB, 0xDC, 0xD5, 0xD2,
        0xFF, 0xF8, 0xF1, 0xF6, 0xE3, 0xE4,
        0xED, 0xEA, 0xB7, 0xB0, 0xB9, 0xBE,
        0xAB, 0xAC, 0xA5, 0xA2, 0x8F, 0x88,
        0x81, 0x86, 0x93, 0x94, 0x9D, 0x9A,
        0x27, 0x20, 0x29, 0x2E, 0x3B, 0x3C,
        0x35, 0x32, 0x1F, 0x18, 0x11, 0x16,
        0x03, 0x04, 0x0D, 0x0A, 0x57, 0x50,
        0x59, 0x5E, 0x4B, 0x4C, 0x45, 0x42,
        0x6F, 0x68, 0x61, 0x66, 0x73, 0x74,
        0x7D, 0x7A, 0x89, 0x8E, 0x87, 0x80,
        0x95, 0x92, 0x9B, 0x9C, 0xB1, 0xB6,
        0xBF, 0xB8, 0xAD, 0xAA, 0xA3, 0xA4,
        0xF9, 0xFE, 0xF7, 0xF0, 0xE5, 0xE2,
        0xEB, 0xEC, 0xC1, 0xC6, 0xCF, 0xC8,
        0xDD, 0xDA, 0xD3, 0xD4, 0x69, 0x6E,
        0x67, 0x60, 0x75, 0x72, 0x7B, 0x7C,
        0x51, 0x56, 0x5F, 0x58, 0x4D, 0x4A,
        0x43, 0x44, 0x19, 0x1E, 0x17, 0x10,
        0x05, 0x02, 0x0B, 0x0C, 0x21, 0x26,
        0x2F, 0x28, 0x3D, 0x3A, 0x33, 0x34,
        0x4E, 0x49, 0x40, 0x47, 0x52, 0x55,
        0x5C, 0x5B, 0x76, 0x71, 0x78, 0x7F,
        0x6A, 0x6D, 0x64, 0x63, 0x3E, 0x39,
        0x30, 0x37, 0x22, 0x25, 0x2C, 0x2B,
        0x06, 0x01, 0x08, 0x0F, 0x1A, 0x1D,
        0x14, 0x13, 0xAE, 0xA9, 0xA0, 0xA7,
        0xB2, 0xB5, 0xBC, 0xBB, 0x96, 0x91,
        0x98, 0x9F, 0x8A, 0x8D, 0x84, 0x83,
        0xDE, 0xD9, 0xD0, 0xD7, 0xC2, 0xC5,
        0xCC, 0xCB, 0xE6, 0xE1, 0xE8, 0xEF,
        0xFA, 0xFD, 0xF4, 0xF3
    ];
    var crc = 0x0000;
    for (var j = 0; j < data.length; j++) {
        crc = table[crc ^ data[j]];
    }
    return (crc ^ xorOut) & 0xFFFF;
}
```



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