micropelt
EH4 GmbH

Wireless heating valve actuator

MLR003 REV1.0 LoRaWAN

LoRaWAN CLASS A EU868MHz
SF7BW125
User manual and device specification

2 Revision History

Rev.-No.	Description of Revision	Revised by	Date	Approved by
	v8e has been derived from the Micropelt technology platform description v7e. Changed name to MLR003. Document describes the first release of MLR003. Most recent changed against the general-purpose platform description.			
v8e	- Removed Summer mode - Added 480min RF CI in Payload - Added temperature offset for valve- and ambient-sensor. - Added harvesting halt during radio communication.	Schmidt/ Volkert	Jan. 21, 2021	
v10e	- Change product name to MLR003 - General update on description and user guide	Volkert	Jun. 21, 2021	
v11e	Change downlink payload Added Label spec.	Couzens Volkert	Jun. 22, 2021	
v12e	Change Activating from Mounting Position operating flow diagram Changed front page picture of MLR003	Couzens Volkert	Aug. 04, 2021 Aug. 20, 2021	
v13e	Full document review Update cover page, headlines, added sect. 7.2	Couzens Volkert	Sept. 22, 2021 Sept. 23, 2021	
v14e	Adjust speaker beeping communication in user interface Added SF7BW125 to front page Removed downlink “reserved” bytes 7 and 8 Added picture of MLR003-KEY	Couzens Volkert	Sept. 28, 2021 Oct. 11, 2021	
V15e	Added clauses and information required by product safety, EN60335-1:2012. Described the position of the labels Corrected distortion of “CE”-print on product label	Schmidt	Nov. 05, 2021	
V16e	Added certification details Added contact email devicecredentials@micropelt.com	Volkert	Nov 19, 2021	

3 Use and Safety

Use and safety instructions:

- This appliance is not intended for use by persons (including children) with reduced physical, sensory or mental capabilities, or a lack of experience and knowledge, unless they have been given supervision or instruction concerning the use of the device by a person responsible for their safety.
- This product is not a toy. Children shall be advised to refrain from playing with it.
- The metallic part of the unit's housing serves as a heat sink. Be sure that the air circulation around it is not obstructed by furniture, curtains, plants, or other objects.
- If the device has been stored in a cold environment, make sure that it resumes close to room temperature before use. This is to prevent damaging due to condensation.
- The thermostatic radiator valve is designed for indoor use only. Do not allow the thermostatic radiator valve to get wet. Its sensitive electronics can be affected.
- The unit is best cleaned with a dry or slightly damp cloth. Do not use aggressive cleaning agents or solvents.
- Refrain from exposing the unit to environmental stress such as high mechanical forces (do not step on it), strong vibrations, direct sunlight or extreme temperatures.
- The unit must not be disassembled or modified. There are no user-serviceable parts inside.
- Be aware that correct operation can be affected by strong electromagnetic fields. Typical sources of such are mobile phones, 2-way radios, RC transmitters, microwave ovens, electric motors.
- The thermostatic radiator valve has been designed and must solely be used for the purpose of controlling a M30 x 1.5 heater valve. Any other use may pose a hazard to the device itself, to the equipment involved, or to the health of the user.
- When operating the device in a workplace environment, be sure to observe the workplace regulations that may apply.

Intended use: The self-powered thermostatic radiator valve is suitable solely for controlling water-filled heating radiators. Any other use – including control of floor heating systems – is not permitted and can result in damage. Do not disassemble or modify any part of the product. It is important to comply with the safety notice included in these operating instructions.

In case of questions, please contact:

Micropelt - a brand of EH4 GmbH. Email: info@micropelt.com. Telephone +49 7665 932183 0

4 General Description

This document defines the properties of Micropelt's maintenance free, intelligent thermostatic radiator valve actuator MLR003. MLR003 is used for single room control of heating radiators with standard valve connection M30x1.5 (Section 0).

The actuator generates the required electrical energy for operation (motor, sensors, and radio communication) by means of a built-in thermoelectric generator (TEG) and therefore operates maintenance-free. It harvests energy from the temperature difference between the radiator heat and ambient temperature (usually room temperature). An additional energy source such as a primary battery or external power supply is not required. The internal energy storage device is fully charged upon delivery, so that sufficient energy is available for installation and up to approximately 10 years of operation. In winter and during the heating season, the actuator then operates autonomously from the converted heat of the heating circuit. On top of this, winter operation generates a surplus of energy to charge the internal storage device. This then provides sufficient energy for 366 days of operation per year, covering both transition periods and summer. To protect the product's radio from interference, energy harvesting is briefly interrupted during radio communication.

MLR003 is an 868MHz LoRaWAN CLASS-A wireless actuator operating in SF7BW125. LoRaWAN end-devices of Class A allow for bidirectional communications whereby each end-device's uplink transmission is followed by two short downlink receive windows. The transmission slot scheduled by the end-device is based on its own communication needs with a small variation based on a random time basis (ALOHA-type of protocol). This Class-A operation is the lowest power end-device system for applications that only require downlink communication from the server shortly after the end-device has sent an uplink transmission. Downlink communications from the server at any other time will have to wait until the next scheduled uplink. SF7 is the shortest time-on-air operating to maximize the possible number of end nodes on a single gateway.

Each standard production MLR003 unit does have a unique DEVEUI, APPEUI (JOINEUI) and a randomly generated APPKEY. Device credentials are secret and will only be submitted with the product delivery. Questions related to device credentials can be sent to devicecredentials@micropelt.com.

To operate the device, the unit must be paired with a compatible room controller or gateway unit supporting its communication profile (Section 11). The pairing is done as described in Section 12.3. Once mounted and activated on the valve body, a calibration cycle starts to automatically adapt itself to the individual valve. Then it is ready for use. Adapters are available for a majority of non-M30x1.5 valve bodies.

Success of activation or deactivation is signaled by tone signals and LED (Section 12.1).

The product is delivered in mounting position (off) with the valve plunger completely retracted. When operating, the unit recognizes if it is installed on a valve body by means of internal force and travel distance measurement. The device has built-in motor error detection "ME". The ME bit signals motor issues during normal operation.

The actuator operates with a communication profile as further specified in Section 11. The default radio communication cycle is 10 minutes. Installation, activation and a successful join with the network server will immediately set the radio communication interval to every 10 seconds for an installation period of 5 minutes to provide rapid feedback. Temperature values are transmitted in both raw and corrected temperature formats. The actuator has a built-in, valve-side temperature sensor to determine the flow pipe temperature. A controllable offset of +3°C has been added to compensate for the temperature drop between the hot water and the sensor element located in the actuator's aluminum valve adapter. The device transmits a variety of information to the room control unit by sending an uplink (Section 11.2). The control unit responds by sending a downlink (Section 11.3).

The integrated valve side temperature sensor is also used for freeze protection. Freeze protection is activated at <=6°C.

The ambient sensor is used to measure the room temperature. During heating operation, the ambient sensor is influenced by the near field of the radiator as well as self-heating of the metallic device housing. The algorithm used to estimate the actual ambient temperature is described in Section 12.9.

Unsuccessful radio communication attempts are reported by status bit RCE. After 6 consecutive unsuccessful radio communication attempts, the actuator automatically switches to the safety mode and safety values as specified by the user. In this situation, the radio communication period is increased to once every hour.

5 Operating Modes

	Installation cycle	Standard operation	Idle state	Radio failure	Forced heating	Freeze Protection
Comments		Valve target % Or Flow target temperature Or Room target temperature	Phases between monitoring and communicating	Transmit messages not received by the gateway	Valve opens to 50% (or remains in current position if current position is >= 50%)	Valve opens to 95%
Trigger	Magnetic switch. Join accept from Gateway, & Device is mounted	Internal timer	Internal timer	From activation: No Gateway connect from standard operation: 6 consecutive Gateway communication failures	Battery voltage < 2V	Flow sensor raw temperature <= 6°C
Radio communication interval (RCI)	10 seconds for 5 minutes	5 minutes 10 minutes 60 minutes 120 minutes 480 minutes	OFF	Three times 30 seconds Then once 2 minutes Then 60 minutes	OFF	OFF
Dynamic change of communication interval [1]	No	Yes	No	No	No	No
Sensors (flow, ambient)	Active, every 10 seconds	Active	OFF	Active	OFF	Active, every 2 minutes
Freeze protection	Active, every 10 seconds	Active, every 150 seconds	OFF	Active, every 150 seconds	OFF	Active
Motor operation	Reference run. Then active, according to Radio Communication	Active, according to Radio Communication	OFF	Active	OFF	OFF
Monitoring of battery	Active, every 10 seconds	Active	OFF	Active	Active, every 12 hours	Active, every 2 minutes
Internal temperature controller	If User Mode is Set Point Ambient Temperature or Set Point Flow Temperature: active	If User Mode is Set Point Ambient Temperature or Set Point Flow Temperature: active	OFF	If Safety Mode is Set Point Ambient Temperature or Set Point Flow Temperature: active	OFF	OFF

[1] A change of the communication interval or operating mode is possible with every regular radio telegram.

6 Power Consumption

Function	Power consumption average current draw	Battery runtime w/o charging @ 500mAh**
Mounting position	2.2 µA	25.9 years
Radio communication every 10 min. No motor = unheated room	8.5 µA	6.7 years
Radio communication every 10 min. Motor movement: Morning: Full open Throughout the day: 10% every 30 min. Evening: Full close Total: 400%	43.1 µA	1.3 years

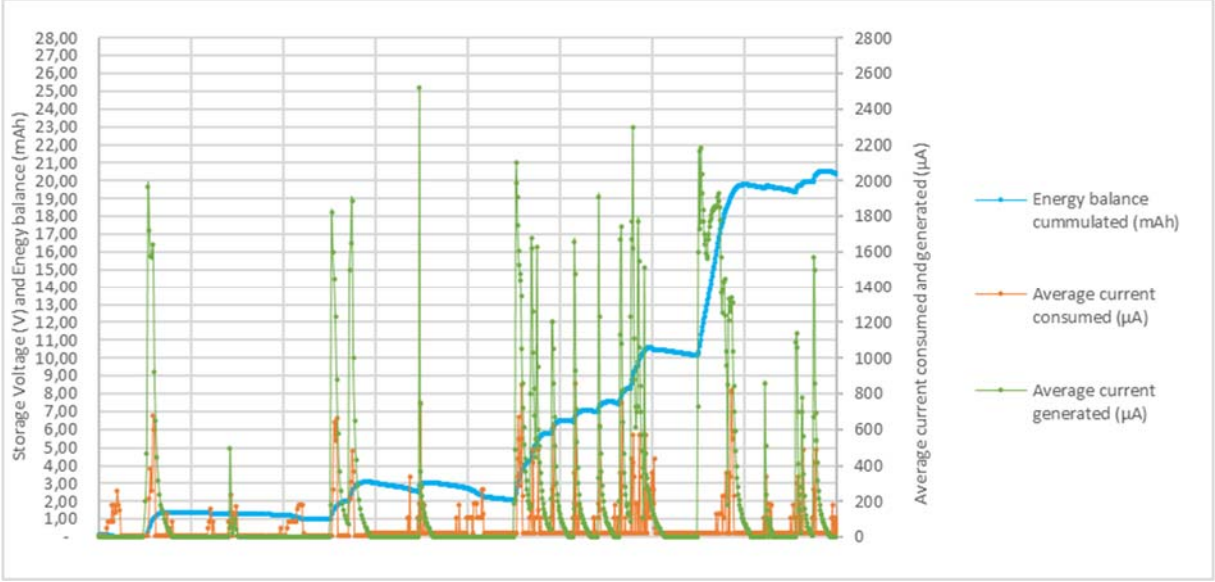
7 Power management

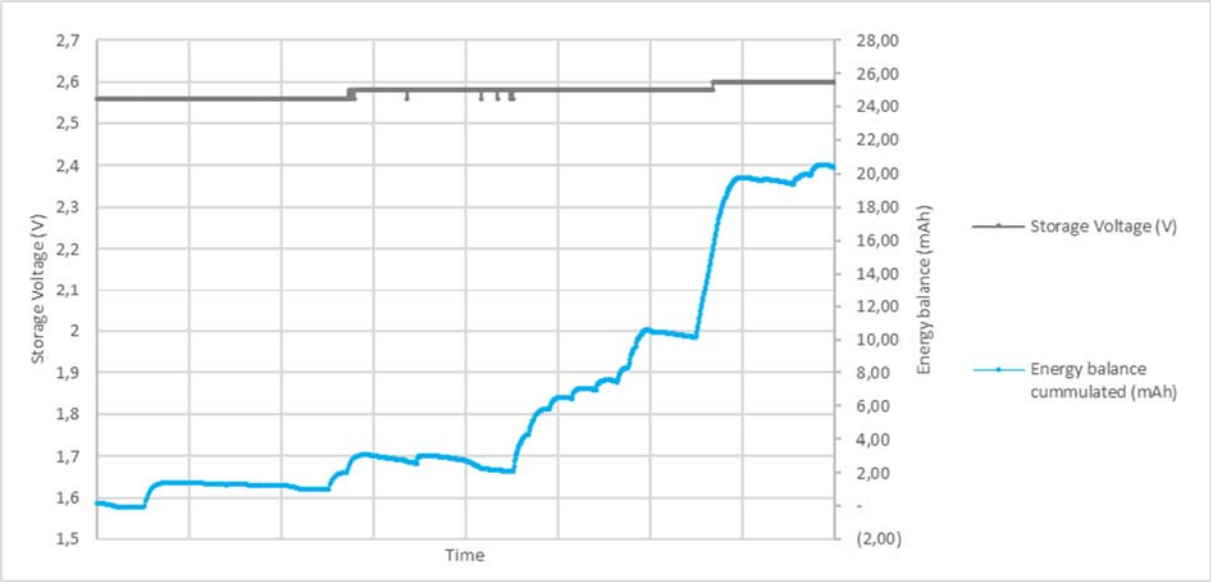
7.1 Energy Harvesting

The actuator obtains the electrical energy required for operation by means of a thermoelectric generator (TEG), from the temperature difference between the heating flow temperature and the room temperature. During heating times, excess energy is accumulated in the internal storage for operation in the transition period and in summer. The energy balance of the actuator is designed to allow operation through 366 days per year when used in typical radiator heating installations. A lack of heating operation as it occurs in unheated rooms inevitably leads to the internal storage being discharged, which means that permanent and normal operation of the device can no longer be guaranteed.

7.2 Device power management

MLR003 allows the end user application to monitor and compute the energy status through regular measurement of the device internal parameters. Internal storage voltage STV (V) and average current generated ACG (µA) are actual measured values whereas average current consumed ACC (µA) is a computed value. The computed average current consumed value includes motor amount and direction of movement, radio communication frequency, and sleep current. The following two diagrams are illustrations of the energy balance from a running application.



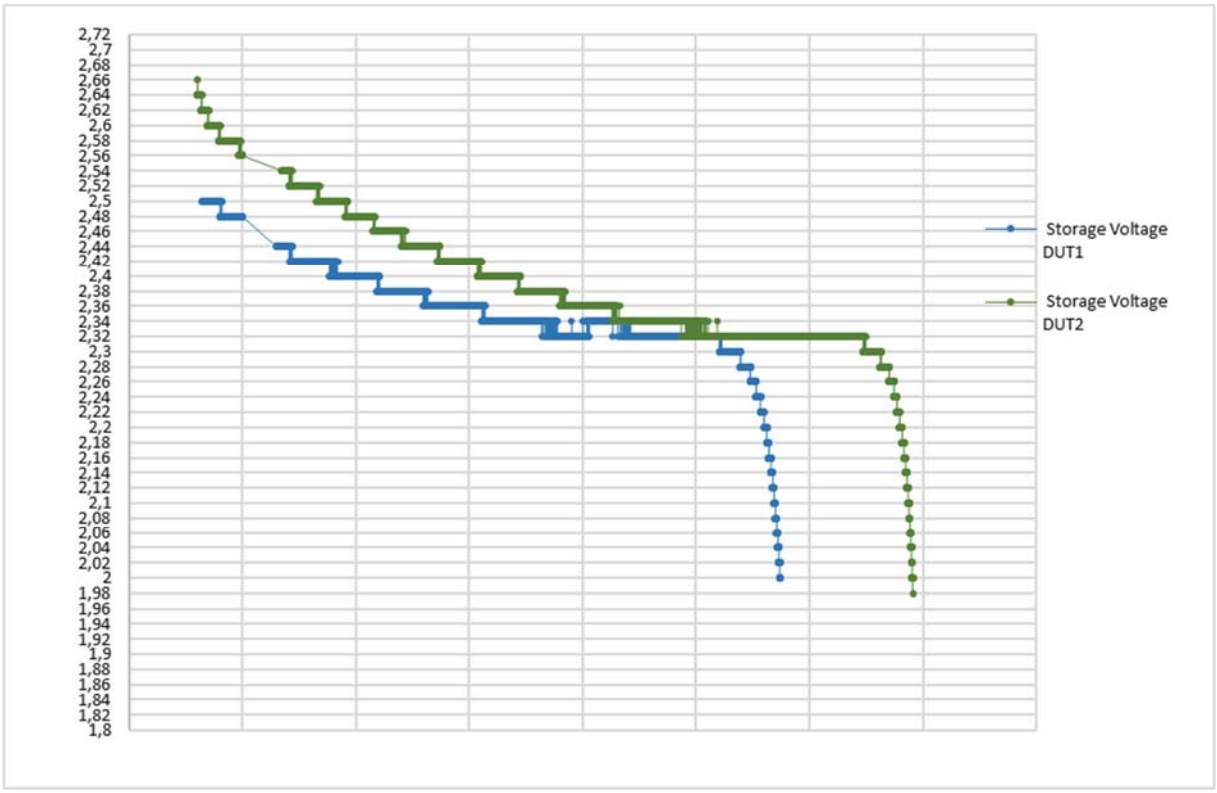

2,7
2,6
2,5
2,4
2,3
2,2
2,1
2
1,9
1,8
1,7
1,6
1,5
Storage Voltage (V)
28,00
26,00
24,00
22,00
20,00
18,00
16,00
14,00
12,00
10,00
8,00
6,00
4,00
2,00
-
(2,00)
Energy balance (mAh)
Time
Storage Voltage (V)
Energy balance cummulated (mAh)

8 Energy Storage

Using its status bit "Energy Storage" (Section 11.2), the unit indicates that its long-term operation consumed more energy than it generated. The remaining charge level at this point is approximately 25%, which is why the device continues with full functionality while signaling a negative energy balance to the user. It is strongly recommended to regularly check the ES bit in order to recognize a discharge of the storage and to prevent its progression by suitable measures (e.g. regular, short heating intervals outside of the standard operating times). If the energy storage continues to discharge and its voltage falls below a certain limit, then the unit automatically goes into the state of forced heating.

Energy storage typical voltage values	Voltage [V] LTO
Fully charged – for charge stop (bq25505 and USB)	2.8
Fully charged – for indicator bit	2.7
Normal operation	2.4 typical (2.0 … 2.8)
Energy storage bit set when below	2.3
Forced heating starts when falling below	2.0
Forced heating ceases when rising above	2.4
Microcontroller turning off all loads and its own power when falling below	1.8
Microcontroller power-up (under hardware-control) when rising above	2.37
Battery spec HTC1450 (capacity / charge stop / discharge stop)	>500mAh / 2.8V / 1.5V

Illustration of discharge curves from different staring voltages:



9 Forced Heating

Forced heating is defined as the state that the actuator assumes when it can no longer maintain normal operation due to the discharge of its internal energy store. Instead, it takes a protective position in heating mode to avoid possible freeze damage. For this purpose, the actuator opens the valve to 50% or maintains the current position if it is more than 50%. The unit then deactivates itself into a state of minimal energy consumption: No radio or motor activities, local inputs are ignored. It remains in this state until the storage is recharged to a sufficient level by the thermoelectric generator. In this operating mode, the unit cannot be addressed neither by radio nor locally, and temperature fluctuations in the room will likely occur. As soon as sufficient charge level is available, the actuator stops the forced heating and resumes normal operation. Restoring the storage device to full charge requires full heating operation for several days, which is why this condition should be avoided by taking appropriate measures in advance (monitoring the ES bit, Slow harvesting).

10 Slow Harvesting

Only supported in release 2

11 Communication Profile

11.1 FPORT operating modes

FPort Number	Type of operation	Payload length	Description
0x00	MAC Commands	8 Bytes	RESERVED
0x01	– Valve position % mode – Temperature setpoint mode (°C) with external ambient temperature sensor or internal ambient temperature sensor – Temperature setpoint mode (°C) with flow temperature sensor	Downlink: 6 Bytes Uplink: 10 Bytes	– Actuator operation mode with valve position % only – Self-regulation mode of the ambient actual temperature (external sensor recommended, or internal ambient sensor value used), using the ambient requested temperature – Self-regulation mode of the flow actual temperature, using the flow requested temperature
0x05	Slow harvesting	8 Bytes	(Release 2)
0x06	Valve opening point detection	8 Bytes	(Release 2)

11.2 FPORT 0x01 UPLINK: MLR003 to Controller / Network Server

BYTE	BIT RANGE	SIZE	OFFSET	ABBREV.	DETAILS
1	DB0.7…0.0	8	0	CVP	Current Valve Position % 0x00 … 0x64 / 0 … 100% Res = 1%
2	DB1.7…1.0	8	8	FSRV	Flow Sensor RAW Value °C 0x00 … 0xFF / 0 … 125.0°C Res = 0.5°C
3	DB2.7…2.0	8	16	FTMP	Flow TEMPERATURE Value °C[2] 0x00 … 0xFF / 0 … 125.0°C Res = 0.5°C
4	DB3.7…3.0	8	24	ASRV	Ambient Sensor RAW Value °C 0x00 … 0xFF / 0 … 63.75°C Res = 0.25°C
5	DB4.7…4.0	8	32	ATMP	Ambient TEMPERATURE Value °C[3] 0x00 … 0xFF / 0 … 63.75°C Res = 0.25°C
6	DB5.7	1	40		RESERVED
	DB5.6	1	41	ES	Energy Storage is low 1 = Battery is low
	DB5.5	1	42	HA	Harvesting 1 = Harvesting is active
	DB5.4	1	43	ASF	Ambient Sensor Failure 1 = Sensor Failure
	DB5.3	1	44	FSF	Flow Sensor Failure 1 = Sensor Failure
	DB5.2	1	45	RCE	Radio Communication Error 1 = Radio Loss[4]
	DB5.1	1	46	RSS	Radio Signal Strength 1 = Weak Radio
	DB5.0	1	47	ME	Motor 1 = Motor Error
7	DB6.7…6.0	8	48	STV	Storage Voltage V 0x00 … 0xFF / 0 … 5100mV Res = 20mV
8	DB7.7…7.0	8	56	ACC	Average Current Consumed 0x00 … 0xFF / 0 … 2550µA Res = 10µA
9	DB8.7…7.0	8	64	ACG	Average Current Generated[5] 0x00 … 0xFF / 0 … 2550µA Res = 10µA
10	DB9.7	1	72	OFF	Operating Condition 0 = Device is in Normal Operation and is Active 1 = Device is in Mounting Position and OFF
	DB9.6	1	73	SFC	Storage Fully Charged 1 = Fully Charged
	DB9.5	1	74		RESERVED
	DB9.4	1	75	REFC	Reference Run Completed 1 = Successfully Completed
	9.3…9.0	4	76		RESERVED

[2] Flow Temperature Value is Flow Raw Value with offset correction
[3] Ambient Temperature Value is Ambient Temperature Estimate, used in Temperature Control Algorithm
[4] Device was not able to join the network server, or an uplink message did not receive an acknowledge
[5] Momentary energy storage charge current (assuming this has been fairly constant for the past RCI)

11.3 FPORT 0x01 DOWNLINK: Controller / Network Server to MLR003

BYTE	BIT RANGE	SIZE	OFFSET	ABBREV.	DETAILS
1	DB0.7…0.0	8	0	SPV	Set Point Value according to user mode VALVE %: 0x00 … 0x64 / 0 … 100% Res = 1% FLOW TEMP: 0x00 … 0xA0 / 0 … 80°C 0x00 = Default = 0x37 = 55°C Res = 0,5°C AMB TEMP: 0x00 … 0x50 / 0 … 40°C 0x00 = Default = 0x28 = 20°C Res = 0,5°C
2	DB1.7…1.0	8	8	RG	Room TMP from RCU °C 0x00 … 0xA0 / 0 … 40°C 0x00 = No Room TMP provided Res = 0,25°C
3	DB2.7…2.0	8	16	SSV	Set Safety Value according to safety mode AMB TEMP: 0x00 … 0x50 / 0 … 40°C 0x00 = Default = 0x28 = 20°C Res = 0,5°C FLOW TEMP: 0x00 … 0xA0 / 0 … 80°C 0x00 = Default = 0x6E = 55°C Res = 0,5°C VALVE %: 0x00 … 0x64 / 0 … 100% Res = 1%
4	DB3.7	1	24		RESERVED
	DB3.6…3.4	3	25	RCI	Radio Communication Interval 0b000 = Default = 10 minutes
					0b000 — 10 minutes
					0b001 — 5 minutes
					0b010 — 60 minutes
					0b011 — 120 minutes
					0b100 — 480 minutes
					0b1zz — RESERVED
	DB3.3…3.2	2	28	UM	User Mode 0b00 = Default = Valve Position
					0b00 — Valve Position %
					0b01 — SP Flow Temperature °C
					0b10 — SP Ambient Temperature °C
					0b11 — RESERVED
	DB3.1…3.0	2	30	SM	Safety Mode 0b00 = Default = SP Ambient Temperature
					0b00 — SP Ambient Temperature °C
					0b01 — SP Flow Temperature °C
					0b10 — Valve Position %
					0b11 — RESERVED
5	DB4.7…4.4	4	32	FSOC	Offset Compensation Flow Sensor °C -8°C … +7°C
					0x00 — +3°C (default)
					0x01 — +1°C
					0x02 — +2°C
					0x03 — +3°C
					0x04 — +4°C
					0x05 — +5°C
					0x06 — +6°C
					0x07 — +7°C
					0x08 — -8°C
					0x09 — -7°C
					0x0A — -6°C
					0x0B — -5°C
					0x0C — -4°C
					0x0D — -3°C
					0x0E — -2°C

					0x0F	-1°C
	DB4.3…4.0	4	36		RESERVED	
6	DB5.7	1	40	REF	Do Reference Run now Default = 0	
	DB5.6…5.5	2	41	GAIN	Proportional Controller Gain 0b00 = Default = 3	
					0b00	3
					0b01	4
					0b10	1
					0b11	2
	DB5.4…5.0	5	43		RESERVED	

11.4 FPORT 0x05 Slow Harvesting

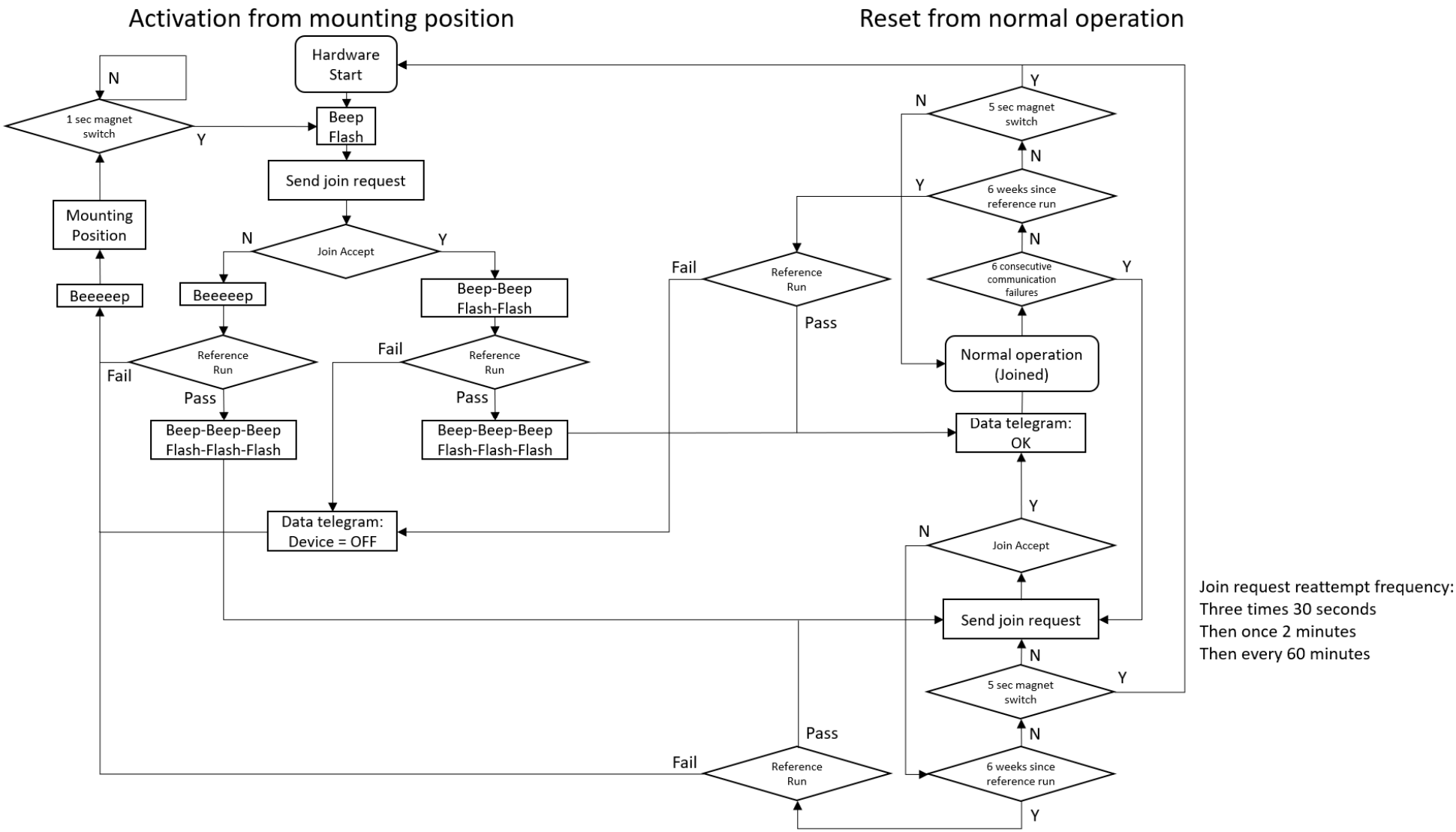
Only supported in release 2

11.5 FPORT 0x06 Valve Opening Detection

Only supported in release 2

12 Operating Instructions

12.1 User Interface functionality



The unit has no user-accessible buttons to avoid manipulation of the device in public environments. Installers rely on a pen-shaped magnet to perform tasks related to the installation.

12.2 Setting up a Gateway

1. In a web browser, navigate to the gateway IP address
2. Login to the gateway
3. LoRaWAN, Network Settings, Join Delay 5 seconds
   LoRaWan, Network Settings, Max Datarate 5 – SF7BW125
   Click Submit
   Wait for Save and Apply to go red, and then click it
4. Firewall, Settings, Input Filter Rules
   Add 'Allow Inbound'
   Click Submit
   Wait for Save and Apply to go red, and then click it

12.3 Pairing the Device with a Room Controller or Gateway

Devices will be accompanied with a spreadsheet containing the following information:

- Device EUI
- Join EUI
- Application Key

The Device EUI is unique to the device and allows identification and communication via LoRaWAN. The Application Key is randomly generated and the password to ensure secure communication.

To pair a device to a MultiTech gateway:

1. In a web browser, navigate to the gateway IP address
2. Login to the gateway
3. (Only needs to be done once:)
   LoRaWAN, Network Settings, Join Delay 5 seconds
   LoRaWAN, Network Settings, Max Datarate 5 – SF7BW125
4. LoRaWAN, Key Management, click Add New
5. For each device, enter the following details, and then click OK:
   Dev EUI (available in the spreadsheet)
   App EUI (available in the spreadsheet)
   App Key (available in the spreadsheet)
   Class: A
   Device Profile: LW102-OTA-EU868
   Network Profile: DEFAULT-CLASS-A
6. Click Submit
7. Wait for Save and Apply to go red, and then click it

12.4 Mounting Position and OFF

In mounting position, the plunger inside the product's valve adaptor is fully retracted, so that the unit can be easily attached to a radiator valve. In mounting position, the product is OFF, preserving the charge of the internal energy storage device. This makes it the preferred mode for shipping and storing.

How to enter mounting position from normal operation:

- If the unit is attached to a valve, remove it
- Hold the pen magnet to the micr°pelt logo on the product's cover until a beep sounds

→ The unit will fail the reference run and consequently end up in mounting position

Upon delivery, all new units are in mounting position.

12.5 Attaching and Activating a unit

Before attempting to attach a unit to a valve, be sure it is in mounting position (refer to the above section).
Check the target valve for contamination and leakage. If the valve requires it, do cleaning or service. Then, place the aluminum connector of the product against the valve and secure it by using the ring nut.

Should the target valve not be of type M30 x 1.5, an adaptor is required.

Once the unit is securely attached to the valve,

- Briefly tap the pen magnet on the micr°pelt logo on the product's cover
- The radio establishes a link to the gateway → upon successful completion, a double-beep sounds
- The motor performs a reference run → upon successful completion, a triple-beep sounds

→ The unit is now active

Activation only works from mounting position. If performed during normal operation, the product will not show any reaction.

12.6 Reset (from Normal Operation only)

The MLR003 RESET function allows access to mounting position. It is also useful to restore correct operation should a malfunction occur.

To RESET the device,

- Hold the pen magnet to the micr°pelt logo on the product's cover until a beep sounds

→ The internal microcontroller will reset and restart
→ If the device is mounted on a valve, it will activate
If the device is unmounted, it will go into mounting position and switch OFF

12.7 No Reset from Mounting Position

12.8 Removal from the Valve

Unscrew the ring nut from the valve and RESET the device. It will move to mounting position and switch OFF.

12.9 Temperature Control Loop

To obtain an estimate of the ambient temperature, the device measures the flow temperature every 5 minutes and performs a moving average across the last 30 minutes. It then performs the following computation:

$$\frac{Ambient\ Sensor\ Raw\ Value^{2.2}}{(Flow\ Sensor\ Raw\ Values\ Moving\ Average)^{1.2}}$$

Having established an estimate of the ambient temperature, the device then compares this estimate to the ambient temperature requested by the user. If they are the same, or if the ambient temperature is already moving towards the requested temperature, the device does not move the motor. Otherwise, the device applies a Proportional Controller Gain algorithm to compute the motor movement:

$$(P * Temperature\ Difference * 4)\%$$

The default value of P is 3. It can be modified via the downlink packet (Section 11.3).

12.10 Antifreeze

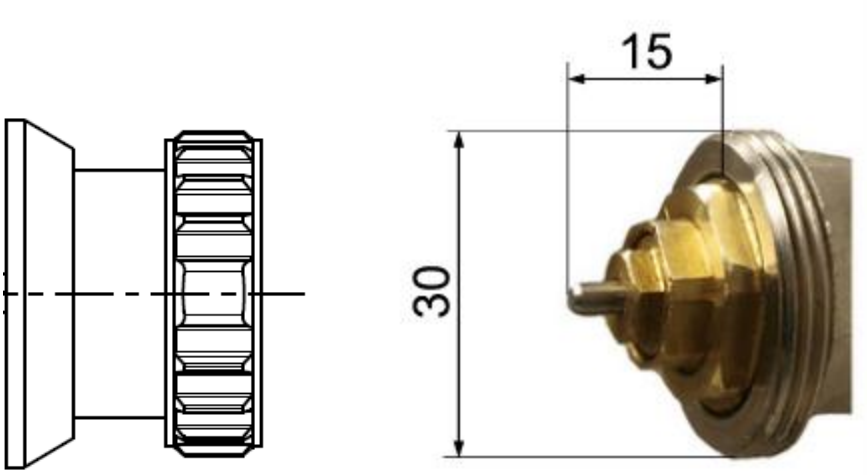
The antifreeze function prevents damage to the radiator and pipes which could potentially happen when a room is not heated during the cold months. Below 6°C at the integrated valve side temperature sensor, the valve opens to 95%. The 6°C is an absolute temperature, any user-offset is ignored.

13 Performance Data

Parameter	Range
Ambient operating temperature	0 to 40°C, max 70% rH
Flow pipe temperature	75°C max
Transportation & storage temperature range	-20 to +65°C, max 70% rH
Dimensions (LWH)	83 x 60 x 64 mm (63 x 60 x 64 without valve connector)
Weight	280 g (not including packing)
Operation at high altitude	Max 2000 m / 6500 ft above sea level
Max pin stroke (calibration range)	> 5.5 mm
Operating pin stroke (0-100%)	2.56 mm typical
Pin Stroke Resolution	Steps of 1%
Adjustment speed	0.727 mm/s typical
Stall force	100N (80 … 120N)
Noise level	< 35 dB(A) @ 70 N load
Radio Communication Interval (default)	10 minutes
Radio Communication Interval during Installation Cycle	10 seconds for 5 minutes
Radio Communication attempt Interval (after join fail or 6 consecutive communication fails)	3 * 10 seconds Then 2 minutes Then 60 minutes
Valve protection and Auto-off when active but not installed on valve body	Every 6 weeks: Execute run-in sequence. On pass return to previous position. On fail enter mounting position, communicate OFF and shut down.
Antifreeze	Valve side sensor <= 6°C
Safe position default	Depending on Safety Mode: Either default temperature Or default valve position
Operating Modes	Valve Position [%] Target Ambient Temperature (°C) Target Flow Temperature (°C)
Accuracy of internal valve side temperature sensor	±0.25°C
Accuracy of internal ambient temperature sensor	±0.25ºC
Default offset of internal valve-side temperature sensor	+3K (Added to the raw sensor value FSRV)
Energy storage	LTO (Nominal 500mAh)
Energy generation minimum requirement	90 days / year @ 45ºC flow pipe temperature
Battery voltage flag (ES)	Battery-low flag will be set when battery voltage drops below 2.3V
Conformity Radio Radio EMC EMC EU Human Exposure Product safety	CE: EN300220-2V3.1.1 & EN300220-2V3.2.1 & EN300220-1V3.1.1 EN301489-1 V2.2.3 / -3 V2.1.1 EN55014-1 / -2 EN62479 EN60335
Radio specification	868.0 - 868.6 MHz, 14 dBm

14 Mechanical Interface to Radiator Valve

The MLR003 is designed to mount onto an M30 x 1.5mm radiator valve.



Several other valve types are served by metallic adapter pieces.

15 CE Conformity

In progress.

16 Accessories

16.1 MLR003-KEY Magnetic switch

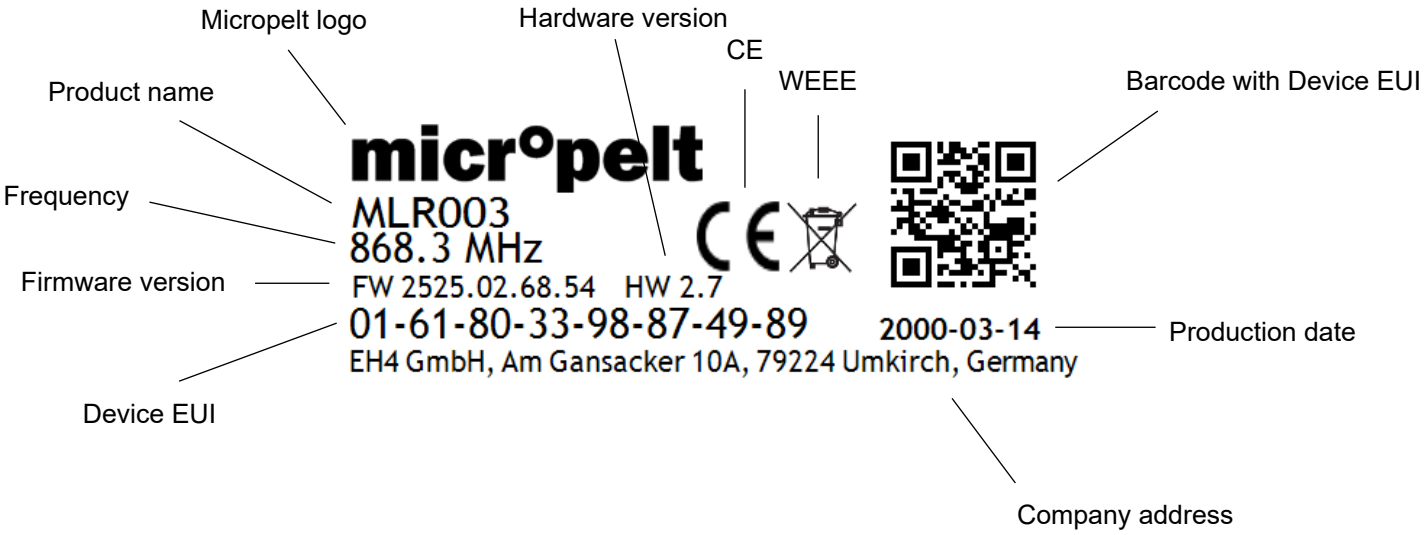
Pen-shaped magnet required for activating and deactivating the device (see Section 12.)

17 Label

17.1 Product label

Product label

NFC tag label



What	Requirement
Product type	On Label
Date of production	On Label
Hardware version	On Label
Firmware version	On Label
LoRaWAN frequency	On Label
Device EUI (16 digits)	On Label
Join EUI (16 digits)	In Spreadsheet
Application Key (32 digits)	Secret
Country of Origin	On Label
Address	On Label
Micropelt Logo	On Label

17.2 NFC Tag Label