

Heating Radiator Thermostat
MLR003RiEU61-07 (EN)
LoRaWAN CLASS A EU868MHz SF7BW125
User Manual and Device Specification



The Micropelt MLR003R product series has been designed for use with heating radiators and M30x1,5 valve thread. Installing the Micropelt MLR003 system is simple and only a matter of hours. Compared to conventional systems, the Micropelt MLR003 product allows significant cost savings on labour and material cost for wiring, network infrastructure, and building structural changes. LoRaWAN allows control of radiators over long distances, even inside buildings.

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1 MLR003RiEU61-07 Revision History

REV. No.	Description of Revision	Beschreibung der Überarbeitung	Revised by	Date
REV1.0	Document describes the first release of MLR003. Most recent changes are against the general-purpose platform description.	Das Dokument beschreibt die erste Version von MLR003. Die letzte Änderung gegenüber der allgemeinen Plattformbeschreibung.		
	<ul style="list-style-type: none"> Removed Summer mode Added 480min RCI in Payload Added temperature offset for valve- and ambient-sensor Added harvesting pause during radio communication 	<ul style="list-style-type: none"> Sommermodus entfernt 480min RF CI in der Payload hinzugefügt Temperatur-Offset für Ventil- und Umgebungs-Sensor hinzugefügt Harvesting-Stopp während der Funkverbindung hinzugefügt 	Schmidt Volkert	2021-01-21
	<ul style="list-style-type: none"> Change product name to MLR003 General update on description and user guide 	<ul style="list-style-type: none"> Änderung des Produktnamens in MLR003 Allgemeine Aktualisierung der Beschreibung und des Benutzerhandbuchs 	Volkert	2021-06-21
	Change downlink payload Added Label spec.	Downlink-Payload ändern Label-Spezifikation hinzugefügt	Becky Volkert	2021-06-22
	Change Activating from Mounting Position operating flow diagram Changed front page picture of MLR003	Betriebsablaufdiagramm für die Aktivierung aus der Montageposition ändern Bild auf der Titelseite von MLR003 geändert	Becky Volkert	2021-08-04 2021-08-20

	<p>Full document review</p> <p>Update cover page, headlines, added section 7.2</p>	<p>Vollständige Überprüfung des Dokuments</p> <p>Aktualisierung der Titelseite, Überschriften, Hinzufügung von Abschn. 7.2</p>	<p>Becky</p> <p>Volkert</p>	<p>2021-09-22</p> <p>2021-09-23</p>
	<p>Adjust speaker beeping communication in user interface</p> <p>Added SF7BW125 to front page</p> <p>Removed downlink "reserved" bytes 7 and 8</p> <p>Added picture of MLR003-KEY</p>	<p>Anpassung der Lautsprecher-Pieps-Kommunikation in der Benutzeroberfläche</p> <p>SF7BW125 auf der Titelseite hinzugefügt</p> <p>Downlink "reservierte" Bytes 7 und 8 entfernt</p> <p>Bild von MLR003-KEY hinzugefügt</p>	<p>Becky</p> <p>Volkert</p>	<p>2021-09-28</p> <p>2021-10-11</p>
	<p>Added clauses and information required by product safety, EN60335-1:2012.</p> <p>Described the position of the labels</p> <p>Corrected distortion of "CE"-print on product label</p>	<p>Hinzufügen von Klauseln und Informationen, die für die Produktsicherheit erforderlich sind, EN60335-1:2012.</p> <p>Die Position der Etiketten wurde beschrieben.</p> <p>Verzerrung des "CE"-Aufdrucks auf dem Produktetikett korrigiert</p>	<p>Schmidt</p>	<p>2021-11-05</p>
	<p>Added certification details</p> <p>Added contact email devicecredentials@micropelt.com</p> <p>Corrected NFC-Tag label (16.2)</p>	<p>Details zur Zertifizierung hinzugefügt</p> <p>E-Mail-Kontakt hinzugefügt devicecredentials@micropelt.com</p> <p>NFC-Etikett korrigiert (16.2)</p>	<p>Volkert</p>	<p>2021-11-19</p>
REV1.1	<ul style="list-style-type: none"> Extend Uplink payload to include User Mode and User Value Extend motor Reference Run travel distance 	<ul style="list-style-type: none"> Erweiterung der Uplink-Payload um User Mode und User Value Erweiterung der Motor-Referenzfahrt-Distanz 	<p>Becky</p>	<p>2022-01-24</p>

	Added declaration of conformity (CE)	Konformitätserklärung (CE) hinzugefügt	Volkert	2022-01-24
	Added new section 09.11 Battery Charging Flow Chart	Neuer Abschnitt 09.11 Flussdiagramm zum Aufladen der Batterie hinzugefügt	Bala	2022-02-16
	Changed product name and article number to MLR003RiEU61-07-1.1 (and) MLR003RiUK61-07-1.1	Produktname und Artikelnummer geändert in MLR003RiEU61-07-1.1 (und) MLR003RiUK61-07-1.1	Volkert	2022-02-23
REV1.3	Remote Commissioning: <ul style="list-style-type: none"> • Port 2: Version • Port 3: Motor Travel Distance • Port 4: LoRa Data Rate 	Remote Commissioning: <ul style="list-style-type: none"> • Port 2: Version • Port 3: Motor Arbeitsbereich • Port 4: LoRa Datenrate 	Becky	2022-05-26
REV1.4	Increased Zero Drift Compensation range to 30%	Der Bereich für die Nullpunktdriftkompensation wurde auf 30% erhöht	Bala	2022-11-30
REV1.5	Increased Motor Force to reduce Zero Drift	Erhöhte Motorkraft zur Reduzierung der Nullpunktverschiebung	Bala	2023-01-20
REV1.6	<ul style="list-style-type: none"> • Reduce default Ambient Temperature from 20°C to 19°C • Reduce ACK frequency from every Uplink to up to every 30 minutes 	<ul style="list-style-type: none"> • Verringerung der Standard-Umgebungstemperatur von 20°C auf 19°C • Verringerung der ACK-Häufigkeit von jedem Uplink auf bis zu alle 30 Minuten 	Becky	2023-01-23
REV1.8	ESD protection for transport	ESD-Schutz für den Transport	Bala	2023-03-27
	Changed the trigger condition for Radio Failure in “Operating Modes”	Geänderte Auslösebedingung für Funkausfall in "Betriebsmodi"	Bala	2023-03-27

	Updated product label design and specification for EU and UKCA versions	Aktualisierte Produktetikett und spezifikation für EU- und UKCA versionen	Bala	2023-05-11
REV2.0	Opening Point Detection and Slow Harvesting	Öffnungspunkterkennung und Slow Harvesting	Becky	2023-05-17
REV2.1	FPORT 0: MAC Command 0x06 returns Battery level information. Fix the scalings: Battery voltage is scaled from 2000mV to 2640mV LoRa report value is from 1 to 254	FPORT 0: MAC-Befehl 0x06 gibt Informationen über den Batteriestand zurück. Die Skalierungen wurden korrigiert: Die Batteriespannung wird von 2000mV bis 2640mV skaliert LoRa-Berichtswert liegt zwischen 1 und 254	Becky	2023-07-20
REV2.2	When the device loses gateway connection, goes into Safety Mode, and then reconnects to the gateway, then always switch back to User Mode. When estimating the ambient temperature, retain precision of the flow moving average.	Wenn das Gerät die Verbindung zum Gateway verliert, in den Sicherheitsmodus wechselt und dann wieder mit dem Gateway verbunden wird, schaltet es immer in den Benutzermodus zurück. Bei der Schätzung der Umgebungstemperatur behält es die Genauigkeit des Durchschnittswertes Vorlauftemperaturen bei.	Becky	2023-09-21
REV2.3	Forced Heating: Activate at 2.2V rather than 2.0V. Flow & Ambient temperature estimation: round rather than truncate.	Erzwungene Heizung: Aktivierung bei 2,2 V anstelle von 2,0 V. Durchfluss und Umgebungstemperatur abschätzen: Runden statt abschneiden.	Becky	2023-10-19

REV2.4	<p>FPORT 0: MAC Command 0x06 Battery voltage scaled from 2200mV to 2640mV</p> <p>FPORT 1: P-Controller Gain removed, replaced with FPORT 7</p> <p>FPORT 6: Temperature Drop Detection</p> <p>FPORT 7: PI Temperature Control</p>	<p>FPORT 0: MAC-Befehl 0x06 Batteriespannung skaliert von 2200mV bis 2640mV</p> <p>FPORT 1: P-Controller Gain entfernt, ersetzt durch FPORT 7</p> <p>FPORT 6: Temperaturabfall-Erkennung</p> <p>FPORT 7: PI Temperaturregler</p>	Becky	2023-11-30
REV2.5	<p>FPORT 0x0F: On/Off</p> <p>Forced Heating: Upon activation, send an Uplink</p>	<p>FPORT 0x0F: Ein/Aus</p> <p>Erzwungene Heizung: Bei Aktivierung wird ein Uplink gesendet</p>	Becky	2023-12-21
REV2.6	<p>Slow Harvesting: By Default Off</p> <p>On/Off: By Default, 6-week Recalibration does not cause switch-off</p>	<p>Slow Harvesting: Default Aus</p> <p>Ein/Aus: Default führt die 6-wöchige Rekalibrierung nicht zur Abschaltung.</p>	Becky	2024-01-18
REV2.9	<p>Reference Runs: Extend delay between motor direction changes</p> <p>Reed Contact: When resetting, wait for motor movement to complete before performing a 5-second magnet hold</p> <p>User Mode: Report Freeze Protect & Forced Heating</p> <p>FPORT 4: Remove unnecessary Rejoin</p> <p>FPORT 8: Temperature Estimation Flow Temperature Offset</p> <p>FPORT 9: External Temperature Sensor Expiry</p>	<p>Referenzfahrten: Längere Verzögerung zwischen den Richtungsänderungen des Motors</p> <p>Reed-Kontakt: Beim Zurücksetzen warten, bis die Motorbewegung abgeschlossen ist, bevor ein 5-Sekunden-Magnethalt ausgeführt wird</p> <p>Benutzer-Modus: Frostschutz und Erzwungene Heizung werden gemeldet</p> <p>FPORT 4: Unnötige Rejoin entfernt</p> <p>FPORT 8: Einstellung der Temperaturabschätzung</p> <p>FPORT 9: Ablauf des externen Temperatursensors</p>	Becky	2024-04-04

REV2.a	<p>FPORT 1: report Used Temperature</p> <p>FPORT 3: extend to 0.624mm FPORT 3: set default to 1.872mm</p> <p>FPORT 7: add D-Coefficient FPORT 7: add Closed Percent FPORT 7: change defaults to 2.4, 0.06, 22.2</p> <p>FPORT 10: send room temperature</p> <p>FPORT 11: beep</p>	<p>FPORT 1: die verwendete Temperatur wird gemeldet</p> <p>FPORT 3: erweitert auf 0,624 mm FPORT 3: Standardeinstellung 1,872 mm</p> <p>FPORT 7: D-Koeffizient wurde hinzugefügt FPORT 7: geschlossenes Prozent wurde hinzugefügt FPORT 7: Standardwerte geändert auf 2,4, 0,06, 22,2</p> <p>FPORT 10: Raum Temperatur</p> <p>FPORT 11: Piep</p>	Becky	2024-06-22
REV2.b	<p>PID: Implementation</p> <p>PID: Add optional "Offset Percent"</p> <p>PID: Stop accumulating error temperatures for k_I when motor is at endstops</p> <p>Temperature Estimate: Apply moving average on the ambient estimate</p>	<p>PID: Implementierung</p> <p>PID: Optionalen „Offset-Prozentwert“ hinzufügen</p> <p>PID: Anhalten der Fehler Temperatur Akkumulation für k_I, wenn der Motor am Endanschlag steht</p> <p>Temperatur-Schätzung: Anwendung des gleitenden Mittelwerts auf die Schätzung der Umgebungstemperatur</p>	Bala	2024-07-19
REV2.c	<p>Temperature Estimate: Weighted moving average for the Flow Temperature and Ambient temperature estimate is calculated based on the weighted flow moving average</p>	<p>Schätzung der Temperatur: Der gewichtete gleitende Durchschnitt für die Schätzung der Vorlauf Temperatur und der Umgebungstemperatur wird auf der Grundlage des gewichteten gleitenden Durchschnitts des Vorlaufs berechnet.</p>	Bala	03 Sep 2024

2 MLR003RiEU61-07 Intended Use

The Micropelt MLR003R product series has been designed for use with controlling water-filled heating radiators. Any other use – including control of floor heating systems – is not permitted and can result in malfunctions or damage. It is important to comply with the safety notice included in these operating instructions.

3 MLR003RiEU61-07 Safety

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 any other object.
- 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 damage due to condensation.
- The thermostatic head is designed for indoor use only. Do not allow the thermostatic head 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 head has been designed and must solely be used for the purpose of controlling a M30 x 1.5 circulation 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.

In case of questions, please contact:

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4 MLR003RiEU61-07 General Description

This document defines the properties of Micropelt's maintenance free, intelligent thermostatic head MLR003.

Installing the Micropelt MLR003 system is simple and only a matter of hours. Compared to conventional systems, the Micropelt MLR003 product allows significant cost savings on labour and material cost for wiring, network infrastructure, and building structural changes.

MLR003 is an 868MHz LoRaWAN CLASS-A wireless actuator. LoRaWAN allows to control over long distances, even inside buildings. 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). 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.

Each standard production MLR003 unit has a unique DEVEUI, JOINEUI (APPEUI) 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 controller or gateway unit supporting its communication profile. Once mounted and activated on the valve body using the magnetic key, a calibration cycle starts to automatically adapt itself to the individual valve. Then it is ready for use.

Success of activation or deactivation is signaled by tone signals and LED.

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. 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.

The actuator has a built-in, valve-side temperature sensor to determine the flow pipe temperature. A controllable offset 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 integrated valve side temperature sensor is also used for freeze protection. Freeze protection is activated at $\leq 6^{\circ}\text{C}$.

The ambient sensor is used to measure the room temperature. During heating operation, the ambient sensor is influenced by self-heating of the metallic device housing. An algorithm is used to estimate the actual ambient temperature.

Temperature values are transmitted in both raw and corrected temperature formats.

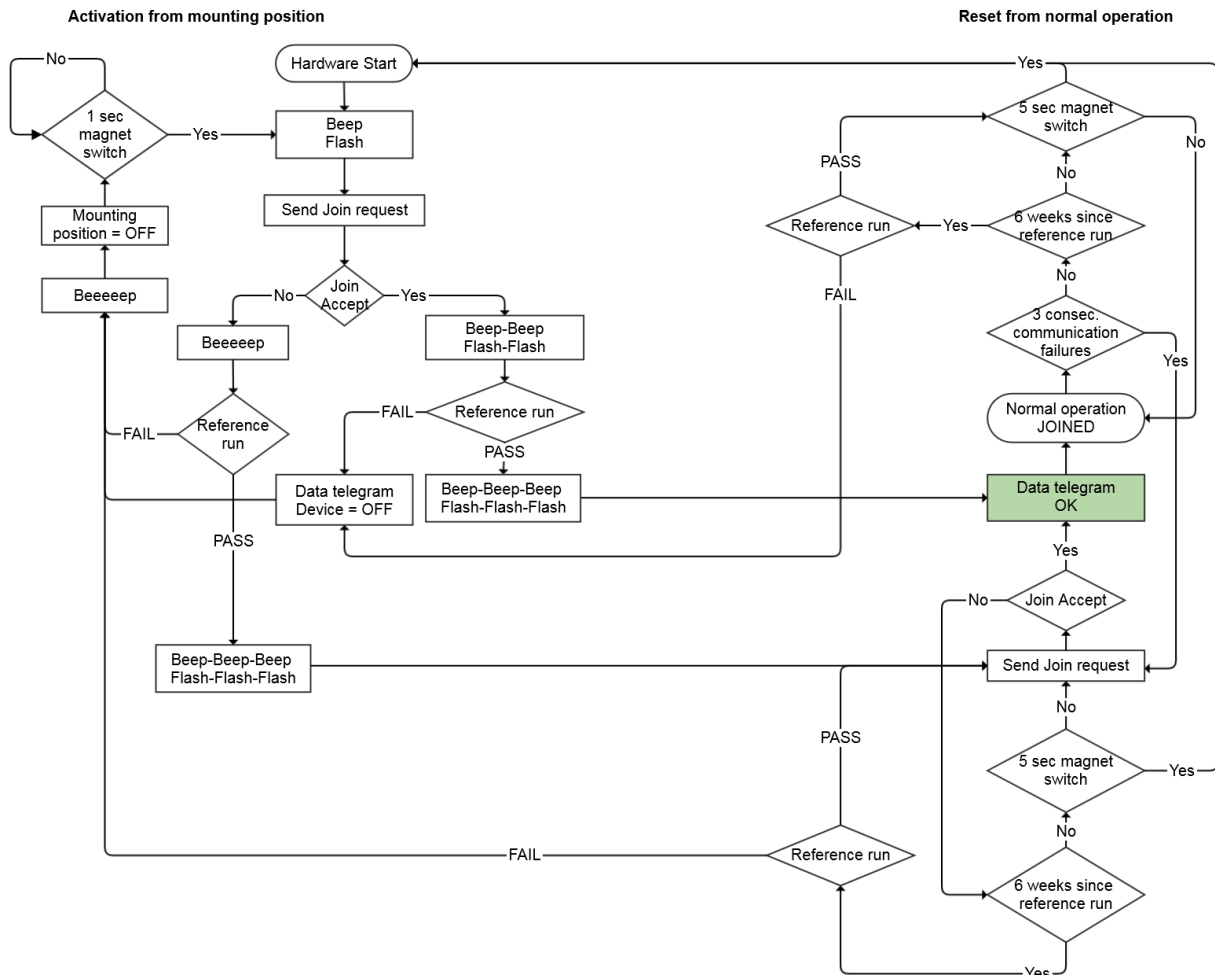
If it has been 30 minutes or more since the device has received communication from the gateway (Join Request success, Downlink from user, ACK response), then the device requests an Acknowledgement of its next Uplink. An ACK request without an ACK response is reported by status bit "RCE". After 3 consecutive unsuccessful ACK requests, the actuator automatically switches to "Rejoin". In this situation,

the actuator switches to Safety Mode and Safety Value as specified by the user, and sends Join Requests every hour until it rejoins a gateway.

The actuator generates the required electrical energy for operation by means of a built-in thermoelectric generator (TEG) and therefore operates maintenance-free.

5 MLR003RiEU61-07 Operating Instructions

5.1 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.

5.2 Setting up a Gateway

In a web browser, navigate to the gateway IP address

1. Login to the gateway
2. LoRaWAN, Network Settings, Join Delay 5 seconds
3. 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'
5. Click Submit
6. Wait for Save and Apply to go red, and then click it

5.3 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 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. LoRaWAN, Key Management, click Add New
4. 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
5. Click Submit
6. Wait for Save and Apply to go red, and then click it

5.4 Mounting Position and OFF

In mounting position, the plunger inside the valve actuator is fully retracted, so that the unit can easily be attached to a circulation 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 micropelt 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.

5.5 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,

1. Briefly tap the pen magnet on the micropelt logo on the product's cover
2. The radio establishes a link to the gateway → upon successful completion, a double-beep sounds
3. The motor performs a reference run → upon successful completion, a triple-beep sounds
4. The unit is now active

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

Upon activation, the device initially moves to 50%. From there it makes adjustments as appropriate (moves to the instructed valve position, or monitors and controls the temperature).

5.6 Reset (from Normal Operation only)

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

To RESET the device,

1. Hold the pen magnet to the micr°pelt logo on the product's cover until a beep sounds
2. 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

Note: During radio communication and motor movement, the device ignores magnet input. If the magnet has been held to the micr°pelt logo for more than 5 seconds but a beep did not sound, briefly remove the magnet and then try again.

5.7 No Reset from Mounting Position

5.8 Removal from the Valve

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

6 MLR003RiEU61-07 Operating Modes

	Installation cycle	Standard operation	Idle state	Radio failure	Forced heating	Freeze Protection
Comments		Valve target % Or Room target temperature	Phases between monitoring, communicating, and motor movement	Uplinks not received by the gateway	Valve opens to 50% (or remains in current position if current position is $\geq 50\%$)	Valve opens to 95% (or remains in current position if current position is $\geq 95\%$)
Trigger	Magnetic switch. Join accept from Gateway, & Device is mounted	Internal timer	Internal timer	From activation: No Gateway connect From standard operation: 3 consecutive Gateway communication failures (9x RCE)	Battery voltage < 2.2V	Flow sensor raw temperature $\leq 6^{\circ}\text{C}$
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	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, every 10 seconds	Setpoint Ambient Temperature: Active, every 5 minutes Valve Position: According to radio communications	OFF	Active, every 5 minutes	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 Setpoint Ambient Temperature: active	If User Mode is Setpoint Ambient Temperature: active	OFF	If Safety Mode is Setpoint Ambient Temperature: active	OFF	OFF

Default upon activation and no downlinks	Setpoint Ambient Temperatur e 19°C	Setpoint Ambient Temperatur e 19°C RCI 10 minutes		Setpoint Ambient Temperatur e 19°C		
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7 MLR003RiEU61-07 Communication Profile

<u>FPort Number</u>	<u>Type of operation</u>	<u>Payload length</u>	<u>Description</u>	<u>Comments</u>
0x00	MAC Commands	8 Bytes	Defined by LoRaWAN	
0x01	<ul style="list-style-type: none"> Valve position % mode Temperature setpoint mode (°C) with ambient or external temperature sensor 	Downlink: 6 Bytes Uplink: 12 Bytes	<ul style="list-style-type: none"> Actuator operation mode with valve position % Self-regulation mode using the requested ambient setpoint temperature 	Strongly recommended to always use an external temperature sensor
0x02	Report: <ul style="list-style-type: none"> REV Hardware Version Firmware Version 	Downlink: 0 Bytes Uplink: 6 Bytes	Request: <ul style="list-style-type: none"> REV Hardware Version Firmware Version 	
0x03	Motor Travel Distance	Downlink: 1 Byte Uplink: 1 Byte	Configure motor travel distance (mm)	
0x04	Data Rate	Downlink: 1 Byte Uplink: 1 Byte	Configure LoRa data rate	Only supported in the MLR003R/ Radiator product line. MLR003F/ Domestic Hot Water product line is using ADR.

0x05	Slow Harvesting (SH) and valve Opening Point Detection (OPD)	Downlink: 1 Byte Uplink: 1 Byte	<ul style="list-style-type: none"> • Activate, configure, and deactivate OPD and SH • View status of OPD and SH 	Only supported in the MLR003R/ Radiator product line.
0x06	Temperature Drop Detection (TDD)	Downlink: 1 Byte Uplink: 1 Byte	Configure response to Detection of a Temperature Drop	Only supported in the MLR003R/ Radiator product line.
0x07	PID Temperature Control	Downlink: 7 Bytes Uplink: 7 Bytes	Configure the PID-Coefficients	Only supported in the MLR003R/ Radiator product line.
0x08	Temperature Estimation Algorithm	Downlink: 1 Byte Uplink: 1 Byte	Configure the Temperature Estimation Algorithm Coefficients	Only supported in the MLR003R/ Radiator product line.
0x09	External Temperature Sensor Expiry	Downlink: 1 Byte Uplink: 2 Bytes	Configure the External Temperature Sensor Expiry Time View Temperature Source currently in use	Only supported in the MLR003R/ Radiator product line.
0x0a	External Temperature	Downlink: 1 Byte Uplink: None	Send the Room Temperature from an external temperature sensor to the device	Only supported in the MLR003R/ Radiator product line.

0x0b	Beep	Downlink: 1 Byte Uplink: None	Instruct the device to beep	
0x0F	On/Off	Downlink: 1 Byte Uplink: 1 Byte	<ul style="list-style-type: none"> • Instruct Device to stay ON even if 6-week Reference Run finds that device is Unmounted • Instruct a Recalibration • Instruct a device to switch OFF 	

7.1 MLR003RiEU61-07 FPORT 0x00 MAC Commands

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSE T	ABBREVIATION	DETAILS
1	DB0.7...0.0	8	0	DevStatusReq	Requests the battery level of the device 0x06 = Device Status Request

Response is communicated in field “opts” (not in an FPORT 0x00 Uplink)

BYTE	BIT RANGE	SIZE	OFFSE T	ABBREVIATION	DETAILS														
1	DB0.7...0.0	8	0		0x06														
2	DB1.7...1.0	8	8	DevStatusAns	<table border="1"> <thead> <tr> <th colspan="2">Battery Level</th> </tr> <tr> <th>Device Response</th> <th>Battery Level</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>The device is connected to an external power source</td> </tr> <tr> <td>1</td> <td>2.20 V</td> </tr> <tr> <td>$1 \leq d \leq 254$</td> <td>$2.2 + \frac{(d - 1) * 0.64}{253} V$</td> </tr> <tr> <td>254</td> <td>2.64 V</td> </tr> <tr> <td>255</td> <td>The device was not able to measure the battery level</td> </tr> </tbody> </table>	Battery Level		Device Response	Battery Level	0	The device is connected to an external power source	1	2.20 V	$1 \leq d \leq 254$	$2.2 + \frac{(d - 1) * 0.64}{253} V$	254	2.64 V	255	The device was not able to measure the battery level
Battery Level																			
Device Response	Battery Level																		
0	The device is connected to an external power source																		
1	2.20 V																		
$1 \leq d \leq 254$	$2.2 + \frac{(d - 1) * 0.64}{253} V$																		
254	2.64 V																		
255	The device was not able to measure the battery level																		
3	DB2.7...2.0	8	16	DevStatusAns	Demodulation Margin SNR in dB rounded to the nearest integer value for the last successfully received DevStatusReq command														

7.2 MLR003RiEU61-07 FPORT 0x01 UPLINK: Device to Controller / Network Server

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	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 ... 127.5°C Res = 0.5°C
3	DB2.7...2.0	8	16	FTMP	Flow TEMPERATURE Value °C 0x00 ... 0xFF / 0 ... 127.5°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 0x00 ... 0xFF / 0 ... 63.75°C Res = 0.25°C
6	DB5.7	1	40	TDD	Temperature Drop Detection 1 = Ambient RAW value dropped by \geq 1.5°C during the last 10 minutes
	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
	DB5.1	1	46	RSS	Radio Signal Strength 0 = Normal Radio Signal (RSSI is \geq -100 dBm) 1 = Weak Radio Signal (RSSI is $<$ -100 dBm)
	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 ... 2550 μ A Res = 10 μ A
9	DB8.7...7.0	8	64	ACG	Average Current Generated 0x00 ... 0xFF / 0 ... 2550 μ A Res = 10 μ A
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	ZE	0% Error 0 = Device can find 0% 1 = Device may be Unmounted	
	DB9.4	1	75	CAL	Calibration OK 0 = Device is Unmounted 1 = Most recent Calibration Succeeded	
	DB9.3	1	76		RESERVED	
	DB9.2...9.0	3	77	UM	User Mode As set by the last received Downlink (DB3.3...3.2)	
					0b000	Valve Position %
					0b001	RESERVED
					0b010	SP Ambient Temperature °C
					0b011	Detecting Opening Point
					0b100	Slow Harvesting
					0b101	Temperature Drop Detected, and device is responding with instructed Action
					0b110	Freeze Protect is active
					0b111	Forced Heating is active

11	DB10.7... 10.0	8	80	UV	<p>User Value according to User Mode</p> <p>As set by the last received Downlink (DB0.7...0.0)</p> <p>VALVE %: 0x00 ... 0x64 / 0 ... 100%</p> <p>Res = 1%</p> <p>AMB TEMP: 0x00 ... 0x50 / 0 ... 40°C</p> <p>Res = 0.5°C</p> <p>If Freeze Protect or Forced Heating is active, this value is the valve percent instructed by the device.</p> <p>If Detecting Opening Point or Slow Harvesting, this value is the maximum flow temperature:</p> <p>MAX FLOW TEMP: 0x00 ... 0x84 / 0 ... 33°C</p> <p>Res = 0.25°C</p>
12	DB11.7... 11.0	8	88	UTMP	<p>Used Temperature °C</p> <p>Ambient Temperature used in temperature control calculation</p> <p>0x00 ... 0xFF / 0 ... 63.75°C</p> <p>Res = 0.25°C</p>

7.3 MLR003RiEU61-07 FPORT 0x01 DOWNLINK: Controller / Network Server to Device

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS						
1	DB0.7...0.0	8	0	SPV	<p>Set Point Value according to User Mode</p> <p>VALVE %: 0x00 ... 0x64 / 0 ... 100%</p> <p>Res = 1%</p> <p>AMB TEMP: 0x00 ... 0x50 / 0 ... 40°C</p> <p>0x00 = Default = 0x26 = 19°C</p> <p>Res = 0.5°C</p>						
2	DB1.7...1.0	8	8	RT	<p>Room Temperature from RCU °C</p> <p>0x00 ... 0xA0 / 0 ... 40°C</p> <p>0x00 = No Room Temperature provided</p> <p>Res = 0.25°C</p>						
3	DB2.7...2.0	8	16	SSV	<p>Set Safety Value according to safety mode</p> <p>AMB TEMP: 0x00 ... 0x50 / 0 ... 40°C</p> <p>0x00 = Default = 0x26 = 19°C</p> <p>Res = 0.5°C</p> <p>VALVE %: 0x00 ... 0x64 / 0 ... 100%</p> <p>Res = 1%</p>						
4	DB3.7	1	24		RESERVED						
	DB3.6...3.4	3	25	RCI	<p>Radio Communication Interval</p> <p>0b000 = Default = 10 minutes</p> <table border="1"> <tr> <td>0b000</td> <td>10 minutes</td> </tr> <tr> <td>0b001</td> <td>5 minutes</td> </tr> <tr> <td>0b010</td> <td>60 minutes</td> </tr> </table>	0b000	10 minutes	0b001	5 minutes	0b010	60 minutes
0b000	10 minutes										
0b001	5 minutes										
0b010	60 minutes										

					0b011	120 minutes
					0b100	480 minutes
					0b101	RESERVED
					0b110	RESERVED
					0b111	RESERVED
	DB3.3...3.2	2	28	UM	User Mode 0b10 = Default = SP Ambient Temperature	
					0b00	Valve Position %
					0b01	RESERVED
					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	RESERVED
					0b10	Valve Position %
					0b11	RESERVED
5	DB4.7...4.0	8	32		RESERVED	

6	DB5.7	1	40	REF	Do Reference Run now Default = 0 1 = Reference Run now
	DB5.6...5.0	7	41		RESERVED

7.4 MLR003RiEU61-07 FPORT 0x02 Version

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS
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Requests a 0x02 Uplink containing the device version details

UPLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS
1	DB0.7...0.4	4	0	REV	REV Minor value
	DB0.3...0.0	4	4		REV Major value
2	DB1.7...1.4	4	8	HW	Hardware Minor value
	DB1.3...0.0	4	12		Hardware Major value
3	DB2.7...2.0	8	16	FWy	Firmware Year value since 2000
4	DB3.7...3.4	4	24		RESERVED
	DB3.3...3.0	4	28	FWm	Firmware Month value (1 = January, 12 = December)
5	DB4.7...4.6	3	32		RESERVED
	DB4.5...4.0	5	35	FWd	Firmware Day value (1 = 1st day of the month)
6	DB5.7...5.0	8	40	FWi	Firmware Minor value

7.5 MLR003RiEU61-07 FPORT 0x03 Motor Travel Distance

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS
1	DB0.7...0.4	4	0		RESERVED
	DB0.3...0.0	4	4	MOR	Motor Operating Range
					0b0000 2.56048mm
					0b0001 RESERVED
					0b0010 RESERVED
					0b0011 0.624mm
					0b0100 0.832mm
					0b0101 1.040mm
					0b0110 1.248mm
					0b0111 1.456mm
					0b1000 1.664mm
					0b1001 1.872mm (Default)
					0b1010 2.080mm
					0b1011 2.288mm
					0b1100 2.496mm
					0b1101 RESERVED
					0b1110 RESERVED

					0b1111	RESERVED
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To receive an Uplink without changing any settings, send an empty Downlink.

UPLINK

Same as Downlink, confirming settings.

7.6 MLR003RiEU61-07 FPORT 0x04 LoRa Data Rate

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS	
1	DB0.7...0.1	7	0		RESERVED	
	DB0.0	1	7	DR	Data Rate	
					0b00	SF7BW125
					0b01	SF8BW125

UPLINK

Same as Downlink, confirming settings.

7.7 MLR003RiEU61-07 FPORT 0x05 Opening Point Detection and Slow Harvesting

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS								
1	DB0.7...0.5	3	0		RESERVED								
	DB0.4	1	3	OPR	<p>Opening Point Reset</p> <p>1 = Reset Opening Point: Device will set Opening Point Percent to Not Found.</p> <p>When it is appropriate for the device to do so, the device will re-find the Opening Point Percent.</p>								
	DB0.3...0.2	2	4	HW	<p>Hot Water Availability</p> <table border="1"> <tr> <td>0b00</td> <td>Use time of year to determine whether hot water is available</td> </tr> <tr> <td>0b01</td> <td>Hot water is off</td> </tr> <tr> <td>0b10</td> <td>Hot water is on</td> </tr> <tr> <td>0b11</td> <td>RESERVED</td> </tr> </table>	0b00	Use time of year to determine whether hot water is available	0b01	Hot water is off	0b10	Hot water is on	0b11	RESERVED
0b00	Use time of year to determine whether hot water is available												
0b01	Hot water is off												
0b10	Hot water is on												
0b11	RESERVED												
	DB0.1...0.0	2	6	SH	<p>Slow Harvesting</p> <p>Default = 0b11</p> <table border="1"> <tr> <td>0b00</td> <td>Default Opening Point Detection and Slow Harvesting</td> </tr> <tr> <td>0b01</td> <td>Do Opening Point Detection and Slow Harvesting now</td> </tr> </table>	0b00	Default Opening Point Detection and Slow Harvesting	0b01	Do Opening Point Detection and Slow Harvesting now				
0b00	Default Opening Point Detection and Slow Harvesting												
0b01	Do Opening Point Detection and Slow Harvesting now												

					0b10	Do Opening Point Detection now Disable Slow Harvesting
					0b11	Disable Opening Point Detection Disable Slow Harvesting
2	DB1.7	1	8		RESERVED	
	DB1.6...1.0	7	9	MAX	Maximum Flow Sensor Raw Temperature °C 0x00 ... 0x42 / 0 ... 33°C 0x00 = Default = 0x34 = 26°C Res = 0.5°C	

To receive an Uplink without changing any settings, send an empty Downlink.

UPLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS	
1	DB0.7	1	0	OPF	Opening Point Percent has been found	
					0	Not Found
					1	Found
	DB0.6...0.0	7	1	OP	Opening Point Percent 0x00 ... 0x64 / 0 ... 100% Res = 1%	
2	DB1.7...1.3	5	8		RESERVED	
	DB1.2...1.0	3	13	SH	Slow Harvesting Status	

					0b000	Not Slow Harvesting because Slow Harvesting is switched off in Downlink
					0b001	Not Slow Harvesting because recently target % \neq 0%
					0b010	Not Slow Harvesting because hot water is expected to be off
					0b011	Cannot detect Opening Point
					0b100	Not Slow Harvesting because battery is high
					0b101	Not Slow Harvesting because Slow Harvesting was attempted but generated insufficient current
					0b110	Detecting Opening Point
					0b111	Slow Harvesting

7.8 MLR003RiEU61-07 FPORT 0x06 Temperature Drop Detection

Device will only check for a Temperature Drop and respond to the Detection of a Temperature Drop when the Radio Communication Interval is 5 minutes or 10 minutes
The temperature drop measurement to detect $\geq 1,5^{\circ}\text{C}$ on the ambient raw sensor is done only in intervals of 10minutes.

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS	
1	DB0.7...0.6	2	0	TDA	Temperature Drop Action Default = 0b00 = Take No Action Upon Detection of a Temperature Drop:	
					0b00	Take No Action
					0b01	RESERVED
					0b10	close to 0% for 30 minutes and then resume normal operation
					0b11	close to 0% for 60 minutes and then resume normal operation
	DB0.5	1	2	TDB	Upon Resumption of Normal Operation:	
					0	Do not Beep
					1	Beep
	DB0.4	1	3	TDP	Temperature Drop Period Activation of Temperature Drop Action after at least:	
					0	one temperature drop

					1	two consecutive temperature drops
	DB0.3...0.0	4	4		RESERVED	

To receive an Uplink without changing any settings, send an empty Downlink.

UPLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS	
1	DB0.7...0.6	2	0	TDA	Temperature Drop Action Upon Detection of a Temperature Drop, device will:	
					0b00	Take No Action
					0b01	RESERVED
					0b10	close to 0% for 30 minutes and then resume normal operation
					0b11	close to 0% for 60 minutes and then resume normal operation
	DB0.5	1	2	TDB	Upon Resumption of Normal Operation, device will:	
					0	not Beep
					1	Beep
	DB0.4	1	3	TDP	Temperature Drop Period Activation of Temperature Drop Action after at least:	
					0	one temperature drop

					1	two consecutive temperature drops
	DB0.3...0.1	3	4		RESERVED	
	DB0.0	1	7	TDD	A Temperature Drop has been Detected	
0					No Detection	
1					Detection Ambient RAW value dropped by $\geq 1.5^{\circ}\text{C}$ during the last 10 minutes	

7.9 MLR003RiEU61-07 FPORT 0x07 PID Temperature Controller

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS
1	DB0.7...0.0	8	0	KP	P Coefficient 0 ... 255 Default = 0x0A = 10 Resolution = 1
2	DB1.7...1.0	8	8	KI	I Coefficient 0 ... 5.12 Default = 0x4B = 1.5 Resolution = 0.02
3	DB2.7...2.0	8	16	KD	D Coefficient 0 ... 51.2 Default = 0x00 = 0 Resolution = 0.2
4	DB3.7	8	24		Operating Style 1: Standard PID Controller
	DB3.6...3.0		25		RESERVED
5	DB4.7...4.0	8	32	CP	Closed Percent Minimum percent that device will close to Default = 0%
6	DB5.7...5.0	8	40	KD0	D Coefficient when closed 0 ... 51.2 Default = 0x00 = 0.0 Resolution = 0.2

7	DB6.7...6.0	8	40	OFP	Offset Percent Percentage Offset to be added to PID Output Default = 0x00 = 0%
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To receive an Uplink without changing any settings, send an empty Downlink.

UPLINK

Same as Downlink, confirming settings.

7.10 MLR003RiEU61-07 FPORT 0x08 Temperature Estimation

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS	
1	DB0.7...0.0	8	0	FADD	Flow Raw Value Offset	
					With 2's complement	
					Default = 0x00 = 0.00°C	
					Resolution = 0.25°C	
					0x00	0.00
					0x01	0.25
					0x02	0.50
				
					0x7F	31.75
					0x80	-32.00
...	...					
0xFF	-0.25					

To receive an Uplink without changing any settings, send an empty Downlink.

UPLINK

Same a Downlink, confirming settings.

Ambient Temperature Estimate Calculation:

$$\text{Flow Smoothened } F_s = \frac{(0.2F + 1.2F_{t-1} + 1F_{t-2} + 0.8F_{t-3} + 0.6F_{t-4} + 0.3F_{t-5} + 0.1F_{t-6})}{4.2} + \text{Flow Offset}$$

where F = Flow Raw Value

where Flow Offset = 0 (default)

if $(F_s - z(F_s - 0.5(F_{s_{t-3}} + F_{s_{t-4}}))) < \text{Ambient Raw Value}$

then

Flow Corrected $F_c = \text{Ambient Raw Value}$

else

Flow Corrected $F_c = (F_s - z * (F_s - 0.5(F_{s_{t-3}} + F_{s_{t-4}})))$

where z = 0.1

$$\text{Ambient Temperature Estimate} = \text{Ambient Raw Value} * \left(\frac{\text{Ambient Raw Value}}{\text{Flow Corrected } F_c} \right)^{1.2}$$

7.11 MLR003RiEU61-07 FPORT 0x09 External Temperature Sensor

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS	
1	DB0.7...0.0	8	0	EXP	External Temperature Sensor expiry. If a Room Temperature is sent by Downlink, continue using it until: a new Room Temperature is sent by Downlink, or until the Device loses Gateway communication, or until	
					0x00	no expiry
					x > 0x00	5 * x minutes pass
					Default = 0x30 = 4 hours	

To receive an Uplink without changing any settings, send an empty Downlink.

UPLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS	
1	DB0.7...0.0	8	0	EXP	External Temperature Sensor expiry. If a Room Temperature is sent by Downlink, it will be used until: a new Room Temperature is sent by Downlink, or until the Device loses Gateway communication, or until	
					0x00	no expiry
					x > 0x00	5 * x minutes pass

2	DB1.7	1	8	RTS	Source of Room Temperature value used for Temperature Control	
					0x00	Device is using internal temperature estimation algorithm
					0x01	Device is using most recently provided external temperature sensor value
	DB1.6...1.0	7	9		RESERVED	

7.12 MLR003RiEU61-07 FPORT 0x0a External Temperature

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS
1	DB0.7...0.0	8	0	RT	Room Temperature °C 0x00 ... 0xA0 / 0 ... 40°C Res = 0.25°C

UPLINK

No Uplink, device responds on Port 0x01.

7.13 MLR003RiEU61-07 FPORT 0x0b Beep

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS
1	DB0.7...0.0	8	0	BEEP	Instruct device to beep n times 0x00 ... 0xFF / 0 ... 255

UPLINK

No Uplink, device responds on Port 0x01.

7.14 MLR003RiEU61-07 FPORT 0x0f On/Off

DOWNLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS
1	DB0.7	1	0	ON	Device will stay on regardless of 6-week Reference Run results Default = 1 0 = If a 6-week Reference Run fails, device will switch off 1 = Device will stay on regardless of 6-week Reference Run results
	DB0.6	1	1	REC	Do a Recalibration Now 1 = Do a Recalibration Now Regardless of whether device is mounted or unmounted, after a Recalibration the device will continue operating
	DB0.5...0.1	5	2		RESERVED
	DB0.0	1	7	OFF	Switch OFF the device 1 = Device will move to mounting position and switch OFF

To receive an Uplink without changing any settings, send an empty Downlink.

UPLINK

BYTE	BIT RANGE	SIZE	OFFSET	ABBREVIATION	DETAILS
------	-----------	------	--------	--------------	---------

1	DB0.7	1	0	ON	Device will stay on regardless of 6-week Reference Run results 0 = If a 6-week Reference Run fails, device will switch off 1 = Device will stay on regardless of 6-week Reference Run results
	DB0.6	1	1	REC	Recalibration was Done 1 = The previous Downlink was an FPORT 0x0F Downlink instructing a Recalibration. Between the previous Downlink and this Uplink, a Recalibration was performed Recalibration result is displayed in FPORT 0x01 Uplink bit CAL
	DB0.5...0.1	5	2		RESERVED
	DB0.0	1	7	OFF	RESERVED OFF response will be displayed in FPORT 0x01 Uplink bit OFF

Activity	Mounted behaviour	Unmounted behaviour
Device Activation or Reset (magnet tap or magnet long hold)	Port 1 CAL bit 1 & OFF bit 0 Uplinks sent at 10 second intervals	Port 1 CAL bit 0 & OFF bit 1 No further Uplinks Long beep Device switches off
Device goes to 0% but does not find an endstop	Port 1 CAL bit 0 & OFF bit 0 until next successful Recalibration (6-weekly or Downlink)	
6-week recalibration	Port 1 CAL bit 0 & OFF bit 0 followed by Port 1 CAL bit 1 & OFF bit 0	Port 1 CAL bit 0 & OFF bit 0 until next successful Recalibration (6-weekly or Downlink)

Port 0x0F Existing configuration DB0.7 to 0 6-week recalibration	Port 1 CAL bit 0 & OFF bit 0 followed by Port 1 CAL bit 1 & OFF bit 0	Port 1 CAL bit 0 & OFF bit 1 No further Uplinks Long beep Device switches off
Port 1 Downlink Reference Run	Reference Run performed Port 1 CAL bit 1 & OFF bit 0	Reference Run performed Port 1 CAL bit 0 & OFF bit 1 No further Uplinks Long beep Device switches off
Port 0x0F Downlink Recalibration	Recalibration performed Port 0x0F acknowledgement Port 1 CAL bit 1 & OFF bit 0	Recalibration performed Port 0x0F acknowledgement Port 1 CAL bit 0 & OFF bit 0
Port 0x0F Downlink OFF	Port 1 CAL bit 1 & OFF bit 1 Device switches off	

8 MLR003RiEU61-07 Power Consumption

Function	Power consumption average current draw	Battery runtime w/o active harvesting @ 500mAh
Mounting position	2.2 μ A	25.9 years
Radio communication every 10 min. No motor = unheated room	10 μ A	5.7 years
Radio communication every 10 min. Motor movement: Morning: Full open Throughout the day: 10% every 30 min. Evening: Full close Total: 400%	50 μ A	1.1 years

9 MLR003RiEU61-07 Power Management

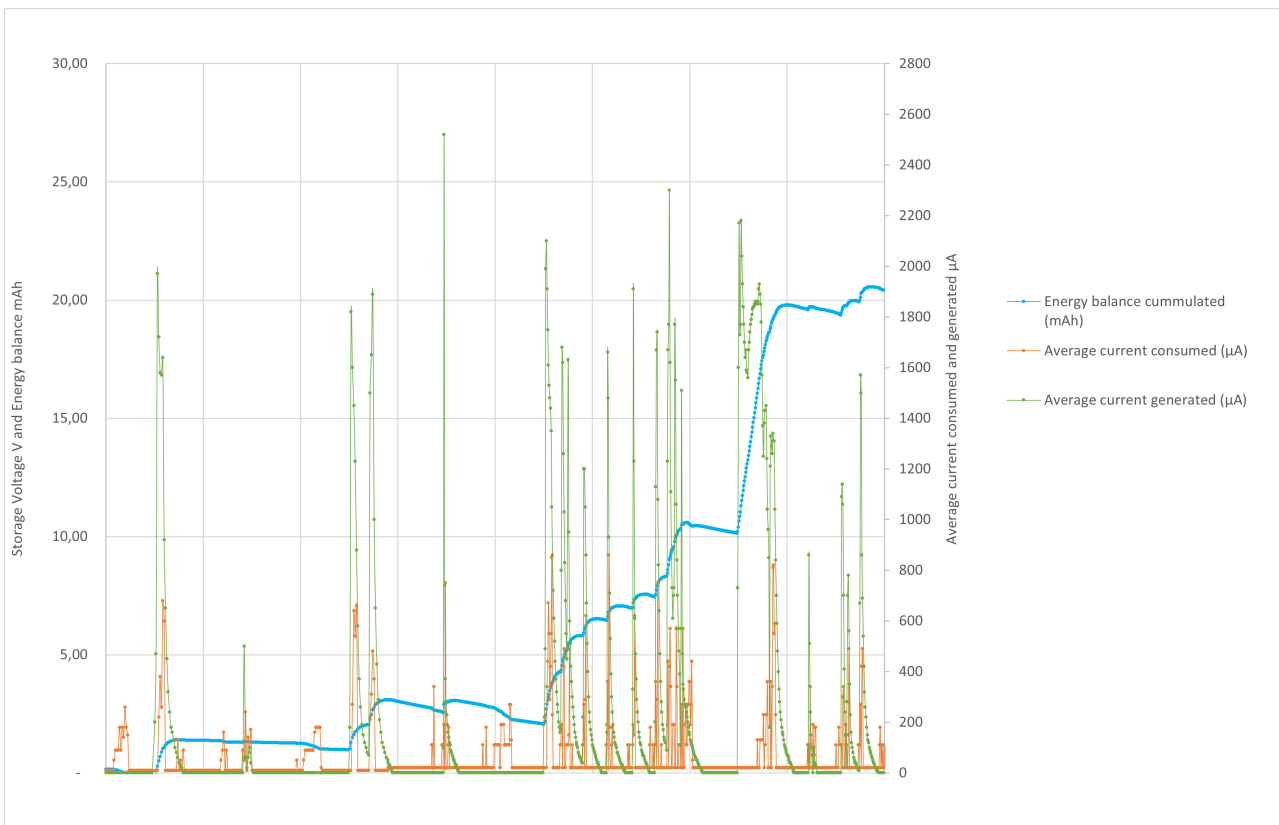
9.1 Energy Harvesting

The actuator generates the electrical energy for required for operation (motor, sensors, radio communication) by means of a built-in thermoelectric generator (TEG) and therefore operates maintenance-free. The TEG harvests energy from the temperature difference between the heating flow temperature and the ambient temperature (usually room temperature), which it accumulates in the internal storage. The energy balance of the actuator is designed to allow operation through 366 days per year when used in typical circulation strands with hot water supply throughout the year. An additional energy source such as a primary battery or external power supply is not required. The internal energy storage device is charged upon delivery, so that sufficient energy is available for installation. An extended lack of hot water, for example because of down times or malfunctions, inevitably leads to the internal storage being discharged, which means that permanent and normal operation of the device can no longer be guaranteed.

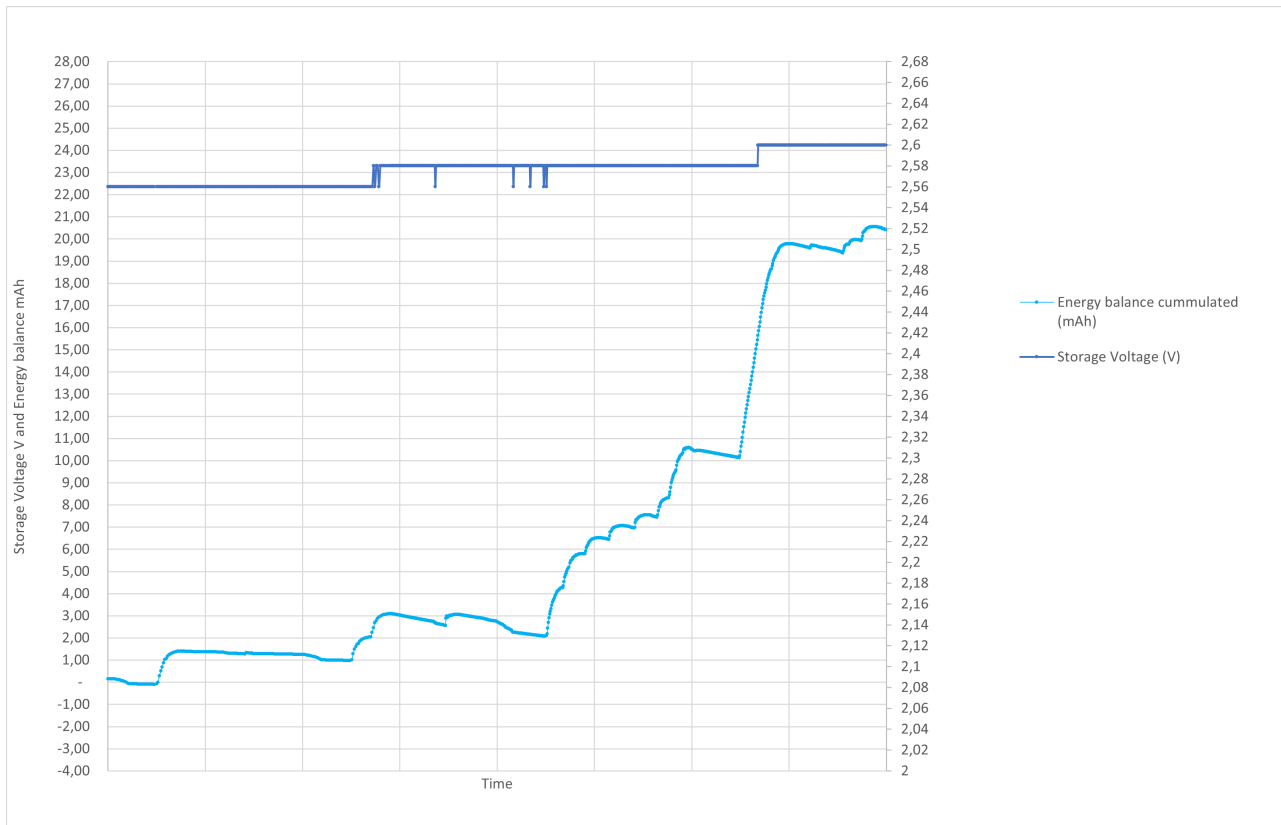


9.1.1 Device power management

The actuator 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 data rate, radio communication frequency, and sleep current. The following two diagrams are illustrations of the energy balance from a running application.



1 Exemplary values for ACC, ACG and computed energy balance.



2 Exemplary values for STV and computed energy balance.

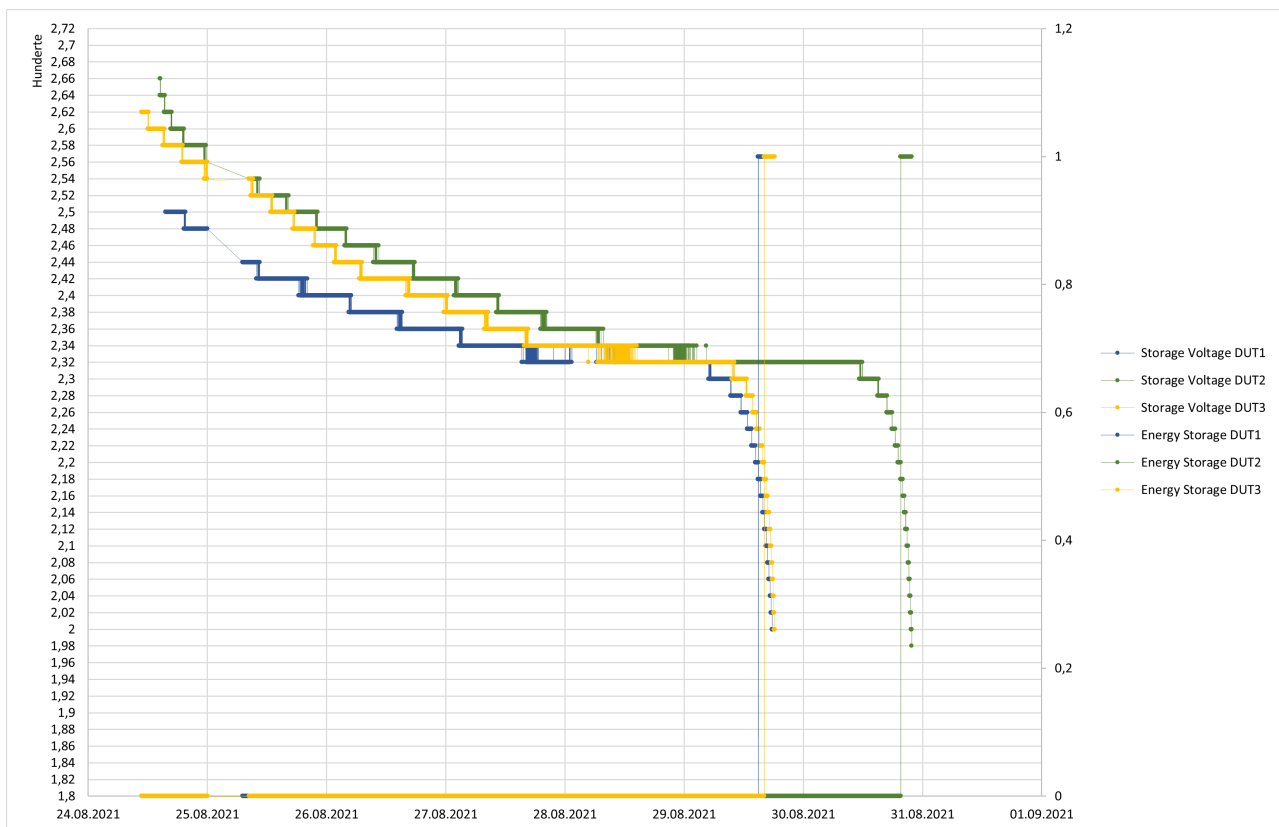
9.1.2 Energy Storage

In Port 1 Uplinks, the actuator uses its "Energy Storage" status bit to indicate that its long-term operation has 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. Slow Harvesting outside of operating times). If the energy storage continues to discharge and its voltage falls below a certain limit, then the device automatically goes into the state of Forced Heating.

In Port 1 Uplinks, the actuator uses its "Storage Voltage" byte to report the device storage voltage.

<u>Energy storage typical voltage values</u>	<u>Voltage [V] LTO</u>
Fully charged – for charge stop (bq25505 and USB)	2.8
Fully charged – for indicator bit	2.7
Normal operation	2.4 typical (2.2 ... 2.8)
Energy storage bit set when below	2.3

Forced Heating starts when below	2.2
Forced Heating stops when above	2.4
Microcontroller turning off all loads and its own power when below	1.8
Microcontroller power-up (under hardware-control) when above	2.37
Battery spec HTC1450 (capacity / charge stop / discharge stop)	>500mAh / 2.8V / 1.5V



3 Illustration of battery discharge curves from different starting point and ES bit activation

10 MLR003RiEU61-07 Temperature Control Loop

It is recommended to use an external temperature sensor to measure the room temperature, and to send the room temperature to the MLR003 device in FPORT 0x01.

In the following situations, the device will estimate the room temperature:

- The device has never received an external sensor temperature
- The last communicated external sensor temperature was "0"
- It has been a long time since the device last received communication of an external sensor temperature (see FPORT 0x09 for adjustment of this expiry time)
- The device has become disconnected from the Gateway

See FPORT 0x08 for the Temperature Estimation Algorithm, and for adjustment of the algorithm.

To achieve the instructed room temperature, the device applies the PID algorithm.

$$e = \text{SetPoint Temperature} - \text{Ambient Temperature}$$

$$\text{Valve Percent} = K_p * e(t) + K_I * \sum e(t) + K_d * (e(t) - e(t - 1)) + \text{Offset Percent}$$

See FPORT 0x07 for adjustment of the PID coefficients and Offset Percent.

The device considers moving the motor every 5 minutes.

11 MLR003RiEU61-07 Freeze Protection

If the pipe flow temperature drops to $\leq 6^{\circ}\text{C}$, then the pipe is at risk of freezing and becoming damaged. In order to avoid possible freeze damage, the actuator opens the valve to 95% or maintains the current position if it is already more than 95%. The 6°C is an absolute temperature, any user-offset is ignored.

12 MLR003RiEU61-07 Forced Heating

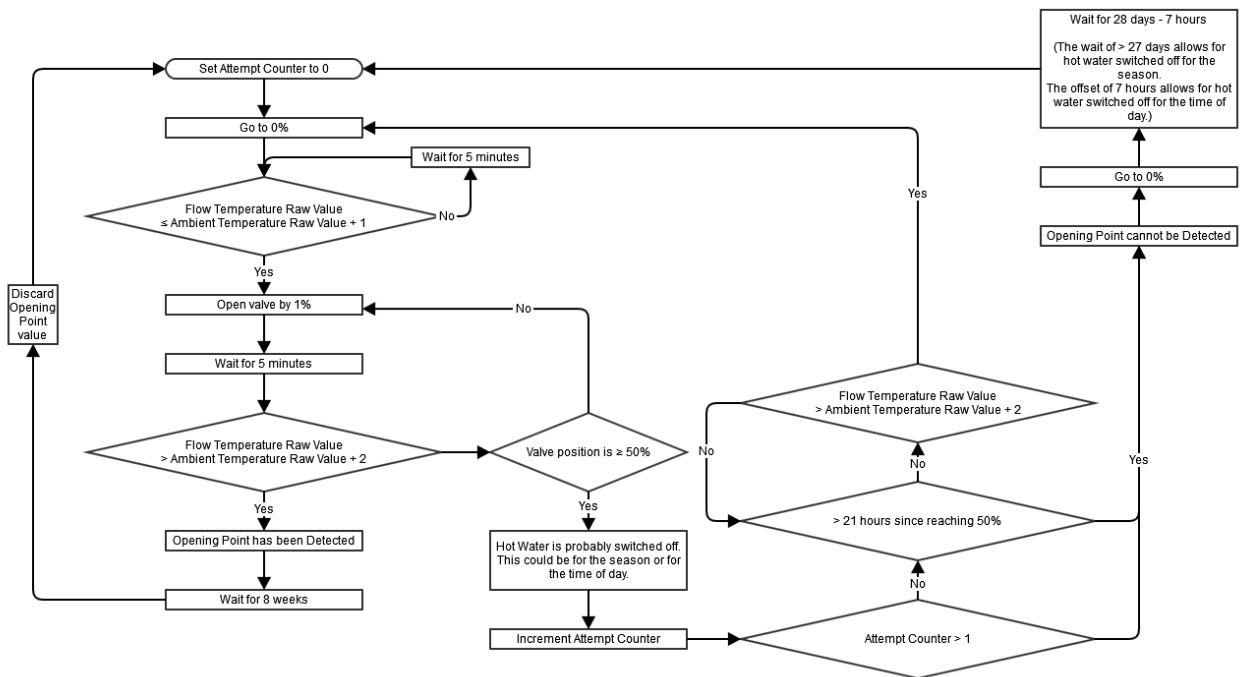
If the actuator storage voltage level discharges to $< 2.2V$, then the device can no longer maintain normal operation. In order to avoid possible freeze damage, the actuator takes a protective position in heating mode. For this purpose, the actuator opens the valve to 50% or maintains the current position if it is already more than 50%. The actuator then deactivates itself from normal operation into a state of minimal energy consumption: no radio activities and no motor activities. 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 by radio and will not perform temperature control. Thus temperature fluctuations and overheating in the room will occur. As soon as sufficient charge level is available, the actuator stops Forced Heating and resumes normal operation. Restoring the storage device to full charge requires manual charging or full heating for several days, which is why this condition must be avoided by taking appropriate measures in advance (monitoring the ES bit and e.g., Slow Harvesting).

13 MLR003RiEU61-07 Opening Point Detection

The Opening Point is the minimum Valve % at which water can flow through the valve.

Detection of the Opening Point can enable the device to significantly reduce the flow of hot water through the valve without actually closing the valve to 0%. This reduces motor movement and thus reduces energy consumption.

Once found, the device uses the Opening Point within Slow Harvesting. However, the Opening Point is not used within the internal Temperature Controller.



14 MLR003RiEU61-07 Slow Harvesting

Slow Harvesting adjusts the radiator valve such that:

- the valve is sufficiently open to enable hot water to flow from the hot water connecting pipe to the valve
- the valve is sufficiently closed to ensure that hot water consumption does not increase, and the radiator and the room are not heated

Slow Harvesting enables the actuator to generate electrical energy and maintain or even recover its internal storage voltage. At the same time, the building hot water consumption will not increase. Additionally, the room temperature will not be effected, and so users will not experience unwanted heating.

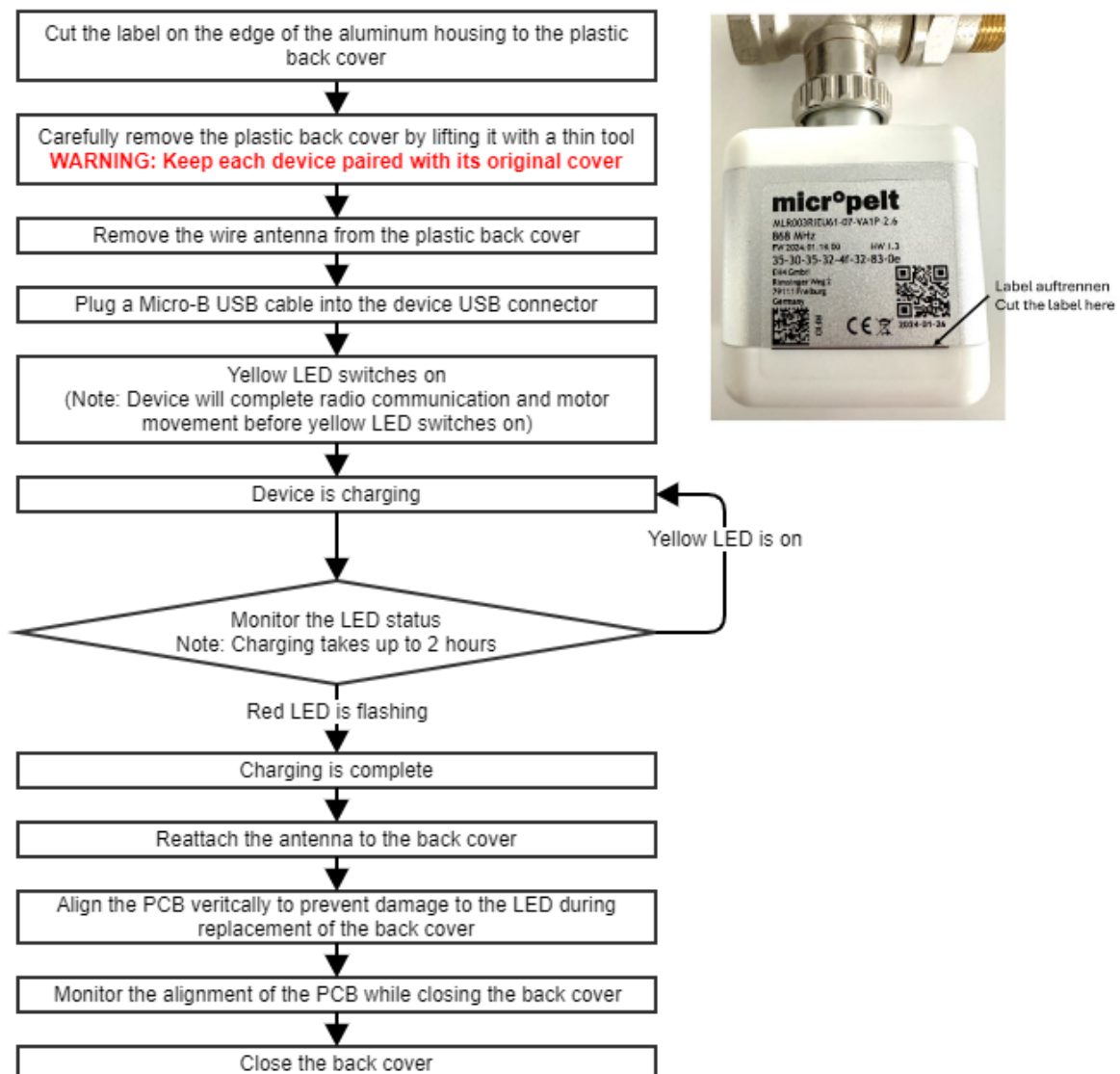


15 MLR003RiEU61-07 Battery Charging

For the LoRaWAN MLR Series

- 15.1 Flowchart instructions
- 15.2 Video instruction

15.1 Flowchart instructions



15.2 Video instruction

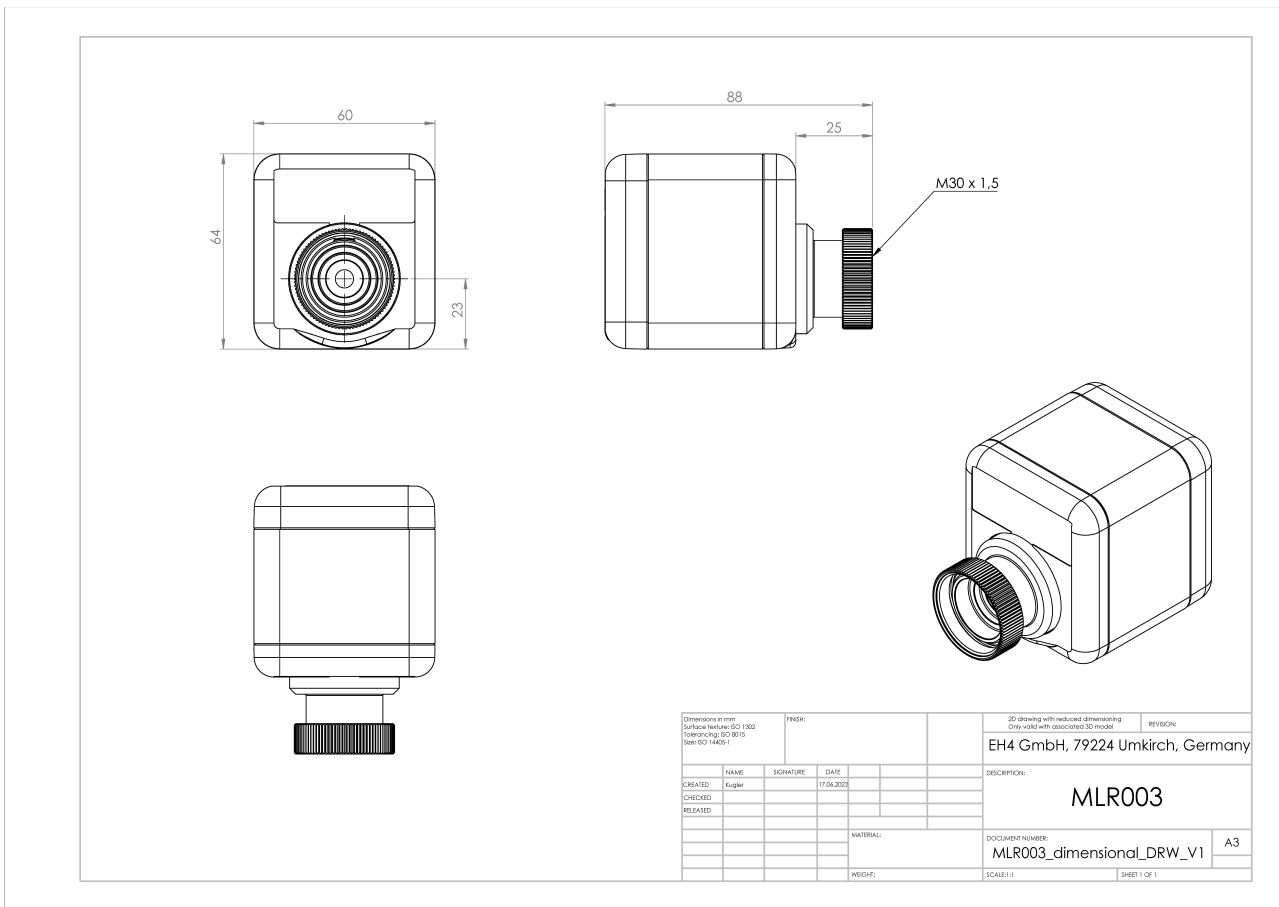


16 MLR003RiEU61-07 Performance Data

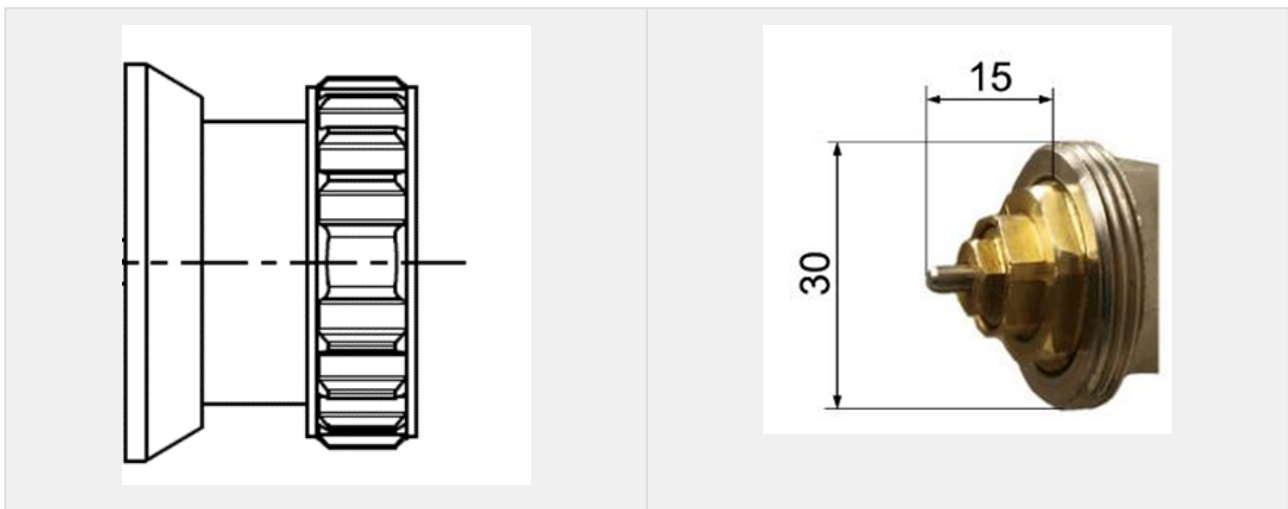
Parameter	Value
Ambient operating temperature range	0 to 40°C, max 70% rH
Flow pipe temperature	75°C max
Transportation & storage temperature range	-20 to +45°C, max 70% rH
Dimensions (LWH)	83 x 60 x 64 mm (63 x 60 x 64 mm without valve connector)
Weight	280 g (excluding packing)
Operation at high altitude	Max 2000 m / 6500 ft above sea level
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
Noise level	< 35 dB(A) @ 70 N load
Valve protection and Auto-off when active but not installed on valve body	Every 6 weeks: Execute run-in sequence. Refer to FPORT 0x0F ON/OFF: MLR003RiEU61-07 FPORT 0x0F On/Off
Antifreeze	Valve side sensor ≤ 6°C
Accuracy of internal valve side temperature sensor	±0.5°C
Accuracy of internal ambient temperature sensor	±0.5°C

Energy storage	LTO (Nominal 500mAh)
Energy generation minimum requirement	90 days / year @ 45°C flow pipe temperature
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
Parameter	Value
Data Rate	SF7BW125 SF7 uses the shortest time-on-air, maximizing the number of end nodes operating on one gateway.
Radio Communication Interval during Installation Cycle	10 seconds for 5 minutes
Radio Communication attempt Interval (after join failure or 90 minutes of continuous communication failure)	3 * 10 seconds Then 2 minutes Then 60 minutes
Default Flow Sensor Offset	+0°C

17 MLR003RiEU61-07 Dimensions and valve connection



The Micropelt series of products is designed to mount onto an M30 x 1.5mm valve thread.



Adapters are available for a majority of non-M30 x 1.5mm valve bodies.

18 MLR003RiEU61-07 CE Conformity

micropelt

Declaration of Conformity
According to EU regulation EU 2019/1020 on market surveillance and product conformity

Manufacturer: EH4 GmbH (Brand Micropelt)
Address: Am Gansacker 10a, 79224 Umkirch, GERMANY

We declare the conformity of the following product:

Product Description: **Wireless heating radiator actuator/thermostat powered by thermal energy harvesting.**
LoRaWAN 868MHz
Product Type(s): MLR003 & MLR003F
Production Year(s): 2021 ff.

With regard to its design and construction and in the form, we first introduced it to the market it is in conformity with the essential health and safety requirements of the Radio Equipment Directive:

Radio Equipment Directive (RED)
ETSI EN 300 220-2 V3.2.1 (2018-06)
ETSI EN 300 220-2 V3.1.1 (2017-02)

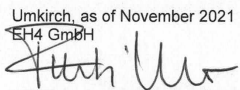
EMC
ETSI EN 301 489-1 V2.2.3 clause 8 & 9 (add. V1.9.2)
ETSI EN 301 489-3 V2.1.1 (add. V1.6.1)
EN 55014-1:2017 (add. EN 55014-1:2006+A1:2009+A2:2011)
EN 55014-2:2015


Human Exposure
EN 62479: 2010

Product Safety
IEC 60335-1: 2010, COR1:2010, COR2:2011, AMD1:2013, COR1:2014, AMD2:2016, COR1:2016
EN 60335-1:2012 + AC:2014 + A11:2014 + A13:2017 + A14:2019 +A1:2019 + A2:2019

Battery Safety
EN 62133-2:2017 (add. AMD1:2021)
Battery Transport UN38.3

Umkirch, as of November 2021
EH4 GmbH

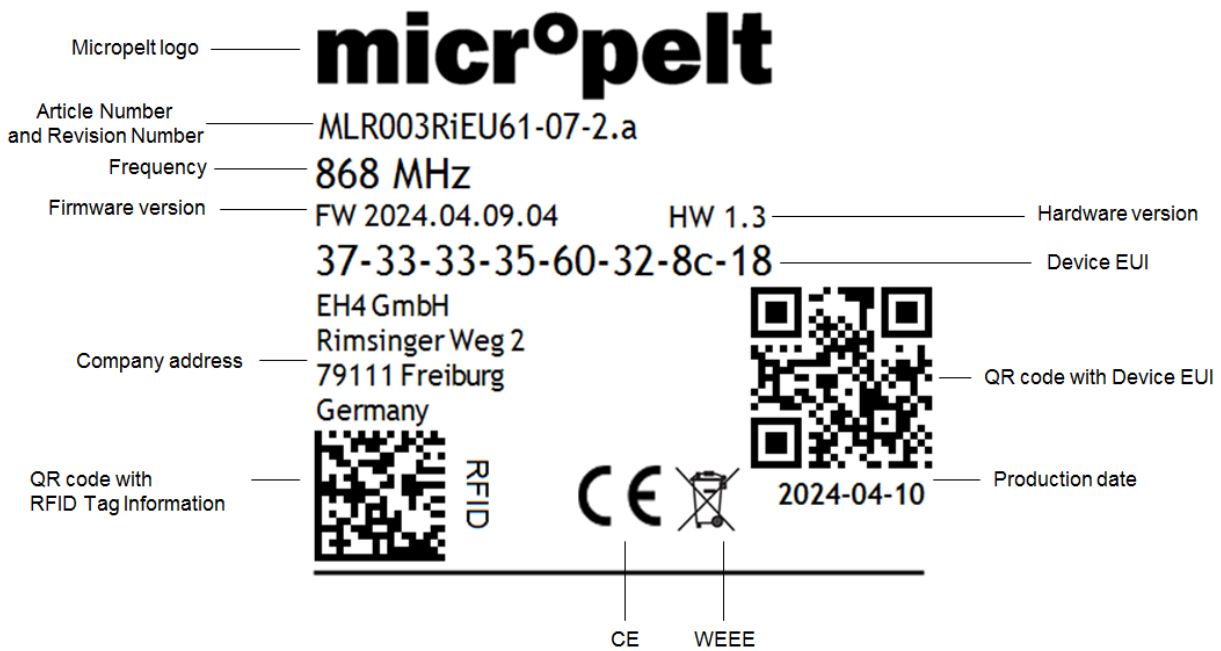

Fritz Volkert, CEO


Martin Schmidt, RND

CE

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EH4 GmbH
Am Gansacker 10a
79224 Umkirch
www.micropelt.com

19 MLR003RiEU61-07 Labels



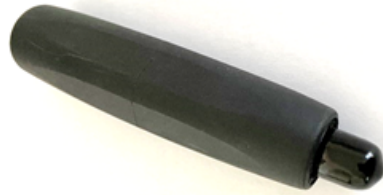
19.1 Product Label

What	Where
Product type	On Label
REVn.n	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)	In Spreadsheet (Secret)
Country of Origin	On Label
Address	On Label
Micropelt Logo	On Label

20 MLR003RiEU61-07 Accessories

20.1 MLR-KEY Magnetic switch



4 Pen-shaped magnet required for activating and deactivating the device

21 MLR003RiEU61-07 Disposal Instructions

Genereller Hinweis zur Entsorgung:

Die EH4 ist unter der WEEE REG Nummer DE90689057 registriert.

Die WEEE-Nummer ist eine Herstellernummer, die nach einer erfolgreichen Registrierung bei der Stiftung ear an Erstinverkehrbringer von Elektro-/Elektronikgeräten vergeben wird. (Elektro- und Elektronikgerätegesetz ElektroG)

Das ElektroG dient der Vermeidung von Abfällen von Elektro- und Elektronikgeräten“, um die zu beseitigende Abfallmenge zu reduzieren sowie den Eintrag von Schadstoffen aus Elektro- und Elektronikgeräten in Abfälle zu verringern.“

Für unsere B2B Geräte (siehe ElektroG: §19), die nicht bei einem kollektiven Rücknahmesystem abgegeben werden können, bieten wir - soweit vertraglich nicht anders vereinbart - die Möglichkeit zur Rückgabe an. Setzen Sie sich im Bedarfsfall direkt mit uns oder dem Anbieter in Verbindung, von der Sie die Geräte erworben haben.

Für in unseren Produkten verwendete Industriebatterien (siehe BattG: § 2 (5)) bieten wir die Möglichkeit zur Rückgabe an. Setzen Sie sich im Bedarfsfall direkt mit dem jeweiligen Anbieter in Verbindung, von dem Sie unsere Industriebatterien erworben haben.

Transport-Verpackungsmaterial sind recyclingfähig.



General information on disposal:

The EH4 is registered under the WEEE REG number DE90689057.

The WEEE number is a manufacturer number that is assigned to the first distributor of electrical/electronic equipment after successful registration with the ear foundation. (Electrical and Electronic Equipment Act ElektroG)

The ElektroG serves to prevent waste from electrical and electronic equipment, in order to reduce the amount of waste to be disposed of and to reduce the entry of pollutants from electrical and electronic equipment into waste."

For our B2B devices (see ElektroG: §19) that cannot be returned to a collective return system, we offer the option of returning them - unless otherwise agreed in the contract. If necessary, contact us or the supplier from whom you purchased the devices directly.

We offer the option of returning industrial batteries used in our products (see BattG: § 2 (5)). If necessary, please contact the supplier from whom you purchased our industrial batteries directly.

Transport packaging materials are recyclable.



Bei allen Fragen zu Entsorgung erreichen Sie uns
unter:

E-Mail recycling@micropelt.com

Telefon +49 761 590 26 190

If you have any questions about disposal, please
contact us at:

E-Mail recycling@micropelt.com

Phone 49 761 590 26 190