aquaradio® Mobile Receiver

Portable radio transceiver with Bluetooth interface

User manual

Table of contents

1. Document Release index ... 3
2. Contact of the organization ... 3
3. Introduction ... 3
4. Important Considerations ... 4
5. Items Supplied and Packaging ... 4
6. Operating Principle ... 5
7. Overview ... 5
8. Establishing a Bluetooth Connection ... 6
9. Bluetooth Communication ... 7
9. 1. Command Format ... 7
9. 2. Request Firmware Version ... 8
9. 3. Read Radio Frame 1 ... 8
9. 4. Read Radio Frame 2 ... 9
9. 5. Read Radio Frame 3 ... 10
9. 6. Receiver Mode ... 10
9. 7. Enable External Serial Interface ... 11
9. 8. Send Data over External Serial Interface ... 11
9. 9. Send Data over External Serial Interface with Wake-Up ... 12
9. 10. Send Radio Frames ... 12
9. 11. Send Radio Frames 2 ... 13
9. 12. Send Radio Frames 2 (EQS mode) ... 14
9. 13. Read Send Radio Frame Configuration ... 15
10. aquaradio® Mobile Receiver Reading Example Using the MBT1ReceiverLib ... 15
11. External Serial Interface ... 18
12. Troubleshooting ... 18
13. Care and Maintenance ... 19
14. Disposal ... 19
15. Specifications ... 19

1. Document Release index

Version	Date	Modifications
01	20/02/2024	First release

2. Contact of the organization

INTEGRA Metering AG
Ringstrasse 75
CH-4106 Therwil
Switzerland

Phone: +33 5 61 11 23 56
info@integra-metering.com
www.integra-metering.com

Reproduction of these instructions or parts of them in whatever form is not permitted without express written permission from the publisher.

The figures and information in these instructions are subject to technical changes that become necessary to improve the product.

© INTEGRA Metering AG / CH-4106 Therwil/ Switzerland/ All rights reserved

The name aquaradio® Mobile Receiver and this manual are protected by copyright laws. Copying, translating, transferring to other media like micro fiches and other electromagnetic or optical storage media without the written permission of the INTEGRA Metering AG is prohibited.

Trademarks or registered trademarks may be used throughout this manual. Even if it is not shown explicitly, they are protected by copyright laws and belong to their respective owners.

The aquaradio® Mobile Receiver and the accompanying documentation were developed with great precision and tested extensively for being free of errors. However, it might be possible that undetected errors appear. The INTEGRA Metering AG is not liable for any incidental, indirect or consequential damages whatsoever regarding the aquaradio® Mobile Receiver and this manual, the use of these products or the inability to use these products (including but not limited to, damages for loss of business profits, business interruption, loss of business information or any other pecuniary losses). The INTEGRA Metering AG's entire liability is limited to the price paid for this product.

3. Introduction

The aquaradio® Mobile Receiver is a portable radio receiver for wireless M-Bus resource meters (currently capable of handling Mode T1, T2, C1), which is equipped with a Bluetooth interface. A rechargeable lithium ion battery assures operating times up to 20 hours with one charge.

The aquaradio® Mobile Receiver is usually used in conjunction with a handheld computer for mobile reading of radio consumption meters (electricity, gas, water, heat and others).

Due to its watertight enclosure (IP 64) and its mechanical rugged construction (EN 60721 class 7M3) it can be used in harsh

environments without additional protection.

Additionally, the aquaradio® Mobile Receiver is equipped with a serial interface to connect e.g. optical meter configuration devices.

4. Important Considerations

- The specific purpose of the aquaradio® Mobile Receiver is the mobile reception of M-Bus Mode T1, T2 and C1 consumption meter radio frames and the transmission to a handheld computer via Bluetooth interface.
- The aquaradio® Mobile Receiver may only be operated by trained personnel.
- The aquaradio® Mobile Receiver is only to be used in environments in conformity with its protection rating (IP64) and operating temperature range (-5° C to +55° C).
- The integrated rechargeable lithium ion battery may not be charged at temperatures below 0° C or above +45° C (battery charging only at 0° C to +45° C)
- Only the accompanying charging device may be used to charge the aquaradio® Mobile Receiver. Do not operate the charging device without the proper wall plug adapter. The charging device may only be used in dry and weather-protected environments.
- Do not use force to insert the round battery charger plug. Turn it until it you can gently push it into the aquaradio® Mobile Receiver connector. Do not screw it too tight.
- Charge the aquaradio® Mobile Receiver completely before using it the first time.
- The aquaradio® Mobile Receiver is not a calibrated measuring device. The transmitted meter counts and consumptions are of informative character only.
- If a fault occurs, do not try to repair the unit yourself. Attempts to do so will void the warranty. Refer all servicing to your supplier.
- Do not open the case of the device. Do especially not remove, open or short circuit the lithium ion battery inside the device.

5. Items Supplied and Packaging

Please ensure that the package contents are complete. These are as follows:

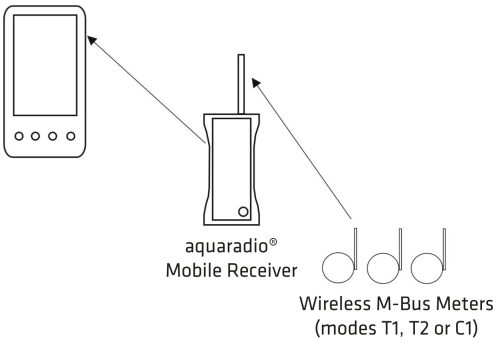
- 1 aquaradio® Mobile Receiver
- 1 Antenna
- 1 Wall plug battery charger
- 1 Short manual
- 1 CD with documentation

The packaging can be reused or recycled. Please dispose properly of any packaging material no longer required. If you notice any transport damage during unpacking, please contact your supplier immediately.

To avoid risk of suffocation, keep packaging film away from children!

6. Operating Principle

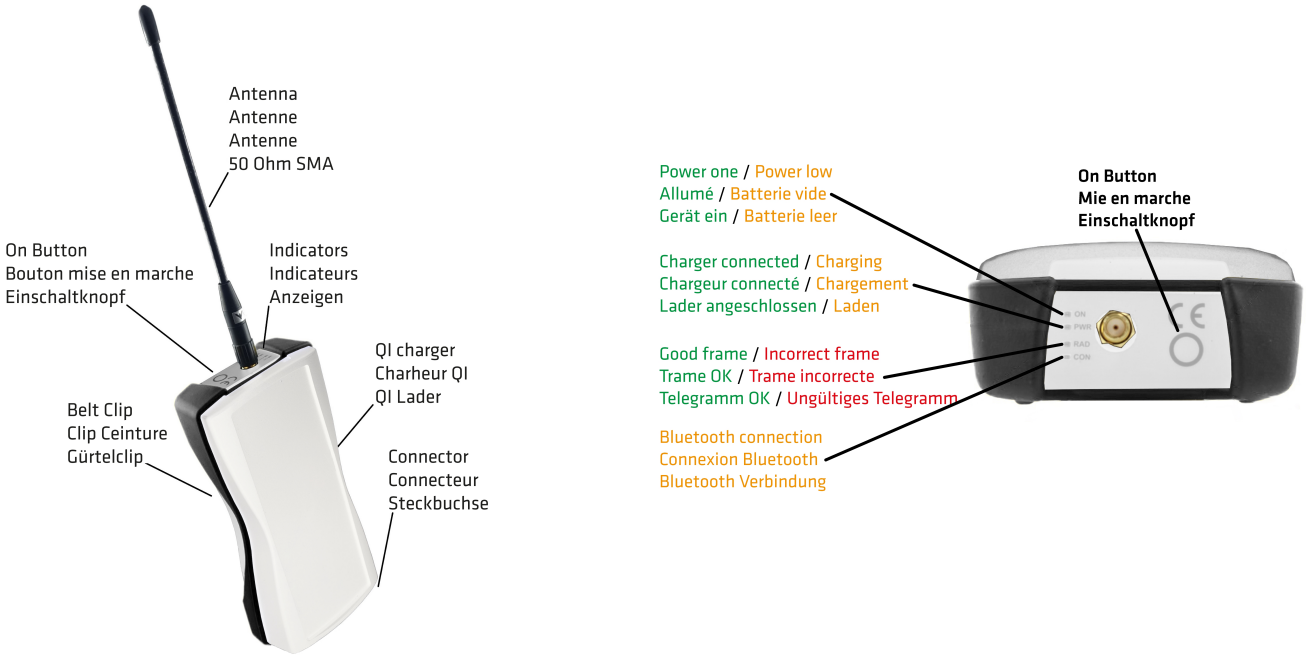
The aquaradio® Mobile Receiver is a radio receiver for wireless M-Bus consumption meters (electricity, gas, water, heat and others). The received radio frames of the consumption meters are stored into an internal memory and are immediately transmitted to a handheld computer using its Bluetooth interface, if a Bluetooth connection is established. If there is no Bluetooth connection the aquaradio® Mobile Receiver collects all radio frames (up to 150) and transmits them at once as soon as the Bluetooth connection is reestablished.



Due to its built-in rechargeable lithium ion battery the aquaradio® Mobile Receiver has got an autonomy of approximately 20 hours (while not using the external serial interface). Recharging takes about 4 to 5 hours depending on the charge state of the battery.

The antenna interface is a standard 50 Ohm SMA connector which can be connected to any suitable antenna.

7. Overview



Antenna:

Screw the antenna gently and without force onto the SMA antenna connector of the device. It is possible to use other 868 MHz, 50 Ohm, SMA antennas like car roof mounted antennas. However, there is no guaranty that other antennas might work as well or work at

all. The warranty is void if you are using other antennas, active antennas or pre-amplifiers on the aquaradio® Mobile Receiver antenna connector. Pay especially attention not to cause any static electric discharge on the antenna connector of the aquaradio® Mobile Receiver.

On Button:

Press this button to switch the device on. The power on LED will light up in green. After approximately 5 seconds the internal self-test has finished and the device is ready to receive radio frames.

The device switches itself off, automatically, if there has not been a Bluetooth connection for more than 10 minutes.

By pressing the on button for more than 5 seconds, you may switch off the device manually.

Connector:

The battery charger connector is placed at the bottom side of the device.

Additionally, this connector contains the external serial interface. Therefore, it is not possible to connect the battery charger and a serial interface device at the same time.

QI charger:

Place the device centered on a QI charger to use wireless charging.

Power on / low LED:

Device is on (ON)

Low power warning (ON)

The ON LED lights up in green if the device is switched on. If the battery power is low, the color of the ON LED turns amber. In this case, the user should immediately connect the battery charger. Approximately 4 minutes after the power low warning, the device is switching itself off.

Charger connected LED:

Battery is full (PWR)

Battery charging LED:

Battery is charging (PWR)

The PWR LED lights up in amber if the battery charger is connected to the device and the device is charging. If the PWR LED turns green the battery is full and the charger can be disconnected. Due to the low self-discharge rate of the lithium ion battery it is not necessary to keep the battery charger connected.

Radio frame LED:

Valid radio frame (RAD)

Invalid radio frame (RAD)

The RAD LED lights up in green if a valid radio frame has been received. The RAD LED lights up in red if an invalid (corrupt) radio frame has been received.

NOTE:

If the RAD LED and the ON LED are flashing in red rapidly, the internal self-test of the device has failed. Switch the device off and on again to see if the error persists. If this is the case, you should turn it in for repair.

Bluetooth LED:

Flashes 1x slowly: no Bluetooth connection (CON)

Flashes 2x rapidly: Bluetooth connection (CON)

The amber CON LED lights up some seconds after the device has been switched on. If there is a permanent error in the Bluetooth module, the amber LED stays on permanently. In this case, switch the device off and on again.

If no Bluetooth connection is established the CON LED flashes one time slowly.

If there is a Bluetooth connection established the CON LED flashes two times rapidly.

8. Establishing a Bluetooth Connection

After the power-on of the device you should wait approximately 5 seconds before trying to establish a Bluetooth connection. This period of time is necessary for starting up all the modules in the aquaradio® Mobile Receiver. Afterwards, you should go to the

Bluetooth configuration page of your computer and perform a device search. This process differs from computer to computer, so please check also the manual or online help of your computer.

To verify if the correct aquaradio® Mobile Receiver device is found you can compare the found Bluetooth name with the name / serial number on the back of the device (e.g. aquaradio® Mobile Receiver 0ABB01).

If you are asked for an authorization code / PIN, enter four times zero: 0000.

You should then bind the aquaradio® Mobile Receiver device to a virtual serial port (SPP, serial profile protocol) using the Bluetooth configuration page of your computer. Note the virtual serial port, which is attributed to the aquaradio® Mobile Receiver (e.g. COM12). By opening this port, the Bluetooth connection is automatically established and you are able to send commands to the aquaradio® Mobile Receiver.

9. Bluetooth Communication

After having bound the aquaradio® Mobile Receiver to a virtual serial port of your computer you can start reading the radio frames. The virtual serial port should be opened with:

115200,8,N,1

115200 baud, 8 data bits, no parity bit, 1 stop bit,

hardware flow control or no flow control

9. 1. Command Format

The general format of the aquaradio® Mobile Receiver communication is (all bytes hexadecimal):

01 FE LL CD [Data] CRC CRC

01 FE:	Two start signs
LL:	Length byte (overall length including start signs and CRC)
CD:	Command
[Data]:	0...249 bytes of data
CRC CRC:	Cyclic redundancy check, the MSB is transmitted first

The CRC is calculated using the creator polynomial shown beneath:

X16 + X13 + X12 + X11 + X10 + X8 + X6 + X5 + X2 + 1

The CRC is calculated over all bytes of the command except the CRC itself (from the first start sign to the last byte before the CRC).

Example code is listed below:

```
WORD CRCTable[256]={
        0x0000,0x3D65,0x7ACA,0x47AF,0xF594,0xC8F1,0x8F5E,0xB23B,
        0xD64D,0xEB28,0xAC87,0x91E2,0x23D9,0x1EBC,0x5913,0x6476,
        0x91FF,0xAC9A,0xEB35,0xD650,0x646B,0x590E,0x1EA1,0x23C4,
        0x47B2,0x7AD7,0x3D78,0x001D,0xB226,0x8F43,0xC8EC,0xF589,
        0x1E9B,0x23FE,0x6451,0x5934,0xEB0F,0xD66A,0x91C5,0xACA0,
        0xC8D6,0xF5B3,0xB21C,0x8F79,0x3D42,0x0027,0x4788,0x7AED,
        0x8F64,0xB201,0xF5AE,0xC8CB,0x7AF0,0x4795,0x003A,0x3D5F,
        0x5929,0x644C,0x23E3,0x1E86,0xACBD,0x91D8,0xD677,0xEB12,
        0x3D36,0x0053,0x47FC,0x7A99,0xC8A2,0xF5C7,0xB268,0x8F0D,
        0xEB7B,0xD61E,0x91B1,0xACD4,0x1EEF,0x238A,0x6425,0x5940,
        0xACC9,0x91AC,0xD603,0xEB66,0x595D,0x6438,0x2397,0x1EF2,
        0x7A84,0x47E1,0x004E,0x3D2B,0x8F10,0xB275,0xF5DA,0xC8BF,
        0x23AD,0x1EC8,0x5967,0x6402,0xD639,0xEB5C,0xACF3,0x9196,
        0xF5E0,0xC885,0x8F2A,0xB24F,0x0074,0x3D11,0x7ABE,0x47DB,
        0xB252,0x8F37,0xC898,0xF5FD,0x47C6,0x7AA3,0x3D0C,0x0069,
        0x641F,0x597A,0x1ED5,0x23B0,0x918B,0xACEE,0xEB41,0xD624,
        0x7A6C,0x4709,0x00A6,0x3DC3,0x8FF8,0xB29D,0xF532,0xC857,
        0xAC21,0x9144,0xD6EB,0xEB8E,0x59B5,0x64D0,0x237F,0x1E1A,
```

```
0xEB93,0xD6F6,0x9159,0xAC3C,0x1E07,0x2362,0x64CD,0x59A8,
0x3DDE,0x00BB,0x4714,0x7A71,0xC84A,0xF52F,0xB280,0x8FE5,
0x64F7,0x5992,0x1E3D,0x2358,0x9163,0xAC06,0xEBA9,0xD6CC,
0xB2BA,0x8FDF,0xC870,0xF515,0x472E,0x7A4B,0x3DE4,0x0081,
0xF508,0xC86D,0x8FC2,0xB2A7,0x009C,0x3DF9,0x7A56,0x4733,
0x2345,0x1E20,0x598F,0x64EA,0xD6D1,0xEBB4,0xAC1B,0x917E,
0x475A,0x7A3F,0x3D90,0x00F5,0xB2CE,0x8FAB,0xC804,0xF561,
0x9117,0xAC72,0xEBDD,0xD6B8,0x6483,0x59E6,0x1E49,0x232C,
0xD6A5,0xEBC0,0xAC6F,0x910A,0x2331,0x1E54,0x59FB,0x649E,
0x00E8,0x3D8D,0x7A22,0x4747,0xF57C,0xC819,0x8FB6,0xB2D3,
0x59C1,0x64A4,0x230B,0x1E6E,0xAC55,0x9130,0xD69F,0xEBFA,
0x8F8C,0xB2E9,0xF546,0xC823,0x7A18,0x477D,0x00D2,0x3DB7,
0xC83E,0xF55B,0xB2F4,0x8F91,0x3DAA,0x00CF,0x4760,0x7A05,
0x1E73,0x2316,0x64B9,0x59DC,0xEBE7,0xD682,0x912D,0xAC48};

WORD                    CRCValue;
int                     Counter;
int                     BufferLen;
BYTE                    Buffer[100];

BufferLen=0;
Buffer[BufferLen++]=0x01;                    // Command for requesting firmware version
Buffer[BufferLen++]=0xFE;
Buffer[BufferLen++]=0x06;
Buffer[BufferLen++]=0x09;
CRCValue=0; for (Counter=0;Counter<BufferLen;++Counter)
{
 CRCValue=CRCTable[(CRCValue>>8) ^ Buffer[Counter]] ^ (CRCValue<<8);
}
Buffer[BufferLen++]=(BYTE)((CRCValue & 0xFF00)>>8); Buffer[BufferLen++]=(BYTE)(CRCValue & 0x00FF);
```

Three command examples with correct CRC:

Request firmware version:	01 FE 06 09 3F DE
Read radio frame 2:	01 FE 06 10 45 09
Read radio frame 3:	01 FE 06 40 E9 C0

9. 2. Request Firmware Version

Returns the firmware version and the device type of the aquaradio® Mobile Receiver (all bytes hexadecimal).

Request:	01 FE 06 09 CRC CRC
Answer OK:	01 FE 0B 09 VMajor VMinor0 VMinor1 VMinor2 DType CRC CRC
Answer error:	01 FE 07 09 FF CRC CRC

VMajor:	major version number
VMinor0:	minor version number 0
VMinor1:	minor version number 1
VMinor2:	minor version number 2
DType:	device type
	50 = aquaradio® Mobile Receiver 868 MHz
	51 = aquaradio® Mobile Receiver 434 MHz

9. 3. Read Radio Frame 1

Note:

You should no longer use this command, use Read Radio Frame 2 instead

Returns the next radio frame from the buffer of the aquaradio® Mobile Receiver , if there is any. This version of the radio frame read command returns a maximum of 120 bytes of data (all bytes hexadecimal):

Request:	01 FE 06 06 CRC CRC
Answer OK:	01 FE 86 06 [Frame data] CRC CRC
Answer error:	01 FE 86 06 FF [127 arbitrary bytes] CRC CRC

The format of [Frame data] is:

LL T0 T1 T2 T3 T4 00 RSSI [Radio Frame]

LL	Overall length of the returned data (including this byte and up to the last byte of [Radio Frame]
T0, T1, T2, T3, T4	Time difference between the reception of the radio frame and the transmission of this radio frame over the Bluetooth interface (resolution 5.3 µs). To calculate the real reception time of the radio frame you have to subtract this value from the current time.
FE / FF	This flag has got two purposes: 1. If it is not zero, T0, T1, T2, T3, T4 are containing the time difference between radio reception and Bluetooth reading. If it is zero they are containing the absolute time of the Bluetooth receiver at the time of the radio reception. 2. If the flag is FF there is no battery low warning, if the flag is FE the battery low warning of the aquaradio® Mobile Receiver is on.
RSSI	Received signal strength indicator 0%...100%. To get the RSSI in dBm: (RSSI -120) dBm
[Radio Frame]	The received radio frame, for format specifications see the documentation of the radio meter manufacturer. The [Radio Frame] field is filled up with arbitrary bytes up to a field length of 120 Bytes.

9. 4. Read Radio Frame 2

Returns the next radio frame from the buffer of the aquaradio® Mobile Receiver, if there is any. This version of the radio frame read command returns a maximum of 241 bytes of data (all bytes hexadecimal). The aquaradio® Mobile Receiver is capable of receiving radio frame with up to 240 bytes, that is the maximum length field of the radio frame is F0 (hex).

Request:	01 FE 06 10 CRC CRC
Answer OK:	01 FE FF 10 [Frame data] CRC CRC
Answer error:	01 FE FF 10 FF [248 arbitrary bytes] CRC CRC

The format of [Frame data] is:

LL T0 T1 T2 T3 T4 00 RSSI [Radio Frame]

LL	Overall length of the returned data (including this byte and up to the last byte of [Radio Frame]
T0, T1, T2, T3, T4	Time difference between the reception of the radio frame and the transmission of this radio frame over the Bluetooth interface (resolution 5.3 µs). To calculate the real reception time of the radio frame you have to subtract this value from the current time.
FE / FF	This flag has got two purposes: 1. If it is not zero, T0, T1, T2, T3, T4 are containing the time difference between radio reception and Bluetooth reading. If it is zero they are containing the absolute time of the Bluetooth receiver at the time of the radio reception. 2. If the flag is FF there is no battery low warning, if the flag is FE the battery low warning of the aquaradio® Mobile Receiver is on.
RSSI	Received signal strength indicator 0%...100%. To get the RSSI in dBm: (RSSI -120) dBm
[Radio Frame]	The received radio frame, for format specifications see the documentation of the radio meter manufacturer. The [Radio Frame] field is filled up with arbitrary bytes up to a field length of 241 Bytes.

9. 5. Read Radio Frame 3

Returns the next radio frame from the buffer of the aquaradio® Mobile Receiver , if there is any. This version of the radio frame read command returns a maximum of 256 bytes of data (all bytes hexadecimal). If you are only using aquaradio® Mobile Receiver with firmware version 3.00 and up it is advised to use this command instead of Read Radio Frame 2. However, if you want a command which works with all versions of the aquaradio® Mobile Receiveruse Read Radio Frame 2.

NOTE:

This command is only available with firmware version 3.00 and up.

NOTE:

The length byte contains only the LSB of the real length (0x128) of this command.

Request:	01 FE 06 40 CRC CRC
Answer OK:	01 FE 28 40 00 [Frame data] CRC CRC
Answer error:	01 FE 28 40 FF [289 arbitrary bytes] CRC CRC

The format of [Frame data] is:

[Radio Frame]	256 Bytes containing the radio frame and at the end arbitrary fill bytes. The first byte of the radio frame contains the length. If there is no received radio frame available from the buffer of the aquaradio® Mobile Receiver (no reception), the length byte is zero and the radio frame, RSSI, radio mode and timestamp are invalid. However, the statistics values (good frames T, CA, CB and so on) are valid.
RSSI	1 Byte containing the received signal strength indicator 0%...100%. To get the RSSI in dBm: (RSSI -120) dBm
Time type	1 byte containing zero (0)
Time type	1 byte containing zero (0) 0x00 = 868 MHz T1 0x01 = 868 MHz C1A 0x02 = 868 MHz C1B 0x03 = 868 MHz S1 0x04 = 868 MHz C2A 0x05 = 868 MHz C2B 0x10 = 434 MHz T1 0x11 = 434 MHz C1A 0x12 = 434 MHz C1B 0x13 = 434 MHz S1 0x14 = 434 MHz C2A 0x15 = 434 MHz C2B 0xFF = unknown NOTE: The radio mode is only available with firmware version 3.42 and up. This byte is invalid (0xFF) for previous firmware versions.
Unused 1	1 byte unused (0xFF)
Unused 2	1 byte unused (0xFF)
Timestamp	4 bytes containing the seconds from starting the aquaradio® Mobile Receiver to reception of the radio frame (LSB first).
Unused 3	4 bytes unused (0xFFFFFFFF)
Good frames T	4 bytes (LSB first) containing the number of correctly received mode T frames
Good frames CA	4 bytes (LSB first) containing the number of correctly received mode C frames (format A)
Good frames CB	4 bytes (LSB first) containing the number of correctly received mode C frames (format B)
3 of 6 errors	4 bytes (LSB first) containing the number of received frames with 3 of 6 errors
CRC errors	4 bytes (LSB first) containing the number of received frames with CRC errors

9. 6. Receiver Mode

Sets the receiver mode (T1/C1 or S1) and receiver frequency (868 MHz or 434 MHz). The 434 MHz setting is only for testing 434 MHz meters and has only a very short reception range.

NOTE: This command is only available with firmware version 2.200 and up.

Request:	01 FE 07 15 Mode CRC CRC
Answer OK:	01 FE 07 15 Mode CRC CRC
Answer error:	01 FE 07 15 FF CRC CRC

Mode:	00:	T1/T2/C1, 868 MHz (default after device power-up)
	01:	S1, 868 MHz
	10:	T1/T2/C1, 434 MHz
	11:	S1, 434 MHz

9. 7. Enable External Serial Interface

Switches the external serial interface on and configures it using the given parameter (all bytes hexadecimal). By default the external serial interface is switched off and it is turned on by this command. The serial interface should be switched off if it is no longer used, to save battery energy.

Request:	01 FE 09 12 BD PR TO CRC CRC
Answer OK:	01 FE 07 12 00 CRC CRC
Answer error:	01 FE 07 12 FF CRC CRC

BD:	Baudrate to use:	
	00:	300 baud
	01:	600 baud
	02:	1200 baud
	03:	2400 baud
	04:	4800 baud
	05:	9600 baud
	06:	19200 baud
	07:	38400 baud
	08:	57600 baud
	09:	115200 baud
	0A:	230400 baud
	0B:	460800 baud
	AA:	460800 baud
PR:	00:	8 bit data no parity
	01:	8 bit data + parity odd
	02:	8 bit data + parity even
TO:	timeout in 0.35 seconds, default = 6 (2.1 seconds) This is the timeout for waiting for an answer from an external device connected to the serial interface of the aquaradio® Mobile Receiver.	

9. 8. Send Data over External Serial Interface

After the external serial interface has been switched on, it is possible to send data to a connected device (all bytes hexadecimal).

Request:	01 FE LL 13 MM [Data] CRC CRC
Answer OK:	01 FE 07 13 00 CRC CRC
Answer error:	01 FE 07 13 FF CRC CRC

LL:	Overall length of request (from start sign to last CRC)
MM:	Number of data bytes in [Data]
[Data]:	Bytes to send over the serial interface (max. 245 bytes)

9. 9. Send Data over External Serial Interface with Wake-Up

After the external serial interface has been switched on, it is possible to send data to a connected device (all bytes hexadecimal). This command supports wake-up commands over a serial optical interfaces (e.g. 0101010... bit streams using the selected baud rate). To realize a wake-up command the given byte CC (see below) is DH:DL times sent over the serial interface before sending the data frame. Between wake-up command and data frame a 50 ms pause is introduced. Using e.g. 0x55 as byte CC a 010101... bit stream of variable length can be realized. The wake-up byte is always sent with no parity bit.

LL:	Overall length of request (from start sign to last CRC)
CC:	Byte used as wake-up command, usually 0x55 or 0x00
DL:	Least significant byte of the number of repetitions of byte CC
DH:	Most significant byte of the number of repetitions of byte CC
MM:	Number of data bytes in [Data]
[Data]:	Bytes to send over the serial interface (max. 245 bytes)

Example: 2.2 seconds 0101010101... sequence according to EN1434-3:

300 baud:	CC = 0x55, DL = 0x42, DH = 0x00
2400 baud:	CC = 0x55, DL = 0x10, DH = 0x02
9600 baud:	CC = 0x55, DL = 0x40, DH = 0x08

9. 10. Send Radio Frames

The aquaradio® Mobile Receiver devices are bidirectional radio transceiver, thus, capable of sending radio frames, also. In general, the configured radio frame is sent after a radio frame from the respective consumption meter has been received. Therefore, the command below is not directly sending the radio frame but stores the radio frame to the internal buffer of the aquaradio® Mobile Receiver.

Request:	01 FE 93 20 RM S0 S1 S2 A0 A1 A2 A3 A4 A5 A6 A7 MO TL [127 bytes] CRC CRC
Answer OK:	01 FE 07 20 00 CRC CRC
Answer Error:	01 FE 07 20 FF CRC CRC

RM:	Radio mode:	00	= auto, according to received frame (T2, S2 or C2)
		else	= invalid **(C2 only with FW version 3.17 and up)**

S0, S1, S2	Transmission speed (chiprate) The registers for the transmission speed are calculated as shown below: S[2,0] = 65536 - (12000000 / chiprate) Examples: 100000 chip/s: S2 = 00, S1 = FF, S0 = 88 32768 chip/s: S2 = 00, S1 = FE, S0 = 91 **(not supported for FW version 3.xx)**
A0, A1, A2, A3,A4, A5, A6, A7	Link layer address of the consumption meter to send the radio frame to. A0 = LSB of manufacturer code A1 = MSB of manufacturer code A2 = LSB of serial number A3 = LSB+1 of serial number A4 = LSB+2 of serial number A5 = MSB of serial number A6 = version number A7 = device type

MO:	Options:	0x01	= transmit radio frame once if a frame from the given address has been received
		0x02	= transmit radio frame always if a frame from the given address has been received
		0x04	= transmit once if any frame is received

	0x08 = transmit always if any frame is received
	0x10 = transmit once immediately
	else = invalid
	If you have used one of the options which transmits always you can shut down the process by sending this command with TL set to 0 (no data in frame). If you have chosen one of the options, which transmits if any frame is received then the address field of the frame to send (byte 2 to byte 7) is automatically replaced by the address field of the received frame.
TL:	Number of bytes to send (length of radio frame)
[127 bytes]	The radio frame to send. It must contain all CRC bytes but neither preamble nor synchronization word. The radio frame is automatically transferred to Manchester code for mode S2 and T2. It is necessary to always send 127 bytes using this command. The length is given by TL (see above). Not used bytes should be set to FF.

To deactivate the radio frame sending, send this command with [TL] = 0.

9. 11. Send Radio Frames 2

The aquaradio® Mobile Receiver devices are bidirectional radio transceiver, thus, capable of sending radio frames, also. The configured radio frame is sent after a radio frame from the respective consumption meter has been received. It is possible to store up to five different frames addressing five different radio meters.

NOTE: This command is only available with firmware version 3.17 and up.

NOTE: If the "Send Radio Frames" command has been used and is still active ([TL] not 0), then the radio frames configured with Send Radio Frame 2 are inactive. Send the command "Send Radio Frames" again with [TL] = 0 to deactivate the "Send Radio Frames" configured radio frame.

NOTE: The length byte contains only the LSB of the real length (0x116) of this command.

Request:	01 FE 16 4B IX NU CT RM DL S0 S1 S2 A0 A1 A2 A3 A4 A5 A6 A7 TL [255 bytes] CRC CRC
Answer OK:	01 FE 07 4B 00 CRC CRC
Answer Error:	01 FE 07 4B FF CRC CRC
IX:	Index of configured radio frame to send [1..5]. Invalid IX are ignored.
NU:	How often the radio frame should be sent. 0: send always if a frame with the respective address has been received 1...255: send the radio frame 1 to 255 times
CT:	delay adjust (DL) in 0.5 ms, set to 0 by default. 01 = DL + 0.5 ms 02 = DL + 1 ms FF = DL – 0.5 ms FE = DL – 1 ms etc.
RM:	Bit coded settings field (FW version 3.44 and up):

0xx00000 (bit 4: 0)	ignoring bidirectional bit in config field
0xx10000 (bit 4: 1)	checking bidirectional bit in config field
000x0000 (bit 5+6: 00)	do not add CRC to radio frame
001x0000 (bit 5+6: 01)	add CRC format A to radio frame
010x0000 (bit 5+6: 10)	add CRC format B to radio frame (format B: length field of radio frame is automatically adjusted for added CRC bytes)
011x0000 (bit 5+6: 11)	invalid (do not add CRC to radio frame)
Example: RM=0x30	check bidirectional bit in config field and add CRC format A

DL:	Delay between end of reception and sending radio frame [2...254 ms]. Invalid delays are set to 2 ms.

	DL = FF (recommended), automatic delay setting: Mode T2 = 2 ms Mode S2 = 10 ms Mode C2 = 100 ms (D bit in config field of ELL = 1) Mode C2 = 1000 ms (D bit in config field of ELL = 0)
S0, S1, S2:	Transmission speed (chiprate) 100000 chip/s: S2 = 01, S1 = 86, S0 = A0 32768 chip/s: S2 = 00, S1 = 80, S0 = 00 **(not supported for FW version 3.xx)**
A0, A1, A2, A3, A4, A5, A6, A7:	Link layer address of the consumption meter to send the radio frame to. A0 = LSB of manufacturer code A1 = MSB of manufacturer code A2 = LSB of serial number A3 = LSB+1 of serial number A4 = LSB+2 of serial number A5 = MSB of serial number A6 = version number A7 = device type It is possible to replace each byte with the M-Bus "wildcard" 0xFF. In this case, the respective byte is ignored during address comparison.
TL:	Number of bytes to send (length of radio frame)
[255 bytes]:	The radio frame to send. It must contain all CRC bytes but neither preamble nor synchronization word. The radio frame is automatically transferred to Manchester code for mode S2 and T2. It is necessary to always send 255 bytes using this command. The length is given by TL (see above). Not used bytes should be set to FF.

To deactivate the radio frame sending, send this command with the correct index IX and [TL] = 0.

9. 12. Send Radio Frames 2 (EQS mode)

This command is in principle the same as before with the exception that the radio mode (RM) is set to 0x80. In this case a proprietary EQS mode is used.

NOTE: This command is only available with firmware version 3.34 and up.

NOTE: If the "Send Radio Frames" command has been used and is still active ([TL] not 0), then the radio frames configured with Send Radio Frame 2 are inactive. Send the command "Send Radio Frames" again with [TL] = 0 to deactivate the "Send Radio Frames" configured radio frame.

NOTE: The length byte contains only the LSB of the real length (0x116) of this command.

Request:	01 FE 16 4B IX NU CT RM DL S0 S1 S2 A0 A1 A2 A3 A4 A5 A6 A7 TL NF CL CM [252 bytes] CRC CRC
Answer OK:	01 FE 07 4B 00 CRC CRC
Answer Error:	01 FE 07 4B FF CRC CRC
IX:	Index of configured radio frame to send [1..5]. Invalid IX are ignored.
NU:	Ignored, set to 0
CT:	delay adjust (DL) in 0.5 ms, set to 0 by default. 01 = DL + 0.5 ms 02 = DL + 1 ms FF = DL – 0.5 ms FE = DL – 1 ms etc.
RM:	Radio mode: 80 = EQS mode
DL:	Always set to FF

S0, S1, S2:	Always set to S2 = 01, S1 = 86, S0 = A0
A0, A1, A2, A3, A4, A5, A6, A7:	Link layer address of the consumption meter to send the radio frame to. A0 = LSB of manufacturer code A1 = MSB of manufacturer code A2 = LSB of serial number A3 = LSB+1 of serial number A4 = LSB+2 of serial number A5 = MSB of serial number A6 = version number A7 = device type It is possible to replace each byte with the M-Bus "wildcard" 0xFF. In this case, the respective byte is ignored during address comparison.
TL:	Number of payload / APL bytes ([252 bytes], usually starting with 2F 2F ...)
NF:	Number of "frame to follow" frames to send after initial SND_UD
CL:	Configuration word of SND_UD (LSB)
CM:	Configuration word of SND_UD (MSB)
[252 bytes]:	Payload / APL of radio frame to send (usually starting with 2F 2F ...) Using this command the aquaradio® Mobile Receiver is automatically building the correct radio frame by adding LL (link layer) and TPL (transport layer). It is necessary to always send 252 bytes using this command. The length is given by TL (see above). Not used bytes should be set to FF.

To deactivate the radio frame sending, send this command with the correct index IX and [TL] = 0.

9. 13. Read Send Radio Frame Configuration

This command is used to read the contents of the radio frame buffers configured with "Send Radio Frames 2".

NOTE: This command is only available with firmware version 3.120 and up.

NOTE: The length byte contains only the LSB of the real length (0x116) of this command.

Request:	01 FE 07 4C IX CRC CRC
Answer OK:	01 FE 16 4C IX NU CT RM DL S0 S1 S2 A0 A1 A2 A3 A4 A5 A6 A7 TL [255 bytes] CRC CRC
Answer Error:	01 FE 07 4C FF CRC CRC

The parameters are the same as for "Send Radio Frames 2", with the following exception:

IX:	[0] Returns the configuration of the radio frame configured with "Send Radio Frames", [1...5] returns the configuration of the radio frames configured with "Send Radio Frames 2".
CT:	Count on how often the radio frame has already been sent. If NU = 0 then CT counts up and overflows to 0x00 at 0xFF.

10. aquaradio® Mobile Receiver Reading Example Using the MBT1ReceiverLib

The MBT1ReceiverLib is a software library containing functions for reading and programming MBT1 devices. It encapsulates also the functions for the aquaradio® Mobile Receiver. Below is one example on how to read out radio devices and another example on how to communicate over the external serial interface

```
Sub aquaradio® Mobile ReceiverReading()
'*****************************************************************************************************************
MBT1COM = 12 'aquaradio® Mobile Receiver device is given the virtual COM port number COM12 'change this value according to your COM port
'*****************************************************************************************************************
```

```
For RowCounter = 1 To 50 'clear all cells
For LineCounter = 1 To 200
Cells(LineCounter, RowCounter) = ""
Next LineCounter
Next RowCounter
Cells(1, 4) = "Running"
'*****************************************************************************************************************
Set aquaradio® Mobile Receiver = CreateObject("MBT1ReceiverLib.MBT1Receiver.1") 'invoke MBT1ReceiverLib software module
'*****************************************************************************************************************
------------------------------------------------------------'general settings
aquaradio® Mobile Receiver.RadioPasskey(1) = "FFFFFFFFFFFFFFFF" 'set 64 bit radio deciphering pass key 1 (if available)
aquaradio® Mobile Receiver.RadioPasskey(2) = "FFFFFFFFFFFFFFFF" 'set 64 bit radio deciphering pass key 2 (if available)
aquaradio® Mobile Receiver.RadioPasskey(3) = "FFFFFFFFFFFFFFFF" 'set 64 bit radio deciphering pass key 3 (if available)
aquaradio® Mobile Receiver.RadioPasskey128(1) = "FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF" 'Set 128 bit radio deciphering pass key 1 (if available)
aquaradio® Mobile Receiver.RadioPasskey128(2) = "FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF" 'Set 128 bit radio deciphering pass key 2 (if available)
aquaradio® Mobile Receiver.RadioPasskey128(3) = "FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF" 'Set 128 bit radio deciphering pass key 3 (if available)
'*****************************************************************************************************************
aquaradio® Mobile Receiver.CurrentCOMPort = MBT1COM 'set the virtual COM port for the aquaradio® Mobile Receiver
'check the Bluetooth manager for the correct setting
aquaradio® Mobile Receiver.ReadParameter 'start with reading the parameter
Do
DoEvents
Loop While aquaradio® Mobile Receiver.CommunicationThreadRuns <> 0
Cells(1, 1) = "aquaradio® Mobile Receiver"
Cells(1, 2) = aquaradio® Mobile Receiver.SerialNumber 'print out serial number of aquaradio® Mobile Receiverdevice
Cells(2, 1) = "Firmware"
Cells(2, 2) = aquaradio® Mobile Receiver.FirmwareVersion 'print out firmware version of aquaradio® Mobile Receiverdevice
If aquaradio® Mobile Receiver.SerialNumber = "" Then 'if the serial number is empty there is no device connected
Cells(3, 1) = "No MBT1Device connected"
GoTo aquaradio® Mobile ReceiverReadingEnd
End If
'*****************************************************************************************************************
Cells(4, 1) = "Reception Time"
Cells(4, 2) = "Manufacturer"
Cells(4, 3) = "Address"
Cells(4, 4) = "Signal Strengh [%]"
Cells(4, 5) = "Generation"
Cells(4, 6) = "Medium"
Cells(4, 7) = "CI Field"
Cells(4, 8) = "Transmission Count"
Cells(4, 9) = "Status"
Cells(4, 10) = "Signature"
For Counter = 1 To 15
CellStr = "Value "
CellStr = CellStr + Str(Counter)
Cells(4, ((Counter * 2) + 9)) = CellStr
CellStr = "Unit "
CellStr = CellStr + Str(Counter)
Cells(4, ((Counter * 2) + 10)) = CellStr
Next Counter
TelegramRow = 5
StartTime = Now
aquaradio® Mobile Receiver.StartRadioReading 'start radio telegram reading
'*****************************************************************************************************************
Do 'read out the aquaradio® Mobile Receiver device for 15 seconds and display all values
DoEvents
```

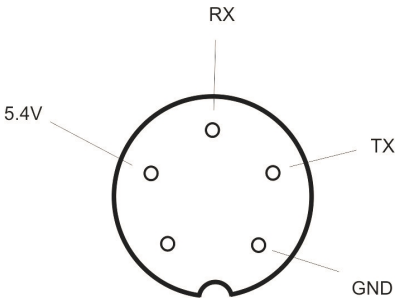
```
TelegramStr = aquaradio® Mobile Receiver.NextRadioTelegram
If Left(TelegramStr, 2) <> "FF" Then 'if the telegram string contains FF there is no telegram available
TelValuesValid = aquaradio® Mobile Receiver.RADExtractDecipherValid(TelegramStr)
'get the deciphering successful flag
aquaradio® Mobile Receiver.TelegramInterpret Mid(TelegramStr, 17, 500), TelValuesValid
'interpret the telegram and its meter counts
Cells(TelegramRow, 1) = aquaradio® Mobile Receiver.RADExtractRecTime(TelegramStr)
Cells(TelegramRow, 2) = aquaradio® Mobile Receiver.RADManufacturer
Cells(TelegramRow, 3) = aquaradio® Mobile Receiver.RADDeviceAddress
Cells(TelegramRow, 4) = aquaradio® Mobile Receiver.RADExtractSignalStrength(TelegramStr)
Cells(TelegramRow, 5) = aquaradio® Mobile Receiver.RADGeneration
Cells(TelegramRow, 6) = aquaradio® Mobile Receiver.RADMedium
Cells(TelegramRow, 7) = aquaradio® Mobile Receiver.RADCIField
Cells(TelegramRow, 8) = aquaradio® Mobile Receiver.RADTransCount
Cells(TelegramRow, 9) = aquaradio® Mobile Receiver.RADStatus
Cells(TelegramRow, 10) = aquaradio® Mobile Receiver.RADSignature 'read the different values of the telegram header
NumberOfValues = aquaradio® Mobile Receiver.RADNumberOfDatarecords 'read the different meter counts
For Counter = 1 To NumberOfValues
Cells(TelegramRow, ((Counter * 2) + 9)) = aquaradio® Mobile Receiver.RADDatarecordValue(Counter)
Cells(TelegramRow, ((Counter * 2) + 10)) = aquaradio® Mobile Receiver.RADDatarecordUnit(Counter)
Next Counter
TelegramRow = TelegramRow + 1
End If
Loop While Now < StartTime + TimeValue("0:00:15") 'read the aquaradio® Mobile Receiverdevice for 15 seconds
'*****************************************************************************************************************************
aquaradio® Mobile Receiver.CommunicationThreadBreak = 1 'Stop radio telegram reading
aquaradio® Mobile ReceiverReadingEnd:
Cells(1, 4) = "Stopped"
End Sub
Sub aquaradio® Mobile ReceiverxtSerial()
'*****************************************************************************************************************************
MBT1COM = 12 'aquaradio® Mobile Receiver device is given the virtual COM port number COM12
'change this value according to your COM port
'*****************************************************************************************************************************
Set aquaradio® Mobile Receiver= CreateObject("MBT1ReceiverLib.MBT1Receiver.1") 'invoke MBT1ReceiverLib software module
'*****************************************************************************************************************************
aquaradio® Mobile Receiver.CurrentCOMPort = MBT1COM 'set the virtual COM port for the aquaradio® Mobile Receiver
'check the Bluetooth manager for the correct setting
aquaradio® Mobile Receiver.ReadParameter 'start with reading the parameter
Do
DoEvents
Loop While aquaradio® Mobile Receiver.CommunicationThreadRuns <> 0
Cells(1, 1) = "aquaradio® Mobile Receiver"
Cells(1, 2) = aquaradio® Mobile Receiver.SerialNumber 'print out serial number of aquaradio® Mobile Receiver device
Cells(2, 1) = "Firmware"
Cells(2, 2) = aquaradio® Mobile Receiver.FirmwareVersion 'print out firmware version of aquaradio® Mobile Receiver device
If aquaradio® Mobile Receiver.SerialNumber = "" Then 'if the serial number is empty there is no device connected
Cells(3, 1) = "No MBT1Device connected"
GoTo aquaradio® Mobile ReceiverReadingEnd
End If
'*****************************************************************************************************************************
SRequest = “1040FE3E16"
aquaradio® Mobile Receiver.BlueExtSerSendData 3, 2, 4, SRequest ‘Initialize external serial interface and send a request command
Do
DoEvents
Loop While aquaradio® Mobile Receiver.CommunicationThreadRuns <> 0 ‘Wait until the external serial interface request has finished
```

```
Cells(4, 1) = aquaradio® Mobile Receiver.BlueExtSerRecData 'Print out received data
aquaradio® Mobile ReceiverReadingEnd:
Cells(1, 4) = "Stopped"
End Sub
```

11. External Serial Interface

The aquaradio® Mobile Receiver is equipped with a simple external serial interface (TX / RX and power supply, only). This external serial interface may be used to connect e.g. optical or other meter configuration devices. The maximum power output is limited to 35 mA (5.4 V).

Exterior view on the connector pins



TX:	aquaradio® Mobile Receiver-> external device	0=+5.4V; 1=-5.4 V
RX:	external device -> aquaradio® Mobile Receiver	0=+3.0 V ...+15.0V; 1=-3.0V...-15.0V
Power:	+5.4V / 35 mA max.	

The corresponding counterpart to the aquaradio® Mobile Receiver connector is:

BINDER - 99-0413-00-05 connector (5-way)

12. Troubleshooting

Should the aquaradio® Mobile Receiver not work as described in this document, please check the list of possible error causes below for a solution:

- After pressing the On button there is no LED lit up.
  - Charge the device for at least 4 hours.
  - If the error persists, turn the device in for repair.
- After having dropped the aquaradio® Mobile Receiverdevice to the ground it is no longer possible to switch it on (there is no LED lit up after pressing the On button).

- Connect the charger for approximately 15 seconds. Try to switch on the device again.
- If the error persists turn the device in for repair.

- After connecting the battery charger the PWR LED is not lit up.
  - Check if the plug of the battery charger is correctly placed onto the aquaradio® Mobile Receiver connector.
  - Check if the battery charger wall plug is connected to mains power supply.
  - If the error persists turn the device in for repair.
- It is not possible to establish a Bluetooth connection.
  - Check if the aquaradio® Mobile Receiver is still switched on.
  - Check if the aquaradio® Mobile Receiver was found during the Bluetooth device search and repeat it, if necessary.
  - Switch the aquaradio® Mobile Receiver off (by holding the On button down for more than 5 seconds), wait 60 seconds and switch it on again. Retry the Bluetooth search then. Note, that it is not possible to switch off the device manually if a Bluetooth connection is established (Bluetooth LED lights up in amber).
  - Switch off and restart your computer.
  - Try another computer for establishing the Bluetooth connection.
  - If the error persists turn the device in for repair.
- The battery operating time is much shorter than specified.
  - If you are using the serial interface intensively with an external device consuming a lot of power, the battery operating time is shorter than specified. This depends on the power consumption of the external device and on how long the external device is switched on.
  - Lithium ion batteries are degrading with time and charging cycles. Usually, after one year or 300 charging cycles the capacity should be still at 80% of the initial capacity. However, if the battery operating time becomes too short after several years, it is possible to replace the lithium ion battery. Do not attempt to replace the battery by yourself but turn the device in.
- The RAD LED and the ON LED are flashing in red rapidly.
  - The internal self-test has failed. Switch the aquaradio® Mobile Receiver off (by holding the On button down for more than 5 seconds). Charge the device for at least 4 hours. Switch the device on and try again.
  - If the error persists turn the device in for repair.

13. Care and Maintenance

- Clean the device only with a soft cloth, moistened with mild soapy water.
- Never use strong detergents or hard brushes.
- Disconnect the battery charger if the battery is full. The lithium ion battery does not need to be constantly connected to the battery charger for keeping its charge.

14. Disposal

The aquaradio® Mobile Receiver must not be disposed together with the domestic waste. All users are obliged to hand in all electrical or electronic devices, regardless of whether or not they contain toxic substances, to ensure a disposal in environmentally acceptable manner.

Therefore, return the device at the end of its lifetime to the manufacturer (address on page 2).

15. Specifications

Name:	aquaradio® Mobile Receiver
Application:	Radio receiver with Bluetooth interface
Place of operation:	Non-weather protected portable applications
Protection rating:	IP 64

Receiver frequency:	868 MHz / 434 MHz
Receiving range:	Depending on environment up to 400 m (outdoor) or up to 30 m (indoor)
Receiver memory:	150 radio frames
Power supply:	3.7 volt lithium ion rechargeable battery
Autonomy:	20 hours (without using the serial interface)
Battery life time expectancy:	> 300 charging cycles
Battery Charger:	Input: 100 V to 240 V AC 50 to 60 Hz 1.0 A max. Output: 5 V DC 3.0 A max. The charging device may only be used in dry and weather-protected environments.
Operating conditions:	-5°C to +55°C (not during battery charging) 0°C to +40°C (during battery charging) 10% to 95% humidity
Storage conditions:	-20°C to +45°C (less than 3 months) -20°C to +25°C (less than 1 year) for keeping at least 80% of the battery capacity
Dimensions:	Approximately 160 x 85 x 40 mm (without antenna) length of antenna approximately 180 mm
Weight:	Approximately 300 g
Interface:	Bluetooth 4.1 (classic) Class 2 (10 m) Microchip BM77SPPx3MC2 module Bluetooth SIG QDID: B021961 EIRP: 4 dBm (2.5 mW) / Antenna gain: 0 dBi

Radio parameters receiver (868 version):

Frequency:	T1/C1: 868.95 MHz, S1: 868.3 MHz
Bandwidth:	200 kHz
Frequency deviation:	T1/S1: 50 kHz, C1: 45 kHz
Chiprate:	T1/C1: 100,000 Chip/s, S1: 32,768 Chip/s
Coding:	T1: 3 of 6 code, C1: none, S1: Manchester

Radio parameters receiver (434version):

Frequency:	T1/C1: 434.475 MHz, S1: 433.5 MHz
Bandwidth:	200 kHz
Frequency deviation:	T1/S1: 50 kHz, C1: 45 kHz
Chiprate:	T1/C1: 100,000 Chip/s, S1: 32,768 Chip/s
Coding:	T1: 3 of 6 code, C1: none, S1: Manchester

Radio parameters transmitter (868 version):

Frequencies:	T2/S2: 868.3 MHz / C2: 869.25 MHz
Frequency deviation:	T2/S2: 50 kHz, C2: 25 kHz
Chiprate:	T2/S2: 32,768 Chip/s, C2: 50,000 Chip/s
Coding:	T2/S2: Manchester, C2: none
Max. Output Power:	8 dBm (6.3 mW)
Antenna gain:	5 dBi
EIRP:	13 dBm (25 mW)

Radio parameters transmitter (434 version):

Frequencies:	T2/S2/C2: 433.5 MHz
Frequency deviation:	T2/S2: 50 kHz, C2: 25 kHz
Chiprate:	T2/S2: 32,768 Chip/s, C2: 50,000 Chip/s
Coding:	T2/S2: Manchester, C2: none

Max. Output Power:	5 dBm (3.2 mW)
Antenna gain:	5 dBi
EIRP:	10 dBm (10 mW)
Approved directives / norms:	ETSI EN 301 489-1 V1.8.1 (2008-04) class 2 ETSI EN 301 489-3 V1.4.1 (2002-08) class 2 ETSI EN 301 489-17 V2.1.1 (2009-05) Non-specific Short Range Device (SRD) ETSI EN ETSI EN 300 220-1 V2.1.1 (2006-04) ETSI EN 300 220-2 V2.1.2 (2007-06) Receiver class 3
CE	EN 60721-3-2 classes 2M2 / 2K2 EN 60721-3-7 classes 7M3 / 7K2 / 7Z14 IP 64
Test laboratory:	TÜV Süd Senton GmbH / Straubing / Germany