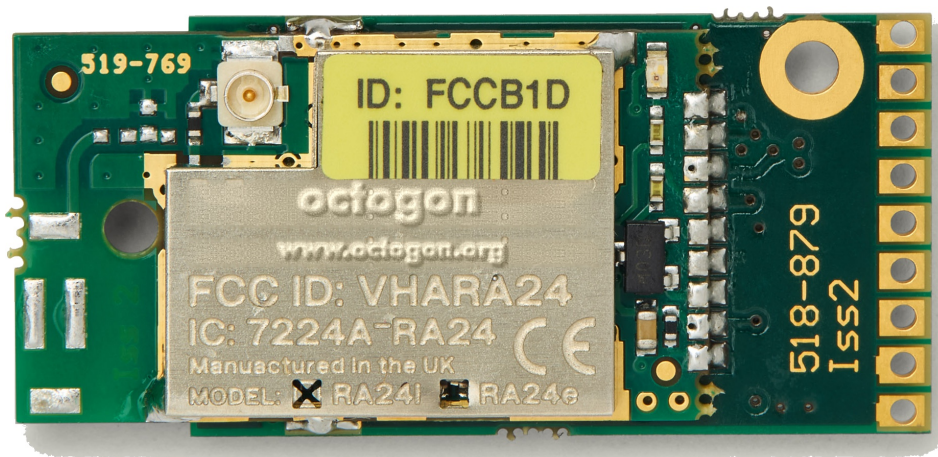


MANUAL

EFMF

WIRELESS STRAIN BRIDGE MODULE

Installation and user manual



Document	Version	Date	Applies to
Installation and user manual	V00x	10/2026	EFMF, both antenna versions, all sensitivity options

This manual describes the integration of the EFMF OEM strain bridge transmitter module into a sensor or product – mechanics, antennas, power supply and connection – as well as configuration and calibration, the radio system it works in, troubleshooting and the radio approvals with the requirements for OEM integrators.



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1 About this manual

The EFMF is a wireless transmitter for strain bridge sensors on a small circuit board, made for building into load cells, torque sensors, strain gauge transducers and pressure modules. This manual is valid for both antenna versions and all sensitivity options.

1.1 Versions covered

Version	Antenna	Note
On-chip antenna	ceramic chip antenna on the board	integrated antenna
External antenna	UFL socket for an external antenna (chapter 4.4)	
Sensitivity (order designation)	standard ± 3.1 mV/V · option A ± 4.5 mV/V · option B 20 mV/V	for both antenna versions
Manufacturer type	T24-SAi (on-chip antenna), T24-SAe (external antenna)	

1.2 Notation

Items, buttons and pages of the configuration software and pad names are set in a fixed-width typeface, for example **Pair** or **+EXC**. Notices:

Notice	Meaning
Important	Pay particular attention to the following instructions.
Note	Further information.

2 Safety and conditions of use

Important The EFMF is not authorised for use in safety-critical applications, that is applications in which a failure of the product would reasonably be expected to cause severe personal injury or death.

- The module is not reverse polarity protected. The maximum supply voltage is 3.6 V.
- The module is not protected against the environment; the product it is built into must provide the protection.
- The mounting hole near the solder pads is connected directly to the battery ground of the module. The mounting hole near the chip antenna must not take metal mounting hardware.
- Keep a separation of at least 5 cm between the antenna and all persons at all times, and do not operate the module co-located or in conjunction with any other antenna or transmitter (Canadian approval, chapter 12).
- Use only approved antennas. The manufacturer of the end product must meet the requirements for OEM integration in section 12.4.

3 Product description

3.1 Overview

The EFMF measures a 4-wire strain bridge, supplies its 5 V excitation and sends the reading by radio at a configurable rate from once per day up to 200 times per second. Its small size allows it to be built into the sensor housing, so that the sensor becomes wireless without a cable leaving the housing. Several receivers can use the readings at the same time: the handheld display EFMD, the large display EFMG, a PC with the USB base station EFME, or other compatible receivers. Between transmissions the module sleeps or can be switched off completely by other devices, which allows several years of operation on two alkaline cells. Configuration and calibration, with up to 9 points of linearisation, are done by radio with the T24 Toolkit software and a base station.

- Two-way radio: calibration and configuration by radio, sleep and wake by radio, battery check by radio; the mV/V calibration is stored in the module.
- Licence-free 2.4 GHz; range depending on antenna and receiver up to 800 m (chapter 10).
- Board 37.5 × 16.8 × 6.6 mm with 9 solder pads.

3.2 Technical data

Measurement (1000 Ω bridge, 2.5 mV/V, 3 V supply, 25 °C)

Item	Value
Excitation system	4-wire
Bridge excitation	5 V DC (4.5 ... 5.25 V)
Bridge resistance	85 ... 5000 Ω ; up to four 350 Ω bridges in parallel (shorter battery life)

Item	Value
Maximum gauge sensitivity	standard ± 3.1 mV/V · option A ± 5.3 mV/V · option B ± 21.0 mV/V (specification values; the options are ordered as ± 4.5 mV/V and 20 mV/V)
Measurement direction	bidirectional (tension and compression)
Factory calibration	2.5 mV/V; user calibration with up to 9 points
Offset temperature stability	typ. 1, max. 4 ppm/°C
Gain temperature stability	typ. 3, max. 5 ppm/°C
Offset stability with time	typ. 20, max. 80 ppm of full range (from the original offset at any time)
Gain stability with time	max. 30 ppm of full range (first year)
Non-linearity before linearisation	typ. 5, max. 25 ppm of full range
Internal resolution	16 000 000 · 24 bit
Noise-free resolution	up to 400 000 · 18.75 bit (table 3.3)
Transmission interval	5 ms ... 1 day (up to 200 readings per second)

Radio

Item	Value
Licence	licence exempt
Radio type	transceiver (two-way)
Radio frequency	2.4000 ... 2.4835 GHz
Channels	15 (DSSS)
Modulation	MS (QPSK)
Data rate	250 kbit/s
Transmit power	10 mW (adjustable 0 ... 100 %, default 100 %)
Antenna	on-chip version: ceramic chip antenna (helix), 1.3 dBi · external version: UFL socket for antennas A ... E (section 4.4)
Range	up to 800 m in the open field, depending on antenna and receiver (chapter 10)
Coexistence · encryption	Wi-Fi, Bluetooth, Zigbee · 128 bit AES

Power supply

Item	Value
Supply voltage	2.1 ... 3.6 V DC, typ. 3.0 V; not reverse polarity protected; the module stops working at 2.1 V
Supply ripple	max. 50 mV AC peak-peak
Current, standby / low power mode	typ. 5 μ A, max. 20 μ A
Current, normal mode (1 k Ω bridge)	typ. 60 mA, max. 65 mA
Peak current	the supply must be capable of 300 mA for 250 μ s (start-up, waking, low power operation)
Battery life	chapter 9

Environment and mechanics

Item	Value
Operating temperature	-20 ... +55 °C
Storage temperature	-40 ... +85 °C (without batteries)
Humidity	0 ... 95 % RH, non-condensing
Degree of protection	none – the module is not protected against the environment
Dimensions	37.5 × 16.8 × 6.6 mm (L × W × H)
Connections	9 solder pads: plated holes $\varnothing$ 1.0 mm, 1.9 mm pitch
Mounting	2 holes $\varnothing$ 2.1 mm (chapter 4)

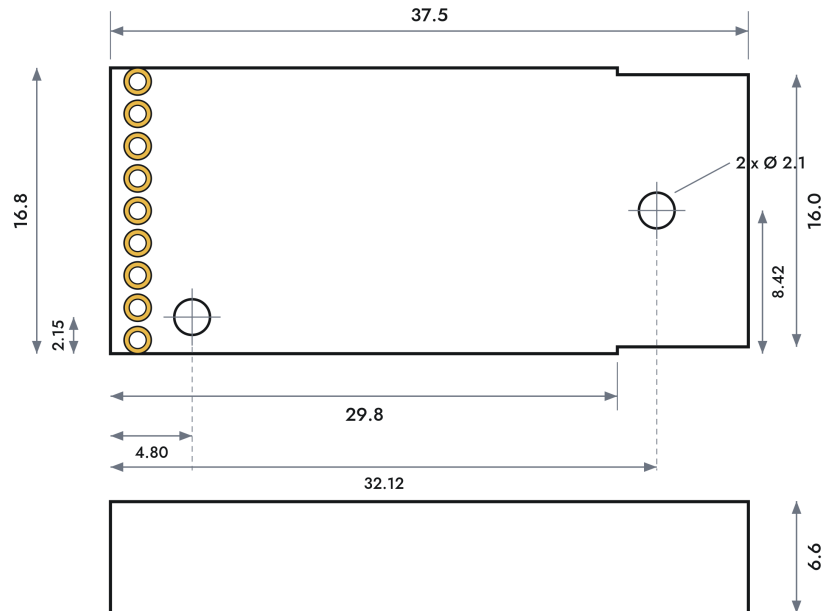
3.3 Noise-free resolution

The noise-free resolution depends on the sample time set in the Toolkit (chapter 8):

Sample time	Noise-free resolution	Bits
< 10 ms	50 000	15.5
< 50 ms	65 000	16
< 100 ms	150 000	17.25
< 1000 ms	250 000	18
> 1000 ms	400 000	18.75

4 Mechanical integration

4.1 Dimensions and mounting holes



9 plated through-holes Ø 1.0 on 1.9 pitch - all dimensions in mm

Dimensions in mm, board seen from the component side.

- There are two mounting holes (Ø 2.1 mm). The hole near the solder pads takes an M2 screw or the American equivalent #0-80.
- Height of the module: 6.6 mm.

Important Do not use a #2 screw. The hole near the solder pads is connected directly to the battery ground of the module. The hole near the chip antenna must not take metal mounting hardware.

4.2 Product enclosure

- Preferred enclosure materials are fibreglass, light-coloured ABS or polypropylene. Other materials attenuate the 2.4 GHz signal, refract it or change its polarisation; dark colours achieved by adding carbon can attenuate the radio signal.
- If the module has to be fitted inside a metal enclosure, keep the specified clearances around the antenna and design in a fibreglass RF window at least as large as the clearance dimensions, ideally as large as possible.

4.3 On-chip antenna version

The ceramic chip antenna sits at the end of the board opposite the solder pads.

- There must be no metal objects within 7 mm of the long edges of the antenna and within 20 mm of its short edges.
- Orient the module so that the chip antenna is vertical when the product is in its normal operating position.

4.4 External antenna version

The module can be mounted anywhere; the restrictions apply to the antenna. Approved antennas for the UFL socket:

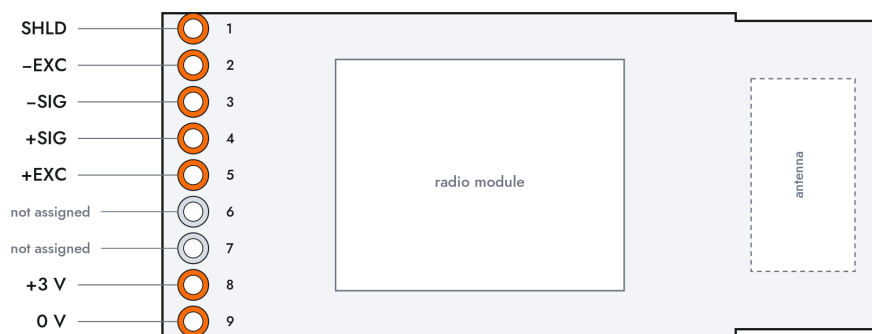
Antenna	Type	Gain	Connection	Protection
Antenna A	PCB antenna, inverted F, for mounting inside plastic or fibreglass enclosures	3.0 dBi	100 mm cable, UFL connector	—
Antenna B	half-wave dipole, fixed right-angle base, for outside mounting	1.1 dBi	RPSMA, 100 mm RPSMA-to-UFL tail	IP67
Antenna C	half-wave dipole, articulated base, for outside mounting	2.2 dBi	RPSMA, 100 mm RPSMA-to-UFL tail	IP67
Antenna D	puck antenna (inverted F) for an outside surface, 53 mm dia., 19 mm high	3.0 dBi	0.66 m cable, RPSMA plug	IP69K
Antenna E	puck antenna (inverted F) close to the module, 53 mm dia., 19 mm high	3.0 dBi	60 mm cable, UFL plug	IP69K

- Antenna A: for a flat surface inside a plastic or fibreglass enclosure, connected directly to the module. The antenna board is 58 × 20 mm and needs 3.0 mm clearance on all edges, also to the RF window (free area 64 × 26 mm). Orient its long axis vertically if possible. Lead the antenna cable along the ground plane section; no cable or wire may run over or near the antenna element.
- Antennas B and C: for outside mounting on a bulkhead or chassis RPSMA jack (usually a 6.4 mm hole), at the end of the 100 mm tail with UFL connector, or at the end of a feeder extension – generally not longer than 2 m. Mount the element vertically and ideally at least 1 m from large metal objects. The user must seal the bulkhead connector to the required level.
- Antennas D and E: 10 mm hole through material up to 3.0 mm thick with nut and shake-proof washer, or thicker with the self-adhesive pad alone; stud length 6 mm. Point the broad face towards the remote device (uppermost for devices passing overhead). D (0.66 m cable) for the outside of a large enclosure or cabinet or another external surface away from the module; E (60 mm cable) close to the module, on metal or plastic enclosures or bulkheads.

Important Approvals: in Europe antennas with a gain above 3 dBi are prohibited; in Canada only antenna A, antenna C and the integrated antenna are approved; for the USA see section 12.3.

5 Electrical connection

5.1 Solder pads



9 SOLDER PADS: PLATED HOLES Ø 1.0 mm, 1.9 mm PITCH

Sensor: 4-wire bridge 85 ... 5000 Ω · up to four 350 Ω bridges · cable below 3 m

Power: 3 V, maximum 3.6 V · no reverse polarity protection

Solder pads seen from the component side.

Pad	Name	Function
1	SHLD	shield
2	-EXC	– excitation
3	-SIG	– signal
4	+SIG	+ signal
5	+EXC	+ excitation (5 V)
6	—	not assigned (no function stated)
7	—	not assigned (no function stated)
8	+ 3V Supply	+ 3 V supply
9	0V Supply	0 V supply

The pads are plated holes of Ø 1.0 mm on a 1.9 mm pitch.

5.2 Power supply

Connect a 3 V power supply or batteries to pads 8 (+) and 9 (0 V).

Important The module is not reverse polarity protected! The maximum voltage is 3.6 V!

- Supply range 2.1 ... 3.6 V DC, ripple max. 50 mV peak-peak.
- The supply must be able to deliver 300 mA for 250 µs on start-up, on waking and during low power operation.
- Batteries, battery holders and battery life: chapter 9.

5.3 Connecting the sensor

- 4-wire connection to pads 1 ... 5; bridge resistance 85 ... 5000 Ω.
- Up to four 350 Ω bridges can be connected in parallel, at the expense of reduced battery life.
- Keep the cable between module and bridge below 3 m and generally as short as possible: with a 4-wire measurement, voltage drops in a longer cable have more effect on the factory mV/V calibration.
- The measurement is bidirectional: tension and compression.

5.4 Shield connection

Situation	Shield
Sensor remote from the module, cable screen NOT connected to the sensor chassis	connect the cable screen to pad 1 (SHLD)
Sensor remote from the module, cable screen connected to the sensor chassis	do NOT connect the cable screen to pad 1
Module integral with the sensor or very close to it, on a metal chassis	find out by experiment whether to connect pad 1 to the chassis (connection as short as possible): chart the radio signal and the reading quality in the Toolkit with and without the connection; if it makes no difference, make the connection

6 The T24 radio system

The EFMF is part of a modular radio system. Its readings can be used by several receivers at the same time, for example the handheld display EFMD, the large display EFMG or a PC with the USB base station EFME. The radios operate licence free in the 2.4 GHz band. The settings and concepts in this chapter are needed to configure, deploy, optimise and troubleshoot such a system.

6.1 Transmitters and receivers

All modules of the system are transceivers, but each works mainly as a transmitter or as a receiver. Transmitters such as the EFMF measure and send messages with the value and status information at a user-defined rate. Receivers use these messages to display, analyse or output them and can also send transmitters to sleep or wake them.

A PC with a base station is needed only to configure the modules, although it may be part of a data collection system. Once configured, the modules work autonomously.

6.2 Radio channel and group key

- Radio channel: the radio band is divided into 15 channels (1 ... 15). Two modules can exchange messages only on the same channel. Channel 16 is reserved for pairing.
- Group key: isolates groups of modules on the same channel. Modules see each other's messages only if they share the same group key. The key is defined by the user and has up to 15 alphanumeric characters.
- Group keys were introduced with radio firmware v3.0 (March 2015). Newer modules work with older ones, but then the group key must be left blank.

When the Toolkit pairs with a module, the base station adopts the radio channel and group key of that module. To give a set of modules the same settings, either pair with each one in turn and set channel and group key, or configure the base station first and then use the remote module radio settings tool (Toolkit chapter, “Radio settings”).

6.3 ID and data tag

Every module has a unique six-character hexadecimal ID (0 ... 9, A ... F), for example **FF1234**, allocated in the factory and used for configuration. A transmitter does not broadcast its ID: its messages carry a four-character hexadecimal data tag. In the factory the data tag is set to the last four characters of the ID; it can be changed.

Receivers select messages by data tag. A transmitter can therefore be replaced without reconfiguring the receivers: give the replacement the same data tag, radio channel and group key.

6.4 Operating modes and sleep delay

Mode	What the transmitter does
Normal	takes a reading, sends a message and enters a very low power state until the next reading
Configuration	pauses its messages and stays awake so that it can be configured; entered by pairing with the Toolkit; afterwards the module returns to normal mode
Sleep	sent to sleep by other modules, or goes to sleep itself when its messages are no longer used; can be woken on demand by other modules or by software via the base station

Sleep delay: most receivers and the T24 software send stay-awake messages when they receive messages from a transmitter, usually every 5 seconds. If the sleep delay has elapsed without a stay-awake message, the transmitter goes to sleep. Set the sleep delay to at least 10 seconds; it can be set up to one hour, for example when the receiver is out of range for a while but the transmitter has to keep working. Usual values are 30 to 300 seconds. A sleep delay of 0 disables the function: the transmitter then sleeps only when it is told to.

6.5 Pairing

Pairing finds and matches the radio settings (radio channel and group key) of two modules and can put a transmitter into configuration mode. Because a module can be built deep into other equipment, pairing is triggered by removing and re-applying the module’s power – for the EFMF: disconnect its supply.

- Pairing from the T24 Toolkit: remove power from the module, click **Pair** in the Toolkit and re-apply power within 10 seconds. The base station adopts the radio settings of the module and puts it into configuration mode. Pairing with the Toolkit does not change the radio settings of the module.
- Pairing from a receiver: some receivers, for example handheld displays, can pair with a transmitter without the Toolkit (see the manual of the receiver). The transmitter then adopts the radio settings of the receiver and simply continues in normal mode.
- Soft pairing: when the power of the module cannot be reached, the Toolkit can connect without a power cycle. The base station must be set to the module’s radio channel and group key, and the unique ID of the module must be known. Transmitters with a transmission interval above 5 seconds may be difficult to soft pair; in high-traffic or noisy radio environments soft pairing may fail – then pair by power cycling.

6.6 Radio traffic, repeaters and logging

- Each message takes about 3 ms. In practice about 200 messages per second are available per radio channel – for example 2 modules at 100 messages per second or 100 modules at 1 message per second. Modules on the same channel share this capacity even with different group keys; the more transmitters, the more messages are lost through collisions.
- Modules that do not need to communicate with each other can be put on separate channels.
- A repeater retransmits messages to increase the range or to bypass obstacles. It must use the same radio channel and group key as the modules it repeats. The repeater subgroup setting (default 0) limits which messages are repeated; it only needs changing when the channel is very full.
- Transmitters send at their own interval, timed from wake-up or power-on, without synchronisation. Logging software records the last value received from each transmitter, so values in one log record can be up to one transmission interval apart. If readings must be taken within a certain time of each other, set the transmission interval to that time; the log interval should always be longer than the transmission interval.

7 Configuration with the T24 Toolkit

7.1 What is needed

- The T24 Toolkit configuration software for Windows. It is free of charge; please ask octogon for the current version. Install it by running **setup.exe** and following the prompts.
- A base station connected to the PC, for example the USB base station EFME: plug it into a USB port.
- The EFMF, with its power accessible for pairing.

In the Toolkit, every item that can be changed is shown in green. Click it to open a dialog with a slider, a text box or a list for the new value.

Important Do not pair with several modules from several instances of the Toolkit at the same time.

7.2 Connecting to the EFMF

- Base station communications: select the interface type of the base station (for a serial base station also the COM port and baud rate). The base station address is usually 1. Click **Home**. If no connection is made, the Toolkit stays on this page – check that the base station is powered and correctly connected.
- Pairing: on the **Home** page remove power from the EFMF (disconnect its supply), click **Pair** and re-apply power within 10 seconds. When the connection is made, the Toolkit shows the Information page. If pairing fails, try again.
- While the Toolkit is connected, the transmitter usually stops its normal transmissions. It returns to normal operation when configuration is complete.
- To configure the attached base station itself, hold the Shift key and click **Pair**.
- If the power of the module cannot be reached, use soft pairing: click the **Click Here** link at the bottom of the Home page and follow the prompts (see “Pairing” in the previous chapter).

7.3 Information page

Shows the connected module. The name can be changed to a short description that helps to recognise the module later. The feature symbols show what the module supports (coloured) or not (greyed out): calibration protected, group keys supported, group key configured, extended range radio (introduced 2015) and v4.0 radio (better performance in hostile radio environments).

7.4 Battery and radio levels

- LQI (link quality indicator): 0 ... 100. Communication is possible across this range; towards 0 it may become intermittent.
- Battery voltage of the transmitter, with the adjustable **Low Battery Level** at which the module reports a low battery; below that level the bar turns orange. At 2.1 V the module stops working.
- **Advanced**: RSSI, the received level, from about –30 dB (good signal) to –98 dB (weak signal), and CV, the correlation value, from 55 (poor) to 110 (excellent).

7.5 Radio settings

Item	Function
Channel	radio channel 1 ... 15, default 1; use the spectrum analyser to find a clean channel
Group Key	only modules with identical group keys communicate; visible only on modules that support group keys; leave blank to work with older modules
Reset Module Only	new radio settings take effect only after a reset or power cycle: this button makes the module adopt them and keeps the base station on the old settings
Reset Module and Base Station	makes the module and the base station adopt the new settings and re-connects
Repeater Subgroup (Advanced)	default 0: every repeater repeats the messages of this module
Remote module radio settings tool (Advanced)	sets a batch of modules to the radio settings of the base station: remove power from the module, click the Click Here link, apply power; repeat for each module

7.6 Save and restore

Save writes all settings of the connected module, including the calibration, to a file with the extension **.tcf**. **Restore** loads such a file into the same or another module and overwrites all its settings, including the user calibration.

7.7 Spectrum analyser and channel monitor

The spectrum analyser shows the radio signal levels on all channels. Use it for a site survey before installation and when communication is poor:

- White trace: the real-time signal level – shows where other radios are active.
- Shaded area: the peak level over time – shows where traffic is strongest.
- Red trace: the minimum level. In a quiet environment it is not visible. As long as it stays below the clear channel assessment (CCA) threshold of the radios, the system works; prefer channels with a low minimum level. Above about –95 dB the achievable range starts to drop.
- Radio firmware up to v3.x does not transmit while the signal is above its CCA threshold; v4.0 has a revised threshold for noisy environments, v5.0 an adaptive one.
- A double-click on the chart resets the peak and minimum values.

The channel monitor lists the messages received from transmitters: data tag, number of messages, rate, link quality, value and errors. The base station must be on the same radio channel and use the same group key as the transmitters. Buttons: **channel** tabs (change the channel of the base station), **Clear List**, **Wake All** (wakes all modules on the channel with the matching group key), **Start Logging** (CSV file with data tag, elapsed time in ms and value), **View Last Log** and **Move Group Channel** (moves all modules with the same channel and group key, and then the base station, to a new channel – only modules that can be woken are moved).

8 Transmitter settings and calibration

Pair with the EFMF in the Toolkit (previous chapter). The pages below set the transmission, the calibration and the advanced settings.

8.1 Data rates and quality

Item	Function
Transmit Interval	transmission interval in ms; default 300, about 3 messages per second, suited to reading on a handheld; slower intervals give longer battery life
Sample Time	time in ms during which the input is sampled before the value is sent: 5 ms up to nearly the transmit interval; shorter means longer battery life but less noise-free resolution (table in the technical data)
Low Power Mode	Yes for every battery powered transmitter: the module sleeps between transmissions, which has a large effect on battery life. No only for special cases, e.g. a master-slave arrangement with a PC
Battery Type, Usable Capacity	not module settings – inputs for the battery life guide. Usable capacity in Ah, counted down to 2.1 V (1.05 V per cell for two cells)
Sensor Resistance	input for the battery life guide: resistance of the connected bridge in Ω
Usage Per 24 Hour Period	input for the battery life guide: hours per day during which a receiver is switched on and communicates with the transmitter

The battery life guide assumes the best case: 20 °C and a battery with suitably low internal resistance, or a suitable capacitor across the battery (chapter on batteries). Temperature and internal resistance are not taken into account.

8.2 Calibration with applied loads

Semi-automatic calibration with known inputs, including linearisation, applied automatically:

- Decide on the number of points: 2 for a linear calibration, 3 ... 9 for a calibration with linearisation.
- Decide which loads will be applied, in ascending order.
- Enter for each point the value in engineering units that the transmitter shall report.
- Apply each input in turn, allow it to settle and click **Acquire** for that point. A point can be acquired again; **Start Again** restarts the calibration.

Important The mV/V signal of the load cell must rise from one calibration point to the next.

The bottom of the page shows the input value and, from the second point on, the calibrated value. **System Zero** removes a fixed value from all subsequent readings, for example the weight of a sling, shackle or load bed: apply it and click the button. The system zero is stored in non-volatile memory in the transmitter and can be edited on the advanced page.

8.3 Calibration by certificate

Click **By Cert.** to calibrate from the calibration table or certificate of the sensor, without connecting it: enter the number of points (2 ... 9), for each point the input (e.g. in mV/V) and the required value in engineering units, then click **Calibrate**.

8.4 Advanced calibration

Click **Advanced** to enter gain and offset for each calibration point directly, for example values calculated from a calibration table. Between the points gain and offset are interpolated linearly; below point 1 and above point 9 the input is extrapolated. The system zero can be set here or set to zero to remove it.

The input (mV/V) is compared with the points starting from point 1; for the point found, the reading is calculated as: $\text{value} = (\text{input} \times \text{gain}) - \text{offset}$.

8.5 Advanced settings

Item	Function
Sleep Delay	time in seconds after which the transmitter returns to deep sleep if no stay-awake message arrives; default 60 s
Data Tag	identifies the transmitted data; default the last 4 characters of the serial number. Change it if two transmitters on the same channel have the same last 4 characters, then pair them with the receiver again
Startup Time	delays the measurement after wake-up for sensors with slow start-up, at the expense of battery life; for strain gauge inputs set it to 0
LED Mirror to Digital Output	Yes: the digital output is active each time the module LED is active – useful when the module is encapsulated or enclosed, to drive a second, externally mounted LED. The documentation does not state which solder pad carries the digital output; ask octagon.
Transmit Power	0 ... 100 %, default 100 %

These settings do not normally need to be changed.

9 Batteries and battery life

9.1 Battery life

Batteries	Use (3 readings per second, 350 Ω load cell, low power mode)	Battery life
2 $\times$ AA	constantly on	3 weeks
2 $\times$ AA	12 sessions of 5 minutes per day	2 years
2 $\times$ D	constantly on	3.5 months
2 $\times$ D	12 sessions of 5 minutes per day	5 years

The Toolkit gives an estimate for the actual settings (chapter 8, data rates and quality). Usable capacity is counted down to 2.1 V, i.e. 1.05 V per cell for two cells.

9.2 Choosing batteries and connections

- Usable capacity depends on temperature: the lower the temperature, the less charge a battery can deliver. Check the operating temperature range of the batteries intended for use.
- Batteries have a shelf life; an alkaline cell typically lasts about 5 years.
- Low internal resistance is important: the transmitter needs a short current peak (300 mA for 250 μ s) on start-up, on waking and during low power operation. Batteries with an internal resistance above 150 m Ω may need an additional capacitor module to supply this peak.
- Battery life is optimised by low power mode, a long transmission interval, the required resolution only (sample time), sleep/wake configuration and a suitable sleep delay.

- Keep the connections between battery and module as short and thick as possible – every voltage drop shortens the useful battery life.
- Battery holders with springs on one side only can briefly disconnect the battery under shock or vibration. This resets the module or wakes it from deep sleep – a module on a vehicle may not reach the calculated battery life. A sleep delay returns it to deep sleep after a period of inactivity. A standard battery holder is a poor choice where vibration occurs.
- Corroded terminals add resistance; a sealed enclosure prevents this.
- Rechargeable batteries: consider how the charger is connected and sealed, when charging is possible and whether the charging voltage exceeds the maximum supply voltage of the module (3.6 V).

10 Antennas and radio range

10.1 Radio range

Module version / antenna	Receiver	Maximum range, open field
On-chip antenna	handheld display EFMD, large display EFMG (antenna A)	600 m
On-chip antenna	USB base station EFME (integrated antenna)	500 m
External antenna A, D or E	handheld display EFMD, large display EFMG	800 m
External antenna A, D or E	USB base station EFME	600 m
External antenna B or C	any of the above	400 m

Test conditions: open field site, transmitter at the top of a 3 m pole, receiver 1.5 m above the ground. The range of the USB base station EFME may be reduced because it is close to the computer and the user.

10.2 Getting the best range

At 2.4 GHz the radio performance depends strongly on the surroundings. Any structure near the radios causes obscuration (an obstruction masks the line of sight – less range), distortion of the coverage pattern (objects close to the antenna) and reflection (signals arriving by indirect paths – less range or poor link quality). The result is a lower RSSI, more lost messages and, in extreme cases, no signal at all.

- Keep line of sight between the modules, and keep objects and structures at least 1 m away from the antennas wherever possible.
- A small change of the antenna height above ground often improves reception.
- Under water the range is only about 100 mm, depending on the message rate. Best results come from low message rates and water-proofed antennas immersed in the water, rather than water-tight enclosures containing the antennas.

11 Troubleshooting

Symptom	What to check
The Toolkit stays on the base station page	Check that the base station is powered and correctly connected; for a serial base station check COM port and baud rate.
Pairing fails	Remove power, click Pair , re-apply power within 10 s; try again. Soft pairing can fail with transmission intervals above 5 s or in busy or noisy radio environments – pair by power cycling.
No readings in the channel monitor or on a receiver	Base station and receivers must be on the same radio channel and use the same group key as the transmitter. The transmitter may be asleep: wake it (wake All) and check its sleep delay (at least 10 s).
Group key setting not available	The module was built before group keys were introduced (2015). To work together with such modules, leave the group key blank.
Two transmitters show the same data	Both have the same data tag (same last 4 characters of the ID): change the data tag of one of them and pair with the receiver again.
Intermittent communication, short range	Check LQI, RSSI and CV (Toolkit, battery and radio levels); look for a quieter channel with the spectrum analyser; keep metal and other objects away from the antennas.
Short range only near the PC	Unshielded USB 3.0 ports can emit radio noise. Use a USB port away from USB 3.0 ports or a short USB extension cable.

Symptom	What to check
Transmitter stops working	Battery voltage too low – the module stops at 2.1 V. Replace the batteries and check the low battery level.
Readings unstable or offset with a long sensor cable	Keep the cable between module and bridge below 3 m; voltage drops in a longer cable affect the factory mV/V calibration (4-wire measurement).
Module restarts or wakes up unexpectedly (vehicles, vibration)	The battery holder interrupts the supply under shock: use a holder with secure contacts or a fixed connection, and set a sleep delay (chapter 9).
Module does not work after connecting the supply	Check the polarity and the voltage at pads 8 and 9: the module has no reverse polarity protection, maximum 3.6 V.

12 Approvals and conformity

Worldwide regional approvals: Europe – CE, USA – FCC, Canada – IC. Not every standard of every country is listed here. The user assumes full responsibility for learning and meeting the requirements of each country in which the product is used or distributed.

12.1 Europe (CE)

Complies with the EMC directive 2014/30/EU and the radio equipment directive 2014/53/EU (European Community, Switzerland, Norway, Iceland and Liechtenstein). This equipment is in compliance with the essential requirements and other relevant provisions of directive 2014/53/EU.

Important Alternative antennas may be used, but antennas with a gain exceeding 3 dBi are strictly prohibited.

The EU declaration of conformity for the T24 product range, dated 16 October 2017, names the LVD directive 2014/35/EU, the EMC directive 2014/30/EU, the RoHS directive 2011/65/EU and the radio equipment directive 2014/53/EU, based on the harmonised standards EN 61326-1:2013, EN 61326-2-3:2013, EN 61010-1:2010 and EN 300 328 V2.1.1. The declaration is available from octogon on request.

12.2 Canada (IC)

IC: 7224A-RA24. This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. The radio transmitter has been approved by Industry Canada to operate with the antenna types listed below; antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Antenna	Gain	Antenna type
Antenna A	3 dBi	inverted F
Antenna C	2.2 dBi	half-wave dipole
Integrated	1.3 dBi	chip antenna

Important To comply with Industry Canada RF radiation exposure limits for general population, the antenna(s) used for this transmitter must be installed such that a minimum separation distance of 5 cm is maintained between the radiator (antenna) and all persons at all times and must not be co-located or operating in conjunction with any other antenna or transmitter.

12.3 USA (FCC)

Family RA24, models i and e, FCC ID: VHARA24.

- This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

- This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions for satisfying RF exposure compliance. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
- Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

For use with the integrated antenna, the antennas A to E and the antennas listed below:

Manufacturer code	Description	Gain
DELTA7A	dual band 2.4 or 5.8 GHz hinged mount whip	2.1 dBi
DELTA14	stubby WiFi / WLAN antenna	2.0 dBi
DELTA15/SMAM/RA/RP11	2.4 GHz right angle RPSMA	2.0 dBi
1699481	AUREL ANT.RP SMA 2.4 GHz	2.0 dBi
537-785	EAD, FBKR35068-RS-KR WiFi antenna	2.0 dBi

12.4 Requirements for OEM integration

When the EFMF is built into a product, the following requirements of the radio approvals apply to the manufacturer of that product.

Europe

- The manufacturer must ensure compliance of the final product with the European harmonised EMC and low-voltage/safety standards. A declaration of conformity must be issued for each of these standards and kept on file.
- The manufacturer must keep a copy of the user manual of the transmitter module and ensure that the final product does not exceed the specified power ratings, antenna specifications and/or installation requirements. If any of these are exceeded, the final product must be submitted to a notified body for compliance testing to all required standards.
- The CE marking must be affixed to a visible location on the OEM product, visibly, legibly and indelibly, at least 5 mm high (except where this is not possible on account of the nature of the apparatus); when reduced or enlarged, its proportions must be kept.

Canada

- The radio module is certified for integration into products only by OEM integrators under two conditions: the antenna(s) must be installed with a minimum separation distance of 5 cm to all persons at all times, and the module must not be co-located or operating in conjunction with any other antenna or transmitter. If these conditions are met, no further transmitter testing is required; the integrator remains responsible for testing the end product for any additional compliance requirements (for example digital device emissions, PC peripheral requirements).
- If these conditions cannot be met, the Industry Canada certification is no longer valid and the IC certification number must not be used on the final product; the integrator is then responsible for re-evaluating the end product (including the transmitter) and obtaining a separate Industry Canada authorisation.
- If the IC certification number of the module is not visible when it is installed, the outside of the end product must carry a label in a visible area: **Contains Model RA24 Radio (2.4 GHz), IC:7224A-RA24.**
- Only the approved antennas listed in section 12.2 may be used.
- The user's manual of the end product must not give the end user information on how to install or remove this RF module or change RF-related parameters.
- The user's manual of the end product must contain the IC notice on RF radiation exposure (5 cm separation, section 12.2) in a prominent location.

USA

- A clearly visible label on the outside of the final product enclosure must read **Contains FCC ID:VHARA24**, followed by the FCC statements of section 12.3.
- Fixed antennas must be installed so that end users cannot replace them with non-approved antennas. Antennas other than antennas A to E and those listed in section 12.3 must be tested to comply with FCC section 15.203 (unique antenna connectors) and section 15.247 (emissions).
- The transmitter modules are certified by the FCC for use with other products without further certification (FCC section 2.1091). Modules with external antennas may be used only with approved antennas.