TR-86G

RF Transceiver Module Series

Data Sheet

Preliminary

IQRF®
Smarter Wireless. Mesh.

Description

TR-86G is a family of IQRF transceiver modules operating in the 868 MHz and 916 MHz license-free ISM (Industry, Scientific, and Medical) frequency band. Its highly integrated ready-to-use design containing RF circuitry, MCU, serial EEPROM, and optional onboard antenna requires no external components. SMT mounting and very small dimensions allow space saving. Extra-low power consumption fits for battery-powered applications. Enhanced RF IC enables higher receiver sensitivity and RF output power. Flexible MCU pins enable extended functionality and simpler application circuitry and PCB. Extended MCU memories include a built-in operating system which significantly reduces application development time. The optional DPA framework supports mesh network applications.

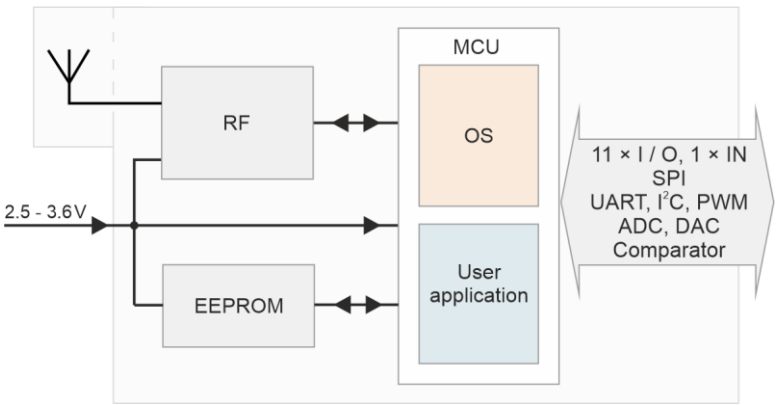
Key features

- Operating system (upgradeable at the user), easy to use
- DPA framework for mesh network applications
- GFSK modulation
- Selectable RF band 868 / 916 MHz, multiple channel
- RF output power 25 mW (14 dBm)
- Effective radiated power 6.3 mW (8 dBm) with on-board antenna
- Enhanced RF sensitivity
- MCU with significantly extended memories for program and data
- Extended MCU resources (interrupt capability and programmable internal pull-ups on all I/O pins, remappable digital peripherals, …)
- Extra low power consumption, power management modes
- SPI interface supported by OS in background
- Serial EEPROM 256 Kb
- Multiple PWM output
- Extended programmable HW timer options
- Power supply monitoring
- 18 pins, 13 I/O pins, 1 input only pin
- A/D converter (multiple channels), D/A converter, and analog comparator
- Options: on-board antenna or soldering antenna pad
- Stamp-hole pads, SMT mounting, compatible with SIM card connector without metallic holder (KON-SIM-02)
- Optional shielding can
- Small dimensions

Applications

- Bidirectional RF communication
- Point-to-point or network wireless connectivity
- Telemetry, AMR (automatic meter reading)
- WSN (wireless sensor network)
- Building automation
- Street lighting control
- Wireless monitoring, control and regulation
- Remote data acquisition
- RF connectivity in many other fields
- Also for municipal and indoor areas
- Internet of Things

Block diagram



Technical specifications — ***Typical values*** *unless otherwise stated*

Supply voltage (V_{CC}) [1]	3.0 V typ., 2.5 V min., 3.6 V max., stabilized, 50 mA min.
Operating temperature [2]	-40 °C to +85 °C
Supply current	
Deep sleep mode	< 300 nA (all peripherals disabled [4], RF IC in Standby mode)
Sleep mode	< 1 µA (all peripherals disabled [4], RF IC in Sleep mode)
Run mode	
RF sleep	1.8 mA
RF ready	3.3 mA
RX mode	
STD	12.5 mA
LP [5]	190 µA
XLP [5]	13 µA
TX mode	8 mA – 25 mA (according to RF output power)
RF band	868 MHz or 916 MHz (software configurable)
RF channels	See IQRF OS User's guide, Appendix *Channel maps*
RF data modulation	GFSK (Gaussian Frequency Shift Keying)
RF data transmission bit rate	19.8 kb/s
RF receiver category	1.5 (according to ETSI EN 300 220-1 V3.1.1)
RF sensitivity [7]	-103 dBm [6A], -94 dBm [6B], (STD RX mode, `checkRF(0)`). See *Diagram 3*.
RF output power [6A]	Up to 10 dBm (for 50 Ω load), programmable in 8 levels (0 – 7).
Effective radiated power [6B, 7]	Up to 2.0 dBm (868 MHz band), 0.0 to 2.0 dBm (916 MHz band). See *Table 1.*
RF interface [6A]	Single-ended, output impedance 50 Ω
Antenna [6B]	PCB meander line, linear polarization, omnidirectional. See *Diagram 1*.
RF range [3, 6B]	500 m
Input voltage on Q4 to Q15 pins	0 V to VCC
A/D converter	10-bit, multiple inputs. Refer to the MCU datasheet.
Size (L x W x H)	15.2 mm x 14.9 mm x 3.3 mm (TR-86G) 23.3 mm x 14.9 mm x 3.3 mm (TR-86GA)
Storage environment	Temperature +16 °C to +24 °C, relative humidity 85 % max., chemically indifferent

Note 1: RF power and other parameters depend on the supply voltage. Refer to datasheets of MCU and RF IC used. Test your application with respect to the required supply voltage range.
Note 2: RF range may change with lower temperature. Frost, condensation, or humidity over 85% may disable module functionality. Module suitability should be tested in the final application under real conditions before volume use.
Note 3: Since the radiated power and the RF sensitivity of the TR-86G(A) and TR-82G(A) are the same, under the same installation conditions the TR-86G(A) has the same RF range as the TR-82G(A).
Note 4: Additional current is consumed when a peripheral (e.g. watchdog, Brown-out detection, etc.) is enabled.
Note 5: Depends on interferences.
Note 6: **6A:** For TR types without a built-in antenna.
6B: For TR types with built-in antenna.
Note 7: The radiated power and sensitivity depend on the size and mechanical arrangement of the host PCB. These parameters are valid for a host PCB with a square or circular shape and a solid ground area of at least 16 cm^2.

The TR-86GxF (with metal shielding of RF circuitry) must be used in countries where FCC regulations apply.

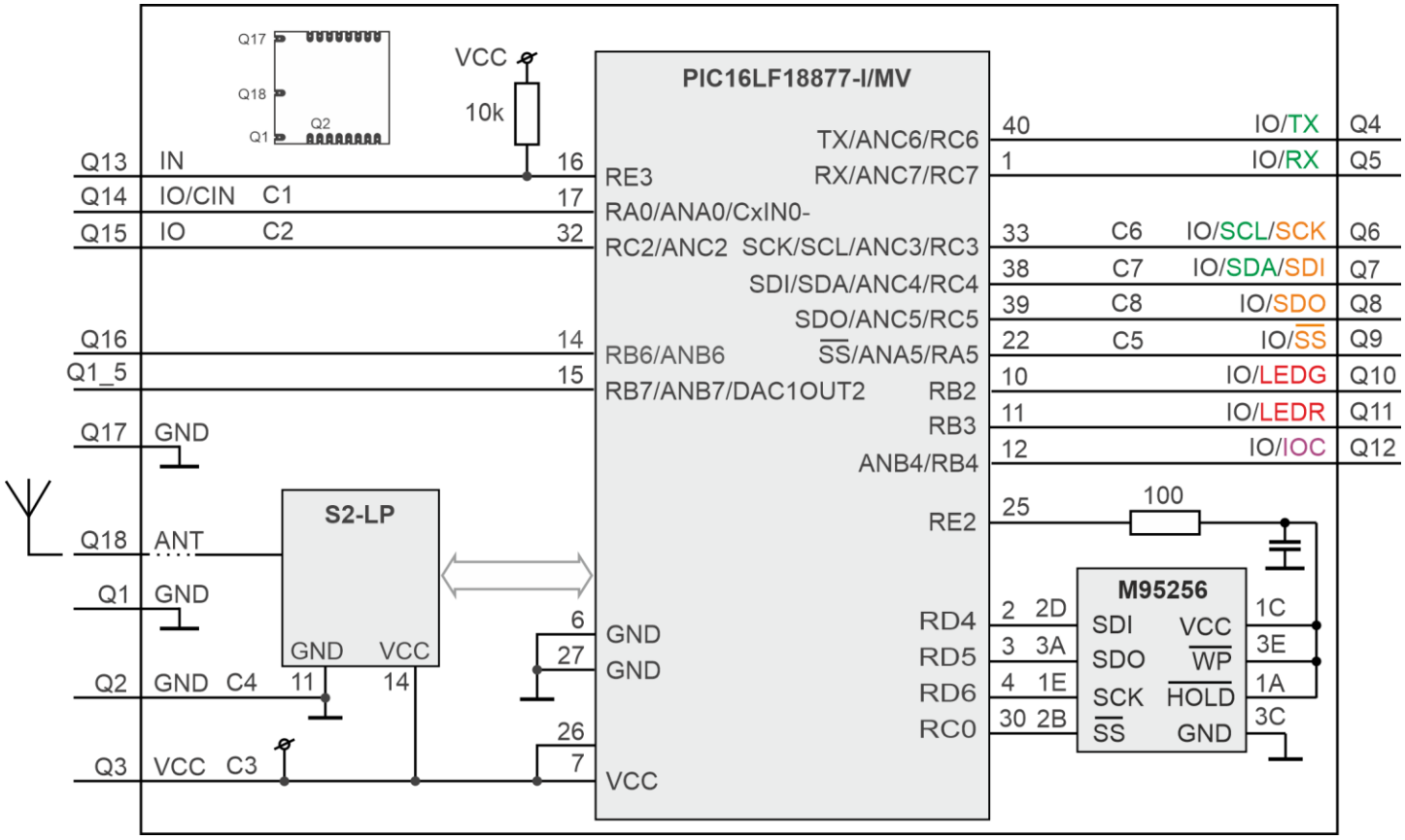
Absolute maximum ratings

Stresses above the listed maximum values may cause permanent damage to the device and affect device reliability. Functional operation under these or any other conditions beyond those specified is not supported.

Supply voltage (V_{CC})	3.9 V
Voltage on Q4 to Q15 pins (configured as inputs) vs. GND	-0.3 V to (V_{CC} + 0.3 V)
Storage temperature	-40 °C to +85 °C
Ambient temperature under bias	-40 °C to +85 °C

Caution: *Electrostatic sensitive device. Observe appropriate precautions for handling.*

Simplified circuit diagram



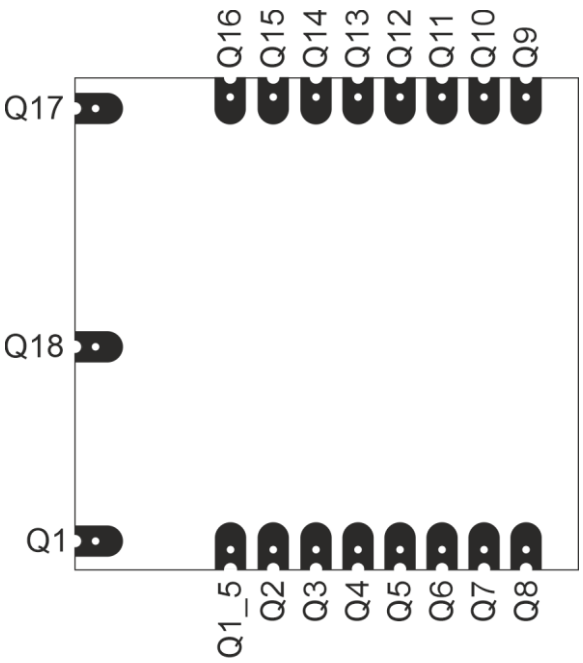
The colors indicate the constraints on the MCU digital peripheral pin remapping using PPS with respect to IQRF OS and DPA. See *Note 2* below and the Application note *AN015 - IQRF HW design*, chapter *PPS*.

Basic components

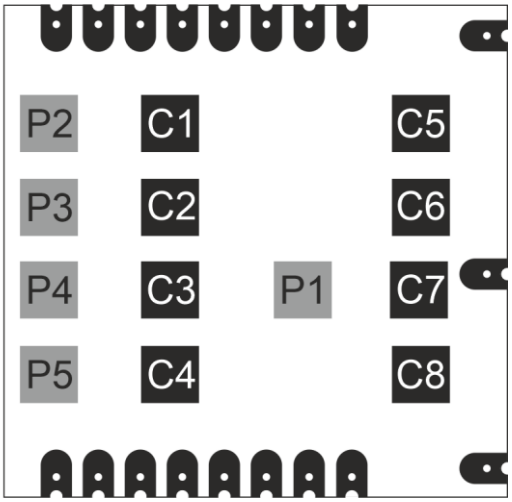
Part	Type	Manufacturer	Note
MCU	PIC16LF18877-I/MV	Microchip	
RF IC	S2-LP	STMicroelectronics	
RF balun	BALF-SPI2-01D3	STMicroelectronics	
EEPROM	M95256-DFCS6	STMicroelectronics	256 Kb
Shielding can		IQRF Tech	Optional. Required for FCC certification.

Pin	Name	Description
Q1 [1]	**GND**	Ground
Q1_5	**IO / DACOUT**	
	RB7	General I/O pin
	DAC1OUT2	D/A converter output
	ANB7	Analog A/D input
Q2, C4	**GND**	Ground
Q3, C3	**Vcc**	Power supply voltage
Q4	**IO / TX**	
	RC6	General I/O pin
	TX [4]	UART TX
	ANC6	Analog A/D input
Q5	**IO / RX**	
	RC7	General I/O pin
	RX [4]	UART RX
	ANC7	Analog A/D input
Q6, C6	**IO / SCK / SCL**	
	RC3	General I/O pin
	SCK [4]	SPI clock input
	SCL [4]	I²C clock
	ANC3	Analog A/D input
Q7 [2], C7	**IO / SDI / SDA**	
	RC4	General I/O pin
	SDI [4]	SPI data input
	SDA [4]	I²C data
	ANC4	Analog A/D input
Q8 [2], C8	**IO / SDO**	
	RC5	General I/O pin
	SDO [4]	SPI data output
	ANC5	Analog A/D input
Q9, C5	**IO / -SS**	
	RA5	General I/O pin
	-SS [4]	SPI Slave select
	ANA5	Analog A/D input
Q10 [3]	**IO / LEDG**	
	RB2	General I/O pin
	LED1	LEDG supported by IQRF OS and DPA
Q11 [3]	**IO / LEDR**	
	RB3	General I/O pin
	LED2	LEDR supported by IQRF OS and DPA
Q12	**IO / ADC**	
	RB4	General I/O pin Interrupt / Wake-up on change (IOC) supported by IQRF OS and DPA. RFPGM / (X)LP mode termination. Dedicated to the DPA menu (for DPA v4.30 or higher).
	ANB4	Analog A/D input
Q13	**IN**	
	RE3	General input only pin
Q14, C1	**IO / C-IN**	
	RA0	General I/O pin
	CxIN0-	Comparator –input
	ANA0	Analog A/D input
Q15, C2	**IO**	
	RC2	General I/O pin
	ANC2	Analog A/D input
Q16	**IO**	
	RB6	General I/O pin
	ANB6	Analog A/D input
Q17 [1]	**GND**	Ground
Q18 [1]	**ANT**	Antenna
P1–P5	For manufacturer only	

Top view



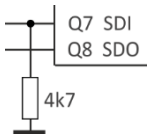
Bottom view



All MCU pins connected to TR I/O pins (Q2 to Q15) are equipped with the interrupt on change capability (except Q13), programmable pull-up resistor, and (except Q13) can be used as analog inputs for A/D converter.

Note 1: Not implemented for TR variants with on-board antenna.

Note 2: Pin Q8 is used as output and pin Q7 as input during the initial approximately 200 ms boot-up (after TR reset) to detect a possible request to enter the programming mode (PGM - wired upload via SPI). After reset, the OS generates a determinate sequence on the Q8 pin. If this sequence is copied to the Q7, the OS jumps to the PGM bootloader. (The PGM mode is indicated by the short red LED flashing every 2 s.)
This must be taken into account to avoid collisions with application circuitry connected to these pins.
The Q7 pin must not be interconnected to Q8 or left unconnected or without a **defined level** on its input. This level must be arranged **by application hardware**. If the application circuitry ensures no such level, a **pull-down resistor on the Q7 pin** must be used otherwise a **cross-talk** between Q8 and Q7 may cause an unintentional switching to PGM.

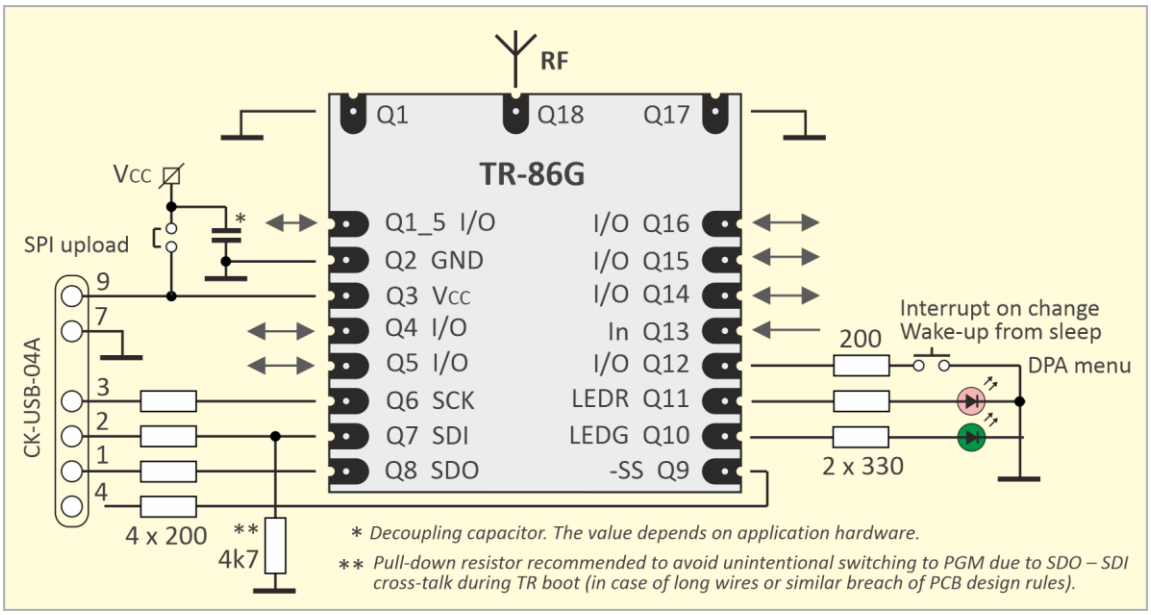


Note 3: This pin is affected by IQRF OS (and possibly DPA) LED functions and system LED indication.

Note 4: All MCU pins dedicated to internal digital peripherals (e.g. UART, I²C, SPI, PWM, timers, analog comparator output, etc.) are remappable in SW. See the MCU datasheet, chapter *Peripheral Pin Select (PPS)*, and the application note *AN015 - IQRF HW design*, chapter *PPS*. The list above denotes only the pins assigned to UART, I²C, and SPI by default. Other remappable peripherals (e.g. PWM or analog comparator output) are not denoted there.

There are no on-board protection series resistors on I/O pins. It is recommended to use 200 Ω series resistors on each pin.
See the application note *AN015 - IQRF HW design*.

Recommended circuit for development



For development, it is recommended to implement the following arrangement:

- A decoupling capacitor on V_{CC} to filter the supply voltage. The type and the value should be selected with respect to general rules observed in electronic design, according to the given application hardware and power source.
- Serial protective resistors on each I/O pin used.
- Both system LEDs (LEDR and LEDG) for IQRF OS and DPA status indication and possible user indication. When the Q10 and Q11 pins are used as user I/Os, it must be taken into account that these pins can be affected by IQRF OS or DPA.
- Pin Q12 configured as an input with the internal pull-up resistor and equipped with a pushbutton connected to the ground. Then pressing the button can generate an interrupt on pin change, wake up the transceiver from sleep, terminate RFPGM mode, initiate bonding, DPA menu control, etc.
- Pull-down resistor on pin Q7 recommended to avoid unintentional switching to PGM mode due to SDO - SDI cross-talk during TR boot.
- SPI interface for wired upload of application code into the transceiver using an IQRF programmer, e.g. CK-USB-04A.

Depending on the actual user application and power supply range, it may be required to isolate interface pins and/or power supply from user circuitry during uploading. For details refer to the CK-USB-04A User's guide, chapter *Application/In-circuit upload*.

RF range

Refer to the Application note *AN014 – RF range.* RF range strongly depends on the following design aspects:

- Hardware:
  - Construction of the devices (especially TR location within the device, PCB layout, ground planes, conductive areas, and bulk objects such as metallic parts and batteries in the nearest surroundings, with respect to possible reflections and counterpoise effect). To achieve an efficient range and reliable connectivity, no parts impacting the range must be placed close to the built-in meander antenna. Even non-conductive parts including a mainboard PCB under the antenna can significantly impact the range.
  - Physical arrangement of devices (especially mutual orientations of antennas with respect to polarization and radiation patterns)
- Application software:
  - RF output power is selectable from 8 levels
  - To increase immunity to RF noise, incoming RF signals can be filtered according to signal strength. See the *IQRF OS Reference guide*, function `checkRF`, and configuration parameter *RX filter.*

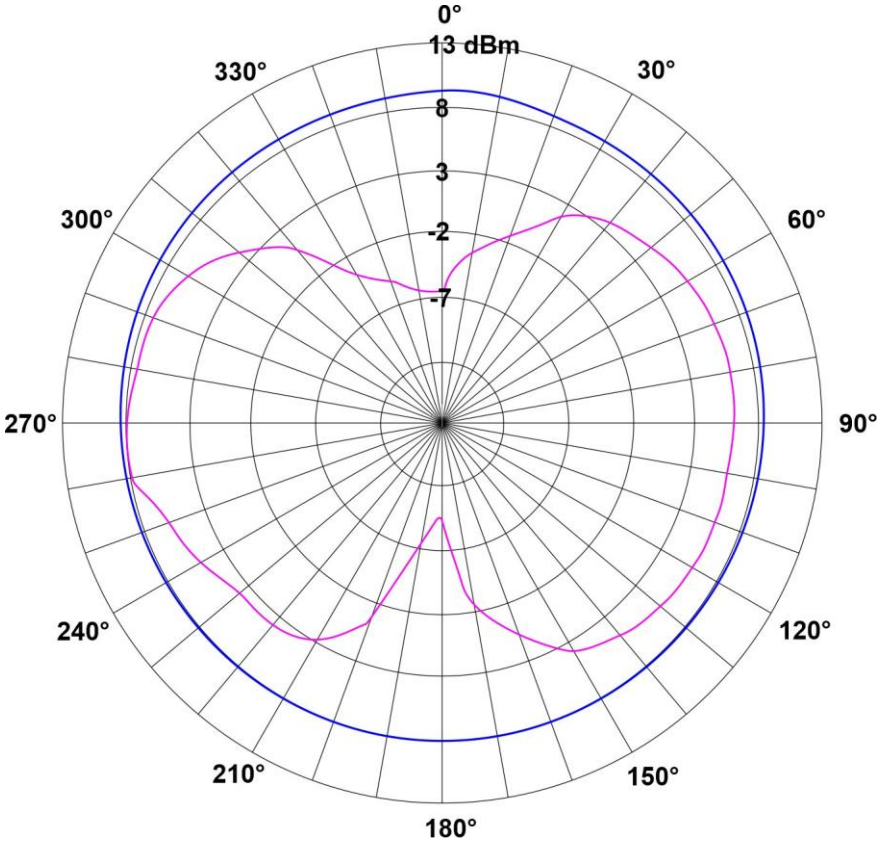
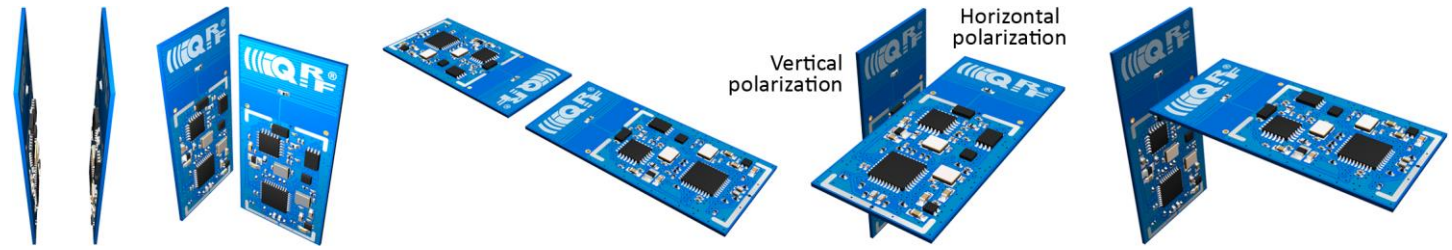


Diagram 1: *TR-8xGA RF output power [in dBm] vs. antenna orientation (radiation patterns).*

Vertical antenna

Horizontal antenna

Examples of the correct and incorrect arrangement of TR-8xGA pairs:



Correct

Correct

Incorrect
Wrong radiation angle

Incorrect
Mismatched polarization

Incorrect
Wrong radiation angle
Mismatched polarization

The **Effective radiated power** (ERP) in the 868 MHz band is constant for all channels. The ERP in the 916 MHz band decreases to higher channels. The ERP drop on channel 255 relative to the power on channel 0 is 2 dBm.

level	ERP [dBm]			
	868 MHz	916 MHz		
	Channels 0 to 67	Channel 0	Channel 104	Channel 255
7	8	8	7	6
6	5	5	4	3
5	0	0	-1	-2
4	-4	-4	-5	-6
3	-10	-10	-11	-12
2	-16	-16	-17	-18
1	-28	-28	-29	-30
0	-36	-36	-37	-38

Table 1: *TR-86GA effective radiated power (ERP) vs.* `level` *in the* `setRFpower(level)` *function.*

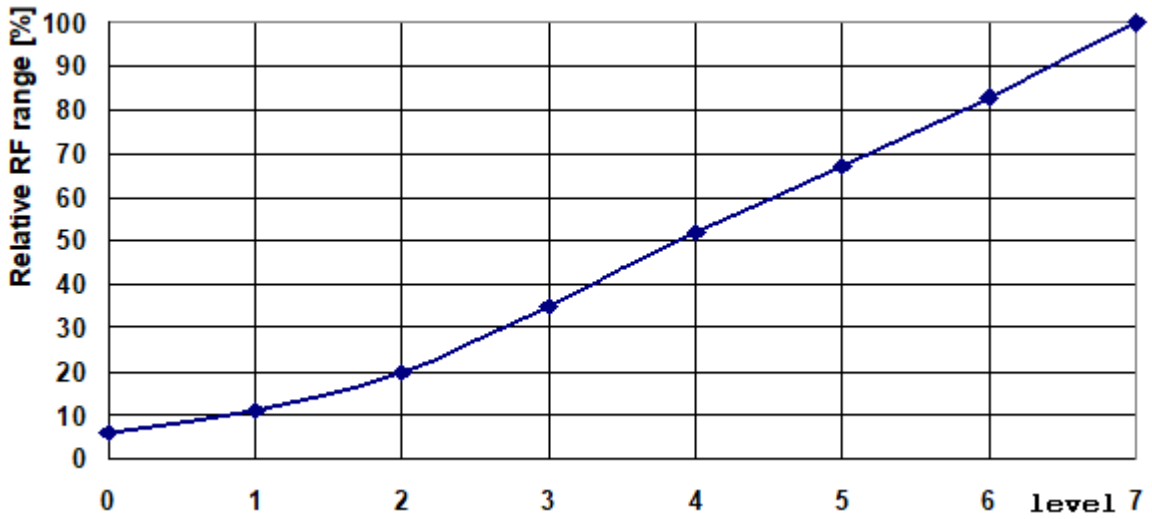


Diagram 2: *TR-86G(A) relative RF range vs.* `level` *in the* `setRFpower(level)` *function.*

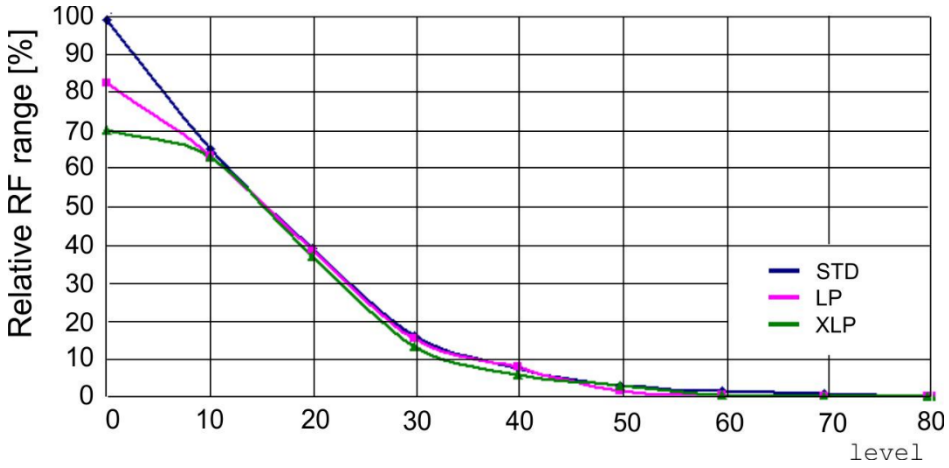


Diagram 3: *Relative RF range vs.* `level` *in the* `checkRF(level)` *function in STD, LP, and XLP RX modes.*

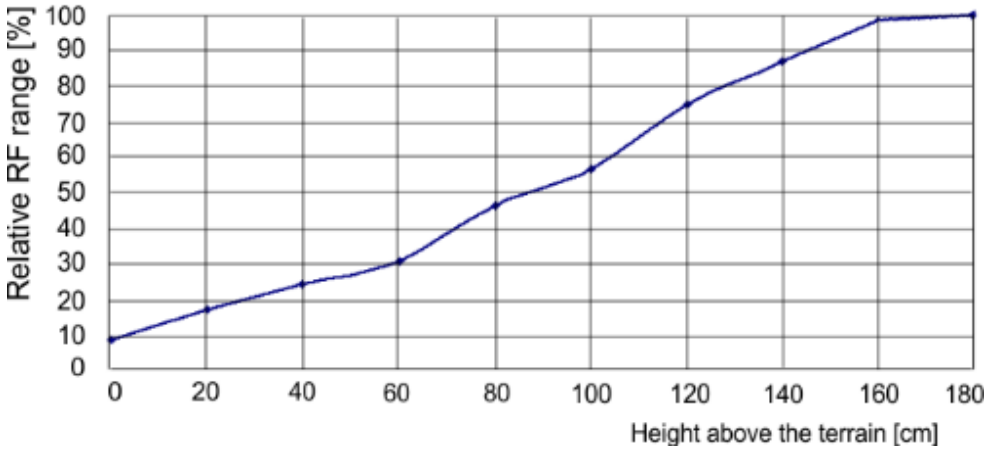
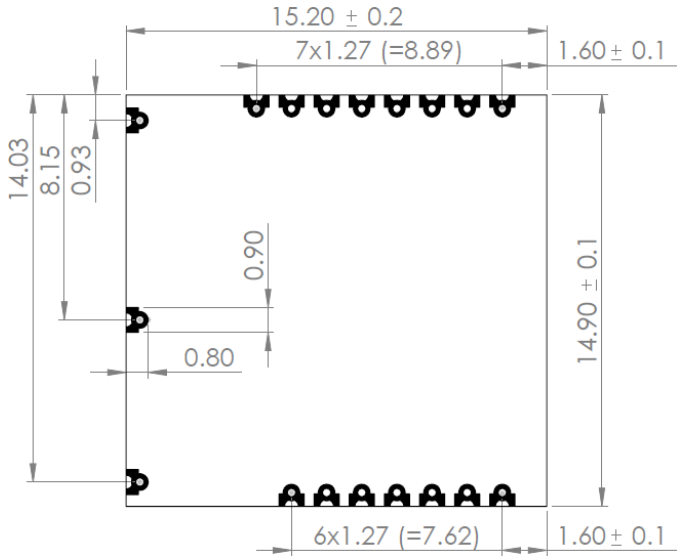


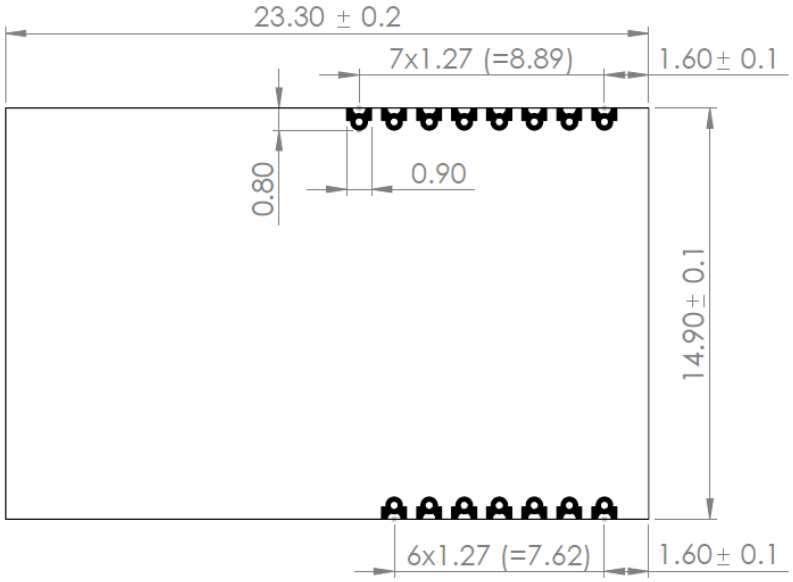
Diagram 4: *TR-86GA relative RF range vs. antenna height above the ground, 868 MHz and 916 MHz bands.*

Mechanical drawings

TR-86G(C)x



TR-86GAx



Top view. Units: mm.

Hardware revision

TR-86G v1.00	First release with PCB for TR-86G non-A variants.
TR-86GA v1.00	First release with PCB for TR-86GA variants.

Application

*Users have to ensure observing local provisions and restrictions relating to the use of short-range devices **by software**, e.g. the CEPT ERC/REC 70-03 Recommendation and subsequent amendments in EU.*

See the Application notes *AN015 - IQRF HW design* and *AN014 – RF range, and* IQRF video tutorial set.

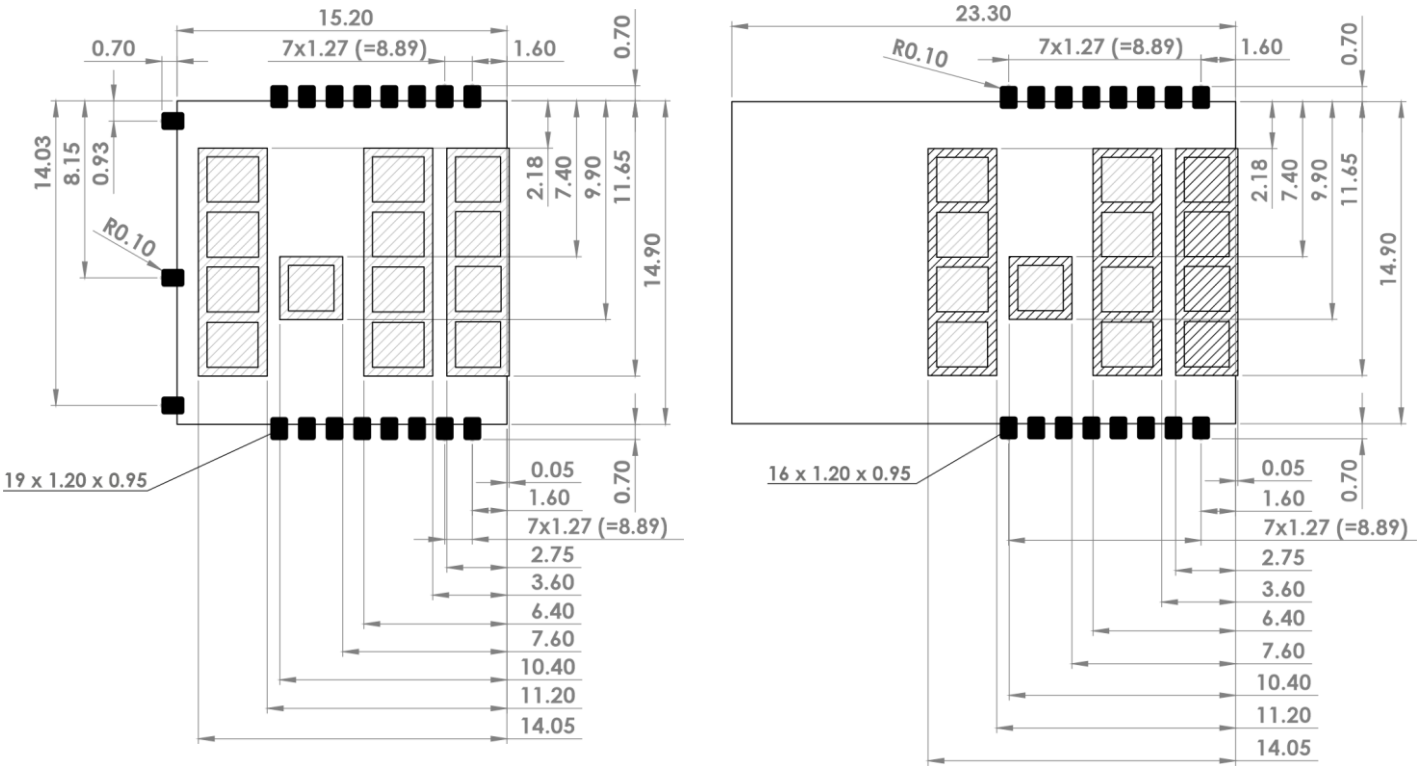
Assembly

For proper mounting of surface mount TR modules and avoiding damage during solder reflow assembly, refer to the reflow profile and other details in the Application note *AN015 - IQRF HW design*, chapter *SMT mounting*.

It is not allowed to connect wires to pads C1 to C8 and P1 to P5 by soldering.

***Caution:** TR-86Gx must not be plugged into a SIM connector with the metallic holder.*

Recommended PCB layout



TR-86G TR-86GA

Pads

Restricted areas for wires on the top side

Top view. Units: mm.

These patterns are for reference purposes only. Consult your producer to ensure that its manufacturing guidelines are met.

Sealing
In case of sealing or protecting TR modules against a harsh environment by coating, encapsulating, or potting using a lacquer, gel, or other filling matter, refer to the *Application note AN015 - IQRF HW design*, chapter *Sealing*.

Operating system

See IQRF OS User's guide and IQRF OS Reference guide.

DPA framework

See the DPA Framework technical guide.

Application software

See IQRF Quick start guide and IQRF application examples.

Programming (upload)

There are the following possibilities to upload an application program in TR-86Gx modules:

- Wired upload with TR-86Gx plugged via the SIM connector in the CK-USB-04A programmer.
- For TR-86Gx modules populated in an application:
  - Wired upload
    - Using the CK-USB-04A programmer. See the CK-USB-04A User's guide.
    - Using the CK-USB-04 programmer and the KON-TR-01P adapter. See the KON-TR-01P User's guide.
    - Completely arranged by the user application. See the *IQRF SPI Technical guide*, chapter *Programming mode*.
  - Wireless upload: See the IQRF OS User's guide, Appendix *RFPGM – RF programming™*.

Product information

Ordering codes

TR-86G A F

Transceiver series — Shielding can (necessary for FCC certification)

Antenna options

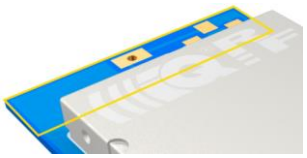
nil **-** soldering pad-hole (no antenna, no U.FL connector)

A **-** PCB antenna

Type	Antenna option	Shielding can	FCC compliant
TR-86G	Soldering stamp-hole	–	–
TR-86GA	PCB antenna	–	–
TR-86GF	Soldering stamp-hole	Yes	Yes
TR-86GAF	PCB antenna	Yes	Yes

TR-86G

TR-86GA



TR-86GF

TR-86GAF

Document history

240425 Preliminary.

Sales and Service

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E-mail (commercial matters): sales@iqrf.org

Technology and development

www.iqrf.org
E-mail (technical matters): support@iqrf.org

Partners and distribution

www.iqrf.org/partners

Quality management

ISO 9001 : 2016 certified

The product complies with the essential requirements and other relevant provisions of directives 2004/108/EC (EMC), 2014/53/EU (RED), 2018/738/EU (ROHS), when used under the conditions of use specified by the manufacturer.

Harmonized standards or other relevant technical specifications used on the basis of which conformity is declared:

Radio spectrum:	*ČSN ETSI EN 301 489-3 V2.1.1*
	FCC directives Part 15 Low Power Communication Device Transmitter. FCC ID: R24-TR8xGx.
EMC:	*ČSN ETSI EN 301 489-1 V2.2.3*
	ČSN EN 55032 ed. 2
	ČSN EN 55035
Safety:	*ČSN EN IEC 62368-1 ed. 2+A11*
RoHS:	*ČSN EN IEC 63000*

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