TR-76G

RF Transceiver Module Series

Data Sheet

IQRF®

Smarter Wireless. Mesh.

Description

TR-76G 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 MCU, RF circuitry, serial EEPROM and optional on-board antenna requires no external components. SMT mounting and very small dimensions allow space saving. Ultra low power consumption fits for battery powered applications. Flexible MCU pins enable extended functionality and simpler application circuitry and PCB. Extended MCU memories include built-in operating system which significantly reduces application development time. Optional DPA framework supports applications even without programming.
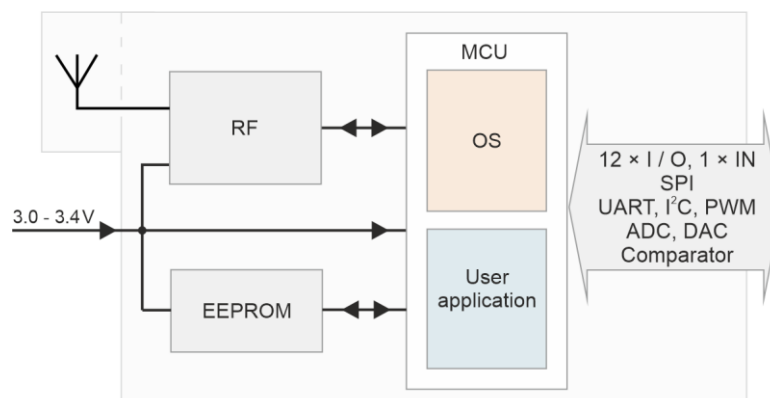
Key features

- Operating system (upgradeable at the user), easy to use
- DPA framework for for mesh network applications
- GFSK modulation
- Selectable RF band 868 / 916 MHz, multiple channel
- RF output power 10 mW (10 dBm) with antenna connector
- Effective radiated power 1.6 mW (2 dBm) with on-board antenna
- 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
- Battery monitoring
- 18 pins, 12 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)
- Shielding can

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*

Parameters specified in this datasheet are typical values. They are at power supply V_{CC} = 3 V only. V_{CC} voltage different from 3 V can impact on RF range and other parameters.

Supply voltage (V_{CC}) [1]	3.0 V min., 3.4 V max., stabilized
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	-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]	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 MCU datasheet.
Size (L x W x H) [11]	15.2 mm x 14.9 mm x 3.3 mm (TR-76G)
	23.3 mm x 14.9 mm x 3.3 mm (TR-76GA)
Storage environment	Temperature +16 °C to +24 °C, relative humidity 65 % 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-76G(A) and TR-72G(A) are the same, under the same installation conditions the TR-76G(A) has the same RF range as the TR-72G(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.

Absolute maximum ratings

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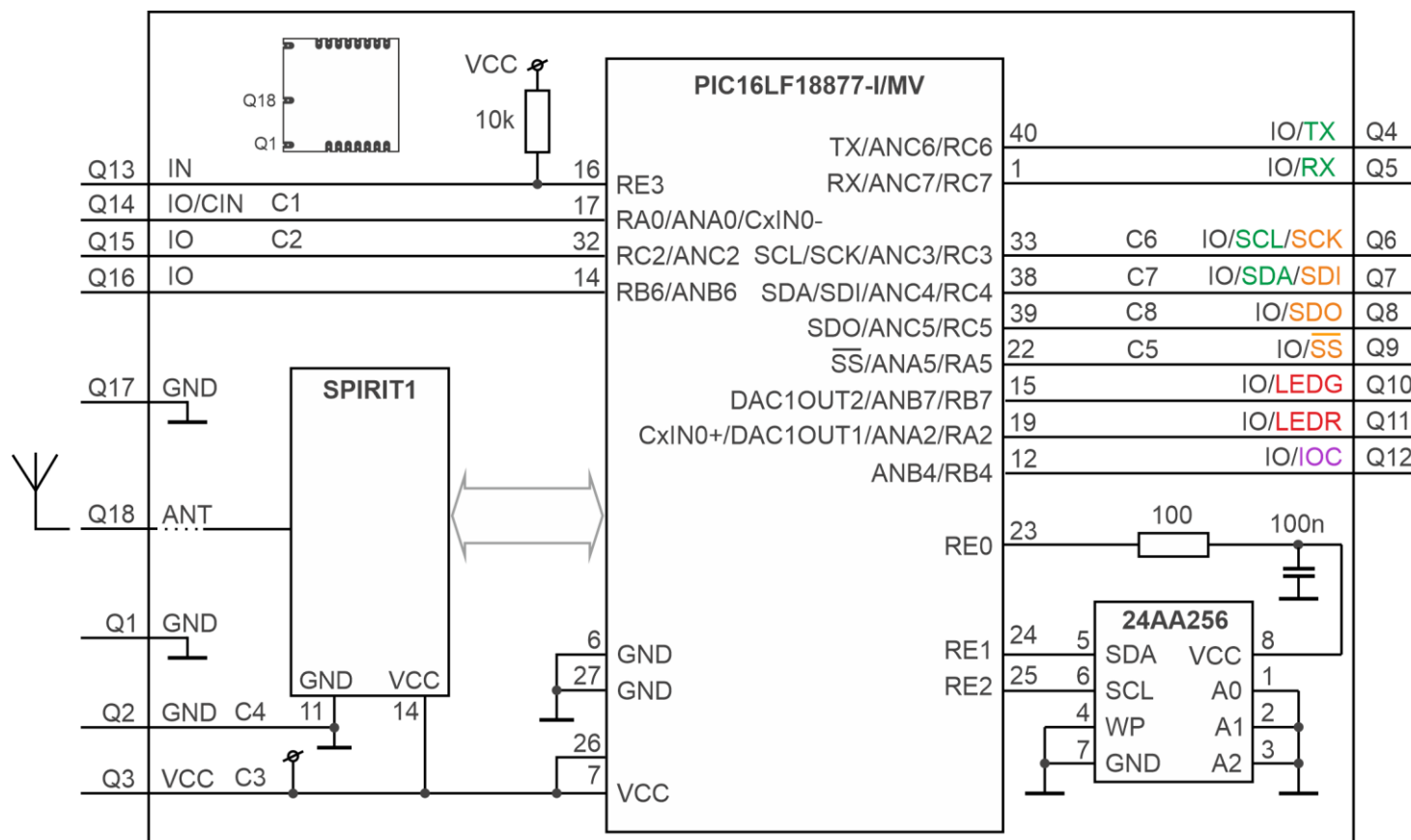
The colors indicate the constraints on the MCU digital peripheral pin remapping using PPS with respect to IQRF OS and DPA. See *Note 2* below and the Application note *AN015 - IQRF HW design*, chapter *PPS*.

Basic components

IC	Type	Manufacturer	Note
MCU	PIC16LF18877–I/MV	Microchip	
RF IC	SPIRIT1	STMicroelectronics	
RF balun	BALF-SPI-01D3	STMicroelectronics	
EEPROM	24AA256-I/CS16K	Microchip	256 Kb

For more information refer to the datasheets of ICs used.

| Pin	Name	Description
Q1 [1]	**GND**	Ground
Q2, C4	**GND**	Ground
Q3, C3	**V_CC**	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
	ANA5	Analog A/D input
	-SS [4]	SPI Slave select
Q10 [3]	**IO / LEDG / DACOUT**	
	RB7	General I/O pin
	DAC1OUT2	D/A converter output
	LED1	LEDG supported by IQRF OS and DPA
Q11 [3]	**IO / LEDR / DACOUT / CIN**	
	RA2	General I/O pin
	DAC1OUT1	D/A converter output
	CxIN0+	Comparator +input
	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 for 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
	ANA0	Analog A/D input
	CxIN0-	Comparator –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
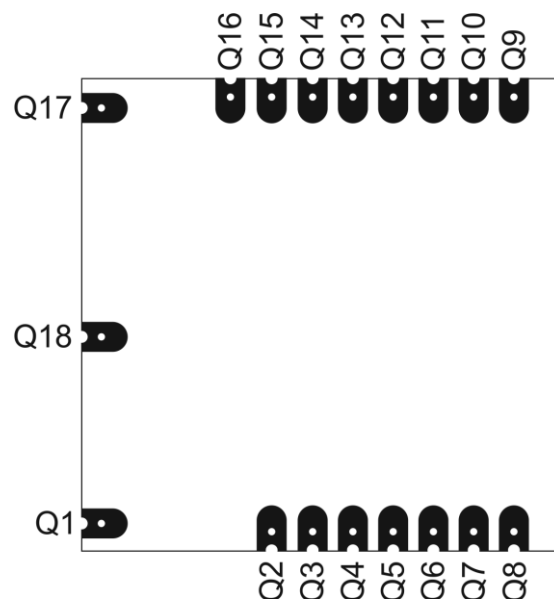
Bottom view
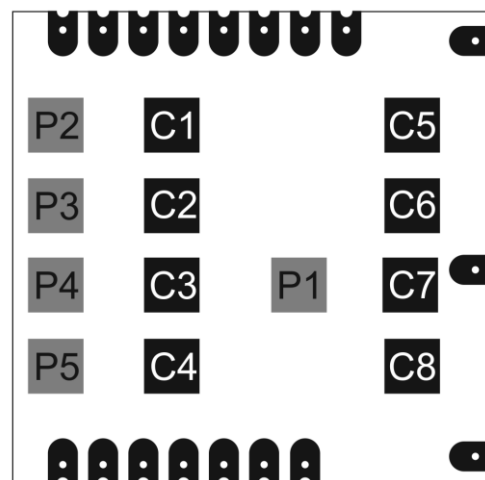
All MCU pins connected to TR I/O pins (Q2 to Q15) are equipped with the interrupt on change capability (except Q13), programmable pull-up resistor, and (except Q13) can be used as analog inputs for A/D converter.

Note 1: Not implemented for TR-76GA.

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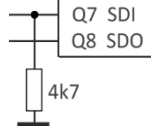
Note 3: This pin is affected by IQRF OS (and possibly DPA) LED functions and system LED indication.

Note 4: All MCU pins dedicated to digital signals of internal 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
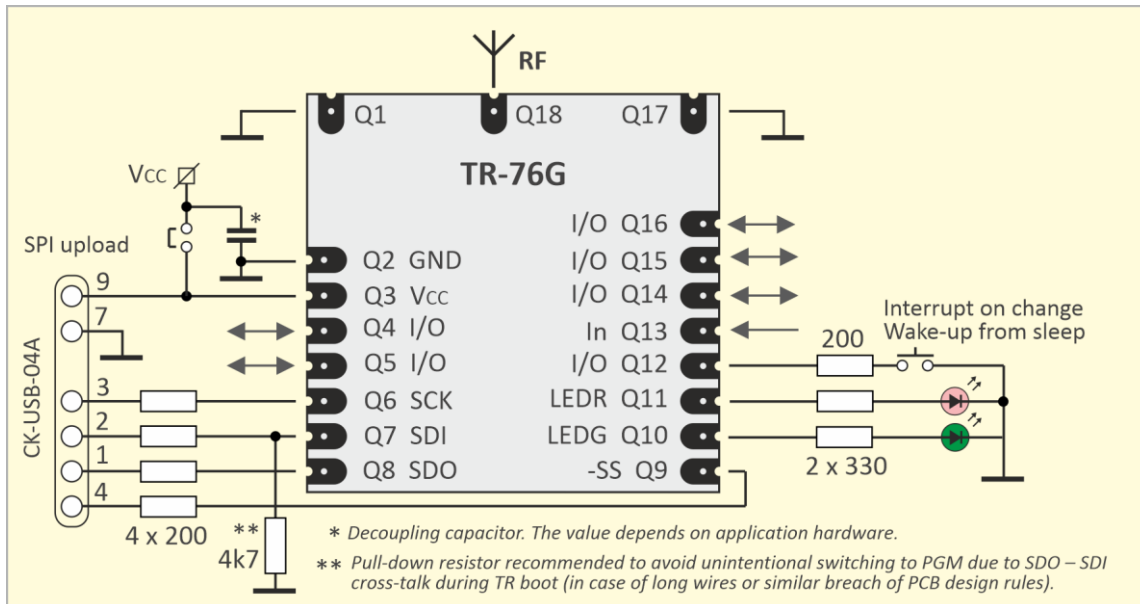
For development, it is recommended to implement the following arrangement:

- 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.
- Unused I/Os must not be left as MCU digital inputs without a proper log. level. See the Application note AN015 – IQRF HW design, chapter *Unused pins*.
- 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, 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*.

Refer to the Application notes AN015 – IQRF HW design and AN014 – RF range.

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` *a*nd configuration parameter *RX filter.*
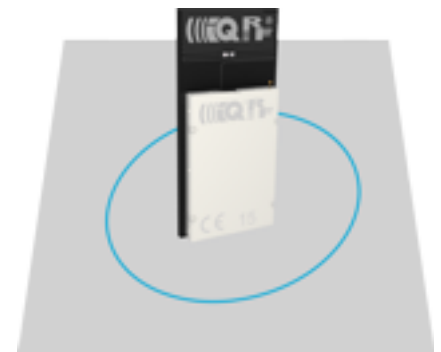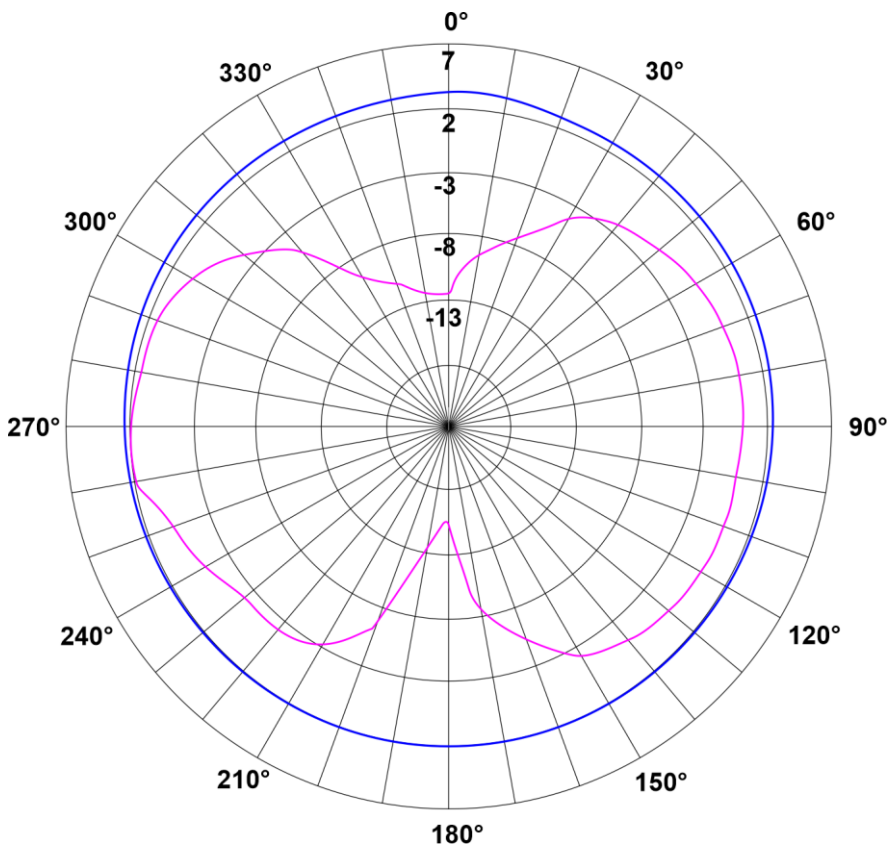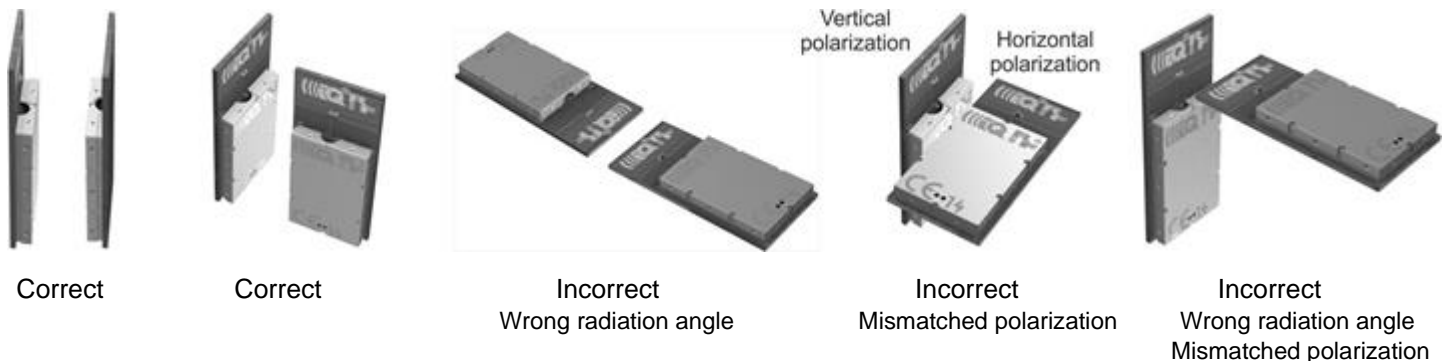

Vertical antenna

Horizontal antenna

Diagram 1: TR-76GA RF output power [in dBm] vs. antenna orientation (radiation patterns).

Examples of the correct and incorrect arrangement of TR-7xGA pairs:

Correct   Correct   Incorrect   Incorrect   Incorrect
                                 Wrong radiation angle   Mismatched polarization   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	2	2	1	0
6	-1	-1	-2	-3
5	-6	-6	-7	-8
4	-10	-10	-11	-12
3	-16	-16	-17	-18
2	-22	-22	-23	-24
1	-34	-34	-35	-36
0	-42	-42	-43	-44

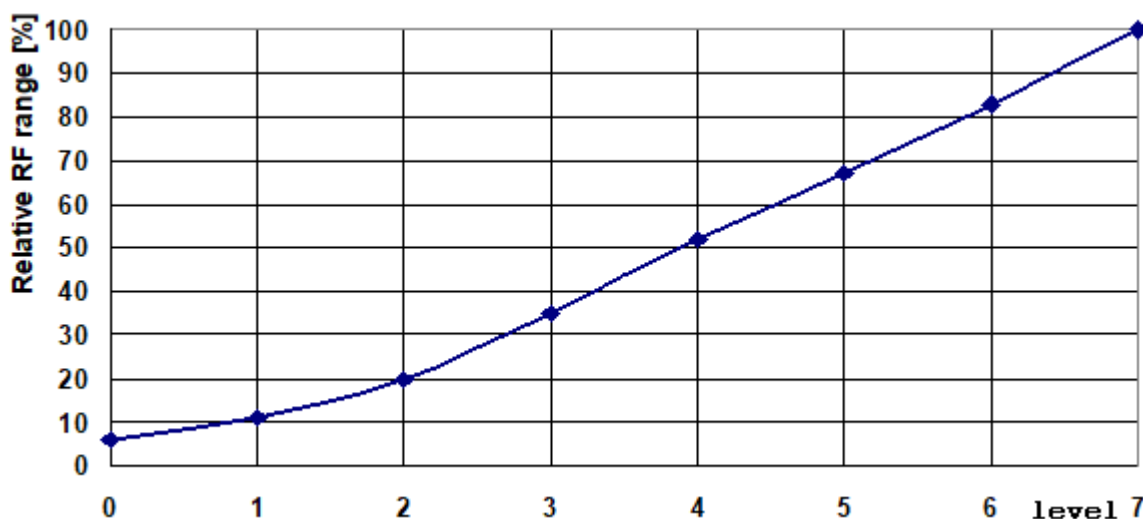*Table 1: TR-76GA effective radiated power (ERP) vs. level in the setRFpower(level) function.*

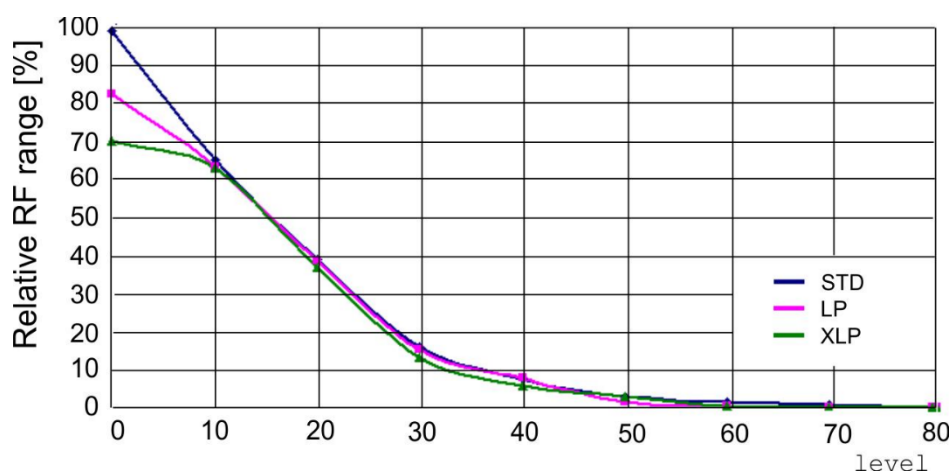*Diagram 2: TR-76G(A) relative RF range vs. level in the setRFpower(level) function.*

Diagram 3: Relative RF range vs. level in the checkRF(level) function in STD, LP, and XLP RX modes.
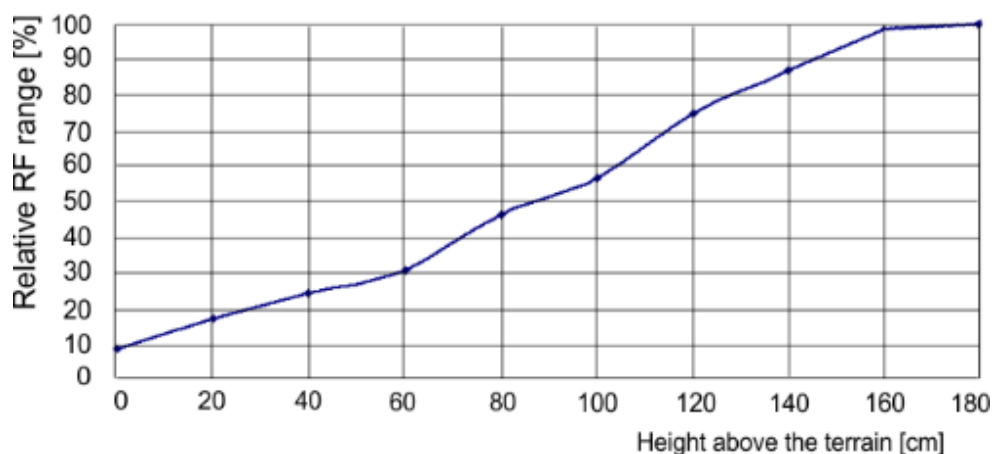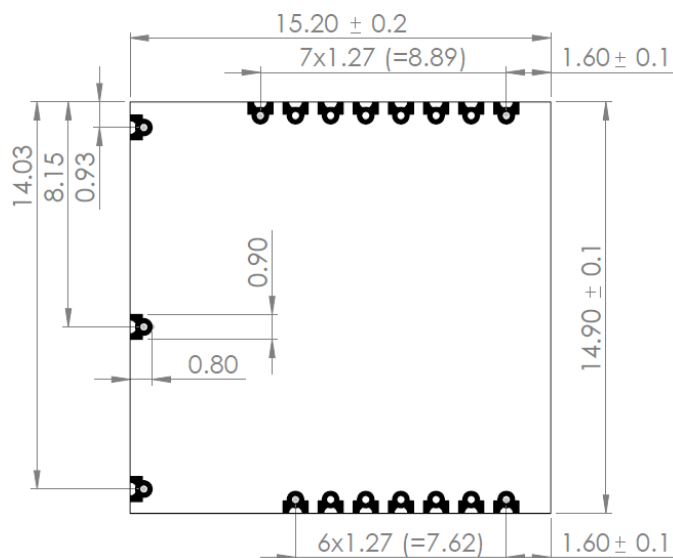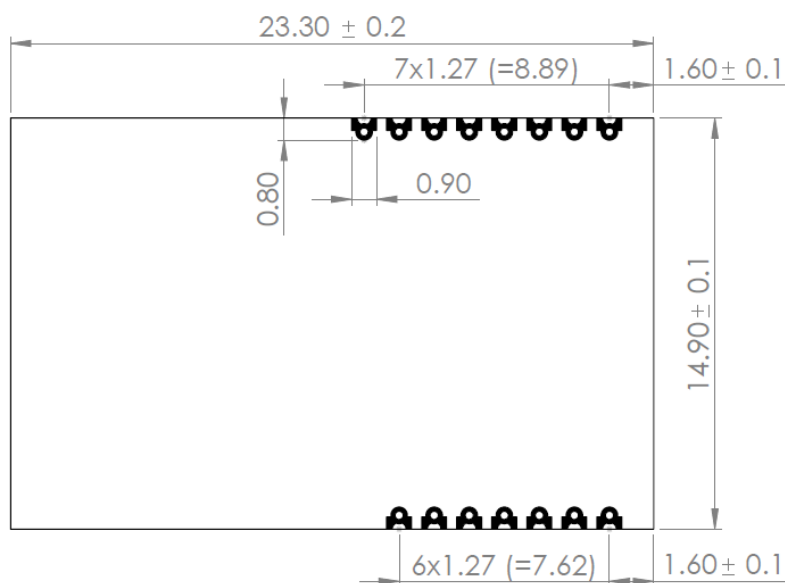
Diagram 4: TR-76GA relative RF range vs. antenna height above the ground, 868 MHz and 916 MHz bands.

Mechanical drawings

TR-76G

TR-76GA

Top view. Units: mm.

Hardware revision

TR-76G(A) v2.00　　　　First release.

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-76Gx must not be plugged into a SIM connector with the metallic holder.

Recommended PCB layout

TR-76G   TR-76GA

■   Pads

▨   Restricted areas for wires on the top side

Top view. Units: mm.
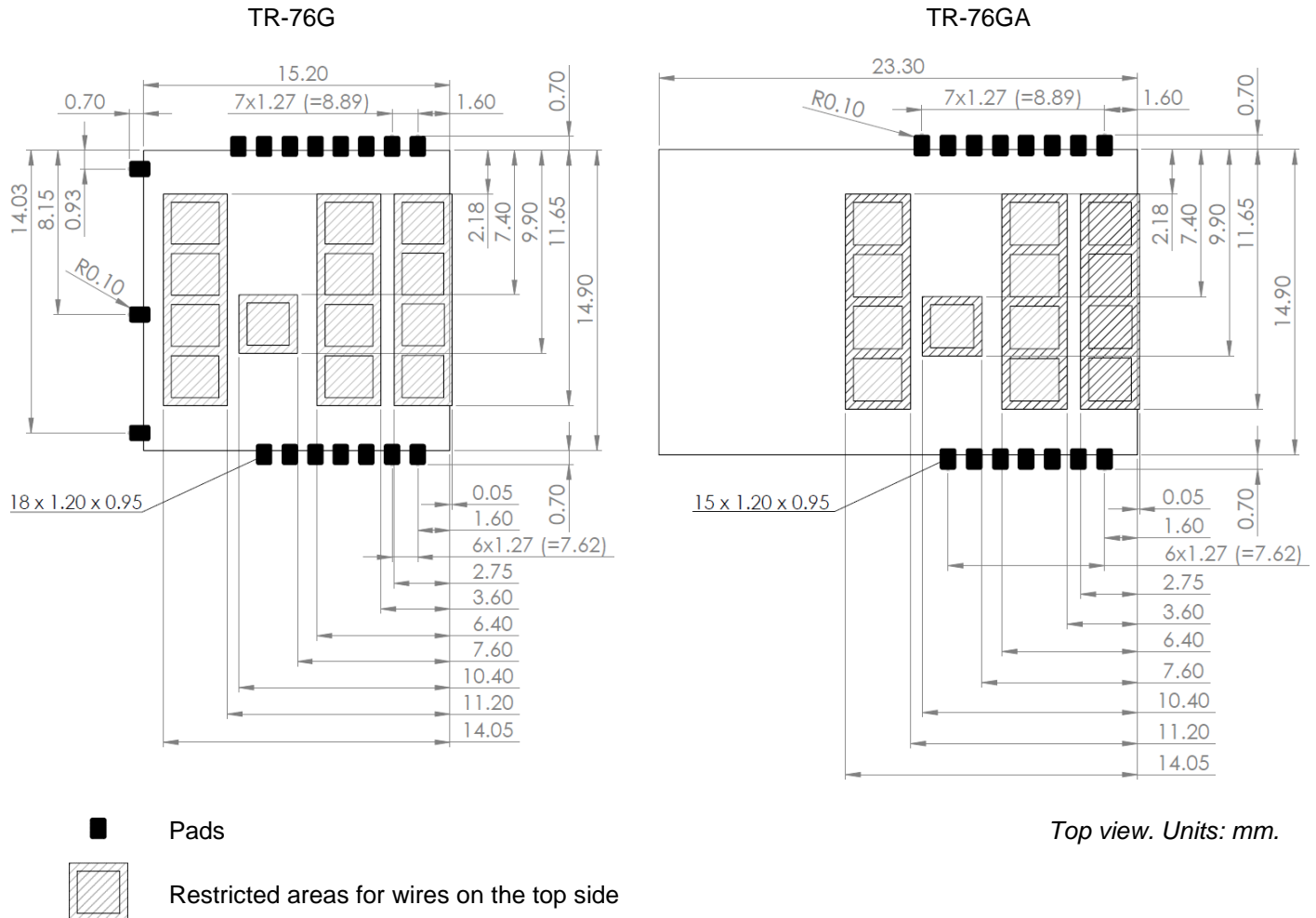
These patterns are for reference purposes only. Consult your producer to ensure that its manufacturing guidelines are met.

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 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-76Gx modules:

- Wired upload with TR-76Gx plugged via the SIM connector in the CK-USB-04A programmer.
- For TR-76Gx 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 ᵀᴹ*.

Product information

Ordering codes

T R-76G A
                                                        Antenna options
                                                                nil - soldering stamp-hole (no antenna, no U.FL connector)
                                                                A - PCB antenna
                                        Transceiver series.

Type	Antenna connection
TR-76G	Soldering stamp-hole
TR-76GA	PCB antenna

TR-76G   TR-76GA

Document history

240415   Bug in *Document history 240410* fixed: Pin Q16 is available as a general purpose I/O.

240410   Pin Q1 is available as a general purpose I/O. The pin description is revised with respect to PPS. *Simplified circuit diagram* is slightly improved. Directives in chapter *Quality management* update. Some minor improvements. Document non-preliminary.

230519   The pull-up resistor value on the -MCLR MCU pin is specified in *Simplified circuit diagram*. The description of pins on page 5 is slightly extended.

221118   Bug in *Table 1* fixed.

220929   Bug in chapter *Hardware revision* fixed.

220718   First release.

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

Partners and distribution

Distributors: www.iqrf.org/partners
IQRF E-shop: https://eshop.iqrf.org

Quality management

ISO 9001 : 2016 certified.

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

Harmonized standards or other relevant technical specifications used on the basis of which conformity is declared:
*   Radio spectrum: ETSI EN 301 489-3 V2.1.1*
*   EMC: ETSI EN 301 489-1 V2.2.3*
*   EN 55032 ed. 2*
*   EN 55035*
*   Safety: EN IEC 62368-1 ed. 2+A11*
*   RoHS: EN IEC 63000*

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