

TR-77D

RF Transceiver Module Series

Data Sheet

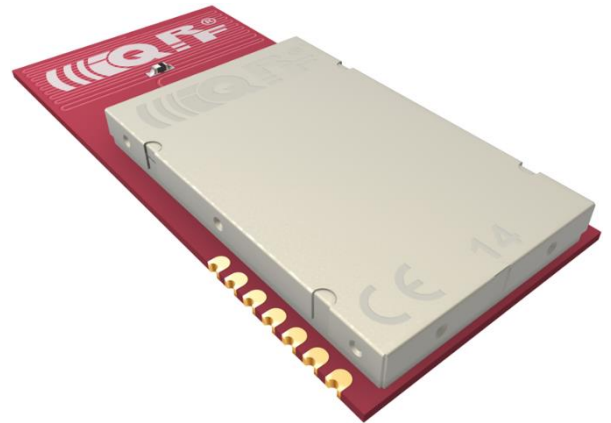


Smarter Wireless. Simply.

Description

TR-77D is a family of IQRF transceiver modules operating in the 868 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. To be applicable for fire sensors and similar applications, unwanted signals are blocked by the SAW filter, only a subset of RF channels is allowed and maximal RF power is limited. MCU with built-in operating system significantly reduces application development time. Optional DPA framework supports applications without programming.

There is no difference between TR-77Dx and DCTR-77Dx transceiver versions. All TRs support both OS as well as DPA approaches.



TR-77Dx transceiver series are EN 54-25:2008, subclause 4.2.4 compliant. They are specially intended for fire alarms and similar demanding applications. In a network utilizing DPA, the TR-77Dx transceivers must not be mixed with other series of TRs. In peer-to-peer application (without DPA), mixing of TR-77Dx transceivers with other TR-7xDx series is allowed.

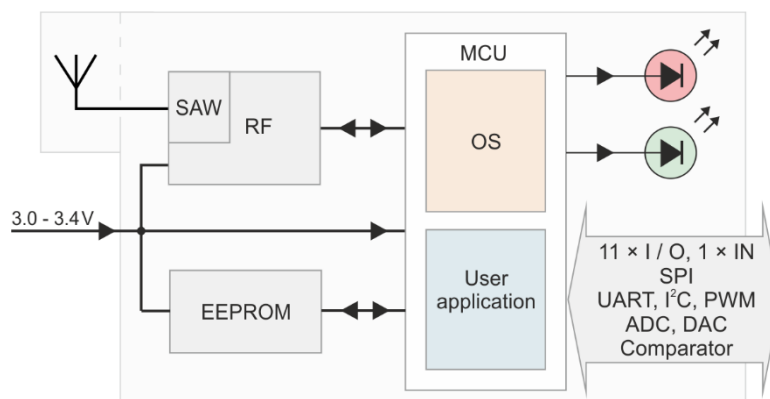
Key features

- Operating system (upgradeable at the user), easy to use
- DPA framework for Data controlled approach (formerly DCTR)
- RF band 868 MHz, multiple channel
- RF output power 4 mW
- SAW filter for extended blocking of unwanted signals, EN 54-25:2008, subclause 4.2.4 compliant
- MCU with extended resources, user interrupt capability
- Extra low power consumption, power management modes
- SPI interface supported by OS in background
- Serial EEPROM 256 Kb
- 2 LEDs, PWM output and programmable HW timer
- Battery monitoring
- 18 pins, 11 I/O pins, 1 input only pin
- A/D converter (4 channels), D/A converter, analog comparator
- Antenna options: on-board antenna, U.FL connector or soldering antenna pad-hole
- Stamp-hole pads, SMT mounting, compatible with SIM card connector without metallic holder (KON-SIM-02)

Applications

- Bidirectional RF communication
- Point-to-point or network wireless connectivity
- Fire sensors
- 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



The information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets your specifications.

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Technical specifications

Typical values unless otherwise stated

Parameters specified in this datasheet are typical values. They are at power supply $V_{CC} = 3\text{ V}$ 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	56 nA (all peripherals disabled ⁴ , RF IC in Standby mode)
Sleep mode	610 nA (all peripherals disabled ⁴ , RF IC in Sleep mode)
Run mode	
RF sleep	1.95 mA
RF ready	3.0 mA
RX mode	
STD	11.8 mA
LP ⁵	250 μ A
XLP ⁵	16.3 μ A
TX mode	8.3 mA – 25 mA (according to RF output power)
RF band	868 MHz
RF channels	See IQRF OS User's guide, Appendix <i>Channel maps</i> . Only channels 45 to 67 are allowed.
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	-101 dBm (channel 57, STD RX mode, <code>checkRF(0)</code>). See <i>Diagram 4 and 7</i> .
RF output power ^{7, 8A, 9}	6 dBm (for 50 Ω load), channel 57, programmable in 7 levels (0 – 6). See <i>Diagrams 1 and 3</i> .
Effective radiated power ^{8B}	4 dBm (channel 57). See <i>Diagrams 2A, 2B</i> .
RF interface ^{8A}	Single-ended, output impedance 50 Ω
Antenna ^{8B}	PCB meander line, linear polarization, omnidirectional
RF range ^{3, 8B}	230 m ^{3A} , 450 m ^{3B}
Input voltage on Q4 to Q15 pins	0 V to VCC
A/D converter	10 bit, 4 inputs. Refer to MCU datasheet.
Size (L x W x H)	25.1 mm x 14.9 mm x 3.3 mm ^{8A} 31.8 mm x 14.9 mm x 3.3 mm ^{8B}
Storage environment	Temperature +16 °C to +24 °C, relative humidity 65 % max., chemically indifferent

Note 1: RF power and other parameters depend on supply voltage. Refer to datasheets of MCU and RF IC used. Test your application with respect to 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 before volume use.

Note 3: Arrangement: Two TR-77DA transceivers plugged in DK-EVAL-04A kits, vertically, 1.6 m above the ground, in free space, bidirectional communication.

3A: TR-77DA transceivers plugged directly in DK-EVAL-04A kits.

3B: TR-77DA transceivers plugged in DK-EVAL-04A kits through the RNG-EXT-01 adapters.

Test software: E09-LINK example (channel 57, STD mode, `setRFpower(6)`, `checkRF(0)`), bit rate 19.8 kb/s.

Note 4: Additional current is consumed when a peripheral (e.g. watchdog, Brown-out detection etc.) is enabled.

Note 5: Depends on interferences.

Note 7: RF circuitry, RF balun and SAW filter included, built-in PCB antenna not included.

Note 8: **8A:** For TR types without built-in antenna.

8B: For TR types with built-in antenna.

Note 9: Level 7 in `setRFpower(level)` function is not allowed.

Absolute maximum ratings

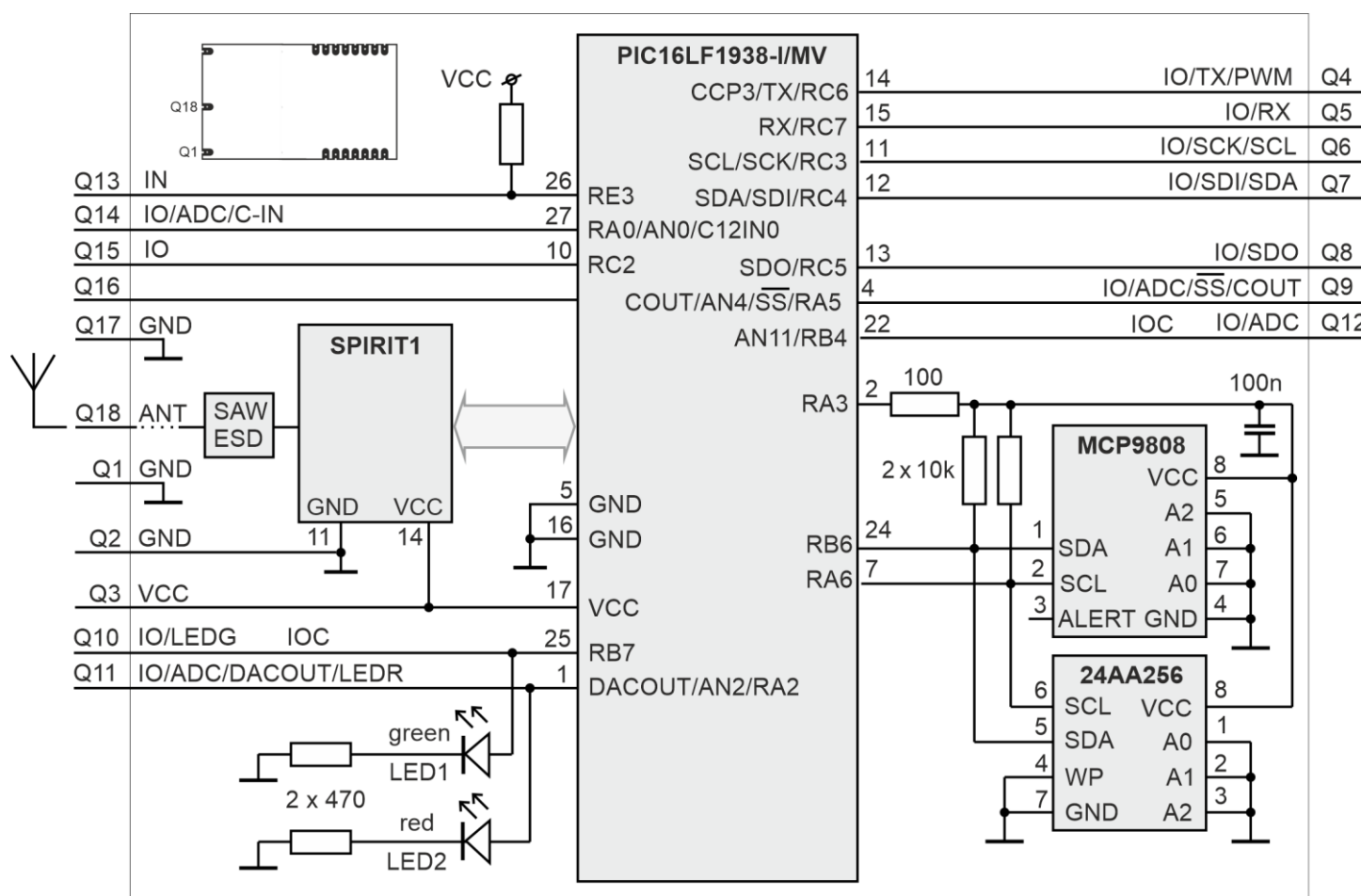
Stresses above listed maximum values may cause permanent damage to the device and affect device reliability. Functional operation under these or any other conditions beyond those specified is not supported.

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.

See the application note [AN015 - IQRF HW design for TR-7xD transceivers](#).

Simplified circuit diagram



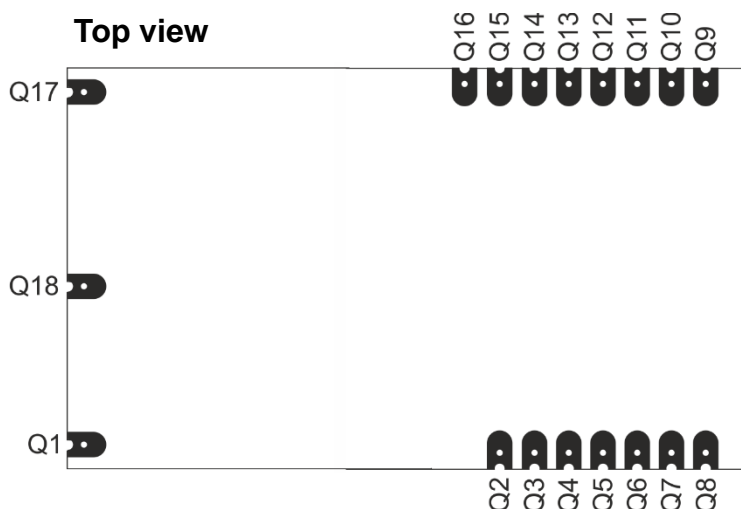
Basic components

IC	Type	Manufacturer	Note
MCU	PIC16LF1938-I/MV	Microchip	
RF IC	SPIRIT1	STMicroelectronics	
RF balun	BALF-SPI-01D3	STMicroelectronics	
SAW filter	B3941	TDK/QTI	
EEPROM	24AA256-I/CS16K	Microchip	256 Kb
Temperature sensor	MCP9808E/MC	Microchip	For types with 'T' postfix only, e.g. TR-77DT

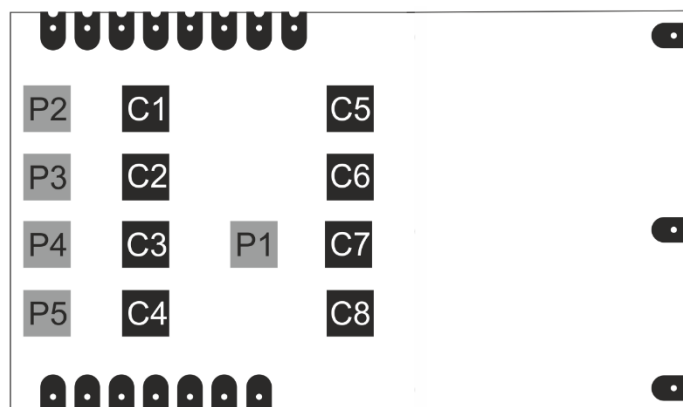
For more information refer to datasheets of ICs used.

Pin	Name	Description
Q1 ¹	GND	Ground
Q2, C4	GND	Ground
Q3, C3	Vcc	Power supply voltage
Q4	IO / TX / PWM	
	RC6	General I/O pin
	TX	UART TX
	CCP3	PWM output
Q5	IO / RX	
	RC7	General I/O pin
	RX	UART RX
Q6, C6	IO / SCK / SCL	
	RC3	General I/O pin
	SCK	SPI clock input
	SCL	I ² C clock
Q7 ² , C7	IO / SDI / SDA	
	RC4	General I/O pin
	SDI	SPI data
	SDA	I ² C data
Q8 ² , C8	IO / SDO	
	RC5	General I/O pin
	SDO	SPI data out
Q9, C5	IO / ADC / -SS / COUT	
	RA5	General I/O pin
	AN4	Analog A/D input
	-SS	SPI Slave select
	C2OUT	Comparator output
Q10 ³	IO / LEDG	
	RB7	General I/O pin, programmable pull-up
		Interrupt/Wake-up on change (IOC)
	LED1	Green LED (LEDG)
Q11 ³	IO / ADC / LEDR	
	RA2	General I/O pin
	AN2	Analog A/D input
	LED2	Red LED (LEDR)
	DACOUT	D/A converter output
Q12	IO / ADC	
	RB4	General I/O pin, with programmable pull-up
		Interrupt/Wake-up on change (IOC)
		RFPGM / (X)LP mode termination
	AN11	Analog A/D input
Q13	IN	
	RE3	General input only pin
Q14, C1	IO / ADC / C-IN	
	RA0	General I/O pin
	AN0	Analog A/D input
	C12IN0	Comparator –input
Q15, C2	IO	
	RC2	General I/O pin
Q16	–	Do not use, leave unconnected
Q17 ¹	GND	Ground
Q18 ¹	ANT	Antenna
P1–P5	For manufacturer only	

Top view



Bottom view

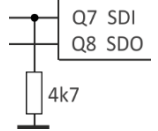


Note 1: Not implemented for TR-77DA.

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 Q7 pin** must be used otherwise a **cross-talk** between Q8 and Q7 may cause an unintentional switching to PGM.

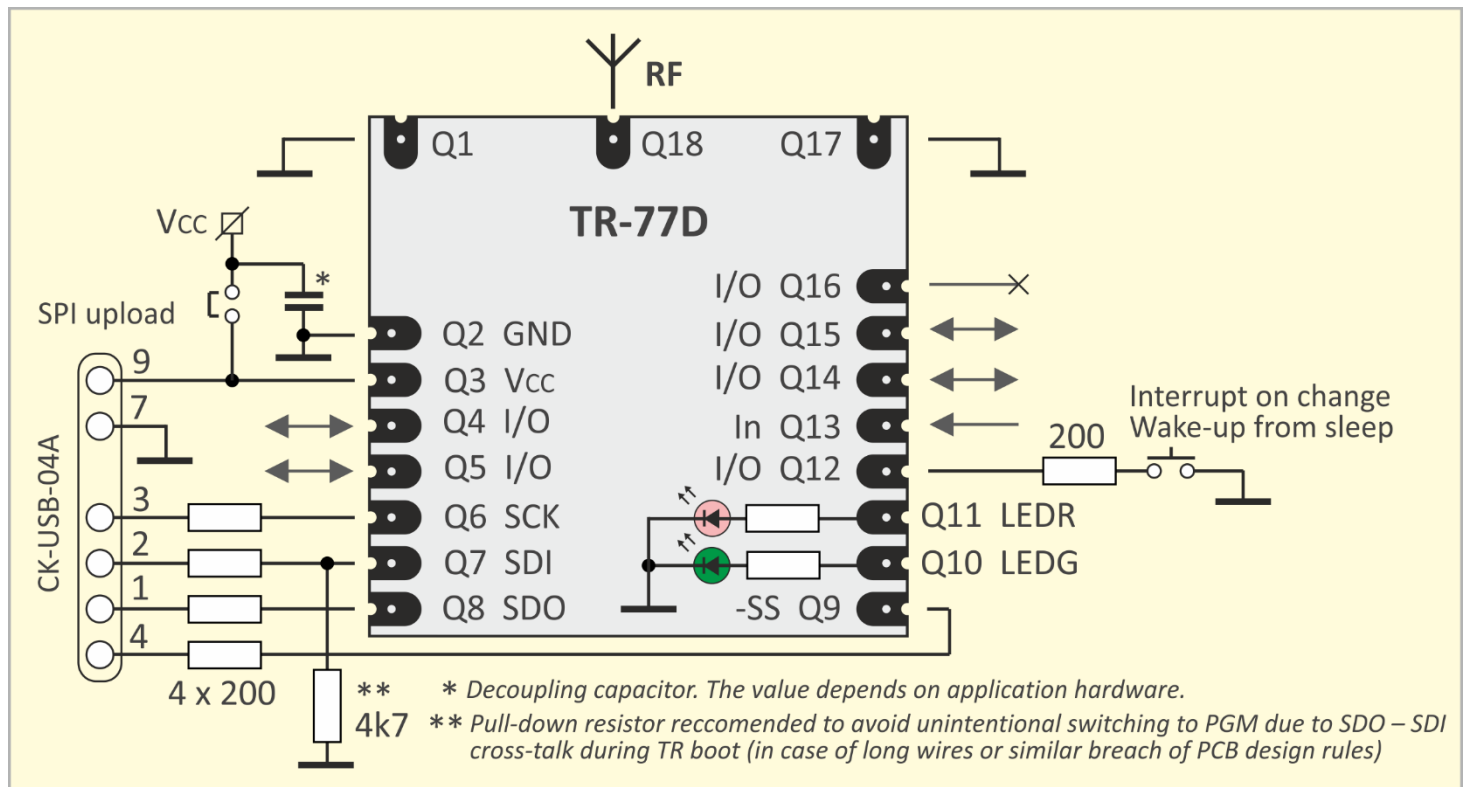


Note 3: This pin is affected by IQRF OS (and possibly DPA) LED functions and system LED indication.

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 for TR-7xD transceivers](#).

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 given application hardware and power source.
- Serial protective resistors on each I/O pin used.
- When the Q10 and Q11 pins are used as the user I/Os or user LED indication, it must be taken into account that these pins can be affected by IQRF OS or DPA LED indication.
- 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.

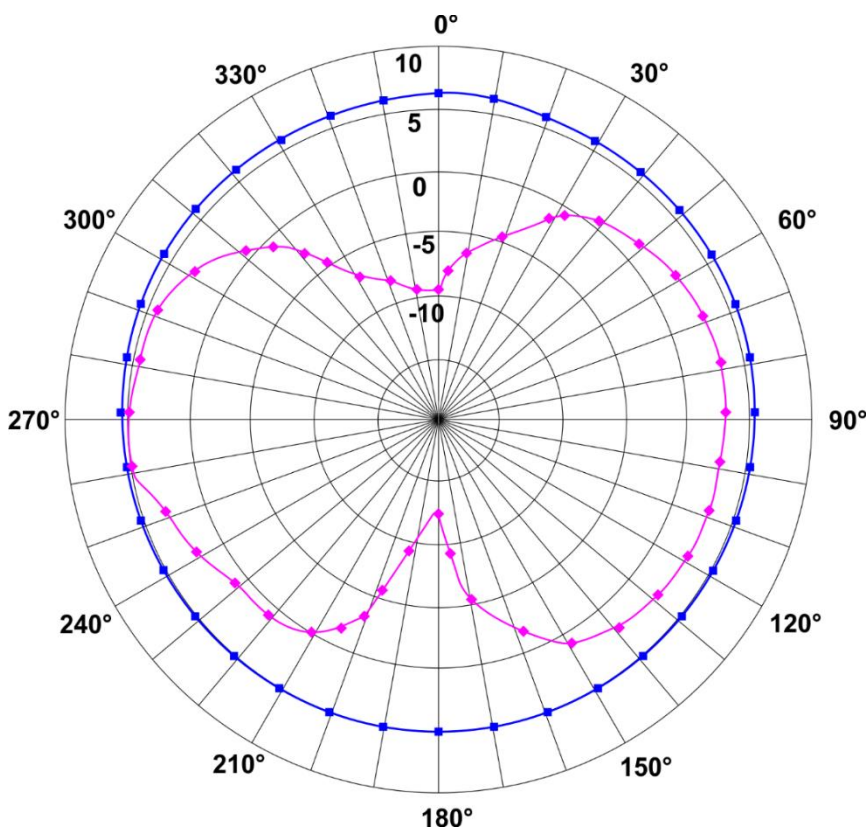
Depending on actual user application and power supply range, it may be required to isolate interface pins and/or power supply from user circuitry during uploading. For details refer to the CK-USB-04A User's guide, chapter *Application/In-circuit upload*.

RF range

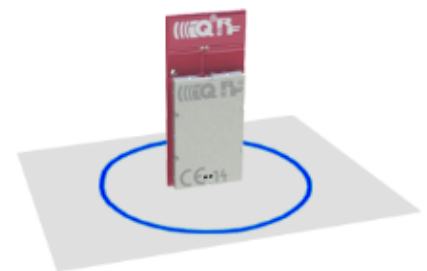
RF range strongly depends on the following design aspects:

- 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 polarizations and radiation patterns)
- Application software:
 - RF output power is selectable from 7 levels
 - To increase immunity to RF noise, incoming RF signal can be filtered according to signal strength. Refer to IQRF OS Reference guide, function `checkRF`.

Refer to Application note AN014 – *RF range at (DC)TR-7xDx transceivers*.



◆ Vertical antenna

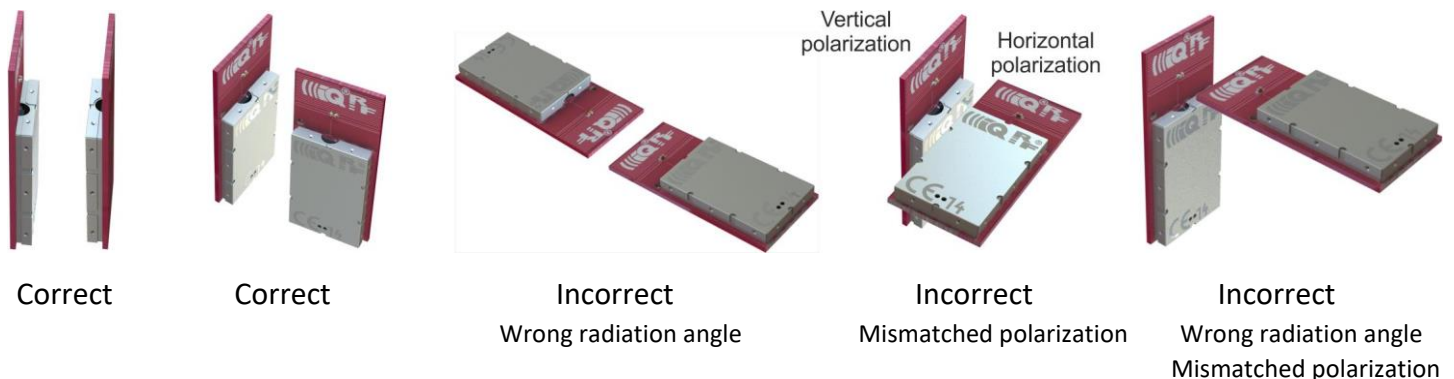


■ Horizontal antenna



Diagram 1: TR-7xDA RF output power [in dBm] vs. antenna orientation (radiation patterns).

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



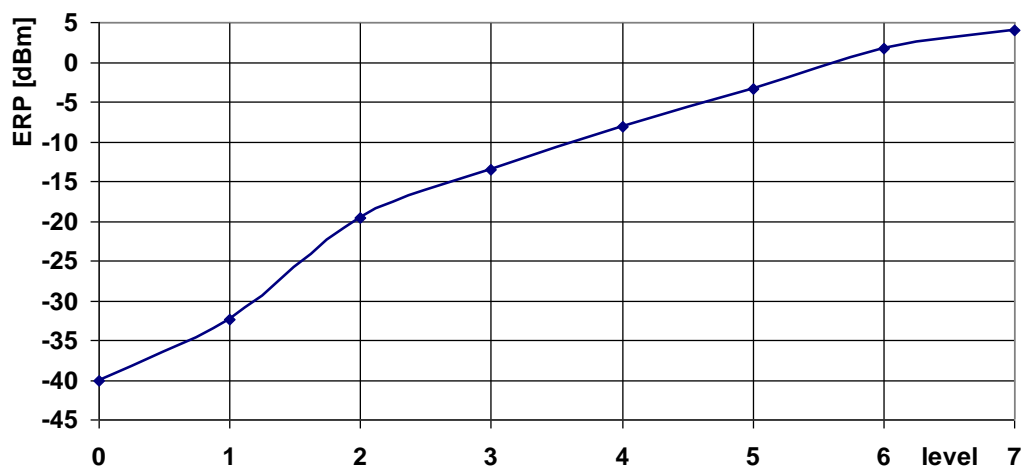


Diagram 2A: Effective radiated power (ERP) vs. level in the `setRFpower(level)` function, TR-77DA, channel 57. Refer to IQRF OS Reference guide.

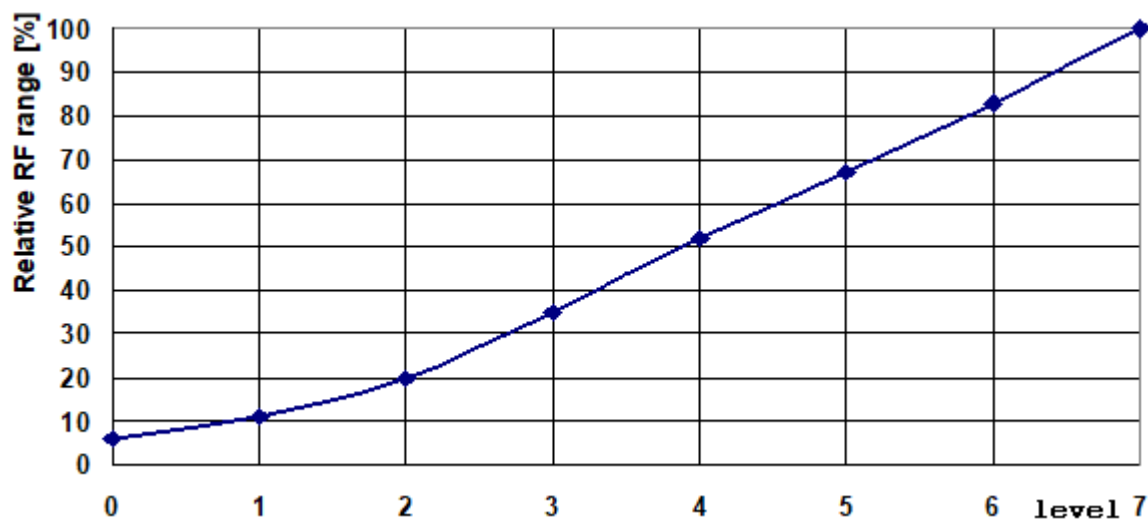


Diagram 2B: Relative RF range vs. level in the `setRFpower(level)` function. TR-77D(A). Refer to IQRF OS Reference guide.

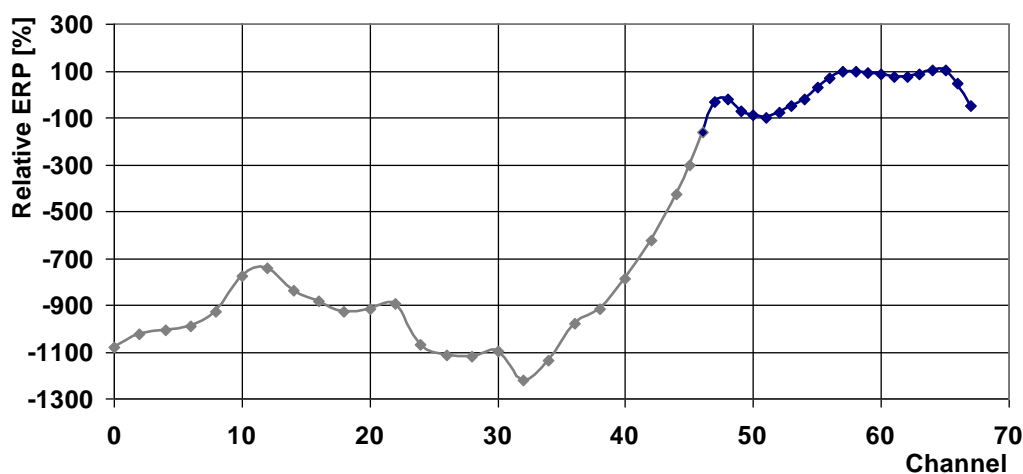


Diagram 3: Relative effective radiated power (ERP) vs. channel, TR-77DA, with respect to channel 57 (100 %).

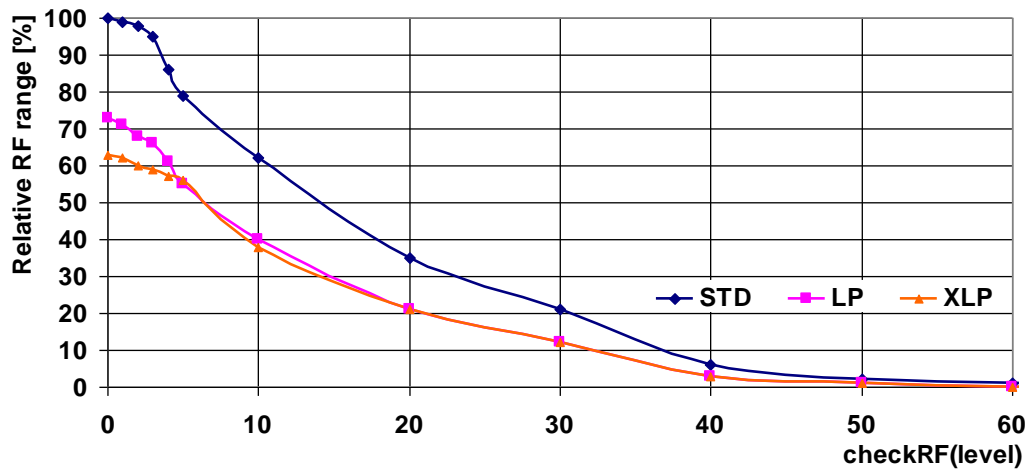


Diagram 4: Relative RF range vs. level in the `checkRF(level)` function in STD, LP and XLP RX modes. Refer to IQRF OS Reference guide.

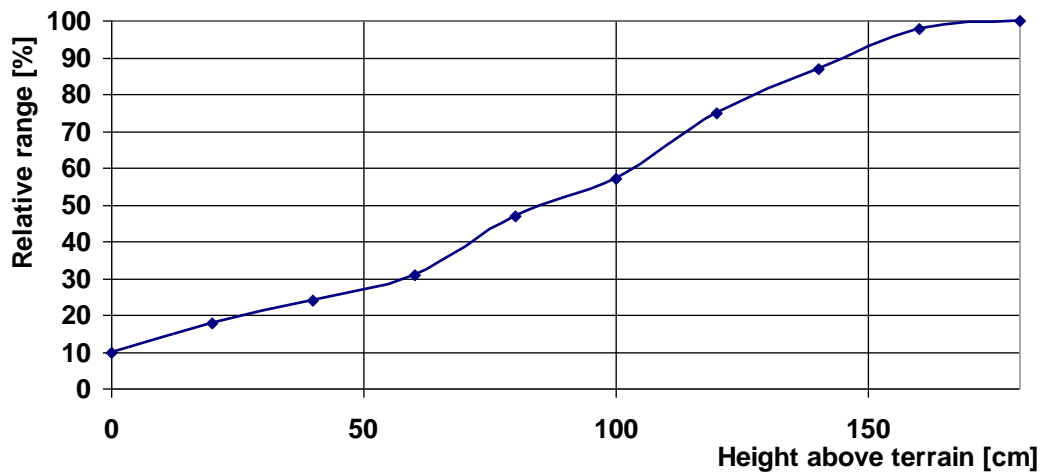


Diagram 5: Relative RF range vs. antenna height above the ground, TR-77DA.

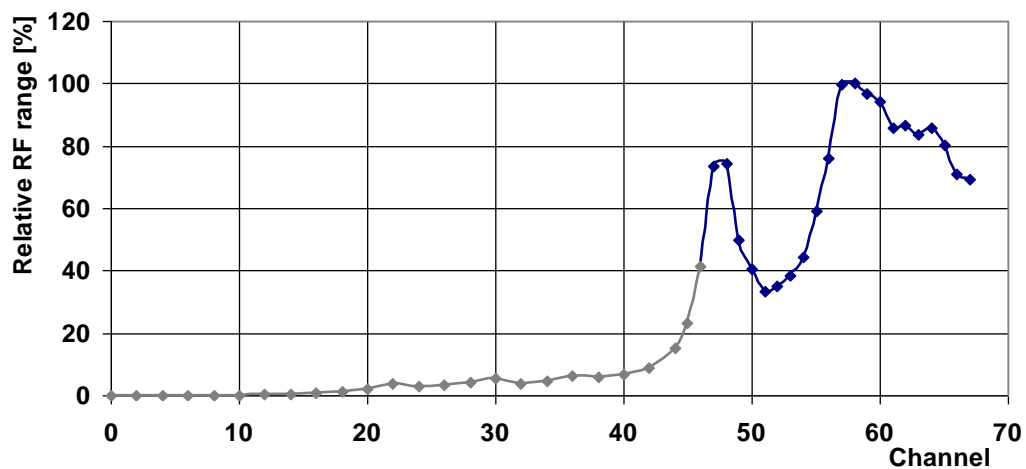


Diagram 6: Relative RF range vs. channel, TR-77DA, with respect to channel 57 (100 %).

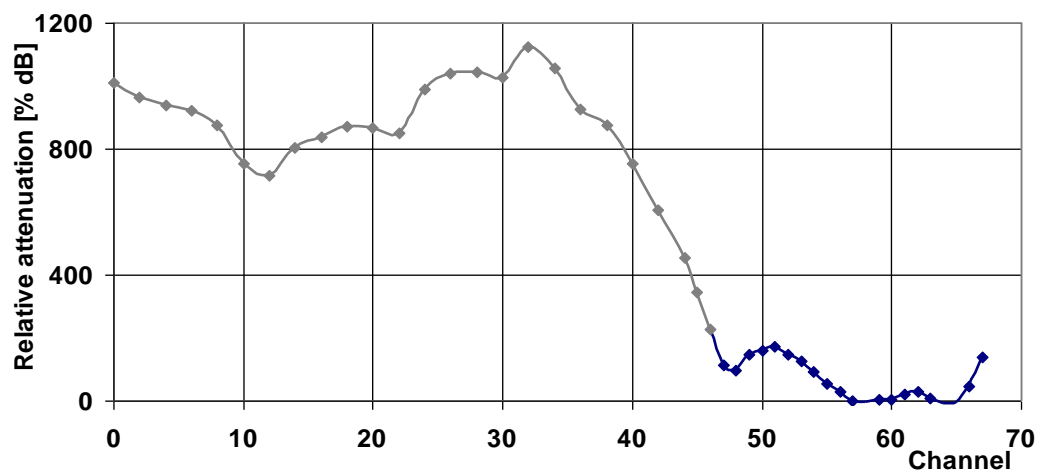
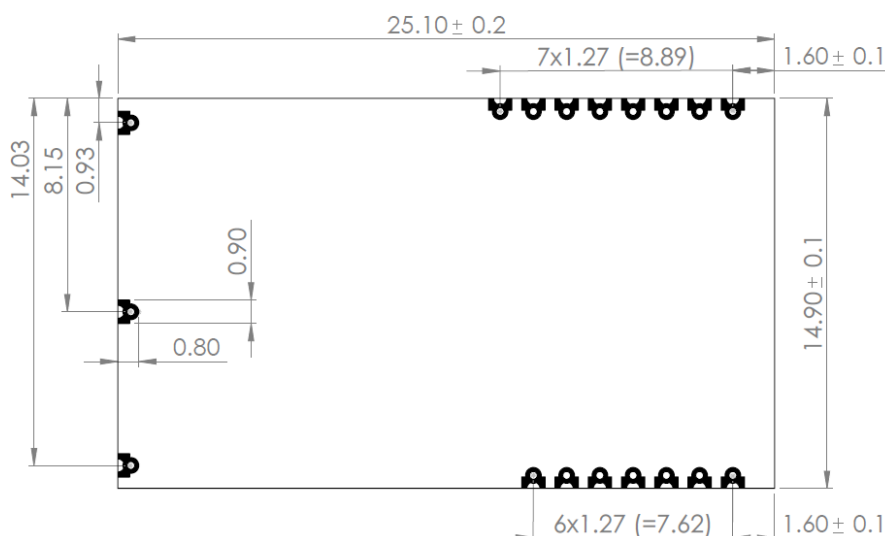


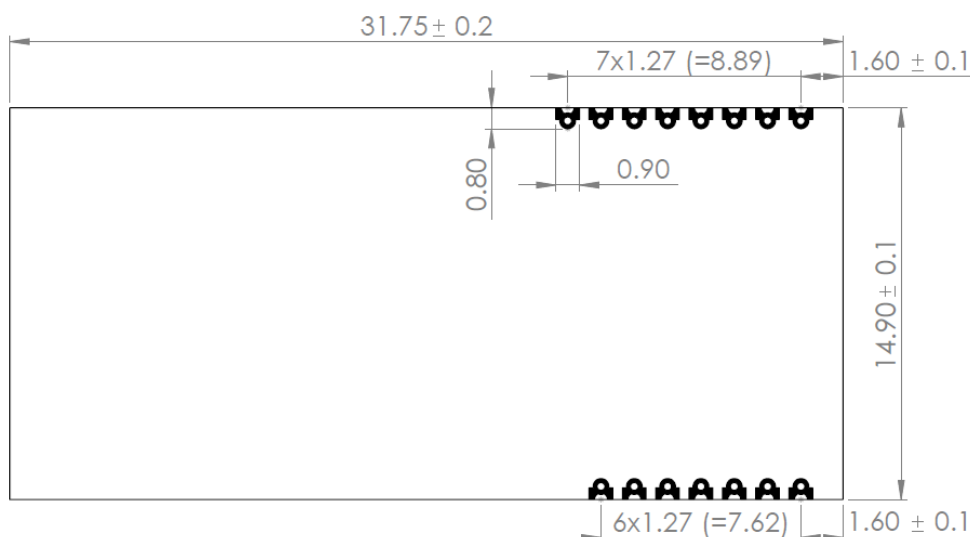
Diagram 7: Relative attenuation of received signal vs. channel, TR-77DA, with respect to channel 57 (100 %).

Mechanical drawings

TR-77D



TR-77DA



Top view. Units: mm.

Hardware revision

- TR-77D(A) v1.00 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 IQRF video tutorial set on www.iqrf.org/videos.

See the application note [AN015](#) - **IQRF HW design for TR-7xD transceivers**.

Assembly

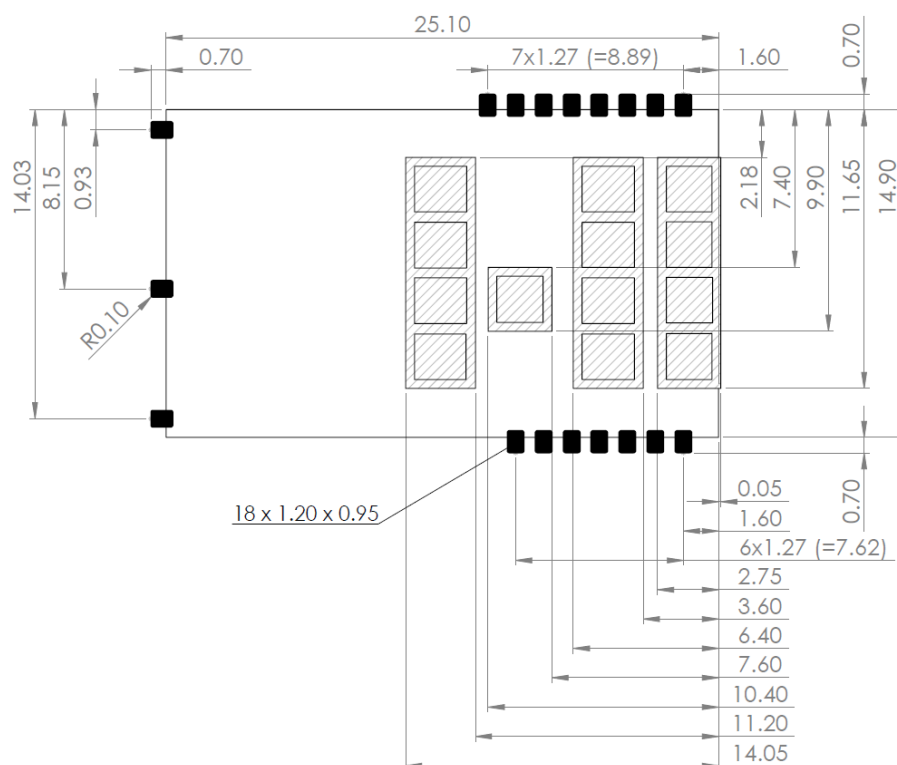
For proper mounting of surface mount TR modules and avoiding damage during solder reflow assembly, refer to the reflow profile and other details in the Application note *AN015 – IQRF HW design*, chapter *SMT mounting*.

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

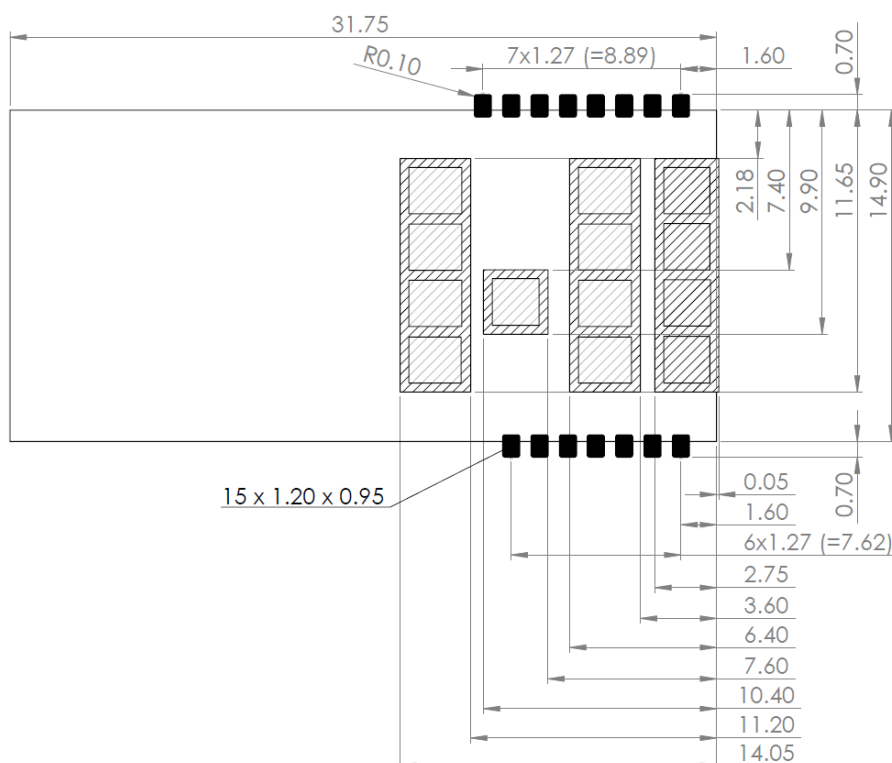
Caution: *TR-76Dx must not be plugged in a SIM connector with metallic holder.*

Recommended PCB layout

TR-77D:



TR-77DA:



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 for TR-7xD transceivers*, chapter *Sealing*.

Operating system

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

DPA framework and DCTR

See DPA Framework technical guide.

Application software

See IQRF Quick start guide and IQRF application examples.

Programming (upload)

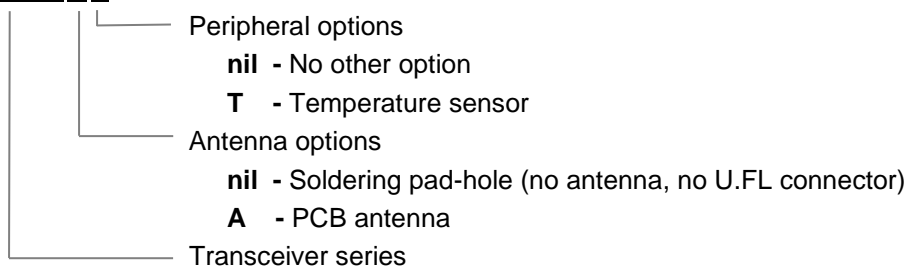
There are the following possibilities to upload an application program in TR-77Dx modules:

- Wired upload with TR-77Dx plugged via the SIM connector in the CK-USB-04A programmer.
- For TR-77Dx 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 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.

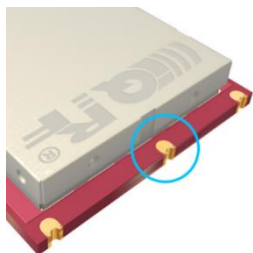
Product information

Ordering codes

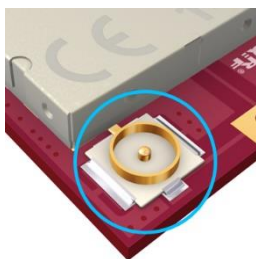
TR-77DAP



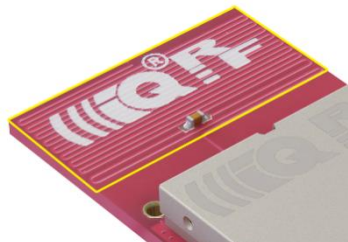
Type	Antenna connection	Temperature sensor	Data controlled
TR-77D	Soldering pad-hole	–	Yes
TR-77DC	U.FL connector	–	Yes
TR-77DA	PCB antenna	–	Yes
TR-77DT	Soldering pad-hole	Yes	Yes
TR-77DCT	U.FL connector	Yes	Yes
TR-77DAT	PCB antenna	Yes	Yes



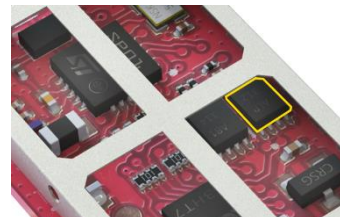
TR-77D



TR-77DC



TR-77DA



TR-77DT

Document history

- 220309 Note 1 on page 6 slightly refined.
- 210712 Storage environment added to chapter *Technical specifications*. Supplied current in RF sleep mode revised. Directives in chapter *Quality management* updated.
- 200525 Chapter *Description* extended. U.FL connector added to chapter *Key features*. References to application note *AN015 – IQRF HW design for TR-7xD transceivers* added.
- 191209 Note 2 in Pin description table extended. Paragraph *Programming (upload)* in chapter *Application* slightly extended. Chapters *Assembly* and *Sealing* relocated into Application note *AN015 – IQRF HW design*, chapters *SMT mounting* and *Sealing*.
- 191010 Supply current in TX mode in *Electrical specifications* modified. Legend added to chapter *Recommended PCB layout*.
- 180627 Diagram 2B added. Decoupling capacitor added to *Recommended circuit for development*.
- 180213 Restrictions regarding RF channels and RF power described in detail.
- 180130 First public release.

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Complies with directives 2011/65/EU (RoHS) and 2012/19/EU (WEEE).



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