TR-76D

RF Transceiver Module Series

Data Sheet

Description

TR-76D 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. Extended RF power results in higher RF range. Ultra low power consumption fits for battery powered applications. MCU with built-in operating system significantly reduces application development time. Optional DPA framework supports applications even without programming.

There is no difference between TR and DCTR transceiver versions from IQRF OS v4.02D. All TRs support both OS as well as DPA approaches.
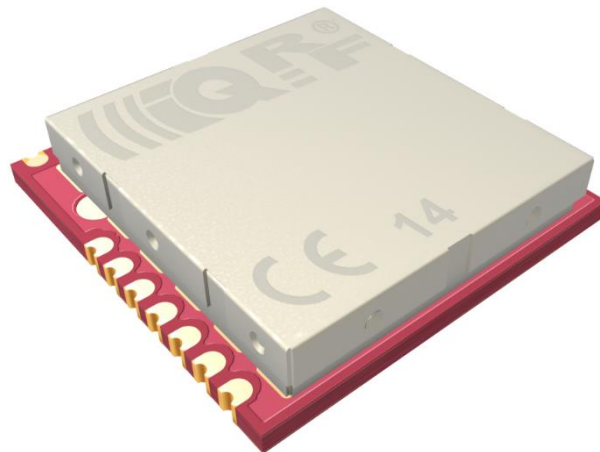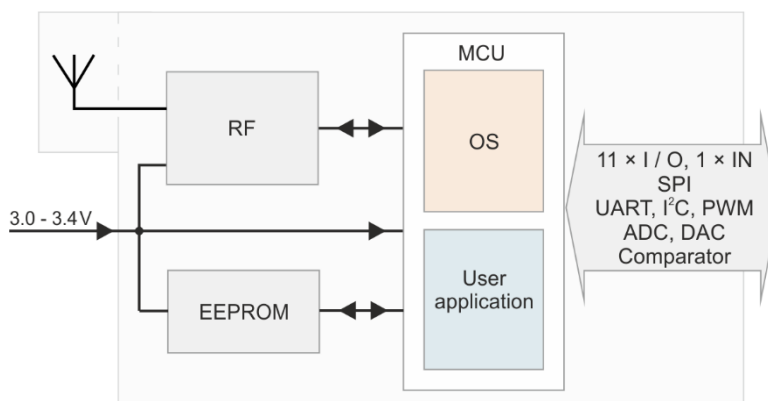
Key features

- Operating system (upgradeable at the user), easy to use
- DPA framework for Data controlled approach (formerly DCTR)
- GFSK modulation
- Selectable RF band 868 / 916 MHz, multiple channel
- RF output power 10 mW
- 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
- PWM output
- 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
- Options: on-board antenna or soldering antenna pad-hole
- 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 (OS v4.00 or higher only)	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 µA
XLP [5]	16.3 µA
TX mode	8.3 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 [6]	-101 dBm (STD RX mode, checkRF(0)). See *Diagram 4*.
RF output power (TR-76D) [6]	Up to 10 dBm (for 50 Ω load), programmable in 8 levels (0 – 7).
Effective radiated power (TR-76DA)	Up to 6.5 dBm [3A], 11 dBm [3B] (868 MHz band), 2.0 to 6.5 dBm [3A] (916 MHz band). See *Diagrams 2A, 2B*.
RF interface (TR-76D)	Single-ended, output impedance 50 Ω
Antenna (TR-76DA)	PCB meander line, linear polarization, omnidirectional. See *Diagram 1*.
RF range (TR-76DA)	500 m [3A], 1100 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)	15.2 mm x 14.9 mm x 3.3 mm (TR-76D) / 23.3 mm x 14.9 mm x 3.3 mm (TR-76DA)
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 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 at real conditions before volume use.
Note 3: Arrangement: Two TR-76DA transceivers plugged in DK-EVAL-04A kits, vertically, 1.6 m above the ground, in free space, bidirectional communication.
  3A: TR-76DA transceivers plugged in DK-EVAL-04A kits through the KON-TR-01 adapters.
  3B: TR-76DA transceivers plugged in DK-EVAL-04A kits through the RNG-EXT-01 adapters.
  Test software: E09-LINK example (STD mode, setRFpower(7), 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 6: RF circuitry and RF balun included, built-in PCB antenna not included.

TR-76D

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**.
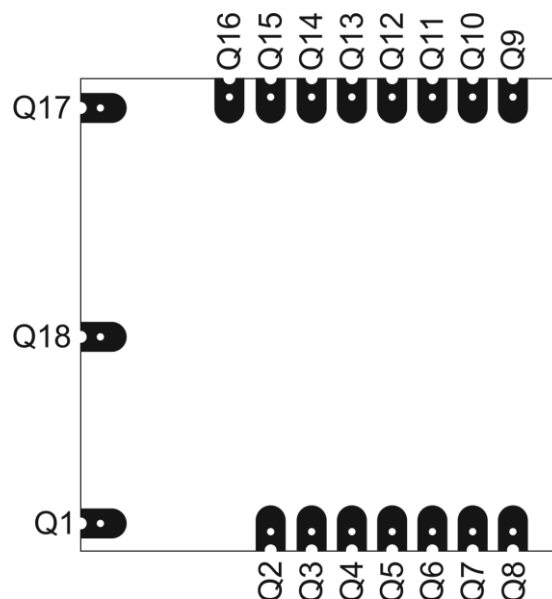
Simplified circuit diagram
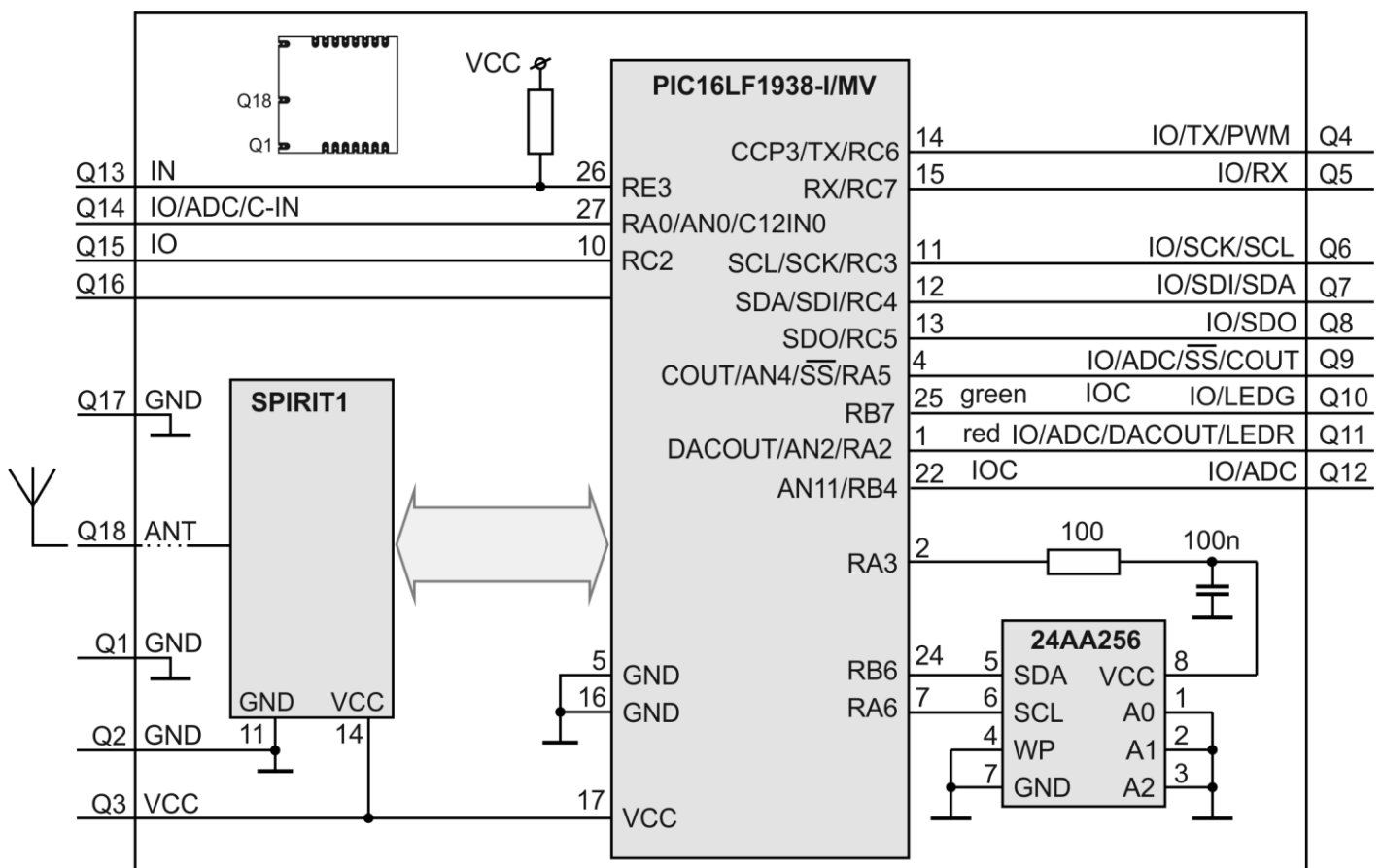
Basic components

IC	Type	Manufacturer	Note
MCU	PIC16LF1938–I/MV	Microchip	
RF IC	SPIRIT1	STMicroelectronics	
RF balun	BALF-SPI-01D3	STMicroelectronics	
EEPROM	24AA256-I/CS16K	Microchip	256 Kb

For more information refer to 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 / 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	I²C clock
Q7 [2], C7	**IO / SDI / SDA**	
	RC4	General I/O pin
	SDI	SPI data
	SDA	I²C 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	LEDG supported by OS
Q11 [3]	**IO / ADC / LEDR**	
	RA2	General I/O pin
	AN2	Analog A/D input
	LED2	LEDR supported by OS
	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
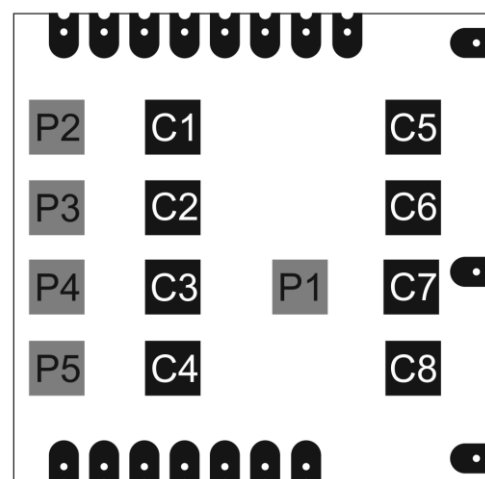
Note 1: Not implemented for TR-76DA.
Note 2: Pin Q8 is used as output and pin Q7 as input during the initial approximately 200 ms boot-up (after TR reset) to detect a possible request to enter the programming mode (PGM - wired upload via SPI). After reset, the OS generates a determinate sequence on the 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.
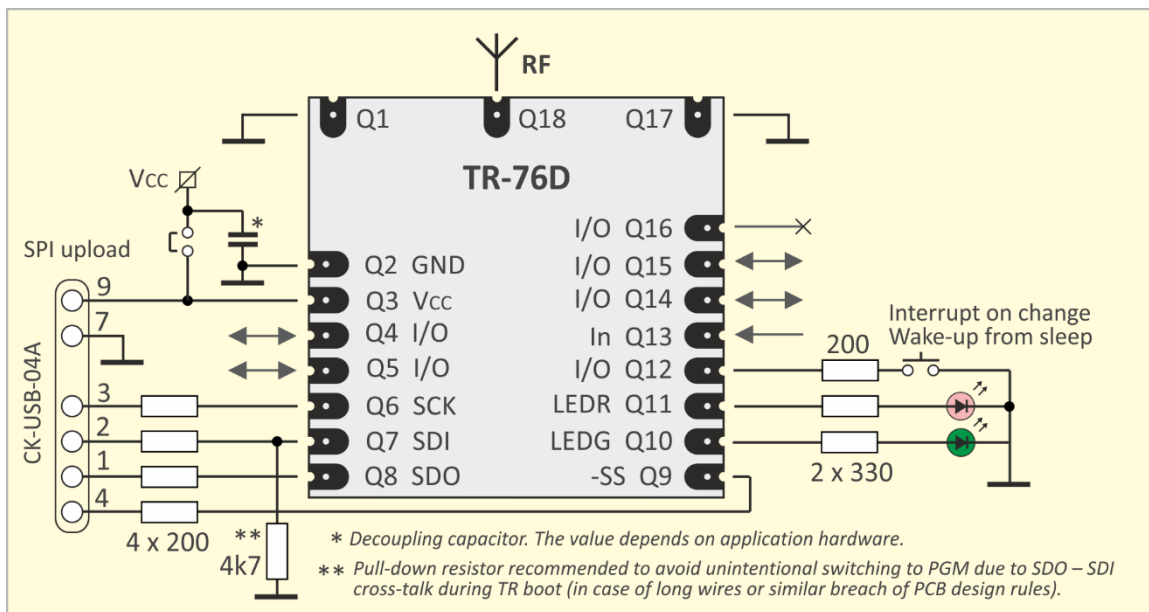**Note 3:** This pin is affected by IQRF OS (and possibly DPA) LED functions and system LED indication.
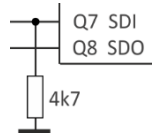
There are no on-board protection series resistors on I/O pins. It is recommended to use 200 Ω series resistors on each pin.

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.
- Both system LEDs (LEDR and LEDG) for IQRF OS and DPA status indication and for 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 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

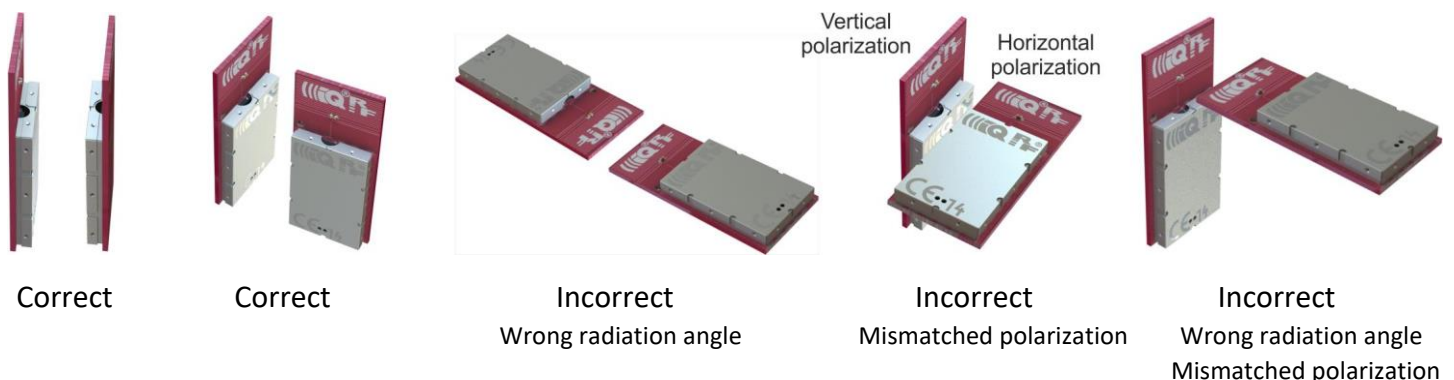RF range strongly depends on the following design aspects:

- 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 8 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` and Application note *AN014 RF range optimizing at TR-7xDx transceivers*.
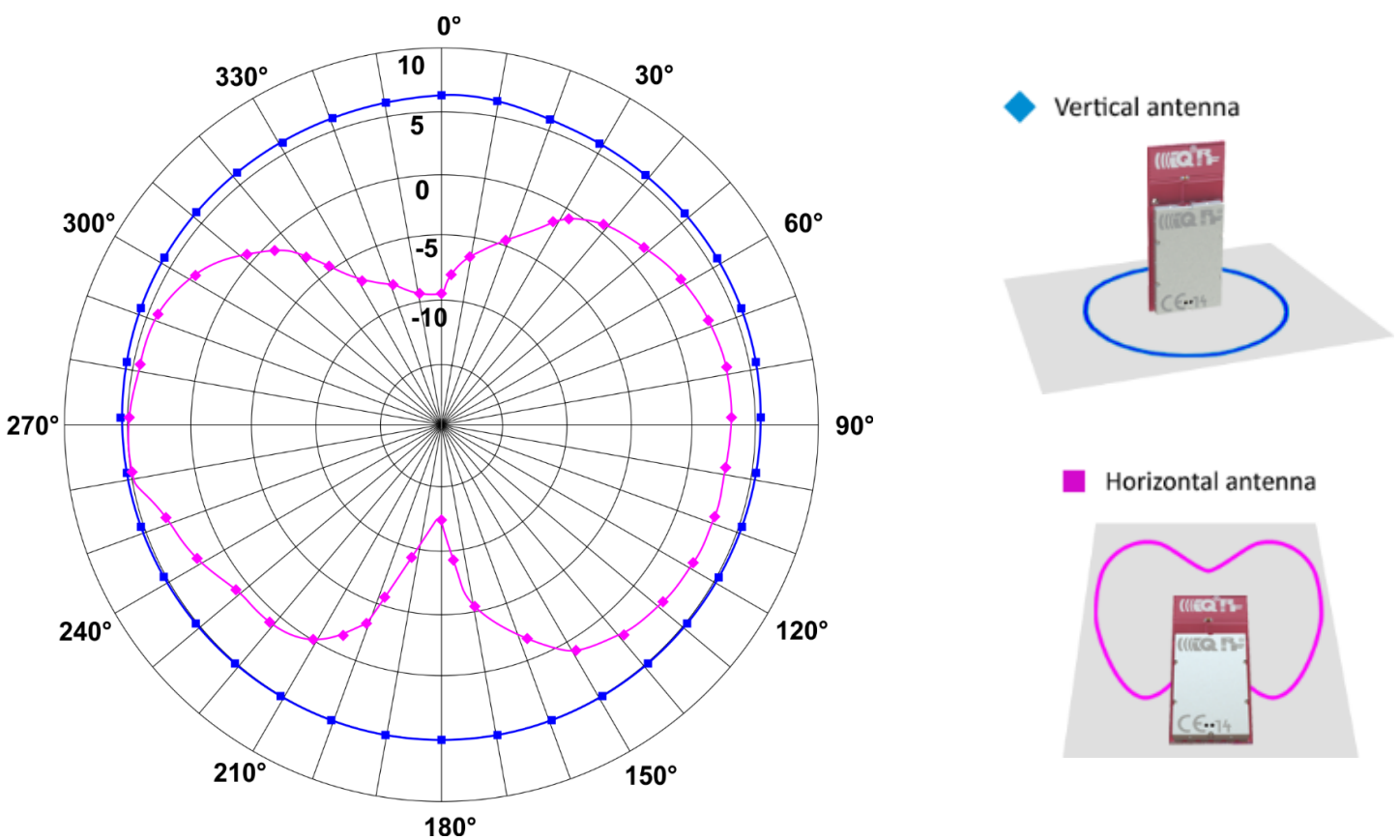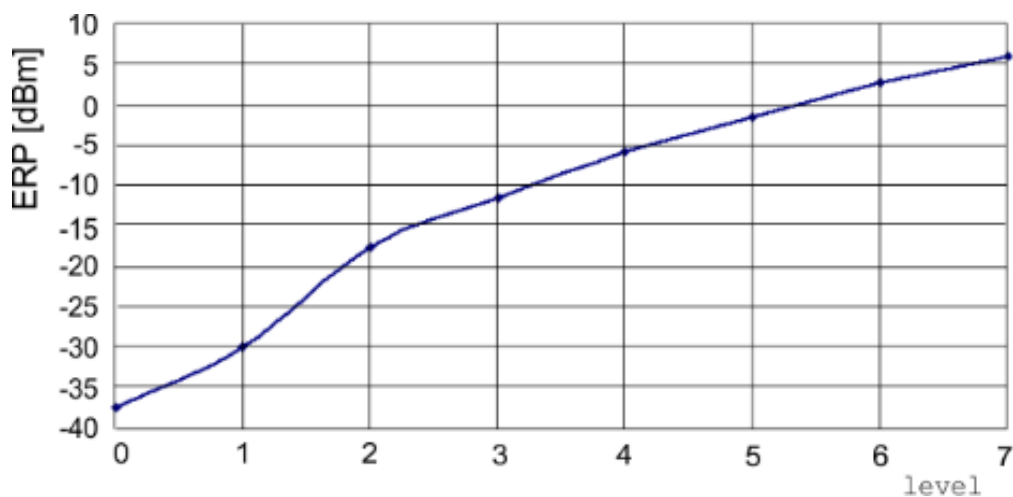

*Diagram 1: TR-7xDA RF output power [in dBm] vs. antenna orientation (radiation patterns).*

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

Correct	Correct	Incorrect	Incorrect	Incorrect
		Wrong radiation angle	Mismatched polarization	Wrong radiation angle Mismatched polarization

Diagram 2A: *Effective radiated power (ERP) vs. level in the* `setRFpower(level)` *function. TR-76D(A), 868 MHz band, channels 0 to 67. Refer to IQRF OS Reference guide.*
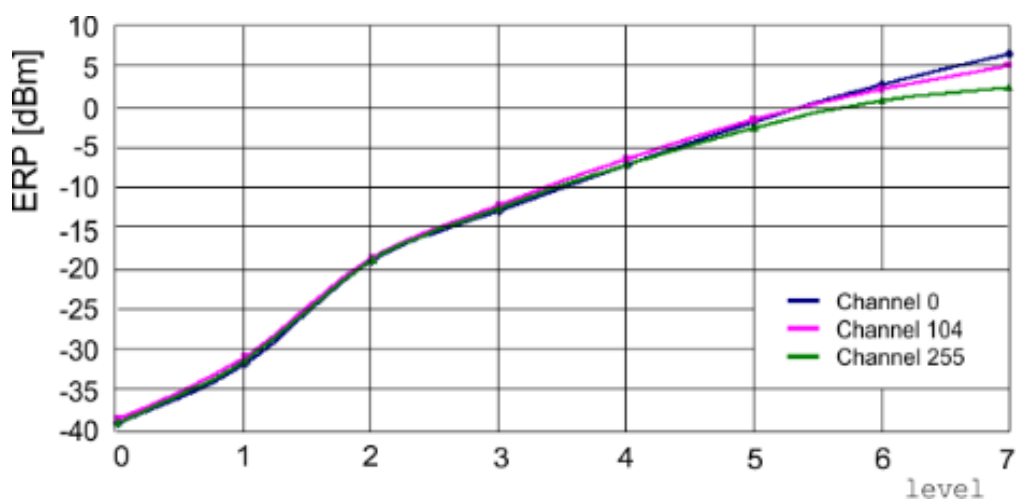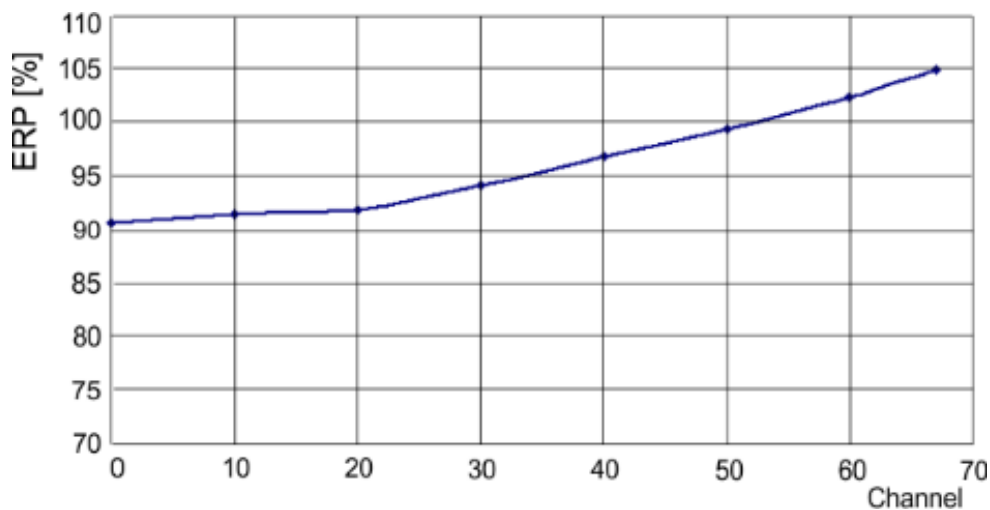

Diagram 2B: *Effective radiated power (ERP) vs. level in the* `setRFpower(level)` *function. TR-76D(A), 916 MHz band. Refer to IQRF OS Reference guide.*
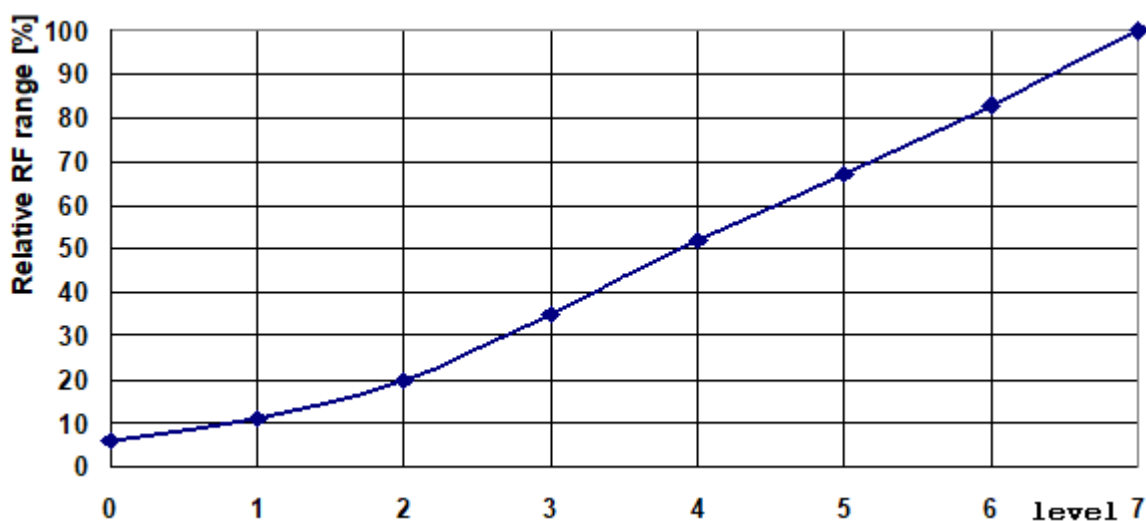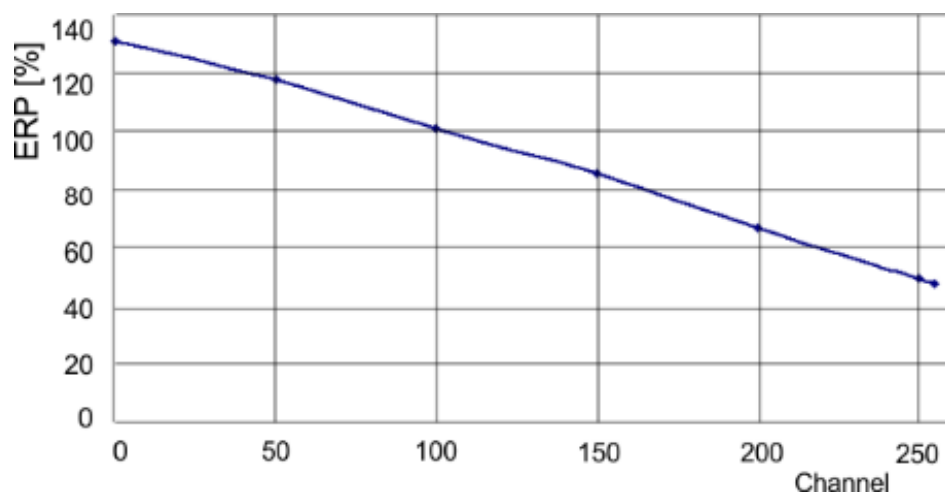

Diagram 2C: *Relative RF range vs. level in the* `setRFpower(level)` *function. TR-76D(A), 868 MHz and 916 MHz bands. Refer to IQRF OS Reference guide.*
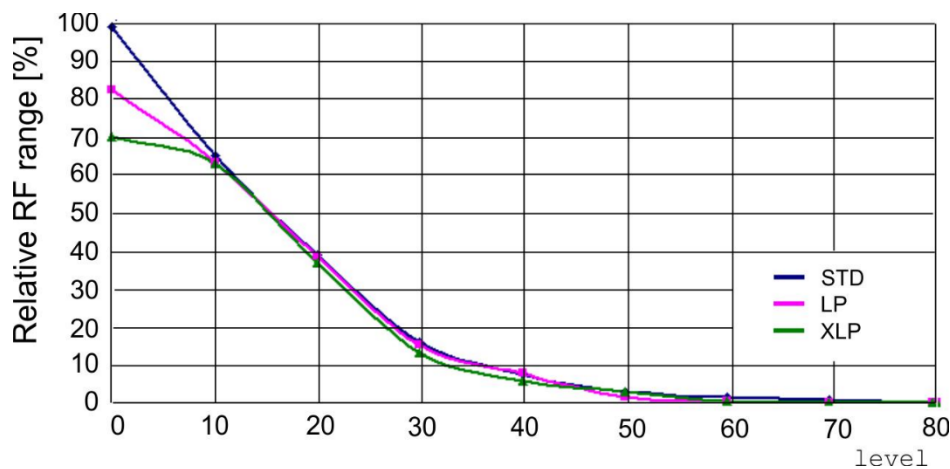
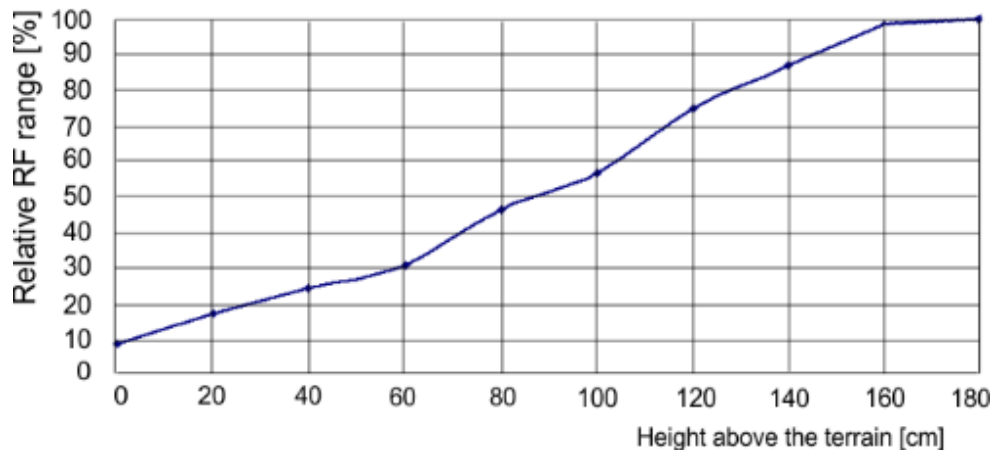**Diagram 3A:** *Relative effective radiated power (ERP) vs. channel, with respect to channel 52 (100 %). TR-76D(A), 868 MHz band.*

Diagram 3B: *Relative effective radiated power (ERP) vs. channel, with respect to channel 104 (100%). TR-76DA, 916 MHz band.*
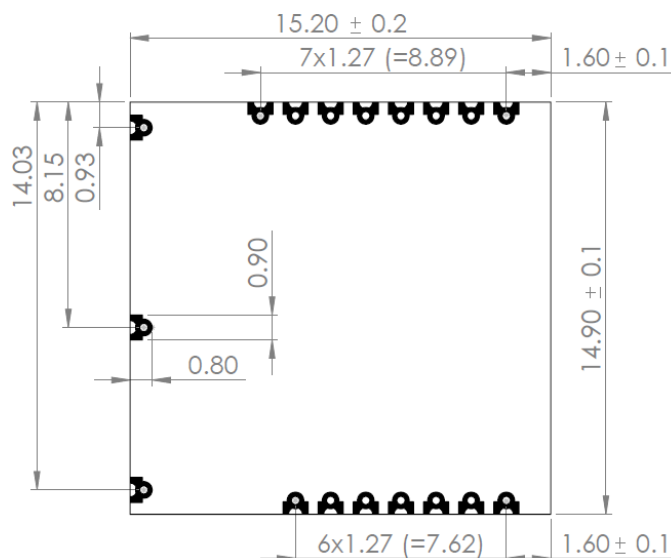

Diagram 4: *Relative RF range vs.* `level` *in the* `checkRF(level)` *function in STD, LP and XLP RX modes. Refer to IQRF OS Reference guide.*

Diagram 5: *Relative RF range vs. antenna height above the ground. TR-76DA, 868 MHz and 916 MHz bands.*

Mechanical drawings

TR-76D

TR-76DA
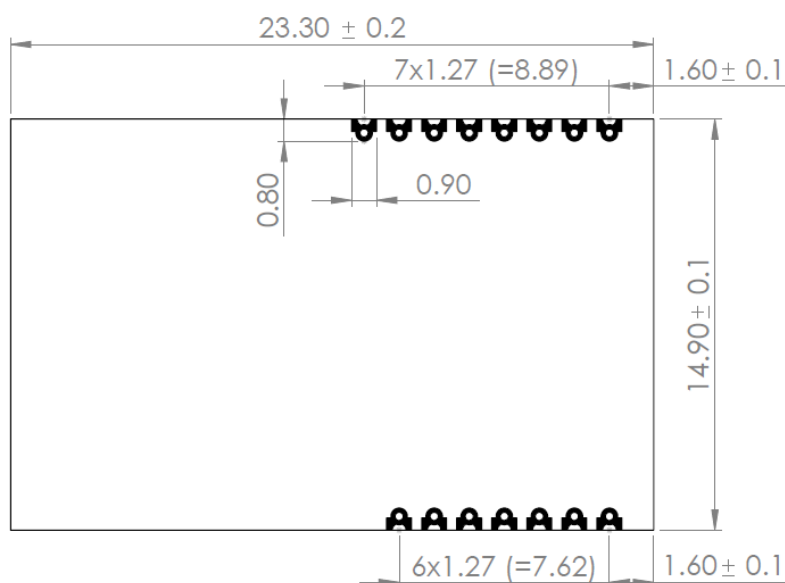
Top view. Units: mm.

Hardware revision

- TR-76DA v1.05   Minor improvements to optimize production.
- TR-76D(A) v1.04   Minor improvements to optimize production.
- TR-76D(A) v1.02   Minor improvements to optimize production. TR-76DA also for 916 MHz band.
- TR-76D(A) v1.01   Minor improvements to optimize production. TR-76DA for 868 MHz band only.
- TR-76D(A) v1.00   First standard release. TR-76DA for 868 MHz band only.

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-76D   TR-76DA

Pads

Restricted areas for wires on top side
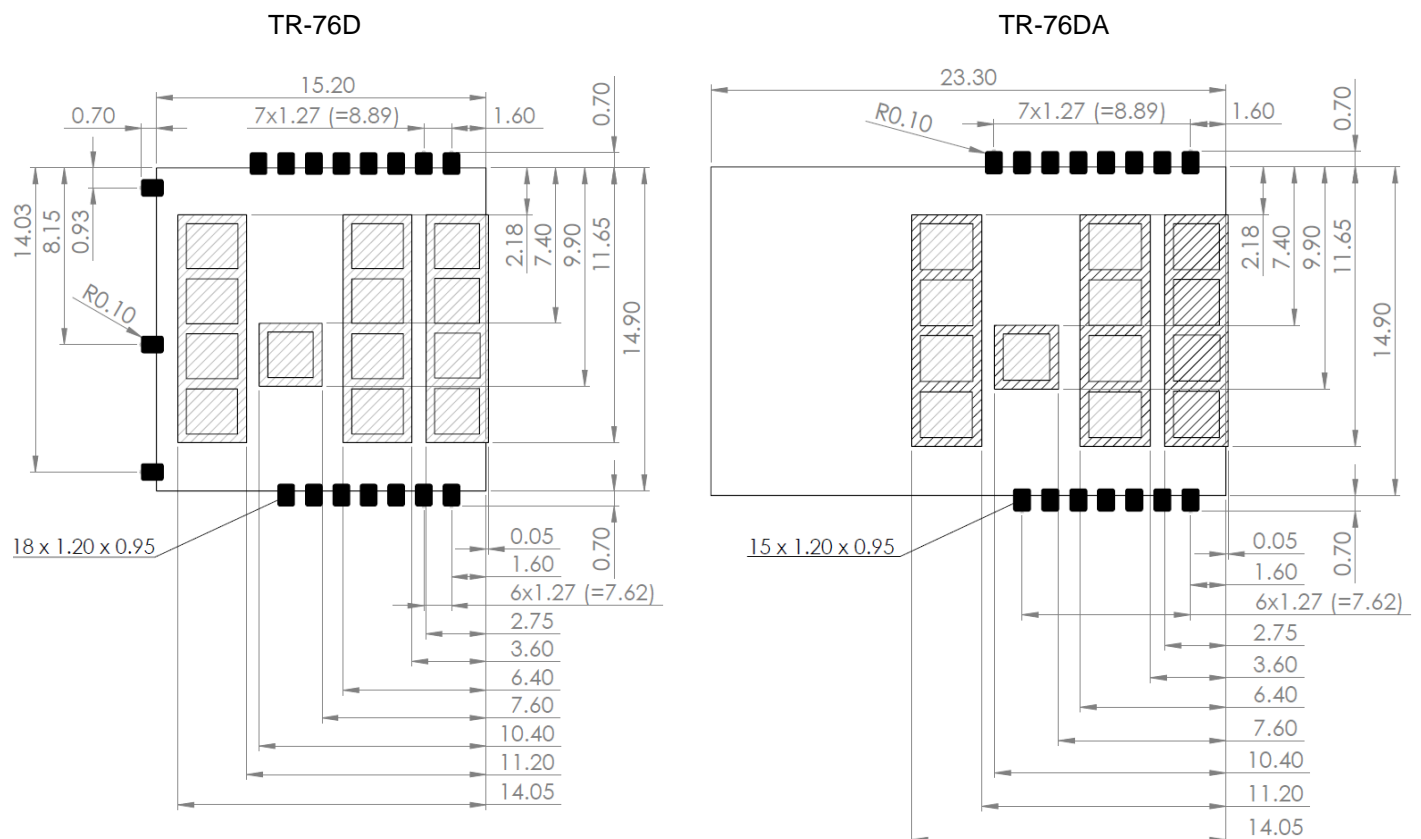
Top view. Units: mm.

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 for TR-7xD transceivers*, 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-76Dx modules:

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

<u>T R-76D</u> <u>A</u>

- Antenna options
  - **nil** - soldering pad-hole (no antenna, no U.FL connector)
  - **A** - PCB antenna
- Transceiver series. TR / DCTR are not differentiated from IQRF OS v4.02D.

Type	Antenna connection	Data controlled
TR-76D	Soldering pad-hole	Yes
TR-76DA	PCB antenna	Yes
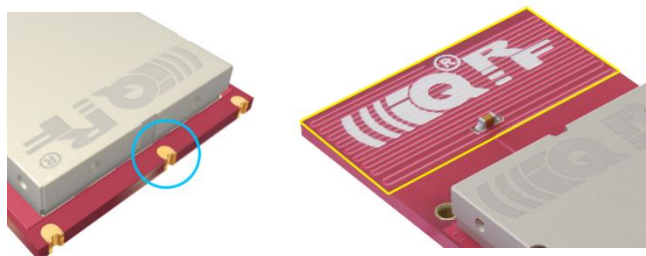
TR-76D   TR-76DA

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   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 and *Note 3A* in *Electrical specifications* modified. Legend added to chapter *Recommended PCB layout*. Updated for TR-76DA HW version 1.05.
- 180627   *Diagram 2C* added. Decoupling capacitor added to *Recommended circuit for development*.
- 180130   Block diagram revised. RF parameters in chapter *Electrical specifications* revised. HW revisions updated. Chapter *RF range* extended. Directives in *Quality management* updated.
- 171108   *Note 3* in chapter *Electrical specification* revised. The legend at Diagrams 2A, 2B, 3A and 3B slightly precised.
- 170823   A bug in *Recommended PCB layout* fixed. Updated for IQRF OS v4.02D.
- 170810 V_{CC} reduced to 3.9 V in chapter *Absolute maximum ratings*. *Diagram 4*, *Mechanical drawings* and *Recommended PCB layout* updated. Updated for TR / DCTR fusion from IQRF OS v4.02D. Some minor improvements.
- 170322   Diagrams 3A and 3B added. Preliminary.
- 170314   Updated for HW v1.02 and IQRF OS v4.00 (preliminary). *Electrical specification* revised. Chapter *Sealing* added. Chapter *Recommended circuit for development* slightly extended. Variances in mechanical drawings slightly precised. Some minor improvements.
- 160304   Pin Q12 description slightly extended.
- 160219   More detailed RF range specification. Q7 and Q8 pin description extended.
- 160118   *Note 10* added to pin description table. Chapter *Recommended circuit for development* added. A bug in *Key features, antenna options* fixed.
- 151005   ETSI directives updated. Preliminary.
- 151001   First release. Preliminary.

Sales and Service

Corporate office

IQRF Tech s.r.o., Prumyslova 1275, 506 01 Jicin, Czech Republic, EU
Tel: +420 493 538 125, Fax: +420 493 538 126, www.iqrf.tech
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

Complies with ETSI directives EN 301 489-1 V1.9.2:2011, EN 301 489-3 V1.6.1:2013, EN 300 220-1 V3.1.1:2017, EN 300 220-2 V3.2.1:2018 and ERC Recommendation 70-03 (2017) and VO-R/10/05.2014-3.

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

CE

Trademarks

The IQRF name and logo are registered trademarks of IQRF Tech s.r.o.
All other trademarks mentioned herein are a property of their respective owners.

Legal

All information contained in this publication is intended through suggestion only and may be superseded by updates without prior notice. No representation or warranty is given and no liability is assumed by IQRF Tech s.r.o. with respect to the accuracy or use of such information.

Without written permission, it is not allowed to copy or reproduce this information, even partially.

No licenses are conveyed, implicitly or otherwise, under any intellectual property rights.

The IQRF® products utilize several patents (CZ, EU, US).

On-line support: support@iqrf.org

Smarter Wireless. Simply.