TR-72D

RF Transceiver Module Series

Data Sheet

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Description

TR-72D 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, integrated LDO regulator, serial EEPROM, optional temperature sensor and optional on-board antenna requires no external components. 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.

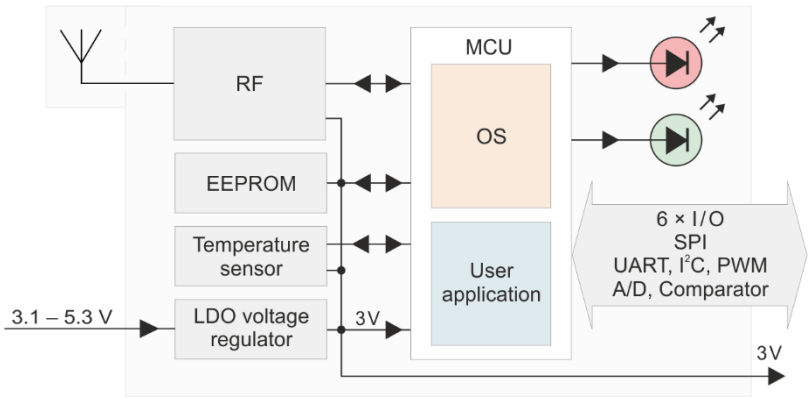
Key features

- 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
- +3 V LDO regulator output, battery monitoring
- 2 LEDs
- 8 pins, 6 I/Os
- A/D converter (2 channels), analog comparator
- Options: on-board antenna, U.FL connector, temperature sensor
- SIM card format fits KON-SIM-02 and KON-SIM-01 connectors
- 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_{OUT} = 3 V only. V_{OUT} voltage different from 3 V can impact on RF range and other parameters.

Supply voltage (V_{CC})	3.1 V to 5.3 V DC
LDO output (V_{OUT})	+3 V ± 60 mV (V_{CC} > 3.1 V), 100 mA max.
Operating temperature [1]	-40 °C to +85 °C
Supply current	
Deep sleep mode (OS v4.00 or higher only)	1.7 µA (all peripherals disabled [3], RF IC in Standby mode)
Sleep mode	2.3 µA (all peripherals disabled [3], RF IC in Sleep mode)
Run mode	
RF sleep	1.95 mA
RF ready	2.8 mA
RX mode	
STD	12.1 mA
LP [4]	260 µA
XLP [4]	18.5 µA
TX mode	8.3 mA – 25 mA (according to RF output power)
Additional LED supply current	About 2 mA per LED. Rough value for brief guidance only.
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 [6, 7A]	Up to 10 dBm (for 50 Ω load), programmable in 8 levels (0 – 7).
Effective radiated power [7B]	Up to 6.5 dBm [2A], 11 dBm [2B] (868 MHz band), 2.0 to 6.5 dBm [2A] (916 MHz band). See *Diagrams 2A, 2B*.
RF interface [7A]	Single-ended, output impedance 50 Ω
Antenna [7B]	PCB meander line, linear polarization, omnidirectional. See *Diagram 1*.
RF range [2, 7B]	500 m [2A], 1100 m [2B]
Input voltage on C1, C2, C5 to C8 pins	0 V to V_{OUT}
A/D converter	10 bit, 2 inputs. Refer to MCU datasheet.
Temperature sensor	MCP9808E/MC (for TR types with 'T' postfix only, e.g. TR-72DT)
Size (L x W x H)	25.1 mm x 14.9 mm x 3.3 mm [7A] 31.8 mm x 14.9 mm x 3.3 mm [7B]
Storage environment	Temperature +16 °C to +24 °C, relative humidity 65 % max., chemically indifferent

Note 1: RF range may change with lower temperature. Frost, condensation or humidity over 85% may disable module functionality. Transceiver suitability should be tested in the final application at real conditions before volume use.

Note 2: Arrangement: Two TR-72DA transceivers in DK-EVAL-04A kits, vertically, 1.6 m above the ground, in free space, bidirectional communication.
2A: TR-72DA transceivers plugged directly in DK-EVAL-04A kits.
2B: TR-72DA 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 3: Additional current is consumed when a peripheral (e.g. watchdog, Brown-out detection etc.) is enabled.

Note 4: Depends on interferences.

Note 6: RF circuitry and RF balun included, built-in PCB antenna not included.

Note 7: **7A:** For TR types without built-in antenna.
7B: For TR types with built-in antenna.

Absolute maximum ratings

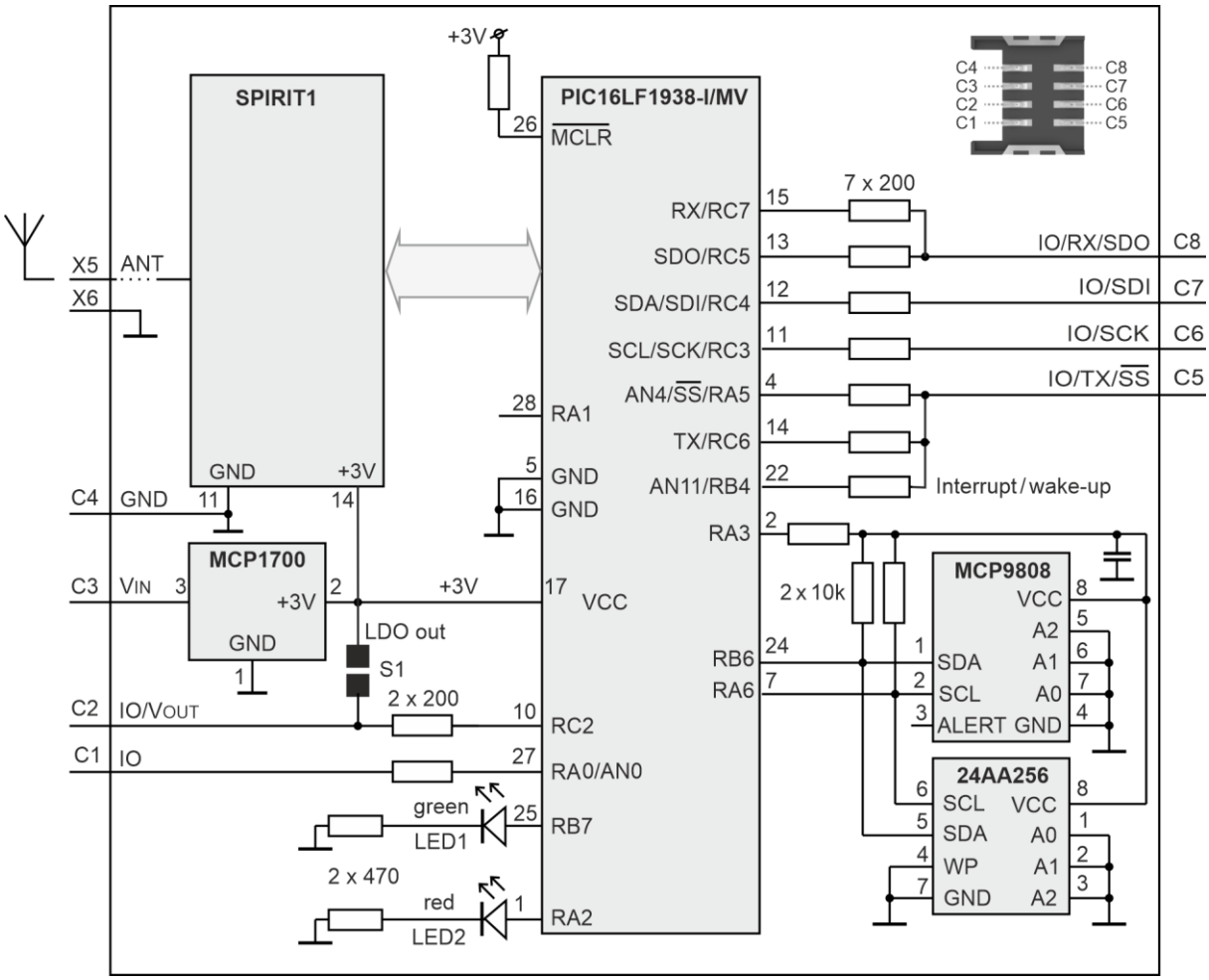
Stresses above listed maximum values may cause permanent damage to the device and affect device reliability. Functional operation under these or any other conditions beyond those specified is not supported.

Supply voltage (V_{CC})	5.5 V
Voltage on C1, C2, C5 to C8 pins (configured as inputs) vs. GND	-0.3 V to (V_{OUT} + 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

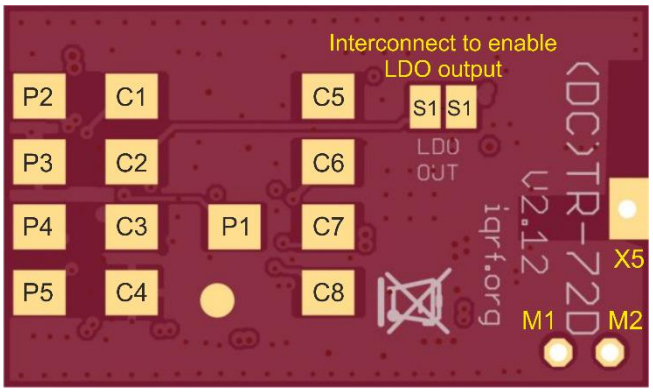


Basic components

IC	Type	Manufacturer	Note
MCU	PIC16LF1938–I/MV	Microchip	
RF IC	SPIRIT1	STMicroelectronics	
RF balun	BALF-SPI-01D3	STMicroelectronics	
LDO voltage regulator	MCP1700T-3002E/TT	Microchip	
Temperature sensor	MCP9808E/MC	Microchip	For types with ‘T‘ postfix only, e.g. TR-72DT
EEPROM	24AA256-I/CS16K	Microchip	256 Kb

For more information refer to datasheets of ICs used.

Pin	Name	Description
C1	**IO / ADC / C-IN**	
	RA0	General I/O pin
	AN0	Analog A/D input
	C12IN0	Comparator –input
C2	**IO / VOUT**	
	RC2	General I/O pin (when S1 disconnected)
	VOUT	On-board +3 V LDO output (when S1 connected)
C3	**VIN**	Power supply voltage
C4	**GND**	Ground
C5	**IO / ADC / TX / -SS / PWM / COUT**	
	RA5	General I/O pin,
	-SS	SPI Slave select
	AN4	Analog A/D input
	C2OUT	Comparator output
	RC6	General I/O pin
	TX	UART TX
	CCP3	PWM output
	RB4	General I/O pin, with programmable pull-up and interrupt/wake-up on change (IOC), RFPGM termination
	AN11	Analog A/D input
C6	**IO / SCK / SCL**	
	RC3	General I/O pin
	SCK	SPI clock input
	SCL	I²C clock
C7 [1]	**IO / SDI / SDA**	
	RC4	General I/O pin. Used as input during initial about 200 ms boot-up (after power supply rising-up) to recognize programming mode.
	SDI	SPI data
	SDA	I²C data
C8 [1]	**IO / RX / SDO**	
	RC5	General I/O pin. Used as output during initial about 200 ms boot-up (after power supply rising-up) to recognize programming mode.
	SDO	SPI data out
	RC7	General I/O pin
	RX	UART RX
X5	**ANT**	Antenna input
P1–P5		For manufacturer only
S1		LDO output enable. Interconnect both S1 pads to enable. Default (from the factory) disabled.
M1, M2		Holes for possible mechanical fixation

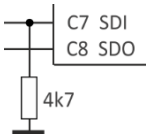


Bottom view

Note 1: Pin C8 is used as output and pin C7 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 C8 pin. If this sequence is copied to the C7, 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 C7 pin must not be interconnected to C8 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 C7 pin** must be used otherwise a **cross-talk** between C8 and C7 may cause an unintentional switching to PGM.



See the application note AN015 - **IQRF HW design for TR-7xD transceivers**.

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.*

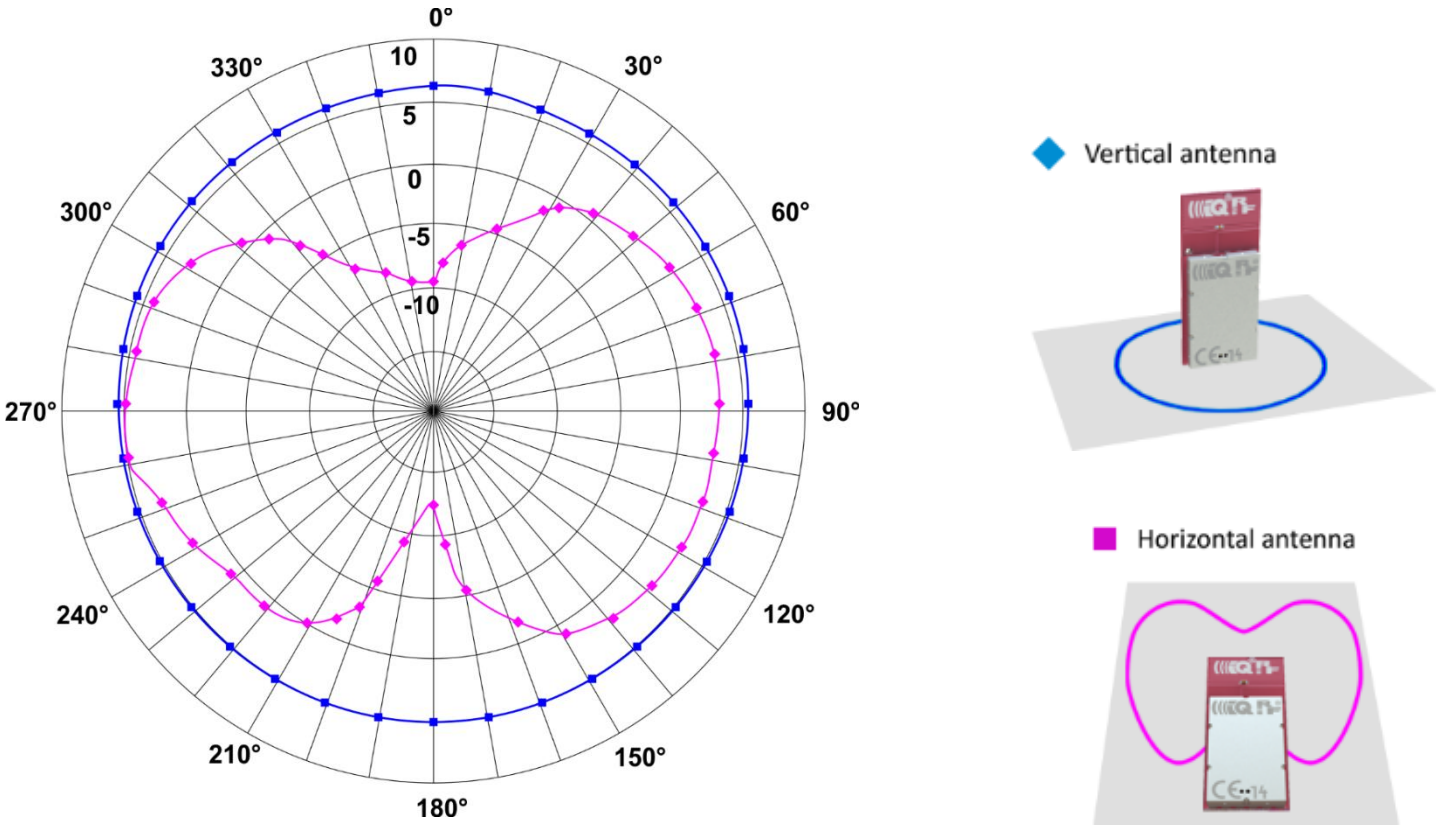
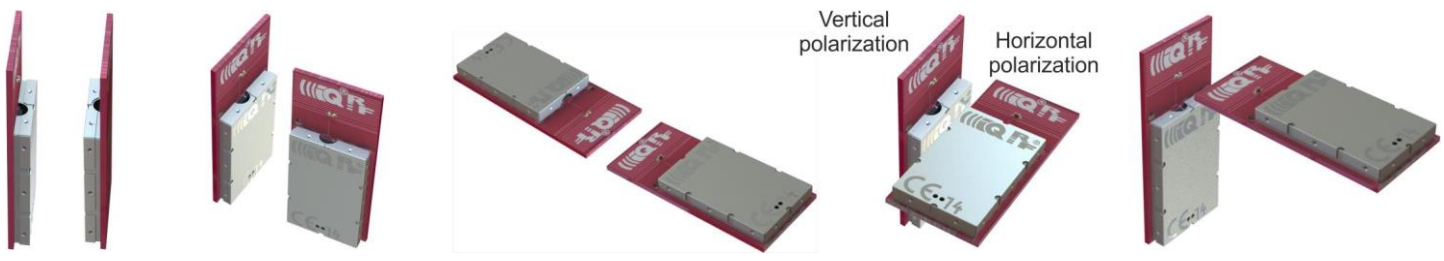


Diagram 1: *TR-7xDA RF output power [in dBm] vs. antenna orientation (radiation patterns).*

Examples of the correct and incorrect arrangement of TR-72DA pairs:



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

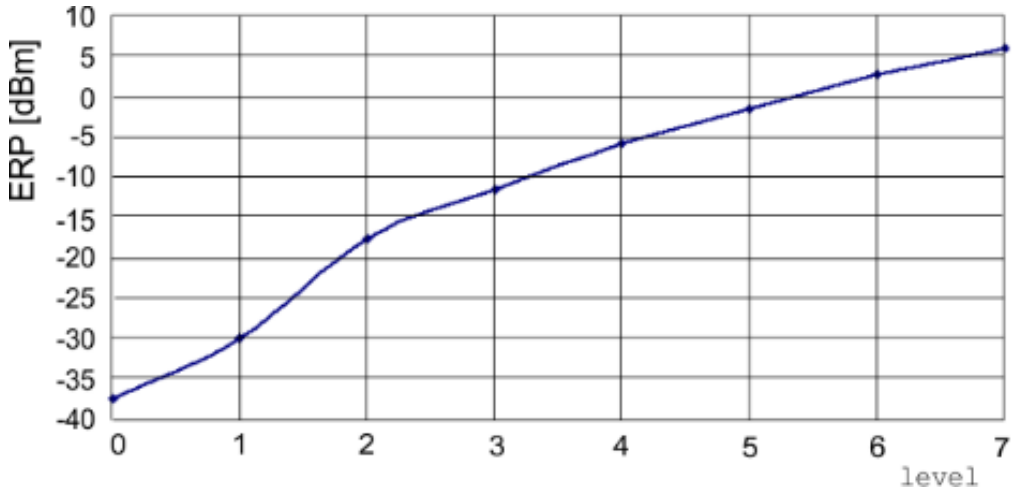


Diagram 2A: *Effective radiated power (ERP) vs. level in the* `setRFpower(level)` *function. TR-72D(A), 868 MHz band, channels 0 to 67. Refer to IQRF OS Reference guide.*

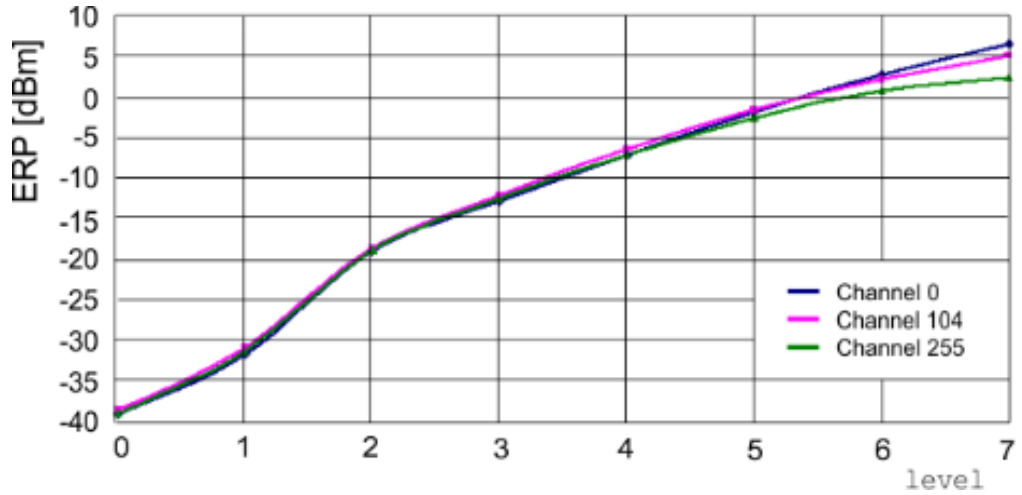


Diagram 2B: *Effective radiated power (ERP) vs. level in the* `setRFpower(level)` *function. TR-72D(A), 916 MHz band. Refer to IQRF OS Reference guide.*

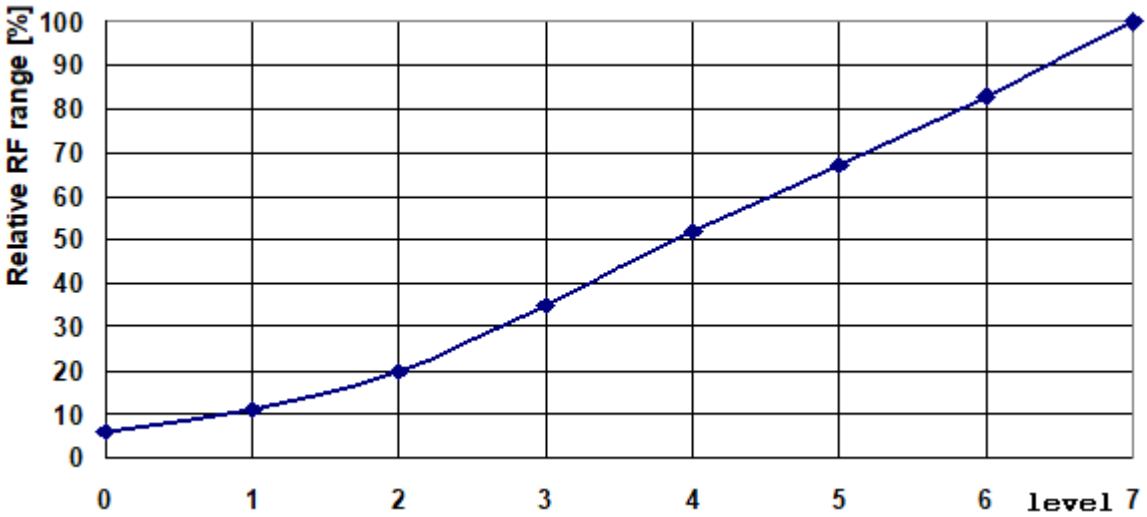


Diagram 2C: *Relative RF range vs. level in the* `setRFpower(level)` *function. TR-72D(A), 868 MHz and 916 MHz bands. Refer to IQRF OS Reference guide.*

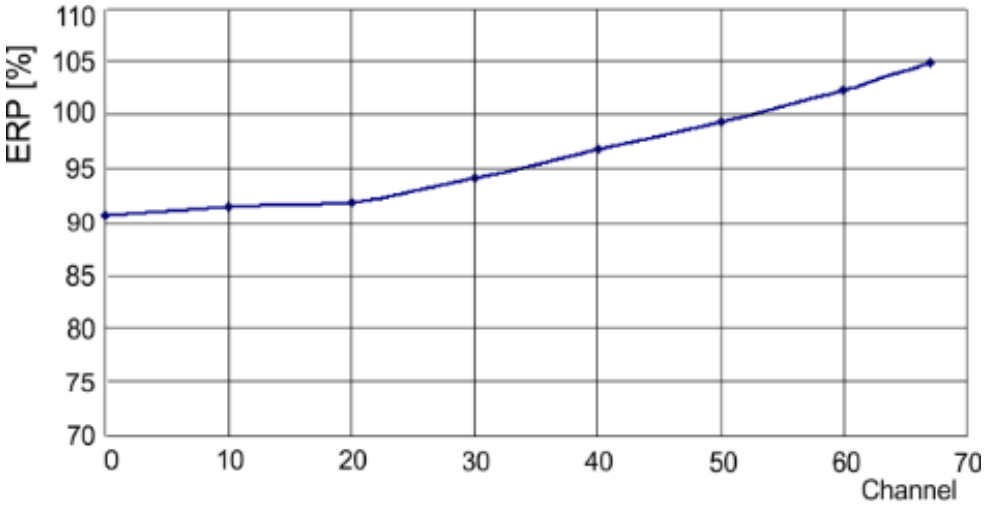


Diagram 3A: *Relative effective radiated power (ERP) vs. channel, TR-72D(A), 868 MHz band, with respect to channel 52 (100 %).*

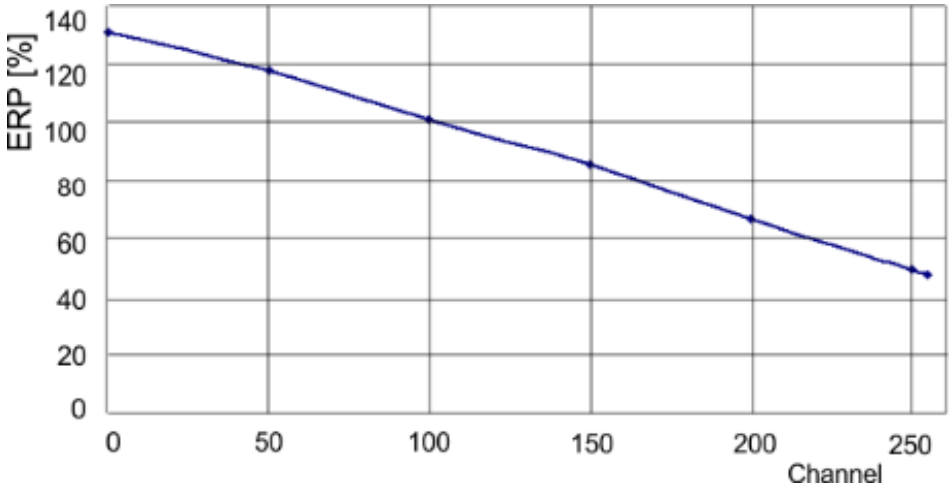


Diagram 3B: *Relative effective radiated power (ERP) vs. channel, TR-72D(A), 916 MHz band, with respect to channel 104 (100 %).*

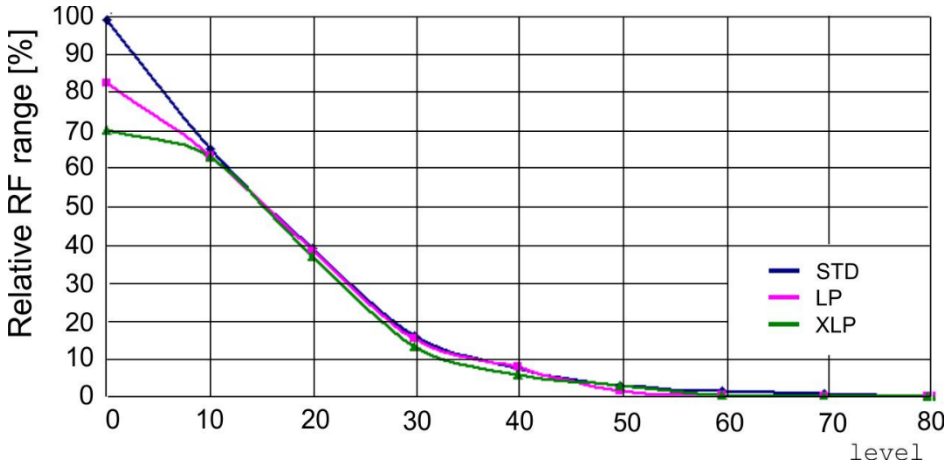


Diagram 4: *Relative RF range vs.* `level` *in the* `checkRF(level)` *function in STD, LP and XLP RX modes. Refer to IQRF OS Reference guide, function* `checkRF()`.

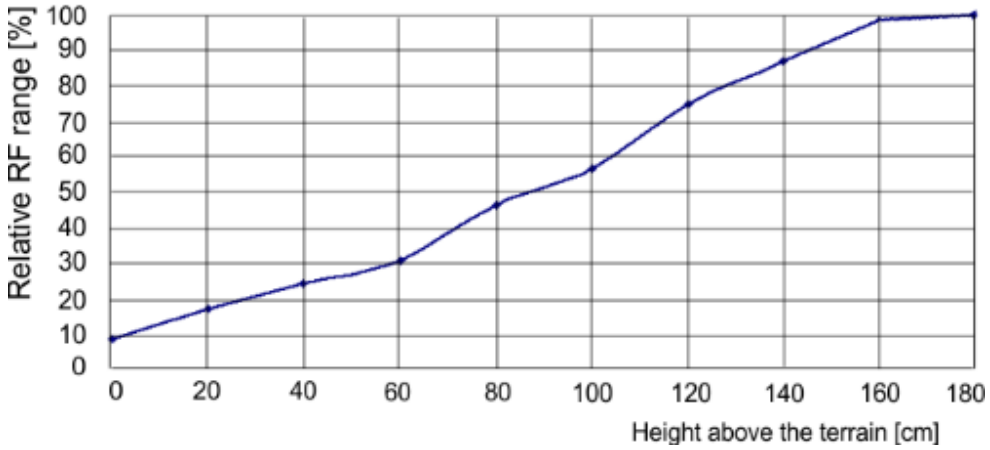
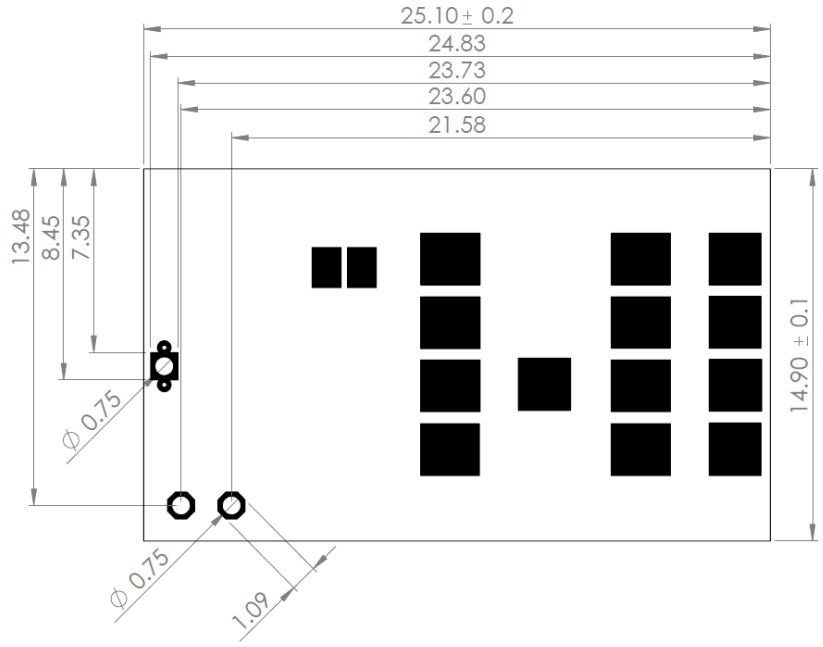


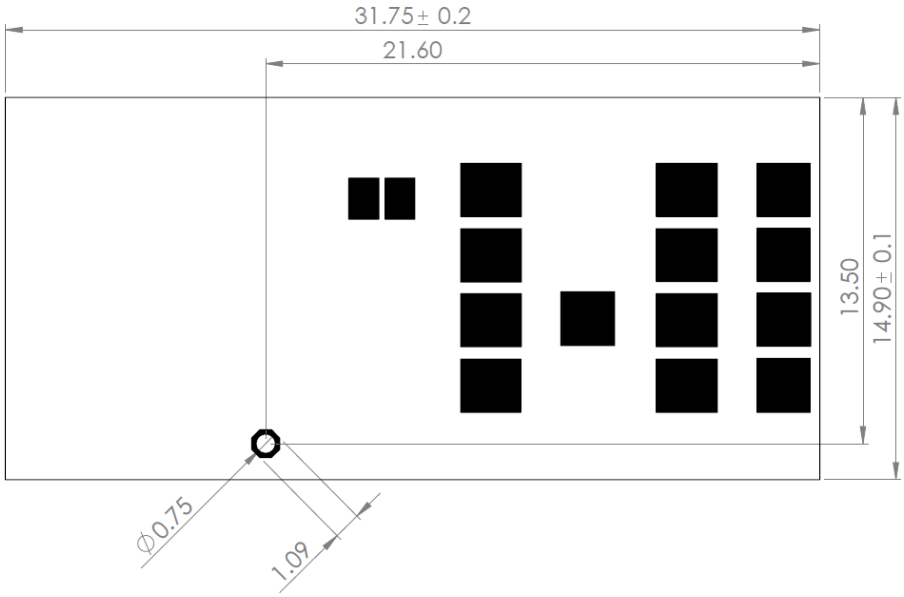
Diagram 5: *TR-72DA relative RF range vs. antenna height above the ground, 868 MHz and 916 MHz bands.*

Mechanical drawings

TR-72D(C)(T)



TR-72DA(T)



Top view, Units: mm

Hardware revision

- TR-72D(A) v2.16 Minor improvements to optimize production.
- TR-72DA v2.15 Minor improvements to optimize production.
- TR-72D(A) v2.14 Minor improvements to optimize production.
- TR-72DA v2.13 Minor improvements to optimize production.
- TR-72D(A) v2.12 Minor HW changes. TR-72DA parts suitable also for 916 MHz band are marked “868/916” by laser.
- TR-72DA v2.11 EAP samples, minor HW changes, 868 MHz only.
- TR-72D v2.10 EAP samples, standard dimensions, 868 MHz only.
- TR-72DA v2.02 EAP samples, length 33.8 mm, 868 MHz only.
- TR-72DA v2.01 EAP samples, limited RF range, 868 MHz 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

TR-72Dx modules should be mounted in SIM connector. They are not intended for SMT reflow soldering. Recommended SIM connector: KON-SIM-02 or KON-SIM-01.

It is not allowed to connect wires to pads (except the M1, M2 and S1 pads) by soldering.

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-72Dx modules:

- Wired upload with TR-72Dx plugged via the SIM connector in the CK-USB-04(A) programmer.
- For TR-72Dx 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 ™*.

Product information

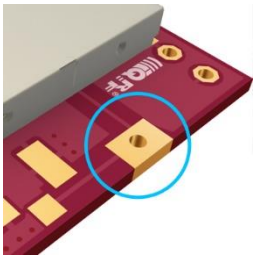
Ordering codes

TR-72D A P

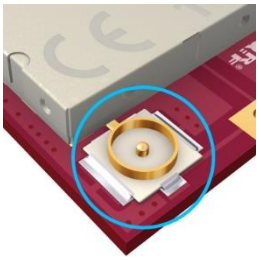
- Peripheral options
  - **nil** - No other option
  - **T** - Temperature sensor
- Antenna options
  - **nil** - soldering pad-hole (no antenna, no U.FL connector)
  - **A** - PCB antenna
  - **C** - U.FL connector (mini-coax)
- Transceiver series. TR / DCTR are not differentiated from IQRF OS v4.02D.

Type	Antenna connection	Data controlled	Temperature sensor
TR-72D	Soldering pad-hole	Yes	–
TR-72DC	U.FL connector	Yes	–
TR-72DA	PCB antenna	Yes	–

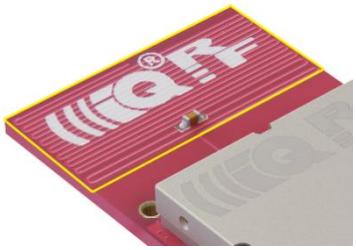
Type	Antenna connection	Data controlled	Temperature sensor
TR-72DT	Soldering pad-hole	Yes	Yes
TR-72DCT	U.FL connector	Yes	Yes
TR-72DAT	PCB antenna	Yes	Yes



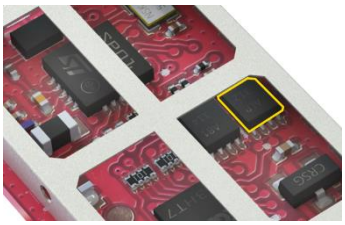
TR-72D



TR-72DC



TR-72DA



TR-72DT

Document history

- 220309 Minor bug in circuit diagram fixed. Note 1 on page 5 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 1* added to Pin description table. Paragraph *Programming (upload)* in chapter *Application* slightly extended. Chapter *Sealing* relocated into Application note *AN015 – IQRF HW design*, chapter *Sealing*.
- 191010 Supply current in TX mode in *Electrical specifications* modified. Updated for TR-72D v2.16.
- 190626 Updated for TR-72DA v2.16.
- 180627 *Diagram 2C* added. TR-72DA HW v2.15 added to chapter *Hardware revision*.
- 180130 Block diagram revised. RF parameters in chapter *Electrical specifications* revised. HW revisions updated. Chapter *RF range* extended. Directives in *Quality management* updated.
- 171108 Pins description page slightly precised regarding mechanical holes M1 and M2. Legend at Diagrams 2A, 2B, 3A and 3B slightly precised.
- 170823 Updated for IQRF OS v4.02D.
- 170810 Updated for TR / DCTR fusion from IQRF OS v4.01D. Mechanical drawings and Recommended PCB layout updated. TR size rounded to 25.1 mm in chapter *Electrical specifications*. *Diagram 4* updated. Some minor improvements.
- 170322 Diagrams 3A and 3B added. Preliminary.
- 170314 Updated for HW v2.14 and IQRF OS v4.00 (preliminary). *Electrical specification* revised. Chapter *Sealing* added. Chapter *RF range* revised. Variances in mechanical drawings slightly precised. Some minor improvements.
- 160302 Notice of local provisions added to chapter *Application*.
- 160219 More detailed RF range specification. C7 and C8 pin description extended.
- 151005 ETSI directives updated.
- 150810 Revised. Preliminary.
- 140430 Preliminary.

Sales and Service

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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).

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