



Operational description

RF-module

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1 Introduction

This document describes the operational description of RF-module and it's operation in the host application.

2 General description

2.1 Application

The modules will be used in a radio remote control system.

These systems can be applied in extreme conditions such as:

- Humid / wet environment (IP65)
- Temperature (-40 to +85 ° C)
- Subject to continuous vibrations (build-up on a machine)
- Long distances required (> 1000m free field)
- Indoor (warehouses; a lot of steel and a lot of reflections)
- Emergency stop systems with radio surveillance (out of range protection, redundant UID control)
- Systems are sold in: Europe (ETSI), America (FCC)
(Optional: Canada (IC), Australia, Japan (ARIB))
- At least 5 sets must be able to work side by side without interference
- Control of winches and motors. So a reaction speed of <100mS possible.

2.2 Standards

The module will have to comply with EN300-220 CAT.1 for the ISM bands (433 MHz / 868MHz) and for the US market the FCC (RP 15,247) in the 915MHz band.

With the usage of defined antenna / antennas the host containing the RF-module will be compliant to the applicable standards.

2.3 Operation

The module must be able to be bi-directional.

Several hand transmitters will have to be able to communicate bi-directionally with a receiver unit.

In order to give our controller time to formulate a response to a message, it will be necessary that there is 20mS between the IRQ becoming active and that a message must be in the module to be returned that same cycle.

Because these are transceivers, this must also be possible the other way around (multiple receivers on one transmitter).

2.4 Dimensions

The module should be a maximum size of 25.40x23.81mm.

The antenna on the handheld transmitter must become internal.

The receiver unit will be equipped with an external antenna.

3 List of requirements

3.1 General requirements:

- Class 1 radio
- Compact size (25.40x23.81mm)
- A 434 / 868MHz PCB version with mounting variants for 434MHz and 868MHz.
- A separate PCB version for 915MHz.
- 433MHz and 868MHz must comply with EN300-220 CAT.1
- 915MHz must comply with FCC / IC (Canada)
- 5 sets can work side by side without problems.
- Response time <100mS (number of TX packets> 10 per second)
- Transmit power <= 50mW (17dBm)
- Reception sensitivity higher than -120dB
- 5 byte data during the teaching (pairing) process.
- Adjustable payload up to 24 bytes
- Automatic package handling with CRC
- Low power consumption mode because of battery powered system
- Bi-directional communication (half duplex)
- On-board controller that controls all RF communication,
- Communication between RF module and our controller via SPI (I2C is an option).
- Adjustable configuration; RF power, RF packet lengths, RF frequency (only at 434MHz), power saving options
- Possibility for firmware updates
- Source HW and SW incl. Commentary and documentation and development tools for Tyro

3.2 Module specific requirements

Requirement	434MHz	868MHz	915MHz
Class	1	1	NA
RF standard	ETSI (EU)	ETSI (EU)	FCC (US)
Required range in open field	1000m	700m	700m
Spread spectrum required	No	Yes	Yes

Since 915MHz uses spread spectrum over 50 channels.

434MHz and 868MHz only hop over 8 channels. As a result, it is not possible to make enough different patterns to minimize the chance that systems will continuously disturb each other. For this it is therefore necessary that a system can recognize and avoid another system

In addition, 434MHz also has the option to be set to a fixed frequency.

3.3 Goal

3 modules (433MHz, 868MHz, 915MHz) will comply to the standards above.
The same RF-chipset will be used for all three variants.

With the chosen topology there is a central master in each set that communicates with multiple slaves. The slaves do not communicate with each other. The master ensures that all modules within a system are synchronized and use the same cycle timing. In a cycle there are several time slots for the master itself and for the different slaves. Time slots are always reserved for the maximum number of slaves (10), even though not many slaves are used. A master and a slave are hardware and software moderately the same, only configured differently at runtime. The rest of this document is based on the above topology.

3.4 Communication interface

- SPI interface (standard)
- I2C interface is defined in hardware (option for future firmware versions)
- IRQ line (packet received in RX mode, packet send in TX mode)

3.5 SPI interface

- Details of the SPI-interface are defined in the SPI-interface-document.

3.6 Payload and addressing

The combination of the chosen cycle time, baud rate and payload size means that it is not possible for all slaves to send the maximum format message (24 bytes) in the same cycle.

Therefore, in this topology it is decided that each slave in each cycle can send a “status message” with a fixed size of 5 bytes. A single slave designated by the master as an “active slave” sends a complete message in a specially designated time slot instead of a status message.

It is also possible that the master does not designate an active slave, so that all slaves send a status message.

The master can indicate in the header of a message for whom that message is intended. It can be for a single specific slave or for all slaves. The slave is set by default to respect this addressing and only put data in the RX buffer that is intended for it. It is possible to place all messages that his master sends in the RX buffer.

This functionality is necessary to maintain a safety-tested out-of-range security without forcing the master to always send everything as broadcast.

3.7 Response speed

The response speed of our systems is specified at 100ms.

This is counted from pressing the button on the transmitter to switching the relays on the receiver.

Reading the keyboard, sending to the module, reading from the module, transferring over the internal bus and switching the relay takes worst-case 35ms together. This would leave 65ms for the radio itself.

This response speed only applies from the sender to the receiver and in many of those situations the full 24 bytes payload is not required

3.8 Buffer

- The master has a separate receive buffer for each slave that can contain 1 complete message.
- The slave has a single buffer that can contain 1 complete message.
- Both have a single transmission buffer that can contain 1 complete message.

3.9 Pairing

All receivers have a button that allows the user to put the receiver in pairing mode. Such a button is not present on the channels. Therefore, it will be necessary for a transmitter to be able to attempt to initiate a pairing process without disrupting normal operation if there is no receiver nearby that is also in pairing mode.

The SPI interface document describes a pairing method that meets this requirement.

3.10 Do not send unnecessarily

Systems should not transmit unnecessarily when not in use.

With hand transmitters, the radio is de-energized when the hand transmitter is not used, so there will be no unnecessary transmission.

Receivers, on the other hand, remain on voltage.

Slave receivers will not transmit unnecessarily because they only transmit in response to a message from a master, which is not present when the system is not used. Master receivers control themselves, even if the system is not used. This requires wake-up functionality.

A master receiver will not transmit after start-up, but will first wait for a wake-up message from a slave transmitter.

After he has received it, he continues to send until we reset it and he starts listening again.

After starting up, a slave transmitter will send wake-up messages on its own initiative if it does not already see its master.

3.11 Voltage range:

2.9V - 3.8V

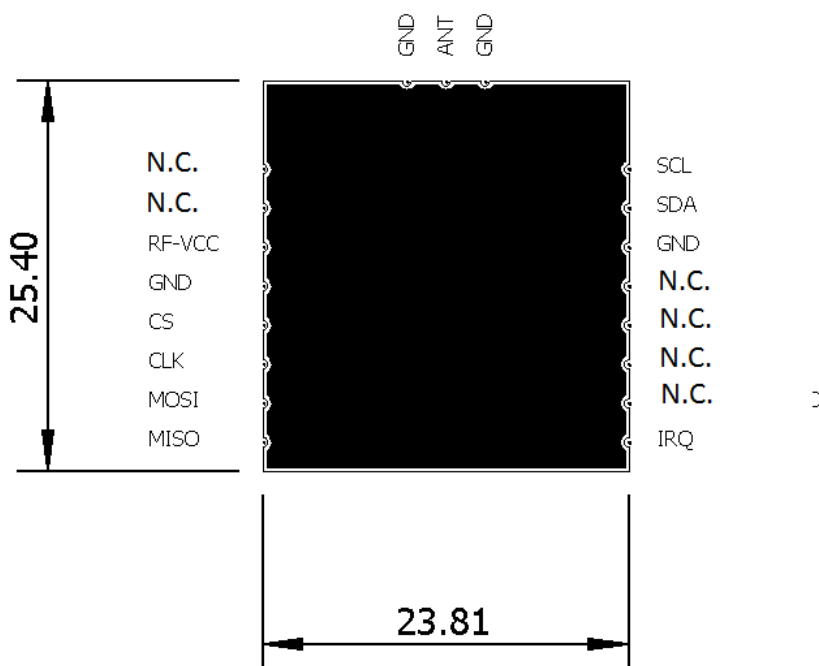
3.12 Power consumption:

The power consumption of the module should be as low as possible because transmitters are battery powered. A specific transmitter is even battery powered and therefore needs additional energy saving options.

- (slave) Do not send empty idle messages
- (master) Send fewer empty idle messages (still enough to keep synchronization)
- (master) Don't expect status messages. Sleep / standby in those timeslots instead of RX mode.

3.13 Format:

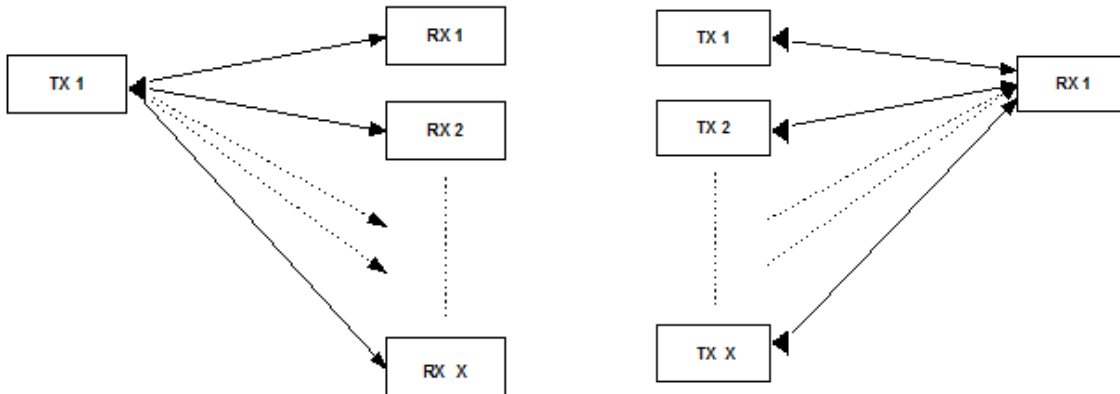
- Stamp contacts (suitable for reflow)
- Pin compatible with existing module (2.54mm pitch, see figure below)
- Antenna via contact or U-FL connector
- Single sided 4-layer 0.8mm pcb. (total height pcb + components + shielding max. 3mm)



4 RF Topology

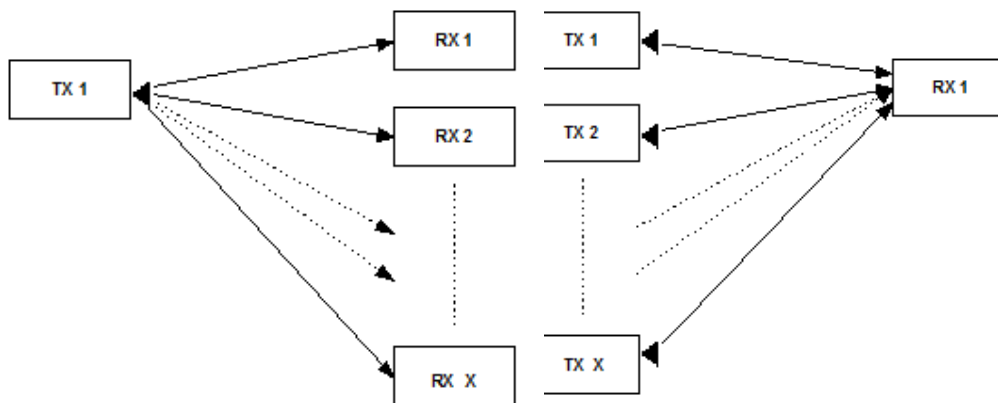
In general there are two different usecases

A) 1-to-10 / 10-to-1



A single module (master) is connected to a maximum of 10 modules (slaves).
Each slave has its own time slot in the protocol. This is the standard situation.

B) 1-op-X / X-op-1



A single module (master) is connected to more than 10 modules (slaves).
Multiple slaves can be set to the same time slot and the master UID is known to all slaves.
But because the slaves are set not to send empty packets (power saving option),
they will not disturb each other as long as they do not want to send messages themselves.

The master can send normal broadcasts that arrive to all slaves because the master UID is known to all slaves.
The slave UIDs are not known to the master, so it will be necessary for the slaves to use the master UID in the messages they send back (with a flag that prevents other slaves from thinking this message is coming from the master).

If several slaves try to control at the same time, they can disturb each other. This will not be detected by the radio module and it is up to the Tyro application itself to resend the message if it is lost.

Using the master UID as a slave should be a configuration option specifically for this mode.

5 FCC Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

Reorient or relocate the receiving antenna.

Increase the separation between the equipment and receiver.

Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Consult the dealer or an experienced radio/TV technician for help.

To assure continued compliance, any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. (Example - use only shielded interface cables when connecting to computer or peripheral devices).

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference, and
- (2) This device must accept any interference received, including interference that may cause undesired operation.

FCC Radiation Exposure Statement:

"This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter".