



Product Development

LRM2+PA Radio Module

Document p/n: 9S02-8969-A004 Rev.B

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Revision History

| Date | Revision | Description | Signature / Date | |
|------------|----------|---------------|------------------|--------|
| 2024-07-10 | A | Initial draft | Prepared | H. Lin |
| | | | Verified | |
| | | | Approved | |
| 2024-09-24 | B | Updated | Prepared | H. Lin |
| | | | Verified | |
| | | | Approved | |
| | | | Prepared | |
| | | | Verified | |
| | | | Approved | |
| | | | Prepared | |
| | | | Verified | |
| | | | Approved | |

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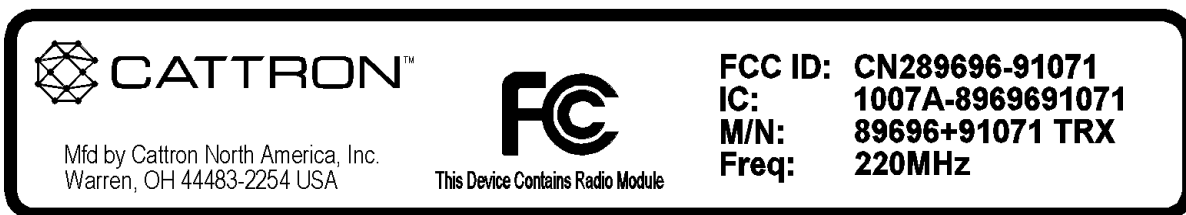
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89696+91071 TRX module meets Part 15 of the FCC and ISSED rules and regulations. Compliance with the labeling requirements, FCC/ISED notices is required. In order to comply with Certification requirements, the Original Equipment Manufacturer (OEM) must fulfill the following requirements.

1. The system integrator must place an exterior label on the outside of the final product housing the 89696+91071 TRX Module. The figure below shows the contents that must be included in this label.
2. 89696+91071 TRX modules may only be used with the antennas that have been tested and approved for use with the module.

Labeling Requirements

The OEM must make sure that FCC/ISED labeling requirements are met. This includes a clearly visible exterior label on the outside of the final product housing that displays the contents shown in below.



WARNING: The 89696+91071 TRX modules have been tested by the FCC for use with other products without further certification (as per FCC Section 2.1091). Changes or modifications to this device not expressly approved by Cattron North America Inc. could void the user's authority to operate the equipment.

NOTICE: OEM's must verify the final product complies with unintentional radiators (FCC Section 15.107 and 15.109) before providing a declaration of conformity for their final product to Part 15 of the FCC Rules.

NOTICE: The 89696+91071 TRX modules have been certified for mobile and fixed radio applications. If the module will be used for portable applications, the final device must undergo SAR testing.

RF Exposure WARNING: This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 22.4 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

NOTICE: The preceding statement must be included as a CAUTION statement in OEM product manuals to alert users of FCC/ISED RF Exposure compliance.

89696+91071 TRX is designed for use in countless wireless applications requiring long range communications with low energy consumption. 89696+91071 TRX is limited to OEM installation ONLY. The OEM integrator is responsible for ensuring that the end-user has no manual instructions to remove or install the module.

FCC Part 15.19 Warning Statement

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 UNDESIRE OPERATION.

FCC Part 15.21 Warning Statement

NOTE: THE **GRANTEE** IS NOT RESPONSIBLE FOR ANY CHANGES OR MODIFICATIONS NOT EXPRESSLY APPROVED BY THE PARTY RESPONSIBLE FOR COMPLIANCE. SUCH MODIFICATIONS COULD VOID THE USER'S AUTHORITY TO OPERATE THE EQUIPMENT.

FCC Part 15.105(b) Warning Statement- (ONLY Required for 15.109-JBP devices)

NOTE: 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 or more 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.

IC RSS-GEN, Sec 8.4 Warning Statement

ENGLISH:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

FRENCH:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Only the following authorized antennas or the antenna gain less than highest gain antenna for each band may be used with the equipment:

- 220MHz ¼ wave whip antenna (50 Ohm, EXB220TN or equivalent, 0dBi),
- 220MHz ½ wave Omni mag Antenna (50 Ohm, ASPH7455 or equivalent, 5.15dBi);
- 220MHz ½ wave dipole antenna (50Ohm, 2.15dBi)

1. Introduction

1.1 Purpose

A new family of RF module, the LRM2 family, is being developed by Catttron North America Inc. This family is employing Silicon Labs EFR32FG13 Flex Gecko SoC (System on Chip), which is including a high performance Radio transceiver and a high performance Micro-Controller Unit.

1.2 Scope

This document describes the host interface signal definitions, timings, operation mode, available functionalities, and provide details about its integration to Unity products. This document does not cover RF specifications or power supply specifications.

1.3 Applicability

Applies to LRM2 and PA family members, P/N 2PCA-8969-xxxx; 2PCA-9107-Xxxxx

1.4 Definitions, Acronyms

1.4.1 Definitions

1.4.2 Acronyms

| | |
|---------|-----------------------|
| LRM2&PA | Radio Module |
| MCU | Machine Control Unit |
| SoC | System-On-Chip |
| OCU | Operator Control Unit |

1.5 References

- [1] “Schematic Drawing for LRM2”, Catttron P/N 9D02-8969-X001
- [2] “Schematic Drawing for PA”, Catttron P/N 9D02-9107-Xxxx
- [3] “Unity RF Telegrams Format”, Catttron P/N 9S01-7640-A101
- [4] “LRM2 Radio Module – Configuration Registers Specifications”, Catttron P/N 9S02-8969-A003

2. Features Summary

The LRM2+PA is designed to replace Remtron products with less cost and improved performance. Its host interface is compatible with previous LRM(2PCA-7954-xxxx) and PA series.

- Direct electrical compatibility to LRM (2PCA-7954-xxxx) interface
- On-board wireless SoC– The interface is controlled by an on-board Silicon Labs EFR32FG13 SoC. The EFR32FG13 Flex Gecko SoC includes both a high-performance radio transceiver and a high performance, low power Micro-Controller.
- Minimum buffers/Minimum Delay – LRM2 firmware is implemented to provide a “almost transparent” operation; transmission and reception delays are kept to a minimum.
- Support for different Modulation modes– The LRM2&PA family is designed to support multiple different RF Modulations , which is transparent to Host firmware.

These different aspects are covered in the rest of this document.

3. Host Interface Definition

3.1 Pins Assignment

| Board to board connector Pin Details | | | |
|--------------------------------------|----------------------|------------|----------------------|
| J1 | | | |
| Pin number | Signal name | Pin number | Signal name |
| 1 | GND | 2 | GND |
| 3 | TDI-RF | 4 | nRESET-RF |
| 5 | MASTER-CTRL-US1-RX-M | 6 | RFIO-2-M |
| 7 | GND | 8 | MASTER-DATA-US0-TX-M |
| 9 | I2C0-SDA-RF | 10 | RFIO-3-M |
| 11 | I2C0-SCL-RF | 12 | TDO-RF |
| 13 | GND | 14 | MASTER-DATA-US0-RX-M |
| 15 | RFIO-1-M | 16 | TMS/SWDIO-RF |
| 17 | BOOT-EN/RFIO-0-M | 18 | TCK/SWDCLK-RF |
| 19 | GND | 20 | MASTER-CTRL-US1-TX-M |

| J5 | | | |
|------------|---------------------|------------|-------------------|
| Pin number | Signal name | Pin number | Signal name |
| 1 | GND | 2 | GND |
| 3 | nRESET-M | 4 | 3.3V |
| 5 | nRESET-S | 6 | 3.3V |
| 7 | BOOT-EN/RFIO-0-S | 8 | GND |
| 9 | SLAVE-DATA-US0-RX-S | 10 | REV_AN |
| 11 | SLAVE-CTRL-US1-RX-S | 12 | RFIO-1-S |
| 13 | SLAVE-DATA-US0-TX-S | 14 | ANT_SEL |
| 15 | SLAVE-CTRL-US1-TX-S | 16 | FWD_AN |
| 17 | READY | 18 | READY (For PA_EN) |
| 19 | GND | 20 | GND |

Table 3.1 – Host Interface pins assignment

3.2 Signals Description

| Net Name | General Description |
|----------------------------|--|
| TCK/SWDCLK-RF | GPIO (5V) |
| TMS/SWDIO-RF | GPIO (5V) |
| TDO-RF | GPIO (5V) |
| TDI-RF | GPIO (5V) |
| MASTER-DATA-US0-TX-M | GPIO (5V), UART_RX for Master data signals |
| MASTER-DATA-US0-RX-M | GPIO (5V), UART_TX for Master data signals |
| RFIO-2-M | GPIO (5V), RFIO-2_Master |
| RFIO-3-M | GPIO (5V), RFIO-3_Master |
| 3.3V | Radio Power Supply |
| 38.4MHz crystal Oscillator | High Frequency Crystal input, 38.4MHz crystal Oscillator |
| | High Frequency Crystal output, 38.4MHz crystal Oscillator |
| nRESET-RF | Reset input, active low, nReset_Radio (Input from JTAG connector) |
| Sub GHz RF Output | Sub GHz Differential RF output, positive path |
| | Sub GHz Differential RF output, negative path |
| Sub GHz RF Input | Sub GHz Differential RF input, positive path |
| | Sub GHz Differential RF input, negative path |
| GND | Radio Ground |
| GND | Power Amplifier (PA) voltage regulator VSS |
| GND | 2.4 GHz Differential RF input/output, negative path |
| 2G4RF_IOP | 2.4 GHz Differential RF input/output, positive path |
| PAVDD | Power Amplifier (PA) voltage regulator VDD input |
| nRESET-M | nRESET_M (Reset output for Master controller) |
| nRESET-S | nRESET_S (Reset output for Slave controller) |
| BOOT-EN/RFIO-0-S | RFIO-0_Slave |
| SLAVE-DATA-US0-RX-S | UART_TX for slave data signals |
| SLAVE-DATA-US0-TX-S | UART_RX for slave data signals |
| SLAVE-CTRL-US1-RX-S | UART_TX for Slave control signals |
| SLAVE-CTRL-US1-TX-S | UART_RX for Slave control signals |
| TCXO_EN | GPIO for TCXO_EN |
| TX/nRX | GPIO (5V), TX/nRX (GPIO to enable RF switch#01 & 02) |
| READY | GPIO for GREEN LED. Multiplexed with READY (GPIO output) |
| REV_AN | REV_AN |
| RFIO-1-S | RFIO-1_Slave |
| 3.3V | Analog power supply |
| ANT_SEL | ANT_SEL (GPIO to enable RF switch#03 which will be located on MCU board) |
| FWD_AN | GPIO for RED LED. Multiplexed with FWD_AN (For power amplifier. It is not required in our design. Just provision for catttron team) |

| | |
|-------------------------|---|
| GND | Voltage regulator VSS |
| NC | Kept it NC |
| 3.3V | 3.3V Supply |
| 3.3V | 3.3V Supply |
| GND with decoupling cap | Decouple output for on-chip voltage regulator |
| 3.3V | 3.3V Supply |
| BOOT-EN/RFIO-0-M | |
| RFIO-1-M | RFIO-1_Master |
| I2C0-SCL-RF | I2C0_SCL |
| I2C0-SDA-RF | I2C0_SDA |
| MASTER-CTRL-US1-RX-M | UART_TX for Master control signals |
| MASTER-CTRL-US1-TX-M | UART_RX for Master control signals |

Table 3.2 - Host Interface signals description

4. Functional Description

4.1 Overview

4.1.1 LRM2 and PA Radio

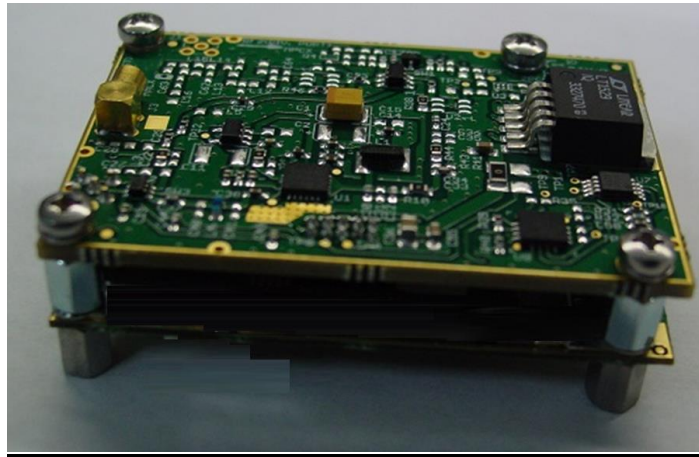


Figure 4.1 –LRM2 +PA Radio

The Silicon Labs ERF32FG13 SoC is located between the host interface and the RF interface, providing decoupling between host and RF interface. The EFR32FG13 SoC has sufficient buffer space for one telegram.

As shown later, telegram processing is defined to minimize delays, so to provide a “transparent-like” behavior.

Sub-GHz will support different frequency bands to support different regions & supported frequency bands are mentioned below:

- Propriety Sub-GHz protocol:
 - 460MHz
 - 868MHz
 - 220MHz

4.1.2 Data Communication Model & Definitions

The communication model defines some of the terminology used in the rest of this document.

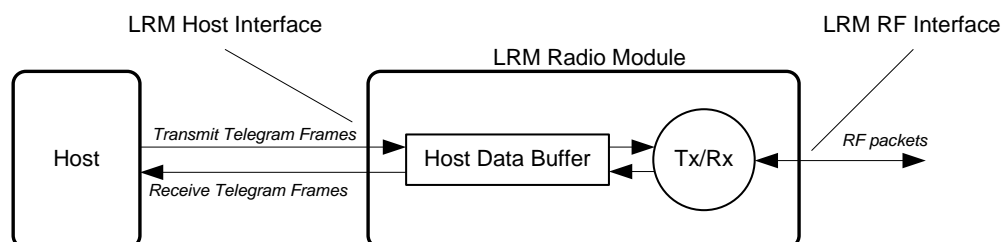


Figure 4.2 - Data communication model

- The LRM2 Radio Module is used to communicate telegrams between **hosts**. In Unity context, hosts are OCU and MCU CPU boards. The LRM2 has two interfaces: a **Host Interface** and a **RF Interface**.
- Transmit and Received Telegrams are relayed through the LRM2 **Host Data Buffer**. This buffer is capable to hold only one telegram at a time. The purpose of this buffer is to relax host timings requirements, and to allow decoupling between Host Interface and RF Interface data rates.
- Telegrams sent/received on the Host Interface and RF interface are encapsulated into **frames** to improve synchronization.
- The LRM2 does not perform any processing on the telegrams content; it controls only the frames overhead.

4.2 Telegram Transmission

Transmit frames have two fields:

- Telegram length (number of bytes). The length is used by the CPU to control the transmission process.
- Telegram (maximum 254 bytes). The content of the telegram is defined by the application. For Unity application, this is the Unity Telegram beginning with the Scrambling byte, the TID and terminated with the 16bits CRC, as defined in ref [2].



Figure 4.3 - Transmit Telegram frame format

4.3 Telegram Reception

Each RF packet received by the LRM2 is sent to the host interface, followed by its RSSI. Also, in order to ensure receive telegram frame synchronization (i.e. unambiguous detection of the start of the frame), the frame is encapsulated according to SLIP framing. SLIP framing is very simple to decode. It is described in section **Error! Reference source not found.**

Receive frame fields are:

- SOF (Start-of-Frame character). This is part of SLIP encapsulation.
- Length of the Telegram field (number of bytes), not counting RSSI fields and any additional control characters introduced for SLIP encapsulation.
- Telegram (maximum 254 bytes). The content of the telegram is defined by the application.
- RSSI: Received signal strength for this frame. RSSI is an 8 bits integer value, expressed in dBm. Range;-128 to +127 dBm.



Figure 4.4 - Receive Telegram frame format

5. LRM2&PA Configuration Concept

All LRM2&PA configuration and status parameters are accessible through addressable registers.

- All parameters can be read and written only in CONFIG mode.

The definition of the configuration registers is given in reference [3]. This section addresses the basic description of all these three methods.

5.1 Console Interface

The Sub-GHz serial interface configuration port is enabled by asserting !CONFIG signal; the serial interface is automatically reconfigured in asynchronous mode, running at 38400bps, 8N1. All ASCII strings received are interpreted as configuration commands. This mode is particularly useful for stand-alone testing, when the unit can be controlled from a PC or by an operator/tester using a terminal emulation program.

5.1.1 “Write” command

wrCmd register value , where:

- wrCmd = write command. “w” or “wr” can be used and are equivalent
- register = register identification. Can use the register name or register address
- value = value to be written, in decimal or hexadecimal format. Hexadecimal values are preceded by ‘0x’

5.1.2 “Read” command

rdCmd reg where:

- rdCmd= read command. **r** or **rd** can be used and are equivalent
- reg = register identification. Can use the register name or register address

5.1.3 “Help” command

helpCmd where:

- helpCmd= help command. **h**, **help** or **?** can be used and are equivalent.

The LRM2&PA responds with the list off all available configuration registers.

5.2 Stand-Alone Test Mode

The LRM2&PA can be operated in stand-alone mode for production/service tests. In this case, only a 5.0VDC supply is needed, and a RS232/TTL transceiver (like Catron FLASHBOX) to connect to a PC serial port.

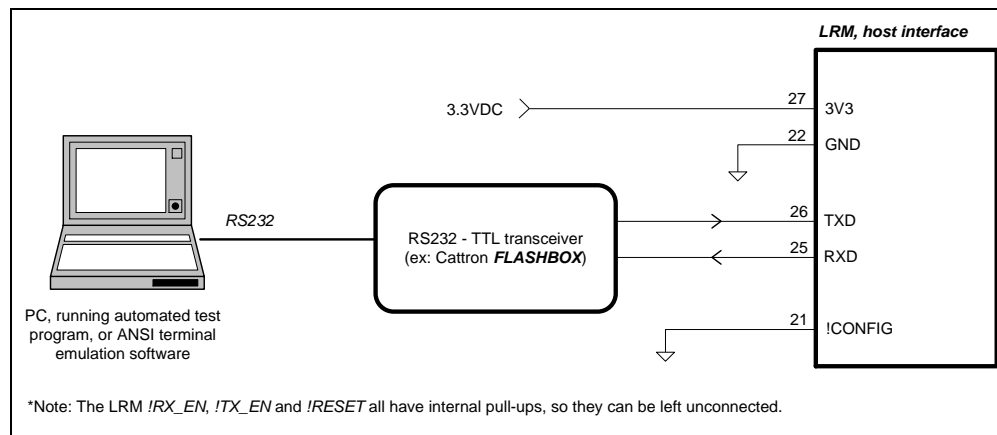


Figure 5.1 - LRM2 connection for stand-alone operation

The LRM2&PA will support several built-in test modes to ease testing from a PC. For example

a. Sub-GHz Transmission Tests

- Generation of different type of carrier: unmodulated (CW), or modulated with "101010.." or pseudo-random sequence
- Automatic generation of test RF frames with predefined content

b. Sub-GHz Reception Tests

- Measure PER (packet error rate) when receiving the predefined test RF frames
- Measure RF input level

c. Bluetooth Tests

- By using Silicon Labs application, "Wireless Gecko", the Bluetooth channel, transmit power level, data speed could be adjusted.