

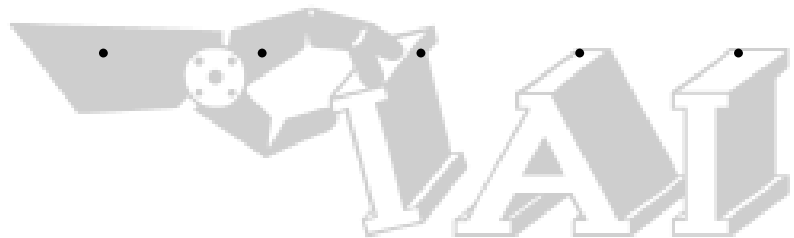
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Intelligent Automation Incorporated

Gallium Radio

User Manual v1.0



Operating Manual

Gallium Radio

Version 1.1, September 20, 2021

1 FCC Certifications and Regulatory Information

FCC Part 15 Class B

Radio Frequency Interface (RFI) (FCC 15.105)

This device has been tested and found to comply with the limits for Class B digital devices pursuant to Part 15 Subpart B, of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential environment. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, 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 and 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.

Labeling Requirements (FCC 15.19)

This device complies with Part 15 of 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.

Modifications (FCC 15.21)

Changes or modifications to this equipment not expressly approved by Intelligent automation, Inc. may void the user's authority to operate this equipment.

Information to the user (FCC 18.213)

Gallium radio is subject to interference in the 902-928 MHz ISM band, to avoid interference, you may want to have the radio physically away from source of interference in this band and/or switch carrier frequency within ISM band. See section 6 for carrier frequency change.

2 Overview

This document explains how to operate and configure Gallium radios via an attached Linux machine.



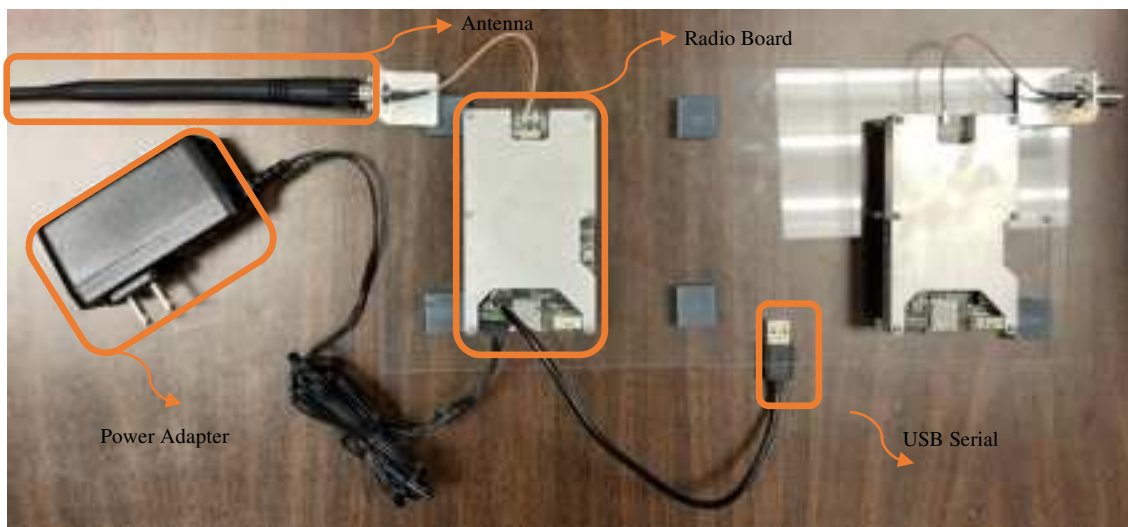
3 Components

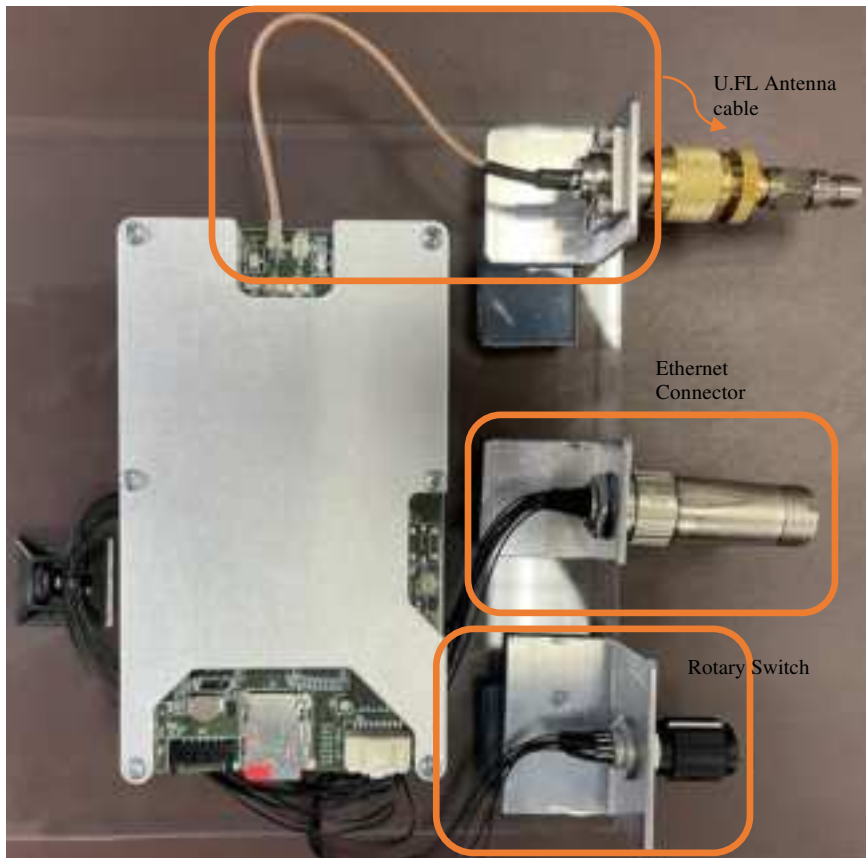
Here are items that come with the radio:

1. Gallium radio board with SD card installed.
2. RP-TNC antenna.
3. Wall power adapter.
4. Micro USB connector.
5. Rotary switch with attached cable.
6. Ethernet circular connector with attached cable.

Compliance with FCC rule part 15.27:

The items and accessories mentioned above are included in the system to comply with the emission limits in this part.





4 Installation & Power up

- Connect the USB cable to a Linux or Windows operating system.
- Connect U.FL cable to port RF1 on the PCB board
- Connect RP-TNC antenna to TNC connector on the radio lab setup.
- Connect Ethernet/Rotary Switch cable to port J4 on the PCB board
- Connect power adapter to a power outlet.
- Switch rotary switch from position 0 to 1. This will power up the radio.
- Wait until green led on the right side of radio board turns green.

5 Connecting to the radio via serial port

With USB cable, we can access the radio via serial port. First, open the terminal app on the laptop by hitting Windows button and search for terminal. To find out the connected USB device on Linux OS, you could perform the following command on the terminal:

```
$ ls /dev/ttyUSB*
```

Results:

/dev/ttyUSB0

Now, you can connect with our serial command app, minicom, to the discovered USB device (ttyUSB0). Here's the Linux command to connect via minicom:

```
$ sudo minicom -s
```

You would root privilege for this command.

```
+-----[configuration]-----+
| Filenames and paths         |
| File transfer protocols     |
| Serial port setup           |
| Modem and dialing           |
| Screen and keyboard         |
| Save setup as dfl           |
| Save setup as..             |
| Exit                         |
| Exit from Minicom           |
+-----+
```

Go to Serial port setup and make sure the device is set according to the recognized USB device (in this case ttyUSB0). The rate is 115200 Bps and NO hardware flow control.

```
+-----+
| A -   Serial Device       : /dev/ttyUSB0 |
| C -   Callin Program      :               |
| D -   Callout Program     :               |
| E -   Bps/Par/Bits        : 115200 8N1    |
| F -   Hardware Flow Control : No          |
| G -   Software Flow Control : No          |
|                               |
|   Change which setting?   |
+-----+
```

Hit Enter to save the settings and exit from the settings.

```
+-----[configuration]-----+
| Filenames and paths          |
| File transfer protocols      |
| Serial port setup           |
| Modem and dialing           |
| Screen and keyboard         |
| Save setup as dfl           |
| Save setup as..             |
| Exit                         |
| Exit from Minicom           |
+-----+

```

If serial port is connected correctly you will be presented with login message like below. You might need to hit more Enter to see the login:

```
Welcome to minicom 2.6.2

OPTIONS: I18n
Compiled on Jun 10 2014, 03:20:53.
Port /dev/ttyUSB0

Press CTRL-A Z for help on special keys

sparrow login: █

```

For login, enter 'root' as username and then password again as 'root'

```
Welcome to minicom 2.6.2

OPTIONS: I18n
Compiled on Jun 10 2014, 03:20:53.
Port /dev/ttyUSB0

Press CTRL-A Z for help on special keys

sparrow login: root
Password:
root@sparrow:~# █

```

After login, we perform waveform reset twice to have radio send heart bit signal (SYNC) periodically. Below is the command:

```
root@sparrow:~# niquist_reset
niquist reset ..
root@sparrow:~# niquist_reset
niquist reset ..
root@sparrow:~#
```

6 Changing Carrier Frequency

The radio configuration is set in the following file `/etc/sparrow_cfg.json`. In order to change any configuration, we can edit this file and run re-initialize the radio. Instead of re-initialization you may opt to reboot the radio too. After the boot up, the changing configuration will take effect.

Here's an example to modify the carrier frequency:

```
root@sparrow:~# vi /etc/sparrow_cfg.json
```

Open the configuration file with `vi` command. Scroll to `"loFreqHz" : 915000000`

```
"adi": {^M
  "loFreqHz": 915000000,           // LO Center frequency in Hz^M
  "rf_bw" : 40000000,             // digital BW^M
  "ext_lo_en": true,              // External LO enable^M
  "txAttnmdB": 10000,             // TX attenuation in mili-dB^M
  "rxGaindB": 15,^M
  "tpm_test": false,              // Enable ADI Transmit Power Monito
                                   // Captures player data via the TPM
  "gainModeAuto": false,          // Enable ADI RX AGC^M
  "dig_loopback_en": false,       // Enable ADI digital interface loo
                                   // FPGA. Digital loopback has highe
- /etc/sparrow_cfg.json 24/67 35%
```

And modify the LO frequency in Hz. To edit, first hit `'i'` and then edit with the new frequency, and then hit `'Esc'` and then `':wq'` and then `'Enter'`.

Note:

- To comply with FCC allowed 900 ISM band, the minimum and maximum frequency we can set is the following: 905,500,000 Hz & 924,500,000 Hz

After the file edited you can verify it by:

```
root@sparrow:~# cat /etc/sparrow_cfg.json
```

To see if the new frequency is set correctly. Then you need to reboot the radio by this command:

```
root@sparrow:~# reboot
```

When radio rebooted, you should login again (login: root, password: root), and perform reset twice.

```
root@sparrow:~# niquist_reset
niquist reset ..
root@sparrow:~# niquist_reset
niquist reset ..
root@sparrow:~#
```

7 Transmit Enable/Disable

We can set a parameter to enable and disable transmission. The radio configuration is set in the following file: /etc/sparrow_cfg.json. In order to change any configuration, we can edit this file and reboot the radio.

We have to open /etc/sparrow_cfg.json file with vi command and set tx_enable parameter to 0 or 1. 1 to enable and 0 to disable radio transmission. After editing, we should close the file with :wq command and reboot the system.

8 Changing Transmit Power

Gallium radio we can operate in 2 power levels. We have 2 stages of power amplifier that depending of settings can generate either 23 dBm or 30 dBm output power. We can change this power both from the configuration file at : /etc.sparrow_cfg.json or by mechanically switching the rotary switch to position 2 from 1.

In order to change the power setting, we can edit this file and reboot the radio. After the boot up, the changing configuration will take effect.

Here's the instruction to modify the transmit power via configuration file:

```
root@sparrow:~# vi /etc/sparrow_cfg.json
```

Open the configuration file with vi command. Scroll to "tx1_pa_en" and set it to either "false" or "true". With "true", we select the highest power at 30 dBm and with "false" the power will change to 23 dBm.


```
// NOTE: The TX channel # is always the opposite of RX channel #.
"tx": {
    "tx_both_ch": false,           // set both RF analog paths for tr.
                                   // If rx_both_ch is set this setti.
    "play_en": false,             // enable the TX player
    "filename1": "tone_32_3.bin",  // TX player channel 1 test vectore
    "filename2": "tone_16_1.bin",  // TX player channel 2 test vectore
    "iq_swap": false,             // Enable TX I/Q samples swap
    "tx1_pa_en": false,           // Enable TX1 Power Amplifier
    "tx2_pa_en": false            // Enable TX2 Power Amplifier
},
```

To edit, first hit ‘i’ and then edit with the new tx1_pa_en, and then hit ‘Esc’ and then ‘:wq” and then ‘Enter’.

After the file edited you can verify it by:

```
root@sparrow:~# cat /etc/sparrow_cfg.json
```

To see if the new configuration is set correctly. Then you need to reboot the radio by this command:

```
root@sparrow:~# reboot
```

When radio rebooted, you should login again (login: root, password: root), and perform reset twice.

```
root@sparrow:~# niquist_reset
niquist reset ..
root@sparrow:~# niquist_reset
niquist reset ..
root@sparrow:~#
```

9 Integrating Instructions

Section 9.1 through 9.8 describe the items that are used by host manufacturer to integrate Gallium radio module in a host product. Some of these items may not applicable for host manufacturer, but nevertheless mentioned per Telecommunication Certification Body (TCB) recommendation.

9.1 List of applicable FCC rules

FCC Part 15 Unlicensed device Rule part 15.247 applies to the Gallium radio.

9.2 Specific use conditions

Gallium radio works with antenna in 900 ISM band via reverse polarity TNC mating connector. The antenna gain should be equal or less than 2.5 dBi. If Gallium radios are used in close proximity (less than 5 meter), the output power should be lowered by rotary switch as explained in section 8.

9.3 Limited module procedures

This section is not applicable to Gallium radio. Gallium radio is NOT approved as “limited module”, therefore, Intelligent Automation, is NOT responsible for approving the host environment that the limited module is used with.

9.4 Trace antenna design

This section is not applicable to Gallium radio.

9.5 RF exposure conditions

Gallium radio can be used by host manufacturer as mobile and/or portable device as long as the attached antenna is separated from the end user body by 200 mm. This separation condition would satisfy SAR Exclusion Threshold for radios operating in 900 MHz band and with less than 1W transmitting power. The host manufacturer must provide the minimum proximity condition to end user in their user manual as well.

9.6 Antennas

We have been testing Gallium radios with RQWD-9/24-RTM that is an RFMAX, Quarter Wave, rubber duck style antenna that operates at 900 MHz ISM band with 2.5 dBi gain over ¼ wave. Any antenna in this frequency range with gain below 2.5 dBi gain would satisfy our minimum condition.

9.7 Label and compliance information

It is necessary for the host manufacturer to show our FCC ID : 2AI6Y-GALLIUM and statement on the host finished product. If the finished product is smaller than “palm-sized” (or 8x10cm), the required statement may be included in the finished user manual. Below is the labeling statement:

Labeling Requirements (FCC 15.19)

This device complies with Part 15 of 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.

9.8 Test modes and additional testing requirements

All test modes and requirements are covered in the user manual from section 5 to section 8.



9.9 Additional testing, Part 15 Subpart B disclaimer

The Gallium radio module is **only** FCC authorized for the specific rule part 15 Unlicensed device Rule part 15.247, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. Gallium radio is Part 15 Subpart B compliant, hence the final host product still requires Part 15 Subpart B compliance testing with the Gallium radio installed.