User Manual

THEUS C-V2X RSU User Manual [ETF-PRO-RC02]

Version 1.0

ETTIFOS

Revision History

Name	Version	Date	Comment
Sijoong Lee	V1.0	Apr 7, 2025	Initial Version

Table of Contents

1. Introduction

This document provides the following information:

- THEUS C-V2X RSU product package
- Installation guide
- How to access the RSU to see or modify configuration settings
- How to configure pre-settings for V2X Communication
- How to transmit and receive data packets using the test application

2. Unpack SIRIUS

The package contains parts as below.

Table 1: Package parts

Item	Q'ty	Model No.	Description	Picture
THEUS C-V2X RSU	1	ETF-PRO-RC02	THEUS C-V2X RSU (Including Mounting Bracket)	
V2X Antenna	2	HKD5850PC-N	10dBi, Dipole	
Wi-Fi/BT Antenna	1	W5097	Wi-Fi/BT Antenna	
GPS Antenna	1	HKGSA301C-N	4dBi, LAN: +30dB	
RJ45 Connector Plug Housing	1	RCM-00AMMA-SLM7001		

3. Technical Specifications

3.1. Equipment Specifications

Table 2: Product characteristics

Item	Specification	Comments
V2X	C-V2X (LTE-V2X)	
Frequency	5.905GHz ~ 5.925 GHz	20MHz
Bandwidth	20 MHz	
Tx power	MAX +23 dBm TYP +20 dBm	
CPU/Memory	**[NXP i.MX 8M Plus]** ▪ 1.6 GHz Quad-core ARM Cortex-A53 + Coretex-M7 ▪ 4GB LPDDR4 RAM ▪ 16GB eMMC ▪ OS Linux	
Interface	**[Antenna]** ▪ x2 C-V2X Port (N-type) ▪ x1 GPS Port (N-type) ▪ x1 Wi-Fi/BT Port (SMA) **[IO]** ▪ x1 Ethernet Prot (RJ45) – **100/1000 Base-T** ▪ x1 Debug Port (M12D-04PMMS-SH8001)	
Power	POE: IEEE 802.3at (25W)	
Display	**[LED]** ▪ Power x1 ▪ Boot Status x1 ▪ FW Status x1 ▪ Alarm Status x1	
Mechanical	▪ **Dimension**: 219 x 200 x 100 mm (Except Antenna Port & Bracket) ▪ **Weight**: ≤ 3.7 kg (Except Bracket) ≤ 4.0 kg (Include Bracket)	
Temperature & Humidity	▪ Operating Temperature: -40 ~ +70°C ▪ Storage Temperature: -40 ~ +85°C ▪ Humidity: +55°C/95%	

Ingress Protection	IP67	
Surge Protection	IEC 61000-4-5	

3.2. Input power characteristics

Table 3: Input power characteristics

Item	Specification	Comments
POE Type	Type-2, IEEE 802.3at	
Input Voltage	42.5 ~ 57 VDC	Nominal Output Voltage 12 VDC ±4%
Continuous Output Current	2.0A max.	
Peak Output Current	2.5A max.	
Line Regulation	±0.1%	Vin = 42.5 ~ 57 VDC, Pout = 0.12 ~ 24W
Load Regulation	±0.2%	Vin = 54 VDC, Pout = 0.12 ~ 24W
Ripple & Noise	50mVp-p max.	Vin = 54 VDC, Pout = 24W
Efficiency	89% min.	Vin = 54 VDC, Pout = 24W
Input to Output Isolation	1500 Vrms	

3.3. Front panel with LEDs

Status indicator LEDs are located on the front panel.

Figure 1: Status indicator LEDs

Table 4: LED descriptions

Item	Specification	Comments
PWR	Green ON Green OFF	Power is ON. Power is OFF.
BOOT	Green Blinking Green ON	While booting. Boot Completed / Normal Operation.
FW	Green ON Green OFF	Firmware Downloading. No Firmware Downloading.
ALARM	Green ON Amber ON	Normal Operation. Abnormal Operation (Alarm Triggered).

3.4. Dimension

Dimension, Unit: 219 x 200 x 100 mm (excluding antenna port and mounting bracket)

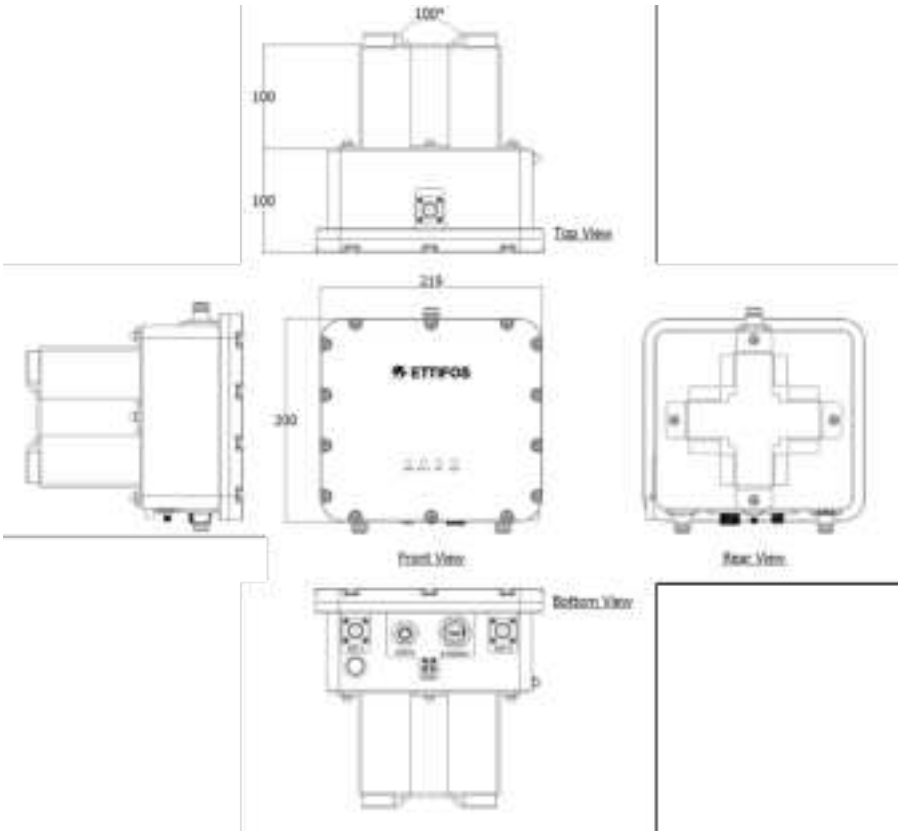

Figure 2: Dimensions

4. User Installation Guide

4.1. Interface Description

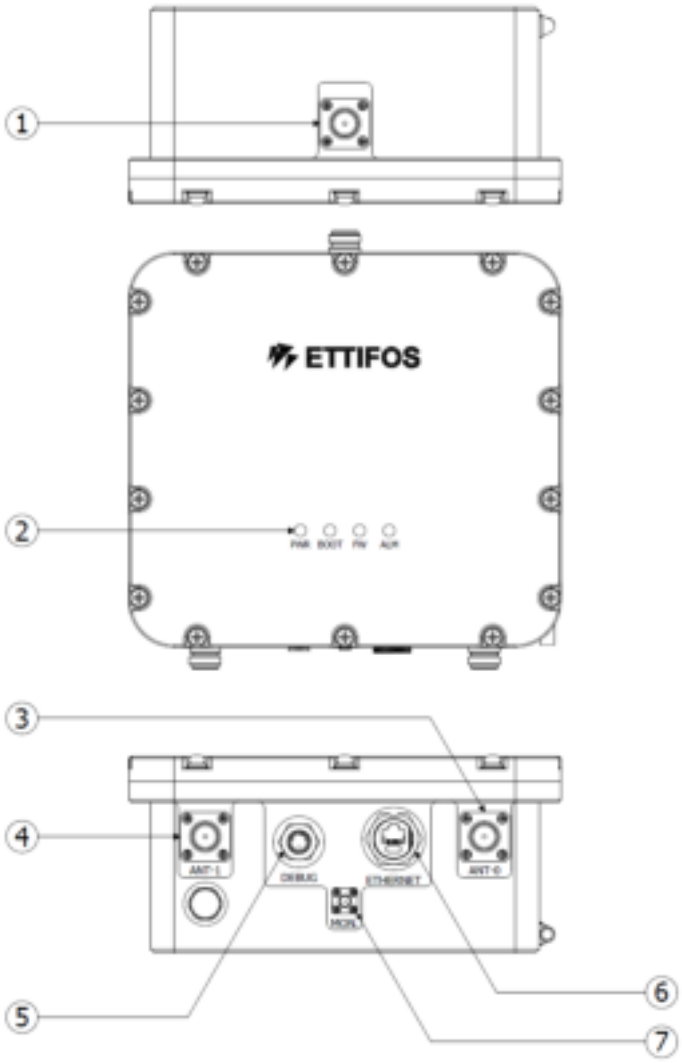

Figure 3: Interfaces

Interfaces from ① to ⑦ in Figure 3 are explained in Table 5.

Table 5: Interface description

Item	Specification	Comments
1	GPS	GPS antenna connection port (N-type)
2	LED	Status indicators
3	ANT-0	ANT-0 V2X antenna connection port (N-type)
4	ANT-1	ANT-1 V2X antenna connection port (N-type)

5	DEBUG	Used for manufacturer's debugging purposes as a debug port
6	ETHERNET	Ethernet that supports POE IEEE 802.3at (25W) ▪ Use Shielding Type Ethernet Cable. ▪ Connect using the provided Amphenol P/N: RCM-00AMMA-SLM7001 Connector Housing
7	MON	Wi-Fi/BT antenna connection port (SMA)

4.2. Installation method

As shown in Figure 4, horizontal or vertical installation is possible. Position the RSU horizontally (or vertically) and secure it using the stainless-steel Band.

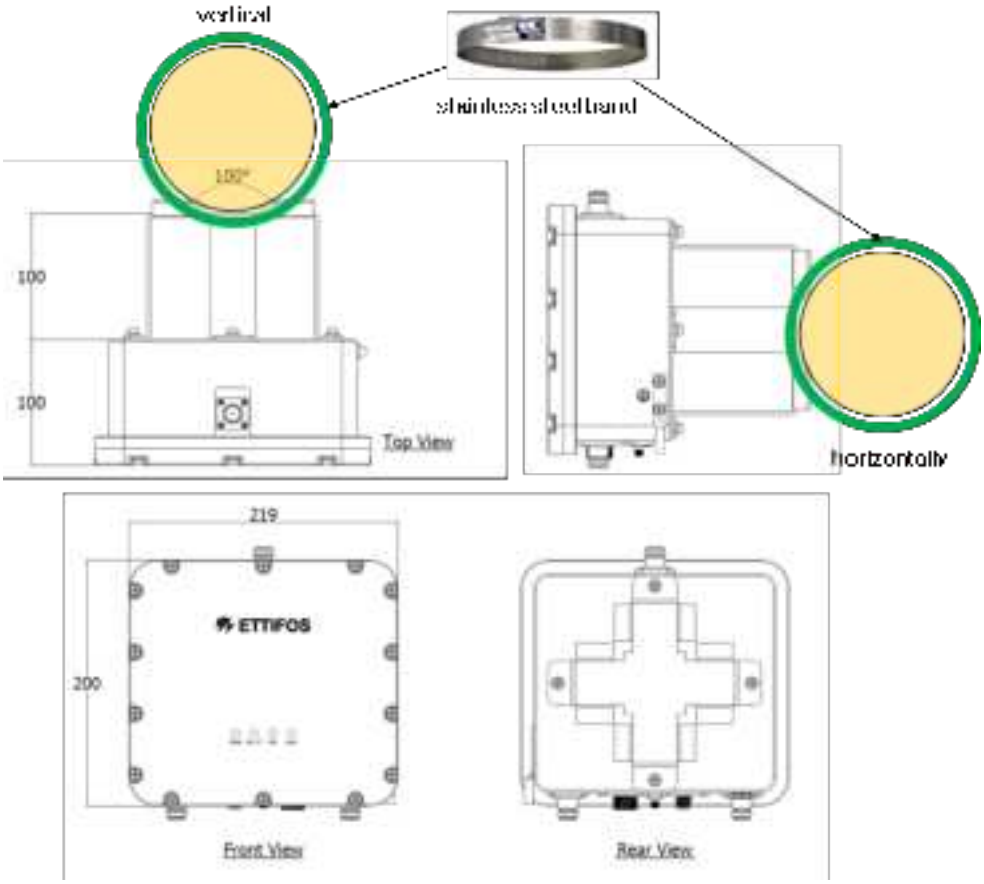

Figure 4: THEUS C-V2X RSU Installation

⚠ FCC Installation Notice:

This device must be installed at a height between 2.5 meters and 8 meters above the ground and shall not exceed the maximum EIRP output power of 23 dBm to comply with FCC RF exposure requirements.

5. Access Methods for Device configuration

The THEUS C-V2X RSU provides three interfaces for system access, allowing users to configure settings and control the device.

- Ethernet
- Wi-Fi
- Serial Debug Port

This chapter describes each method of access and provides instructions on how to change the LTE-V2X frequency settings.

5.1. Access to RSU

5.1.1. Access via Ethernet

The procedure for access to RSU via Ethernet is as below:

① Directly connect the ethernet port of the RSU to the PC.

② Set a static IP address in the Network Manager of the PC. The default IP address of ethernet interface inside RSU is 192.168.70.234, hence, the allowed address to the PC ranges from 192.168.70.1 to 192.168.70.254 except for 192.168.70.234.

③ Access RSU via SSH applications such as Putty and Tera Term with the default IP address and the default port number 22. (refer to Figure 5 for more detail)

PC > Static IP address

PuTTY > SSH connection

Figure 5 Statis IP setting & SSH connection

In case the IP address of the ethernet interface needs to be changed, follow the instructions below.

① Open the '50-eth.network' file and change the 'Address' and 'Gateway' (Line 14 to 15) values to new ones.

```
root@Ettifos:~# vi /lib/system/network/50-eth.network
...
 # Press 'i' to enter insert mode
11 Name=eth0
~
13 [Network]
14 Address=192.168.70.234/24
15 Gateway=192.168.70.2
...
 # Press ':wq!' to save the changes and quit
:wq!
```

② Open the 'resolv.conf' file and change 'nameserver' (Line 0) values to new ones.

```
root@Ettifos:~# vi /etc/resolv.conf
...
 # Press 'i' to enter insert mode
 0 nameserver 8.8.8.8
...
 # Press ':wq!' to save the changes and quit
:wq!
```

③ Restart 'systemd-networkd' or reboot DUT to apply changes

```
 # Restart systemd-networkd or Reboot DUT
 $ systemctl restart systemd-networkd
```

④ Open the '/lib/system/system/ssh.socket' and configure the port number (optional)

```
ListnStream=22
```

⑤ Restart the DUT to apply network configuration

5.1.2. Access via Wi-Fi

The THEUS C-V2X RSU operates in Wi-Fi Access Point (AP) mode, allowing users to wirelessly connect to the device via its SSID.

The default IP address of the RSU's Wi-Fi interface is 192.168.80.1. Users can customize Wi-Fi settings, including SSID, password, and IP address, by editing the configuration file('/etc/create_ap_ettifos.conf').

Once connected to the RSU via Wi-Fi, users can access the system using SSH client in the same way as through the Ethernet interface.

- IP Address: 192.168.80.1
- SSID (Access Point): ETF-AP
- PW: 1234567890

```
root@Ettifos:~# vi etc/create_ap_ettifos.conf


GATEWAY=192.168.80.1
...
SSID=ETF-AP
PASSWORD:1234567890
```

5.1.3. Access via Debug port (RS232)

THEUS C-V2X RSU supports UART serial communication using a manufacturer-supplied USB cable for debugging the device.

The procedure for establishing a serial connection is as follows:

① Connect the cable provided by the manufacturer to a USB port on the computer.

(In case of the device being recognized as an unknown device on Windows Device Manager) Download CP210x USB to UART Bridge VCP driver at CP210x USB to UART Bridge VCP driver – Silicon Labs (silabs.com) and install it by doing a 'driver update' in Windows Device Manager.

② Once installed, check the COM port which responds to Enhanced COM 'Port (COM & LPT)' of Device Manager as shown below. (The COM port number may vary depending on the user's computer environment. In this manual, COM88 is used as an example.)

③ Access RSU via a terminal program (such as Tera Term and Putty) with the COM port (e.g., COM88) and the baud rate 115200.

Figure 6: SSH connection

5.2. Configuration guide

In LTE-V2X communication, the pre-configuration XML file defines the essential parameters for network communication among vehicles, roadside infrastructure, and other system components. This file includes configurations for V2X applications, security settings, network interfaces, and communications protocols.

For LTE-V2X sidelink communication, pre-configuration parameters-particularly the C-V2X channel settings-must be consistent across all devices. When conducting a C-V2X communication test for the first time between the TEHUES C-V2X RSU and another platform, it may be necessary to provide Ettifos with the pre-configuration XML file used on the other platforms.

However, in most use cases, users only need to configure the C-V2X channel (frequency and bandwidth), which can be easily done by selecting from Ettifos' predefined XML files (Table 6).

This chapter explains how to configure the device for operation on different V2X channels.

Currently, THEUS C-V2X RSU provides four XML files in '/etc/v2x/cv2x' directory and each of them have different V2X channel information as shown below.

Table 6: Predefined XML files

Channel Info	Channel	Bandwidth	Center Freq (EARFCN)
V2X_Ch173_20MHz_EARFCN54640.xml	CH. 173	20 MHz	54640
V2X_Ch178_10MHz_EARFCN54890.xml	CH. 178	10 MHz	54890
V2X_Ch178_20MHz_EARFCN54890.xml	CH. 178	20 MHz	54890
V2X_Ch183_20MHz_EARFCN55140.xml	CH. 183	20 MHz	55140

Users can easily change the LTE-V2X channel using 'cv2x-config' program in RUS.

The 'cv2x-config' provides the functions explained in Table 7.

```
Usage: cv2x-config --<command name> <command parameters>
```

Table 7: cv2x-config command list

Command name	Command parameters	Description
get-v2x-status		Read the V2X radio status.
start-v2x-mode		Start V2X radio.
stop-v2x-mode		Stop V2X radio.
update-config-file	<filepath>	Update pre-configuration xml file.

The procedure to change LTE-V2X channel is as follows.

① Stop V2X radio: Turn off V2X radio before channel change.

```
$ cv2x-config --stop-v2x-mode
        [I][init_qmi_services:490] Initialized QMI clients
        [I][stop_v2x_radio:637] Stopped V2X radio
        [I][deinit_qmi_services:501] De-initialized QMI clients
```

② Set pre-configuration xml file: Choose one of four xml files in Table 6.

```
$ cv2x-config --update-config-file [path/xml]
        e.g., cv2x-config -update-config-file V2X Ch178_10MHz_EARFCN54890.xml
        [I][init_qmi_services:490] Initialized QMI clients
        [I][update_v2x_config_file:1572] Sent V2X config file successfully
```

③ Start V2X radio: Turn on V2X radio.

```
$ cv2x-config --start-v2x-mode
        [I][init_qmi_services:490] Initialized QMI clients
        [I][start_v2x_radio:617] Started V2X radio
        [I][deinit_qmi_services:501] De-initialized QMI clients
```

6. Test application 'acme'

'acme' (Automotive Communications Modem Emulator) is a test application developed by LTE-V2X chipset vendor and designed to provide a platform for testing and validation V2X modems in real-world scenarios. This tool assists in evaluating the performance and compliance of V2X communication devices.

The way for users to do packet transmission/reception using 'acme' is introduced below.

6.1. Usage of 'acme'

The options that 'acme' support are as follows.

```
$ acme <option>
```

Table 8 acme options

option	Ref.	Description
-h	--Help | Usage	Print this Usage.
-A		ASCII dump packet data after sequence#.
-a		Additional SPS/Event Flow Pair. Subsequent -E, -l, -r, -o flow params will apply to new reservation.
-d		Dump raw packet.
-k	<qty>	Quit after <qty> packets are received or transmitted.
-l	<bytes [bytes] ...>	List of Payload Lengths in bytes, at least one length required Specify multiple payloads. Tx will send one packet of each length in sequence. The maximum length of the sequence is 1000.
-P	<V2X ID>	V2X session ID to be used.
-R		RECEIVE mode, default is Tx.
-V		Increase verbosity level +1 for each -V, default=0.

6.2. Tx/Rx Test Guide

One RSU works as a transmitter, and the other one works as a receiver. The default mode of 'acme' is Tx (transmission) mode, hence, -R option is needed for the receiver. The following are simple examples of the 'acme' commands for Tx/Rx.

Example of Tx Command: $acme

```
$ acme
        [W][radio_listener:556] Tx/Rx Status Changed to <Active> ****
        Modem rmnet_detal capability:
        non IP MTU: 8188 (rmnet_detal)
        IP MTU: 1500 (rmnet_data0)
        min periodicity: 100 ms
        max periodicity (lowest reserved Freq): 1000 ms
        highest priority number supported: 7 (lower # is more urgent)
        lowest priority number supported: 0 (lower # is more urgent)
        tx pool ids supported:
                ID: 0, min_freq: 55090, max_freq: 55190
# SPS Interval periodicity not specified, using packet -gen interval: 100 ms.
Flow#0: type=3 file-description: (-1 -1) sps_port=2500 evt_port=2600, 100 ms, 287 bytes
# interval=100000000 ns (approximately 10 per second)
Tx count: 1, len = 287
Tx count: 2, len = 187
```

Example of Rx Command: $ acme -R

```
$ acme -R
        [W][radio_listener:556] Tx/Rx Status Changed to <Active> ****

        Modem rmnet_detal capabilities:
                non IP MTU: 8188 (rmnet_detal)
                IP MTU: 1500 (rmnet_data0)
                min periodicity: 100 ms
                max periodicity (lowest reserved Freq): 1000 ms
                highest priority number supported: 7 (lower # is more urgent)
                lowest priority number supported: 0 (lower # is more urgent)
                tx pool ids supported:
                ID: 0, min_freq: 55090, max_freq: 55190
Epoch-ms |    Tot-pkts    |    New-pkts    |    pps    |    Latency    | RV's | CBP %

<1698743818326242> | 0 | + 0 packets | 0.00 packets per second (PPS) | 0.00 ms avg latency |
RV Count=0 | CBP= 0%
```

```
<1698743819326244> | 0 | + 0 packets | 0.00 packets per second (PPS) | 0.00 ms avg latency |
RV Count=0 | CBP= 0%

|#1    |I=287|UE#1|<latency= 13.70 ms> |total missed=0| per UE lost/sent=[0|1]    0.0 %|
```

7. Troubleshooting

7.1. Troubleshooting with RF Tx/Rx

- No RF signal is transmitted

Make sure that V2X antennas are correctly connected to the ANT-0 and ANT-1 antenna ports.

C-V2X Status Check

```
$ cv2x-config—get-v2x-stuats
        [I][init_qmi_services:490] Initialized QMI clients
        [I][init_v2x_radio_status:596] Read V2X radio status
        V2X rx_status=1, tx_status=1
        rx_pool_0_status=1, rx_pool_1_status=0, rx_pool_2_status=0, rx_pool_3_status=0,
        tx_pool_0_stauts=1, tx_pool_1_stauts=0,
        [I][deinit_qmi_services:501] De-initialized QMI clients
```

V2X Status: [0: Initial / 1: Normal / 2: Error]

7.2. Safety Precautions

- Always turn off the power before moving, installing, or connecting/disconnecting the cables and connectors.
- Make sure that the power source matches the required input power of the devices.
- Do not modify any part of the device and do not open the housing case as this may cause malfunctions or electric shocks. Opening the housing case will avoid your warranty.
- Keep the device dry. Humidity and all types of liquid or moisture may corrode electric circuits.
- Be sure that the ventilation holes are not obstructed during operation, as this may cause malfunctions due to overheating.
- Make sure that all antenna ports relate to antennas or properly terminated (e.g., with a 50 Ω coaxial termination resistor) during operation. Unterminated ports may cause RF signal distortion or hardware damage due to excessive reflected energy.

Our aim is to provide customers with a timely and comprehensive service.

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New customers: please email pr@ettifos.com for any assistance.

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⚠ FCC notification to users

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.

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 when the equipment is operated in a commercial environment.

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, the user is encouraged to try to correct the interference by consulting with a dealer or an experienced technician for technical assistance.

Any changes or modifications to equipment not expressly approved by the party responsible for compliance could void user's authority to operate the equipment.

The antenna(s) used for this device must be installed to provide a separation distance of a least 15 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

NDA Requirement:

This device is distributed under a Non-Disclosure Agreement (NDA). Any technical documentation including this manual must not be disclosed without permission. Refer to the attached NDA exhibit submitted to the FCC.