

# ETERNA2 User Guide

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# 1 Introduction

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## 1.1 Purpose

This document is provided to OEMs for the installation of the ETERNA2 into a finished product. Provided the OEM's usage of ETERNA2 is compliant with the requirements included in Section 6, the OEM is not required to complete radio certification of ETERNA2's radio performance in FCC, IC and CE regulated geographies. In addition, this document provides the information necessary to perform certification of the ETERNA2 module for other geographies.

## 1.2 Scope

This document is intended for those who are responsible for designing with, installing and testing the ETERNA2 module.

This document covers the following order codes:

LTP5901IPC-IPMAxxx#PBF  
LTP5901IPC-WHMAxxx#PBF  
LTP5901IPC-IPRAxxx#PBF  
LTP5901IPC-IPRBxxx#PBF  
LTP5901IPC-IPRCxxx#PBF  
LTP5901IPC-IPAAxxx#PBF  
LTP5902IPC-IPMAxxx#PBF  
LTP5902IPC-WHMAxxx#PBF  
LTP5902IPC-IPRAxxx#PBF  
LTP5902IPC-IPRBxxx#PBF  
LTP5902IPC-IPRCxxx#PBF  
LTP5902IPC-IPAAxxx#PBF

## 1.3 References

- [1] IEEE Std 802.15.4-2006, Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs)
- [2] [ETERNA2 Certification Package](#), containing ETERNA2 design files, antenna specifications, test reports, declarations and certificates.

## 1.4 Definitions

|              |  |
|--------------|--|
| DUT          | Device Under Test  |
| Mote         | A node in a mesh network   |
| Low Channel  | The lowest frequency channel occupied by ETERNA2 is channel 0 centered at 2405 MHz. This channel corresponds to channel 11, as defined by [1].                               |
| Mid Channel  | The channel closest to the center of the 2.4 GHz ISM band occupied by ETERNA2 is channel 7, centered at 2440 MHz. This channel corresponds to channel 18, as defined by [1]. |
| High Channel | The highest frequency channel occupied by ETERNA2 is channel 14, centered at 2475 MHz. This channel corresponds to channel 25, as defined by [1].                            |

## 1.5 General Description

ETERNA2 combines a microprocessor and a IEEE-802.15.4 radio with networking capabilities to provide a time synchronized, ultra low power network, designed to enable operation from battery sources for extended periods of time. The design is a PCB including “castellated” leads for access to the device and network, a SoC (includes radio and CPU), power supply filtering, and an MMCX connector to the antenna port or integral antenna.

## 1.6 Operational Description

ETERNA2 provides an IEEE 802.15.4 compliant radios that modulate a DSSS OQPSK set of symbols at a chip rate of 2 Mcps. Dust radios operate on a TDMA time schedule that uses either 7.25 or 10 ms timeslots. A transmit timeslot consists of 5 stages:

1. Initialization: radio is prepared for transmit (transmitter is off)
2. Ramp: transmitter is ramped to peak power
3. Transmit: 128 bytes of data maximum + 5 bytes preamble/SFD
4. Turnaround: radio is set to receive
5. Receive: radio waits in receive for ACK, then turns off

Total transmit time for a 128 byte packet plus all overhead (SFD / Preamble / Ramp) is 4.33ms.

A receive timeslot consists of 5 stages:

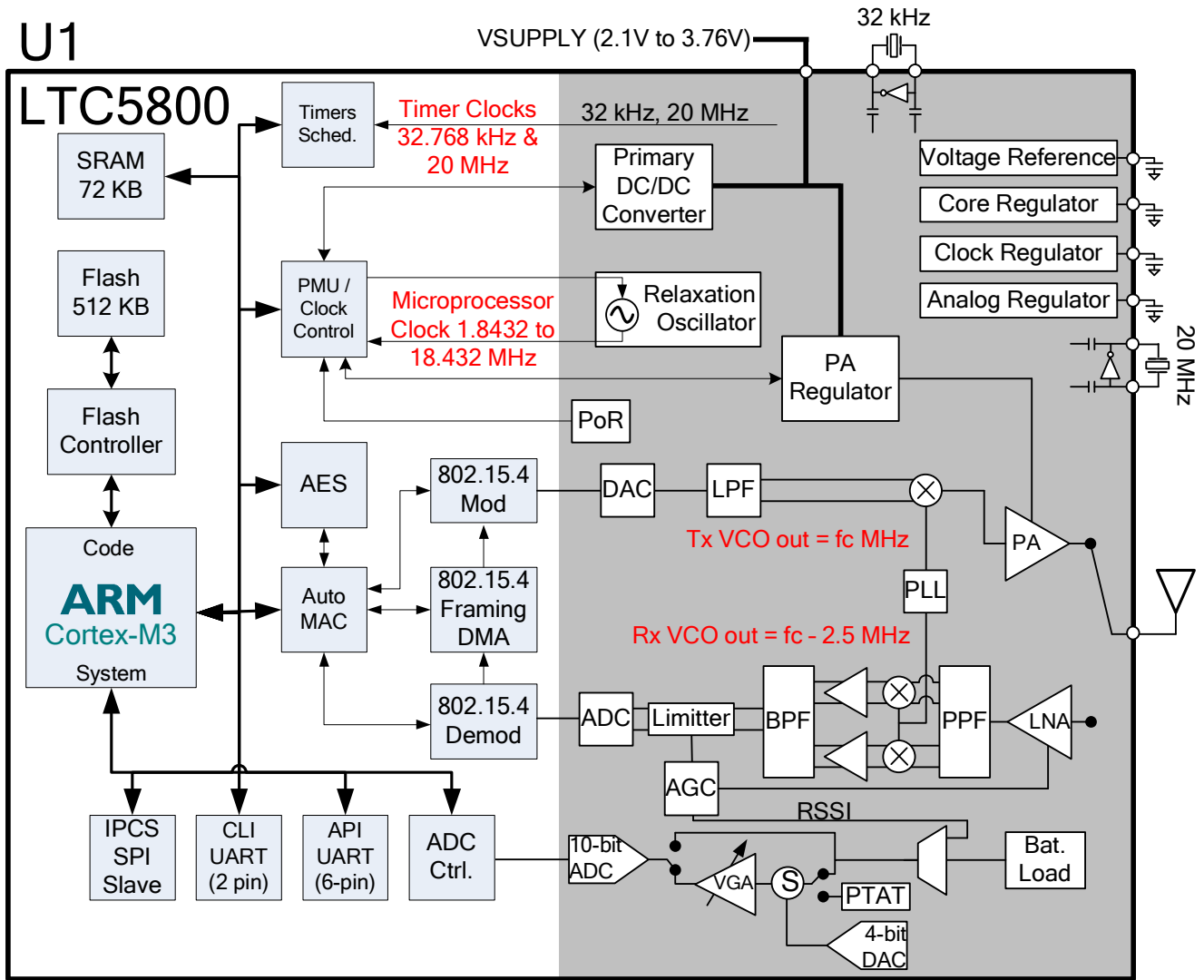
1. Initialization: radio is prepared for receive
2. Check for start of packet – if no packet is received within a guard time the radio is disabled and no further action is taken
3. Receive the packet: up to 128 bytes of data maximum + 5 bytes preamble/SFD
4. Turnaround: radio waits 1 ms and then is set to transmit
5. Transmit: radio sends an ACK (21 bytes of data + 5 bytes preamble/SFD), then turns off

Total transmit time for an ACK is plus all overhead (SFD / Preamble / Ramp) is 1.101 ms.

Measured records and calculations of ETERNA2 radio transmit duty cycling are included in “ETERNA Duty cycle.pdf”.

When the radio is not in operation, the CPU is occasionally (every few seconds for a few milliseconds) operating, monitoring temperature and voltage. The remainder of the time the ETERNA2 is in a low power mode operating solely from a 32 kHz crystal source.

## 1.7 Block Diagram



Note that  $f_c = 2405 + n \cdot 5$  MHz, where  $n = 0, 1, 2, \dots, 14$ .

## **2 Command and Response**

---

### **2.1 CLI UART**

ETERNA2 includes a Command Line Interface, CLI, UART that supports a full set of text commands described in this document to enable product certification. The interface operates at LVTTTL levels matching the VSUPPLY input to ETERNA2. The UART is configured at 9600 baud, 8-bit, no parity, 1 stop bit, and does not support flow control.

### **2.2 API UART**

ETERNA2 offers a comprehensive Application Programming Interface, API, that provides full programmatic access to control the device, monitor its status (such as battery charge and network status), and provide access to the wireless mesh network. Messages over the API UART are HDLC encoded and require specific software to support command and response communication required for regulatory testing. Refer to the SmartMesh API Guide for details.

## 3 Test Configurations

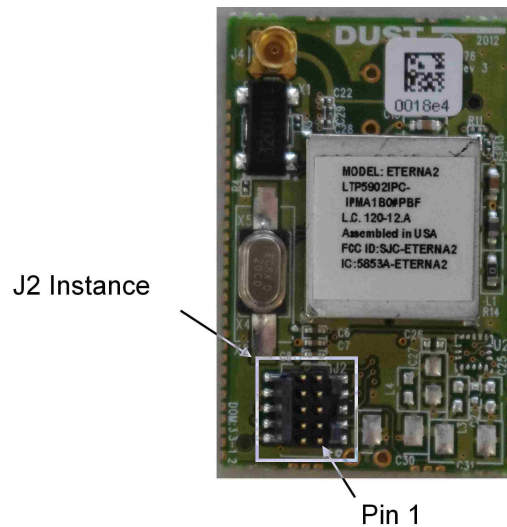
Test configurations can be divided into two distinct configurations, one for Radiated immunity and a second for Emissions and Conducted Measurements.

### 3.1 Radiated Immunity

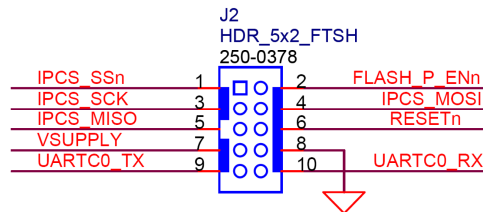
Operation of the network in the presence of an interferer can most easily be monitored by operating ETERNA2 as a mote participating in a network. In this configuration, the RF link between the ETERNA2 and a network manager can be exercised and simultaneously monitored via the network managers UART CLI port. Communication and monitoring to the UART CLI port can be done via generally available terminal emulation software, such as TeraTerm, HyperTerminal, or iTerm2.

### 3.2 Emissions and Conducted Measurements

Emissions and Conducted measurements can be made with ETERNA2 integrated into a product or stand alone. When integrated into a product a convenient method to invoke commands over ETERNA2's CLI or API UART should be considered as part of the product design. To access the CLI port and power on ETERNA2 in a stand alone configuration, a Samtec MTMM-111-04-S-S-175-003, connector should be installed on J2, as shown below,



J2 per the pinout shown below, provides both power and connection to ETERNA2's CLI port. Connection to pins 1 through 6 are optional for CLI access.





## 4 Tests

---

### 4.1 Conventions

Input from the user during a test will be in **bold**. Command line information will be shown in Plain Text. Command parameters, either numerical, alphanumeric or enumerated, are shown between greater than and less than symbols. I.e. **<parameter>**.

#### 4.1.1 Channel Map

Radiotest commands use the **<chanMask>** parameter to define which channel or channels the radio will operate on when a command is issued. The parameter **<chanMask>** is a hex bitmap of channels to use with the LSB corresponding to channel 0 and the MSB corresponding to channel 15. Channel 15 in product is never used. For example, 0x7fff results in operation on channels 0 through 14 and 0x0001 results in operations only on channel 0. Table 1 provides a mapping for single channel operation for each channel and the corresponding channel number as defined in this document.

**Table 1 Channel Mask Parameter Channel Mapping**

| <b>&lt;chanMask&gt;<br/>(Hex)</b> | <b>Center Frequency<br/>(MHz)</b> | <b>Channel #</b> |
|-----------------------------------|-----------------------------------|------------------|
| 0x0001                            | 2405                              | 0                |
| 0x0002                            | 2410                              | 1                |
| 0x0004                            | 2415                              | 2                |
| 0x0008                            | 2420                              | 3                |
| 0x0010                            | 2425                              | 4                |
| 0x0020                            | 2430                              | 5                |
| 0x0040                            | 2435                              | 6                |
| 0x0080                            | 2440                              | 7                |
| 0x0100                            | 2445                              | 8                |
| 0x0200                            | 2450                              | 9                |
| 0x0400                            | 2455                              | 10               |
| 0x0800                            | 2460                              | 11               |
| 0x1000                            | 2465                              | 12               |
| 0x2000                            | 2470                              | 13               |
| 0x4000                            | 2475                              | 14               |

### 4.2 Receiver Emission Tests

Much of the testing focused on the receiver can be accomplished by enabling ETERNA2's radio to receive for an extended period of time using the following sequence:

Power up ETERNA2 and connect to the CLI port. Enter the following command

```
> radiotest on
```

Reset or power cycle ETERNA2 and enter the following command

```
> radiotest rx <chanMask> <time> <stationId>
```

---

Where [<chanMask>](#) would nominally be set to 0x0001 (low) , 0x0080 (mid) or 0x4000 (high) and [<time>](#) in seconds. The [<stationId>](#) parameter was added in the version 1.4.0 release of the SmartMesh IP Mote, version 1.3.0 of the SmartMesh IP Manager and version 1.1.2 of the SmartMesh WirelessHART mote. Earlier versions of software should omit the [<stationId>](#) parameter. The [<stationId>](#) parameter should be set to 0, zero, for all certification radio testing.

This sequence enables testing of:

- Receiver Conducted Spurious Emissions Operating (EN 300 328)
- Receiver Radiated Spurious Emissions Operating (EN 300 328, FCC 15.109)
- AC Conducted Emissions (FCC 15.207)

After completing tests that require radiotest commands (tx and rx) use the **radiotest off** command to return the device to its normal state:

```
> radiotest off
```

Reset or power cycle ETERNA2.

### 4.3 Transmitter Power and Spectral Tests

Much of the testing focused on the transmitter can be accomplished by enabling ETERNA2's radio to continuously transmit a modulated signal using the following sequence:

Power up ETERNA2 and connect to the CLI port. Enter the following command:

```
> radiotest on
```

Reset or power cycle ETERNA2 and enter the following command:

```
> radiotest tx cm <chanMask> <power>
```

Where [<chanMask>](#) would nominally be set to 0x0001 (low) , 0x0080 (mid) or 0x4000 (high) and [<power>](#) to 8 (+8dBm), the highest output power setting used in the OEM product.

This sequence enables testing of:

- Effective Isotropic Radiated Power (EN 300 328)
- Maximum Spectral Power Density (EN 300 328, FCC 15.247(e))
- Frequency Range / Band Edge (EN 300 328 / FCC 15.247(d))
- Transmitter Conducted Spurious Emissions Operating (EN 300 328, FCC 15.247(d))
- Transmitter Radiated Spurious Emissions Operating (EN 300 328, FCC 15.247(d))
- AC Conducted Emissions (FCC 15.207)
- Bandwidth (FCC 15.247(a)(2), RSS 210 99% Bandwidth)
- RF Power Output (FCC 15.247(b)(3))

After completing tests that require radiotest commands (tx and rx) use the **radiotest off** command to return the device to its normal state:

```
> radiotest off
```

Reset or power cycle ETERNA2.

**NOTE:** If testing encompasses measuring ETERNA2's output power or PSD, Power Spectral Density, over a range of voltages, the **radiotest off** command must be issued every time the voltage to ETERNA2 is changed to ensure accurate output power measurements. During product operation ETERNA2, dynamically adjusts its regulation to its power amplifier, based upon the supply voltage to keep the supply to the PA constant. The **radiotest tx cm** and **radiotest tx cw** commands do **not** dynamically adjust the power to the PA, only taking a single measurement when the command is issued.

**WARNING:** It is possible to permanently damage ETERNA2, by initiating a **radiotest tx cm** or **radiotest tx cw** command at a low voltage and subsequently raising the voltage without issuing a **radiotest off** command.

## 4.4 Transmitter Carrier Tests

Testing ETERNA2's carrier frequency accuracy can be done by enabling ETERNA2's radio to continuously transmit an unmodulated signal using the following sequence:

Power up ETERNA2 and connect to the CLI port. Enter the following command

```
> radiotest on
```

Reset or power cycle ETERNA2 and enter the following command

```
> radiotest tx cw <chanMask> <power>
```

Where <chanMask> would nominally be set to 0x0001 (low) , 0x0080 (mid) or 0x4000 (high) and <power> to 8, the highest output power setting used in the OEM product.

After completing tests that require radiotest commands (tx and rx) use the **radiotest off** command to return the device to its normal state:

```
> radiotest off
```

Reset or power cycle ETERNA2.

## 4.5 Radiated Emissions

Radiated emission tests, such as described in EN 301 489-17, are designed to test that a DUTs unintentionally radiated emissions are below defined limits. As the radio itself has been modularly certified this is not a test of the emissions with the radio in operation. To prevent ETERNA2 from actively running the radio during connect to ETERNA2's CLI port and enter the **set** command as follows:

```
> radiotest on
```

Reset or power cycle ETERNA2. The radio is now inactive and will remain inactive until a **tx** or **rx** command is given.

After completing tests that require radiotest commands (tx and rx) use the **radiotest off** command to return the device to its normal state:

```
> radiotest off
```

Reset or power cycle ETERNA2.

---

## 4.6 Radiated Immunity

Radiated immunity tests, such as described in EN-61000-4-3, are designed to test a DUTs operation due to an out of band interferer. When performing such tests the test system should be verified to prove the test system is not injecting noise due to harmonic distortion into the 2.4 to 2.4835 GHz band. To perform this class of test ETERNA2 should be placed in a network and the network function can be demonstrated as follows:

Create a network of devices with a network manager and two ETERNA2 motes (the minimum configuration to form a network). Make sure the MAC addresses for both ETERNA2 motes and the manager are clearly labeled on each device. Make sure radiotest is off on both devices. Connect to the manager's CLI port and issue the following commands:

```
> login user
```

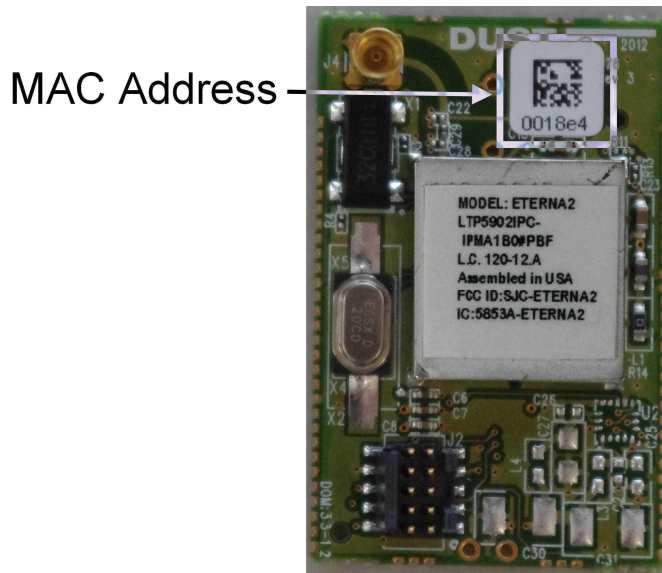
```
> show mote *
```

```
Mote #1, mac: 00-17-0D-00-00-19-20-2C, ver: 2.2.1.7
  State:  Oper, Hops: 0.0, Uptime: 2561, Age: 0
  Number of neighbors (parents): 2 (0)
  Number of links (tx/rx): 17 (0/4)
  Number of no bitmap links : 13
  Neighbors:
    <- #2   Q: 28
    <- #3   Q: 28
```

```
Mote #2, mac: 00-17-0D-00-00-19-33-07, ver: 2.2.1.7
  State:  Oper, Hops: 1.0, Uptime: 2475, Age: 13
  Number of neighbors (parents): 2 (1)
  Number of links (tx/rx): 15 (2/2)
  Neighbors:
    -> #1   Q: 28
    <- #3   Q: 29
```

```
Mote #3, mac: 00-17-0D-00-00-10-20-4D, ver: 2.2.1.7
  State:  Oper, Hops: 1.4, Uptime: 2460, Age: 7
  Number of neighbors (parents): 2 (2)
  Number of links (tx/rx): 14 (2/0)
  Neighbors:
    -> #1   Q: 28
    -> #2   Q: 29
```

Note: It can take up to 10 minutes for the network to form and will take longer if the manager has been powered up for a lengthy period of time. For best results power up all devices within a couple of minutes. Mote 1 is always the mote in the Network Manager and the assignment of motes 2 through 3 are based upon order of joining the network which is not deterministic. To determine which mote number is which device use the MAC address as a reference:



To force a message to a particular mote enter: **ping <mote number>** which will look like:

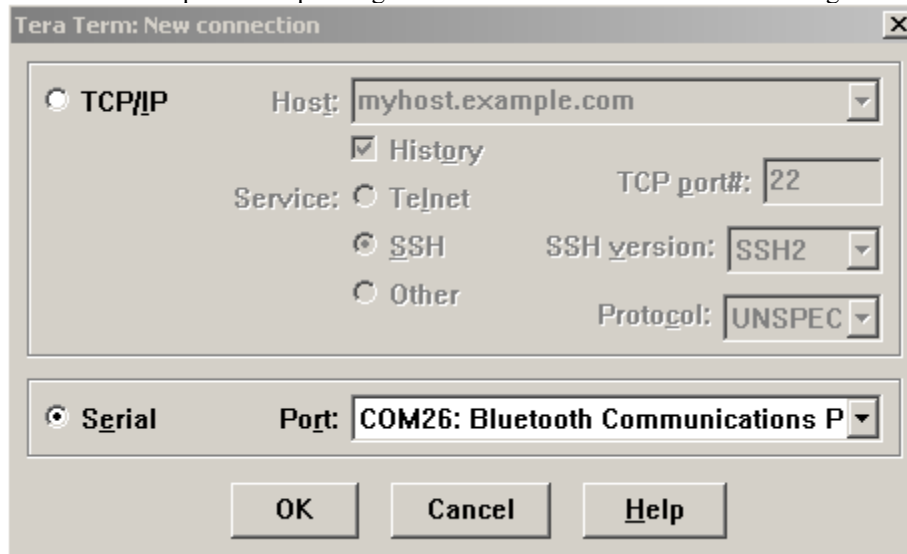
```
> ping 2
> Sending ping request to mote 2
> Ping response from mote 2, time=900 msec v=3645 t=25
```

Ping commands that fail will return with a timeout error message:

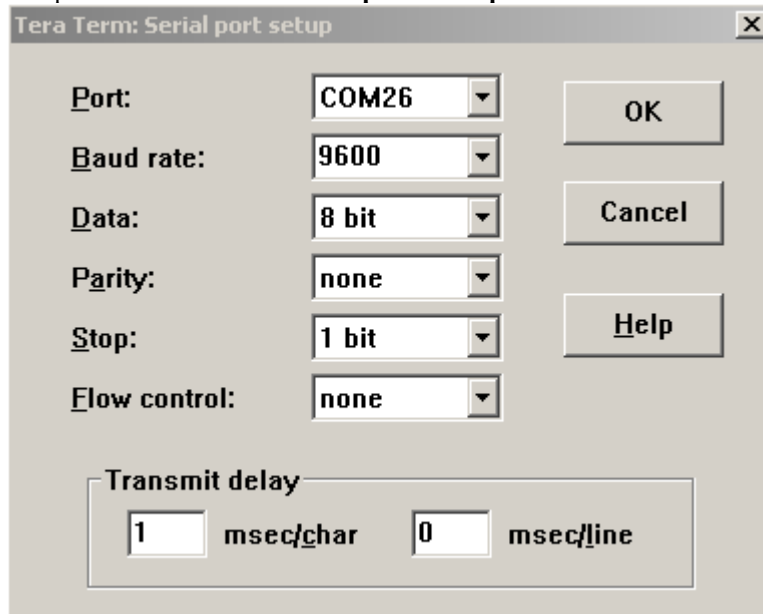
```
Ping from mote 2 timed out
```

Inherently the manager CLI port will generate a notification when a device fails to communicate and falls off the network. During normal network operation devices are communicating at least every 15 seconds. To reduce dwell time the use of a script to ping the target device will increase the radio traffic. The traffic rate will be twice the rate of the ping command being sent. A simple method, uses the windows program TeraTerm Pro. TeraTerm Pro can be downloaded at <http://sourceforge.jp/projects/tssh2/releases/>. Configure TeraTerm as follows to communicate with the network managers CLI port with the following steps:

1. Launch TeraTerm
2. Select the serial port corresponding to the CLI interface to the network manager



3. Setup the Serial Port via the **Setup -> Serial port ...** Menu item:



4. Create a TeraTerm macro, a text file with the extension \*.ttl, with the following content:

```
; Tera Term macro for pinging Dust motes in a network over the managers CLI port
;
; File: ping_loop.ttl
; Description: Looping ping macro for support of Radiated Immunity testing of Dust
; Networks Radios. Set for one ping two messages every delayInMiliSeconds period,
; with 255 steps from 80 to 1000 MHz. For Radiated Immunity above 1 GHz testing is
; only intended to be performed for bands where portable radios are permitted to
; operate - this range and therefore the test duration will change over time.
```

```
timeout = 10
steps = 255
delayInMiliSeconds = 3000
sendln
for i 1 steps
    sendln
    sendln "ping 2"
    mpause delayInMiliSeconds
next

pause 5
sendln "#----- Macro Finish -----"
end
```

5. Call the macro from the TeraTerm menu **Control -> Macro** and load the created macro file.

This will create a series of Ping request and responses from the mote.

## 4.7 Duty Cycle, Tx-Sequence, Tx-Gap and Medium Utilization

The follow command sequences provide a method for demonstrating the maximum duty cycle ETERNA2 could generate in a SmartMesh IP or SmartMesh WirelessHART network:

```
> radiotest on
```

Start test:

```
> radiotest tx <testType> <chanMask> <power> <sysId> [<repeatCnt> {<pkLen> <delay>...}]
```

<testType> is Type of transmission test to initiate: 'pkcca' = packets with clear channel assessment, 'pk' = packets, 'cm' = continuous modulation, 'cw' - continuous wave. <chanMask> is a hex bitmap of channels to use with the LSB corresponding to channel 0 and the MSB corresponding to channel 15. Channel 15 in product is never used. E.g. 0x7FFF results in operation on channels 0 through 14 and 0x0001 results in operations only on channel 0. <power> sets the radio output power, a value of 8 should be used for maximum power. <sysId> is the network ID used for packet transmission this parameter allows for testing of multiple devices in the same RF space and is intended for manufacturing support, not radio certification testing. The <sysId> field for certification testing can be left at zero, 0. The transmitter will transmit in a sequence of packets and gaps defined by a series of alternating <pkLen> and <delay> parameters. The <pkLen> parameter defines the packet length in terms of bytes and is limited to a range of 2 to 125 bytes. Note the protocol will append 8 bytes to the packet payload, so the actual transmitted length of bytes <pkLen> + 8, for a maximum of 133 bytes. The <delay> parameter defines the delay from the start of one packet to the next in  $\mu$ s. The <repeatCnt> parameter defines the number of times that the defined packet sequence will repeat. A <repeat> value of 0 results in the sequence repeating indefinitely. To demonstrate the maximum duty cycle of an IP system on the low channel using every slot issue the following command:

```
> radiotest tx pkcca 0x0001 8 0 0 125 10035 24 5700 24 5700 24 5700
```

This will demonstrate a sequence of one transmission of a maximum length packet followed by three acknowledge packets. To have the radio operate in a hopping sequence that enables hopping on all 15 channels issue the following command:

```
> radiotest tx pkcca 0x7FFF 8 0 0 125 10035 24 5700 24 5700 24 5700
```

To demonstrate the maximum duty cycle of a WirelessHART system on the highest channel when every slot is active, issue the following command:

```
> radiotest tx pkcca 0x4000 8 0 0 125 14733 24 8700 24 8700 24 5822
```

To have the radio operate in a hopping sequence that enables hopping on all 15 channels issue the following command:

```
> radiotest tx pkcca 0x7FFF 8 0 0 125 14733 24 8700 24 8700 24 5822
```

After completing tests that require the DUT to hop outside of a network, use the **radiotest off** command to return the device to its normal state:

```
> radiotest off
```

Reset or power cycle ETERNA2.

## 4.9 Radio Inactive Emission Tests

To test ETERNA2 for emissions with the radio inactive:

Power up ETERNA2 and connect to the CLI port. Enter the following commands:

```
> set mode slave
```

```
> reset
```

**NOTE:** The device will remain inactive through power cycling. To resume radio testing, enter the following commands:

```
> set mode master
```

```
> reset
```

---

## 4.10 Packet Error Rate (PER) Tests

Packet Error Rate support in `radiotest` has been added outside of the production release cycle. The PER tests described in the following section are not supported on software releases prior to May of 2017. Future production releases may include PER support. To enable PER testing the LTC5800 should be loaded with a software image from the `Eterna/Radio Certification` folder in the software release zip file, provided through the customer's document locker on their MyLinear account.

PER rate testing provides a measure of the fraction of packets successfully communicated from one device to another. To simplify PER testing for certification the ETERNA2 can be configured as either the transmitter as part of the test infrastructure or the DUT as the receiver. When configured as the transmitter ETERNA2 will generate a configuration packet instructing the DUT how many packets will be sent and the channels over the radio will hop over followed by a series of packets. The control packet is not included in the receivers packet totals when the receiver calculates the packet error rate.

To test measure packet error rate on ETERNA2 first setup the DUT:

Power up ETERNA2 and connect to the CLI port. Enter the following command:

```
> radiotest on
```

Reset or power cycle ETERNA2 and enter the following command:

```
> radiotest per_rx
```

Now power up the second ETERNA2 to be used as the transmitter and connect to the CLI port. Enter the following command:

```
> radiotest on
```

Reset or power cycle ETERNA2 and enter the following command:

```
> radiotest per_tx <power> <numPacket> <chanMask> <numRepeats>
```

`<power>` sets the radio output power, a value of 8 should be used for maximum power. `<numPacket>` is the number of packets to be sent to establish the PER. A larger value provides greater precision. A value of 100 will provide 1% resolution and a test time of approximately 1 second. 1000 will provide a resolution of 0.1% and a test time of 10 seconds.

`<numPacket>` is limited to a maximum of 2000. `<chanMask>` is a hex bitmap of channels to use with the LSB corresponding to channel 0 and the MSB corresponding to channel 15. Channel 15 in product is never used. E.g. 0x7FFF results in operation on channels 0 through 14 and 0x0001 results in operations only on channel 0. The `<numRepeats>` parameter defines the number of times that the defined packet sequence will repeat. A `<numRepeats>` value of 0 results in the sequence repeating indefinitely. The recommended command for PER is:

```
> radiotest per_tx 8 1000 0x7FFF 0
```

The transmitter's CLI port should appear as:

```
> radiotest per_tx 8 1000 0x7FFF 0
```

```
> Starting tx: 1000 packets, 0x7fff chan mask
Tx completed
Starting tx: 1000 packets, 0x7fff chan mask
Tx completed
```



The first line “Starting tx: 1000 packets, 0x7fff chan mask” indicates the number of packets and the channel mask being used. The second line “Tx complete” indicates all 1000 packets have been sent. The first two lines will repeat until the device is reset, given `<numRepeats>` is set to 0.

On the DUT CLI port should appear as:

```
> radiotest per_rx
```

```
> Rx cfg packet: expecting 1000 packets, 0x7fff chan mask
Rx completed
Rx OK: 988
Rx errors: 6
Rx invalid: 1
Rx missed: 5
PER: 1.20%
Rx cfg packet: expecting 1000 packets, 0x7fff chan mask
Rx completed
Rx OK: 987
Rx errors: 2
Rx invalid: 1
Rx missed: 10
PER: 1.30%
```

The first line “Rx cfg packet: expecting 1000 packets, 0x7fff chan mask” indicates the DUT has received a configuration packet. The second line “Rx completed” indicates the DUT has listened for the total number of packets specified in the configuration packet. The third line “Rx OK: 998” indicates the DUT successfully received 998 packets. The fourth line “Rx errors: 2” indicates that two packets were received with invalid CRCs. The fifth line “Rx invalid: 1” indicates the DUT received an invalid packet, where an invalid packet is defined as an 802.15.4 packet not generated by the transmitter. “Rx invalid” values greater than 0 indicate the RF environment is not clean and there is another 802.15.4 network interfering with the PER measurement. The sixth line “Rx missed: 10” indicates that while listening the radio did not hear an 802.15.4 packet when it expected to hear a packet. The seventh line is the calculated PER where  $PER = 1 - (Rx\ OK) / (\text{expected number of packets})$ .

**NOTE:** During PER testing there is a probability the DUT will not receive the configuration packet. In this case the DUT will continue to listen for a configuration packet until it receives a packet. As a result there will be some sets of packets sent by the transmitter which will be ignored by the receiver. If the test is designed to search for the 10% PER point one should expect roughly 1 out of 10 sequences to be missed.

## 5 Specifications

**Table 2 Normal Operating Conditions**

| Parameter   | Min | Typ | Max  | Units | Comments                            |
|---|-----|-----|------|-------|-------------------------------------|
| Operational supply voltage range (between V <sub>DD</sub> and V <sub>SS</sub> ) | 2.1 |     | 3.76 | V     | Including noise and load regulation |
| Operating temperatures  | -40 |     | +85  | °C    |                                     |
| Mass  |     | 4   |      | grams |                                     |

### 5.1 Radio Specifications

ETERNA2 operates as an IEEE-802.15.4 compliant radio, both transmitting and receiving in a TDMA channel access method.

**Table 3 Radio Specifications**

| Parameter                        | Min  | Typ                 | Max    | Units | Comments  |
|----------------------------------|--|---------------------|--------|-------|---|
| Frequency Band of Operation      | 2400                                       |                     | 2483.5 | MHz   |   |
| Number of channels               |  | 15                  |        |       |   |
| Carrier Frequencies              |  | $2400 + (n-10) * 5$ |        | MHz   | Where n = 11 to 25  |
| Occupied Channel Bandwidth       |  | 2.7                 |        | MHz   | At -20 dBc  |
| Channel separation               |  | 5                   |        | MHz   |   |
| Frequency Accuracy               | -40  |                     | 40     | ppm   |   |
| Conducted Output Power (LTP5902) | 6  | 8                   | 9      | dBm   |   |
| Radiated Output Power (LTP5901)  |  | 100.6               |        | dBuV  | Measured at 3 meters. The LTP5901 orderable instantiation of ETERNA2 includes an integral antenna with a peak gain of 1.5 dBi |
| ITU Designation of Emission      | <b>2M70G1DDT</b> (numbers in <b>bold</b> ) |                     |        |       |   |
| Modulation                       | OQPSK                                      |                     |        |       |   |
| Signal Information               | IEEE-802.15.4, TDMA                        |                     |        |       |   |

## 6 Regulatory and Standards Compliance

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### 6.1 RF Exposure

The radiated output power of ETERNA2 is far below the FCC, IC and CE radio frequency exposure limits. ETERNA2 complies with FCC, IC and CE radiation exposure limits set forth for an uncontrolled environment. When nearby persons has to be kept to ensure RF exposure compliance, in order to comply with RF exposure limits established in the ANSI C95.1 standards, the distance between the antennas and the user should not be less than 20 cm (8 inches). ETERNA2 shall not be co-located with any other transmitter within 20 cm; otherwise further transmitter testing may be required.

### 6.2 User's Manual Language

The user's manual for end users must include the following information in a prominent location:

**IMPORTANT NOTE:** To comply with FCC, IC and CE RF exposure compliance requirements, the antenna used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons.

**IMPORTANT NOTE:** Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

**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:

1. Reorient or relocate the receiving antenna.
2. Increase the separation between the equipment and receiver.
3. Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
4. Consult the dealer or an experienced radio/TV technician for help.

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..

### 6.3 FCC Compliance

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.

#### 6.3.1 FCC Testing

ETERNA2 complies with Part 15.247 modular (Intentional Radiator) of the FCC rules and regulations. In order to fulfill FCC certification requirements, products incorporating ETERNA2 must comply with the following:

1. An external label must be provided on the outside of the final product enclosure specifying the FCC identifier as described in 6.3.3 below.
2. The antenna must have lower gain than specified in 6.3.2.
3. The device integrating ETERNA2 may not cause harmful interference and must accept any interference received, including interference that may cause undesired operation.
4. An unintentional radiator scan must be performed on the device integrating ETERNA2, per FCC rules and regulations, CFR Title 47, Part 15, Subpart B. See FCC rules for specifics on requirements for declaration of conformity.

---

### 6.3.2 Antenna Selection

Per KDB Publication No. 558074, ETERNA2 may be mated with an antenna with a maximum gain of 10 dBi.

### 6.3.3 OEM Labeling Requirements

The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. The outside of the final product enclosure must have a label with the following (or similar) text specifying the FCC identifier. The FCC ID and certification code must be in Latin letters and Arabic numbers and visible without magnification.

Contains transmitter module FCC ID: SJC-ETERNA2

Or

Contains FCC ID: SJC-ETERNA2

## 6.4 Industry Canada (IC) Compliance / Conformité à la norme Industrie Canada (IC)

Under Industry Canada regulations, this radio transmitter may only operate using an antenna with a maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna gain should be so chosen that the equivalent isotropic radiated power (e.i.r.p.) is not more than that necessary for successful communication.

Suivant la législation Industrie Canada, ce transmetteur radio ne peut être utilisé qu'avec une antenne dont le gain est inférieur au gain approuvé pour le transmetteur par Industrie Canada. Pour réduire le risque d'interférence aux autres utilisateurs, l'antenne doivent être choisies telle que la puissance isotrope rayonnée équivalente (PIRE) ne dépasse pas ce qui est nécessaire pour une communication réussie.

### 6.4.1 RF Exposure / Exposition aux Rayonnements Radiofréquences

The radiated output power of ETERNA2 is far below the IC radio frequency exposure limits. ETERNA2 complies with IC radiation exposure limits set forth for an uncontrolled environment. When nearby persons has to be kept to ensure RF exposure compliance, in order to comply with RF exposure limits established in the ANSI C95.1 standards, the distance between the antennas and the user should not be less than 20 cm (8 inches). ETERNA2 shall not be co-located with any other transmitter within 20 cm; otherwise further transmitter testing may be required.

La puissance émise par ETERNA2 est largement inférieure aux limites d'exposition aux rayonnements de la norme IC. ETERNA2 est conforme aux limites d'exposition aux rayonnements de la norme IC établies pour un environnement non contrôlé. Pour garantir la conformité aux limites d'exposition aux rayonnements de la norme ANSI C95.1, la distance entre l'antenne et toute personne doit être supérieure à 20 cm (8 pouces). ETERNA2 ne doit pas être localisé à proximité d'un autre transmetteur à moins de 20 cm ; le cas échéant, d'autres mesures de rayonnement pourraient être nécessaires.

### 6.4.2 User's Manual Language / Libellé du Manuel d'Utilisateur

The user's manual for end users must include the following information in a prominent location:

**IMPORTANT NOTE:** To comply with IC RF exposure compliance requirements, the antenna used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons.

**IMPORTANT NOTE:** Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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..

Le manuel d'utilisateur du produit final doit comprendre et mettre en évidence les informations suivantes:

**NOTE IMPORTANTE :** afin d'assurer la conformité aux limites Industrie Canada d'exposition aux rayonnements, l'antenne utilisée pour ce transmetteur doit être installée en considérant une distance de séparation à toute personne d'au moins 20 cm.

NOTE IMPORTANTE : Toute modification non expressément approuvée par la partie responsable de la conformité pourrait annuler l'autorisation accordée à l'utilisateur d'utiliser cet équipement.

Cet appareil est conforme à la norme RSS Industrie Canada exempt de licence. Son fonctionnement est soumis aux deux conditions suivantes : (1) cet appareil ne peut pas provoquer d'interférences ; et, (2) Cet appareil doit accepter toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement du dispositif.

### **6.4.3 IC Testing / Protocole d'Essai**

ETERNA2 is certified for modular Industry Canada (IC) RSS-210 approval. The OEM is responsible for its product to comply with IC ICES-003 and FCC Part 15, Sub. B - Unintentional Radiators. The requirements of ICES-003 are equivalent to FCC Part 15 Sub. B and Industry Canada accepts FCC test reports or CISPR 22 test reports for compliance with ICES-003.

ETERNA2 est un module certifié conforme d'après la norme RSS-210 d'Industrie Canada (IC). Le fabricant d'appareil d'origine est responsable de la conformité de son produit aux normes IC ICES-003 et FCC Part15, Sub. B « Unintentional Radiators ». Les exigences de ICES-003 sont équivalentes aux exigences de FCC Part 15 Sub.B et Industrie Canada reconnaît les rapports d'essai FCC ou CISPR 22 pour démontrer la conformité avec ICES-003.

### **6.4.4 Antenna Selection / Choix de l'antenne**

This radio transmitter ETERNA2 has been approved by Industry Canada to operate with the antenna with the maximum permissible gain listed below. Antenna's having a gain greater than the maximum gain indicated, are strictly prohibited for use with this device.

ETERNA2 may be mated with an antenna with a maximum gain of 10 dBi.

Le transmetteur radiofréquence ETERNA2 est approuvé par Industrie Canada pour opération avec une antenne dont le gain est inférieur ou égal au gain maximal ci-dessous. Il est strictement interdit d'utiliser ce produit avec une antenne de gain supérieur au gain indiqué.

ETERNA2 peut être utilisé avec une antenne de gain maximal de 10 dBi

### **6.4.5 OEM Labeling Requirements / Etiquetage des appareils**

The Original Equipment Manufacturer (OEM) must ensure that IC labeling requirements are met. The outside of the final product enclosure must have a label with the following (or similar) text specifying the IC identifier. The IC ID and certification code must be in Latin letters and Arabic numbers and visible without magnification.

Le fabricant d'appareil d'origine est responsable de la conformité de l'étiquetage aux exigences IC. Le texte suivant (ou semblable) indiquant le code IC d'identification et de certification doit figurer à l'extérieur du produit final. Le code IC doit être écrit en alphabet latin et chiffres arabes et doit être visible à l'œil nu.

|                            |
|----------------------------|
| Contains IC: 5853A-ETERNA2 |
|----------------------------|

---

## 6.5 CE Compliance

### 6.5.1 Declaration of Conformity

We, Dust Networks, of Suite 910, 32990 Alvarado-Niles Road, Union City, CA 94587, declare under our sole responsibility that our product, ETERNA2, and in combination with our accessories, to which this declaration relates is in conformity with the appropriate standards ETSI EN 300 328, ETSI EN 301 489-17 and EN 60950, following the provisions of Radio Equipment and Telecommunication Terminal Equipment Directive 99/5/EC with requirements covering EMC Directive 2004/108/EC, and Low Voltage Directive 2006/95/EC.

### 6.5.2 European Compliance

If ETERNA2 is incorporated into a product, the manufacturer must ensure compliance of the final product to the European harmonized EMC and low-voltage/safety standards. A Declaration of Conformity must be issued for each of these standards and kept on file as described in European Union Directive (2014/53/EU). Furthermore, the manufacturer must maintain a copy of the ETERNA2 user documentation and ensure the final product does not exceed the specified power ratings, antenna specifications, and/or installation requirements as specified in the user manual. If any of these specifications are exceeded in the final product, a submission must be made to a notified body for compliance testing to all required standards.

### 6.5.3 Antenna Selection

Per EN 300 328, ETERNA2 when operating as a WirelessHART device may be mated with an antenna with a maximum gain of +8.5 dBi, provided all 15 channels are in use. If less than 15 channels are used, ETERNA2 may be mated with an antenna with a maximum gain of +2dBi.

Per EN 300 328, ETERNA2 when operating as a SmartMesh IP device may be mated with an antenna with a maximum gain of +7.25 dBi, provided all 15 channels are in use. If less than 15 channels are used, ETERNA2 may be mated with an antenna with a maximum gain of +2dBi.

### 6.5.4 OEM Labeling Requirements

The 'CE' marking must be affixed to a visible location on the OEM product. The CE mark shall consist of the initials "CE" taking the following form:

- If the CE marking is reduced or enlarged, the proportions given in the drawing below must be respected.
- The CE marking must have a height of at least 5 mm except where this is not possible on account of the nature of the apparatus.
- The CE marking must be affixed visibly, legibly, and indelibly.



See the European Union Directive (2014/53/EU) on Radio Equipment for more information.



## 6.6 Compliance to Japan Radio Law

ETERNA2 is compliant to Japan Radio Law Article 38, Section 24.

### 6.6.1 OEM Labeling Requirements

The Original Equipment Manufacturer (OEM) must ensure that Japan Radio Law labeling requirements are met. The outside of the final product enclosure must have a label including the Mark, , and the  symbol indicating radio equipment and the identification code as follows:

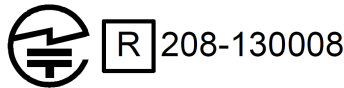



Figure 2 JRL Label Requirements

The Mark, , must be reproduced with a minimum diameter of 3mm.

### 6.6.2 Antenna Selection

ETERNA2 may be used with the following antennas:

Table 4 Japan Approved Antennas

| Manufacturer | Part #           | Peak Gain |
|--------------|------------------|-----------|
| Fractus      | FR05-S1-N-0-102  | 1.5 dBi   |
| Laird        | WXE2400          | 3 dBi     |
| Laird        | CAF28841         | 2.5 dBi   |
| Nearson      | S152CL-03251     | 2 dBi     |
| Nearson      | S152AM-2450S     | 4 dBi     |
| Nearson      | S152AH-2450S     | 4 dBi     |
| Nearson      | S181FL-RMM-2450S | 2 dBi     |
| Nearson      | S181XX-2450S     | 2 dBi     |
| PCTEL        | MHO24004NM       | 4 dBi     |
| PCTEL        | MHO24002NM       | 2 dBi     |
| PCTEL        | BOA24004NF       | 4 dBi     |
| PCTEL        | MMSO2300         | 0 dBi     |
| PCTEL        | MMSO2300PT       | 0 dBi     |
| PCTEL        | PCTMI24-RPC      | 2.2 dBi   |
| Pulse        | W1030            | 2.0 dBi   |
| Pulse        | W5001            | 1.5 dBi   |
| Pulse        | W5010            | 1.5 dBi   |
| Pulse        | W5011            | 1.5 dBi   |
| RFM          | BM242            | 2.5 dBi   |
| Sirio        | SCO-2.4-6        | 6 dBi     |
| taoglas      | FXP73.09.0100A   | 2.5 dBi   |
| taoglas      | GW.71.5153       | 3.8 dBi   |
| taoglas      | FXP.810.09.0100C | 2.4 dBi   |
| taoglas      | FXP831.09.0100C  | 3.0 dBi   |
| taoglas      | FXP832.03.0458D  | 3.66 dBi  |

| <b>Manufacturer</b> | <b>Part #</b>     | <b>Peak Gain</b> |
|---------------------|-------------------|------------------|
| taoglas             | PC11.09.0100A     | 3 dBi            |
| taoglas             | WPC.25B.35        | 3.75 dBi         |
| taoglas             | GW.05.0153        | 3.88 dBi         |
| taoglas             | GW26.0151         | 1.8 dBi          |
| taoglas             | GW26.0152         | 1.8 dBi          |
| taoglas             | GW.59.3153        | 2.37 dBi         |
| taoglas             | WSA.2400.A.101151 | 3.67 dBi         |
| taoglas             | FW.24.SMA.M       | 4.26 dBi         |
| taoglas             | GW.11.A153        | 2.3 dBi          |
| taoglas             | WS.02.B.205111    | 4.42 dBi         |
| taoglas             | GW.11.A153W       | 2.3 dBi          |
| STAF                | 1019-16A          | 2.14 dBi         |
| STAF                | 1019-17A          | 2.14 dBi         |
| STAF                | 1019-18A          | 2.14 dBi         |
| STAF                | 1019-19A          | 2.14 dBi         |
| Cortec              | AN2400-6710BRS    | 3.5 dBi          |
| Cortec              | R-AN2400-5701RS   | 2.5 dBi          |



## 6.7 Korean Compliance

ETERNA2 is compliant with Korean modular certification criteria. The warnings in the following section are applicable to both ETERNA2 and any product that incorporates ETERNA2.

### 6.7.1 경고 \ Warnings

- 1) 해당무선설비기기는운용중전파혼신가능성이있으므로인명안전과관련된서비스는할수없습니다
- 2) 해당무선설비기기는운용중전파혼신가능성이있음

### 6.7.2 Product Packaging Requirements

OEM products that incorporate ETERNA2 will be required to include ETERNA2's KCC ID on the product label, if practical, and on the packing of the shipped product, in addition to the products other labeling requirements.

인증번호 : KCC-CRM-LT9-ETERNA2

### 6.7.3 Antenna Selection

ETERNA2 may be used with the following antennas:

**Table 5 Korea Approved Antennas**

| Manufacturer | Part #             | Peak Gain |
|--------------|--------------------|-----------|
| Fractus      | FR05-S1-N-0-102    | 1.5 dBi   |
| Nearson      | S151FL-L-RMM-2450S | 5 dBi     |
| Nearson      | S152AH-2450S       | 4 dBi     |
| Nearson      | S181FL-RMM-2450S   | 2 dBi     |
| Nearson      | S181XX-2450S       | 2 dBi     |
| PCTEL        | MHO24004NM         | 4 dBi     |
| PCTEL        | MMSO2300           | 0 dBi     |
| PCTEL        | MMSO2300PT         | 0 dBi     |
| PCTEL        | PCTMI24-RPC        | 2.2 dBi   |
| Pulse        | W1030              | 2.0 dBi   |
| Pulse        | W5001              | 1.5 dBi   |
| Pulse        | W5010              | 1.5 dBi   |
| Pulse        | W5011              | 1.5 dBi   |
| RFM          | BM242              | 2.5 dBi   |
| taoglas      | GW.71.5153         | 3.8 dBi   |
| Cortec       | AN2400-6710BRS     | 3.5 dBi   |
| Cortec       | R-AN2400-5701RS    | 2.5 dBi   |
| Sirio        | W-LAN SCO-2.4-6    | 6 dBi     |

## 6.8 NCC \ Taiwan Compliance

ETERNA2 is compliant with Taiwanese modular certification criteria. The warnings in the following section are applicable to both ETERNA2 and any product that incorporates ETERNA2.

### 6.8.1 NCC Warnings (English)

According to “Administrative Regulations on Low Power Radio Waves Radiated Devices” Without permission granted by the NCC, any company, enterprise, or user is not allowed to change frequency, enhance transmitting power or alter original characteristic as well as performance to an approved low power radio-frequency devices shall not influence aircraft security and interfere legal communications; If found, the user shall cease operating immediately until no interference is achieved. The said legal communications means radio communications is operated in compliance with the Telecommunications Act.

The low power radio-frequency devices must be susceptible with the interference from legal communications or ISM radio wave radiated devices.

### 6.8.2 NCC Warnings (Traditional Chinese)

根據NCC 低功率電波輻射性電機管理辦法 規定:

第十二條 經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。

第十四條 低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。  
前項合法通信，指依電信法規定作業之無線電通信。低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

### 6.8.3 Antenna Selection

ETERNA2 may be used with the following antennas (for antennas that offer both RPSMA and SMA connectors, only RPSMA connectors can be used):

Table 6 Taiwan Approved Antennas

| Manufacturer | Part #                                      | Peak Gain | Type   | Connector |
|--------------|---|-----------|--------|-----------|
| Fractus      | FR05-S1-N-0-102                             | 1.5 dBi   | Chip   | SMD       |
| Nearson      | S151FL-L-RMM-2450S                          | 5 dBi     | Dipole | MMCX      |
| Nearson      | S152AH-2450S                                | 4 dBi     | Dipole | RPSMA     |
| Nearson      | S181FL-RMM-2450S                            | 2 dBi     | Dipole | MMCX      |
| Nearson      | S152CL-03251                                | 2 dBi     | Dipole | MMCX      |
| PCTEL        | MMSO2300#MMCX – or -<br>MMSO2300#RAMMCX     | 0 dBi     | Dipole | MMCX      |
| PCTEL        | MMSO2300PT#MMCX – or -<br>MMSO2300PT#RAMMCX | 0 dBi     | Dipole | MMCX      |
| PCTEL        | PCTMI24-RPC                                 | 2.2 dBi   | Dipole | RPTNC     |
| Pulse        | W1030                                       | 2.0 dBi   | Dipole | RPSMA     |
| Pulse        | W5001                                       | 1.5 dBi   | Dipole | RPSMA     |
| Pulse        | W5010                                       | 1.5 dBi   | Dipole | RPSMA     |
| taoglas      | GW.71.5153                                  | 3.8 dBi   | Dipole | RPSMA     |
| Cortec       | AN2400-6710BRS                              | 3.5 dBi   | Dipole | SMA       |
| Cortec       | R-AN2400-5701RS                             | 2.5 dBi   | Dipole | SMA       |

## 6.9 Thailand Compliance

This telecommunication equipment is in compliance with NBTC requirements (เครื่องโทรคมนาคมและอุปกรณ์นี้ มีความสอดคล้องตามข้อกำหนดของ กสทช).

**Note:** Thailand's National Telecommunications Commission (NTC) does not support modular certification; end-product using an ETERNA2 module must be independently certified. The module's FCC and CE reports containing the conducted data may be leveraged for the certification for end-products using the ETERNA2 module, however additional testing for the end-product (such as spurious emissions) may be needed for the end-product certification.

## 6.10 Singapore Compliance

ETERNA2 is compliant with Singapore IMDA Standards DA103548.



**Figure 3 Singapore Compliance with IMDA Standards DA103548**

**Note:** Singapore does not support modular certification; end-product using an ETERNA2 module must be independently certified. The module's FCC and CE reports containing the conducted data may be leveraged for the certification for end-products using the ETERNA2 module, however additional testing for the end-product (such as spurious emissions) may be needed for the end-product certification.

## 6.11 Compliance to Restriction of Hazardous Substances (RoHS)

Restriction of Hazardous Substances (RoHS) is a directive that places maximum concentration limits on the use of cadmium (Cd), lead (Pb), hexavalent chromium(Cr+6), mercury (Hg), Polybrominated Biphenyl(PBB) and Polybrominated Diphenyl Ethers (PBDE). Dust Networks is committed to meeting the requirements of the European Community directive 2002/95/EC.

This product has been specifically designed to utilize RoHS compliant materials and to eliminate, or reduce, the use of restricted materials to comply with 2002/95/EC.

The Dust Networks RoHS compliant design features include:

- RoHS compliant solder for solder joints
- RoHS compliant base metal alloys
- RoHS compliant precious metal plating
- RoHS compliant cable assemblies and connector choices

## 6.12 Encryption Cipher

ETERNA2's 128-bit Advanced Encryption Standard (AES) cipher has been certified compliant to the United States National Institute of Standards and Technology (NIST) FIPS-197 (NIST certificate number, AES: 1437). To view the FIPS-197 validation list, go to: <http://csrc.nist.gov/groups/STM/cavp/documents/aes/aesval.html>

# 7 Mechanical Specifications

## 7.1 Mote Module

The ETERNA2 comes in 66-lead, 1 mm lead pitch castellated PCB, as illustrated in Figure 4 and in Figure 5.

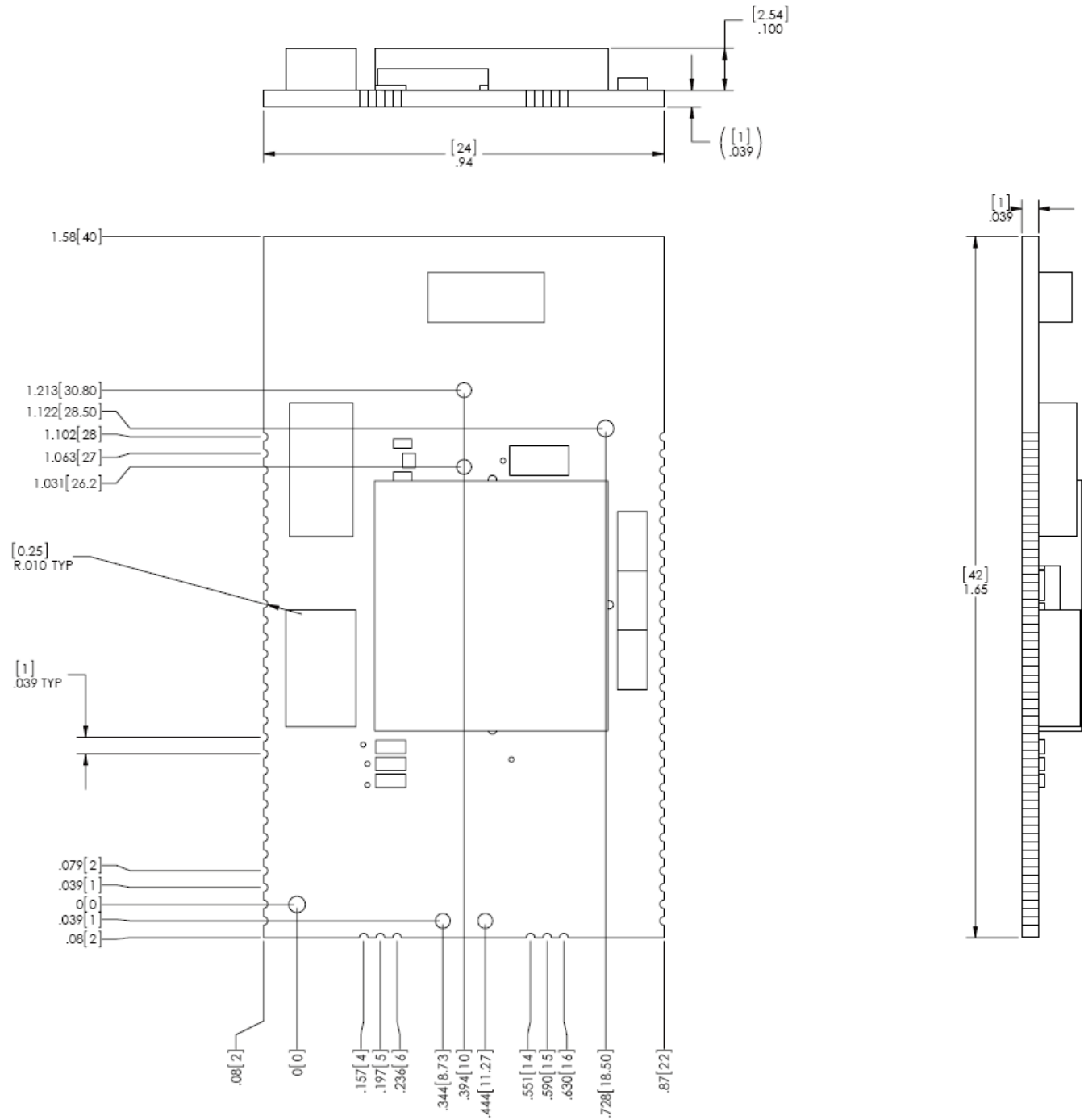


Figure 4 Mechanical Drawing – LTP5901

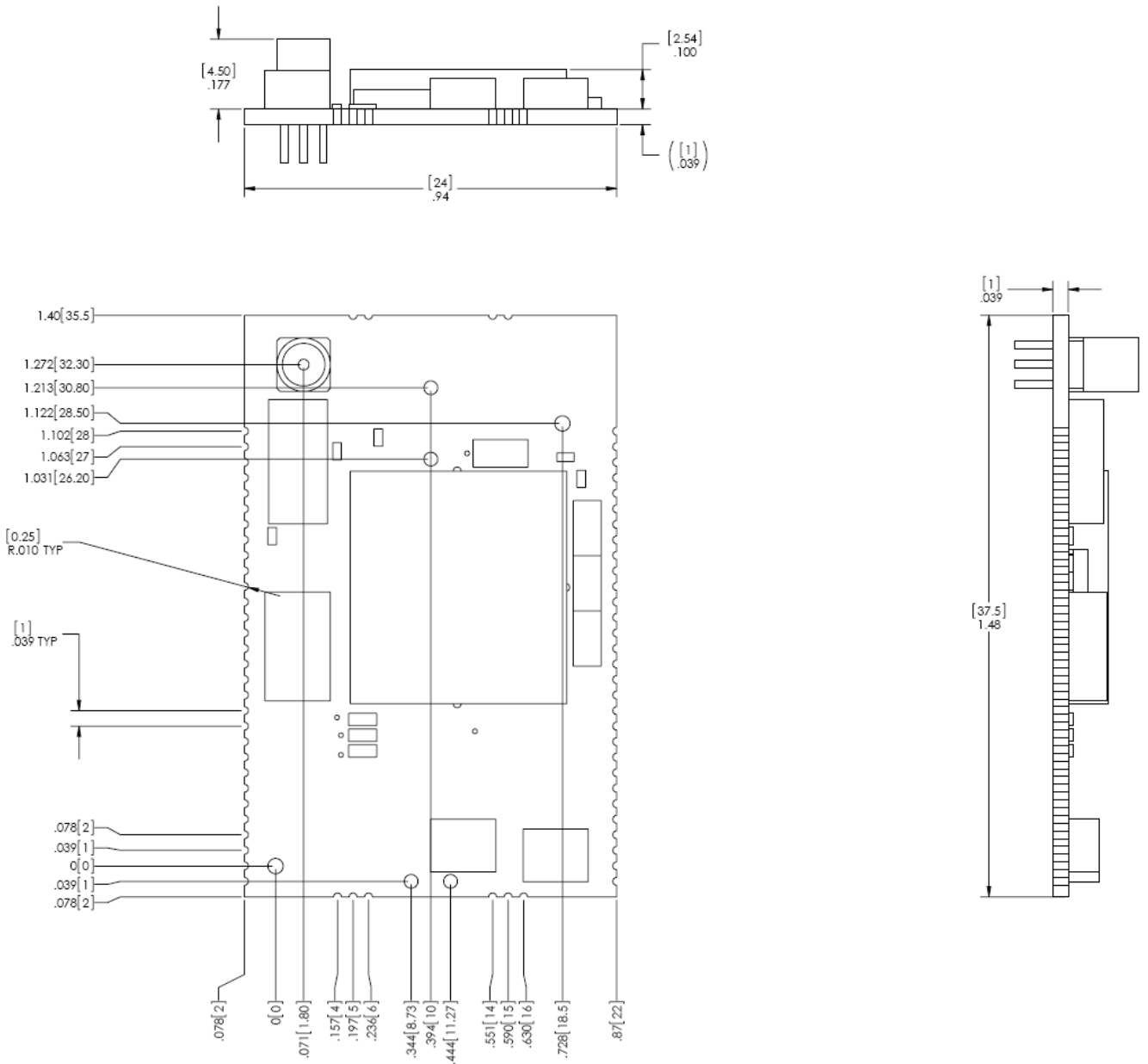


Figure 5 Mechanical Drawing – LTP5902