OptConnect ema™

mPCIe Adaptor User Guide

V1.0 Updated June 2020

OptConnect
MANAGED WIRELESS SOLUTIONS

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1. Introduction

1.1 Scope

The OptConnect ema™ Mini PCI Express (mPCIe) Adaptor is an accessory card utilizing the PCI Express Full Mini-Card Revision 1.2 Specification. Its purpose is to allow any host system or device with an available mPCIe slot full access to OptConnect ema™ modems and all of their features, without the need to obtain additional certifications. This document will outline best practices, relative to both hardware and software integrations that designers should follow for a robust cellular experience.

1.2 Contact Information

For more information regarding OptConnect ema™ contact OptConnect Sales at 1.877.678.3343 ext. 2 during normal business hours. For technical support contact OptConnect Customer Care Center at 1.877.678-3343 ext. 3 from 6 am until 7 pm MST Monday through Saturday.

1.3 Orderable Part Numbers

Orderable Device	Primary Module Firmware Revision	Operating Temperature	LTE Bands	3G UMTS	Network	Region
EMA-L4-1-XX-A-A (discontinued)	20.00.505	-40 to +85˚C	FDD B2, B4, B5, B12, B13	B2, B5	AT&T, Verizon	North America
EMA-L4-1-US-B-A (discontinued)	20.00.005	-40 to +85˚C	FDD B2, B4, B5, B12, B13	B2, B5	AT&T, Verizon	United States
EMA-L4-1-XX-A-A-000	20.00.506	-40 to +85˚C	FDD B2, B4, B5, B12, B13	B2, B5	AT&T, Verizon	North America
EMA-L4-1-US-B-A-000	20.00.006	-40 to +85˚C	FDD B2, B4, B5, B12, B13	B2, B5	AT&T, Verizon	United States

Unless instructed otherwise EMA-L4-1-XX… will utilize AT&T as the primary carrier and Verizon as the secondary carrier. Unless instructed otherwise, EMA-L4-1-US… will utilize Verizon as the primary carrier and AT&T as the secondary carrier.

Orderable Device	Description	Operating Temperature	Region
EMA-ZZ-1-XX-Z-C	Mini PCI Express adaptor for OptConnect ema™ modems	0 to +70˚C	North America

1.4 Additional Resources

OptConnect ema™ and accessories are supported by a full range of documentation, including User Guides and Application Notes as well as related code samples. The latest versions of these resources can be found at **http://optconnect.com/ema** . Suggested prerequisites for this document are the following:

- OptConnect ema™ Hardware Guide
- OptConnect ema™ Getting Started
- OptConnect ema™ emaLink AT Command Manual
- OptConnect ema™ Windows Networking Guide - Application Note: 002

2. Overview

2.1 Contents

The mPCIe Adaptor ships ready to use. The only other requirement is an OptConnect ema™ modem. The contents of the mPCIe Adaptor package include the following:

1. mPCIe Adaptor
2. Shunt jumper (default positioned at 'DIS" on PCB)

2.2 Features

- Compatible with OptConnect ema™ modems
- Power and Status LED indicators
- Provides access to all OptConnect ema™ communication interfaces
    - Onboard 2x1 UART to USB bridge
        - Exposes both the ema modem UART and the emaLink UART
    - Onboard USB 2.0 hub
        - Exposes both UARTs as Virtual COM Ports
        - Exposes native USB interface
- Selectable software/hardware ema on/off/reset control
    - Allows software control of ema via emaLink as an alternate to traditional mPCIe PERST#/W_DISABLE# hardware control
- Conforms to PCI Express Full Mini-Card Revision 1.2 Specification

3. Hardware

Section 3 outlines the hardware and components of the mPCIe Adaptor. *Figures 1-2* can be used as quick reference guides for navigating the various components and features.

3.1 Specifications

Technical Specifications	
Hardware	
Form Factor	Mini PCI Express Full Size
Dimensions	ema not inserted: 30 x 50.95 x 7.7 mm ema inserted: 30 x 50.95 x 12.3 mm
Power	
Input Voltage	2.5V to 5.5V, nominal 3.3V
I/O Voltage	2.5V - 5.5V
Max Current	1.1A @ 3.3V, 1.68A @ 2.5V, 0.8A @ 5.5V
Interfaces	
Type	UART(2) to USB Bridge(Virtual COM Port), USB 2.0 Hub
USB Driver Support	USB 2.0, Linux, Windows, Android
LED Indicators	Host/System Power (Green), ema Power (Green), ema ready (Amber)
Mini PCI Express IO	WAKE#, W_DISABLE#, PERST#, LED_WWAN#
Control Mode (HW/SW)	2mm 2 pos jumper to disconnect W_DISABLE# from host system
Approvals	
Compliance	RoHS compliant
Temperature Range	
Commercial/Industrial	0°C to +70°C
Support and Warranty	1 Year standard warranty

3.1.1 PCI Express Mini Card Specification

The OptConnect mPCIe Adaptor conforms to the PCI Express Mini Card Revision 1.2 Specification. As such, the signals outlined in *Table 1* are used by its implementation.

PCI Express Rev 1.2 Signal Name	OptConnect mPCIe board edge Connector (J4) pin(s)
3.3Vaux	2, 24, 39, 41, 52
GND	4, 9, 15, 18, 21, 26, 27, 29, 34, 35, 37, 40, 43, 50
WAKE#	1
W_DISABLE#	20
PERST#	22
USB_D-	36
USBD+	38
LED_WWAN#	42

Table 1

3.2 At a Glance

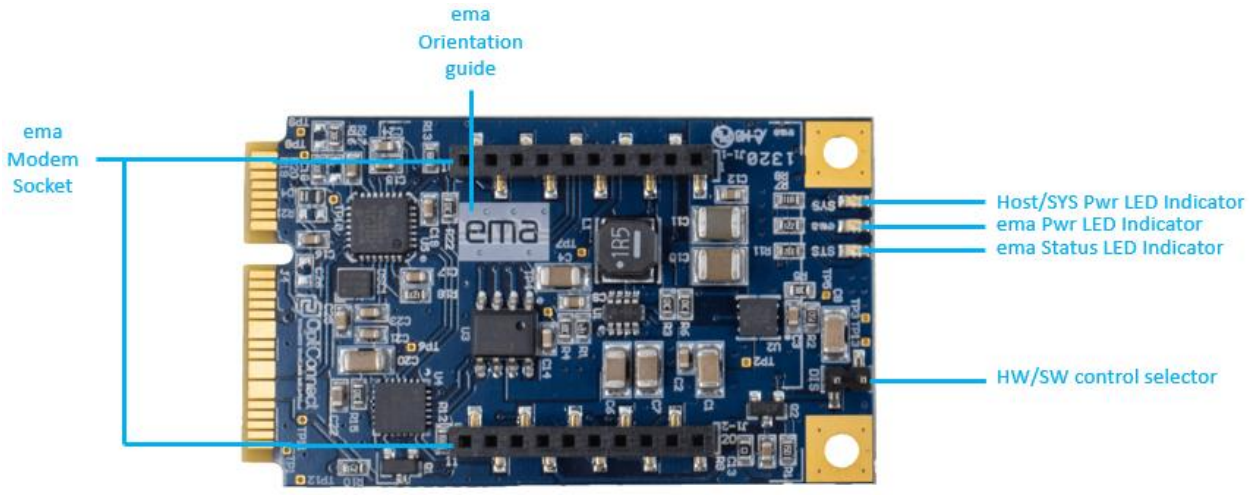


Figure 1

3.2 System Architecture

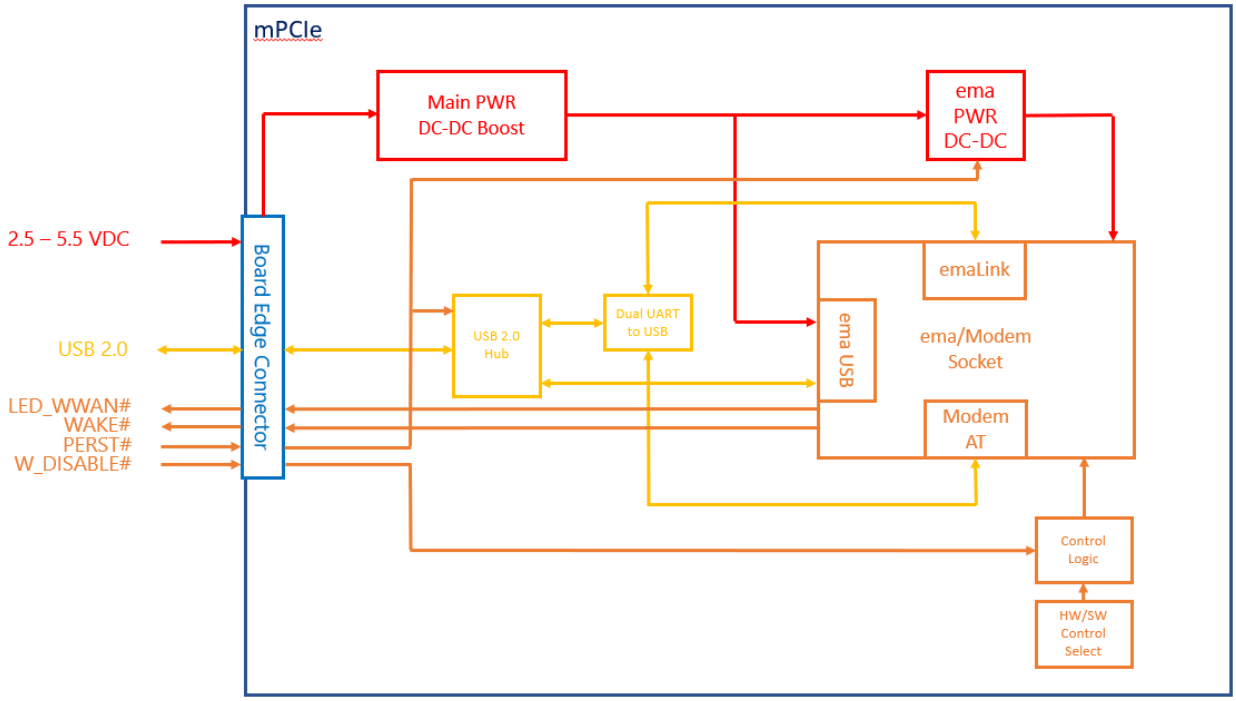


Figure 2

3.3 Power

The OptConnect mPCIe Adaptor must be powered by the host system that it is plugged into. The host must provide a robust power supply operating in the range of 2.5 – 5.5 VDC, and capable of delivering sufficient current. Refence *Table 2* for measured max current consumption values. The power must be applied at signals *3.3Vaux/GND*.

Operating Voltage (DC)	Max Current (DC)
2.5 V	1.68 A
3.3 V	1.1 A
5.5 V	.9 A

Table 2

3.4 mPCIe Auxiliary Signals

The PCI Express Mini Card Revision 1.2 Specification defines Auxiliary and Communication Specific Signals in sections 3.2.4 and 3.2.5. The OptConnect mPCIe Adaptor implements the following signals from these sections; *PERST#, W_DISABLE#, WAKE#, LED_WWAN#.* Sections 3.4.1 – 3.4.4 of this document outline best practices that designers should follow for integrating these signals when selecting or creating a custom host system main board.

3.4.1 PERST# Signal

The *PERST#* signal can be provided by the host system and driven high (de-asserted) when the host system's power sources are stable. Relative to the mPCIe Adaptor, this signal is internally pulled to *3.3Vaux* through a 10Kohm resistor. Driving the *PERST#* signal low (asserted) will disable both the onboard USB 2.0 hub as well as ema's main power supply. This signal is not required by the host, but recommended.

3.4.2 W_DISABLE# Signal

The *W_DISABLE#* signal can be provided by the host system and driven low (asserted) when the host system requires that ema's onboard cellular module be turned off. Relative to the mPCIe Adaptor, this signal is internally pulled to *3.3Vaux* through a 140Kohm resistor and effectively controls ema's Pin 20 (ON_OFF). Driving the *W_DISABLE#* signal high (de-asserted) will turn on ema's onboard cellular module. This signal is not required by the host, but recommended.

3.4.3 WAKE# Signal

The *WAKE#* signal is connected directly to ema's Pin 19 (RING) and can be monitored by the host system for various events. These events must be programmed into ema using its modem UART interface. Relative to the mPCIe Adaptor, the *WAKE#* signal is an open drain output and internally pulled to *3.3Vaux*. It will drive or pulse low (asserted) when the programmed event occurs. This signal is not required by the host.

3.4.4 LED_WWAN# Signal

The *LED_WWAN#* signal is connected to ema's Pin 13 (STATUS) through an inverter, and can be monitored by the host system to check for ema ready status. Relative to the mPCIe Adaptor, the *LED_WWAN#* signal is internally pulled to *3.3Vaux* through a 24Kohm resistor. It will drive low (asserted) when ema and its interfaces are ready for use. It will drive high (de-asserted) when ema and its interfaces are not ready or have been removed temporarily. Typically, this signal is connected to an LED circuit on the host system main board. A connection example is shown in *Figure 3*. Current sinked through the LED must be limited to 9 mA. This signal is not required by the host.

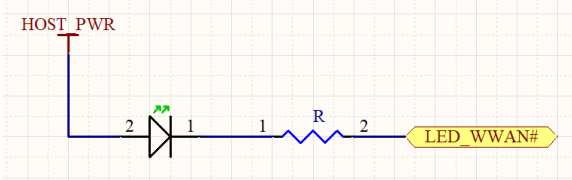


Figure 3

3.5 Communications

The mPCIe Adaptor exposes all ema's communication interfaces including the modem UART interface, emaLink UART Interface, and the native USB interface. The two UART interfaces are converted to USB onboard and an onboard USB 2.0 hub makes all three interfaces available to the host system over the PCI Express Mini Card Revision 1.2 Specification signals *USB_D+ and USB_D-*. Furthermore, the two UART interfaces will enumerate with the host system as Virtual Comm Ports over USB, allowing serial communications to be available. ema's native USB interface will enumerate with the host system as a Network Adaptor (CDC/ACM/MBIM) instance.

3.6 Power and Status LED Indicators

The mPCIe Adaptor has three onboard LEDs used for user feedback. *Table 3* outlines the behavior of each LED.

LED	Description
SYS (Green)	Turns ON when host/system power has been supplied at signal 3.3Vaux
ema (Green)	Turns ON when ema power has been turned on by the onboard logic
STS (Amber)	Turns on when ema is ready for use

Table 3

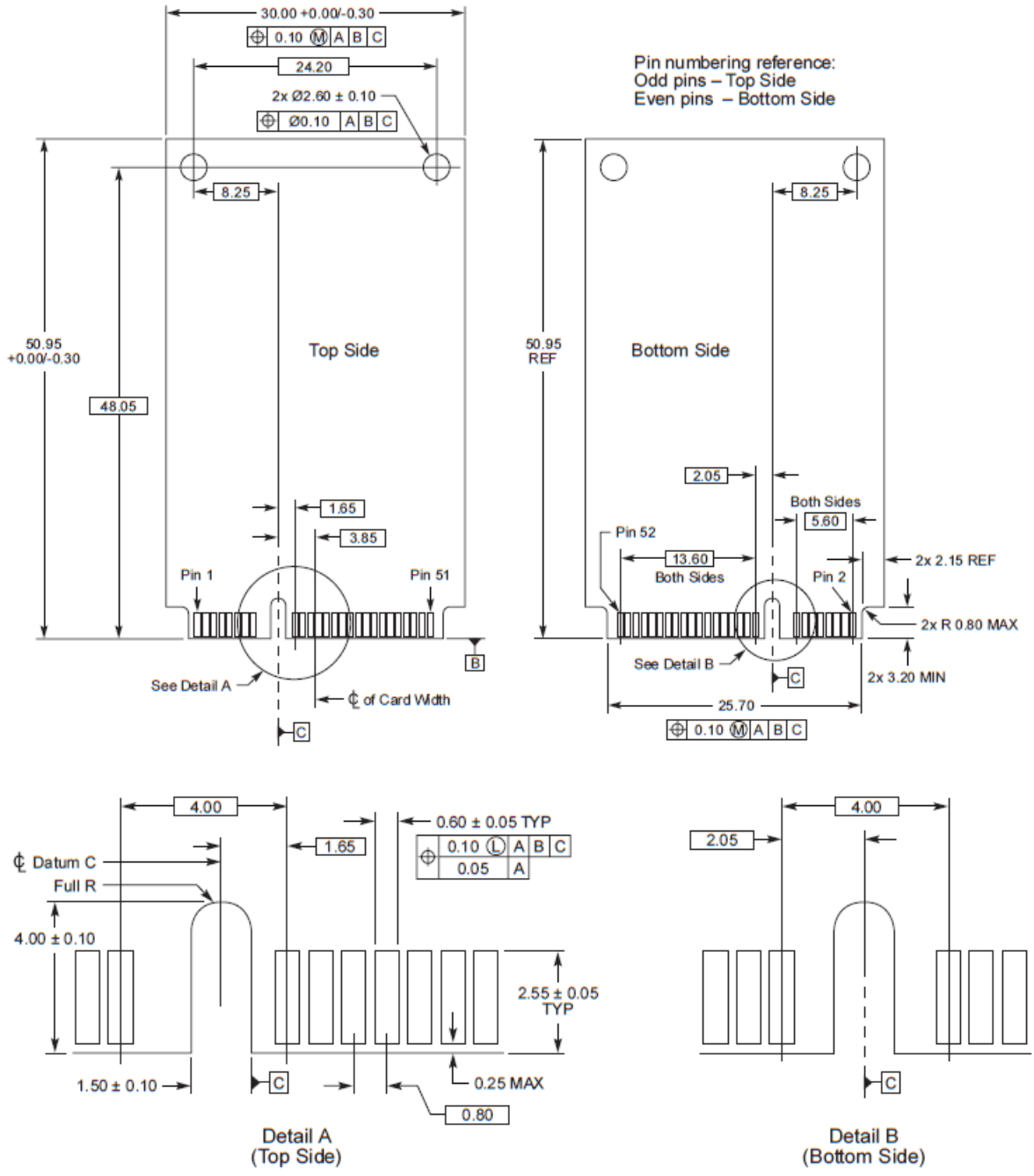
3.7 Selectable ema Hardware/Software Control

The mPCIe Adaptor includes a 2-pin header (DIS) that can be used to select whether or not the on/off/reset control of ema's onboard cellular module should be controlled via hardware using the mPCIe Auxiliary Signals (section 3.4), or controlled via software***** using the emaLink interface. Shorting or placing the provided shunt on the 2-pin header effectively disconnects the usage of the *W_DISABLE#* signal from the host system main board. This is known as *Software Control Mode******, and is explained in more detail in section 4.2. In this mode, the host system must use the emaLink interface (exposed as a Virtual COM Port) to control the on/off/reset of ema's cellular module. If the shunt is removed from the 2-pin header, then the mPCIe Adaptor expects the host system to control the mPCIe Auxiliary Signals accordingly.

*** Contact an OptConnect representative to check availability of this feature.**

3.9 Mechanical

3.9.1 Dimensions



4. Software

Section 4 provides guidance on the Software related components of the mPCIe Adaptor, and how best to integrate with the host system.

4.1 Communications

All three ema communication interfaces can be used by the host system to communicate with ema via the mPCIe Adaptor. All three of the interfaces are made available to the host system over a single USB 2.0, so the host system must support USB 2.0 Host functionality. *Table 4* summarizes these interfaces and how they will enumerate with the host.

Interface	Description
Native USB	Enumerates with the host as a "Network Adaptor" in the form of *CDC/ACM/MBIM*. USB drivers required.
ema Modem UART	Enumerates with the host as a "Virtual COM Port" in the form of *Standard COM Port*. USB drivers required.
emaLink	Enumerates with the host as a "Virtual COM Port" in the form of *Enhanced COM Port*. USB drivers required.

Table 4

It is required by the host system to implement the emaLink interface and one of the other two interfaces.

4.1.1 Native USB

The mPCIe Adaptor's native USB interface connects to ema's USB data bus, Pin 7 (USB_P) and Pin 8 (USB_N). This interface is typically used by, but not limited to, high level operating systems. The appropriate USB drivers must be used and are available from OptConnect. Supported drivers are as follows:

- Windows
- Linux
- Android

4.1.2 ema Modem UART

The mPCIe Adaptor's ema Modem UART interface connects to ema's Pin 2 (D_OUT) and Pin 3 (D_IN). This interface is typically used by, but not limited to, embedded systems. Relative to the mPCIe Adaptor, this interface is bridged from a UART to USB, in the form of a Virtual COM Port. USB drivers are required and can be downloaded at **https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers** . Reference *Figure 4* for a sample snapshot of the ema Modem UART over USB enumeration as Virtual COM Port (Standard COM Port) description in a Windows 10 environment.

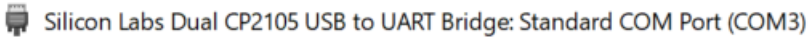


Figure 4

4.1.3 emaLink

The mPCIe Adaptor's emaLink interface connects to ema's Pin 17 (ema_DOUT) and Pin 18 (ema_DIN). This interface should be used and monitored by all host system implementations. Relative to the mPCIe Adaptor, this interface is bridged from a UART to USB, in the form of a Virtual COM Port. USB drivers are required and can be downloaded at **https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers** . Reference *Figure 5* for a sample snapshot of the emaLink over USB enumeration as Virtual COM Port (Enhanced COM Port) description in a Windows 10 environment.

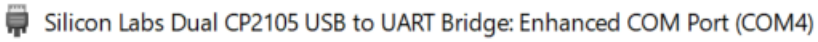


Figure 5

4.2 Software Control Mode*

The mPCIe Adaptor allows the host system the ability to control ema's on, off, and reset logic using AT commands over the emaLink interface. This feature makes the mPCIe Adaptor robust, and should allow most off-the-shelf (OTS) host systems and devices the ability to integrate with ema seamlessly. For example, an integrator may wish to purchase an industrial embedded computer with an onboard mPCIe slot, and use it as the main control mechanism inside of a larger machine. Since the integrator did not design the embedded computer and does not have access to its schematics, they cannot be certain that the onboard mPCIe slot follows the PCI Express Mini Card revision 1.2 specification. This casts doubt that

the embedded computer is provisioned correctly for the mentioned mPCIe Auxiliary Signals (section 3.4), to accommodate full hardware control of ema through the OptConnect mPCIe Adaptor. To alleviate these concerns, the OptConnect mPCIe Adaptor's *Software Control Mode**** can be enabled (reference section 3.7) to allow it and ema to function as designed, independent of the mPCIe Auxiliary Signals. In this scenario, the host embedded computer need only provide sufficient power (reference section 3.3) and use the emaLink interface to control ema's onboard cellular module accordingly with AT commands.

*** Contact an OptConnect representative to check availability of this feature.**

5. Reference

5.1 Integration Notes

1. If designing a custom host system main board, follow the PCI Express Full Mini-Card Revision 1.2 Specification. This document can be provided by an OptConnect representative if needed.
2. If using an off-the-shelf (OTS) host system, review its datasheet and specification for conformance with the PCI Express Full Mini-Card Revision 1.2 Specification.
3. When placing an ema modem into the mPCIe Adaptor modem socket, the ema Orientation Guide (section 3.2) defines how the ema modem should be orientated before placing it into the socket. Also, double check the pin alignment, as it is easy to insert the ema modem mis-aligned by one or more pins.
4. The two mounting holes on the mPCIe Adaptor are electrically connected to the GND net.
5. In airflow constrained host system environments, if possible, it is recommended to transfer the heat of the ema modem to a larger surface area like a heat-sink or metal enclosure. This can be accomplished by using a thermal conductive pad.

6. Revision History

Revision	Date	Description	Author
1.0	6/10/2020	Initial Release	MSV