

OptConnect ema™ Hardware Guide

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Table of Contents

Table of Contents	3
1. Introduction	5
1.1 Scope	5
1.2 Contact Information	5
1.3 Orderable Part Numbers	5
1.4 Additional Resources	6
1.5 Product Overview	6
1.6 Block Diagram	7
1.7 Software and Drivers	7
2. Technical Specifications	8
2.1 Electrical Specifications	8
2.1.1 Absolute Maximum Ratings	8
2.1.2 Typical Power Consumption	8
2.1.3 Module Pinout for Connectors J1 and J2	9
2.1.4 Module Pinout for Connectors J3, X1, X2	12
2.2 RF Specifications	12
2.2.1 TX Power	12
2.2.2 RX Sensitivity	13
2.2.3 4G LTE Uplink and Downlink Speeds	13
2.3 Mechanical Characteristics	13
2.3.1 Mechanical Specifications	13
2.3.2 Mating Connectors	14
2.3.3 Mechanical Drawings	14
2.3.3.1 Modem Dimensions	14
2.3.3.2 SIM Card Rib Drawings	15
2.3.4 Device Placement	15
2.3.5 Environmental Specifications	15
3. Design Considerations	15
3.1 Power Supply Requirements	16
3.1.1 Power Supply Design Guidelines	16
3.2 Serial Communications	17
3.2.1 OptConnect ema™ emaLink Interface	17
3.2.2 OptConnect ema™ Modem UART Interface	18
3.2.3 USB Interface	18

3.3	VREF	18
3.3	Power Control	19
3.3.1	ON_OFF	19
3.3.2	Shutdown	19
3.3.3	nRESET_REQUEST	19
3.4	Firmware Updates Over the Air (FOTA)	19
3.5	Cellular Antenna Requirements	20
3.5.1	Primary Antenna Requirements	20
3.5.2	Diversity Antenna Requirements	21
3.5.3	Antenna Placement	22
3.5.4	Recommended Antennas	22
3.6	Reference Designs	22
4.	<i>Basic Modem Operation</i>	22
4.0	Power up	22
4.1	Standard operation	23
4.2	AT Commands Not to Use	23
5.	<i>Mounting Guidelines</i>	23
5.0	Board-to-Board Connectors	23
5.0.1	Mechanical Retention	24
5.1	Solder to Board Connection	24
6.	<i>Regulatory Information</i>	26
6.0	Carrier Specific Certifications	26
6.1	Export Control Classification Number (ECCN)	26
6.2	Harmonized Tariff Schedule Code	26
6.3	RoHS Compliance	26
6.4	Interference Statement	26
6.5	FCC & IC Compliance	26
6.6	Wireless Notice	27
6.7	Modification Statement	27
6.8	End Product Labeling Requirements	27
7.	<i>Revision History</i>	29

1. Introduction

1.1 Scope

This document serves as a hardware guide for the OptConnect ema™ cellular modem.

1.2 Contact Information

For more information regarding OptConnect ema™ contact OptConnect Sales at 1.877.678.3343 ext. 2020 during normal business hours. For technical support contact OptConnect Customer Care Center at 1.877.678-3343 ext. 2021 from 8 am till 9 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	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	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-B	ema:Play Evaluation Kit, OptConnect ema™ evaluation platform	-40 to +85°C	North America
EMA-L4-1-XX-A-B	ema:Play Evaluation Kit, OptConnect ema™ evaluation platform, EMA-L4-1-XX ema modem included	-40 to +85°C	North America
EMA-L4-1-US-B-B	ema:Play Evaluation Kit, OptConnect ema™ evaluation platform, ema EMA-L4-1-US ema modem included	-40 to +85°C	United States

1.4 Additional Resources

OptConnect ema™ is supported by a full range of documentation in addition to this Hardware Guide; including User Guides and Application Notes as well as an ema: Play Evaluation Kit User Guide and related code samples. The latest versions of these resources can be found at <http://optconnect.com/ema> .

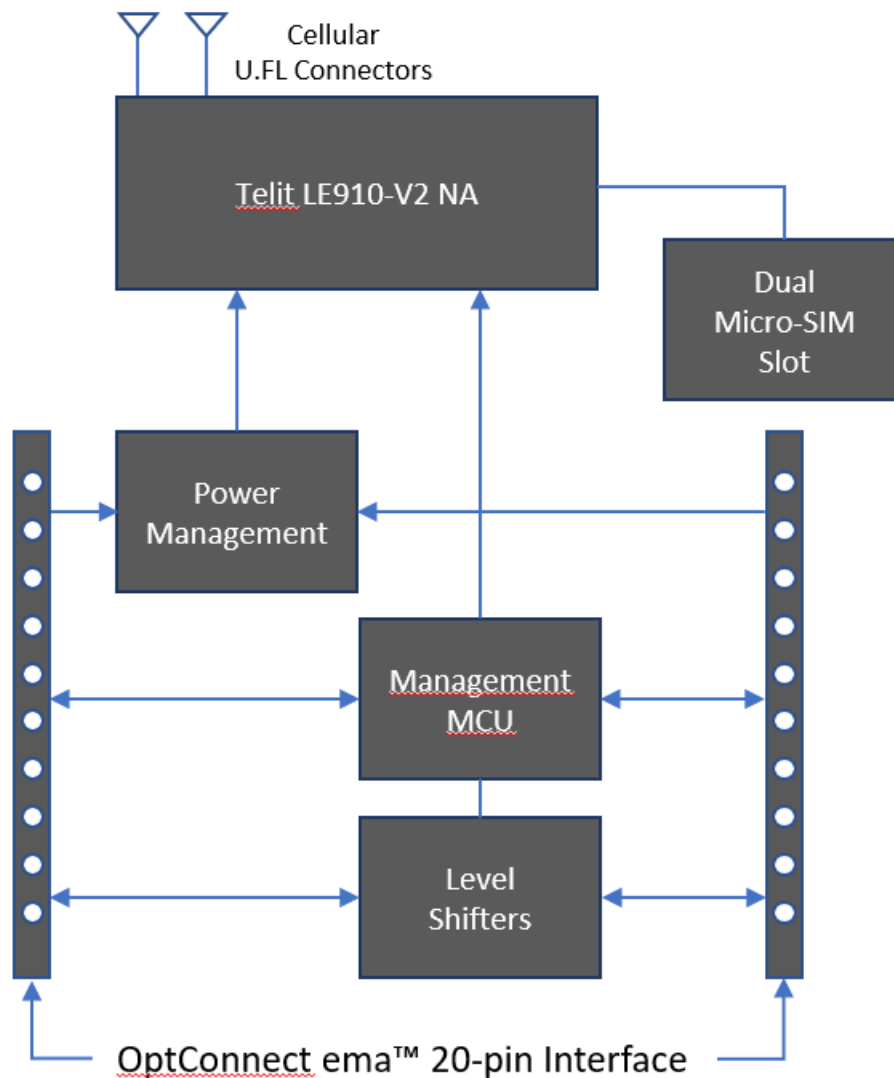
1.5 Product Overview

OptConnect ema™ is a fully end user certified modem with built in intelligence for autonomous monitoring, management, and self-healing. Its Embedded Managed Modem Architecture enables customers to rapidly design and deploy cellular connected solutions while eliminating the delays and complexities of typical IoT deployments. Each OptConnect ema™ modem comes integrated with an industry leading suite of OptConnect managed services that include:

- OptConnect SIM cards
- Cellular data plans
- Connectivity monitoring and management
- Device management portal
- 24x7x365 technical support
- Warranty replacement services
- Simple ready-to-use back office API cloud integrations
- Logistics
- Fast fulfillment

OptConnect ema™ is fully certified as an end user modem and eliminates the need for a customer's host board and equipment to be certified by carriers. By using the OptConnect ema™ modem, customers can introduce new board designs as often as necessary and never have to send their designs through a time consuming and costly certification process. OptConnect ema™ is a complete solution for a headache-free IoT strategy.

1.6 Block Diagram



1.7 Software and Drivers

OptConnect ema™ can be deployed in almost any design architecture, from a simple bare metal or RTOS Microcontroller design to higher level Windows and Linux integrations.

Available drivers:

- Windows
- Linux
- Android

2. Technical Specifications

2.1 Electrical Specifications

2.1.1 Absolute Maximum Ratings

Parameter	Signal	Maximum Rating
Main Power Supply	VCC	4.5V
I/O Voltage Reference	VREF	5.5V

2.1.2 Typical Power Consumption¹

Mode	Signal Attenuation (dB)	RSRP	RSRQ	Peak Current (mA)	Average Current (mA)	Charge Consumed (mAh)	Measurement Notes
Active Socket Dial	0	-57	-8	248.636	139.666	75.070 (μAh)	Tested at: 3.8V Time elapsed: 1.935 s Test: Open socket, HTTP POST, read HTTP response, close socket.
	20	-75	-8	722.435	169.771	95.968 (μAh)	Tested at: 3.8V Time elapsed: 2.035 s Test: Open socket, HTTP POST, read HTTP response, close socket.
	40	-95	-8	647.929	178.169	101.457 (μAh)	Tested at: 3.8V Time elapsed: 2.050 s Test: Open socket, HTTP POST, read HTTP response, close socket.
Idle, Registered on network.	0	-57	-8	555.222	67.915	5.638	Tested at: 3.8V Time elapsed: 300 s Test: 300 second measurement while modem is registered on network.
Off	0	N/A	N/A	16.259	16.259	16.259	Tested at: 3.8V Time elapsed: 300 s Test: Module powered off with AT#SHDN.

1. The measurements presented here were taken from Engineering Samples and are subject to change.

2.1.3 Module Pinout for Connectors J1 and J2

The following table details the pinout of the OptConnect ema™ modem and lists the recommended ratings for the modem interface on connectors J1 and J2. More details and design requirements for these pins are documented in Section 3.

Pin	Name	Direction	Description	Min	Typ.	Max
1 (J1-1)	VCC	Input	Main power supply pin.	3.4V	3.8V	4.2V
2 (J1-2)	DOUT	Output	Modem UART data out, I/O level tied to VREF.	VOL	0	0.60V
				VOH	VREF x 0.7	VREF
3 (J1-3)	DIN	Input	Modem UART data in, I/O level tied to VREF.	VREF Range	VIL (max)	VIH (min)
				1.8V to 1.95V	VREF x 0.35V	VREF x 0.65
				2.3V to 2.7V	0.7V	1.7V
				3.0V to 3.6V	0.8V	2V
				4.5V to 5.5V	VREF x 0.3V	VREF x 0.7
4 (J1-4)	GND	Input	Ground Pin.		0V	
5 (J1-5)	nRESET_REQUEST	Input	Reset request signal.	VIL	0V	0.50V
				VIH	1.30V	1.8V

6 (J1-6)	VUSB	Input	USB connection detection.		4.4V	5.0V	5.25V
Pin	Name	Direction	Description		Min	Typ.	Max
7 (J1-7)	USB_P	I/O	USB differential data bus (+). Requires differential impedance of 90Ω.		0V		5.25V
8 (J1-8)	USB_N	I/O	USB differential data bus (-). Requires differential impedance of 90Ω.		0V		5.25V
9 (J1-9)	DTR	Input	"Data Terminal Ready" hardware flow control input.	VREF Range	VIL (max)		VIH (min)
				1.8V to 1.95V	VREF x 0.35V		VREF x 0.65
				2.3V to 2.7V	0.7V		1.7V
				3.0V to 3.6V	0.8V		2V
				4.5V to 5.5V	VREF x 0.3V		VREF x 0.7
10 (J1-10)	GND	Input	Ground Pin.			0V	
11 (J2-1)	GND	Input	Ground Pin.			0V	
12 (J2-2)	CTS	Output	"Clear to Send" hardware flow control output.	VOL	0		0.60V
				VOH	VREF x 0.7		VREF
13 (J2-3)	STATUS	Output	Status pin. High when modem is ready for use.	VOL	0		0.60V
				VOH	VREF x 0.7		VREF

14 (J2-4)	VREF	Input	Voltage reference for offboard I/O signals.	1.8V		5.5V
15 (J2-5)	GND	Input	Ground Pin.		0V	
Pin	Name	Direction	Description	Min	Typ.	Max
16 (J2-6)	RTS	Input	"Request to Send" hardware flow control input.	VREF Range	VIL (max)	VIH (min)
				1.8V to 1.95V	VREF x 0.35V	VREF x 0.65
				2.3V to 2.7V	0.7V	1.7V
				3.0V to 3.6V	0.8V	2V
				4.5V to 5.5V	VREF x 0.3V	VREF x 0.7
17 (J2-7)	ema_DOUT	Output	emaLink serial data output signal.	VOL	0	0.60V
				VOH	VREF x 0.7	VREF
18 (J2-8)	ema_DIN	Input	emaLink serial data input signal.	VREF Range	VIL (max)	VIH (min)
				1.8V to 1.95V	VREF x 0.35V	VREF x 0.65
				2.3V to 2.7V	0.7V	1.7V
				3.0V to 3.6V	0.8V	2V
				4.5V to 5.5V	VREF x 0.3V	VREF x 0.7
19 (J2-9)	RING_IND	Output	"Ring Indicator" output pin.	VOL	0	0.60V

				VOH	VREF x 0.7		VREF
20 (J2-10)	ON_OFF	Input	On/Off signal. Internally pulled up to 1.8V.	VIL	0V		0.50V
				VIH	1.30V		1.8V

Additional information on OptConnect ema™ pinout is available in Section 3.

2.1.4 Module Pinout for Connectors J3, X1, X2

Connector Designator	Description	Connector Location
J3	Dual Micro SIM Connector	Bottom Side of Modem
X1	Primary Cellular Antenna Connection	Top side of Modem
X2	Diversity Cellular Antenna Connection	Top side of Modem

2.2 RF Specifications

2.2.1 TX Power

Available Cellular Technologies and Output Power	
4G LTE Technology	4G LTE CAT 4
4G LTE TX Output Power	0.2 W (Class 3) 23 dBm
3G Technology	WCDMA
3G TX Output Power (all bands)	0.25 W (Class 3) 24 dBm

2.2.2 RX Sensitivity

Available Cellular Technologies and RX Sensitivity		
4G	LTE FDD B2	-103.0 dBm
	LTE FDD B4	-102.5 dBm
	LTE FDD B5	-103.0 dBm
	LTE FDD B12	-103.0 dBm
	LTE FDD B13	-103.0 dBm
3G	WCDMA FDD B2	-113.0 dBm
	WCDMA FDD B5	-113.0 dBm

2.2.3 4G LTE Uplink and Downlink Speeds

4G LTE Peak Uplink and Downlink Speeds	
Uplink	50 Mbps*
Downlink	150 Mbps*

Actual network speeds will depend on local network conditions

2.3 Mechanical Characteristics

2.3.1 Mechanical Specifications

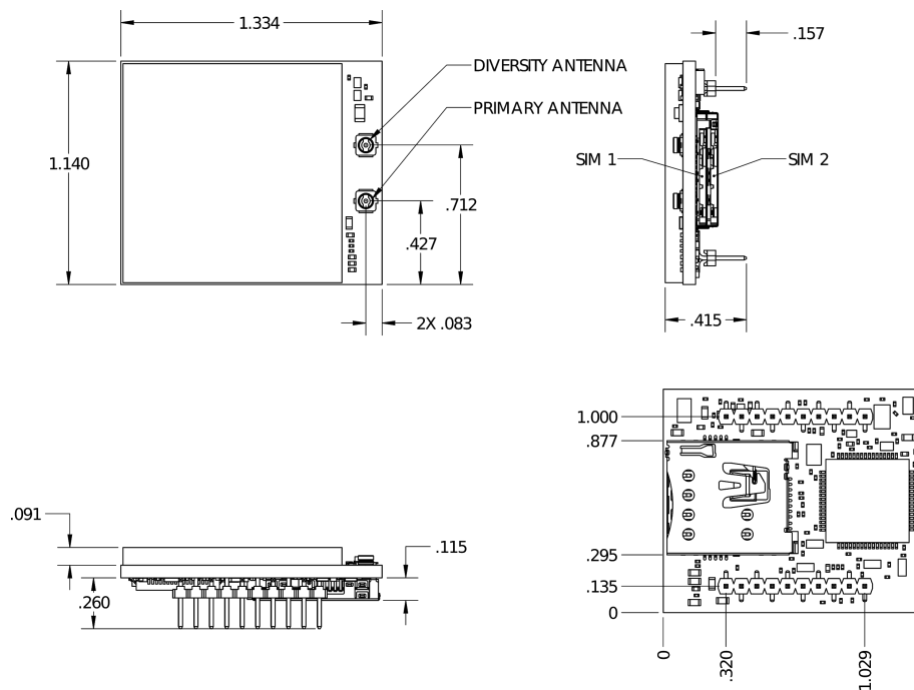
Parameter	Typical	Unit
Dimensions	29.00 x 33.78 x 10.67	mm
	1.14 x 1.33 x 0.42	inches
Weight	12	Grams
	0.4	oz
Socket Insertion/Removal	hundreds	Cycles

2.3.2 Mating Connectors

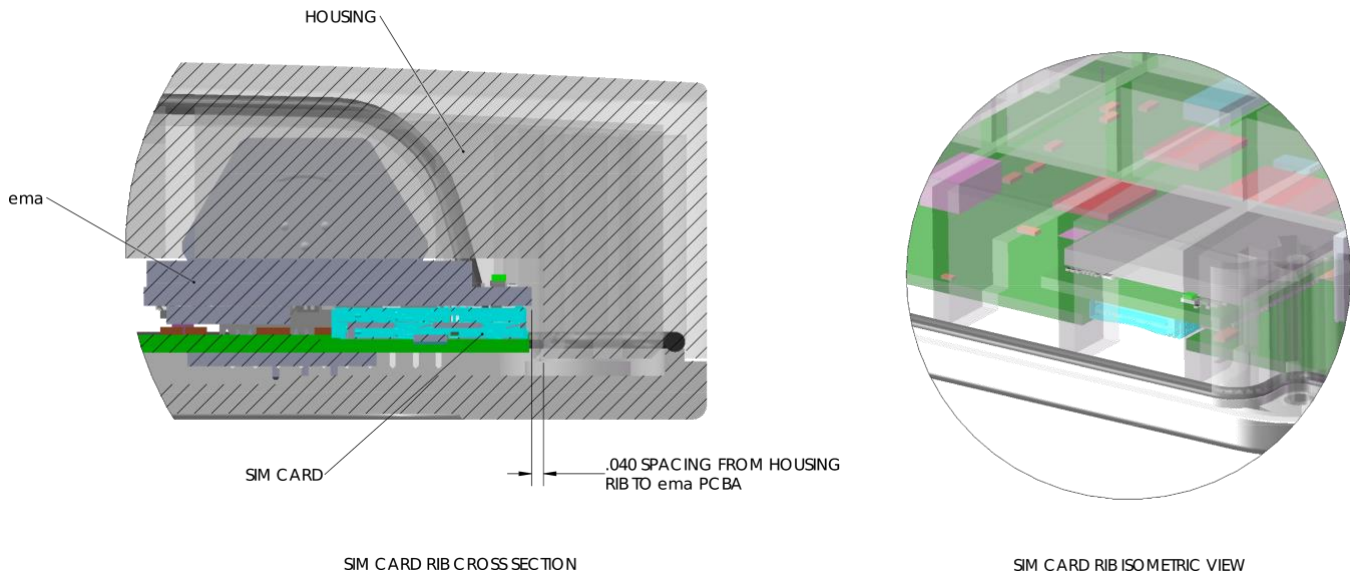
Connector Designator	Manufacturer	Populated on ema	Recommended Mate	Mate Manufacturer
J1, J2	3M	951110-2530-AR-PR	950510-6102-AR	3M
			Acceptable alternate: NPPN101BFCN-RC	Sullins Connector Solutions
X1, X2	Hirose	U.FL-R-SMT(10)	CAB.011	Taoglas

2.3.3 Mechanical Drawings

2.3.3.1 Modem Dimensions



2.3.3.2 SIM Card Rib Drawings



2.3.4 Device Placement

⚠ Make sure the OptConnect ema™ modem is installed in the correct orientation into the host board. Failure to do so will damage the device and void the warranty.

2.3.5 Environmental Specifications

Parameter	Min	Typical	Max	Unit	Note
Operating Temperature	-40	+25	+85	°C	
Storage Temperature	-40	+25	+85	°C	
Operating Humidity	20		90	%	Non-condensing

3. Design Considerations

The following sections detail various design considerations that system designers should follow when designing an OptConnect ema™ modem into their system. OptConnect offers reference schematics and PCB layout designs, and can review designs for customers integrating an OptConnect ema™ modem into their system. For more details please reach out to OptConnect’s product support team at 1.877.678.3343.

3.1 Power Supply Requirements

OptConnect ema™ modems will regularly consume significant amounts of current on the main power supply input Pin 1 (VCC). For LTE and WCDMA transmits and receives, this current consumption can be up to 1 A.

The baseboard power supply should be designed to support peak currents of at least 1.5 Amps to ensure enough power is available for the modem during high current operations.

A 0.1 μF & 100 μF low ESR ceramic capacitor should be placed near Pin 1 (VCC) of the modem to ensure that a local energy supply is available, with a low inductance path to the VCC pin.

Parameter	Value
Nominal Supply Voltage	3.8V
Operating Voltage Range	3.40V to 4.20V

OptConnect ema™ modems have a normal operating voltage range of 3.40V to 4.20V, with a recommended input voltage of 3.80V.

Extreme care must be taken when operating the modem to ensure it stays within its operating voltage range. If there is a voltage drop or overshoot that exceeds the limits of the operating voltage range, it may cause damage to the modem and void the modem’s warranty.

Customers should thoroughly test their power supply systems to ensure they are capable of meeting the rigorous current demands of an LTE modem without falling outside of the operating voltage range.

3.1.1 Power Supply Design Guidelines

When designing the power supply for an OptConnect ema™ modem it is recommended to adhere to the following design guidelines:

- For most applications, a switching power supply is recommended to supply power to the modem. This is because switching power supplies are able to rapidly respond to the sudden current demands of an LTE modem. To ensure compatibility with OptConnect ema™ modems, it is recommended to use a switching regulator capable of supporting up to 1.5A. Example designs using a switching DC/DC regulator can be found in OptConnect ema™ reference designs.
- To reduce EMI from the switching regulator, it is important to follow the design guidelines from the device manufacturer.
- Bypass ceramic capacitors (low ESR) with adequate capacity must be placed near the input to Pin 1 (VCC) of the modem. It is recommended that the capacitor have a rated voltage of at least 2x the input voltage to the modem. A minimum of a 100 μF & 0.1 μF capacitor is recommended. The 0.1 μF capacitor should be placed as close as possible to Pin 1 (VCC) of the modem, followed by the 100 μF capacitor.

- The PCB traces from the power regulator and the bypass capacitors must be at least 80 mils to ensure that there is a low impedance power delivery circuit available to the modem. This ensures that no significant voltage drops occur. Try to keep the trace(s) as short as possible.
- A dedicated ground plane is recommended.
- Direct connect from pours should be used in the power supply sections.
- Power supply input cables should be kept away from noise sensitive lines, such as antennas.

OptConnect offers the ema:Play Evaluation Kit in order to assist customers with their designs. Reference schematics and layout examples can be found at <http://optconnect.com/ema> .

While prototyping with the OptConnect ema™ modem, it is recommended to use the ema:Play Evaluation Kit, as opposed to a breadboard setup.

Prototyping with Cellular Modems and Modules:

Power supply and power management are critical to the performance of production cellular products and to their pre-production prototypes. The OptConnect ema:Play Evaluation Kit implements the necessary power management techniques to enable customers to easily prototype their equipment that will incorporate an OptConnect ema™ modem. OptConnect strongly recommends that prototype designers do not utilize a simple breadboard setup to test their designs as improper power management can make the ema modem temporarily or permanently inoperable. In addition to the necessary power management features, the OptConnect ema:Play Evaluation Kit includes assets to allow robust firmware development and debugging, sensors for example instrumentation, and source code for example applications.

3.2 Serial Communications

OptConnect ema™ modems have two UART interfaces; one for the modem and one for the OptConnect ema™ management Microcontroller Unit (MCU), referred to as emaLink. OptConnect ema™ modems also support a USB connection. Customers integrating the OptConnect ema™ modem are required to connect to the emaLink interface and either one of the modem's UART or USB interfaces.

The modem's UART interface is targeted for applications using lower speed 8/16/32 bit MCU's that do not have a USB interface or easily available USB interface drivers. The modem's USB interface is intended for use by higher end systems with a native USB interface controller or operating system (Single board computers, Linux/Windows, etc.).

For designs that are not using the modem's USB interface, it is recommended that designers include test points or a non-populated USB connector footprint in their designs as well. This allows for future access to the modem's USB interface to enable easy debugging and firmware updates.

3.2.1 OptConnect ema™ emaLink Interface

The emaLink interface resides on Pins 17 (ema_DOUT) and 18 (ema_DIN). This interface connects to the OptConnect ema™ Management MCU on the modem that controls the behind the scenes operations of the modem. This interface serves as a status and control interface for the OptConnect ema™ modem's Management MCU. Host systems must monitor this interface for URC's (Unsolicited Result Codes) that will indicate modem status and behaviors. This interface defaults to 19200 8N1 baud. This interface is also

reserved for future feature support. Please reference the **OptConnect ema™ emaLink AT Command Manual** for further details.

3.2.2 OptConnect ema™ Modem UART Interface

The modem UART interface resides on Pins 2 (DOUT) and 3 (DIN) and is a serial interface into the cellular module on the modem. This interface can be used to send and receive data over the cellular network.

The baud rate defaults to 115200 Baud 8N1. If a different baud rate is required, it can be changed with the **AT+IPR** command as defined in the AT command manual. The modem also supports RTS/CTS flow control on Pins 12 (CTS) and 16 (RTS).

By default, the modem has flow control enabled. To modify the flow control setting, please see the **AT+IFC** command in the AT command manual. It is recommended that any designs using the modem UART interface connect the RTS/CTS flow control lines to the host and enable them in their application.

3.2.3 USB Interface

The OptConnect ema™ modem also supports a USB 2.0 interface on Pins 6 (VUSB), 7 (USB_P), and 8 (USB_N) which connects into the cellular module on the modem. Monitoring of the OptConnect ema™ Management MCU is not available through this interface.

Systems connecting to the modem's USB interface must observe proper design practices for connecting to a high-speed USB device including, but not limited to, the following:

- The USB D± traces should be routed as a 90-ohm impedance differential pair.
- The USB D± traces should be length matched.
- USB trace lengths should be minimized.
- USB differential pairs should be carefully routed to ensure they have a continuous return path beneath the traces. Do not route differential pairs over splits in ground or power planes.
- If the USB signals will be used off-board, ESD protection should be implemented near the off-board connector.

Pin 6 (VUSB) is used to detect if a USB host controller has been connected to the modem. This pin has an internal pulldown and must have a voltage between 4.4V and 5.25V applied to it in order to activate the USB interface. The VUSB pin will draw less than 5mA when connected. VUSB must be disconnected or asserted to ground before activating Power Saving Mode.

3.3 VREF

Pin 14 (VREF) drives the input voltage side of onboard buffers which convert external I/O voltages from the VREF range to the modem's internal voltage range in order to interface with the modem's systems. System designers should connect the reference voltage of their system to this pin. The VREF signal will draw less than 5mA when the modem is powered.

3.0 Power Control

3.0.1 ON_OFF

Pin 20 (ON_OFF) is used to trigger the modem to turn on and off. To turn the modem on, drive the ON_OFF signal to ground and hold it there.

The ON_OFF signal is a 1.8V IO and must be driven with an open drain/collector output or external discrete open drain/collector transistor. Do not power this pin or apply a pullup resistor, as doing so may prevent the modem from booting, or may cause damage to the modem.

3.0.2 Shutdown

The modem must be shut down in a controlled manner, so as to gracefully disconnect it from the network and to safely power down the cellular module on the modem. Failure to do so violates carrier requirements. In rare events, failure to properly shut down the modem could render the modem inoperable due to firmware corruption.

The modem can be gracefully shut down by releasing Pin 20 (ON_OFF) from ground. This method will force the modem to issue a detach request to the network, which informs the network that the device will be unreachable for an indefinite time. After issuing this request, the modem will power down.

3.0.3 nRESET_REQUEST

In the event that the modem becomes unresponsive, Pin 5 (nRESET_REQUEST) can be used to request the OptConnect ema™ Management MCU to reset the modem.

To request a modem reset, the nRESET_REQUEST signal should be driven to ground for at least one (1) second, and then released. The signal is internally pulled up to the modem's internal 1.8V rail and should be driven with an open drain/collector. Do not drive this signal high or apply a pull up resistor.

When the nRESET_REQUEST signal is detected by the OptConnect ema™ Management MCU, it will attempt to properly reset the modem with a controlled shutdown. If that fails it will unconditionally shutdown the modem.

Network providers request that a device gracefully detach from the network before shutting down. Unconditional shutdowns violate this requirement. As such, the OptConnect ema™ Management MCU attempts to use an unconditional reset as an emergency reset only when the modem is not responding to commands.

In high noise (high EMI) environments, it is recommended that designers place a 0.01 μ F – 0.1 μ F capacitor on the nRESET REQUEST signal near the J1 connector.

3.1 Firmware Updates Over the Air (FOTA)

LTE networks are constantly being updated, improved, and enhanced with new features. As a result, carriers are making frequent network changes. Most changes will not negatively affect devices connected to those networks, but occasionally an update will prevent an unprepared device from re-connecting to the network permanently.

To account for these future changes, FOTA (Firmware Over the Air) capability is added to cellular modules by each module manufacturer. OptConnect ema™ supports this functionality, and automatically manages the modems FOTA processes. The OptConnect ema™ modem has the capability to update the on-board cellular module as well as the OptConnect ema™ Management MCU using microFOTA.

When a FOTA update is triggered, the modem will output FOTA specific URC's over the emaLink interface to notify the host system that FOTA is in progress. When a FOTA update is in progress the host system must keep the modem powered and connected until the process is complete.

Failure to accommodate FOTA processes may result in interruptions in cellular connectivity in the event of network changes. If a device can no longer access the network, FOTA cannot be used to remedy the problem. The only way to recover functionality is to physically retrieve the device and update its firmware.

FOTA Instructions are available by contacting OptConnect's product support team at 1.877.678.3343.

3.2 Cellular Antenna Requirements

The OptConnect ema™ modem supports a primary cellular antenna connection, and a diversity antenna connection. These connectors are U.FL connectors, and are labeled as X1 and X2, respectively. To fulfill carrier certification requirements, system integrators are required to use both the primary and diversity antennas in their application.

Note: many antennas will require the use of a U.FL to SMA cable, such as the [Taoglas CAB.011](#).

3.2.1 Primary Antenna Requirements

Depending on the frequency band(s) provided by the network operator, the customer shall use the most suitable antenna for that/those band(s):

Available Cellular Technologies and Required Primary Antenna Bandwidth		
4G	LTE FDD B2	140 MHz
	LTE FDD B4	445 MHz
	LTE FDD B5	70 MHz
	LTE FDD B12	47 MHz
	LTE FDD B13	41 MHz
Available Cellular Technologies and Required Primary Antenna Bandwidth		
3G	WCDMA FDD B2	140 MHz
	WCDMA FDD B5	70 MHz

Note: Any antennas used with the modem will need to comply with the Wireless Notice detailed in Section 6.6.

In addition to the bandwidth requirements above, the chosen antenna must conform to the specifications below:

Relevant Primary Antenna Specifications	
Impedance	50 Ω
Input Power	\geq 24 dBm Average Power
VSWR Absolute Max ¹	\leq 10:1
VSWR Recommended ²	\leq 2:1

1. Limit to avoid permanent damage
2. Limit to fulfill all regulatory requirements

3.2.2 Diversity Antenna Requirements

Depending on the frequency band(s) provided by the network operator, the customer shall use the most suitable antenna for that/those band(s):

Available Cellular Technologies and Required Diversity Antenna Bandwidth		
4G	LTE FDD B2	60 MHz
	LTE FDD B4	45 MHz
	LTE FDD B5	25 MHz
	LTE FDD B12	15 MHz
	LTE FDD B13	10 MHz
3G	WCDMA FDD B2	60 MHz
	WCDMA FDD B5	25 MHz

Note: Any antennas used with the modem will need to comply with the Wireless Notice detailed in Section 6.6.

In addition to the bandwidth requirements above, the chosen antenna must conform to the specifications below:

Relevant Diversity Antenna Specifications	
Impedance	50 Ω
VSWR Recommended ¹	\leq 2:1

1. Limit to obtain maximum sensitivity

3.2.3 Antenna Placement

The OptConnect ema™ modem’s cellular antenna placement will directly affect the modem’s performance. It is vital that system designers carefully consider the placement of the antenna and follow all of the guidelines and specifications set by the antenna manufacturer. The following guidelines are general recommendations for antenna installation:

- The antenna must have an impedance of 50 ohms.
- Keep the antenna cable as short as possible.
- The antenna must not be installed inside a metal enclosure, nor near metal objects unless specified by the antenna manufacturer.
- The antenna must be installed according to the manufacturer’s instructions.
- Antenna gain must not exceed the values indicated in the regulatory requirements in Section 6.6.
- Antenna integration should optimize antenna efficiency. Antennas are recommended to have >50% efficiency on all frequency bands.
- Antenna should not be mounted near noisy EM devices and signals (e.g. LCD’s, engines, high speed signals, power supplies, etc.)

3.2.4 Recommended Antennas

Type	Manufacturer	Part Number
Internal Cellular Antenna	Taoglas	FXUB65.07.0180C
Internal Cellular Antenna	Taoglas	FXUB66.07.0150C
External Cellular Antenna ¹	Taoglas	TG.30.8113
External Cellular Antenna ¹	Taoglas	GSA.8841.A.105111
External Cellular MIMO Antenna ^{1 2}	2J	2J7724Ma

Note 1: U.FL to SMA adapter required.

Note 2: Available from OptConnect.

3.3 Reference Designs

OptConnect offers reference schematic and layout files as examples of how to integrate OptConnect ema™ modems into various systems. Schematics, design files, Gerber files, and Application Notes for a variety of different systems can be requested by contacting OptConnect’s product support team and are available at <http://optconnect.com/ema> .

4. Basic Modem Operation

4.0 Power up

Turning on the OptConnect ema™ modem is accomplished by driving Pin 20 (ON_OFF) to ground. The OptConnect ema™ Management MCU will start the cellular module and verify it is working. This process takes approximately ten (10) seconds from the time Pin 20 (ON_OFF) is driven to ground.

The emaLink interface will send relative URC’s during the boot up process to indicate status. Additionally,

pin 13 (STATUS) will drive logic-level HIGH to indicate that the cellular module is ready for use.

4.1 Standard operation

OptConnect ema™ will maintain a constant cellular connection on specific sockets in order to measure metrics and perform troubleshooting and/or debugging. If the connection is interrupted for any reason (SIM card is removed, antenna is disconnected, signal quality is poor, etc.), the modem will attempt to reconnect. If it is not able to reconnect, it will issue a URC on the emaLink interface notifying the user that it will shortly disable communications and attempt to regain the network connection. Pin 13 (STATUS) will drive logic-level LOW, to indicate this condition.

If the modem is able to regain the cellular connection, it will notify the user through the emaLink interface and Pin 13 (STATUS) will drive logic-level HIGH. If it cannot regain the connection, additional steps may be taken, depending on your current plan with OptConnect. Please contact OptConnect technical support for more information about your specific deployment.

4.2 AT Commands Not to Use

In order to function, OptConnect ema™ has reserved specific AT commands used by the cellular module, that are prohibited for customer use. Modifying or using these AT commands will result in OptConnect ema™ removing communication with your device, resetting the commands, and restoring communication with your device. Here is a list of AT commands reserved for use by OptConnect ema™:

AT+CGDCONT for context 6

AT#PORTCFG

AT#PING

AT#SCFG for sockets 9 and 10

AT#SCFGEXT for sockets 9 and 10

AT#SD for sockets 9 and 10

AT#SRECV for sockets 9 and 10

5. Mounting Guidelines

OptConnect ema™ cellular modems support multiple connection methods. The two primary methods are board-to-board connectors and soldering directly to the host board.

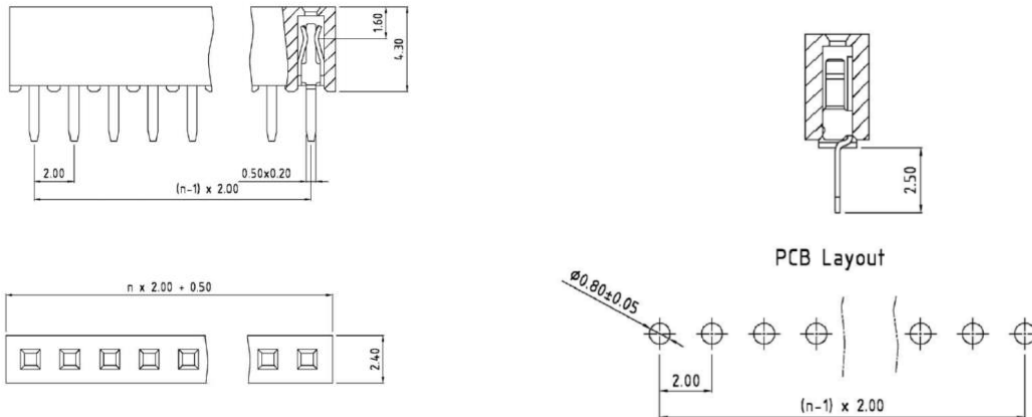
5.0 Board-to-Board Connectors

Using this approach, the OptConnect ema™ 20-pin interface requires two 10-pin, 2mm pitch, female receptacles spaced 22 mm apart. There are many connector manufacturers that can be used. Below is one readily available product:

Manufacturer: Sullins Connector Solutions

Part Number: NPPN101BFCN-RC

Typical part drawing and footprint information for the NPPN101BFCN-RC connector:



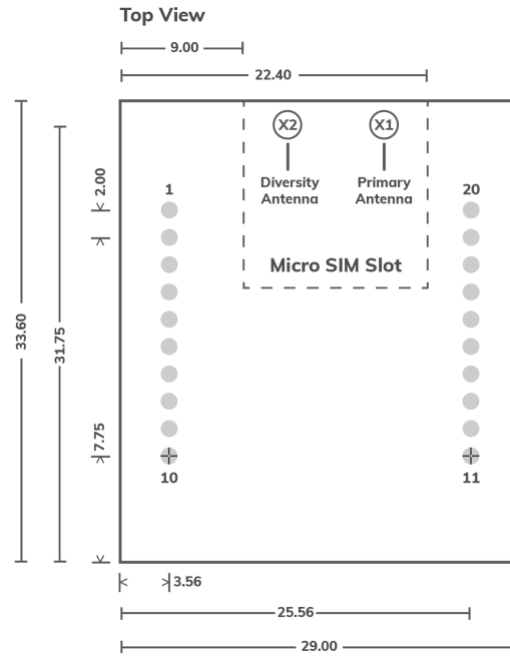
5.0.1 Mechanical Retention

Certain applications where the modem is mounted on the host board using the connector approach detailed in section 5.0 may require the need to mechanically secure the modem and its SIM card(s) in order to prevent the modem from vibrating out of the mating connectors. OptConnect ema™ modems do not have any dedicated attachment points for securing to the host board, however it can easily be secured by one of the following methods:

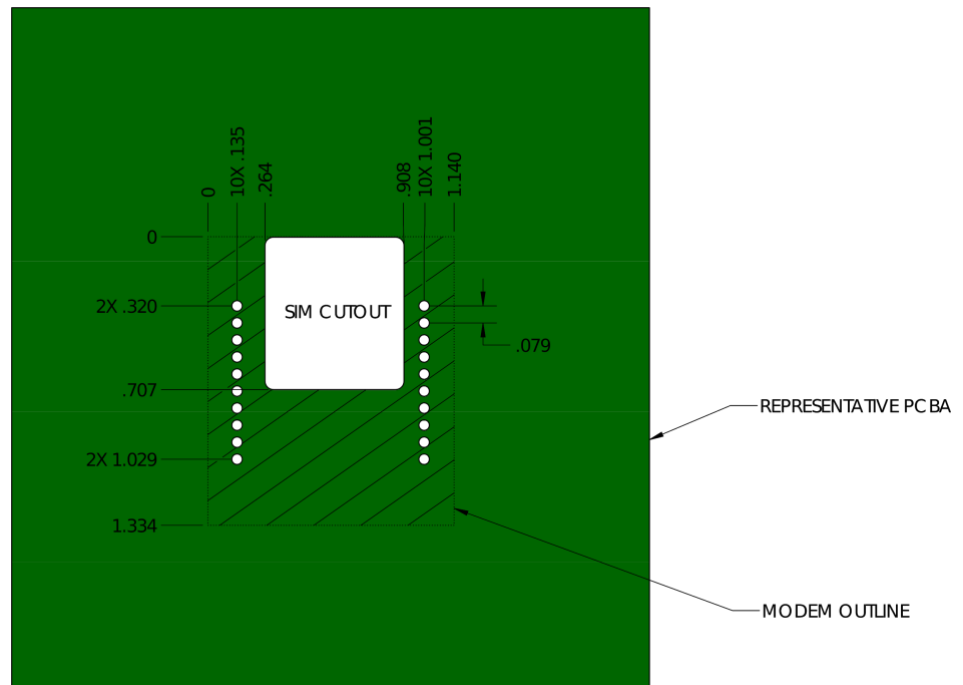
- Zip ties
- Foam tape mounted on the modem to press against the enclosure
- Mechanical retention of the modem and SIM by the enclosure
- Solder the OptConnect ema™ to the host board (as described in Section 5.1)

5.1 Solder to Board Connection

Alternatively, OptConnect ema™ can be soldered directly to a host PCB. The PCB should be designed with two rows of ten 0.8mm plated through holes spaced 2mm apart. The two rows should be 22 mm apart. See the figures below for the recommended footprint. All measurements are in millimeters. U.FL locations are marked with circles, X1 and X2 are on the top of the board. J3 is the Micro SIM card slot on bottom side of board. It is also recommended to create a cutout for the SIM cage.



Example Host PCB Design



6. Regulatory Information

6.0 Carrier Specific Certifications

- **EMA-L4-1-XX... : PTCRB, AT&T, Verizon ODI**
- **EMA-L4-1-US... : PTCRB, AT&T, Verizon ODI**

6.1 Export Control Classification Number (ECCN)

ECCNs are five-character alphanumeric designations used on the Commerce Control List (CCL) to identify dual-use items for export control purposes. An ECCN categorizes items based on the nature of the product, i.e. type of commodity, software, or technology and its respective technical parameters.

ECCN for OptConnect ema™ modems: 5A992.c

6.2 Harmonized Tariff Schedule Code

HTS Code: 8517.62.0010

6.3 RoHS Compliance

OptConnect ema™ modems comply with the RoHS (Restriction of Hazardous Substances) directive of the European Union, EU Directive 2011/65/EU.

6.4 Interference Statement

This device complies with Part 15 of the FCC Rules and Industry Canada license-exempt RSS standards. Operation is subject to the following two conditions: (1) This device may not cause harmful interferences, and (2) this device must accept any interference received, including interference that may cause undesired operation.

6.5 FCC & IC Compliance

If the modem's antenna is located farther than 20cm from the human body and there are no adjacent transmitters, the FCC/IC approvals of the on-board Telit LE910-V2 NA cellular module can be reused by the end product.

Should the modems antenna be mounted closer than 20cm from the human body or if there are adjacent transmitters, additional FCC/IC testing may be required for the end product.

OptConnect ema™ modems make use of the on-board Telit LE910-V2 NA module's FCC & IC identification numbers.

Orderable Device	FCC ID	IC ID (certification number)
EMA-L4-1-XX...	R17LE910NAV2	5131A-LE910NAV2
EMA-L4-1-US...	R17LE910NAV2	5131A-LE910NAV2

The FCC certificate is available at the following link by searching for the FCCID listed above:

<https://www.fcc.gov/oet/ea/fccid>

The IC ID certificate is available at the following link by searching for the IC ID listed above:
<https://sms-sgs.ic.gc.ca/equipmentSearch/searchRadioEquipments?execution=e1s1&lang=en>

6.6 Wireless Notice

In order to maintain FCC/IC radiation exposure limits set forth for an uncontrolled environment alongside carrier specific certifications the antennas cannot exceed the maximum gain levels listed here:

Available Bands and Max Antenna Gain		
4G	LTE FDD B2	8.51 dBi
	LTE FDD B4	6.00 dBi
	LTE FDD B5	6.63 dBi
	LTE FDD B12	6.63 dBi
	LTE FDD B13	6.63 dBi
3G	WCDMA FDD B2	8.51 dBi
	WCDMA FDD B5	6.63 dBi

6.7 Modification Statement

OptConnect has not approved any changes or modifications to this device by the user. Any changes or modifications could void the user's authorization to operate the equipment.

6.8 End Product Labeling Requirements

End products utilizing EMA-L4-1-XX-A-A modems should be labeled with the following information:

Device Uses Approved Radio: EMA-L4-1-XX-A-A

Contains FCC ID: RI7LE910NAV2

Contains IC: 5131A-LE910NAV2

This device complies with Part 15 of the FCC Rules and Industry Canada license-exempt RSS standards. Operation is subject to the following two conditions: (1) This device may not cause harmful interferences, and (2) this device must accept any interference received, including interference that may cause undesired operation.

End products utilizing EMA-L4-1-XX-A-A-100 modems should be labeled with the following information:

Device Uses Approved Radio: EMA-L4-1-XX-A-A-100

Contains FCC ID: RI7LE910NAV2

Contains IC: 5131A-LE910NAV2

This device complies with Part 15 of the FCC Rules and Industry Canada license-exempt RSS standards. Operation is subject to the following two conditions: (1) This device may not cause harmful interferences, and (2) this device must accept any interference received, including interference that may cause undesired operation.

End products utilizing EMA-L4-1-US-B-A modems should be labeled with the following information:

Device Uses Approved Radio: EMA-L4-1-US-B-A

Contains FCC ID: RI7LE910NAV2

Contains IC: 5131A-LE910NAV2

This device complies with Part 15 of the FCC Rules and Industry Canada license-exempt RSS standards. Operation is subject to the following two conditions: (1) This device may not cause harmful interferences, and (2) this device must accept any interference received, including interference that may cause undesired operation.

End products utilizing EMA-L4-1-US-B-A-100 modems should be labeled with the following information:

Device Uses Approved Radio: EMA-L4-1-US-B-A-100

Contains FCC ID: RI7LE910NAV2

Contains IC: 5131A-LE910NAV2

This device complies with Part 15 of the FCC Rules and Industry Canada license-exempt RSS standards. Operation is subject to the following two conditions: (1) This device may not cause harmful interferences, and (2) this device must accept any interference received, including interference that may cause undesired operation.

7. Revision History

Revision	Date	Description	Author
1.0	6/4/2019	Initial Release	MSV
1.1	9/9/2019	Simplified Table of Contents, removed reference to whitepaper(sec 3.1), 115200->19200(3.2.1), Moved nRESET_REQUEST info to Power Control section 3.4, Re-worded various sections.	MSV
1.2	12/2/2019	Added Section 1.7. General document cleanup. ema Management UART is now referred to as emaLink	MSV
1.3	5/18/2020	Updated ema p/n's. Expanded emaLink section 3.2.1 for pdf file. Fixed formatting in pdf file.	MSV