epConnected Vehicle

4G LTE-M Cellular Modem + GNSS, CAN interface, I/O, Bluetooth, & Sensors

Product User Manual

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www.embeddedplanet.com

About This Manual

The **epConnected Vehicle User Manual** provides detailed information encompassing the design, description, and integration of the epConnected V device. For elaboration on drawings, software, or other specific product details there may be other sources of information to which this document points as reference. For the latest documentation, including document & certification updates, please always refer to the Embedded Planet documentation page: https://www.embeddedplanet.com/product-documentation

Product Web Page

The **epConnected Vehicle product page** by Embedded Planet provides description & resources related to this product. This page can be located at https://www.embeddedplanet.com/connected-vehicle

Acrynyms & Abbreviations

Term	Description
EPI	Embedded Planet, Inc.
ToF	Time-of-Flight
IoT	Internet of Things
PCBA	Printed Circuit Board Assembly
epCV	epConnected Vehicle
I/O	Inputs/Outputs
GPIO	General Purpose Inputs / Outputs
IC	Integrated Circuit [component]
BT	Bluebooth
BLE	Bluetooth Low Energy
IMU	Inertial Measurement Unit [sensor]
LiPo	Lithium-Ion Polymer

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1. Introduction

The epConnected Vehicle provides a solution for bringing wireless data collection & management to vehicle interfaces. The device is composed of a carrier board that connects an integrated Agora to a vehicle's OBDII port, bringing the capabilities of an Agora to the vehicle. The epConnected Vehicle can collect data from input I/O and provide control through driving output I/O. Monitored data can be sent over available wireless methods on the Agora (Cellular, Bluetooth) with control actions performed through the nRF52840 microcontroller module on the Agora or control through cloud applications. The board is powered through an OBDII cable (12V) with a lithium battery backup for lightweight activities after the ignition is turned off & the OBDII power source is shut off. The epConnected Vehicle includes a plastic housing with user interfaces for CAN/power, cellular antenna (SMA), GNSS antenna (SMA), and data I/O, as well as flanges for mounting.

Powered by Agora

The epConnected Vehicle leverages the capabilities of the Agora module by Embedded Planet. Agora is an IoT solution platform that incorporates the processing power of an onboard MCU with the wireless connectivity of cellular, Bluetooth, & LoRa while collecting sensor data. Onboard sensors can include 6-axis IMU, 9-axis IMU, Time-of-Flight (ToF) distance, temperature/humidity, temperature/humidity/pressure/VOC gas, and sound/microphone. The cellular module is available in configurations that include GNSS capabilities. Some configurations of Agora include custom plastics & a LiPo battery with recharging capabilities. Agora can operate as a standalone module or be integrated into new or existing hardware designs. To learn more about Agora & how to leverage its capabilities, visit https://www.embeddedplanet.com/agora.

2. Orderable Part Numbers

This table shows the flexibility of possible device configurations. Availability of specific configurations is contingent on current stocking & ordering conditions. Please contact Embedded Planet sales to ask about a configuration not found in the Embedded Planet shop: sales@embeddedplanet.com. The Embedded Planet shop is hosted at https://shop.embeddedplanet.com.

TABLE 1 – PART NUMBER CONFIGURATOR

Configuration:	EPCNCT-VEH1.2-A	1	2	3	4	5	6	7	8

#	Feature
1	Environment sensor
2	**Inertia sensor**
3	Range sensor
4	***Reserved***
5	*Reserved*
6	***Reserved***
7	Backup Battery
8	**External I/O**

TABLE 2 – OPTION CONFIGURATOR

Option	Designator	Description	Notes
1 Environment *(Agora PCBA)*	1	*None*	
	A	Bosch BME680: temp, humidity, pressure, gas	
	B	SiLabs Si7021-A20: temp, humidity	
	C	**BOTH (BME680 + Si7021-A20): temp, humidity + pressure, gas**	default
2 Inertia *(Agora PCBA)*	2	*None*	
	D	6-Axis IMU: InvenSense ICM-20602 | 3-axis accel, 3-axis gyro	
	E	9-Axis IMU: ST LSM9DS1 | 3-axis accel, 3-axis gyro, 3-axis mag	
	F	**BOTH (6-Axis + 9-Axis IMU): ICM-20602 & ST LSM9DS1 (gyro, accel + mag)**	default
3 Time of Flight *(Agora PCBA)*	3	*None*	
	G	**ST VL53L0X**	default
4 *Reserved*	4	*None*	
5 *Reserved*	5	*None*	
6 *Reserved*	6	*None*	
7 Battery Backup	7	*None*	
	J	**Internal 4.3V LiPo and Charger (Carrier PCB Mounted)**	default
8 Customer I/O	8	*None*	
	K	**4 inputs, 6 outputs, 2 RS-232, Voltage Monitor (Carrier PCB Mounted)**	default

Below are some example configurations for the epConnected Vehicle device:

TABLE 3 – EXAMPLE CONFIGURATIONS

Full Configuration Part Number	Configuration Description
EPCNCT-VEH1.2-A12345678	**No** optional features included
EPCNCT-VEH1.2-ACFG456JK	**All** optional features included *(Default)*
EPCNCT-VEH1.2-AAEG456JK	Only **one** of each available feature included

3. Additional Resources

- Agora module:
  https://www.embeddedplanet.com/agora

- epConnected Vehicle:
  https://www.embeddedplanet.com/connected-vehicle

- Embedded Planet Documentation:
  https://www.embeddedplanet.com/product-documentation/#connected-vehicle

4. Feature Callouts

4.1. Feature Callouts | Basic Board Information

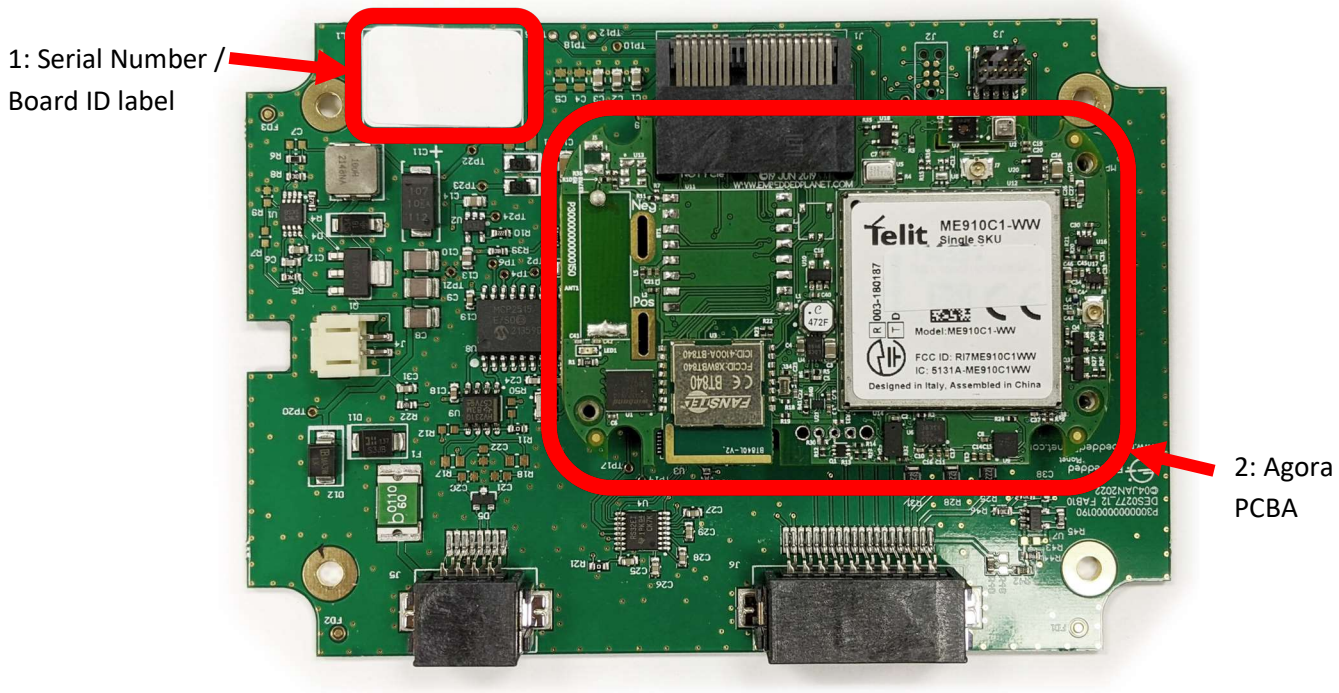


TABLE 4 – BASIC BOARD INFORMATION

Category	Reference	Component Type	Description / Purpose
Label	1	Label	Serialization & board identification
Modem	2	Agora PCBA module	Cellular/GNSS connectivity, sensors

4.2. Feature Callouts | Connectors & Hardware (Board)

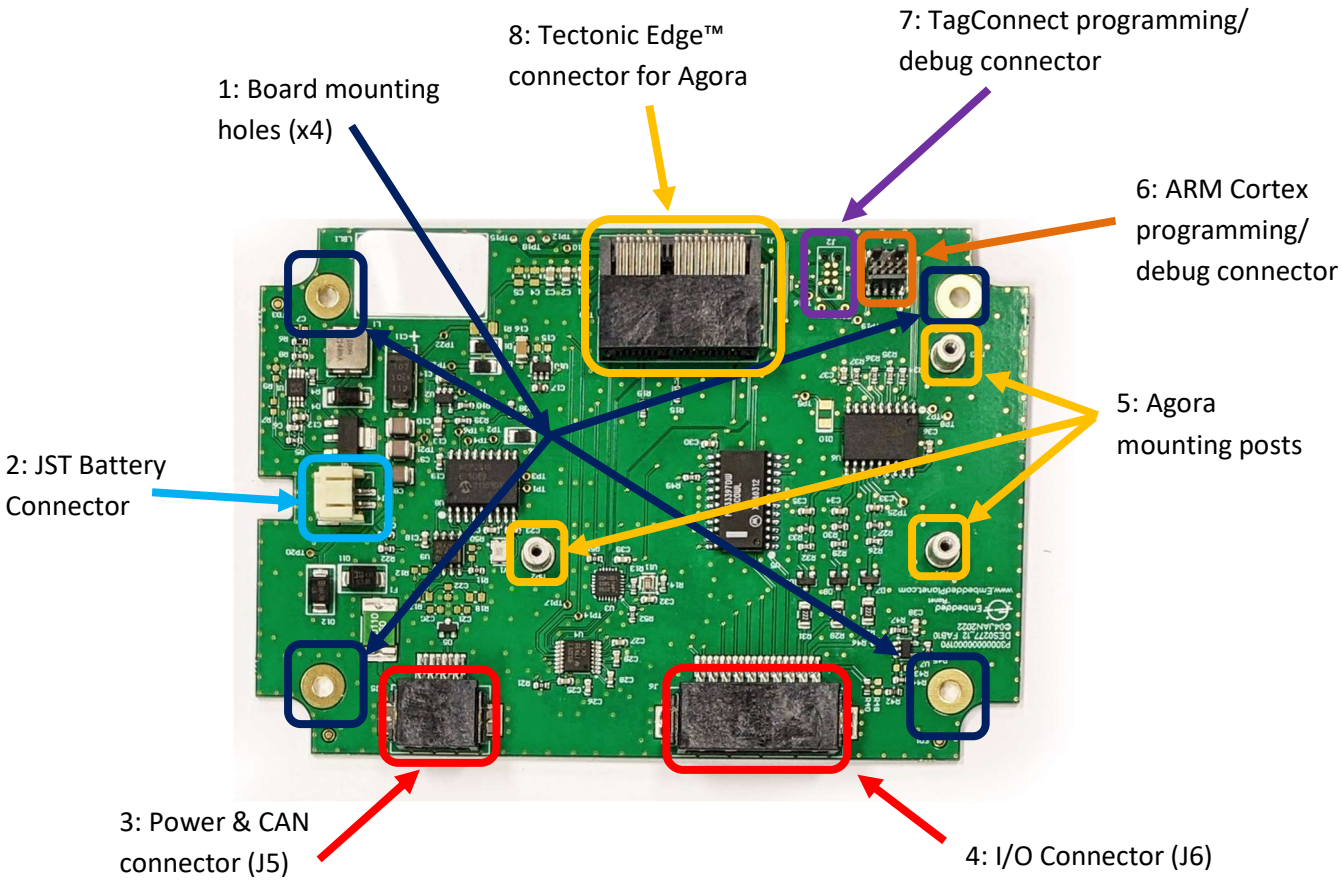


TABLE 5 - BOARD CONNECTORS & HARDWARE

Category	Reference	Component Type	Description / Purpose
Mechanical	1	Board mounting holes	Mounting hardware for use with enclosure
Connector	2	JST / Battery	Connector input for LiPo battery power
Connector	3	Power & CAN	Interface for CAN & power input
Connector	4	I/O array	Interface for assorted I/O
Mechanical	5	Agora mounting posts	For securing Agora to the host board
Connector	6	ARM Cortex	For programming/debug (SWD)
Connector	7	TagConnect	For programming/debug (SWD)
Connector	8	Tectonic Edge™	Board Edge/Finger interface for Agora

4.3. Feature Callouts | Connectors & Hardware (Enclosure)

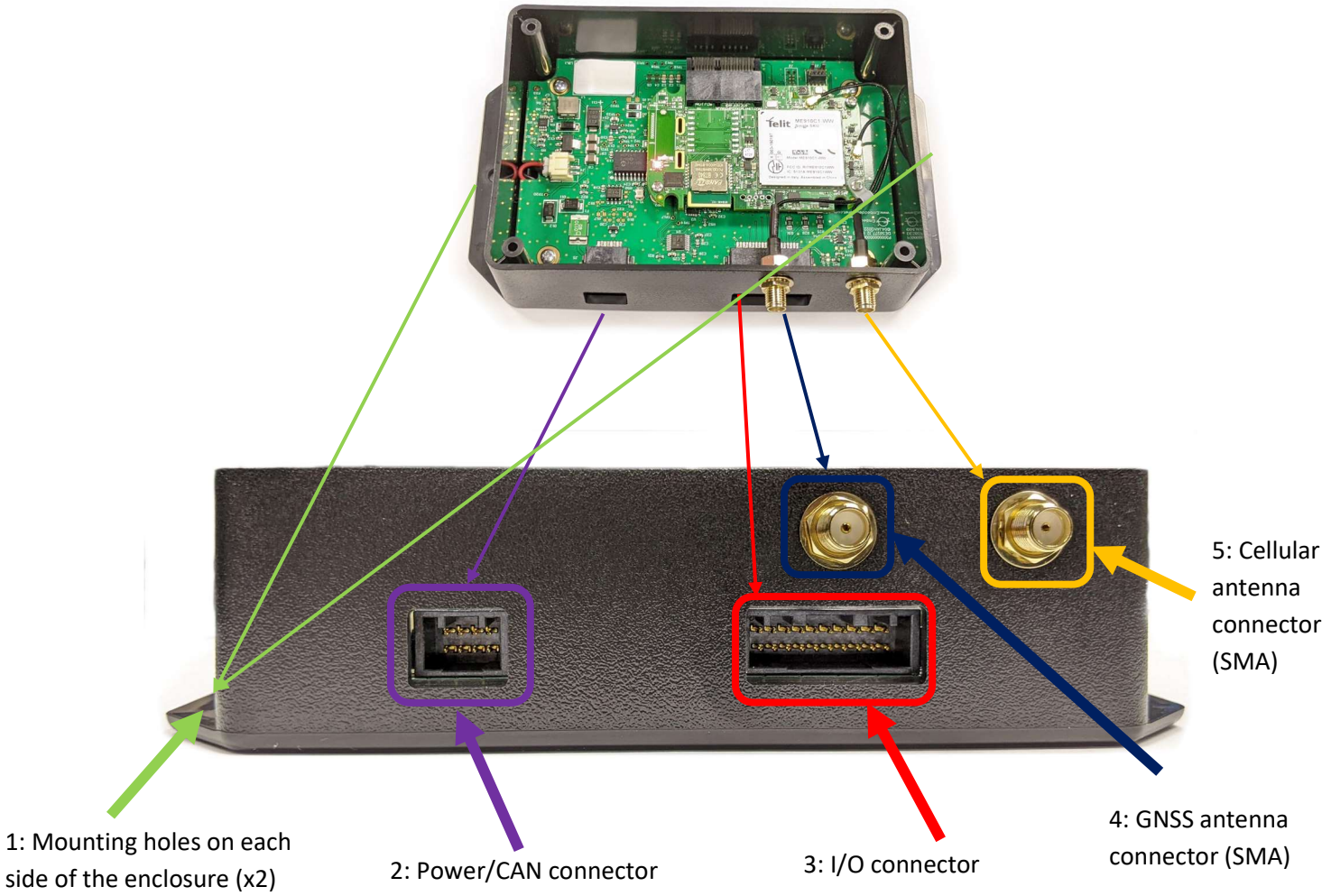
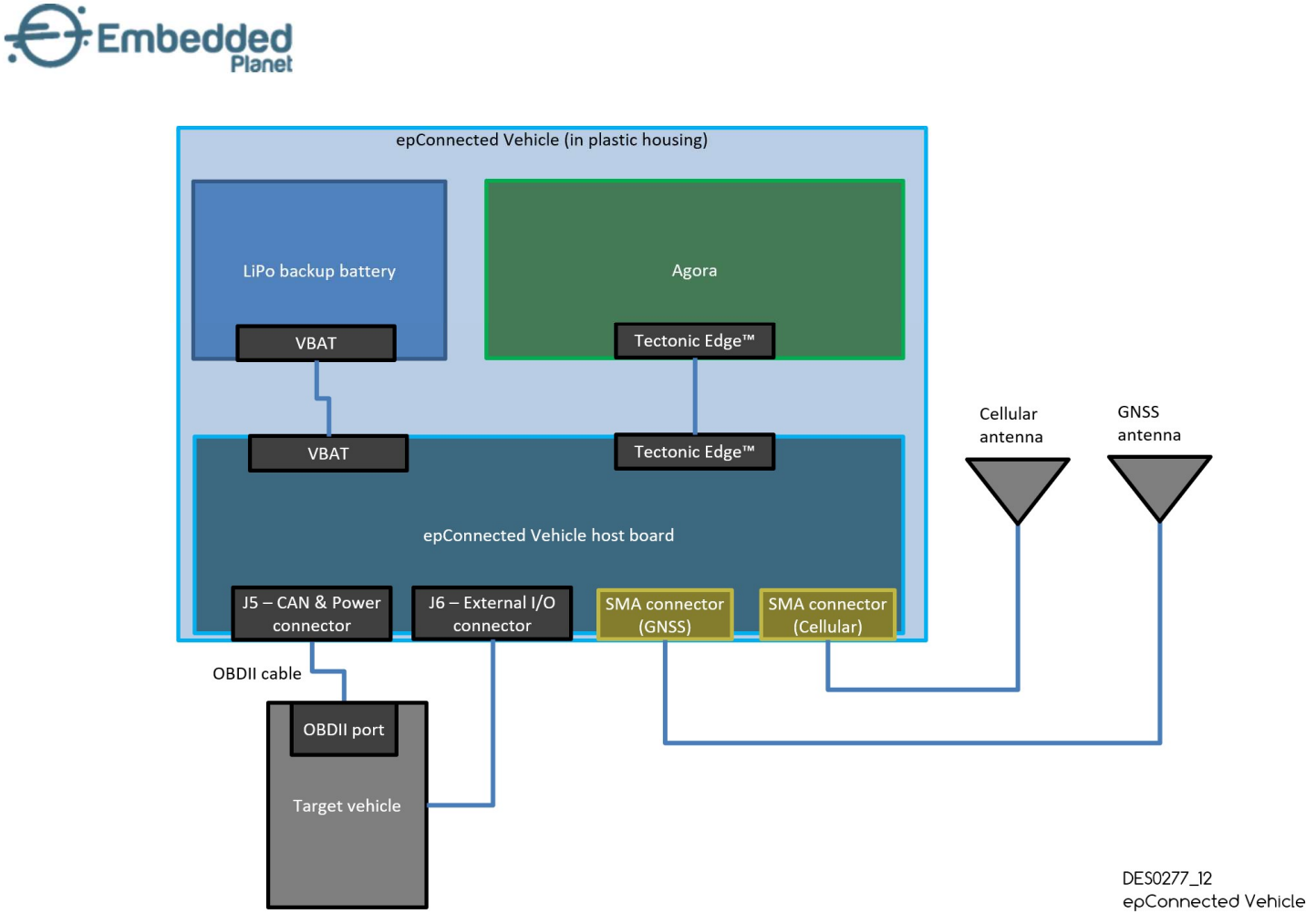


TABLE 6 – ENCLOSURE CONNECTORS & HARDWARE

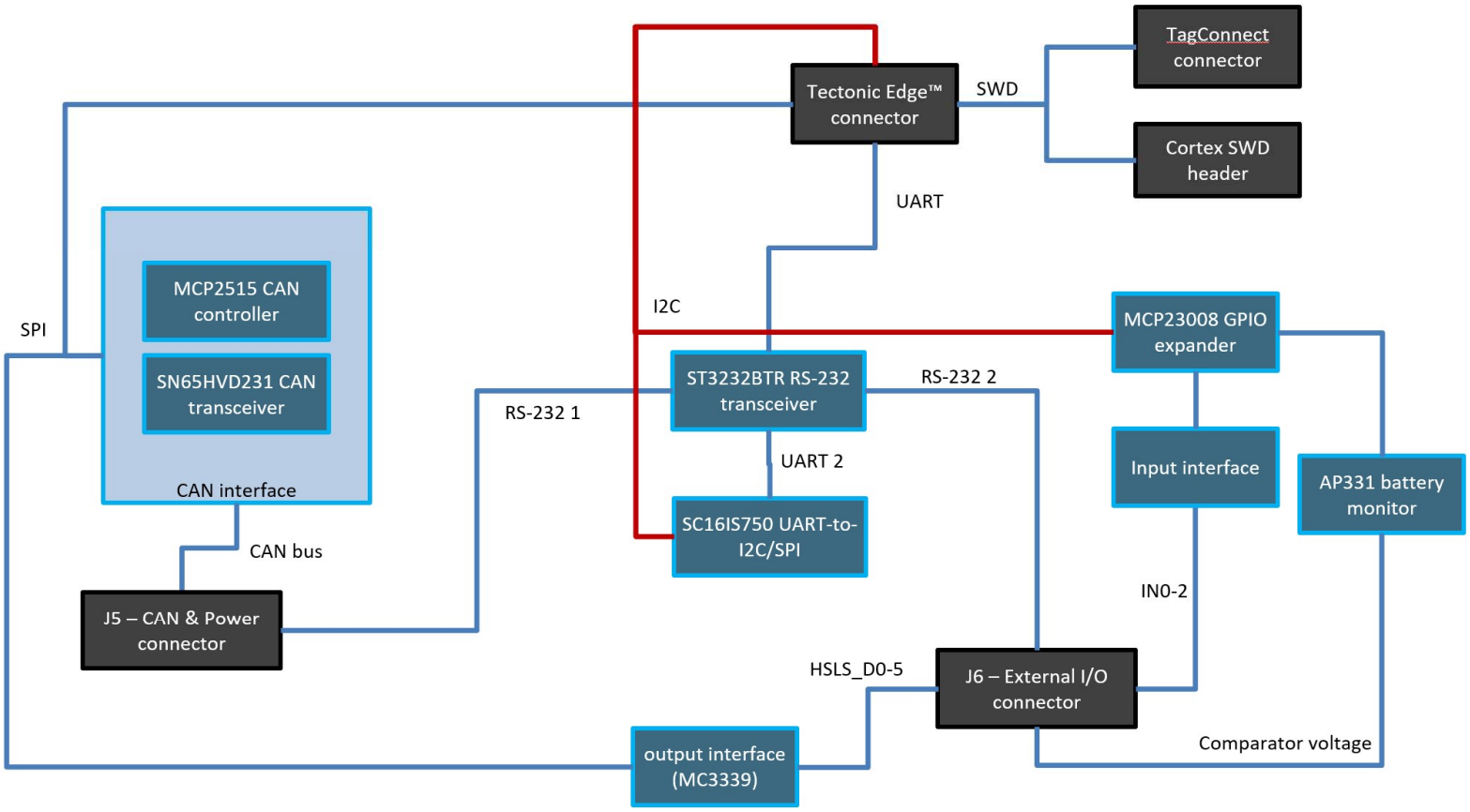
Category	Reference	Component Type	Description / Purpose
Mechanical	1	Enclosure mounting holes	For securing device enclosure
Connector	2	Power/CAN	Connector for power & CAN bus
Connector	3	I/O array	Connector for external I/O array
Connector	4	GNSS antenna	External SMA-style GNSS antenna port
Connector	5	Cellular antenna	External SMA-style Cellular antenna port

5. Block Diagrams

5.1. Block Diagram | System



5.2. Block Diagram | Board



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Board Block Diagram
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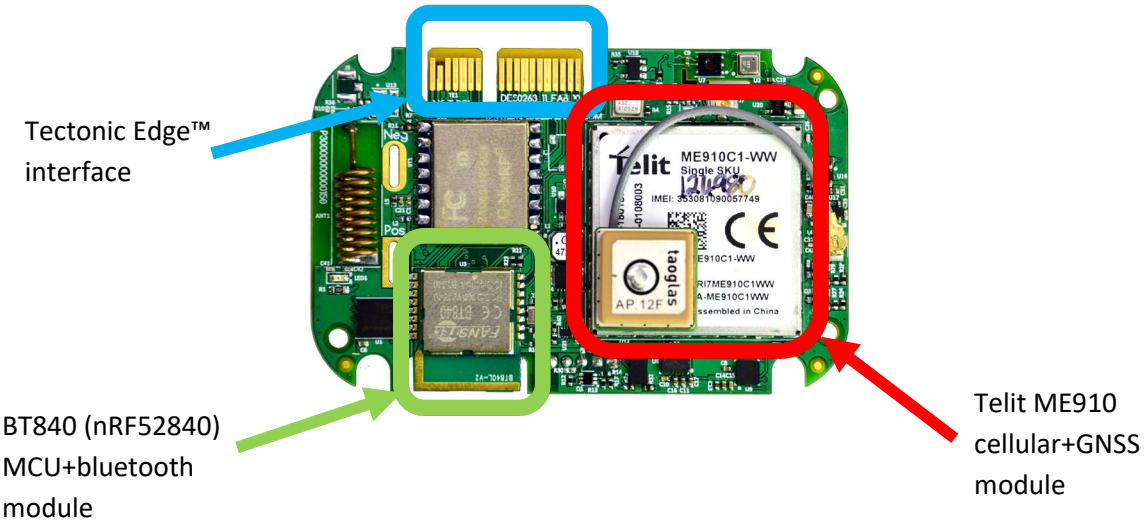
6. Device Specifications

TABLE 7 – DEVICE SPECIFICATIONS

Feature/Specification	Description
Cellular Capabilities	**Cellular Technologies**: LTE-M (LTE CAT M1), SMS **Lower power modes**: PSM, eDRX **Operating Frequencies**: 699MHz to 1980MHz **Cellular Operating Mode**: Half-duplex FDD **RF Output Power:** Up to +23 ±2 dBm (Power Class 3)
Internet Protocols	IPv4/IPv6 stack with TCP and UDP protocols TLS/DTLS
LTE CAT M1 Specification	**Bands (WW)**: B1(2100), B2(1900), B3(1800), B4(AWS1700), B5(850), B8(900), B12(700), 13(700), B18(800), B19(800), B20(800), B26(850), B28(700) **Bands (NA):** B2(1900), B4(AWS1700), B12(700) B13(700) **Uplink**: up to 375 kbps **Downlink**: up to 300 kbps
SIM	**Removable**: 4FF (nano) SIM card slot **Board-mounted**: MFF2 **Internal**: Telit simWISE™
Cellular Certifications	**PTCRB**: Complete (Agora) **AT&T**: Complete (Agora) **Verizon**: Complete (Agora)
GNSS Specifications	**Constellations**: GPS, GLONASS, BeiDou, Galileo, QZSS **Tracking Sensitivity**: -161dBm **Navigation Sensitivity**: -158dBm **Cold Start Sensitivity**: -146dBm
Input Voltage	**Nominal:** 12V (supplied via OBDII) **Voltage Range:** 5-20 VDC
Dimensions	**In plastics housing:** 102.3 mm x 59.3 mm x 43 mm (4.03 in x 2.33 in x 1.69 in)
Environmental	**Operating Temperature Range (with battery)**: 0°C to +45°C **Storage Temperature Range (with battery)**: 0°C to +45°C **Humidity Range (with battery)**: 20% RH to 60±25% RH **Operating Temperature Range** (without battery): -17°C to +80°C **Storage Temperature Range** (without battery): -17°C to +80°C **Humidity Range** (without battery): 20% RH to 90% RH
Sensor Options	**Environmental:** Temperature, humidity, barometric pressure, VOC gas **Inertial**: 6-axis IMU, 9-axis IMU (accelerometer, gyroscope, magnetometer) **Range**: Time-of-Flight (ToF)
Fault-Protected I/O	**12V/350mA analog outputs:** x6 **12V digital inputs:** x3

7. Agora Module

The epConnected Vehicle leverages the Agora board by Embedded Planet for its cellular + GNSS connectivity as well as for its sensor options. The MCU on Agora is Nordic's nRF52840; details of this MCU can be found here: https://www.nordicsemi.com/Products/Low-power-short-range-wireless/nRF52840. Shown below is a figure outlining the basic features on Agora as relevant to the epConnected Vehicle. More detail on the Agora board is available through the Embedded Planet website & documentation.



8. Sensors

The epConnected Vehicle board is designed to accommodate up to 5 Agora-mounted sensors across 3 different sensor categories. The following sensor options are available:

- **Environmental**
  - **Temperature, humidity**
    - *SiLabs Si7021-A20*
  - **Temperature, humidity, barometric pressure, VOC gas**
    - *Bosch BME680*
- **Inertial**
  - **6-Axis IMU (accelerometer, gyroscope)**
    - *InvenSense ICM-20602*
  - **9-Axis IMU (accelerometer, gyroscope, magnetometer)**
    - *ST LSM9DS1*
- **Range/Tampering**
  - **Time-of-Flight (ToF)**
    - *ST VL53L0X*

For more detail on sensor functions, specifications, development, or more please refer to the *Agora Product User Manual* which can be found at https://www.embeddedplanet.com/product-documentation/#agora.

9. Power

The epConnected Vehicle board is designed to be powered by 12V through an OBDII cable connected to J5. The 12V input on the PCB includes input protection elements designed to guard against egregious fault conditions and withstand alternator load dump conditions. A 1.1A, 60V resettable PTC fuse (polyfuse) in line with the 12V input protects against potential high input current levels. A series rectifier diode at the 12V input assures a one-way flow of energy at the connector. There is a TVS diode positioned for transients at the 12V input with a reverse stand-off voltage of 22V and a maximum clamping voltage of 35.5V. A capacitor bank provides conditioning & stability on the system side of the protection circuitry.

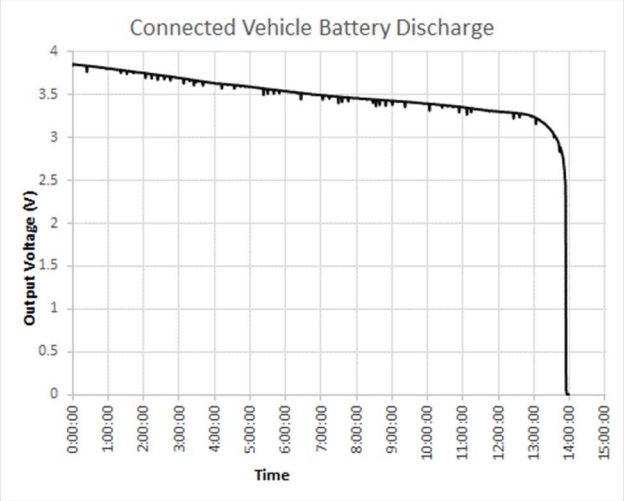
9.1. Power | Battery

The battery backup option for the epConnected Vehicle includes a small LiPo battery. This battery assists in the safe & consistent shutdown of the system when the +12V system power becomes cut from the system due to the vehicle turning off. If the system is in the middle of a transmission, sensor reading, or other sensitive process, the backup battery can help ensure that the process is carried through to completion before the system is fully shut down. A voltage monitor input to the epConnected Vehicle system monitors for the presence of 12V power and alerts the system if the power is cut off, allowing the system to move into a state of preparation for soft shutdown.

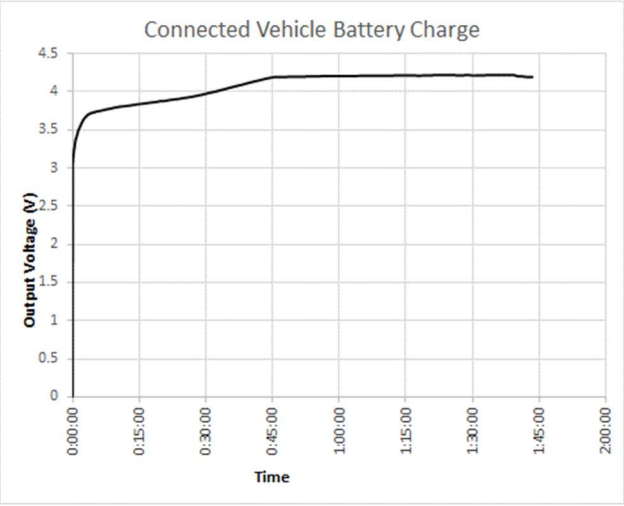
The battery provided with the epConnected Vehicle is a 3.7V, 500mAh rechargeable Lithium-Ion Polymer (LiPo) battery. The output ranges from 4.2V when completely charged down to 3.0V. The battery includes protection circuitry to keep the battery voltage from going too high or low; the battery will cut out when completely dead at 3.0V. When power is applied through the 12V system the battery charging is active. The battery is only meant to be charged using the onboard circuitry using the JST battery connection; never charge the battery using a non-recommended charging method. For the epConnected Vehicle the battery charge current limit is set to 450mA, and the charge termination voltage is set to 4.2V. The charge manager IC used is the Microchip MCP73831. More on the Microchip MCP73831 can be found at https://www.microchip.com/en-us/product/MCP73831.

If the 12V input is cut (e.g., the vehicle that is supplying power is turned off), the PWR_STATUS GPIO line will transition from high (3.3V) to low (0V) to indicate the loss of system input power. The system can then finish its current operations using the battery backup and then do a safe power shutoff once ready. The PWR_STATUS line corresponds to GP5 (pin 15) of the MCP23008 LiPo charger IC. This IC is connected to the Agora over I^2C bus using the address 0b01001110 (0x4E).

The following shows an example battery voltage discharge curve of the internal system when it continues to operate on battery power after the removal of system +12V power:



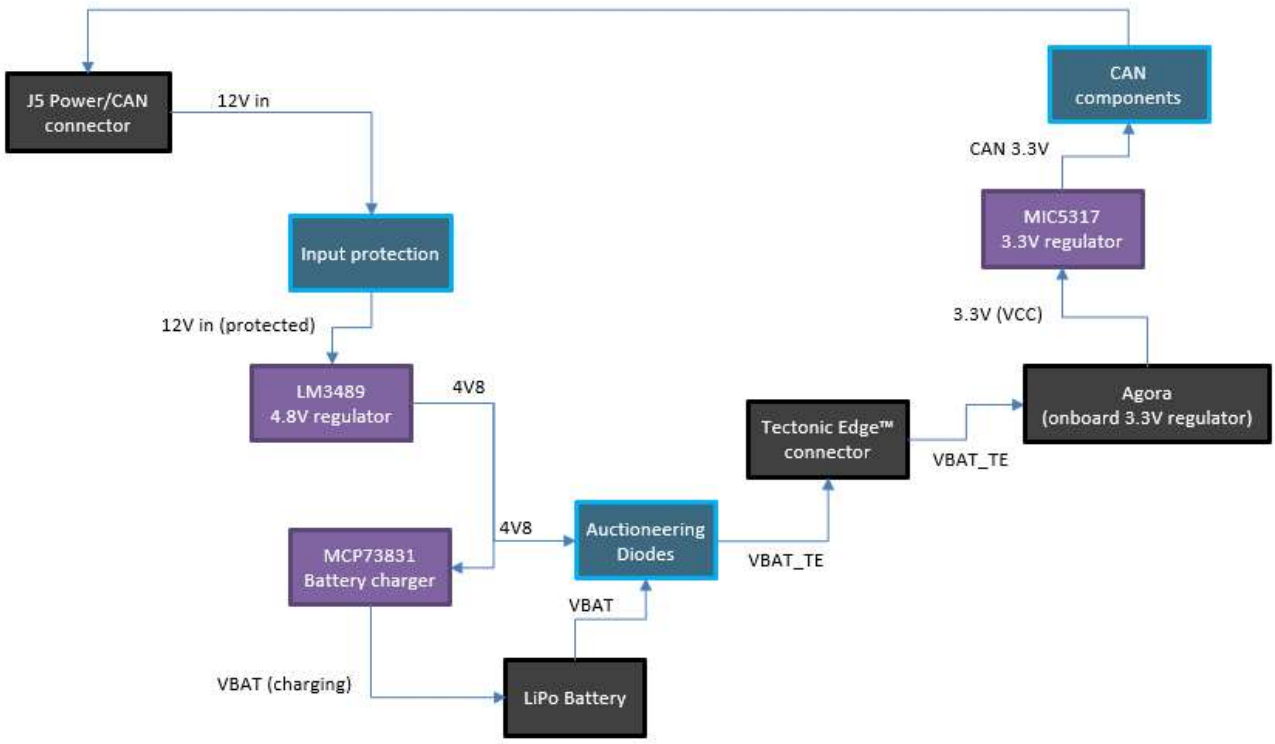
The following depicts a typical battery voltage curve during charging (+12V applied to the system via the OBDII interface powers the battery charging circuitry):



9.2. Power | Internal Power

Power to the CAN-specific components is provided by a dedicated, onboard 3.3V regulator. The enable to this regulator is tied to the *CAN_WAKE_CTRL* signal which is controlled by P0.06 of the nRF52840. This is an active-high signal.

The Power Block Diagram for the epConnected Vehicle is depicted below:



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epConnected Vehicle
Power Block Diagram
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10. Programming, Debugging, & Development

The processing power of the epConnected Vehicle is provided through the Agora module mounted to it. Programming & debug access to the Agora module for the development of custom applications is available through the epConnected Vehicle host board. The host board provides both an Arm Cortex SWD header and a TagConnect footprint for programming & debug use. Alternately, users may remove the Agora from the host board and program it with a Flidor development board by Embedded Planet. Flidor contains an OpenSDA programming and debug interface that can support simple drag-and-drop programming of files onto the target device (in this case the target is the epConnected Vehicle board).

More on Flidor can be found at https://www.embeddedplanet.com/product-documentation/#flidor

Available documentation on programming the epConnected Vehicle device (including example software or other development resources) can be found at https://www.embeddedplanet.com/product-documentation/#connected-vehicle

11. Component Interfaces

11.1. Component Interfaces | Outputs (U5)

*For detail on the output component interface, please refer to the section titled **External I/O Pinout (J6)**.*

11.2. Component Interfaces | GPIO Expander (U6)

The GPIO expander component U6 is an MCP23008. It is configured in I^2C mode with the address 0x4E. The interrupt line is from the CAN interface (U3) and optionally the I/O expander (U6 through R3). The expander must be configured as open drain when R3 is populated. The reset, enable, interrupt, and chip select signals for this device are active-low.

TABLE 8 – U6 PIN ASSIGNMENTS

Category	Signal	U6 Pin
UART	UART2_RESET#	U6 GP4 (pin 14)
System	PWR_STATUS	U6: GP5 (pin 15)
System	GPO_EN#	U6: GP6 (pin 16)
System	GPO_CS#	U6: GP7 (pin 17)
System	IO_INT# *	U6: INT (pin 6)
Input	IN0	U6: GP0 (pin 10)
Input	IN1	U6: GP1 (pin 11)
Input	IN2	U6: GP2 (pin 12)
Input	IN3 (voltage monitor output)	U6: GP3 (pin 13)

For more detail on the MCP23008, please refer to https://www.microchip.com/en-us/product/MCP23008.

11.3. Component Interfaces | UART Managers

The RS-232 transceiver IC is an ST3232BTR (U4). This component drives both of the two RS-232 interfaces hosted on the epConnected Vehicle device. The first UART interface communicates with the Agora MCU through UART signals, while the second UART interface is converted to the I^2C bus using a SC16IS750IBS (U3). The I^2C address for this component is 0x9A. The interrupt signal IO_INT# is shared between U3 and U8 (U6 optional; not connected by default).

For more detail on the ST3232BTR please refer to https://www.st.com/en/interfaces-and-transceivers/st3232b.html

For more detail on the C16IS750IBS please refer to https://www.nxp.com/part/SC16IS750IBS#/

TABLE 9 – U4 PIN ASSIGNMENTS

Signal	U4 pin
RS232_TX_OUT_CON_2	T2OUT (pin 7)
RS232_RX_IN_CON_2	R2IN (pin 8)
RS232_TX_IN_CON	R1IN (pin 13)
RS232_RX_OUT_CON	T1OUT (pin 14)
TX_OUT (to MCU)	T1IN (pin 11)
RX_IN (to MCU)	R1OUT (pin 12)
RX (U3 pin 24)	R2OUT (pin 9)
TX (U3 pin 23)	T2IN (pin 10)

11.4. Component Interfaces | CAN Managers

The CAN interface for the epConnected Vehicle consists of a TI SN65HVD231 CAN transceiver (U9) paired with an MCP2515 CAN controller (U8). The MCP2515 communicates with the MCU over a SPI interface. The chip select line for this component (CAN_CS#) is controlled by pin P1.09 on the nRF52840 MCU.

For more on the SN65HVD231, please refer to https://www.ti.com/product/SN65HVD231/.

Power to the CAN components can be discretely managed by the MCU. For more detail on this, please refer to the power section of this manual.

12. Pinouts

12.1. Pinouts: MCU Pinout

TABLE 10 – MCU PINOUT (BT840 VIA AGORA)

Fanstel Pin	nRF52840 pin	Function	Connected to	Tectonic Edge™ Pin
1	P0.26/SDA	SDA	Sensors	B7
2	P0.27/SCL	SCL	Sensors	B6
3	P0.00/XL1	32.768kHz	Crystal	-
4	P0.01/XL2	32.768kHz	Crystal	-
5	P0.02/AIN0	Battery Voltage ADC	Battery Voltage Monitor	-
6	P0.03/AIN1	Board ID ADC	Board ID resistor divider	-
7	P0.09/NFC1	NFC	JST connector	-
8	P0.10/NFC2	NFC	JST connector	-
9	VDD	Power	Vin	A12
10	GND	Common	COM	A5
11	P0.11/TRACEDATA2	LoRa_MOSI/TRACEDATA2	LoRa Module	B2
12	P1.00/TRACEDATA0	SWO/TRACEDATA0	EP Debug Header	A18
13	P0.13	Debug_TX	EP Debug Header and cell aux UART	B12
14	P0.18/nRESET	BT840 Reset	EP Debug Header	A17
15	SWCLK	SWD clock	EP Debug Header	A16
16	SWDIO	SWD data	EP Debug Header	A15
A0	VSS	Common	COM	A8
A1	P0.28/AIN4	CELL_PWR_EN	Telit cell module	-
A2	P0.29/AIN5	PB	Pushbutton	-
A3	P0.04/AIN2	INT_LIGHT_TOF	Light sensor INT and ToF sensor INT	-
A4	P0.05/AIN3	LED_RED	LED	-
A5	P0.07/TRACECLK	LoRa_SCLK/TRACECLK	LoRa Module	B3
A6	P1.08	CELL_CTS	Telit cell module	A4
B0	VSS	Common	COM	A14
B1	P0.25	I2S_SD	Microphone	B11
B2	P0.30/AIN6	CELL_ON_OFF	Telit cell module	B9
B3	P0.31/AIN7	SENSOR_PWR_EN	Load Switch	B10
B4	P0.06	I2S_SCK	Microphone	A7
B5	P0.08	I2S_WS	Microphone	A6
B6	P1.03	CELL_DSR	Telit cell module	-
C0	VSS	Common	COM	B5
C1	P0.24	CELL_HW_SHUTDOWN	Telit cell module	-
C2	P0.22	QSPI IO2	QPSI Flash	-
C3	P0.17	QSPI CS#	QPSI Flash	B15
C4	P0.15	CELL_DCD	Telit cell module	-
C5	P1.02	CELL_TX	Telit cell module	A1
C6	P1.04	CELL_DTR	Telit cell module	-
D0	VSS	Common	COM	B8

D1	P0.23	QSPI IO3	QPSI Flash	-
D2	P0.19	QSPI CLK	QPSI Flash	B18
D3	P0.16	Debug_RX	EP Debug Header and cell aux UART	B13
D4	P0.14	CELL_RTS	Telit cell module	A2
D5	P1.01	CELL_RX	Telit cell module	A3
D6	P1.05	INT_ACCEL	6-axis or 9-axid INT	-
E0	P1.07	LoRa_DIO0	LoRa Module	-
E1	P0.20	QSPI IO0	QPSI Flash	B17
E2	P0.21	QSPI IO1	QPSI Flash	B16
E3	P1.09/TRACEDATA3	LoRa_SS#/TRACEDATA3	LoRa Module	B4
E4	D+	USB	EP Debug Header	A9
E5	D-	USB	EP Debug Header	A10
E6	P0.12/TRACEDATA1	LoRa_MISO/TRACEDATA1	LoRa Module	B1
F0	VSS	Common	COM	B14
F1	VSS	Common	COM	-
F2	VSS	Common	COM	-
F3	VSS	Common	COM	-
F4	VDDH	Power	Vin	-
F5	DCCH	Power	NC	-
F6	VBUS	USB	EP Debug Header	A11
Z0	P1.11	BATT_MON_EN	Battery Voltage Monitor	-
Z1	P1.12	LoRa_DIO1	LoRa Module	-
Z2	P1.13	LoRa_DIO2	LoRa Module	-
Z3	P1.14	LoRa_DIO3	LoRa Module	-
Z4	P1.15	LoRa_DIO4	LoRa Module and cell module PWRMON	-
Z5	P1.10	LoRa_RESET#	LoRa Module	-
Z6	P1.06	Board ID EN#	Board ID resistor divider	-

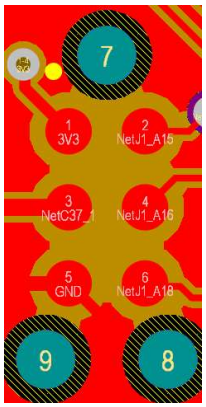
For more complete detail on the **BT840** module please refer to: https://www.fanstel.com/bt840.

For more complete detail on the **nRF52840** MCU please refer to: https://www.nordicsemi.com/Products/nRF52840.

12.2. Pinouts: TagConnect Programming Header (J2)

TABLE 11 –TAGCONNECT DEBUG HEADER PINOUT (J2)

Signal	Pin	Notes
VCC	1	3.3V
SWDIO	2	SWDIO
RESET#	3	RESET#
SWCLK	4	SWDCLK
COM	5	COM (0V)
SWO	6	SWO

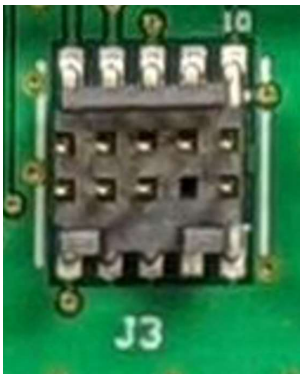


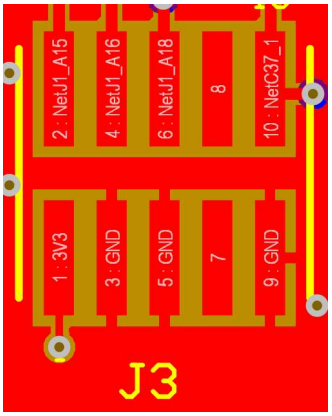
For TagConnect resources and information, please refer to
https://www.tag-connect.com/product-category/products/cables/6-pin-target

12.3. Pinouts: Arm Cortex Programming Header (J3)

TABLE 12 – ARM CORTEX DEBUG HEADER PINOUT (J3)

Signal	Pin	Notes
VCC	1	3.3V
SWDIO/TMS	2	SWDIO
COM	3	COM (0V)
SWDCLK/TCK	4	SWDCLK
COM	5	COM (0V)
SWO/TDO	6	SWO
KEY	7	No connect
NC/TDI	8	No connect
COM Detect	9	COM (0V)
RESET#	10	RESET#



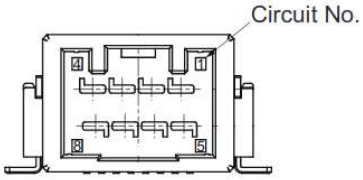


12.4. Pinouts: Power/CAN Pinout (J5)

The CAN interface on the epConnected Vehicle allows the device to communicate with the vehicle using an OBDII converter cable. The interface uses a Microchip MCP2515 SPI-to-CAN controller and TI SN65HVD231 CAN transceiver to manage the CAN bus.

TABLE 13 – POWER/CAN CONNECTOR (J5) PINOUT

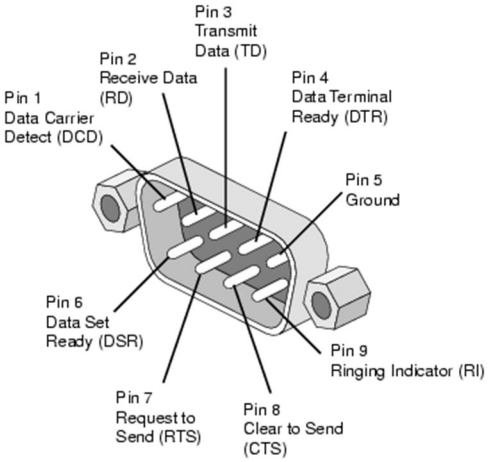
Pin	Category	Description
1	Reference	COM
2	CAN	CAN Low
3	RS-232	RS-232 TX IN
4	Power	+12V power input
5	Power	+12V power input
6	CAN	CAN High
7	RS-232	RS-232 RX OUT
8	Reference	COM



The OBDII cable for the epConnected Vehicle has three wires that break out a connection to an RS-232 port of a PC, as shown below*.

TABLE 14 – J5 TO DB9 PIN MAP

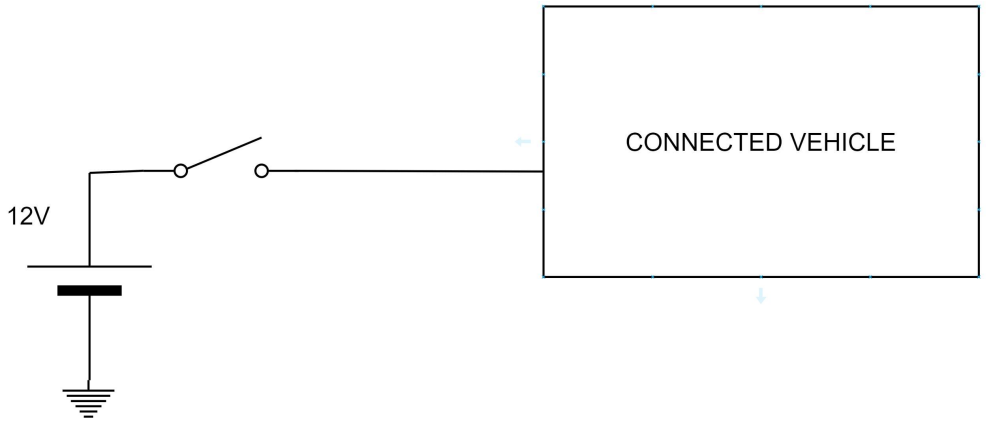
J5 Pin	Description	DB9 Pin
J5 pin 3	RS-232 TX IN (PC Tx)	DB9 pin 2
J5 pin 7	RS-232 RX OUT (PC Rx)	DB9 pin 3
J5 pin 8	COM (Ground/0V)	DB9 pin 5



**Virtual RS-232 ports through USB converters like the Tripp Lite: U209-000-R are also supported.*

12.5. External I/O Pinout (J6)

The I/O connector J6 has 3 inputs designed for high side switching (switch is connected between +12V and input). The basic input switch scheme is illustrated below:



I/O connector J6 also has 6 outputs designed for low side switching (relay is connected between +12V and output). The driving outputs are managed by a Freescale MC33397DW power switch driver (U5). This component communicates with the MCU on Agora using SPI. For more detail on the MC33397DW, please refer to https://www.nxp.com/docs/en/data-sheet/MC33397.pdf.

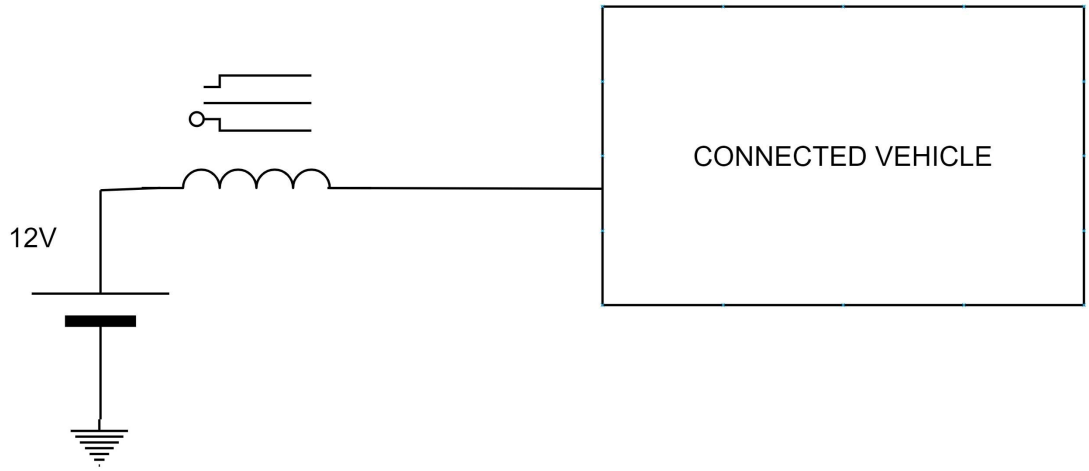
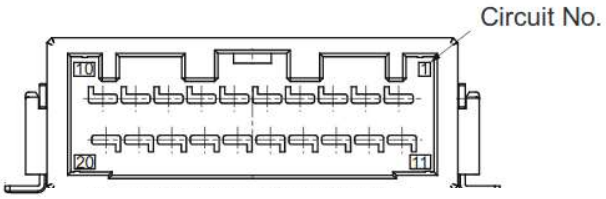


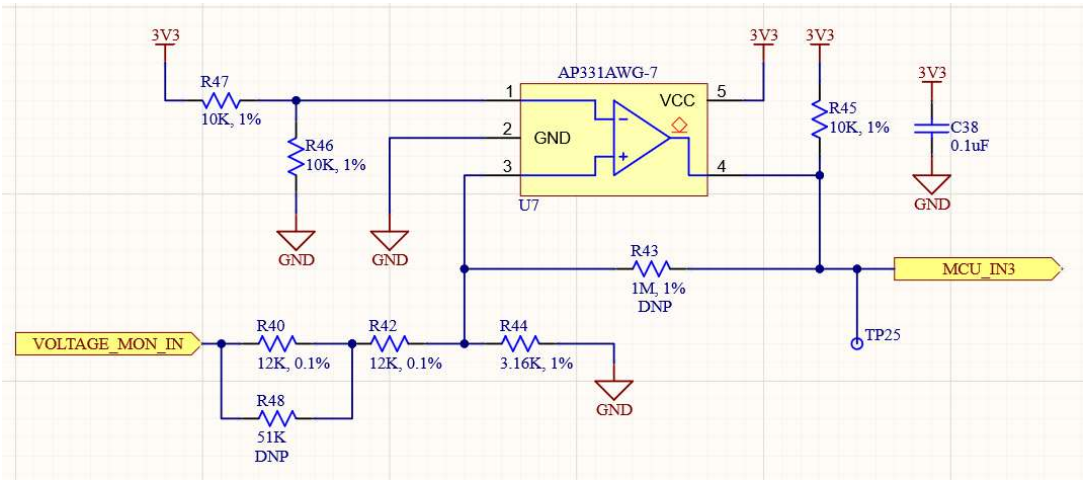
TABLE 15 – J6 HEADER PIN LIST

Pin	Category	Description
1	Input	IN2
2	Input	IN0
3	Output	D0
4	Output	D1
5	Output	D2
6	Output	D3
7	Output	D4
8	Output	D5
9	Reference	COM
10	RS-232	RS-232 TX OUT
11	Input	Voltage monitor
12	Input	IN1
13	Reference	COM
14	Reference	COM
15	Reference	COM
16	Reference	COM
17	Reference	COM
18	Reference	COM
19	Reference	COM
20	RS-232	RS-232 RX IN



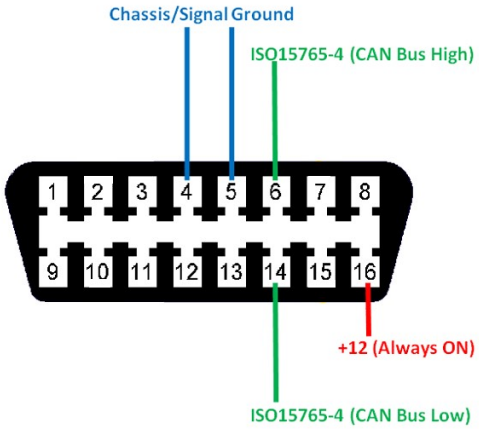
I/O connector (as viewed by user)

The voltage monitor is an analog input line that accepts a voltage input and compares it to a reference voltage. The output of the comparator is sent to the MCU through signal IN3. The trip condition for the voltage monitor is 1.65V at the comparator input; taking into consideration the scaling resistors at the positive input terminal of the comparator, the trip condition with respect to the external voltage input is 14.2V.



12.6. OBDII Cable Pinout

The epConnected Vehicle is compatible with a standard OBDII cable with the following connections:



Shown above is the OBDII pinout according to the receptacle piece.

TABLE 16 – OBDII CABLE PINOUT

Pin	Category	Description
4	Reference	COM
5	Reference	COM
6	CAN	CAN HIGH
14	CAN	CAN LOW
16	Power	+12V power input

Some configurations of the epConnected Vehicle may include a compatible OBDII cable.

13. Antennae

The epConnected Vehicle uses two antenna types: a cellular antenna and a GNSS antenna. Both antennae are attached using SMA(F) connectors mounted to the plastic housing of the device. The GNSS antenna port is located above the I/O connector while the Cellular antenna port is located on the far side of the housing. Both of the SMA(F) ports on the housing are socket-type SMA(F) ports with outer threads. Consequently, both of the connecting antennae must have pin-type SMA(F) connectors with inner threads.

Enclosure-mounted connector

Example antenna connector

The required antenna specifications correspond to those of the Agora. Please refer to the *Agora User Manual* for further detail on the antenna specifications: https://www.embeddedplanet.com/product-documentation/#agora.

Any antenna used with the epConnected Vehicle should be mounted either to the exterior of the vehicle or anywhere on the vehicle that provides appropriate antenna performance according to the distinct characteristics of the antenna used.

The antenna recommended for use with the epConnected Vehicle is the MA140.A.LB.001 combination cellular + GNSS antenna by Taoglas. This antenna is appropriate for mounting to the exterior of a vehicle; it features an ingress protection rating of IP67 and does not require a ground plane.

For more information on the Taoglas MA140.A.LB.001 combination antenna, please refer to: https://www.taoglas.com/product/olympian-ma140-2in1-gpsglonass-2g3g4g-permanent-mount-antenna/.

14. Electrical Specifications

14.1. Pin Map + Maximum/Minimum Operation Ratings

TABLE 17 – PIN MAP + MAXIMUM/MINIMUM OPERATION RATINGS

Category	Signal	Header	Pin	nRF52840	Min (V)	Typ (V)	Max (V)	Notes
UART	RS232_TX_IN_CON	J5	3	P0.16	-25	-	+25	RX_IN B13
UART	RS232_RX_OUT_CON	J5	7	P0.13	-13.2	-	+13.2	TX_OUT B12
UART	UART2_RESET#	-	-	I²C (0x4E)	-	-	-	U6 GP4 (pin 14)
UART	RS232_TX_OUT_CON_2	J6	10	I²C (0x9A)	-13.2	-	+13.2	SC16IS750 (U4)
UART	RS232_RX_IN_CON_2	J6	20	I²C (0x9A)	-25	-	+25	SC16IS750 (U4)
CAN	CAN_L	J5	2	SPI (CAN_CS#)	-4	-	16	SPI (U8)
CAN	CAN_H	J5	6	SPI (CAN_CS#)	-4	-	16	SPI (U8)
CAN	CAN_RST#	-	-	P0.08	-	-	-	GPIO04 A6
CAN	CAN_WAKE_CTRL	-	-	P0.06	-	-	-	GPIO05 A7
CAN	IO_INT# *	-	-	P0.25	-	-	-	GPIO03 B11
SPI	CAN_MISO	-	-	P0.12	-	-	-	MISO B1
SPI	CAN_MOSI	-	-	P0.11	-	-	-	MOSI B2
SPI	CAN_SCLK	-	-	P0.07	-	-	-	SCLK B3
SPI	CAN_CS#	-	-	P1.09	-	-	-	SS# B4
I²C	I2C_SCL	-	-	P0.27	-	-	-	I2C_SCL B6
I²C	I2C_SDA	-	-	P0.26	-	-	-	I2C_SDA B7
Power	VCC	J2	1	-	-	3.3V	-	Output only
		J3	1					
Power	+12V	J5	4,5	-	5	12	20	Supply Voltage
Power	COM	J2	5	COM	-	0	-	Reference
		J3	3,5,9					
		J5	1,8-10					
		J6	9,13-19					
SWD	SWDIO	J2	2	SWDIO	-	3.3V	-	SWDIO A15
		J3	2					
SWD	SWCLK	J2	4	SWCLK	-	3.3V	-	SWDCLK A16
		J3	4					
SWD	SWO	J2	6	P1.00	-	3.3V	-	SWO A18
		J3	6					
SWD	RESET#	J2	3	P.018 U6: RESET#	-	3.3V	-	RESET# A17
		J3	10					
		-	-					
Analog Input	VOLTAGE_MON_IN	J6	11	*See IN3*	0	-	50	Comparator input
System	PWR_STATUS	-	-	I²C (0x4E)	-	-	-	U6: GP5 (pin 15)

System	GPO_EN#	-	-	I^2C (0x4E)	-	-	-	U6: GP6 (pin 16)
System	GPO_CS#	-	-	I^2C (0x4E)	-	-	-	U6: GP7 (pin 17)
System	IO_INT# *	-	-	U6 INT (opt)	-	-	-	U6: INT (pin 6)
Input	IN0	J6	2	I^2C (0x4E)	8	12	20	U6: GP0 (pin 10)
Input	IN1	J6	12	I^2C (0x4E)	8	12	20	U6: GP1 (pin 11)
Input	IN2	J6	1	I^2C (0x4E)	8	12	20	U6: GP2 (pin 12)
Input	IN3 (voltage monitor output)	-	-	I^2C (0x4E)	-	-	-	U6: GP3 (pin 13)
Output	HSLS_D0	J6	3	*See SPI signals*	-	12	20	U5: A5 (pin 1)
Output	HSLS_D1	J6	4	*See SPI signals*	-	12	20	U5: A4 (pin 2)
Output	HSLS_D2	J6	5	*See SPI signals*	-	12	20	U5: A3 (pin 11)
Output	HSLS_D3	J6	6	*See SPI signals*	-	12	20	U5: A2 (pin 12)
Output	HSLS_D4	J6	7	*See SPI signals*	-	12	20	U5: A1 (pin 14)
Output	HSLS_D5	J6	8	*See SPI signals*	-	12	20	U5: A0 (pin 23)

** Interrupt from CAN interface (U3) and optionally the I/O expander (U6 through R3). The expander must be configured as open drain when R3 is populated. Accessible through TP5.*

15. Mechanical Specifications

15.1. Physical Parameters

TABLE 18 – PHYSICAL PARAMETERS

Parameter (enclosure)	Value (in)	Value (mm)
Length (with mounting tabs)	6.006	152.6
Length (box walls)	5.002	127.1
Width	3.570	90.7
Height	1.64	41.7

15.2. Enclosure

The enclosure for the epConnected Vehicle is a Polycase LP-55FMB. The enclosure includes a lid secured by 4 screws with 2 mounting tabs on either side of the enclosure. For more information on the enclosure, including detailed drawings, please refer to https://www.polycase.com/lp-55f.

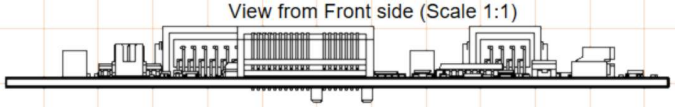
15.3. Mechanical Drawings

Within this section are mechanical drawings provided for the purpose of understanding the general size, shape, and layout of the epConnected Vehicle device. For the most complete & up-to-date documentation on mechanical drawings, along with more on the epConnected Vehicle device, please refer to the materials provided at https://www.embeddedplanet.com/product-documentation/#connected-vehicle.

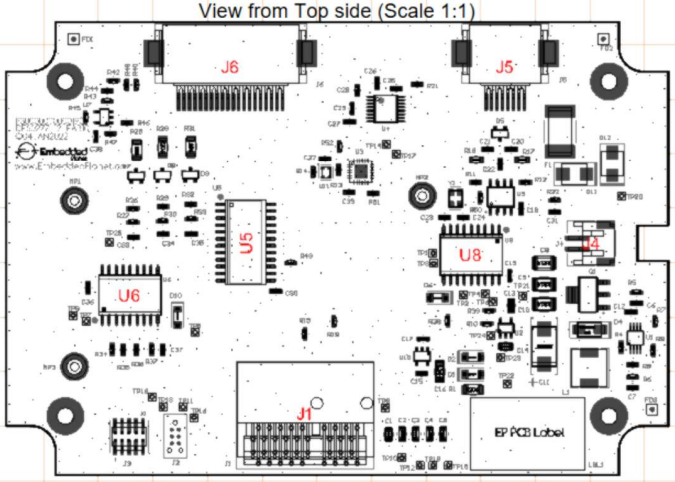
15.3.1. Mechanical Drawings | Host Board Features (Top/Bottom)

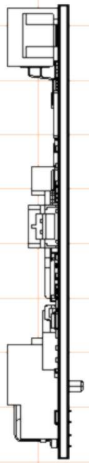
Note: This content is imported from a separate dimensional drawing document and the scale is not realistically as noted

View from Front side (Scale 1:1)

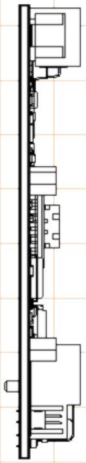


View from Top side (Scale 1:1)

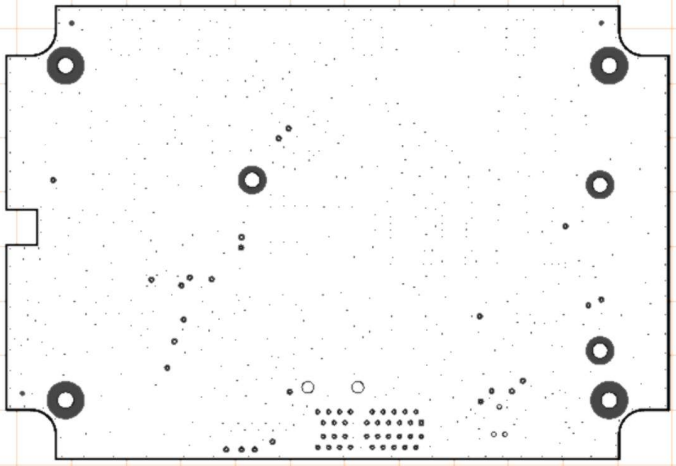




View from Right side (Scale 1:1)

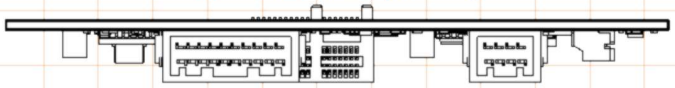


View from Left side (Scale 1:1)



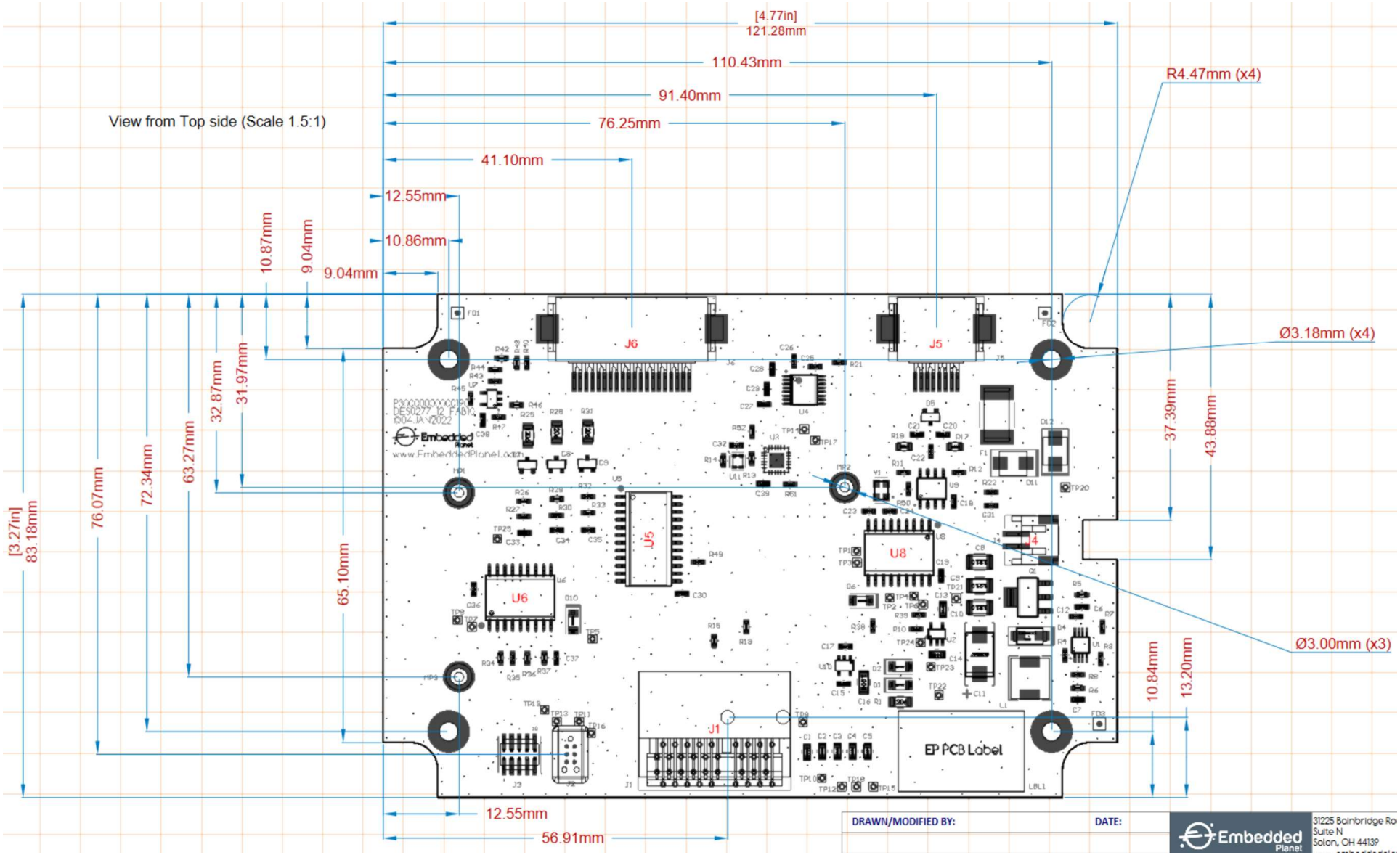
View from Bottom side (Scale 1:1)

View from Back side (Scale 1:1)



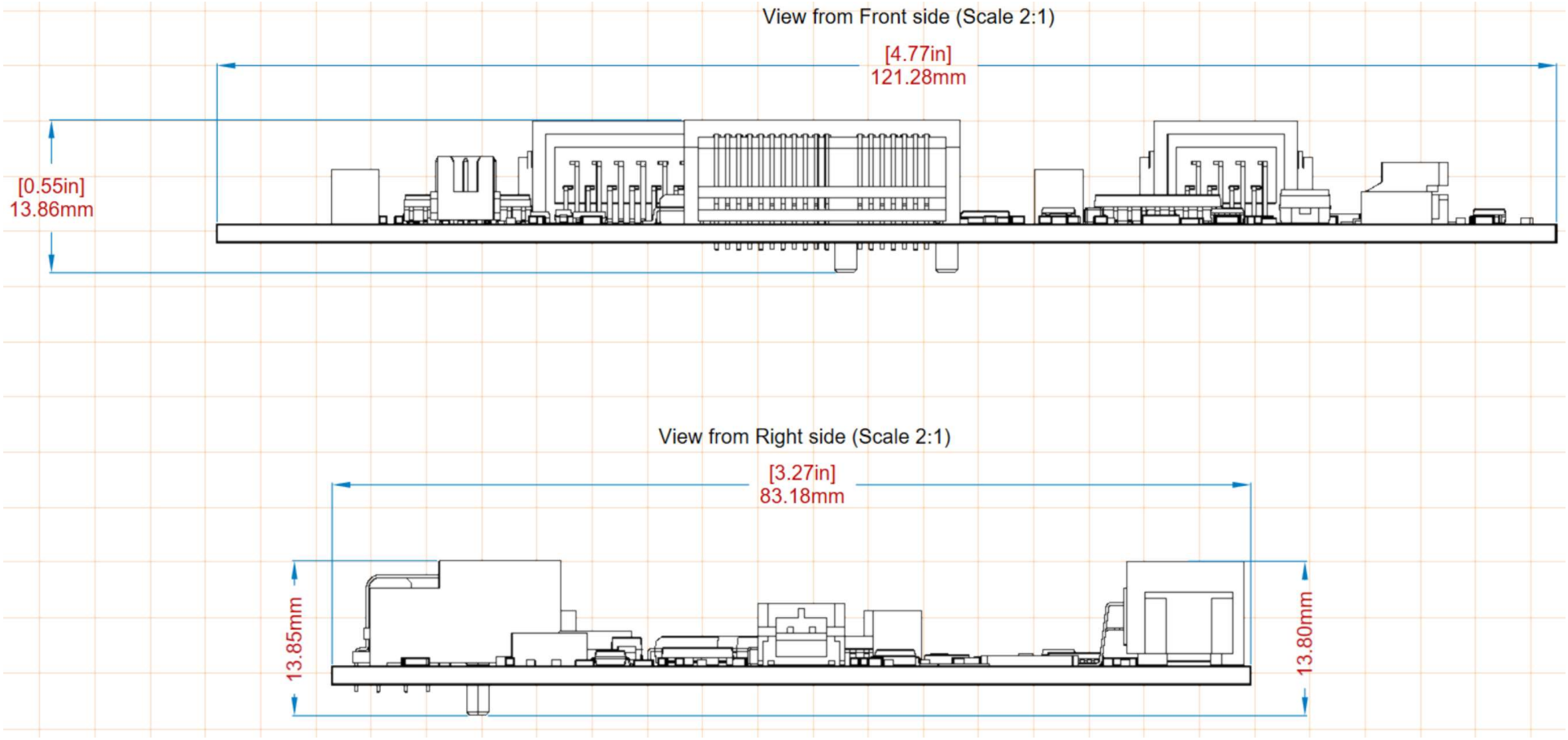
15.3.2. Mechanical Drawings | Host Board Dimensions

Note: This content is imported from a separate dimensional drawing document and the scale is not realistically as noted

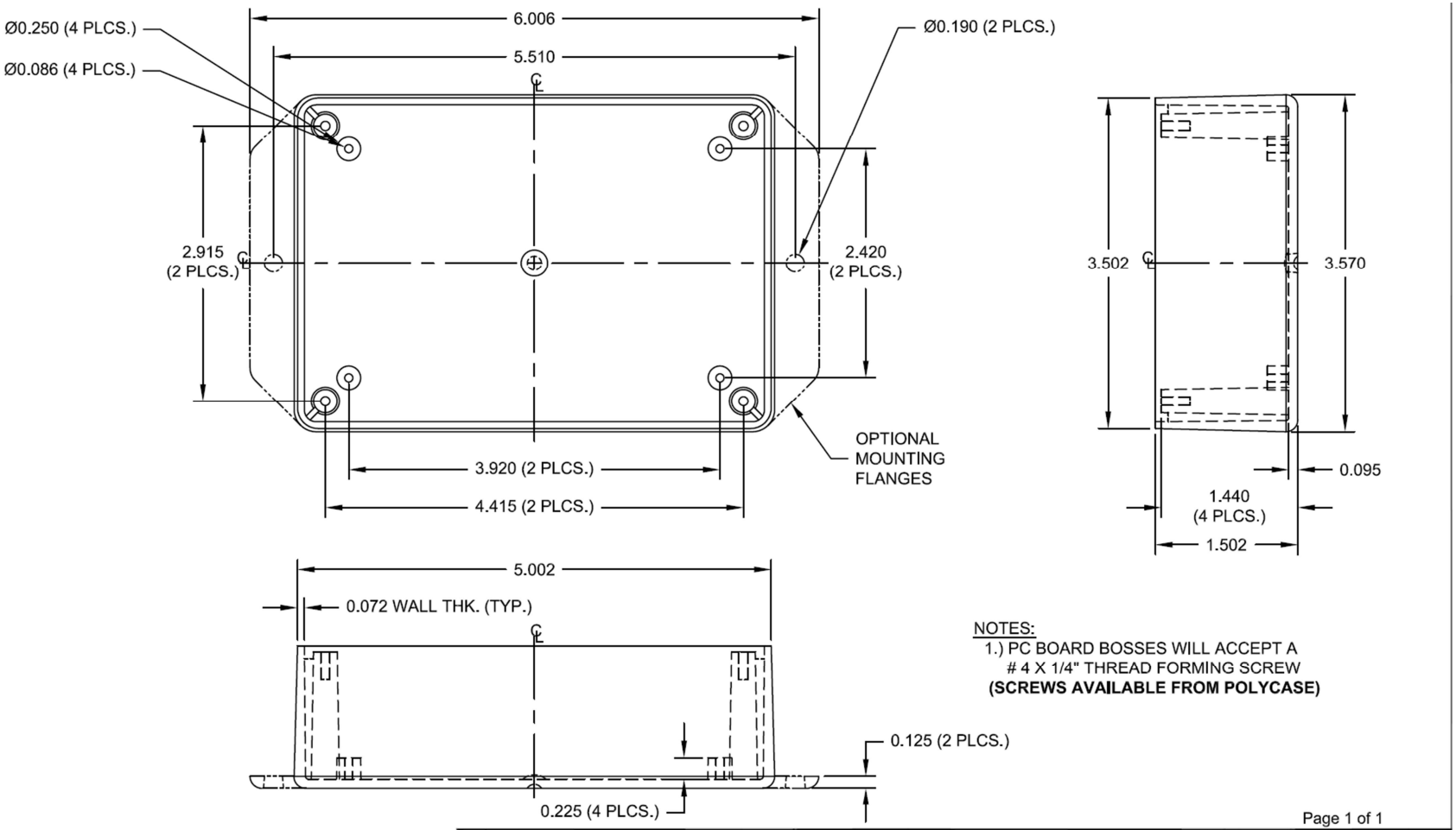


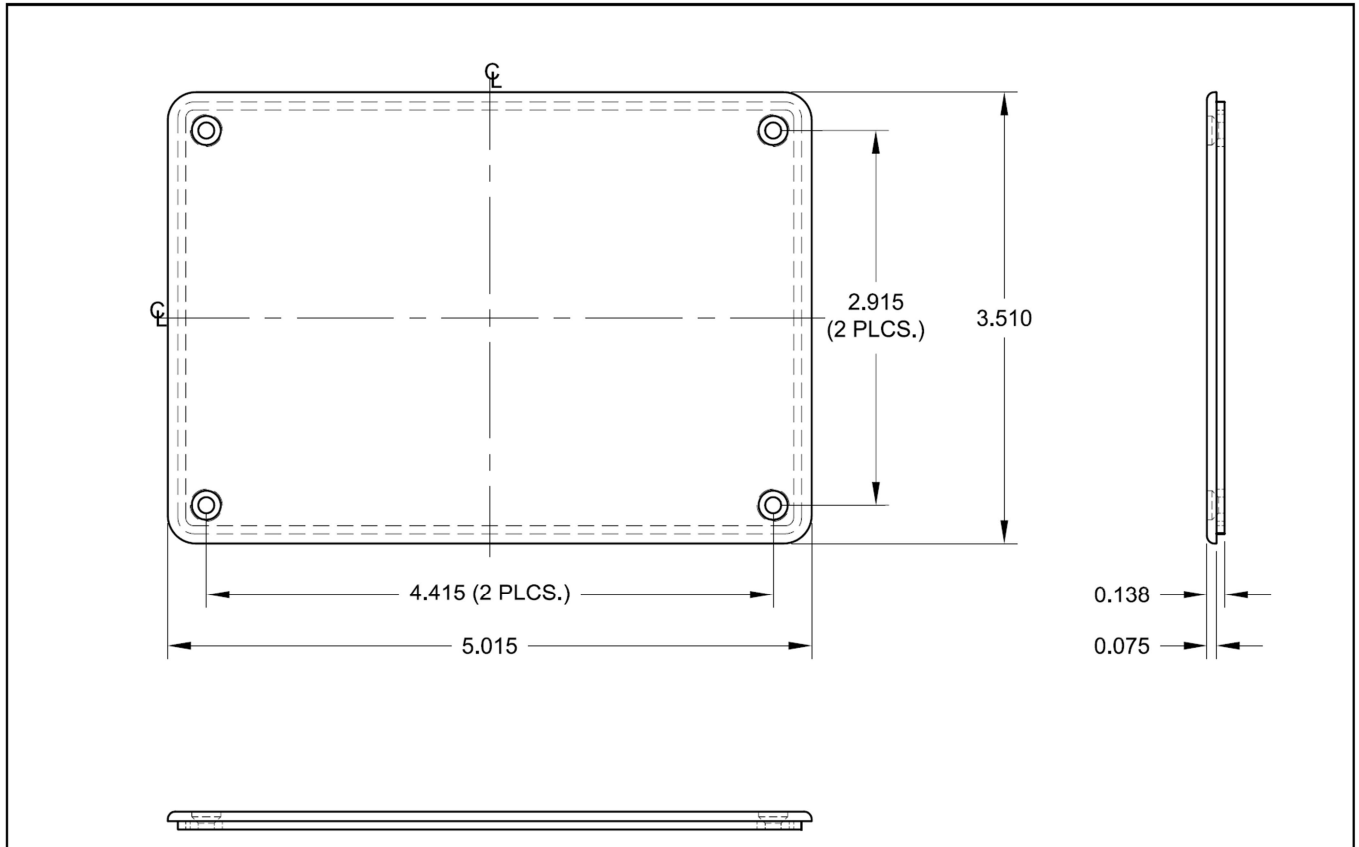
15.3.3. Mechanical Drawings | Host Board Dimensions (Side)

Note: This content is imported from a separate dimensional drawing document and the scale is not realistically as noted



15.3.4. Mechanical Drawings | Enclosure Dimensions





Page 1 of 1

REV	DESCRIPTION	BY	CHK	DATE

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X.XX ±.020
X.XXX ±.010

DRWN BY	APP. BY	SCALE	DATE:
M.M.T.	B.B.	FULL	09/13/00

JOB NO:	PRODUCT:
- -	- LP-55C

CUSTOMER:

TITLE: PRODUCT DETAIL DRAWING

15.4. Environmental Specifications

TABLE 19 – ENVIRONMENTAL SPECIFICATIONS

Parameter	Min	Typ	Max
Operating Temperature ***(with battery)***	0°C	+25°C	+45°C
Storage Temperature ***(with battery)***	0°C	+25°C	+45°C
Operating Humidity, non-condensing ***(with battery)***	20% RH	-	60±25% RH
Operating Temperature *(without battery)*	-17°C	+25°C	+80°C
Storage Temperature *(without battery)*	-17°C	+25°C	+80°C
Operating Humidity, non-condensing *(without battery)*	20% RH	-	90% RH

16. Regulatory Information

16.1. Cellular Certifications & Endorsements

Certifications

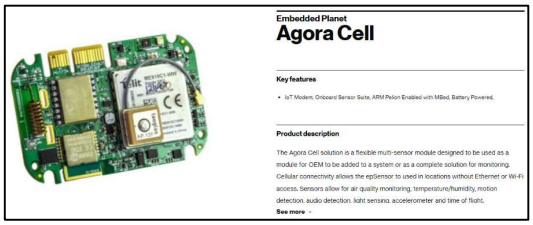
PTCRB: (Agora)
https://www.ptcrb.com/device-details/?model=43504

Manufacturer	Model Name / Number	Device Type	Technologies
Embedded Planet	EPM2M-AG-CELL	Integrated Device	4G, LPWA

AT&T TRENDI: (Agora)
https://marketplace.att.com/certified-devices

Embedded Planet	EP-CHRONOS
	EPM2M-AG-CELL

Verizon ODI: (Agora)
https://opendevelopment.verizonwireless.com/device-showcase/device/10940



Portal Recommendations

Thingsboard is the current nominally recommended portal for setting up & viewing IoT data.

An simple example dashboard instance of Thingsboard using Agora-collected sensor data in real-time can be viewed here: https://demo.thingsboard.io/dashboard/0f3c20a0-3bde-11ec-a0a8-5356543a831d?publicId=62c6b9c0-58f7-11ec-8f43-1d800e6c37b6

For more on Thingsboard please refer to https://thingsboard.io/.

16.2. RoHS Compliance

This device complies with the RoHS (Reduction of Hazardous Substances) directive of the European Union, EU Directive 2011/65/EU.

16.3. Interferance Statement

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:

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

16.4. FCC and ISED Compliance

If the antenna for the Agora device is located farther than 20cm from the human body and there are no adjacent transmitters, the FCC and ISED approvals of the device's Telit ME910C1 cellular module can be reused by the end product.

If the device's antenna is mounted closer than 20cm from the human body, or if there are adjacent transmitters, additional FCC/ISED testing may be required for the end device.

Orderable Device	FCC ID	ISED ID
Telit ME910C1-WW	RI7ME910C1WW	5131A-ME910C1WW
Telit ME910C1-NA	RI7ME910C1NA	5131A-ME910C1NA

16.4.1. FCC and ISED Compliance | FCC Certificate

The FCC ID certificate for the Telit ME910C1-WW/NA can be viewed through the portal in the links below:

ME910C1-WW
https://fcc.report/FCC-ID/RI7ME910C1WW
https://fccid.io/RI7ME910C1WW

ME910C1-NA
https://fcc.report/FCC-ID/RI7ME910C1NA
https://fccid.io/RI7ME910C1NA

16.4.2. FCC and ISED Compliance | ISED Certificate

The ISED ID certificate for Agora is available at the link below:

https://sms-sgs.ic.gc.ca/equipmentSearch/searchRadioEquipments

- **For ME910C1-WW** *(5131A-ME910C1NA)*

Enter "ME910C1-WW" in *the Product Marketing Name (PMN)* field to find the entry for **ME910C1-WW**

- **For ME910C1-NA** *(5131A-ME910C1NA)*

Enter "ME910C1-NA" in *the Product Marketing Name (PMN)* field to find the entry for **ME910C1-NA**

16.5. Wireless Notice

The Agora device complies with FCC/ISED radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines and RSS-102 of the ISED radio frequency (RF) Exposure rules. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. The antenna should be installed and operated with minimum distance of 20 cm between the radiator and your body.

16.6. Antenna Notice: FCC & ISED

The Agora radio transmitter has been approved by the FCC & ISED to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with that device.

TABLE 20 – FCC & ISED MAX GAIN BY BAND

Antenna Gain: 2.14 dBi (Omnidirectional type)		
Band	Max Gain for FCC (dBi): NA	Max Gain for FCC (dBi): WW
FDD 2	9.01	9.0
FDD 4	6.00	8.7
FDD 5	- -	7.1
FDD 12	6.6	6.6
FDD 13	6.9	6.9
FDD 26	- -	7.0

16.7. End-Product Labeling Requirements

The Agora module contains an ME910 module which has an FCC ID label on it pertaining to its FCC certification. Consequently, with Agora used in any host assemblies, the OEM host end product manufacturer must display a label on the exterior of the assembly referring to the enclosed module. The exterior label will read as follows:

For ME910C1-**WW** ("**Worldwide**") models:

> **Device Uses Approved Radio: ME910C1-WW**
> **Contains FCC ID: RI7ME910C1WW**
> **Contains IC: 5131A-ME910C1WW**
>
> **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.**

16.8. FCC Additional Testing, Part 15 Subpart B Disclaimer

The modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed. The end product with an embedded module may also need to pass the FCC Part 15 unintentional emission testing requirements and be properly authorized per FCC Part 15.

17. Revision History

TABLE 21 – REVISION HISTORY

Revision	Author	Description	Date
1.0.0	M. Trowbridge	Initial Release (preliminary)	25 Feb 2022

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