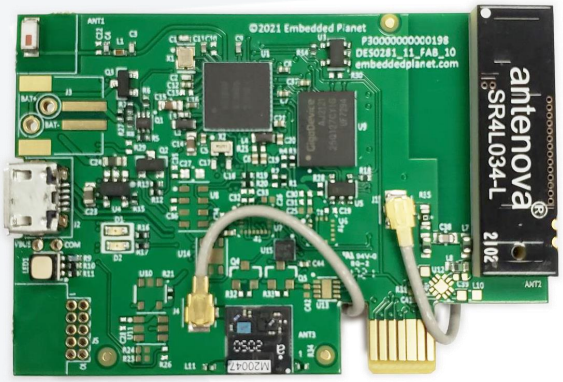
epConnected Asset

4G LTE-M Cellular Modem + GNSS Tracking, Bluetooth, & Sensors

Product User Manual

Embedded Planet Inc. | v1.0.1 | 05 APR 2022



www.embeddedplanet.com

About This Manual

The **epConnected Asset User Manual** provides detailed information encompassing the design, description, and integration of the epConnected Asset 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

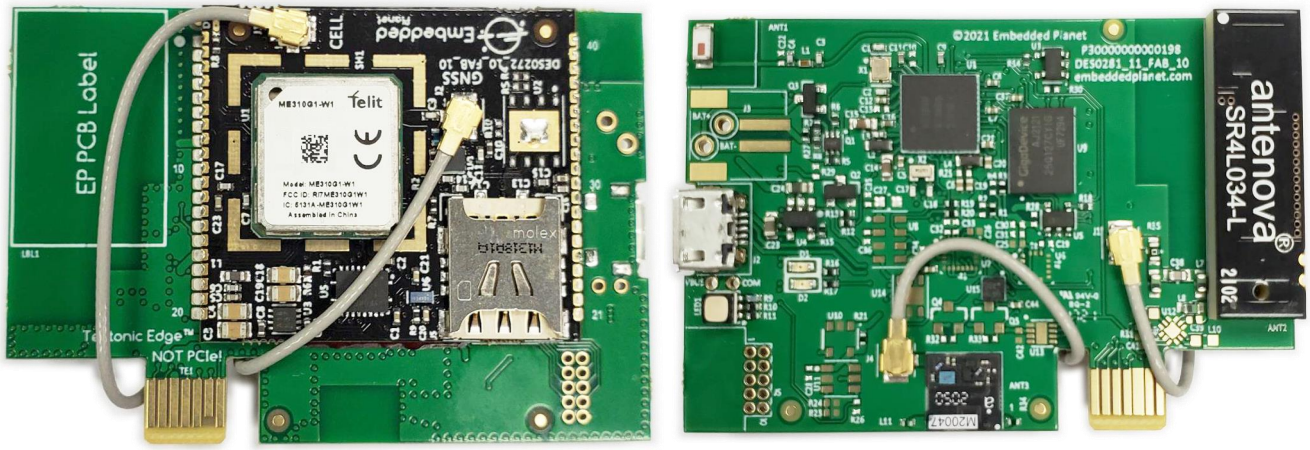
Product Web Page

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

Contents

1. Introduction

The epConnected Asset is a GNSS asset tracker with cellular connectivity designed as part of Embedded Planet's epConnect ecosystem. The epConnected Asset takes advantage of the 4G LTE CAT M1 cellular connection and GNSS capability provided by Embedded Planet's Chronos module. An onboard MCU provides the processing control to leverage the attached Chronos module & on-board sensors. Device sensors include a barometer/altimeter, a 3-axis accelerometer, a 6-axis IMU, and a 9-axis IMU. An ultra-low power timer is present to enable long battery life applications. Rechargeable LiPo battery compatibility is also supported. Acquired data can be stored in the provided on-board flash memory. Data can be transferred over the cellular connection hosted by the Chronos module, through the Bluetooth connection of the MCU, or via USB. A micro-B USB connector is present for battery charging & data transfer. Configuration of the epConnected Asset device can be performed over the Bluetooth connection. An onboard RGB LED is provided for user feedback through the programmed application.



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 shop.embeddedplanet.com.

TABLE 1 – PART NUMBER CONFIGURATOR

Option	Designator	Description
1 Battery Connector	N	None
	J	JST S2B-PH-SM4-TB(LF)(SN)
2 Battery Charger	N	None
	L42	Lithium 4.2V
3 USB Connector	N	None
	B	USB Micro-B
4 Flash Memory	N	None
	16	16MB
5 Inertial Measurement	N	None
	3	3-axis accelerometer
	6	3-axis accelerometer, 3-axis gyroscope
	9	3-axis accelerometer, 3-axis gyroscope, 3-axis magnetometer
6 Barometer	N	None
	M	MPL3115A2
7 Temperature/Humidity	N	None
	S	Si7021-A20
8 Low-power Timer	N	None
	T	TPL5110
9 GNSS	N	None
	G	GNSS
10 Cellular	N	None
	M1	4G LTE CAT M1

An example configuration for the epConnected Asset device is 281B-**NL42B163NNNGM1** as shown above. For ordering, please refer to the details on the Embedded Planet shop website for confirmation on configuration specifics: https://shop.embeddedplanet.com

3. Additional Resources

- Chronos module:
  https://www.embeddedplanet.com/chronos
- epConnected Asset:
  https://www.embeddedplanet.com/connected-asset
- Embedded Planet Documentation:
  https://www.embeddedplanet.com/product-documentation

4. Feature Callouts

4.1. Feature Callouts | Connectors / Interfaces

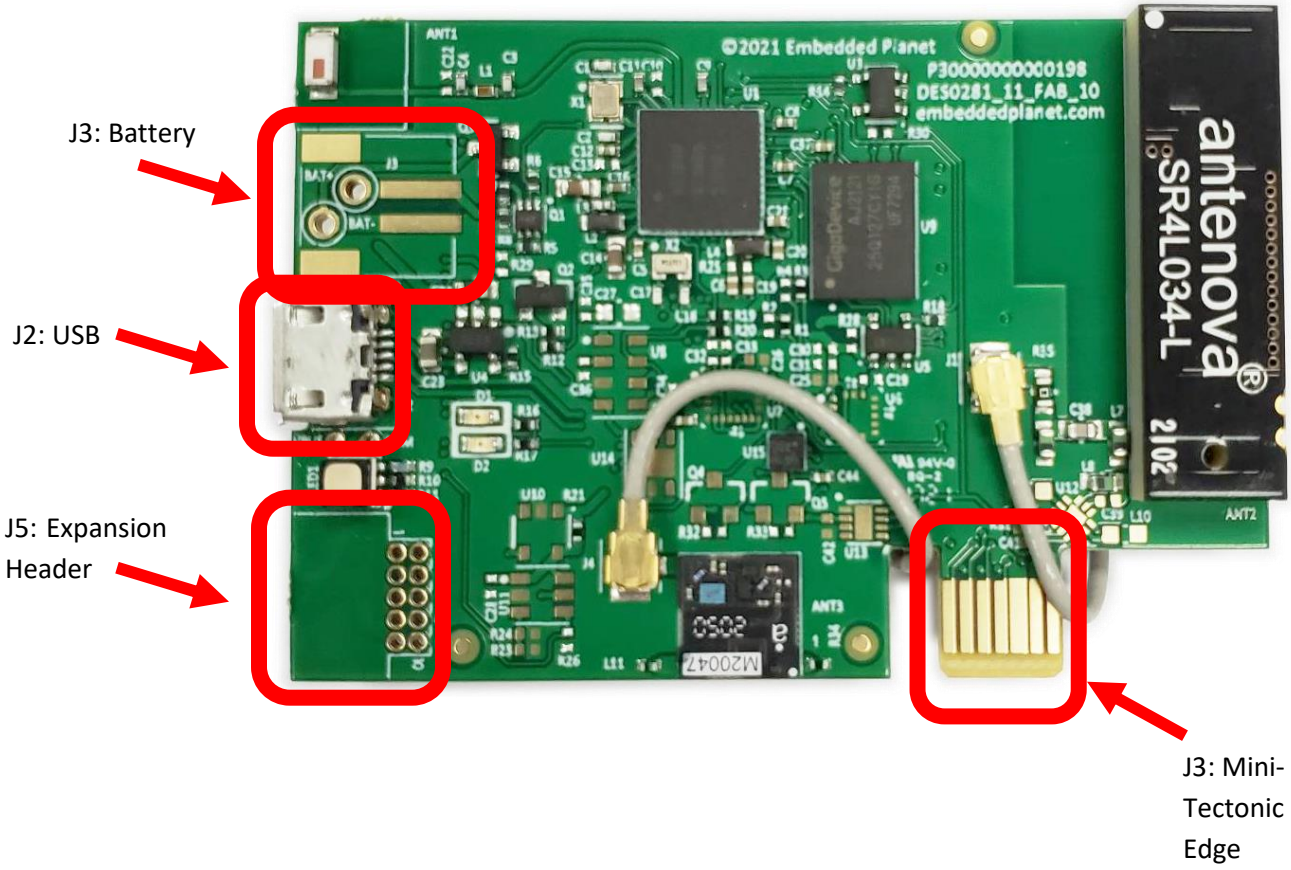


TABLE 2 - BOARD CONNECTORS

Category	Reference Designator	Component Type	Description / Purpose
Connector	J3	JST / Battery	For use with external LiPo battery
Connector	J2	Micro-USB	Battery charging and data transfer
Connector	J5	Expansion Header	SPI, GPIO, 3.0V I/O ref, battery voltage
Connector	Mini-Tectonic Edge™	Board Edge / Finger	Mini-Tectonic Edge™ for programming

4.2. Feature Callouts | Key Board Components (Top)

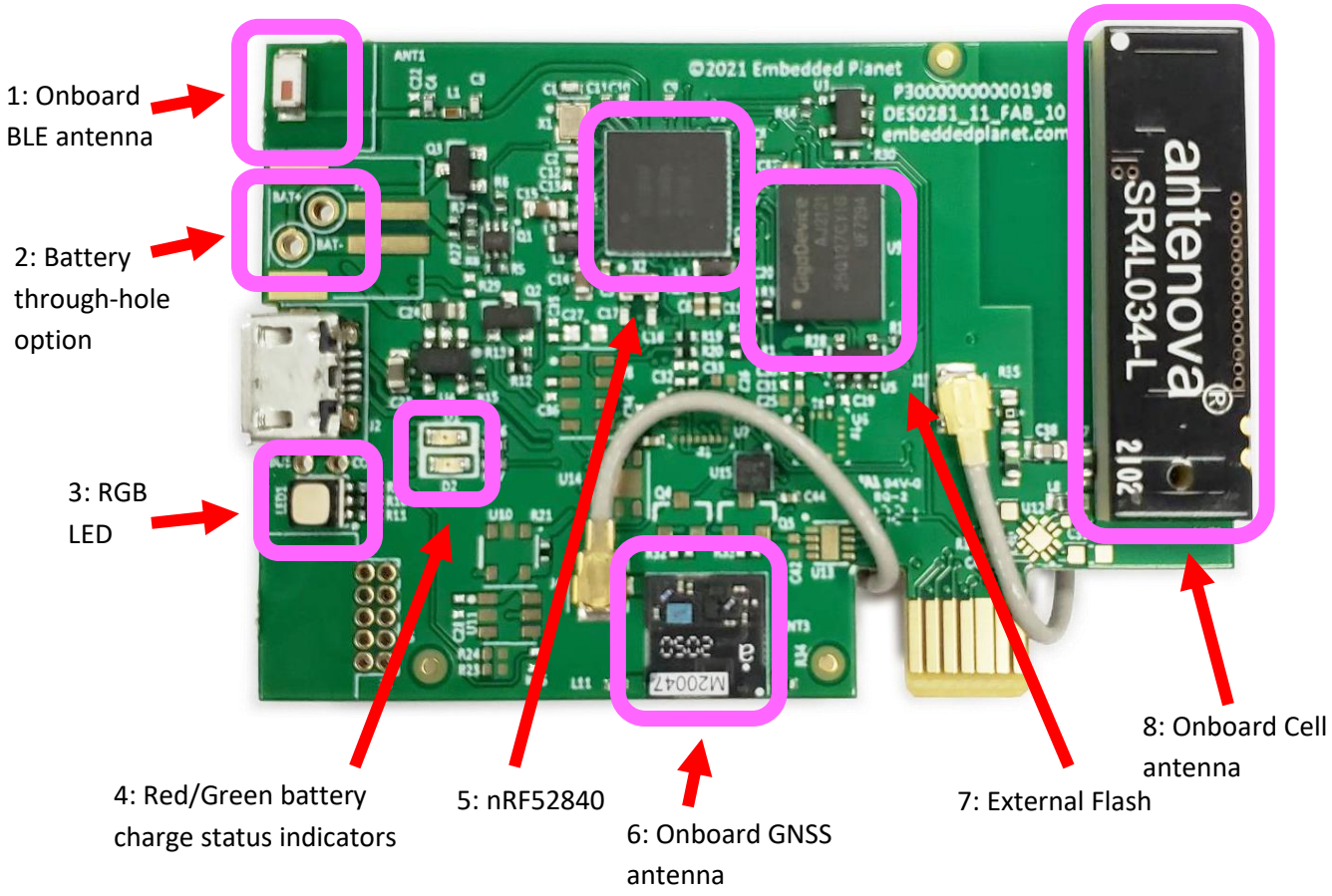


TABLE 3 – KEY BOARD COMPONENTS

Category	Reference	Component Type	Description / Purpose
Antenna	1	BLE antenna	BLE connectivity for the nRF52840
Power	2	Battery through-holes	Alternate option to the JST connector
LED	3	RGB LED	Useful as a status indicator or for debug
LED	4	Red/Green LEDs	Indicate battery charging status
MCU	5	nRF52840	Main processor that controls the system
Antenna	6	GNSS antenna	Onboard option for GNSS antenna
Flash	7	External NOR Flash	Dedicated flash memory for nRF52840
Antenna	8	Cellular antenna	Onboard option for Cell antenna

4.3. Feature Callouts | Key Board Components (Bottom)

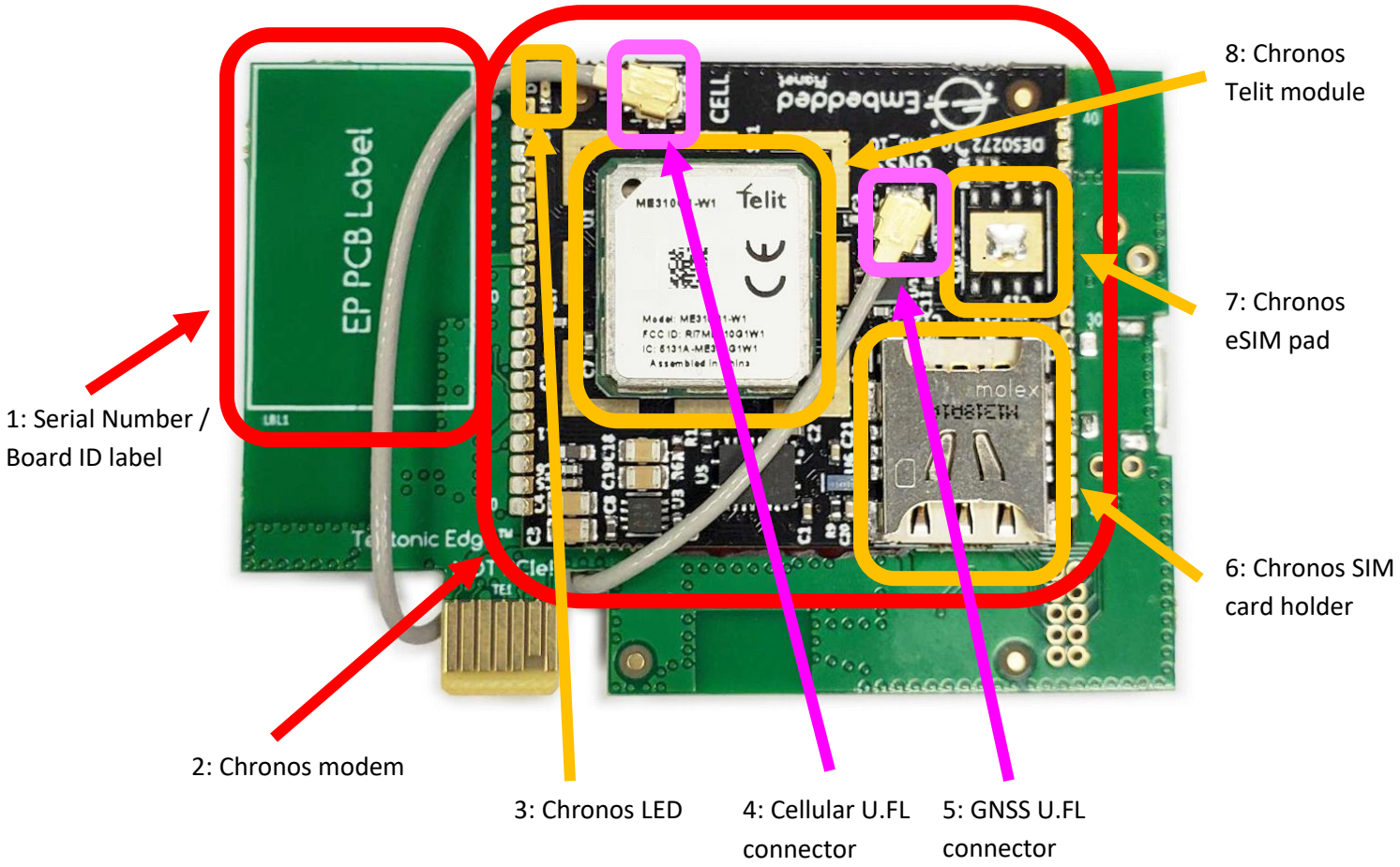
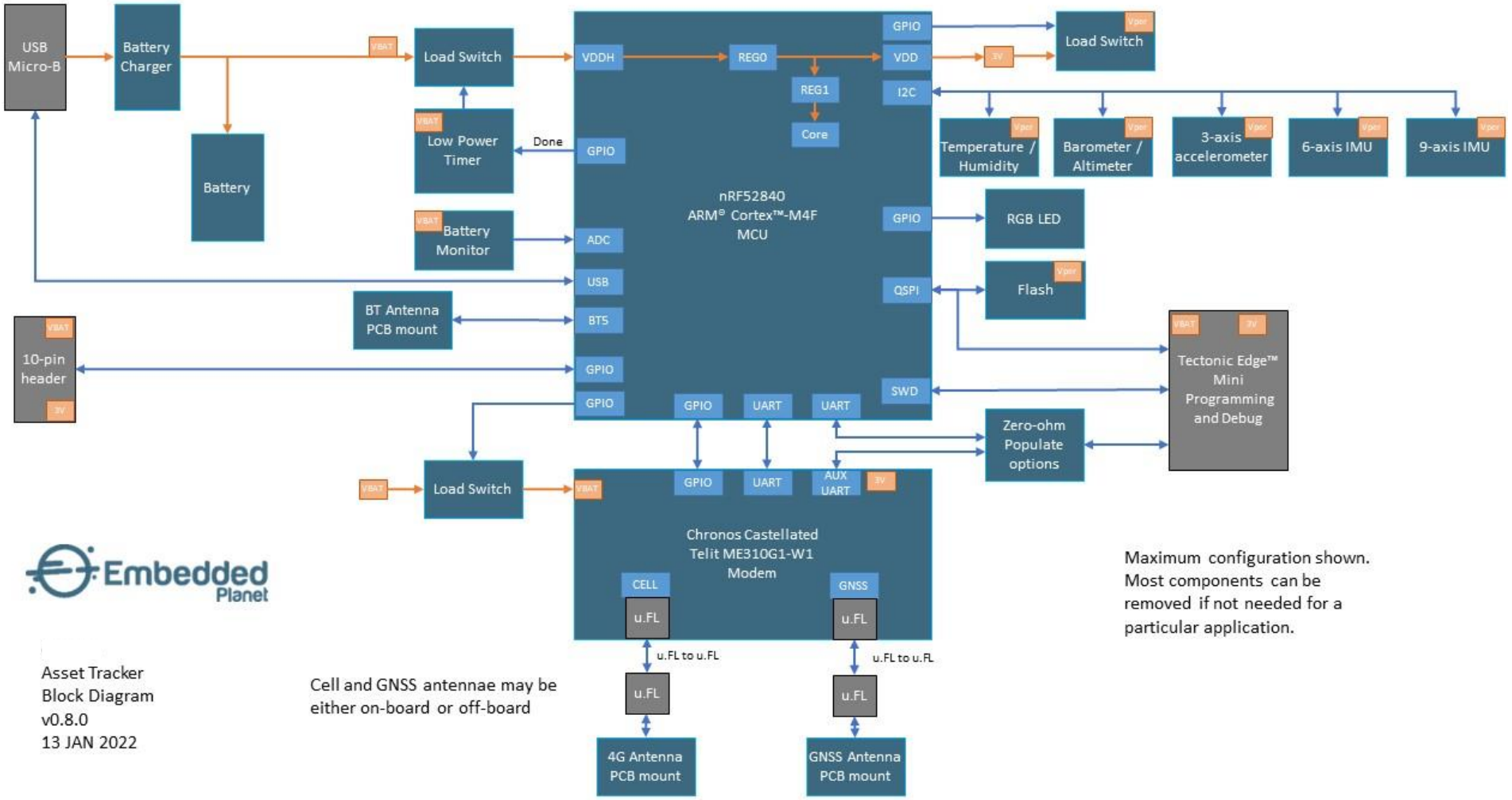


TABLE 4 – KEY BOARD COMPONENTS (BOTTOM)

Category	Reference	Component Type	Description / Purpose
Label	1	Label	Serialization & board identification
Modem	2	Chronos modem module	Cellular/GNSS connectivity modem
LED	3	Red LED	Status/debug indication
SIM	4	Nano-SIM	SIM usage (default)
SIM	5	eSIM (embedded SIM)	SIM usage (optional)
Cell module	6	Telit cellular module	Cellular/GNSS connectivity

5. Block Diagram



6. Device Specifications

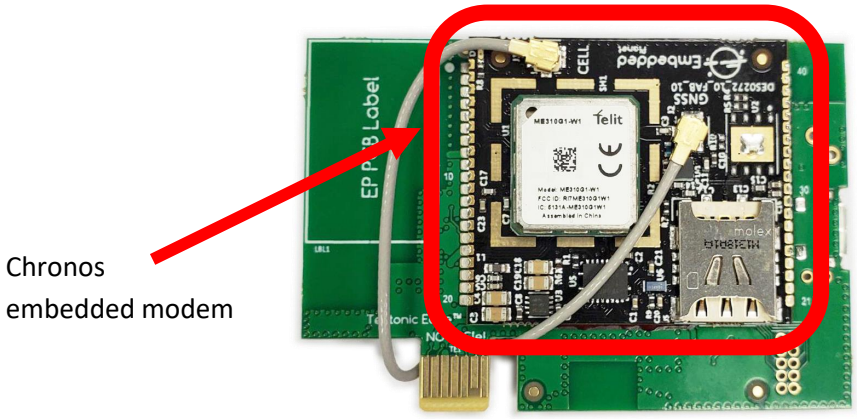
TABLE 5 – DEVICE SPECIFICATIONS

Feature/Specification	Description
Cellular Capabilities	**Cellular Technologies**: LTE-M (LTE CAT M1) **SMS**: over NAS **Lower power modes**: PSM, eDRX **Operating Frequencies**: 699MHz to 1980MHz **Cellular Operating Mode**: Half-duplex FDD **RF Output Power:** Up to +20dBm (Power Class 5)
Internet Protocols	IPv4/IPv6 stack with TCP and UDP protocols TLDS/DTLS
LTE CAT M1 Specification	**Bands**: B1, B2, B3, B4, B5, B8, B12, B13, B18, B19, B20, B25, B26, B27, B28, B66, B71, B85 **RX Sensitivity CAT M1**: -102.2 to -107.5 dBm depending on band **Uplink**: up to 1Mbps **Downlink**: up to 588kbps
SIM	**Removable**: 4FF (nano) SIM card slot **Soldered down**: MFF2 **Internal**: Telit simWISE™
Cellular Certifications	**PTCRB**: Complete (Chronos) **AT&T**: Complete (Chronos) **Verizon**: Complete (Chronos)
GNSS Specifications	**Constellations**: GPS, GLONASS, BeiDou, Galileo, QZSS **Tracking Sensitivity**: -159dBm **Navigation Sensitivity**: -155dBm **Cold Start Sensitivity**: -144dBm
Power Supply	**For battery charging:** 3.75Vdc to 5.5Vdc into J2 (USB connector) **For device operation:** 3.2Vdc-4.2Vdc into J3 (JST battery connector/through-holes) 3.7Vdc nominal
Dimensions	**Fully populated board:** 46.4mm x 38.4mm x 12.67mm (1.83in x 1.51in x 0.50in)
Environmental	**Operating Temperature Range**: -40°C to +85°C **Storage Temperature Range**: -40°C to +85°C **Humidity Range**: 20% RH to 90% RH

7. Chronos Module

Chronos is Embedded Planet's custom 4G LTE CAT M1 embedded cellular modem. The epConnected Asset device leverages the abilities of Chronos for its cellular and GNSS connectivity. In the default configuration of the epConnected Asset board Chronos is already included as a board-mounted component. Details for Chronos itself can be found here: https://www.embeddedplanet.com/product-documentation/#chronos

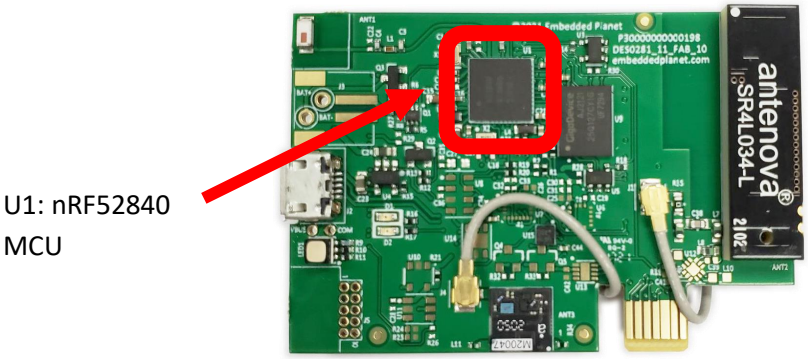
Chronos provides two U.FL connectors; one for a cellular antenna and one for a GNSS antenna. Both of these connectors are routed to the epConnected Asset board through U.FL-to-U.FL cables. Section 15 (*Antennae*) goes into further detail on these connections.



8. MCU

The MCU on the epConnected Asset is Nordic's nRF52840 (U1). Details of this MCU can be found here: https://www.nordicsemi.com/Products/Low-power-short-range-wireless/nRF52840

The nRF52840 is used to control power to the on-board sensors and to Chronos using GPIO. The sensors are connected to the nRF52840 on the I^2C bus. The Chronos module is connected to the nRF52840 via UART and GPIO. The ultra-low power timer's *DONE* pin is controlled by GPIO, allowing the nRF52840 to stay on for an arbitrary amount of time once the timer has applied power to the nRF52840. The external flash memory is connected to the nRF52840's QSPI peripheral. The battery monitor is connected to an ADC channel on the nRF52840. For the MCU pinout, refer the section of this report titled, "*MCU Pinout*" under "*Pinouts*".



9. Sensors

The epConnected Asset board is designed to accommodate up to 5 onboard sensors. The following are available:

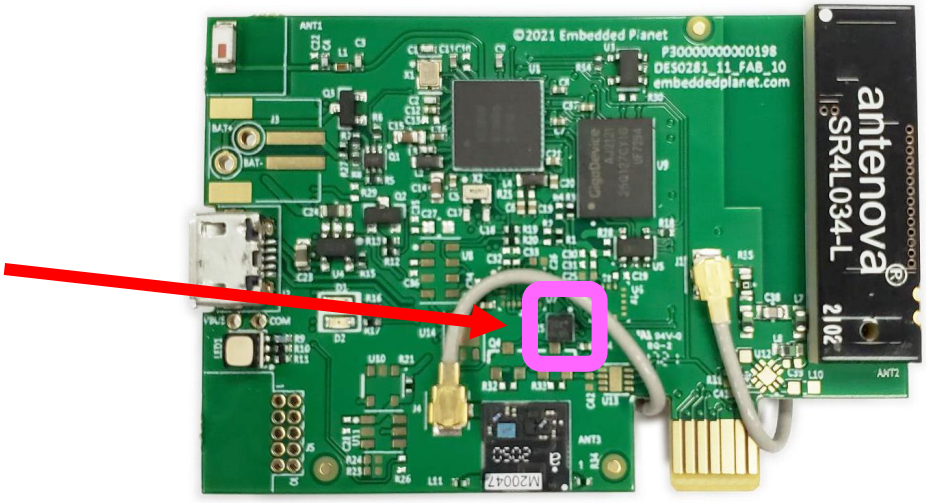
- 3-Axis Accelerometer (U15)
- 6-Axis IMU (U6)
- 9-Axis IMU (U7)
- Barometer/Altimeter (U8)
- Temperature & Humidity (U14)

9.1. Sensors | 3-Axis Accelerometer (U15)

The onboard 3-axis accelerometer option is the Memsic MC3479. This device accommodates an I^2C operating frequency of up to 1MHz. The I^2C address is 1001100b (0x4C). The accelerometer has programmable full-scale ranges of ±2g, ±4g, ±8g, ±12g and ±16g. The accelerometer has a 16-bit ADC, and the internal sample rate can be set from 0.5Hz to 1kHz. The ADC readings are presented in signed 2's complement with the MSB as the sign.

More on this device can be found at http://www.memsic.com/en/product/info.aspx?lcid=49&itemid=389#item389.

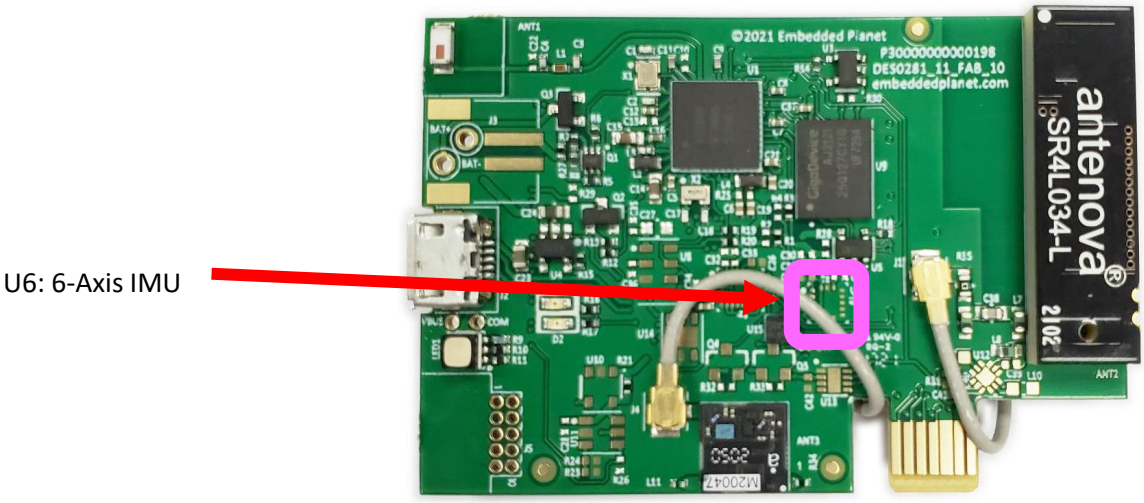
U15: 3-Axis Accelerometer



9.2. Sensors | 6-Axis IMU (U6)

The onboard 6-axis IMU option is the TDK InvenSense ICM-20602. This device is comprised of a 3-axis accelerometer function and a 3-axis gyroscope function. The device provides an I^2C operating frequency of 100kHz in standard mode and up to 400kHz in fast mode. The I^2C address is 1101000b (0x68).

More on this device can be found at https://invensense.tdk.com/products/motion-tracking/6-axis/icm-20602/



9.2.1. U6 | 3-Axis Accelerometer

Each axis has a separate proof mass. The accelerometers are factory-calibrated and nominally independent of supply voltage. The MEMS accelerometer has programmable full-scale ranges of ±2g, ±4g, ±8g and ±16g. A wake-on-motion interrupt, user programmable interrupts, and self-test features are all available. The accelerometer has a 16-bit ADC that provides output in 2's complement format. The ADC sample rate is programmable from 3.9Hz to 4kHz.

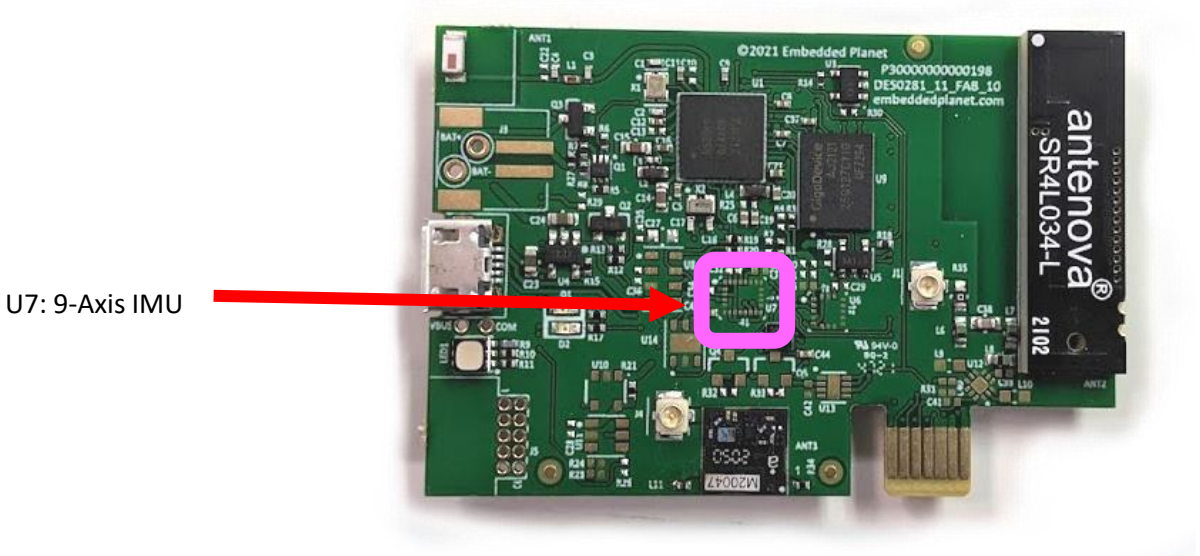
9.2.2. U6 | 3-Axis Gyroscope

Each axis has a separate independent vibratory MEMS rate gyroscope. The output of each gyroscope is amplified, demodulated, and filtered to produce a voltage that is proportional to the angular rate. The MEMS gyroscope has programmable full-scale ranges of ±250dps, ±500dps, ±1000dps, and ±2000dps. The gyroscope has a 16-bit ADC word length, and the ADC sample rate is programmable from 3.9Hz to 8kHz. User-selectable low-pass filters enable a wide variety of cut-off frequencies.

9.3. Sensors | 9-Axis IMU (U7)

The onboard 9-axis IMU option is the ST LSM9DS1. This device is comprised of a 3-axis accelerometer function, a 3-axis gyroscope function, and a 3-axis magnetometer function. The device provides an I^2C operating frequency of 100kHz in standard mode and up to 400kHz in fast mode. The I^2C addresses are 1101010b (0x6A) for the accelerometer and gyroscope and 0011011b (0x1B) for the magnetometer.

More on this device can be found at https://www.st.com/en/mems-and-sensors/lsm9ds1.html



**Shown without U.FL cables connected for visual reference only. The device must have its U.FL cables connected.*

9.3.1. U7 | 3-Axis Accelerometer

The MEMS accelerometer has the following specifications:

- Programmable full-scale ranges of ±2g, ±4g, ±8g and ±16g
- 16-bit ADC word length
- Programmable ADC sample rate from 14.9Hz to 952Hz

9.3.2. U7 | 3-Axis Gyroscope

The MEMS gyroscope has the following specifications:

- Programmable full-scale ranges of ±245dps, ±500dps and ±2000dps
- 16-bit ADC word length
- Programmable ADC sample rate from 14.9Hz to 952Hz

9.3.3. U7 | 3-Axis Magnetometer

The magnetometer has the following specifications:

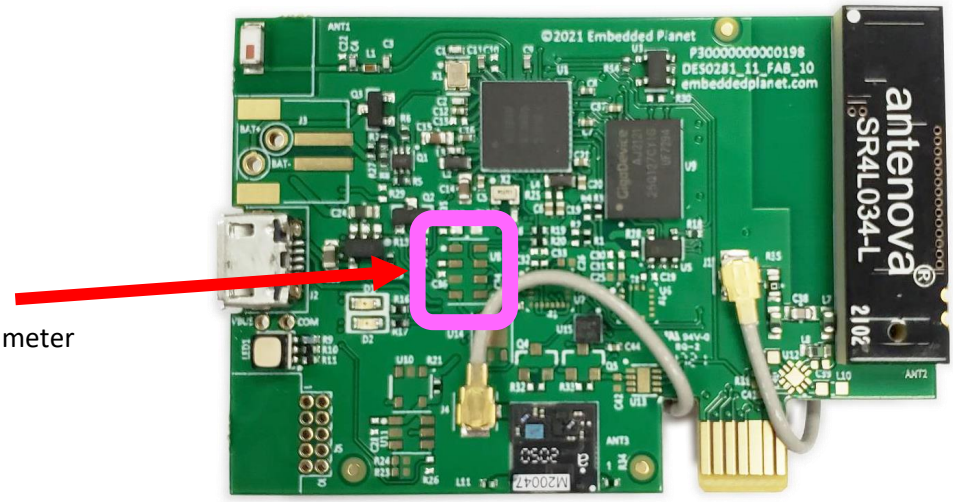
- programmable full-scale ranges of ±4gauss, ±8gauss, ±12gauss and ±16gauss
- 16-bit ADC word length
- ADC sample rate is programmable from 14.9Hz to 952Hz

9.4. Sensors | Barometer / Altimeter (U8)

The onboard barometer/altimeter option is provided by the NXP MPL3115A2. This device accommodates an I^2C operating frequency of up to 400kHz in fast mode. The I^2C address is 1100000b (0x60).

More on this device can be found at:
https://www.nxp.com/products/sensors/pressure-sensors/barometric-pressure-15-to-115-kpa/20-to-110-kpa-absolute-digital-pressure-sensor:MPL3115A2

U8: Barometer / Altimeter



9.4.1. U8 | Barometer

In barometer mode, the absolute pressure sensor measures external pressure relative to a zero-pressure reference (vacuum) sealed inside the reference chamber of the die during manufacturing. Absolute pressure is reported as 20-bit unsigned data in Pascals and fractions of a Pascal. The value is represented in Q18.2 fixed-point format: 18 integer bits and 2 fractional bits. 1LSB = 0.25Pa.

9.4.2. U8 | Altimeter

In altimeter mode all pressure data is converted to equivalent altitude based on the US Standard Atmosphere 1976 (NASA). The altitude is calculated from the pressure using the following equation:

$$h = 44330.77\left\{1 - \left(\frac{p}{p_o}\right)^{0.1902632}\right\} + OFF\_H(register\ value)$$

where:

h = altitude in meters
p = pressure reading
p0 = sea level pressure (101,325 Pascals)
OFF_H(Register value) = user supplied equivalent sea level pressure to compensate for local weather conditions

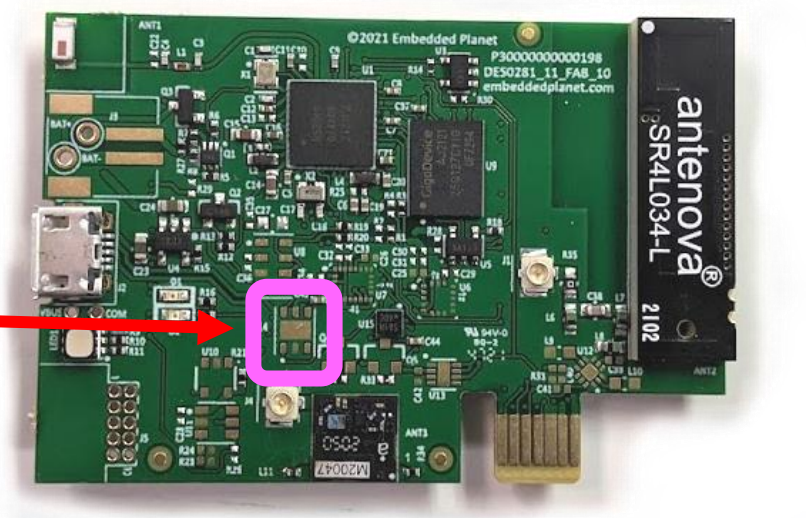
Altitude data is stored as 20-bit 2's complement values in meters and fractions of a meter. The value is represented in Q16.4 fixed-point format; 16 integer bits and 4 fractional bits. 1LSB = 0.0625m.

9.5. Sensors | Temperature & Humidity (U14)

The onboard temperature & humidity option is provided by the Silicon Labs Si7021-A20. This device accommodates an I^2C operating frequency of up to 400kHz in fast mode. The I^2C address is 1000000b (0x40).

More on this device can be found at:
https://www.silabs.com/sensors/humidity/si7006-13-20-21-34/device.si7021-a20-gm

U14: Temperature & Humidity



**Shown without U.FL cables connected for visual reference only. The device must have its U.FL cables connected.*

9.5.1. U14 | Temperature

The operating range of the temperature sensor is -40°C to +85°C. The typical accuracy is 0.3°C in the -10°C to +85°C range, and up to 0.9°C outside that range. Once a temperature measurement has been made the results may be converted to [°C] by using the following expression:

$$\text{Temperature (°C)} = \frac{175.72 * \text{Temp\_Code}}{65536} - 46.85$$

Where the variable *Temp_Code* is the 16-bit word returned by the Si7021.

9.5.2. U14 | Humidity

The operating range of the humidity sensor is 0-100% relative humidity, non-condensing. The typical accuracy is 2% in the 0-80% RH range, and 3% in the 80-100%RH range. Once a relative humidity measurement has been made, the results may be converted to percent relative humidity (%RH) by using the following expression:

$$\%RH = \frac{125 * \text{RH\_Code}}{65536} - 6$$

where the variable *RH_Code* is the 16-bit word returned by the Si7021.

Due to normal variations in RH accuracy of the device, it is possible for the measured value of %RH to be slightly less than 0 when the actual RH level is close to or equal to 0. Similarly, the measured value of %RH may be slightly greater than 100 when the actual RH level is close to or equal to 100. This is expected behavior, and it is acceptable to limit the range of RH results to 0 to 100%RH in the host software by truncating values that are slightly outside of this range.

10. Indicators

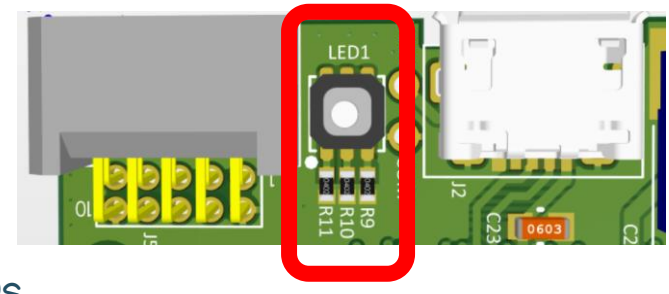
The epConnected Asset device contains two indicator elements. While the primary intended purpose for the device as a whole is to leverage the wireless capabilities for asset tracking, the indicators can provide a form of visual status feedback to the operator or simply be used to streamline application development. The indicator elements for the epConnected Asset include an RGB LED with individually controllable channels and a pair of red/green single-color LEDs to indicate battery charge status.

10.1. Indicators | RGB LED

An RGB LED (LED1) is provided on-board for user feedback. This RGB LED is under the control of the MCU (nRF52840) and can be configured according to the programmed application.

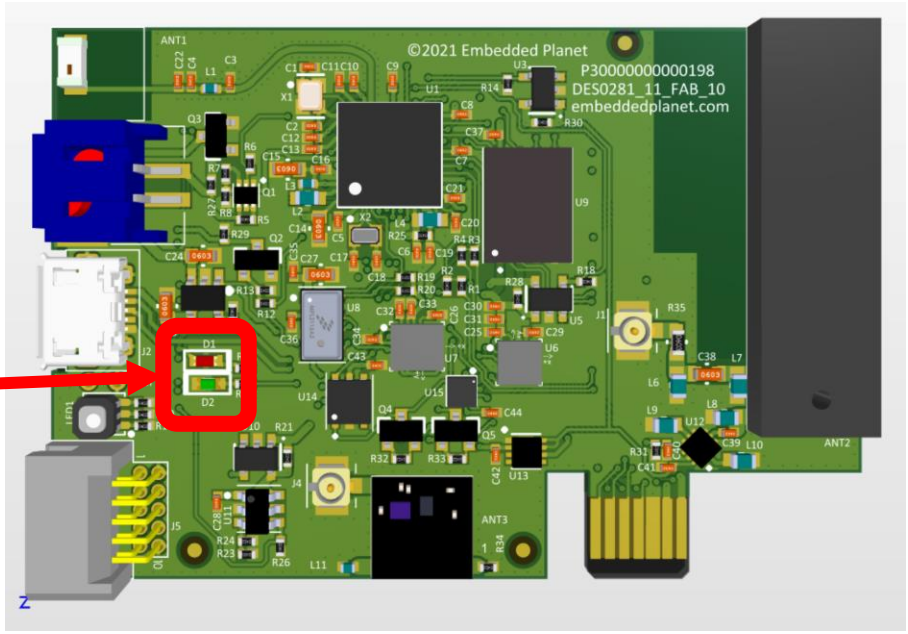
TABLE 6 – RGB LED PIN DETAILS

Color	Pin	Name	Resistor
Red	N1	P0.08	R9
Green	U1	P0.12	R10
Blue	R1	P1.09	R11



10.2. Indicators | Battery Status LEDs

The epConnected Asset device comes with an onboard battery charge manager for LiPo batteries. LEDs D1 and D2, positioned on the board as a parallel pair, are used as battery charger status indicators. Active-red (D1) means the battery is charging; active-green (D2) means the battery charge activity is complete. These LEDs are directly controlled by the battery charge manager and are not user programmable.

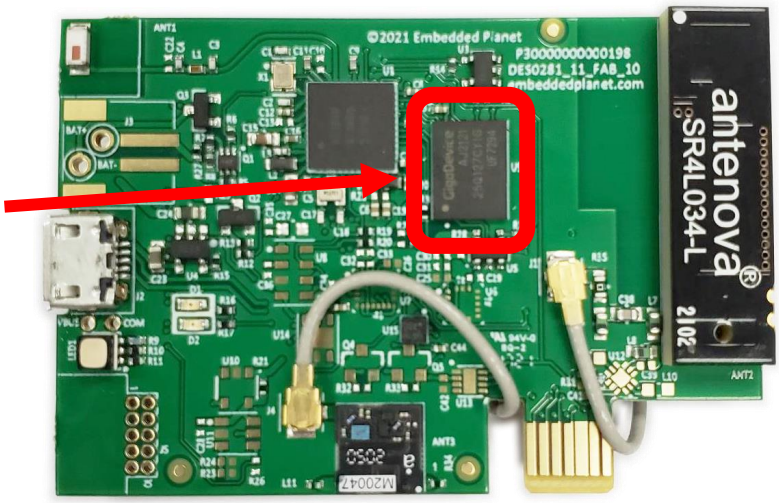


11. Memory

An external flash memory component (U9) is provided for data logging and other uses that require non-volatile memory. The package is in the standard 8x6mm format. The device used is GigaDevice GD25Q127CYIG NOR flash.

More information on this component can be found here: https://www.gigadevice.com/datasheet/gd25q127c/

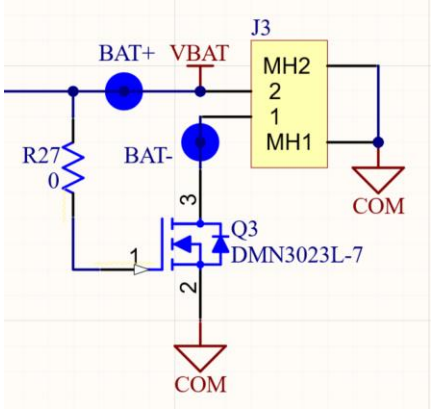
U9: Flash memory



12. Power

12.1. Power | Battery

The epConnected Asset device is designed to operate while powered from a battery connected to JST connector J3. The battery must be a secondary, 1SxP lithium battery. A 3.7V nominal lithium-ion or lithium-polymer battery is the suggested battery choice for the epConnected Asset. The battery should be chosen with the consideration that the minimum required voltage is 3.2V and the charge termination voltage is 4.2V. The capacity of the battery may vary based on the needs of the end application. The battery charger has a charge current limit of 500mA which should be taken into consideration when the capacity and maximum allowable charge current of the battery are determined. Reverse polarity protection for battery connection is provided by N-MOS component Q3. If a battery is not available, the operator may apply a DC voltage (such as from a bench power supply) within the battery operating voltage range specification (nominally 3.7V).



12.2. Power | Battery Charging

The epConnected Asset device includes a battery charger capable of charging lithium batteries in the 1SxP configuration. The designated charge manager for this role is the Microchip MCP73831 (U4). The input voltage range for the battery charger U4 is 3.75Vdc to 5.5Vdc. This voltage comes in from USB connector J2 and/or the alternate through-holes next to it (see the "Power | USB Connector" section for more detail). For the epConnected Asset device the charge current limit is set to 500mA, and the charge termination voltage is set to 4.2V. The epConnected Asset device is designed to run off battery power; the USB connector is for battery charging while the JST connector is for powering the device during operation. More on the Microchip MCP73831 can be found at https://www.microchip.com/en-us/product/MCP73831

U4: Battery charge manager

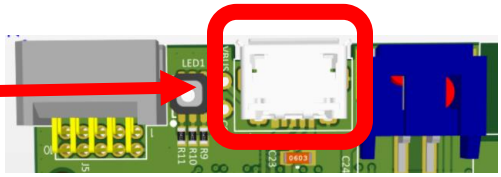
12.3. Power | Battery Monitor

The epConnected Asset includes a battery voltage monitor that is connected to an ADC input (AIN0) on the nRF52840. This allows the system to monitor the battery voltage and react to battery voltage levels and/or changes. The low-power monitor circuit (DMC2400UV, Q1) is enabled by setting P1.11 high, while the battery voltage (VBAT) is scaled to 50% and connected to AIN0.

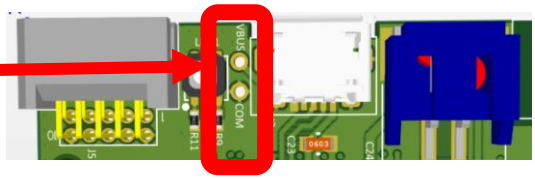
12.4. Power | USB Connector

A standard micro-B USB connector (J2) is used for battery charging (using standard USB 5V) and data transfer. Two through-hole connections are provided for the charger input if the USB connector is not required or desired.

J2 USB connector for battery charging & data transfer

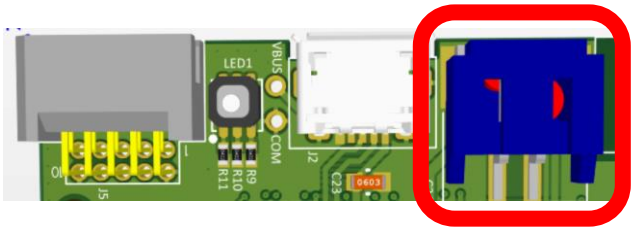


J2 through-hole connections for battery charging



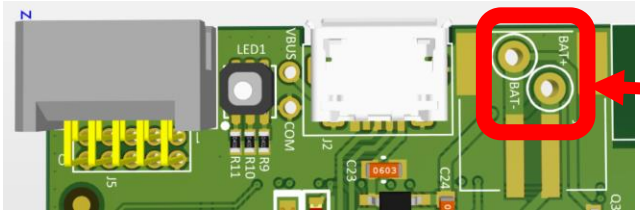
12.5. Power | Battery Connector

A 2-pin JST S2B-PH-SM4-TB connector (J3) is used for a LiPo battery connection. The connection is wired with pin 2 (VBAT) positive, and pin-1 (COM) negative to mate with LiPo batteries terminated with standard JST female connectors.



J3 JST battery connector for device operation

As an alternate option to the JST connector there are two through-hole pads available for connecting a battery voltage. These pads are labeled, “BAT+” & “BAT-“ to reflect their connection to the positive and negative terminals of the battery.



J3 through-hole connections for device operation

12.6. Power | nRF52840 Power Control

In the case where the ultra-low power timer is populated (U11: TPL5110), the timer controls power to the MCU via a load switch. This ensures the lowest possible idle state power consumption. The nRF52840 remains on for a long as is needed to perform the actions required. When all tasks are complete, the nRF52840 indicates to the timer that it is DONE and the timer resets. The timer can also be configured in timer mode with the timing set by the resistors on the Delay/M_DRV pin. Overall battery life can be maximized by using the nRF52840 timer control to power the MCU only while it is needed.

- The “*DONE”* pin on the nRF52840 is L1 (P0.06)
- The *“DONE*” signal is recognized by the TPL5110 as a low-to-high logic transition

12.7. Power | Sensor Power Control

The nRF52840 controls power to the sensors via a load switch (U5: AP22802AW5-7). This provides maximum flexibility for balancing power consumption and data acquisition requirements to address as many applications as possible. Overall battery life can be maximized by using the *sensor power enable* to turn off power to the sensors & peripheral devices while not needed.

- The *sensor power enable* pin on the nRF52840 is A8 (P0.31)
- The *sensor power enable* signal is active-high

Peripheral onboard components collectively powered by the sensor power enable signal:

- U15 (3-axis accelerometer)
- U6 (6-axis IMU)
- U7 (9-axis IMU)
- U8 (Barometer/Altimeter)
- U9 (Flash memory)
- U14 (Temperature/Humidity)

12.8. Power | Chronos Power Control

The nRF52840 controls power to Chronos via a load switch (U3: AP22802AW5-7). This provides maximum flexibility for balancing power consumption and data transmission requirements to address as many applications as possible. Overall battery life can be maximized by using the *Chronos power enable* to turn off power to the Chronos module while not needed.

- The *Chronos power enable* pin on the nRF52840 is B11 (P0.28)
- The *Chronos power enable* signal is active-high

12.9. Power | Power Tree

The nRF52840 MCU, Chronos, and timer device receive their power directly from the battery (VBAT). REG0 of the nRF52840 is set for DC/DC configuration to ensure the most efficient use of the available energy in the battery. The output of REG0 is set for 3.0V and is used to power the external sensors and flash while enabled by sensor power load switch U5. This also means that the I/O reference voltage on the nRF52840 is 3.0V. REG0 can supply up to a collective 25mA to these components when the nRF52840's radio is off or transmitting at +4dB or less. REG1 of the nRF52840 is also set to DC/DC configuration. The output of REG1 powers the nRF52840 and is not available to power external components.

13. Programming, Debugging, & Development

The epConnected Asset provides SWD interface for programming & debug through a Mini-Tectonic Edge™ connector (TE1). Tectonic Edge™ is a programming and debug board-to-board connection method used among Embedded Planet devices for connectivity & development ease-of-use.

The recommended programming and debug tool for the epConnected Asset device is the Flidor 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 Asset board).

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

Available documentation on programming the epConnected Asset device (including example software) can be found at https://www.embeddedplanet.com/product-documentation/#connected-asset

14. Pinouts

14.1. MCU Pinout

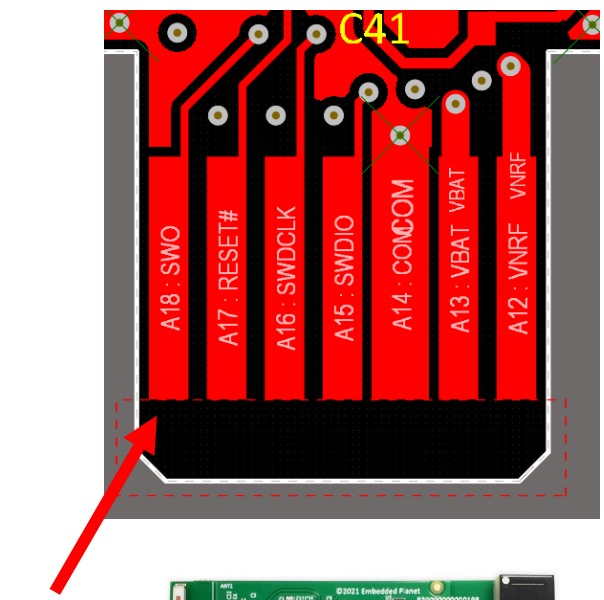
TABLE 7 – MCU PINOUT

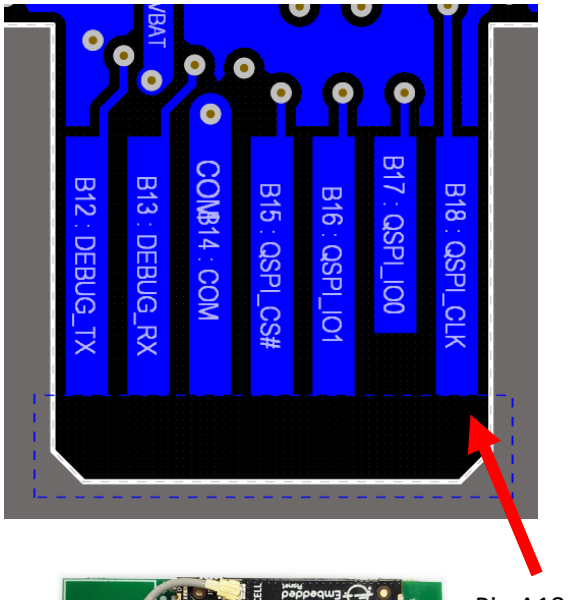
Pin	Pin name	Net Name	Direction	Notes
C1	DEC1	none	n/a	Bypass capacitor
D2	P0.00/XL1	none	n/a	32.768kHz crystal
F2	P0.01/XL2	none	n/a	32.768kHz crystal
G1	P0.26	SDA	I/O	I^2C
H2	P0.27	SCL	O	I^2C
J1	P0.04/AIN2	INT_ACCEL2	I	Interrupt 2 from 3-axis accel or 9-axis IMU
K2	P0.05/AIN3	none	n/a	not connected
L1	P0.06	DONE	O	0 = timer and MCU running, 1 = DONE, reset timer
M2	P0.07	INT_ALT1	I	Interrupt 1 from altimeter
N1	P0.08	LED_RED	O	0 = off, 1 = on
P2	P1.08	CELL_CTS	I	Cell modem UART
R1	P1.09	LED_BLU	O	0 = off, 1 = on
T2	P0.11	INT_ALT2	I	Interrupt 2 from altimeter
U1	P0.12	LED_GRN	O	0 = off, 1 = on
W1	VDD	VNRF	Power	Output of nRF52840 REG0. Default = 1.8V. SW should set to 3.0V to run peripherals.
AB2	DCCH	none	Power	
Y2	VDDH	VMCU	Power	5V maximum
AC5	DECUSB	none	n/a	Bypass capacitor
AD2	VBUS	VBUS	I	USB power detection
AD4	D-	USB_D_N	I/O	USB data negative
AD6	D+	USB_D_P	I/O	USB data positive
AD8	P0.13	DEBUG/AUX_TX	O	Debug UART
AC9	P0.14	CELL_RTS	O	Cell modem UART
AD10	P0.15	CELL_PWRMON	I	0 = cell modem off, 1 = cell modem on
AC11	P0.16	DEBUG/AUX_RX	I	Debug UART
AD12	P0.17	QSPI_CS#	O	QPSI flash
AC13	P0.18/RESET	RESET#	I	Active low reset (internally pulled up)
Pin	Pin name	Net Name	Direction	Notes
AD14	VDD	VNRF	Power	Output of nRF52840 REG0. Default = 1.8V. SW should set to 3.0V to run peripherals.
AC15	P0.19	QSPI_CLK	O	QPSI flash
AD16	P0.20	QSPI_IO0	I/O	QPSI flash
AC17	P0.21	QSPI_IO1	I/O	QPSI flash
AD18	P0.22	QSPI_IO2	I/O	QPSI flash
AC19	P0.23	QSPI_IO3	I/O	QPSI flash
AD20	P0.24	CELL_LED	I	Cell modem LED monitor. 0 = off, 1 = on
AC2	P0.25	none	n/a	not connected
AD22	P1.00	SWO	O	Single Wire Debug

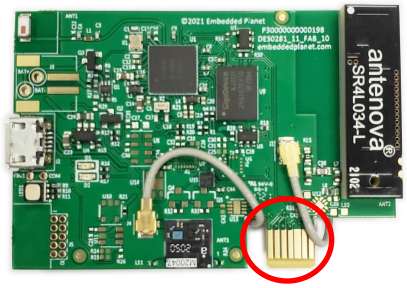
AD23	VDD	VNRF	Power	Output of nRF52840 REG0. Default = 1.8V. SW should set to 3.0V to run peripherals.
AA24	SWDCLK	SWDCLK	I	Single Wire Debug
AC24	SWDIO	SWDIO	I/O	Single Wire Debug
Y23	P1.01	CELL_RX	I	Cell modem UART
W24	P1.02	CELL_TX	O	Cell modem UART
V23	P1.03	CELL_RING	I	Cell modem RING output
U24	P1.04	CELL_DTR	O	Cell modem UART (not always needed)
T23	P1.05	INT_ACCEL1	I	Interrupt 1 from 3-axis accel, 6-axis IMU or 9-axis IMU
R24	P1.06	none	n/a	not connected
P23	P1.07	none	n/a	not connected
N24	DEC5	none	Power	Bypass capacitor
L24	P0.09/NFC1	none	n/a	not connected
J24	P0.10/NFC2	none	n/a	not connected
F23	VSS_PA	COM	n/a	Board common
H23	ANT	none	I/O	Bluetooth antenna
E24	DEC6	DEC4_6	Power	Bypass capacitor
D23	DEC3	none	Power	Bypass capacitor
B24	XC1	none	n/a	32MHz crystal
A23	XC2	none	n/a	32MHz crystal
A22	VDD	VNRF	Power	Bypass capacitor
A20	P1.10	P1.10	I/O	J5, pin 7
B19	P1.11	BAT_MON_EN	O	Turn on battery voltage monitor. 0 = off, 1 = on
Pin	Pin name	Net Name	Direction	Notes
A18	DEC2	none	Power	Bypass capacitor
B17	P1.12	P1.12	I/O	J5, pin 5
A16	P1.13	P1.13	I/O	J5, pin 4
B15	P1.14	P1.14	I/O	J5, pin 3
A14	P1.15	ANT_MATCH_CNTL	O	Not implemented
B13	P0.03/AIN1	P0.03/AIN1	I/O or Analog Input	J5, pin 6
A12	P0.02/AIN0	BATTERY	Analog Input	1/2 of battery voltage is presented to this input
B11	P0.28/AIN4	CELL_PWR_EN	O	Cell modem power. 0 = off, 1 = on
A10	P0.29/AIN5	P0.29/AIN5	I/O or Analog Input	J5, pin 8
B9	P0.30/AIN6	CELL_ON_OFF	O	See Telit ME310G1 HW Design Guide for correct operation
A8	P0.31/AIN7	SENSOR_PWR_EN	O	Power to sensors. 0 = off, 1 = on
B7	VSS	COM	n/a	Board common
B5	DEC4	DEC4_6	Power	
B3	DCC	none	Power	
C1	VDD	VNRF	Power	Bypass capacitor
74	EP	COM	n/a	Board common

14.2. Mini-Tectonic Edge™ Pinout

In the diagrams below, the red (left) represents the side of the epConnected Asset board *without* the Chronos module, while the blue (right) represents the side of epConnected Asset board *with* the Chronos module. Both diagrams are shown looking at the side of interest shown in the image below it. Note that the board reverses its x-axis with the change in view sides, as if the physical board itself was being flipped over.







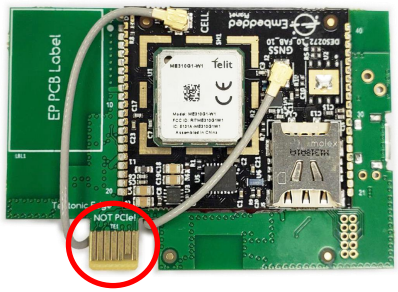


TABLE 8 – MINI-TECTONIC EDGE™ PINOUT

Pin	Direction	Description
SWO	Output	Single wire debug output
RESET#	Input	nRF52840 reset, active low
SWDCLK	Input	Single wire debug clock
SWDIO	I/O	Single wire debug data
COM	n/a	Board common
VBAT	Power Input	3.4V to 4.2V input to power the board
VnRF	Power Output	3.0V reference output from nRF52840
DEBUG_TX	Output	Debug UART output (see below)
DEBUG_RX	Input	Debug UART input (see below)
QSPI_CS#	Input	QSPI flash chip select, active low
QSPI_IO1	Output	QSPI flash single SPI data out
QSPI_IO0	Input	QSPI flash single SPI data in
QSPI_CLK	Input	QSPI flash clock

Resistor options may divert one of the nRF52840's UARTs to the Mini-Tectonic Edge™ connector for debug purposes.

TABLE 9 – MINI-TECTONIC EDGE™ RESISTOR OPTIONS

Debug (UART to Tectonic Edge)	Debug (UART to cellular modem)
R1 populated, R2 unpopulated	R2 populated, R1 unpopulated
R3 populated, R4 unpopulated	R4 populated, R3 unpopulated

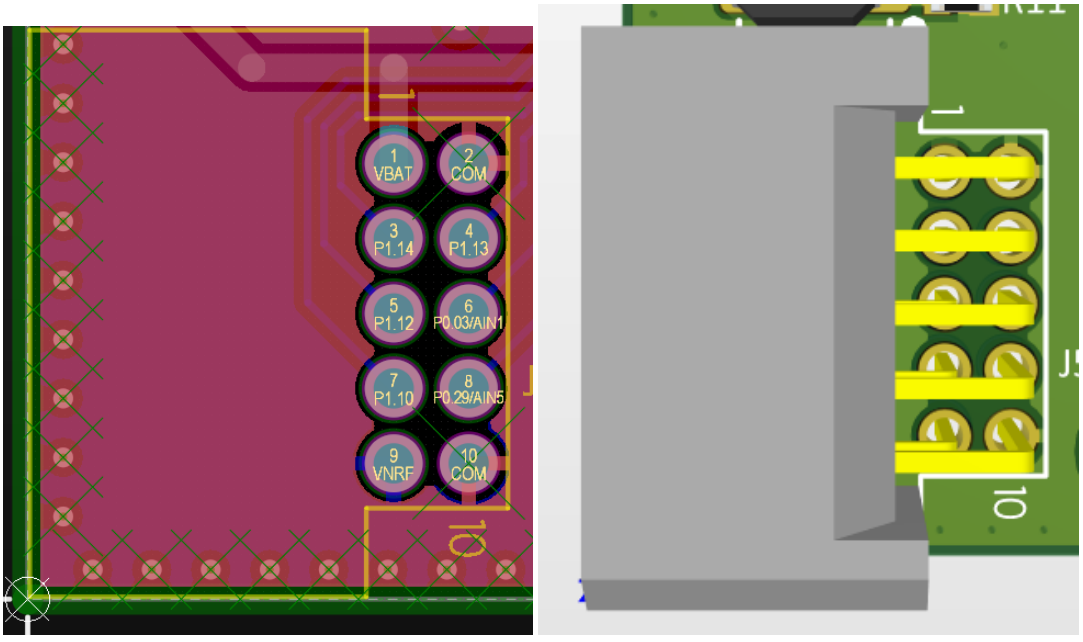
14.3. Expansion Header Pinout (J5)

The expansion header is a 10-pin header (J5) with access to the nRF52840 SPI port, additional GPIO, the 3.0V IO reference voltage, and the battery voltage.

TABLE 10 – EXPANSION HEADER PINOUT

Category	Pin	Description
Power	1	VBAT (battery voltage)
COM	2	COM
Signal	3	P1.14
Signal	4	P1.13
Signal	5	P1.12
Signal	6	P0.03/AIN1
Signal	7	P1.10
Signal	8	P0.29/AIN5
Power	9	VNRF (logic high reference)
COM	10	COM

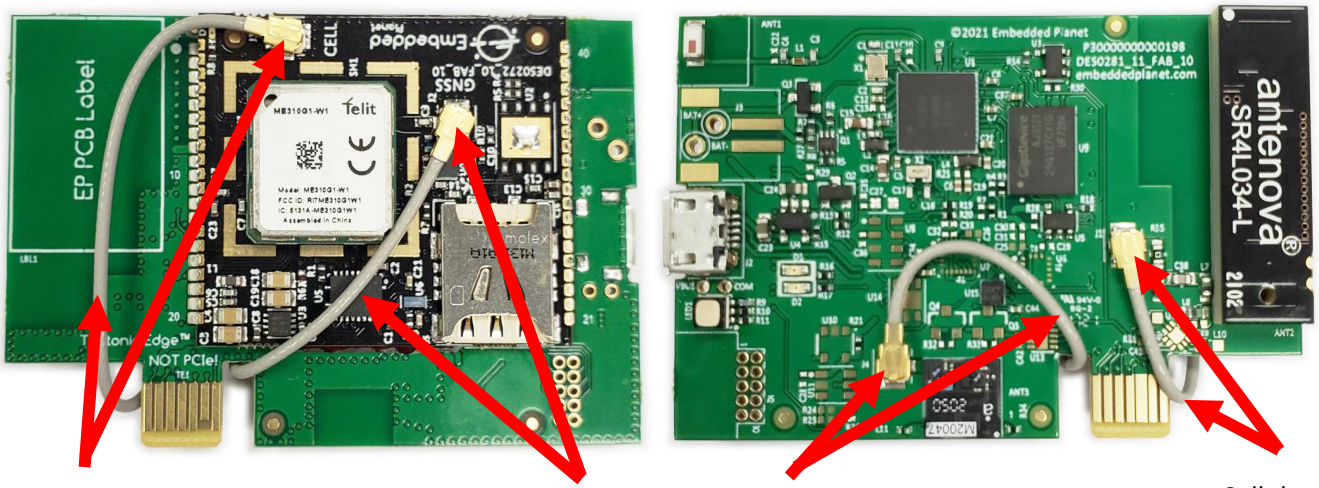
**Note: The [BAT-] net is tied to COM through N-MOS component Q3. Therefore, though electrically connected in normal operation, [BAT-] is not a direct connection to COM.*



15. Antennae

The epConnected Asset uses two antenna types: a cellular antenna and a GNSS antenna. Both antennae are provided on board. The operator should not attach any external antennae to the board, including via the U.FL connectors. The U.FL connectors are only to be used for attaching the cell and GNSS antenna connections between Chronos and the epConnect Asset main board. The correct connection configuration is depicted in the figure below.

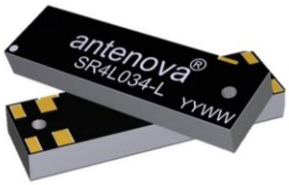
***Note**: The U.FL connection wires MUST be attached between Chronos and the epConnected Asset board for the cellular & GNSS functionalities to work.*



Cellular antenna | GNSS antenna | GNSS antenna | Cellular antenna

15.1. Antennae | Cellular Antenna

The onboard PCB-mounted 4G cellular antenna (ANT2) used on the epConnected Asset is the Antenova SR4L034-L.



More on this device can be found at https://www.antenova.com/product/4g-lte-3g-inversa-compact-high-performing-antenna/

The epConnected Asset is designed to use this onboard antenna. External antennae may be used with the epConnect Asset device; please contact Embedded Planet for details: support@embeddedplanet.com

15.2. Antennae | GNSS Antenna

The onboard PCB-mounted GNSS antenna (ANT3) used on the epConnected Asset is the Antenova M20047-1.

More on this device can be found at https://www.antenova.com/product/1559-1609-mhz-active-sinica-one-gnss-antenna/

The epConnected Asset is designed to use this onboard antenna. External antennae may be used with the epConnect Asset device; please contact Embedded Planet for details: support@embeddedplanet.com

16. Electrical Specifications

16.1. Absolute Maximum & Minimum Ratings

TABLE 11 – ABSOLUTE MAXIMUM & MINIMUMS

Board Pin	Min (V)	Max (V)	Notes
VBUS	-0.3	5.5	With respect to COM
VBAT	-0.3	4.5	With respect to COM
All I/O pins (Mini-Tectonic Edge™, Expansion Header)	-0.3	VnRF + 0.3	With respect to COM

16.2. Recommended Operating Conditions

TABLE 12 – RECOMMENDED OPERATING CONDITIONS

Board Pin	Min (V)	Typ (V)	Max (V)	Notes
VBUS	3.75	5.0	5.25	When used for battery charging only
VBUS	4.75	5.0	5.25	When used for data transfer
VBAT	3.2	3.7	4.2	LiPo battery power to the board. Labeled as “BAT+”
VnRF	1.7	3.0	3.6	3.0V reference output from nRF52840
COM		0		Reference

17. Mechanical Specifications

17.1. Physical Parameters

TABLE 13 – PHYSICAL PARAMETERS

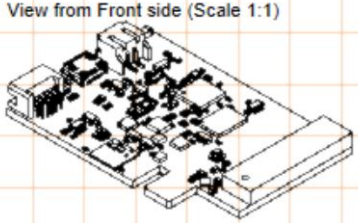
Parameter	Description	Length	Width	Height
Dimensions, J3 & J5 populated	With JST connector and expansion header	28.40mm	56.5mm	12.67mm
Dimensions, J3 & J5 unpopulated	No JST connector or expansion header	28.40mm	56.5mm	10.24mm

17.2. Mechanical Drawings

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

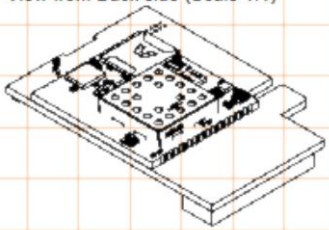
17.2.1. Mechanical Drawings | Assembly Views

View from Front side (Scale 1:1)

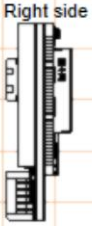


View from Front side (Scale 1:1)

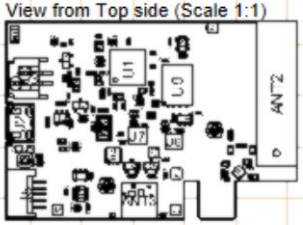
View from Back side (Scale 1:1)



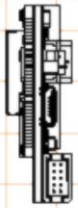
View from Right side (Scale 1:1)



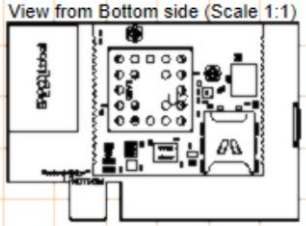
View from Top side (Scale 1:1)



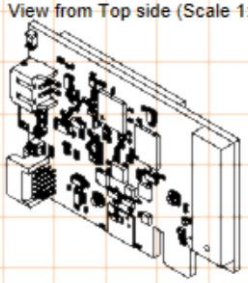
View from Left side (Scale 1:1)



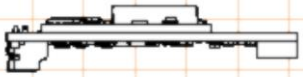
View from Bottom side (Scale 1:1)



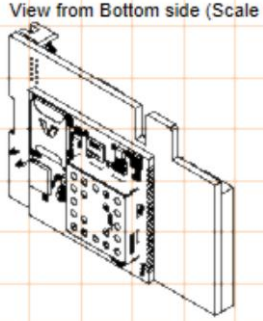
View from Top side (Scale 1:1)



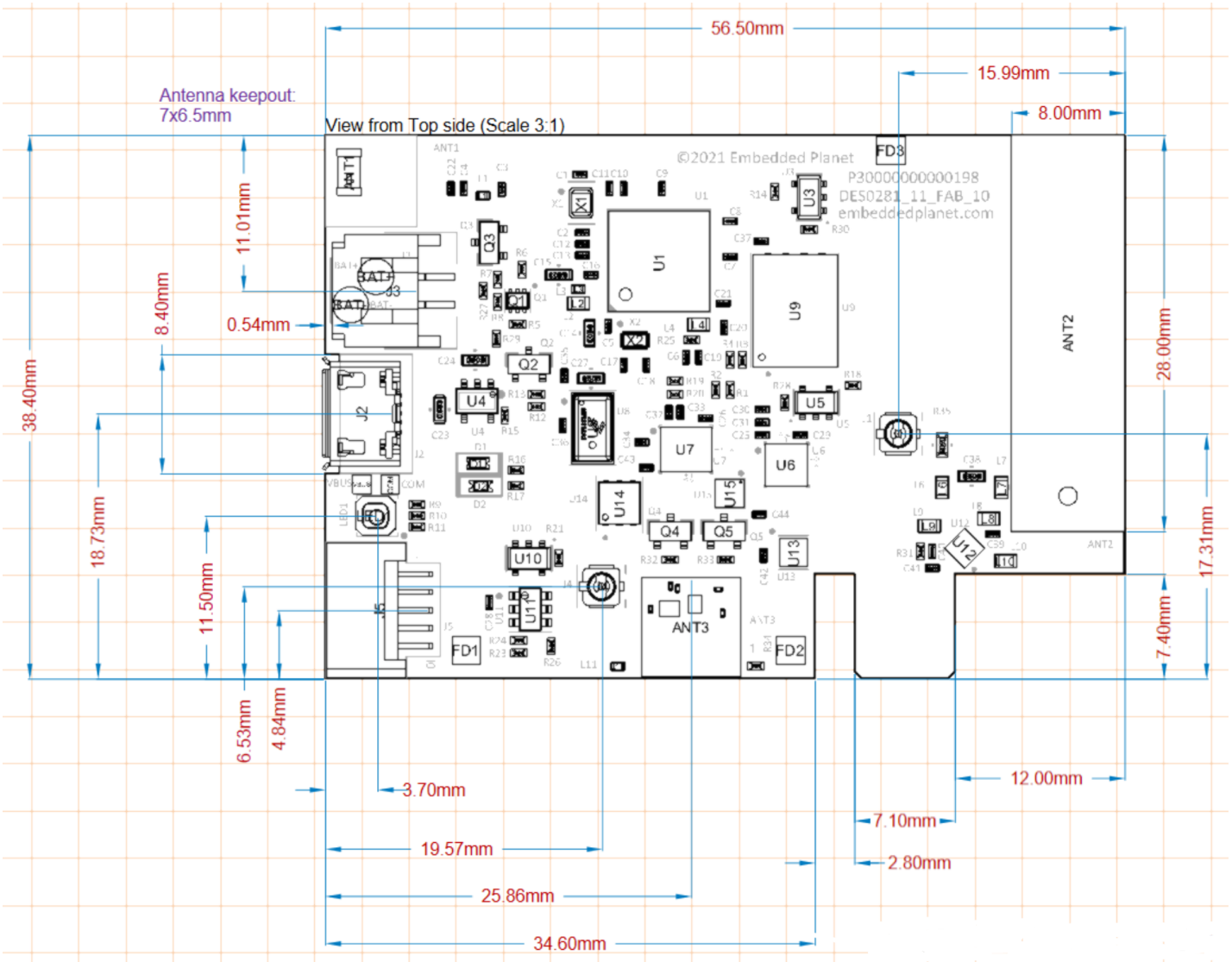
View from Back side (Scale 1:1)



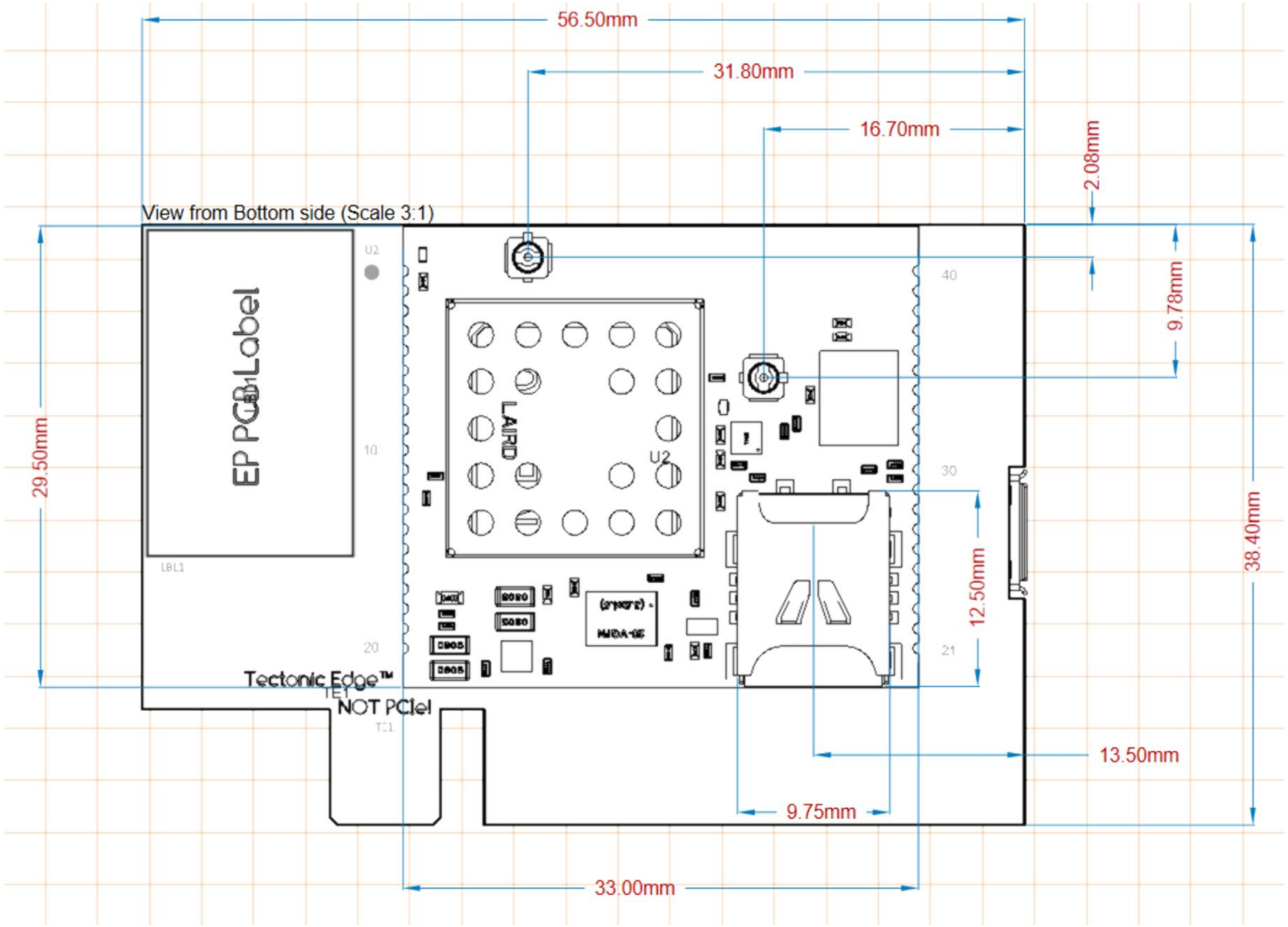
View from Bottom side (Scale 1:1)



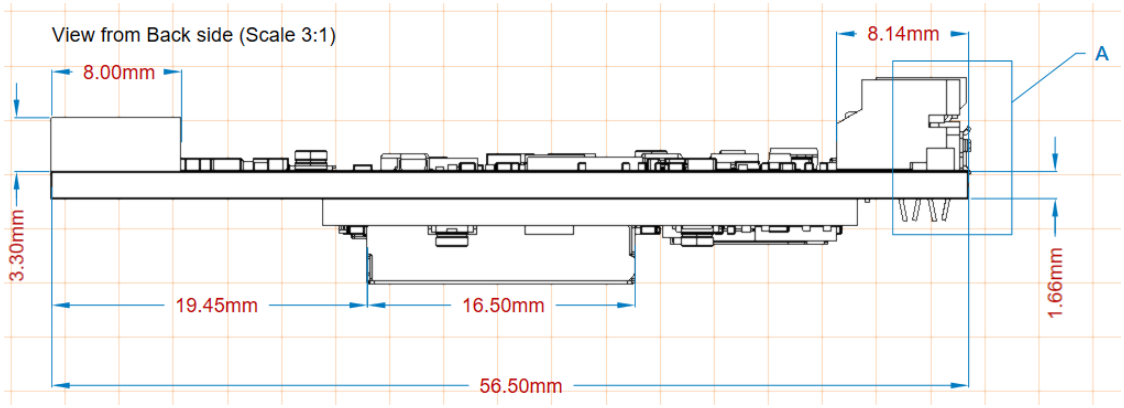
17.2.2. Mechanical Drawings | Dimensions (Top)



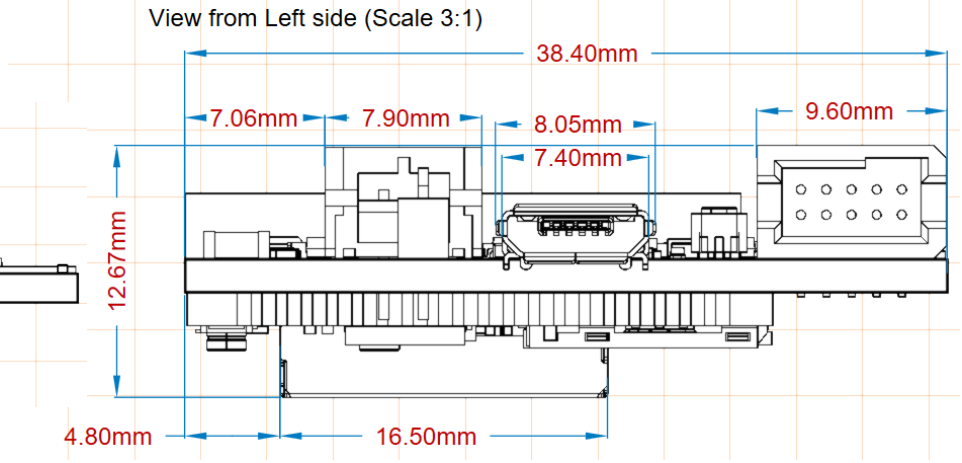
17.2.3. Mechanical Drawings | Dimensions (Bottom)



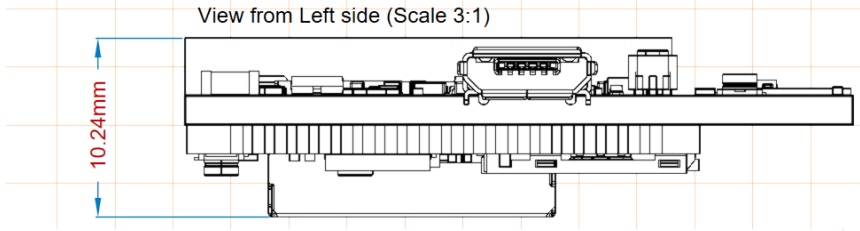
17.2.4. Mechanical Drawings | Dimensions (Side)



All components



J3 & J5 unpopulated (JST connector & Expansion header)



17.3. Environmental Specifications

TABLE 14 – ENVIRONMENTAL SPECIFICATIONS

Parameter	Min	Typ	Max
Operating Temperature	-40°C	+25°C	+85°C
Storage Temperature	-40°C	+25°C	+85°C
Operating Humidity, non-condensing	20% RH		90% RH

18. Regulatory Information

18.1. Cellular Certifications

PTCRB: (Chronos)
https://www.ptcrb.com/device-details/?model=45454

Manufacturer	Model Name / Number	Device Type	Technologies
Embedded Planet	EP-CHRONOS	Integrated Device	4G, LPWA

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

Embedded Planet	EP-CHRONOS
	EPM2M-AG-CELL

Verizon ODI: (Chronos)
https://opendevelopment.verizonwireless.com/device-showcase/device/11766

18.2. RoHS Compliance

The epConnected Asset device (including Chronos) complies with the RoHS (Reduction of Hazardous Substances) directive of the European Union, EU Directive 2011/65/EU.

18.3. 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.

18.4. FCC and ISED Compliance

If the antenna for the Chronos modem is located farther than 20cm from the human body and there are no adjacent transmitters, the FCC and ISED approvals of the modem's Telit ME301G1-W1 cellular module can be reused by the end product.

If the modem'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 ME310G1W1	RI7ME310G1W1	5131A-ME310G1W1

The FCC ID certificate for Chronos can be viewed through the portal in the link below:
https://www.fcc.gov/oet/ea/fccid

The ISED ID certificate for Chronos is available at the link below:
https://sms-sgs.ic.gc.ca/equipmentSearch/searchRadioEquipments?execution=e1s3&index=0

18.5. Wireless Notice

The Chronos 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.

18.6. Antenna Notice: FCC

The Chronos radio transmitter has been approved by FCC 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 15 – FCC MAX GAIN BY BAND

Omnidirectional Antenna Gain: 2.14dBi	
Band	Max Gain for FCC (dBi)
FDD2	11.0
FDD 4	8.0
FDD 5	12.4
FDD 12	11.6
FDD 13	12.1
FDD 25	11.0
FDD 26	12.3
FDD 66	8.0
FDD 71	11.4
FDD 85	11.6

18.7. Antenna Notice: ISED

The radio transmitter in Chronos has been approved by 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 16 – ISED MAX GAIN BY BAND

Omnidirectional Antenna Gain: 2.14dBi	
Band	Max Gain for FCC (dBi)
FDD2	11.0
FDD 4	8.0
FDD 5	9.1
FDD 12	8.6
FDD 13	8.9
FDD 25	11.0
FDD 26	9.0
FDD 66	8.0
FDD 71	8.4
FDD 85	8.6

18.8. End-Product Labeling Requirements

The Chronos module contains an ME310 module which has an FCC ID label on it pertaining to its FCC certification. Consequently, with Chronos used in the epConnected Asset device, the OEM host end product manufacturer must display a label referring to the enclosed module. The exterior label will read as follows:

Device Uses Approved Radio: ME310G1-W1
Contains FCC ID: RI7ME310G1W1
Contains IC: 5131A-ME310G1W1

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.

18.9. 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.

19. Revision History

TABLE 17 – REVISION HISTORY

Revision	Author	Description	Date
1.0.0	M. Trowbridge	Initial Release (preliminary)	26 Jan 2022
1.0.1	M. Leopold	Corrected VBUS maximum voltage to 5.5V	05 APR 2022

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