

Asset Tracker SoM Datasheet (pre)

This is a preliminary datasheet and is subject to change

TODO: Photo goes here

Functional description

OVERVIEW

The AssetTracker SoM is a System-on-a-Module (SoM) with:

- LTE Cat 1 (EMEA) or LTE Cat M1 (North America) cellular modem
- GNSS (supports GPS, SBAS, QZSS, GLONASS, BeiDou, and Galileo) with up to 1.8m accuracy and unteathered dead-reckoning
- Support for CAN bus
- Castellated module can be reflow soldered to your base board, and is available on an evaluation board or carrier board

FEATURES

- GNSS u-blox Neo M8U for GNSS with on-board dead-reckoning for up to 1.8m CEP50 GPS accuracy
 - Supports GPS L1C/A, SBAS L1C/A, QZSS L1C/A, QZSS L1-SAIF, GLONASS L1OF, BeiDou B1I, Galileo E1B/C
- Quectel BG96-NA modem
 - LTE Cat M1 module for North America (United States, Canada, and Mexico)
 - 3GPP E-UTRA Release 13
 - LTE FDD bands supported: 2, 4, 12, 13
 - EGPRS 850, 1900
- Quectel EG91-E modem
 - LTE Cat 1 module for EMEA region
 - 3GPP E-UTRA Release 13
 - Cat 1 bands supported: 1, 3, 7, 8, 20, 28A
 - Support for Europe only at this time
- Nordic Semiconductor nRF52840 SoC
 - ARM Cortex-M4F 32-bit processor @ 64MHz
 - 1MB flash, 256KB RAM in SoC
 - Bluetooth 5: 2 Mbps, 1 Mbps, 500 Kbps, 125 Kbps
 - Supports DSP instructions, HW accelerated Floating Point Unit (FPU) calculations
 - ARM TrustZone CryptoCell-310 Cryptographic and security module
 - Up to +8 dBm TX power (down to -20 dBm in 4 dB steps)
 - NFC-A tag
- Wi-Fi location: on-board ESP32 offers SSID scanning for using third-party Wi-Fi location services
- PMIC (Power Management IC) and Fuel Gauge
- On-module additional 8MB SPI flash
- CAN Bus: on-board, integrated CAN Bus controller and transceiver making it ideal for fleet and micromobility
- RTC: Battery-backed external real-time clock
- Watchdog Timer: integrated hardware WDT
- 10 Mixed signal GPIO (8 x Analog, 10 x Digital), UART, I2C, SPI
- USB 2.0 full speed (12 Mbps)
- JTAG (SWD) pins
- Support for external RGB status LED
- Support for external Reset and Mode buttons
- On-module MFF2 Particle SIM
- Bluetooth chip antenna on module, switchable to use U.FL connector in software.
- Two on-module U.FL connectors for cellular, GNSS, BLE, Wi-Fi, and alternative GNSS.

- Castellated module designed to be reflow soldered to your own custom base board, or pre-populated on a Particle Evaluation Board or Carrier Board.
- FCC, IC, and CE certified
- RoHS compliant (lead-free)

BLOCK DIAGRAM

**VIN**

LiPo

When powered from a LiPo battery alone, the power management IC switches off the internal regulator and supplies power to the system directly from the battery. This reduces the conduction losses and maximizes battery run time. The battery provided with the module is a Lithium-Ion Polymer battery rated at 3.7VDC 1,800mAh. You can substitute this battery with another 3.7V LiPo with higher current rating. Remember to never exceed this voltage rating and always pay attention to the polarity of the connector.

Typical current consumption is around 180mA and up to 1.8A transients at 5VDC. In deep sleep mode, the quiescent current is 130uA (powered from the battery alone).

The MAX17043 fuel gauge is only compatible with single cell lithium-ion batteries. The state-of-charge (SoC) values will not be accurate with other battery chemistries.

A battery temperature sensor can be added if desired. Connect a negative temperature coefficient thermistor to the TS pin and GND. Charge suspends when the TS pin is out of range. A 103AT-2 thermistor is recommended.

VBUS

VBUS is connected to the USB detect pin of nRF52840 to enable the USB interface. The recommended input voltage range is between 4.35V to 5.5V DC. It is also connected to the bq24195 PMIC to allow for DPDM, detection of the power capacity of the USB port.

3V3 Pin

This pin is the output of the on-board 3.3V switching regulator that powers the microcontroller and the peripherals. This pin can be used as a 3.3V power source with a max load of 800mA. Unlike the Photon, this pin *CANNOT* be used as an input to power the module.

RTC_BAT

This is the supply to the real-time clock battery backup. 1.4 to 3.6V.

Voltage	Typical Current	Maximum Current	Unit
3.0V	56	330	nA
1.8V	52	290	nA

GNSS_BAT

This is the supply for maintaining the u-blox GNSS ephemeris and almanac data when removing power. This can use the same battery as RTC_BAT, can be a super-capacitor, or can be omitted. 1.5 to 3.6V. Typical current is 15 uA.

PMID

This pin is the output of the internal boost regulator of the PMIC that can source 5.1VDC from the battery in OTG (On The Go) mode. This feature is useful when your circuitry needs a 5V source from the module when powered by the battery alone.

The confusing bit about this pin is that it will continue to provide 5.1VDC but only when the input voltage (VIN) is between 3.6V to 5.1VDC. As soon as the input voltage exceeds this limit, the PMID starts tracking *that* voltage. For example if VIN = 9VDC, the PMID will be 9VDC and *NOT* 5.1VDC. So you need to be careful when using it as a source for powering your external circuitry. The max current draw on this pin is 2.1A but is not recommended due to thermal limitations of the circuit board.

ANTENNAS

There are a number of U.FL antenna connectors on the Asset Tracker SoM:

Label	Purpose
GNSS	u-blox GNSS antenna (GPS)
CELL	Quectel cellular modem antenna
WIFI	Wi-Fi antenna for Wi-Fi geolocation (optional) ¹
BLE	External Bluetooth (optional) ²
GNSS/DIV	Quectel GNSS antenna (optional) ¹

¹Not supported in initial release.

²There is a BLE chip antenna on the module, the external BLE antenna is optional.

There is no U.FL connector for NFC. If you wish to use the NFC tag feature, you'll need to add an antenna or antenna connector on your base board.

- The antenna placement needs to follow some basic rules, as any antenna is sensitive to its environment. Mount the antenna at least 10mm from metal components or surfaces, ideally 20mm for best radiation efficiency, and try to maintain a minimum of three directions free from obstructions to be able to operate effectively.
- Needs tuning with actual product enclosure and all components.
- For the BLE antenna, it is recommended to use a 2.4 GHz single-frequency antenna and not a 2.4 GHz + 5 GHz antenna, so as to avoid large gain at the frequency twice of 2.4 GHz which can cause the second harmonic radiation of 2.4 GHz to exceed standards.

PERIPHERALS AND GPIO

Peripheral Type	Qty	Input(I) / Output(O)
Digital	10 (max)	I/O
Analog (ADC)	8 (max)	I
UART	1	I/O
SPI	1	I/O
I2C	1	I/O
USB	1	I/O
PWM	10 (max) ¹	O
NFC	1	O
CAN	1	I/O

¹PWM is divided into three PWM groups. Each group must share the same frequency, but can have different periods.

Note: All GPIO are only rated at 3.3VDC max. CAN bus has a [higher voltage rating](#).

JTAG (SWD)

The AssetTracker SoM exposes the nRF52 SWD interface on the following pins. The Evaluation Board connects these pins to the 2x5 connector used on the Argon and Boron to easily connect the Particle Debugger.

#	Pin	Function	Connected To	Description
22	SWDIO	JTAG	nRF52	nRF52 MCU SWDIO
23	SWDCLK	JTAG	nRF52	nRF52 MCU SWDCLK
24	SWO	JTAG	nRF52	nRF52 MCU SWO

This interface can be used to debug your code or reprogram your bootloader, device OS, or the user firmware.

Memory map

NRF52840 FLASH LAYOUT OVERVIEW

- Bootloader (48KB, @0xF4000)
- User Application (128KB, @0xD4000)
- System (656KB, @0x30000)
- SoftDevice (192KB)

EXTERNAL SPI FLASH LAYOUT OVERVIEW (DFU OFFSET: 0X80000000)

- Reserved (4MB, @0x0040000)
- OTA (1500KB, @0x00289000)
- Reserved (420KB, @0x00220000)
- FAC (128KB, @0x00200000)
- LittleFS (2M, @0x00000000)

Pins and button definitions

PINOUT DIAGRAM

TODO: Update this diagram

SOM PIN DESCRIPTION

#	Pin	Function	Connected To	Description
				Right Side
1	GND	POWER		Ground
2	GNSS_BAT	POWER IN	GNSS	Battery backup for GNSS
3	GNSS_RESET	IO	GNSS & IOEX	GNSS hardware reset. Can be controlled by this pin or software.
4	GNSS_VBUS	USB PWR	GNSS	GNSS USB power. Optional.
5	GNSS_P	USB D+	GNSS	GNSS USB interface D+. Optional.
6	GNSS_N	USB D-	GNSS	GNSS USB interface D-. Optional.
7	GNSS_PULSE	OUT	GNSS	GNSS time pulse output. Can be used for a GPS fix LED.
8	GND	POWER		Ground
9	NC			Leave unconnected.
10	GND	POWER		Ground
11	WIFI_EN	IO	WIFI & IOEX	ESP32 enable. Can be controlled by this pin or software.
12	WIFI_BOOT	IO	WIFI & IOEX	ESP32 boot mode. Can be controlled by this pin or software.
13	WIFI_TXD	OUT	WIFI	ESP32 serial TX
14	WIFI_RXD	IN	WIFI	ESP32 serial TX
15	CELL_VBUS	USB PWR	CELL	Cellular modem USB power. Optional.
16	CELL_D+	USB D+	CELL	Cellular modem USB interface D+. Optional.
17	CELL-D-	USB D-	CELL	Cellular modem USB interface D-. Optional.
18	NC SOM18			Leave unconnected.
19	NC SOM19			Leave unconnected.
20	NC SOM20			Leave unconnected.
21	NC SOM21			Leave unconnected.
22	SWDIO	JTAG	nRF52	nRF52 MCU SWDIO
23	SWDCLK	JTAG	nRF52	nRF52 MCU SWDCLK
24	SWO	JTAG	nRF52	nRF52 MCU SWO
25	GND	POWER		Ground
26	NFC1	NFC	nRF52	nRF52 NFC antenna. Supports NFC tag mode only. Optional.
27	NFC2	NFC	nRF52	nRF52 NFC antenna. Supports NFC tag mode only. Optional.
28	RGB_BLUE	RGB LED	nRF52	Common anode RGB status LED, blue. Optional.
29	RGB_GREEN	RGB LED	nRF52	Common anode RGB status LED, green. Optional.
30	RGB_RED	RGB LED	nRF52	Common anode RGB status LED, red. Optional.
31	GND	POWER		Ground
32	MODE	INPUT	nRF52	External MODE button input. Optional.
33	RESET	INPUT	nRF52	External RESET button input. Optional.
34	NC SOM34			Leave unconnected.

35	NC SOM35			Leave unconnected.
36	NC SOM36			Leave unconnected.
37	NC SOM37			Leave unconnected.
38	A7	IO	nRF52	A7, D7, SS, WKP
39	A6	IO	nRF52	A6, D6, SPI SCK
40	A5	IO	nRF52	A5, D5, SPI MISO
41	A4	IO	nRF52	A4, D4, SPI MOSI
42	GND	POWER		Ground
Top Side				
43	GND	POWER		Ground
44	NC SOM44			Leave unconnected.
45	3V3	POWER OUT	TPS62291	3.3V power output. 1000 mA maximum include nRF52 and other peripheral use.
46	TS	IN	PMIC	Battery temperature sensor
47	PMID	POWER OUT	PMIC	PMIC power output in OTG mode.
48	GND	POWER		Ground
49	VIN	POWER IN	PMIC	Power input 3.88VDC to 12VDC.
50	STAT	OUT	PMIC	PMIC charge status. Can be connected to an LED. Optional.
51	VBUS	POWER IN	PMIC & nRF52	nRF52 USB power input. Can be used as a power supply instead of VIN.
52	GND	POWER		Ground
53	LI+	POWER	PMIC	Connect to Li-Po battery. Can power the device or be recharged by VIN or VBUS.
Left Side				
54	GND	POWER		Ground
55	A0	IO	nRF52	A0 D0 Wire SDA
56	A1	IO	nRF52	A1 D1 Wire SCL
57	A2	IO	nRF52	A2 D2 SerialI CTS
58	A3	IO	nRF52	A3 D3 SerialI RTS
59	NC SOM59			Leave unconnected.
60	NC SOM60			Leave unconnected.
61	NC SOM61			Leave unconnected.
62	NC SOM62			Leave unconnected.
63	AGND	POWER	nRF52	nRF52 analog ground. Can connect to regular GND.
64	CAN_N	CAN	CAN	CAN Data-
65	CAN_P	CAN	CAN	CAN Data+
66	CAN_5V		XCL9142F40	5V power out, 0.8A maximum. Can be controlled by software.
67	GND	POWER		Ground
68	MCU-D-	USB D-	nRF52	MCU USB interface D-. Optional.
69	MCU_D+	USB D+	nRF52	MCU USB interface D+. Optional.
70	GND	POWER		Ground
71	MCU_RX	IO	nRF52	Serial RX, GPIO D9
72	MCU_TX	IO	nRF52	Serial TX, GPIO D8
73	RTC_BAT	POWER	AM18X5	RTC/Watchdog battery +. Connect to GND if not using.
74	RTC_BTN	IN	AM18X5	RTC EXTI. Can use as a wake button.

75	GND	POWER		Ground
76	NC SOM76			Leave unconnected.
77	NC SOM77			Leave unconnected.
78	NC SOM78			Leave unconnected.
79	NC SOM79			Leave unconnected.
80	NC SOM80			Leave unconnected.
81	NC SOM81			Leave unconnected.
82	NC SOM82			Leave unconnected.
83	CELL_GPS_TX	OUT	CELL	Cellular modem GPS serial TX data.
84	CELL_GPS_RX	IN	CELL	Cellular modem GPS serial RX data.
85	CELL_RI	OUT	CELL	Cellular modem ring indicator output.
86	GND	POWER		Ground
87	CELL_GPS_RF	RF	CELL	Cellular modem GPS antenna. Optional.
88	GND	POWER		Ground
89	GND	POWER		Ground
90	GNSS_BOOT		GNSS	u-blox GNSS boot mode
91	GNSS_ANT_PWR		GNSS	u-blox GNSS antenna power
92	GNSS_LNA_EN		GNSS	u-blox GNSS LNA enable or antenna switch
93	GND	POWER		Ground
94	GNSS_RF		GNSS	GNSS antenna.
95	GND	POWER		Ground

NRF52 PIN ASSIGNMENTS

SoM Pin	GPIO	Analog	Other	PWM	nRF Pin
55	D0	A0	Wire SDA	Group 0	P0.03
56	D1	A1	Wire SCL	Group 0	P0.02
57	D2	A2	Serial1 CTS	Group 0	P0.28
58	D3	A3	Serial1 RTS	Group 0	P0.30
41	D4	A4	SPI MOSI	Group 1	P0.31
40	D5	A5	SPI MISO	Group 1	P0.29
39	D6	A6	SPI SCK	Group 1	P0.04
38	D7	A7	SPI SS, WKP	Group 1	P0.05
72	D8		Serial1 TX	Group 2	P0.06
71	D9		Serial1 RX	Group 2	P0.08

System peripheral GPIO

Name	Description	Location
BTN	MODE Button	P1.13
PMIC_INT	PMIC Interrupt	P0.26
LOW_BAT_UC	Fuel Gauge Interrupt	IOEX
RTC_INT	Real-time clock Interrupt	P0.27
BGRST	Cellular module reset	P0.7
BGPWR	Cellular module power	P0.8
BGVINT	Cellular power on detect	P1.14
BGDTR	Cellular module DTR	IOEX

CAN_INT	CAN interrupt	P1.9
CAN_RST	CAN reset	IOEX
CAN_PWR	5V boost converter enable	IOEX
CAN_STBY	CAN standby mode	IOEX
CAN_RTS0	CAN RTS0	IOEX
CAN_RTS1	CAN RTS1	IOEX
CAN_RTS2	CAN RTS2	IOEX
SEN_INT	IMU interrupt	P1.7
ANT_SW1	BLE antenna switch	P1.15
GPS_PWR	u-blox GNSS power	IOEX
GPS_INT	u-blox GNSS interrupt	IOEX
GPS_BOOT	u-blox GNSS boot mode	IOEX
GPS_RST	u-blox GNSS reset	IOEX
WIFL_EN	ESP32 enable	IOEX
WIFL_INT	ESP32 interrupt	IOEX
WIFI_BOOT	ESP32 boot mode	IOEX

STATUS LED

The Asset Tracker SoM does not have an on-module RGB system status LED. We have provided its individual control pins for you to connect an LED of your liking. This will allow greater flexibility in the end design of your products.

Device OS assumes a common anode RGB LED. One common LED that meets the requirements is the [Cree CLMVC-FKA-CL1D1L71BB7C3C3](#) which is inexpensive and easily procured. You need to add three current limiting resistors. With this LED, we typically use 1K current limiting resistors. These are much larger than necessary. They make the LED less blinding but still provide sufficient current to light the LEDs. If you want maximum brightness you should use the calculated values, 33 ohm on red, and 66 ohm on green and blue.

A detailed explanation of different color codes of the RGB system LED can be found [here](#).

Technical specifications

ABSOLUTE MAXIMUM RATINGS ^[1]

Parameter	Symbol	Min	Typ	Max	Unit
Supply Input Voltage	V _{IN-MAX}			+17	V
Supply Output Current	I _{IN-MAX-L}			1	A
Battery Input Voltage	V _{LiPo}			+6	V
Supply Output Current	I _{3V3-MAX-L}			800	mA
Storage Temperature	T _{stg}	-30		+75	°C
ESD Susceptibility HBM (Human Body Mode)	V _{ESD}			2	kV

^[1] Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Supply voltages

Parameter	Symbol	Min	Typ	Max	Unit
Supply voltages					
Supply Input Voltage	V _{IN}	3.88		12	V
VBUS USB supply voltage	V _{USB}	-0.3		+5.8	V
Supply Output Voltage	V _{IN}		+4.8		V
Supply Output Voltage	V _{3V3}		+3.3		V
LiPo Battery Voltage	V _{LiPo}	+3.6		+4.4	V
I/O pin voltage					
V _{I/O}	I _O	-0.3		+3.6	V
NFC antenna pin current					
I _{NFC1/2}	NFC1/NFC2			80	mA
Radio					
BT RF input level (52840)				10	dBm
Environmental					
Storage temperature		-40		+85	°C

^[1] Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min	Typ	Max	Unit
Supply voltages					
Supply Input Voltage	V _{IN}	+3.8		+12.0	V
VBUS USB supply voltage	V _{USB}	+4.35	+5.0	+5.5	V
Environmental					
Normal operating temperature ¹		-20	+25	+75 ³	°C

Extended operating temperature ²	-40	+85	°C
Humidity Range Non condensing, relative humidity		95	%

Notes:

¹ Normal operating temperature range (fully functional and meet 3GPP specifications).

² Extended operating temperature range (RF performance may be affected outside normal operating range, though module is fully functional)

³ The maximum operating temperature is 75°C on the B523 (Quectel) but is 65°C on the B402 (u-blox LTE M1). For compatibility across modules, limit this to 65°C.

GNSS SPECIFICATIONS

- u-blox NEO-M8U untethered dead reckoning module including 3D inertial sensors
- SPI Interface
- Supports GPS L1C/A, SBAS L1C/A, QZSS L1C/A, QZSS L1-SAIF, GLONASS L1OF, BeiDou B1I, and Galileo E1B/C

Parameter	Specification
Dynamics operational limit ¹	≤ 4g
Altitude operational limit ¹	50000 m
Velocity operational limit ¹	500 m/s
Velocity accuracy ²	0.5 m/s
Heading accuracy ²	1 degree
Max navigation update rate ³	30 Hz
Max navigation latency ³	< 10 ms

Parameter		GPS & GLONASS	GPS	GLONASS	BeiDou	Galileo
Time-To-First Fix ⁵	Cold start	26s	30s	31s	39s	57s
	Hot start	1.5s	1.5s	1.5s	15s	1.5s
	Aided start ⁶	3s	3s	3s	7s	7s
Sensitivity ⁷⁸	Tracking & Navigation	-160 dBm	-160 dBm	-157 dBm	-160 dBm	-154 dBm
	Reacquisition	-160 dBm	-159 dBm	-156 dBm	-155 dBm	-152 dBm
	Cold Start	-148 dBm	-147 dBm	-145 dBm	-143 dBm	-133 dBm
	Hot Start	-157 dBm	-156 dBm	-155 dBm	-155 dBm	-151 dBm
Horizontal positioning accuracy	Autonomous ⁹	2.5m	2.5m	4.0m	3.0m	TBC ¹⁰
	With SBAS ¹¹	1.5m	1.5m	-	-	-
Altitude accuracy	With SBAS ¹²	3.5m	3.0m	7.0m	5.0m	-

¹ Configured for Airborne < 4g platform ² 50% at 30 m/s ³ High navigation rate mode

⁵ All satellites at -130 dBm, except Galileo at -127 dBm ⁶ Dependent on aiding data connection speed and latency ⁷ Demonstrated with a good external LNA ⁸ Configured min. CNO of 6 dB/Hz, limited by FW with min. CNO of 20 dB/Hz for best performance ⁹ CEP, 50%, 24 hours static, -130 dBm, > 6 SVs ¹⁰ To be confirmed when Galileo reaches full operational capability ¹¹ CEP, 50%, 24 hours static, -130 dBm, > 6 SVs ¹² CEP, 50%, 24 hours static, -130 dBm, > 6 SVs

GNSS GPIO:

Name	Description	Location
GPS_PWR	u-blox GNSS power	IOEX
GPS_INT	u-blox GNSS interrupt	IOEX
GPS_BOOT	u-blox GNSS boot mode	IOEX
GPS_RST	u-blox GNSS reset	IOEX

CAN SPECIFICATIONS

- Microchip MCP25625 CAN Controller with Integrated Transceiver
- SPI Interface
- Implements CAN2.0B (ISO11898-1)
- Implements ISO-11898-2 and ISO-11898-5 standard physical layer requirements
- Up to 1 Mb/sec operation
- 3 transmit buffers with prioritization and abort features
- 2 receive buffers
- 6 filters and 2 masks with optional filtering on the first 2 data bytes
- CAN bus pins are disconnected when device is unpowered
- High-ESD protection on CANH and CANL, meets IEC61000-4-2 up to ±8 kV
- Very low standby current, 10 uA, typical
- 5V step-up converter (XCL9142F40CER), 0.8A

CAN GPIO:

Name	Description	Location
CAN_INT	CAN interrupt	P1.9
CAN_RST	CAN reset	IOEX
CAN_PWR	5V boost converter enable	IOEX
CAN_STBY	CAN standby mode	IOEX
CAN_RTS0	CAN Request to Send 0	IOEX
CAN_RTS1	CAN Request to Send 1	IOEX
CAN_RTS2	CAN Request to Send 2	IOEX

CANH, CANL Absolute Maximum Ratings:

Parameter	Maximum
DC Voltage at CANH, CANL	-58V to +58V
Transient Voltage on CANH, CANL (ISO-7637)	-150V to +100V
ESD Protection on CANH and CANL Pins (IEC 61000-4-2)	±8 kV
ESD Protection on CANH and CANL Pins (IEC 801; Human Body Model)	±8 kV

CAN Transceiver Characteristics

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Supply Input Voltage	V _{DDA}		5.0		V	
Supply Current	I _{DD}		5	10	mA	Recessive; V _{TXD} = V _{DDA}
			45	70	mA	Dominant; V _{TXD} = 0V
Standby Current	I _{DDS}		5	15	µA	Includes I _{IO}
CANH, CANL Recessive Bus Output Voltage	V _{O(R)}	2.0	2.5	3.0	V	V _{TXD} = V _{DDA}
CANH, CANL Bus Output Voltage in Standby	V _{O(S)}	-0.1	0.0	+0.1	V	STBY = V _{TXD} = V _{DDA} ; No load
Recessive Output Current	I _{O(R)}	-5		+5	mA	-24V < V _{CAN} < +24V
CANH: Dominant Output Voltage	V _{O(D)}	2.75	3.5	4.5	V	T _{XD} = 0; R _L = 50 to 65Ω
CANL: Dominant Output Voltage	V _{O(D)}	0.5	1.5	2.25	V	R _L = 50 to 65Ω
Dominant: Differential Output Voltage	V _{O(DIFF)}	1.5	2.0	3.0	V	T _{XD} = V _{SS} ; R _L = 50 to 65Ω
Recessive: Differential Output Voltage		-120	0	12	mV	T _{XD} = V _{DDA} ; R _L = 50 to 65Ω
		-500	0	50	mV	T _{XD} = V _{DDA} ; No load

CANH: Short-Circuit Output Current	I _{O(SC)}	-120	85	mA	V _{TXD} = V _{SS} ; V _{CANH} = 0V; CANL: floating	
CANL: Short-Circuit Output Current			75	120	mA	V _{TXD} = V _{SS} ; V _{CANL} = 18V; CANH: floating
Recessive Differential Input Voltage	V _{DIFF(R)} (I)	-1.0		+0.5	V	Normal mode; -12V < V _(CANH, CANL) < +12V
		-1.0		+0.4	V	Standby mode; -12V < V _(CANH, CANL) < +12V
Dominant Differential Input Voltage	V _{DIFF(D)} (I)	0.9		5.0	V	Normal mode; -12V < V _(CANH, CANL) < +12V
		1.0		5.0	V	Standby mode; -12V < V _(CANH, CANL) < +12V

OTHER COMPONENTS

IMU (Inertial Measurement Unit)

- Bosch Sensortec BMI160
- SPI Interface connected to SPI1 (MISO1, MOSI1, SCK1)
- Can wake nRF52 MCU on movement (SEN_INT2)
- 16 bit digital, triaxial accelerometer and triaxial gyroscope
- Very low power consumption: typically 925 μA with accelerometer and gyroscope in full operation
- Allocatable FIFO buffer of 1024 bytes (capable of handling external sensor data)
- Hardware sensor time-stamps for accurate sensor data fusion
- Integrated interrupts for enhanced autonomous motion detection

PMIC

- Texas Instruments bq24195
- I2C interface (Wire1 address 0x6B)
- Can interrupt nRF52 MCU on charge status and fault
- Handles switching between USB, VIN, and battery power
- LiPo battery charger
- Charge safety timer, thermal regulation, and thermal shutdown
- Optional connection for battery thermistor

Fuel Gauge

- MAX17043
- I2C interface (Wire1 address 0x36)
- Can interrupt nRF52 MCU on low battery
- Fuel-gauge system for single cell lithium-ion (Li+) batteries
- Precision voltage measurement $\pm 12.5mV$ Accuracy to 5V
- Accurate relative capacity (RSOC) Calculated from ModelGauge algorithm
- No offset accumulation on measurement
- No full-to-empty battery relearning necessary

RTC/Watchdog

- Ambiq Micro AM18X5 Real-Time Clock with Power Management
- 55 nA power consumption
- Crystal oscillator
- I2C interface (Wire1 address 0x68)
- Can wake MCU at a specific time using RTC_INT.
- Programmable hardware watchdog
- RTC powered by XC6504 ultra-low consumption regulator so the main TPS62291 can be shut down from RTC

Wi-Fi Geolocation

The Wi-Fi module is intended for Wi-Fi geolocation only. It cannot be used as a network interface instead of using cellular. An external service provider such as the Google Geolocation Service is required for mapping Wi-Fi networks to a location.

- ESP32-D2WD
- SPI Interface
- Connected to SPI1 (MISO1, MOSI1, SCK1)
- Chip Select: WIFI_CS (connected to SPI CS Multiplexer Y3)
- Interrupt: ESP32 IO4 is connected to MCP23517T I/O Expander GPA4.

The SoM connector has several pins dedicated to Wi-Fi:

#	Pin	Function	Connected To	Description
11	WIFI_EN	IO	WIFI & IOEX	ESP32 enable. Can be controlled by this pin or software.
12	WIFI_BOOT	IO	WIFI & IOEX	ESP32 boot mode. Can be controlled by this pin or software.
13	WIFI_TXD	OUT	WIFI	ESP32 serial TX
14	WIFI_RXD	IN	WIFI	ESP32 serial TX

The WIFI_EN pin turns on the Wi-Fi module. LOW=Off, HIGH=On. The default is off (with a 100K weak pull-down). It can be turned on from Pin 11 on the SoM connection, or in software from the MCP23517T I/O Expander GPA3.

The WIFI_BOOT pin enables programming mode.

3.3V Regulator

- Texas Instruments TPS62291
- 1.0A at 3.3V
- Powers nRF52840 MCU and ESP32 Wi-Fi module
- Can be used by your base board to power 3.3V components
- 3.3V supply can be powered down from the RTC/Watchdog

RADIO SPECIFICATIONS

nRF52840

- Bluetooth® 5, 2.4 GHz
 - 95 dBm sensitivity in 1 Mbps Bluetooth® low energy mode
 - 103 dBm sensitivity in 125 kbps Bluetooth® low energy mode (long range)
 - 20 to +8 dBm TX power, configurable in 4 dB steps

4G LTE cellular characteristics for EG91-E

Parameter	Value
Protocol stack	3GPP Release 13
RAT	LTE Cat 1
LTE FDD Bands	Band 28A (700 MHz)
	Band 20 (800 MHz)
	Band 8 (900 MHz)
	Band 3 (1800 MHz)
	Band 1 (2100 MHz)
	Band 7 (2600 MHz)
WCDMA Bands	Band 8 (900 MHz)
	Band 1 (2100)
GSM Bands	EGSM900 (900 MHz)
	DCS1800 (1800 MHz)
Power class	Class 4 (33dBm \pm 2dB) for EGSM900
	Class 1 (30dBm \pm 2dB) for DCS1800
	Class E2 (27dBm \pm 3dB) for EGSM900 8-PSK
	Class E2 (26dBm \pm 3dB) for DCS1800 8-PSK
	Class 3 (24dBm \pm 3dB) for WCDMA bands
	Class 3 (23dBm \pm 2dB) for LTE FDD bands

4G LTE cellular characteristics for BG96-NA

Parameter	Value
Protocol stack	3GPP Release 13
RAT	LTE Cat M1
	EGPRS
LTE FDD Bands	Band 12 (700 MHz)
	Band 13 (700 MHz)
	Band 4 (1700 MHz)
	Band 2 (1900 MHz)
GSM Bands	EGSM850 (850 MHz)
	DCS1900 (1900 MHz)

ESP32

Espressif Systems ESP32 for Wi-Fi geolocation:

Feature	Description
WLAN Standards	IEEE 802.11b/g/n
Antenna Port	Single Antenna
Frequency Band	2412 to 2484 MHz

I/O CHARACTERISTICS

These specifications are based on the nRF52840 datasheet.

Symbol	Parameter	Min	Typ	Max	Unit
VIH	Input high voltage	0.7 xVDD		VDD	V

VIL	Input low voltage	VSS	0.3 xVDD	V	
VOH,SD	Output high voltage, standard drive, 0.5 mA, VDD ≥1.7	VDD - 0.4	VDD	V	
VOH,HDH	Output high voltage, high drive, 5 mA, VDD ≥= 2.7 V	VDD - 0.4	VDD	V	
VOH,HDL	Output high voltage, high drive, 3 mA, VDD ≥= 1.7 V	VDD - 0.4	VDD	V	
VOL,SD	Output low voltage, standard drive, 0.5 mA, VDD ≥1.7	VSS	VSS + 0.4	V	
VOL,HDH	Output low voltage, high drive, 5 mA, VDD ≥= 2.7 V	VSS	VSS + 0.4	V	
VOL,HDL	Output low voltage, high drive,3 mA, VDD ≥= 1.7 V	VSS	VSS + 0.4	V	
IOL,SD	Current at VSS+0.4 V, output set low, standard drive, VDD≥1.7	1	2	4	mA
IOL,HDH	Current at VSS+0.4 V, output set low, high drive, VDD ≥= 2.7V	6	10	15	mA
IOL,HDL	Current at VSS+0.4 V, output set low, high drive, VDD ≥= 1.7V	3			mA
IOH,SD	Current at VDD-0.4 V, output set high, standard drive, VDD≥1.7	1	2	4	mA
IOH,HDH	Current at VDD-0.4 V, output set high, high drive, VDD ≥= 2.7V	6	9	14	mA
IOH,HDL	Current at VDD-0.4 V, output set high, high drive, VDD ≥= 1.7V	3			mA
tRF,15pF	Rise/fall time, standard drivemode, 10-90%, 15 pF load ¹		9		ns
tRF,25pF	Rise/fall time, standard drive mode, 10-90%, 25 pF load ¹		13		ns
tRF,50pF	Rise/fall time, standard drive mode, 10-90%, 50 pF load ¹		25		ns
tHRF,15pF	Rise/Fall time, high drive mode, 10-90%, 15 pF load ¹		4		ns
tHRF,25pF	Rise/Fall time, high drive mode, 10-90%, 25 pF load ¹		5		ns
tHRF,50pF	Rise/Fall time, high drive mode, 10-90%, 50 pF load ¹		8		ns
RPU	Pull-up resistance	11	13	16	kΩ
RPD	Pull-down resistance	11	13	16	kΩ
CPAD	Pad capacitance		3		pF
CPAD_NFC	Pad capacitance on NFC pads		4		pF
INFC_LEAK	Leakage current between NFC pads when driven to different states		1	10	μA

¹Rise and fall times based on simulations

Mechanical specifications

DIMENSIONS AND WEIGHT

TODO: Dimensions and weight

Parameters	Value	Unit
Width		mm
Height		mm
Thickness		mm
Weight		grams

MECHANICAL DRAWING

TODO: Mechanical drawing

Dimensions are in millimeters.

LAYOUT CONSIDERATIONS

TODO: keep-out area around the BLE antenna.

Product Handling

ESD PRECAUTIONS

The Asset Tracker SoM contains highly sensitive electronic circuitry and is an Electrostatic Sensitive Device (ESD). Handling an module without proper ESD protection may destroy or damage it permanently. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates the module. ESD precautions should be implemented on the application board where the B series is mounted. Failure to observe these precautions can result in severe damage to the module!

CONNECTORS

The U.FL antenna connectors are not designed to be constantly plugged and unplugged. The antenna pin is static sensitive and you can destroy the radio with improper handling. A tiny dab of glue (epoxy, rubber cement, liquid tape or hot glue) on the connector can be used securely hold the plug in place.

Default settings

The AssetTracker SoM comes pre-programmed with a bootloader and a user application called Tinker. This application works with an iOS and Android app also named Tinker that allows you to very easily toggle digital pins, take analog and digital readings and drive variable PWM outputs.

The bootloader allows you to easily update the user application via several different methods, USB, OTA, Serial Y-Modem, and also internally via the Factory Reset procedure. All of these methods have multiple tools associated with them as well.

Revision history

Revision	Date	Author	Comments
pre	31 Mar 2020	RK	Preview Release