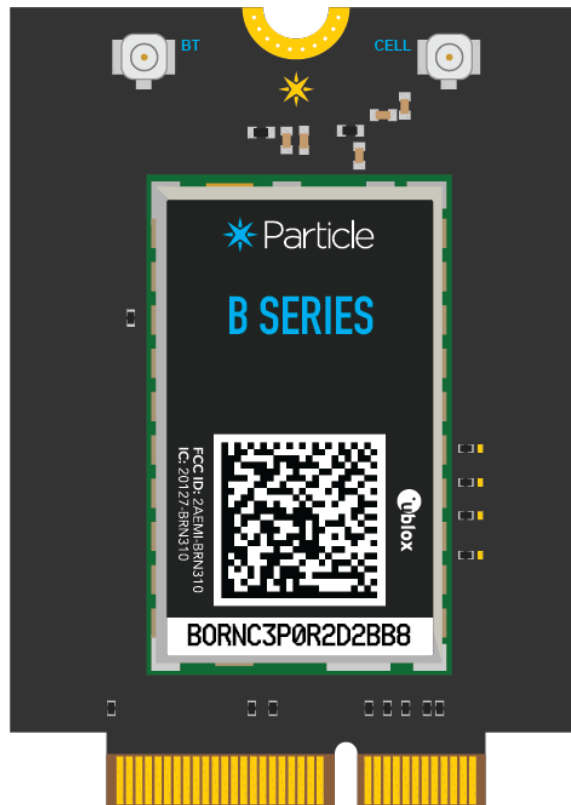


# B402 Datasheet (draft-005)



# Functional description

## OVERVIEW

---

The B Series System-on-a-Module (SoM) can act as either a standalone cellular endpoint or LTE enabled gateway for Particle Mesh networks. It is based on the Nordic nRF52840 micro-controller.

The B Series is designed to be integrated into your circuit board design, plugging a M.2 NGFF connector on your board, allowing the module to be changed or upgraded easily.

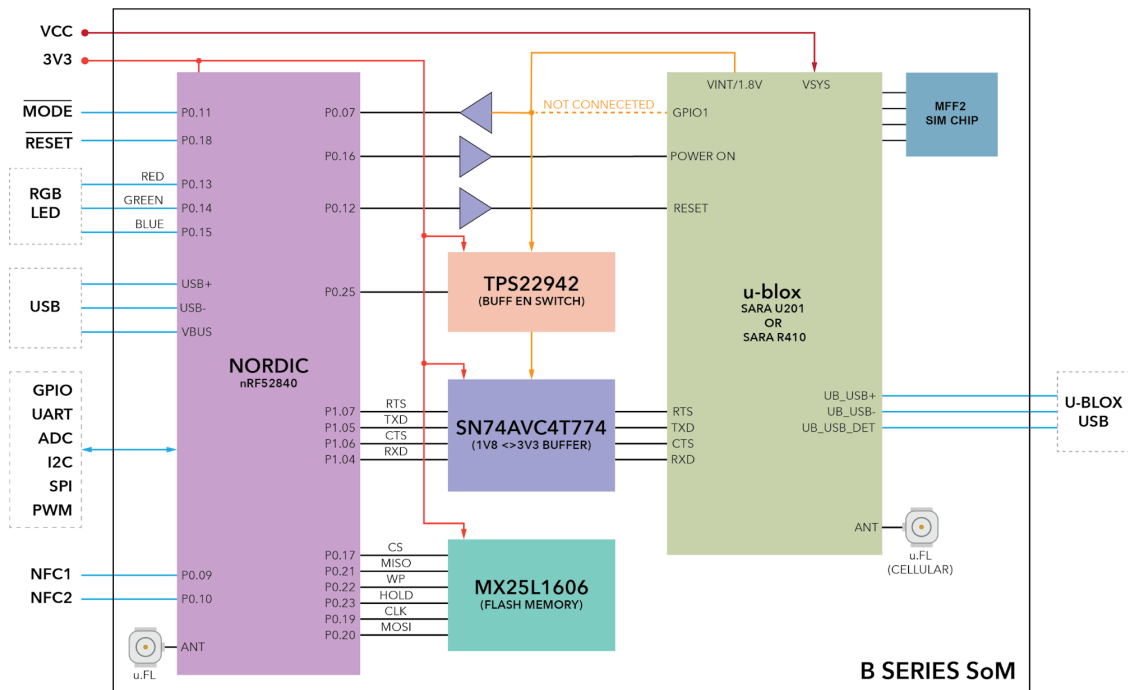
## FEATURES

---

- u-blox SARA-R410-02B LTE modem (Boron LTE)
  - LTE CAT M1 module with global hardware support (MVNO support for US only)
  - 3GPP Release 13 LTE Cat M1
  - Cat M1 bands: 2, 3, 4, 5, 8, 12, 13, 20, 28
- Nordic Semiconductor nRF52840 SoC
  - ARM Cortex-M4F 32-bit processor @ 64MHz
  - 1MB flash, 256KB RAM
  - IEEE 802.15.4-2006: 250 Kbps
  - 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
- On-module additional 4MB SPI flash
- 24 mixed signal GPIO (8 x Analog, 4 x PWM), UART, I2C, SPI
- USB 2.0 full speed (12 Mbps)
- JTAG (SWD) pins
- RGB status pins for LED
- Reset and Mode pins for buttons
- On-module MFF2 SIM
- Two on-module u.FL connectors for external antennas
- M.2 interface
- FCC and PTCRB certified
- RoHS compliant (lead-free)

# Interfaces

## BLOCK DIAGRAM



## POWER

### VCC

VCC is used to supply power to the u-blox SARA-R410M cellular module. The recommended input voltage range on this pin is between 3.6V to 4.2V DC. Make sure that the supply can handle currents of at least 2 A.

### 3V3

3V3 is used to supply power to mesh system (nRF52840, logic ICs, memory, etc.) and 3.3v is recommended. VCC input voltage range is between 3V to 3.6V DC. Make sure that the supply can handle currents of at least 150mA.

### VBus

VBus is connected to the USB detect pin of nRF52840 to enables the USB interface. The recommended input voltage range is between 4.35V to 5.5V DC.

## ANTENNA

---

There are two radios on the B402 module. A Mesh radio (nRF52840) and a cellular radio (u-blox). We have provided two u.FL connectors to plug in the cellular and Mesh antenna. These are required if you wish to use the cellular and Mesh connectivity.

- 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 mesh 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	24 (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	4 (max)	O
NFC	1	O

There are some optional B402 module specific I/O:

- External SIM card connector
- u-blox USB and VBUS (for u-blox firmware upgrades)

**Note:** All GPIOs are only rated at 3.3VDC max.

## JTAG AND SWD

---

The B402 module has 4 pads at the bottom exposing the SWD interface of the nRF52840. This interface can be used to debug your code or reprogram your E402 bootloader, device OS, or the user firmware. We use 4 pogo-pins connecting to these pads during production for firmware flashing.

# 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)**

---

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

# Pins and button definitions

## PINOUT DIAGRAM

PARTICLE MESH SOM				
BORON				
	H1	H3		
	H5			
VCC	2	1	GND	
VCC	4	3	GND	
VCC	6	5	GND	
VCC	8	7	GND	
3V3	10	9	GND	
3V3	12	11	USB D+	
RESERVED	14	13	USB D-	
VUSB	16	15	GND	
RESERVED	18	17	NFC1	
SCL	20	19	NFC2	
SDA	22	21	GND	
KEY	23		ADC0	
MODE	32	33	ADC1	
RESET	34	35	ADC2	
TX	36	37	ADC3	
RX	38	39	AGND	
CTS	40	41	ADC4	
RTS	42	43	ADC5	
u-blox USB+	44	45	ADC6	
u-blox USB-	46	47	ADC7	
CS	48	49	AGND	
MISO	50	51	RESERVED	
MOSI	52	53	RESERVED	
SCK	54	55	RESERVED	
GND	56	57	RESERVED	
RESERVED	58	59	RESERVED	
RESERVED	60	61	RED	
GPIO0	62	63	GREEN	
GPIO1	64	65	BLUE	
PWM0	66	67	SIM_VCC	
PWM1	68	69	SIM_RST	
PWM2	70	71	SIM_CLK	
PWM3	72	73	SIM_DATA	
u-blox VBUS	74	75	NC	
	H2	H4		

Pins SOM0 to SOM9 will vary across various SoM modules. For example, cellular-specific pins exists in this range.

Additionally there are reserved pins, whose functions vary depending on the SoM. For example, nRF52 MCU-based modules use some of these pins for additional ADC and GPIO.

For maximum cross-module flexibility, you should try to use only the common pins when possible.

## PIN DESCRIPTION

#	Pin	Common	Function	Description
1	GND	GND	POWER	System ground.
2	VCC	VCC	POWER	System power in, connect to the +LiPo or supply a fixed 3.6-4.2v power.
3	GND	GND	POWER	System ground.
4	VCC	VCC	POWER	System power in, connect to the +LiPo or supply a fixed 3.6-4.2v power.
5	GND	GND	POWER	System ground.
6	VCC	VCC	POWER	System power in, connect to the +LiPo or supply a fixed 3.6-4.2v power.
7	GND	GND	POWER	System ground.
8	VCC	VCC	POWER	System power in, connect to the +LiPo or supply a fixed 3.6-4.2v power.
9	GND	GND	POWER	System ground.
10	3V3	3V3	POWER	System power in, supply a fixed 3.0-3.6v power.
11	USB D+	USB D+	IO	Data+ pin of the NRF52840 USB port.
12	3V3	3V3	POWER	System power in, supply a fixed 3.0-3.6v power.
13	USB D-	USB D-	IO	Data- pin of the NRF52840 USB port.
14	NC	RESERVED <sup>3</sup>	NC	Leave unconnected.

15	GND	GND	POWER	System ground.
16	VUSB	VUSB	POWER	System power in, USB detect pin for nRF52840. 5V on this pin enables the USB interface.
17	NFC1	SOM3 <sup>3</sup>	NFC input	NFC antenna connection.
18	NC	RESERVED <sup>3</sup>	NC	Leave unconnected.
19	NFC2	SOM4 <sup>3</sup>	NFC input	NFC antenna connection.
20	D1	SCL	IO	I2C SCL, and digital only GPIO.
21	GND	GND	POWER	System ground.
22	D0	SDA	IO	I2C SDA, and digital only GPIO.
23	A0	ADC0	IO	Analog input ADC0 <sup>2</sup> , and digital GPIO.
32	MODE	MODE	IO	Connected to the MODE button input, and digital only GPIO.
33	A1	ADC1	IO	Analog input ADC1 <sup>2</sup> , and digital GPIO.
34	RESET	RESET	I	Active-low reset input.
35	A2	ADC2	IO	Analog input ADC2 <sup>2</sup> , and digital GPIO.
36	D9	TX	IO	Primarily used as UART TX, but can also be used as a digital GPIO.
37	A3	ADC3	IO	Analog input ADC3 <sup>2</sup> , and digital GPIO.
38	D10	RX	IO	Primarily used as UART RX, but can also be used as a digital GPIO.
39	AGND	AGND	POWER	System analog ground.
40	D3	RESERVED <sup>3</sup>	IO	UART flow control interface CTS, and digital only GPIO.
41	A4	RESERVED <sup>3</sup>	IO	Analog input ADC4 <sup>2</sup> , and digital GPIO.
42	D2	RESERVED <sup>3</sup>	IO	UART flow control interface RTS, and digital only GPIO.
43	A5	RESERVED <sup>3</sup>	IO	Analog input ADC5 <sup>2</sup> , and digital GPIO.
44	u-blox USB D+	SOM0	IO	Data+ pin of the R410M USB port.
45	A6	RESERVED <sup>3</sup>	IO	Analog input ADC6 <sup>2</sup> , and digital GPIO.
46	u-blox USB D-	SOM1	IO	Data- pin of the R410M USB port.
47	A7	RESERVED <sup>3</sup>	IO	Analog input ADC7 <sup>2</sup> , and digital GPIO.
48	D8	CS	IO	SPI interface CS, and digital only GPIO.
49	AGND	AGND	POWER	System analog ground.
50	D11	MISO	IO	SPI interface MISO, and digital only GPIO.
51	NC	RESERVED <sup>3</sup>	NC	Leave unconnected.
52	D12	MOSI	IO	SPI interface MOSI, and digital only GPIO.
53	NC	RESERVED <sup>3</sup>	NC	Leave unconnected.
54	D13	SCK	IO	SPI interface SCK, and digital only GPIO.
55	NC	RESERVED <sup>3</sup>	NC	Leave unconnected.
56	GND	GND	POWER	System analog ground.
57	NC	RESERVED <sup>3</sup>	NC	Leave unconnected.
58	NC	RESERVED <sup>3</sup>	NC	Leave unconnected.
59	NC	RESERVED <sup>3</sup>	NC	Leave unconnected.
60	NC	RESERVED <sup>3</sup>	NC	Leave unconnected.
61	RGBR	RED	IO	Red pin of the RGB LED.
62	D22	GPIO0	IO	GPIO0, digital only.
63	RGBG	GREEN	IO	Green pin of the RGB LED.

64	D23	GPIO1	IO	GPIO1, digital only.
65	RGBB	BLUE	IO	Blue pin of the RGB LED.
66	D4	PWM0	IO	Digital only GPIO, and PWM0.
67	SIM_VCC <sup>1</sup>	SOM5 <sup>3</sup>	POWER	Default open, 1.8V/3V SIM Supply Output from R410M.
68	D5	PWM1	IO	Digital only GPIO, and PWM1.
69	SIM_RST <sup>1</sup>	SOM6 <sup>3</sup>	IO	1.8V/3V SIM Reset Output from R410M.
70	D6	PWM2	IO	Digital only GPIO, and PWM2.
71	SIM_CLK <sup>1</sup>	SOM7 <sup>3</sup>	IO	Default open, 1.8V/3V SIM Clock Output from R410M.
72	D7	PWM3	IO	Digital only GPIO, and PWM3.
73	SIM_DATA <sup>1</sup>	SOM8 <sup>3</sup>	IO	Default open, 1.8V/3V SIM Data I/O of R410m with internal 4.7 k pull-up, Connect to SIM card Data PINs.
74	u-blox VBUS	SOM2 <sup>3</sup>	IO	USB detect pin for R410M. 5V on this pin enables the u-blox USB interface.
75	NC	SOM9 <sup>3</sup>	NC	Leave unconnected.

Note 1: By default, these pins are connected to the internal MFF2 SIM and should be left open. If the internal SIM is disabled, then these pins can be used with an external SIM card.

Note 2: A0-A7 are 12-bit Analog-to-Digital (A/D) inputs (0-4095).

Note 3: SoM-specific and Reserved pins will vary depending on module.

## LED STATUS

### System RGB LED

Unlike the Boron, the B402 module 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.

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



# Technical specifications

## ABSOLUTE MAXIMUM RATINGS <sup>[1]</sup>

### Supply voltages

Parameter	Symbol	Min	Typ	Max	Unit
<b>Supply voltages</b>					
Supply Input Voltage	VCC	-0.3		+6.0	V
Supply Input Voltage	3V3	-0.3		+3.9	V
VBUS USB supply voltage	VUSB	-0.3		+5.8	V
<b>I/O pin voltage</b>					
VI/O, VDD ≤ 3.6 V	IO	-0.3		VDD + 0.3	V
VI/O, VDD > 3.6 V	IO	-0.3		+3.9	V
<b>NFC antenna pin current</b>					
I <sub>NFC1/2</sub>	NFC1/NFC2			80	mA
<b>Radio</b>					
BT RF input level (52840)				10	dBm
<b>Environmental</b>					
Storage temperature		-40		+85	°C

<sup>[1]</sup> 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
<b>Supply voltages</b>					
Supply Input Voltage	VCC	+3.6	+3.8	+4.2	V
Supply Input Voltage	3V3	+3.0	+3.3	+3.6	V
VBUS USB supply voltage	VUSB	+4.35	+5.0	+5.5	V
<b>Environmental</b>					
Normal operating temperature <sup>1</sup>		-20	+25	+65	°C
Extended operating temperature <sup>2</sup>		-40		+85	°C
Humidity Range Non condensing, relative humidity				95	%

### Notes:

<sup>1</sup> Normal operating temperature range (fully functional and meet 3GPP specifications).

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

## RADIO SPECIFICATIONS

---

Boron has two radio modules.

### nRF52840

- Bluetooth® 5, IEEE 802.15.4-2006, 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

### u-blox SARA-R410M-02-B

Parameter	Value
Protocol stack	3GPP Release 13
RAT	LTE Cat M1 Half-Duplex
LTE FDD Bands	Band 12 (700 MHz)
	Band 17 (700 MHz)
	Band 28 (700 MHz)
	Band 13 (750 MHz)
	Band 20 (800 MHz)
	Band 26 (850 MHz)
	Band 18 (850 MHz)
	Band 5 (850 MHz)
	Band 19 (850 MHz)
	Band 8 (900 MHz)
	Band 4 (1700 MHz)
	Band 3 (1800 MHz)
	Band 2 (1900 MHz)
	Band 25 (1900 MHz)
	Band 1 (2100 MHz)
LTE TDD bands	Band 39 (1900 MHz)
Power class	Class 3 (23 dBm)

## 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 <sup>1</sup>		9		ns
tRF,25pF	Rise/fall time, standard drive mode, 10-90%, 25 pF load <sup>1</sup>		13		ns
tRF,50pF	Rise/fall time, standard drive mode, 10-90%, 50 pF load <sup>1</sup>		25		ns
tHRF,15pF	Rise/Fall time, high drive mode, 10-90%, 15 pF load <sup>1</sup>		4		ns
tHRF,25pF	Rise/Fall time, high drive mode, 10-90%, 25 pF load <sup>1</sup>		5		ns
tHRF,50pF	Rise/Fall time, high drive mode, 10-90%, 50 pF load <sup>1</sup>		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

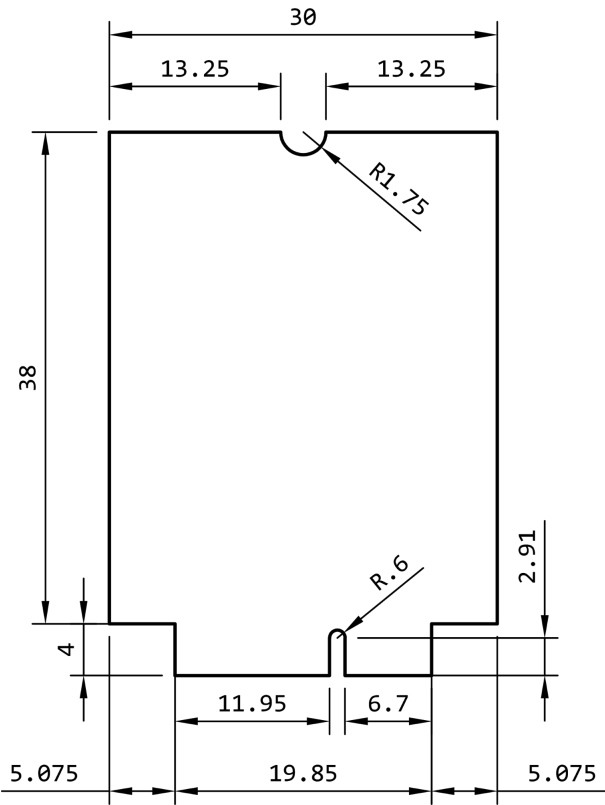
<sup>1</sup>Rise and fall times based on simulations

# Mechanical specifications

## DIMENSIONS AND WEIGHT

Parameters	Value	Unit
Width	30	mm
Height	42	mm
Thickness	5.5	mm
Weight	6.2	grams

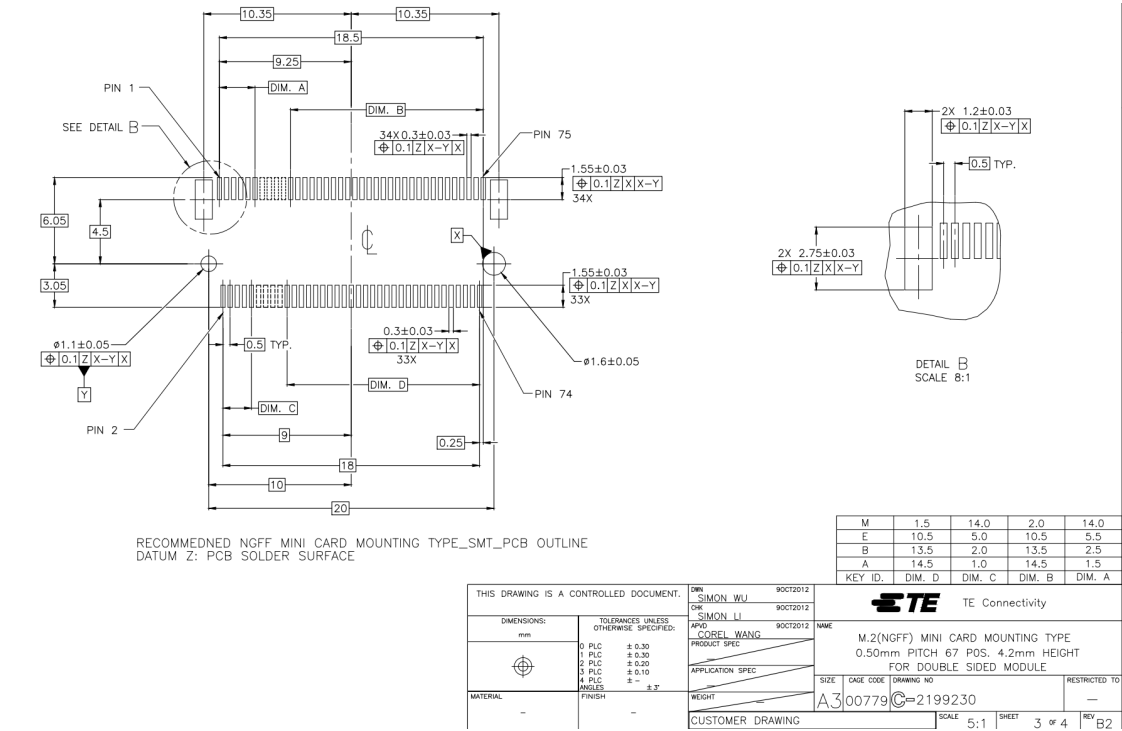
## MECHANICAL DRAWING

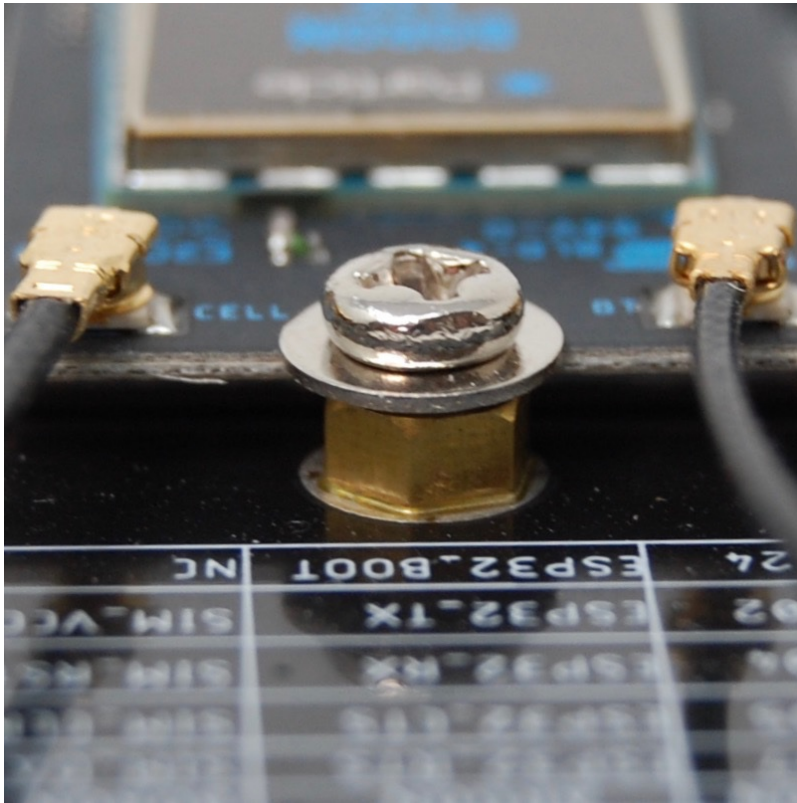


MATING CONNECTOR AND LAND PATTERN

The mating connector is a an M.2 (NGFF) type 4. Note that there are several different key configurations for the M.2, and type 4 is different than is commonly used on SSDs.

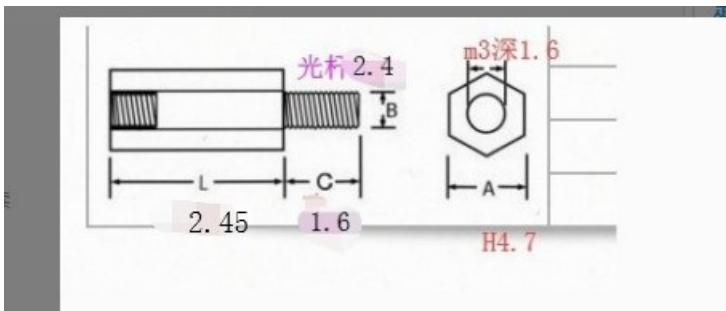
One compatible connector is the [TE 2199230-4](#). It is widely available including at suppliers such as [Digikey](#).





We recommend this screw assembly to securely affix the B series SoM to your circuit board. From top to bottom:

- M3 screw, 3\*3mm
- M3 washer
- M3 standoff, 2.45mm



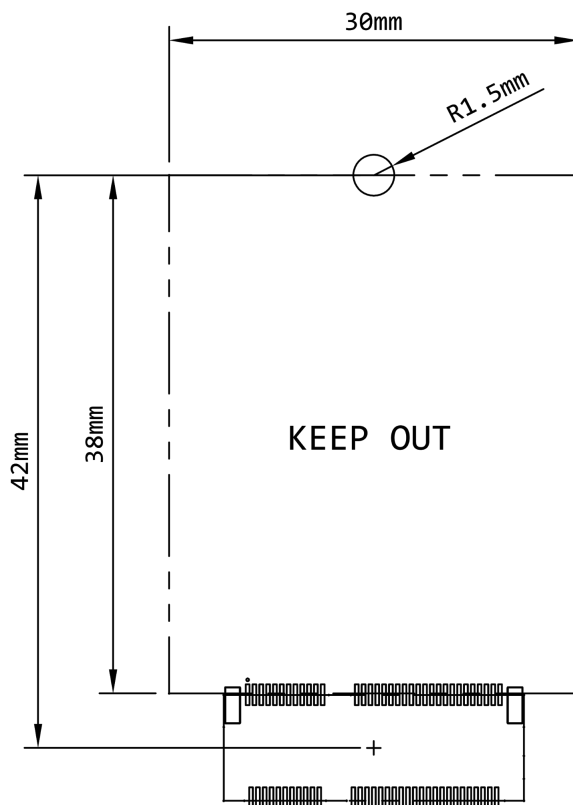
- Mounting hole, 2.6 mm metal hole, 3.1mm metal ring diameter (picture is of the bottom side of the circuit board)



#### DESIGN CONSIDERATIONS

---

We strongly recommend against placing components under the SOM board because there is not enough height.



# Product Handling

## **ESD PRECAUTIONS**

---

The B series contains highly sensitive electronic circuitry and is an Electrostatic Sensitive Device (ESD). Handling an B series 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 B series 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 B series!

## **CONNECTORS**

---

The u.FL antenna connectors are a very fragile piece of hardware (and is fancy too with all the gold plating). The connector was not designed to be constantly plugged and unplugged. Care must be taken not to put stress on it at any time (yes, swinging the B series by the antenna is a very bad idea, this is not your cat). The antenna pin is also the most static sensitive and you can destroy the radio with improper handling. If you are feeling adventurous, we highly recommend putting a tiny dab of glue (epoxy, rubber cement, liquid tape or hot glue) on the connector to securely hold the plug in place.

The M.2 edge connector is static sensitive and should be handled carefully. The M.2 connector is not designed for repeated removal and insertion of the module.



## Default settings

The B series 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
draft-001	07 Mar 2019	RK	Initial draft
draft-002	09 Mar 2019	RK	Removed empty sections
draft-003	15 Mar 2019	RK	Updated mechanical drawings
draft-004	18 Mar 2019	RK	Updated top picture
draft-005	21 Mar 2019	RK	Added generic pin column