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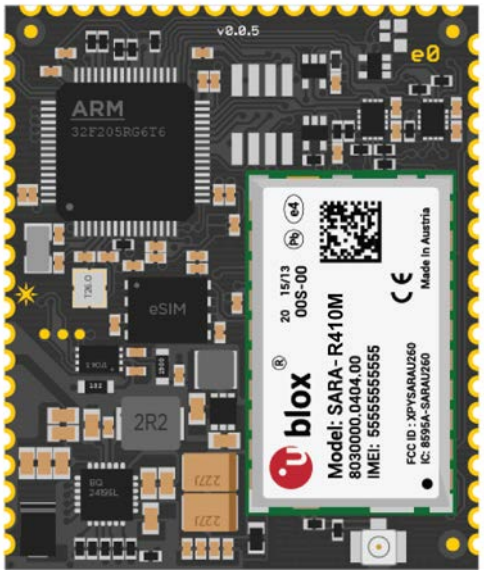
Particle E402 User Manual



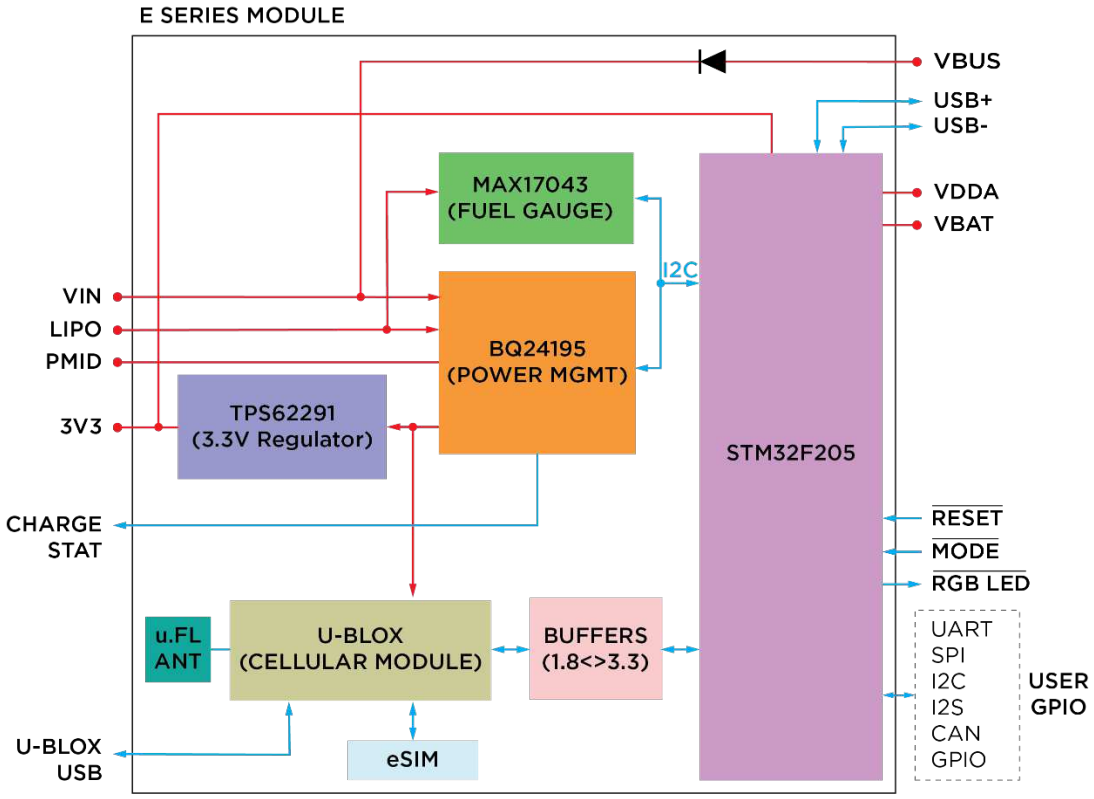
Overview

The Particle E402 is an IOT hardware platform for creating cellular-connected products. The E402 supports LTE M1 connectivity. It is specifically designed for mass scale manufacturing and integration. It comes with an affordable data plan for low-bandwidth applications.

It also comes with Particle's development tools and cloud platform for managing and interacting with your new connected hardware.

Features

- U-blox SARA-R410M-02B cellular module
- STM32F205RGT6 120MHz ARM Cortex M3 microcontroller
- 1MB flash, 128KB RAM
- BQ24195 power management unit and battery charger
- MAX17043 fuel gauge
- 30 mixed-signal GPIO and advanced peripherals
- Open source design
- Real-time operation system (RTOS)
- FCC, CE and IC certified



Power

The E402 can be powered via the VIN (3.88V-12VDC) pin, over USB, or a LiPo battery.

VIN

The input voltage range on VIN pin is 3.88VDC to 12VDC. When powering from the VIN pin alone, make sure that the power supply is rated at 10W (for example 5 VDC at 2 Amp). If the power source is unable to meet this requirement, you'll need connect the LiPo battery as well. An additional bulk capacitance of 470uF to 1000uF should be added to the VIN input when the LiPo Battery is disconnected. The amount of capacitance required will depend on the ability of the power supply to deliver peak currents to the cellular modem.

LIPO

This pin serves two purposes. You can use this pin to connect a LiPo battery directly without having to use a JST connector or it can be used to connect an external DC power source (and this is where one needs to take extra precautions). When powering it from an external regulated DC source, the recommended input voltage range on this pin is between 3.6V to 4.4VDC. Make sure that the supply can handle currents of at least 1Amp. This is the most efficient way of powering the E402 since the PMIC by-passes the regulator and supplies power to the E402 via an internal FET leading to lower quiescent current.

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 E402 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 0.8A transients at 5VDC. In deep sleep mode, the quiescent current is 90uA (powered from the battery alone).

VBUS

This pin is internally connected to USB supply rail and will output 5V when the E402 is plugged into an USB port. It is intentionally left unpopulated. This pin will *NOT* output any voltage when the E402 is powered via VIN and/or the LiPo battery.

Most USB ports can supply only a maximum of 500mA, but the u-blox module on the E402 alone can consume a peak of 800mA of current during transmission. In order to compensate of this deficit, one must connect the LiPo battery at all times when powering from a traditional USB port. The E402 will intelligently source power from the USB most of the time and keep the battery charged. During peak current requirements, the additional power will be sourced from the battery. This reduces the charge-discharge cycle load on the battery, thus improving its longevity.

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 or the Core, this pin *CANNOT* be used as an input to power the E402.

VDDA

Unlike the Electron, the E402 exposes the VDDA pin of the STM32 microcontroller separately. This pin powers the ADC block of the microcontroller. A maximum difference of 300 mV between VDD (in this case, 3V3) and VDDA can be tolerated during power-up and power-down operation. Under normal operations, connect the VDDA to 3V3 pin of the E402

VBAT

This is the supply to the internal RTC, backup registers and SRAM. You can connect a backup battery to it (1.65 to 3.6VDC), if you wish to retain RTC/RAM when 3V3 is absent or simply tie it up to 3V3.

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 E402 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.

JTAG AND SWD

Pin D3 through D7 are JTAG interface pins. These can be used to reprogram your E402 bootloader or user firmware image with standard JTAG tools such as the ST-Link v2, J-Link, R-Link, OLIMEX ARM-USB-TINI-H, and also the FTDI-based Particle JTAG Programmer. If you are short on available pins, you may also use SWD mode which requires less pins.

E402 Pin	JTAG	SWD	STM32F205RGT6 Pin	Default Internal[1]
D7	JTAG_TMS	SWD/SWDIO	PA13	~40k pull-up
D6	JTAG_TCK	CLK/SWCLK	PA14	~40k pull-down
D5	JTAG_TDI		PA15	~40k pull-up
D4	JTAG_TDO		PB3	Floating
D3	JTAG_TRST		PB4	~40k pull-up
3V3	Power			
GND	Ground			
RST	Reset			

Notes: [1] Default state after reset for a short period of time before these pins are restored to GPIO (if JTAG debugging is not required, i.e. `USE_SWD_JTAG=y` is not specified on the command line.)

Memory Map

STM32F205RGT6 Flash Layout Overview

- Bootloader (16 KB)
- DCD1 (16 KB), stores keys, mfg info, system flags, etc.
- DCD2 (16 KB), swap area for DCD1
- EEPROM emulation bank 1 (16 KB)
- EEPROM emulation bank 2 (64 KB) [only 16k used]
- Device OS (512 KB) [256 KB comms + 256 KB hal/platform/services]
- Factory backup, OTA backup and user application (384 KB) [3 x 128 KB]

DCD Layout

The DCD area of flash memory has been mapped to a separate DFU media device so that we can incrementally update the application data. This allows one item (say, server public key) to be updated without erasing the other items.

DCD layout as of v0.4.9 found here in firmware

Region	Offset	Size
system flags	0	32
version	32	2
device private key	34	1216
device public key	1250	384
ip config	1634	128
claim code	1762	63
claimed	1825	1
device id	1852	6
version string	1858	32
dns resolve	1890	128
reserved1	2018	64

Region	Offset	Size
server public key	2082	768
padding	2850	2
flash modules	2852	100
product store	2952	24
cloud transport	2977	1
alt device public key	2978	128
alt device private key	3106	192
alt server public key	3298	192
alt server address	3490	128
reserved2	3618	1280

Note: Writing 0xFF to offset 3106 (DEFAULT key used on E402) will cause the device to re-generate a new private UDP/ECC key on the next boot. TCP keys are currently unsupported on the E402 but would be located at offset 34. You should not need to use this feature unless your keys are corrupted.

Memory Map (Common)

Region	Start Address	End Address	Size
Bootloader	0x8000000	0x8004000	16 KB
DCD1	0x8004000	0x8008000	16 KB
DCD2	0x8008000	0x800C000	16 KB
EEPROM1	0x800C000	0x8010000	16 KB
EEPROM2	0x8010000	0x8020000	64 KB

Memory Map (Modular Firmware - default)

Before 0.6.0 firmware

Region	Start Address	End Address	Size
System Part 1	0x8020000	0x8040000	128 KB
System Part 2	0x8040000	0x8060000	128 KB
Application	0x8080000	0x80A0000	128 KB
Factory Reset/Extended Application	0x80A0000	0x80C0000	128 KB
OTA Backup	0x80C0000	0x80E0000	128 KB
Decompress region	0x80E0000	0x8100000	128 KB

Since 0.6.0 firmware

Region	Start Address	End Address	Size
System Part 2	0x8020000	0x8040000	128 KB
System Part 3	0x8040000	0x8060000	128 KB
System Part 1	0x8060000	0x8080000	128 KB
Application	0x8080000	0x80A0000	128 KB

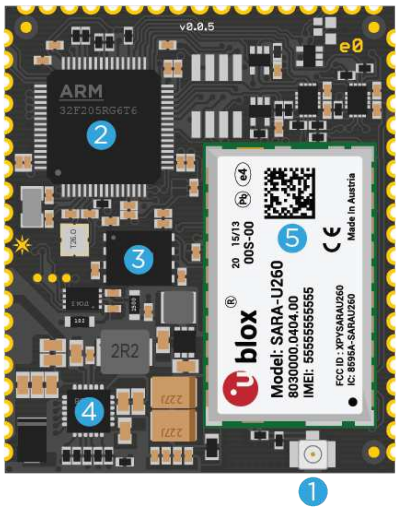
Region	Start Address	End Address	Size
Factory Reset/Extended Application	0x80A0000	0x80C0000	128 KB
OTA Backup	0x80C0000	0x80E0000	128 KB
Decompress region	0x80E0000	0x8100000	128 KB

Memory Map (Monolithic Firmware - optional)

Region	Start Address	End Address	Size
Firmware	0x8020000	0x8080000	384 KB
Factory Reset	0x8080000	0x80E0000	384 KB
Unused (factory reset modular)	0x80E0000	0x8100000	128 KB

Pin and button definition

Pin markings:



1. u.FL ANT CONN.
2. STM32 MICRO
3. eSIM CHIP
4. PMIC
5. u-blox CELL MODULE

LED Status

Charge status LED

State	Description
ON	Charging in progress
OFF	Charging complete
Blink at 1Hz	Fault condition[1]
Rapid blinking	Battery disconnected[2]

Notes:

[1] A fault condition can occur due to several reasons, for example, battery over/under voltage, temperature fault or safety timer fault. You can find the root cause by reading the fault register of the power management IC in firmware.

[2] You can stop this behavior by either plugging in the LiPo battery or by disabling the charging using the appropriate firmware command.

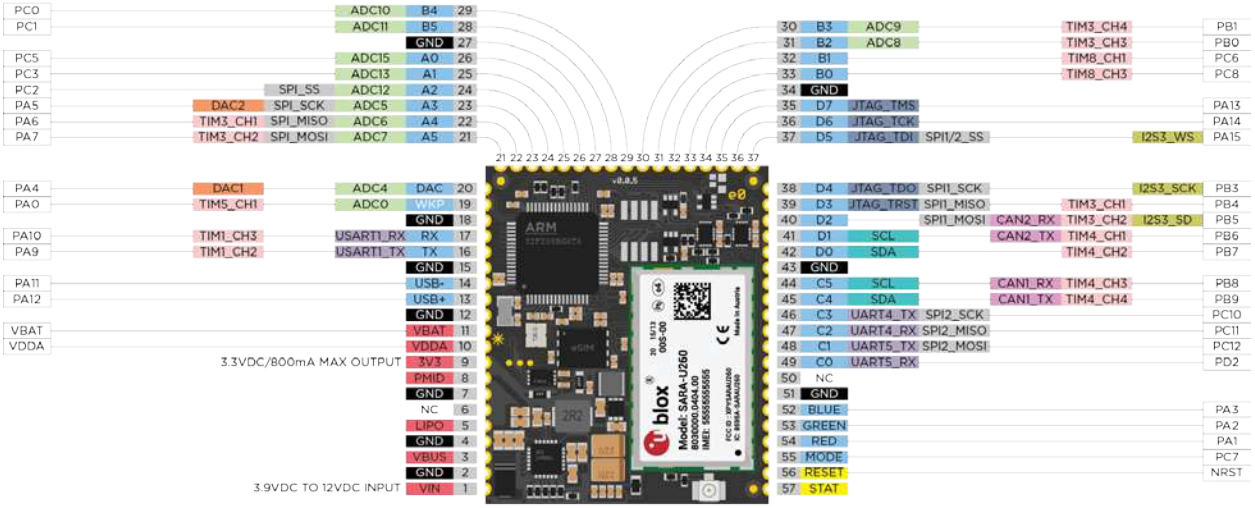
System RGB LED

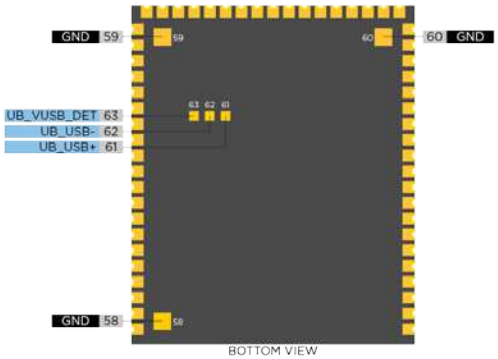
Unlike the Electron, the E402 does not have an on-board RGB status LED. We have provided its individual control pins for you to connect an LED of your liking. This will allow greater flexibility in the end design of your products.

For a detailed explanation of different color codes of the RGB system LED, please take a look here.

Pin description

PARTICLE E SERIES PIN MAP v004





#	PIN	FUNCTION	DESCRIPTION
1	VIN	POWER	This pin can be used as an input or output. As an input, supply 5VDC to 12VDC to power the Electron. When the Electron is powered via the USB port, this pin will output a voltage of approximately 4.8VDC due to a reverse polarity protection series Schottky diode between VBUS and VIN. When used as an output, the max load on VIN is 1Amp.
2	GND	POWER	System ground.
3	VBUS	POWER	This is connected to the VBUS power pin of the USB port.
4	GND	POWER	System ground.
5	LIPO	POWER	This is connected to the +LiPo connector.
6	NC	TBD	Do not connect.
7	GND	POWER	System ground.
8	PMID	POWER	This is connected to the PMID pin of the PMIC.
9	3V3	POWER	This is the output of the 3V3 regulator on the E0.
10	VDDA	POWER	This is the input to the analog block of the STM32.
11	VBAT	POWER	Supply to the internal RTC, backup registers and SRAM when 3V3 is not present (1.65 to 3.6VDC).
12	GND	POWER	System ground.
13	USB+	IO	Data+ pin of the USB port.
14	USB-	IO	Data- pin of the USB port.
15	GND	POWER	System ground.
16	TX	IO	Primarily used as UART TX, but can also be used as a digital GPIO or PWM.
17	RX	IO	Primarily used as UART RX, but can also be used as a digital GPIO or PWM.
18	GND	POWER	System ground.
19	WKP	IO	Active-high wakeup pin, wakes the from sleep/standby modes. When not used as a WAKEUP, this pin can also be used as a digital GPIO, ADC input or PWM. Can be referred to as A7 when used as an ADC.

#	PIN	FUNCTION	DESCRIPTION
20	DAC	IO	12-bit Digital-to-Analog (D/A) output (0-4095), referred to as DAC or DAC1 in software. Can also be used as a digital GPIO or ADC. Can be referred to as A6 when used as an ADC.
21	A5	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), and also digital GPIOs.
22	A4	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), and also digital GPIOs.
23	A3	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), and also digital GPIOs.
24	A2	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), and also digital GPIOs.
25	A1	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), and also digital GPIOs.
26	A0	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), and also digital GPIOs.
27	GND	POWER	System ground.
28	B5	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), and also digital GPIOs.
29	B4	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), and also digital GPIOs.
30	B3	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), PWM and also digital GPIOs.
31	B2	IO	12-bit Analog-to-Digital (A/D) inputs (0-4095), PWM and also digital GPIOs.
32	B1	IO	Digital only GPIO, and PWM.
33	B0	IO	Digital only GPIO, and PWM.
34	GND	POWER	System ground.
35	D7	IO	Digital only GPIO.
36	D6	IO	Digital only GPIO.
37	D5	IO	Digital only GPIO.
38	D4	IO	Digital only GPIO.

#	PIN	FUNCTION	DESCRIPTION
39	D3	IO	Digital only GPIO, and PWM.
40	D2	IO	Digital only GPIO, and PWM.
41	D1	IO	Digital only GPIO, and PWM.
42	D0	IO	Digital only GPIO, and PWM.
43	GND	POWER	System ground.
44	C5	IO	Digital only GPIO, and PWM.
45	C4	IO	Digital only GPIO, and PWM.
46	C3	IO	Digital only GPIO.
47	C2	IO	Digital only GPIO.
48	C1	IO	Digital only GPIO.
49	C0	IO	Digital only GPIO.
50	NC	TBD	Do not connect.
51	GND	POWER	System ground.
52	BLU	IO	Blue pin of the RGB LED.
53	GRN	IO	Green pin of the RGB LED.
54	RED	IO	Red pin of the RGB LED.
55	MODE	IO	Connected to the MODE button input.
56	RST	I	Active-low reset input.
57	STAT	O	Connected to the charge status pin of the PMIC.
58	GND	POWER	System ground.
59	GND	POWER	System ground.
60	GND	POWER	System ground.
61	UB_USB+	IO	Data+ pin of the ublox USB port.
62	UB_USB-	IO	Data- pin of the ublox USB port.
63	UB_VUSB_DET	IO	USB detect pin of the ublox USB port. 5V on this pin enables the ublox's USB interface.

[1] PWM is available on D0, D1, D2, D3, B0, B1, B2, B3, A4, A5, WKP, RX, TX with a caveat: PWM timer peripheral is duplicated on two pins (A5/D2) and (A4/D3) for 11 total independent PWM outputs. For example: PWM may be used on A5 while D2 is used as a GPIO, or D2 as a PWM while A5 is used as an analog input. However A5 and D2 cannot be used as independently controlled PWM outputs at the same time.

I/O Characteristics

These specifications are based on the STM32F205RGT6 datasheet, with reference to E402 pin nomenclature.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Standard I/O input low level voltage	V_{IL}		-0.3		0.28*(V_{3V3}-2)+0.8	V
I/O FT[1] input low level voltage	V_{IL}		-0.3		0.32*(V_{3V3}-2)+0.75	V
Standard I/O input high level voltage	V_{IH}		0.41*(V_{3V3}-2)+1.3		V_{3V3}+0.3	V
I/O FT[1] input high level voltage	V_{IH}	V_{3V3} > 2V	0.42*(V_{3V3}-2)+1		5.5	V
	V_{IH}	V_{3V3} ≤ 2V	0.42*(V_{3V3}-2)+1		5.2	V
Standard I/O Schmitt trigger voltage hysteresis[2]	V_{hys}		200			mV
I/O FT Schmitt trigger voltage hysteresis[2]	V_{hys}		5% V_{3V3}[3]			mV
Input leakage current[4]	I_{lkg}	GND ≤ V_{io} ≤ V_{3V3}GPIOs			±1	µA
Input leakage current[4]	I_{lkg}	R_{PU}	V_{io} = 5V, I/O FT		3	µA
Weak pull-up equivalent resistor[5]	R_{PU}	V_{io} = GND	30	40	50	k Ω
Weak pull-down equivalent resistor[5]	R_{PD}	V_{io} = V_{3V3}	30	40	50	k Ω
I/O pin capacitance	C_{IO}			5		pF

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
DAC output voltage (buffers enabled by default)	V_{DAC}		0.2		V_{3V3}-0.2	V
DAC output resistive load (buffers enabled by default)	R_{DAC}		5			k Ω
DAC output capacitive load (buffers enabled by default)	C_{DAC}				50	pF

Notes:

[1] FT = Five-volt tolerant. In order to sustain a voltage higher than V_{3V3}+0.3 the internal pull-up/pull-down resistors must be disabled.

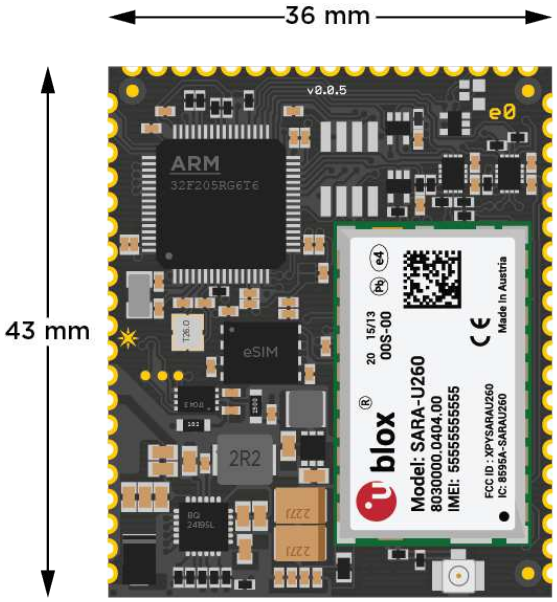
[2] Hysteresis voltage between Schmitt trigger switching levels. Based on characterization, not tested in production.

[3] With a minimum of 100mV.

[4] Leakage could be higher than max. if negative current is injected on adjacent pins.

[5] Pull-up and pull-down resistors are designed with a true resistance in series with switchable PMOS/NMOS. This PMOS/NMOS contribution to the E402 resistance is minimum (~10% order).

Mechanical Specifications



Dimensions and Weight

- Width = 36 mm
- Height = 43 mm
- Thickness = 4.6 mm
- Weight = 8 gms

Soldering

We recommend no clean solder paste over water soluble as it does not require additional cleaning processes.

Alloy specification

- 95.5% Sn / 3.9% Ag / 0.6% Cu (95.5% Tin / 3.9% Silver / 0.6% Copper)
- 95.5% Sn / 4.0% Ag / 0.5% Cu (95.5% Tin / 4.0% Silver / 0.5% Copper)

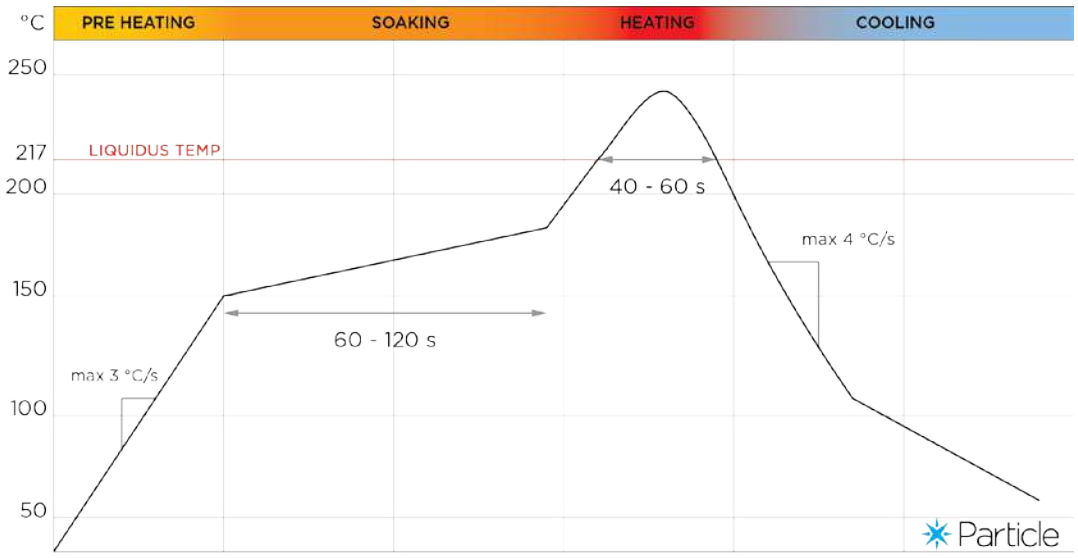
Melting temperature: 217 °C

Stencil thickness: 150 micrometer

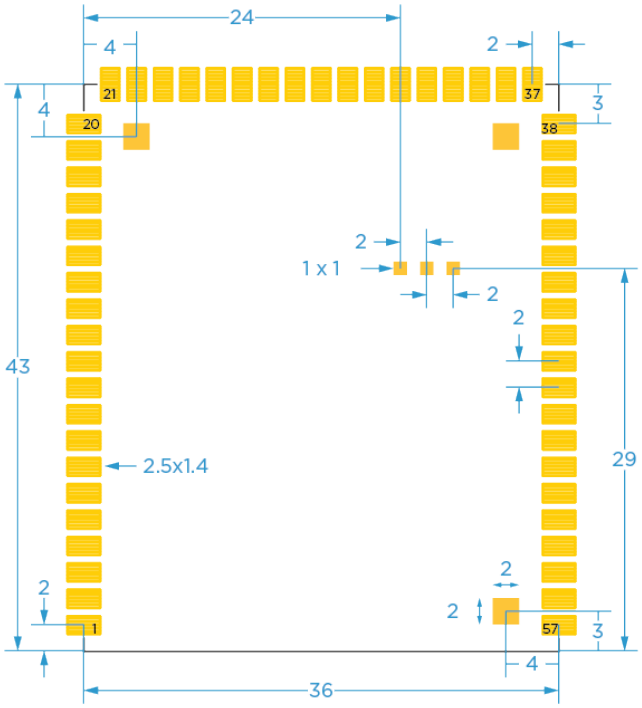
Reflow

We recommend a three phase convection reflow oven process. Please refer to IPC-7530 guidelines for in depth details on reflow temperature profiles.

Typical reflow profile for a Pb free solder paste:



Recommended PCB land pattern



* ALL DIMENSIONS IN MM