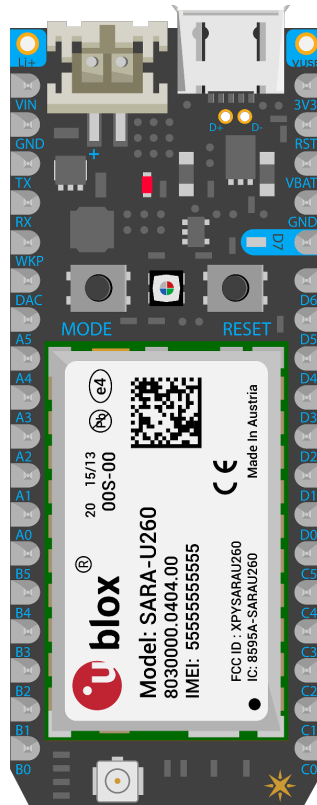


# Electron Datasheet (v007)



# Functional description

## OVERVIEW

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The Electron is a tiny development kit for creating cellular-connected electronics projects and products. It comes with a SIM card (Nano 4FF)<sup>[1]</sup> and an affordable data plan for low-bandwidth things. Plus it's available for more than 100 countries worldwide!

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

## FEATURES

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- U-blox SARA-U260/U270 (3G with 2G fallback), G350 (2G), or R410M (LTE Cat M1) cellular module
- STM32F205RGT6 120MHz ARM Cortex M3 microcontroller
- 1MB flash, 128KB RAM
- BQ24195 power management unit and battery charger
- MAX17043 fuel gauge
- RGB status LED
- 30 mixed-signal GPIO and advanced peripherals
- Open source design
- Real-time operation system (RTOS)
- FCC, CE and IC certified

<sup>[1]</sup>The LTE model uses a MFF2 SMD Particle SIM instead of a physical SIM card. The Electron LTE is only available to existing enterprise customers who have deployed an Electron 2G/3G solution and would like to upgrade to LTE. It is only available in tray quantities. New designs should use the Boron LTE or B Series B402 SoM. It can only be used in the United States, Canada, and Mexico at this time.

# Interfaces

## BLOCK DIAGRAM



## POWER

The Electron can be powered via the VIN (3.9V-12VDC) pin, the USB Micro B connector or a LiPo battery.

### USB

Most USB ports can supply only a maximum of 500mA, but the u-Blox GSM module on the Electron alone can consume a peak of 800mA to 1800mA (2G/3G) or 490 mA (LTE) 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 for 2G/3G. The Electron 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.

### VIN

The input voltage range on VIN pin is 3.9VDC to 12VDC. When powering from the VIN pin alone, make sure that the power supply is rated at 10W (for example 5VDC at 2Amp). 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.

The Electron LTE (ELC402, LTE Cat 1) can be powered with as little as 550 mA at 5V.

### LiPo Battery

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 Electron 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).

### **Li+**

This pin is internally tied to the positive terminal of the LiPo battery connector. It is intentionally left unpopulated. Please note that an incorrect usage of this pin can render the Electron unusable.

Li+ 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 2 Amps.

This is the most efficient way of powering the Electron since the PMIC by-passes the regulator and supplies power to the Electron via an internal FET leading to lower quiescent current.

### **VUSB**

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

### **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. 3.3V will also be available on that pin while the device being in deep sleep. Unlike the Photon or the Core, this pin *CANNOT* be used as an input to power the Electron.

### **VBAT**

Supply to the internal RTC, backup registers and SRAM when 3V3 is not present (1.65 to 3.6VDC). The Pin is internally connected to 3V3 supply via a 0 ohm resistor. If you wish to power VBAT via an external supply, you'll need to remove this resistor with a desoldering iron. Contact us if you wish to request trays of electrons with this jumper depopulated.

### **Powering the Electron without a battery**

The most forgiving way to power the Electron without a battery is via the VIN input [see VIN above](#). Power may also be applied separately to the Li+ pin or LiPo JST connector [see Li+ above](#).

### **FCC APPROVED ANTENNAS**

---

Antenna Type	Manufacturer	MFG. Part #	Gain
2G/3G PCB antenna	Taoglas	<a href="#">PC104.07.0165C</a>	1dBi ~ 2.39dBi
LTE flex antenna	Taoglas	<a href="#">FXUB63.07.0150C</a>	5.00dBi peak

Peripheral Type	Qty	Input(I) / Output(O)	FT <sup>[1]</sup> / 3V3 <sup>[2]</sup>
Digital	30	I/O	FT/3V3
Analog (ADC)	12	I	3V3
Analog (DAC)	2	O	3V3
UART	3	I/O	3V3
SPI	2	I/O	3V3
I2S	1	I/O	3V3
I2C	1	I/O	FT
CAN	2	I/O	3V3 <sup>[4]</sup>
USB	1	I/O	3V3
PWM	13 <sup>3</sup>	O	3V3

**Notes:** <sup>[1]</sup> FT = 5.0V tolerant pins. All pins except A3 and DAC are 5V tolerant (when not in analog mode). If used as a 5V input the pull-up/pull-down resistor must be disabled.

<sup>[2]</sup> 3V3 = 3.3V max pins.

<sup>[3]</sup> 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.

<sup>[4]</sup> Technically these pins are 5.0V tolerant, but since you wouldn't operate them with a 5.0V transceiver it's proper to classify them as 3.3V.

## JTAG AND SWD

Pin D3 through D7 are JTAG interface pins. These can be used to reprogram your Electron 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 connections.

Electron Pin	JTAG	SWD	STM32F205RGT6 Pin	Default Internal <sup>[1]</sup>
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:** <sup>[1]</sup> 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)
- 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 in *release/stable* [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	120
feature flags	1754	4
country code	1758	4
claim code	1762	63
claimed	1825	1
ssid prefix	1826	26
device code	1852	6
version string	1858	32
dns resolve	1890	128
reserved1	2018	64
server public key	2082	768
padding	2850	2
flash modules	2852	100
product store	2952	24
antenna selection	2976	1
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
device id	3618	12
radio flags	3630	1
mode button mirror	3631	32

led mirror	3663	96
led theme	3759	64
reserved2	3823	435

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

```
// Regenerate Alternate Keys (Default)
echo -en "\xFF" > fillbyte && dfu-util -d 2b04:d00a -a 1 -s 3106 -D fillbyte
// Regenerate TCP Keys (Unsupported)
echo -en "\xFF" > fillbyte && dfu-util -d 2b04:d00a -a 1 -s 34 -D fillbyte
```

#### 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*

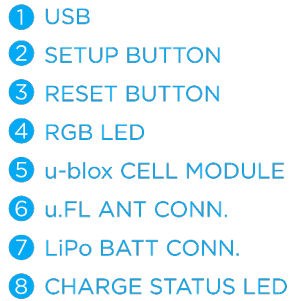
Region	Start Address	End Address	Size
System Part 2	0x8020000	0x8040000	128 KB
System Part 3	0x8040000	0x8060000	128 KB
System Part 1	0x8060000	0x8080000	128 KB
Application	0x8080000	0x80A0000	128 KB
Factory Reset/Extended Application	0x80A0000	0x80C0000	128 KB
OTA Backup	0x80C0000	0x80E0000	128 KB
Decompress 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 MARKINGS:**



## PIN DESCRIPTION

Pin	Description
VIN	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 VUSB and VIN. When used as an output, the max load on VIN is 1Amp.
RST	Active-low reset input. On-board circuitry contains a 10k ohm pull-up resistor between RST and 3V3, and 0.1uF capacitor between RST and GND.
VBAT	Supply to the internal RTC, backup registers and SRAM when 3V3 is not present (1.65 to 3.6VDC). The Pin is internally connected to 3V3 supply via a 0 ohm resistor. If you wish to power VBAT via an external supply, you'll need to remove this resistor with a desoldering iron. Contact us if you wish to request trays of electrons with this jumper depopulated.
3V3	This pin is the output of the on-board regulator. When powering the Electron via VIN or the USB port, this pin will output a voltage of 3.3VDC. The max load on 3V3 is 800mA. It should not be used as an input to power the Electron.
WKP	Active-high wakeup pin, wakes the module from sleep/standby modes. When not used as a WAKEUP, this pin can also be used as a digital GPIO, ADC input or PWM <sup>[1]</sup> . Can be referred to as <b>A7</b> when used as an ADC.
DAC	12-bit Digital-to-Analog (D/A) output (0-4095), referred to as <b>DAC</b> or <b>DAC1</b> in software. Can also be used as a digital GPIO or ADC. Can be referred to as <b>A6</b> when used as an ADC.
RX	Primarily used as UART RX, but can also be used as a digital GPIO or PWM <sup>[1]</sup> .
TX	Primarily used as UART TX, but can also be used as a digital GPIO or PWM <sup>[1]</sup> .
D0-D7	Digital only GPIO. <b>D0</b> , <b>D1</b> , <b>D2</b> , <b>D3</b> can also be used as PWM <sup>[1]</sup> outputs.
A0-A7	12-bit Analog-to-Digital (A/D) inputs (0-4095), and also digital GPIOs. A6 and A7 are code convenience mappings, which means pins are not actually labeled as such but you may use code like <code>analogRead(A7)</code> . A6 maps to the <b>DAC</b> pin and A7 maps to the <b>WKP</b> pin. A3 is also a second DAC output used as <b>DAC2</b> or <b>A3</b> in software. A4 and A5 can also be used as PWM <sup>[1]</sup> outputs.
B0-B5	<b>B0</b> and <b>B1</b> are digital only while <b>B2</b> , <b>B3</b> , <b>B4</b> , <b>B5</b> are 12-bit A/D inputs as well as digital GPIOs. <b>B0</b> , <b>B1</b> , <b>B2</b> , <b>B3</b> can also be used as PWM <sup>[1]</sup> outputs.
C0-C5	Digital only GPIO. <b>C4</b> and <b>C5</b> can also be used as PWM <sup>[1]</sup> outputs.
VUSB	This pin is internally connected to USB supply and will output 5V when the Electron is plugged into an USB port. It is intentionally left unpopulated.
Li+	This pin is internally connected to the positive terminal of the LiPo battery. It is intentionally left unpopulated.

### Notes:

<sup>[1]</sup> 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.

## LED STATUS

### Charge status LED

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

#### Notes:

<sup>[1]</sup> 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.

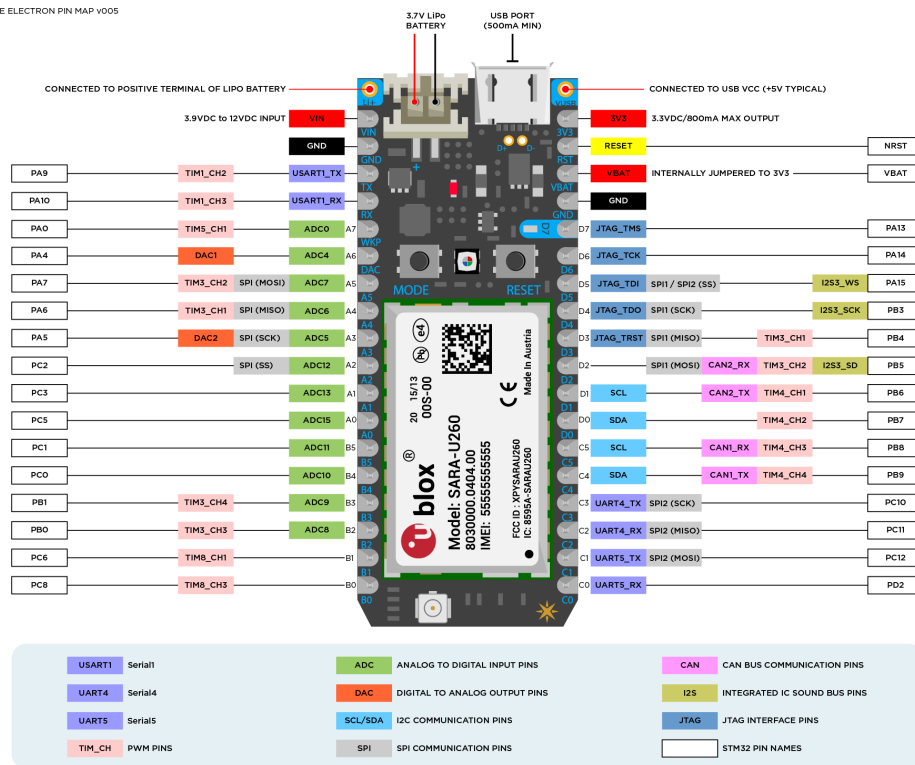
<sup>[2]</sup> You can stop this behavior by either plugging in the LiPo battery or by disabling charging using firmware command: `PMIC().disableCharging();`.

### System RGB LED

For a detailed explanation of different color codes of the RGB system LED, please take a look [here](#).

## PINOUT DIAGRAM

\* PARTICLE ELECTRON PIN MAP V005



You can download a high resolution pinout diagram in a [PDF version here](#).

# Technical Specifications

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

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

<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
Supply Input Voltage	V <sub>VIN</sub>	+3.88 <sup>[1]</sup>		+12	V
Supply Output Voltage	V <sub>VIN</sub>		+4.8		V
Supply Output Voltage	V <sub>3V3</sub>		+3.3		V
LiPo Battery Voltage	V <sub>LiPo</sub>	+3.6		+4.4	V
Supply Input Voltage	V <sub>VBAT</sub>	+1.65		+3.6	V
Supply Input Current (VBAT)	I <sub>VBAT</sub>			19	uA
Operating Current (uC on, Cellular ON)	I <sub>VIN avg</sub>		180	250	mA
2G/3G Peak Current (uC on, Cellular ON)	I <sub>IN pk</sub>	800 <sup>[2]</sup>		1800 <sup>[3]</sup>	mA
LTE Peak Current (uC on, Cellular ON)	I <sub>IN pk</sub>		550		mA
Operating Current (uC on, Cellular OFF)	I <sub>VIN avg</sub>		47	50	mA
Sleep Current (4.2V LiPo, Cellular OFF)	I <sub>Qs</sub>		0.8	2	mA
Deep Sleep Current (4.2V LiPo, Cellular OFF)	I <sub>Qds</sub>		110	130	uA
Operating Temperature	T <sub>op</sub>	-20		+60	°C
Humidity Range Non condensing, relative humidity				95	%

### Notes:

<sup>[1]</sup> The minimum input voltage is software defined with a user selectable range of 3.88V to 5.08V in 80mV increments. Out of the box, the minimum input voltage is set to 4.36V in order for the LiPo battery to be able to properly charge.

<sup>[2]</sup> 3G operation

<sup>[3]</sup> 2G operation

**POWER CONSUMPTION**

Parameter	Symbol	Min	Typ	Max	Unit
Operating Current (uC on, peripherals and radio disabled)	$I_{idle}$	29.5	33.3	34.6	mA
Operating Current (uC on, cellular on but not connected)	$I_{cell\_idle}$	26.8	42.6	786	mA
Operating Current (uC on, cellular connecting to tower)	$I_{cell\_conn\_twr}$	59.7	103	592	mA
Operating Current (uC on, cellular connecting to cloud)	$I_{cell\_conn\_cloud}$	54.0	106	897	mA
Operating Current (uC on, cellular connected but idle)	$I_{cell\_cloud\_idle}$	30.8	37.0	114	mA
Operating Current (uC on, cellular connected and transmitting)	$I_{cell\_cloud\_tx}$	49.9	114	914	mA
STOP mode sleep, GPIO wake-up	$I_{stop\_gpio}$	1.72	2.40	3.14	mA
STOP mode sleep, analog wake-up	$I_{stop\_analog}$	5.48	6.03	6.69	mA
STOP mode sleep, RTC wake-up	$I_{stop\_intrtc}$	1.92	2.53	3.12	mA
STOP mode sleep, serial wake-up	$I_{stop\_usart}$	12.5	13.1	13.9	mA
STOP mode sleep, cellular wake-up	$I_{stop\_cell}$	23.8	28.1	93.0	mA
ULP mode sleep, GPIO wake-up	$I_{ulp\_gpio}$	1.91	2.42	2.99	mA
ULP mode sleep, RTC wake-up	$I_{ulp\_intrtc}$	1.94	2.55	3.21	mA
HIBERNATE mode sleep, GPIO wake-up	$I_{hib\_gpio}$	108	114	121	uA
HIBERNATE mode sleep, RTC wake-up	$I_{hib\_rtc}$	108	114	120	uA

## RADIO SPECIFICATIONS

The Electron is available in four different versions: A 2G version based on u-blox G350 cellular module, two 3G versions based on U260 and U270 modules, and a LTE Cat M1 model (R410M-02B).

Some countries have already stopped supporting 2G, including Australia, Japan, Korea, Singapore, and Taiwan. The cellular carrier used by the Electron no longer supports 2G in New Zealand and Switzerland. The G350 cannot be used in these countries.

The difference between the 3G versions is their operating frequency band which differs based on the country. All of these cellular modules are GSM only and do not support CDMA networks. Both 3G models can fall back to using 2G in areas that support 2G and not 3G.

Note that LTE is LTE Cat M1, not the standard LTE (LTE Cat 1) used by your mobile phone. It is a low-power and low-data-rate variation of LTE for use with IoT devices.

### Electron

#### 3G

Module	Compatible Countries
U260	United States, Australia, Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico, New Zealand, Nicaragua, Panama, Paraguay, Peru, Venezuela
U270	Austria, Bahrain, Belarus, Belgium, Bulgaria, China, Congo, Croatia, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Estonia, Finland, France, Germany, Ghana, Gibraltar, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Jersey, Kenya, Republic of Korea, Latvia, Lithuania, Luxembourg, Republic of Macedonia, Malaysia, Republic of Moldova, Republic of Montenegro, Netherlands, Nigeria, Norway, Pakistan, Philippines, Poland, Portugal, Qatar, Reunion, Romania, Russian Federation, Rwanda, Saudi Arabia, Republic of Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Swaziland, Sweden, Switzerland, Taiwan, United Republic of Tanzania, Thailand, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, Uruguay, Zambia
R410M	United States, Canada, Mexico

Please be sure to order a board that works in the country where you want to deploy your project.

### 2G cellular characteristics for G350, U260, and U270 modules:

Parameter	SARA-U260	SARA-U270	SARA-G350
Protocol stack	3GPP Release 7	3GPP Release 7	3GPP Release 99
MS Class	Class B	Class B	Class B
Bands	GSM 850 MHz PCS 1900 MHz	E-GSM 900 MHz DCS 1800 MHz	GSM 850 MHz E-GSM 900 MHz DCS 1800 MHz PCS 1900 MHz
Power Class	Class 4 (33 dBm) for 850 band Class 1 (30 dBm) for 1900 band	Class 4 (33 dBm) for 900 band Class 1 (30 dBm) for 1800 band	Class 4 (33 dBm) for 850/900 bands Class 1 (30 dBm) for 1800/1900 bands

### 3G cellular characteristics for U260, and U270 modules:

Parameter	SARA-U260	SARA-U270
Protocol stack	3GPP Release 7	3GPP Release 7
UE Class	Class A	Class A
Bands	Band V (850 MHz) Band II (1900 MHz)	Band VIII (900 MHz) Band I (2100 MHz)
Power Class	Class 3 (24 dBm) for all bands	Class 3 (24 dBm) for all bands

### LTE cellular characteristics for the SARA-R410M-02-B module

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 STM32F205RGT6 datasheet, with reference to Electron pin nomenclature.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Standard I/O input low level voltage	$V_{IL}$		-0.3		$0.28 \cdot (V_{3V3} - 2) + 0.8$	V
I/O FT <sup>[1]</sup> input low level voltage	$V_{IL}$		-0.3		$0.32 \cdot (V_{3V3} - 2) + 0.75$	V
Standard I/O input high level voltage	$V_{IH}$		$0.41 \cdot (V_{3V3} - 2) + 1.3$		$V_{3V3} + 0.3$	V
I/O FT <sup>[1]</sup> input high level voltage	$V_{IH}$	$V_{3V3} > 2V$	$0.42 \cdot (V_{3V3} - 2) + 1$		5.5	V
	$V_{IH}$	$V_{3V3} \leq 2V$	$0.42 \cdot (V_{3V3} - 2) + 1$		5.2	V
Standard I/O Schmitt trigger voltage hysteresis <sup>[2]</sup>	$V_{hys}$		200			mV
I/O FT Schmitt trigger voltage hysteresis <sup>[2]</sup>	$V_{hys}$		$5\% V_{3V3}$ <sup>[3]</sup>			mV
Input leakage current <sup>[4]</sup>	$I_{lkg}$	$GND \leq V_{io} \leq V_{3V3}$ GPIOs			$\pm 1$	$\mu A$
Input leakage current <sup>[4]</sup>	$I_{lkg}$	$R_{PU}$		$V_{io} = 5V$ , I/O FT	3	$\mu A$
Weak pull-up equivalent resistor <sup>[5]</sup>	$R_{PU}$	$V_{io} = GND$	30	40	50	k $\Omega$
Weak pull-down equivalent resistor <sup>[5]</sup>	$R_{PD}$	$V_{io} = V_{3V3}$	30	40	50	k $\Omega$
I/O pin capacitance	$C_{IO}$			5		pF
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 $\Omega$
DAC output capacitive load (buffers enabled by default)	$C_{DAC}$				50	pF

### Notes:

<sup>[1]</sup> 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.

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

<sup>[3]</sup> With a minimum of 100mV.

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

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



# Mechanical Specifications

## DIMENSIONS AND WEIGHT

- Width = 0.8"
- Height = 0.65"
- Length = 2.05"
- Weight = 10 grams

## MATING CONNECTORS

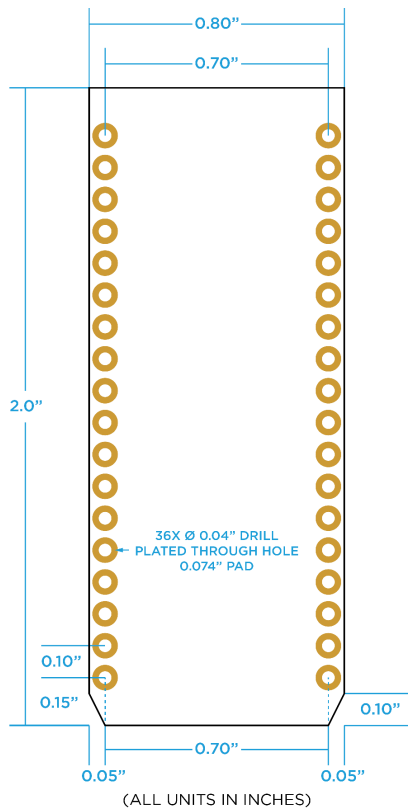
The Electron can be mounted with (qty 2) 18-pin single row 0.1" female headers. Typically these are 0.335" (8.5mm) tall, but you may pick a taller one if desired. When you search for parts like these it can be difficult to navigate the thousands of parts available online so here are a few good choices for the Electron:

Description	MFG	MFG Part Number	Distributor
18-pin 0.1" (2.54mm) Female Header (Tin)	Sullins Connector Solutions	<a href="#">PPTC181LFBN-RC</a>	DigiKey
18-pin 0.1" (2.54mm) Female Header (Tin)	3M	<a href="#">929974-01-18-RK</a>	DigiKey
18-pin 0.1" (2.54mm) Female Header (Tin)	Harwin	<a href="#">M20-7821846</a>	Mouser

You may also use other types, such as reverse mounted (bottom side SMT) female headers, low profile types, etc..

## RECOMMENDED PCB LAND PATTERN

The Electron can be mounted with 0.1" 18-pin female header receptacles using the following PCB land pattern:



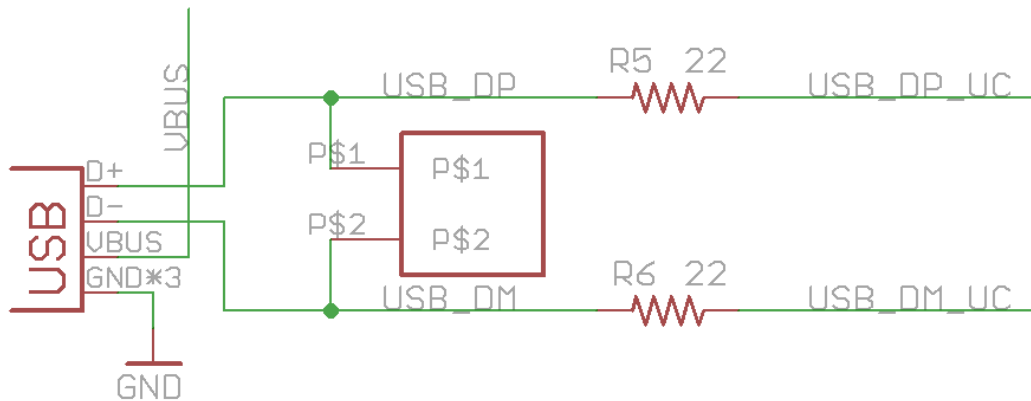
An Electron part for EAGLE can be found in the [Particle EAGLE library](#)

# Schematic

All of the Electron hardware design files are open source and available under a Creative Commons Public License. The schematic and PCB designs were made using EAGLE CAD. You can access these files [here](#).

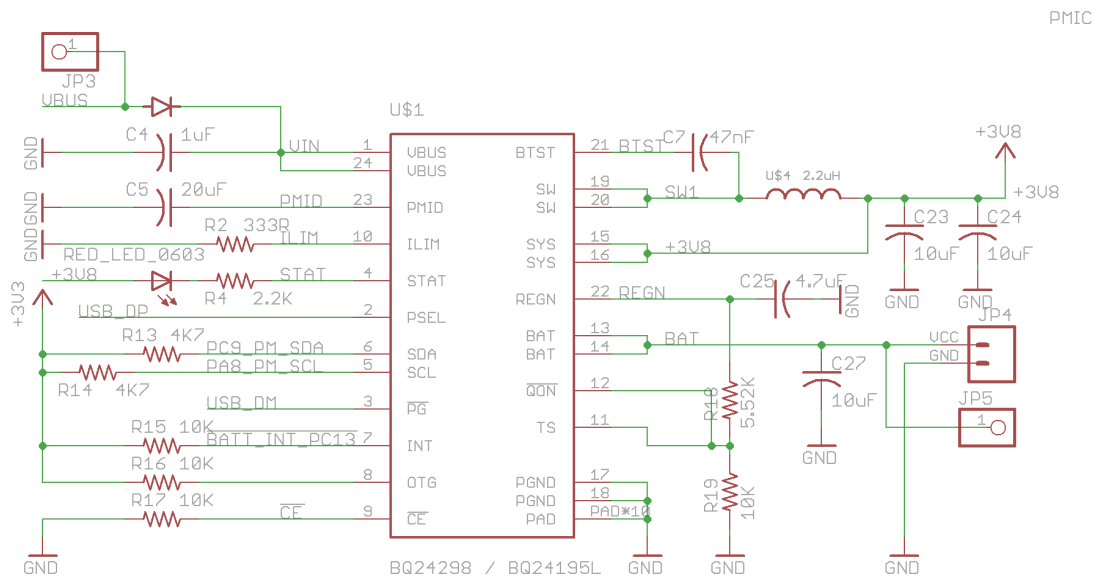
**Note:** Clone or Download the complete repository as a ZIP file to avoid corrupted data in Eagle files.

## USB



The USB data lines are terminated with 22 Ohm resistors. These data pins are also exposed via small through holes next to the USB connector and are labeled D+ and D-. The VBUS (+5VDC VCC of the USB port) is fed to the PMIC via a 3Amp Schottky diode ([SS3P3](#)). The VBUS pin is also available via the unpopulated header hole on the top-right side of the Electron.

## PMIC (POWER MANAGEMENT INTEGRATED CIRCUIT)



The Electron uses TI's [BQ24195](#) as the power management and charging unit. This PMIC intelligently sources power from either the VIN pin, the USB port and/or the LiPo battery. When all

the power sources as connected, the unit tries to source power from the USB or VIN as default and continues to charge the LiPo battery. When the battery is completely charged, the power is then sourced from USB/VIN alone. If there is a power deficit (which generally occurs during cellular radio transmission), the additional power is then sourced from the battery as required. The unit can also seamlessly switch back to the battery when other sources of power are suddenly removed.

The DP data pin of the USB is used by the PMIC to detect the presence of a USB power source. It then adjusts the charge current and the limit based on the type of USB power source it detects. This does not always happen successfully since there are a lot of USB hubs and chargers out there that do not meet the USB design guidelines. If the detection is unsuccessful, the PMIC defaults to a 500mA current limit. A user can always adjust these parameters via software.

The microcontroller communicates with the PMIC via an I2C interface (pins PC9 and PA8). This interface allows the microcontroller to read the status of the PMIC and set its various parameters.

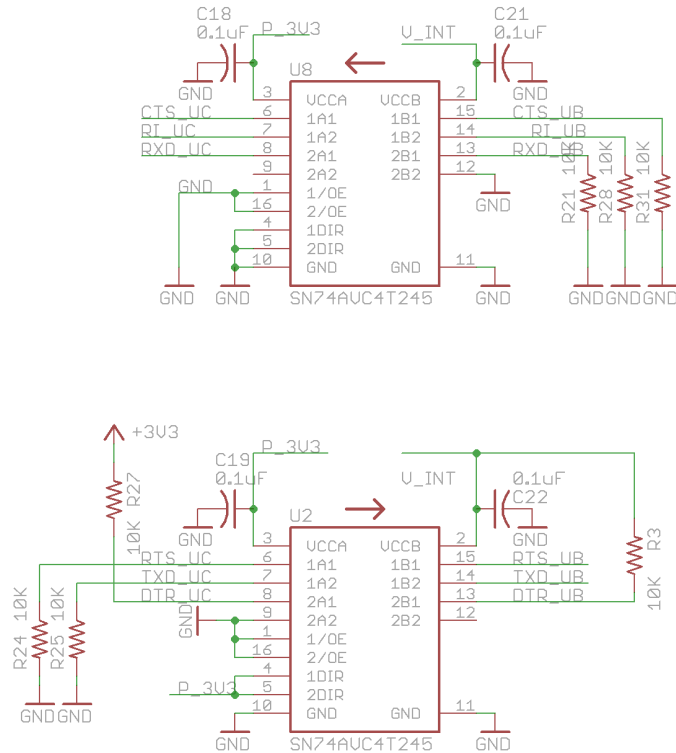
## MICROCONTROLLER



The Electron uses ST Microelectronics's STM32F205RGT6 ARM Cortex M3 microcontroller running at 120MHz.



The u-blox cellular module talks to the microcontroller over a full-duplex USART interface using a standard set of AT commands. The SIM (Nano 4FF) card is directly connected to the u-blox. The power to the SIM card is also provided by the cellular module.



Since u-blox module's communication interface operates at 1.8VDC, while the STM32F205RGT6 microcontroller operates at 3.3VDC, we need voltage translators in-between them. This is achieved with two [SN74AUC4T245](#) non-inverting buffers. The default state of the USART pins is set with the help of pull-up and pull-down resistors, and the unused input pins are tied to GND.

## 3.3V REGULATOR AND FUEL GAUGE



The output (3.8V net) of the PMIC is fed directly to the u-blox cellular module and a 3.3VDC high efficiency switching regulator ([TPS62290](#)). This 3.3VDC regulator helps power the microcontroller, fuel gauge and the buffers.

The Electron employs a [MAX17043](#) fuel gauge to monitor the LiPo battery voltage and it's state of charge. The microcontroller communicates with it over an I2C interface (same channel as the PMIC).

# Layout

The Electron uses a four layer circuit board. Top layer consists of a signal layer followed by ground (GND), 3.3V power (3V3), and bottom signal.



# Bill of Materials

QTY	Device	Value	Package	Designator	Manufacturer	MFG. Part #
14	CAPACITOR	0.1uF, 6.3V, 10%	0402	C14, C17, C18, C19, C2, C20, C21, C22, C29, C30, C31, C6, C8, C9	Fenghua	0402B104K160NT
2	CAPACITOR	10nF, 6.3V, 10%	0402	C1,C38	Fenghua	0402B103K500NT
5	CAPACITOR	10uF, 6.3V, 10%	0603	C23, C24, C27, C40, C41	Yageo	CC0603KRX5R5BB106
2	CAPACITOR	12pF, 6.3V, 10%	0402	C33, C34	Fenghua	0402CG120J500NT
1	CAPACITOR	15pF, 6.3V, 10%	0402	C16	Fenghua	0402CG150J500NT
2	CAPACITOR	1uF, 6.3V, 10%	0402	C37, C39	Fenghua	0402X105K6R3NT
1	CAPACITOR	1uF, 25V, 10%	0603	C4	Yageo	CC0603KRX5R8BB105
2	CAPACITOR	2.2uF, 6.3V, 10%	0402	C32, C35	Yageo	CC0402KRX5R5BB225
2	CAPACITOR	20pF, 6.3V, 10%	0402	C26, C28	Fenghua	0402CG200J500NT
1	CAPACITOR	22uF, 6.3V, 10%	0603	C5	Samsung	CL10A226KQ8NRNE
1	CAPACITOR	220uF, 6.3V, 10%	2312 (6032 metric)	C3	AVX	TAJ227K006
1	CAPACITOR	4.7uF, 6.3V, 10%	0402	C36	Samsung	CL05A475KQ5NRNC
1	CAPACITOR	4.7uF, 6.3V, 10%	0603	C25	Yageo	CC0603KRX5R5BB475
1	CAPACITOR	47nF, 6.3V, 10%	0402	C7	Fenghua	0402B473K160NT
4	CAPACITOR	47pF, 6.3V, 10%	0402	C10, C11, C12, C13	Fenghua	0402CG470J500NT
1	CAPACITOR	68pF, 6.3V, 10%	0402	C15	Fenghua	0402CG680J500NT
1	CONNECTOR	2-pin	SMD, 2-pin, Vertical	JP4	Kaweei	CW2001-02T-M01-D
1	CONNECTOR	1x18	1x18, 0.1" pitch"	JP1	Kaweei	CP25411-18G-S116A-A
1	CONNECTOR	1x18	1x18, 0.1" pitch"	JP2	Kaweei	CP25411-18G-S116B-A
1	CONNECTOR		USB-MICROB-SLOT-HOLE	X1	Kaweei	CMCUSB-5BFM2G-01-D
1	CONNECTOR		SMD	J2	Kaweei	PI163-0140R
1	CONNECTOR		10mm x 12.3mm	J1	Kaweei	CSIM2545-06S-D
1	CRYSTAL	26MHz, <±20ppm	4-SMD, 5.0 x 3.2mm	Y2	Song Ji	SJSMD5026M00018F20
1	CRYSTAL	32.768KHz, <±20ppm	2-SMD, 1.5 x 3.2mm	Y1	Song Ji	SJ FC1332K012F520P

1	DIODE	30V, 3A	DO-220AA	U\$3	Vishay	SS3P3-M3/84A
2	IC - Buffer		SC-70-5	U5, U6	Texas Instruments	SN74LVC1G07DCKR
1	IC - Fuel Gauge		TDFN-8	U4	Maxim	MAX17043G+T
1	IC - Cell Module		16 x 26 x 3mm	U1	u-blox	SARA-G350SARA-U260SARA-U270
2	IC - Buffer		16-UQFN	U2, U8	Texas Instruments	SN74AVC4T245RSVR
1	IC - Microcontroller		LQFP64	U3	ST Microelectronics	STM32F205RGT6
1	IC - PMIC		24VQFN	U\$1	Texas Instruments	BQ24195RGER
1	IC - MOSFET		SC70-5	U9	Texas Instruments	TPS22942DCKR
1	IC - 3V3 Reg	1A	6-SON (2x2)	U\$5	Texas Instruments	TPS62291DRVR
1	INDUCTOR	2.2uH, 1.5A, 20%	3.0 mm x 3.0 mm	U\$6	Taiyo Yuden	NR3015T2R2M
1	INDUCTOR	2.2uH, 4A	4.45mm x 4.06mm	U\$4	Bourns, Inc.	SRP4020TA-2R2M
1	LED	Blue	0603	LED1	Everlight	19-217/BHC-ZL1M2RY/3T
1	LED	Red	0603	LED3	Everlight	19-217/R6C-AL1M2VY/3T
1	LED	RGB	4-PLCC (3.2 mm x 2.8mm)	LED2	Cree	CLMVB-FKA-CFHEHLCBB7A363
1	RESISTOR	0R, 1/16W	0201	R32	Fenghua	
1	RESISTOR	100k, 1/16W, 5%	0402	R1	Fenghua	RC-02W104JT
14	RESISTOR	10K, 1/16W, 5%	0402	R3, R8, R15, R16, R17, R19, R21, R24, R25, R27, R28, R29, R30, R31	Fenghua	RC-02W103JT
1	RESISTOR	150R, 1/4W, 1%	0603	R22	Vishay	CRCW0603150RFKEAHP
1	RESISTOR	1K, 1/16W, 5%	0603	R23	Fenghua	RC-03K102JT
4	RESISTOR	1K, 1/16W, 5%	0402	R10, R11, R12, R9	Fenghua	RC-02W102JT
1	RESISTOR	2.2K, 1/16W, 5%	0402	R4	Fenghua	RC-02W222JT
2	RESISTOR	22R, 1/16W, 1%	0402	R5, R6	Fenghua	RC-02W22R0FT
1	RESISTOR	330R, 1/16W, 1%	0402	R2	Fenghua	RC-02W3300FT
2	RESISTOR	4K7, 1/16W, 5%	0402	R13, R14	Fenghua	RC-02W472JT
1	RESISTOR	5.49K, 1/16W, 1%	0402	R18	Fenghua	RC-02W5491FT
2	SWITCH	160gF	3.6mm x 3.1mm	MODE, RESET	Haoyu	TS-1185A-C



## Ordering information

Electrons are available from [store.particle.io](https://store.particle.io) in single quantities in 2G, and 3G versions.

# Product Handling

## ESD PRECAUTIONS

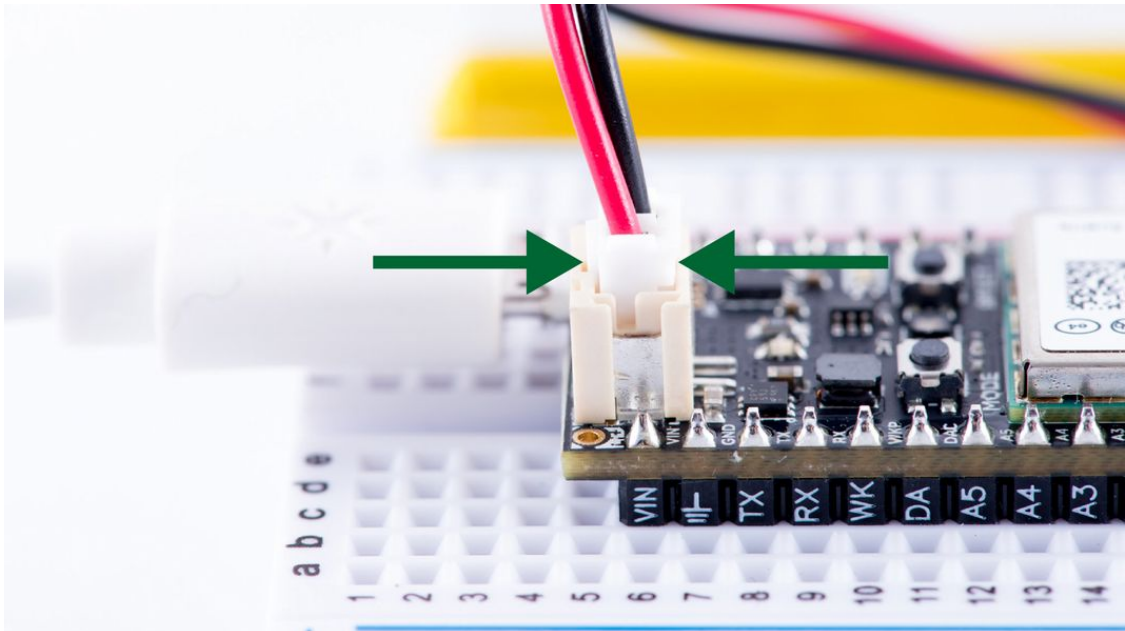
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The Electron contains highly sensitive electronic circuitry and is an Electrostatic Sensitive Device (ESD). Handling a Electron without proper ESD protection may destroy or damage it permanently. Proper ESD handling and packaging procedures must be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

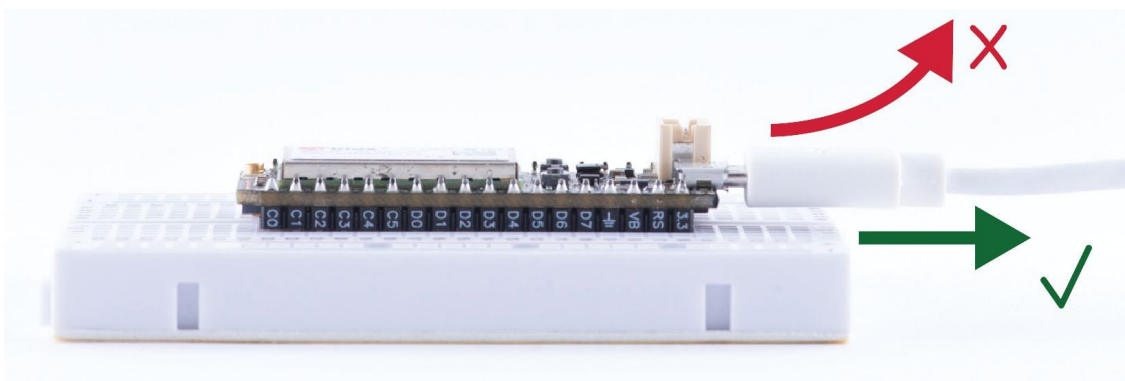
## CONNECTORS

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There are three connectors on the Electron that will get damaged with improper usage. The JST connector on the circuit board, where you plug in the LiPo battery, is very durable but the connector on the battery itself is not. When unplugging the battery, take extra precaution to **NOT** pull the connector using the wires, but instead hold the plug at its base to avoid putting stress on the wires. This can be tricky with bare hands - nose pliers are your friend here.



The micro B USB connector on the electron is soldered on the PCB with large surface pads as well as couple of through hole anchor points. Despite this reinforcement, it is very easy to rip out the connector if too much stress is put on in the vertical direction.



The U.FL antenna connector is 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.

## **BREADBOARDING**

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The breadboard provided with the Electron is specifically designed to require low insertion force. This makes it easy to plug the Electron in and out of the breadboard. If you end up using a different breadboard, remember that it may require more force. In this case, always remember to pinch-hold your precious Electron by the sides (along the header pins) when plugging-unplugging and **not** by the USB connector (don't be this person).

## Default settings

The Electron 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.

You may use the [Particle Web IDE](#) to code, compile and flash a user application OTA (Over The Air). [Particle Workbench](#) is a full-featured desktop IDE for Windows, Mac, and Linux based on VSCode and supports both cloud-based and local gcc-arm compiles. The [Particle CLI](#) provides a command-line interface for cloud-based compiles and flashing code over USB.

# Glossary

Term	Definition
SMPS	Switch Mode Power Supply
SIM	Subscriber Identity Module ( <a href="#">Size: Nano 4FF</a> )
RF	Radio Frequency
SMT	Surface Mount Technology (often associated with SMD which is a surface mount device).
LED	Light Emitting Diode
RGB LED	Red green and blue LEDs combined and diffused in one package.
USB	Universal Serial Bus
Quiescent current	Current consumed in the deepest sleep state.
FT	Five-tolerant; Refers to a pin being tolerant to 5V.
3V3	+3.3Volt; The regulated +3.3V supply rail. Also used to note a pin is only 3.3V tolerant.
PMIC	Power Management Integrated Circuit
LiPo	Lithium-ion Polymer Battery
GSM	Global System for Mobile Communications
CDMA	Code Division Multiple Access
OTA	Over The Air; describing how firmware is transferred to the device.
uC	Microcontroller

# FCC IC CE Warnings and End Product Labeling Requirements

**Federal Communication Commission Interference 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 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.

**FCC Caution:** Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. 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.

**FCC Radiation Exposure Statement:** This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This transmitter module must not be co-located or operating in conjunction with any other antenna or transmitter. This End equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body.

**IMPORTANT NOTE:** In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

**End Product Labeling** The final end product must be labeled in a visible area with the following:

Contains FCC ID:

- XPYSARAG350 (For 2G Electron using the G350 module)
- XPYSARAU260 (For 3G Electron using the U260 module)
- XPYSARAU270 (For 3G Electron using the U270 module)
- XPY2AGQN4NNN (For LTE Electron module using the R410 module)

**Manual Information to the End User** The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

**Canada Statement** This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions:

1. This device may not cause interference; and
2. This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence.

**L'exploitation est autorisée aux deux conditions suivantes:**

1. l'appareil ne doit pas produire de brouillage;
2. l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

**Caution Exposure:** This device meets the exemption from the routine evaluation limits in section 2.5 of RSS102 and users can obtain Canadian information on RF exposure and compliance. Le dispositif répond à l'exemption des limites d'évaluation de routine dans la section 2.5 de RSS102 et les utilisateurs peuvent obtenir des renseignements canadiens sur l'exposition aux RF et le respect.

**The final end product must be labelled in a visible area with the following:** The Industry Canada certification label of a module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labelled to display the Industry Canada certification number of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

Contains transmitter module IC:

- 8595A-SARAG350 (For 2G Electron using the G350 module)
- 8595A-SARAU260 (For 3G Electron using the U260 module)
- 8595A-SARAU270 (For 3G Electron using the U270 module)
- 8595A-2AGQN4NNN (For LTE Electron module using the R410 module)

This End equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body. Cet équipement devrait être installé et actionné avec une distance minimum de 20 centimètres entre le radiateur et votre corps.

The end user manual shall include all required regulatory information/warning as shown in this manual.

For an in-depth review on certifications, please click [here](#).

# Revision history

Revision	Date	Author	Comments
v001	20-Jan-2016	MB	Initial release
v002	24-March-2016	MB	Added: Memory map, DAC limits, SIM card size, SWD pin locations. Updated: Power section, pin diagram, block diagram, operating conditions.
v003	12-Sept-2016	BW	Error in Cellular off operating current, changed from 2-15mA to 47-50mA. Also qualified these current readings with uC on/off. Updated the Pin Description section. Updated Mating connectors section.
v004	27-Oct-2016	BW	Replaced one STM32F205RGY6 with STM32F205RGT6, and replaced all STM32 mentions with full part number STM32F205RGT6
v005	14-Aug-2017	BW	Updated DCD layout and Memory Map, renamed SPI1_/SPI3_ to match Particle API instead of STM32 pin names to avoid confusion (now SPI, SPI1 and SPI2), updated the Pin Description section and added high resolution pinout PDF, updated LED Status section, VBAT info, added Power the Electron without a battery section
v006	31-Jul-2019	RK	Added LTE information
v017	16-Sep-2020	RK	Added power consumption information



## Known Errata

We are tracking [known errata with this datasheet here](#). These issues/errors in the datasheet will be resolved in subsequent revisions.

# Contact

## Web

<https://www.particle.io>

## Community Forums

<https://community.particle.io>

## Email

<https://support.particle.io>