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### Functional description

### OVERVIEW

Particle's Internet of Things hardware development kit, the Photon, provides everything you need to build a connected product. Particle combines a powerful ARM Cortex M3 microcontroller with a Broadcom Wi-Fi chip in a tiny thumbnail-sized module called the PØ (P-zero).

To get you started quickly, Particle adds a rock solid 3.3VDC SMPS power supply, RF and user interface components to the PØ on a small single-sided PCB called the Photon. The design is open source, so when you're ready to integrate the Photon into your product, you can.

The Photon comes in two physical forms: with headers and without. Prototyping is easy with headers as the Photon plugs directly into standard breadboards and perfboards, and may also be mounted with 0.1" pitch female headers on a PCB. To minimize space required, the Photon form factor without headers has castellated edges. These make it possible to surface mount the Photon directly onto your PCB.

#### FEATURES

- Particle PØ Wi-Fi module
  - Broadcom BCM43362 Wi-Fi chip
  - 802.11b/g/n Wi-Fi
  - STM32F205RGY6 120Mhz ARM Cortex M3
  - 1MB flash, 128KB RAM
- On-board RGB status LED (ext. drive provided)
- 18 Mixed-signal GPIO and advanced peripherals
- Open source design
- Real-time operating system (FreeRTOS)
- Soft AP setup
- FCC (United States), CE (European Union), and ISED (Canada) certified

#### DEVICE OS SUPPORT

It is recommended that you use the latest version in the 2.x LTS release line with the all Photons.

While the devices are compatible with older versions of Device OS and 3.x, these versions as past the end-of-support date and are not recommended for use in production. Only 2.x LTS remains in the Extended Support and Maintenance (ESM) window.

For information on upgrading Device OS, see <u>Version information</u>. For the latest version shipped from the factory, see <u>Manufacturing firmware versions</u> page. See also <u>Long Term Support (LTS)</u> releases.

### Interfaces

### BLOCK DIAGRAM



Power to the Photon is supplied via the on-board USB Micro B connector or directly via the VIN pin. If power is supplied directly to the VIN pin, the voltage should be regulated between 3.6VDC and 5.5VDC. When the Photon is powered via the USB port, VIN will output a voltage of approximately 4.8VDC due to a reverse polarity protection series schottky diode between V+ of USB and VIN. When used as an output, the max load on VIN is 1A. 3V3 can also be used as an output, but has a limited overhead of only 100mA available. (Please refer to <u>Absolute Maximum Ratings</u> for more info).

Typical average current consumption is 80mA with 5V @ VIN with Wi-Fi on. Deep sleep quiescent current is typically 80uA (Please refer to <u>Recommended Operating Conditions</u> for more info). When powering the Photon from the USB connector, make sure to use a quality cable to minimize IR drops (current x resistance = voltage) in the wiring. If a high resistance cable (i.e., low current) is used, peak currents drawn from the Photon when transmitting and receiving will result in voltage sag at the input which may cause a system brown out or intermittent operation. Likewise, the power source should be sufficient enough to source 1A of current to provide an adequate amount of current overhead (especially if powering additional circuitry off of VIN).

**Warning:** When powering the Photon from long wires on USB and VIN, care should be taken to protect against damaging voltage transients. **From the Richtek datasheet:** 

When a ceramic capacitor is used at the input and the power is supplied by a wall adapter through long wires, a load step at the output can induce ringing at the input, VIN. At best, this ringing can couple to the output and be mistaken as loop instability. At worst, a sudden inrush of current through the long wires can potentially cause a voltage spike at VIN large enough to damage the part.

To avoid these voltage spikes, keep input wiring as short as possible. If long wires are unavoidable, it is advisable to add a 5.1V zener diode or similar transient suppression device from VIN to GND. Another technique is adding more capacitance to the input using an electrolytic capacitor. Please refer to AN-88 by Linear for a good discussion on this topic.

#### RF

The RF section of the Photon is a finely tuned impedance controlled network of components that optimize the efficiency and sensitivity of the Wi-Fi communications.

An RF feed line runs from the PØ module into a SPDT RF-switch. Logic level control lines on the PØ module select which of the two ports of the RF-switch is connected to the RF feed line. A 100pF decoupling capacitor is located on each control line. One port is connected to a PCB ceramic chip antenna, and the other is connected to a U.FL connector for external antenna adaptation. The default port will be set to the chip antenna.

Additionally, a user API is available to switch between internal, external and even an automatic mode which continuously switches between each antenna and selects the best signal. All three RF ports on the RF-switch have a 10pF RF quality DC-blocking capacitor in series with them. These effectively pass 2.4GHz frequencies freely while blocking unwanted DC voltages from damaging the RF-switch. All RF traces are considered as tiny transmission lines that have a controlled 50 ohm impedance.

The chip antenna is impedance matched to the 50 ohm RF feed line via a Pi network comprised of three RF inductors (1 series, 2 shunt). These values are quite specific to the Photon due to the PCB construction and layout of the RF section. Even if the Photon's layout design is copied exactly, to achieve the best performance it would be worth re-examining the Pi network values on actual samples of the PCB in question.

Antenna Type	Manufacturer	MFG. Part #	Gain
Dipole antenna	LumenRadio	104-1001	2.15dBi
Chip antenna	Advanced Ceramic X	AT7020-E3R0HBA	1.3dBi

#### PERIPHERALS AND GPIO

The Photon has ton of capability in a small footprint, with analog, digital and communication interfaces.

Digital	18	I/O	FT/3V3
Analog (ADC)	8	I	3V3
Analog (DAC)	2	0	3V3
SPI	2	I/O	3V3
I2S	1	I/O	3V3
I2C	1	I/O	FT
CAN	1	I/O	3V3 <sup>[4]</sup>
USB	1	I/O	3V3
PWM	9 <sup>[3]</sup>	0	3∨3

### Peripheral Type Qty Input(I) / Output(O) $FT^{[1]} / 3V3^{[2]}$

#### 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, A4, A5, WKP, RX, TX with a caveat: PWM timer peripheral is duplicated on two pins (A5/D2) and (A4/D3) for 7 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.

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

Photon Pin	JTAG	SWD	STM32F205RGY6 Pin	PØ Pin #	PØ Pin Name	Default Internal <sup>[1]</sup>
D7	JTAG_TMS	SWD/SWDIO	PA13	44	MICRO_JTAG_TMS	~40k pull-up
D6	JTAG_TCK	CLK/SWCLK	PA14	40	MICRO_JTAG_TCK	~40k pull-down
D5	JTAG_TDI		PA15	43	MICRO_JTAG_TDI	~40k pull-up
D4	JTAG_TDO		PB3	41	MICRO_JTAG_TDO	Floating
D3	JTAG_TRST		PB4	42	MICRO_JTAG_TRSTN	~40k pull-up
3V3	Power	Power				
GND	Ground	Ground				
RST	Reset	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.)



A standard 20-pin 0.1" shrouded male JTAG interface connector should be wired as follows:

**Note:** This interface is not supported by the P0 module and cannot be used.

There are three gold pads on the top side of the PCB near pin A3. These pads are 0.035" square, spaced 0.049" apart.



These pads would be used for the external coexistent interface to prevent simultaneous transmission on with an external radio, such as Bluetooth, while the Wi-Fi radio is transmitting. However the Wi-Fi radio software that runs on the P0, Broadcom/Cypress WICED, never supported this feature, so it cannot be enabled.

### Memory map

### STM32F205RGY6 FLASH LAYOUT OVERVIEW

- Bootloader (16 KB)
- DCTI (16 KB), stores Wi-Fi credentials, keys, mfg info, system flags, etc..
- DCT2 (16 KB), swap area for DCTI
- EEPROM emulation bank 1 (16 KB)
- EEPROM emulation bank 2 (64 KB)
- Device OS (512 KB) [256 KB Wi-Fi/comms + 256 KB hal/platform/services]
- Factory backup, OTA backup and user application (384 KB) [3 x 128 KB]

### DCT LAYOUT

The DCT 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.

### DCT 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

### MEMORY MAP (COMMON)

Region		Start Address	End Address	Size
	Bootloader	0x8000000	0x8004000	16 KB
	DCTI	0x8004000	0x8008000	16 KB
	DCT2	0x8008000	0x800C000	16 KB
	EEPROM1	0x800C000	0x8010000	16 KB
	EEPROM2	0x8010000	0x8020000	64 KB

### MEMORY MAP (MODULAR FIRMWARE - DEFAULT)

Region	Start Address	End Address	Size
System Part 1	0x8020000	0x8060000	256 KB
System Part 2	0x8060000	0x80A0000	256 KB
User Part	0x80A0000	0x80C0000	128 KB
OTA Backup	0x80C0000	0x80E0000	128 KB
Factory Backup	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



Pin	Description
VIN	This pin can be used as an input or output. As an input, supply 3.6 to 5.5VDC to power the Photon. When the Photon 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 1A.
RST	Active-low reset input. On-board circuitry contains a 1k 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).
3V3	This pin is the output of the on-board regulator and is internally connected to the VDD of the Wi-Fi module. When powering the Photon via VIN or the USB port, this pin will output a voltage of 3.3VDC. This pin can also be used to power the Photon directly (max input 3.3VDC). When used as an output, the max load on 3V3 is 100mA. NOTE: When powering the Photon via this pin, ensure power is disconnected from VIN and USB.
RX	Primarily used as UART RX, but can also be used as a digital GPIO or $PWM^{[2]}$ .
ТХ	Primarily used as UART TX, but can also be used as a digital GPIO or PWM <sup>[2]</sup> .
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>[2]</sup> . Can be referred to as A7 when used as an ADC.
DAC	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. A3 is a second DAC output used as DAC2 in software.
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 analogRead(A7). A6 maps to the DAC pin and A7 maps to the WKP pin. A4,A5,A7 may also be used as a PWM <sup>[2]</sup> output.

D0~D7 Digital only GPIO pins. D0~D3 may also be used as a  $\mathsf{PWM}^{[2]}$  output.

**Notes:** <sup>[1]</sup> In addition to the 24 pins around the outside of the Photon, there are 7 pads on the bottom the Photon PCB that can be used to connect to extra signals: RGB LED outputs, SETUP button, SMPS enable line and USB D+/D-. Photon Pins #25-31 are described in the <u>Pin out</u> diagrams. Also refer to the <u>Recommended PCB land pattern photon without headers</u> section for their location on the bottom of the Photon.

<sup>[2]</sup> PWM is available on D0, D1, D2, D3, A4, A5, WKP, RX, TX with a caveat: PWM timer peripheral is duplicated on two pins (A5/D2) and (A4/D3) for 7 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.

		• • •			
	VIN		Sec 3v3	3V3	
	GND GND			RST	E8
PA9 TIM1_CH2 Serial1 (TX)	ТХ			VBAT	A9
PA10 TIM1_CH3 Serial1 (RX)	RX			GND	
PA0 TIM5_CH1	ADC0 A7 WKP	≫≹		SWDIO JTAG TMS	PA13
PA4 DAC1	ADC4 A6 DAC		8 <b>6</b>	SWCLK JTAG TCK	PA14
PA7 TIM3_CH2 SPI (MOSI)	ADC7 A5	22	2 Ct D5	JTAG TDI - SPI1 (SS)	PA15
PA6 TIM3_CH1 SPI (MISO)	ADC6 A4		800	JTAG TDO - SPI1 (SCK)	PB3
PA5 SPI (SCK) DAC2	ADC5 A3	850104 BM-09-5	800 03	JTAG RST - SPI1 (MISO) - TIM3_CH1	PB4
PC2 SPI (SS)	ADC12 A2		800 02	SPI1 (MOSI) TIM3_CH2	PB5
PC3	ADC13 A1			Wire (SCL) TIM4_CH1	PB6
PC5	ADC15 A0	<b>₩</b> ₹	800	Wire (SDA) TIM4_CH2	PB7

Pin	USB		Exposed Functions		STM32 Pin PØ Pin #		PØ Pin Name		
VIN		VIN							
GND		GND							
ТХ	P			USART1_TX	TIM1_CH2		PA9	39	MICRO_UART_TX
RX	н			USART1_RX	TIM1_CH3		PA10	38	MICRO_UART_RX
WKP		ADC0			TIM5_CH1		PA0	27	MICRO_WKUP
DAC	Ο	ADC4				DAC1	PA4	22	MICRO_SPI_SSN <sup>[1]</sup>
A5	т	ADC7	SPI (MOSI)		TIM3_CH2		PA7	23	MICRO_SPI_MOSI
A4		ADC6	SPI (MISO)		TIM3_CH1		PA6	25	MICRO_SPI_MISO
A3	Ο	ADC5	SPI (SCK)			DAC2	PA5	24	MICRO_SPI_SCK
A2	N	ADC12	SPI (SS)				PC2	2	MICRO_GPIO_6
A1		ADC13					PC3	1	MICRO_GPIO_7
A0		ADC15					PC5	54	MICRO_GPIO_8
USB	Pin			Exposed Fu	nctions		STM32 Pin	PØ Pin #	PØ Pin Name
	3V3	3V3							
	RST	RST					E8	26	MICRO_RST_N
P	VBAT	VBAT					A9	28	VBAT
н	GND	GND							
	D7	JTAG_TMS					PA13	44	MICRO_JTAG_TMS
0	D6	JTAG_TCK					PA14	40	MICRO_JTAG_TCK
т	D5	JTAG_TDI	SPI1 (SS)			12S3_WS	PA15	43	MICRO_JTAG_TDI
	D4	JTAG_TDO	SPI1 (SCK)			I2S3_SCK	PB3	41	MICRO_JTAG_TDO
0	D3	JTAG_TRST	SPI1 (MISO)		TIM3_CH1		PB4	42	MICRO_JTAG_TRSTN
N	D2		SPI1 (MOSI)	CAN2_RX	TIM3_CH2	12S3_SD	PB5	3	MICRO_GPIO_5
	D1	SCL		CAN2_TX	TIM4_CH1		PB6	5	MICRO_GPIO_3
	D0	SDA			TIM4_CH2		PB7	4	MICRO_GPIO_4
	L	Jser I/O	Photon Pin	#	Exposed Fu	nctions	STM32 Pin	PØ Pin #	PØ Pin Name
	RGB I	LED - RED	27		TIM2_CH2		PA1	8	MICRO_GPIO_0
Ρ	RGB I	LED - GREEN	28		TIM2_CH3		PA2	7	MICRO_GPIO_1
	RGB I	LED - BLUE	29		TIM2_CH4		PA3	6	MICRO_GPIO_2
H	Setup	Button	26		TIM3_CH2	I2S3_MCK	PC7	53	MICRO_GPIO_9
0	Reset	Button	23				E8	26	MICRO_RST_N
-	USB [	Data+	31				PB15	51	MICRO_USB_HS_DP
	USB [	)ata-	30				PB14	52	MICRO_USB_HS_DM
0	SMPS	Enable	25						
			ADC	SPI	PWM/Se	rvo/Tone			
N	Per	ripheral Key	JTAG	SPI1	125	DAC			
			I2C/Wire	Serial1	CAN				

Notes:

<sup>[1]</sup> MICRO\_SPI\_SSN is only for reference as a PØ module pin name. It is technically speaking the STM32 pin PA4 which is the SS pin in an hardware SPI driven sense, however in the Particle API SPI SS is only user controlled as a GPIO. The hardware SS pin is not implemented. The default SS pin for the Particle SPI API is A2 (STM32 pin PC2), but any GPIO can be used for this function with SPI.begin(pin).

## Technical specification

### ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min	Тур	Max	Unit
Supply Input Voltage	V <sub>VIN-MAX</sub>			+6.5	V
Supply Output Current	I <sub>VIN-MAX-L</sub>			1	А
Supply Output Current	I <sub>3V3-MAX-L</sub>			100	mA
Storage Temperature	T <sub>stg</sub>	-40		+85	°C
Enable Voltage	$V_{EN}$			V <sub>VIN</sub> +0.6	V
ESD Susceptibility HBM (Human Body Mode)	V <sub>ESD</sub>			2	kV

#### **RECOMMENDED OPERATING CONDITIONS**

Parameter	Symbol	Min	Тур	Max	Unit
Supply Input Voltage	V <sub>VIN</sub>	+3.6		+5.5	V
Supply Input Voltage	V <sub>3V3</sub>	+3.0	+3.3	+3.6	V
Supply Output Voltage	$V_{\text{VIN}}$		+4.8		V
Supply Output Voltage	V <sub>3V3</sub>		+3.3		V
Supply Input Voltage	$V_{VBAT}$	+1.65		+3.6	V
Supply Input Current (VBAT)	I <sub>VBAT</sub>			19	uA
Operating Current (Wi-Fi on)	I <sub>VIN avg</sub>		80	100	mA
Operating Current (Wi-Fi on)	I <sub>VIN pk</sub>	235[1]		430[1]	mA
Operating Current (Wi-Fi on, w/powersave)	I <sub>VIN avg</sub>		18	100 <sup>[2]</sup>	mA
Operating Current (Wi-Fi off)	I <sub>VIN avg</sub>		30	40	mA
Sleep Current (5V @ VIN)	$I_{Qs}$		1	2	mA
Deep Sleep Current (5V @ VIN)	I <sub>Qds</sub>		80	100	uA
Operating Temperature	T <sub>op</sub>	-20		+60	°C
Humidity Range Non condensing, relative humidity				95	%

### Notes:

<sup>[1]</sup> These numbers represent the extreme range of short peak current bursts when transmitting and receiving in 802.11b/g/n modes at different power levels. Average TX current consumption in will be 80-100mA.

 $^{[2]}$  These are very short average current bursts when transmitting and receiving. On average if minimizing frequency of TX/RX events, current consumption in powersave mode will be 18mA

Parameter	Symbol	Min	Тур	Peak	Unit
Operating Current (uC on, peripherals and radio disabled)	l <sub>idle</sub>	53.3	54.6	55.7	mA
Operating Current (uC on, Wi-Fi on but not connected)	l <sub>wifi_idle</sub>	32.1	60.4	302	mA
Operating Current (uC on, Wi-Fi connecting to ap)	I <sub>wifi_conn_ap</sub>	88.3	103	308	mA
Operating Current (uC on, Wi-Fi connecting to cloud)	I <sub>wifi_conn_cloud</sub>	79.8	94.5	270	mA
Operating Current (uC on, Wi-Fi connected but idle)	I <sub>wifi_cloud_idle</sub>	89.9	106	296	mA
Operating Current (uC on, Wi-Fi connected and transmitting)	I <sub>wifi_cloud_tx</sub>	80.2	107	294	mA
STOP mode sleep, GPIO wake-up	I <sub>stop_gpio</sub>	2.15	2.75	3.26	mA
STOP mode sleep, analog wake-up	I <sub>stop_analog</sub>	6.66	7.56	8.45	mA
STOP mode sleep, RTC wake-up	I <sub>stop_intrtc</sub>	2.11	2.82	3.39	mA
STOP mode sleep, serial wake-up	I <sub>stop_usart</sub>	16.7	18.2	21.6	mA
ULP mode sleep, GPIO wake-up	l <sub>ulp_gpio</sub>	2.14	2.76	3.24	mA
ULP mode sleep, RTC wake-up	I <sub>ulp_intrtc</sub>	2.11	2.83	3.33	mA
HIBERNATE mode sleep, GPIO wake-up	I <sub>hib_gpio</sub>	45.0	114	319	uA
HIBERNATE mode sleep, RTC wake-up	I <sub>hib_rtc</sub>	44.7	114	319	uA

<sup>1</sup>The min, and particularly peak, values may consist of very short transients. The typical (typ) values are the best indicator of overall power consumption over time. The peak values indicate the absolute minimum capacity of the power supply necessary, not overall consumption.

### WI-FI SPECIFICATIONS

Feature	Description
WLAN Standards	IEEE 802 11b/g/n
Antenna Port	Single Antenna
Frequency Band	2.412GHz 2.462GHz (United States of America and Canada)
	2.412GHz 2.472GHz (EU/Japan)
Sub Channels	1 11 (United States of America and Canada)
	1 13 (EU/Japan)
Modulation	DSSS, CCK, OFDM, BPSK, QPSK, 16QAM, 64QAM

PØ module Wi-Fi output power		Тур.	Tol.	Unit
RF Average Output Power, 802.11b CCK Mode	1M	Avail. upon request	+/- 1.5	dBm
	11M	-	+/- 1.5	dBm
RF Average Output Power, 802.11g OFDM Mode	6M	-	+/- 1.5	dBm
	54M	-	+/- 1.5	dBm
RF Average Output Power, 802.11n OFDM Mode	MCS0	-	+/- 1.5	dBm
	MCS7	-	+/- 1.5	dBm

These specifications are based on the STM32F205RGY6 datasheet, with reference to Photon pin nomenclature.

Parameter	Symbol	Conditions	Min	Тур	Max	Unit
Standard I/O input low level voltage	V <sub>IL</sub>		-0.3		0.28*(V <sub>3V3</sub> - 2)+0.8	V
I/O $FT^{[1]}$ input low level voltage	V <sub>IL</sub>		-0.3		0.32*(V <sub>3V3</sub> - 2)+0.75	V
Standard I/O input high level voltage	$V_{\text{IH}}$		0.41*(V <sub>3V3</sub> - 2)+1.3		V <sub>3V3</sub> +0.3	V
$I/O \ FT^{[1]}$ input high level voltage	$V_{\text{IH}}$	V <sub>3V3</sub> > 2V	0.42*(V <sub>3V3</sub> - 2)+1		5.5	V
	$V_{\text{IH}}$	V <sub>3V3</sub> ≤ 2V	0.42*(V <sub>3V3</sub> - 2)+1		5.2	V
Standard I/O Schmitt trigger voltage hysteresis <sup>[2]</sup>	V <sub>hys</sub>		200			mV
I/O FT Schmitt trigger voltage hysteresis <sup>[2]</sup>	V <sub>hys</sub>		5% V <sub>3V3</sub> <sup>[3]</sup>			mV
Input/Output current max	l <sub>io</sub>				±25	mA
Input/Output current total	l <sub>io total</sub>				±120	mA
Input leakage current <sup>[4]</sup>	l <sub>lkg</sub>	$GND \le V_{io} \le V_{3V3}$ GPIOs			±l	μA
Input leakage current <sup>[4]</sup>	l <sub>lkg</sub>	R <sub>PU</sub>	V <sub>io</sub> = 5V, I/O FT		3	μA
Weak pull-up equivalent resistor <sup>[5]</sup>	R <sub>PU</sub>	V <sub>io</sub> = GND	30	40	50	kΩ
Weak pull-down equivalent resistor <sup>[5]</sup>	R <sub>PD</sub>	V <sub>io</sub> = V <sub>3V3</sub>	30	40	50	kΩ
I/O pin capacitance	C <sub>IO</sub>			5		pF
DAC output voltage (buffers enabled by default)	$V_{\text{DAC}}$		0.2		V <sub>3V3</sub> -0.2	V
DAC output resistive load (buffers enabled by default)	R <sub>DAC</sub>		5			kΩ
DAC output capacitive load (buffers enabled by default)	C <sub>DAC</sub>				50	pF

### Notes:

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

<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

Headers	Dimensions in inches (mm)	Weight
With	1.44 x 0.8 x 0.27 (36.58 x 20.32 x 6.86)	5 grams
Without	1.44 x 0.8 x 0.17 (36.58 x 20.32 x 4.32)	3.7 grams

#### MATING CONNECTORS

The Photon (with headers) can be mounted with (qty 2) 12-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 Photon:

| Description | MFG | MFG Part Number | Distributor | |:-:|:-:| | 12-pin 0.1" Female Header (Tin) | Sullins Connector Solutions | <u>PPTC121LFBN-RC</u> | Digi-Key | | 12-pin 0.1" Female Header (Gold) | Sullins Connector Solutions | <u>PPPC121LFBN-RC</u> | Digi-Key | | 12-pin 0.1" Female Header (Tin) | Harwin | <u>M20-</u> 7821246 | Mouser |

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

### RECOMMENDED PCB LAND PATTERN (PHOTON WITH HEADERS)

The Photon (with headers) can be mounted with 0.1" 12-pin female header receptacles using the following PCB land pattern:



A Photon with headers part for EAGLE can be found in the Particle EAGLE library

The Photon (without headers) can be surface mounted directly in an end application PCB using the following PCB land pattern:



In addition to the 24 pins around the outside of the Photon, there are 7 pads on the bottom the Photon PCB that can be used to connect to extra signals: RGB LED outputs, SETUP button, SMPS enable line and USB D+/D-. Photon Pins #25-31 are described in the Pin out diagrams.

Solder mask around exposed copper pads should be 0.1mm (4 mils) larger in all directions. E.g., a 0.08" x 0.10" pad would have a 0.088" x 0.108" solder mask.

A Photon without headers part for EAGLE can be found in the Particle EAGLE library

### Schematic

### SCHEMATIC - USB



### SCHEMATIC - POWER



#### SCHEMATIC - USER I/O







#### SCHEMATIC - PØ WI-FI MODULE





PHOTON VI.0.0 GND LAYER (G2L)



PHOTON VI.0.0 TOP LAYER (GTL)

Layout



PHOTON VI.0.0 BOTTOM LAYER (GBL)





### Recommended solder reflow profile

### Bill of materials

### BUILD YOUR OWN DESIGN BASED ON THE PHOTON!

		Minimum				
Qty	Device	Specification	Package/Case	Part Designator	MFG.	MFG. PN
1	ANTENNA	2.4GHz Ceramic	5.0mm × 2.0mm x 2.6mm	ΑΝΤΙ	Advanced Ceramic X	AT7020-E3R0HBA
2	CERAMIC CAPACITOR	22uF Ceramic 6.3V 10% X5R	0603	C4,C5	Samsung	CL10A226MQ8NRNC
6	CERAMIC CAPACITOR	0.1uF Ceramic 6.3V 10% X5R	0402	C6,C7,C8,C11,C12,C16	RongFu	0402B104K01A
2	CERAMIC CAPACITOR	100pF Ceramic 6.3V 10% X5R	0402	C2,C3	Fenghua	0402CG101J500NT
4	CERAMIC CAPACITOR	10uF Ceramic 6.3V 10% X5R	0603	C9,C11,C13,C15	Sumsung	CL10A106MQ8NNNC
3	CERAMIC CAPACITOR (RF)	10pF Ceramic 6.3V 10% X5R	0402	C1,C14,C17	Murata	GJM1555C1HR80BB01D
1	CONNECTOR	USB Micro-B w/tabs & slots	USB-MICROB	ΓX	Kaweei	CMCUSB-5BFM2G-01- D
1	CONNECTOR	uFL Connector	SMD	X2	Kaweei	P1163-0140R
2	HEADER	Single String 1.2" Mating Length	0.1" 12-pin	JPI,JP2	Kaweei	CP25411-12G-S116-A
1	DIODE	Diode Schottky 30V 3A	DO-220AA	DI	Vishay	SS3P3-M3/84A
1	DIODE (LED)	Blue	SMD 0603	LEDI	Everlight	19-217/BHC- ZL1M2RY/3T
1	DIODE (LED)	LED RGB Common Anode Diffused SMD	4-PLCC (2.0mm x 2.0mm)	LED2	Cree	CLMVB-FKA- CFHEHLCBB7A363
1	INDUCTOR	2.2uH 1.5A	3mm x 3mm	L4	Taiyo Yuden	NR3015T2R2M
1	INDUCTOR (RF)	3.9nH RF inductor	0402	L3	Johanson	L-07C3N9SV6T
1	INDUCTOR (RF)	4.7nH RF inductor	0402	LI	Johanson	L-07C4N7SV6T
1	INDUCTOR (RF)	6.8nH RF inductor	0402	L2	Johanson	L-07C6N8JV6T
1	WI-FI + MCU	Broadcom Wi-FI + STM32F205RGY6 MCU	Custom USI SMD	UI	USI	WM-N-BM-09-S
1	RF SWITCH	RF Switch SPDT	UQFN-6 (lx1mm)	U3	Skyworks	SKY13350-385LF
1	POWER REGULATOR	3.3V 1.5MHz 600mA High Efficiency PWM Step-Down DC/DC Converter	SOT23-5	U2	Richtek	RT8008-33GB
1	RESISTOR	100k 5%	0402	R4	Fenghua	RC-02W104FT
2	RESISTOR	22R 5%	0402	R5,R6	Fenghua	RC-02W220JT
1	RESISTOR	10k 5%	0402	R8	Fenghua	RC-02W103JT
4	RESISTOR	1k 5%	0402	R1,R2,R3,R7	Fenghua	RC-02W102JT
2	SWITCH	Button 160gf	3.6mm x 3.1mm	SETUP,RESET	Haoyu	TS-1185A-C

# Ordering information

Photons are available from <u>store.particle.io</u> in single quantities with and without headers, and also included in different maker kits.

SKU	Description	Region	Lifecycle	Replacement
PHNTRAYH	Photon with Headers, Tray [x50]	Global	Deprecated	
PHNTRAYNOH	Photon without Headers, Tray [x50]	Global	Deprecated	
PHOTONH	Photon with Headers, [x1]	Global	Deprecated	
PHOTONKIT	Photon with Headers Starter Kit, [x1]	Global	Deprecated	
PHOTONNOH	Photon without Headers, Dev board Kit [x1]	Global	Deprecated	

# Qualification and approvals



### **Photon with Headers**

- Model Number: PHOTONH
- RoHS
- CE
- FCC ID: 2AEMI-PHOTON
- ISED: 20127-PHOTON

### **Photon without Headers**

- Model Number: PHOTONNOH
- RoHS
- CE
- FCC ID: 2AEMI-PHOTON
- ISED: 20127-PHOTON

### Product handling

### PACKAGING

The Photon comes in two primary styles of packaging: Matchbox and Kit Box. The matchbox packaging contains the bare essentials to get you started, while the Photon Kit contains a breadboard, Micro B USB cable, sticker, prototyping card and a couple sensors to build your first Internet connected project!



Photons without headers in matchbox packaging are also available in JEDEC style trays for automated pick and place machines. Request more details from us on this in the Contact section below.

### MOISTURE SENSITIVITY LEVELS

The Moisture Sensitivity Level (MSL) relates to the packaging and handling precautions required. The PØ module on the Photons dominate the MSL requirements and are rated level 3. In general, this precaution applies for Photons without headers. If reflowing a Photon directly onto an application PCB, increased moisture levels prior to reflow can damage sensitive electronics on the Photon. A bake process to reduce moisture may be required.

For more information regarding moisture sensitivity levels, labeling, storage and drying see the MSL standard see IPC/JEDEC J-STD-020 (can be downloaded from www.jedec.org).

#### ESD PRECAUTIONS

The photon contains highly sensitive electronic circuitry and is an Electrostatic Sensitive Device (ESD). Handling a photon 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 photons. ESD precautions should be implemented on the application board where the photon is mounted. Failure to observe these precautions can result in severe damage to the photon!

### Default settings

The Photon comes preprogrammed 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 <u>Particle Web IDE</u> to code, compile and flash a user application OTA (Over The Air). <u>Particle Workbench</u> 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 <u>Particle CLI</u> provides a commandline interface for cloud-based compiles and flashing code over USB.

### Glossary

### SMPS

Switched-Mode Power Supply

### RF

Radio Frequency

### Castellated

The edge of the PCB has plated holes that are cut in half which resemble the top of a castle. These make it easy to solder the Photon down to another PCB with a SMT reflow process.

### SMT

Surface Mount Technology (often associated with SMD which is a surface mount device).

### AP

Access Point

### 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

+3.3V; The regulated +3.3V supply rail. Also used to note a pin is only 3.3V tolerant.

### RTC

Real Time Clock

### ΟΤΑ

Over The Air; describing how firmware is transferred to the device.

# FCC ISED 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: 2AEMI-PHOTON

**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 ISED: 20127-PHOTON

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.

# Revision history

Revision	Date	Author	Comments
-	30-March- 2015	BW	Initial release
v003	7-April-2015	BW	Updated template
v004	8-April-2015	BW	Updated Overview, Block diagram, Power, RF, and Pin markings sections
v005	9-April-2015	BW	Updated BOM
v006	21-April- 2015	BW	Added JTAG, BT CO-EX, I/O Characteristics, Schematic, Layout, Reflow Profile, Glossary, Updated Operating Conditions
∨007	28-April- 2015	BW	Added Layout, Updated analog pins, Land patterns, Packaging, Mating Connectors
v008	11-May-2015	BW	Updated BT CO-EX, PWM info, Qualifications
∨009	31-May-2015	BW	Updated Pinouts, DAC info, Height dimensions, Solder mask info, Recommended operating conditions
v010	1-June-2015	BW	Updated VBAT info
v011	24-July- 2015	BW	Added FCC ISED CE Warnings and End Product Labeling Requirements, Updated power output, added approved antennas, Corrected DAC2 as A3, Added pin numbers to PCB Land Pattern for Photon without headers.
v012	15-January- 2016	WH	Added TELEC Certification information and expanded explanation of Photons with and without headers.
v013	7-April-2016	BW	Added: full STM32 part number, Memory map, DAC limits, SWD pin locations, max source/sink current, more descriptive info about bottom side pads, known errata URL. Updated: BT COEX info, pin diagram, block diagram, operating conditions, pin descriptions, land-pattern image signal keepout note.
v014	13- September- 2016	BW	Updated Mating connectors section.
v015	25-July- 2017	BW	Updated the Pin Description section and added high resolution pinout PDF, PWM notes and DCT layout, added warning to power section
v016	31-May-2018	BW	Updated External Coexistence Interface section (unsupported)
v017	16-Sep- 2020	RK	Added power consumption information
v018	15-Mar-2021	RK	Updated ordering information
v019	19-May-2021	RK	Updated External Coexistence Interface section
v020	10-Sep-2021	RK	Changed wording of peak vs. max current
v021	14-Mar- 2023	RK	Added deprecation notice
v022	31-Jan-2023	RK	Added Device OS versions

### 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