Particle

PØ Datasheet


```
void setup() {
    Particle.publish("my-event","The internet just got smarter!");
}
```

Contents

1. Functional description

1.1 Overview

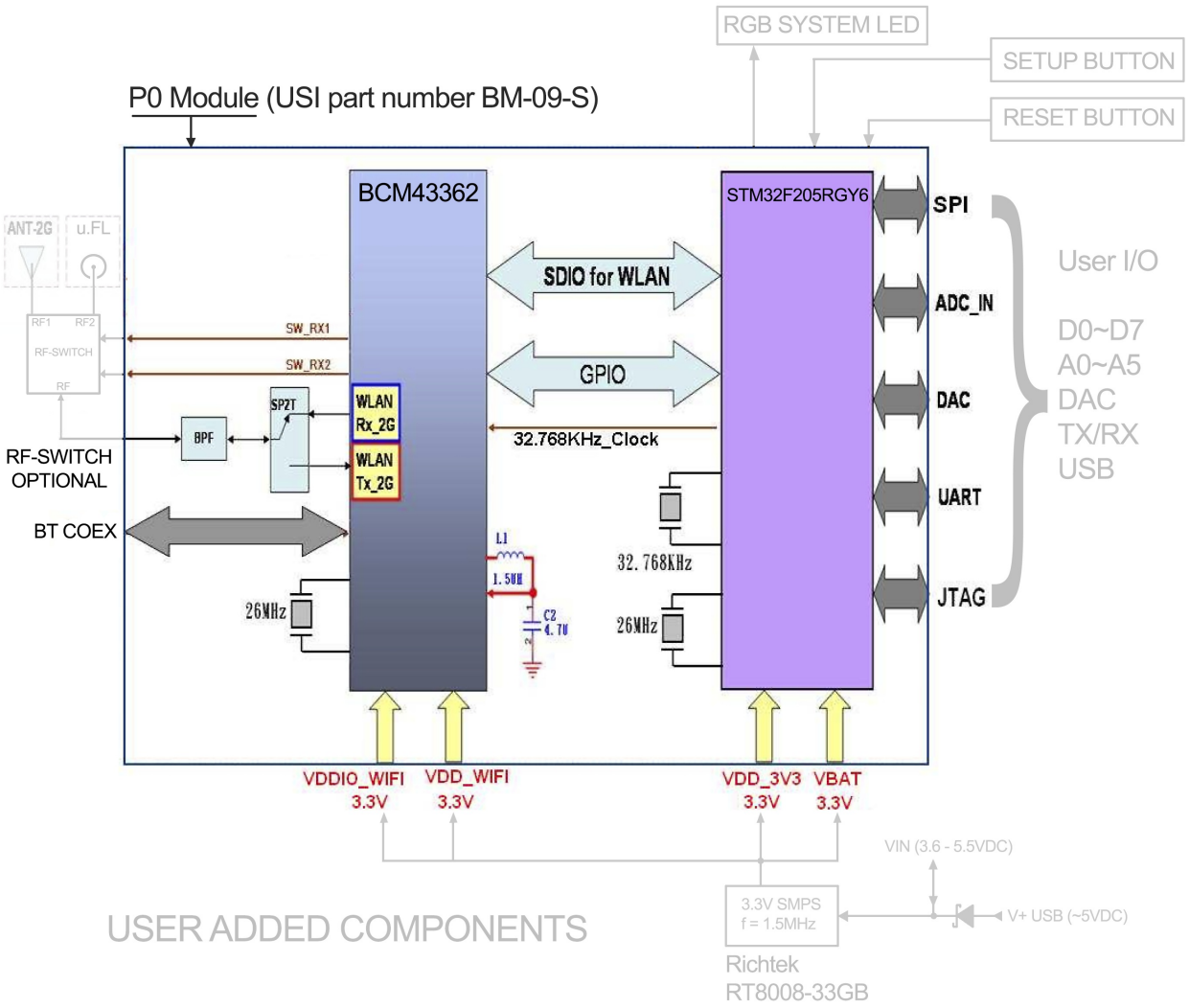
The PØ is Particle's tiny Wi-Fi module that powers the Photon that contains both the Broadcom Wi-Fi chip and a reprogrammable STM32 32-bit ARM Cortex-M3 microcontroller. The PØ comes preloaded with Particle firmware libraries, just like our dev kits, and it's designed to simplify your transition from prototype to production. Every PØ includes free cloud service.

1.2 Features

- Particle PØ Wi-Fi module
  - Broadcom BCM43362 Wi-Fi chip
  - 802.11b/g/n Wi-Fi
  - STM32F205 120Mhz ARM Cortex M3
  - 1MB flash, 128KB RAM
  - RF avg. output power (max)
    - b / g / n, 16.5dBm / 15.0dBm / 14.5dBm (+/-1.5dBm)
- 18 Mixed-signal GPIO and advanced peripherals
- Open source design
- Real-time operating system (FreeRTOS)
- Soft AP setup
- FCC, CE and IC certified

2. Interfaces

2.1 Block Diagram



2.2 Power

Power to the PØ is supplied via 3 different inputs: VDD_WIFI (pin 19 & 20), VDD_3V3 (pin 46 & 47), and VDDIO_WIFI (pin 49). Optionally +3.3V may be supplied to VBAT (pin 28) for data retention in low power sleep modes. Each of these inputs also requires a 0.1uF and 10uF ceramic decoupling capacitor, located as close as possible to the pin (see Fig 1). The voltage should be regulated between 3.0VDC and 3.6VDC.

Typical current consumption is 80mA with a 3.3V input. Deep sleep quiescent current is 160uA. When powering the PØ make sure the power supply can handle 600mA continuous. If a lesser power supply is provided, peak currents drawn from the PØ 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 be on the safe side.

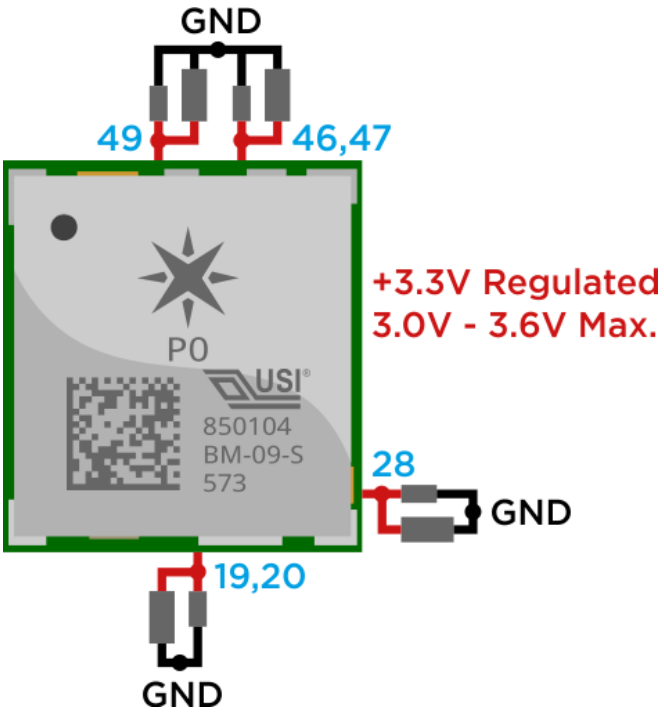


Fig. 1 Recommended power connections with decoupling capacitors.

2.3 RF

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

The PØ module provides one RF output that may be used in a dedicated antenna application such as a ceramic chip antenna or u.FL connector. Alternatively, the PØ module RF output can be feed into a SPDT RF-switch to support two separate antennae, such as is done on the Photon. 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. The default port will be set to the chip antenna.

All RF traces are considered as tiny transmission lines that have a controlled 50 ohm impedance. If using a chip antenna, it must be impedance matched to the 50 ohm RF feed line via a Pi network comprised of three RF inductors (1 series, 2 shunt). These values, PCB construction and RF layout are quite specific to the PØ FCC certification and must be followed precisely to avoid re-certification. Even when 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.

2.4 Peripherals and GPIO

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

Note: PØ pin names will be preserved as they are named in the USI datasheet, however for the scope of this datasheet we will also refer to them as their Photon and code equivalents, i.e. D7 instead of MICRO_JTAG_TMS and A2 instead of MICRO_GPIO_6. This will help to simplify descriptions, while providing a quick reference for code that can be written for the PØ such as `int value = analogRead(A2);`

Peripheral Type	Qty	Input(I) / Output(O)	FT[1] / 3V3[2]
Digital	18	I/O	FT/3V3
Analog (ADC)	9	I	3V3
Analog (DAC)	2	O	3V3
SPI	2	I/O	3V3
I2S	1	I/O	3V3
I2C	1	I/O	FT
CAN	1	I/O	FT
USB	1	I/O	3V3
PWM	9[3]	O	3V3

Notes:

[1] 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.

[2] 3V3 = 3.3V max pins.

[3] 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.

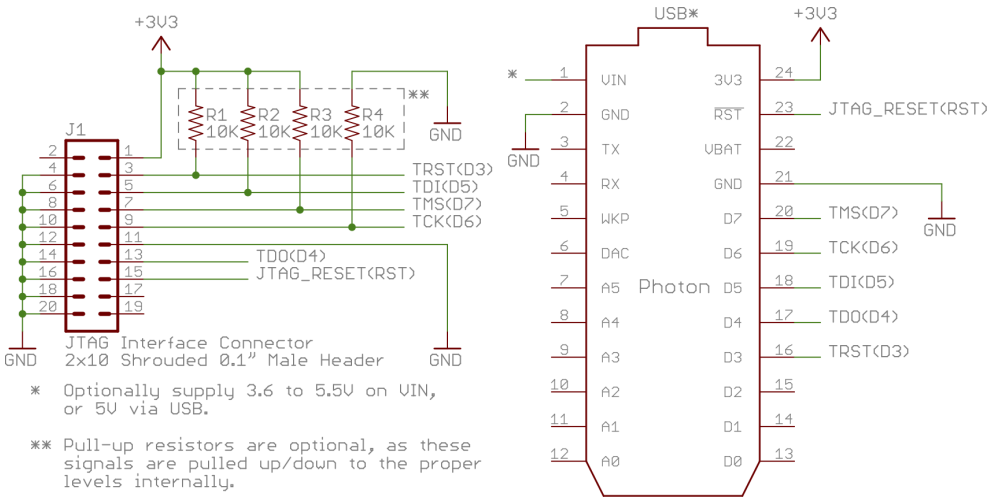
2.5 JTAG

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

Photon Pin	Description	STM32 Pin	PØ Pin #	PØ Pin Name	Default Internal[1]
D7	JTAG_TMS	PA13	44	MICRO_JTAG_TMS	~40k pull-up
D6	JTAG_TCK	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				
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.

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



2.6 External Coexistence Interface

The PØ supports coexistence with Bluetooth and other external radios via the three gold pads on the top side of the PCB near pin A3. These pads are 0.035” square, spaced 0.049” apart. This spacing supports the possibility of tacking on a small 1.25mm - 1.27mm pitch 3-pin male header to make it somewhat easier to interface with.

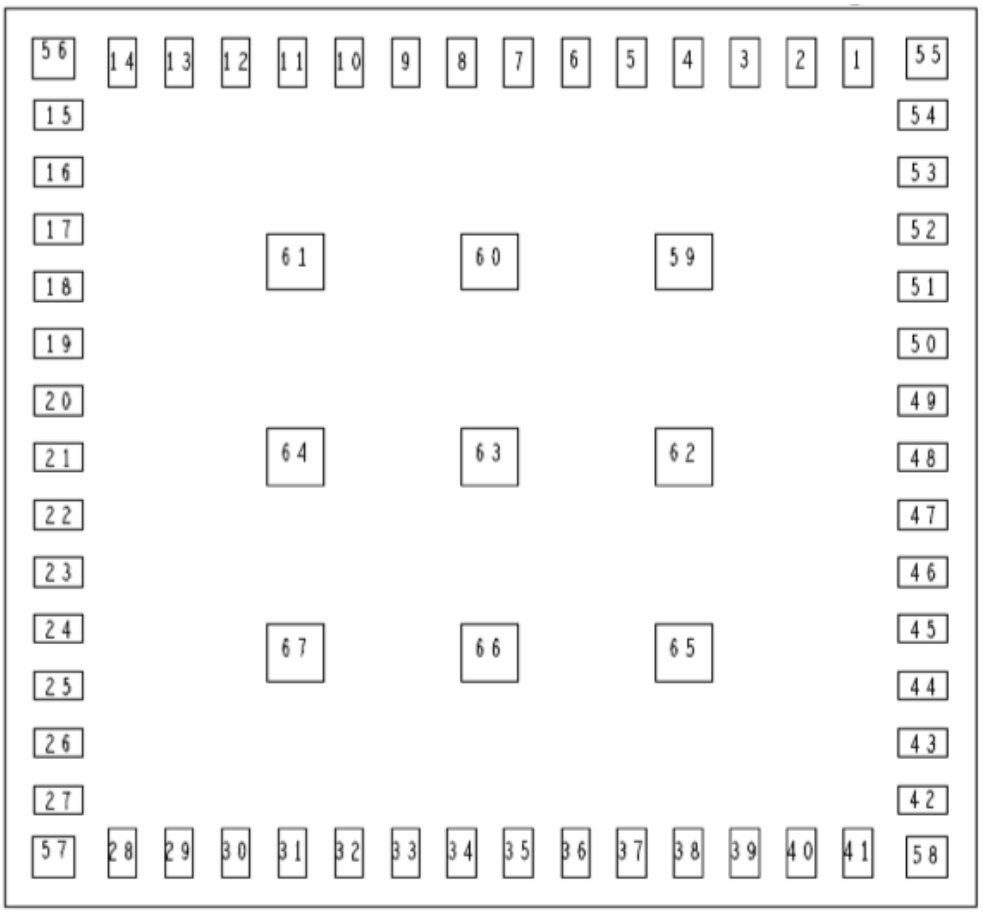
When two radios occupying the same frequency band are used in the same system, such as Wi-Fi and Bluetooth, a coexistence interface can be used to coordinate transmit activity, to ensure optimal performance by arbitrating conflicts between the two radios.

PØ Pin Name	PØ Pin #	I/O	Description
BTCX_RF_ACTIVE	9	I	Coexistence signal: Bluetooth is active
BTCX_STATUS	10	I	Coexistence signal: Bluetooth priority status and TX/RX direction
BTCX_TXCONF	11	O	Output giving Bluetooth permission to TX

When these pads are programmed to be used as a Bluetooth coexistence interface, they’re set as high impedance on power up and reset. Alternatively, they can be individually programmed to be used as GPIOs through software control. They can also be programmed to have an internal pull-up or pull-down resistor.

3. Pin definition

3.1 Pin locations



Top View

3.2 Pin description

Pin	Description
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 (1.8 to 3.3VDC).
3V3	This pin represents the regulated +3.3V DC power to the PØ module. In reality, +3.3V must be supplied to 3 different inputs: VDD_WIFI (pin 19 & 20), VDD_3V3 (pin 46 & 47), and VDDIO_WIFI (pin 49). Optionally +3.3V may be supplied to VBAT (pin 28) for data retention in low power sleep modes. Each of these inputs also requires a 0.1uF and 10uF ceramic decoupling capacitor, located as close as possible to the pin.
D0~D7	Digital only GPIO pins.
A0~A5, A7~A9	12-bit Analog-to-Digital (A/D) inputs, and also digital GPIOs. A7~A9 are code convenience mappings, which means pins are not actually labeled as such but you may use code like `analogRead(A9)`. A7 maps to the WKP pin, A8 to the RX pin and A9 to the TX pin.
DAC	10-bit Digital-to-Analog (D/A) output, and also a digital GPIO.
RX	Primarily used as UART RX, but can also be used as a digital GPIO, ADC input or PWM.
TX	Primarily used as UART TX, but can also be used as a digital GPIO, ADC input or PWM.

3.3 Pin out diagrams (based on Photon Reference Design)

The Photon pinouts do a great job of explaining all available functions of each PØ pin.

USB	Pin	Exposed Functions					STM32 Pin	P0 Pin #	P0 Pin Name
PHOTON	3V3	3V3							
	RST	RST					E8	26	MICRO_RST_N
	VBAT	VBAT					A9	28	VBAT
	GND	GND							
	D7	JTAG_TMS					PA13	44	MICRO_JTAG_TMS
	D6	JTAG_TCK					PA14	40	MICRO_JTAG_TCK
	D5	JTAG_TDI	SPI3_SS			I2S3_WS	PA15	43	MICRO_JTAG_TDI
	D4	JTAG_TDO	SPI3_SCK			I2S3_SCK	PB3	41	MICRO_JTAG_TDO
	D3	JTAG_TRST	SPI3_MISO		TIM3_CH1		PB4	42	MICRO_JTAG_TRSTN
	D2		SPI3_MOSI	CAN2_RX	TIM3_CH2	I2S3_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

Pin	USB	Exposed Functions					STM32 Pin	P0 Pin #	P0 Pin Name
VIN	PHOTON	VIN							
GND		GND							
TX		ADC2		USART1_TX	TIM1_CH2		PA9	39	MICRO_UART_TX
RX		ADC3		USART1_RX	TIM1_CH3		PA10	38	MICRO_UART_RX
WKP		ADC0			TIM5_CH1		PA0	27	MICRO_WKUP
DAC						DAC1	PA4	22	MICRO_SPI_SSN
A5		ADC7	SPI1_MOSI		TIM3_CH2		PA7	23	MICRO_SPI_MOSI
A4		ADC6	SPI1_MISO		TIM3_CH1		PA6	25	MICRO_SPI_MISO
A3		ADC5	SPI1_SCK			DAC2	PA5	24	MICRO_SPI_SCK
A2		ADC12	SPI1_SS				PC2	2	MICRO_GPIO_6
A1		ADC13					PC3	1	MICRO_GPIO_7
A0		ADC15					PC5	54	MICRO_GPIO_8

USB	User I/O	Exposed Functions			STM32 Pin	P0 Pin #	P0 Pin Name
PHOTON	RGB LED - RED		TIM2_CH2		PA1	8	MICRO_GPIO_0
	RGB LED - GREEN		TIM2_CH3		PA2	7	MICRO_GPIO_1
	RGB LED - BLUE		TIM2_CH4		PA3	6	MICRO_GPIO_2
	Setup Button		TIM3_CH2	I2S3_MCK	PC7	53	MICRO_GPIO_9
	Reset Button				E8	26	MICRO_RST_N
	USB Data+				PB15	51	MICRO_USB_HS_DP
	USB Data-				PB14	52	MICRO_USB_HS_DM

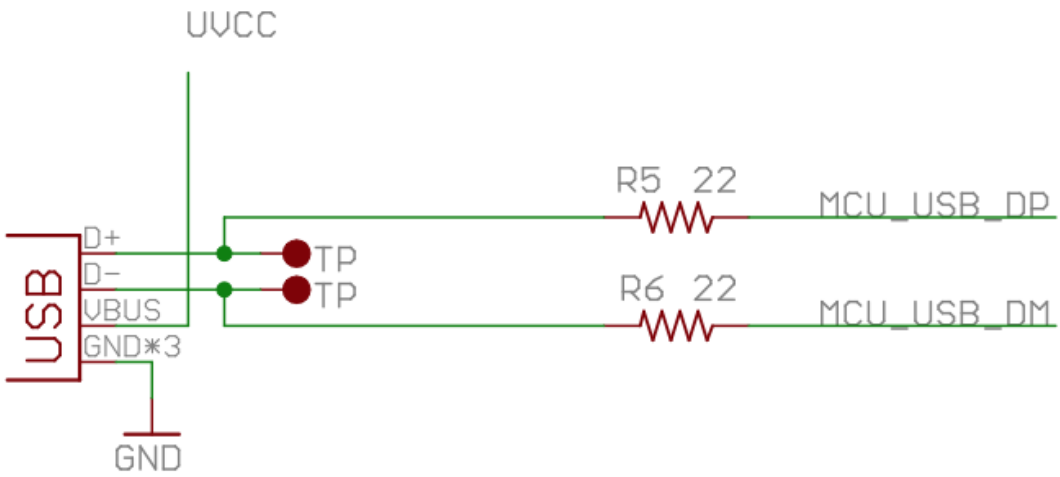
3.4 Complete PØ Module Pin Listing

PØ Pin #	PØ Pin Name	Type	Description
1	MICRO_GPIO_7	I/O	GPIO pin
2	MICRO_GPIO_6	I/O	GPIO pin
3	MICRO_GPIO_5	I/O	GPIO pin
4	MICRO_GPIO_4	I/O	GPIO pin
5	MICRO_GPIO_3	I/O	GPIO pin
6	MICRO_GPIO_2	I/O	GPIO pin
7	MICRO_GPIO_1	I/O	GPIO pin
8	MICRO_GPIO_0	I/O	GPIO pin
9	BTCX_RF_ACTIVE	I	Coexistence signal: Bluetooth is active
10	BTCX_STATUS	I	Coexistence signal: Bluetooth status and TX/RX direction
11	BTCX_TXCONF	O	Output giving Bluetooth permission to TX
12	RF_SW_CTRL3_ANT1	O	RF switch control line. low after reset.
13	RF_SW_CTRL0_ANT0	O	RF switch control line. high after reset.
14	GND	PWR	Ground
15	ANT	I/O	Antenna port for WLAN
16~18	GND	PWR	Ground
19~20	VDD_WIFI	PWR	+3.3V
21	GND	PWR	Ground
22	MICRO_SPI_SS	I/O	SPI SS
23	MICRO_SPI_MOSI	I/O	SPI MOSI
24	MICRO_SPI_SCK	I/O	SPI SCK
25	MICRO_SPI_MISO	I/O	SPI MISO
26	MICRO_RST_N	I/O	Active low MCU reset

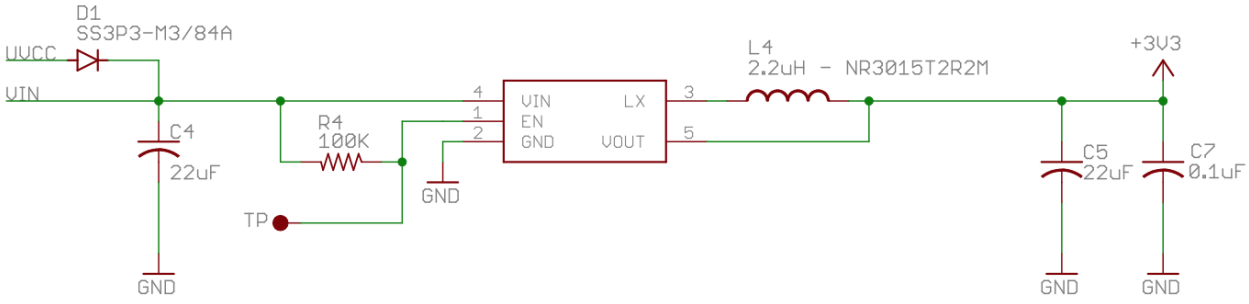
PØ Pin #	PØ Pin Name	Type	Description
27	MICRO_WKUP	I/O	Active high MCU wake up
28	VBAT	PWR	Supply to the internal RTC, backup registers and SRAM (1.8 to 3.3VDC)
29~30	GND	PWR	Ground
31~36	NC	NC	No Connection
37	GND	PWR	Ground
38	MICRO_UART_RX	I/O	UART RX
39	MICRO_UART_TX	I/O	UART TX
40	MICRO_JTAG_TCK	I/O	JTAG TCK
41	MICRO_JTAG_TDO	I/O	JTAG TDO
42	MICRO_JTAG_TRSTN	I/O	JTAG TRSTN
43	MICRO_JTAG_TDI	I/O	JTAG TDI
44	MICRO_JTAG_TMS	I/O	JTAG TMS
45	GND	PWR	Ground
46~47	VDD_3V3	PWR	+3.3V
48	GND	PWR	Ground
49	VDDIO_WIFI	PWR	+3.3V
50	GND	PWR	Ground
51	MICRO_USB_HS_DP	I/O	USB Data+
52	MICRO_USB_HS_DN	I/O	USB Data–
53	MICRO_GPIO_9	I/O	GPIO pin
54	MICRO_GPIO_8	I/O	GPIO pin
55~67	GND	PWR	Ground

4. Photon Reference Design Schematic

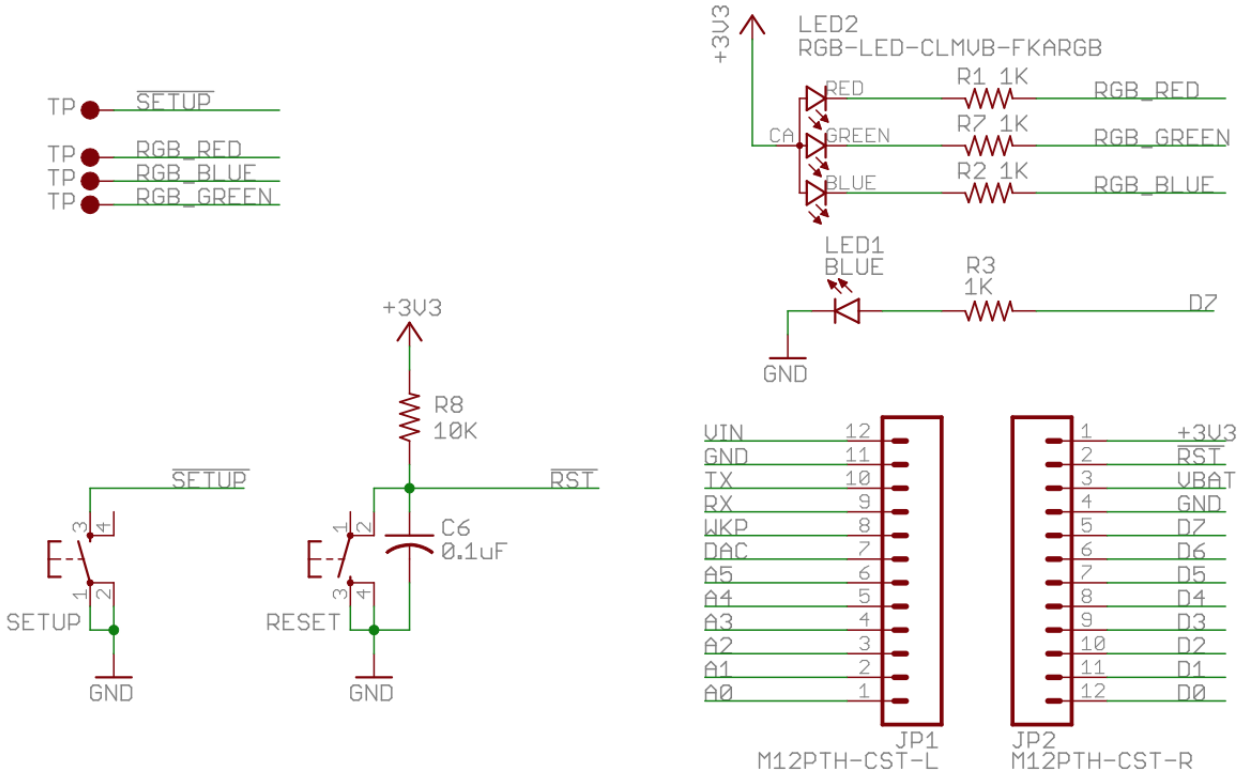
4.1 Schematic - USB



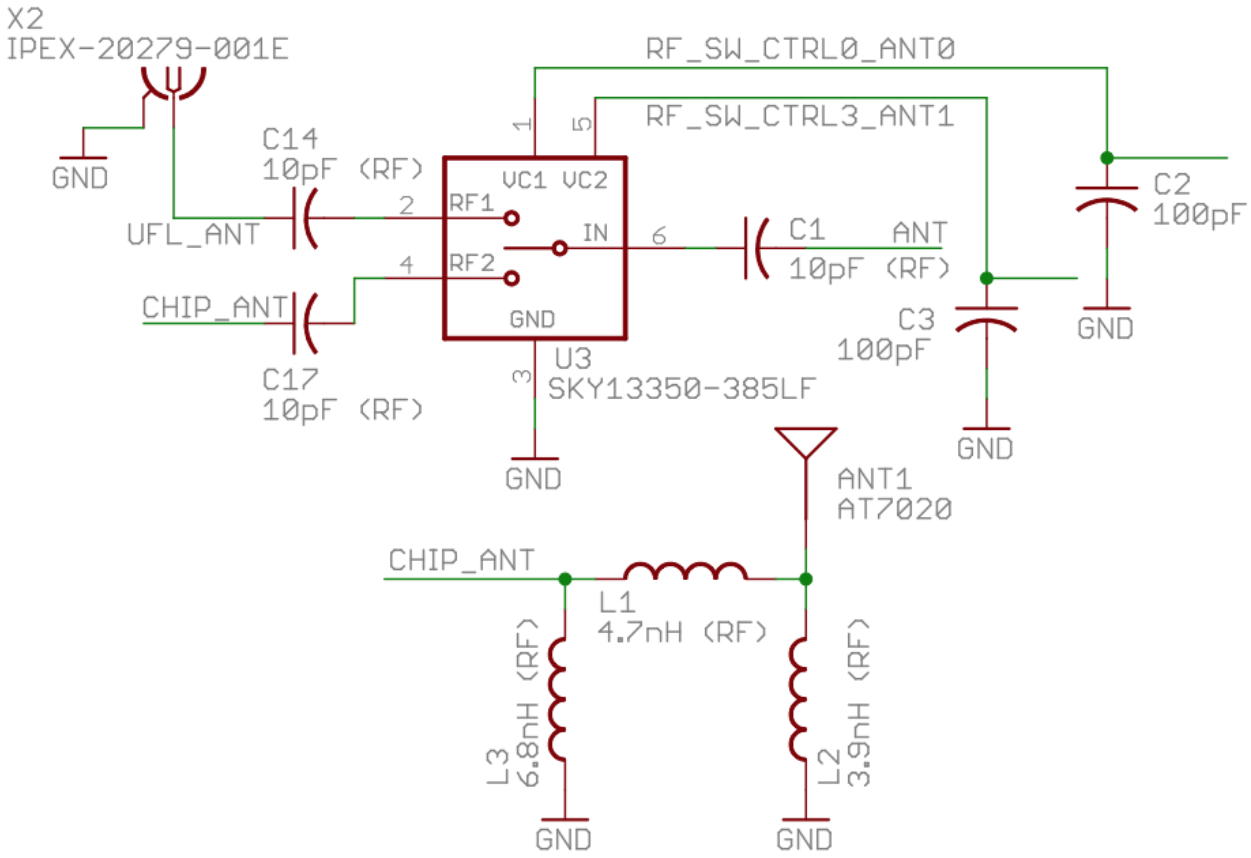
4.2 Schematic - Power



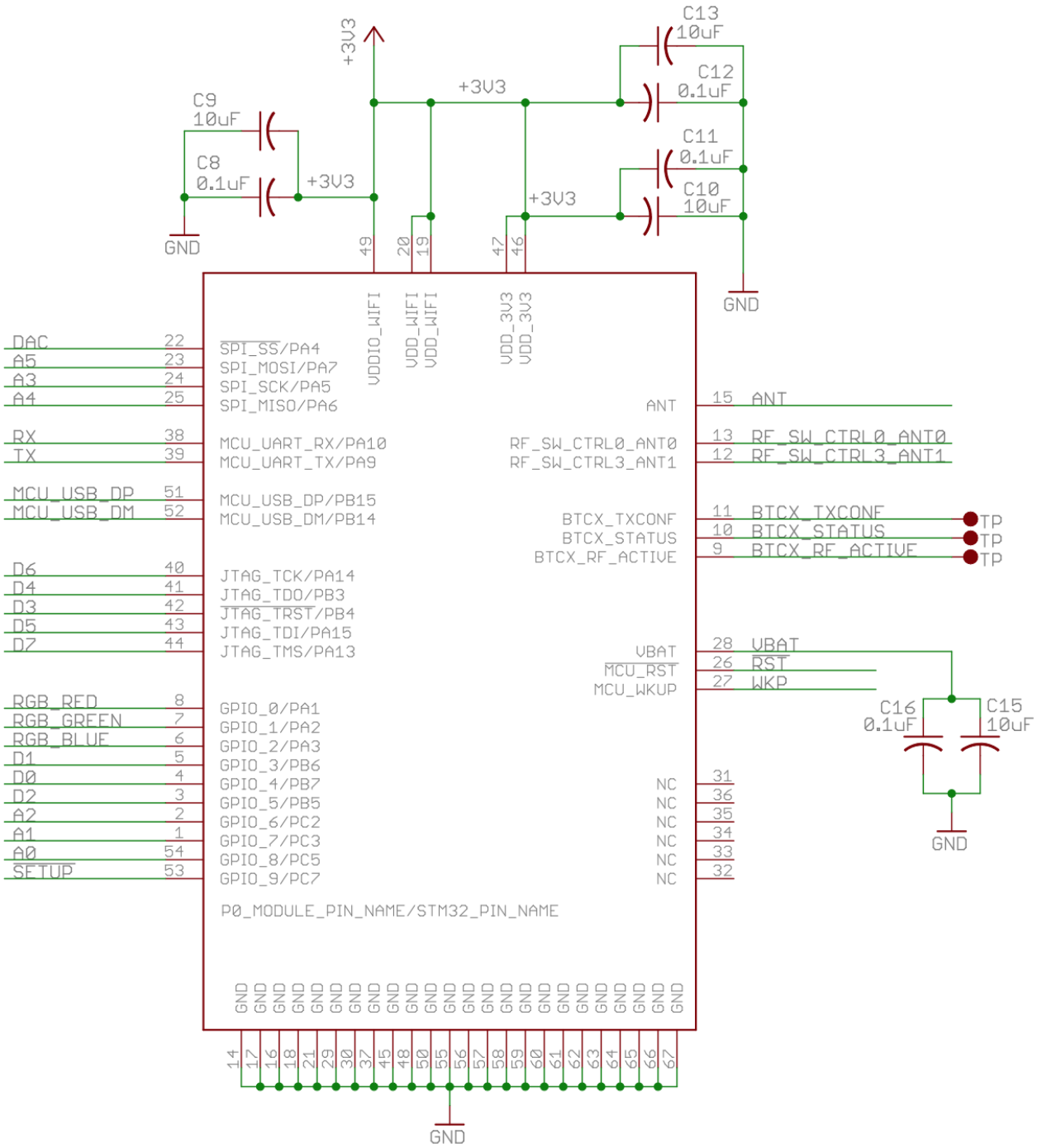
4.3 Schematic - User I/O



4.4 Schematic - RF

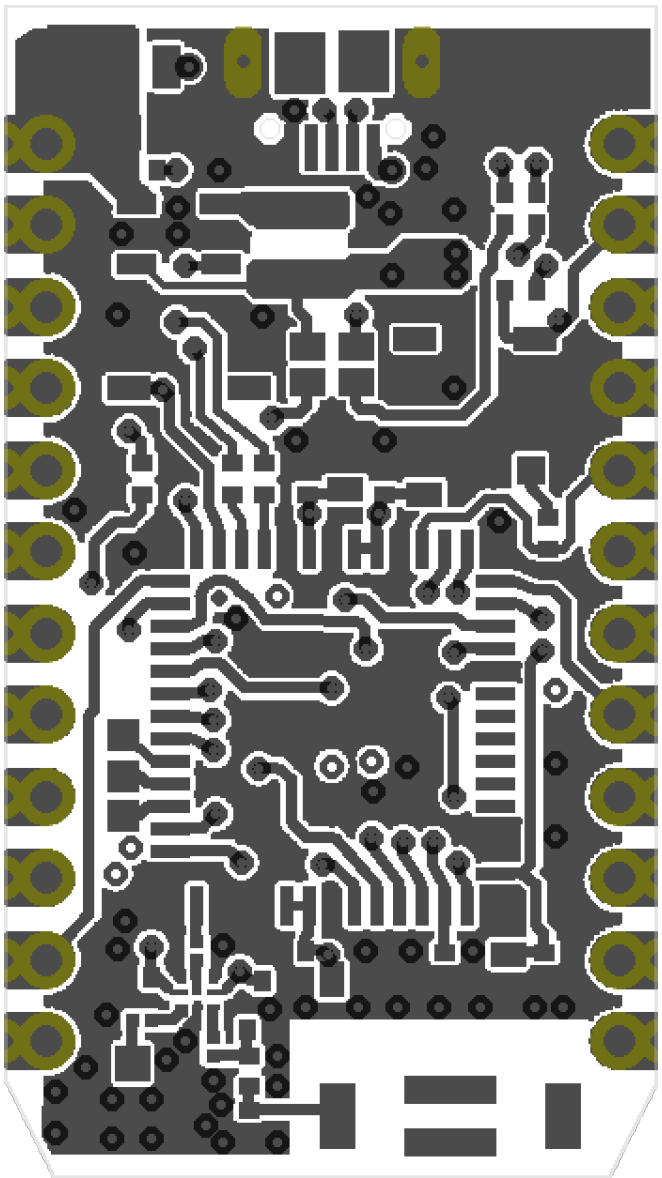


4.5 Schematic - PØ Wi-Fi Module

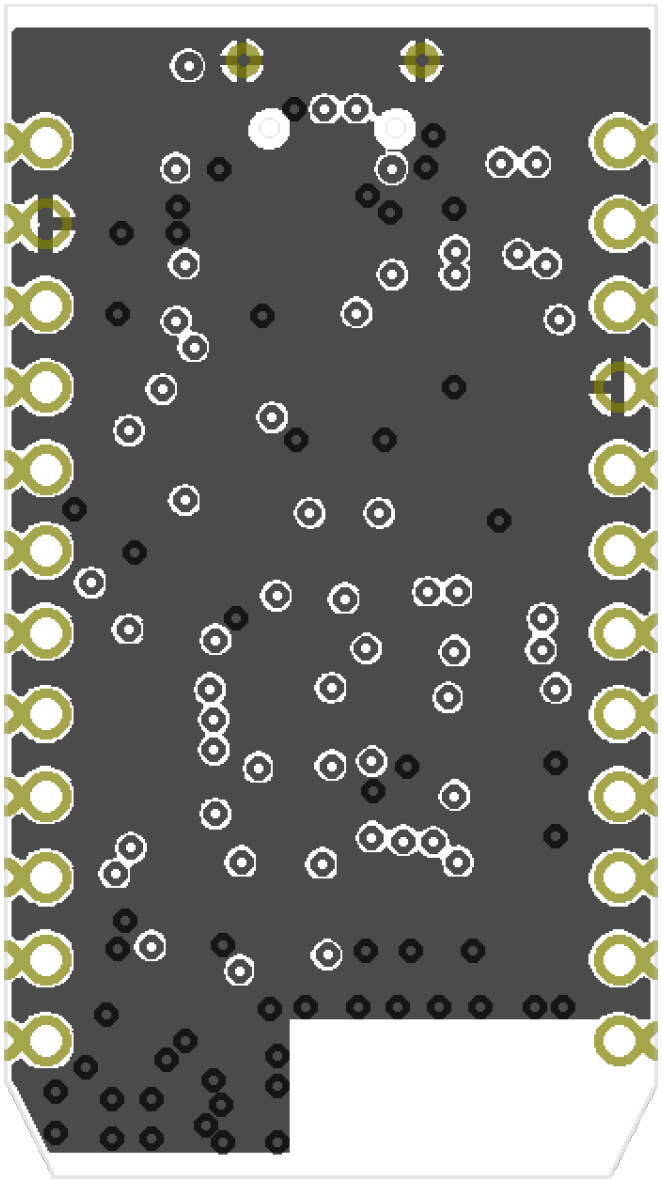


5. Photon Reference Design Layout

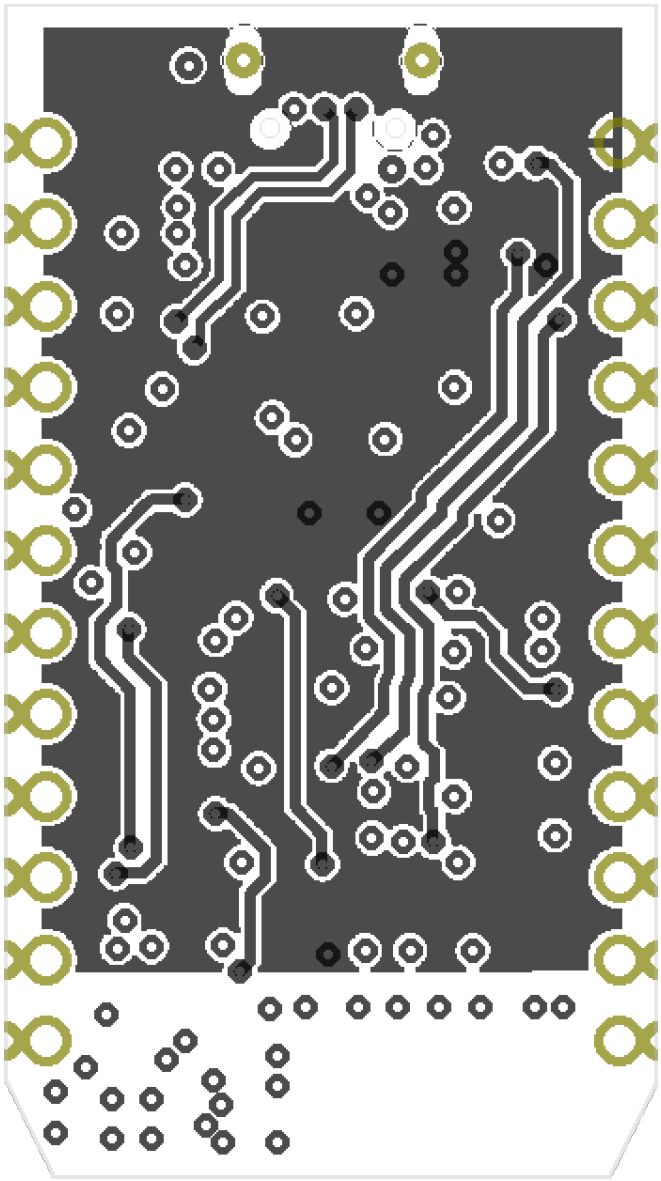
5.1 Photon v1.0.0 Top Layer (GTL)



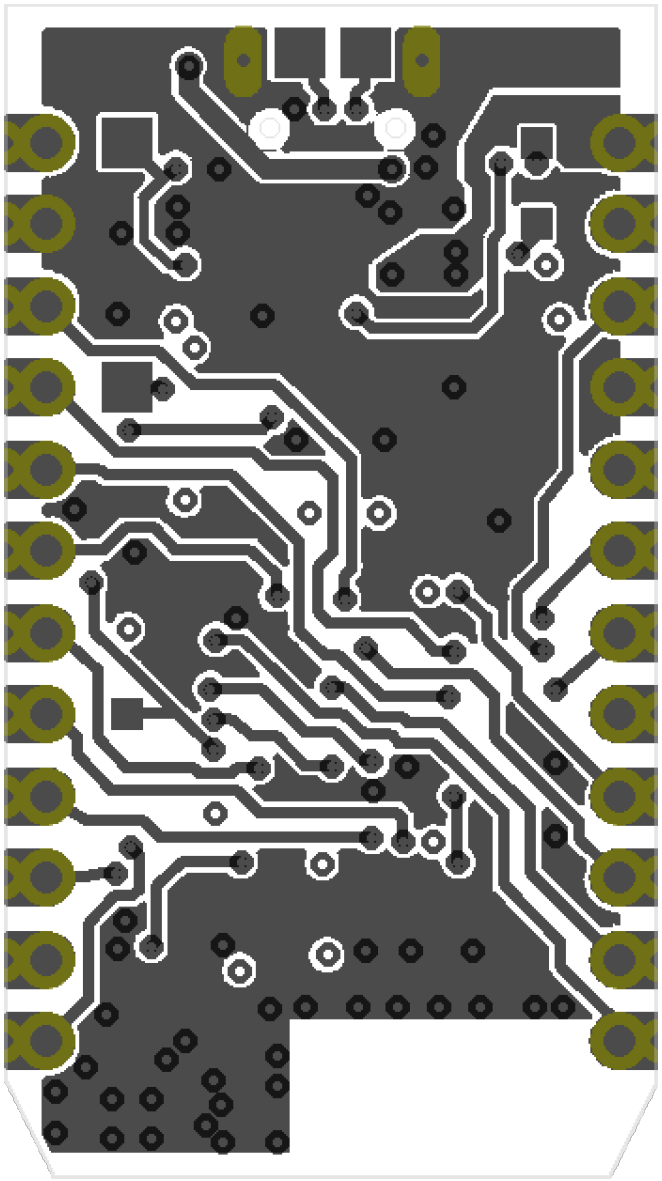
5.2 Photon v1.0.0 GND Layer (G2L)



5.1 Photon v1.0.0 3V3 Layer (G15L)



5.1 Photon v1.0.0 Bottom Layer (GBL)



6. Technical specification

6.1 Absolute maximum ratings ⚠

Parameter	Symbol	Min	Typ	Max	Unit
Supply Input Voltage	$V_{3V3-MAX}$			+3.6	V
Storage Temperature	T_{stg}	-40		+85	°C
ESD Susceptibility HBM (Human Body Mode)	V_{ESD}			2	kV

6.2 Recommended operating conditions

Parameter	Symbol	Min	Typ	Max	Unit
Supply Input Voltage	V_{3V3}[1]	+3.0	+3.3	+3.6	V
Supply Input Current (VDD_WIFI)	I_{VDD_WIFI}			310	mA
Supply Input Current (VDDIO_WIFI)	I_{VDDIO_WIFI}			50	mA
Supply Input Current (VDD_3V3)	I_{VDD_3V3}			120	mA
Supply Input Current (VBAT)	I_{VBAT}			50	mA
Operating Current (Wi-Fi on)	$I_{3V3\ avg}$[1]		80	100	mA
Operating Current (Wi-Fi on)	$I_{3V3\ pk}$[1]	235[2]		430[2]	mA
Operating Current (Wi-Fi on, w/powersave)	$I_{3V3\ avg}$[1]		18	100[3]	mA
Operating Current (Wi-Fi off)	$I_{3V3\ avg}$[1]		30	40	mA
Sleep Current	I_Q		1	2	mA
Deep Sleep Current	I_Q		160	187	uA
Operating Temperature	T_{op}	-20		+60	°C
Humidity Range Non condensing, relative humidity				95	%

Notes:

[1] V_{3V3} and I_{3V3} represents the the combined 4 inputs that require +3.3V: VDD_WIFI, WDDIO_WIFI, VDD_3V3 and VBAT.
[2] 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.
[3] 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

6.3 Wi-Fi Specifications

Feature	Description
WLAN Standards	IEEE 802 11b/g/n
Antenna Port	Single Antenna
Frequency Band	2.400 GHz – 2.484 GHz
Sub Channels	1 ~ 14
Modulation	DSSS, CCK, OFDM, BPSK, QPSK,16QAM, 64 QAM

PØ module Wi-Fi output power		Typ.	Tol.	Unit
RF Average Output Power, 802.11b CCK Mode	1M	16.5	+/- 1.5	dBm
	11M	16.5	+/- 1.5	dBm
RF Average Output Power, 802.11g OFDM Mode	6M	15	+/- 1.5	dBm
	54 M	13	+/- 1.5	dBm
RF Average Output Power, 802.11n OFDM Mode	MCS0	14.5	+/- 1.5	dBm
	MCS7	12	+/- 1.5	dBm

6.4 I/O Characteristics

These specifications are based on the STM32F205RG datasheet, with reference to Photon 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
Weak pull-up equivalent resistor[5]	R_{PU}	V_{io} = GND	30	40	50	kΩ
Weak pull-down equivalent resistor[5]	R_{PD}	V_{io} = V_{3V3}	30	40	50	kΩ
I/O pin capacitance	C_{IO}			5		pF

Notes:

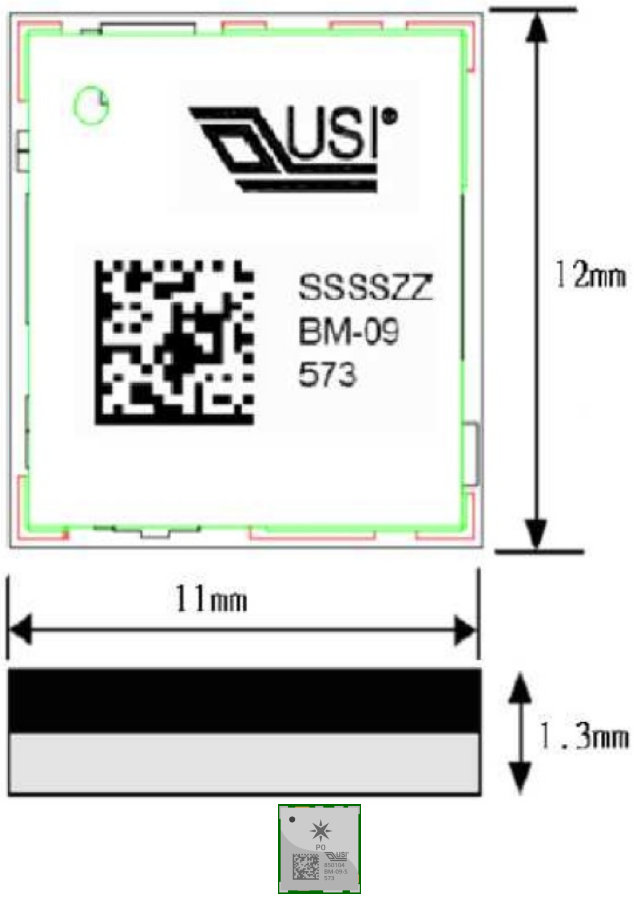
[1] FT = Five-volt tolerant. In order to sustain a voltage higher than V_{3V3}+0.3 the internal pull-up/pull-down resistors must be disabled.
[2] Hysteresis voltage between Schmitt trigger switching levels. Based on characterization, not tested in production.
[3] With a minimum of 100mV.
[4] Leakage 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 series resistance is minimum (~10% order).

7. Mechanical specifications

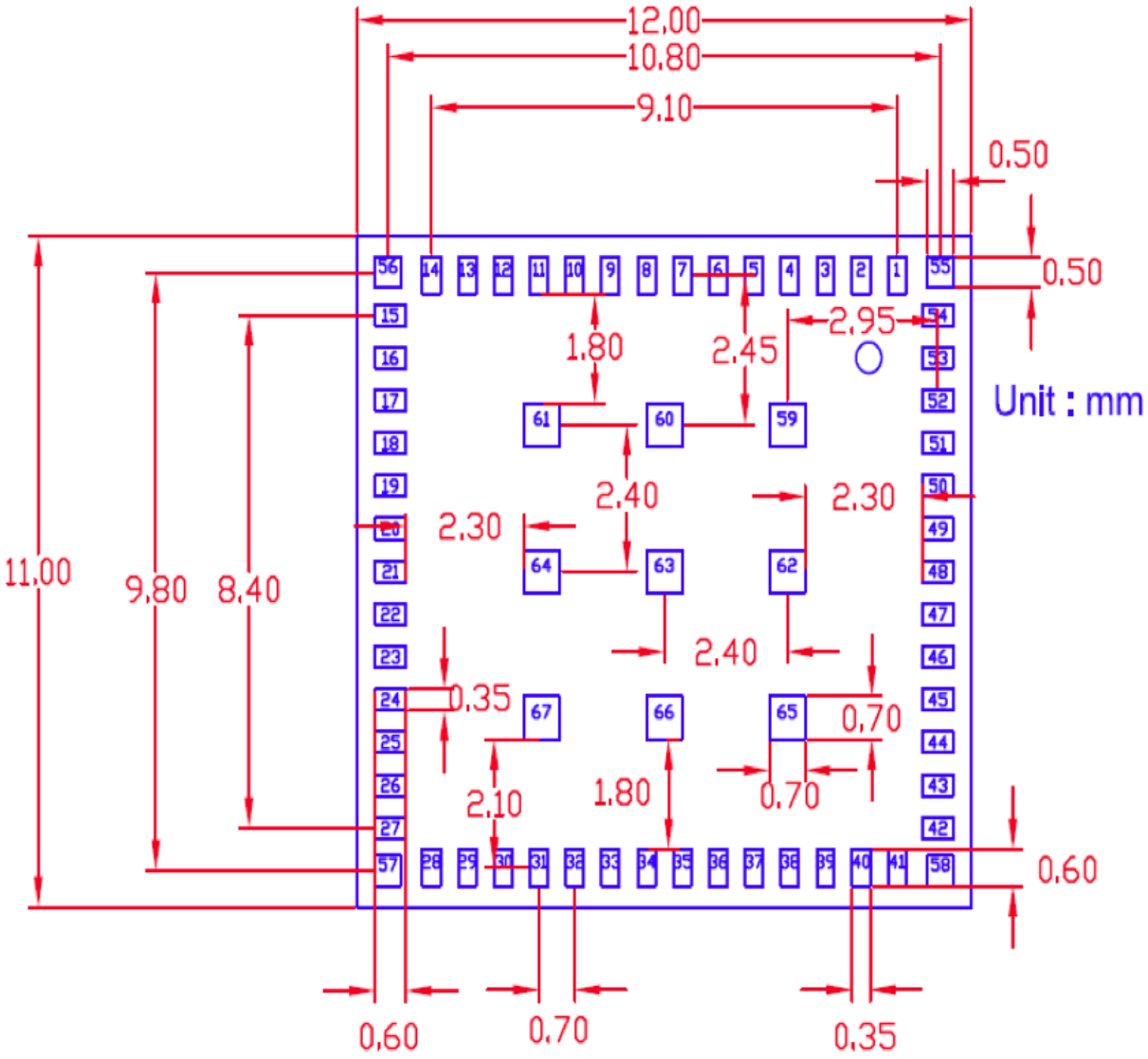
7.1 Overall Dimensions

PØ module dimensions are: 12 mm (W) x 11 mm (L) x 1.3 mm (H) +/-0.1mm (includes metal shielding)



Actual size (so tiny!)

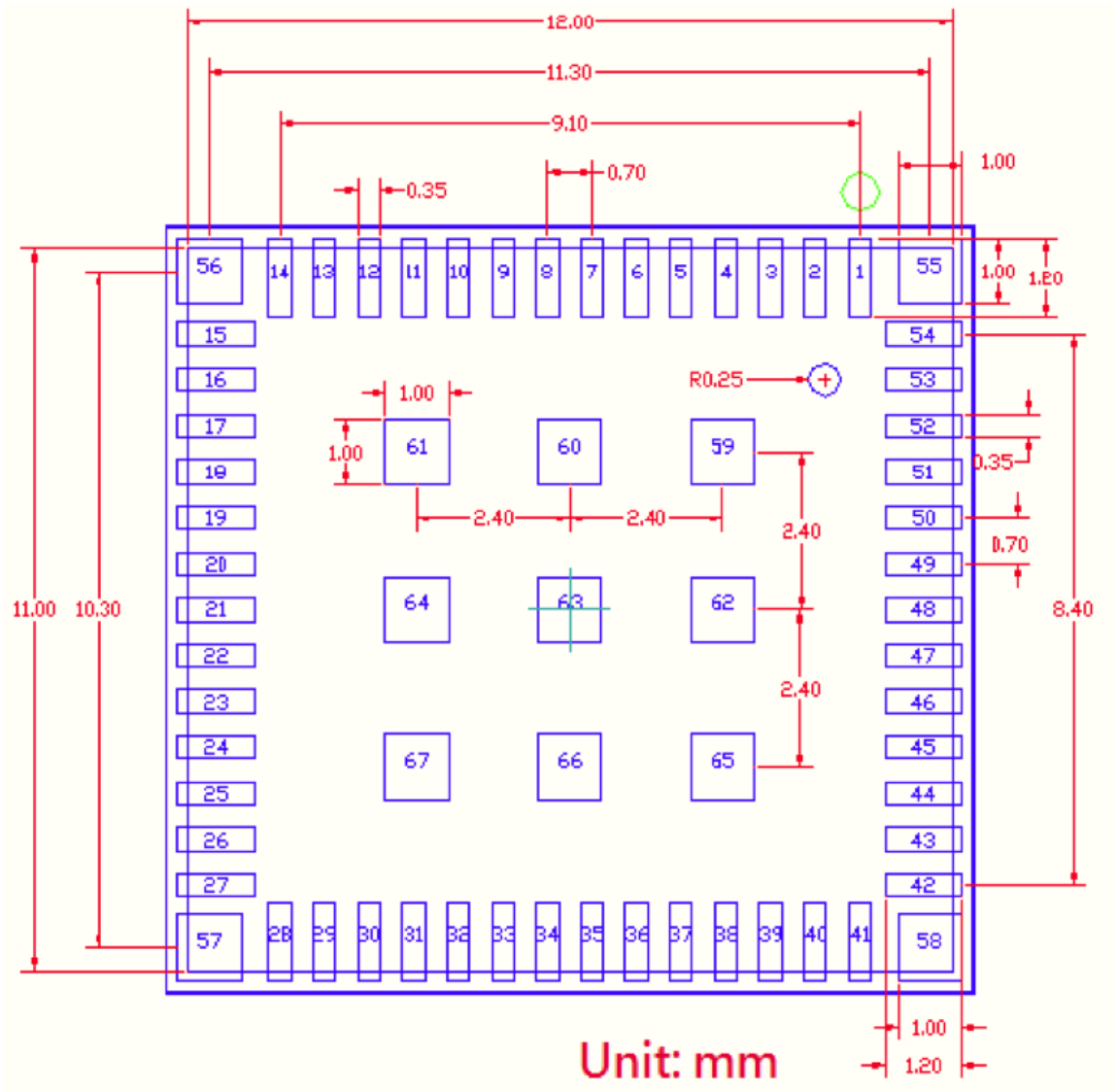
7.2 PØ Module Dimensions



Top Through View

7.3 PØ Module Recommended pcb land pattern

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

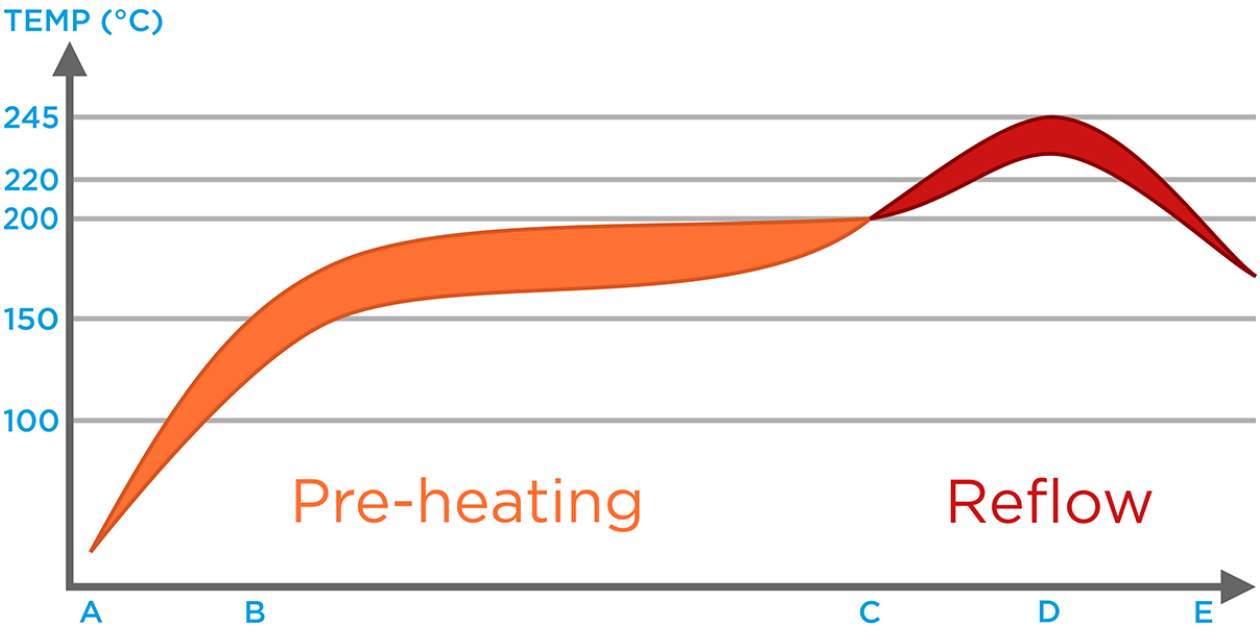


Top Through View

Solder mask should be: SPARK SPARK SPARK.

This land pattern can be found in the Spark.lbr Eagle library, as a Device named `WM-N-BM-09`. **Note: Clone or Download the complete repository as a ZIP file to avoid corrupted data in Eagle files.**

8. Recommended solder reflow profile



Phase	Temperatures and Rates
A-B.	Ambient~150°C, Heating rate: < 3°C/s
B-C.	150~200°C, soak time: 60~120 s
C-D.	200~245°C, Heating rate: < 3°C/s
D.	Peak temp.: 235~245°C, Time above 220°C: 40~90 s
D-E.	245~220°C, Cooling rate: < 1°C/s

9. Ordering information

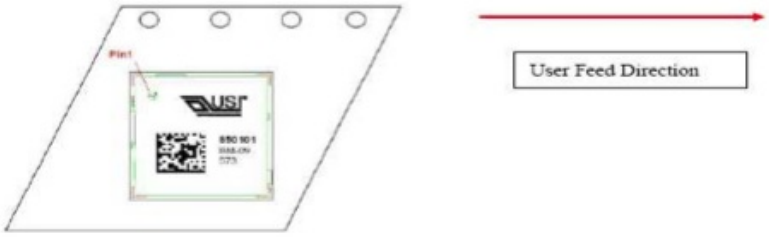
PØ modules are available from store.particle.io as cut tape in quantities of 10 each.

10. Qualification and approvals

- RoHS
- CE
- FCC ID: 2AEMI-PHOTON
- IC: 20127-PHOTON

11. Product handling

11.1 Tape and Reel Info



11.2 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).

11.3 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! ⚠

12. Default settings

The PØ module 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 online Web IDE Particle Build to code, compile and flash a user application OTA (Over The Air). Particle Dev is a local tool that uses the Cloud to compile and flash OTA as well. There is also a package `Spark DFU-UTIL` for Particle Dev that allows for Cloud compiling and local flashing via DFU over USB. This requires `dfu-util` to be installed on your system. 'dfu-util' can also be used with Particle CLI for Cloud compiling and local flashing via the command line. Finally the lowest level of development is available via the GNU GCC toolchain for ARM, which offers local compile and flash via dfu-util. This gives the user complete control of all source code and flashing methods. This is an extensive list, however not exhaustive.

Glossary

RF

Radio Frequency

SMT

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

AP

Access Point

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

OTA

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

Revision history

Revision	Date	Author	Comments
v001	1-May-2015	BW	Initial release
v002	11-May-2015	BW	Added info about PWMs, Updated Qualifications

Contact

Web
https://www.particle.io

Community Forums
https://community.particle.io

Email
hello@particle.io

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