METAMOTIONS r0.1

PRODUCT

SPECIFICATION v0.5

mbientlab

MetaMotionS r0.1

Wearable and connected devices product solution

Product Specification v0.5

Key Features

- Nordic Semiconductor® nRF52840 BLE SoC
    - 2.4 GHz transceiver
    - 64 MHz ARM® Cortex™-M4F 32 bit processor
    - 1 MB flash program memory
    - 256 kB RAM
    - USB 2.0 Full Speed PHY
- Texas Instruments® TPS62743 Ultra Low Power Buck Converter
    - 1.8V Power Efficient Supply Architecture
- Micron® MT29F4G01ABBFDWB 4Gbit SLC NAND Flash Extended Log Memory
- Bosch® BMI270 6-Axis Accelerometer/Gyroscope
    - ±2g/±4g/±8g/±16g selectable scale
    - 125/250/500/1000/2000 degrees/sec
    - 685 uA at full ODR
    - Aliasing free operation
- Bosch® BMM150 3-Axis Magnetometer
- Bosch® BMP280 Digital Pressure Sensor
    - 30 to 110 kPa range
    - 0.16 Pa resolution
- Lite-On® LTR-329ALS-01 Ambient Light Sensor
    - 0.01 to 64k lux range
- Firmware-enabled 9-axis sensor fusion
- 32.768kHz 20ppm RTC Crystal
- Lithium Ion/Polymer battery charger
- Micro-USB rechargeable
- Bright RGB LED
- Miniature push-button switch
- High current / haptic driver
- Accurate Thermistor Temperature Sensor
- I/O Expansion
    - Digital I^{2}C Bus
    - 6 Analog/Digital Pins
    - 1 Digital Pins
- Tiny 26mm x 17mm x 2.5mm form factor
- Form factor compatible with MetaMotionR

Table of Contents

1   Introduction

MetaMotionS is a complete development and production platform for wearable and connected device applications. It features the ultra-low power nRF52840 SoC, providing energy efficient smartphone communication and central processing. MetaMotionS integrates this radio with high value sensors and a rechargeable battery architecture into a miniature form factor. All circuits have been designed from the ground up with energy efficiency in mind.

2   Product Overview

2.1   Block Diagram
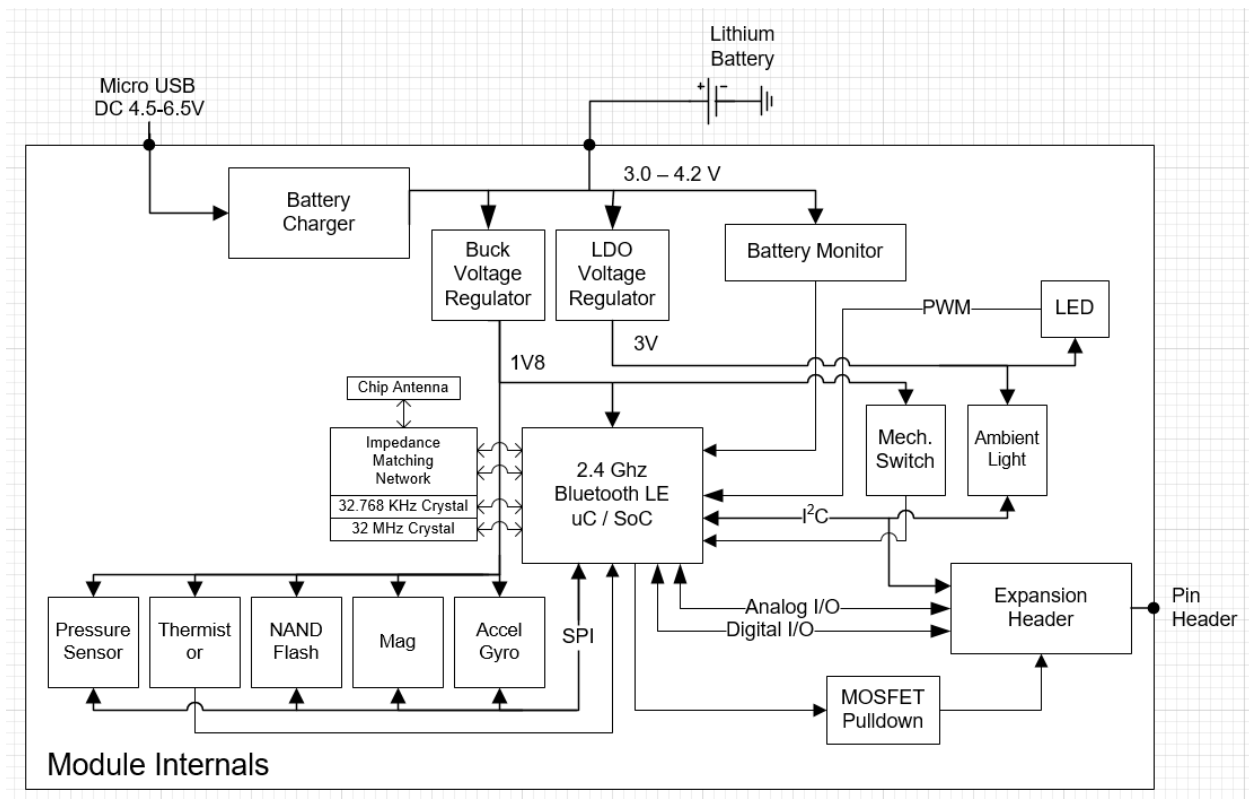
Figure 1 *Block Diagram*

2.2 Pin Assignments

1 V_{USB}/5V
2 V_{BAT}
3 V_{GND}
4 V_{GND}

5 V_{GND}
6 SDA
7 SCL
8 V_{3V}

9 D0/A0
10 D1/A1
11 HCD
12 V_{3V}
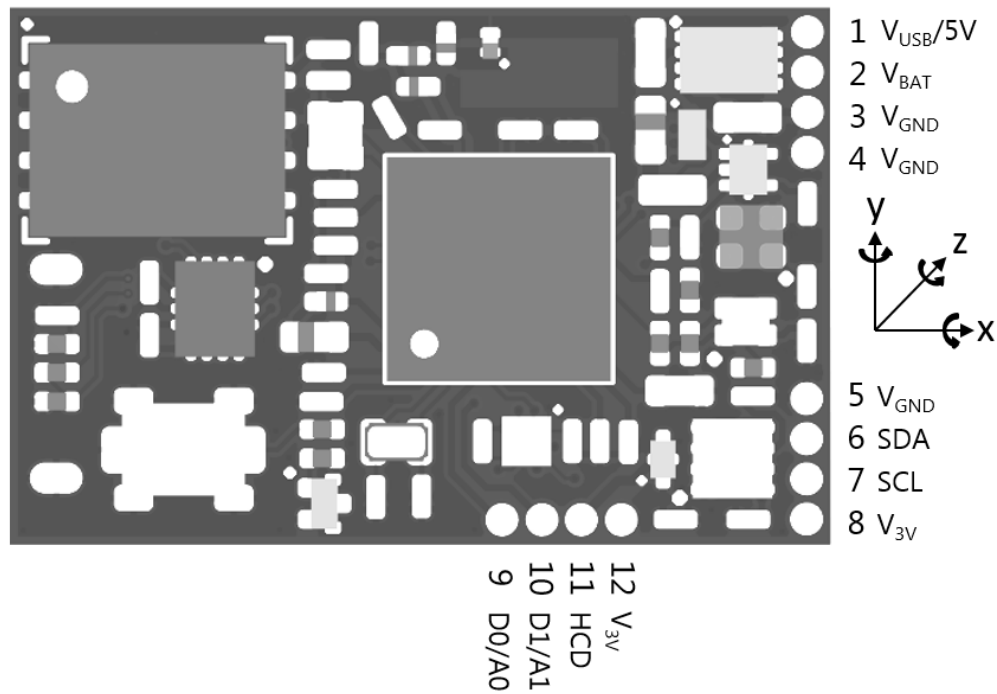
Figure 2 *Front Pin Assignments*

13 D2/A2
14 D3/A3
15 D4/A4
16 D5/A5
17 D6
18 TRACECLK
19 TRACEDATA3
20 TRACEDATA2
21 TRACEDATA1
22 TRACEDATA0
23 V_{1V8}
24 VGND
25 SWDIO
26 SWCLK
27 V_{USB}
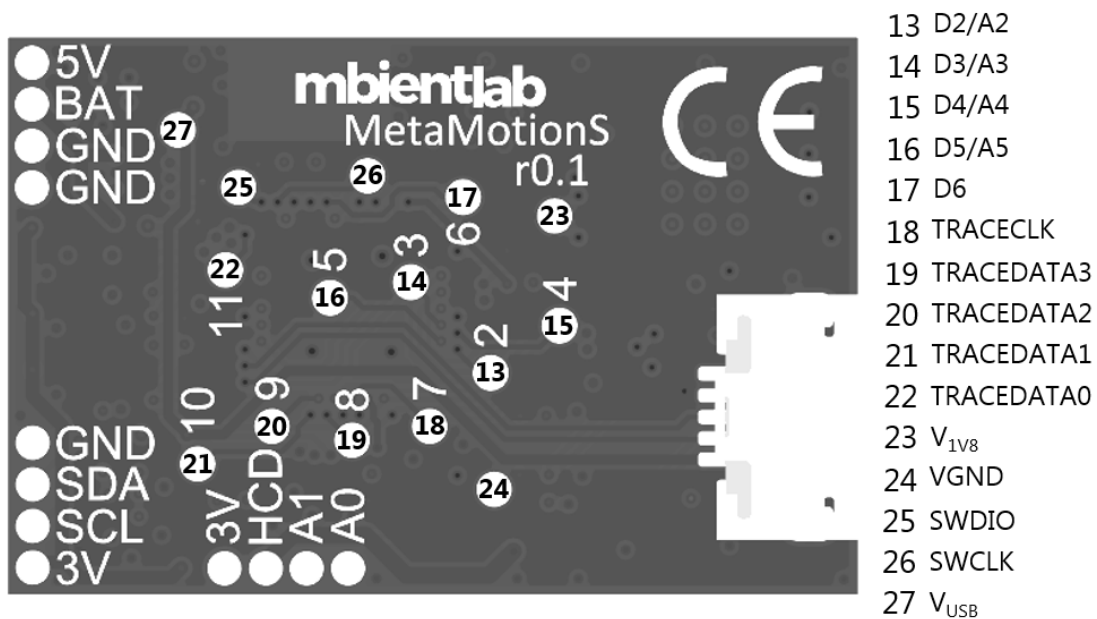
Figure 3 *Back Pin Assignments*

2.3 Pin Functions

Pin	Pin Name	Function	Description
Power Supply			
1	V_{USB}	Power	Positive supply alternative to micro USB port.
2	V_{BAT}	Power	Positive battery connection.
3	V_{GND}	Power	Ground connection intended for battery.
4	V_{GND}	Power	Ground connection intended for battery.
Digital Peripheral Bus			
5	V_{GND}	Power	Supplementary ground for peripheral expansion.
6	SDA	I/O	I^2C serial data. 1V8 Logic.
7	SCL	I/O	I^2C serial clock. 1V8 Logic.
8	V_{3V}	Power	Regulated 3V output for peripheral expansion.
Analog / High Current Driver Bus			
9	D0/A0	I/O	General purpose I/O and analog input.
10	D1/A1	I/O	General purpose I/O and analog input.
11	HCD	High Current Driver	Switch for sinking high current peripherals.
12	V_{3V}	Power	Regulated 3V output for high current peripheral.
Surface Mount Breakout			
13	D2/A2	I/O	General purpose I/O and analog input.
14	D3/A3	I/O	General purpose I/O and analog input.
15	D4/A4	I/O	General purpose I/O and analog input.
16	D5/A5	I/O	General purpose I/O and analog input.
17	D6	I/O	General purpose I/O.
SWD Debug			
18	TRACECLK	Debug	ARM ETM Trace clock.
19	TRACEDATA3	Debug	ARM ETM Trace data 3.
20	TRACEDATA2	Debug	ARM ETM Trace data 2.
21	TRACEDATA1	Debug	ARM ETM Trace data 1.
22	TRACEDATA0	Debug	ARM ETM Trace data 0.
23	V_{1V8}	Power	System supply for debugger.
24	V_{GND}	Power	System ground for debugger.
25	SWDIO	Debug	SWD debugger data.
26	SWDCLK	Debug	SWD debugger clock.
27	V_{USB}	Power	Positive supply alternative to USB connector.

Table 1 *Pin Functions*

2.4 Module to SoC Pin Mapping

Module Pin	nF52840 Pin	Function	Description
GPIO			
D0/A0	P0.04	GPIO	General purpose I/O and analog input.
D1/A1	P0.05	GPIO	General purpose I/O and analog input.
D2/A2	P0.31	GPIO	General purpose I/O and analog input.
D3/A3	P0.28	GPIO	General purpose I/O and analog input.
D4/A4	P0.29	GPIO	General purpose I/O and analog input.
D5/A5	P0.30	GPIO	General purpose I/O and analog input.
D6	P1.06	GPIO	General purpose I/O.
High Current/Haptic Driver			
HCD	P1.10	Haptic	Open drain MOSFET pull-down.
I2C			
SDA	P0.22	Serial Bus	I^2C serial data.
SCL	P0.20	Serial Bus	I^2C serial clock.
Internal Module Pins			
	P1.14	Switch	Micro Push Button. Active Low.
	P1.01	3V Enable	3V regulator enable.
	P0.30	Battery Voltage	Analog voltage at V_{BAT} *(4.02/14.02)
	P0.02	Battery Charging	Open drain, active low indicator that the charger is active.
	P1.15	Thermistor En	Active High Enable for Thermistor
	P0.03	Thermistor Voltage	Voltage output from Thermistor Voltage Divider
	P1.13	Acc/Gyro Interrupt	INT1 Pin of BMI270.
	P1.12	Acc/Gyro Interrupt	INT2 Pin of BMI270.
	P0.27	Shared SPI SCK	SCK Pin of BMI270, BMM150, BMP280.
	P0.06	Shared SPI MISO	MISO Pin of BMI270, BMM150, BMP280.
	P0.26	Shared SPI MOSI	MOSI Pin of BMI270, BMM150, BMP280.
	P1.08	Acc/Gyro nCS	nCS Pin of BMI270.
	P1.04	Mag Interrupt	INT Pin of BMM150.
	P0.10	Mag Data Ready	DRDY Pin of BMM150.
	P0.09	Mag nCS	nCS Pin of BMM150
	P1.07	Barometer nCS	nCS Pin of BMP280
	P0.18	NAND Flash nCS	nCS Pin of MT29F4G01ABBFDWB.
	P0.17	NAND Flash SCK	SCK Pin of MT29F4G01ABBFDWB.
	P0.13	NAND Flash D0	D0 Pin of MT29F4G01ABBFDWB.

P0.16	NAND Flash D1	D1 Pin of MT29F4G01ABBFDWB.
P0.14	NAND Flash D2	D2 Pin of MT29F4G01ABBFDWB.
P0.21	NAND Flash D3	D3 Pin of MT29F4G01ABBFDWB.
P0.15	LED Red nEn	Current Sink for Red LED Channel.
P0.08	LED Green nEn	Current Sink for Green LED Channel.
P0.24	LED Blue nEn	Current Sink for Blue LED Channel.

Table 2 *Module Pin Mapping*

3   Circuit and Sensor Details

3.1   SoC Circuit
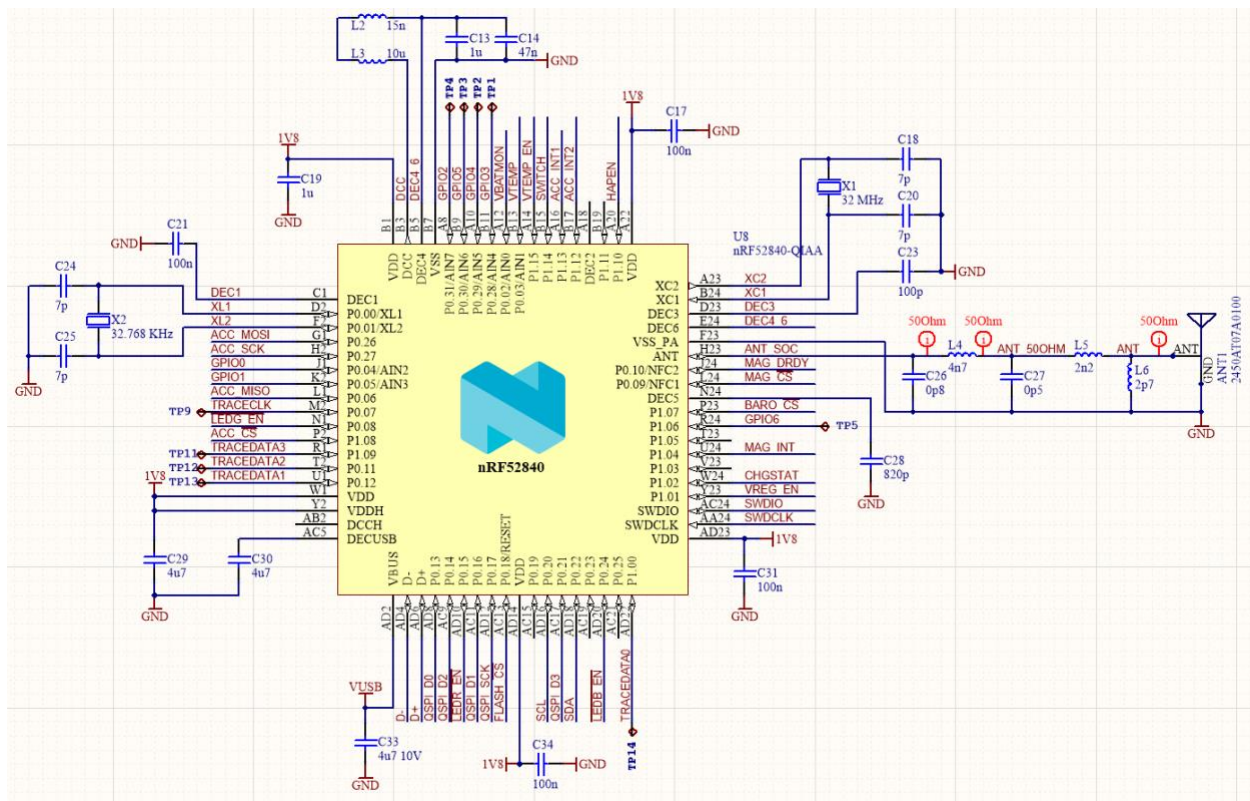
Figure 4 *SoC Circuit*

The SoC circuit includes dual tight tolerance crystal oscillators, USB full speed data, streaming trace capable debug, capacitive detuning resilient antenna, 1V8 supply operation, and 1V3 core/radio buck converter for efficiency.

3.2   Power Supply Circuit

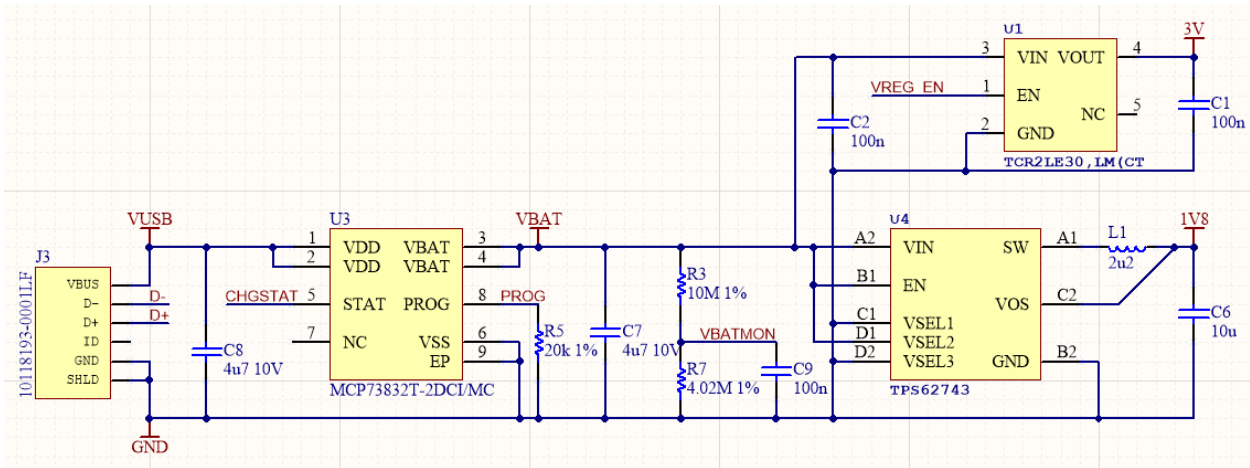
Figure 5 *Power Supply Circuit*

The power supply circuit includes a lithium ion/polymer battery charger, charge status indication, battery voltage monitor, ultra high efficiency 1V8 buck converter and low Iq 3V low dropout regulator. The 3V supply may be put in standby when its peripherals are not in use. All high uptime and continuous output sensors are powered by the 1V8 supply and gain the energy efficiency of the buck converter.

3.3   High Current/Haptic Drive Circuit
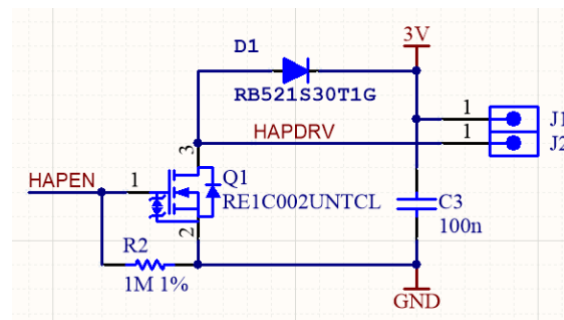
Figure 6 *Haptic Driver Circuit*

The haptic drive circuit features a logic level gate drive N-Channel MOSFET, and a flyback diode to 3V for switching inductive loads.

3.4   NAND Flash
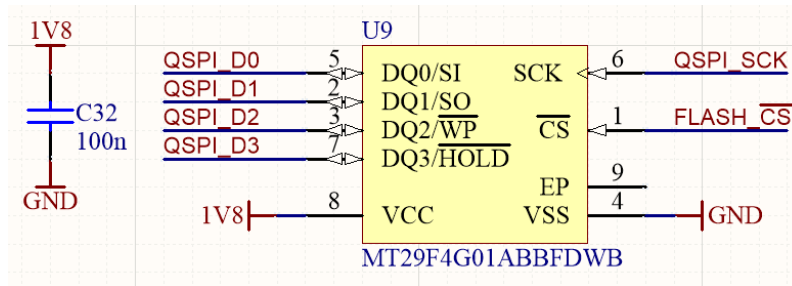
Figure 7 *NAND Flash Circuit*

The NAND Flash MT29F4G01ABBFDWB is attached to a dedicated SPI bus.

3.5   Barometric Pressure Sensor
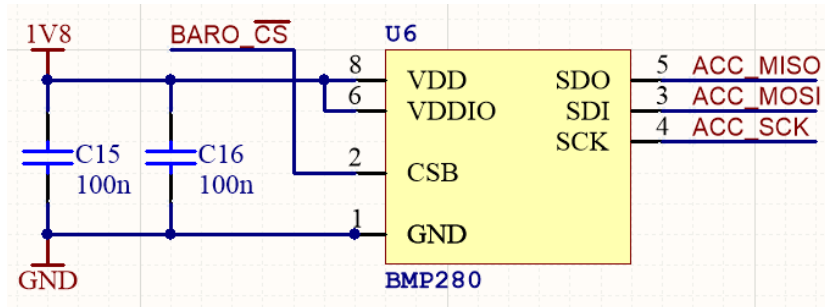
Figure 8 *Barometric Pressure Sensor Circuit*

The Barometric Pressure Sensor BMP280 is attached to the shared SPI bus with a dedicated chip select.

3.6   Accelerometer / Gyroscope
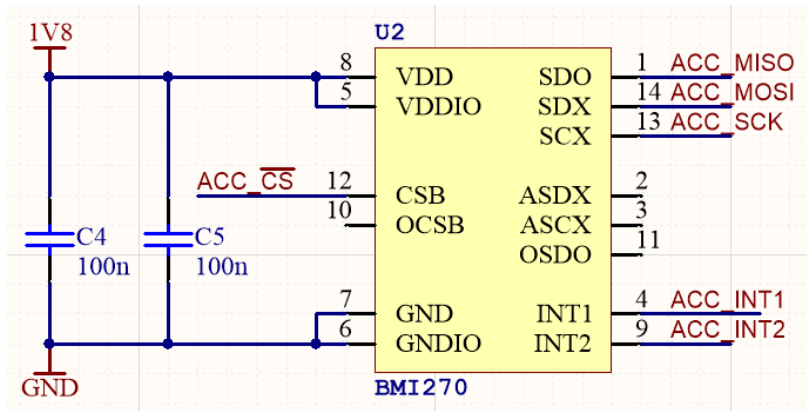
Figure 9 *Accelerometer / Gyro Circuit*

The 6-axis accelerometer and gyroscope sensor BMI270 is attached to the shared SPI bus with a dedicated chip select.

3.7   Magnetometer
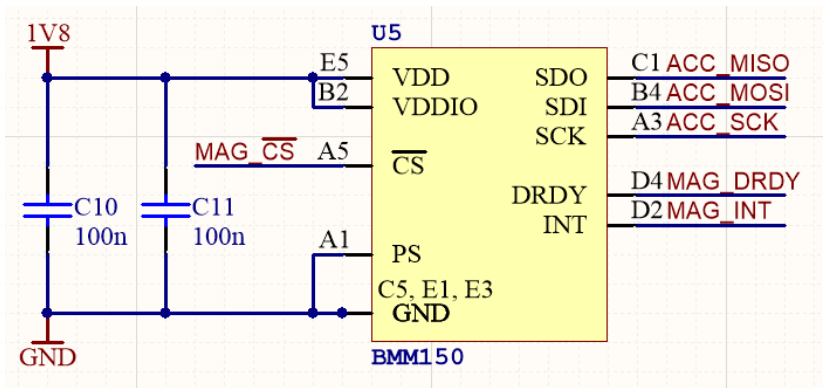
Figure 10 *Magnetometer Circuit*

The 3-axis magnetometer BMM150 is attached to the shared SPI bus with a dedicated chip select.

3.8   Ambient Light Sensor
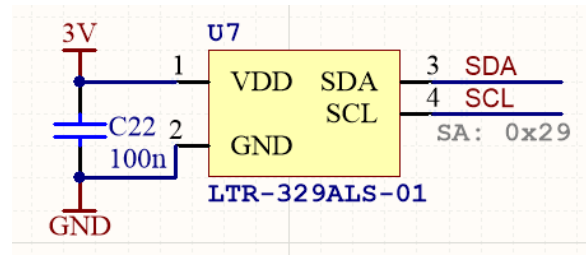
Figure 11 *ALS Circuit*

The Ambient Light Sensor LTR-329ALS-01 is attached to the shared I^{2}C bus at slave address 0x29.

3.9   Mechanical Switch
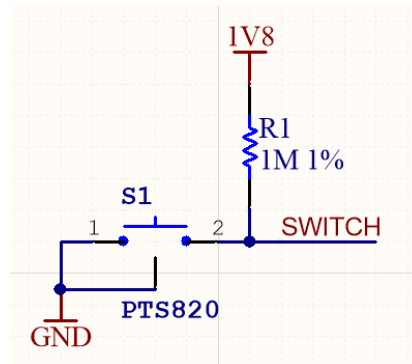
Figure 12 *Switch Circuit*

The switch is active low with a relatively high resistance load provided for power efficiency.

3.10   Thermistor Temperature Circuit
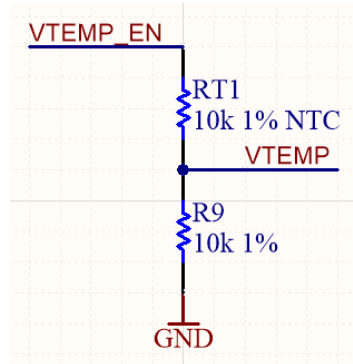
Figure 13 *Thermistor Temperature Circuit*

The thermistor circuit features a voltage divider and active high enable for power saving. Details on the sensor characteristics can be found in the data sheet for part number NCP15XH103F03RC.

3.11   RGB LED Circuit
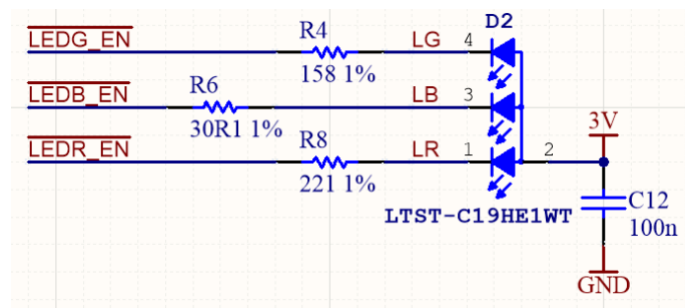
Figure 14 *RGB LED Circuit*

The RGB LED channels are driven by an active low PWM signal from the SoC. The resistance values have been chosen to approximately match intensity at 100 percent duty cycle. The high current bit should be set on the GPIOs to sink up to 5mA.

4   Absolute Maximum Ratings

Spec	Description	Min.	Typ.	Max.	Units
V_{USB}	USB charging voltage.	-0.3		+7.0	V
V_{BAT}	Lithium battery voltage.	-0.3		+6.0	V
V_{GND}	Ground voltage			0	V
V_{IO}	I/O Pin Voltage	-0.3		V_{DD}+0.3	V
T_{MAX}	Storage Temperature	-40		125	°C

Table 3 *Absolute Maximum Ratings*

5   Operating Conditions

Spec	Description	Min.	Typ.	Max.	Units
V_{USB}	USB charging voltage.	4.0	5.0	6.0	V
V_{BAT}	Lithium battery voltage.	3.0	3.7	4.2	V
V_{3V}	3V supply voltage.	0	3.0		V
V_{1V8}	1V8 supply voltage.	1.75	1.8	1.85	V
T_A	Operating temperature.	-40	25	85	°C
I_{IDLE}	Idle current consumption.		20	50	uA

Table 4 *Operating Conditions*

6   Electrical Specifications

6.1   General Purpose I/O (GPIO) Specifications

Spec	Description	Min.	Typ.	Max.	Units
V_{IH}	Input high voltage.	1.3		1.8	V
V_{IL}	Input low voltage.	0		0.5	V
V_{OH}	Output high voltage.	1.4		1.8	V
V_{OL}	Output low voltage.	0		0.4	V
R_{PU}	Pull-up resistance.	11	13	16	kΩ
R_{PD}	Pull-down resistance.	11	13	16	kΩ

Table 5 *General Purpose I/O (GPIO) Specifications*

6.2   Oscillator Specifications (OSC)

Spec	Description	Min.	Typ.	Max.	Units
$f_{HF,NOM}$	High frequency crystal frequency		32		MHz
$f_{HF,TOL}$	High frequency crystal tolerance		±20		ppm
$f_{LF,NOM}$	Low frequency oscillator frequency		32.768		kHz
$f_{HF,TOL}$	Low frequency oscillator tolerance		±20		ppm

Table 6 *Crystal Oscillator Specifications*

6.3   SAADC (ADC) Specifications

Spec	Description	Min.	Typ.	Max.	Units
DNL_{10b}	Differential non-linearity (10 bit mode).		<1		LSB
INL_{10b}	Integral non-linearity (10 bit mode).		1		LSB
V_{OS}	Offset error.		±2		LSB
V_{REF_INT}	Internal reference voltage.	-3	0.6 V	+3	%
t_{ADC10b}	Sample conversion time.		<2		µs
t_{ACQ}	Sample acquisition time. Configurable.	3		40	µs
f_{MAX}	Maximum sampling rate.			200	kHz

Table 7 *SAADC Specifications*

6.4   Temperature Sensor (TEMP) Specifications

Spec	Description	Min.	Typ.	Max.	Units
T_{RANGE}	Temperature sensor range.	-40		85	°C
T_{ACC}	Temperature sensor accuracy.	-5		+5	°C
T_{RES}	Temperature sensor resolution.		0.25		°C
T_{THM_RANGE}	Thermistor sensor range.	-40		85	°C
T_{THM_ACC}	Thermistor sensor accuracy.	-1		+1	°C
T_{THM_RES}	Thermistor sensor resolution.		0.125		°C

Table 8 *Temperature Sensor (TEMP) Specifications*

6.5   High Current Driver (HCD) Specifications

Spec	Description	Min.	Typ.	Max.	Units
$I_{ON,SS25}$	Steady state on current at 25°C.			200	mA
$I_{ON,SS85}$	Steady state on current at 85°C.			120	mA
$P_{ON,SS}$	Steady state power dissipation at 25°C.			150	mW
$I_{ON,PULSE}$	Pulsed current for 10 µs.			800	mA
R_{ON}	On state resistance.		2.0	2.8	Ω
$I_{OFF,LEAK}$	Off state leakage.			1	uA
V_{CLAMP}	Clamping diode voltage threshold.		3.3		V

Table 9 *High Current Driver (HCD) Specifications*

6.6   Accelerometer (ACCEL) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	±2		±16	g
	Resolution.	2048		16384	counts/g
f_{DATA}	Data sample frequency.	0.78		1600	Hz
I_{LP25}	Low power current (25 Hz).		10		uA
I_{1600}	High data rate current (1600 Hz).		210		uA
$I_{STANDBY}$	Standby current.		3.5		uA

Table 10 *Accelerometer (ACCEL) Specifications*

6.7   Gyroscope (GYRO) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	±125		±2000	°/s
	Resolution.	16		262	counts/°
f_{DATA}	Data sample frequency.	25		3200	Hz
I_{AGLP}	Accel+Gyro low power mode current.		420		
I_{AGNP}	Accel+Gyro normal mode current.		685		
I_{AGHP}	Accel+Gyro performance mode current.		970		uA
$I_{STANDBY}$	Standby current. Included in Accel Standby Current.				

Table 11 *Gyroscope (GYRO) Specifications*

6.8   Magnetometer (MAG) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	±1200	±1300		uT
	Heading Accuracy.			±2.5	°
f_{DATA}	Data rate.		25	300	Hz
$I_{STANDBY}$	Standby current.		1	3	uA

Table 12 *Magnetometer (MAG) Specifications*

6.9   Pressure (BAROMETER) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	30		110	kPa
	Resolution in ultra high resolution mode.		0.16		Pa
f_{DATA}	Data sample frequency at max data rate.			157	Hz
I_{ACTIVE}	Active current. Data rate and oversampling sensitive.	0.14		650	uA
$I_{STANDBY}$	Standby current.		0.1	0.3	uA
I_{PEAK}	Peak current during measurement.		720	1120	uA

Table 13 *Pressure (BAROMETER) Specifications*

6.10   LED (LED) Specifications

Spec	Description	Min.	Typ.	Max.	Units
I_{RGB}	Drive current per channel.	2	4	5	mA
λ_{RPEAK}	Red peak wavelength.		624		nm
λ_{GPEAK}	Green peak wavelength.		525		nm
λ_{BPEAK}	Blue peak wavelength.		470		nm
I_{vR}	Red luminous intensity.	12	60		mcd
I_{vG}	Green luminous intensity.	15	60		mcd
I_{vB}	Blue luminous intensity.	10	60		mcd
	Viewing Angle		120		°

Table 14 *LED (LED) Specifications*

6.11   Ambient Light (ALS) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	0.01		64k	lux
	Resolution.		16		bit
f_{DATA}	Data sample frequency.	0.5		20	Hz
I_{PEAK}	Peak active current.			220	uA
$I_{STANDBY}$	Standby current.			5	uA

Table 15 *Ambient Light (ALS) Specifications*

6.12   NAND Flash (NAND) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Powerdown current.		15	50	uA
	Write cycles per sector.	100,000			cycles
	Data retention @ 85C	10			years
	Page Size (excluding spare)		4096		Bytes
	Block Size		64		Pages
	ECC correctable bits per page		8		bits
	Valid Blocks	2008	2048		
I_{READ}	Read current.		25	30	mA
$I_{PROGRAM}$	Program current.		20	25	mA
I_{ERASE}	Erase current.		15	20	mA
t_{PR}	Page Read time.		90	170	us
t_{PP}	Page Program time.		240	600	us
t_{BE}	Block Erase time.		2	10	ms

Table 16 *NAND Flash (NAND) Specifications*

6.13   Sensor Fusion (SF) Specifications

Spec	Description	Min.	Typ.	Max.	Units
f_{NDOF}	NDoF operating frequency.	-1%	100	+1%	Hz
$f_{IMUPLUS}$	IMUPlus operating frequency.	-1%	100	+1%	Hz
$f_{COMPASS}$	Compass operating frequency.	-1%	25	+1%	Hz
f_{M4G}	M4G operating frequency.	-1%	50	+1%	Hz

Table 17 *Sensor Fusion (SF) Specifications*

6.14   1V8 Power Supply (1V8) Specifications

Spec	Description	Min.	Typ.	Max.	Units
f_{SW}	Switching frequency.		1.2		MHz
I_q	Quiescent current.		360		nA
	Efficiency @ 10uA	80	83		%
	Efficiency > 10uA	85	90		%
V_{1V8}	Output Voltage	1.74	1.8	1.86	V
I_{OUT}	Output Current	100		300	mA

Table 18 *1V8 Power Supply (1V8) Specifications*

6.15   3V Power Supply (3V) Specifications

| Spec	Description	Min.	Typ.	Max.	Units
I_q	Quiescent current (V_{BAT} > 3.1V)		2	2	uA
V_{1V8}	Output Voltage	2.95	3	3.05	V
I_{OUT}	Output Current			150	mA

Table 19 *3V Power Supply (3V) Specifications*

6.16   Battery Charger (BAT) Specifications

Spec	Description	Min.	Typ.	Max.	Units
I_{CC}	Constant current phase.		50		mA
V_{CV}	Constant voltage phase.		4.2		V
I_{PRE}	Preconditioning Current.		50		mA

Table 20 *Battery Charger (BAT) Specifications*

7 Mechanical Specifications
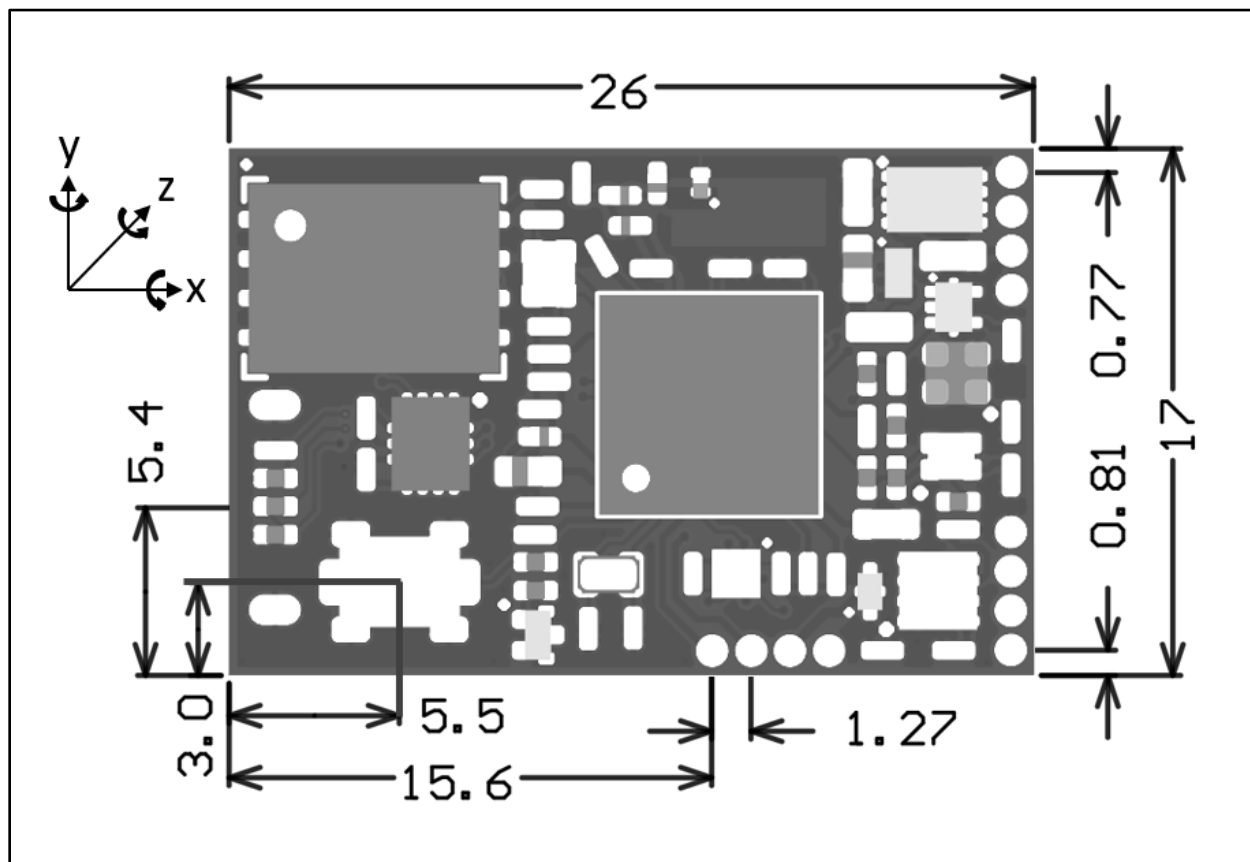
Figure 15 *Module dimensions in mm*

9 Revision History

Date	Version	Change Description
January 7, 2021	0.5	Initial Draft

Table 21 Revision History