
METAMOTIONC r0.2
PRODUCT
SPECIFICATION v0.5



MetaMotionC r0.2

Wearable and connected devices product solution

Product Specification v0.5

Key Features

- Nordic Semiconductor nRF52832 BLE SoC
 - 2.4 GHz transceiver
 - ARM[®] Cortex™-M4F 32 bit processor
 - 512 kB flash program memory
 - 64 kB RAM
- Macronix MX25R6435 64Mbit Low Power NOR Flash Extended Log Memory
- Bosch[®] BMI160 6-Axis Accelerometer/Gyroscope
 - $\pm 2g/\pm 4g/\pm 8g/\pm 16g$ selectable scale
 - 125/250/500/1000/2000 degrees/sec
 - Industry Leading 900uA active current gyro
- 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
- Bright RGB LED
- Miniature push-button switch
- High current / haptic driver
- Accurate Thermistor Temperature Sensor
- I/O Expansion
 - Digital I²C Bus
 - 5 Analog/Digital Pins
- Tiny 24mm diameter x 6.5mm form factor
- Form factor compatible with MetaWearC
- Powered by low cost, easily sourced CR2032 Lithium Coin Cell
- FCC, IC, CE certification

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1 Introduction

MetaMotionC is a complete development and production platform for wearable and connected device applications. It features the ultra-low power nRF52832 SoC, providing energy efficient smartphone communication and central processing. MetaMotionC integrates this radio with high value sensors and a coin cell 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

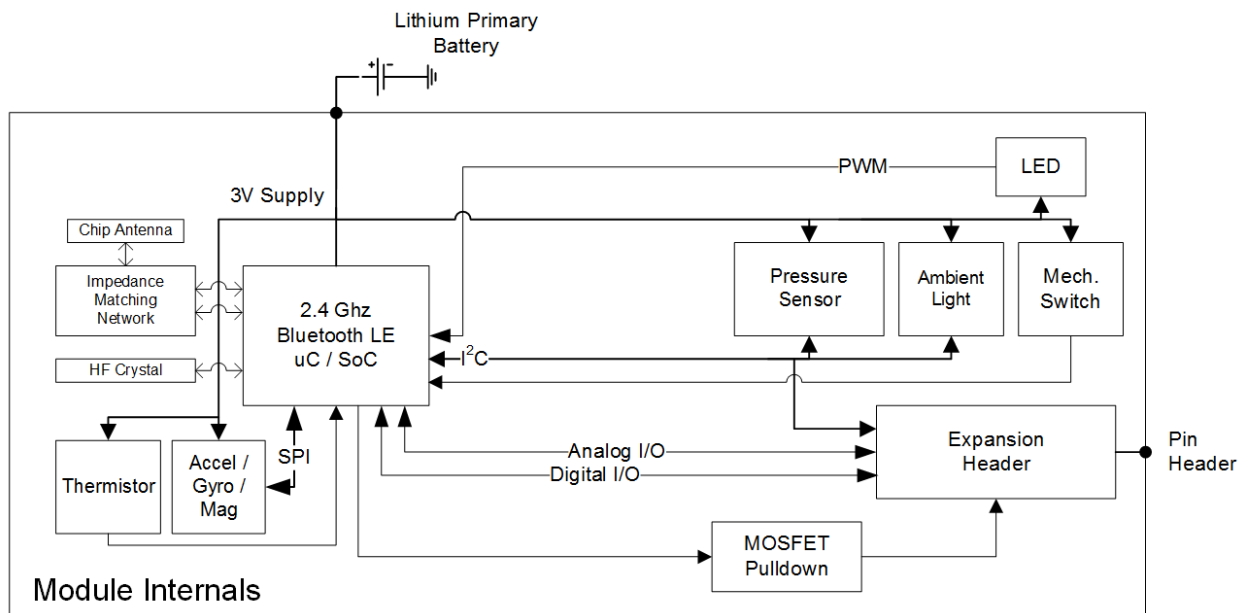


Figure 1 Block Diagram

2.2 Pin Assignments

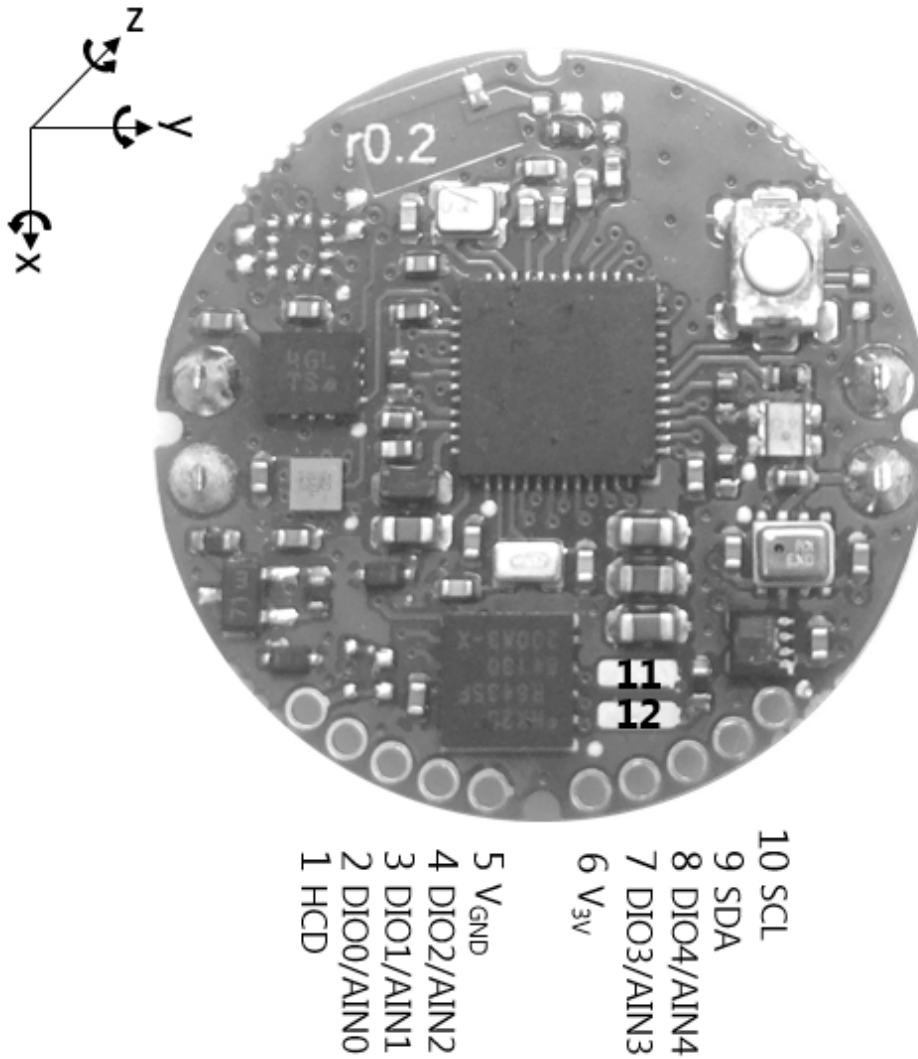


Figure 2 Front Pin Assignments

2.3 Pin Functions

Pin	Pin Name	Function	Description
Power Supply			
5	V _{GND}	Power	Ground connection.
6	V _{3V}	Power	+3V battery connection.
Peripherals			
1	HCD	High Current Driver	Switch for sinking high current peripherals.
2	DIO0 AIN0	Digital I/O Analog I/O	General purpose I/O and analog input.
3	DIO1 AIN1	Digital I/O Analog I/O	General purpose I/O and analog input.
4	DIO2 AIN2	Digital I/O Analog I/O	General purpose I/O and analog input.
7	DIO3 AIN3	Digital I/O Analog I/O	General purpose I/O and analog input.
8	DIO4 AIN4	Digital I/O Analog I/O	General purpose I/O and analog input.
9	SDA	I2C Data	I2C data line.
10	SCL	I2C Clock	I2C clock line.
SWD Debug Header			
11	SWDIO	Debug	SWD debugger I/O line.
12	SWDCLK	Debug	SWD debugger clock line.

Table 1 Pin Functions

2.4 Module to SoC Pin Mapping

Module Pin	nF52832 Pin	Function	Description
GPIO			
D0/A0	P0.31	GPIO	General purpose I/O and analog input.
D1/A1	P0.03	GPIO	General purpose I/O and analog input.
D2/A2	P0.02	GPIO	General purpose I/O and analog input.
D3/A3	P0.04	GPIO	General purpose I/O and analog input.
D4/A4	P0.05	GPIO	General purpose I/O and analog input.
High Current/Haptic Driver			
HCD	P0.07	Haptic	Open drain MOSFET pull-down.
I2C			
SDA	P0.11	Serial Bus	I ² C serial data.
SCL	P0.13	Serial Bus	I ² C serial clock.
Internal Module Pins			
	P0.16	Switch	Micro Push Button. Active Low.
	P0.26	Thermistor En	Active High Enable for Thermistor
	P0.30	Themistor Voltage	Voltage output from Thermistor Voltage Divider
	P0.21	Acc/Gyro Interrupt	INT1 Pin of BMI160.
	P0.20	Acc/Gyro Interrupt	INT2 Pin of BMI160.
	P0.23	Acc/Gyro SCK	SCK Pin of BMI160, BMM150, W25Q64FV.
	P0.25	Acc/Gyro MISO	MISO Pin of BMI160, BMM150, W25Q64FV.
	P0.22	Acc/Gyro MOSI	MOSI Pin of BMI160, BMM150, W25Q64FV.
	P0.28	Acc/Gyro nCS	nCS Pin of BMI160.
	P0.27	Mag Interrupt	INT Pin of BMM150.
	P0.29	Mag Data Ready	DRDY Pin of BMM150.
	P0.09	Mag nCS	nCS Pin of BMM150
	P0.06	NOR Flash nCS	nCS Pin of MX25R6435.
	P0.08	NOR Flash nWP	nWP Pin of MX25R6435.
	P0.12	LED Red nEn	Current Sink for Red LED Channel.
	P0.14	LED Green nEn	Current Sink for Green LED Channel.
	P0.15	LED Blue nEn	Current Sink for Blue LED Channel.

Table 2 Module Pin Mapping

3 Circuit and Sensor Details

3.1 High Current/Haptic Drive Circuit

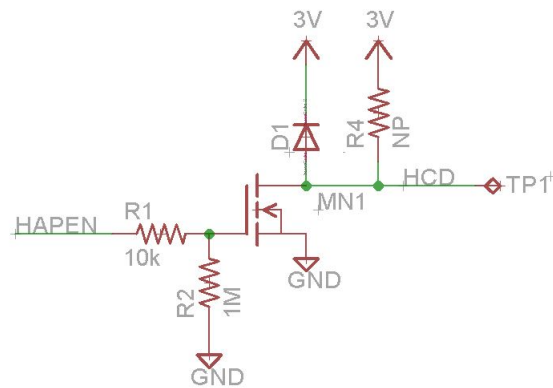


Figure 3 Haptic Driver Circuit

The haptic drive circuit features a logic level gate drive N-Channel MOSFET. On the MetaMotionC model, the flyback diode is de-populated making the output open drain for switching higher load voltages.

3.2 NOR Flash

The NOR Flash MX25R6435 is attached to the shared SPI bus, with dedicated nCS and nWP pins as detailed in the SoC mapping table.

3.3 Barometric Pressure Sensor

The Barometric Pressure Sensor BMP280 is attached to the shared I²C bus at slave address 0x77.

3.4 Accelerometer / Gyroscope

The 6-axis accelerometer and gyroscope sensor BMI160 attached via the SPI bus, with pin numbers detailed in the module to SoC mapping table.

3.5 Magnetometer

The 3-axis magnetometer BMM150 is attached via the SPI bus, with pin numbers detailed in the module to SoC mapping table.

3.6 Ambient Light Sensor

The Ambient Light Sensor LTR-329ALS-01 is attached to the shared I²C bus at slave address 0x29.

3.7 Mechanical Switch

The GPIO internal pullup resistor should be used with the mechanical switch, which is active low.

3.8 Thermistor Temperature Circuit

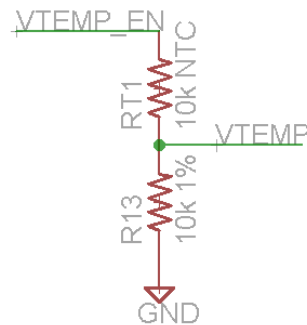


Figure 4 Thermistor Temperature Circuit

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.

3.9 RGB LED Circuit

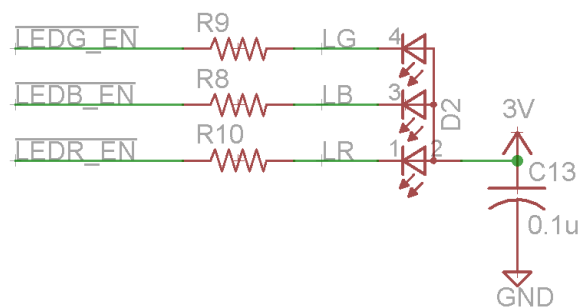


Figure 5 RGB LED Circuit

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 _{3V}	3V supply voltage.	-0.3		+3.6	V
V _{GND}	Ground voltage.			0	V
V _{IO}	I/O Pin Voltage.	-0.3		+3.6	V
T _{MAX}	Storage Temperature.	-40		125	°C

Table 3 Absolute Maximum Ratings

5 Operating Conditions

Spec	Description	Min.	Typ.	Max.	Units
V _{3V}	3V supply voltage.	2.7	3.0	3.6	V
T _A	Operating temperature.	-25	25	75	°C
I _{IDLE}	Idle current consumption.		10	25	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.	2.1		3.0	V
V _{IL}	Input low voltage.	0		0.9	V
V _{OH}	Output high voltage.	2.6		3.0	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 Crystal 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		±40		ppm
f _{LF,NOM}	Low frequency oscillator frequency		32.768		kHz
f _{LF,TOL}	Low frequency oscillator tolerance		±250		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.			310	mA
I _{ON,SS85}	Steady state on current at 85°C.			220	mA
P _{ON,SS}	Steady state power dissipation.			280	mW
I _{ON,PULSE}	Pulsed current for 10 µs.			1.4	A
R _{ON}	On state resistance.		2	5	Ω
I _{OFF,LEAK}	Off state leakage.			1	nA

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
$I_{12.5}$	Low data rate current (3.125 Hz).		5		uA
I_{100}	Mid data rate current (100 Hz).		24		uA
I_{1600}	High data rate current (1600 Hz).		180	300	uA
$I_{STANDBY}$	Standby current.		3	10	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_{GYRO}	Gyro active current. All Data Rates.		850	900	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	μA
$I_{STANDBY}$	Standby current.		0.1	0.3	μA
I_{PEAK}	Peak current during measurement.		720	1120	μA

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		$^{\circ}$

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	μA
$I_{STANDBY}$	Standby current.			5	μA

Table 15 Ambient Light (ALS) Specifications

6.12 NOR Flash (NOR) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Write cycles per sector.	100,000			cycles
	Data retention	20			years
I_{READ}	Read current.		4.2	6.5	mA
I_{PROGRAM}	Program current.		5.8	10	mA
I_{ERASE}	Erase current.		3.5	10	mA
t_{SSE}	Subsector Erase time.		58	240	ms
t_{CE}	Chip Erase time.		120	240	s
	Powerdown current.		0.01	0.35	uA
	Standby current		9	50	uA

Table 16 NOR Flash (NOR) 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

7 Mechanical Specifications

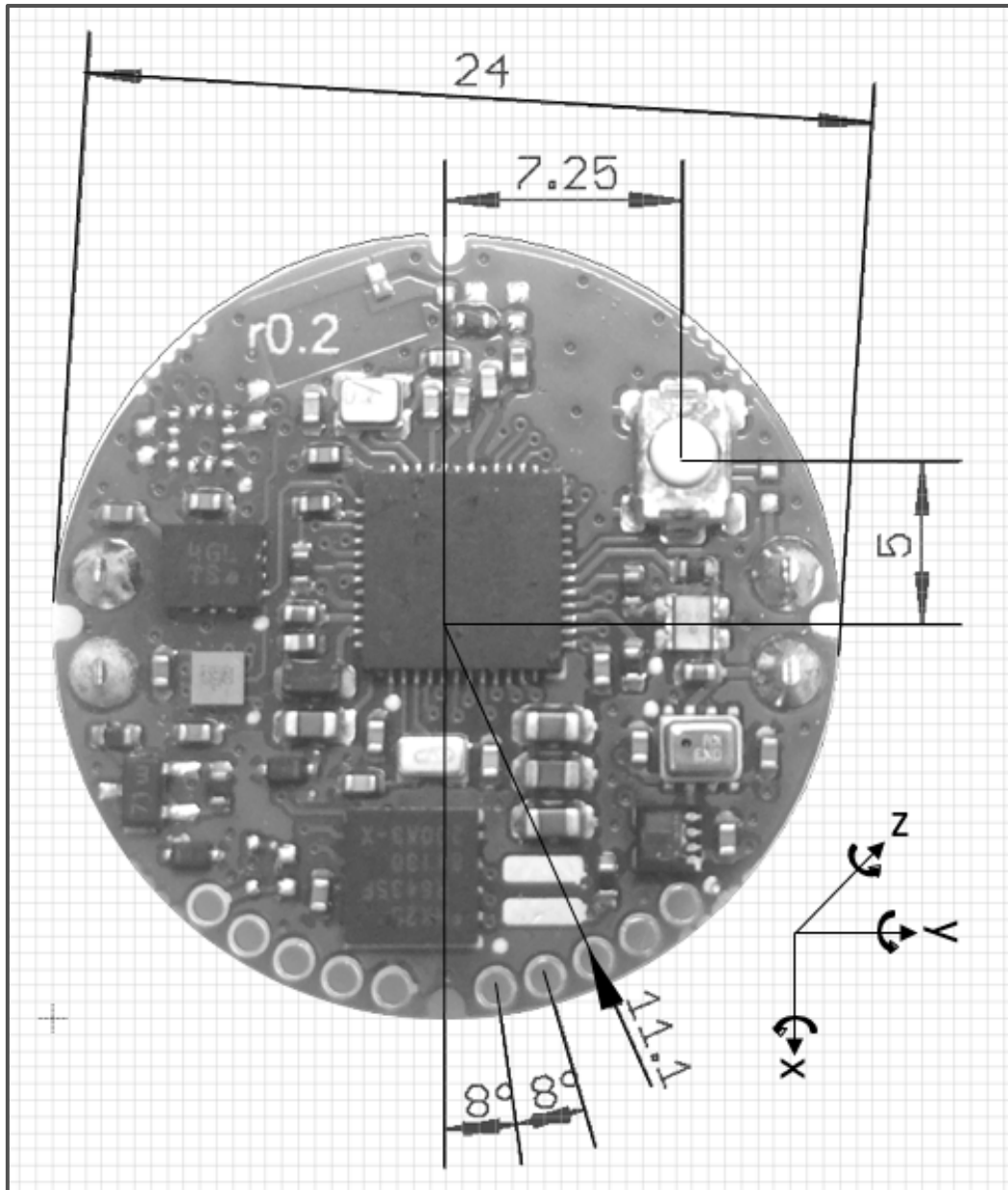


Figure 6 Module dimensions in mm

9 Revision History

Date	Version	Change Description
May 22, 2017	0.5	Initial Draft

Table 18 *Revision History*

10 Regulatory Statements

10.1 North America

United States: Federal Communications Commission



FCC COMPLIANCE STATEMENT:

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.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of 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. If not installed and used in accordance with the instructions, it 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 tuning the equipment off and on, the user is encouraged to try and correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the distance between the equipment and the receiver.
- Connect the equipment to 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 ID: 2ACEB-MMC

Canada: Industry Canada



IC COMPLIANCE STATEMENT:

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

Cet appareil est conforme avec Industrie Canada exempts de licence standard RSS (s). L'utilisation de ce dispositif est autorisée seulement aux conditions suivantes : (1) il ne doit pas produire de brouillage et

(2) l'utilisateur du dispositif doit être prêt à accepter tout brouillage radioélectrique reçu, même si ce brouillage est susceptible de compromettre le fonctionnement du dispositif.

IC ID: 12118A-MMC

10.2 European Union

European Union: CE directive



STATEMENT:

Hereby, MbientLab declares that MetaMotionC is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EC:

- ETSI EN 300 328 V2.1.1:
- ETSI EN 301 489-1 V2.1.1 (2017-02),
- ETSI EN 301 489-17 V3.1.1 (2017-02),
- EN 55032: 2012/AC:2013,
- EN 55024:2010:
- EN 62368-1:2014/AC:2015:

The EU Declaration of Conformity can be found at: www.mbientlab.com/documentation

10.3 Warning

The changes or modifications not expressly approved by MbientLab could void the user's authority to operate the equipment.

ATTENTION: MetaMotionC's battery life can be shortened with heavy use.

METAMOTIONR IS NOT A TOY OR MEDICAL DEVICE.

WARNING: choking hazard - small parts.

CAUTION: Risk of Explosion if Battery is replaced by an Incorrect Type.

Please dispose of used battery according to local regulations. Replace battery with a 3V CR2032 battery.

10.4 WEEE and RoHS



The symbol on the product or its packaging signifies that this product has to be disposed separately from ordinary household wastes at its end of life. Please kindly be aware that this is your responsibility to dispose electronic equipment at recycling centers so as to help conserve natural resources.

Each country in the European Union should have its collection centers for electrical and electronic equipment recycling. For information about your recycling drop off point, please contact your local related electrical and electronic equipment waste management authority or the retailer where you bought the product.

- Do not dispose of the MetaMotionC with household waste.
- Disposal of the packaging and your MetaMotionC should be done in accordance with local regulations.
- Batteries are not to be disposed of in municipal waste stream and require separate collection.