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METAMOTIONR r0.5  
PRODUCT  
SPECIFICATION v0.5

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# MetaMotionR r0.5

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
- Winbond W25Q64JV 64Mbit 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
- Firmware-enabled 9-axis sensor fusion
- 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<sup>2</sup>C Bus
  - 4 Analog/Digital Pins
  - 3 Digital Pins
- Tiny 26mm x 17mm x 2.5mm form factor
- Form factor compatible with MetaWearRG/RPro
- FCC, IC, CE certification

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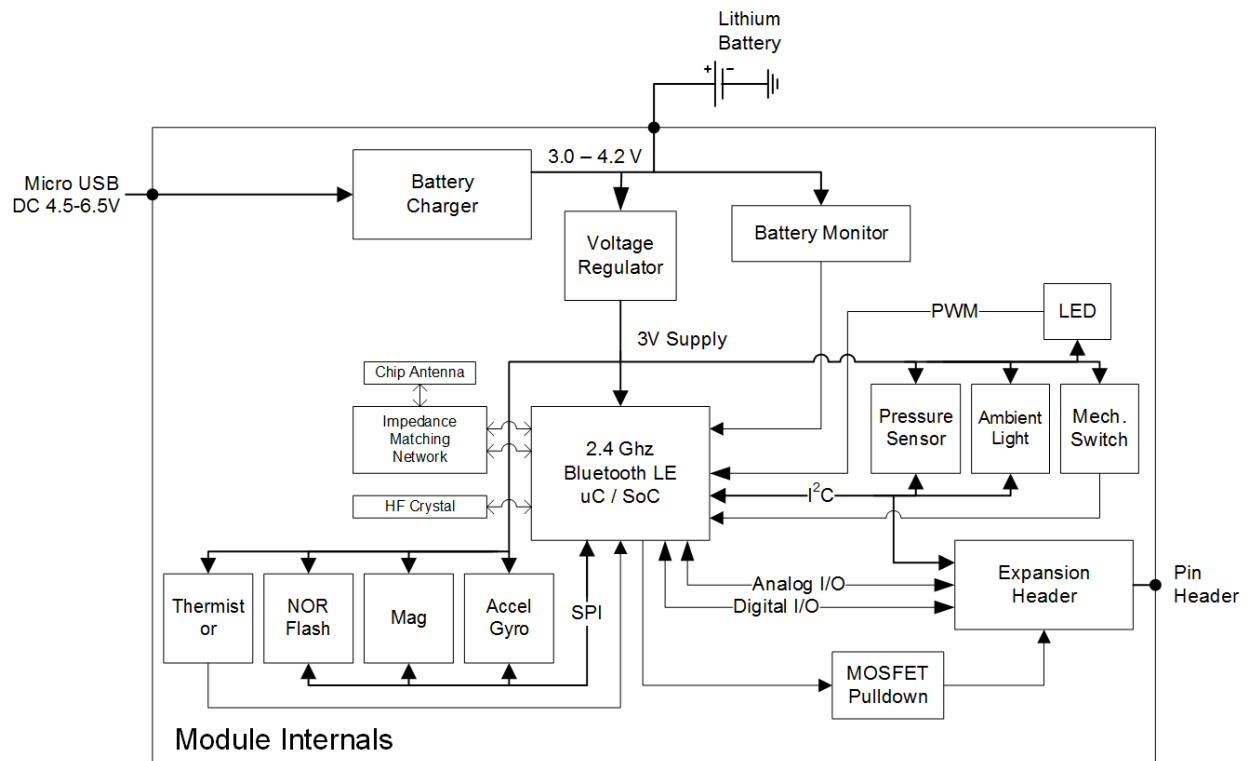
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# 1 Introduction

MetaMotionR 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. MetaMotionR 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.

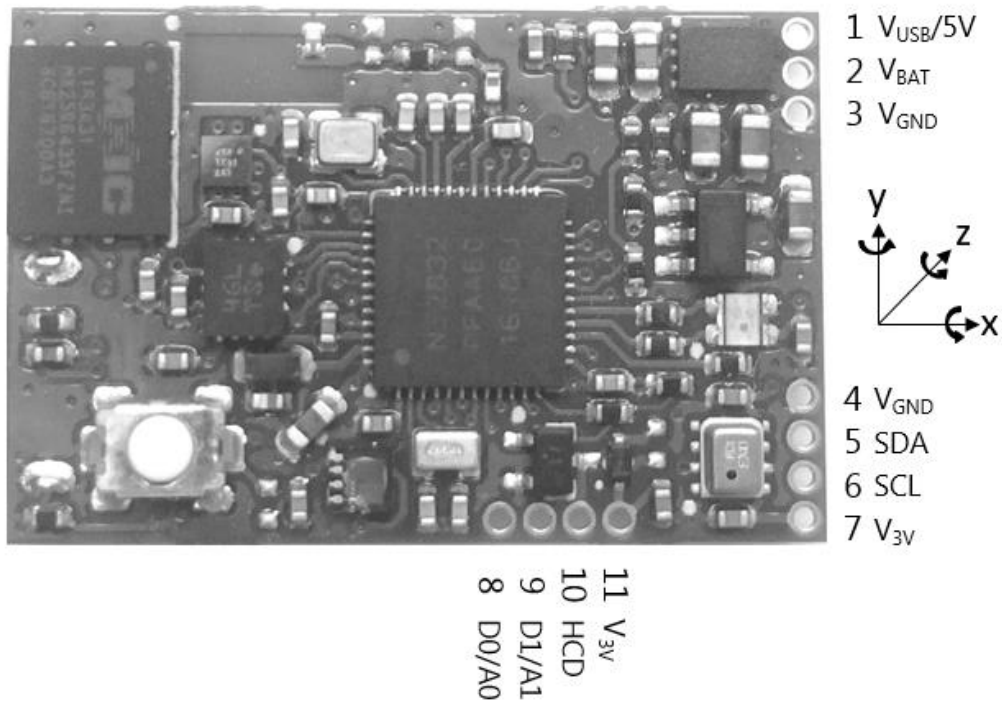
## 2 Product Overview

### 2.1 Block Diagram

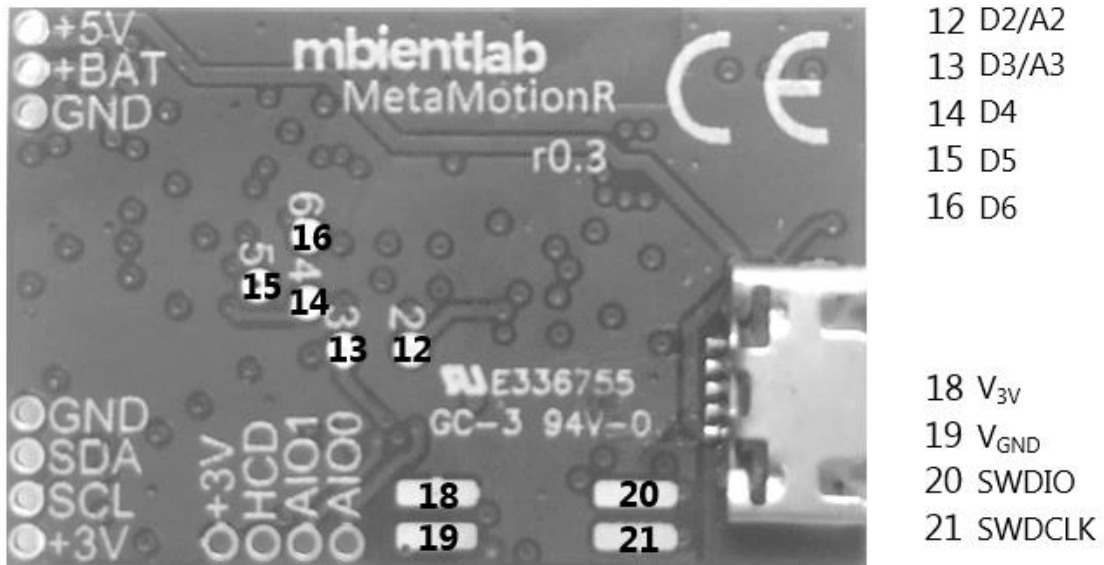


**Figure 1** Block Diagram

## 2.2 Pin Assignments



**Figure 2** Front Pin Assignments



**Figure 3** Back Pin Assignments

## 2.3 Pin Functions

Pin	Pin Name	Function	Description
<b>Power Supply</b>			
1	V <sub>USB</sub>	Power	Positive supply alternative to micro USB port.
2	V <sub>BAT</sub>	Power	Positive battery connection.
3	V <sub>GND</sub>	Power	Ground connection intended for battery.
<b>Digital Peripheral Bus</b>			
4	V <sub>GND</sub>	Power	Supplementary ground for peripheral expansion.
5	SDA	Digital I/O	I <sup>2</sup> C serial data.
6	SCL	Digital I/O	I <sup>2</sup> C serial clock.
7	V <sub>3V</sub>	Power	Regulated 3V output for peripheral expansion.
<b>Analog / High Current Driver Bus</b>			
8	D0	Digital I/O	General purpose I/O and analog input.
	A0	Analog I/O	
9	D1	Digital I/O	General purpose I/O and analog input.
	A1	Analog I/O	
10	HCD	High Current Driver	Switch for sinking high current peripherals.
11	V <sub>3V</sub>	Power	Regulated 3V output for high current peripheral.
<b>Surface Mount Extra Breakout</b>			
12	D2	Digital I/O	General purpose I/O and analog input.
	A2	Analog I/O	
13	D3	Digital I/O	General purpose I/O and analog input.
	A3	Analog I/O	
14	D4	Digital I/O	General purpose I/O.
15	D5	Digital I/O	General purpose I/O.
16	D6	Digital I/O	General purpose I/O.
<b>SWD Debug Header</b>			
18	V <sub>3V</sub>	Power	System supply for debugger.
19	V <sub>GND</sub>	Power	System ground for debugger.
20	SWDIO/nRESET	Debug	SWD debugger I/O line and system reset.
21	SWDCLK	Debug	SWD debugger clock line.

**Table 1** Pin Functions

## 2.4 Module to SoC Pin Mapping

Module Pin	nF52832 Pin	Function	Description
<b>GPIO</b>			
D0/A0	P0.02	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	P0.04	GPIO	General purpose I/O and analog input.
D4	P0.15	GPIO	General purpose I/O.
D5	P0.17	GPIO	General purpose I/O.
D6	P0.21	GPIO	General purpose I/O.
<b>High Current/Haptic Driver</b>			
HCD	P0.10	Haptic	Open drain MOSFET pull-down.
<b>I2C</b>			
SDA	P0.18	Serial Bus	I <sup>2</sup> C serial data.
SCL	P0.19	Serial Bus	I <sup>2</sup> C serial clock.
<b>Internal Module Pins</b>			
	P0.06	Switch	Micro Push Button. Active Low.
	P0.16	5V Present	Active high indicator of an attached power source.
	P0.30	Battery Voltage	Analog voltage at $V_{BAT} * (10.0/14.02)$
	P0.20	Battery Charging	Open drain, active low indicator that the charger is active.
	P0.07	Thermistor En	Active High Enable for Thermistor
	P0.03	Themistor Voltage	Voltage output from Thermistor Voltage Divider
	P0.25	Acc/Gyro Interrupt	INT1 Pin of BMI160.
	P0.11	Acc/Gyro Interrupt	INT2 Pin of BMI160.
	P0.28	Acc/Gyro SCK	SCK Pin of BMI160, BMM150, W25Q64FV.
	P0.26	Acc/Gyro MISO	MISO Pin of BMI160, BMM150, W25Q64FV.
	P0.27	Acc/Gyro MOSI	MOSI Pin of BMI160, BMM150, W25Q64FV.
	P0.29	Acc/Gyro nCS	nCS Pin of BMI160.
	P0.23	Mag Interrupt	INT Pin of BMM150.
	P0.22	Mag Data Ready	DRDY Pin of BMM150.
	P0.24	Mag nCS	nCS Pin of BMM150
	P0.09	NOR Flash nCS	nCS Pin of W25Q64FV.
	P0.08	NOR Flash nWP	nWP Pin of W25Q64FV.
	P0.13	LED Red nEn	Current Sink for Red LED Channel.
	P0.14	LED Green nEn	Current Sink for Green LED Channel.

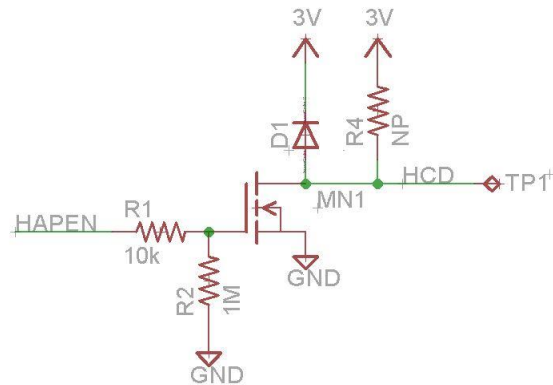


P0.12	LED Blue nEn	Current Sink for Blue LED Channel.
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**Table 2** Module Pin Mapping

### 3 Circuit and Sensor Details

#### 3.1 High Current/Haptic Drive Circuit

**Figure 4** 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.

#### 3.2 NOR Flash

The NOR Flash W25Q64JV is attached to the shared SPI bus, with dedicated nCS and nWP pins as detailed in the SoC mapping table.

#### 3.3 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.

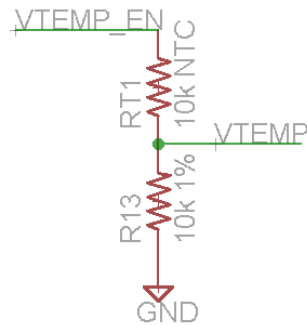
#### 3.4 Magnetometer

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

### 3.5 Mechanical Switch

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

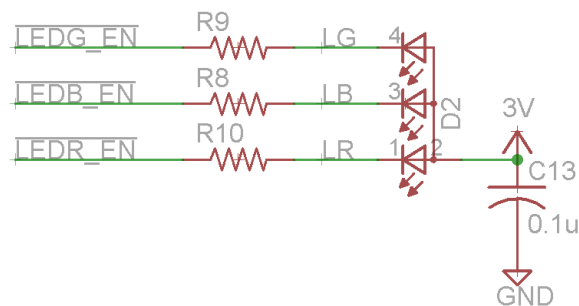
### 3.6 Thermistor Temperature Circuit



**Figure 5** 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.

### 3.7 RGB LED Circuit



**Figure 6** 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 <sub>USB</sub>	USB charging voltage.	-0.3		+7.0	V
V <sub>BAT</sub>	Lithium battery voltage.	-0.3		+6.0	V
V <sub>GND</sub>	Ground voltage			0	V
V <sub>IO</sub>	I/O Pin Voltage	-0.3		+3.3	V
T <sub>MAX</sub>	Storage Temperature	-40		125	°C

**Table 3** Absolute Maximum Ratings

## 5 Operating Conditions

Spec	Description	Min.	Typ.	Max.	Units
V <sub>USB</sub>	USB charging voltage.	4.0	5.0	6.0	V
V <sub>BAT</sub>	Lithium battery voltage.	3.0	3.7	4.2	V
T <sub>A</sub>	Operating temperature.	-40	25	85	°C
I <sub>IDLE</sub>	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 <sub>IH</sub>	Input high voltage.	2.1		3.0	V
V <sub>IL</sub>	Input low voltage.	0		0.9	V
V <sub>OH</sub>	Output high voltage.	2.6		3.0	V
V <sub>OL</sub>	Output low voltage.	0		0.4	V
R <sub>PU</sub>	Pull-up resistance.	11	13	16	kΩ
R <sub>PD</sub>	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		$\pm 40$		ppm
$f_{LF,NOM}$	Low frequency oscillator frequency		32.768		kHz
$f_{LF,TOL}$	Low frequency oscillator tolerance		$\pm 250$		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.		$\pm 2$		LSB
$V_{REF\_INT}$	Internal reference voltage.	-3	0.6 V	+3	%
$t_{ADC10b}$	Sample conversion time.		<2		$\mu s$
$t_{ACQ}$	Sample acquisition time. Configurable.	3		40	$\mu s$
$f_{MAX}$	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	$^{\circ}C$
$T_{ACC}$	Temperature sensor accuracy.	-5		+5	$^{\circ}C$
$T_{RES}$	Temperature sensor resolution.		0.25		$^{\circ}C$
$T_{THM\_RANGE}$	Thermistor sensor range.	-40		85	$^{\circ}C$
$T_{THM\_ACC}$	Thermistor sensor accuracy.	-1		+1	$^{\circ}C$
$T_{THM\_RES}$	Thermistor sensor resolution.		0.125		$^{\circ}C$

**Table 8** Temperature Sensor (TEMP) Specifications

## 6.5 High Current Driver (HCD) Specifications

Spec	Description	Min.	Typ.	Max.	Units
I <sub>ON,SS25</sub>	Steady state on current at 25°C.			310	mA
I <sub>ON,SS85</sub>	Steady state on current at 85°C.			220	mA
P <sub>ON,SS</sub>	Steady state power dissipation.			280	mW
I <sub>ON,PULSE</sub>	Pulsed current for 10 $\mu$ s.			1.4	A
R <sub>ON</sub>	On state resistance.		2	5	$\Omega$
I <sub>OFF,LEAK</sub>	Off state leakage.			1	nA
V <sub>CLAMP</sub>	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.	$\pm 2$		$\pm 16$	g
	Resolution.	2048		16384	counts/g
f <sub>DATA</sub>	Data sample frequency.	0.78		1600	Hz
I <sub>12.5</sub>	Low data rate current (3.125 Hz).		5		$\mu$ A
I <sub>100</sub>	Mid data rate current (100 Hz).		24		$\mu$ A
I <sub>1600</sub>	High data rate current (1600 Hz).		180	300	$\mu$ A
I <sub>STANDBY</sub>	Standby current.		3	10	$\mu$ A

**Table 10** Accelerometer (ACCEL) Specifications

## 6.7 Gyroscope (GYRO) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Measurement range.	$\pm 125$		$\pm 2000$	$^{\circ}/s$
	Resolution.	16		262	counts/ $^{\circ}$
f <sub>DATA</sub>	Data sample frequency.	25		3200	Hz
I <sub>GYRO</sub>	Gyro active current. All Data Rates.		850	900	$\mu$ A
I <sub>STANDBY</sub>	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 <sub>DATA</sub>	Data rate.		25	300	Hz
I <sub>STANDBY</sub>	Standby current.		1	3	uA

**Table 12** Magnetometer (MAG) Specifications

## 6.9 LED (LED) Specifications

Spec	Description	Min.	Typ.	Max.	Units
I <sub>RGB</sub>	Drive current per channel.	2	4	5	mA
λ <sub>RPEAK</sub>	Red peak wavelength.		624		nm
λ <sub>GPEAK</sub>	Green peak wavelength.		525		nm
λ <sub>BPEAK</sub>	Blue peak wavelength.		470		nm
I <sub>VR</sub>	Red luminous intensity.	12	60		mcd
I <sub>VG</sub>	Green luminous intensity.	15	60		mcd
I <sub>VB</sub>	Blue luminous intensity.	10	60		mcd
	Viewing Angle		120		°

**Table 13** LED (LED) Specifications

## 6.10 NOR Flash (NOR) Specifications

Spec	Description	Min.	Typ.	Max.	Units
	Powerdown current.		1	25	uA
	Write cycles per sector.	100,000			cycles
	Data retention	20			years
I <sub>READ</sub>	Read current.			15	mA
I <sub>PROGRAM</sub>	Program current.		20	25	mA
I <sub>ERASE</sub>	Erase current.		20	25	mA
t <sub>SSE</sub>	Subsector Erase time.		60	400	ms
t <sub>CE</sub>	Chip Erase time.		20	100	s

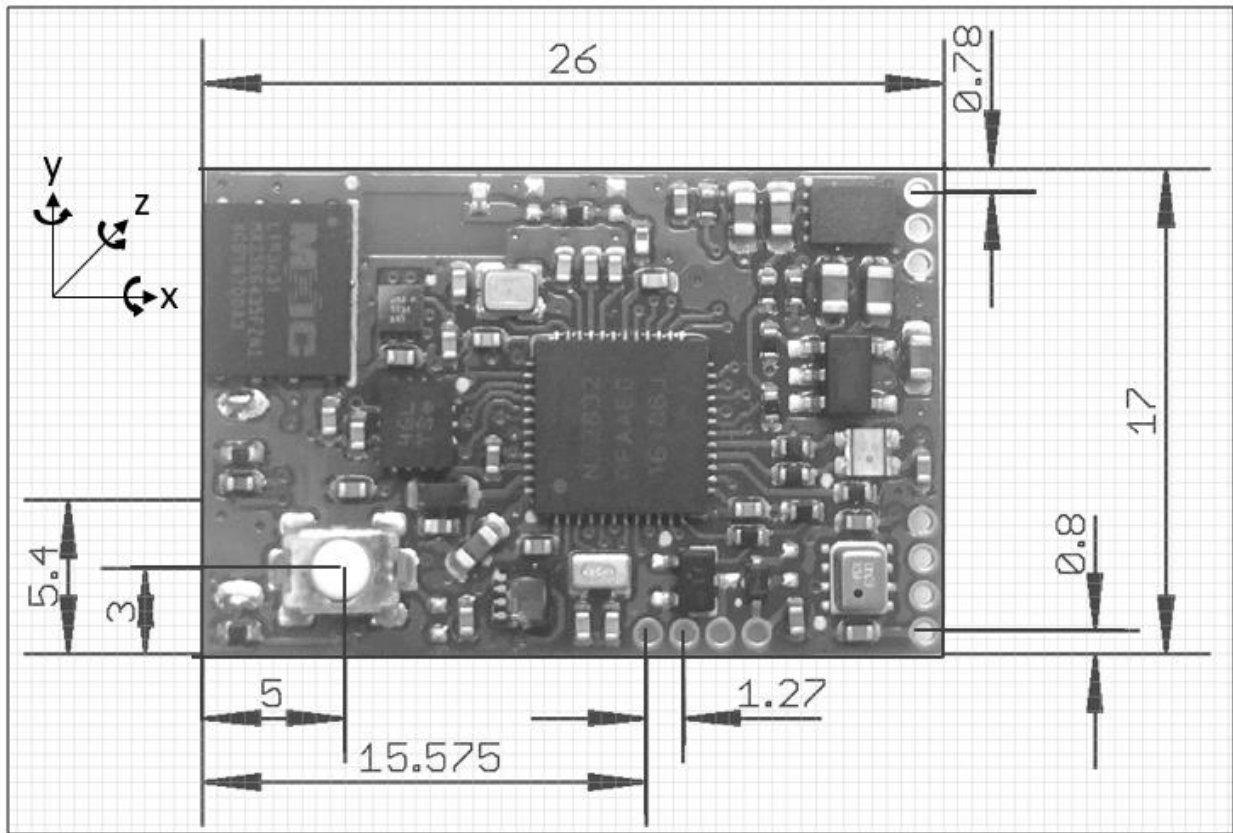
**Table 14** NOR Flash (NOR) Specifications

## 6.11 Sensor Fusion (SF) Specifications

Spec	Description	Min.	Typ.	Max.	Units
f <sub>NDOF</sub>	NDoF operating frequency.	-1%	100	+1%	Hz
f <sub>IMUPLUS</sub>	IMUPlus operating frequency.	-1%	100	+1%	Hz
f <sub>COMPASS</sub>	Compass operating frequency.	-1%	25	+1%	Hz
f <sub>M4G</sub>	M4G operating frequency.	-1%	50	+1%	Hz

**Table 15** Sensor Fusion (SF) Specifications

## 7 Mechanical Specifications



**Figure 7** Module dimensions in mm



## 9 Revision History

Date	Version	Change Description
January 7, 2021	0.5	Initial Draft

**Table 16** *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 MetaMotionR 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](http://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:** MetaMotionR's battery life can be shortened with heavy use.

**METAMOTIONR IS NOT A TOY OR MEDICAL DEVICE.**

**WARNING:** choking hazard - small parts.

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