User manual

DA14583 IoT sensor reference application

UM-B-064

Abstract

This document describes the hardware design of the DA14583 IoT sensor reference application, which is based on the Dialog Semiconductor DA14583 Bluetooth® Smart SoC with an integrated Flash memory. This module includes a geomagnetic sensor, an accelerometer and a combined environmental sensor that can sense temperature, pressure and humidity levels.

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1 Terms and definitions

BLE	Bluetooth Low Energy (now: Bluetooth Smart)
GPIO	General Purpose Input/Output
I^2C	Inter-Integrated Circuit (interface)
IoT	Internet of Things
JTAG	Joint Test Action Group (test interface)
PCB	Printed Circuit Board
SMD	Surface Mount Device
SoC	System on Chip
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter

2 References

[1] DA14583 Low Power Bluetooth Smart SoC, Datasheet, Dialog Semiconductor.
[2] Battery holder, Keystone Electronics Corp.
[3] BMI160 Inertial Measurement unit, Bosch Sensortec.
[4] BME280 Environmental Sensor, Bosch Sensortec.
[5] BMM150 Geomagnetic Sensor, Bosch Sensortec.
[6] SMD ceramic antenna, Johanson Technology Inc.
[7] UM-B-063 DA14583 IoT sensor development kit, User manual, Dialog Semiconductor.

3 Introduction

The DA14583 IoT sensor reference design is based on the Dialog Semiconductor DA14583 Bluetooth® Smart SoC with an integrated Flash memory. This module includes a geomagnetic sensor, an accelerometer and a combined environmental sensor that can sense temperature, pressure and humidity levels.

4 System overview

4.1 Features

- Highly integrated DA14583 Bluetooth® Smart SoC with integrated SPI Flash memory.
- Stand-alone module
- Module passes all Bluetooth® Smart requirements
- Access to processor via JTAG and UART
- 15 mm^2 PCB

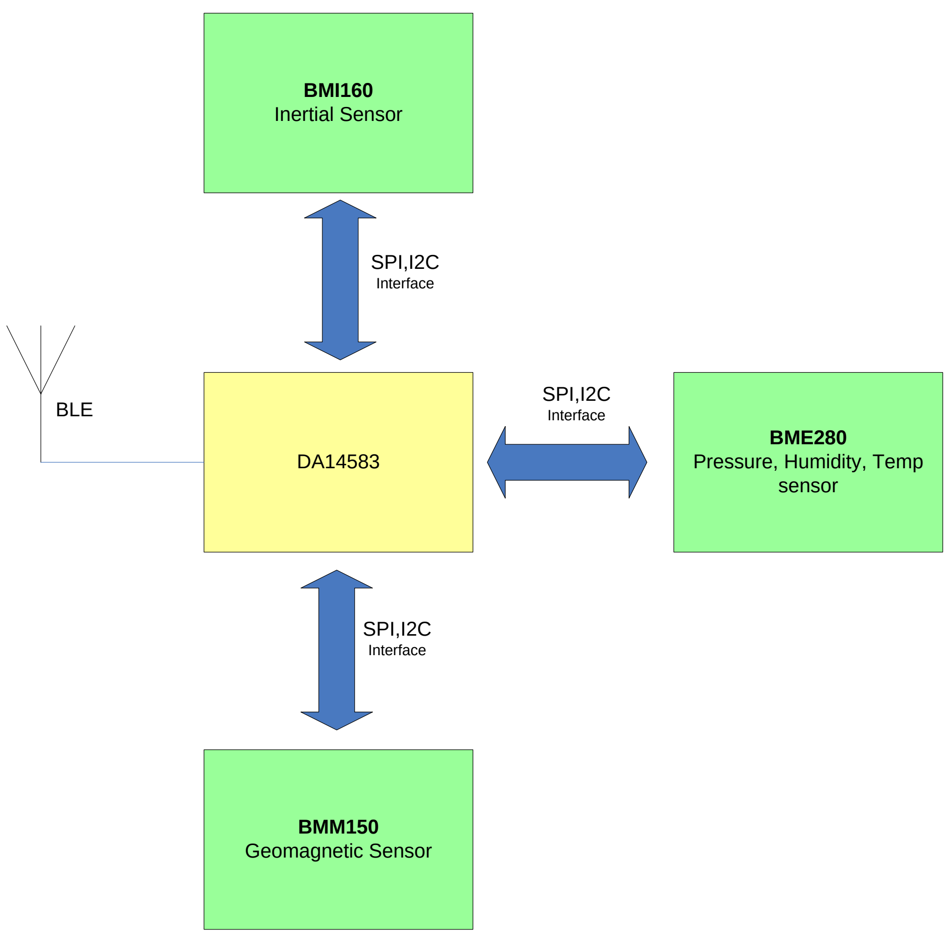

Figure 1: Top level block diagram of the IoT sensor reference design

4.2 Electrical characteristics

Table 1: Electrical specifications

Parameter	Min	Typ	Max	Unit
BMI160 Inertial Sensor				
Supply Voltage (VDD)	1.71	3.0	3.6	V
Supply Voltage (VDD I/O)	1.2	2.4	3.6	V
Voltage Input Low Level			0.3*VDD I/O	V
Voltage Input High Level	0.7*VDD I/O			V
Voltage Output Low Level			0.2*VDD I/O	V
Voltage Output High Level			0.23*VDD I/O	V
Operating Temperature	-40		85	ºC
BME280 Environmental Sensor (pressure, humidity, temperature)				
Supply Voltage (VDD)	1.71	1.8	3.6	V
Supply Voltage (VDD I/O)	1.2	1.8	3.6	V
Operating Temperature	-40	25	85	ºC
BMM150 Geomagnetic Sensor				
Supply Voltage (VDD)	1.62	2.4	3.6	V
Supply Voltage (VDD I/O)	1.2	1.8	3.6	V
Operating Temperature	-40	25	85	ºC
DA14583 BLE SoC				
Battery Supply Voltage (VBAT)-Buck mode	2.35		3.3	V
Operating Temperature	-40		85	ºC

Table 2: Current consumption

Item	BMI160	BME280	BMM150	Total current
Operating current (mA)	0.950 (full mode)	0.340 (Humidity @ 85 ºC) 0.714 (Pressure @ 85 ºC) 0.350 (Temperature @ 85 ºC) 1.4 (Total)	0.500 (normal mode)	2.8 mA
Sleep current (µA)	3 (suspend mode)	0.3	3 (suspend mode)	6.3 µA

5 Description

The DA14583 IoT sensor reference design consists of the following components:

- **BMI160:** Low-power, low-noise 16 bit Inertial Measurement Unit designed for use in mobile and indoor applications which require highly accurate, real-time sensor data. In full operation mode, with the **accelerometer** and **gyroscope** enabled, the current consumption is typically 950 µA, enabling always-on applications in battery driven devices. The BMI160 combines an accelerometer and a gyroscope both with a 16-bit resolution.
- **BME280:** Integrated environmental sensor developed specifically for mobile applications. The built-in **humidity** sensor features an extremely fast response time which supports performance requirements for emerging applications such as context awareness, and high accuracy over a wide temperature range. The humidity sensor features an extremely fast response time. The **pressure** sensor is an absolute barometric pressure sensor with features exceptionally high accuracy and resolution at very low noise. The integrated **temperature** sensor is primarily used for temperature compensation of the pressure and humidity sensors, and can also be used for estimating ambient temperature.
- **BMM150:** Low power and low noise 3-axis digital **geomagnetic** sensor to be used in compass applications.
- **DA14583:** BLE SoC with an integrated SPI Flash memory

Table 3 gives a summary of the sensor data rates and the digital interfaces that are available for data acquisition. Data rates are given to check for possible speed limitations (especially in case of the I^{2}C interface).

Table 3: Sensor data rate information

Item	BMI160	BME280	BMM150
Digital interface	SPI, I^{2}C	SPI, I^{2}C	SPI, I^{2}C
Data rate	1.6 kHz (Accelerometer) 6.4 kHz (Gyroscope)	87 Hz (Forced mode) 13.5 Hz (Normal mode)	30 Hz

Table 4 shows the sensor pin assignment, including the GPIOs that are assigned for the SPI interface and other interrupt functions.

Table 4: Sensor and GPIO pin assignment

Pin	Description	Direction	DA14583 pin	GPIO pin count
BMI160 Inertial sensor				
SDO (MISO)	Serial SPI out	→	**P0_0**	5
SDI (MOSI)	Serial SPI in	←	**P0_1**	
SCK	Serial clock	←	**P0_2**	
CSB1	Chip select	←	**P0_3**	
INT1	Interrupt	→	**P0_6**	
BME280 Environmental sensor (pressure, humidity, temperature)				
SDO (MISO)	Serial SPI out	→	(P0_0)	1
SDI (MOSI)	Serial SPI in	←	(P0_1)	
SCK	Serial clock	←	(P0_2)	

Pin	Description	Direction	DA14583 pin	GPIO pin count
CSB2	Chip select	←	**P0_7**	
BMM150 Geomagnetic sensor				
SDO (MISO)	Serial SPI out	→	(P0_0)	
SDI (MOSI)	Serial SPI in	←	(P0_1)	
SCK	Serial clock	←	(P0_2)	2
CSB3	Chip select	←	**P1_0**	
INT2	Interrupt output	→	**P1_1**	
Additional pins				
UTX	Transmit	←	**P0_4**	2
URX	Receive	→	**P0_5**	
Total				**10**

5.1 BMI160 Inertial sensor pinout

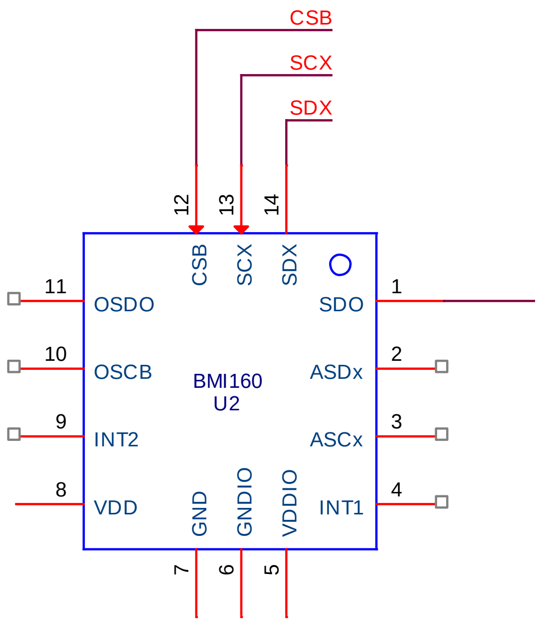

Figure 2: BMI160 Inertial sensor: pinning diagram

Table 5: BMI160 Inertial sensor: pin description

Pin#	Name	I/O Type	Interface	Description
1	SDO	Digital I/O	Primary	Serial data output in SPI Address select in I2C mode
2	ASDx	Digital I/O	Secondary	Magnetometer interface*)
3	ASCx	Digital out	Secondary	Magnetometer interface
4	INT1	Digital I/O	Primary	Interrupt pin 1 *)
5	VDDIO	Supply	-	Digital I/O supply voltage (1.2 ... 3.6V)
6	GNDIO	Ground	-	Ground for I/O
7	GND	Ground	-	Ground for digital & analog
8	VDD	Supply	-	Power supply analog & digital domain (1.71V – 3.6V)
9	INT2	Digital I/O	Primary	Interrupt pin 2 *)
10	OCSB	Digital I/O	Secondary	OIS interface
11	OSDO	Digital I/O	Secondary	OIS interface
12	CSB	Digital in	Primary	Chip select for SPI mode / Protocol selection pin
13	SCx	Digital in	Primary	SCK for SPI serial clock SCL for I²C serial clock
14	SDx	Digital I/O	Primary	SDA serial data I/O in I2C MOSI serial data input in SPI 4W SISO serial data I/O in SPI 3W

5.2 BME280 Environmental sensor pinout

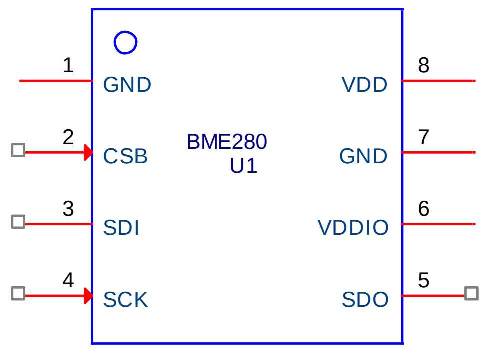

Figure 3: BME280 Environmental sensor: pinning diagram

Table 6: BME280 Environmental sensor: pin description

Pin	Name	I/O Type	Description	Connect to		
				SPI 4W	SPI 3W	I²C
1	GND	Supply	Ground	GND		
2	CSB	In	Chip select	CSB	CSB	V_{DDIO}
3	SDI	In/Out	Serial data input	SDI	SDI/SDO	SDA
4	SCK	In	Serial clock input	SCK	SCK	SCL
5	SDO	In/Out	Serial data output	SDO	DNC	GND for default address
6	V_{DDIO}	Supply	Digital / Interface supply	V_{DDIO}		
7	GND	Supply	Ground	GND		
8	V_{DD}	Supply	Analog supply	V_{DD}		

5.3 BMM150 Geomagnetic sensor pinout

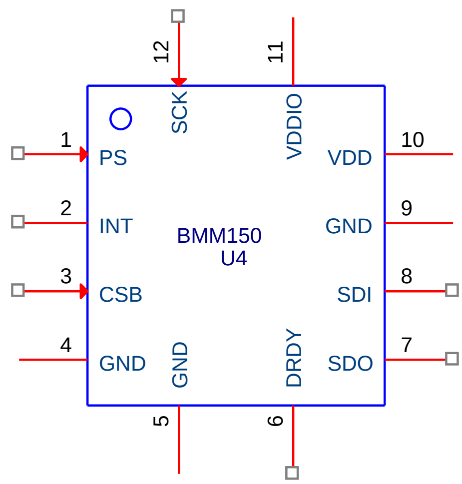

Figure 4: BMM150 Geomagnetic sensor: pinning diagram

Table 7: BMM150 Geomagnetic sensor: pin description

Pin	Name	I/O Type	Description	Connect to		
				SPI 4W	SPI 3W	I²C
A1	PS	In	Protocol select	GND	GND	V_{DDIO}
D2	INT	Out	Interrupt output	INT input or DNC if unused		
A5	CSB	In	Chip Select	CSB	CSB	GND for default address
C5	GND	Supply	Ground	GND		
E1	GND	Supply	Ground	GND		
D4	DRDY	Out	Data ready	DRDY input or DNC if unused		
C1	SDO	Out	SPI: Data out	SDO / MISO	DNC (float)	GND for default address
B4	SDI	In/Out	SPI: Data, I²C: Data	SDI / MOSI	SDI/SDO	SDA
E3	GND	Supply	Ground	GND		
E5	VDD	Supply	Supply voltage	V_{DD}		
B2	VDDIO	Supply	I/O voltage	V_{DDIO}		
A3	SCK	In	Serial clock	SCK	SCK	SCL

DA14583 IoT sensor reference application

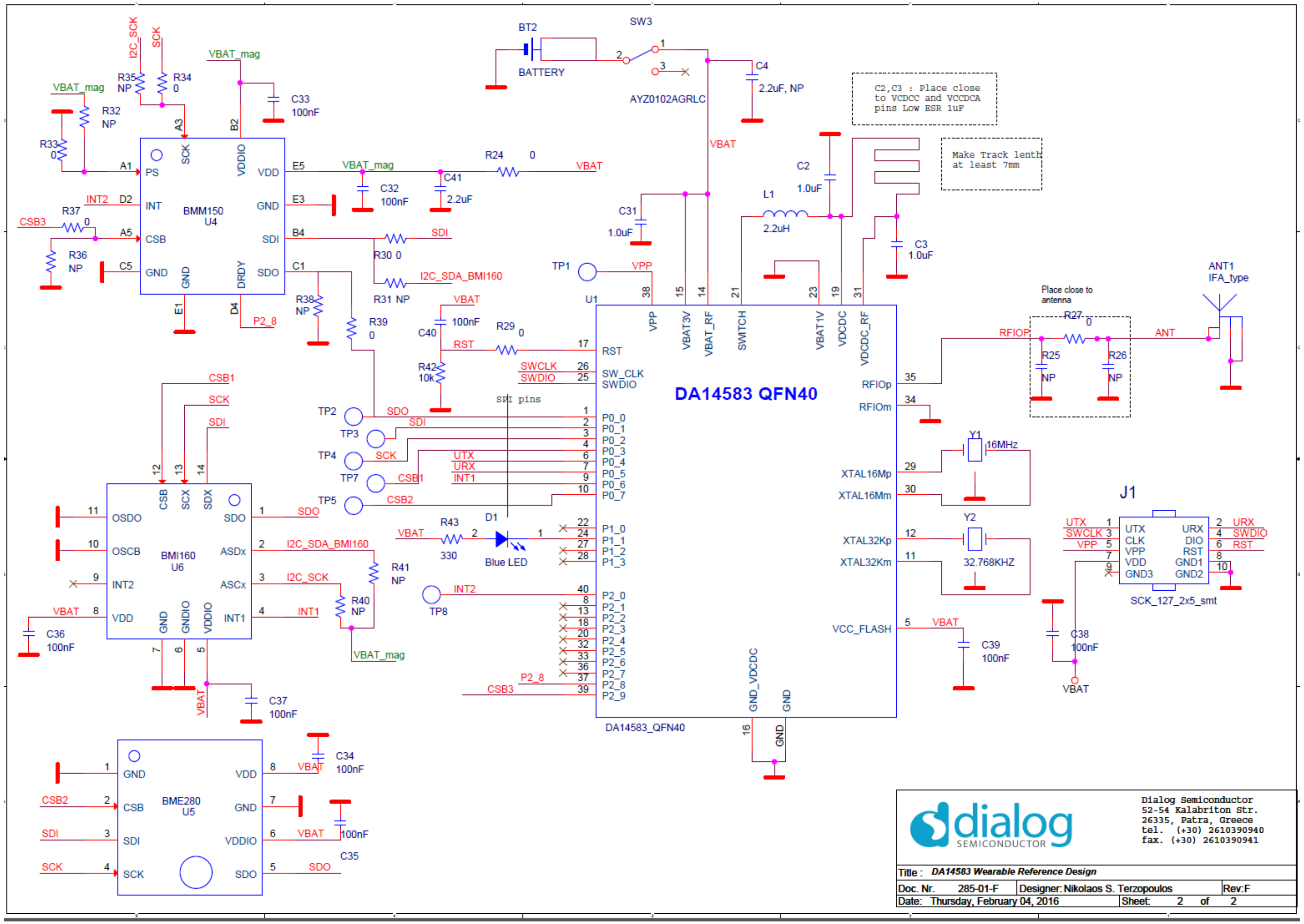

Figure 5: Top level schematic of the IoT sensor reference design (Rev. F)

5.4 Antenna type

The IoT Sensor reference application uses a ceramic chip antenna. This type of antenna has the following advantages:

- SMD miniature type for easy manufacturability.
- Remains reliable and versatile.
- Easy tuning.

Mechanical Dimensions

	In	mm
L	0.039 ± 0.004	1.00 ± 0.10
W	0.020 ± 0.004	0.50 ± 0.10
T	0.014	0.37
a	0.006 +.004/-.006	0.15 +0.1/-0.05
b	0.010 +.004/-.006	0.25 +0.1/-0.05
c	0.003 +.004/-.006	0.08 +0.1/-0.05

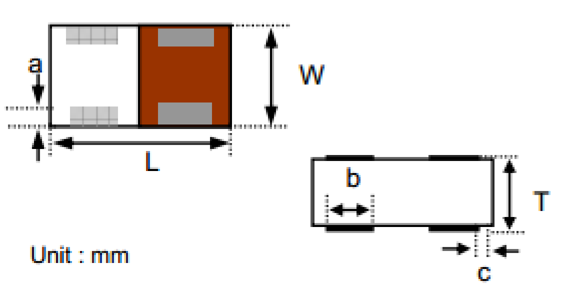

Figure 6: Ceramic antenna: PCB footprint and mechanical specifications

Table 8: Antenna features

Part Number	Frequency (MHz)	Peak Gain	Ave. Gain	Return Loss	S-Param	Product Life Cycle Status	Case
2450AT18A100	2400 - 2500	0.5 dBi typ (XZ-V)	-0.5 dBi typ (XZ-V)	9.5 dB min.	S-Param	PROD	18-4

Table 9: Antenna purchasing cost

Manufacturer	Part number	Price (€)
Johanson Technology Inc.	2450AT07A0100	0.33/1000 pcs

5.5 IoT Sensor reference board

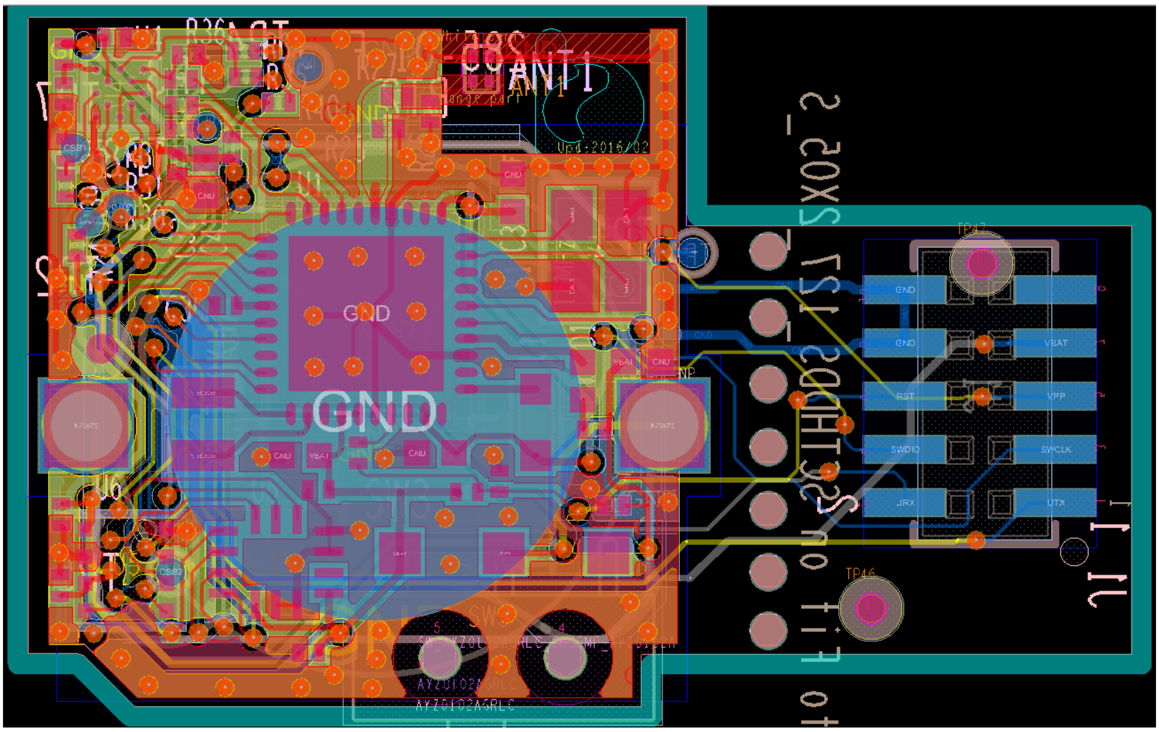

Figure 7: IoT Sensor reference board: top view (Rev. F)

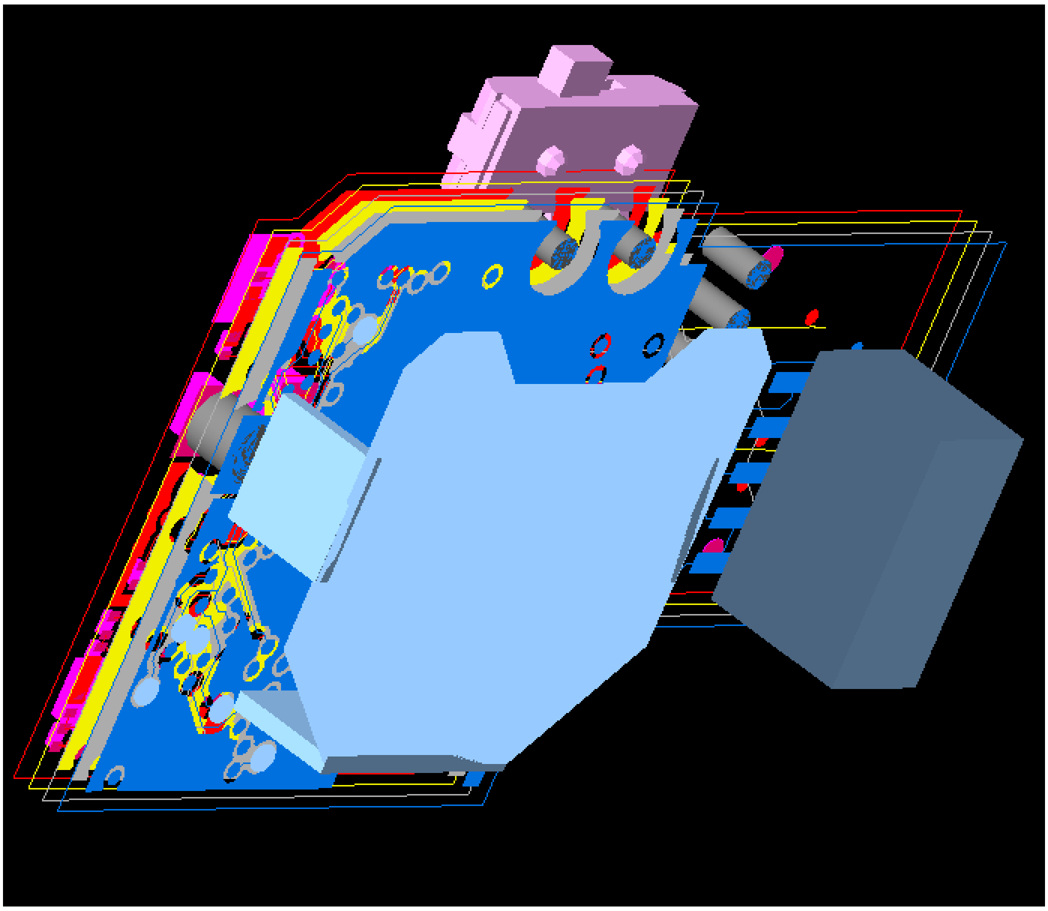

Figure 8: IoT Sensor reference board: 3D bottom view with battery holder (Rev. F)

The THM Holder for 12 mm Cell-Tin Nickel Plate P/N 3001 (see Ref. [2]) has been selected as the battery holder. See Figure 8.

Figure 9 shows the PCB including the actual antenna at a top right orthogonal placement scenario with antenna clearance.

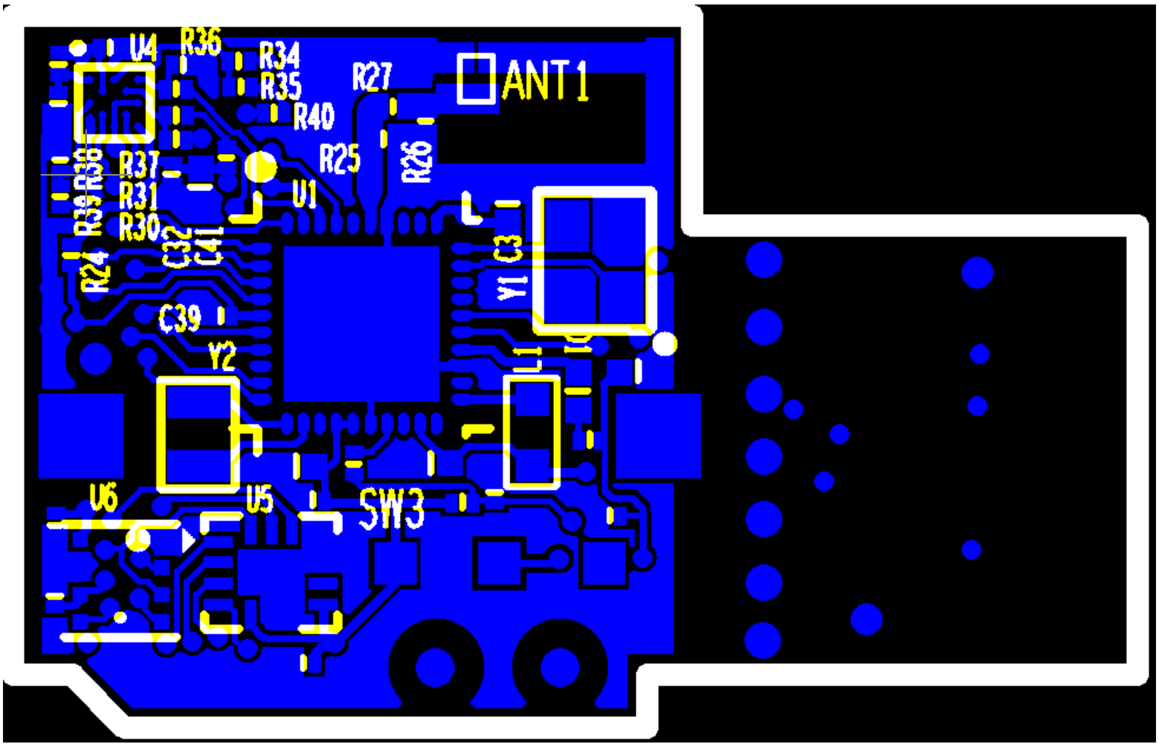

Figure 9: IoT Sensor reference board: Gerber top layer and silk screen layer

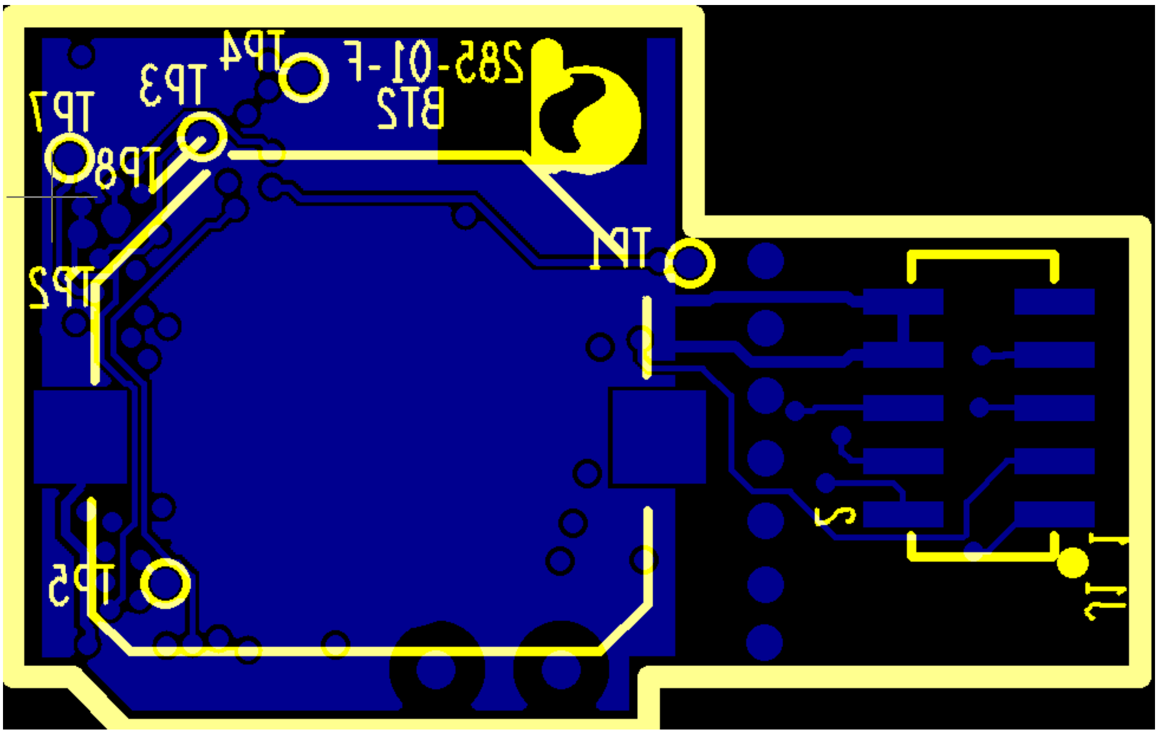

Figure 10: IoT Sensor reference board: Gerber bottom layer and silk screen layer

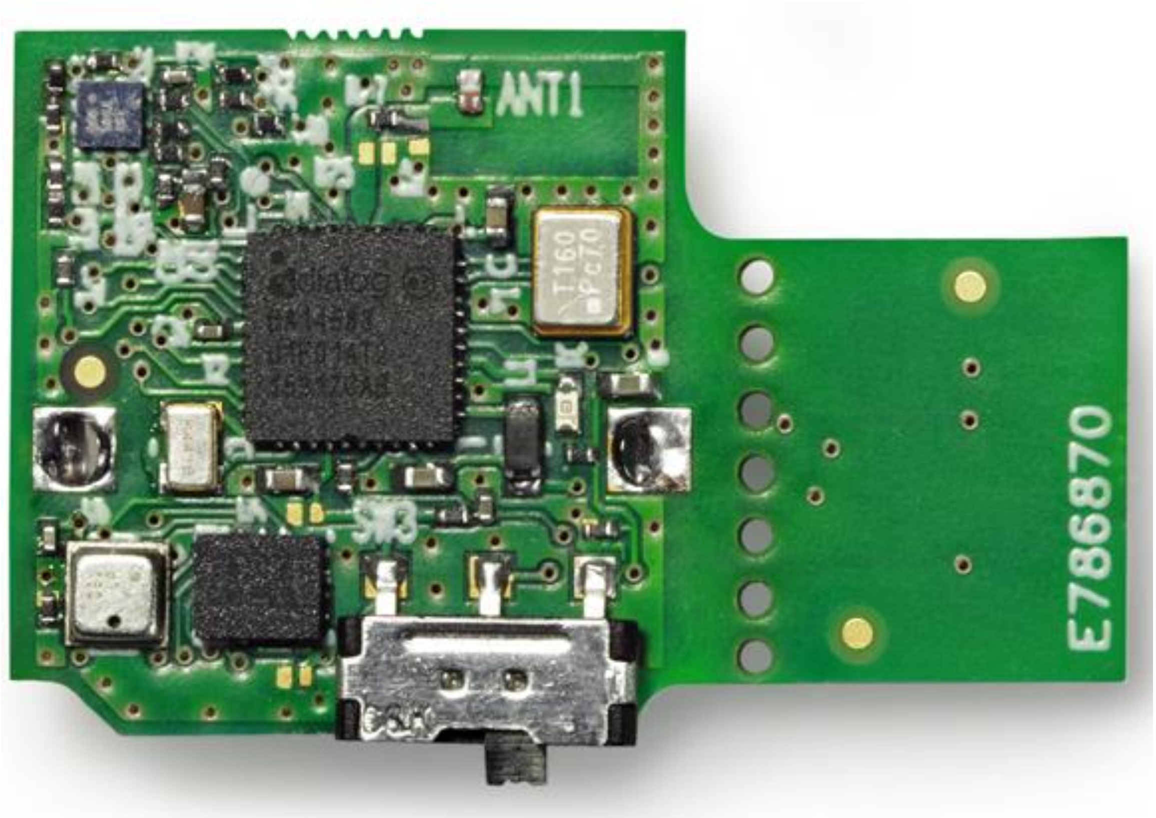

Figure 11: IoT Sensor reference board (top view)

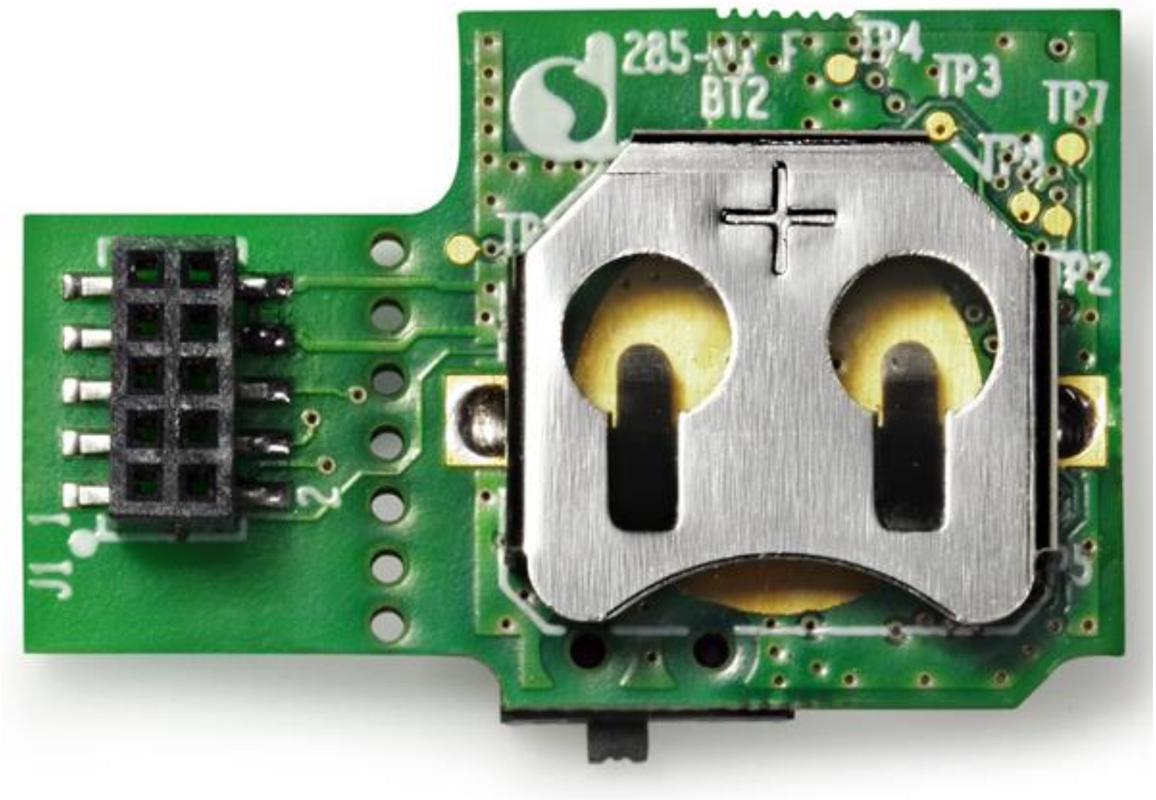

Figure 12: IoT Sensor reference board (bottom view)

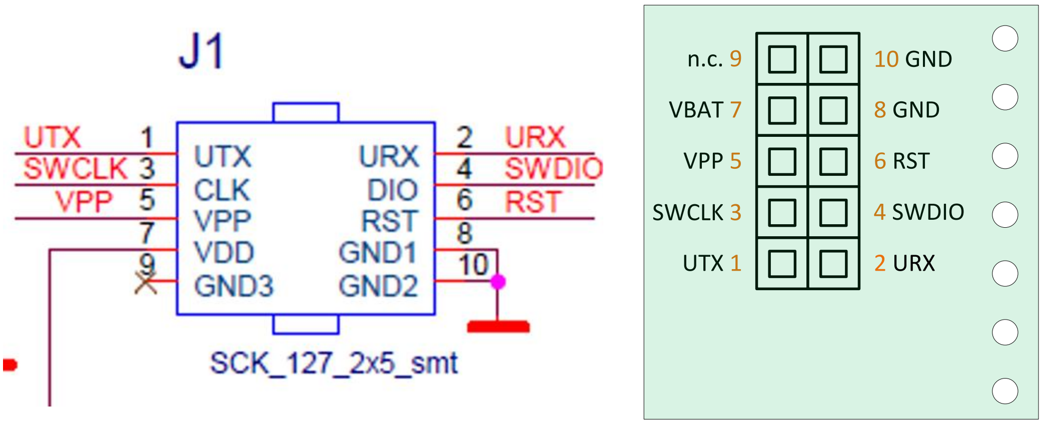

Figure 13: Schematic of connector J1 (left) and the actual mirrored PCB pinout (right)

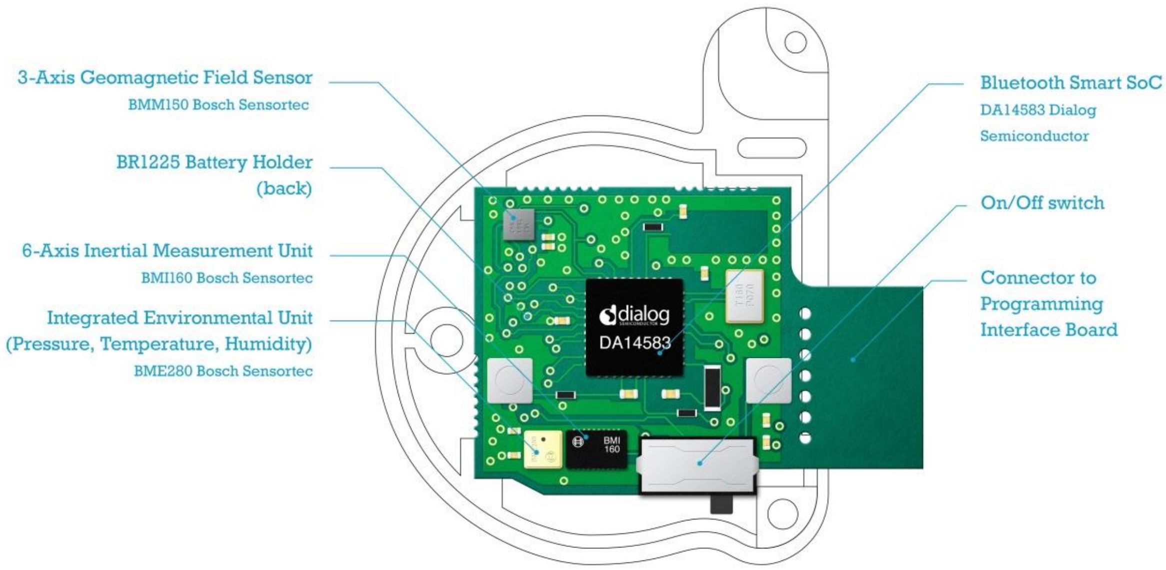

Figure 14: IoT Sensor reference board: component placement overview

6 Magnetic scan simulation measurements

6.1 Passive tests

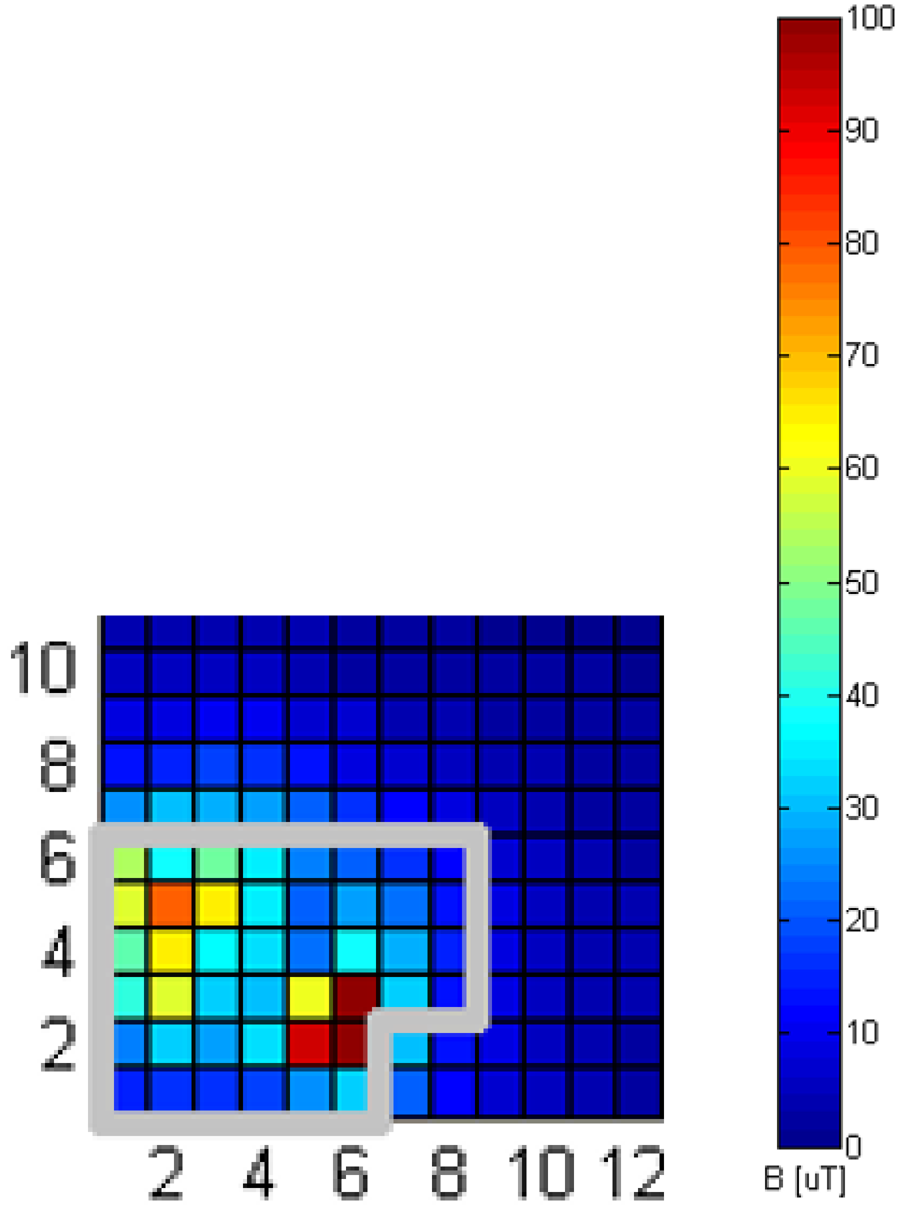

Figure 15: Magnetic field strength

Figure 15 shows the magnetic field strength (vector length) on the PCB. The earth's magnetic field is subtracted, so what is visible is the field caused by the components populating the PCB. The PCB has a grey outline. The position of the magnetometer is in the bottom-left corner.

The two (red) hot spots are caused by the pressure sensor package (magnetic lens effect) and by the T160 component (coil/converter).

The placement of the BMM150 Geomagnetic sensor is optimal: when it is placed in a blue region, which means that it is not in the proximity of a permanent magnet or any object producing magnetic fields.

6.2 Soft iron scan (magnetic field deformation test)

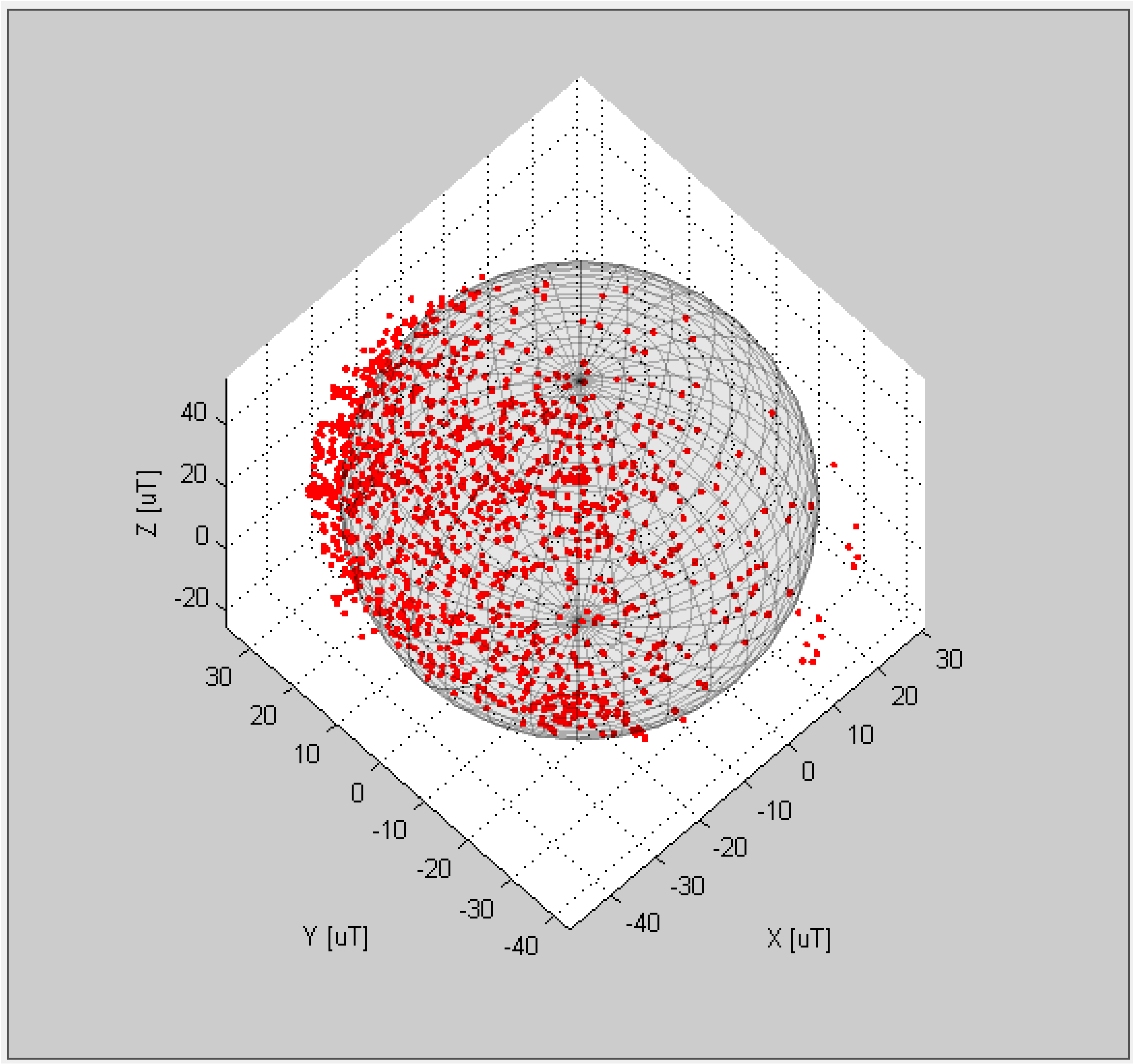

Figure 16: Magnetic field deformation by soft iron effects of the coin cell battery and its holder

In Figure 16, there is some deformation of the natural magnetic field, caused by the battery on top of the PCB. The deformation is visible as points lying off the sphere (not on its surface). Since the effect is deterministic, it can be compensated for by an appropriate compensation matrix (see Ref. [7])

Revision history

Revision	Date	Description
1.0	10-Mar-2016	Initial version.

Status definitions

Status	Definition
DRAFT	The content of this document is under review and subject to formal approval, which may result in modifications or additions.
APPROVED or unmarked	The content of this document has been approved for publication.

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