# 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

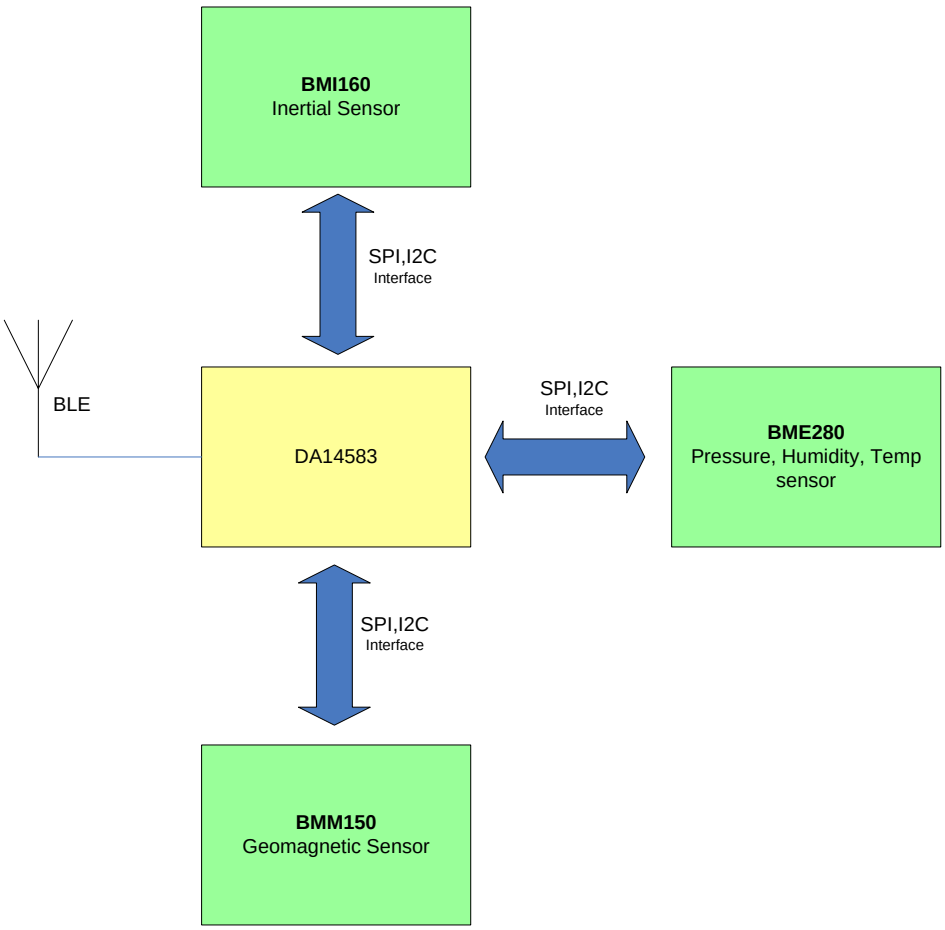


**Figure 1: Top level block diagram of the IoT sensor reference design**

## 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 | $^{o}$C |
| **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 | $^{o}$C |
| **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 | $^{o}$C |
| **DA14583 BLE SoC** | | | | |
| Battery Supply Voltage (VBAT)-Buck mode | 2.35 | | 3.3 | V |
| Operating Temperature | -40 | | 85 | $^{o}$C |

**Table 2: Current consumption**

| Item | BMI160 | BME280 | BMM150 | Total current |
|---|---|---|---|---|
| Operating current (mA) | 0.950 (full mode) | 0.340 (Humidity @ 85 $^{o}$C)<br>0.714 (Pressure @ 85 $^{o}$C)<br>0.350 (Temperature @ 85 $^{o}$C)<br>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 $I^2C$ interface).

**Table 3: Sensor data rate information**

| Item | BMI160 | BME280 | BMM150 |
|---|---|---|---|
| Digital interface | SPI, $I^2C$ | SPI, $I^2C$ | SPI, $I^2C$ |
| Data rate | 1.6 kHz (Accelerometer)<br>6.4 kHz (Gyroscope) | 87 Hz (Forced mode)<br>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) | |
| CSB2 | Chip select | ← | **P0_7** | |

| Pin | Description | Direction | DA14583 pin | GPIO pin count |
|---|---|---|---|---|
| **BMM150 Geomagnetic sensor** | | | | |
| SDO (MISO) | Serial SPI out | → | (P0_0) | 2 |
| SDI (MOSI) | Serial SPI in | ← | (P0_1) | |
| SCK | Serial clock | ← | (P0_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

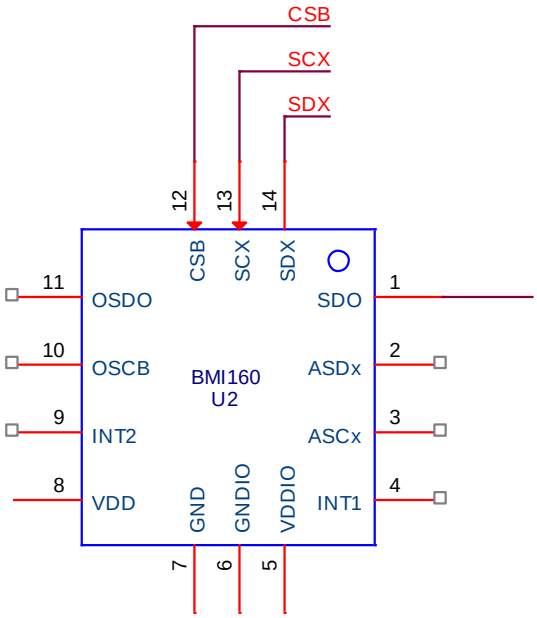


**Figure 2: BMI160 Inertial sensor: pinning diagram**

**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<br>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<br>(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<br>SCL for I²C serial clock |
| 14 | SDx | Digital I/O | Primary | SDA serial data I/O in I2C<br>MOSI serial data input in SPI 4W<br>SISO serial data I/O in SPI 3W |

## 5.2 BME280 Environmental sensor pinout

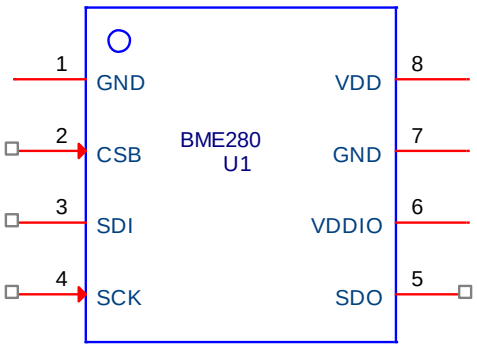


**Figure 3: BME280 Environmental sensor: pinning diagram**

**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

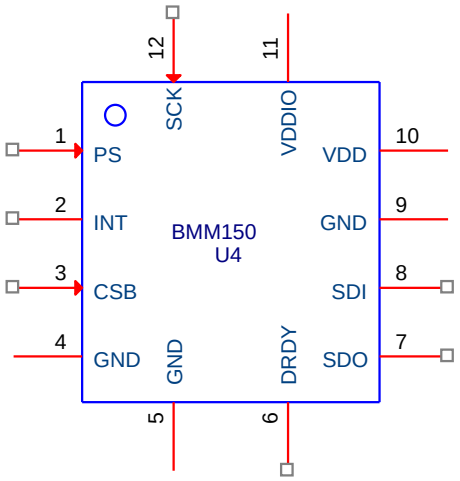


**Figure 4: BMM150 Geomagnetic sensor: pinning diagram**

**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 |

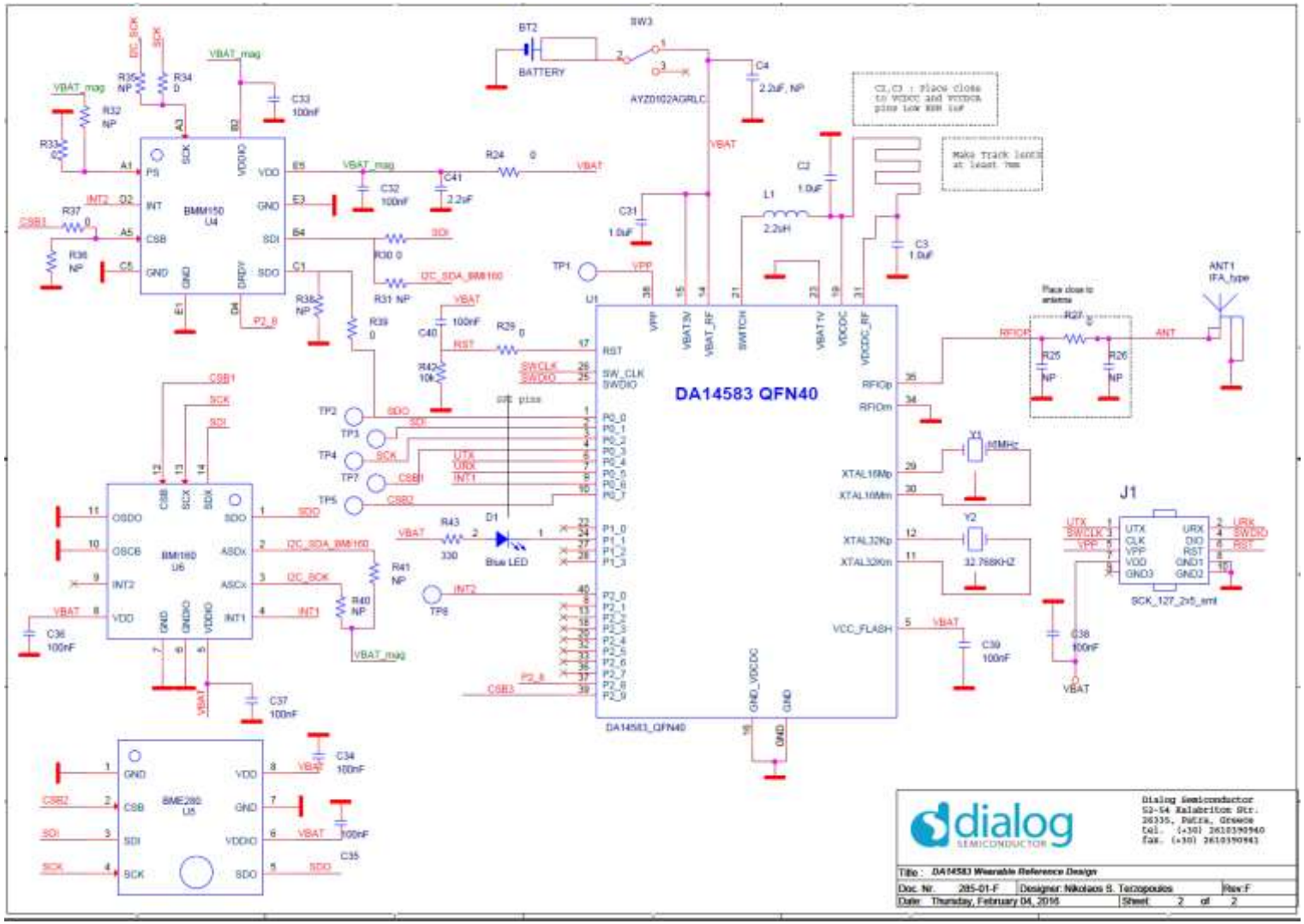


**Figure 5: Top level schematic of the IoT sensor reference design (Rev. F)**

## 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.

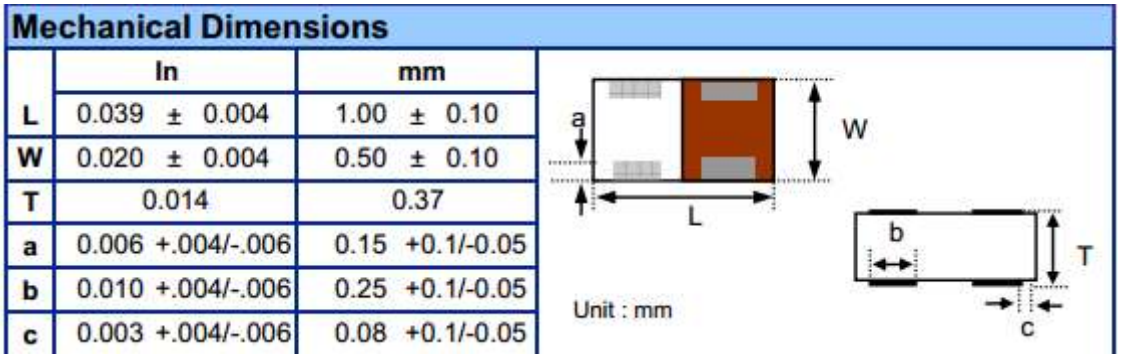


**Figure 6: Ceramic antenna: PCB footprint and mechanical specifications**

**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

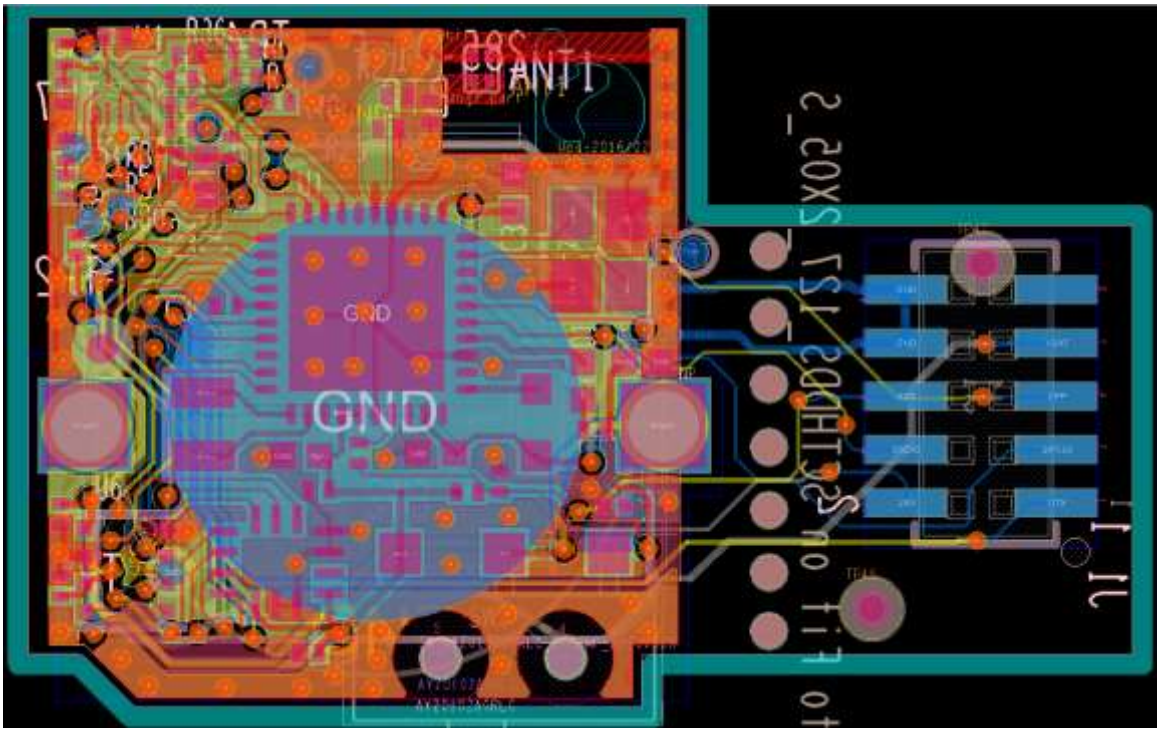


**Figure 7: IoT Sensor reference board: top view (Rev. F)**

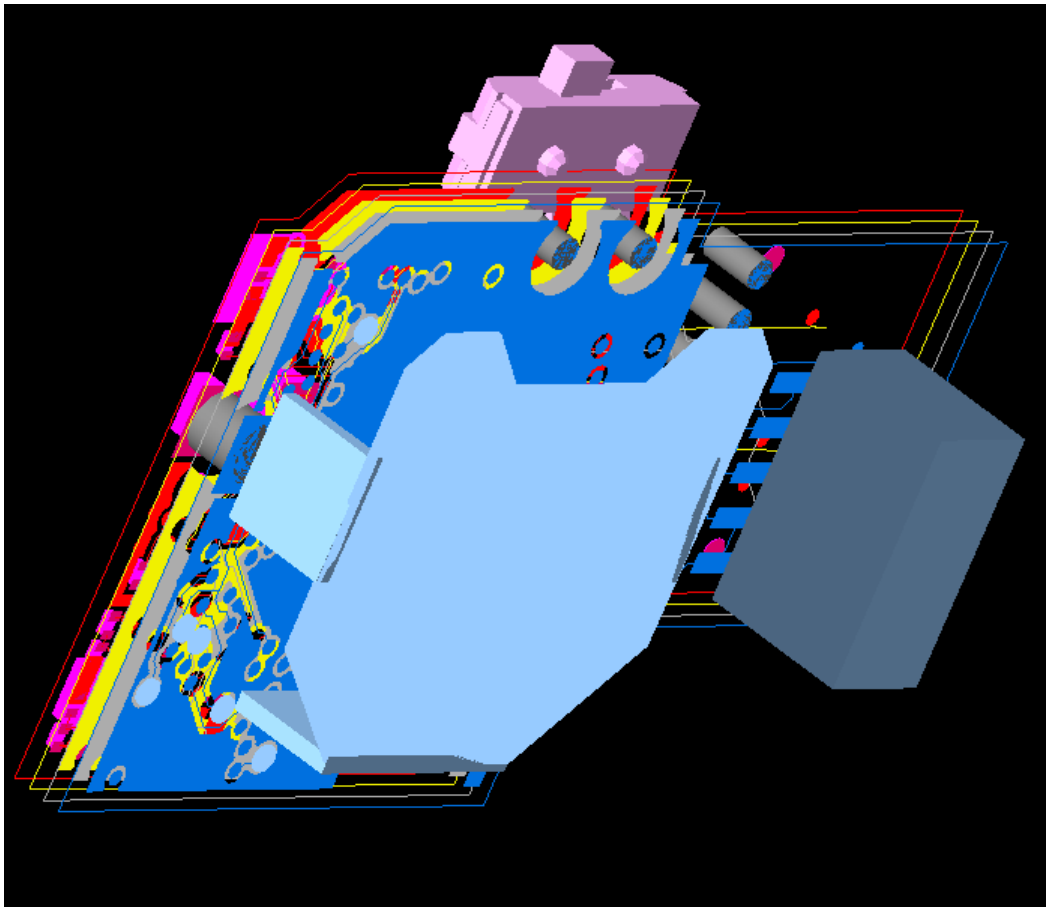

**Figure 8: IoT Sensor reference board: 3D bottom view with battery holder (Rev. F)**

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.

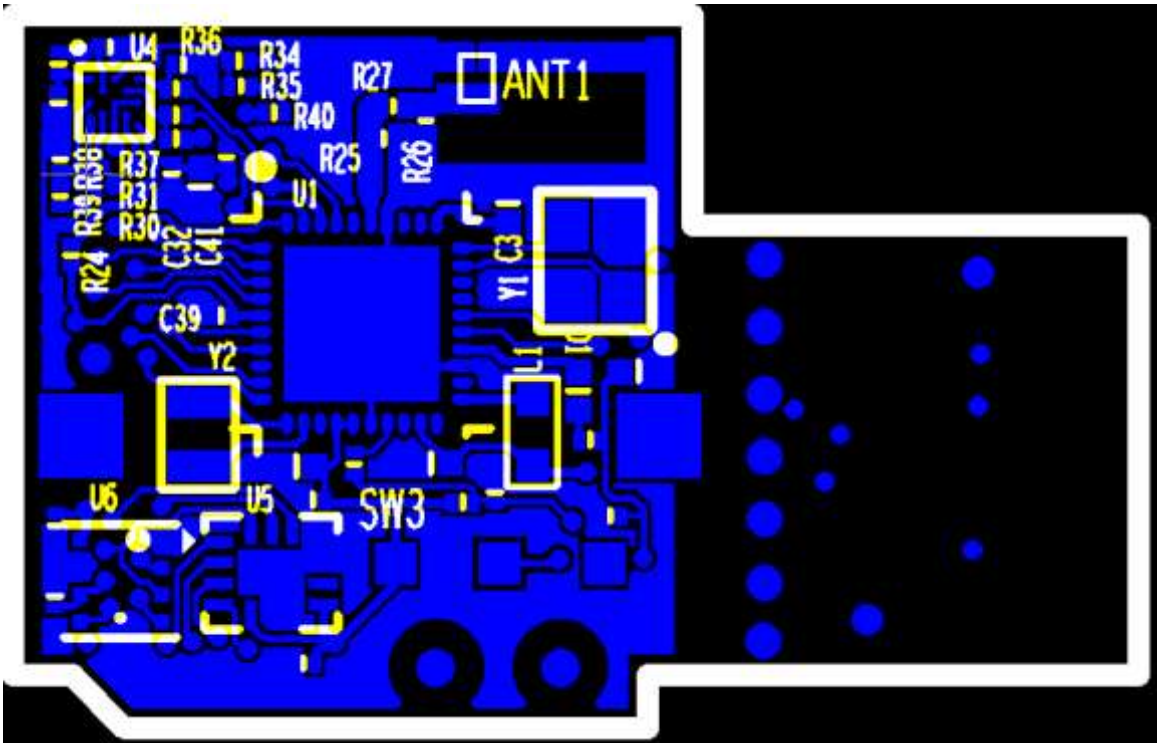


**Figure 9: IoT Sensor reference board: Gerber top layer and silk screen layer**

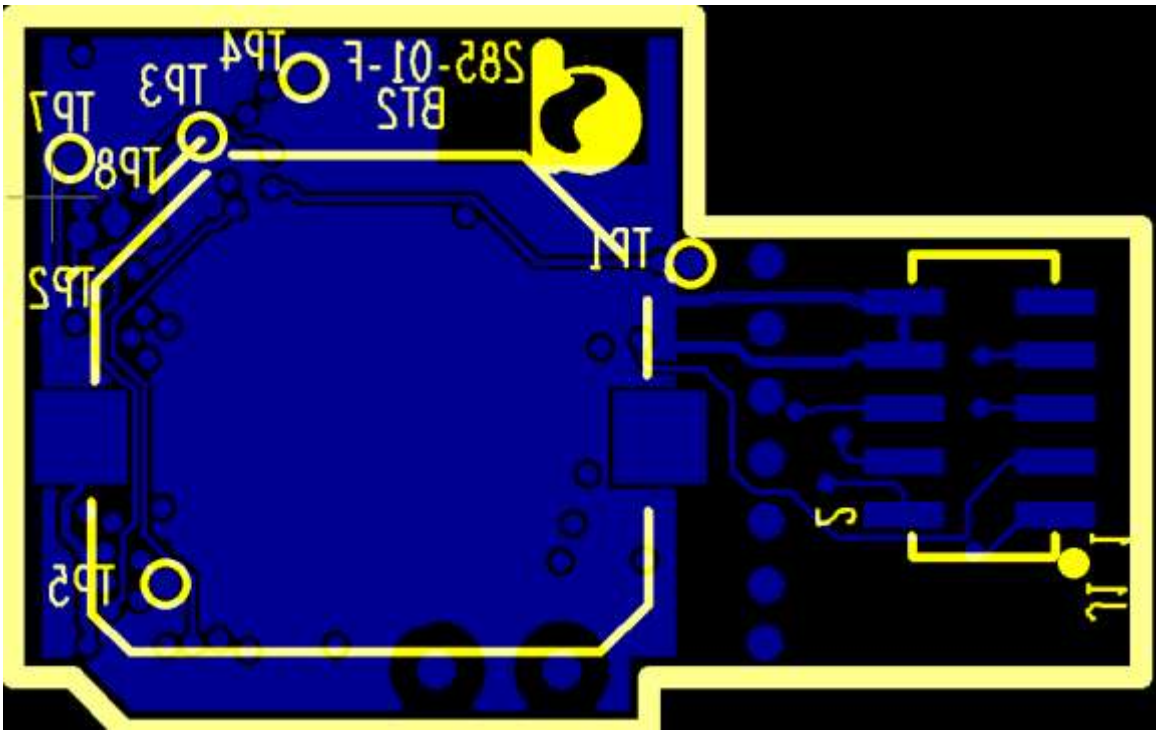


**Figure 10: IoT Sensor reference board: Gerber bottom layer and silk screen layer**

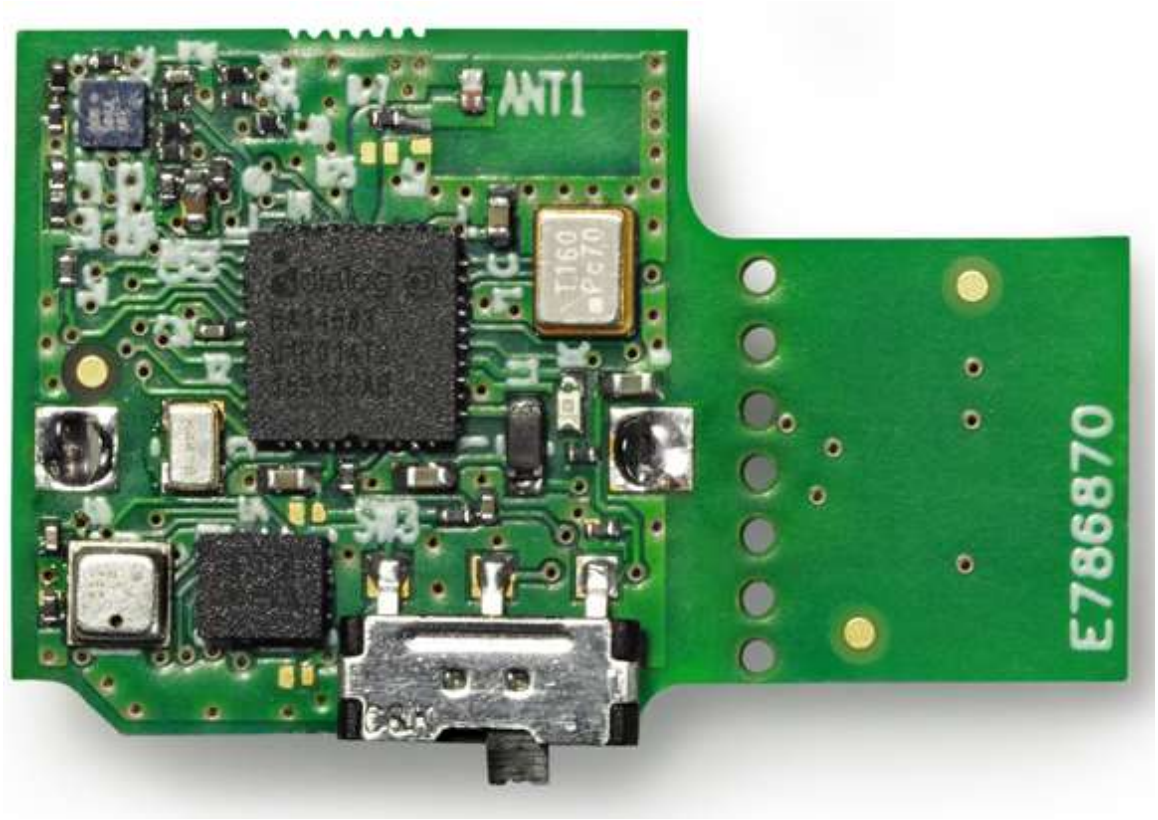


**Figure 11: IoT Sensor reference board (top view)**

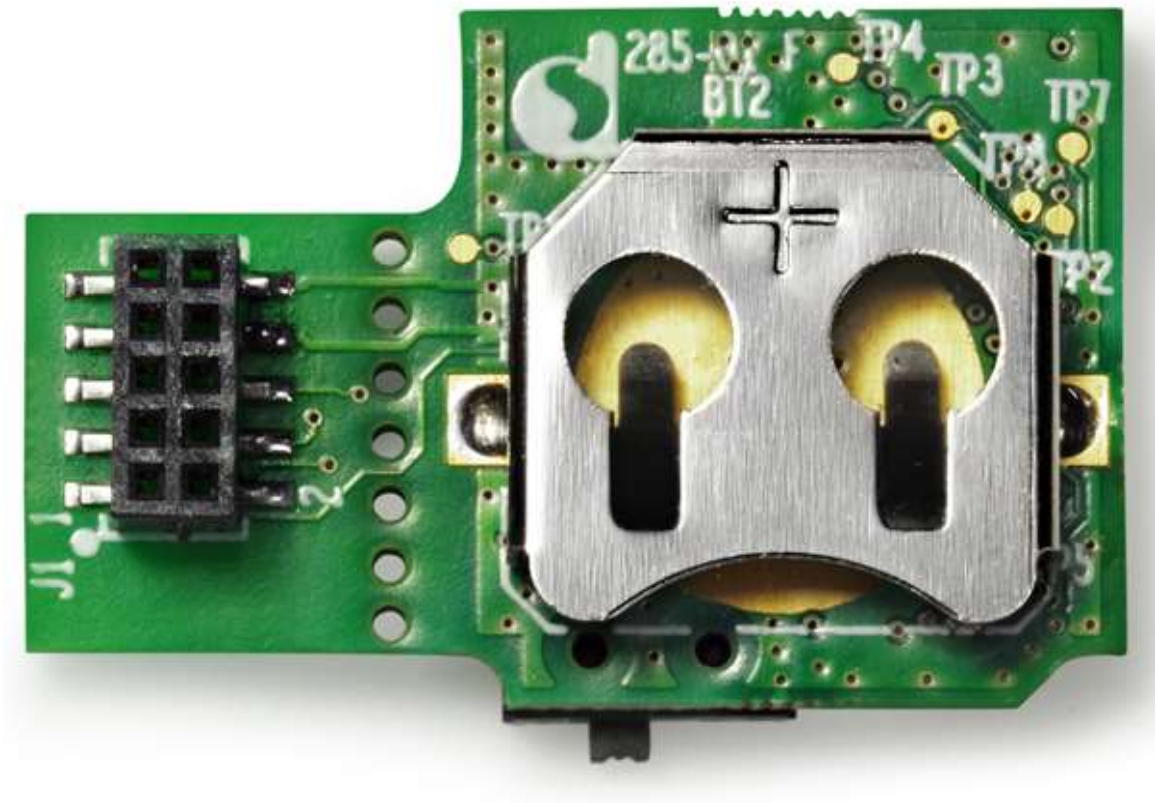


**Figure 12: IoT Sensor reference board (bottom view)**

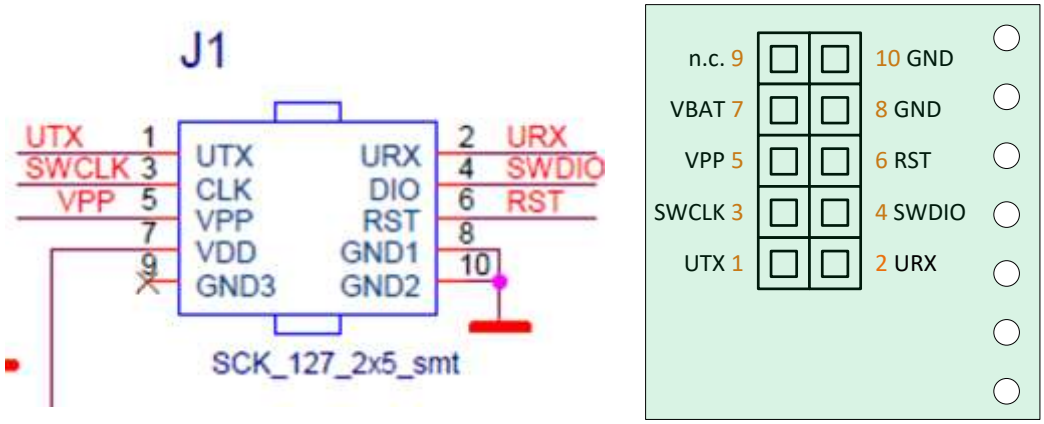


**Figure 13: Schematic of connector J1 (left) and the actual mirrored PCB pinout (right)**

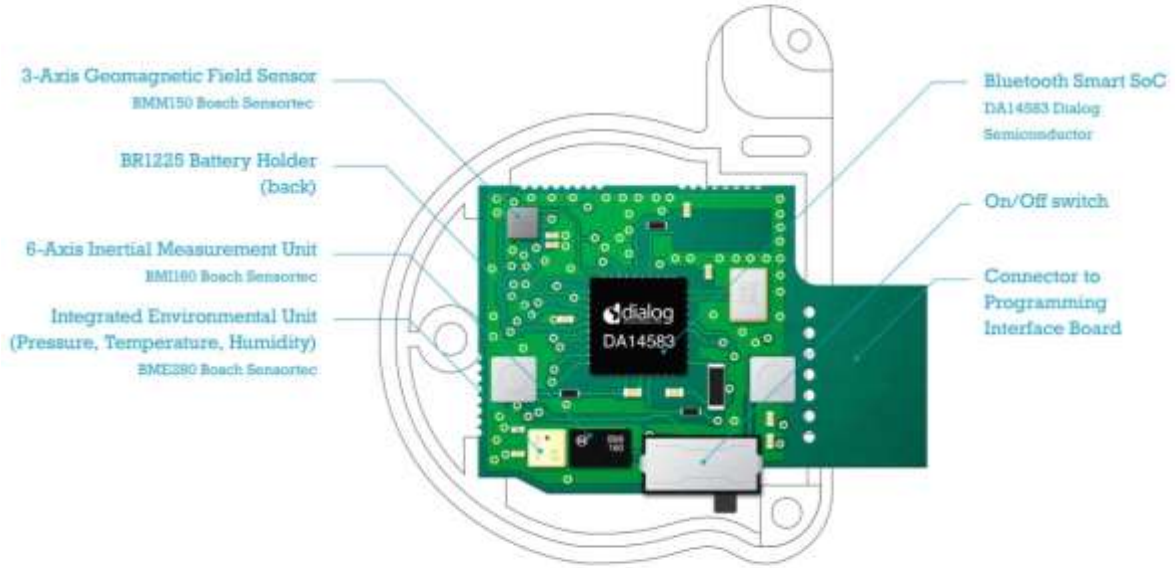


**Figure 14: IoT Sensor reference board: component placement overview**

# 6 Magnetic scan simulation measurements

## 6.1 Passive tests

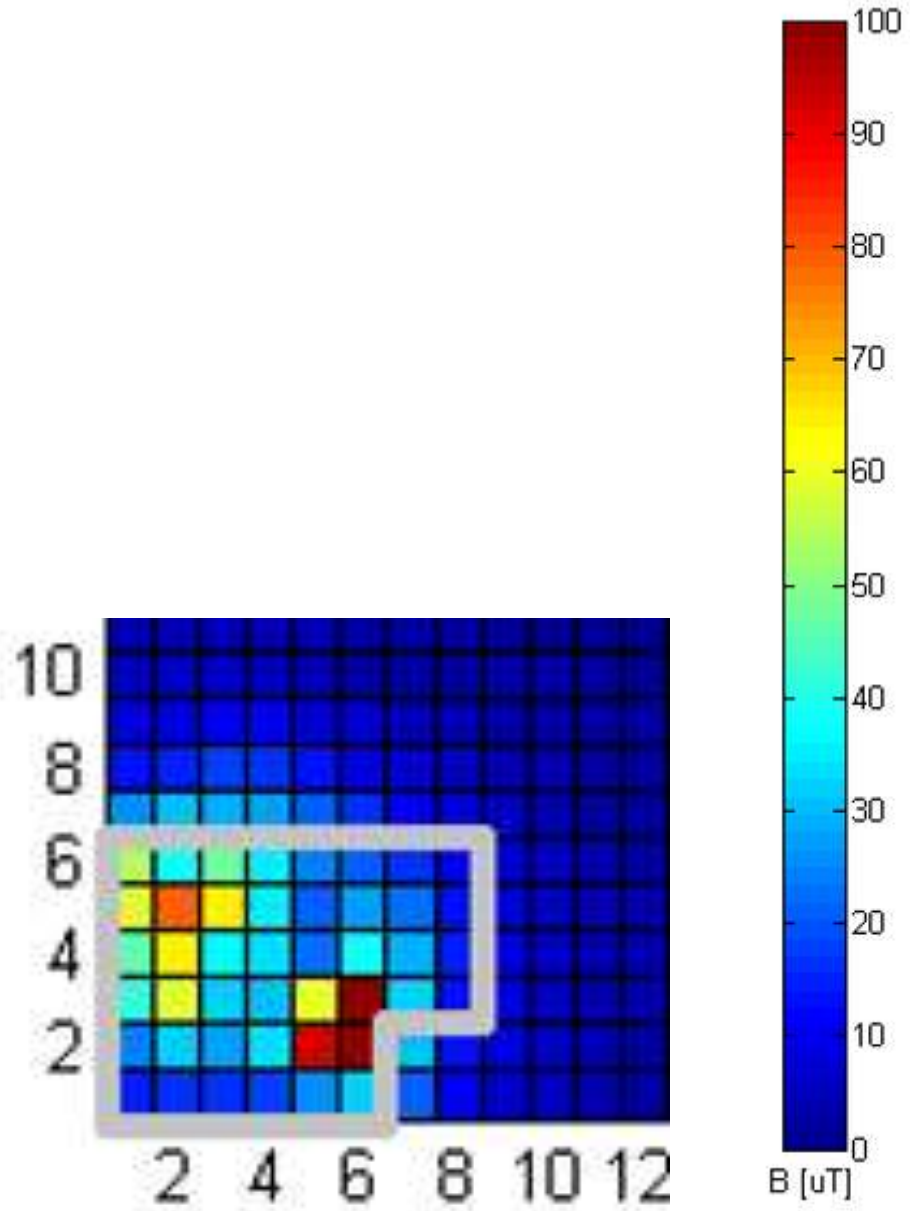


**Figure 15: Magnetic field strength**

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)

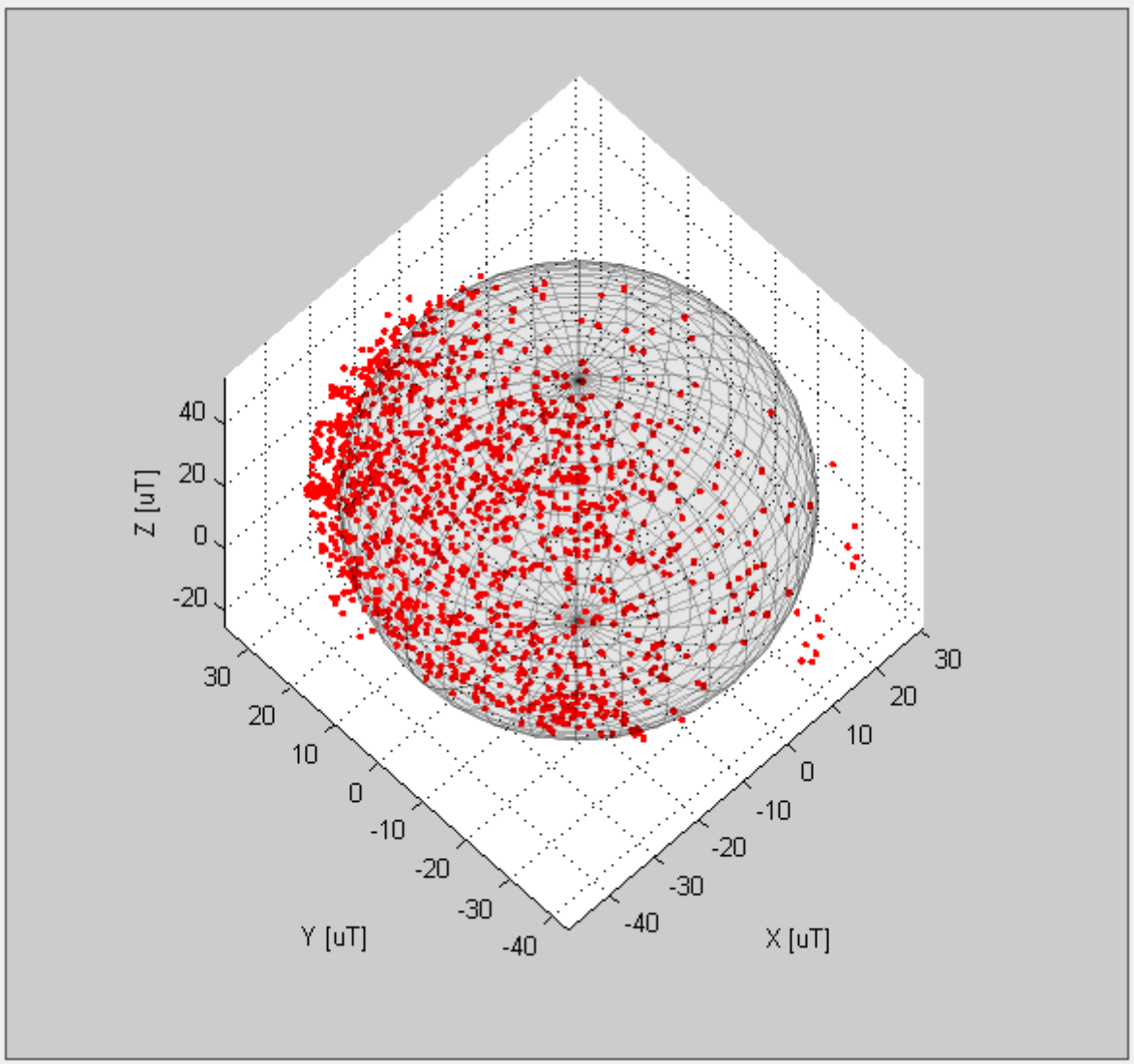


**Figure 16: Magnetic field deformation by soft iron effects of the coin cell battery and its holder**

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 |
|---|---|---|
| 1.1 | 24-Dec-2021 | Updated logo, disclaimer, copyright. |
| 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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