XM122 IoT Module

Datasheet v1.0

Abstract

The XM122 is a reference module with optimized formfactor that can be used to support customer in their own design for commercial use, for evaluation and development purpose.

The XM122 is built around the nRF52840 Bluetooth® 5 SoC (System on Chip) from Nordic Semiconductor and features an integrated antenna for Bluetooth connectivity.

The XM122 can be used as a stand-alone module where customer can embed their application on top of the Acconeer RSS (Radar System Software). It can also be used as with an external host controller where communication to the module is through a register command protocol.

Figure 1. XM122 Top view (left) and XM122 bottom view (right).

 © 2019 Copyright by Acconeer

Table of Content

1 Revision History 4
2 Functional description 5
2.1 Overview 5
2.2 Product features 5
2.3 Block diagram 6
2.4 Module board connector and pin description 7
2.5 Software options 9
2.6 MAC addresses 9
3 Interfaces 10
3.1 Module supply input 10
3.2 System functions 10
3.3 Serial interfaces 10
3.4 Digital I/O interfaces 10
3.5 Analog I/O interfaces 10
3.6 Module reset 10
3.7 Debug interface 10
4 Electrical specifications 11
4.1 Absolute maximum ratings 11
4.2 Recommended operating conditions 11
4.3 Power consumption summary 12
4.4 RF specification 13
5 Reference design description 14
5.1 Schematics & BOM 14
5.2 Component Placement Drawing 22
6 Mechanical specifications 24
7 Reference documents 26
8 Abbreviations 27
Disclaimer 28

 © 2019 Copyright by Acconeer

1 Revision History

Revision	Comment
V1.0	Released version

This document applies to the following product:

Product name	Part number
XM122	XM122-001 (module)

 © 2019 Copyright by Acconeer

2 Functional description

2.1 Overview

The XM122 comes with Nordic nRF52840 SoC and A111 Pulsed Coherent Radar (PCR) sensor, see ref [1]. The Nordic nRF52840 supports Bluetooth 5/Bluetooth Mesh/Thread/Zigbee/ 802.15.4/ANT/2.4 GHz.

The XM122 is delivered with a bootloader enabling customer to download Acconeer RSS software including SDK (Software Development Kit) for stand-alone usage where customer can embed their own application on top of Acconeer RSS software. Acconeer RSS software provides API to set A111 sensor configuration and to retrieve supported radar services and detector data.

XM122 offers support as well to act as controlled by external host through register command protocol on UART, SPI and I2C.

2.2 Product features

The XM122 is an IoT module based on Acconeer A111 pulsed coherent radar (PCR) and the Nordic nRF52840 SoC.

XM122 features:

- The A111 60 GHz Pulsed Coherent radar (PCR) with integrated baseband, RF front-end and Antenna in Package (AiP).
- Low power connected radar module.
- The nRF52840 protocol stack support for Bluetooth 5, Bluetooth mesh, Thread, Zigbee, 802.15.4, ANT and 2.4 GHz proprietary stacks and is built around the 64 MHz ARM® Cortex™-M4 CPU with 256 KB SRAM and 1 MB Flash.
- Integrated 2.4 GHz antenna with support for external 2.4 GHz antenna.
- Optional NFC antenna support for quick Bluetooth pairing via the PCB test points.
- Optimized circular form factor with a diameter of 33 mm.
- Wide single supply operating voltage range 2.0 V to 5.5 V.
- Operating temperature -40° to 85°C.
- External I/F support - SPI, UART, I2C, GPIO, Reset.
- SWD/JTAG for SW flash and debug.

The XM122 can be used for accurate distance measurement, tank level measurement, waste bin level measurement, parking space occupancy and presence detection:

- High precision distance measurements with configurable update frequency.
- Measures absolute range up to 7 m with an absolute accuracy in mm.
- Measures relative accuracy in 42 µm (using RSS software IQ service).
- Possible to recognize movement of multiple objects.

Easy integration:

- XM122 can be integrated behind plastic or glass without any need for a physical aperture. See ref [6] *User guide – Sensor Integration Electromagnetic Scattering* for more information.

 © 2019 Copyright by Acconeer

2.3 Block diagram

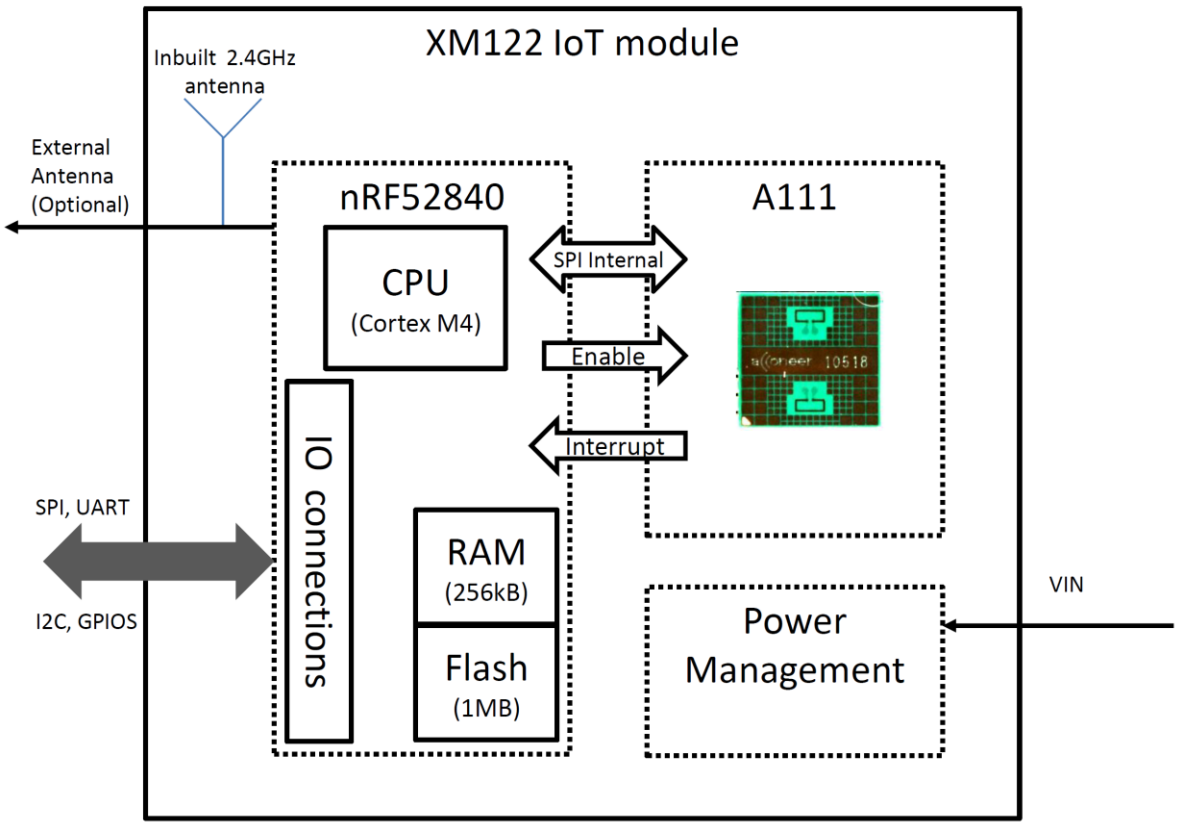


Figure 2.1. XM122 block diagram.

The XM122 block diagram shows the A111 60 GHz PCR radar connected to the nRF52840 microcontroller. The module provides a pin connector where the MCU external I/F are accessible including single voltage supply.

 © 2019 Copyright by Acconeer

2.4 Module board connector and pin description

The board to board connector provides the external interface to the module. Figure 2.2 shows the connector footprint and Table 2.1 describes each signal.

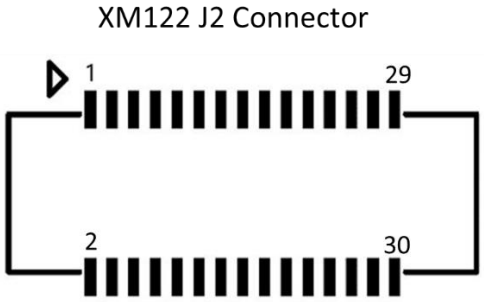


Figure 2.2. XM122 J2 connector footprint.

Pin Number	Signal	Description	nRF52840* pin
1	GPIO		P0.23
2	GND	Ground	-
3	GND	Ground	-
4	VIN	2.0-5.5 V external power supply. Pin 4 and Pin 6 are interconnected.	-
5	GPIO		P0.21
6	VIN	2.0-5.5 V external power supply. Pin 4 and Pin 6 are interconnected.	-
7	GND	Ground	-
8	GND	Ground	-
9	GPIO		P0.24
10	GPIO	Configurable as Analog Input.	P0.04
11	GND	Ground	-
12	GPIO	Configurable as JTAG Trace signal.	P0.11 TRACEDATA2
13	GPIO		P0.22
14	GPIO	Configurable as JTAG Trace signal.	P0.12 TRACEDATA1
15	GND	Ground	-
16	VDD	Regulated 1.8 V output voltage.	-
17	GPIO/UART_RX	Default configuration in Acconeer Module server SW is UART. Could also be used as miscellaneous GPIO.	P0.06
18	GPIO, nRESET	nRF52840 reset pin.	P0.18 nRESET

 © 2019 Copyright by Acconeer

19	GPIO/UART_TX	Default configuration in Acconeer Module server SW is UART. Could also be used as miscellaneous GPIO.	P0.16
20	SWDIO	SWD interface for flash and debug.	SWDIO
21	GND	Ground	-
22	GPIO, SWO	SWD interface for flash and debug. Configurable as JTAG Trace signal.	P1.00 TRACEDATA0
23	GPIO	Configurable as JTAG Trace signal.	P0.07 TRACECLK
24	GND	Ground	-
25	GPIO	Configurable as JTAG Trace signal.	P1.09 TRACEDATA3
26	SWDCLK	SWD interface for flash and debug.	SWDCLK
27	GPIO/UART_RTS	Default configuration in Acconeer Module server SW is UART. Could also be used as miscellaneous GPIO.	P0.20
28	GND	Ground	-
29	GPIO/UART_CTS	Default configuration in Acconeer Module server SW is UART. Could also be used as miscellaneous GPIO.	P0.19
30	GPIO, DFU	Device Firmware Upgrade. Set low during reset to enter bootloader mode. Could also be used as miscellaneous GPIO.	P0.25

Table 2.1. J2 connector pinout.

 © 2019 Copyright by Acconeer

2.5 Software options

The XM122 module can be used in two regimes:

- **Stand-alone module:** The module operates as an independent system. The application is customized to a specific use case by the customer and runs on the embedded MCU. The customers application is accessing the RSS API.
- **Controlled module:** The module is connected to an external host where the customer runs their application software. The customers are accessing the RSS API via a hardware interface through the module server, that provides register command protocol. The module output is either detector output data or service radar data through the XM122 external interfaces such as SPI, UART and I2C.

Using the XM122 as stand-alone module Acconeer offers SDK that provides RSS, hardware abstraction layer, device drivers and build system. Based on SDK it is possible for the customer to develop their own application. Both RSS and applications runs on the embedded MCU.

Using the XM122 as Controlled module Acconeer provides SW image including RSS and module server application that provides hardware interface accessing the RSS API through a register command protocol, see ref [3].

For further software information, see XM122 IoT Module Evaluation Kit User guide, ref [2].

2.6 MAC addresses

The XM122 module comes with a Static Random Bluetooth Address provided by the Nordic nRF52840 SoC. This address is assigned randomly during manufacturing. This static address can be used for evaluation.

 © 2019 Copyright by Acconeer

3 Interfaces

3.1 Module supply input

The XM122 support external single power supply for battery power applications, see table 4.2 recommended operating conditions.

Note that supply voltage conditions (E.g. slew rate) need to be taken into consideration according to nRF52840 datasheet, ref [5].

3.2 System functions

The XM122 IoT module supports system power states, see XM122 Module Software User guide, Ref [3] for further information.

Module RESET is supported by activating NRST pin (active low).

Module ERASE is used to reinitialize the MCU Flash content and some of its NVM (Non-Volatile Memory) bits to an erased state. See nRF52840 datasheet, ref [5] for further information.

3.3 Serial interfaces

The XM122 nRF52840 GPIO pins can be configured to support up to two UART, up to four SPI master or three SPI slave and up to two I2C compatible 2-wire master/slave external serial interfaces. See table 2.1 for HW configuration. See also nRF52840 datasheet, ref [5] for further information.

3.4 Digital I/O interfaces

The XM122 module support General Purpose IOs (GPIOs), 16 GPIOs are available. The GPIO pins are configurable for different functions, only the debug and RESET pins are fixed to specific GPIOs. See table 2.1 for HW configuration. See also nRF52840 datasheet, ref [5] for further information.

3.5 Analog I/O interfaces

The XM122 module support one analog input (pin 10 on XM122 connector J2) and up to four individual PWM outputs which can be assigned to any of the GPIO pins. See table 2.1 for HW configuration.

3.6 Module reset

The XM122 has an external reset option (Pin 18 on XM122 connector J2) that can be configured as a GPIO or RESET input.

3.7 Debug interface

The XM122 has 7 debug pins, SWDIO, SWDCLK and Trace signals. TRACE signals reuse GPIO pins. See table 2.1 for HW configuration.

 © 2019 Copyright by Acconeer

4 Electrical specifications

4.1 Absolute maximum ratings

The below table shows the XM122 absolute maximum ratings over operating temperature range, unless otherwise noted:

Parameter	Description	Min.	Max.	Unit
VIN	power supply	-0.3	6.0	V
I/O	Voltage on I/O pins	-0.3	2.1	V
T_{OP}	Operating temperature range	-40	85	°C
T_{STG}	High temperature storage		125	°C

Table 4.1. Absolute maximum ratings.

Stresses beyond those listed in table 5.1 may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions or at any other conditions beyond those indicated under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods of time may affect device reliability.

4.2 Recommended operating conditions

The below table shows the XM122 recommended operating conditions:

Parameter	Min.	Typ.	Max.	Unit
VIN, operating power supply voltage[1)]	2.0		5.5	V
I/O operating range	0		1.8	V
Operating temperature[1)]	-40		85	ºC

Table 4.2. Recommended operating conditions.

[1] Minimum battery voltage depends on battery internal resistance and temperature.

 © 2019 Copyright by Acconeer

4.3 Power consumption summary

The below table summarizes the XM122 power consumption, maximum current ratings and average current ratings at power terminal at T_A = 25ºC and 2.0 V/3.0 V supply:

Parameter	Min.	Typ.	Max.	Unit
Average power consumption, 2.0 V supply, 0.1 Hz update rate		0.07 (1)		mW
Average power consumption, 3.0 V supply, 0.1 Hz update rate		0.08 (1)		mW
Average power consumption, 2.0 V supply, 1 Hz update rate		0.66 (1)		mW
Average power consumption, 3.0 V supply, 1 Hz update rate		0.67 (1)		mW
Average power consumption, 2.0 V supply,10 Hz update rate		6.43 (1)		mW
Average power consumption, 3.0 V supply, 10Hz update rate		6.51 (1)		mW
Idle current		3.75 (2)		µA

Table 4.3. Average power dissipation ratings at power terminal.

[1] Measuring window set to 0.6m, configuration with Envelope service, maximize SNR profile used. Bluetooth advertisement according to given update rate.

[2] Sensor is powered off and nRF52840 is in sleep mode (System ON) with full RAM retention and wake-up on RTC enabled.

 © 2019 Copyright by Acconeer

4.4 RF specification

The below table shows the XM122 A111 PCR RF specification:

Parameter	Min.	Typ.	Max.	Unit
Center frequency fc		60.5		GHz
EIRP (Equivalent Isotropically Radiated Power)			10	dBm
HPBW (Half Power Beam Width), elevation plane		45		degrees
HPBW (Half Power Beam Width), horizontal plane		70		degrees

Table 4.4. XM122 RF specification.

The XM122 support Bluetooth v5 including BLE, mesh, long range and advertising extensions.

The below table shows the XM122 Bluetooth radio performance:

Parameter	Min.	Typ.	Max.	Unit
Frequency (40 channels)	2.4		2.48	GHz
Data rate		2		Mbps
Total radiated power (TRP)		5.5		dBm
Conducted RX sensitivity (BLE)		-97		dBm
Conducted RX sensitivity (Long range)		-101		dBm
Conducted total link budget		-109		dBm

Table 4.5. XM122 Bluetooth radio performance.

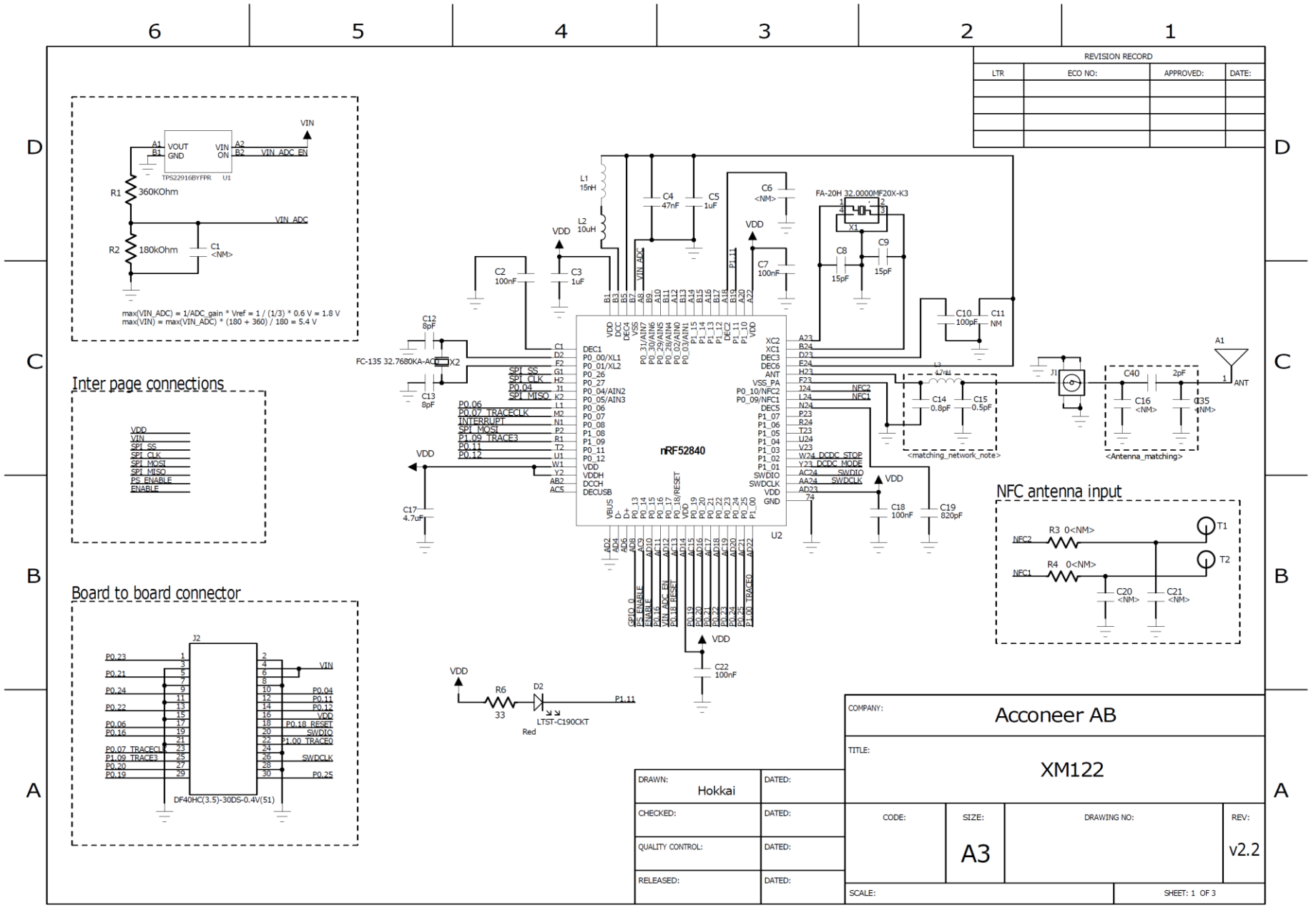
 © 2019 Copyright by Acconeer

5 Reference design description

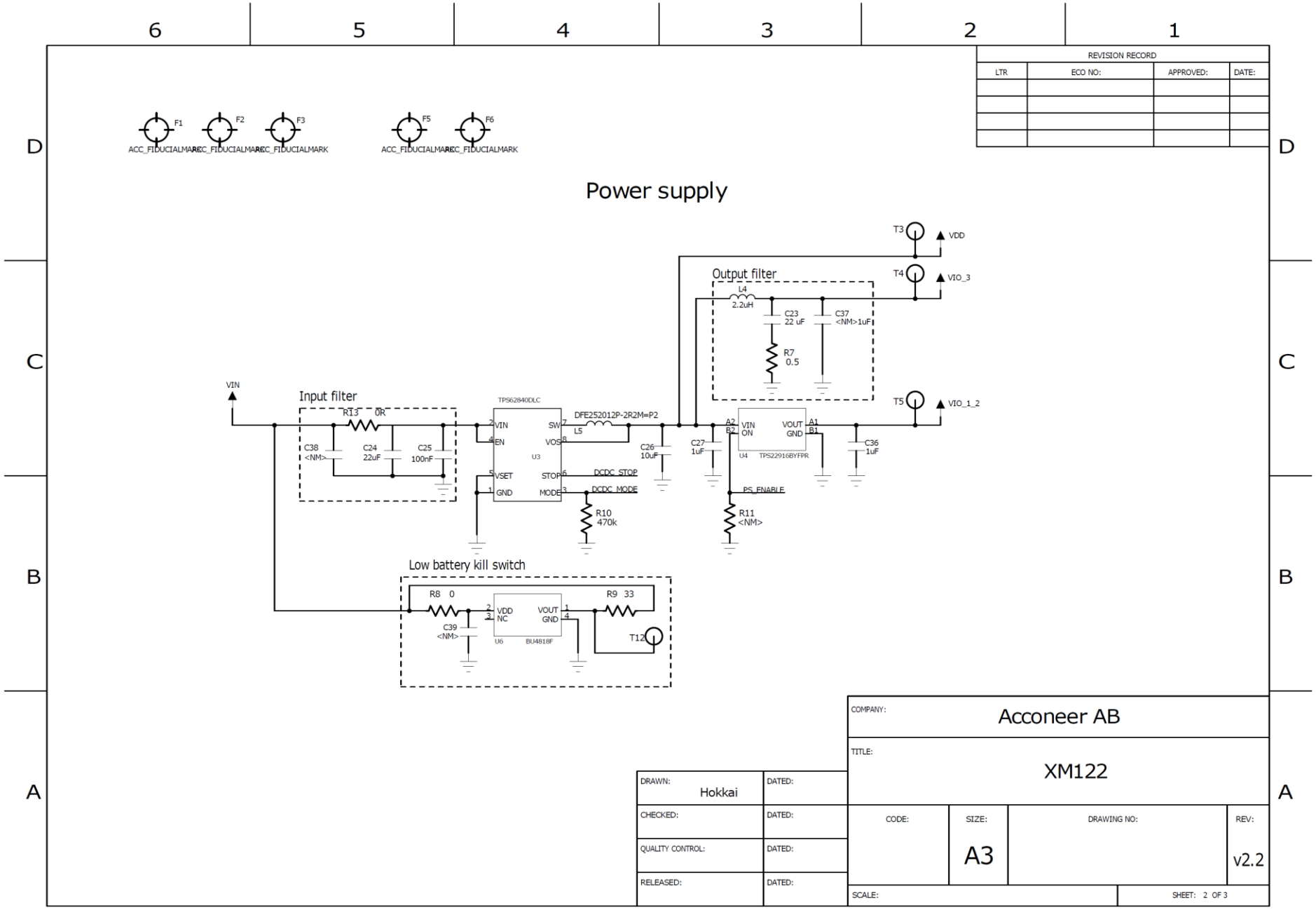
5.1 Schematics & BOM

The following pages include the module schematics and bill of materials:

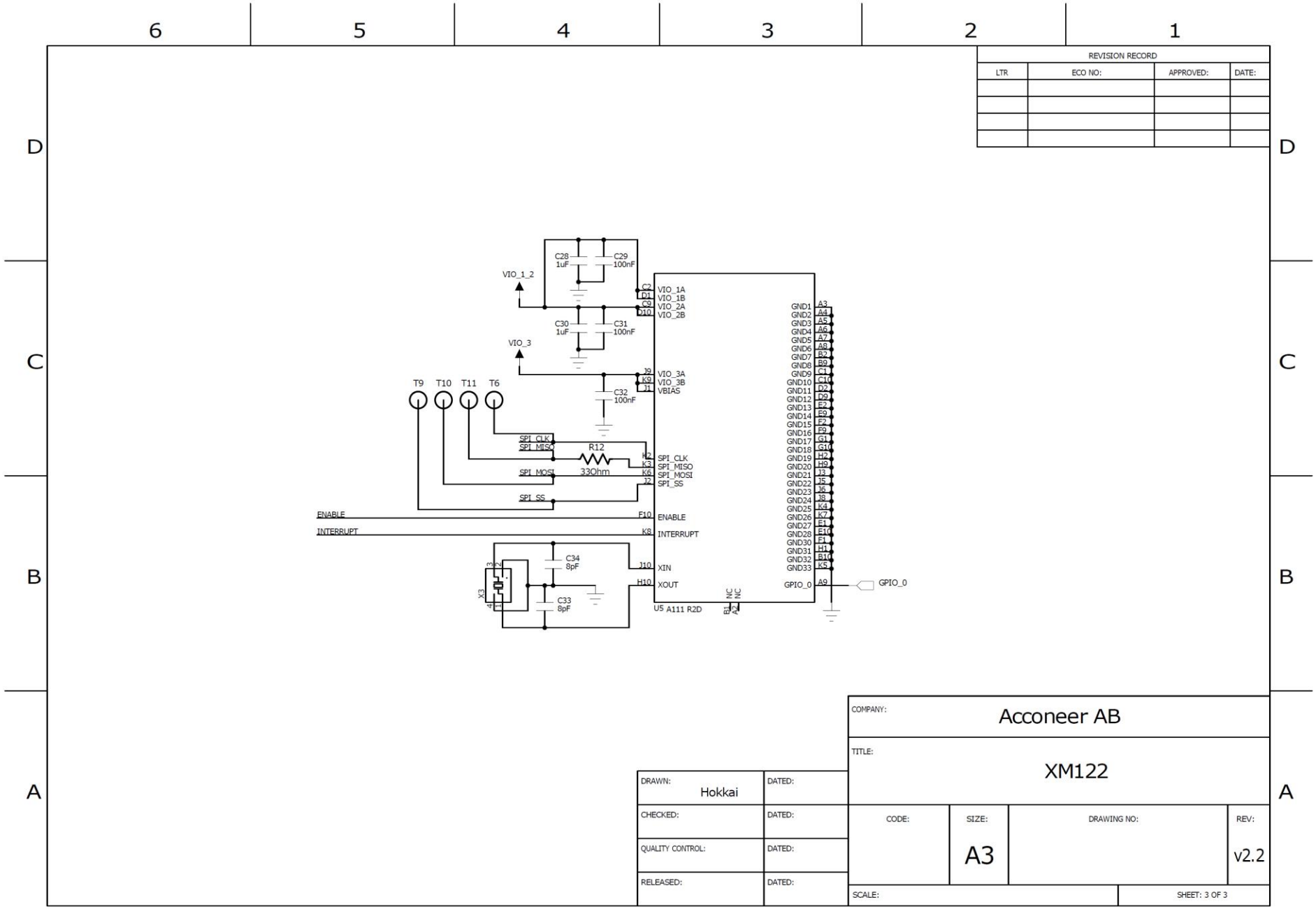
 © 2019 Copyright by Acconeer



 © 2019 Copyright by Acconeer



 © 2019 Copyright by Acconeer



 © 2019 Copyright by Acconeer

Bill of Material

Table 5.1 shows the BOM for XM122.

Component Ref.	Specification	QTY	Value	Comment
C10	NP0,C0G/1005	1	100 pF	
C12, C13, C33, C34	NP0,C0G/1005	4	8 pF	
C14	C0G/1005	1	0.75 pF	
C15	C0G/1005	1	0.5 pF	
C17	X5R/1005	1	4.7 uF	
C19	NP0/1005	1	820 pF	
C2,C7, C18, C22, C25, C29, C31, C32	X7R/1005	8	100 nF	
C23, C24	X5R/1608	2	22 uF	
C26	X5R/1005	1	10 uF	
C3,C5, C27, C28, C30, C36	X5R/1005	6	1 uF	
C4	X5R/1005	1	47 nF	
C40	N/A/1005	1	2pF	
C8, C9	NP0/1005	2	15 pF	
D2	LTST-C190CKT	1	N/A	
J1	MM8130-2600	1	N/A	
J2	DF40HC(3.5)-30DS-0.4V(51)	1	J2	
L1	15/NH/1005/J	1	15 nH	
L2	10/UH/1608	1	10 uH	
L3	4.7/nH/1005/+-0.3nH	1	4.7 µH	
L4	2.2/uH/1608/M	1	2.2 uH	Footprint 1608
L5	2.2/UH/2520/M Murata DFE252012P-2R2M=P2	1	2.2 uH	Footprint 2520
R1		1	360 Ohm	
R10		1	470 KOhm	
R2		1	180 kOhm	
R6, R9, R12		3	33 Ohm	
R7		1	0.5 Ohm	
R8, R13		2	0 Ohm	
U1, U4	TPS22916BYFPR	2	N/A	Regulator
U2	NORDIC_BT5.0_LONGRANGE_NRF5284	1	N/A	MCU/BT module

U3	TPS62840DLCR	1	N/A	Regulator
U5	A111	1	N/A	PCR
U6		1	N/A	BU4818F-**
X1	32MHz/10ppm/10PF/50OHM/2520	1	32 MHz	
X2	32.768kHz/20ppm/9.5PF/90KOHM/2	1	32.768kHz	
X3	TSX-3225 24.0000MF20G-AC0/SMD(3225Size)	1	24 MHz	

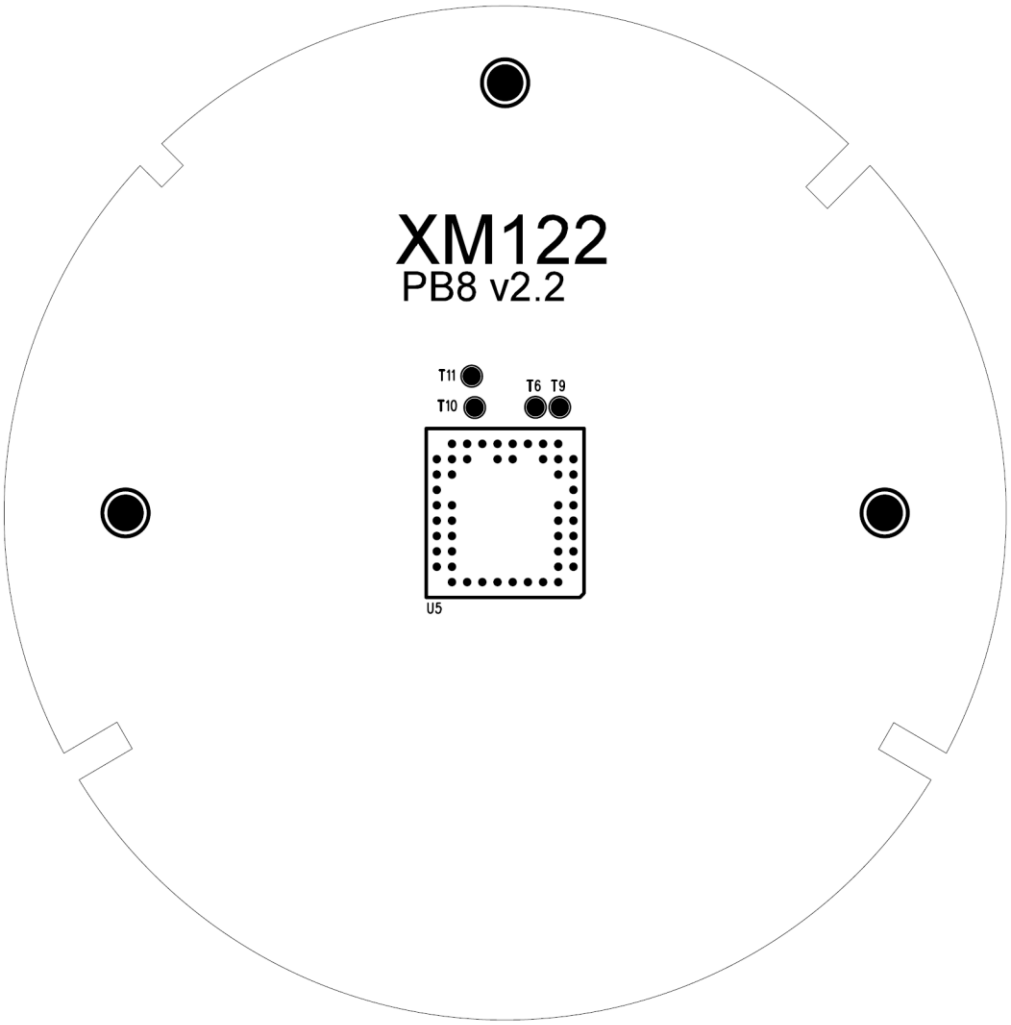
Table 5.1. XM122 BOM list.

 © 2019 Copyright by Acconeer

5.2 Component Placement Drawing

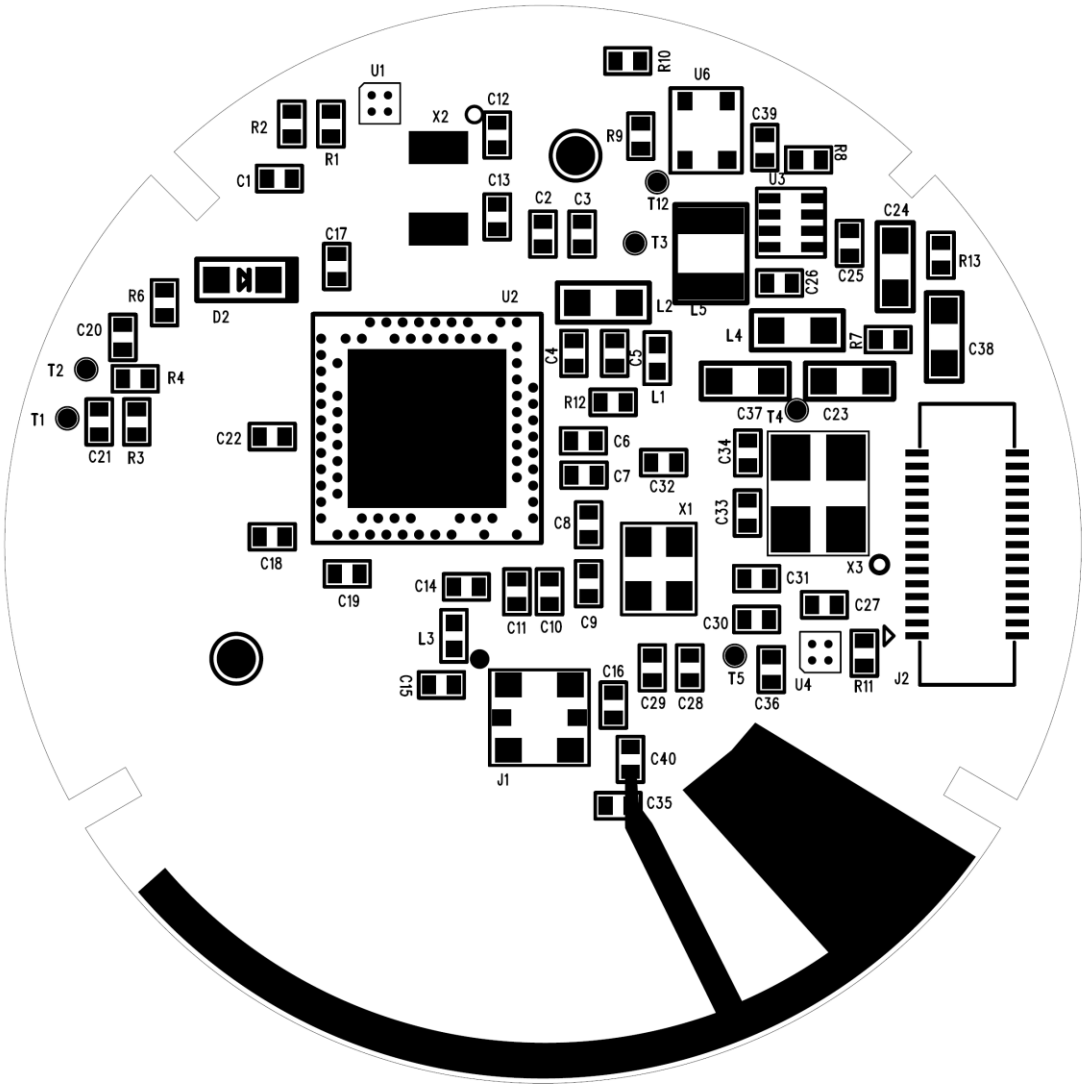
The component placement drawing of XM122 is found below:

Top side



 © 2019 Copyright by Acconeer

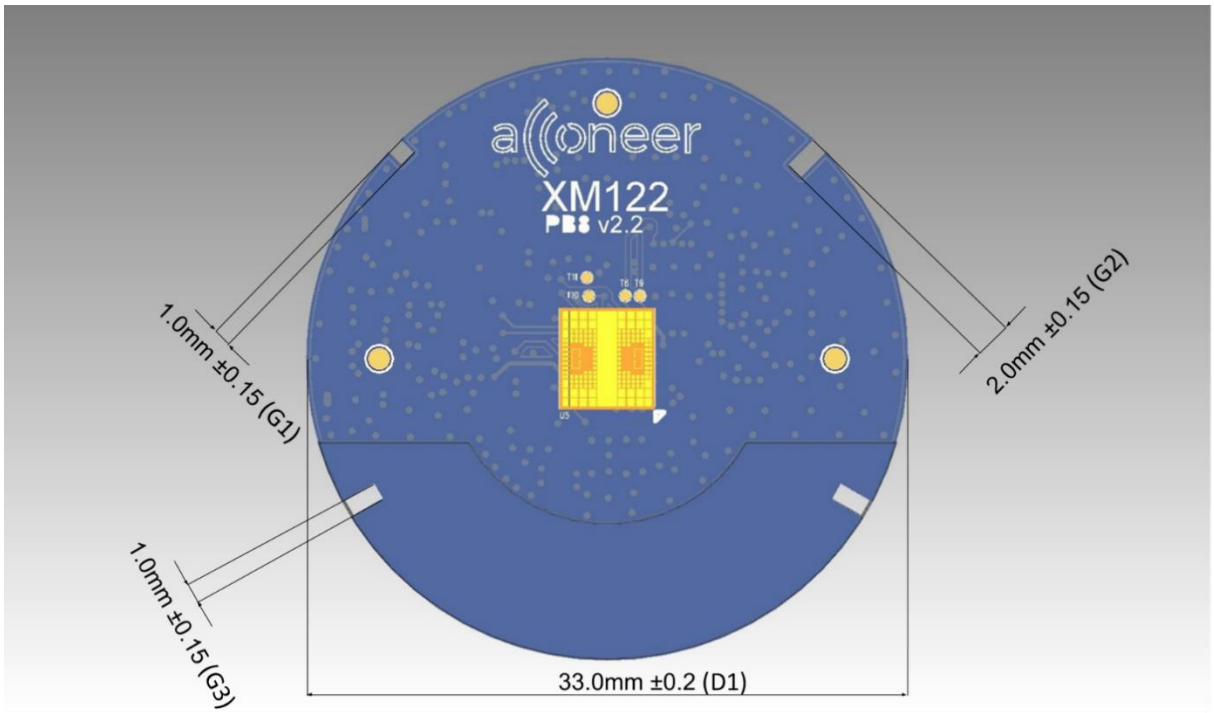
Bottom side:



 © 2019 Copyright by Acconeer

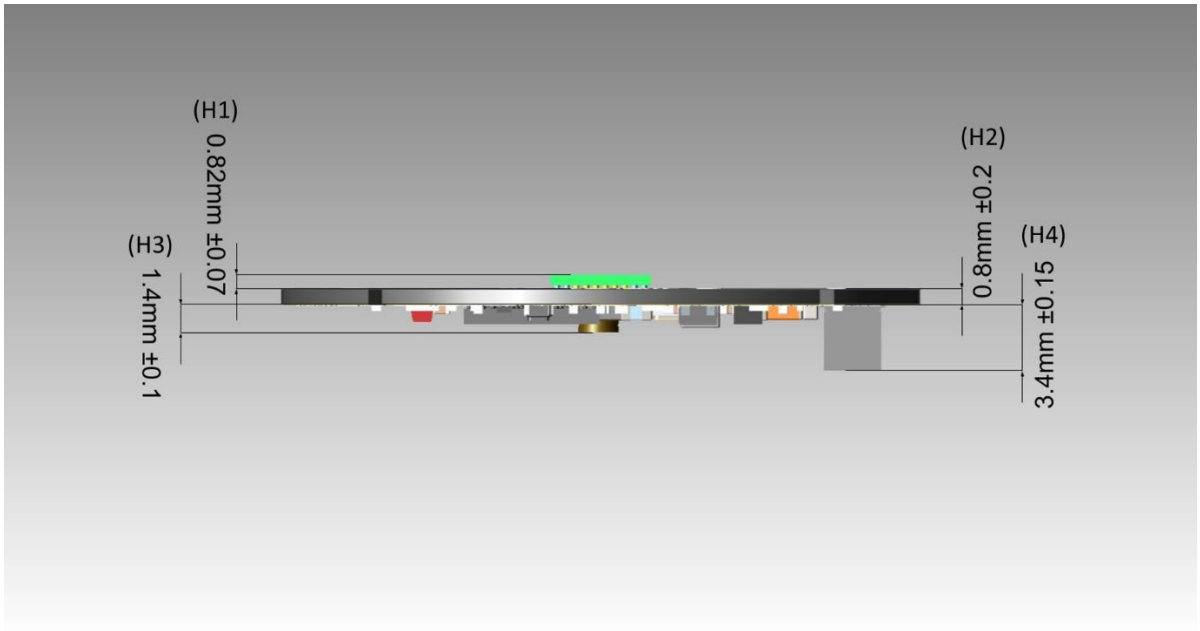
6 Mechanical specifications

XM122 Module outline – Top view



 © 2019 Copyright by Acconeer

XM122 Module outline – Side view



Distance	Value	Tolerance
D1	33.0 mm	+/-0.2 mm
H1	0.82 mm	+/-0.07 mm
H2	0.8 mm	+/-0.2 mm
H3	1.4 mm	+/-0.1 mm
H4	3.4 mm	+/-0.15 mm
G1	1.0 mm	+/-0.15 mm
G2	2.0 mm	+/-0.15 mm
G3	1.0 mm	+/-0.15 mm

 © 2019 Copyright by Acconeer

7 Reference documents

[1] A111 Pulsed Coherent Radar (PCR) Datasheet:
https://www.acconeer.com/products

[2] XM122 IoT Module Evaluation Kit, User guide
https://www.acconeer.com/products

[3] XM122 Module Software User guide
https://www.acconeer.com/products

[4] XB122 IoT Module Breakout board, Product brief
https://www.acconeer.com/products

[5] Nordic nRF50840:
Nordic Semiconductor

[6] User Guide – Sensor Integration Electromagnetic Scattering
https://www.acconeer.com/products

 © 2019 Copyright by Acconeer

8 Abbreviations

AiP	Antenna in Package
API	Application Programming Interface
BLE	Bluetooth Low Energy
BOM	Bill of Materials
EIRP	Equivalent Isotropically Radiated Power
GND	Ground
GPIO	General Purpose Input/Output
HPBW	Half Power Beamwidth
HW	HardWare
I2C	Inter-Integrated Circuit
MAC	Media Access Control
MCU	MicroController Unit
NVM	Non-Volatile Memory
PCR	Pulse Coherent Radar
RF	Radio Frequency
RSS	Radar System Software
SDK	Software Development Kit
SoC	System on Chip
SPI	Serial Peripheral Interface
SW	SoftWare
SWD	Serial Wire Debug
UART	Universal Asynchronous Receiver/Transmitter

 © 2019 Copyright by Acconeer

Disclaimer

The information herein is believed to be correct as of the date issued. Acconeer AB ("**Acconeer**") will not be responsible for damages of any nature resulting from the use or reliance upon the information contained herein. Acconeer makes no warranties, expressed or implied, of merchantability or fitness for a particular purpose or course of performance or usage of trade. Therefore, it is the user's responsibility to thoroughly test the product in their particular application to determine its performance, efficacy and safety. Users should obtain the latest relevant information before placing orders.

Unless Acconeer has explicitly designated an individual Acconeer product as meeting the requirement of a particular industry standard, Acconeer is not responsible for any failure to meet such industry standard requirements.

Unless explicitly stated herein this document Acconeer has not performed any regulatory conformity test. It is the user's responsibility to assure that necessary regulatory conditions are met and approvals have been obtained when using the product. Regardless of whether the product has passed any conformity test, this document does not constitute any regulatory approval of the user's product or application using Acconeer's product.

Nothing contained herein is to be considered as permission or a recommendation to infringe any patent or any other intellectual property right. No license, express or implied, to any intellectual property right is granted by Acconeer herein.

Acconeer reserves the right to at any time correct, change, amend, enhance, modify, and improve this document and/or Acconeer products without notice.

This document supersedes and replaces all information supplied prior to the publication hereof.

© 2018 by Acconeer – All rights reserved

Acconeer AB
IDEON Gateway
Scheelevägen 27
223 63 LUND
Sweden

www.acconeer.com
info@acconeer.com
+46 10 218 92 00

 © 2019 Copyright by Acconeer