SENSIUM

part of The Surgical Company

SH-DOD-ENG-0170

Issue 1

SH-DOD-ENG-0170

SH202075/6 Sensium Base Station Hardware Description

Contents

Document History

The following table summarises the status of this document. Details of document change authorisation are available from the Sensium Healthcare document control system.

Issue	Department	Author	Date
1	RF EMC & Safety Compliance	Chris Nunn	01-SEP-2021

1 Scope

This document describes the overall design of the SH20207x radio modules.

2 Introduction

2.1 Product Reference

The Radio Modules described in this document are: -

SH202075-XX (operating in the 915 MHz band)

SH202076-XX (operating in the 866 MHz Band)

Where -XX refers to the regulatory region where the product is deployed.

Typical product numbers are:-

SH202075-US for the US region

SH202076-EU for the EU region

2.2 Abbreviations

ADC	Analogue to Digital Convertor
AFC	Automatic Frequency Control
CCA	Clear Channel Assesment
EEPROM	Electrically Erasable Programmable Read Only Memory
FSK	Frequency Shift Keying
GPIO	General Purpose Input Output
ISM	Industrial Scientific Medical (RF bands)
LDO	Low Drop Out (Regulator)
LO	Local Oscillator
LNA	Low Noise Amplifier
MAC	Media Access Control
MDD	Medical Device Directive
N/A	Not Applicable
PA	Power Amplifier
PCB	(Bare) Printed Circuit Board
PCBA	Printed Circuit Board Assembly
R&D	Research & Development
RF	Radio Frequency
RED	Radio Equipment Directive.
SAW	Surface Acoustic Wave
SPI	Serial Peripheral Interface
TDMA	Time Division Multiple Access
UHF	Ultra High Frequency (300 MHz → 3 GHz)
VCO	Voltage Controlled Oscillator
VXO	Voltage (Controlled) Crystal Oscillator
WLAN	Wireless Local Area Network

2.3 Appearance

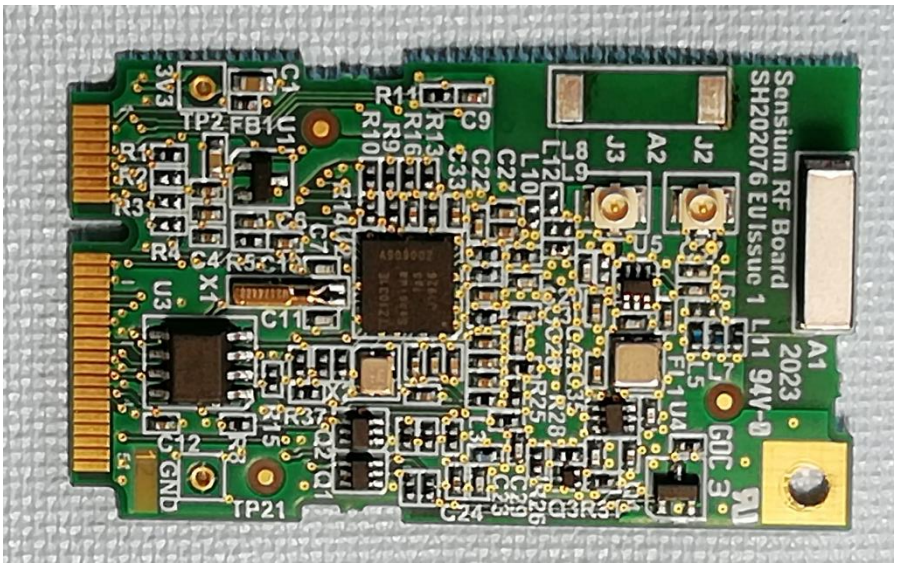


Figure 1 Component Side

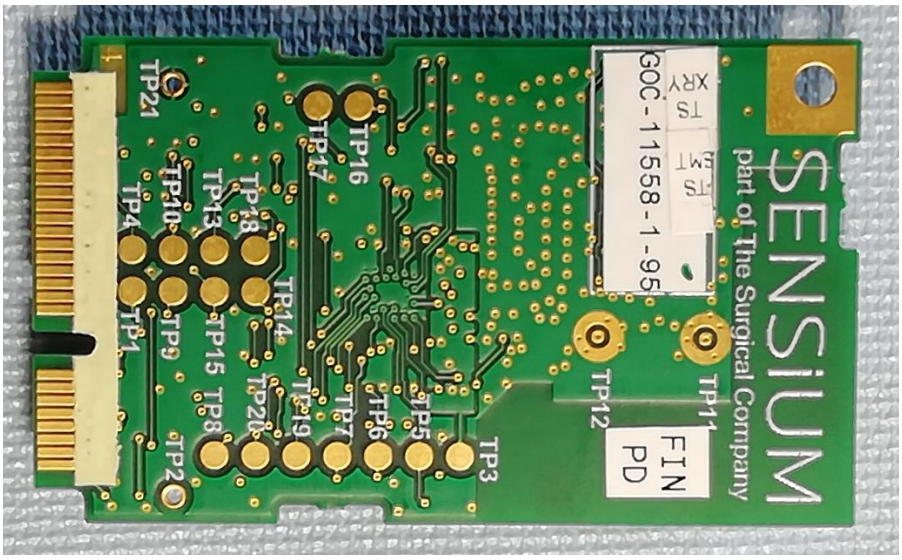


Figure 2 Underside

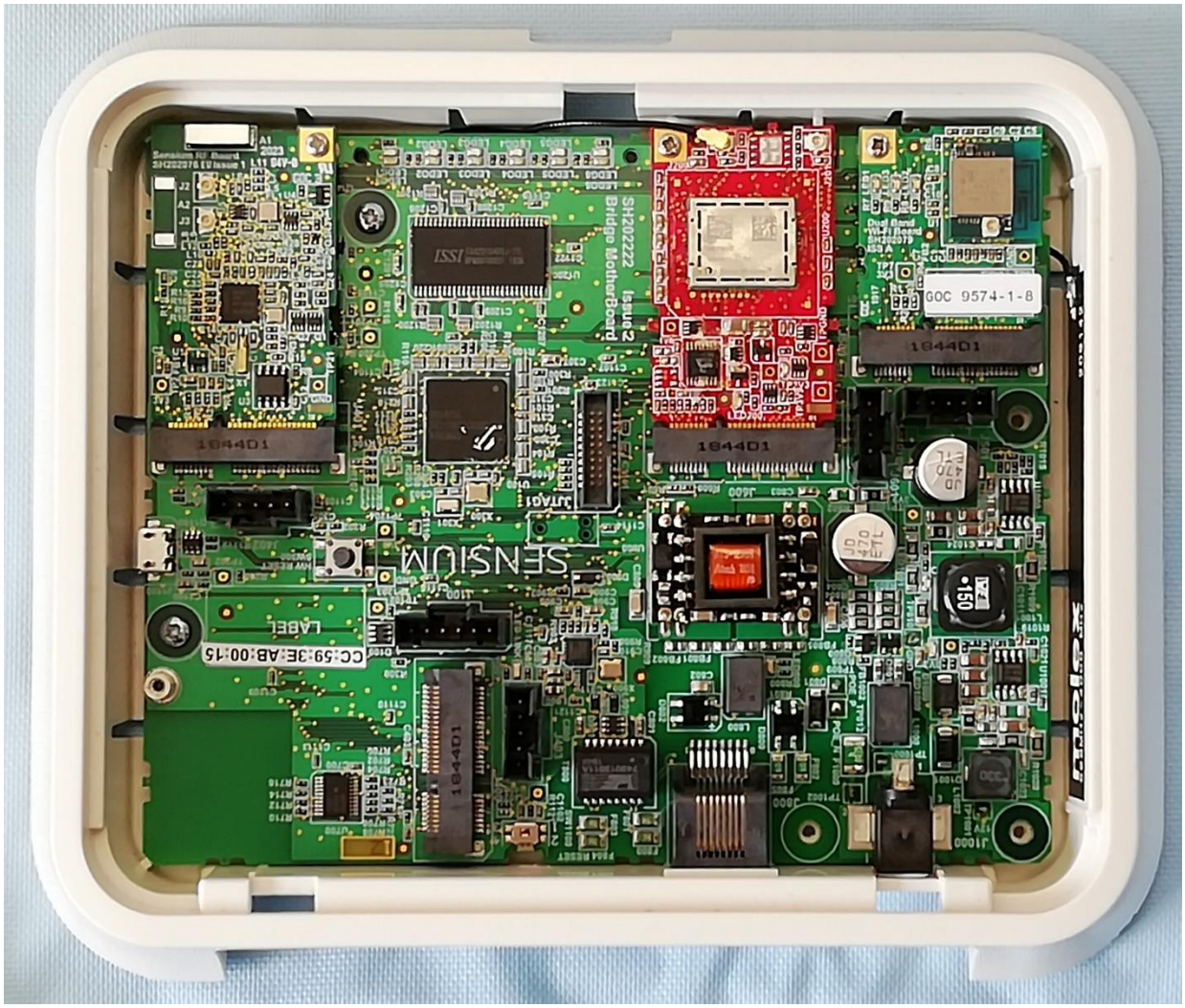


Figure 3 Fitted in Host (top left)

2.4 Dimensions

Approximately 51 x 30 x 5 mm

3 Functional Description

3.1 General Description

The RF Module is an UHF ISM radio transceiver with integral antenna. It receives patient vital signs data from the Patient worn Patch and transfers to the motherboard processor.

3.2 Operating Frequency

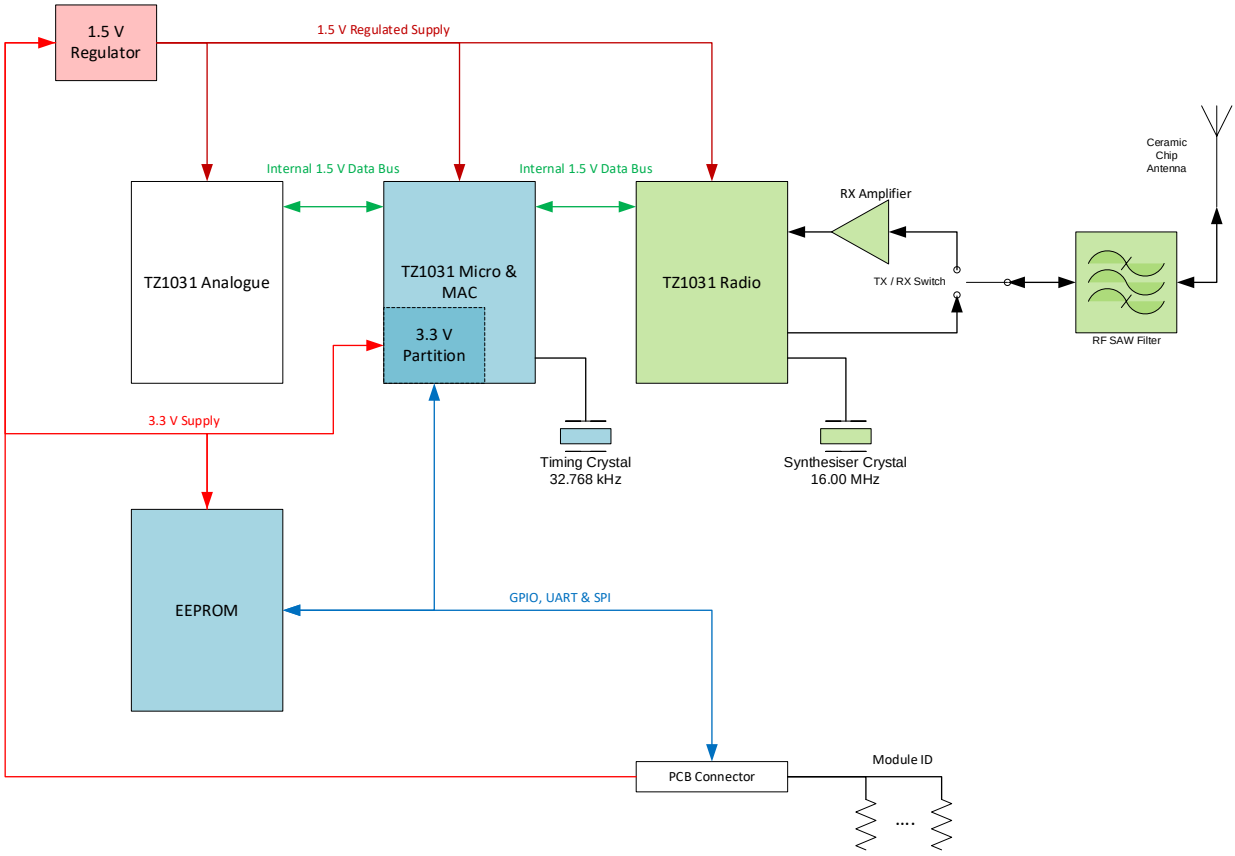
The part numbers and operating frequencies are listed in Table 1.

Table 1 Base Station Versions

	915 Version	866 Version	
Base Station PCBA Number	SH202075	SH202076	
Lowest Operating Frequency	903.2	863.2	MHz
Highest Operating Frequency	927.8	869.8	MHz
Channel Spacing	200	200	kHz
Channel Width (20 dB)	180	180	kHz

3.3 System

The system consists of 3 main functional blocks, power supply, digital and RF. The analogue front end of the TZ1031 is not utilized on the Base Station. The block diagram is shown in Figure 4 and the schematic diagram in § 6.



SH202075 / 6 Sensium RF Module Block Diagram

Figure 4 SH202075/6 System Block Diagram

3.4 Power

The power for the SH202075/6 is supplied on pins 2 & 8 of the Mother Board Connector, J1. This directly supplies the EEPROM, TZ1031 unbuffered GPIOs and Voltage Regulator. The 1.5 V fixed regulator, U1, supplies the main TZ1031 digital and RF sub-systems.

Bulk decoupling is provided on both the input and output of the regulator. Further decoupling is provided at each IC within the digital and RF sub-systems.

3.5 Digital

The digital system has 2 main elements, the TZ1031 IC's 8051 µController, U2, and a 25AA512 EEPROM, U3.

These sections and the motherboard connector are linked by a control and data bus running at a nominal 3.3 V. The signals comprise of an SPI bus, serial buses, reset and module ID signals.

The 8051's code is contained in the EEPROM and is read after a hard reset. The reset is controlled by the main processor on the mother board. The SPI bus is used between the EEPROM & 8051 and is also connected to the mother board processor. This allows the EEPROM to be updated by the mother board and also by during manufacture via the test points on the PCB. The µC uses the 16 MHz clock from the RF sub-system.

The system includes an AES encryption block to secure the data sent over the RF link.

The communications link between the base station and the motherboard processor is via a 3.3 V bi-direction serial link.

Resistors are fitted to the PCBA to identify the module version.

3.6 RF Transceiver

3.6.1 Overview

The radio transceiver contained within the TZ1031, consists of a transmitter, receiver, and common frequency synthesiser. There are external impedance matching circuits, RX amplifier, TX/RX switch and SAW filter, Figure 5. There is an option for antenna diversity that is not used on this module. The radio is controlled by the digital MAC system.

The radio operates in a TDMA system using the same uplink and downlink frequency. The base station communicates with up to 8 digital patches over a 16 second schedule, allowing up to 2 seconds for each digital patch. It operates on a single frequency channel within the operating band. This channel is chosen on the basis of channel occupancy available during switch on or when interference occurs.

The radio uses CCA to ensure that it does not interfere with other base stations or devices using the same frequency channel as itself.

The MAC is hardware encoded within the TZ1031 and is controlled by the 8051. The MAC timing during RF communications is derived from a low power 16.0 MHz crystal oscillator (X2) while the timing between TDMA Frames is from a 32.768 kHz crystal oscillator (X1) synchronised to an external input.

The transceiver system consists of a separate super-heterodyne transmit and receive chains with a common Local Oscillator system. The channel spacing is 200 kHz.

The transceiver uses FSK modulation with a deviation of ± 50 kHz and data rate of 50 kbits/s. The data is subject to Forward Error Correction (Hamming) and is whitened. This occurs in hardware to minimise power consumption. If the data is not received and acknowledged it is re-sent.

The PCB has footprints & tracking to allow a 2nd diversity antenna, but this is not populated.

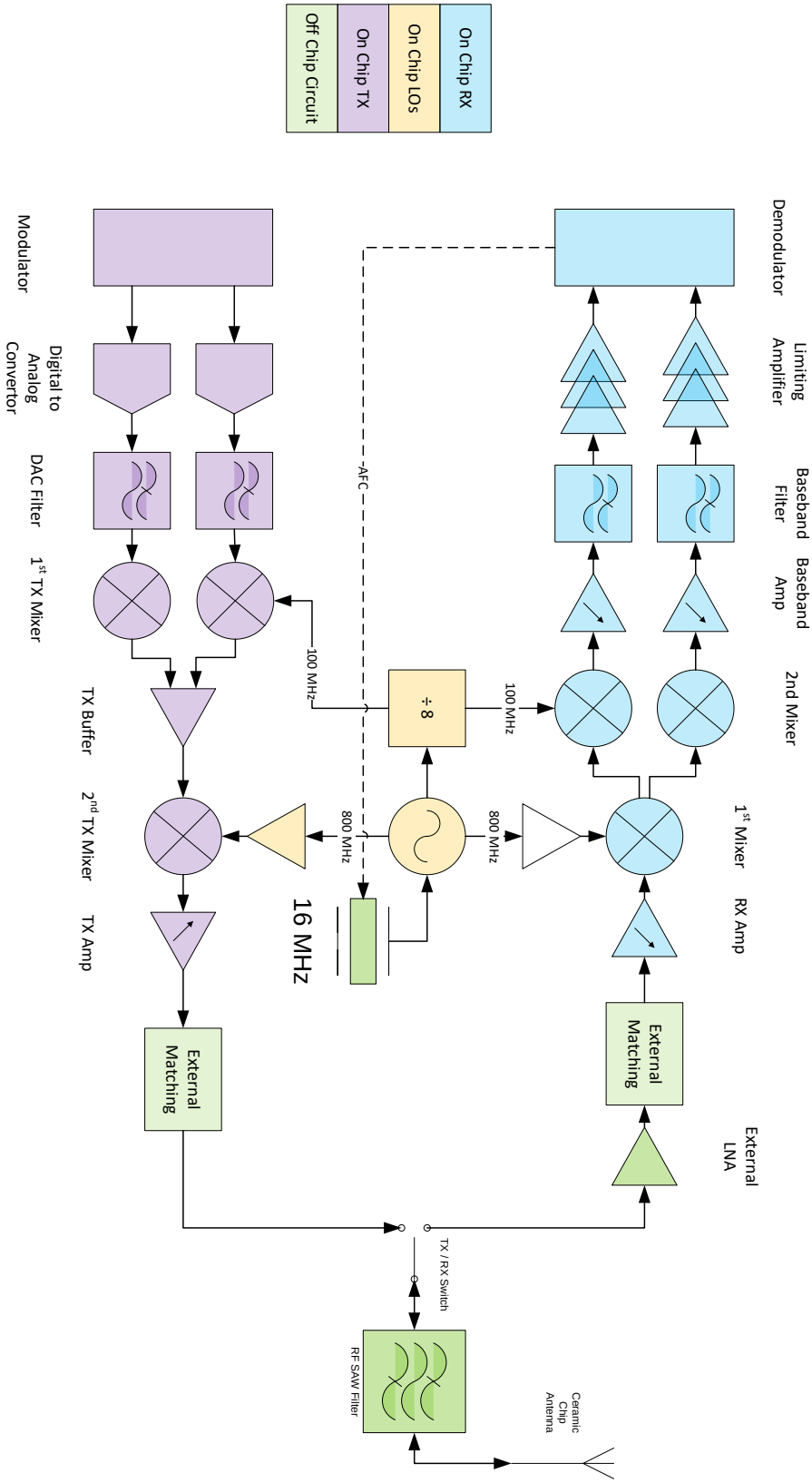


Figure 5 Transceiver Block Diagram

3.6.2 Transmitter

Figure 5 shows the major parts of the transceiver system.

The transmit section of the Sensium transceiver comprises I Q modulation from baseband up to an IF of approximately 100 MHz followed by a final up conversion by 800 MHz to a final transmit frequency of around 900 MHz at a maximum level of – 4 dBm conducted. The output impedance of the PA is matched to 50 Ω by 2 external Hi-Q inductors (L1 & 2). An external TX / RX switch connects the SAW filter (FL1) which in turn is connected to a ceramic chip antenna (A1).

The 3rd harmonic of the 1st IF is not in the RF band. The lower sideband of final up-conversion is around 700 MHz and is filtered by the PA tuning and external RF SAW.

3.6.3 Receiver

Following the SAW filter and external TX / RX switch a low noise amplifier improves the RX sensitivity to ensure that ETSI 300 220 limits are met.

The transistor, Q3, achieves best NF match when the base is terminated in 50 Ω so no I/P matching is used. O/P matching of R26 & L3 ensures that the amplifier is un-conditionally stable, a π attenuator R 25, 29 & 30, further reduces excess gain. L4 & C30 provide a match to the high (≈ 1 kΩ) TZ1031 I/P impedance.

The receiver mixes the wanted signal down to a sliding IF frequency at approximately 100 MHz followed by conversion to I & Q baseband. The image frequency is approximately 200 MHz away from the wanted and is filtered using the RF SAW.

The receiver locks it's LO to the received signal using an AFC loop to keep the receiver on the same frequency as the transmitter. This uses the 1010 preamble at the start of the TX burst to acquire the correct frequency. The loop maintains phase synchronization over the whole received RF packet burst.

3.6.4 Synthesiser

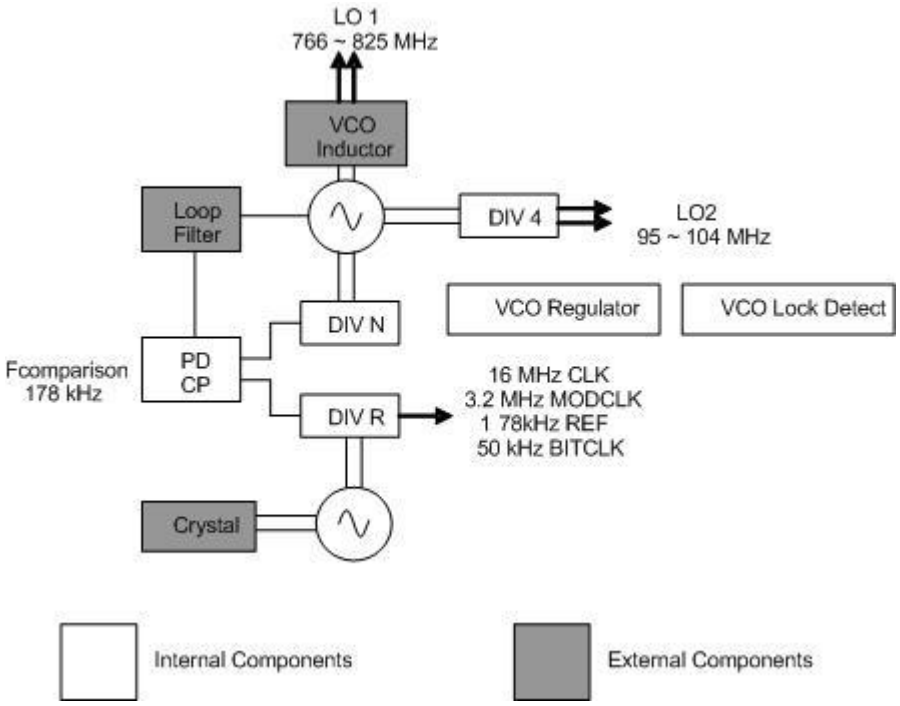


Figure 6 VCO Block Diagram

The on-chip VCO is uses internal balanced inductors which resonate with a variable internal capacitance. The VCO charge-pump output is fed via 2nd order low-pass loop to the variable capacitor. With the exception of C31, the filtering is internal. The VCO loop bandwidth is approximately 10 kHz. The block diagram is shown in Figure 6.

3.6.5 Voltage Controlled Crystal Oscillator (VXO)

A crystal provides the 16.000 MHz reference for the frequency synthesiser system. In receive the crystal oscillator is tuned by the AFC loop to match the received signal frequency.

3.6.6 Antenna

The antenna, A1, is a ceramic chip antenna, this antenna is detuned by the presence of the host plastic casing. The matching network of L5, 7 & 11 takes this into account.

3.6.7 EU – US differences

Most of the components are the same. Differences are the SAW filter, the antenna matching network and the Module ID resistors.

3.6.8 PCB

The PCB has 4 layers with a thickness of 1.0mm ± 0.1mm.

A PCIe mini shape edge-card connector is used.

4 Regulatory Compliance Standards

4.1 RF

4.1.1 EU

The EU version of the product, SH202076, complies with EN 300 220.

4.1.2 US

The US version of the product, SH202075, complies with the relevant sections of 47 CFR Ch. I Part 15.

4.2 EMC & Safety

As the module is used as a component in larger products the Safety & EMC standards to not apply directly to the module.

5 Mother Board Connector (J1) Signals

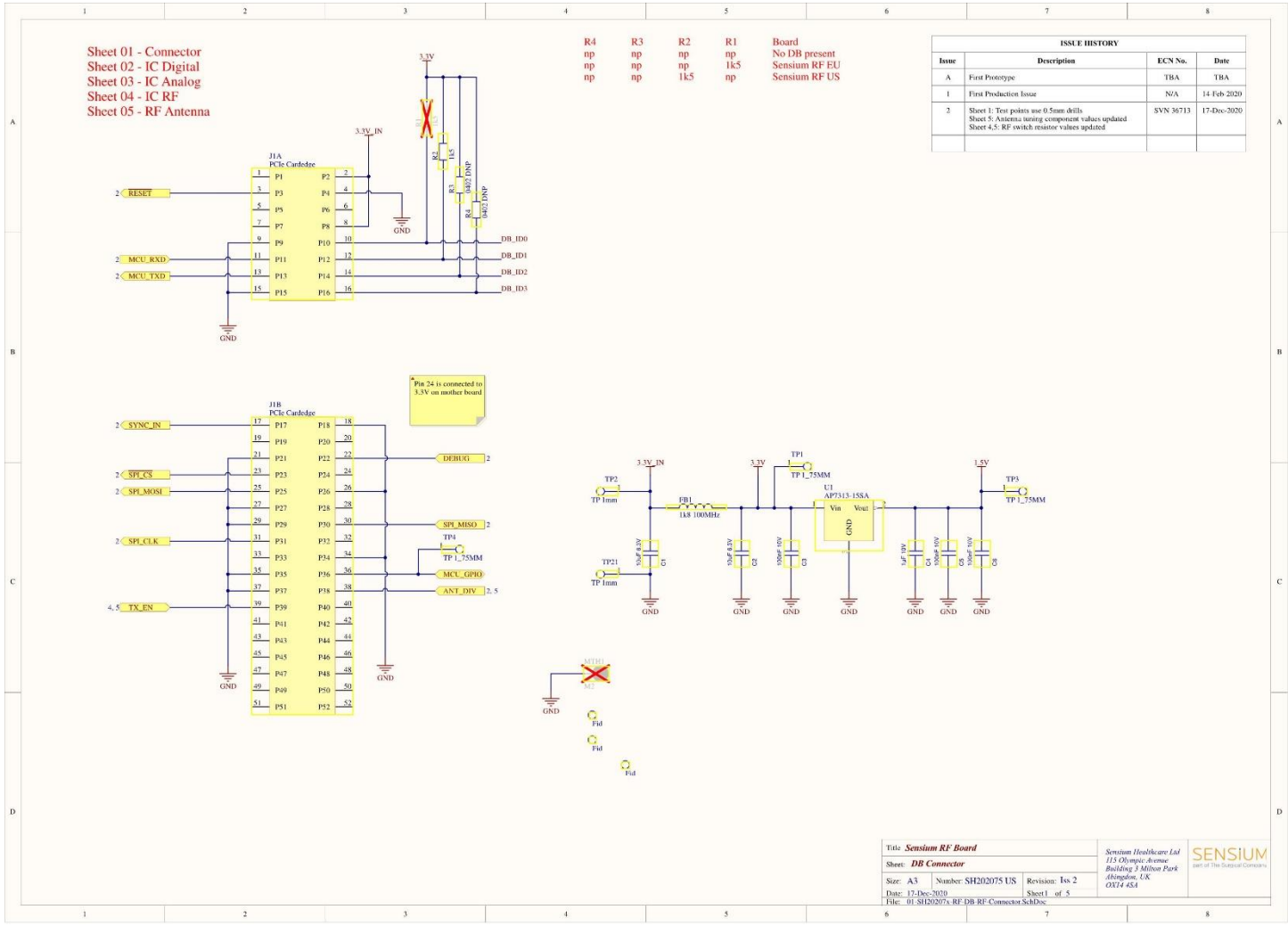
5.1 J1A

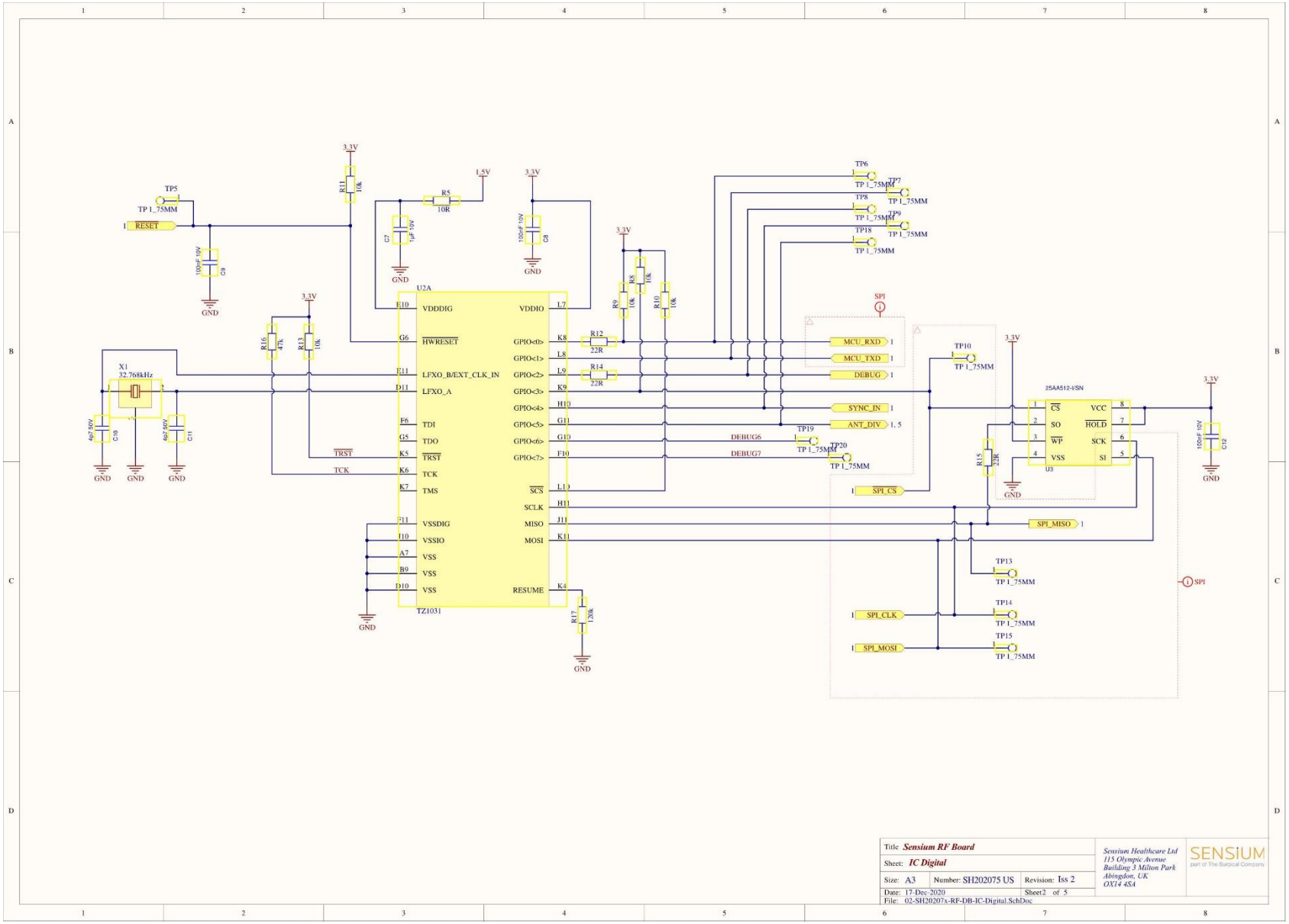
Pin	Signal	Description
1	N/A	Pin Not Used
2	3.3V	Power Input from Host Motherboard
3	\Reset	Sensium IC reset signal, there is a 47k pull-down resistor on MB. Dedicated reset signal is provided for each DB.
4	GND	Power & Signal return
5	N/A	Pin Not Used
6	N/A	Pin Not Used
7	N/A	Pin Not Used
8	3.3V	Power Input from Host Motherboard
9	GND	Power & Signal return
10	ID0	Board type ID signal for host.
11	MCU_RXD	UART output to the host
12	ID1	Board type ID signal for host.
13	MCU_TXD	UART input from host
14	ID2	Board type ID signal for host.
15	GND	Power & Signal return
16	ID3	Board type ID signal for host.

5.2 J1B

Pin	Signal	Description
17	RF_SYNC	Synchronises the radio TDMA frames when 2 RF modules are fitted in the host.
18	GND	Power & Signal return
19	N/A	Pin Not Used
20	N/A	Pin Not Used
21	GND	Power & Signal return
22	RF_DBG	Serial data used for R&D debug
23	\SPI_CS	Chip-select signal for EEPROM. 10k pull-up on RF module.
24	N/A	Pin Not Used
25	SPI_MOSI	SPI serial data from RF module µCU.
26	GND	Power & Signal return
27	GND	Power & Signal return
28	N/A	Pin Not Used
29	GND	Power & Signal return
30	SPI_MISO	SPI serial data to RF module µCU
31	SPI_CLK	SPI clock from RF module µCU
32	N/A	Pin Not Used
33	N/A	Pin Not Used
34	GND	Power & Signal return
35	GND	Power & Signal return
36	RES_IO	Spare GPIO – not allocated
37	GND	Power & Signal return
38	ANT_DIV	Logic Antenna selection signal used for R&D debug
39	TX_EN	Logic Transmit enable signal used for R&D debug
40	N/A	Pin Not Used
41	N/A	Pin Not Used
42	N/A	Pin Not Used
43	N/A	Pin Not Used
44	N/A	Pin Not Used
45	N/A	Pin Not Used
46	N/A	Pin Not Used
47	N/A	Pin Not Used
48	N/A	Pin Not Used
49	N/A	Pin Not Used
50	N/A	Pin Not Used
51	N/A	Pin Not Used
52	N/A	Pin Not Used

6 Base Station Schematics




U2A
TZ1031
VDDDIG
HWRESET
LFXO_B/EXT_CLK_IN
LFXO_A
TDI
TDO
TRST
TCK
TMS
VSSDIG
VSSIO
VSS
VSS
VSS
VDDIO
GPIO<0>
GPIO<1>
GPIO<2>
GPIO<3>
GPIO<4>
GPIO<5>
GPIO<6>
GPIO<7>
SCS
SCLK
MISO
MOSI
RESUME
RESET
MCU_RXD
MCU_TXD
DEBUG
SYNC_IN
ANT_DIV
DEBUG6
DEBUG7
SPI_CS
SPI_MISO
SPI_CLK
SPI_MOSI
25AA512-I/SN
CS
SO
WP
VSS
VCC
HOLD
SCK
SI
X1
32.768kHz
3.3V
1.5V
GND
Title Sensium RF Board
Sheet: IC Digital
Size: A3
Number: SH202075 US
Revision: Iss 2
Date: 17-Dec-2020
Sheet2 of 5
File: 02-SH20207x-RF-DB-IC-Digital.SchDoc
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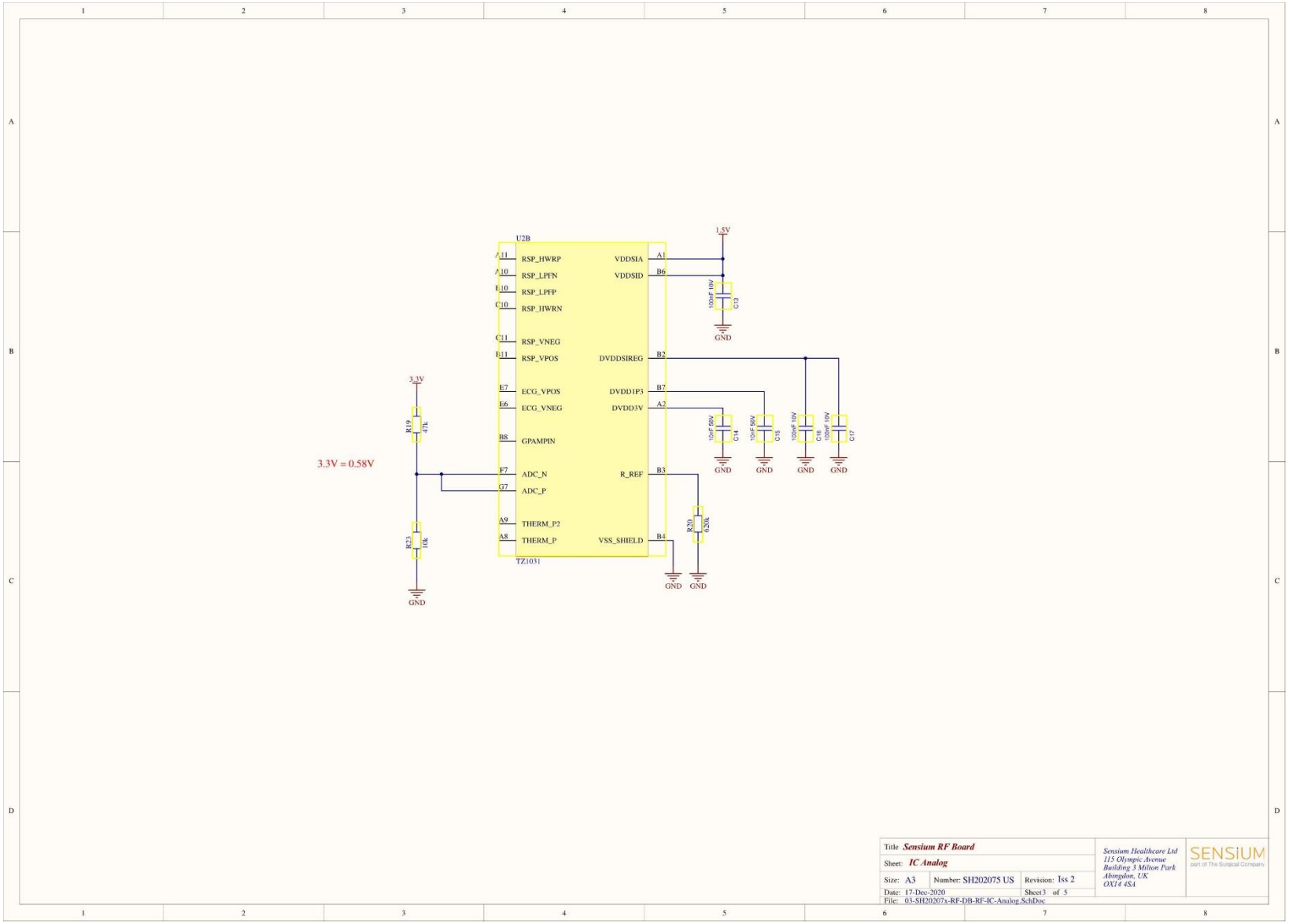
Abingdon, UK
OX14 4SA


U2B
RSP_HWRP
RSP_LPFN
RSP_LPFP
RSP_HWRN
RSP_VNEG
RSP_VPOS
ECG_VPOS
ECG_VNEG
GPAMPIN
ADC_N
ADC_P
THERM_P2
THERM_P
VDDSIA
VDDSID
DVDDSIREG
DVDD1P3
DVDD3V
R_REF
VSS_SHIELD
TZ1031
1.5V
3.3V
3.3V = 0.58V
R19 47k
R23 10k
R20 620k
C13 100nF 10V
C14 10nF 50V
C15 10nF 50V
C16 100nF 10V
C17 100nF 10V
GND
Title Sensium RF Board
Sheet: IC Analog
Size: A3
Number: SH202075 US
Revision: Iss 2
Date: 17-Dec-2020
Sheet 3 of 5
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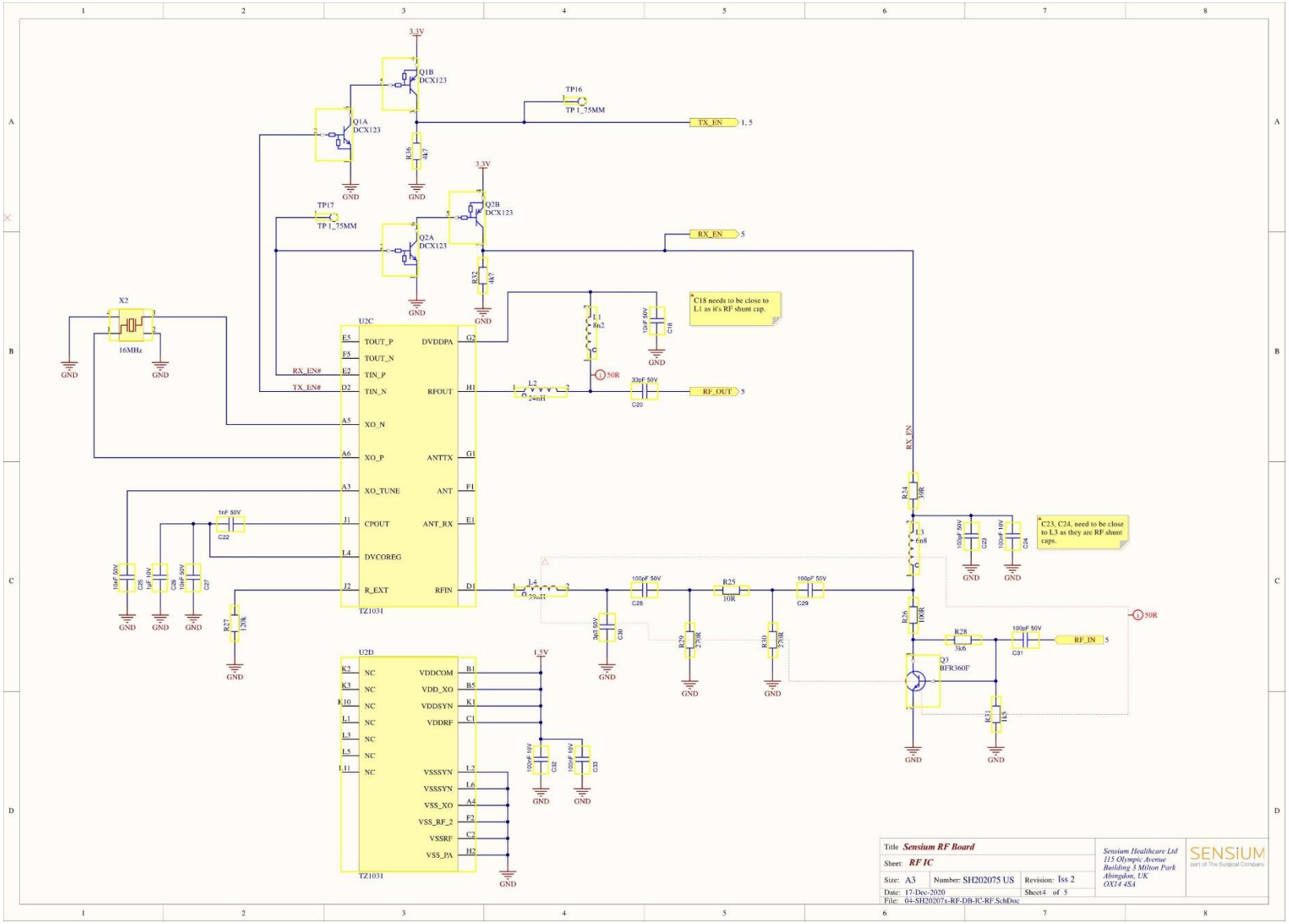
Sensium Healthcare Ltd
115 Olympic Avenue
Building 3 Milton Park
Abingdon, UK
OX14 4SA


3.3V
Q1B DCX123
Q1A DCX123
Q2B DCX123
Q2A DCX123
TP16
TP 1_75MM
TP17
TP 1_75MM
TX_EN
RX_EN
R36 4K7
R32 4K7
X2
16MHz
U2C
TOUT_P
TOUT_N
TIN_P
TIN_N
XO_N
XO_P
XO_TUNE
CPOUT
DVCOREG
R_EXT
DVDDPA
RFOUT
ANTTX
ANT
ANT_RX
RFIN
TZ1031
RX_EN#
TX_EN#
C18 needs to be close to L1 as it's RF shunt cap.
L1 8n2
L2 24nH
L4 39nH
50R
RF_OUT
C20 33pF 50V
C18 10nF 50V
C22 1nF 50V
C25 10nF 50V
C26 1uF 10V
C28 100pF 50V
C27 10nF 50V
R27 120K
C30 3p3 50V
C28 100pF 50V
R25 10R
C29 100pF 50V
R29 270R
R30 270R
U2D
NC
VDDCOM
VDD_XO
VDDSYN
VDDRF
VSSSYN
VSS_XO
VSS_RF_2
VSSRF
VSS_PA
1.5V
C32 100nF 10V
C33 100nF 10V
RX_FN
R24 39R
L3 6n8
C23 100pF 50V
C24 100nF 10V
C23, C24, need to be close to L3 as they are RF shunt caps.
R26 100R
R28 3k6
C31 100nF 50V
RF_IN
Q3 BFR360F
R33 1k5
GND
Title Sensium RF Board
Sheet: RF IC
Size: A3
Number: SH202075 US
Revision: Iss 2
Date: 17-Dec-2020
Sheet 4 of 5
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Sensium Healthcare Ltd
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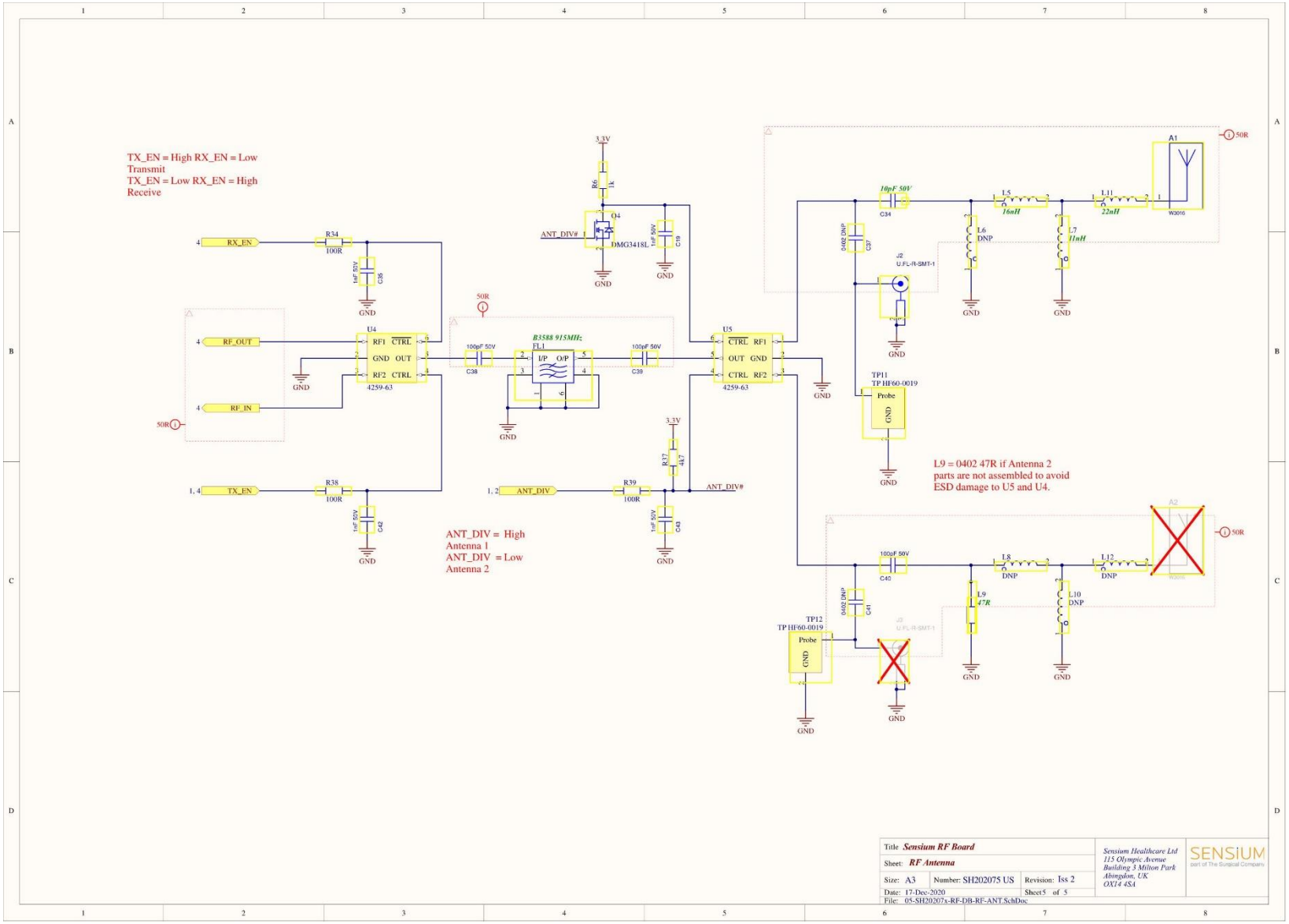
Building 3 Milton Park
Abingdon, UK
OX14 4SA


TX_EN = High RX_EN = Low
Transmit
TX_EN = Low RX_EN = High
Receive
ANT_DIV = High
Antenna 1
ANT_DIV = Low
Antenna 2
L9 = 0402 47R if Antenna 2
parts are not assembled to avoid
ESD damage to U5 and U4.
Title Sensium RF Board
Sheet: RF Antenna
Size: A3
Number: SH202075 US
Revision: Iss 2
Date: 17-Dec-2020
Sheet 5 of 5
File: 05-SH20207x-RF-DB-RF-ANT.SchDoc
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