

User Manual

RIIM- Development Kit
Rev 1.20

INTRODUCTION TO RIIM.....	3
DEVELOPMENT KIT INTRODUCTION	4
RC1882-RIIM-DK KIT CONTENT.....	4
RC18X2HP-RIIM-DK KIT CONTENT	5
QUICK START.....	6
FURTHER DEVELOPMENT	7
BORDER ROUTER BOARD INTRODUCTION.....	8
Block Diagram	9
I/O connection.....	10
DEVELOPMENT BOARD INTRODUCTION	11
Block Diagram	12
I/O connection.....	13
SENSOR BOARD INTRODUCTION	14
Block Diagram Sensor Board	15
Powering the Sensor Board.....	16
Controlling and Configuring the Sensor Board.....	16
I/O Connection.....	17
I/O Silkscreen (revision 1.0 only).....	18
SHT35 Temperature and Humidity Sensor	19
HDC2010 Low Power Temperature and Humidity Sensor.....	19
BME680 Environmental sensor (available on revision 1.0 only)	19
SGPC3 VOC sensor (available on revision 2.0 and later).....	19
ALS-PT-315C, Analogue Light Sensor.....	20
SL353LT Hall Detector	20
LIS3DE Accelerometer	20
Blue LED.....	20
Prototyping with the Sensor Board	21
Sensor Board PCB and Assembly Layout.....	22
Sensor Board Circuit Diagram.....	22
Sensor Board Bill of Materials	25
REFERENCES	27
DOCUMENT REVISION HISTORY	27
DISCLAIMER	27
TRADEMARKS.....	27
LIFE SUPPORT POLICY.....	27
CONTACT INFORMATION	27

Introduction to RIIM

The RIIM network consists of these key elements

- The RIIM SDK
 - o Software development kit with ICI application frameworks and tools for creating and uploading end ICI applications to the RC1882-IPM/RC18x2HP-IPM
- The RC1882-IPM/RC18x2HP-IPM module
 - o The IPM module can be configured as Border Router node, Mesh Router node or Leaf node.
 - As a Border Router it acts as the base of the mesh network. It can connect to an external network via ethernet or custom user ICI application on other interfaces such as UART
 - As a Mesh Router, it will be able to transport packets in the RIIM mesh network
 - As a Leaf, it is not able to transport packets to other nodes except its parent. This mode uses the least amount of energy.
 - o All node configurations require an ICI application for RF and interface configuration and the user application. The same RIIM Software Development Kit (SDK) is used to create the ICI application for all node configurations.

Below is an illustration of the different elements and the documentation available

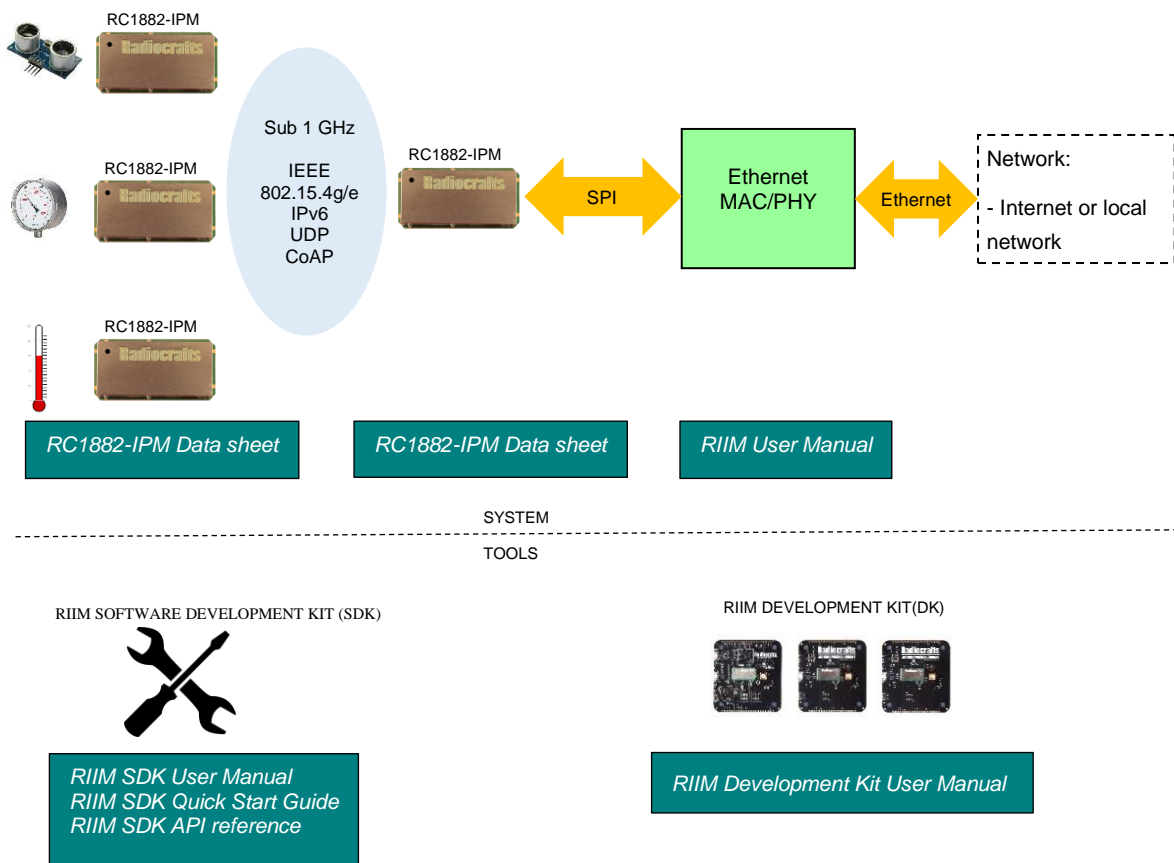


Figure 1. RIIM network – system and documentation overview

Development Kit Introduction

The Development Kit (DK) is designed to make it easy for the user to evaluate the RIIM network and to run preloaded ICI application or to make a user specific ICI application with minimal time and effort.

This document covers three variants of the RIIM development kit, given below by their ordering number

- RC1882-RIIM-DK
- RC1882HP-RIIM-DK
- RC1892HP-RIIM-DK

RC1882-RIIM-DK kit content

Your development kit contains the following boards:



Figure 2. Sensor board(left) and development board(middle) and border router board(right)

Kit contents		
Item	Number of articles	Preloaded firmware
Sensor board w/RC1882CEF-IPM module	1	Sensor read example
Development board w/RC1882CEF-IPM module	1	Mesh router example
Border router board w/RC1882CEF-IPM module	1	Border router example
Antenna, 50Ω quarter-wave monopole, SMA male connector	3	
USB cable (micro)	2	
USB cable (USB-C)	2	
USB power supply	1	

This User Manual describes how to use the Development Kit and provides detailed documentation for the Border Router board, the Sensor board and the Development board

RC18x2HP-RIIM-DK kit content

Your high power development kit contains the following boards:



Figure 3. 2 Sensor boards and border router board(right)

Kit contents		
Item	Number of articles	Preloaded firmware
Sensor board w/RC18x2HPCF-IPM module	2	Sensor read example
Border router board w/RC18x2HPCF-IPM module	1	Border router example
Antenna, 50Ω quarter-wave monopole, SMA male connector	3	
USB cable (micro)	4	
USB cable (USB-C)	2	
USB power supply	3	

This User Manual describes how to use the Development Kit and provides detailed documentation for the Border Router board, the Sensor board and the Development board

Quick Start

The boards in the development kit comes programmed with ready to go ICI applications that allow the user to make wireless connection and see data coming through the network. The example code is pre-loaded on the board in the development kit is also included in the RIIM SDK.



- **Sensor Board**

Preloaded with an application that automatically joins the network, reads on-board sensors and sends data to the Border Router using CoAP.



- **Development Board (Sensor board for high power kit)**

Preloaded with a router application that will operate as a mesh router and forward messages. The development board automatically joins the network.



- **Border Router Board**

Preloaded with an ICI application that starts the network as root node. Packets received on the border router board is printed on the UART.

Step-by-step setup

- Mount antenna on all three boards. (angled antenna on border router board)
- Power up the Border router board
- Connect PC to console input and open a terminal program to monitor this port (Putty, LookRS232, Teraterm, YAT etc). Baud rate 115200, 8N1, no flow control.
- Power up the Development Board through USB micro connector (Can be powered from PC) Blue led will blink when it has joined the network
- Power up the Sensor Board through USB micro connector (Can be powered from PC for RC1882 kit non-HP)
- Observe data being received at border router board though a terminal program.

```
(09:41:14.212) Starting RIIM ROOT
(09:41:14.212) # RIIM node configuration:
(09:41:14.212) # - PAN ID: 0x9812
(09:41:14.262) # - Node ID: 28271
(09:41:14.262) # - Link-layer address: 00124b0018d36e6f
(09:41:14.262) # - Local IPv6 address: fe80:0000:0000:0000:0212:4b00:18d3:6e6f:
(09:41:14.262) # - Global IPv6 address: fd00:0000:0000:0000:0212:4b00:18d3:6e6f:
(09:41:14.262) # - IPv4 address: 0.0.0.0
(09:41:14.262) # - IPv4 Netmask: 0.0.0.0
(09:41:14.262) # - IPv4 Gateway: 0.0.0.0
(09:41:14.772) ;
(09:41:14.772) {"Temp": 26.1, "Hum": 17}
(09:41:19.187) ;
(09:41:19.187) {"Temp": 26.1, "Hum": 17}
(09:41:22.568) ;
(09:41:22.568) {"Temp": 26.1, "Hum": 17}
(09:41:27.578) ;
(09:41:27.578) {"Temp": 26.1, "Hum": 17}
(09:41:29.159) ;
(09:41:29.159) {"Temp": 26.1, "Hum": 17}
(09:41:29.349) ;
(09:41:29.349) {"Temp": 26.1, "Hum": 17}
(09:41:33.316) ;
(09:41:33.316) {"Temp": 26.1, "Hum": 17}
(09:41:33.596) ;
(09:41:33.596) {"Temp": 26.1, "Hum": 17}
```

Figure 4. Log from Border Router Board startup and packet reception(YAT)

Further development

Before starting to develop with RIIM, please download the RIIM SDK from www.radiocrafts.com.

Start making your own custom ICI application

- Read a different sensor
- Use other channels or output power level
- Add new timer events
- Make events based on button
- Make smart solution by adding intelligence processing on IPM module
- Send downlink messages from gateway to end node

The possibilities are infinite. Details for making your own ICI application can be found in RIIM SDK Quick Start, RIIM SDK User Manual and RIIM SDK API reference.

The rest of the document goes through the HW in the kit in detail, to allow further development and prototyping with the kit.

Border Router Board Introduction

The border router board contains an Ethernet (RJ45) connector, USB connector, USB to serial converter, LEDs, voltage regulator, power switch and programming/debug connector. All I/O signals are routed to holes at the edge suitable for 2.54 mm pitch pin headers.

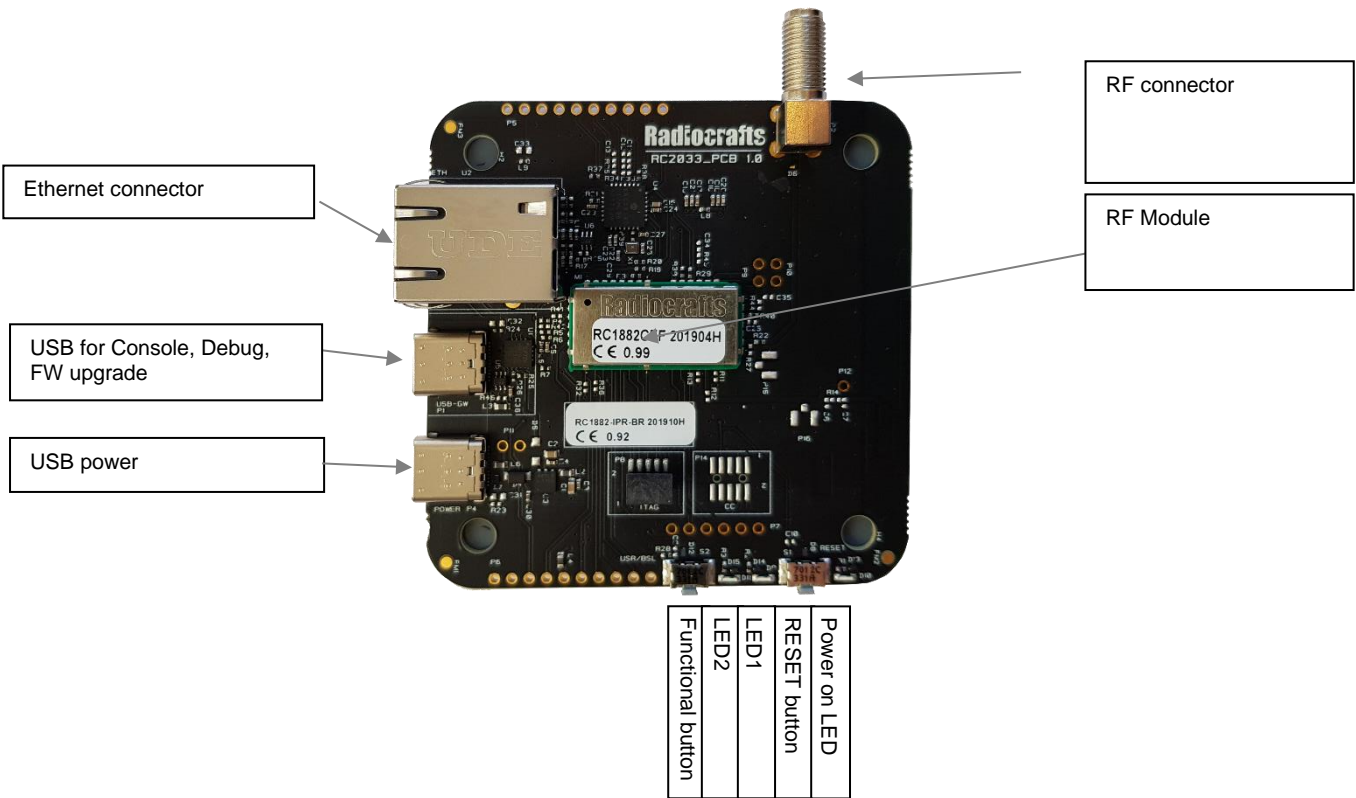


Figure 5: Border Router Board

Block Diagram

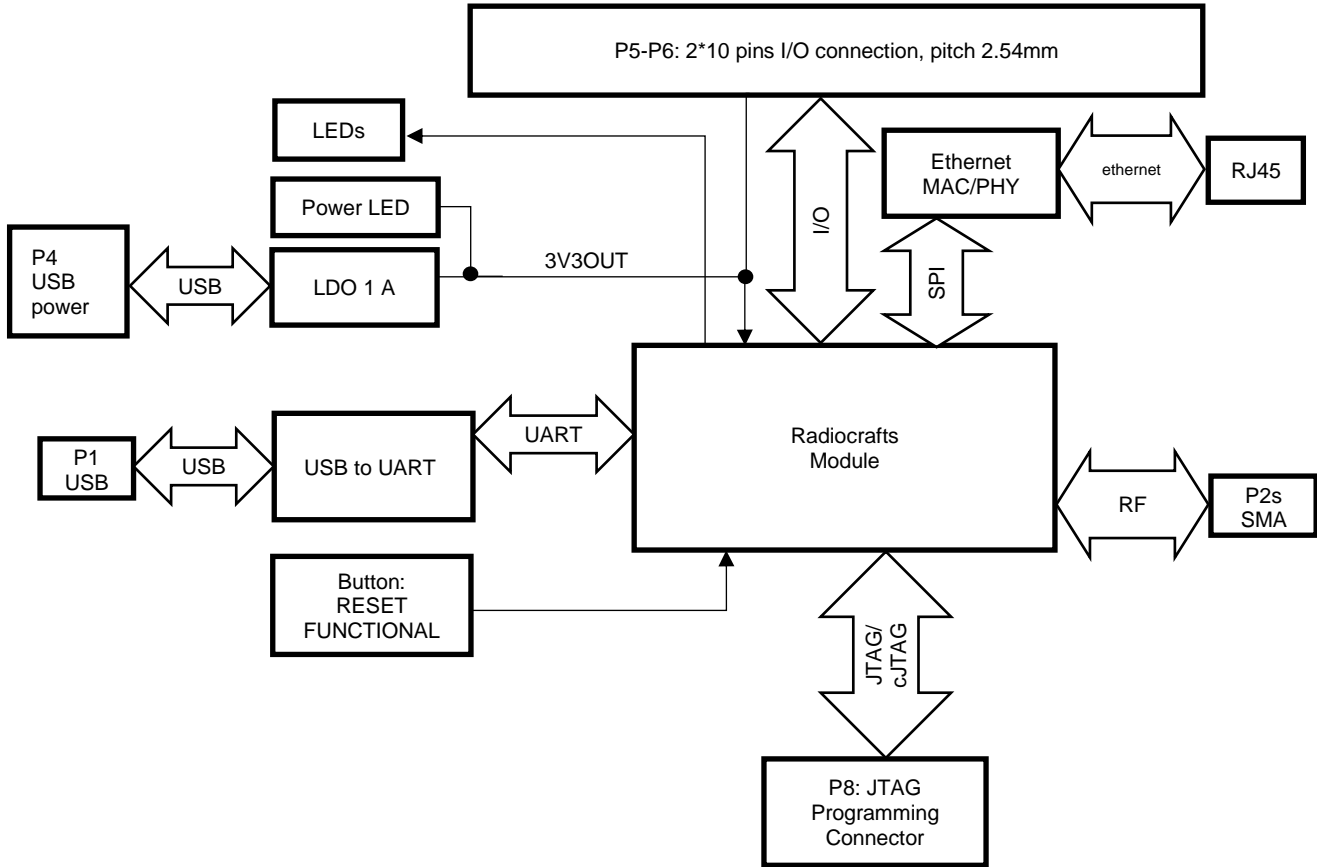


Figure 6. Block schematic Border Router Board

I/O connection

All pins to the module are available through standard pin rows using a pitch distance of 100 mil (2.54 mm). These pins are connected to 2 x 10 pins holes named P5 to P6. The table below gives an overview of the edge connectors and their logical signals. Details on the module pinning can be found in module data sheet [6]/[7].

I/O connection				
Connector	PIN	Signal	Module PIN	Note
P5	1	INT	35	
	2	SPI_MISO	31	
	3	SPI_MOSI	32	
	4	SPI_CLK	33	
	5	SPI_CS	36	
	6	RESET_ETH	34	
	7	DIO_9	38	No functional use. Option for debug
	8	DIO_10	39	No functional use. Option for debug
	9	DIO_11	40	No functional use. Option for debug
	10	GND		
P6	1	ADC_2	11	
	2	ADC_1	10	
	3	SCL	9	
	4	SDA	8	
	5	DIO_18	4	
	6	VCC	27	3.3 V regulated power
	7	RXD	6	
	8	TXD	7	
	9	Not connected		
	10	GND		

Development Board Introduction

The development board contains an USB connector, USB to serial converter, LEDs, voltage regulator, power switch and programming/debug connector. All I/O signals are routed to holes at the edge suitable for 2.54 mm pitch pin headers.

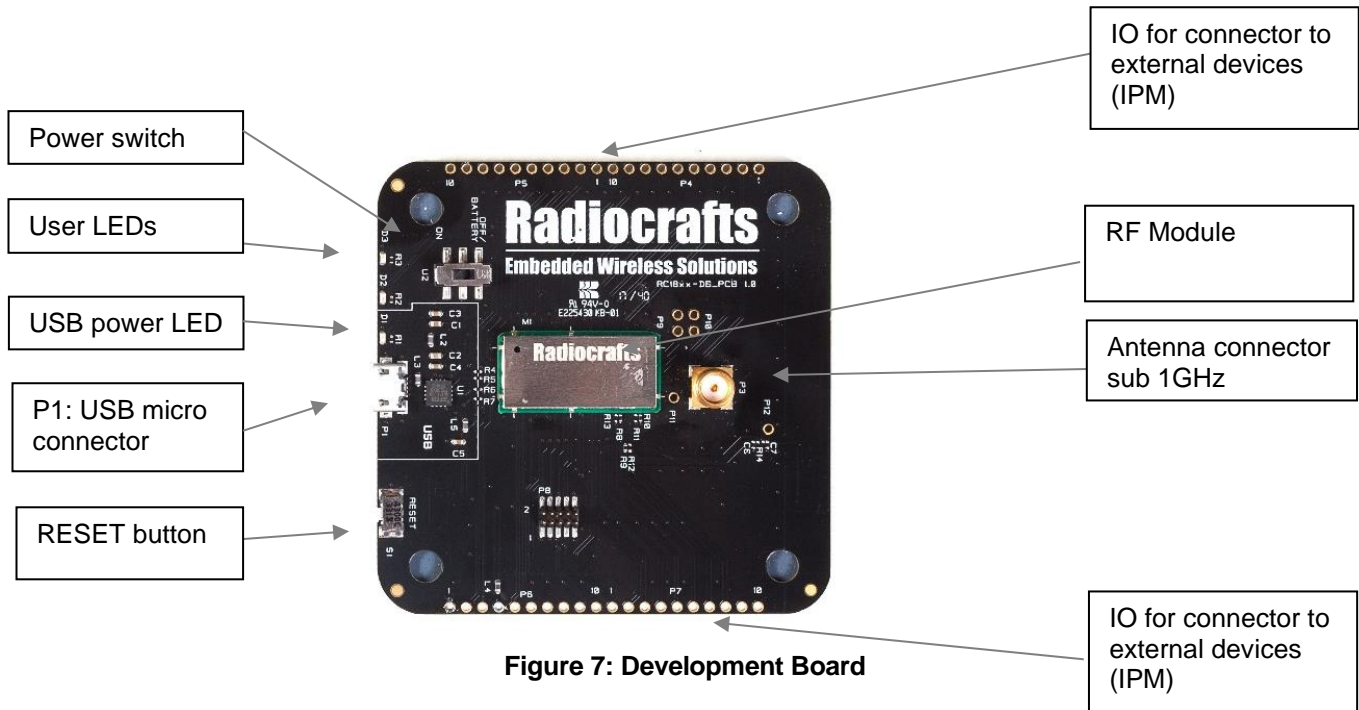


Figure 7: Development Board

Block Diagram

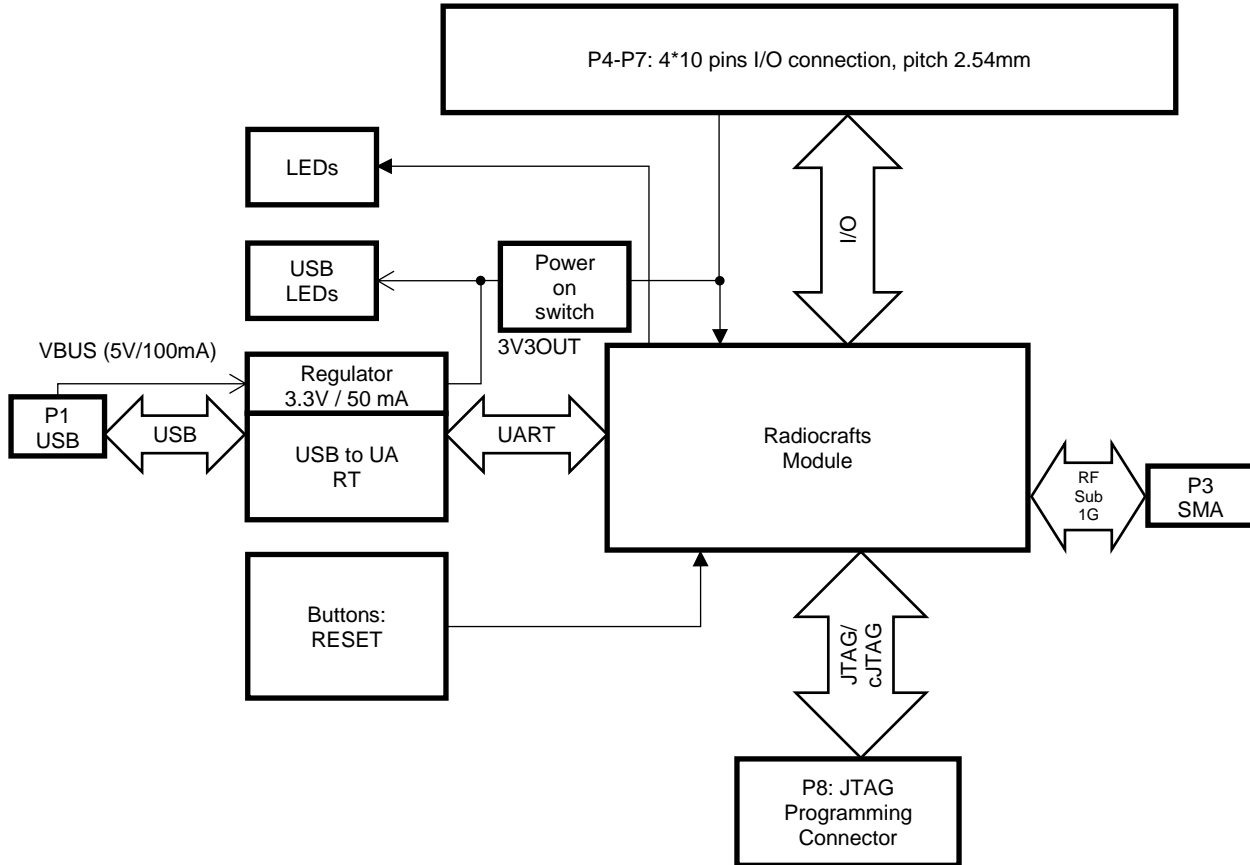


Figure 8. Block schematic Development Board

I/O connection

All pins to the module are available through standard pin rows using a pitch distance of 100 mil (2.54 mm). These pins are connected to 4 x 10 pins holes named P4 to P7. The table below gives an overview of the edge connectors and their logical signals. Details on the module pinning can be found in module data sheet [6]/[7].

I/O connection				
Connector	PIN	Signal	Module PIN	Note
P4	1	GND		
	2	RX/TX	25	Not used
	3	RESET	26	
	4	DIO_1	30	
	5	DIO_2	31	
	6	DIO_3	32	
	7	DIO_4	33	
	8	DIO_5	34	
	9	DIO_6	35	
	10	DIO_7	36	
P5	1	DIO_8	37	
	2	DIO_9	38	
	3	DIO_10	39	
	4	DIO_11	40	
	5	DIO_12	41	
	6	DIO_13	42	
	7	DIO_14	2	
	8	DIO_15	3	
	9	DIO_18	4	
	10	GND		
P6	1	GND		
	2	DIO_19	5	TXD output (Connected to USB FTDI chip)
	3	DIO_20	6	RXD input (Connected to USB FTDI chip)
	4	VCC_EXTERN	27	Via EMI bead to RC1882CEF-IPM
	5	DIO_21	8	
	6	DIO_22	9	
	7	DIO_23	10	
	8	DIO_24	11	
	9	TMSC	12	
	10	TCKC	13	
P7	1	DIO_16/TDO	14	
	2	DIO_17/TDI	15	
	3	DIO_25	16	
	4	DIO_26	17	
	5	DIO_27	18	
	6	DIO_28	19	Not connected for RC1885. Module pin 19-21 are RF port for 2.4 GHz. (do not mention R1885. This document only talks about the RC1882CEF-IPM)
	7	DIO_29	20	
	8	DIO_30	21	
	9			Not connected
	10	GND		

Sensor Board Introduction

The Sensor Board includes the module to be evaluated. In addition it contains other circuitry needed for powering and communication to the module. All I/O signals are routed to holes at the edge suitable for 2.54 mm pitch pin headers for easy monitoring and control externally.

The board includes 6 different sensors and a controllable LED to demonstrate GPIO control options.

Sensor	Manufacturer	Sensor Type
SHT35	Sensirion	Precision Temperature and Humidity Sensor
HDC2010	Texas Instruments	Low Power Temperature and Humidity Sensor
SGPC3	Sensirion	VOC sensor
ALS-PT-315C	Everlight	Analogue Light Sensor
SL353LT	Honeywell	Hall detector
LIS3DE	ST	Accelerometer

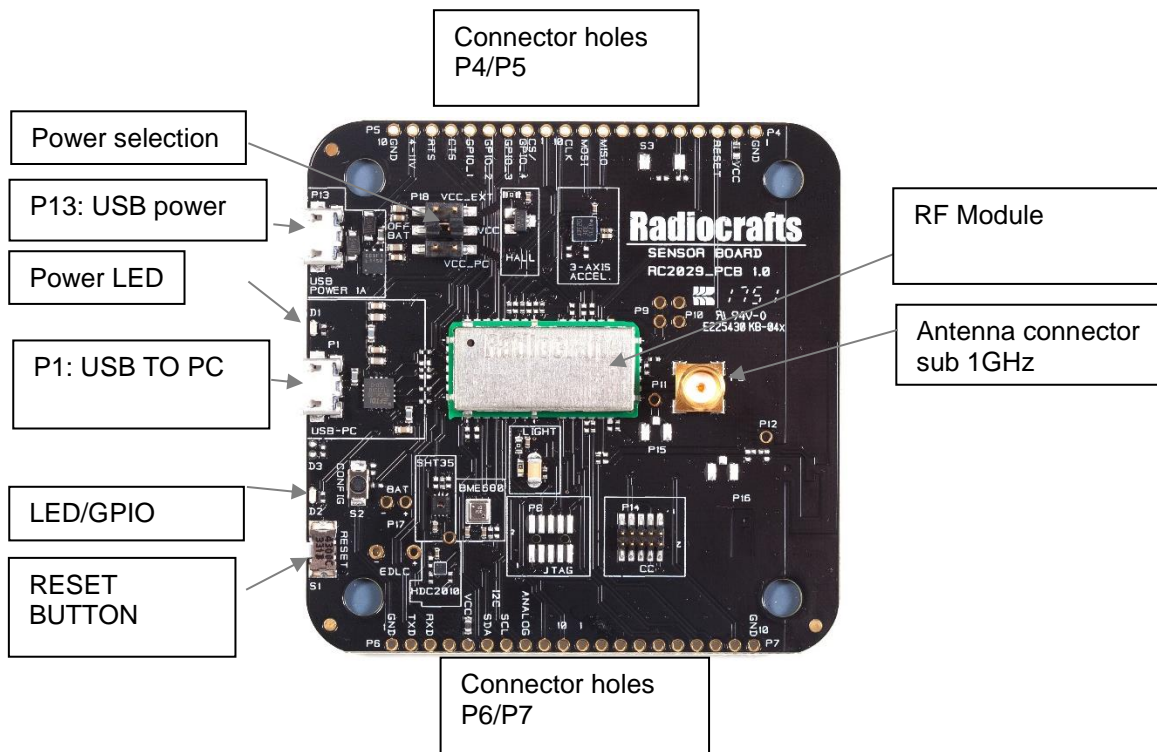


Figure 9: Sensor Board

Block Diagram Sensor Board

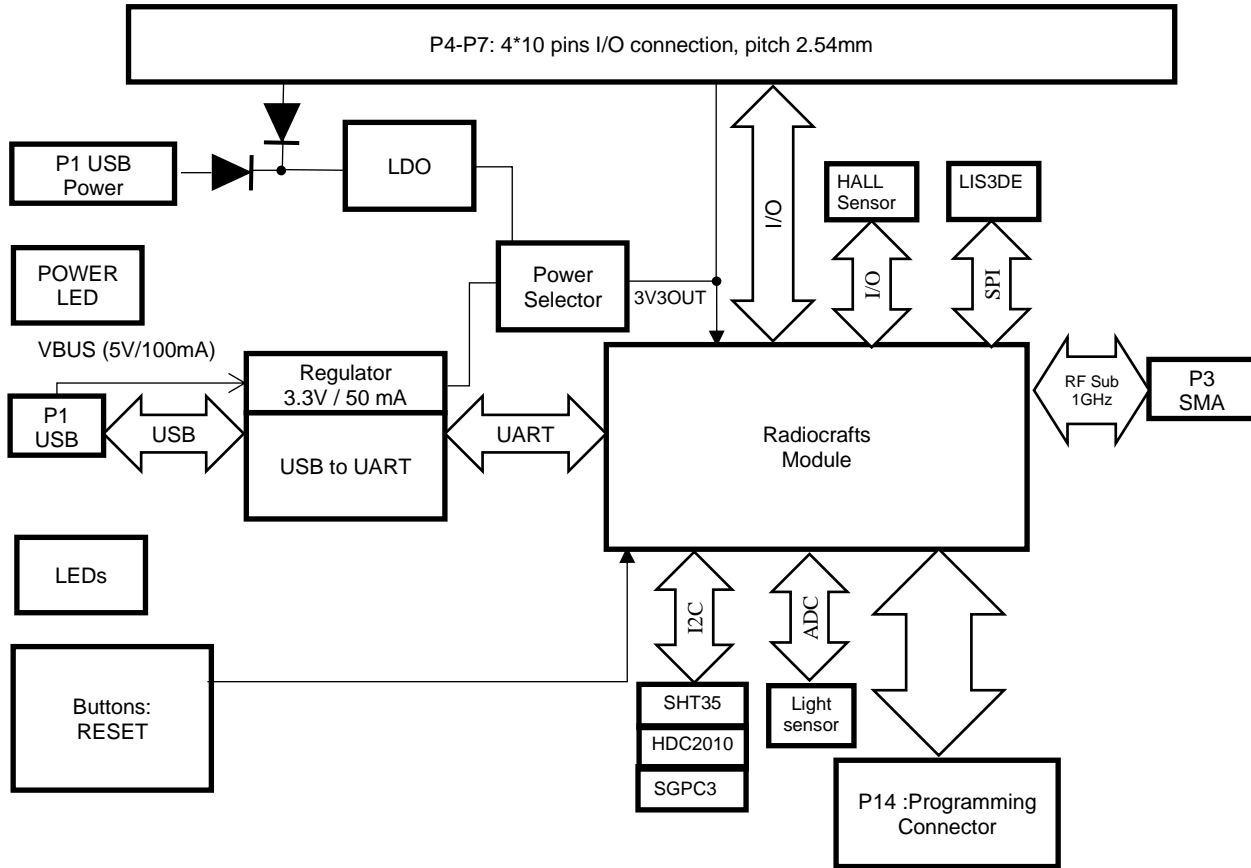

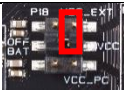




Figure 10. Block schematic Sensor board

Powering the Sensor Board

The sensor board can be power in several different ways, thus giving flexibility and ease of use.

Power source	Jumper position/RED	Comment
USB power 1A	 VCC - VCC_EXT	Make sure to use a USB power source capable of 1 A. A PC does normally not offer that high current
Extern Volt 4-11 V /9V battery	 VCC - VCC_EXT	Connect through pin holes at edge. Here a 9V battery can also be connected. NB: Using VCC > 6V, continuous transmission test mode cannot be used.
Battery 3.0/3.6V	 VCC - OFF/BAT	Battery can be connected
USB PC	 VCC - VCC_PC	NOT TO BE USED ON HIGH POWER MODULES. (RC1882HPCF/RC1892HPCF)

The sensor board is setup with a green power on LED, D1. This draws 2 mA and is always on. In case of using the sensor board for battery operated proof of concept, this LED need to be removed to ensure low power consumption



Controlling and Configuring the Sensor Board

The sensor module can be controlled and configured through UART. For ease of use the UART is connected through a UART-to-USB bridge from FTDI and to a micro USB contact.

By connecting a computer to this USB connector on the sensor board, a terminal emulator program can be used to communication with the module. There is also a config button on the board to easily put the module in configuration mode. See datasheets and user manual for details on communication via UART.

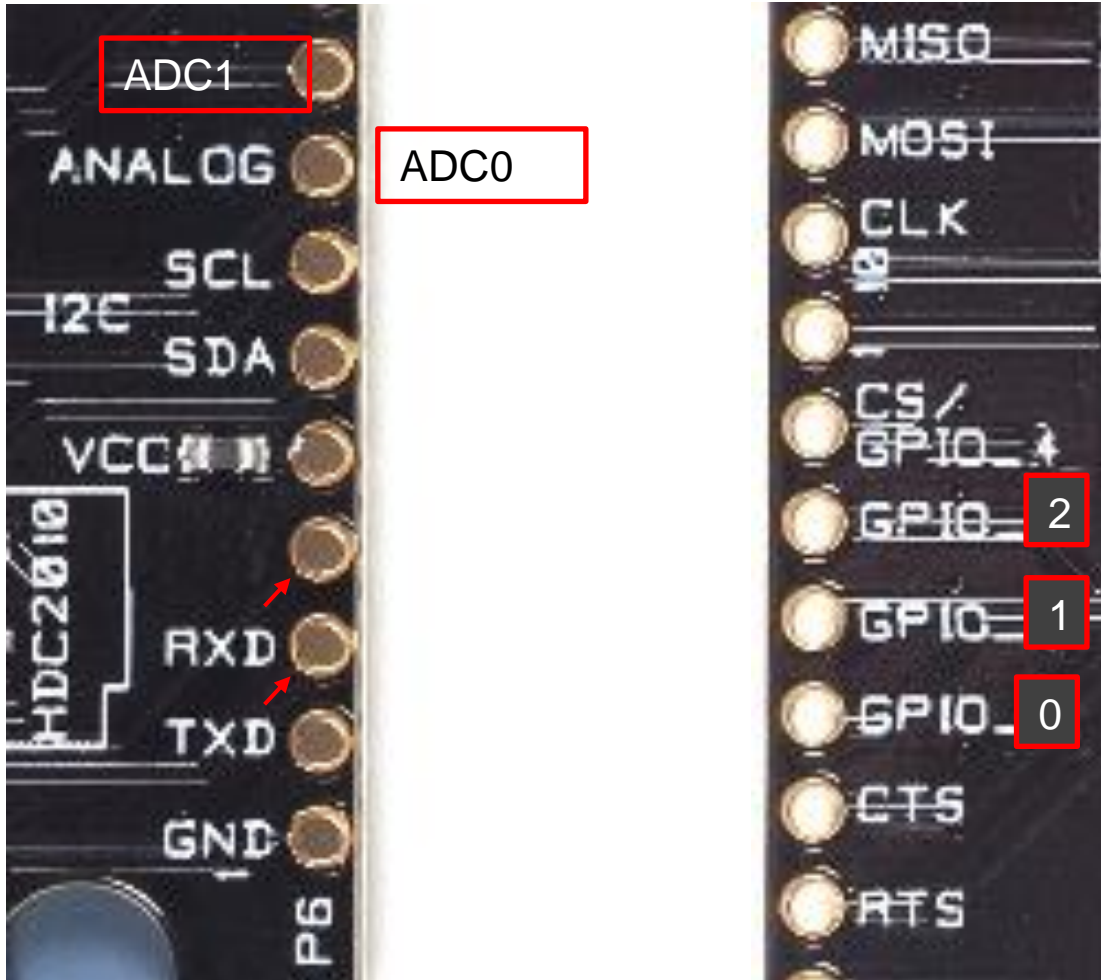
I/O Connection

All pins to the module are available through standard pin rows using a pitch distance of 100 mils (2.54 mm). These pins are connected to 4 x 10 pins holes named P4 to P7. The table below gives an overview of the edge connectors and their logical signals. Details on the pinning can be found in module datasheet.

I/O connection				
Connector	PIN	Signal Module (Sensor board)	Module PIN	Note
P4	1	GND		
	2	VCC		Not used
	3	RESET		
	4	Not used		Internally connected – Do not use
	5	GPIO8	34	
	6	GPIO7	35	
	7	GPIO6	36	
	8	GPIO5	37	
	9	SPI_MISO	31	
	10	SPI_MOSI	32	
P5	1	SPI_CLK	33	
	2	GPIO4	38	
	3	GPIO3 (SPI_CS)	39	
	4	GPIO2 (HALL_OUT)	40	
	5	GPIO1 (DRDY)	41	
	6	GPIO0 (LED_1)	42	
	7	CTS	2	
	8	RTS	3	
	9	VCC_4_11V		Not connected to module
	10	GND		
P6	1	GND		
	2	BSL	4	
	3	TXD	5	TXD output (Connected to USB FTDI chip)
	4	RXD	6	RXD input (Connected to USB FTDI chip)
	5	VCC	27	Via EMI bead to module
	6	SDA	8	
	7	SCL	9	
	8	ADC0 (LIGHT_OUT_ANALOG)	10	
	9	ADC1	11	
	10	TMSC	12	JTAG programming interface. Do not use.
P7	1	TCKC	13	
	2	TDO	14	
	3	TDI	15	
	4	SENS_1	16	Reserved for future use.
	5	SENS_2	17	
	6	SENS_3	18	
	7	PA_CTR	19	
	8	PA_CTR	20	
	9	PA_CTR	21	
	10	GND		

I/O Silkscreen (revision 1.0 only)

On revision 1.0 of the sensor board there are some inaccuracies in the silkscreen print. GPIO numbering is wrong and ADC1 marking is missing. Marking of RXD/TXD are offset. See below.



SHT35 Temperature and Humidity Sensor

SHT35 is one of Sensirion's temperature and humidity sensors. It has a typical accuracy of $\pm 1.5\%RH$ and $\pm 0.1\text{ }^{\circ}C$. It connected to sensor module by I2C and is setup with I2C address 0x44.



HDC2010 Low Power Temperature and Humidity Sensor

The HDC2010 is an integrated humidity and temperature sensor from Texas Instruments, with very low power consumption and in an ultra-compact package. It has an accuracy of $\pm 2\%RH$ and $\pm 0.2\text{ }^{\circ}C$. It connected to sensor module by I2C and is setup with I2C address 0x40.

The data ready pin is connected to the GPIO1 of the sensor module.



BME680 Environmental sensor (available on revision 1.0 only)

BME680 is an integrated environmental sensor developed specifically for mobile applications and wearables where size and low power consumption are key requirements. The sensor reads is a 4-in-1 sensor that measure gas, humidity, pressure and temperature. It connected to sensor module by I2C and is setup with I2C address 0x76.



SGPC3 VOC sensor (available on revision 2.0 and later)

SGPC3 is an integrated VOC (Volatile Organic Compound) sensor developed for mobile, low power applications. It connected to sensor module by I2C and is setup with I2C address 0x58.



ALS-PT-315C, Analogue Light Sensor

The ALS-PT-315C is light sensor that gives an analogue output based on the illuminance (Lux). The output is connected to the analogue input of the sensor module. On the sensor board this sensor is always on.



SL353LT Hall Detector

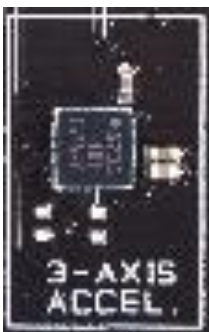
The SL353LT is a state-of-the-art hall detector that enable magnetic detection. It has a very low power consumption of 1.8 uA in average for 2.8V operation. The output of the hall detector is connected to GPIO2 on the sensor module.



LIS3DE Accelerometer

The LIS3DE is an ultra-low-power high-performance 3-axis linear accelerometer belonging to the “nano” family, with digital I²C/SPI serial interface standard output. The device features ultra-low-power operational modes that allow advanced power saving and smart embedded functions.

It is connected to the sensor module via the SPI and GPIO3 is the chip select pin.



Blue LED

There is a blue LED on the board (D2) that is connected to GPIO0 of the sensor module. This is used to demonstrate the GPIO output control capabilities of the sensor module.



Prototyping with the Sensor Board

The sensor board is well suited for prototyping/bread boarding. With all I/O pins easily accessible at the edge, connection to external boards can be made through board stacking with standard pin headers or cabled with standard 2.54 mm pitch cable.

With angled header mounted on I/O connector, the sensor board can also be mounted vertically to other boards with 2.54mm pitch connectors.

The idea is that an external application specific circuitry/sensors etc. easily can be connected to the sensor board as a proof of concept for the final product.

The sensor board is built to fit a commercially off the shelf enclosure named *Router Cube* from New Age Enclosure. Available at Mouser. The sensor board is not delivered with enclosure. Machining for connectors/antenna is required.

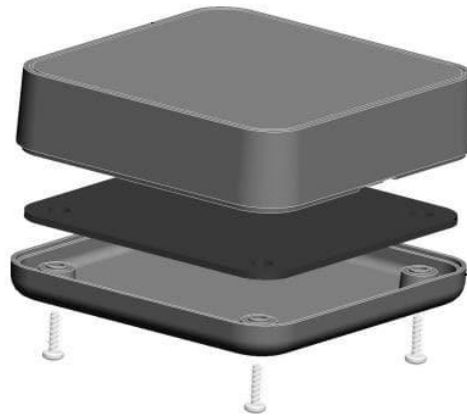


Figure 11 Optional enclosure from New Age Enclosures

Sensor Board PCB and Assembly Layout

The PCB is a simple 4-layer board where Layer 2 is used as ground plane. The laminate used is standard FR-4 board material. The PCB is 1.6mm thick. Full resolution layout and assembly drawing are found in [9].

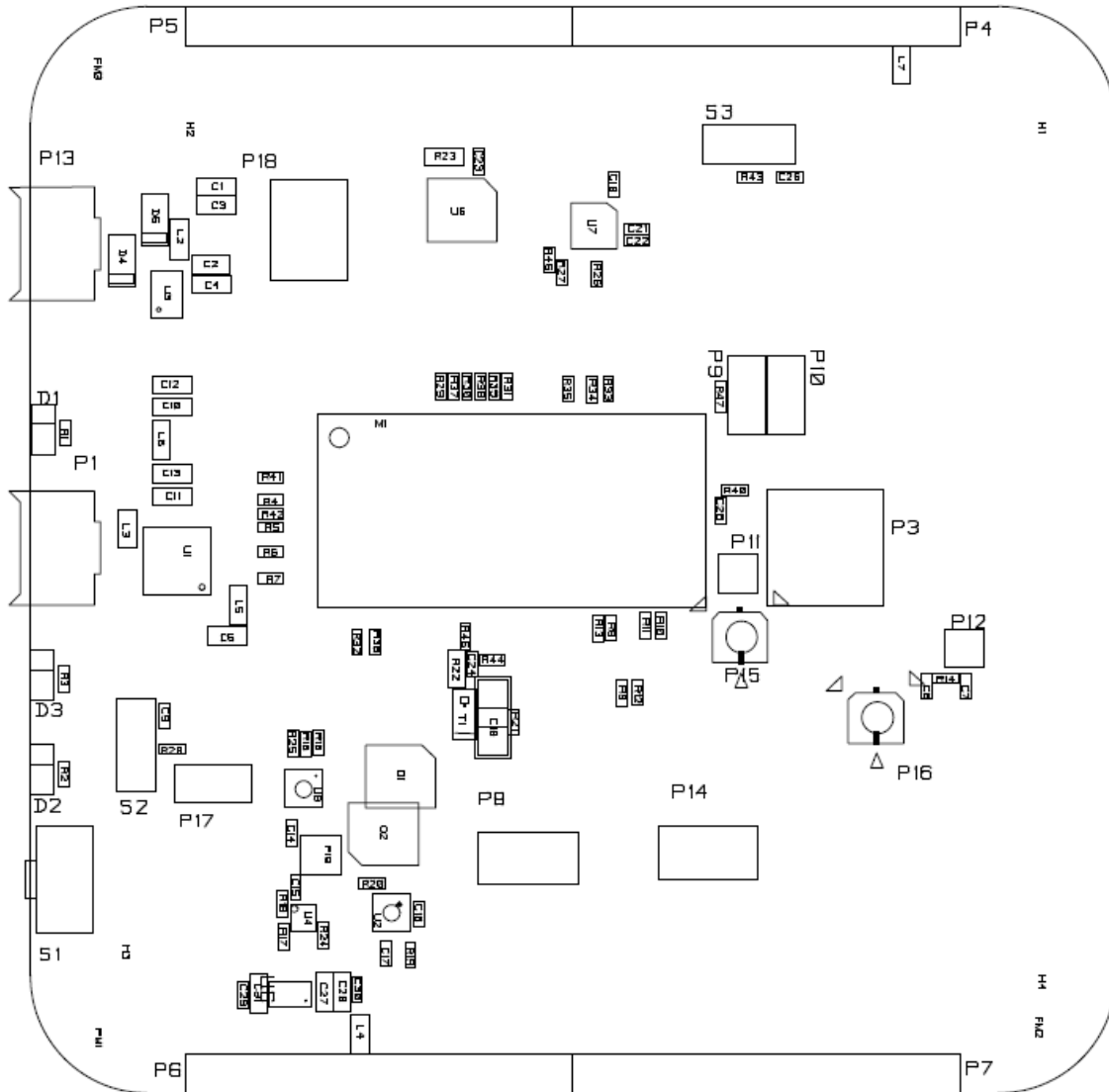


Figure 2. Sensor Board PCB component placement, top side

Sensor Board Circuit Diagram

The circuit diagram of the Sensor Board is in figure 6. For better quality please see PDF in [9] and [10].

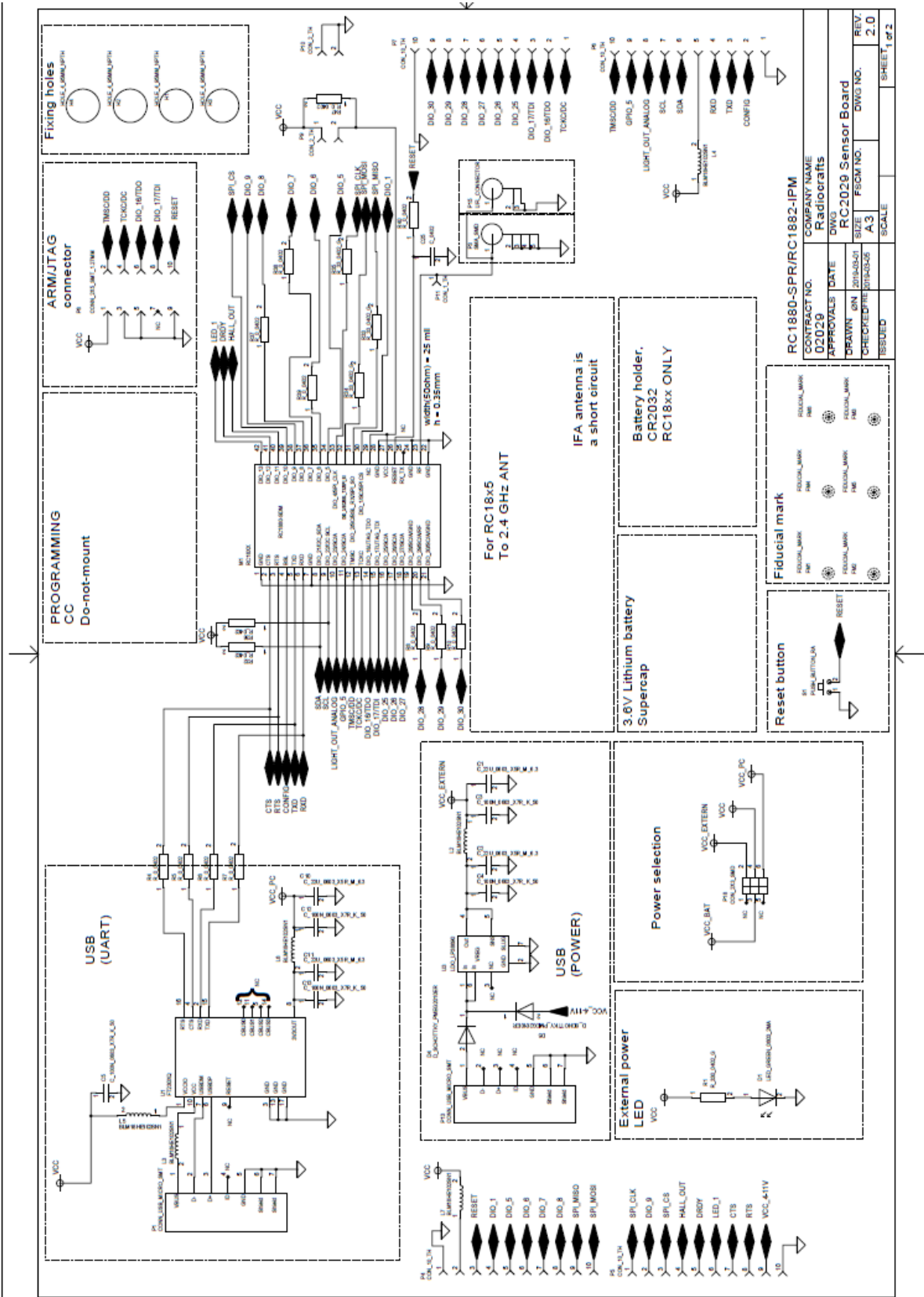


Figure 3: Sensor Board Circuit diagram, page 1

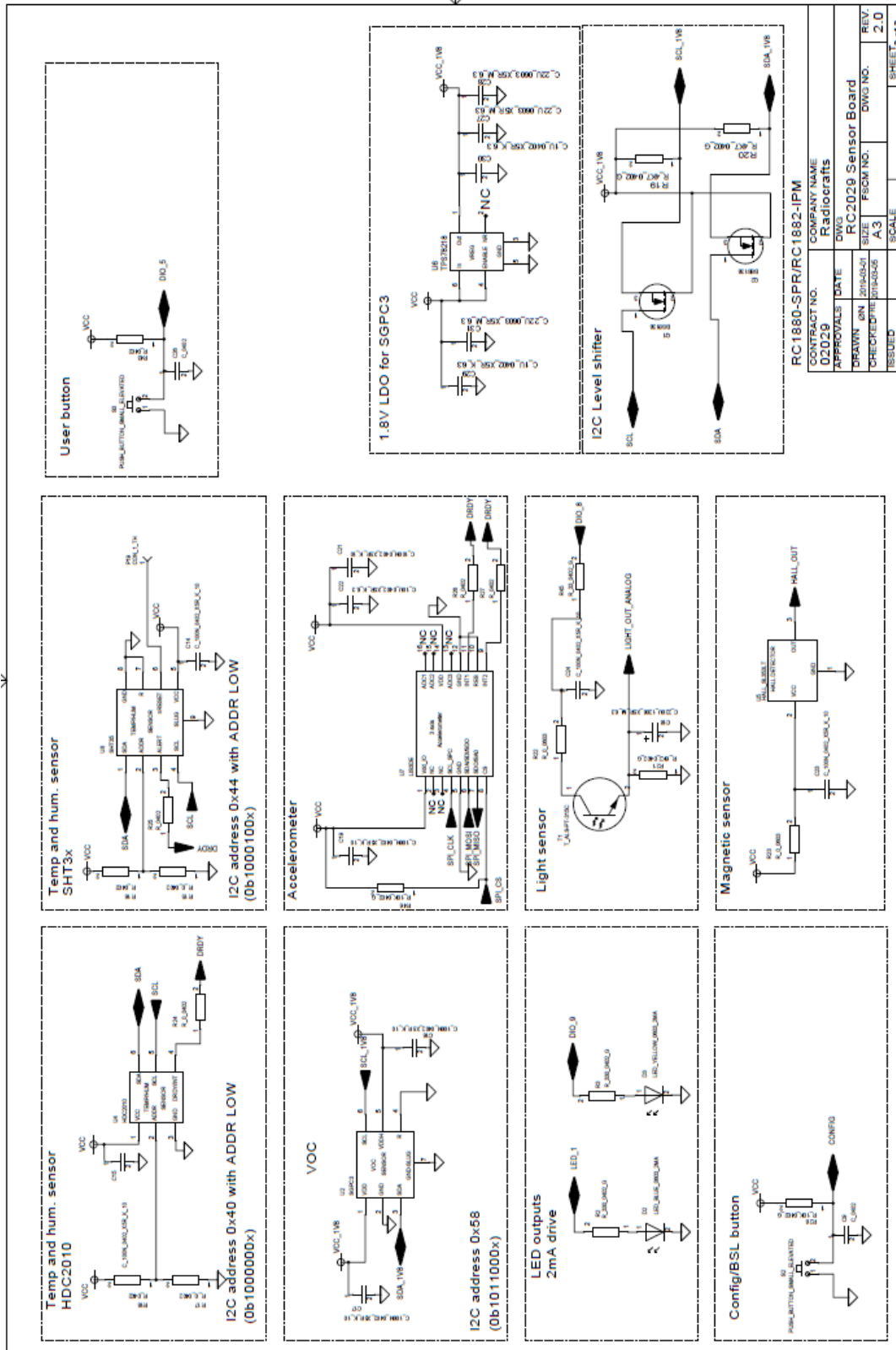


Figure 7: Sensor Board Circuit diagram, page 2

Sensor Board Bill of Materials

The circuit diagram includes all components of RC1882CEF-IPM-SB, but the Bill of Material describes which components are mounted. Details are listed in the following table. Components not mounted are marked *DNM* (*Do Not Mount*) in the 'Quantity/#' column.

Bill of materials for Sensor board rev 2.0			
Reference	Quantity	Part number	Description
L2-7	6	BLM18HE102SN1	EMI filter bead, 1000ohm@1GHz
U2	1	SGPC3	VOC gas sensor
P14	1	CONN_2X5_SMT_1.27MM	Connector 2x5 SMT with 1.27 mm spacing
P8	<i>DNM</i>	CONN_2X5_SMT_1.27MM	Connector 2x5 SMT with 1.27 mm spacing
P1;P13	2	CONN_USB_MICRO_SMT	USB micro connector SMT
P4-7	<i>DNM</i>	CON_10_TH	Connector, 0.9mm pin
P11-12;P19	<i>DNM</i>	CON_1_TH	Connector, 0.9 mm pin
P18	1	CON_2X3_SMD	Connector, 2x3 pins, SMD, pitch 2.54mm
P9-10;P17	<i>DNM</i>	CON_2_TH	Connector, 0.9 mm pin
P2	<i>DNM</i>	CR2032 HOLDER	HOLDER for coin cell
C6-7; C9;C25;C26	<i>DNM</i>	C_0402	Capacitor, 0402, general
C14-17;C19; C21;C23-24	8	C_100N_0402_X5R_K_10	Capacitor, 0402
C3-5;C12-13	5	C_100N_0603_X7R_K_50	Capacitor, 0603
C22	1	C_10U_0402_X5R_K_6.3	Capacitor, 0402
C18	1	C_220U_1206_X5R_M_6.3	Capacitor, 1206
C8	<i>DNM</i>	C_1206	Capacitor, 1206
C1-2;C10-11	4	C_22U_0603_X5R_M_6.3	Capacitor, 0603
C20	<i>DNM</i>	C_VSCM_005R4_155A	EDLC capacitor, 1.5F, 5.4V
D4-5	2	D_SCHOTTKY_PMEG2010ER	Schottky diode, low Vf =.24V @ 200mA
U1	1	FT230XQ	FTDI USB to UART
U5	1	HALL_SL353LT	Hall sensor, low duty cycle, SOT23
U4	1	HDC2010	Temp and humidity sensor
U3	1	LDO_LP38690	Low drop regulator, 3.3V, 1 A, 3x3mm WSON
D2	1	LED_BLUE_0603_2MA	LED 0603 Blue 2mA If
D1	1	LED_GREEN_0603_2MA	LED 0603 Green 2mA If
D3	<i>DNM</i>	LED_YELLOW_0603_2MA	LED 0603 Yellow 2mA If
U7	1	LIS3DE	3 axis accelerometer
S1	1	PUSH_BUTTON_RA	Push button, SMD, Right angled
S2	1	PUSH_BUTTON_SMALL_ELEVATED	Push button, SMD
S3	<i>DNM</i>	PUSH_BUTTON_SMALL_ELEVATED	Push button, SMD
M1	1	RC1882CEF-IPM	
R3-5 ;R11-14 ;R16;R18;R20; R25-27; R32; R33-35;R36; R37- 39;R43;R45-46	22	R_0402	Resistor, 0402, general

R6-10; R15; R17; R19; R24;R29-31; R40-42	15	R_0_0402	Resistor, 0402
R22-23	2	R_0_0603	Resistor, 0603
R28	1	R_10K_0402_G	Resistor, 0402
R1-2	2	R_330_0402_G	Resistor, 0402
R21	1	R_6K2_0402_G	Resistor, 0402
U8	1	SHT35	Temp and humidity sensor
P3	1	SMA_SMD	Surface-mount SMA, straight
T1	1	T_ALS-PT-315C	Phototransistor, ambient light, SMT
P15-16	2	UFL_CONNECTOR	U.FL compatible connector

References

- [1] RIIM Net Controller Quick Start
- [2] RIIM User Manual
- [3] RIIM SDK User Manual
- [4] RIIM SDK Quick Start Guide
- [5] RIIM SDK API reference
- [6] RC1882-IPM Datasheet
- [7] RC18x2HP-IPM Datasheet
- [8] RC188xDB 1.00.zip Schematic and PCB
- [9] RC188xSB 1.00.zip Schematic and PCB
- [10] RC188xSB 2.00.zip Schematic and PCB

Document Revision History

Document Revision	Changes
1.00	First release
1.10	NEW PCB layout on Sensor board. Added VOC sensor Added pullup on SPI_CS Added GPIO powering of light sensor
1.20	Updated to cover RIIM kit with high power modules RC18x2HP

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