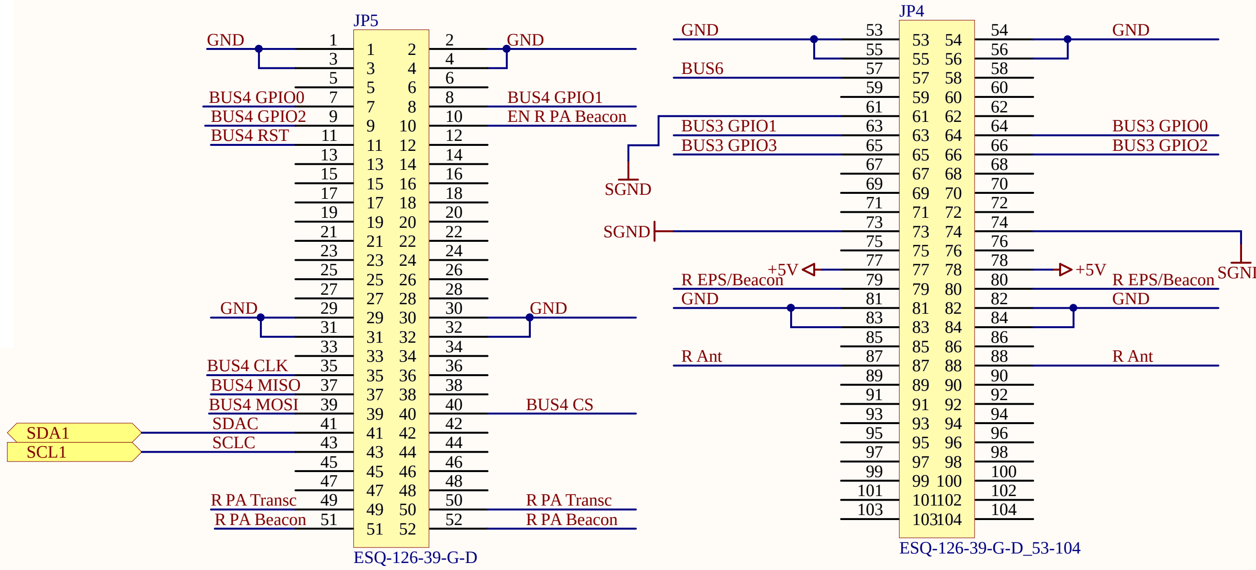
J1 (Inner header)			
RAD_LVDS_MOSI+	1	2	RAD_LVDS_MOSI-
RAD_LVDS_MISO+	3	4	RAD_LVDS_MISO-
GND	5	6	GND
I2C_iADCS_DATA	7	8	I2C_iADCS_CLK
SunS_iADCS_5V	9	10	Reserved for iADCS
*GPS, RXD0, GPIO A0**	11	12	*GPS, TXD0, GPIO A1**
GPS, PPS, GPIOA7	13	14	GPS, XRESET
+12V AaSI	15	16	+5V AaSI
+12V RAD	17	18	+5V RAD
GPS, BOOT SELECT	19	20	GPS, ON/OFF
Reserved	21	22	Reserved
Reserved	23	24	Reserved
GND	25	26	+3.3V EPB
+3.3V OBC	27	28	+12V ADS
Reserved for ADS	29	30	+12V EPB
+5V EPB	31	32	+5V_USB_CHARGING
GND	33	34	GND
AaSI_CLK+	35	36	AaSI_CLK-
AaSI_LVDS_MISO+	37	38	AaSI_LVDS_MISO-
GND	39	40	GND
I2C_PRI DATA	41	42	I2C_PRI DATA
I2C_PRI CLK	43	44	I2C_PRI CLK
UHF_enable1	45	46	UHF_enable2
Reserved for GPS	47	48	Reserved for GPS
Reserved	49	50	Reserved
HDMA	51	52	HDPA

J2 (Outer header)			
Reserved for iADCS	1	2	Reserved for iADCS
Reserved for iADCS	3	4	Reserved for iADCS
OBC_DRXD	5	6	OBC_DTXD
GND	7	8	GND
Sband_CLK	9	10	Sband_enable
Sband_MOSI	11	12	Reserved for Sband
GND	13	14	GND
S-band EN/FS	15	16	S-band READY
S-band V24_DX	17	18	S-band CLK
S-band ADR_0	19	20	S-band ADR_1
S-band EXT_ON	21	22	GND
GND	23	24	+12V
+5V	25	26	+5V
+3.3V	27	28	+3.3V
GND	29	30	GND
GND	31	32	GND
BATT POS	33	34	BATT POS
PCM IN	35	36	PCM IN
DL	37	38	DL
SEP_SW1	39	40	SEP_SW2
BCR OUT	41	42	BCR OUT
BCR OUT	43	44	BCR OUT
VBATT+	45	46	VBATT+
UHF/UHF +12V	47	48	UHF/UHF +12V
UHF_RXD2	49	50	UHF_TXD2
UHF_RXD1	51	52	UHF_TXD1

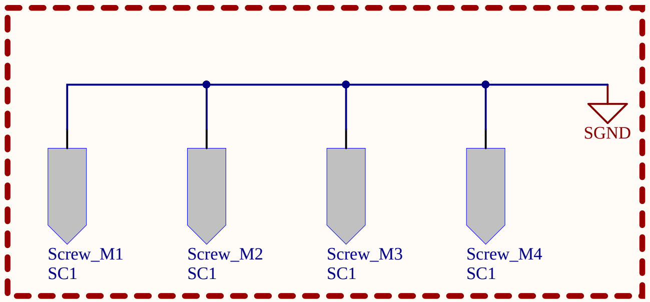
Connectors

PCI/104 Cubesat Bus



We have two PCI-104 connectors of 26x2 pins each. The pins between 1-4, 29-32, 53-56 and 81-84 are connected to ground. The "JP5" connector is exclusively responsible for radio connections, while the "JP4" connector is used for the connection with the microcontroller (MCU). The BUS4 takes care of the radio part, while the BUS3 does the same with the microcontroller. Pins 7, 8 and 9 are controllable (GPIO: general purpose input / output); that is, we can control whether they are used as input or output while it is running. Through pin 10 we introduce a voltage signal to enable the radio module. Pin 11 is the reset of the previously described (BUS4). Pin 35 is the clock of the radio part. Pin 40 is the chip selector (chip select). Pin 37 is the MISO (Master Input Slave Output), which is responsible for receiving the data sent from the microcontroller, while pin 39 is the MOSI (Master Output Slave Input), which does the reverse operation. Pin 41 is the SDAC (Server Data Access Components), which provides our PCB with a direct connection to a database. Pin 43 is the SCLC (Serial Controlled Load Center). On pins 49 and 50 a voltage source is connected to power the transceiver, while on pins 51 and 52 another voltage source is connected to power the radio antenna. At feet 61, 73 and 74 another mass is placed (SGND: Signal Ground). On pin 57 the BUS6 is connected. This bus is not carrying any information. In the pins between 63 and 66 we find the GPIO0-3 of the microcontroller part (BUS3). On pins 77 and 78 a +5 volt supply is introduced. Through pins 79 and 80, we introduce a voltage to the system to power the microcontroller. Pins 87 and 88 are used to power the microcontroller antenna.

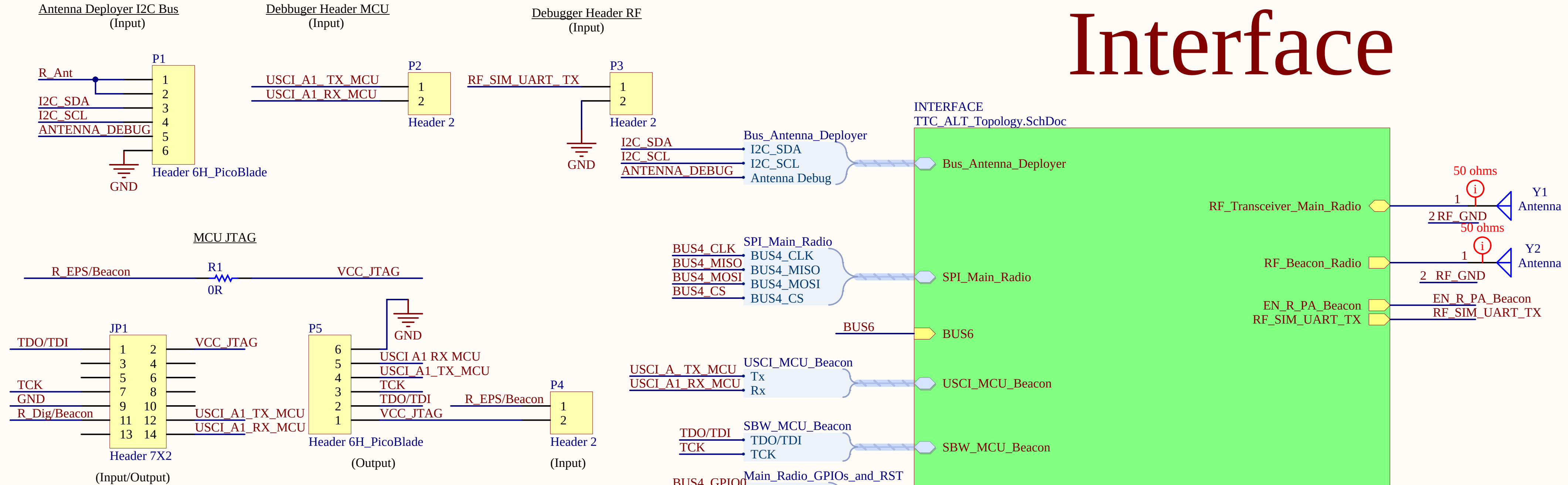
M3 Support Screws

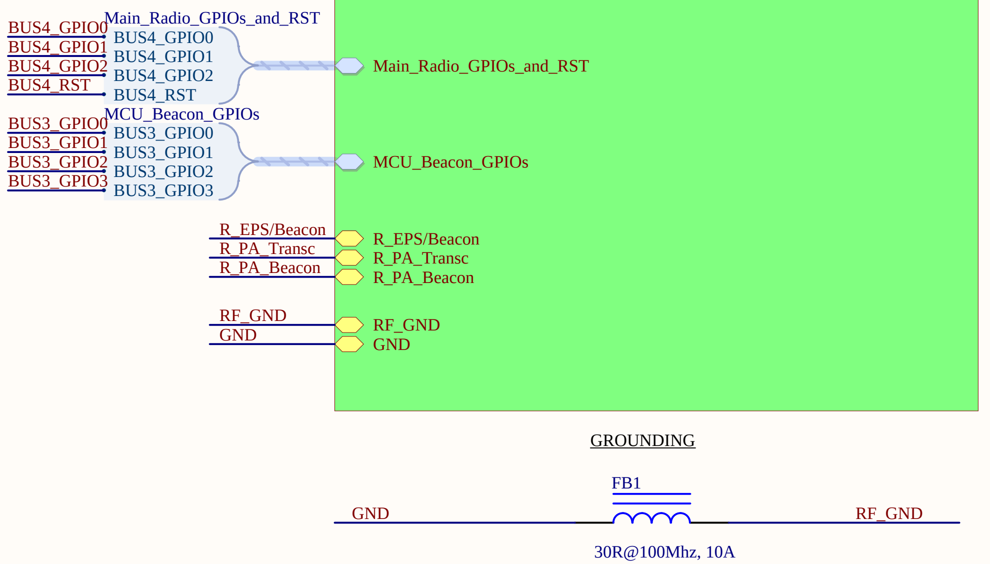


The "Screw_Mx" (with x content between 1 and 4) are referred to the holes found in the corners of the PCB, which are connected to ground. We can appreciate this in the photo attached to the left of this text.

Designer's signature	Sheet title: * **Connectors**			Dpto. Electrónica y Tecnología de Computadores
	Project title: PCB_GranaSat.PrjPcb			University of Granada
Supervisor's signature	Desginer: * Juan Francisco & Antonio			C/ Fuente Nueva, s/n, 18001 Granada, Granada, Spain
	Date: * 15-1-2019	Revision: *v003	Sheet *1 of *11	Sr. Andrés Roldán Aranda

Interface

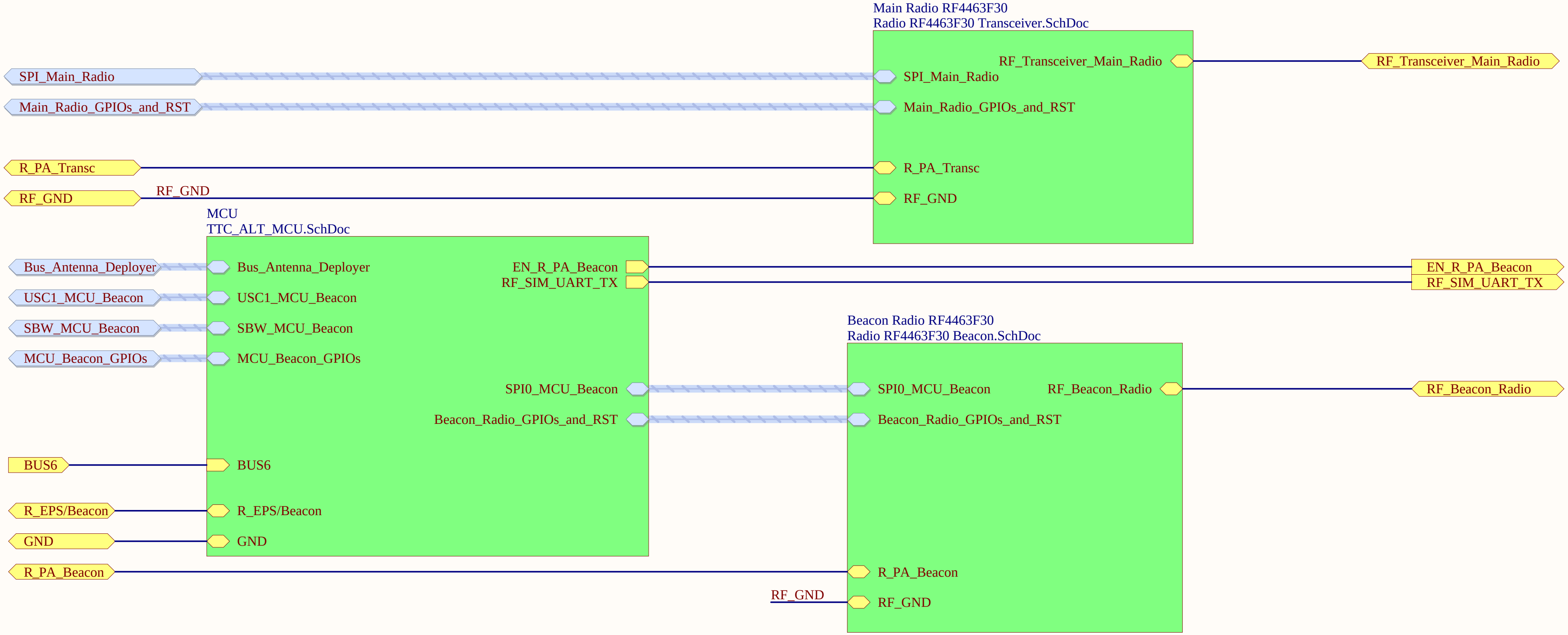




We find different connectors:
--- The P1 connector is 6x1, and it will be used to create an I2C bus (serial data bus) for the microcontroller antenna. On pins 1 and 2 we will connect the power to the microcontroller antenna. Pins 3 and 4 will be used for the data line (SDA) and for the serial clock (SCL), respectively. Pin 5 will be used to perform tests ("debug"). Finally, pin 6 is connected to ground.
--- The P2 connector is 2x1. We will use it to perform tests on the microcontroller ("debug"). For this, we use one pin to transmit data, and another to receive data.
--- The P3 connector is 2x1, and serves to perform tests on the RF module ("debug"). In this case, we will only use one pin to transmit data, while the remaining pin will be connected to ground.
--- The P4 connector is 2x1. In it we introduce the power of the microcontroller in the first pin, and a voltage to perform tests on our PCB ("JTAG") in the second.
--- The P5 connector is 6x1. In the first pin we introduce the same signal as in the second pin of connector P4. On the second pin you can enter a test data entry (TDI), or a test data output (TDO). Pin number 3 corresponds to the test clock. Pins 4 and 5 are used to transmit and receive data to test the microcontroller. Pin 6 is directly connected to ground.
--- The JP1 connector is 7x2. Their connections are the same as those of the P5 connector, with the exception of pin 11, to which we have introduced a power identical to that of "R_EPS / Beacon", which we will use to power the digital part of the microcontroller. This power is the "R_Dig / Beacon".
Connectors P4, P5 and JP1 are used to perform tests on the microcontroller.
A resistor 0R is placed between the power supply signal of the microcontroller and the test power supply ("VCC_JTAG").
We place an inductance between the mass and the RF mass, to avoid that possible current pulls in one adversely affect the other (shock inductance).
The set of all the tracks of the PCB can be seen in this schematic (the green box is representing the set of circuitry referring to the RF module and the microcontroller).
We observe that we have two antennas, adapted to 50 ohms; first one connected to a bidirectional port, and second one to an output port.

Designer's signature	Sheet title: * **TT&C Interface**	*Dpto. Electrónica y Tecnología de Computadores University of Granada C/ Fuente Nueva, s/n, 18001 Granada, Granada, Spain Sr. Andrés Roldán Aranda*
	Project title: **PCB_GranaSat.PrjPcb**	
Supervisor's signature	Desginer: * Juan Francisco & Antonio	
	Date: * 15-1-2019 Revision: * v003 Sheet * 2 of * 11	

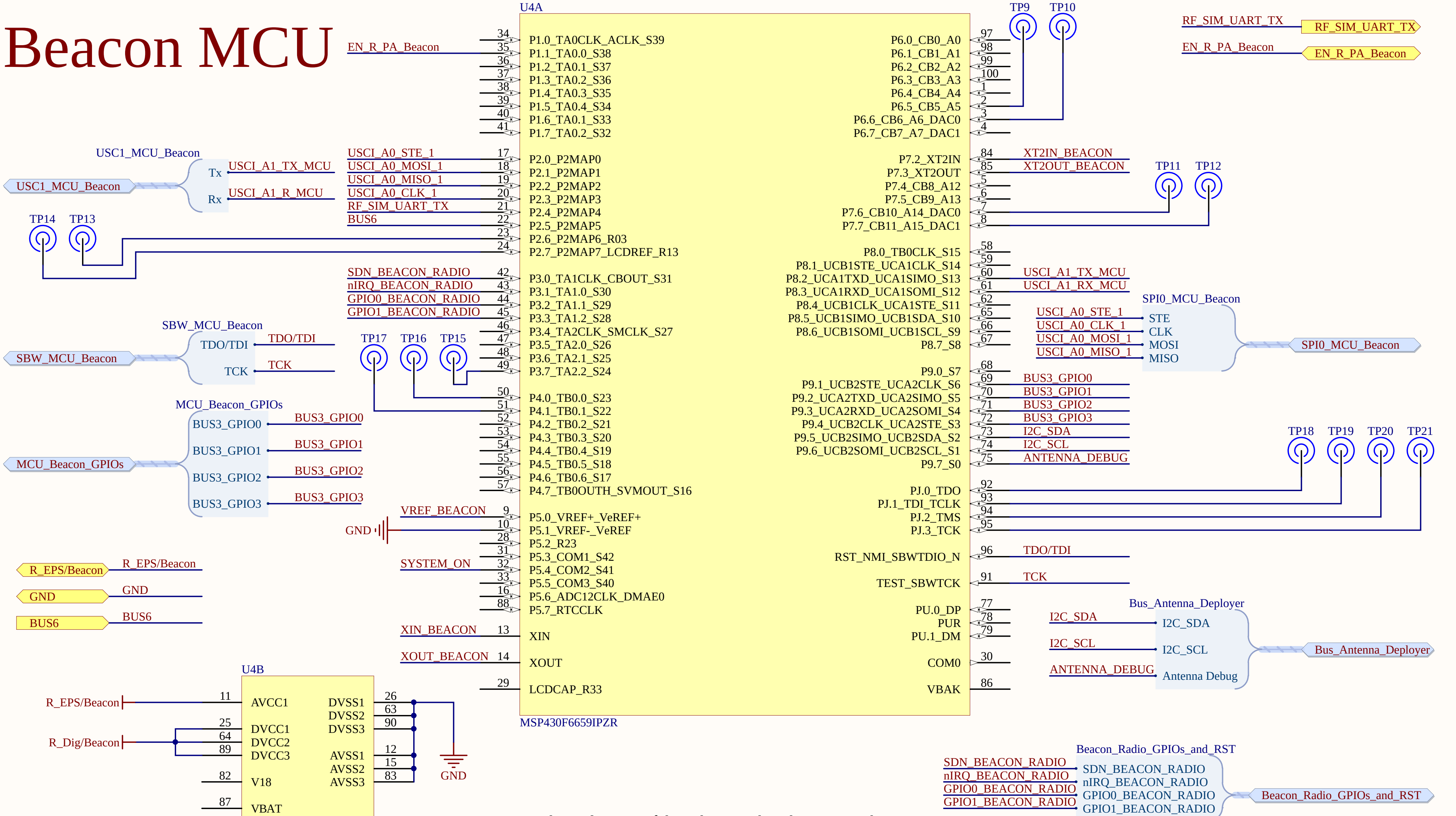
Modules



We observe the microcontroller scheme and the two RF modules that we will use, as well as the connections already explained above. The antenna module ("Beacon") is connected directly to the microcontroller, while the transmitter module ("Transceiver") is not connected to the microcontroller. The following schematics will explain both the microcontroller and the RF modules, as well as the electronics needed to work.

Designer's signature	Sheet title: *TT&C Modules	*Dpto. Electrónica y Tecnología de Computadores*
Supervisor's signature	Project title: PCB_GranaSat.PrjPcb	*University of Granada*
	Desgner: *Juan Francisco & Antonio	*C/ Fuente Nueva, s/n, 18001*
	Date: *15-1-2019 Revision: *v003 Sheet *3 of *11	*Granada, Granada, Spain* *Sr. Andrés Roldán Aranda*

Beacon MCU



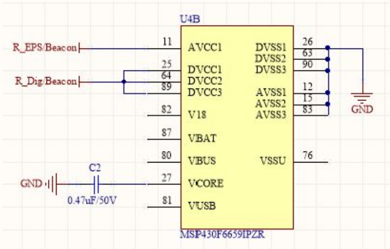
You can see the explanation of this scheme in the schematic number 5.

Designer's signature	Sheet title: * **TT&C MCU**		Dpto. Electrónica y Tecnología de Computadores University of Granada C/ Fuente Nueva, s/n, 18001 Granada, Granada, Spain Sr. Andrés Roldán Aranda
	Project title: **PCB_GranaSat.PrjPcb**		
Supervisor's signature	Desginer: * Juan Francisco & Antonio		
	Date: * 15-1-2019	Revision: * v003	Sheet *4 of *11

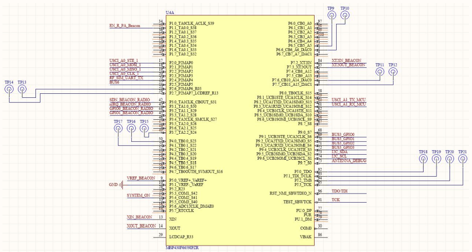
Beacon MCU: Explanation

In the previous schematic we can see the microcontroller that uses our PCB, which is the MSP430F6659IPZR. It consists of 100 pins, of which 74 are input / output (I / O), 4 16-bit timers, a 12-bit high-performance analog-digital converter, a hardware multiplier, a RTC (Real Time Clock) module , a comparator, a USB 2.0, three USCIs (Universal serial communication interface) and a DMA (Direct memory access).
Our schematic is divided into two parts: the signals that enter and leave the microcontroller, and the microcontroller scheme, which in turn is divided into two parts: the part of signal processing and the power part of the microcontroller.

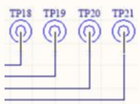
We will comment first on this second part of the microcontroller. In it we can see the introduction of a voltage supply on pins 11, 25, 64 and 89. Pin 11 is the pin that provides the analog power. Pins 25, 64 and 89 are the pins that provide digital power. On the other hand, we have ground connection in different pins: 12, 15, 26, 27, 63, 83 and 90. Pins 26, 63 and 90 are pins used to provide mass to the digital part. Pins 12, 15 and 83 provide mass to the analog part. Pin 27 is a regulated internal power source. A 0.47 microfarad capacitor is connected between said pin and ground to prevent the microcontroller from running out of this voltage at any time (as a reserve of energy).



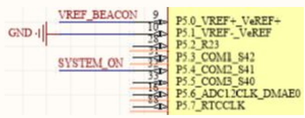
Now we will proceed to comment on the part of the microcontroller that remains. Practically all the pins that we will use are input / output pins (communication in both directions); however, there are a few pins that are unidirectional.



Now we will proceed to comment the bidirectional terminals (I / O, they are sent and receive data by the same pin). Our design contains a series of Test Points on pins 2, 3, 7, 8, 23, 24, 49, 50, 51, 92, 93, 94 and 95.



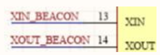
Pin 9 is used as input to an external voltage reference . Pin 10 is the negative terminal of the previous pin, and is connected directly to ground. Terminal 32 is used to power a red LED that we will see in later diagrams.

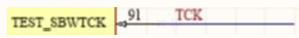


On pin 35 we are introducing a signal that enables the radio module. Pins 17, 18, 19 and 20 are used for communication between the microcontroller and the radio module. Pin 17 is responsible for the "slave transmit enable": this pin is used to enable a slave and proceed to data transmission and receive operations. Pin 18 is the "Master Output Slave Input"; that is, data output from the master and data entry to the slave. Pin 19 is the "Master Input Slave Output"; Data entry to the master and data output of the slave. Pin 20 is the pulse that marks the synchronization (the clock).The next pin to analyze is 21, which transmits data to the radio module. Pin 22 is connected to a bus, BUS6, which is not in use in our design, but could be used as a receiver pin for data coming from the radio module.

The next set of 4 pins we find are 42, 43, 44 and 45, which are connected to the receiving part of the radio module, and its functions are to turn off the radio module (shutdown) (SDN), create one interruption (nIRQ) and the one of transmission of data of general use (GPIO0 and GPIO1).
In terminals 60 and 61 we have the tracks by which data is transmitted and received to and from the radio module.
The pins included between 69 and 72 are temporary general purpose input and output, which are used so that the user can obtain information from the microcontroller externally (through the previously mentioned connectors). Pins 73, 74 and 75 are used for the antenna deployment: they are the "Serial Data", the "Serial Clock", and a third terminal to perform tests on the antenna. Terminals 84 and 85 are analogous to pins 13 and 14, only in this case they are connected to the 4 MHz ceramic resonator, and they are also input / output terminals. Pin 96 is a terminal used for input and output of test data.

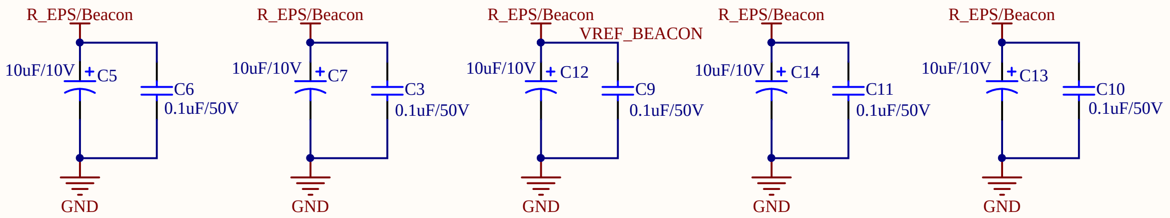
Those are the unidirectional pins. First of them is pin 13. It is an input terminal for the 32'768 kHz crystal oscillator that we will use in our design. Pin 14 is the output terminal for the same oscillator. The last pin that communicates unidirectionally is 91. It is an input terminal which can have two different uses: to be used as a test pin (select inputs and / or digital outputs on the JTAG pins), or as a clock of Spy-By-Wire entry.
Spy-By-Wire is a protocol that Texas Instruments developed for the model of microcontroller that we are using, in which two connections are used instead of the 4 pins that are usually used for the JTAG interface. In this pin we are going to introduce the signal of the test clock (TCK) of the JTAG protocol.





Designer's signature	Sheet title: *TT&C MCU Explanation			Dpto. Electrónica y Tecnología de Computadores University of Granada C/ Fuente Nueva, s/n, 18001 Granada, Granada, Spain Sr. Andrés Roldán Aranda
	Project title: PCB_GranaSat.PrjPcb			
Supervisor's signature	Desginer: *Juan Francisco & Antonio			
	Date: *15-1-2019	Revision: *v003	Sheet *5 of *11	

Decoupling Capacitors



In this schematic can be seen the decoupling capacitors that are used in the design. These capacitors are used to decouple the alternating current signals from the DC signals, and thus eliminate possible noises.
We use 10 uF capacitors in parallel with 0.1 uF capacitors to work in the entire frequency range we need. The impedance of a capacitor is decreasing, but at a certain frequency, the frequency starts to increase; that is, for a given frequency, a capacitor behaves like an inductor. Therefore, to have a capacitive behavior in all frequency ranges, we use small capacitors placed in parallel with capacitors of greater capacity.

Designer's signature

Supervisor's signature

Sheet title: ***MCU Decoupling Capacitors**

Project title: **PCB_GranaSat.PrjPcb**

Desginer: *Juan Francisco & Antonio

Date: *15-1-2019 Revision: *v003 Sheet *6 of *11

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Granada, Granada, Spain
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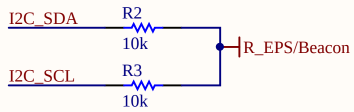
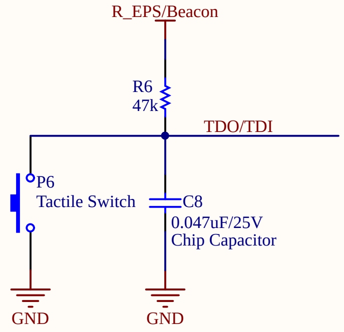
Pull-Up Resistors



We can see two pullup resistors. They are placed between the third and fourth pin of the P1 connector, and R_EPS/Beacon signal. We have done this in order to avoid wrong readings in case that we do not have nothing connected to our connector.

Designer's signature	Sheet title: *MCU Pull-Up Resistors	*Dpto. Electrónica y Tecnología de Computadores* *University of Granada* *C/ Fuente Nueva, s/n, 18001* *Granada, Granada, Spain* *Sr. Andrés Roldán Aranda*
	Project title: PCB_GranaSat.PrjPcb	
Supervisor's signature	Desginer: * Juan Francisco & Antonio	
	Date: * 15-1-2019 Revision: * v003 Sheet *7 of *11	

Reset



The reset system has a switch, a 47k resistor and a 47 nF capacitor. This reset affects to TDO via, which comes from the JP1 connector. Its voltage is provided by the R_EPS/Beacon signal.

Designer's signature	Sheet title: *MCU Reset	*Dpto. Electrónica y Tecnología de Computadores*
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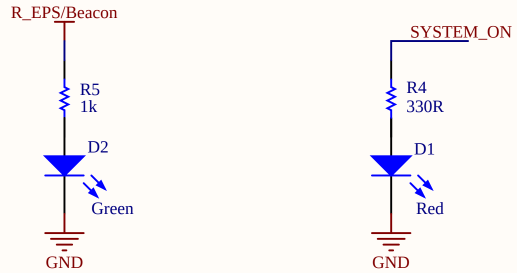
Supervisor's signature	Desginer: *Juan Francisco & Antonio	*C/ Fuente Nueva, s/n, 18001*
	Date: *15-1-2019 Revision: *v003 Sheet *8 of *11	*Granada, Granada, Spain* *Sr. Andrés Roldán Aranda*

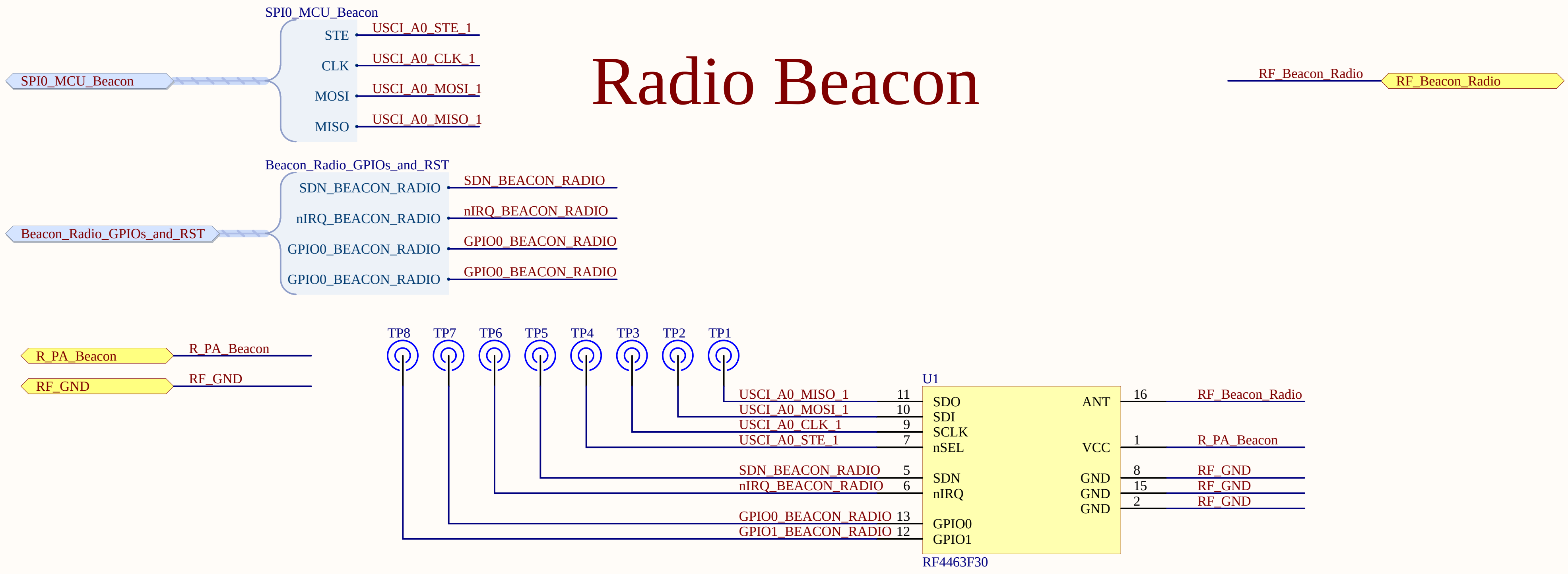
Leds System



Our leds system has two leds: one green, connected to a 1k resistor, and with the R_EPS/Beacon alimentation. The other led is red, and is connected to a 330 ohms resistor and to the SYSTEM_ON signal. When our system is not receiving any signal, the red led will shine. If we have signal, then this will turn off, and the green one will shine.

Designer's signature	Sheet title: * **TT&C Leds System**	*Dpto. Electrónica y Tecnología de Computadores*
	Project title: **PCB_GranaSat.PrjPcb**	*University of Granada*
Supervisor's signature	Desginer: * Juan Francisco & Antonio	*C/ Fuente Nueva, s/n, 18001*
	Date: * 15-1-2019 Revision: * v003 Sheet *9 of *11	*Granada, Granada, Spain*
		Sr. Andrés Roldán Aranda

Radio Beacon



This is the radio beacon schematic. We are using a RF4463F30 module. Different signals can be seen (two signal harnesses). Those different signals are ruted to different test points.
The pin number one is the positive power supple, where we introduce R_PA_Beacon signal. Pins number 2, 8 and 15 are connected to the RF ground. Pin number 5 is the power down control. If its value is 1, the power will go down; if it is 0, we will have normal working. The pin number 6 is the interruptor output. Pin number 7 is the serial data selection for SPI interfaces. Pin number 9 is the serial data clock. Pin number 10 is serial data input, and pin number 11 is serial data output. Pins 12 and 13 are just general purpose inputs and outputs pins. Pin number 16 is a 50 ohm antenna.

Designer's signature	Sheet title: * TT&C Radio Beacon
Supervisor's signature	Project title: PCB_GranaSat.PrjPcb
	Desginer: * Juan Francisco & Antonio
	Date: * 15-1-2019 · Revision: * v003 · Sheet * 10 of * 11

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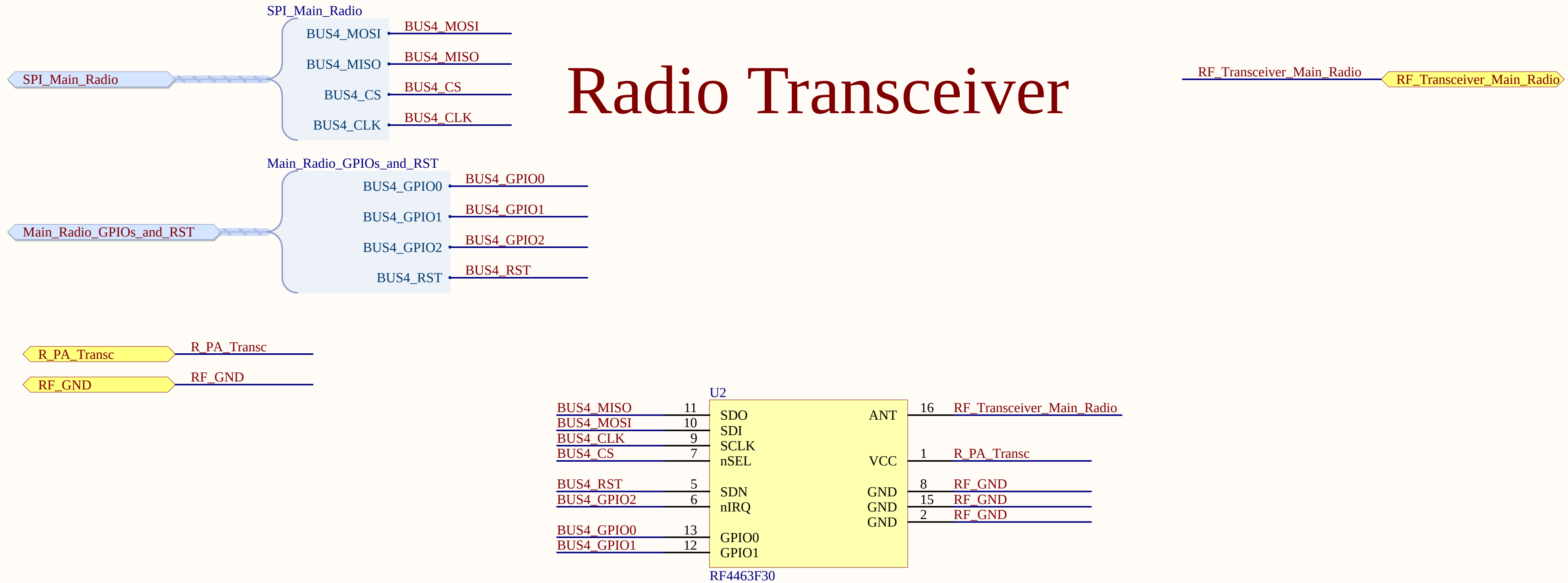
Radio Transceiver



This is the transceiver schematic. We will use another RF4463F30 module. The pin number one is the positive power supple, where we introduce R_PA_Beacon signal. Pins number 2, 8 and 15 are connected to the RF ground. Pin number 5 is the power down control. If its value is 1, the power will go down; if it is 0, we will have normal working. The pin number 6 is the interruptor output. Pin number 7 is the serial data selection for SPI interfaces. Pin number 9 is the serial data clock. Pin number 10 is serial data input, and pin number 11 is serial data output. Pins 12 and 13 are just general purpose inputs and outputs pins. Pin number 16 is a 50 ohm antenna.

Designer's signature

Supervisor's signature

Sheet title: *TT&C Radio Transceiver

Project title: PCB_GranaSat.PrjPcb

Desginer: * Juan Francisco & Antonio

Date: * 15-1-2019 | Revision: * v003 | Sheet *11 of *11

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