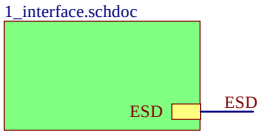
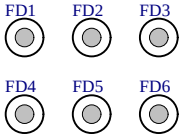
Rev	Description	Date	Author
0.1	- Initial release	01-Apr-2021	Andre M. P. Mattos

Revision History

PCB



FIDUTIALS



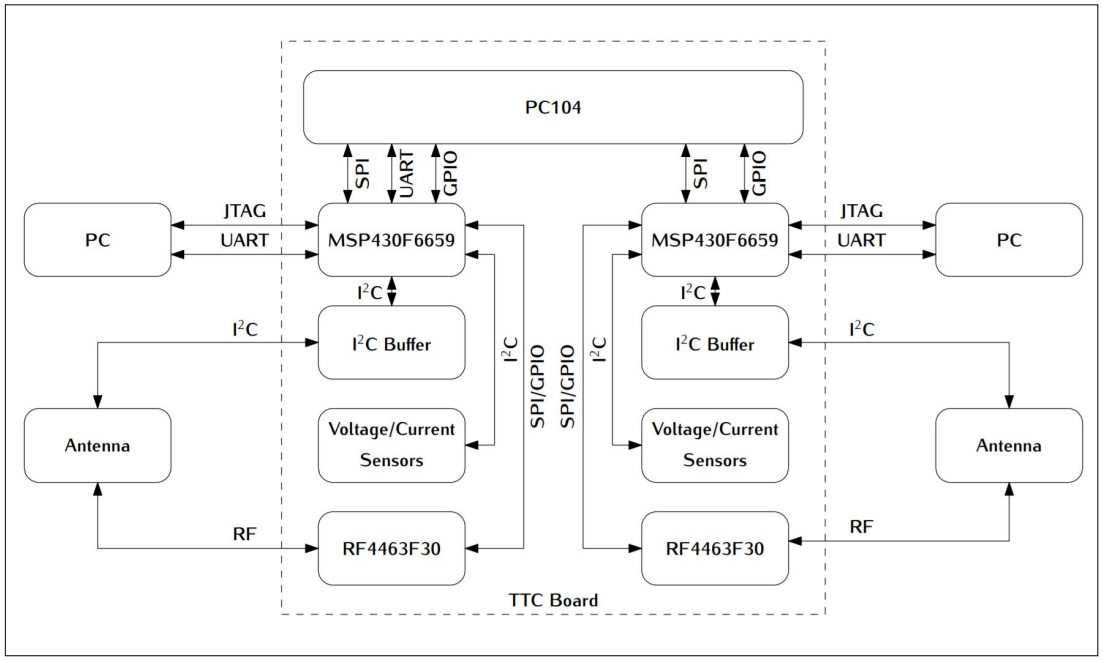
MECHANICAL HOLES

PCB Elements

TTC2 Hardware:

- Drawn by: André M. P. Mattos
- Reviewers: Yan C. Azeredo
- Based on FloripaSat-I TTC designed by: Sara V. Martinez
- Support: Gabriel M. Marcelino

Project Contributions

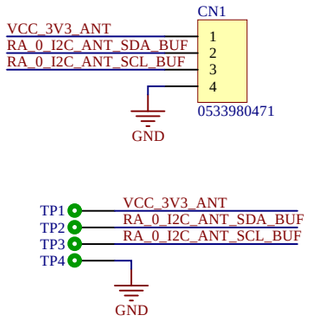


Block Diagram

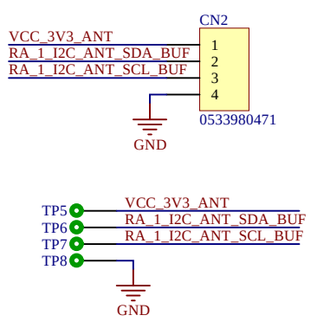
Project Information

SpaceLab - Federal University of Santa Catarina			
Project: *ttc2_project.prjpcb / [No Variations]*			
Title: *Hardware Archictecture*			
Designed by: *André M. P. Mattos*			Project Code: *TTC2*
Date: 24/04/2021	Revision: *v0.1*	Sheet *0* of *6*	Size: A4

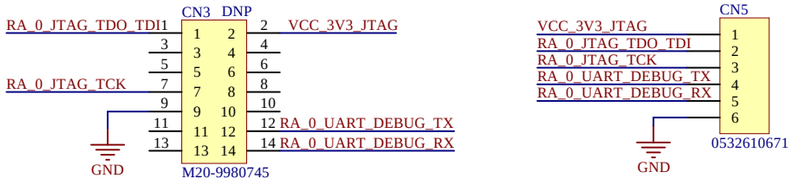
ANTENNA DEPLOYER INTERFACE (RADIO_0)
Picoblade Connector and debug testpoints



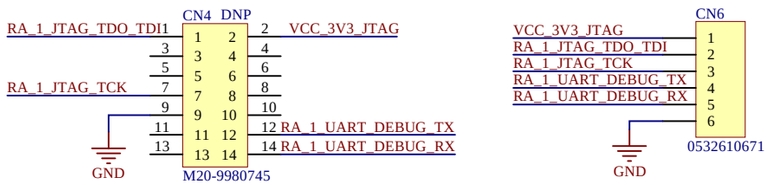
ANTENNA DEPLOYER INTERFACE (RADIO_1)



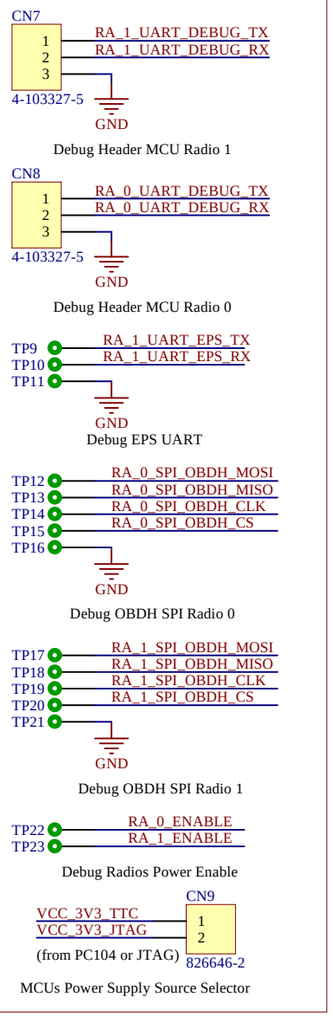
PROGRAMMING HEADERS MCU RADIO 0
(JTAG Spy Bi-Wire)



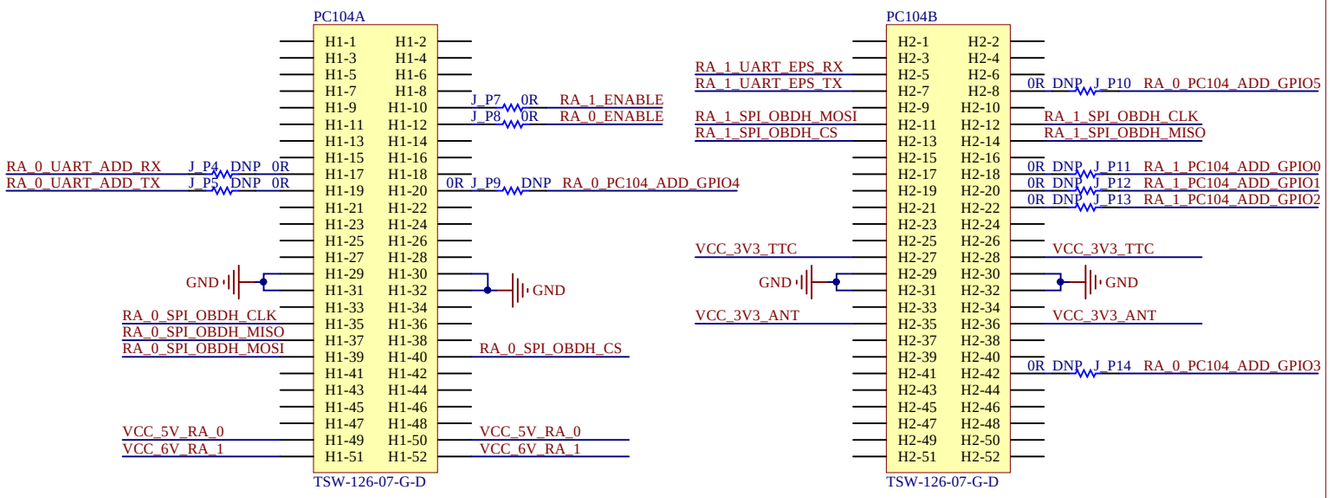
PROGRAMMING HEADERS MCU RADIO 1
(JTAG Spy Bi-Wire)

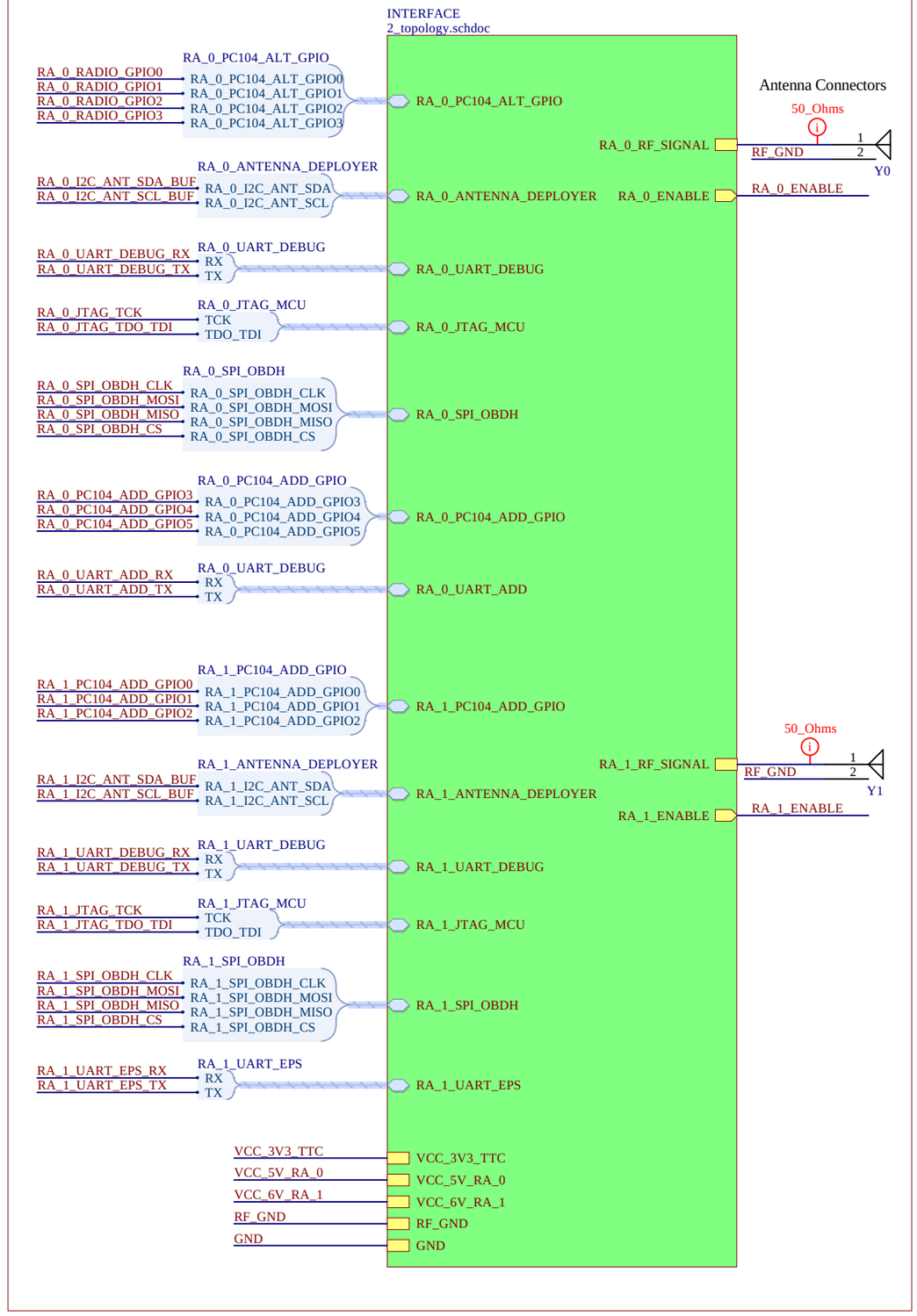


DEBUG HEADERS AND TESTPOINTS



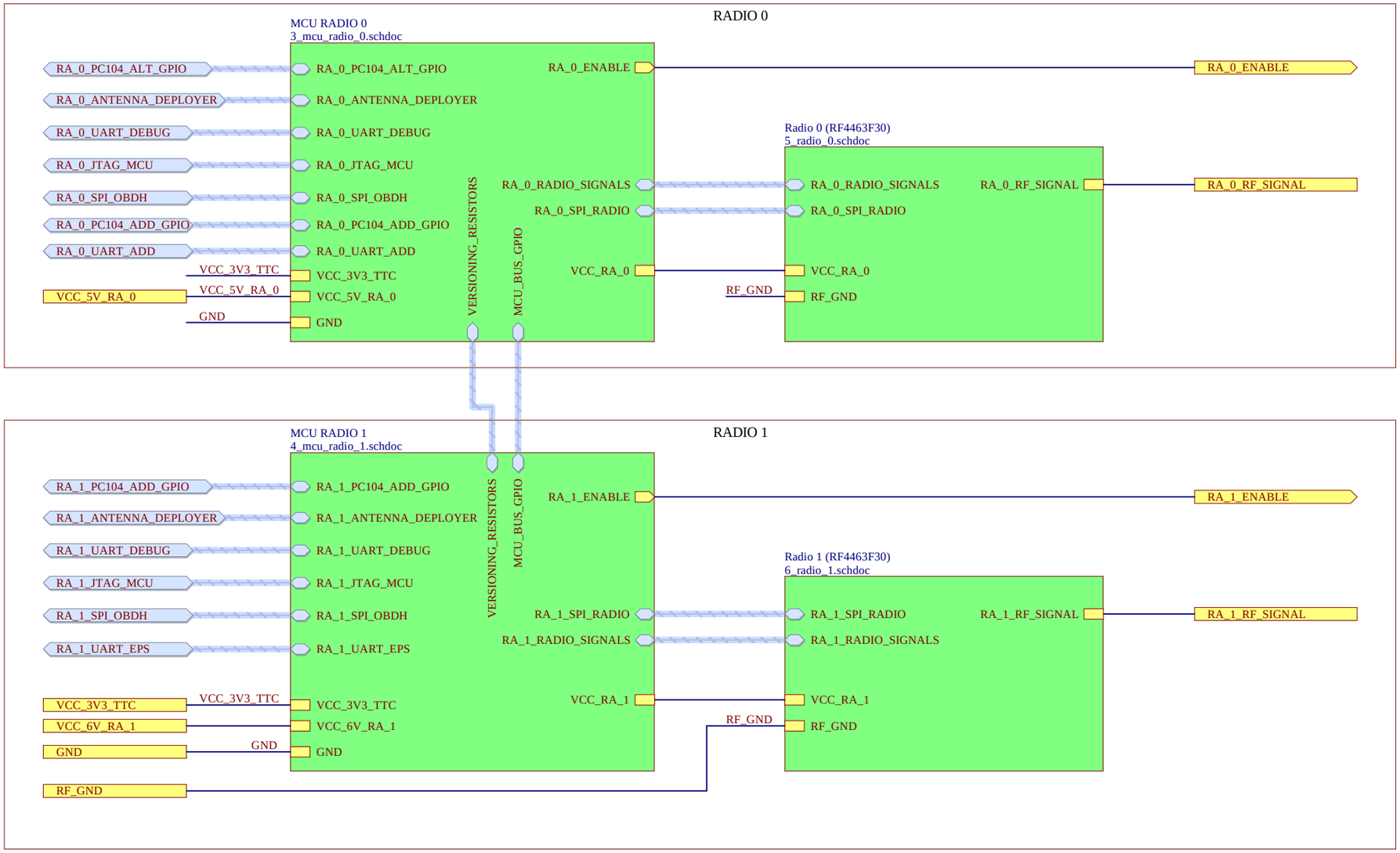
PC104 INTERFACE



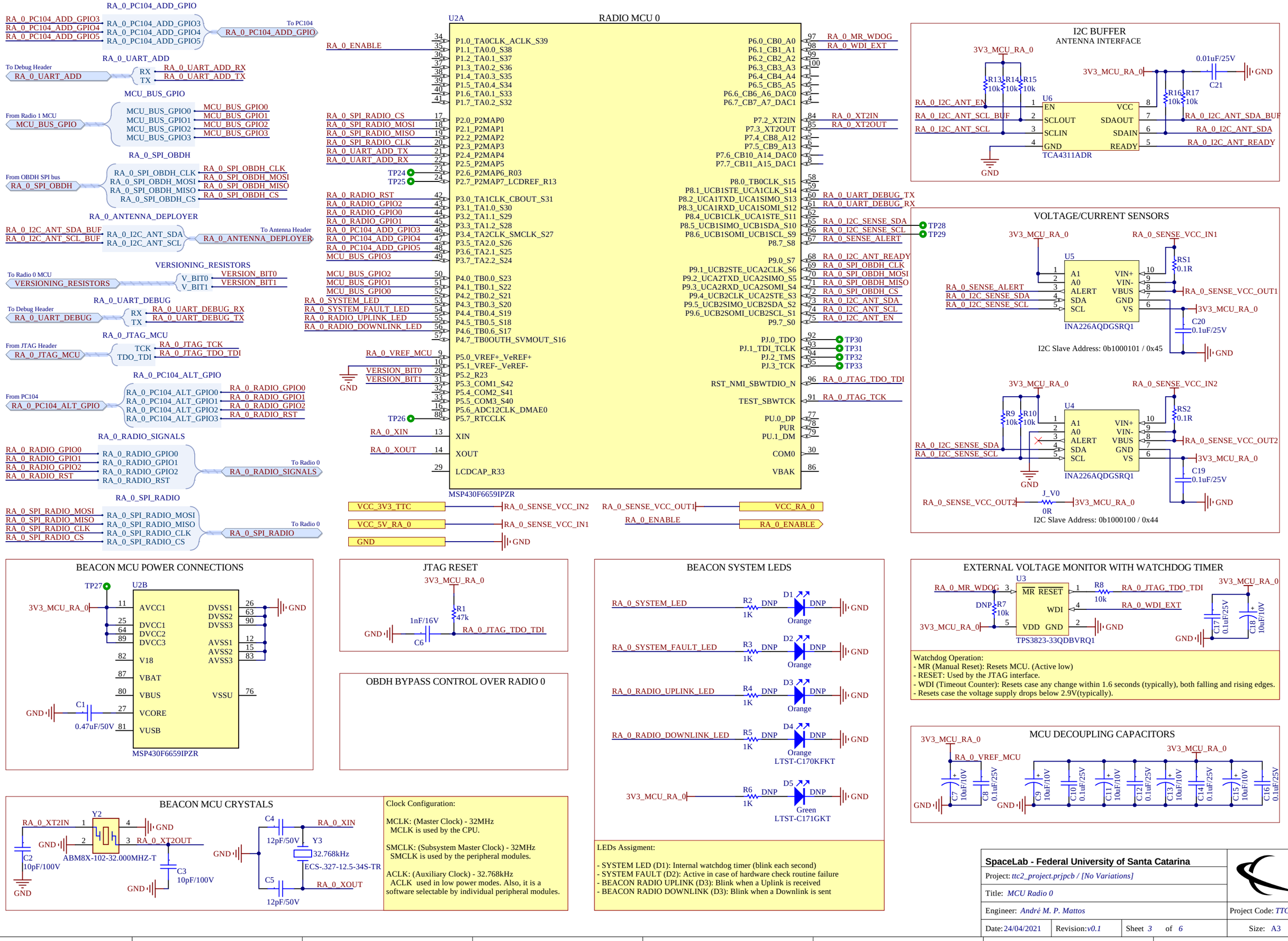


GROUNDING

SpaceLab - Federal University of Santa Catarina			
Project: *ttc2_project.prjpcb / [No Variations]*			
Title: *Interface*			
Engineer: *André M. P. Mattos*			Project Code: *TTC2*
Date: 24/04/2021	Revision: *v0.1*	Sheet *1* of *6*	Size: A3



SpaceLab - Federal University of Santa Catarina			
Project: *ttc2_project.prjpcb / [No Variations]*			
Title: *Topology*			
Engineer: *André M. P. Mattos*			Project Code: *TTC2*
Date: 24/04/2021	Revision: *v0.1*	Sheet *2* of *6*	Size: A3


RADIO MCU 0
U2A
MSP430F6659IPZR
RA_0_PC104_ADD_GPIO
RA_0_UART_ADD
MCU_BUS_GPIO
RA_0_SPI_OBDH
RA_0_ANTENNA_DEPLOYER
VERSIONING_RESISTORS
RA_0_UART_DEBUG
RA_0_JTAG_MCU
RA_0_PC104_ALT_GPIO
RA_0_RADIO_SIGNALS
RA_0_SPI_RADIO
To PC104
To Radio 0
To Antenna Header
From Radio 1 MCU
From OBDH SPI bus
From JTAG Header
From PC104
To Debug Header
I2C BUFFER
ANTENNA INTERFACE
VOLTAGE/CURRENT SENSORS
I2C Slave Address: 0b1000101 / 0x45
I2C Slave Address: 0b1000100 / 0x44
BEACON MCU POWER CONNECTIONS
JTAG RESET
OBDH BYPASS CONTROL OVER RADIO 0
BEACON SYSTEM LEDS
EXTERNAL VOLTAGE MONITOR WITH WATCHDOG TIMER
Watchdog Operation:
- MR (Manual Reset): Resets MCU. (Active low)
- RESET: Used by the JTAG interface.
- WDI (Timeout Counter): Resets case any change within 1.6 seconds (typically), both falling and rising edges.
- Resets case the voltage supply drops below 2.9V(typically).
MCU DECOUPLING CAPACITORS
BEACON MCU CRYSTALS
Clock Configuration:
MCLK: (Master Clock) - 32MHz
MCLK is used by the CPU.
SMCLK: (Subsystem Master Clock) - 32MHz
SMCLK is used by the peripheral modules.
ACLK: (Auxiliary Clock) - 32.768kHz
ACLK used in low power modes. Also, it is a software selectable by individual peripheral modules.
LEDs Assigment:
- SYSTEM LED (D1): Internal watchdog timer (blink each second)
- SYSTEM FAULT (D2): Active in case of hardware check routine failure
- BEACON RADIO UPLINK (D3): Blink when a Uplink is received
- BEACON RADIO DOWNLINK (D3): Blink when a Downlink is sent
SpaceLab - Federal University of Santa Catarina
Project: ttc2_project.prjpcb / [No Variations]
Title: MCU Radio 0
Engineer: André M. P. Mattos
Project Code: TTC2
Date: 24/04/2021
Revision: v0.1
Sheet 3 of 6
Size: A3

RADIO MCU 1

U7A — MSP430F6659IPZR

P1.0_TA0CLK_ACLK_S39 (34)
P1.1_TA0.0_S38 (35)
P1.2_TA0.1_S37 (36)
P1.3_TA0.2_S36 (37)
P1.4_TA0.3_S35 (38)
P1.5_TA0.4_S34 (39)
P1.6_TA0.1_S33 (40)
P1.7_TA0.2_S32 (41)
P2.0_P2MAP0 (17)
P2.1_P2MAP1 (18)
P2.2_P2MAP2 (19)
P2.3_P2MAP3 (20)
P2.4_P2MAP4 (21)
P2.5_P2MAP5 (22)
P2.6_P2MAP6_R03 (23)
P2.7_P2MAP7_LCDREF_R13 (24)
P3.0_TA1CLK_CBOUT_S31 (42)
P3.1_TA1.0_S30 (43)
P3.2_TA1.1_S29 (44)
P3.3_TA1.2_S28 (45)
P3.4_TA2CLK_SMCLK_S27 (46)
P3.5_TA2.0_S26 (47)
P3.6_TA2.1_S25 (48)
P3.7_TA2.2_S24 (49)
P4.0_TB0.0_S23 (50)
P4.1_TB0.1_S22 (51)
P4.2_TB0.2_S21 (52)
P4.3_TB0.3_S20 (53)
P4.4_TB0.4_S19 (54)
P4.5_TB0.5_S18 (55)
P4.6_TB0.6_S17 (56)
P4.7_TB0OUTH_SVMOUT_S16 (57)
P5.0_VREF+_VeREF+ (9)
P5.1_VREF-_VeREF- (10)
P5.2_R23 (28)
P5.3_COM1_S42 (31)
P5.4_COM2_S41 (32)
P5.5_COM3_S40 (33)
P5.6_ADC12CLK_DMAE0 (16)
P5.7_RTCCLK (88)
XIN (13)
XOUT (14)
LCDCAP_R33 (29)
P6.0_CB0_A0 (97)
P6.1_CB1_A1 (98)
P6.2_CB2_A2 (99)
P6.3_CB3_A3 (100)
P6.4_CB4_A4 (1)
P6.5_CB5_A5 (2)
P6.6_CB6_A6_DAC0 (3)
P6.7_CB7_A7_DAC1 (4)
P7.2_XT2IN (84)
P7.3_XT2OUT (85)
P7.4_CB8_A12 (5)
P7.5_CB9_A13 (6)
P7.6_CB10_A14_DAC0 (7)
P7.7_CB11_A15_DAC1 (8)
P8.0_TB0CLK_S15 (58)
P8.1_UCB1STE_UCA1CLK_S14 (59)
P8.2_UCA1TXD_UCA1SIMO_S13 (60)
P8.3_UCA1RXD_UCA1SOMI_S12 (61)
P8.4_UCB1CLK_UCA1STE_S11 (62)
P8.5_UCB1SIMO_UCB1SDA_S10 (65)
P8.6_UCB1SOMI_UCB1SCL_S9 (66)
P8.7_S8 (67)
P9.0_S7 (68)
P9.1_UCB2STE_UCA2CLK_S6 (69)
P9.2_UCA2TXD_UCA2SIMO_S5 (70)
P9.3_UCA2RXD_UCA2SOMI_S4 (71)
P9.4_UCB2CLK_UCA2STE_S3 (72)
P9.5_UCB2SIMO_UCB2SDA_S2 (73)
P9.6_UCB2SOMI_UCB2SCL_S1 (74)
P9.7_S0 (75)
PJ.0_TDO (92)
PJ.1_TDI_TCLK (93)
PJ.2_TMS (94)
PJ.3_TCK (95)
RST_NMI_SBWTDIO_N (96)
TEST_SBWTCK (91)
PU.0_DP (77)
PUR (78)
PU.1_DM (79)
COM0 (30)
VBAK (86)

RA_1_ENABLE
RA_1_SPI_RADIO_CS
RA_1_SPI_RADIO_MOSI
RA_1_SPI_RADIO_MISO
RA_1_SPI_RADIO_CLK
RA_1_UART_EPS_TX
RA_1_UART_EPS_RX
TP34
TP35
RA_1_RADIO_RST
RA_1_RADIO_GPIO2
RA_1_RADIO_GPIO0
RA_1_RADIO_GPIO1
RA_1_PC104_ADD_GPIO2
RA_1_PC104_ADD_GPIO1
RA_1_PC104_ADD_GPIO0
RA_1_SYSTEM_LED
RA_1_SYSTEM_FAULT_LED
RA_1_RADIO_UPLINK_LED
RA_1_RADIO_DOWNLINK_LED
RA_1_VREF_MCU
GND
VERSION_BIT0
VERSION_BIT1
TP36
RA_1_XIN
RA_1_XOUT
RA_1_MR_WDOG
RA_1_WDI_EXT
MCU_BUS_GPIO0
MCU_BUS_GPIO1
MCU_BUS_GPIO2
MCU_BUS_GPIO3
RA_1_XT2IN
RA_1_XT2OUT
RA_1_UART_DEBUG_TX
RA_1_UART_DEBUG_RX
RA_1_I2C_SENSE_SDA
RA_1_I2C_SENSE_SCL
RA_1_SENSE_ALERT
TP38
TP39
RA_1_I2C_ANT_READY
RA_1_SPI_OBDH_CLK
RA_1_SPI_OBDH_MOSI
RA_1_SPI_OBDH_MISO
RA_1_SPI_OBDH_CS
RA_1_I2C_ANT_SDA
RA_1_I2C_ANT_EN
RA_1_I2C_ANT_SCL
RA_1_UART_EPS_RX
RA_1_UART_EPS_TX
RA_1_I2C_ANT_EN
TP40
TP41
TP42
TP43
RA_1_JTAG_TDO_TDI
RA_1_JTAG_TCK

RA_1_PC104_ADD_GPIO

RA_1_PC104_ADD_GPIO0
RA_1_PC104_ADD_GPIO1
RA_1_PC104_ADD_GPIO2
RA_1_PC104_ADD_GPIO0
RA_1_PC104_ADD_GPIO1
RA_1_PC104_ADD_GPIO2
To PC104
RA_1_PC104_ADD_GPIO

MCU_BUS_GPIO

From Radio 0 MCU
MCU_BUS_GPIO
MCU_BUS_GPIO0
MCU_BUS_GPIO1
MCU_BUS_GPIO2
MCU_BUS_GPIO3
MCU_BUS_GPIO0
MCU_BUS_GPIO1
MCU_BUS_GPIO2
MCU_BUS_GPIO3

RA_1_SPI_OBDH

From OBDH SPI bus
RA_1_SPI_OBDH
RA_1_SPI_OBDH_CLK
RA_1_SPI_OBDH_MOSI
RA_1_SPI_OBDH_MISO
RA_1_SPI_OBDH_CS
RA_1_SPI_OBDH_CLK
RA_1_SPI_OBDH_MOSI
RA_1_SPI_OBDH_MISO
RA_1_SPI_OBDH_CS

VERSIONING_RESISTORS

To Radio 0 MCU
VERSIONING_RESISTORS
V_BIT0
V_BIT1
VERSION_BIT0
VERSION_BIT1

RA_1_ANTENNA_DEPLOYER

RA_1_I2C_ANT_SDA_BUF
RA_1_I2C_ANT_SCL_BUF
RA_1_I2C_ANT_SDA
RA_1_I2C_ANT_SCL
To Antenna Header
RA_1_ANTENNA_DEPLOYER

RA_1_UART_EPS

To EPS (through PC104)
RA_1_UART_EPS
RX
TX
RA_1_UART_EPS_RX
RA_1_UART_EPS_TX

RA_1_UART_DEBUG

To Debug Header
RA_1_UART_DEBUG
RX
TX
RA_1_UART_DEBUG_RX
RA_1_UART_DEBUG_TX

RA_1_JTAG_MCU

From JTAG Header
RA_1_JTAG_MCU
TCK
TDO_TDI
RA_1_JTAG_TCK
RA_1_JTAG_TDO_TDI

RA_1_RADIO_SIGNALS

RA_1_RADIO_GPIO0
RA_1_RADIO_GPIO1
RA_1_RADIO_GPIO2
RA_1_RADIO_RST
RA_1_RADIO_GPIO0
RA_1_RADIO_GPIO1
RA_1_RADIO_GPIO2
RA_1_RADIO_RST
To Radio 1
RA_1_RADIO_SIGNALS

RA_1_SPI_RADIO

RA_1_SPI_RADIO_MOSI
RA_1_SPI_RADIO_MISO
RA_1_SPI_RADIO_CLK
RA_1_SPI_RADIO_CS
RA_1_SPI_RADIO_MOSI
RA_1_SPI_RADIO_MISO
RA_1_SPI_RADIO_CLK
RA_1_SPI_RADIO_CS
To Radio 1
RA_1_SPI_RADIO

VCC_3V3_TTC — RA_1_SENSE_VCC_IN2
VCC_6V_RA_1 — RA_1_SENSE_VCC_IN1
GND — GND
RA_1_SENSE_VCC_OUT1 — VCC_RA_1
RA_1_ENABLE — RA_1_ENABLE

I2C BUFFER
ANTENNA INTERFACE

3V3_MCU_RA_1
R30 10k, R31 10k, R32 10k
0.01uF/25V
C50
GND
R33 10k, R34 10k
U11
EN, SCLOUT, SCLIN, GND, VCC, SDAOUT, SDAIN, READY
TCA4311ADR
RA_1_I2C_ANT_EN
RA_1_I2C_ANT_SCL_BUF
RA_1_I2C_ANT_SCL
RA_1_I2C_ANT_SDA_BUF
RA_1_I2C_ANT_SDA
RA_1_I2C_ANT_READY

VOLTAGE/CURRENT SENSORS

3V3_MCU_RA_1
RA_1_SENSE_VCC_IN1
U10
A1, A0, ALERT, SDA, SCL, VIN+, VIN-, VBUS, GND, VS
INA226AQDGSRQ1
RS3 0.1R
RA_1_SENSE_ALERT
RA_1_I2C_SENSE_SDA
RA_1_I2C_SENSE_SCL
RA_1_SENSE_VCC_OUT1
C49 0.1uF/25V
I2C Slave Address: 0b1000101 / 0x45

3V3_MCU_RA_1
RA_1_SENSE_VCC_IN2
R26 10k, R27 10k
U9
INA226AQDGSRQ1
RS4 0.1R
RA_1_I2C_SENSE_SDA
RA_1_I2C_SENSE_SCL
RA_1_SENSE_VCC_OUT2
C48 0.1uF/25V
J_V1 0R
I2C Slave Address: 0b1000100 / 0x44

BEACON MCU POWER CONNECTIONS

TP37
U7B
3V3_MCU_RA_1
AVCC1 (11)
DVCC1 (25), DVCC2 (64), DVCC3 (89)
V18 (82)
VBAT (87)
VBUS (80)
VCORE (27)
VUSB (81)
DVSS1 (26), DVSS2 (63), DVSS3 (90)
AVSS1 (12), AVSS2 (15), AVSS3 (83)
VSSU (76)
GND
C30 0.47uF/50V
MSP430F6659IPZR

JTAG AND VERSIONING COMPONENTS

3V3_MCU_RA_1
R18 47k
1nF/16V
C35
RA_1_JTAG_TDO_TDI
V1 47k, VERSION_BIT0, V2 DNP 47k
V3 47k, VERSION_BIT1, V4 DNP 47k
Configuration for version v0.1

BEACON SYSTEM LEDS

RA_1_SYSTEM_LED — R19 DNP 1K — D6 DNP Orange
RA_1_SYSTEM_FAULT_LED — R20 DNP 1K — D7 DNP Orange
RA_1_RADIO_UPLINK_LED — R21 DNP 1K — D8 DNP Orange
RA_1_RADIO_DOWNLINK_LED — R22 DNP 1K — D9 DNP Orange LTST-C170KFKT
3V3_MCU_RA_1 — R23 DNP 1K — D10 DNP Green LTST-C171GKT

LEDs Assigment:

- SYSTEM LED (D1): Internal watchdog timer (blink each second)
- SYSTEM FAULT (D2): Active in case of hardware check routine failure
- BEACON RADIO UPLINK (D3): Blink when a Uplink is received
- BEACON RADIO DOWNLINK (D3): Blink when a Downlink is sent

EXTERNAL VOLTAGE MONITOR WITH WATCHDOG TIMER

U8
RA_1_MR_WDOG
DNP R24 10k
3V3_MCU_RA_1
MR, RESET, WDI, VDD, GND
TPS3823-33QDBVRQ1
R25 10k
RA_1_JTAG_TDO_TDI
RA_1_WDI_EXT
C46 0.1uF/25V
C47 10uF/10V

Watchdog Operation:
- MR (Manual Reset): Resets MCU. (Active low)
- RESET: Used by the JTAG interface.
- WDI (Timeout Counter): Resets case any change within 1.6 seconds (typically), both falling and rising edges.
- Resets case the voltage supply drops below 2.9V(typically).

MCU DECOUPLING CAPACITORS

3V3_MCU_RA_1
RA_1_VREF_MCU
C36 10uF/10V, C37 0.1uF/25V
3V3_MCU_RA_1
C38 10uF/10V, C39 0.1uF/25V, C40 10uF/10V, C41 0.1uF/25V, C42 10uF/10V, C43 0.1uF/25V, C44 10uF/10V, C45 0.1uF/25V

BEACON MCU CRYSTALS

Y4
RA_1_XT2IN
RA_1_XT2OUT
GND
C31 10pF/100V
ABM8X-102-32.000MHZ-T
C32 10pF/100V
C33 12pF/50V
C34 12pF/50V
Y5
ECS-.327-12.5-34S-TR
RA_1_XIN
RA_1_XOUT

Clock Configuration:

MCLK: (Master Clock) - 32MHz
MCLK is used by the CPU.

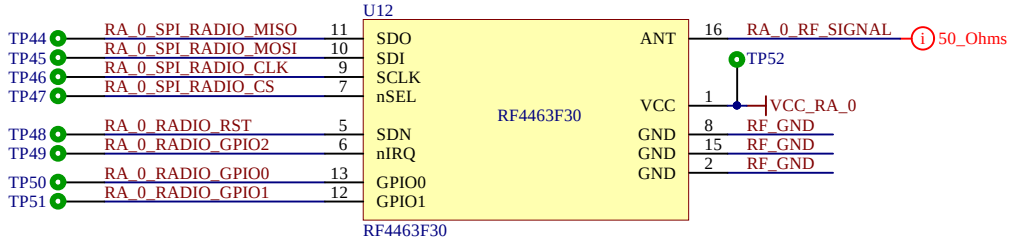
SMCLK: (Subsystem Master Clock) - 32MHz
SMCLK is used by the peripheral modules.

ACLK: (Auxiliary Clock) - 32.768kHz
ACLK used in low power modes. Also, it is a software selectable by individual peripheral modules.

SpaceLab - Federal University of Santa Catarina			
Project: *ttc2_project.prjpcb / [No Variations]*			
Title: *MCU Radio 1*			
Engineer: *André M. P. Mattos*			Project Code: *TTC2*
Date: 24/04/2021	Revision: *v0.1*	Sheet *4* of *6*	Size: A3

RADIO 0 (TRANSCEIVER)

Notes:
nIRQ - Interrupt output
GPIO0/1 - Si4463 GPIOs
SDN - Power down control
(SDN=1, power down)



NiceRF RF4463F30 transceiver module:
- Based on the Si4463/61/60-C transceiver
- Antenna matching network and two-way switch control
- 3.3-6.5 V Power supply
- Receiving current: 15mA
- Transmitting current: 500mA (at VCC=5V and TX=30dBm)
- Typical output power: +30dBm (at 433MHz and VCC=5V)
- Sensitivity up to -126 dBm (at 433MHz and Data rate=600bps)
- Operating Temperature Range:-40 + 85 °C

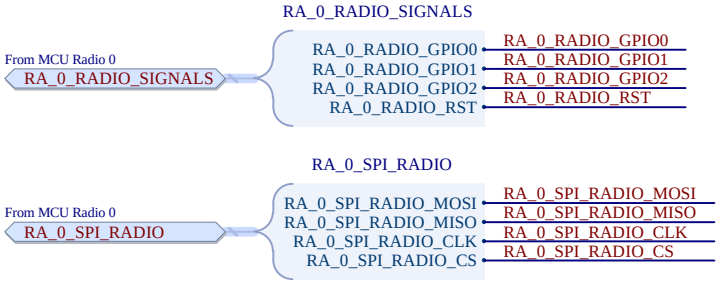
- Frequency Range: 315/433/490/868/915 (Customizable 142-1050MHz)
- Modulation: (G)FSK,4(G)FSK,(G)MSK,OOK and ASK
- Data transfer rate: 0.1-1000Kbps
- TX/RX FIFO: 64/128Byte data register

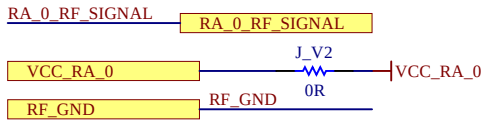
FloripaSat-1 Configuration:
Customization:
- Center Frequency: 433Mhz

Operating parameters:
- Sensitivity up to -126dBm
- Data transfer rate: 2.4Kbps
- Input voltage: 5V
- Maximum output power: +30dBm
- Transmitting current: 500mA
- Receiving current (always on): 15mA
- Modulation: GFSK

FloripaSat-2 Configuration:
Customization:
- Center Frequency: 450Mhz

Operating parameters:
- Sensitivity up to -126dBm
- Data transfer rate: 4.8Kbps
- Input voltage: 5V
- Maximum output power: +30dBm
- Transmitting current: 500mA
- Receiving current (always on): 15mA
- Modulation: GMSK

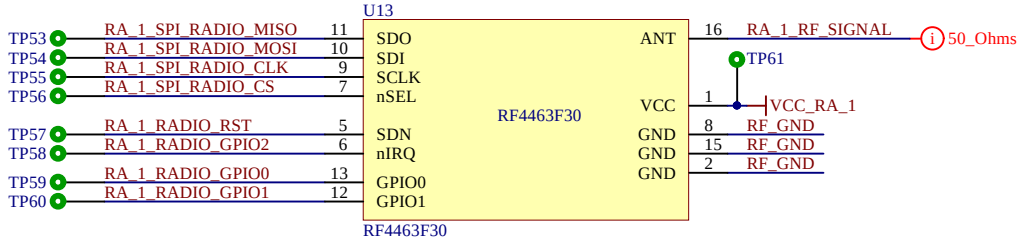




SpaceLab - Federal University of Santa Catarina			
Project: *ttc2_project.prjpcb / [No Variations]*			
Title: *Radio 0*			
Designed by: *André M. P. Mattos*			Project Code: *TTC2*
Date: 24/04/2021	Revision: *v0.1*	Sheet *5* of *6*	Size: A4

RADIO 1 (TRANSCEIVER)

Notes:
nIRQ - Interrupt output
GPIO0/1 - Si4463 GPIOs
SDN - Power down control
(SDN=1, power down)



NiceRF RF4463F30 transceiver module:
- Based on the Si4463/61/60-C transceiver
- Antenna matching network and two-way switch control
- 3.3-6.5 V Power supply
- Receiving current: 15mA
- Transmitting current: 500mA (at VCC=5V and TX=30dBm)
- Typical output power: +30dBm (at 433MHz and VCC=5V)
- Sensitivity up to -126 dBm (at 433MHz and Data rate=600bps)
- Operating Temperature Range:-40 + 85 °C

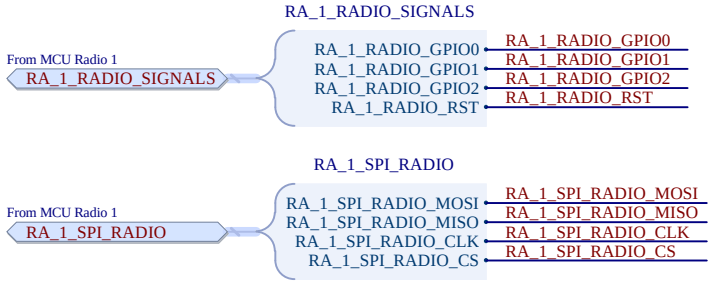
- Frequency Range: 315/433/490/868/915 (Customizable 142-1050MHz)
- Modulation: (G)FSK,4(G)FSK,(G)MSK,OOK and ASK
- Data transfer rate: 0.1-1000Kbps
- TX/RX FIFO: 64/128Byte data register

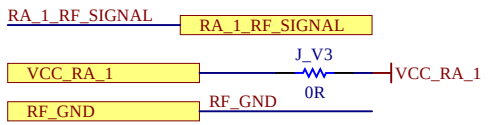
FloripaSat-1 Configuration:
Customization:
- Center Frequency: 160Mhz

Operating parameters:
- Sensitivity up to -126dBm
- Data transfer rate: 1.2Kbps
- Input voltage: 5V
- Output power: +28.6dBm
- Transmitting current: 500mA
- Receiving current (always on): 15mA
- Modulation: GFSK

FloripaSat-2 Configuration:
Customization:
- Center Frequency: 160Mhz

Operating parameters:
- Sensitivity up to -126dBm
- Data transfer rate: 1.2Kbps
- Input voltage: 6V
- Maximum output power: +30dBm
- Transmitting current: 550mA
- Receiving current (always on): 15mA
- Modulation: GMSK





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Project: *ttc2_project.prjpcb / [No Variations]*			
Title: *Radio 1*			
Designed by: *André M. P. Mattos*			Project Code: *TTC2*
Date: 24/04/2021	Revision: *v0.1*	Sheet *6* of *6*	Size: A4