SLB-TTC2-DOC-v0.2

TTC 2.0 Documentation

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SpaceLab, Universidade Federal de Santa Catarina, Florianópolis - Brazil

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Revision Control:

Version	Author	Changes	Date
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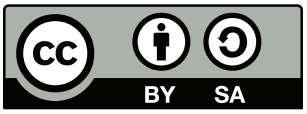
0.1	G. M. Marcelino	First release	2021/06/16
0.2	G. M. Marcelino, TBD	TBD	TBD



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Nomenclature

PCB	*Printed Circuit Board.*
PCB	*Printed Circuit Board.*
CCITT	*Comité Consultatif International Téléphonique et Télégraphique.*
CRC	*Cyclic Redundancy Check.*
SPI	*Serial Peripheral Interface.*
TTC	*Telemetry, Tracking and Command.*

Contents

CHAPTER 1

Introduction

The TTC 2.0 is an Telemetry, Tracking and Command module designed for nanosatellites. It is one of the service modules developed for the FloripaSat-2 CubeSat Mission [1].

The module is a direct upgrade from the TTC of FloripaSat-1 [2], which grants a flight heritage rating. The improvements focus on providing a cleaner and more generic implementation in comparison with the previous version, more reliability in software and hardware implementations, and adaptations for the new mission requirements. All the project, source and documentation files are available freely on a GitHub repository [3] under the GPLv3 license.

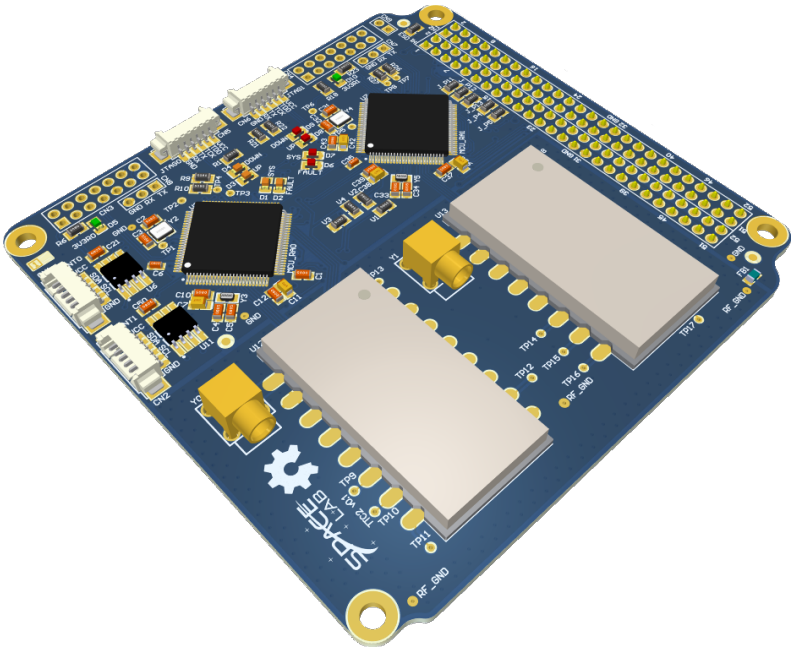

Figure 1.1: 3D view of the TTC 2.0 PCB.

CHAPTER 2

System Overview

2.1 Product tree

The product tree of the TTC 2.0 module is available in Figure 2.1.

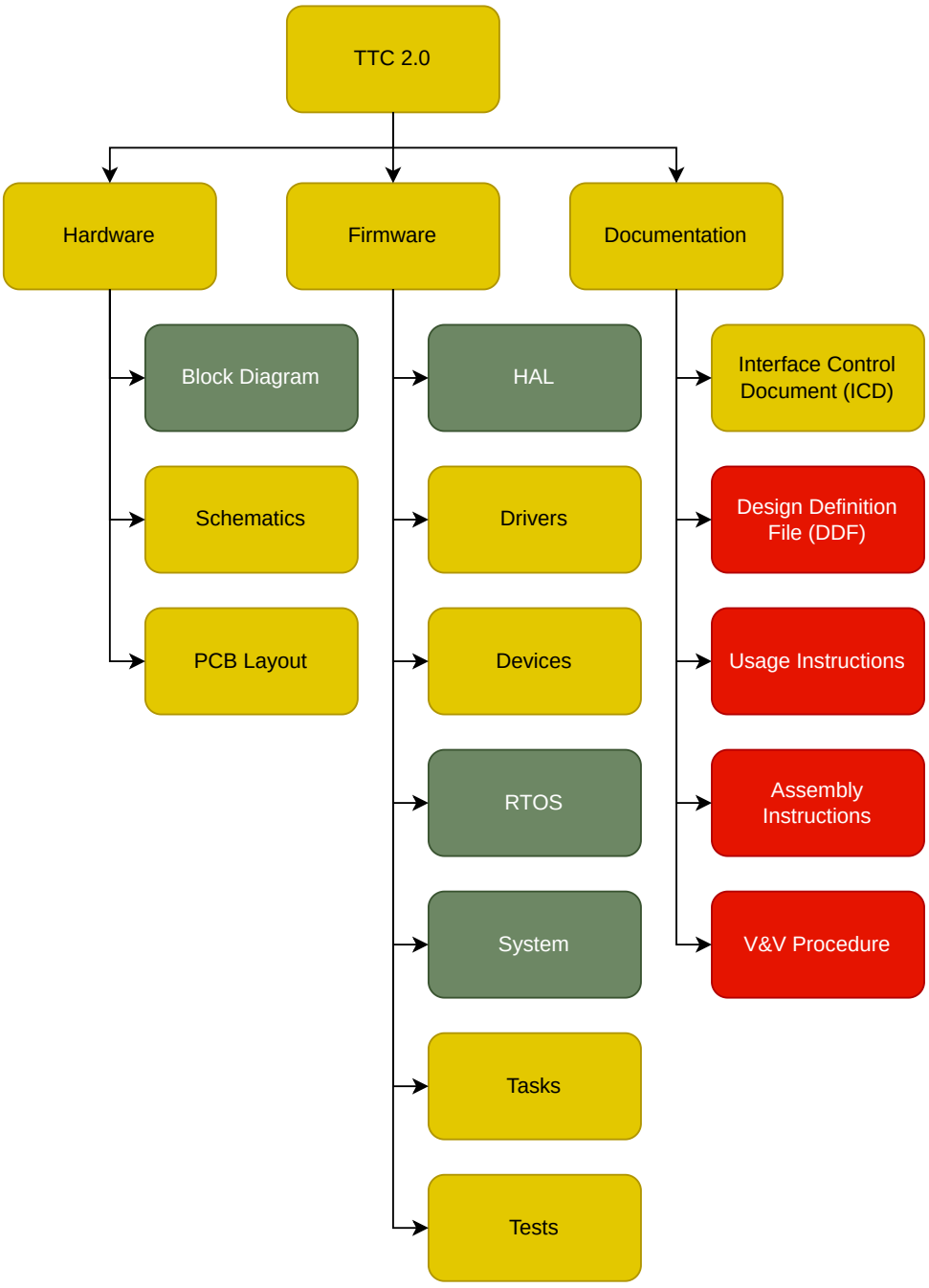

Figure 2.1: Product tree of the TTC 2.0 module.

CHAPTER 3

Hardware

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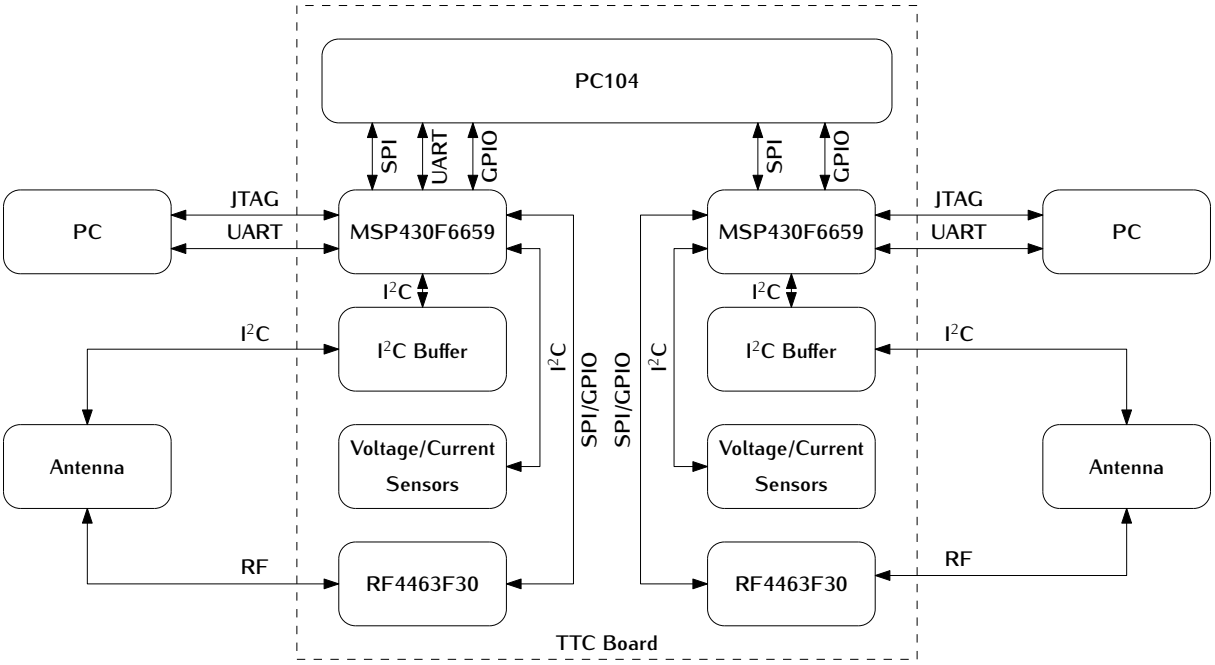

Figure 3.1: Block diagram of the TTC 2 hardware.

3.1 PC-104

The connector referred as PC-104 is a junction of two double row 26 pin headers (*SSW-126-04-G-D*). These connectors create a solid 104-pin interconnection across the different satellite modules. Table 3.1 provides the connector pinout[1] for the pins that are connected to the module. A reference of the pins' position can also be seen in Figure 3.2, a description of the signal is available in Table 3.2.

The distribution pattern of pins adopted in this project is a mix of multiple different patterns from CubeSat modules manufacturers, like GomSpace, ISIS and Endurosat. Some pins are positioned to attend specific project requirements, and it is possible that the adopted pattern is not totally compatible to some commercial modules.

[1]This pinout is simplified since additional interfaces were omitted. Refer to *option sheet* in chapter ??.

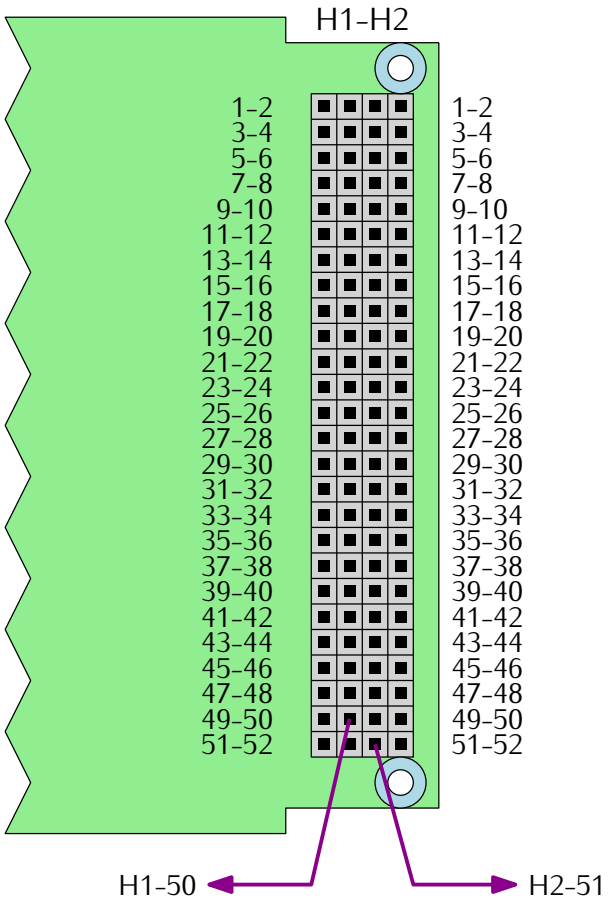

Figure 3.2: Reference diagram of the PC-104 bus (top view of a generic module).

Pin Row	H1 Odd	H1 Even	H2 Odd	H2 Even
1-2	-	-	-	-
3-4	-	-	-	-
5-6	-	-	RA_1_UART_RX	-
7-8	GPIO_6	GPIO_7	RA_1_UART_TX	GPIO_0
9-10	RA_1_SPI_INT	RA_1_EN	-	-
11-12	RA_0_SPI_INT	RA_0_EN	RA_1_SPI_MOSI	RA_1_SPI_CLK
13-14	-	-	RA_1_SPI_CS	RA_1_SPI_MISO
15-16	-	-	-	-
17-18	-	-	-	GPIO_1
19-20	-	GPIO_2	-	GPIO_3
21-22	-	-	-	GPIO_4
23-24	-	-	-	-
25-26	-	-	-	-
27-28	-	-	VCC_3V3	VCC_3V3
29-30	GND	GND	GND	GND
31-32	GND	GND	GND	GND
33-34	-	-	-	-
35-36	RA_0_SPI_CLK	-	VCC_3V3_ANT	VCC_3V3_ANT
37-38	RA_0_SPI_MISO	-	-	-
39-40	RA_0_SPI_MOSI	RA_0_SPI_CS	-	-
41-42	-	-	-	GPIO_5
43-44	-	-	-	-
45-46	-	-	-	-
47-48	-	-	-	-
49-50	VCC_5V_RA_0	VCC_5V_RA_0	-	-
51-52	VCC_6V_RA_1	VCC_6V_RA_1	-	-

Table 3.1: PC-104 bus pinout.

Signal	Pin(s)	Description
GND	H1-29/30/31/32, H2-29/30/31/32	Ground reference
VCC_3V3	H2-27, H2-28	TTC power supply (3,3 V)
VCC_3V3_ANT	H2-35, H2-36	Antenna power supply (3,3 V)
VCC_5V_RA_0	H1-49, H1-50	Radio 0 power supply (5 V)
VCC_6V_RA_1	H1-51, H1-52	Radio 1 power supply (6 V)
RA_0_SPI_CLK	H1-35	CLK signal of the radio 0 SPI bus
RA_0_SPI_MISO	H1-37	MISO signal of the radio 0 SPI bus
RA_0_SPI_MOSI	H1-39	MOSI signal of the radio 0 SPI bus
RA_0_SPI_CS	H1-40	CS signal of the radio 0 SPI bus
RA_0_SPI_INT	H1-11	INT signal of the radio 0 SPI bus
RA_1_SPI_CLK	H2-12	CLK signal of the radio 0 SPI bus
RA_1_SPI_MISO	H2-14	MISO signal of the radio 0 SPI bus
RA_1_SPI_MOSI	H2-11	MOSI signal of the radio 0 SPI bus
RA_1_SPI_CS	H1-13	CS signal of the radio 0 SPI bus
RA_1_SPI_INT	H1-9	INT signal of the radio 0 SPI bus
RA_1_UART_RX	H2-5	RX signal of the radio 1 UART
RA_1_UART_TX	H2-7	TX signal of the radio 1 UART
RA_0_EN	H1-11	Radio 0 power enable
RA_1_EN	H1-9	Radio 1 power enable
GPIO_N	H1-7/8/19, H2-8/18/20/22/42	GPIO pin (not used)

Table 3.2: PC-104 bus signal description.

CHAPTER 4

Firmware

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4.1 Product tree

The product tree of the firmware part of the TTC 2.0 module is available in Figure 4.1.

4.2 Commands

The SPI commands of the TTC module are available in Table 4.1. All commands are composed by an ID field (1 byte), the content of the command and a checksum at the end of the command (2 bytes). The used checksum algorithm is the CRC16-CCITT (initial value = 0x0000, polynomial = 0x1021) the value is calculated with the entire packet (ID field + command content).

ID	Name/Description	Content
0	NOP	None
1	Read parameter/variable	Parameter ID (1B) + Value (4B) + Checksum (2B)
2	Write parameter/variable	Parameter ID (1B) + Value (4B) + Checksum (2B)
3	Transmit packet	Packet data (1-220B) + Checksum (2B)
4	Receive packet	Packet data (1-220B) + Checksum (2B)

Table 4.1: List of commands.

4.2.1 Variables and Parameters

A list of all the variables of TTC with their identification number (ID) and variable type that can be read from the sensors and peripherals is seen in the Table 4.2.

ID	Name/Description	Type	Access
0	Device ID (0xCC2A or 0xCC2B)	uint16	R
1	Hardware version	uint8	R
2	Firmware version (ex.: "v1.2.3"' = 0x00010203)	uint32	R
3	Time counter in millseconds	uint32	R
4	Reset counter	uint16	R

5	Last reset cause: - 0x00 = No interrupt pending - 0x02 = Brownout (BOR) - 0x04 = RST/NMI (BOR) - 0x06 = PMMSWBOR (BOR) - 0x08 = Wakeup from LPMx.5 (BOR) - 0x0A = Security violation (BOR) - 0x0C = SVSL (POR) - 0x0E = SVSH (POR) - 0x10 = SVML_OVP (POR) - 0x12 = SVMH_OVP (POR) - 0x14 = PMMSWPOR (POR) - 0x16 = WDT time out (PUC) - 0x18 = WDT password violation (PUC) - 0x1A = Flash password violation (PUC) - 0x1C = Reserved - 0x1E = PERF peripheral/configuration area fetch (PUC) - 0x20 = PMM password violation (PUC) - 0x22 to 0x3E = Reserved	uint8	R
6	Input voltage of the μC in mV	uint16	R
7	Input current of the μC in mA	uint16	R
8	Temperature of the μC in K	uint16	R
9	Input voltage of the radio in mV	uint16	R
10	Input current of the radio in mA	uint16	R
11	Temperature of the radio in K	uint16	R
12	Last valid command (uplink packet ID)	uint8	R
13	RSSI of the last valid telecommand	uint16	R
14	Temperature of the antenna module in K	uint16	R
15	Antenna module status bits: - Bit 15: The antenna 1 is deployed (0) or not (1) - Bit 14: Cause of the latest activation stop for antenna 1 - Bit 13: The antenna 1 deployment is active (1) or not (0) - Bit 11: The antenna 2 is deployed (0) or not (1) - Bit 10: Cause of the latest activation stop for antenna 2 - Bit 9: The antenna 2 deployment is active (1) or not (0) - Bit 8: The antenna is ignoring the deployment switches (1) or not (0) - Bit 7: The antenna 3 is deployed (0) or not (1) - Bit 6: Cause of the latest activation stop for antenna 3 - Bit 5: The antenna 3 deployment is active (1) or not (0) - Bit 4: The antenna system independent burn is active (1) or not (0) - Bit 3: The antenna 4 is deployed (0) or not (1) - Bit 2: Cause of the latest activation stop for antenna 4 - Bit 1: The antenna 4 deployment is active (1) or not (0) - Bit 0: The antenna system is armed (1) or not (0)	uint16	R
16	Antenna deployment status (0=never executed, 1=executed)	uint8	R

17	Antenna deployment hibernation (0=never executed, 1=executed)	uint8	R
18	TX enable (0=off, 1=on)	uint8	R/W
19	TX packet counter	uint32	R
20	RX packet counter (valid packets)	uint32	R
21	TX packets available in the FIFO buffer	uint8	R
22	RX packets available in the FIFO buffer	uint8	R
23	Number of bytes of the first available packet in the RX buffer	uint16	R

Table 4.2: Variables and parameters of the TTC 2.0.

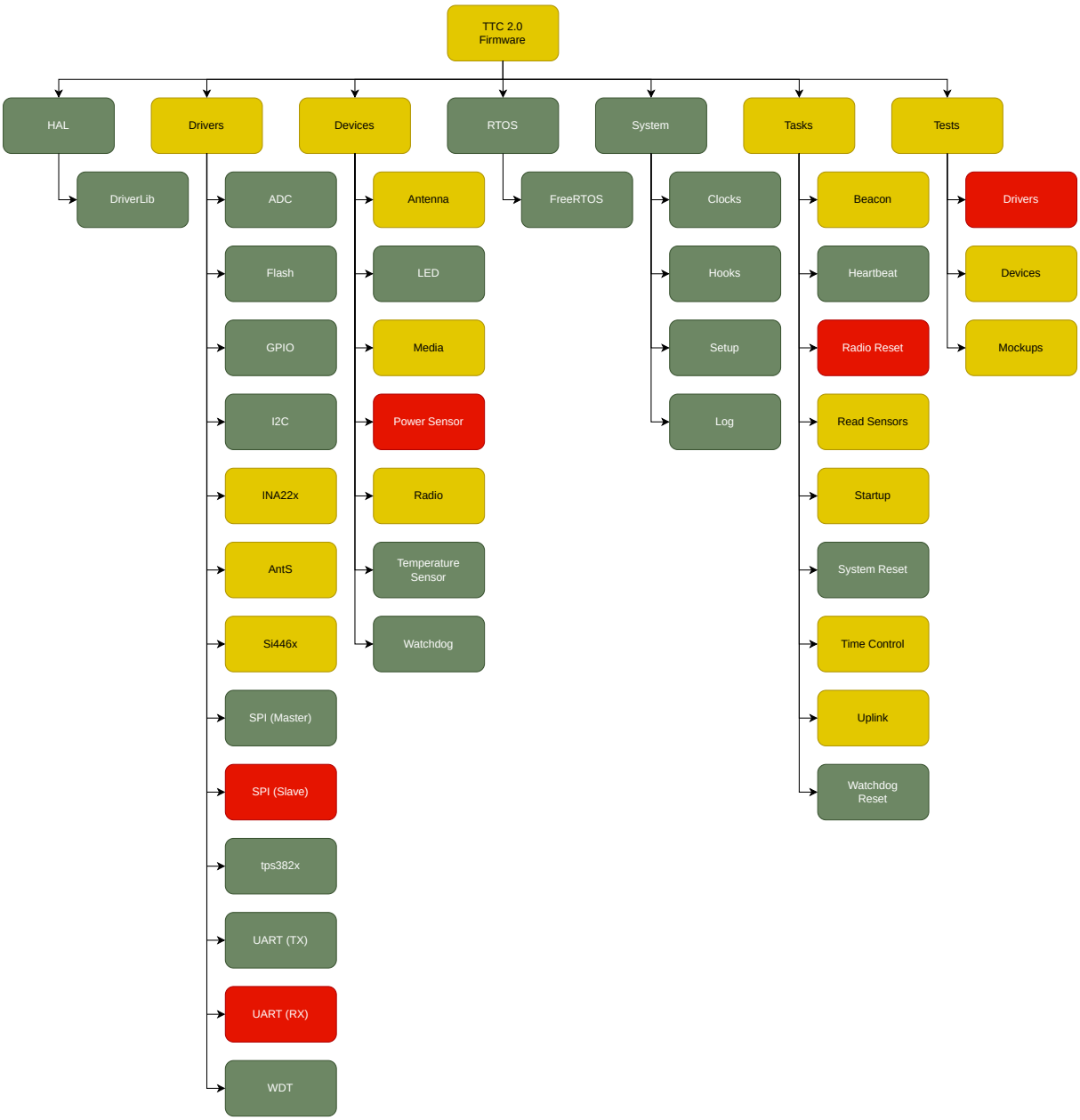

Figure 4.1: Product tree of the firmware of the TTC 2.0 module.

Bibliography

[1] SpaceLab. FloripaSat-2 Documentation, 2021. Available at <https://github.com/spacelab-ufsc/floripasat2-doc>.

[2] SpaceLab. Telemetry, Tracking and Command, 2019. Available at <https://github.com/floripasat/ttc>.

[3] SpaceLab. Telemetry, Tracking and Command 2.0, 2021. Available at <https://github.com/spacelab-ufsc/ttc2>.

APPENDIX A

Test Report of v0.1.1 Version

This appendix is a test report of the first manufactured and assembled PCB (version v0.1.1).

- **PCB manufacturer**: PCBWay (China)
- **PCB assembly**: PCBWay (China)
- **PCB arrival date**: 2022/04/18
- **Execution date**: 2022/04/22 to 2022/04/29
- **Tester**: Gabriel M. Marcelino and Vitória B. Bianchin
- **DNP components**: J_P10, J_P4, J_P11, J_P5, J_P9, J_P12, J_P13, J_P14, R7, R24, V2, V4, ESD, U12, U13

A.1 Visual Inspection

- **Test description/Objective**: Inspection of the board, visually and with a multimeter, searching for fabrication and assembly failures.
- **Material**:
  - Multimeter Fluke 17B+
  - Digital microscope (1000x)
- **Results**: The results of this test can be seen in Figures A.1 (top view of the board) and A.2 (bottom view of the board).
- **Conclusion**: No problems were identified on this test.

A.2 Firmware Programming

- **Test description/Objective**: Inspection of the board, visually and with a multimeter, searching for fabrication and assembly mistakes.
- **Material**:
  - Code Composer Studio v9.3.0

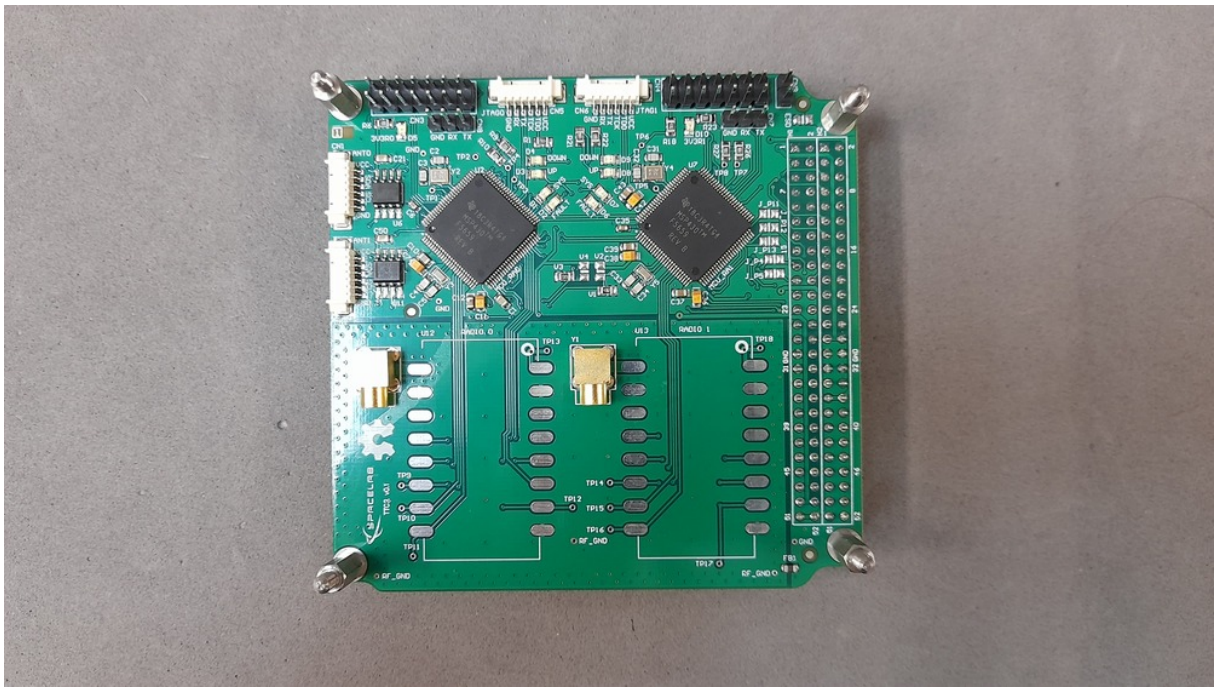

Figure A.1: Top view of the TTC 2.0 v0.1.1 board.

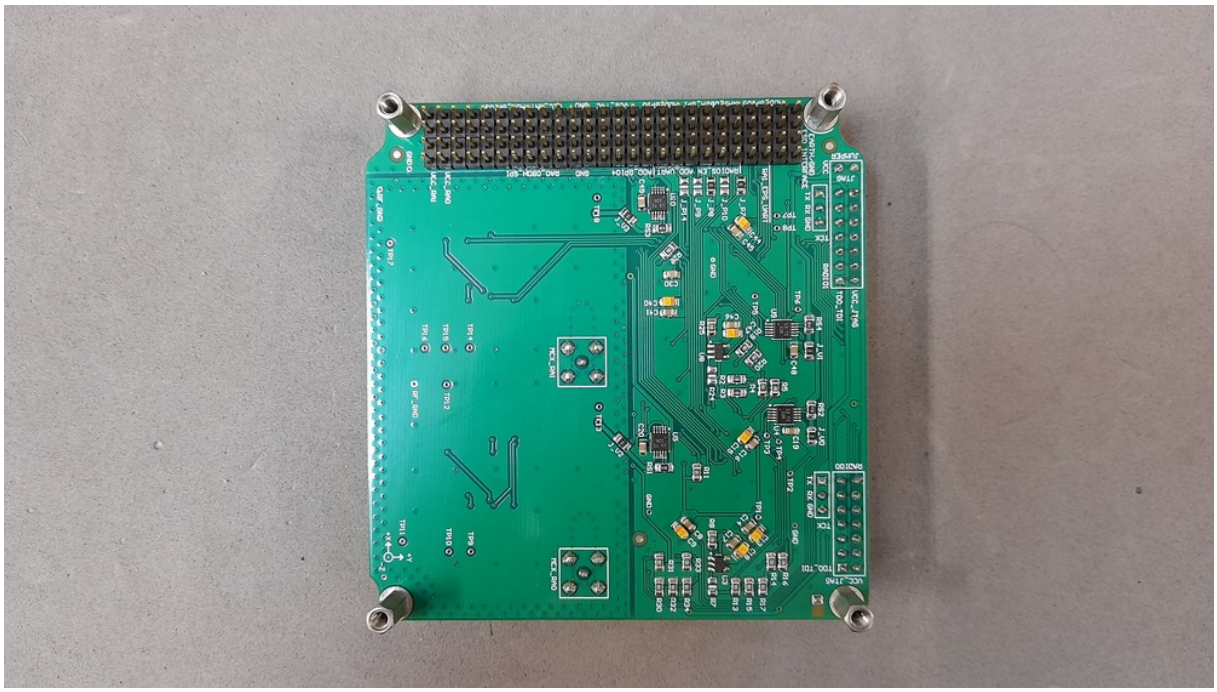

Figure A.2: Bottom view of the TTC 2.0 v0.1.1 board.

  - MSP-FET Flash Emulation Tool
  - USB-UART converter
  - Screen (Linux software)

- **Results**:

- **Conclusion**:

A.3 Communication Busses

- **Test description/Objective**:
- **Material**:
  - Saleae Logic Analyzer (24 MHz, 8 channels)
  - Saleae Logic software (v1.2.18)
  - MSP-FET Flash Emulation Tool
- **Results**:
- **Conclusion**:

A.4 Sensors

A.4.1 Input Voltage

- **Test description/Objective**: .
- **Material**:
  - Code Composer Studio TBC
  - MSP-FET Flash Emulation Tool
  - USB-UART converter
  - Screen (Linux software)
- **Results**: .
- **Conclusion:** .

A.4.2 Input Current

- **Test description/Objective**: .
- **Material**:
  - Code Composer Studio TBC
  - MSP-FET Flash Emulation Tool
  - USB-UART converter
  - Screen (Linux software)
- **Results**: .
- **Conclusion:** .

A.5 Peripherals

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A.6 Conclusion

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