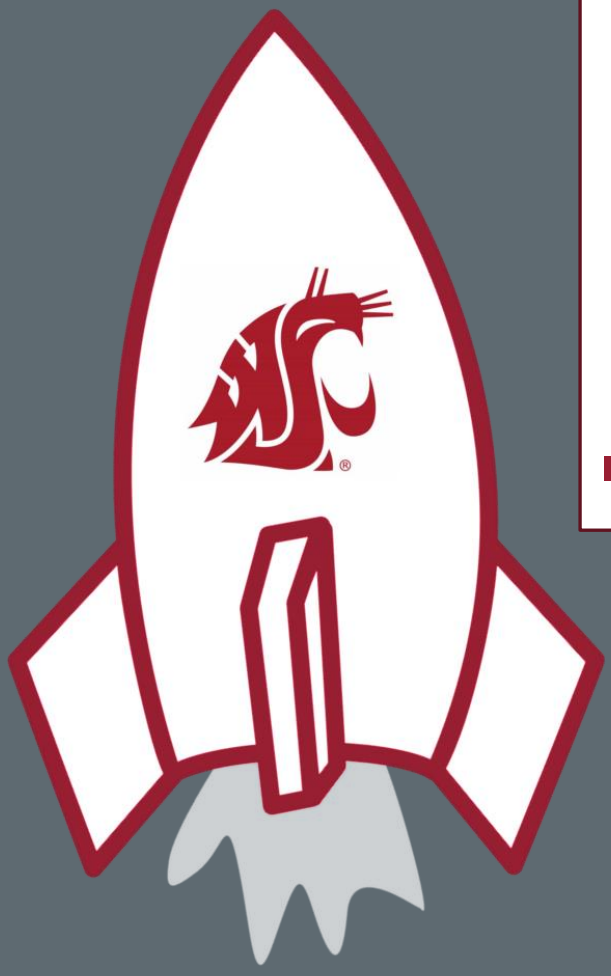
This document explains the function of the Umbilical, its schematic level design, and its board level design.

Umbilical

Umbilical Design

Revision: 1.0.3



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1 Introduction

This document explains how the Umbilical will fulfill the following Functions and conform to the following Requirements. This document refers to the Umbilical version 1.0.

1.1 Functions

The Umbilical is responsible for the following:

- Charging the battery on Earth without the sun
- Provide a bi-directional testing communication link to CD&H subsystem

1.2 Requirements

1. Provide $4.2V$ $0.8A$ battery charging
2. Provide a UART to USB conversion of at least up to 115200 $baud$.

2 Detailed Description

This section references the Umbilical schematic. Page numbers will be listed and may have coordinates listed (number and letter combination found around the frame).

2.1 Functional Block Diagram

The block diagram can be found on the first page of the schematic.

2.1.1 Battery Charger

Charges the battery sourced from a $5V$ $2A$ wall adapter. Charges lithium-ion batteries at $4.2V$.

2.1.2 UART to USB

Provides a UART serial interface as a USB device.

2.2 Schematic

2.2.1 Battery Charger

The battery charger portion of the umbilical uses the BQ24650[1] battery charger IC (page 2, B2) to charge the lithium-ion batteries found on the EPS board. The purpose of this is to provide a fast, reliable way to charge the batteries without having to rely on the sun during testing.

Power for the battery charger is supplied from an AC-to-DC wall adapter which is capable of supplying $5V$ $2A$. An ideal diode[2] ensures that current can only flow one way from the wall adapter to the battery, without allowing the battery to discharge back to the supply.

Unless otherwise stated, the typical application layout for the BQ24650 IC is used for this design. The notable changes will be detailed below.

No thermistor is used in this design next to the battery because the batteries that will be charged by the umbilical board are located on a different PCB, making the use of a thermistor for this chip impractical. Instead, the voltage divider between VREF and TS is set such that the temperature registered by the BQ24650 is always be between the low and high acceptable temperatures, meaning that the charger never turns off due to temperature. The temperature of the batteries on the EPS board is already monitored by the processor on the EPS so battery temperature should not be an issue. It is still recommended to not leave the charger on and unattended for long periods of time as lithium-ion batteries are very sensitive and may be dangerous.

[1] BQ24650
[2] LTC4411

The MPPSET pin is tied to the input connector, meaning that the power is unlimited, as this occurs anytime that this pin is at least $1.2V$.

The resisters that go to STAT1 and STAT2 are $1k\Omega$, typical application $10k\Omega$, to maintain consistency with other LEDs on CougSat-1. This leads to brighter LEDs compared to those from the original datasheet.

The output voltage to the battery is set using $10k\Omega$ resistors to $4.2V$ as below:

$$V_{bat} = 2.1V * \left[1 + \frac{R_2}{R_1}\right] = 2.1 * \left[1 + \frac{10k\Omega}{10k\Omega}\right] = 4.2V \quad (1)$$

The battery charge current is set using a $50m\Omega$ resistor as below:

$$I_{charge} = \frac{40\ mV}{R_{SR}} = \frac{40\ mV}{50\ m\Omega} = 0.8\ A \quad (2)$$

2.2.2 UART to USB Transceiver

This section of the umbilical contains an adapter that takes in a UART signal from the C&DH and converts it into USB via the FT230XQ[3] IC (page 3, B4).

Unless otherwise stated, the typical application layout for the FT230XQ IC is used for this design. The notable changes will be detailed below.

An RC time constant of $1\ ms$ is on the RESET pin of the FT230XQ to ensure that the power supply has enough time to reach its full steady-state value before the chip begins to function. This time constant is achieved using a $10k\Omega$ resistor and a $100nF$ capacitor.

The ferrite bead shown between V_{CC} of the USB adapter and V_{CC} of the FT230XQ filters out high frequency noise. Additional capacitors are added around the ferrite bead for further filtering purposes.

2.3 Board

The board shall be double layered with $1\ oz$ copper and ENIG finish.

2.3.1 Layout Constraints

Unless specified in the following subsections, all signals shall use the default parameters below. Signals in the following subsections do not include their sense signals unless otherwise specified. Trace width can be broken if a trace needs to bottleneck down to a pin, the bottleneck shall be minimized.

Trace width:	$0.16mm$
Vias:	$\emptyset 0.3mm$, unlimited count
Separation:	$0.16mm$
Length:	unlimited

[3] FT230XQ

Devices with specific placement and routing considerations are called out on the schematic, see "CAD Note:"

2.3.1.1 *Charger Power Traces- 5.0V, DIODE_OUT, PH, SR_P, UMB_IN, PGND*

PGND applies to between the input and output connectors

Trace Width: $0.4mm$

2.3.1.2 *USB Differential Pair - USB_CONN_N , USB_CONN_P, USB_N, USB_P*

Length: Length match $\pm 1.0\ mm$

Trace width: $0.8mm$

Gap width: $0.16mm$

3 Testing

All tests shall be performed at room temperature and will not be performed under vacuum since the umbilical PCB will not be included on the actual satellite. If any modifications are performed, take note. Include enough information to understand circuit behavior and for others to replicate the results. Include any software written to execute the test and link it in the test notes section. Save all software, waveforms, etc. in a subfolder of the board's test folder for each test. When testing, keep the following guidelines in mind:

- Waveforms shall be captured whenever appropriate
- Have the event take fill the screen (for fast events, zoom in, for slow events, zoom out)
- Label each channel accurately
- Only have bandwidth limiting if necessary, for the test (this applies to the oscilloscope and probe settings)
- If ringing or overshoot occurs, use a ground spring or differential probe

Test results location: https://github.com/CougsInSpace/CougSat1-Hardware/tree/master/CougSat1-Umbilical/Testing/Umbilical.1.0

Common test instructions can be found on the wiki.

3.1 Before First Power-On Check

Configuration: Board Name

This test is required to be executed before the Umbilical board is connected to any external power source.

3.1.1 Test Instructions

Measure the resistance of various points in reference to PGND located at the output connector.

3.1.2 Test Data

The data for this test will be recorded into the table below:

Node	Resistance		Node	Resistance
5.0V (TP1)			UMB_OUT (TP4)	
DIODE_OUT (TP2)			USB5V (TP5)	
PH (TP3)			USB5V_FILTERED (TP6)	

3.1.3 Test Notes

Delete me if no notes are required.

3.2 UART to USB

Results: Pass/Fail
Configuration: Board Name

This test evaluates the circuit described in UART to USB

3.2.1 Test Instructions

Configure the UART to USB transceiver to $115200\ baud$, $8b$, no parity, $1b$ stop using the configuration utility[4]. Connect the umbilical to CougSat-1 and the USB to a computer. Do not connect the wall adapter. Using a terminal program[5], validate transmit and receive are functional.

3.2.2 Test Data

Connect the umbilical to CougSat-1 and a computer, validate transmit and receive functionality		
Direction	Passing Criteria	Pass / Fail
Transmit	Functionality	
Receive	Functionality	

3.2.3 Test Notes

Delete me if no notes are required.

3.3 Charging Voltage

Results: Pass/Fail
Configuration: Board Name

This test evaluates the circuit described in Battery Charger

3.3.1 Test Instructions

Apply various loads to the output and then measure the output voltage at the output connector.

3.3.2 Test Data

Voltage should be measured at the output connector			
Load	Voltage	Passing Criteria	Pass / Fail
No load		$4.1V < V < 4.2V$	
500mA		$4.1V < V < 4.2V$	

3.3.3 Test Notes

Delete me if no notes are required.

3.4 Charging Current

Results: Pass/Fail
Configuration: Board Name

This test evaluates the circuit described in Battery Charger

[4] Instructions can be found on FTDI's website
[5] PuTTY is compatible and recommended

3.4.1 Test Instructions

Apply an increasing load to the output until the current no longer increases.

3.4.2 Test Data

Measure the current at the output connector		
Max current	Passing Criteria	Pass / Fail
	$700mA < I < 800mA$	

3.4.3 Test Notes

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3.5 Battery Charging

Results: Pass/Fail
Configuration: Board Name

This test evaluates the circuit described in Battery Charger

3.5.1 Test Instructions

Attach a battery discharge at 3.3V to the output and then turn on the charging and let it charge for 30 minutes. Then verify that the battery voltage has increased.

3.5.2 Test Data

Measure the voltage of the battery		
Voltage increase	Passing Criteria	Pass / Fail
	$\Delta V < 100mV$	

3.5.3 Test Notes

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