This document explains the function of the +X Panel, its schematic level design, its board level design, and its functional testing

+X Panel

Exterior PCB Panel Design

Revision: 1.0.9

Reid Collins, Jayson Gonzalez

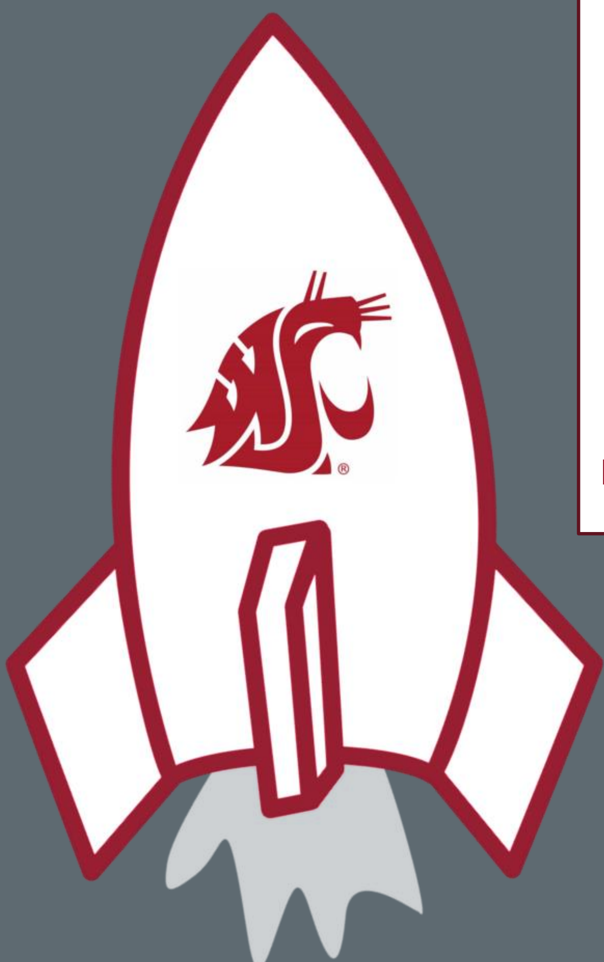

Table of Contents

1 Introduction

This document explains how the +X Panel will fulfil the following Functions and conform to the following Requirements. This document refers to the +X Panel version 1.0.

1.1 Functions

The +X panel is responsible for the following:

- Bi-directional low gain antenna for communicating with the ground station (with deployment mechanism)
- GPS Patch Antenna
- Photodiode sensor for ADCS

1.2 Requirements

The system requirements and Comms design requirements can be viewed on GitHub.

2 Detailed Description

This section references the +X Panel 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 Low-Gain Antenna

The low-gain antenna is deployed via high-power resistors, thermal knife, burning through a monofilament. Once deployed, the low-gain antenna is used to transmit/receive data to/from the Ground. Transmission from this antenna consists of lower speed data transfers to the ground. Faster data rate transmissions, such as sending images, are handled by the high-gain antenna on the -Z Panel.

2.1.2 GPS Patch Antenna

The GPS antenna is used to receive GPS information for the attitude determination and control subsystem (ADCS).

2.1.3 Photodiode Sensor

The +X Panel board has a photodiode which is used to sense light intensity which pertains to the position of the sun. The ADCS uses an I^2C ADC to read this intensity.

2.2 Schematic

2.2.1 Photodiode

The photodiode[1] can be found on page 2 of the schematic. The photodiode is placed near the center of the board facing outward. This particular photodiode has a spectral sensitivity of $6.3 nA/lx$ and the expected illuminance is on the order of $< 1 Mlx$.

2.2.2 Low–Gain Antenna

The low-gain antenna that can be found on page 3 (B1), of the schematic is a half wave dipole: length of $357\ mm$, impedance of 50Ω, gain of $2.15\ dB$, and linear polarization. It interfaces with the communications board via a coaxial cable (page 3, B2). As the coax is unbalanced and the antenna requires a balanced signal, a balun[2] does this conversion. The antenna is deployed using a thermal knife (page 3, B4:B6) consisting of two $1\ W$ resistors. When power is applied, they burn through a monofilament tied to the stowed antenna, releasing the antenna. The power for the thermal knife is provided by the EPS.

---

[1] CIS PN: 63-0003
[2] CIS PN: 39-0001

While stowed, the antenna is wrapped around metal pegs (page 3, C1:C4) shorting them together. Upon deployment, the short is removed. The EPS senses this change and can determine the deployment state of the antenna.

2.2.3 GPS Patch Antenna

The GPS patch antenna (page 3, B3)[3] is connected to the avionics board via a coaxial cable (page 3, B3). The antenna has an impedance of 50Ω, a center frequency of $1575\ MHz \pm 3\ MHz$, a bandwidth of $10\ MHz$ for $-10\ dB$, and right-hand circular polarization. The antenna is compatible with GPS and GALILEO signals.

2.2.4 Thermistors

The +X Panel contains seven thermistors[4] (page 2, C4:C6). These will be used to record temperature data at various points of the +X Panel for monitoring purposes. The thermistor measurements are passed to the ADC on page 2 of the schematic where they are then read by the ADCS.

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

Trace Width:	$0.2\ mm$
Vias:	$0.3\ mm$, unlimited count
Separation:	$0.2\ mm$
Length:	Unlimited

Devices with specific placement and routing considerations are noted in the schematic, see "CAD Note".

2.3.1.1 I²C – I2C_[SDA_ADCS, SCL_ADCS]

Length:	Each node shall be length matched ± $1.0\ mm$
Stubs:	< $10.0\ mm$

2.3.1.2 RF Traces – LOW_GAIN_[P, N, COAX], GPS_COAX

Track Width:	$1.5\ mm$
Gap Width:	$0.5\ mm$
Impedance:	50Ω

2.3.1.3 Power Resistors

Trace Width:	$0.5\ mm$

[3] CIS PN: 65-0010
[4] CIS PN: 26-0008

3 Testing

All tests shall be performed at room temperature and not under vacuum unless otherwise specified. 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. All tests shall be performed prior to attaching the solar cells to the solar panel.

- 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

Results location: https://github.com/CougsInSpace/CougSat1-Hardware/tree/master/CougSat1-RadioBoard/Testing/+XPanel.1.0

Common test instructions can be found on the wiki.

3.1 Before First Power-On Check

Configuration: Jacques

This test is required to be executed before any external power is applied to the +X-Panel.

3.1.1 Test Instructions

Measure the resistance of various points in reference to PGND, DGND, and RFGND depending on whatever is appropriate.

3.1.2 Test Data

Node	Resistance		Node	Resistance
AVREF_UNBUF	$11.3K\Omega$		*3.3V*	$81.1K\Omega$
AVREF	$8.9K\Omega$		*AVDD*	$9.1K\Omega$
I2C_SDA_ADCS	$89K\Omega$		*SENSE*	$> 100M\Omega$
I2C_SCL_ADCS	$130.7K\Omega$		*LOW_GAIN_COAX*	$> 100M\Omega$
PHOTODIODE	$1.2K$		*LOW_GAIN_P*	$> 100M\Omega$
			LOW_GAIN_N	0.086Ω
			GPS_COAX	$57.2M\Omega$
			Deployable	6.76Ω

3.2 Antenna Deploy Release

Results: Fail
Configuration: Jacques

This test evaluates the circuit described in Low-Gain Antenna.

3.2.1 Test Instructions

Setup the antenna and flaps in the stowed position. Connect the EPS and Comms boards. Apply $3.7\,V$ to thermal knife resistors. Verify sense node changes from low to high. Verify antennas and flaps properly deploy.

3.2.2 Test Data

Test the antenna deployment release			
State	Property	Passing Criteria	Pass / Fail
Stowed	Sense node	$< 0.5V$	Fail
Deployed	Sense node	$> 1.5V$	Fail
Stowed	Antenna	Properly stowed	Fail
Deployed	Antenna	Properly deployed	Fail

3.2.3 Test Notes

Wasn't very well stowed in, the antenna interfered with the rails. Thermal knife efficiency was too low leading to long deployment time thus too excessive energy.

3.3 Antenna Voltage Standing Wave Ratio (VSWR)

Results: Pass
Configuration: Jacques

This test evaluates the circuit described in Low-Gain Antenna. This describes how well the impedance is matched between source and load.

3.3.1 Test Instructions

Connect a directional coupler to the spectrum analyzer's input and tracking generator (TG) output. Run a sweep, $420MHz\ to\ 450MHz, 30kHz\ BW$ with the TG, normalize, and store this reference. There should be a flat line at $0dB$. Connect the antenna, the line should drop. Isolate the antenna as much as possible like space. Capture the antenna's response. Record the VSWR for $420MHz$ & $450MHz$.

$$VSWR = \frac{10^{\frac{return\ loss\ (dB)}{20}} + 1}{10^{\frac{return\ loss\ (dB)}{20}} - 1}$$

3.3.2 Test Data

Test the antenna's VSWR			
Frequency	VSWR	Passing Criteria	Pass / Fail
$420MHz$	1.3	< 1.5	Pass
$450MHz$	1.4	< 1.5	Pass

3.3.3 Spectrum Analyzer Plot

Add the antenna's response from the spectrum analyzer. Forget, will add on next revision. Response had classic band pass shape.

3.4 Photodiode

Results: Pass
Configuration: Jacques

This test evaluates the circuit described in Photodiode.

3.4.1 Test Instructions

Connect the ADC to the ADCS. Illuminate the photodiode with a bright light, measure the output voltage. Repeat with a dim light and a dark room. Verify the voltage changes accordingly

3.4.2 Test Data

Test the photodiode's response			
Light source	Voltage	Passing Criteria	Pass / Fail
Dark room Or shaded	$1.4mV$	$< 100mV$	Pass
Dim light	$4.85mV$	$Higher\ than\ V_{dark}$ $< 900mV$	Pass
Bright light	$800mV$	$Higher\ than\ V_{dim}$ $< 900mV$	Pass

3.4.3 Test Notes

Dark was covering it up with a finger. Dim was ambient room light. Bright light was a cell phone flashlight.

3.5 GPS

Result: Pass
Configuration: Jacques

This test evaluates the GPS Patch Antenna.

3.5.1 Test Instructions

Connect the GPS coax to the ADCS. Turn on the ADCS and validate the GPS gets a location fix within $10m$ within two minutes.