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This document explains the function of the Camera Payload, its schematic level design, its board level design, and its functional testing

Camera Payload

Camera Payload Design

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# Introduction

This document explains how the Camera Payload will fulfill the following Functions and conform to the following Requirements.

## Functions

The Camera Payload is responsible for the following:

* Imaging Earth
* Counting ionizing radiation hits

## Requirements

The system requirements and Camera Payload design requirements can be found on [GitHub](https://github.com/CougsInSpace/CougSat1-Readme/blob/master/CougSat1-Requirements.pdf).

# Detailed Description

This section refers to the Camera Payload [schematic](https://github.com/CougsInSpace/CougSat1-Hardware/blob/master/CougSat1-Payload/Documentation/Payload-Camera.pdf). Page numbers will be listed and may have coordinates listed (number and letter combination found around the frame).

## Functional Block Diagram

The block diagram can be found on page 1 of the schematic.

### Ionizing Radiation Sensor

The Ionization Radiation Sensor is responsible for detecting high-energy photons and particles, and turning them into electrical signals.

### Particle Counter

The Particle Counter is responsible for counting the number of electrical pulses generated by the Ionizing Radiation Sensor.

### Cameras

The Cameras will take pictures of the Earth’s surface. There are two cameras on board, one with a wide-angle lens for taking large scale pictures, and another with a telephoto lens, for taking pictures of locations of interest, such as Pullman.

Data from the Cameras will be received and stored by the [C&DH](https://github.com/CougsInSpace/CougSat1-Hardware/blob/master/CougSat1-AvionicBoard/Documentation/C&DH-Design.pdf) subsystem.

### Temperature Monitoring

The Temperature Monitoring is carried out by an ADC connected to the [C&DH](https://github.com/CougsInSpace/CougSat1-Hardware/blob/master/CougSat1-AvionicBoard/Documentation/C&DH-Design.pdf) subsystem. The temperature of various components and at various points on the board are periodically measured and recorded.

## Schematic

### Power Rails

Page 2 of the schematic shows the various power rails used by the Camera Payload.

### Isolated Grounds

The 4 isolated grounds can be found on page 4 of the schematic. Power ground () is connected to the backplane and to the power devices (regulators). All other grounds are shorted to through a resistor rated up to . The expected current is led than . Digital ground () is connected to the digital components on the board, including the Counter, GPIO Expander, and Cameras. Analog ground () is connected to the analog components on the board, including the amplifiers and ADC. Chassis ground () is connected to the mechanical features of the satellite, including the bolt holes and card rails.

### 5V Regulation

The regulation can be found on page 3 of the schematic and contains two parts. The first is a switching mode boost converter[[1]](#footnote-1), chosen for its high efficiency. The feedback is set through a voltage divider such that the output is . The second part is a linear regulator[[2]](#footnote-2), chosen for its low noise and low dropout voltage, which will regulate the SMPS output down to and remove any ripple or noise introduced by the switching.

### Temperature Monitoring

The temperature monitoring ADC[[3]](#footnote-3) can be found on page 3 of the schematic. The ADC is an I­2C device which lives on *BUS\_I2C1*, and relays it’s data to the IHU. There are 8 single-ended inputs, all of which are reading thermistors from various locations on the board.

### Analog Voltage Reference and Supply

The Camera Payload has an analog voltage supply (Page 3, D3) fed by power rail *PR3.3-10* and filtered by a ferrite bead and capacitors. This powers the ADC and the reference voltage buffer. Precision on this rail is not required, as the ADC produces its own precision voltage reference. This voltage reference is fed through a unity gain buffer[[4]](#footnote-4) and used to power the thermistors.

### Cameras

The Cameras[[5]](#footnote-5) can be found on page 4 of the schematic. There are two cameras. The first has a wide-angle lens for taking large-scale photos of the earth, and the second has a telephoto lens, for taking images of locations of interest, such as Pullman or Area 51. Each camera uses the I2C bus *BUS\_I2C1* for receiving commands, and *BUS\_SPI* for transferring data. The cameras are operated by the C&DH[[6]](#footnote-6) subsystem.

### Ionizing Radiation Sensor

The ionizing radiation sensor[[7]](#footnote-7) can be found on page 4 (C1) of the schematic. The sensor itself is a photodiode primarily sensitive to radiation energies from about . The amplifiers are designed to amplify the signal from the photodiode so that the counter can read them. The exact design is taken directly from the white poper[[8]](#footnote-8) for the device, with a comparator added to the output to square up the output signal.

### Particle Counter

The particle counter is a 12-bit binary counter[[9]](#footnote-9) which counts the pulses from the sensor. The data is read by an I2C GPIO expander[[10]](#footnote-10) operated by the IHU on *BUS\_I2C1*. The same GPIO expander can be used to reset the counter.

## Board

The board shall be double layered with 1 𝑜𝑧 copper and ENIG finish. The board shall also conform to the dimensions specified by the [CougSat Module Standard](https://github.com/CougsInSpace/CougSat1-Hardware/blob/master/CougSat1-Backplane/Documentation/CougSatModuleStandard.pdf).

### Layout Constraints

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

Trace width:

Vias: , unlimited count

Separation:

Length: unlimited

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

#### Camera Power Rails – 3.3V-[11,12], PGND

PGND Applies between the cameras and the backplane connector

Trace width:

# 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.

* 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

Common test instructions can be found on the wiki.

## Before First Power-On Check

**Configuration:**

This test shall be executed before any power is applied to the board.

### Test Instructions

Measure the resistance of various points in reference to *PGND* located at the backplane. When measuring in-circuit resistances, flip the probes and take the lower value.

### Test Data

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Node | Resistance |  | Node | Resistance |
| *3.3V-10* |  |  | *5.0V* |  |
| *3.3V-11* |  |  | *AVDD* |  |
| *3.3V-12* |  |  | *AVREF-0* |  |
| *BOOST\_OUT* |  |  |  |  |

### Test Notes

Delete me if no notes are required.

## 5V Regulator

**Configuration:**

**Result:**

This test evaluates the circuit described in 5V Regulation.

### Output Voltage

#### Test Instructions

Apply to *3.3V-10* at the backplane before executing this test. Measure the voltage of the 5.0V regulator at no load and at a resistive load.

Note: Measure the DC Component of the voltage with .

#### Test Data

|  |  |  |  |
| --- | --- | --- | --- |
| Measure the DC voltage at the output of the 5.0V regulator | | | |
| Load | Voltage | Passing Criteria | Pass / Fail |
|  |  |  |  |
|  |  |  |  |

#### Test Notes

Delete me if no notes are required.

### Output Ripple and Noise

#### Test Instructions

Apply to *3.3V-10* at the backplane before executing this test. Measure the ripple of the 5.0V regulator at no load and at a resistive load.

Note: Measure the RMS value of the AC component with .

#### Test Data

|  |  |  |  |
| --- | --- | --- | --- |
| Measure the RMS ripple at the output of the 5.0V regulator | | | |
| Load | Ripple | Passing Criteria | Pass / Fail |
|  |  |  |  |
|  |  |  |  |

#### Test Notes

Delete me if no notes are required.

## Analog Voltage Reference and Supply

**Configuration:**

**Result:**

This test evaluates the circuits described in Analog Voltage Reference and Supply.

### Analog Voltage Supply

#### Test Instructions

Apply to *3.3V-10* at the backplane before executing this test.

Measure the noise and ripple of *AVDD* under a load.

Note: Measure DC voltage with , measure the RMS AC component with .

#### Test Data

|  |  |  |  |
| --- | --- | --- | --- |
| Measure the noise and ripple of *AVDD* under a load | | | |
| Measured | Voltage | Passing Criteria | Pass / Fail |
| DC Voltage |  |  |  |
| Ripple |  |  |  |

#### Test Notes

Delete me if no notes are required.

### Analog Voltage Reference

#### Test Instructions

Apply to *3.3V-10* at the backplane before executing this test.

Measure the DC voltage, noise, and ripple of *AVREF-0*.

Note: Measure DC voltage with , measure the RMS AC component with .

#### Test Data

|  |  |  |  |
| --- | --- | --- | --- |
| Measure the noise and ripple of *AVREF-0* | | | |
| Measured | Voltage | Passing Criteria | Pass / Fail |
| DC Voltage |  |  |  |
| Ripple |  |  |  |

#### Test Notes

Delete me if no notes are required.

## Temperature Monitoring

**Configuration:**

**Result:**

This test evaluates the circuit described in Temperature Monitoring.

### Test Instructions

Apply to *3.3V-10* before executing this test. Connect the ADC to a microcontroller on *BUS\_I2C1*. Compare the voltage measured by the microcontroller and the voltage measured by a thermometer at the following temperature sensors:

* Camera 0
* Top Left

Note:

### Test Data

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Compare the temperatures read by a Controller and a Thermometer | | | | | |
| Location | C Temperature | Thermometer Temperature | Error | Passing Criteria | Pass / Fail |
| Camera 0 |  |  |  |  |  |
| Top Left |  |  |  |  |  |

### Test Notes

Delete me if no notes are required.

## Cameras

**Configuration:**

**Result:**

This test evaluates the circuit described in Cameras.

### Test Instructions

Apply to both *3.3V-11* and *3.3V-12* before executing this test.

Connect the cameras to a microcontroller on *BUS\_I2C1* and *BUS­\_SPI*. Take a photo with each. Include the photograph.

### Test Data

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
| Camera | Photo | Passing Criteria | Pass / Fail |
| Camera 0 |  | Look good? |  |
| Camera 1 |  | Look good? |  |

### Test Notes

Delete me if no notes are required.

## Geiger Counter

**Configuration:**

**Result:**

This test evaluates the circuits described in Ionizing Radiation Sensor and Particle Counter.

### Test Instructions

Apply to *3.3V-10* before executing this test. Read the value on the binary counter continuously while bringing a banana close to the sensor. If nothing happens, try a sample of radium.

### Test Data

|  |  |  |
| --- | --- | --- |
| Bring a banana close to the sensor, observe the value on the counter. | | |
| Sample | Passing Criteria | Pass / Fail |
| Banana | Counter value increases |  |
| Radium (if necessary) | Counter value increases a lot |  |

### Test Notes

Delete me if no notes are required.

1. CIS PN: [60-0007](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/60%20-%20Power%20IC/60-0007/TI_tps61220.pdf) [↑](#footnote-ref-1)
2. CIS PN: [60-0012](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/60%20-%20Power%20IC/60-0012/TI_tps732.pdf) [↑](#footnote-ref-2)
3. CIS PN: [27-0003](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/27%20-%20Conversion%20IC/27-0003/ANALOG_AD7291.pdf) [↑](#footnote-ref-3)
4. CIS PN: [08-0002](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/08%20-%20Amplifier%20(excluding%20RF)/08-0002/ANALOG_AD8515.pdf) [↑](#footnote-ref-4)
5. CIS PN: [66-0005](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/66%20-%20Sensor/66-0005/ArduCAM_Mini_5MP_Plus_OV5642_Camera_Module_DS.pdf) [↑](#footnote-ref-5)
6. [C&DH](https://github.com/CougsInSpace/CougSat1-Hardware/blob/master/CougSat1-AvionicBoard/Documentation/C&DH-design.pdf) [↑](#footnote-ref-6)
7. CIS PN: [66-0004](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/66%20-%20Sensor/66-0004/FIRSTSENSOR_x100-7-thd-501400%5B2%5D-203179.pdf) [↑](#footnote-ref-7)
8. [Photodiode white paper](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/66%20-%20Sensor/66-0004/gamma-ray-detection.pdf) [↑](#footnote-ref-8)
9. CIS PN: [28-0004](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/28%20-%20Logic%20IC/28-0004/TI_cd74hc4040.pdf) [↑](#footnote-ref-9)
10. CIS PN: [27-0001](https://github.com/CougsInSpace/Resources/blob/master/SupplierDocuments/27%20-%20Conversion%20IC/27-0001/TI_tca9535.pdf) [↑](#footnote-ref-10)