

CubeSat - Radiation detection system

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Concept

- A CubeSat (U-class spacecraft) is a type of miniaturized satellite for space research that is made up of multiples of $10 \times 10 \times 10 \text{ cm}^3$ units.
- Inside the Cube there are technological elements for projects in various areas of science.
- The cube is wrapped in solar cells capable to supply $5V \times 1A$ per unit.

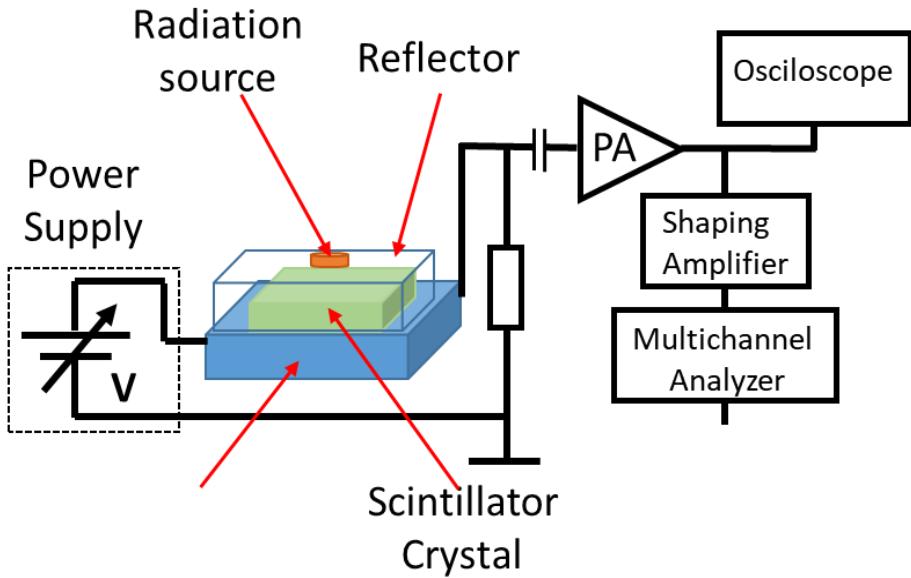
<https://en.wikipedia.org/wiki/CubeSat>



Electrical Requirements

- Must have power source for all components
- All electronics to work on 5V, or a power supply block needed to provide necessary voltages
- Total consumption of the electronics to be less than $5 \text{ V} \times 1 \text{ A}$ per unit
- The components need to be radiation hardened

Schematics



A **scintillator** is a detector for charged particles and gamma rays in which scintillations produced in a phosphor are detected and amplified by a photomultiplier, giving an electrical output signal. This is arguably one of the most important parts of the CubeSat. However, we must introduce a component to process these signals.

SiPM 24 - 30 V

CubeSat → micro-compact detector

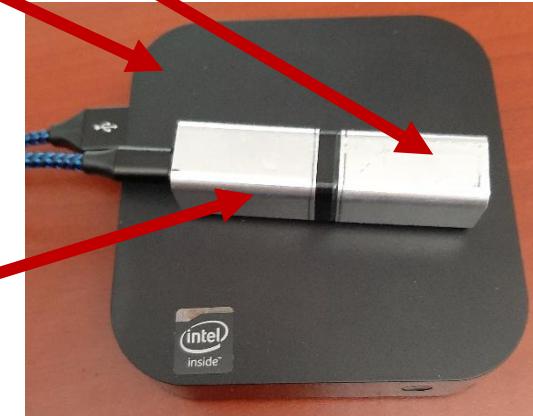
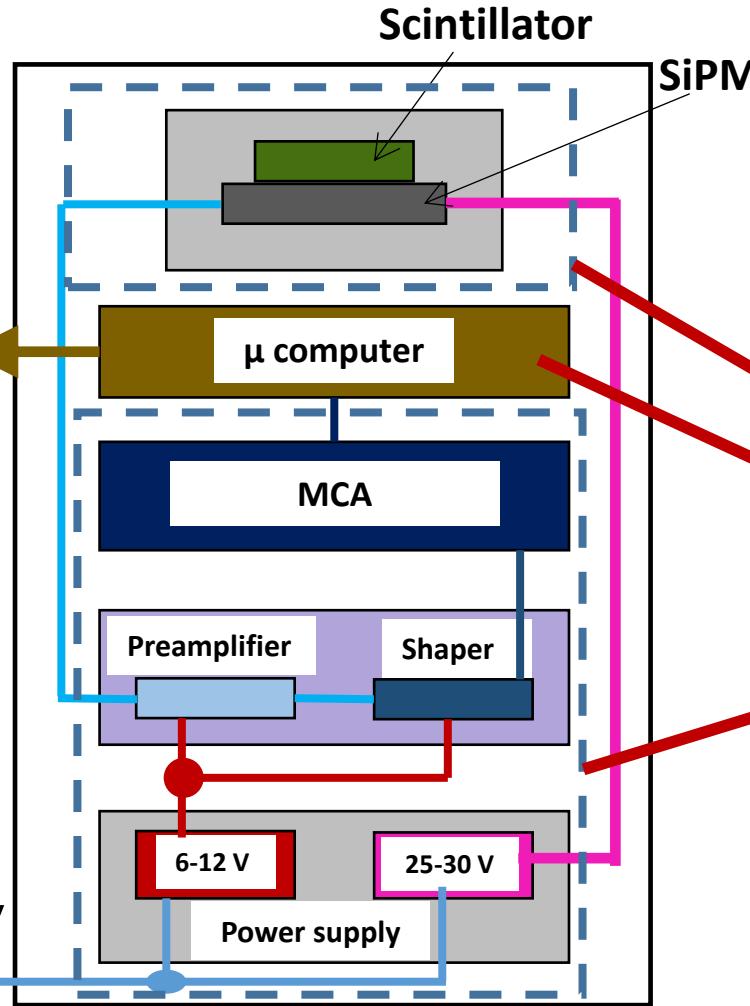
CubeSat Chassis with
detector and all the
electronics and
microcomputer included



1.5U CubeSat
10x10x15 cm³

USB

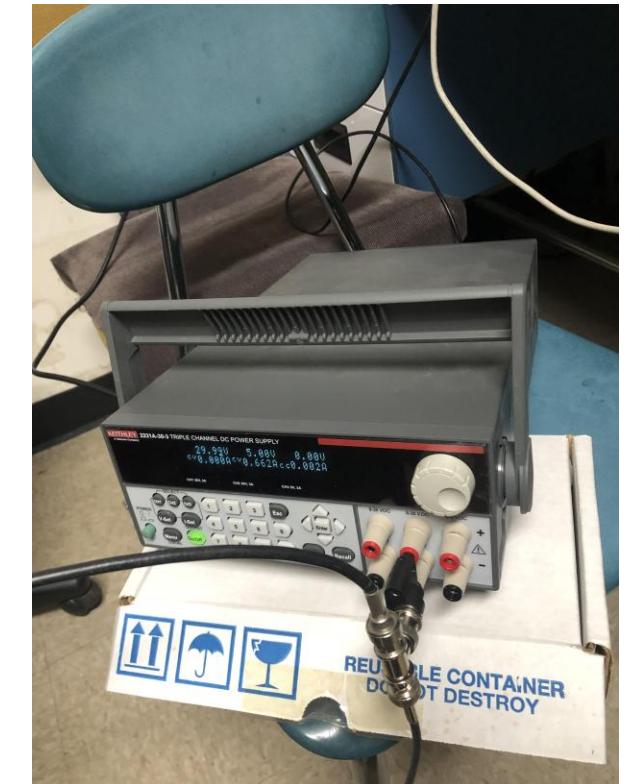
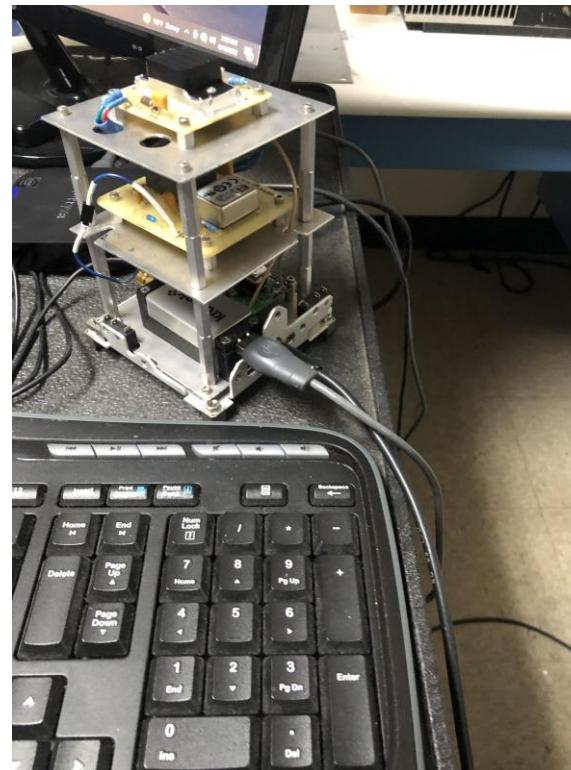
+5V



Encapsulated scintillator
coupled with SiPM
and the micro-computer
to be fit inside the
CubeSat

Power Consumption

- Since we would like to keep the $5V \times 1.5A = 7.5W$ power consumption (due to the dimensions of the CubeSat at 1.5U and the solar cells) we chose to run a series of test.



Powered Off, Connected To Voltage Source

- With monitor, mouse, keyboard, micro computer, and CubeSat system
 - Amps drained is mostly steady at $I_{max}=.177A$
- With micro computer, and CubeSat system
 - $I_{max}=.177A$
- With micro computer
 - $I_{max}=.097A$
- With CubeSat system
 - Amps drained is mostly steady at $I_{max}=.080A$

Powering Up

- With monitor, mouse, keyboard, micro computer, and CubeSat system
 - Amps drained varies rapidly. Starts at .400A range and reaches up to 1.00A and above range for awhile then falls down to stationary eventually. for a brief second (past limit) $I_{max} = 1.610 \text{ A}$
- With micro computer, and CubeSat system
 - (same concept as above) $I_{max} = 1.52\text{A}$

Powered On, Stationary

- With monitor, mouse, keyboard, micro computer, and CubeSat system
 - Amps drained is varying moderately, mostly stays at .650A range but will increase to higher values. $I_{max} = .97A$
- With mouse, keyboard, micro computer, and CubeSat system
 - Amps drained is varying moderately but mostly stays at .610A range but will increase up to higher values. $I_{max} = .91A$
- With micro computer, and CubeSat system
 - Amps drained is varying moderately, mostly stays at .550A range but will increase up to the .600A range values occasionally $I_{max} = .7A$

Powered On, Operating

- With monitor, mouse, keyboard, micro computer, and CubeSat system on app such as edge while clicking and loading
 - Amps drained is varying moderately, mostly stays at 1.00A range with values fluctuating. $I_{max} = 1.52A$
- With micro computer, and CubeSat system controlled by team viewer, on Multispeck acquiring data
 - Amps drained fluctuates rapidly, mostly values in .700A, .800A and .900A range, but will occasionally go higher than that and reaches values in the low 1.0 A range. $I_{max}=1.33A$

Steps Implemented to Reduce Power Consumption

- Clean up micro computer to cut down on power consumption
- Remove unnecessary bloat programs
- Free up storage
- Limiting startup apps
- Windows power slider
- The main issue was powering up, so implementing these made sure the I_{max} wouldn't rise above 1.5A

Heat Consumption

- On Earth, when a current flows through a resistor, electrical energy is converted into heat energy.
- The heat generated in the components of a circuit, all of which possess at least some resistance, is dissipated into the air around the components.
- In space however, we do not have this luxury as there is no air to dissipate the heat.
- That is why the calculation of heat is important for this CubeSat System to ensure that the components of the circuit don't overheat.

Heat Calculation

- $Q = m \cdot c \cdot \Delta T$ for general 1U device
- $m = \text{mass} = (\text{max mass}) = 2\text{kg} = 2000\text{g}$
- $c = \text{specific heat capacity} = 0.89 \text{ (J/g } ^\circ\text{C)}$
- $Q = \text{heat energy} = 5 \text{ W} * 1 \text{ hr} = 5*(3600\text{J}) = 18000\text{J}$
- $\Delta T = \text{change in temperature} = 10.112 \text{ } ^\circ\text{C}$
- Which is proportional to 1.5 U
- Most electronics can function well above 40 $^\circ\text{C}$

Experimental Battery Test

- Plugged in to an 8000mAh battery
- The system was able to last for around 6 hours.
- $8000 * 10^{-3} = 8\text{Ah}$
- So $8\text{Ah}/6\text{h} = \text{average current of } 1.33\text{A}$
- We don't know for sure if battery was fully charged, (we assume it but don't know for sure)

Thank You

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