Design of Electrical Power System for Space Based Proton Electron Detector

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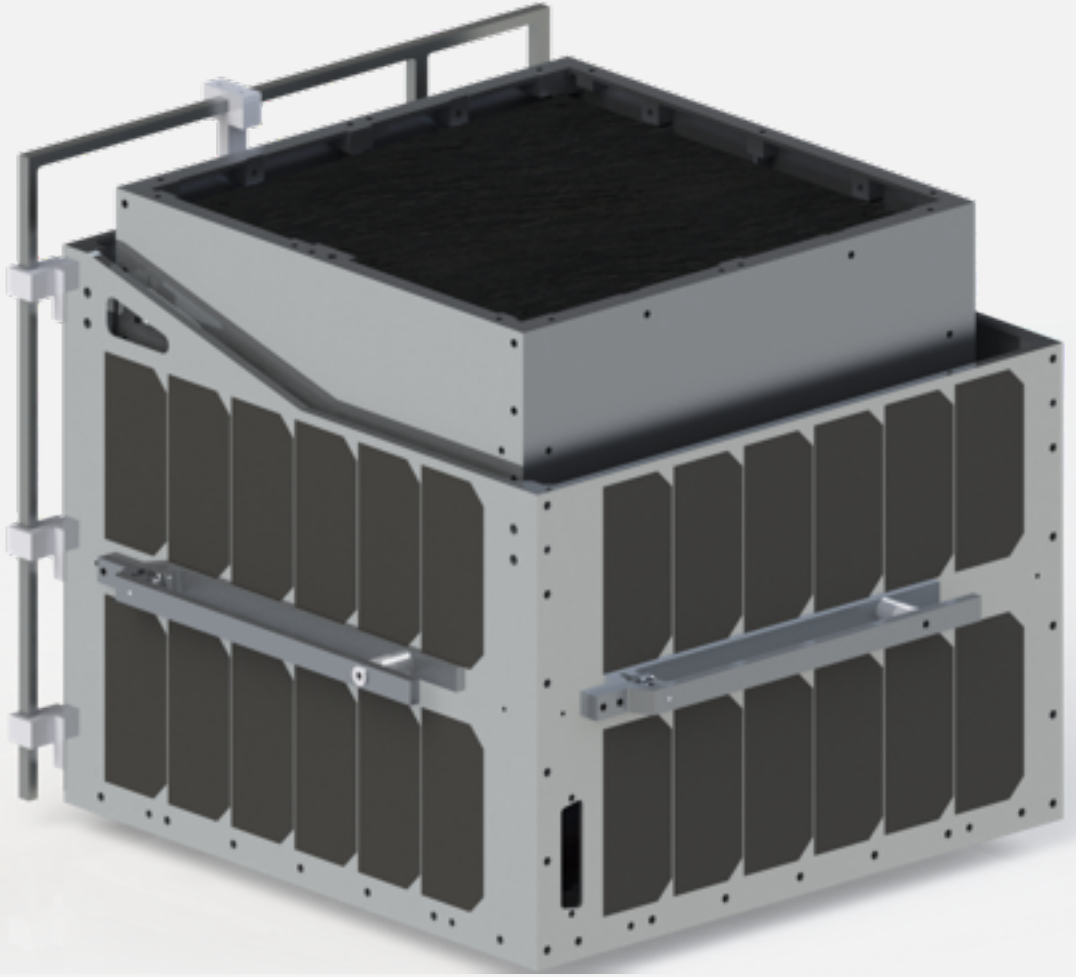
13TH Annual Cubesat Developer's Workshop
CalPoly , San Louis Obispo , CA , US
22nd April 2016

IITMSAT : A Student Driven Satellite Project

Mission Objectives :

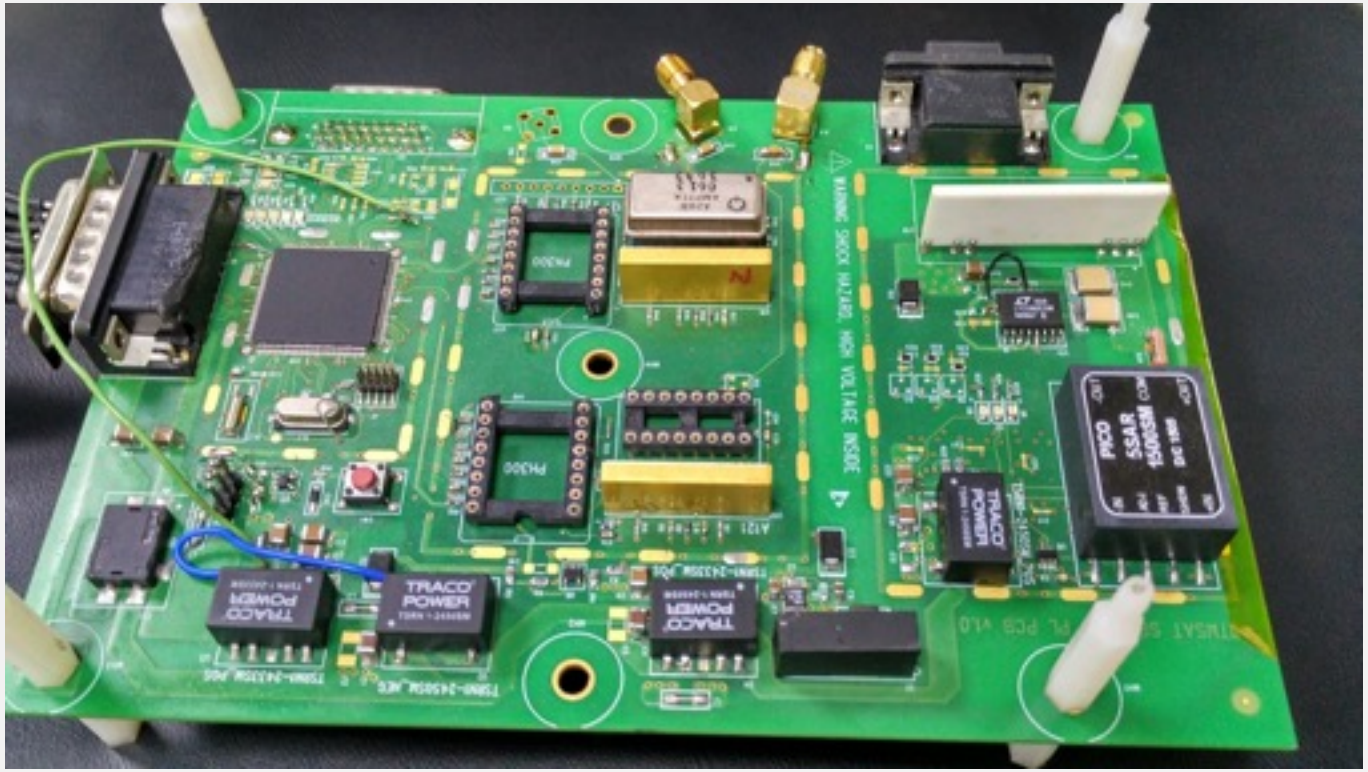
- To design, fabricate, test and launch a small-satellite (12kg),
  that demonstrates all features of satellite functioning
  and build a ground station for collection of data
  from the satellite
- To measure the energy spectrum of protons and electrons
  beneath the inner-Van Allen radiation belt boundary
  (600-800 km) to aid earthquake prediction studies.
- Interpret the data received from the satellite
  and analyse the effects of solar flares, lightning storms
  and seismic activity on the radiation belts



IITMSAT : Space Based Proton Electron Detector (SPEED)

- We are trying to find a possible correlation between short-term increase in the high energy charged particle fluxes (particle busts) below the inner Van Allen radiation belts and seismic activity.
- The Space-Based Proton-Electron Energy Detector (SPEED) is designed to capture the variation in these charge particle fluxes and hence will be able to assert any correlation between the particle bursts and seismic activity with greater certainty.
- SPEED uses electronics support the high count rates, while keeping the power consumption as low as possible.
- SPEED requires different voltages varying from 5V, 3.3V, 12V, -5V and 1000V with very strict ripple requirements.
- The SPEED electronics consists of Peak hold Detector, Charge Sensitive Pre-Amplifier, TIVA microcontroller and Photo Multiplier Tubes .

SPEED :Electrical Power System Grounding Scheme & Power Architecture



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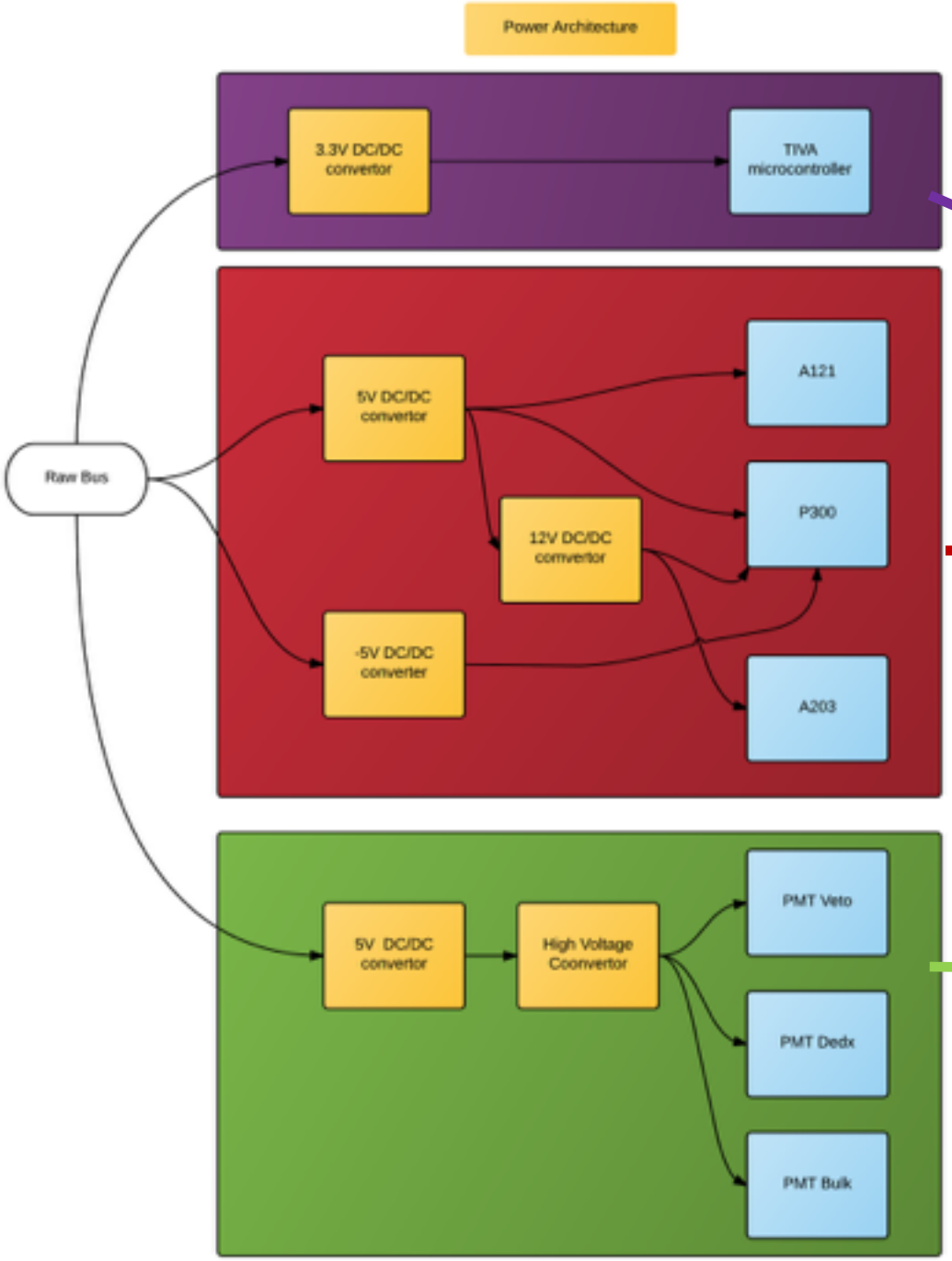
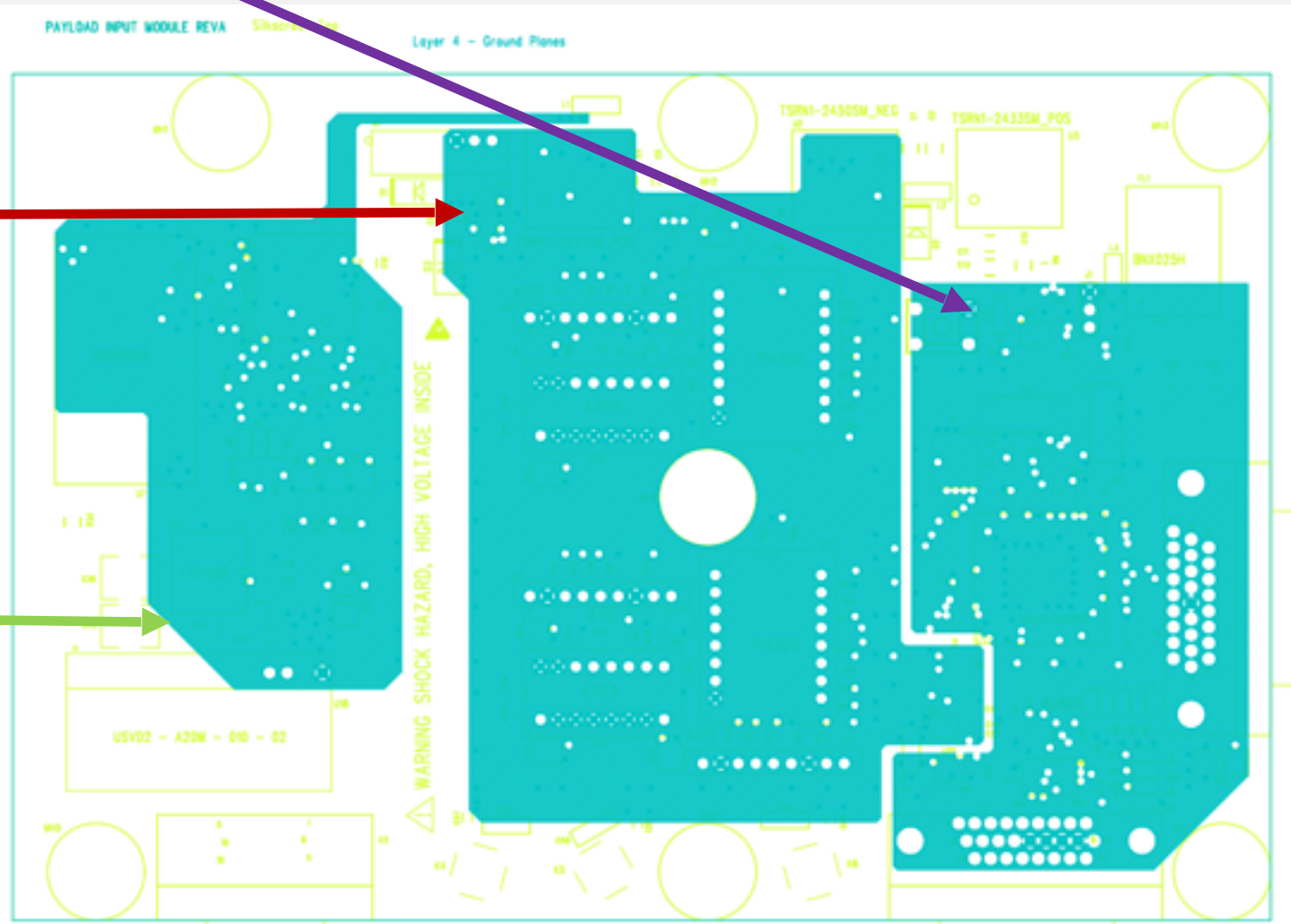
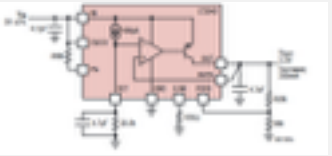
- Raw Bus : 6 V – 18 V (from solar panels to EPS of Payload)
- Ground 1 : Digital (Micro - Controller)
- Ground 2 : Analog (Front End Electronics (FEE))
- Ground 3 : Analog (High Voltage Power Supply)



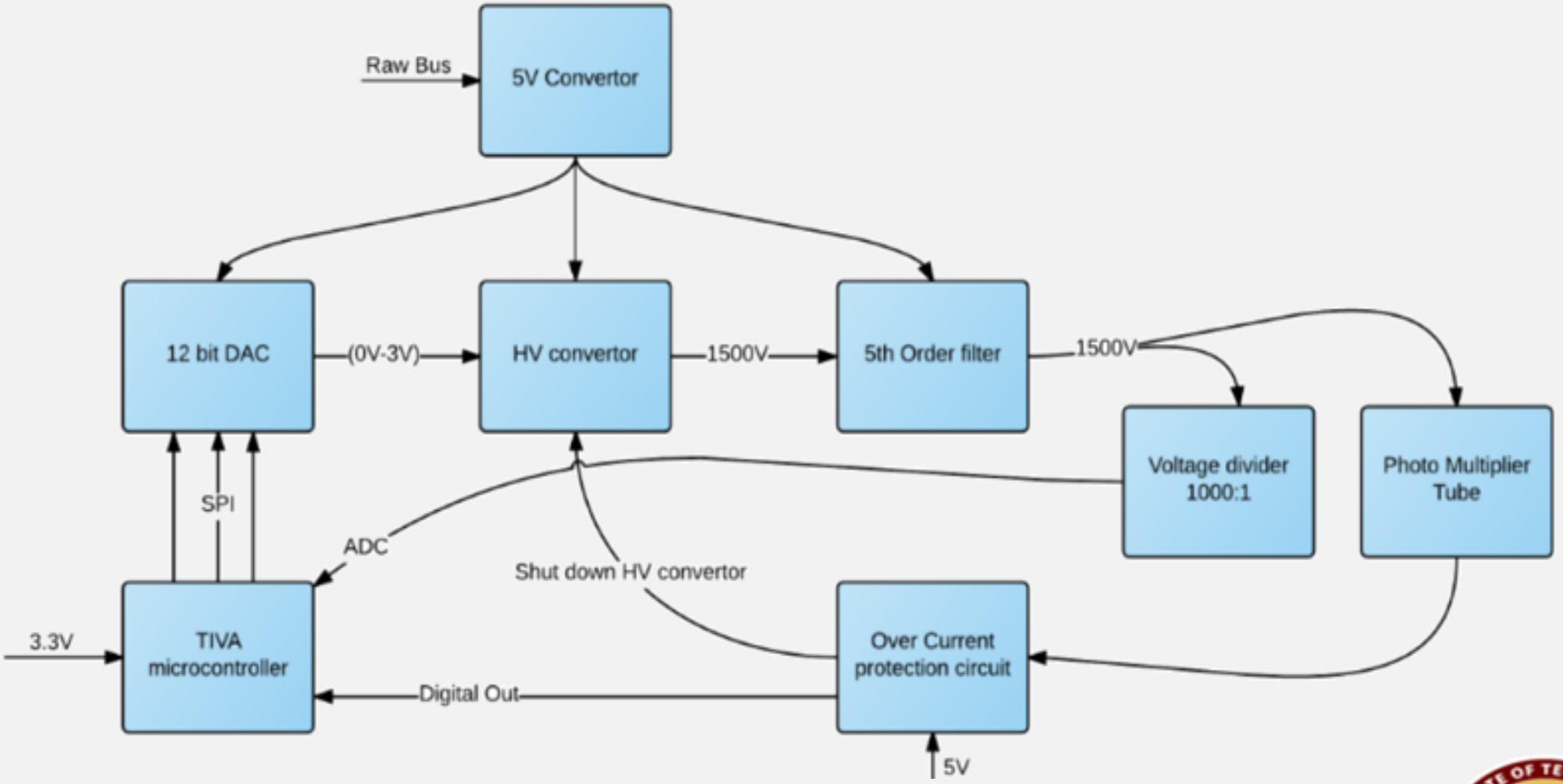


Electrical Power System: Low Voltage DC – DC Converters



	TSRN1-2433	TSRN1-2450	TSRN1-2450	MEV1S051SC+LT3042
Output Voltage	3.3V	5V	-5V	12V
Input Voltage Range	4.6V-42V	6.5V-42V	4.6V-32V	4.5V to 5.5V
Maximum Output Current	1A	1A	0.4A	84mA
Ripple	37mVp-p	52mVp-p	23mVp-p	37.5mVp-p
Efficiency (full load)	87%	91%	79%	78 %

Electrical Power System: High Voltage Power Circuitry



Electrical Power System: High Voltage Power converter

- The 5SAR1500 Series of Adjustable, Isolated, Single Output High Voltage ultra miniature DC-DC Converters that are fully encapsulated for use in a harsh environment.

- The units in the SAR Series have high efficiency, excellent line/load regulation, and operate over a temperature range of -40°C to +80°C with no electrical de-rating or heat-sinking required.

- The converter is very compact at 12g with dimensions of 2.79cmx2.03cmx1.143cm.

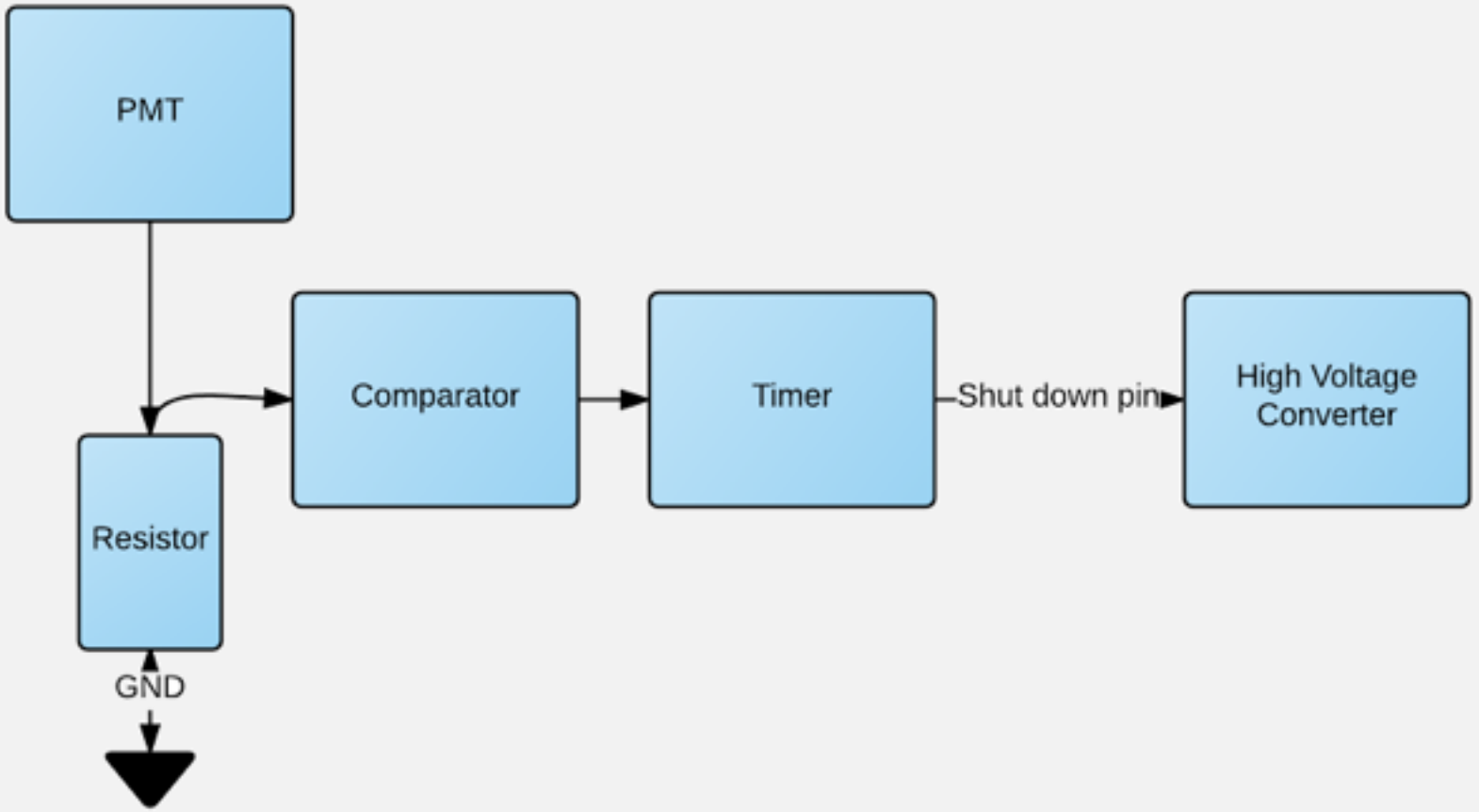
- The ripple of 130khz with 1.2Vp-p for 1000V.

- But the ripple requirement was even more stringent, hence we implemented an active filter that is repurposed to work in high voltages. It is a 5th Order Low pass filter with corner frequency of 1khz, which rolls of AC signals from the supply.

Electrical Power System: Need for over current protection circuit

- The PMT Power supply current can exceed 100uA due to various reasons and this can damage the PMT permanently.
- A circuit was needed to be designed which monitors PMT Power supply current and turn the HV converter off once an over current is detected.
- The key challenge here is that we are playing with 1000V and standard current limiting ICs is not rated for such High Voltages.
- So an over current protection circuit was implemented at the Low side of PMT to solve this problem.

Electrical Power System: Over current protection circuit



PMT Return is connected to Resistor in series with the ground

The current flowing through PMT will create a voltage drop in the resistor

if the current from PMT exceeds a threshold, it will trigger the timer and shut down the High Voltage converter

Conclusion

- The implementation of Integrated converters from TRACO and Murata saved us a lot of time and allowed us to concentrate on the hard part of designing and implementing the high voltage power supply.
- The cost of implementing integrated converters outweigh the cost and time of fabricating a custom DC-DC converters for low volume applications.
- A careful grounding scheme has been implemented to have achieve better SNR in analog circuits.
- A lot of emphasis had to be given on choosing the right connector and traces that carries High Voltage supply for safe and low noise operation.

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Special Thanks to our Sponsers

- Dr Krishna Chivakula (Indo-MiM)
- Mr V. Shankar
- Mr, Srikanth Jadcherla
- Dr Sriram Jaisimha
- Mr D. Chandrashekar
- Batch of 1985 of IIT-Madras

Thanks to

- Central Electronics Center, IIT-Madras for helping us in prototyping
- IIT-Madras for facilitating this Project

The IITMSAT team consist of Students from various disciplines as well as an equally interdisciplinary project Coordinators and Professors. We would like to acknowledge all of them.