

# Power Distribution System for a CubeSat

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# Objective

To design and implement a fully autonomous power generation, storage and distribution system for a CubeSat

# Project Outline

## Electrical Power System (EPS):

- Harvests energy from the solar panels
- Manages power storage and distribution
- Protects circuits from damage
- Redundant architecture

# Literature Review

S.No.	Title	Author	Features
1	A Comprehensive Review on CubeSat Electrical Power System Architectures, in IEEE Transactions on Power Electronics, vol. 37, no. 3, pp. 3161-3177, March 2022	Amarendra Edpuganti , Vinod Khadkikar, Mohamed Shawky El Moursi, Hatem Zeineldin , Naji Al-Sayari, Khalifa Al Hosani	Architecture with PPT an regulated DC-bus was selected.
2	Output power analysis of Tel-USat electrical power system, AIP Conference Proceedings 2226, 030007 (2020)	Aulia Indana, Dharu Arseno, Edwar, Adilla Safira	Centralised architecture was selected.
3	Comparison of Peak Power Tracking Based Electric Power System Architecture for CubeSats, IEEE Transactions on Industry Applications, vol. 57, no. 3, pp. 2758-2768, May-June 2021	A. Edpuganti, V. Khadkikar, H. Zeineldin, M. S. E. Moursi, M. Al Hosani	Peak power transfer is preferred to direct power transfer.

## Literature Review (contd...)

S.No	Title and Journal	Author	Features
4	A Review of Battery Technology in CubeSats and Small Satellite Solutions, Energies, vol. 13, 2020	Knap, Vaclav & Vestergaard, Lars & Stroe, Daniel-Ioan	Solar cells with Li-ion batteries for storage is preferred.
5	Review on the charging techniques of a Li-Ion battery, Third International Conference on Technological Advances in Electrical, Electronics and Computer Engineering (TAEECE), 2015	E. Ayoub and N. Karami	Charging at 5-45°C

# Methodology

- Identifying the power requirements
- Architecture design and topology selection
- Forming Specifications
- Design and simulation
- Procurement of components
- Fabrication and testing

# Power Budget

Sub-system		Voltage (V)	Max. Current (mA)	Power (mW)	Contingency 5%	Margin 20%	Duty Cycle (%)	Energy (Wh)
<b>ADCS</b>	ADCS	3.3	20	66	69.3	83.16	100	0.133725438
	Magnetorquer	3.3	100	330	346.5	415.8	50	0.334313595
<b>OBC</b>	OBC	5	40	200	210	252	100	0.4052286
<b>CxTx</b>	Telemetry	5	300	1500	1575	1890	11	0.334313595
	Beacon	5	20	100	105	126	100	0.2026143
	GPS	3.3	40	132	138.6	166.32	30	0.0802352628
<b>Payload</b>	LoRa	5	20	100	105	126	10	0.02026143
<b>EPS</b>	EPS	-	-	160	168	201.6	100	0.32418288
	Thermal	-	-	250	262.5	315	32	0.16209144
					<b>Tot Power(mW)</b>	<b>3575.88</b>	<b>Tot. Energy</b>	<b>1.997</b>



# System Architecture

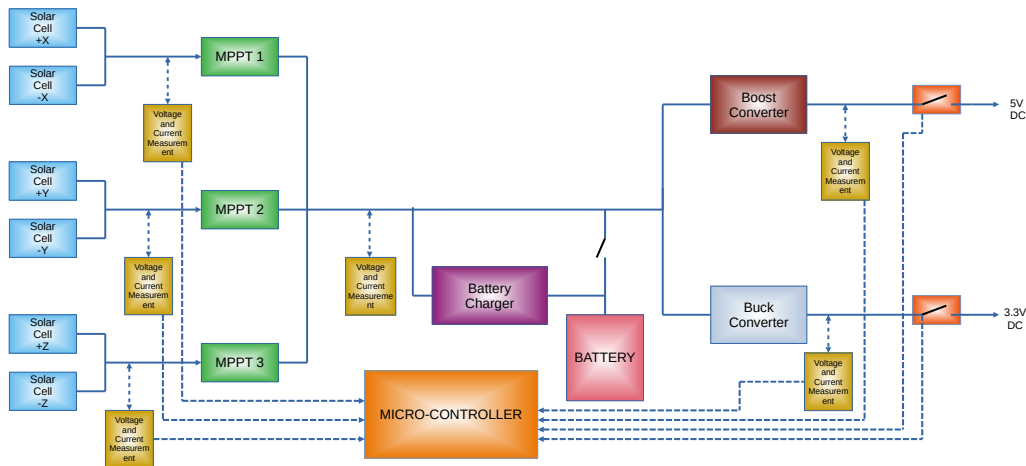


Figure 1: CubeSat EPS Architecture

# Hardware Design - Buck and Boost Converters

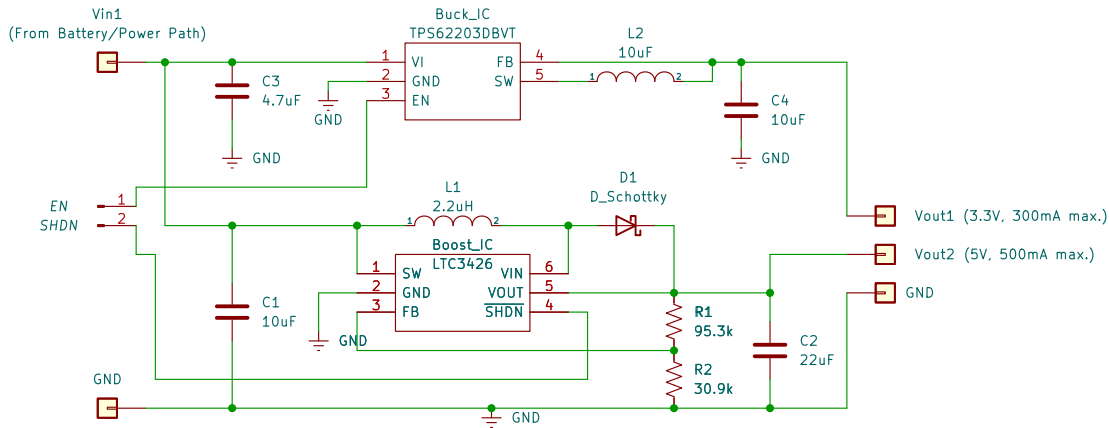


Figure 2: Circuit design of buck and boost converters.

# Hardware Design - Buck and Boost Converters (Contd.)

## Buck Converter:

- IC: TPS62203
- Input Voltage: 3.6 - 5V
- Output Voltage: 3.3V
- Switching Frequency: 1MHz
- Output Current: 300mA (max.)

## Boost Converter:

- IC: LTC3426
- Input Voltage: 3.6 - 5V
- Output Voltage: 5V
- Switching Frequency: 1.2MHz
- Output Current: 500mA (max.)

# Hardware Design - Battery Charger

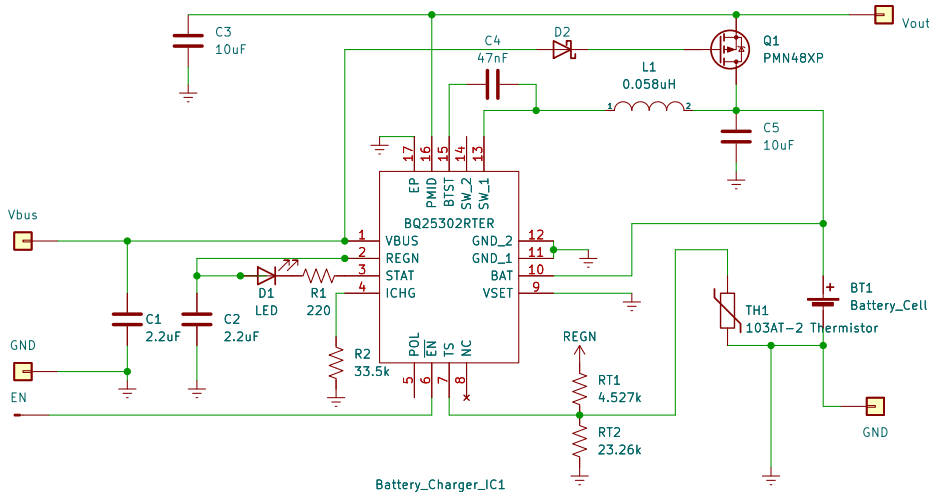


Figure 3: Circuit design of Battery Charger

## Hardware Design - Battery Charger (Contd.)

### Synchronous Buck Battery Charger:

- IC: BQ25302 (With External Power Path configuration)
- Input Voltage: 5V
- Output Voltage: 4.2V (max.)
- Switching Frequency: 1.2MHz
- Output Current: Limited to 1.2A
- Thermistor: Semitec 103AT-2 (10k $\Omega$ )
- Charging Temperature: Limited between 0 - 45 C

# Hardware Design - MPPT

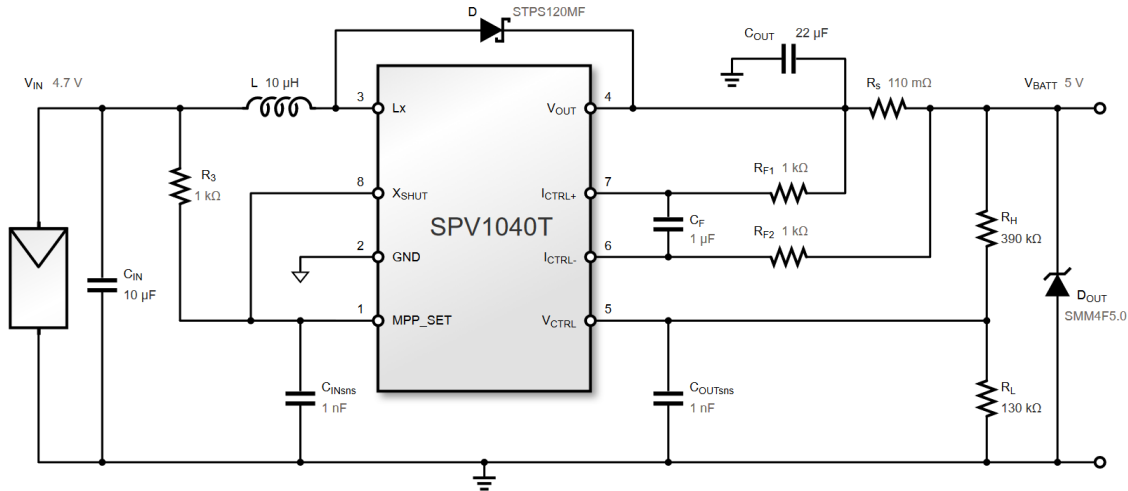


Figure 4: Circuit design of MPPT.

## Hardware Design - MPPT (Contd.)

- IC: SPV1040
- MPPT with P&O algorithm
- Input Voltage: 0.3 - 5.5V
- Output Voltage: 5V
- Switching Frequency: 100kHz
- Inbuilt over-current, temperature protection
- Efficiency: 95/

# Hardware Design - Solar panels

Solar panel:

- TJ Solar Cell 3G30C
- 30% Triple Junction GaAs Junction Solar Cell
- Average Open Circuit Voltage: 2.7V
- Maximum Power Point Voltage: 2.41V
- Average Short Circuit Current: 520.2 mA
- Maximum Power Point Current: 504.4mA
- Average Efficiency at  $1353 \text{ W/m}^2$ : 29.8%



# Hardware Design - Battery

Solar panel:

- Panasonic NCR 18650 GA Li Ion cell
- Voltage: 3.7V - 4.2V
- Maximum Current: 3500mAh

# Hardware Design - Voltage and Current monitoring IC

- IC: LTC 2990
- Quad input
- Communication via I2C serial interface

# Requirements

## Equipments Requirements:

- SMD Soldering Station
- Oscilloscope
- Power Supply
- Function Generator

## Software Requirements:

- MATLAB/Spice
- KiCad
- STM32 CubeIDE

## Budget Estimate: Component cost

SI No.	Component	Description	No.	Cost per unit	Total Cost
1	SPV1040T	MPPT IC	6	400	2400
2	BQ25302	Battery Charger IC	2	150	300
3	NCR18650	Battery	2	800	1600
4	TPS62203DBVTGH	Buck Converter	2	150	300
5	LTC3426ES6#TRPBF	Boost Converter	2	500	1000
6	LTC2990CMS#TRPBF	Voltage, Current Measuring	5	560	2800
7	LTC 4361CT68-1	Overvoltage, overcurrent protection	5	500	2500
8	STM 32 F401RE	Microcontroller	1	2500	2500
9	Miscellaneous costs				2000
					15400

## Budget Estimate: Fabrication cost

Sl. No.	Item	Amount (Rs.)
1	PCB Printing	5000
2	SMD soldering	990
3	Inductor Fabrication	1000

# Project Timeline

Activity	Oct week 3-4	Nov week 1-2	Nov week 3-4	Dec week 1-2	Dec week 3-4
Literature Review					
Hardware Design					
Report Writing					
Component selection					
Component Procurement					

# References

- [1] Knap, Vaclav & Vestergaard, Lars & Stroe, Daniel-loan (2020 )  
A Review of Battery Technology in CubeSats and Small Satellite Solutions  
*Energies, vol. 13*
- [2] A. Edpuganti, V. Khadkikar, H. Zeineldin, M. S. E. Moursi and M. Al Hosani (2021)  
Comparison of Peak Power Tracking Based Electric Power System Architectures for CubeSats  
*IEEE Transactions on Industry Applications, vol. 57, no. 3, pp. 2758-2768, May-June 2021*
- [3] E. Ayoub and N. Karami  
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*IEEE Access*, vol. 10, pp. 55396-55407
- [5] A. Edpuganti, V. Khadkikar, M. S. E. Moursi, H. Zeineldin, N. Al-Sayari and K. Al Hosani (2022)  
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*IEEE Transactions on Power Electronics*, vol. 37, no. 3, pp. 3161-3177, March 2022
- [6] Aulia Indana, Dharu Arseno, Edwar, and Adilla Safira (2020)  
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# Thank You