Power Distribution System for a CubeSat

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Contents

Objective

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

Project Outline

CubeSat (1U):

- Dimensions - 10x10x10 cm^3
- Weight - 2 kg.

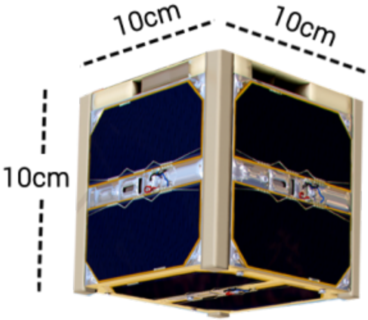

Figure 1: CubeSat 1U (Source: GIS Geography)

Project Outline (Contd.)

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 over 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

System Architecture

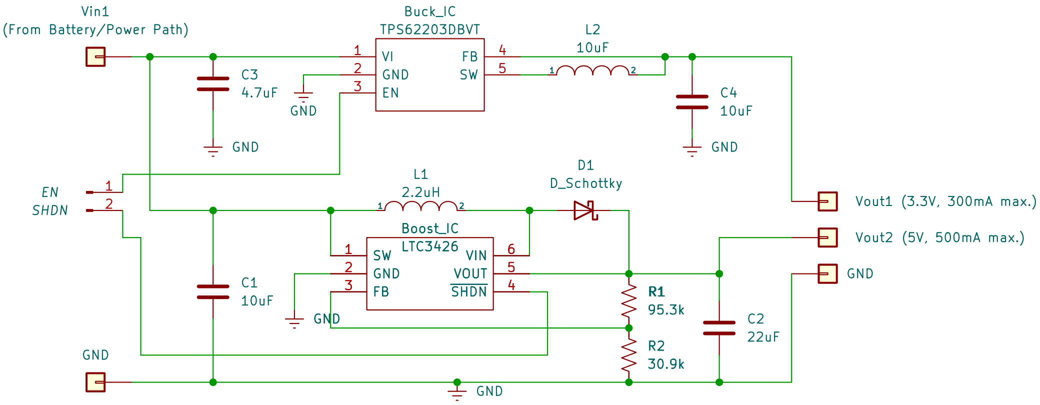

Figure 2: CubeSat EPS Architecture

Power Budget

Sub-system		Voltage (V)	Max. Current (mA)	Power (mW)	Contingency 5%	Margin 20%	Duty Cycle (%)	Energy (Wh)
ADCS	ADCS	3.3	20	66	69.3	83.16	100	0.133725438
	Magnetorquer	3.3	100	330	346.5	415.8	50	0.334313595
OBC	OBC	5	40	200	210	252	100	0.4052286
CxTx	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
Payload	LoRa	5	20	100	105	126	10	0.02026143
EPS	EPS	-	-	160	168	201.6	100	0.32418288
	Thermal	-	-	250	262.5	315	32	0.16209144
					Tot Power(mW)	**3575.88**	**Tot. Energy**	**1.997**

Methodology

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

Requirements

Equipments Requirements:

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

Software Requirements:

- MATLAB/Spice
- KiCad
- STM32 CubeIDE

Budget Estimate: Component cost

Sl 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 Procurement					
Fabrication					
Software Development					
Testing					

References

[1] Knap, Vaclav & Vestergaard, Lars & Stroe, Daniel-Ioan (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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[4] B. Hussein, A. M. Massoud and T. Khattab (2022)
Centralized, Distributed, and Module-Integrated Electric Power System Schemes in CubeSats: Performance Assessment
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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Thank You