Power Distribution System for a CubeSat

Presented by :

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Contents

- 1. Objective
- 2. System Architecture
- 3. Hardware Design
- 4. Components List
- 5. Project Timeline
- 6. References

Objective

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

System Architecture

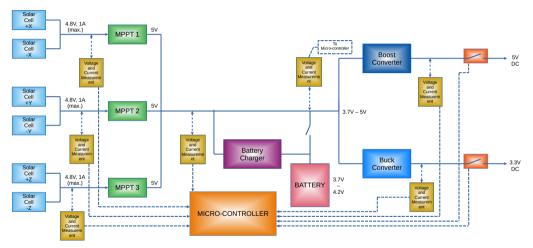


Figure 1: CubeSat EPS Architecture

Hardware Design - Buck and Boost Converters with Monitoring

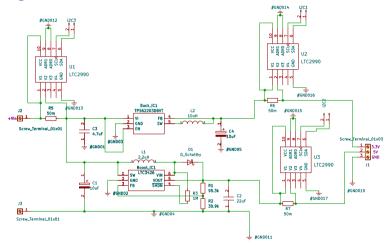


Figure 2: Circuit design of buck and boost converters with monitoring

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.)

All converters operate in continuous conduction mode.



Hardware Design - Buck and Boost Converters with Monitoring (Contd.)

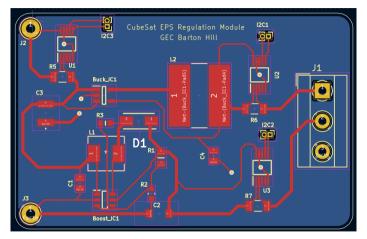


Figure 3: PCB Layout of buck and boost converters with monitoring (55mm x 35mm)

Hardware Design - Buck and Boost Converters with Monitoring (Contd.)

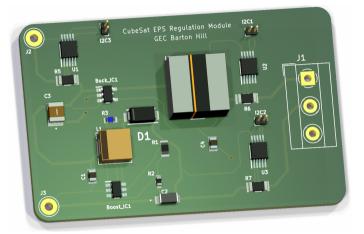


Figure 4: 3-D model of buck and boost converters with monitoring

Hardware Design - Voltage and Current monitoring IC

- IC: LTC 2990
- Quad input
- Voltage and Current Monitoring
- Communication via I2C serial interface

Hardware Design - Battery Charger

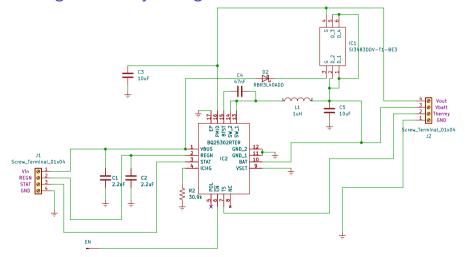


Figure 5: Circuit design of Battery Charger

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 - Battery Charger (Contd.)

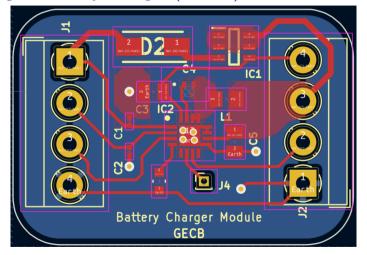


Figure 6: PCB Layout of Battery Charger (29mm x 20mm)

Hardware Design - Battery Charger (Contd.)

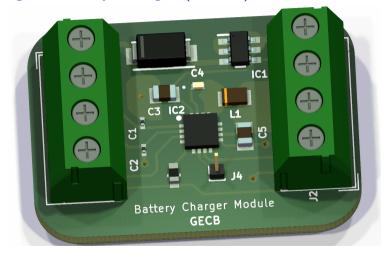


Figure 7: 3-D model of Battery Charger

Hardware Design - MPPT

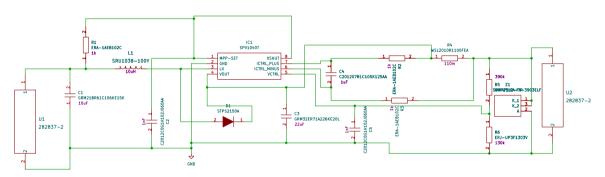


Figure 8: Circuit design of MPPT

Hardware Design - MPPT (Contd.)

- IC: SPV1040
- MPPT with Perturb and Observe algorithm
- Input Voltage: 0.3 5.5V
- Output Voltage: 5V
- Switching Frequency: 100kHz
- Inbuilt over-current, temperature protection
- Efficiency: 95%

Hardware Design - MPPT (Contd.)

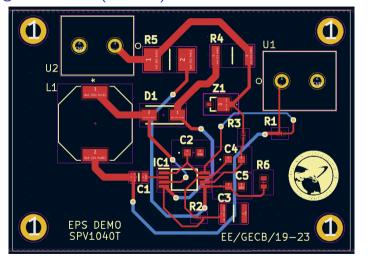


Figure 9: PCB Layout of MPPT



Hardware Design - MPPT (Contd.)

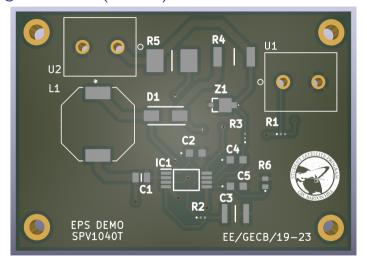


Figure 10: 3-D model of MPPT

Hardware Design - Protection

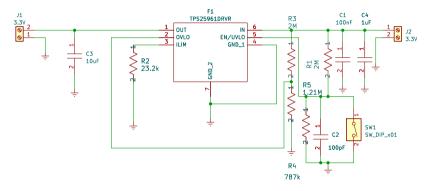


Figure 11: Circuit design for protection

Hardware Design - Protection (Contd.)

- IC: TPS25961
- Under-voltage, Over-voltage, Short circuit, Over-current, Over-temperature protection
- Input Voltage Range: 0.3 21V
- ullet Maximum Output Voltage: $V_{in}\,+\,0.3$
- Temperature Range of -40°C 125°C
- Adjustable current limit threshold from 0.1A 2A.

Hardware Design - Protection (Contd.)

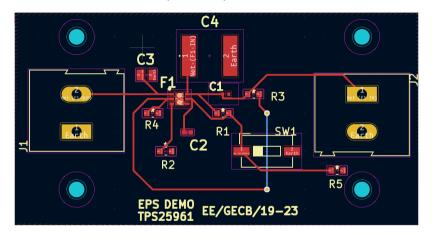


Figure 12: PCB Layout of protection circuit (55mm x 28mm)

Hardware Design - Protection (Contd.)

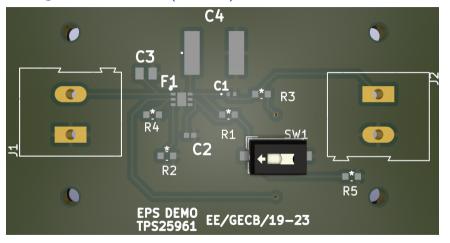


Figure 13: 3-D model of protection circuit

Components List

SI NO.	MANUFACTURER PART#	DESCRIPTION	QUANTITY					
	1 C1210C475K4RACAUTO	Multilayer Ceramic Capacitors MLCC - SMD/SMT 16V 4.7uF X7R 1210 10% AEC-Q200	4					
	2 ERA-1AEB102C Thin Film Resistors - SMD 0201 1Kohm 0.1% 25ppm							
3	3 C2012X7R1C105K125AA Multilayer Ceramic Capacitors MLCC - SMD/SMT 1.0UF 16V 10% 0805							
4	4 MCT0603MD1004BP500	Thin Film Resistors - SMD .125W 1Mohms .1% 0603 25ppm	4					
	WSL2010R1100FEA Current Sense Resistors - SMD 1/2watt .11ohms 1%							
(5 SI3483DDV-T1-BE3	I3483DDV-T1-BE3 MOSFET P-CHANNEL 30-V (D-S)						
7	CMP2512-FX-3903ELF Thick Film Resistors - SMD ResHighPower 2512 390k 1% 1.5W TC100							
8	B C2012C0G1H102J060AA	Multilayer Ceramic Capacitors MLCC - SMD/SMT	6					
9	9 ERJ-PB6B3002V	Thick Film Resistors - SMD 0805 Anti-Surge Res. 0.1%, 30Kohm	4					
10	GRM32ER71A226KE20L	Multilayer Ceramic Capacitors MLCC - SMD/SMT	4					
13	1 GRM21BR61C106KE15K	Multilayer Ceramic Capacitors MLCC - SMD/SMT 10UF 16V 10% 0805	10					
12	2 ERJ-UP3F1303V	Thick Film Resistors - SMD 0603 Anti-sulfurated anti-surge resistor	4					
13	CL03A225KP3CRNC	Multilayer Ceramic Capacitors MLCC - SMD/SMT X5R, 2.2uF, +/-10%, 10v, 0201	6					
14	4 0805YC106KAT2A	Multilayer Ceramic Capacitors MLCC - SMD/SMT 16V 10uF X7R 0805 10%	11					
15	5 RC0603FR-0730K9L	Thick Film Resistors - SMD 30.9 kOhms 100mW 0603 1%	7					
16	5 SRN1060-100M	Power Inductors - SMD 10uH 20% SMD 1060	4					
17	7 IHLP2020CZER2R2M8A	Power Inductors - SMD 2.2uH 6.6A 26Mohm	5					
18	B C1005X8R1C473M050BB	Multilayer Ceramic Capacitors MLCC - SMD/SMT	10					
19	9 LTC3426ES6#TRMPBF	Switching Voltage Regulators 1.2MHz Boost DC/DC Conv in SOT-23	3					
20	SPV1040T	Battery Management Hi efficiency solar battery charger	3					
2:	1 CR0805-FX-9532ELF	Thick Film Resistors - SMD 95.3K 1%	5					
22	2 WSLP1206R0500FEA	Current Sense Resistors - SMD 1Watt 0.05Ohms 1%	10					
23	3 C3216JB1C226M160AB	Multilayer Ceramic Capacitors MLCC - SMD/SMT	4					
24	4 STPS2150A	Schottky Diodes & Rectifiers 2.0 Amp 150 Volt	5					
25	5 SRU1038-100Y	Power Inductors - SMD 10uH 30% SMD 1038	4					
26	HHP0805ZHER1R0M01	Power Inductors - SMD 0805 1uH 20%	4					
27	LTC2990CMS#PBF	I2C V, C & Temp Mon	3					
28	LTC4361CDC-2#TRMPBF	Overvoltage/Overcurrent Prot Cntr	3					
29	TPS62203DBVT	Switching Voltage Regulators 3.3V Out Hi-Eff Step-Down Converter	3					
30	BQ25302RTER	Li ion Battery Charger	3					
	1 511-SMM4F5.0	ESD Suppressors / TVS Diodes 400W HI JCT TMP	3					
	STPS2150A	Schottky Diodes & Rectifiers 2.0 Amp 150 Volt	3					
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Project Timeline

Activity	Jan week 3-4	Feb week 1-2	Feb week 3-4	Mar week 1-2	Mar week 3-4	Apr week 1-2	Apr week 3-4	May week 1-3
PCB design and fabrication								
Component procurement								
Microcontroller programming								
Soldering								
Troubleshooting								
Report Writing								

References

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- Comparison of Peak Power Tracking Based Electric Power System Architectures for CubeSats

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Thank You