

Electrical Power System[☆]

A. A. Viana Júnior^{a,b}, O. M. Petito^{a,b,*}, T. A. D. O. Cordeiro^{a,b}, A. O. Santos^{a,b,1}

^a*Praça Mauá, 1, São Caetano do Sul, São Paulo, Brasil*

^b*Escola de Engenharia Mauá do Instituto Mauá de Tecnologia*

Abstract

This article discusses the development of a power system, capable of supplying the entire energy demand of the attitude control subsystem, communication, data processing and payload of the CubeSat, Escola de Engenharia Mauá's project. The power system developed is responsible for generating, distribution and control of the entire energy flow of the CubeSat Mauá. The energy generated by high efficiency aerospace photocells, endowed with the triple junction technology (GaInP/GaAs/Ge) is stored in Ion-Lithium batteries. The distribution of energy is made by three levels of stabilized voltages and regulated in 3.3V, 5V, 12V and there is a unregulated level supplied directly from the battery. In case of failure, a set of redundant power supplies are able to take any of the regulated voltages levels. All control of the power system is performed by a microcontroller, which collects and analyzes data, such as temperature, voltage and current to determine whether the system power will come from major sources or from redundant ones. Through a CAN network, the microcontroller transmits telemetry information to a Data Processing Unit, which takes more complex decisions involving all the CubeSat subsystems.

Keywords:

EPS, power system, CubeSat, power management.

1. Objective

This Electrical Power System (EPS), was part of the Escola de Engenharia Mauá's project of developing a CubeSat of NSEE-IMT², in addition to helping to promote research and development projects to educate and train students and researchers in the aerospace area, aimed to provide the necessary energy with direct impact or not sunlight, to ensure the success of space missions.

2. Topology

The circuit topology was the first step to the development of the Electrical Power System, which was defined through a block diagram how the proposed circuit works, always following the assumptions of NSEE-IMT's project.[1]

The solar panels are responsible for capture sunlight, converting it into electricity. This electricity goes to the charger board, passes through the battery charging system and, also, by a voltage sensor and current sensor. The battery energy has two different destinies, being one of them the backup converter (that provides

[☆]This article is a collaborative effort.

*Corresponding author

Email addresses: arnaldoavianajr@gmail.com (A. A. Viana Júnior), otaviompetito@gmail.com (O. M. Petito), tiagoademay@gmail.com (T. A. D. O. Cordeiro), aleosantos@maua.br (A. O. Santos)

¹Professor advisor

²Núcleo de Sistemas Eletrônicos Embarcados do Instituto Mauá de Tecnologia, or in English, Center for Embedded Electronic Systems

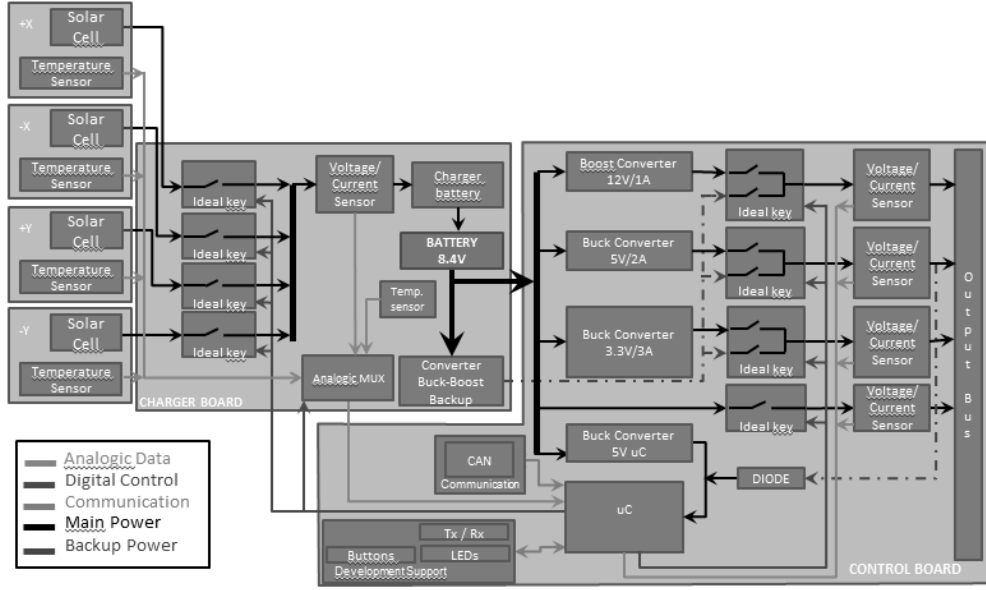


Figure 1: Block diagram.
Font: Elaborated by the authors.

3.3V, 5V and 12V, it can also provide the three voltages in the same time) and, the other one, is the control board.

In the control board there are three voltage converters of 3.3V, 5V and 12V, that are responsible for realize the supply these voltages to the output bus, where, also, is possible have the battery voltage.

In this same board is allocated a microcontroller that is powered independently, because of its dedicated converter. However, if this converter shows any failure, the output bus can provide the 5V for keep the microcontroller working. Between the converters and the output bus, there are smart keys of low losses that make a comparative between the voltages from main converters with the backup converter and send one of them in the output. The circuit of the backup converter was projected to provide a value slightly lower than the main converters, in this way the smart keys, by default, always enable the main converters.

Still on the control board, there is a microcontroller to realize the telemetry of the system and communicating via the CAN protocol, with the Data Processing Unit. In case of any failure with this microcontroller, the system keeps working, losing only the communication with the DPU and monitoring of sensors.

3. Hardware development

The hardware development was divided in three parts.

3.1. Solar panel

For the development of solar panel, had been used solar cells of triple-junction (GaInP/GaAS/Ge) of the model TrisolX Solar Wings, which has a efficiently approximately 28.0%. As each one provides until 2.33V, was realized a arrangement with four solar cells in series, managing to provide a voltage of 9.32V, enough to make charging the Lithium-Ion battery of 7.4V. Were implemented, in parallel, six sets with four solar cells in series, totaling 24 solar cells on the solar panel. Bypass diodes were used to avoid damages and power losses system, due the differences of electrical characteristics from solar cells.[2]

3.2. Charger board

In this board are allocated the charging battery system and the backup converter (LTC1941, one output boost and two bucks), that supply energy to output bus, in case it happens any failure in the main system. Besides having a analogic multiplex that performs the reads from temperature sensors of the solar cells according the panel desired by microcontroller.[3]

3.3. Control board

The control board is responsible for three main converters (one LM3488 and two TPS563200), smart keys of low losses (LTC4412) and voltage and current sensors, besides the microcontroller (PIC18F66K80) that performs all system monitoring.[4][5][6][7]



Figure 2: Solar panel.

Font: Picture taken by the authors.

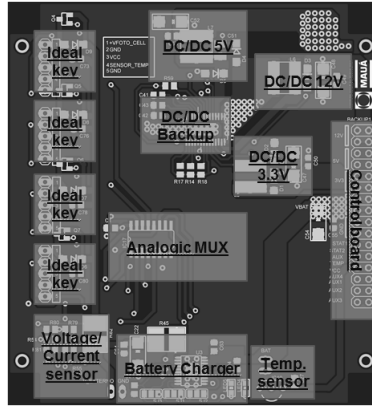


Figure 3: Charger board.

Font: Elaborated by the authors.

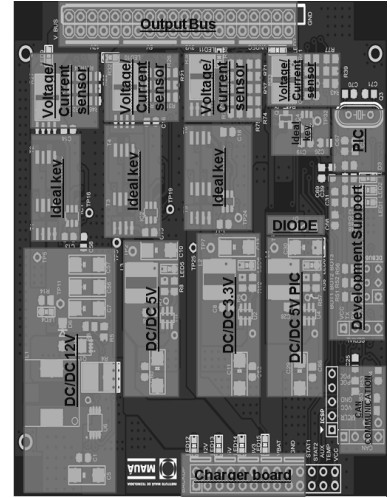


Figure 4: Control board, top vision.

Font: Elaborated by the authors.

4. Software development

A simple software for the realization of EPS telemetry was developed, which can be seen in a simplified manner in the Figure 4.1.

The calibration of the system is done in seven steps: the microcontroller forces the smart key to provides the voltage from the main converter, reads the value and stores into memory, then the microcontroller forces the smart key to supply the voltage from the backup converter, reads the value and compares with the main converter if there is a small difference, if the condition is satisfied it stores the value and does the same cycle for the others voltages.

5. Conclusion

The solution implemented for improve the lifespan of Electrical Power System, using a backup source shows itself quite effective, the switching between the main source and backup source, with the use of ideal keys, showed itself quite functional, because has low losses and do not causes disturbances in the payload during the switching, that keeps working normally.

The way the system was implemented can become a didactical platform for study of power electronic in the aerospace area, respecting the specified norms from the Cal Poly.[8]

Redundancies worked as designed by the group, so, if the main converter decrease its voltage to the point of getting the low voltage provided by the backup converter, this takes its place and begins, immediately,

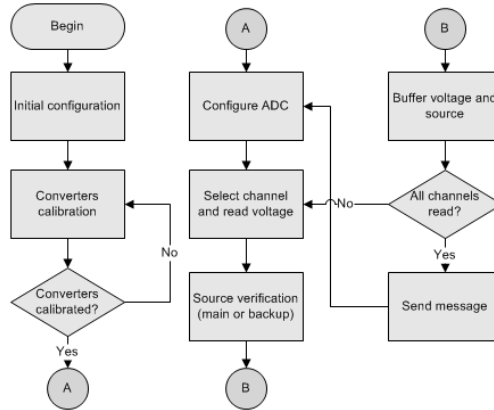


Figure 5: Software flowchart
Font: Elaborated by the authors.

to provide the energy in the output bus, without the load feel switching between sources. This occurs individually for each converter or, even to all together, and does not impair the power supply to the other subsystems of the CubeSat.

6. References

- [1] R. C. FERRÃO, Especificação do produto CubeSat, NSEE-IMT, São Caetano do Sul, 1st Edition (2014).
- [2] TrisolX, Nova Iorque, TrisolX Solar Wings (2015).
- [3] Linear Technology, Low Loss PowerPath Controller in ThinSOT (2014).
URL <http://cds.linear.com/docs/en/datasheet/1941fb.pdf>
- [4] Texas Instruments, LM3488/-Q1 High-Efficiency, Low-Side, N-Channel Controller for Switching Regulators (2014).
URL <http://www.ti.com/lit/ds/snvs089n/snvs089n.pdf>
- [5] Texas Instruments, Tps56x200 4.5 V To 17 V Input, 2 A, 3 A Synchronous Step-Down Voltage Regulator In 6 Pin SOT-23 (2014).
URL <http://www.ti.com/lit/ds/symlink/tps563200.pdf>
- [6] Linear Technology, Low Loss PowerPath Controller in ThinSOT (2014).
URL <http://cds.linear.com/docs/en/datasheet/4412fb.pdf>
- [7] Microchip, PIC18F66K80 Family Data Sheet (2014).
URL <http://ww1.microchip.com/downloads/en/DeviceDoc/39977c.pdf>
- [8] A. MEHRPARVAR, D. PIGNATELLI, CubeSat Design Specification, Cal Poly, Califórnia, 13th Edition (2014).