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FloripaSat-3: Platform Design Methodology and Preliminar Analysis

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Abstract

This paper details the development of the third version of the FloripaSat CubeSat platform, focusing on enhanced reliability and robustness. CubeSats have gained popularity due to their low cost and rapid development cycle, yet the affordability of commercial platforms remains a barrier for many educational and research institutions. The SpaceLab team at UFSC aims to address this issue by creating an open-source, robust satellite platform. The FloripaSat-3 platform improves upon its predecessors, FloripaSat-1 and 2, by introducing a systematic design methodology for key subsystems such as On-Board Data Handling (OBDH), Telemetry and Telecommand (TMTC), and the Electrical Power System (EPS). The design process is based on ECSS guidelines and divided into four stages: requirement analysis, schematic and layout design, preliminary testing, and final adjustments with full subsystem integration. The primary goal is to create a reliable platform that can be reused for various missions, addressing the limitations encountered in earlier versions, particularly those related to scalability and processing power. Additionally, the paper emphasizes the open-source nature of the project, providing detailed documentation, schematics, and block diagrams, which can be further developed by other teams. FloripaSat-3 is expected to serve as a foundation for more ambitious space projects, making space technology more accessible to a broader range of users and contributing to the evolution of small

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satellite platforms.

1 Introduction

In June 2003, the first CubeSat, XI-IV, was launched by the team at the Intelligent Space Systems Laboratory (ISSL) of the University of Tokyo. This satellite not only made history by remaining operational for over 15 years [1], but it also marked the beginning of a new era in satellite development and launch. This era is characterized by the development and mass launch of miniaturized satellites following a well-defined standard [2].

This standard was conceived in 1999 by researchers from California Polytechnic State University and Stanford University, with the goal of democratizing access to the space environment. Initially, most CubeSat missions were conducted by students and researchers at universities, focusing on hands-on learning and scientific/technological research [3]. Currently, they are being used for Earth observation [4], remote sensing [5] and even deep-space applications [6].

Despite their diverse applications, all CubeSats share a common architecture, comprising of a service module and one or more payloads. Payloads are the satellite's equipment or instruments that enable the mission, such as a camera for Earth observation applications. The service module, on the other hand, ensures the satellite's overall functionality throughout the mission and typically consists of three main subsystems: Electrical Power System (EPS), On-Board Data Handling (OBDH), and Telemetry and Telecommand (TMTC).

Given the importance of the satellite's service module, it is common to either purchase COTS platforms from well-known companies, like EnduroSat, GomSpace, or ISISpace, or to develop a custom, reusable platform, which can be more cost-effective. The SpaceLab team opted for the latter to promote hands-on learning and to create a more economical and adaptable platform for both current and future missions.

The FloripaSat-1 [7] was SpaceLab's first platform, successfully used in the satellite of the same name launched in 2019. It was subsequently improved through hardware modifications and firmware restructuring, leading to the development of the FloripaSat-2 platform [8]. This platform is closer to a multi-mission design and is currently used in several missions, including GOLDS-UFSC [9], Catarina-A1 and A3[1], Aldebaran-1[2], CIMATELITE [10], and others. However, the MSP430 microcontrollers used in previous platforms present several limitations, and other constraints have been observed that impact its scalability.

To overcome the limitations of previous platforms, we aim to develop FloripaSat-3, a new platform that prioritizes flexibility, reliability, and robustness without compromising practicality. The development methodology for FloripaSat-3 entails a comprehensive analysis of existing platforms (both commercial and custom-built), followed by a assessment of requirements and evaluation of various components. This systematic approach will inform the design of the new platform, ensuring it addresses the shortcomings of its predecessors. This article focuses on the development methodology, emphasizing the lessons learned

[1] https://www.gov.br/aeb/pt-br/acoes-e-programas/desenvolvimento-tecnologico/constelacao-catarina

[2] https://www.gov.br/aeb/pt-br/centrais-de-conteudo/publicacoes/instagram-do-periodo-de-defeso-eleitoral-2022/missao-aldebaran-i

from previous platforms to achieve continuous improvement and enhanced accessibility.

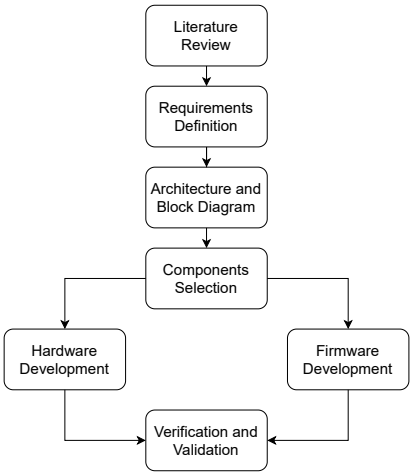
The remainder of this work is organized as follows: In section 2, we present the development methodology for a CubeSat platform, outlining the step-by-step process used to develop SpaceLab's new platform. Also in this section, specific aspects of developing each subsystem of the platform are presented. section 4 addresses the next steps in the development process. Finally, section 5 presents the conclusions drawn from this study.

2 Methodology

The methodology adopted for the development of the FloripaSat-3 platform is structured into several key stages: *1)* a comprehensive literature review, *2)* definition of baseline requirements, *3)* block diagram creation, *4)* components selection, *5)* hardware and firmware development, and *6)* verification and validation of the platform. So far, the SpaceLab team has completed the initial stages, including the literature review, requirements definition, and component selection, along with the creation of an initial block diagram. These foundational steps set the stage for the subsequent development phases, which will involve detailed hardware and firmware work. For a clearer understanding of the entire process, Figure 1 provides a flowgraph of the proposed approach.

Initially, an extensive literature review was conducted on existing projects at other institutions to identify best practices, innovations, and challenges faced in similar developments. The predecessor platforms developed by the laboratory, FloripaSat-1 [7] and FloripaSat-2 [9], played a crucial role in shaping the decisions for the current system. The experience gained from these earlier projects provided valuable insights into key design choices, such as in component selection, system architecture, and mission requirements. This foundation ensures that lessons learned from previous modules, commercial and non-commercial, were incorporated to enhance performance and reliability.

Figure 1: Flowgraph of the development and design methodology proposed for the FloripaSat-3.



Clear and well-defined requirements are essential to align each module to the mission objectives and guide design and testing. For this project, the European Cooperation for Space Standardization (ECSS) recommendations were used as a foundation [11] [12], covering aspects like performance, reliability, and verification. Insights gained from previous missions, including FloripaSat-1 and GOLDS-UFSC, also influenced these criteria. Requirements were classified by type, verification method, and system level following IEEE standards [13]. Additionally, the laboratory

introduced its own nomenclature for the requirements: SLB-SYS-REQ-XYY, where SLB refers to SpaceLab, SYS represents the name of the system module, REQ stands for requirements, and XYY is the requirement code. The first digit indicates the type of requirement, while the last digit indicates its specific order (e.g., first, second, etc.).

Next, the overall architecture of the module was defined based on those requirements, depicted on a detailed block diagram disposed in Figure 1. It included all main components and their interconnections, serving as a guide for subsequent project stages. With the architecture in place, specific electronic components were selected to meet the established requirements. The component selection considered factors such as availability, cost, performance and reliability. Selecting preferably automotive components due to its temperature range and extreme conditions resistence, improving its reliability.

In the hardware development phase, detailed schematics for the functional blocks will be created and reviewed. Once approved, circuit board layouts must be designed. For its development, the methodolgy of [14] is used. Even without a specific mission, parallel development of firmware is feasible once components are selected, as development kits for the ICs can be utilized and the base code can be written. This allows for early firmware development and testing alongside hardware design.

The board for each module is then fabricated and subjected to bench tests, including visual inspection, electrical checks, performance tests, and reliability analyses, to ensure that each part of the subsystem operates according to the established requirements [15].

Based on the results of bench tests and firmware development, final adjustments are made to the schematics and layouts. These modifications aim to correct any faults, improve efficiency, and ensure seamless integration between all components. After adjustments, the final module board can be fabricated, integrating all the previously developed and tested functional blocks. The complete board undergoes another round of bench tests, verifying the interaction between all components and the combined operation of hardware and firmware.

Furthermore, the project adheres to open-source principles, utilizing the CERN-OHL-S license for hardware, GPLv3 for software, and Creative Commons BY-SA 4.0 for documentation. This commitment to open-source philosophy ensures the project's accessibility to other research groups and external contributions. For instance, the hardware development for the FloripaSat-3 platform is being carried out entirely using KiCad EDA software, rather than the proprietary Altium Designer used in previous generations. KiCad's open-source nature allows for greater accessibility and collaboration, with project files publicly available on GitHub for community use.

Throughout the entire process, documentation shall continuously updated to reflect any changes or improvements. This documentation may include all technical specifications, schematics, layouts, test results, and firmware utilization, ensuring traceability and compliance with the initial requirements.

3 Preliminary analysis and definitions

In this section, it is presented a preliminary analysis and initial definitions so far for the

three main subsystems of FloripaSat-3 platform: TMTC, OBDH and EPS.

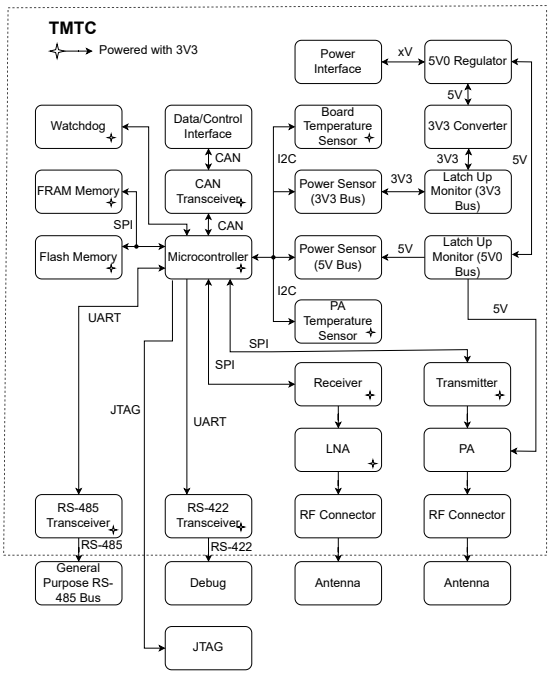
3.1 TMTC

Designing a robust telemetry and telecommand module requires a detailed analysis of the state of the art. In this context, the review began with the analysis of the TTC 2.0, the telemetry and telecommand module from SpaceLab's FloripaSat-2. This module uses GFSK/GMSK modulation, operates at VHF and/or UHF bands, and follows the NGHam protocol, with UART, I^2C, and SPI interfaces. This previous telecommunication module influenced several decisions regarding the current TMTC. Additionally, a review was conducted of commercial modules from EnduroSat [16], ISISpace [17] and GomSpace [18], focusing on UHF modules and comparing their characteristics, as shown in Table 1.

After conducting a thorough review of the state of the art, the requirements for the TMTC module were developed and refined according to the proposed methodology. These requirements encompass both the specific functionalities of the module and its integration with the rest of the satellite system. An example of TMTC requirement is that the TMTC module shall operate correctly between -40 and 85 °C, in order to perform a safe operation in LEO environment. This type of requirement led the team to select components such as RS-422/RS-485 transceiver MAX3362AKA+T, MMZ09332B power amplifier and also the LTC4361ITS8-2 overvoltage/overcurrent protection controller, for example.

With the requirements clearly defined, the architecture of the module was determined. The corresponding block diagram in Figure 2 illustrates the design and functional components of the module. It describes the architecture and data flow of the TMTC module, focusing on the core components and their functions. The microcontroller is central to the module's operations, communicating with other subsystems via buses like RS-485 or CAN, and managing the internal peripherals of the module, such as the radio ICs and sensors.

Figure 2: Block diagram of TMTC.



Key components include the CAN transceiver, which enables communication with other systems on the CAN bus, and the power interface, responsible for converting input power to required voltage levels using a 5 V regulator and a 3.3 V converter. Latch-up monitors protect the system from latch-up events, while power sensors track power consumption for health monitoring.

Parameter	Manufacturer				
	EnduroSat	**GomSpace**	**ISISpace**	**SpaceLab**	**SpaceLab**
Model	UHF TRANSCEIVER II	AX100	TRXVU	TTC 2.0	TMTC
Frequency range	400-403/430-440 MHz	395-405/430-440	145.8-146/148-150.05 MHz (RX), 400.15-402/435-438 MHz (TX)	145-146/400-402/435-438/468-469	400-402 (RX), 468-469 MHz (TX)
Modulation	OOK, (G)FSK, (G)MSK, 4(G)FSK	FSK, MSK, (G)FSK, (G)MSK	BPSK/(G)MSK	(G)FSK, (G)MSK	(G)FSK, (G)MSK
Protocol	AX.25	CSP + RS	AX.25/HDLC	NGHam	NGHam
TX power	30 dBm	24-30 dBm	27 dBm	30 dBm	30 dBm
Power consumption	0.12 W (RX)/2.7 W (TX)	1 W	0.48 W (RX)/4 W (TX)	0.16 W (RX)/2.8 W (TX)	$\leq$ 0.3 W (RX)/3 W (TX)
Data transmission mode	Half-Duplex	Half-Duplex	Full-Duplex	Half-Duplex	Full-Duplex
Frequency stability	2.5 ppm	Unknown	3.5 kHz	10 ppm	1 ppm
Data rate	up to 19200 bps	up to 19200 bps	1200-9600 bps	1200-9600 bps	1200-9600 bps
Sensitivity	down to -121 dBm	down to –137 dBm	down to -104 dBm	down to -126 dBm	down to -126 dBm
Interfaces	RS-485, UART, I^2C, USB	I^2C, UART, CAN	I^2C	UART, SPI	RS-485, RS-422, CAN
Dimensions	88.3 $\times$ 95 $\times$ 23.2 mm	65 $\times$ 40 $\times$ 7.2 mm	90 $\times$ 96 $\times$ 15 mm	89.15 $\times$ 92.13 $\times$ 15 mm	$\leq$ 90 $\times$ 95 $\times$ 20 mm
Mass	94 g	24.5 g	75 g	73 g	$\leq$ 100 g

Table 1: Commercial TMTC board comparison.

Temperature sensors monitor both the Power Amplifier (PA) and the board temperature. Memory components, including NOR flash and FRAM, provide reliable storage, while a watchdog timer enhances system safety by resetting the system during malfunctions.

The module also handles RF signals through its receiver and transmitter units. The use of a PA in the trasnmitter, and a Low-Noise Amplifier in the receiver, ensures the appropriate power level for incoming and transmitted packets. For debugging and programming, a JTAG interface is included, together with a RS-422 bus for transmitting log messages.

A significant change was made to the key component of the radio compared to its predecessor: the entire RF circuit chain was designed from the ground up by the laboratory. Only off-the-shelf integrated circuits were selected for the PA, LNA, transmitter and receiver IC. This approach was adopted to provide greater flexibility in the design, allowing the team to tailor the system to specific requirements, such as the desired frequency range, avoid dependency on specific manufacturers, and maintain full control over the quality of the components used within the radio. Alongside, this subsystem is designed for full-duplex communication, enabling simultaneous data transmission and reception, in contrast to its previous generation that was half-duplex.

The module will incorporate an aluminum shield to mitigate radiation [19] effects, and electromagnetic interference (EMI) to and/or from other subsystems within the satellite. The choice of aluminum is driven by its effective EMI shielding properties, alongside providing good protection against radiation ef-

fects, considering its lighter density compared to other metals.

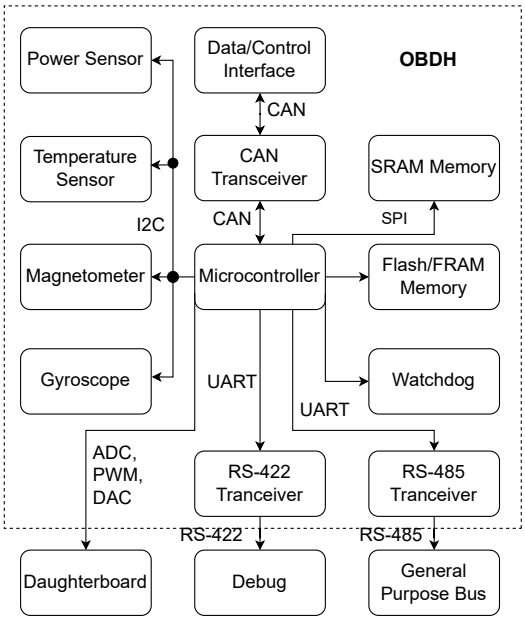
3.2 OBDH

The On-Board Data Handling (OBDH) module centralizes data management and communication across the satellite's subsystems. To enhance the FloripaSat-3 platform, a new OBDH module was developed following an analysis of SpaceLab's OBDH 2.0. This module uses a Texas Instruments MSP430F6659 microcontroller and supports various interfaces, including I^2C, SPI, UART, JTAG, PC-104, and a daughterboard connector for expansion. It also features non-volatile memory, an external watchdog timer, voltage and current sensors, I^2C buffers, and an RS-485 transceiver. Additionally, other commercial modules were reviewed, as shown in Table 2, including the OBC [20] from EnduroSat, the Kryten M3 [21] from AAC Clyde Space, and the NanoMind A3200 [22] from GomSpace.

Another point is that the OBDH 2.0 is based on the MSP430F6659 microcontroller, which does not support the CAN protocol. As already mentioned, CAN is one of the most suitable protocols when developing projects for space applications [23]. That condition led to a search for different microcontrollers. From the analysis of the Table 2, it can be inferred that both the Kryten M3 and the NanoMind A3200 are CAN compatible. The analysis also shows that all the modules have ARM-based processors and offer various communication interfaces. In detail, they differ in memory capacity, power consumption and functionality. The Kryten M3 and EnduroSat OBC have better radiation tolerance, an essential feature for space [24] [25]. In addition, the NanoMind A3200 has a very low mass, which is valuable in CubeSats with strictly limited mass budgets. Other differences in the sensors onboard each module are notable, as the NanoMind A3200 has sensors such as magnetometers, accelerometers, and gyroscopes, which are essential for determining attitude in space, while the EnduroSat OBC offers fewer sensor capabilities. The inclusion of these sensors on a new version of the OBDH board is an important factor in meeting mission requirements, as they increase the satellite's ability to determine its attitude in space, thus enabling active attitude control.

These preliminary analyses have produced a first draft of the OBDH block diagram, as can be seen in Figure 3. This diagram outlines the structure of the new board, including the addition of sensors, and thus forms a starting point for further design and refinement.

Figure 3: Block diagram of OBDH.



The block diagram of the OBDH module

Parameter	Manufacturer				
	EnduroSat	**AAC Clyde**	**GomSpace**	**SpaceLab**	**SpaceLab**
Model	Onboard Computer	Kryten M3	NanoMind A3200	OBDH 2.0	OBDH 3.0
Processor	ARM Cortex M7	SmartFusion2 ARM Cortex-M3 based SoC FPGA	AT32UC3C	MPS430F6659	SmartFusion2 ARM Cortex-M3 based SoC FPGA
Clock	Unknown	50 MHz	8 to 64 MHz	32 MHz	166 MHz
Memory (RAM)	SRAM: 1 MB	SDRAM: 64 MB	SDRAM: 32 MB	SRAM: 64 kB	SRAM: $\geq$ 1 MB
Memory (non-volatile)	FRAM: 8 MBit	MRAM: 16MB	FRAM: 32 kB, NOR Flash: 128 MB	FRAM: 2 MBit, NOR Flash: 128 MB	FRAM: $\geq$ 2 MBit, Flash: $\geq$ 256 MB
Power consumption	Unknown	Typ.: 400 mW, Max.: 1W	0.9 W	0.66 W	$\leq$ 1 W
Interfaces	4xRS-485, 2xRS-422, 3xUART, 2xI^2C, SPI, USB, CAN	8xUART, 2xI^2C, 1xSPI, 1xCAN, 1xRS-422, 1xDTM, 1xLVDS, 3xQSPI, 17xGPIO	SPI, I^2C, UART, CAN	UART, I^2C, SPI, GPIO, PWM, ADC, DAC and RS-485	CAN, UART, I^2C, SPI, GPIO, PWM, ADC, DAC, RS-422 and RS-485
Sensors	Magnetometer	Unknown	Magnetometer, Gyroscope, Temperature	Voltage, Current, Temperature	Magnetometer, Gyroscope, Temperature, Power
Dimensions	95.89 $\times$ 90.17 $\times$ 5.51 mm	95.89 $\times$ 90.17 $\times$ 5.51 mm	65 $\times$ 40 $\times$ 7.1 mm	89.15 $\times$ 92.13 $\times$ 15 mm	$\leq$ 90 $\times$ 95 $\times$ 20 mm
Mass	130 g	61.9 g	24 g	53 g	$\leq$ 100 g

Table 2: Comparison of commercial OBDH boards.

outlines its basic structure and main components. The microcontroller is the centerpiece of such a system and has many design considerations, including the kind of communication interfaces and memory that will be implemented. Communication interfaces, including CAN, I^2C, and SPI, are incorporated according to the protocols mandated by the sensors and subsystems. Furthermore, the module facilitates ADC, PWM, and DAC capabilities to enable external communication via a daughterboard. In this context, the OBDH is equipped with sensors such as a power sensor for monitoring power usage, a temperature sensor for evaluating internal environmental conditions, a magnetometer for collecting information about the satellite's orientation, and a gyroscope for measuring the angular motion of the satellite. All of these shall respect precision requirements. The satellite must also have internal communication with all the modules, for which the CAN bus and/or RS-485 will be used. Moreover, the system must have externally accessible interfaces for programming the microcontroller, for this a JTAG will be available. Other memory options such as SRAM and Flash/FRAM are selected based on the capability of the microcontroller for internal storage. If internal memory is not sufficient in the microcontroller, more external memory can also be added to handle the data efficiently. Finally, a watchdog timer is added to enhance the system's reliability and security against robust operations over the entire mission, according to the system's requirements.

As mentioned above, the selection of a microcontroller depends on the requirements of the module and the mission, which demands a

balance between processing capacity, flexibility and robustness. One of the requirements mentioned is that the processor has a 32-bit architecture, in this view, some processors used in commercial OBDHs and CubeSat missions have been compared that have this architecture. All content are detailed in Table 3.

This process has shown that the cheapest version of the SmartFusion2 model was chosen to save costs, provided it meets the required specifications. SmartFusion2 M2S005 combines an Field-Programmable Gate Array (FPGA) with a 32-bit ARM Cortex-M3 processor. This combination provides a great deal of flexibility in terms of hardware customization.

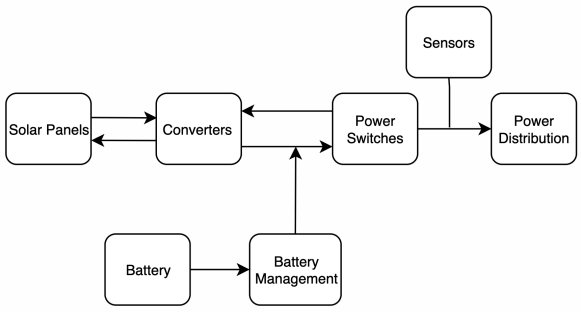
In contrast, the STM32H747/757 delivers enhanced computational capabilities owing to its dual-core design, which incorporates both a Cortex-M7 core and a Cortex-M4 core. The TMS570LS3137 Hercules is distinguished by its notable characteristics, including a dual lockstep processor and supplementary security features; however, it is characterized by a higher power consumption [27].

3.3 *EPS*

The Electrical Power System (EPS) function is the heart of a CubeSat. It is the module responsible for channeling the energy generated by the solar panels to the payloads that operate the satellite. However, this process involves several stages. Starting with the energy received by the panels, there are methods that can be employed to redistribute this energy with the highest possible efficiency, thus ensuring the proper functioning of the CubeSat. Once this is established, the power module also requires protection, both for the battery and for itself and the payloads.

The use of components that safeguard our system against overcurrent, overvoltage, and overload is indispensable for any project related to this subsystem. For the system's charging, components are required to manage the battery charging process, from monitoring its state to controlling the energy flow from the supplying source and regulating voltage and current based on the monitoring performed. For the interaction of the energy generated by the panels with the subsystems connected to the EPS, the voltage applied to them must be regulated. To achieve this, DC-DC converters must be selected to fulfill this task. With all this in mind, system telemetry must also be implemented to monitor the magnitude of the current and voltage data in the battery regulation system and the subsystem regulator. This data will be read by a processing center that may or may not be located within the EPS. If it is within the EPS, it becomes necessary to choose a microprocessor that will handle communication with each of the sensors. A figure of a base EPS block diagram can be seen on Figure 4.

Figure 4: Simplified EPS diagram.



The third-generation of the EPS for FloripaSat platform is in its initial design phase, with a focus on defining its architecture. As part of this, the power management system is

Processor	SmartFusion2 M2S005	TMS570LS3137 Hercules	STM32H747/757
Manufacturer	Microchip Technology	Texas Instruments	STMicroelectronics
Architecture	Hard 166-MHz 32-Bit ARM Cortex-M3 based SoC FPGA	ARM Cortex-R4F 32-Bit RISC CPU	480 MHz fCPU on the Cortex-M7 and 240 MHz on the Cortex-M4
Power consumption	∼60 mW	700 mA	Unknown
Interfaces	CAN, 2xSPI, 2xI^2C, UART, USB, Ethernet	CAN, I^2C, UART, Ethernet	2xCAN, 6xSPI, 4xI^2C, 4xUART, 2xUSB, Ethernet
Memory	128 KB eNVM, 64 KB eSRAM, Total RAM 191Kbit	3MB Flash, 256KB RAM, 64KB Flash for Emulated EEPROM	1 to 2 Mbytes of Flash memory; 1 Mbyte of SRAM; 192 Kbytes TCM RAM; 864 Kbytes of user SRAM, and 4 Kbytes of Backup SRAM
Operating temperature	-40 to 125 °C	-40 to 125 °C	-40 to 125 °C
CubeSat missions use	IDEASSat, ArcticSat	Aalto-1, CubeBug-1 and -2	Unknown
Commercial OBDH use	Kryten-M3 [21]	UNISAT-7 [26]	EnduroSat OBC [20]

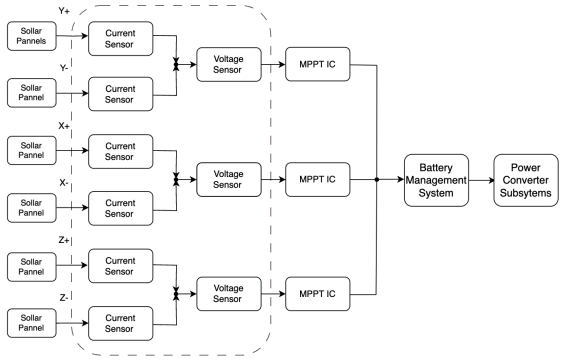
Table 3: Comparison of the selected microcontrollers.

being conceptualized, requiring a decision on the power distribution method for the satellite. The chosen power regulation method is Maximum Power Point Tracking (MPPT), known for its reliability in CubeSats where solar panels and batteries might not be ideally matched. This is often the case as solar panel size is typically constrained by the satellite's dimensions [28]. With the power regulation method established, the next step involves selecting the components that will form the interface between the solar panels and the battery. In the pursuit of components to implement MPPT, options include custom-designed converters (as in the FloripaSat-2 platform), commercial converters, or dedicated MPPT-capable ICs.

With the aim of improving reliability and performance, a comparative study was made, and for the new platform, two possible MPPT-capable ICs were quoted: SPV1040 and LT3652. SPV1040 is a charge module with a 3 × 4 mm footprint that operates in a range of 0.3-5.5 V, with an MPPT algorithm and a PWM frequency of 100 kHz. It protects itself and the other circuit components from overcurrent and overvoltage, but it does not have protection for undervoltage, which is a problem when the panels are connected in parallel, as pointed out by the ESTCube-1 mission [29]. This problem can be avoided by an ideal diode system. The other option, LT3652, is a more feature-rich integrated circuit. It has temperature sensing, overvoltage, and overcurrent protection, just like the SPV1040, but it also includes native undervoltage protection and has a 3 × 3 mm footprint [30]. An IC MPPT system is represented in the Figure 5.

The same way that the system's input converters are important, the output converters are equally vital, as they are responsible for supplying power to the other CubeSat modules. The EPS 2.0 incorporated several output converters from the TPS family, for example the TPS5420QDRQ1. The TPS converters utilized in the EPS 2.0 employ an asynchronous architecture, which while offering cost and im-

Figure 5: MPPT circuit diagram.



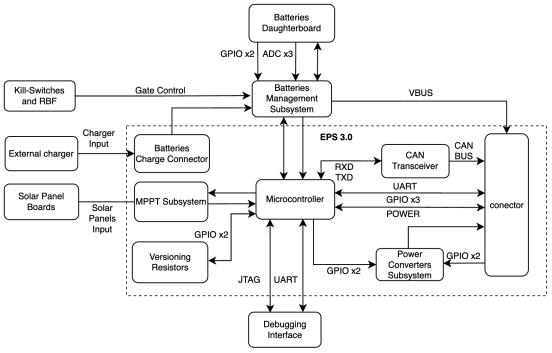
plementation advantages, may exhibit lower efficiency compared to synchronous alternatives such as the LTC3833 step-down controller. Furthermore, the LTC3833 controller features radiation tolerance [31] [32], a notable characteristic for components destined for integration into a CubeSat. A significant departure from the previous platform to the new one lies in the battery monitoring circuitry. Previously, this circuit resided on the EPS 2.0 board, managed by a DS2777G+. In the new platform, battery monitoring will be integrated directly onto the system's battery board itself.

This realocation potentially frees up valuable space on the EPS board for other components or functionalities. In the development of the next-generation EPS platform, a key decision was made to upgrade the microcontroller from the legacy MSP430 to a modern Cortex-M0 architecture. This transition aims to enhance the EPS's capabilities in terms of processing power, energy efficiency, and peripheral integration. While the MSP430 has served reliably in previous EPS iterations, its limitations in processing power and peripheral integration presented challenges in meeting the complex requirements of modern satellite missions.

The Cortex-M0, with its 32-bit architecture and higher clock speeds, offers significantly enhanced processing capabilities, enabling faster execution of power management algorithms and real-time data processing [33]. Moreover, the Cortex-M0's power management features and sleep modes translate to improved energy efficiency, crucial for extending the satellite's operational lifetime. Additionally, the Cortex-M0's peripheral set, including high-resolution ADCs, timers, and communication interfaces such as CAN, simplifies the EPS. The ability to communicate via CAN is particularly crucial as it is a requirement for all modules in this platform, ensuring seamless integration and data exchange. This upgrade to the Cortex-M0 microcontroller in the EPS platform represents a significant step forward, enabling the EPS to meet the increasingly demanding requirements of modern satellite missions, ensuring reliable power management, and contributing to the overall success of the mission.

The preliminary block diagram of the EPS module can be veryfied in Figure 6.

Figure 6: Block diagram of EPS.



4 Discussion: trends and directions

A key aspect of FloripaSat-3's evolution was reassessing the technologies and standards used in previous missions, particularly FloripaSat-2. This transition reflects a clear trend towards adopting more advanced and reliable components. The replacement of outdated elements with newer, more robust technologies demonstrates a shift in focus towards enhancing the overall performance and longevity of the platform.

One of the main changes was the introduction of the CAN protocol for communication between subsystems. This decision was driven by the need for more robust and fault-tolerant communication compared to I^2C, which was identified as a vulnerability in high-interference environments.

Another crucial adaptation was the change in connection standards. The use of RS-485 and RS-422 buses, replacing previous options (UART), will provide greater resistance to noise and improved signal integrity. This choice was based on performance analyses in adverse conditions, showing significant improvements in the reliability of internal satellite communications.

Additionally, an important change was the replacement of the PC-104 interface, widely used in previous versions like FloripaSat-2. The PC-104 interface had several disadvantages, including limited expansion capacity and compatibility issues with new modules. Its rigid architecture and reliance on a specific stack of modules made system reconfiguration challenging for different missions, limiting the flexibility needed for new experiments and technologies. In response, FloripaSat-3 adopted a more modular and flexible approach using dedicated connectors for each interface, allowing easy integration of new components and system customization according to mission requirements.

An additional innovation in FloripaSat-3 is the development of an in-house designed RF chain. While the overall design and architecture are developed by the team, the project leverages commercial components, such as the PA, LNA, and transceivers. This approach allows for a custom optimization tailored to specific mission needs while benefiting from the proven reliability and performance of off-the-shelf components. The internally designed RF circuit offers the flexibility to adjust specifications and functionalities as required, ensuring efficient and high-quality performance.

Moreover, the design methodologies discussed underscore the growing need for modularity and flexibility in satellite projects. The trend towards developing modular systems that can be easily adapted or upgraded in response to technological advancements or mission requirements is indicative of the industry's future direction. This approach not only addresses current trends but also paves the way for innovations like the potential reuse of components in different missions or in-orbit upgrades.

Ultimately, the FloripaSat-3 development team actively sought to incorporate open standards and best industry practices, including guidelines such as ECSS, to ensure that the platform meets mission requirements while contributing to the broader advancement of CubeSat technology. In line with them, the selection of components prioritizes automotive-grade parts, whenever possible with flight heritage and radiation resistance. This focus ensures that the components used in FloripaSat-3 can withstand the harsh conditions of space, con-

tributing to the overall reliability and longevity of the satellite.

5 Conclusion

FloripaSat-3 introduces a systematic design approach aimed at improving the reliability and robustness of its predecessor FloripaSat-2. The modular architecture of FloripaSat-3 allows for easier integration of new technologies and components, providing adaptability for future missions. Through its open-source framework and adherence to industry standards, the platform promotes wider accessibility and collaboration within the CubeSat community, supporting both educational and research-driven projects.

The transition from the previous FloripaSat-2 platform to FloripaSat-3 involves several key upgrades aimed at improving performance and reliability. The new platform replaces outdated communication protocols with the CAN protocol. It also moves from a rigid PC-104 interface to a modular system with dedicated connectors, enhancing flexibility and integration. These changes, along with the adoption of custom RF circuits and the use of modern standards and components, collectively advance the platform's capabilities and operational efficiency.

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