

Designing, Implementing and Testing a Low-Power GPS Rx Subsystem for LEO Satellites

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EgSÁ

- Navigation Systems and Segments.
- Project RoadMap.

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- GPS Rx Subsystem Prototype.
- GPS Rx Subsystem Engineering Model.
- MisrSat Constellation GPS Rx Subsystem EM.
- Conclusion and Future Work.

Navigation Systems

Global Navigation Satellite System (GNSS) is the standard generic term for satellite navigation systems:

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- Beidou (China),
- Galileo (Europe),
- GLONASS (Russia)
- QZASS (Japan)
- GPS(USA).

A GNSS allows small electronic receivers to determine their location (longitude, latitude and altitude).



Satellite navigation using a laptop and a GPS receiver

Navigation Segments



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All three parts of a GPS system work in such a manner to provide the information regarding time and location.

GPS Receivers Subsystems

- Output position and velocity determination messages.
- Broadcast UTC.
- Broadcast the 1PPS signal which synchronizes satellite time.

Project RoadMap

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Main Block Diagram of the Proposed GPS Rx Subsystem

In developing a satellite Subsystem, three primary units shall be involved:

• The Hardware Unit.

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- The Software Unit.
- Check and Test Equipment Unit.



Block Diagram for Proposed GPS Receiver

1. HW Designing and Manufacturing

Components Selection and Trade-OFF

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- Space Certified/ Space Heritage.
- Tolerance.
- Temperature Range of Operation.
- Price.

1. HW Designing and Manufacturing



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Samples of Schematic Design

1. HW Designing and Manufacturing



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Samples of Layout Design



1. HW Designing and Manufacturing

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Top and Bottom Layers after Assembly

2. SW Implementation

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Software Specifications and Functionalities

- Serial Communication Protocol and Drivers.
- Interfacing the Microcontroller with the GPS Module and the Flash memory.
- Ground Station Commands Handling and Execution.
- NMEA Data Analysis; Filtering, Parsing and Storing.



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2. SW Implementation







Grading Docklight V1.9 (Eval) - Project: testing MCU

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2. SW Implementation

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2. SW Implementation

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3. Check and Test Equipment Implementation

- The CTE is used to simulate the behavior of other subsystems/ Ground Control Station.
- The Software and Hardware are tested Using the CTE.





GPS Rx Subsystem Integrated Testing

and Dark:																					
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Navigation Data



Testing Setup



1PPS signal from GNSS Rx Subsystem after locking

GPS Rx Subsystem Functionality Testing

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1PPS signal from GNSS Rx Subsystem after locking

GPS Prototype

Prototype Specifications

- Power Consumption: 3.3 Watt.
- Accuracies

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- Position 2.5m.
- Velocity 0.1m/sec.
- Timing 10ns.
- Customized for Low Earth Orbit missions.



To ensure the system's capability to withstand the harsh conditions of space, rigorous **environmental testing** was conducted.

1. Thermal Testing

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2. Mechanical Testing

GPS Rx Subsystem Environmental Testing-Cont.

1. Thermal Vacuum Testing Results

The DUT was installed into a thermal vacuum (TVAC) chamber to perform a thermal cycling test at vacuum.

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Different Cycles for Subsystem Qualification Part of the Test Setup

GPS Rx Subsystem Environmental Testing-Cont.

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1. Thermal Vacuum Testing Results

Test Conditions

The DUT was installed into a thermal vacuum (TVAC) chamber to perform a thermal cycling test at vacuum.



Different Cycles for Subsystem Qualification

Maximum Operational Temperature	50 deg.
Minimum Operational Temperature	-40 deg.
Temperature at the start and end of the test	23 deg.
Pressure set point	1.0E+001 Torr
Total number of cycles	4

Test Log

Day (Date)	Temperature	Pressure	Functional Test
Day1 (12/2/2023)	High	Vacuum	FT1
	Low	Vacuum	FT2
	High	Vacuum	FT3
Day2 (13/2/2023)	Low (Cold Restart)	Vacuum	FT4
	High	Vacuum	FT5
Day3 (15/2/2023)	Low	Vacuum	FT6
	High	Vacuum	FT7
Day4 (16/2/2023)	Low	Vacuum	FT8

GPS Rx Subsystem Environmental Testing-Cont.

2. Mechanical Vibration Testing Results

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GPS Rx Subsystem EM

By June 2023, the initial In-Home GPS-RX Subsystem had been developed, implemented, and thoroughly tested, demonstrating successful and reliable functionality through various functional and environmental tests.



Due to the constellation platform, New Specifications are added:

- External and Internal Interfaces.
- Internal Communication Protocol: CAN.
- Voltage Supply: 29 volt.

Thus, the three main units shall be modified.

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The GPS Rx subsystem is designed for utilization in the upcoming Misrsat constellation. Nonetheless, in the first satellite of the constellation, it will be the auxiliary subsystem rather than the primary one.



Block Diagram for Proposed GPS Receiver

Misrsat Constellation GPS Rx Subsystem Designing and Implementation

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1. HW Design and Manufacturing



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Misrsat Constellation GPS Rx Subsystem Designing and Implementation

1. HW Design and Manufacturing

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2. SW Implementation

Software Modifications:

- Board Drivers.
- Communication Protocol.
- Ground Station Commands Handling and Execution.



Misrsat Constellation GPS Rx Subsystem Designing and Implementation

3. Check and Test Equipment Implementation

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Check and Test Equipment

3. Check and Test Equipment Implementation

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Conclusion

In 2021, our project started with the objective of designing, implementing, and testing an In-Home GPS Receiver Subsystem characterized by high accuracy, and low power consumption compared to existing subsystems in the market. The initial prototype was developed in 2022, while the engineering model (EM) was generated by the end of June 2023.

Future Work

- By the end of July 2024, we shall have MisrSat Const. GPS Rx EM.
- Within the first quarter of 2025 the FM will be ready to be used in constellation mission.



Remark



Satellite Communication Lab



AIT Station



Thermal Vacuum Chamber

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Remark



The Space Weather Monitoring Center

Thanks

EgSA

Egyptian Spac

Eng. Ranya Salah Elagooz Email: <u>Ranya.elagooz@egsa.gov.eg</u>