Thin Satellite Plasma Research Data Communication

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[1] Purpose

The purpose of this project is to modify the existing Virginia Space Thin Satellite to incorporate additional sensors that can take readings on plasma in space. This poster focuses on the data communication between sensors and modifications of the Thin Sat design.

[2] Background Information

The United States Coast Guards Academy's Plasma Laboratory, Mechanical Engineering department, and Navy Research Labs are working together, with the Virginia Space Program to conduct plasma research in space. The Virginia Space Thin Sat program works with Universities across the United Sates to provide a learning experience for High School students to assemble and program a Thin Satellite that will then be launched into space. In addition to working with a New London High School, the Coast Guard Academy is altering the original design of the Thin Sat to incorporate an impedance probe and a multispectral imager.

[1] Plasma in Space
https://www.physics.uu.se/research/astronomy-and-space-physics/research/fundamental/turbulence/

[3] Impedance Probe

An impedance probe is being added to the original Thin Sat design to allow data to be taken on plasma in space. The impedance probe design is based on Navy Research Labs' Space PlasmA Diagnostic suitE (SPADE) used on the ISS, but our impedance probe is not as complex, and is significantly smaller. The impedance probe will measure the amplitude and the phase of the current and voltage of the plasma in space. This data will be used to calculate the temperature of plasma in space.

[2] Plasma in Space
https://en.wikipedia.org/wiki/Astrophysical_plasma

[4] Multispectral Imager

A multispectral imager is being added on the original design of the Thin Sat to capture data from the visual portion of the electromagnetic spectrum. The multispectral imager, PixelTech, has eight sensor arrays in a compact 9mm x 9mm area that allows it be added to the Thin Sat with minimal impact to the original design..

[3] Multi spectral imager
https://www.oceaninsight.com/products/imaging/multi-band-sensor/pixelsensor/vis-pixelsensor/

[5] Packet Format

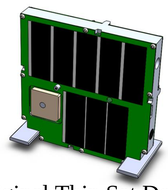
The data packet for the Thin Sat communication is comprised of 36 bytes of data, with one reserved for packet ID, leaving 35 for data. The data packet will be broken up with 8 bytes of data for the multispectral imager, one for each light intensity in each frequency band of an image, and 8 bytes for the impedance probe. The impedance probe's bytes are to be divided into two-byte sections for voltage, current, voltage 90 degrees out of phase and current 90 degrees out of phase (RFI_0, RFV_0, RFI_90, RFV_90).

[6] Data Communication

With the additional components, we had to find a way for the impedance probe and multispectral imager to communicate with the Thin Sat data bus, using the pins available on the Thin Sat. The multispectral imager is serial peripheral interface (SPI) based and the impedance probe is inter-integrated circuit (I2C) based. The multispectral imager (AD9834-SPI device) is connected to the Arduino Pro Mini on the Thin Sat by three SPI pins (MOSI, MISO, and CLK). SPI is full duplex communication where both the master (Thin Sat) and the slave (imager) can communicate with each other simultaneously. I2C is two wire data communication that has one pin for data (SDA) and one pin for the clock (SCL). The I2C data communication with the Impedance probe is bidirectional and half duplex, where both parties communicate with each other, but not simultaneously. These two different types of data communication allow for the addition of the impedance probe and the multispectral imager on to the Thin Sat's original design.

[8] Design Changes

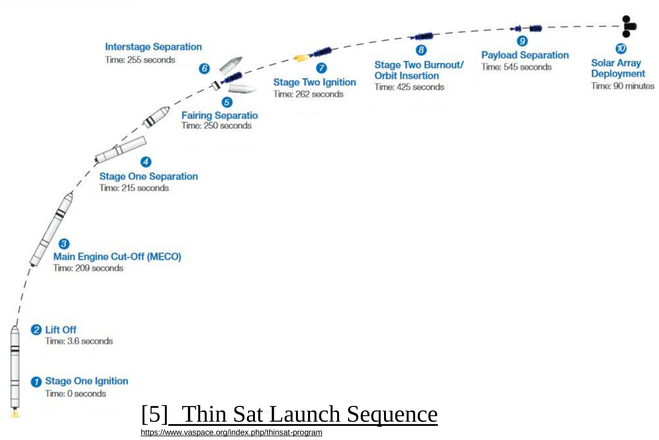
In order to add the additional sensors on to the original Thin Sat, the design had to be changed as well. To make room for the additional sensors, the width of the Thin Sat was doubled using a 3D printed body to make it a "Thick Sat". This modification incorporates the original body of the Thin Sat and the additional sensors added for research.



[4] Original Thin Sat Design
https://www.vaspace.org/index.php/thinsat-program

[9] Additional Information

After the "Thick Sat" building and programming is complete, it will undergo data transmission testing and will be tested on a high altitude balloon flight. Once the "Thick Sat" has been tested it will be launched during a cargo resupply mission to the ISS. The satellites are released during the second stage of the Antares rocket into Extreme Low Earth Orbit (ELEO). They should transmit data for approximately five days before burning up on re-entry.



[5] Thin Sat Launch Sequence
https://www.vaspace.org/index.php/thinsat-program

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