Radio Amateur Satellite Corporation

Maximum Power Point Tracker

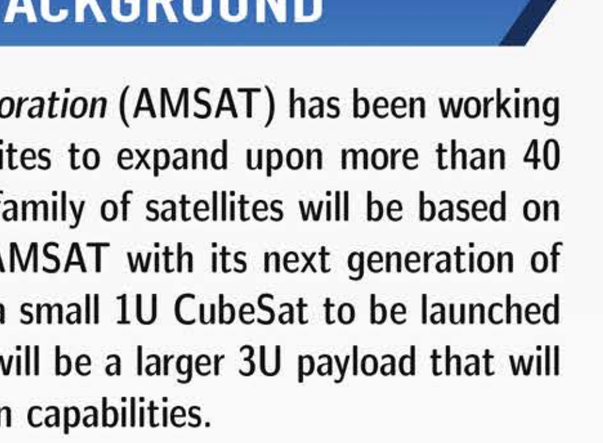
Project Background

The *Radio Amateur Satellite Corporation* (AMSAT) has been working to produce a new family of satellites to expand upon more than 40 years of flight heritage. The Fox family of satellites will be based on the CubeSat standard providing AMSAT with its next generation of spacecraft. The Fox-1 satellite is a small 1U CubeSat to be launched in 2013, while the Fox-2 satellite will be a larger 3U payload that will require upgraded power production capabilities.

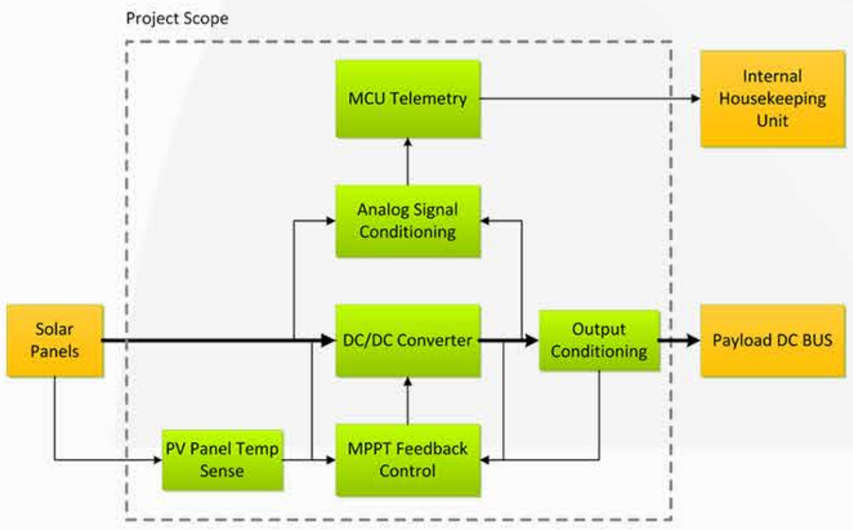
P13271 has been tasked with providing AMSAT an engineering prototype of a *Maximum Power Point Tracker* (MPPT) design capable of handling the increased power requirements of the Fox-2 satellite. This project will be further developed into a flight ready design to be launched into orbit around 2015.

Maximizing Power

In order to maximize the power obtained from a solar array, each solar panel must be operated at a voltage that is largely dependent on temperature. A maximum power point tracker transforms the impedance of the solar panel to the impedance of the load.



Tracking is performed by predicting the maximum power point voltage based on solar panel temperature and adjusting the panel voltage to match the predicted value. This transfers the maximum power available from the solar panel when required.



Objectives

- Provide a proof-of-concept MPPT board to AMSAT
- Maximize energy extraction from solar array
- Survive extreme environment of space (i.e. temperature and radiation)
- Report health and status information to the satellite's main computer

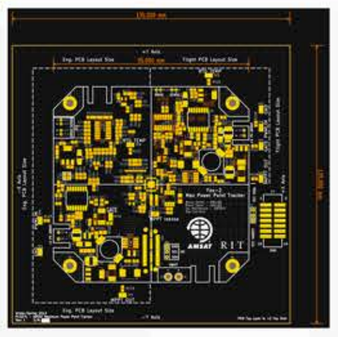
Specifications

- Max. Power Output: 7.24 Watts
- Max. Input Voltage: 22 Volts
- Max. Output Voltage: 4.1 Volts
- MPPT Response Time: <100 ms
- MPPT Efficiency: >90%
- Operational Temp. Range: -40 to 85 °C
- Ionizing Radiation Expectation: 30 kRad TID
- PCB Layout Area Constraint: 144.5 cm²
- Component Height Restriction: 5 mm
- IHU Communications

Mission Assurance

A robust design is required due to the mission critical nature of the maximum power point tracker. NASA derating was a technique applied to increase the margin of safety between component design limits and applied stresses, therefore reducing degradation and increasing reliability. In addition, ionizing radiation causes "wear and tear" on electronic components, and can lead to premature failure. Due to the expense of radiation-hardened devices, *commercial off the shelf* (COTS) components were used. COTS parts that exhibited radiation tolerance in published data were chosen whenever possible. When no suitable component with radiation test data could be found, a component with a radiation resistant structure was selected.

Final Product



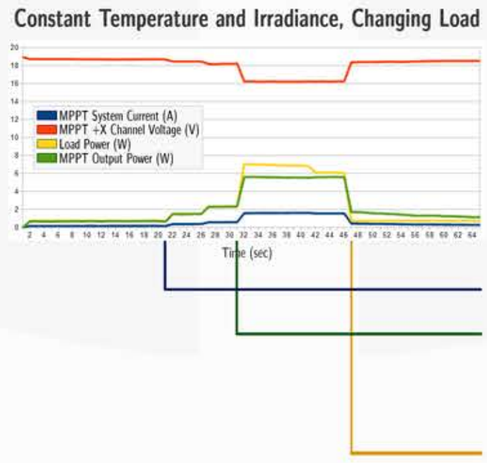
Assembly ▷

Printed Circuit Board

◁ Design

The MPPT properly supplied the maximum power when necessary.

Constant Temperature and Irradiance, Changing Load



During this test, solar panel temperature and irradiance were held constant as the MPPT output current was varied.

The MPPT was tested using a solar panel to power a constant current load and a supercapacitor for energy storage.

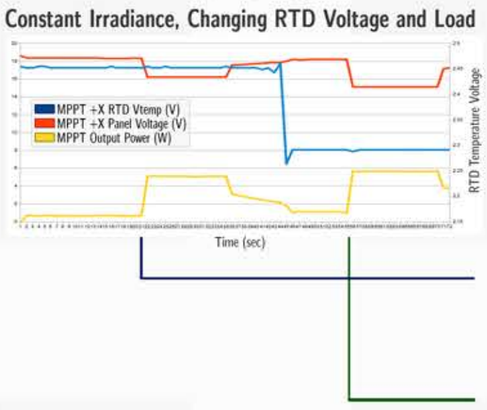
Load requires more power, which the MPPT provides

Load requests more power than the MPPT can deliver, and supercapacitors start discharging. Maximum power is delivered from the MPPT during this time.

Load power requirement drops, MPPT moves away from delivering maximum power as it is no longer needed

The MPPT properly tracked the maximum power point with panel temperature.

Constant Irradiance, Changing RTD Voltage and Load



During this test, solar panel irradiance was held constant as the solar panel RTD voltage and the MPPT output current were varied.

The MPPT was tested using a solar panel to power a constant current load and using a potentiometer to simulate an RTD.

Load forces MPPT to deliver maximum power. RTD is not properly set, MPPT behaves as though panel is cooler than it actually is. Maximum available power is not delivered.

RTD voltage is decreased to represent a warmer panel. Power delivered to load is increased.

The P13271 Team

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