Active Short Circuit - Chassis Short Characterization and Potential Mitigation Technique for the MMRTG

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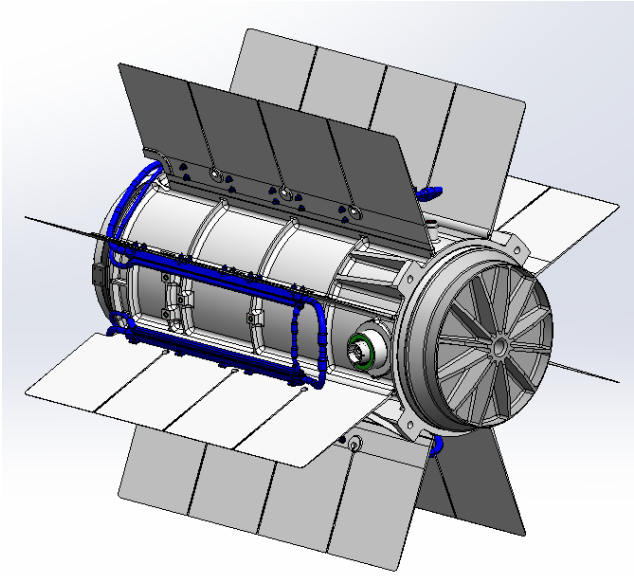

Agenda

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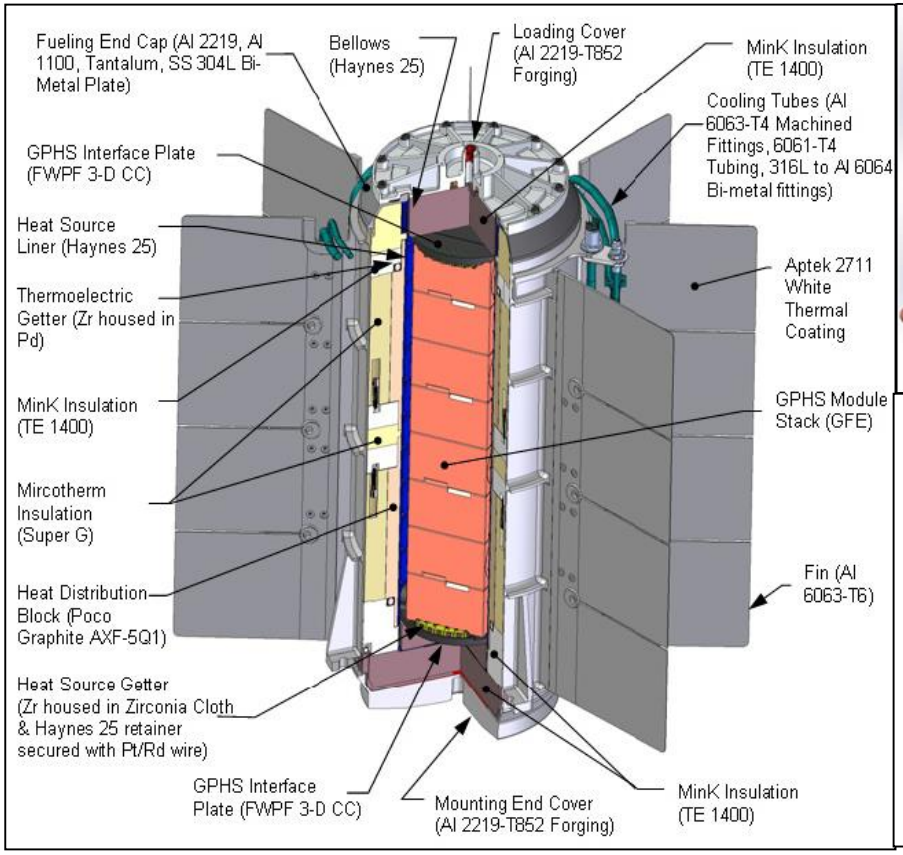
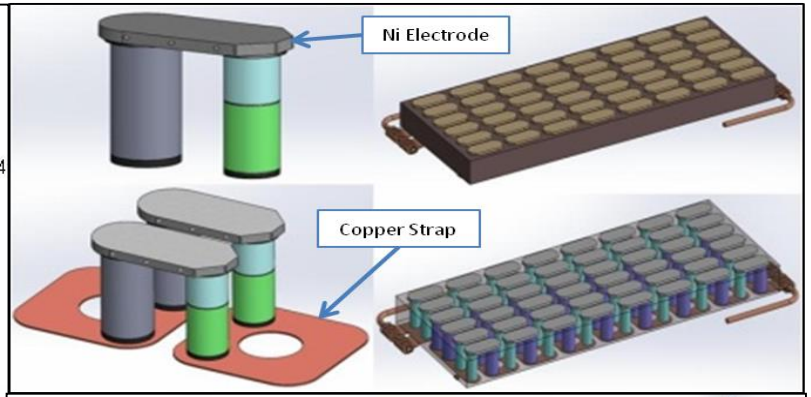
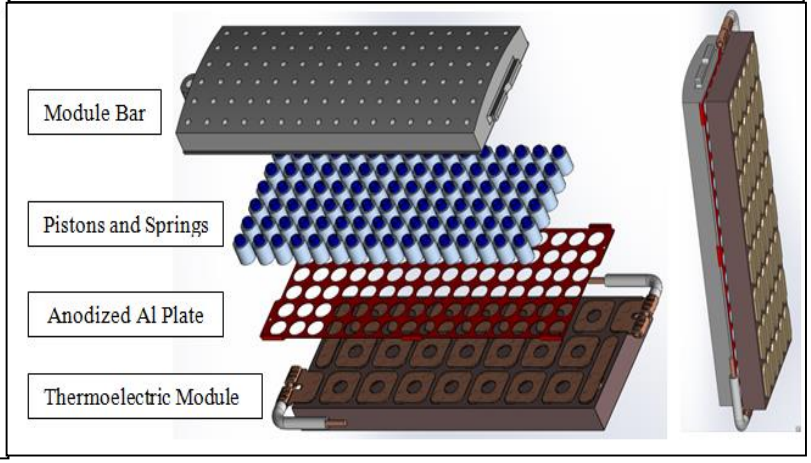
  - Internal MMRTG Chassis Shorts
- **Active Short Circuit Purpose**
- **Active Short Circuit Theory**
- **Active Short Design and Component Layout**
- **Conclusion and Future Work**

Introduction – MMRTG

- **The Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) utilizes a combination of PbTe, PbSnTe, and TAGS thermoelectric couples to produce electric current from the heat generated by the radioactive decay of plutonium – 238.**

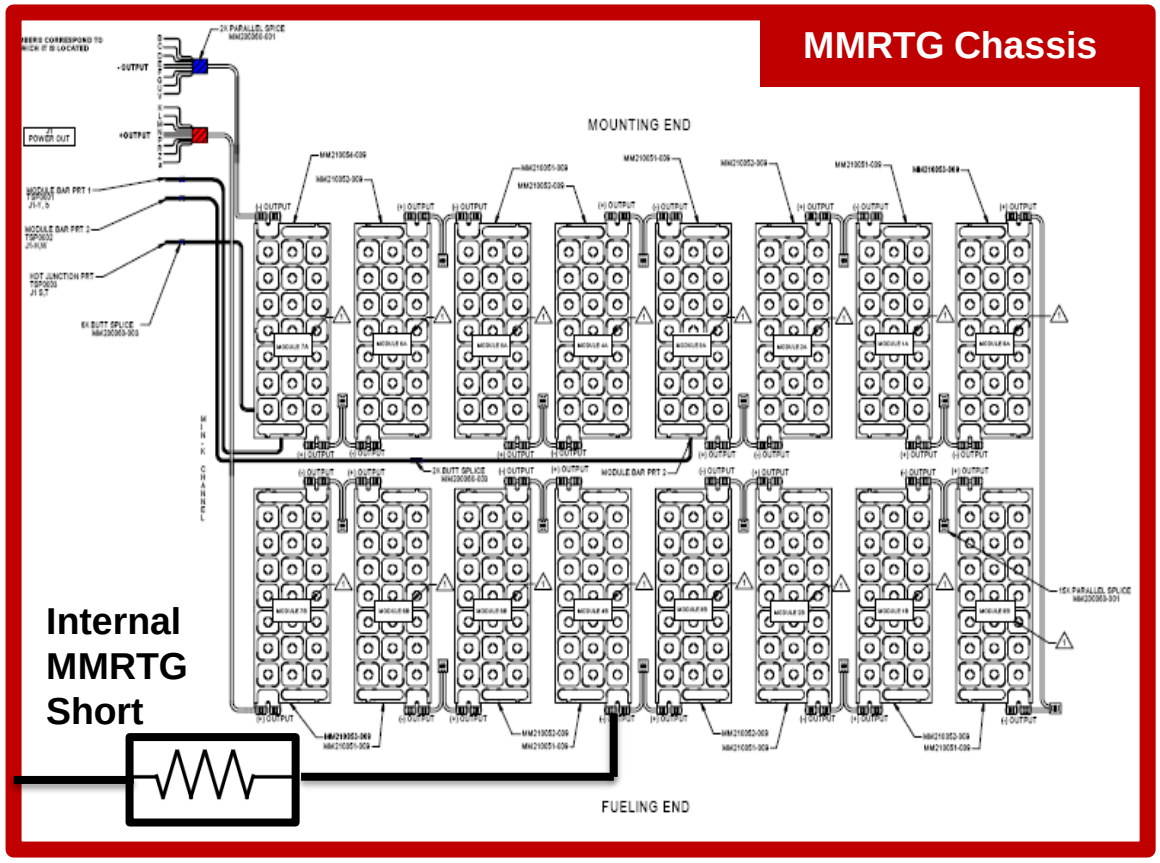


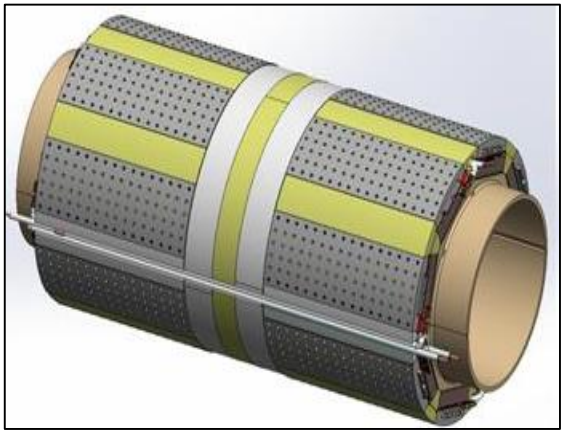


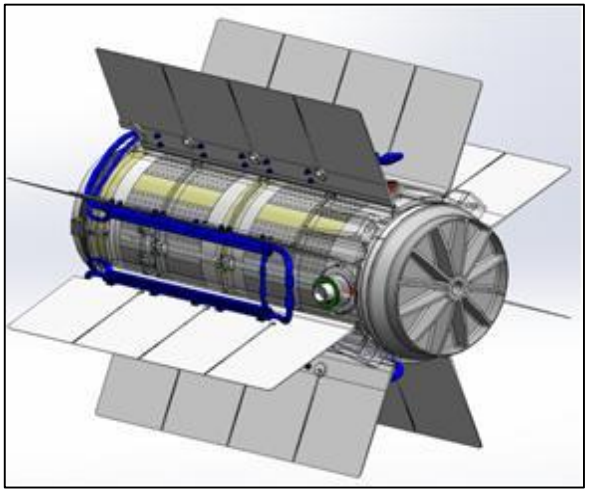


Introduction – Internal MMRTG Chassis Shorts

- **Shorts inside the MMRTG between the electrical power circuit and the MMRTG chassis have been detected via isolation checks and/or changes in the bus balance voltage.**
- **Example location of short shown below**







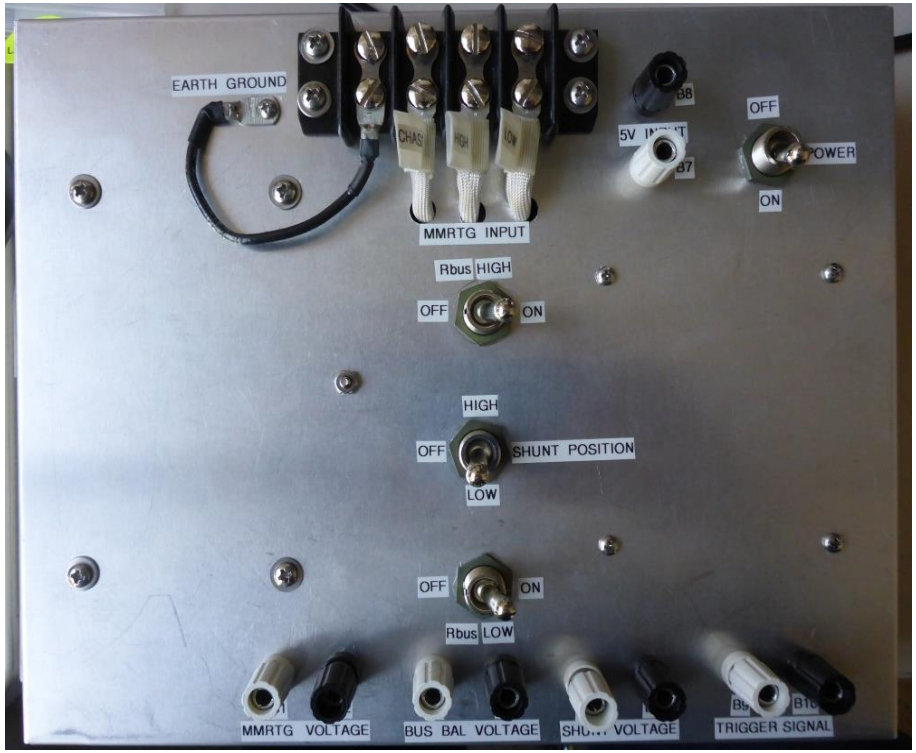
Active Short Circuit Purpose

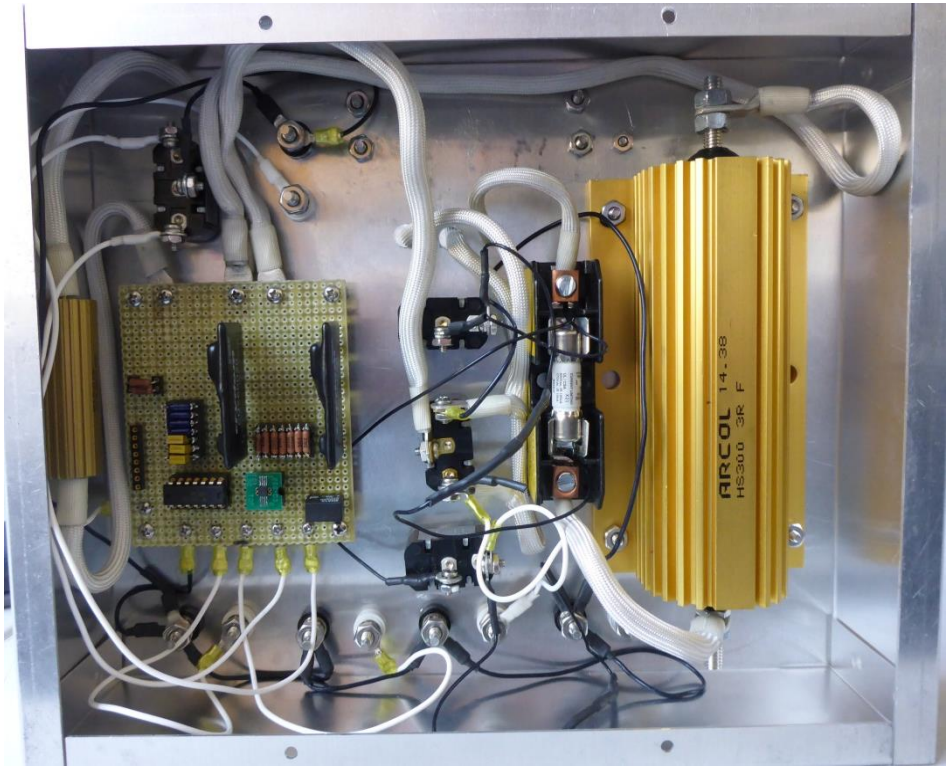
- **The leading hypothesis suggests that the FOD which is causing the internal shorts are extremely small pieces of material that could potentially melt and/or sublimate away given a sufficient amount of current.**
- **By inducing a controlled second short (in the presence of an internal MMRTG chassis short), a significant amount of current flow can be generated to achieve three main design goals:**
  1) **Measure and characterize the MMRTG internal short to chassis,**
  2) **Safely determine if the MMRTG internal short can be cleared in the presence of another controlled short**
  3) **Quantify the amount of energy required to clear the MMRTG internal short.**
- **This controlled second short is implemented in conjunction with a combination of relays and switches, which allows the short to be activated or de-activated accordingly.**
  - **Thus the device is referred to as the Active Short Circuit**

Active Short Circuit Theory

- **Energy to clear short is calculated as:** $J = R_{short} {I_s}^2 t$
  - Where R_{short} is the resistance of the MMRTG internal short, I_s is the amount of surge current through the MMRTG internal short, and t is the pulse width of the surge of current.
- **R_{short} can be determined by measuring the voltage from chassis to both the high and low of the MMRTG, and then performing simple circuit analysis using KVL.**
- **The current through the MMRTG internal short can be calculated by measuring the voltage across the precision shunt resistor of the active short circuit.**
- **If the FOD inside the MMRTG cannot tolerate the surge in current generated from the active short, the small piece of debris causing the internal short will burn or sublimate away as a result of joule heating.**
- **By monitoring the current surge using an oscilloscope, one can determine the pulse width**

Active Short Circuit Design and Component Layout





Conclusion and Future Work

- **Currently, if an internal short forms within the engineering unit or qualification unit, the action is to do nothing. Data is better than no data!**
- **The active short circuit can be used to characterize the internal shorts, quantify the risk, and potentially lead to the development of a mitigation technique for future MMRTG missions.**
- **Future Work:**
  - Perform analysis to calculate the energy rating of the expected type of FOD present within the MMRTG.
  - Select fuses similar in size to the expected type of FOD and simulate the internal MMRTG short in the lab to validate the functionality of the active short circuit.
  - Select desired oscilloscope and settings to utilize during experiment to accurately capture the surge current pulse waveform
  - Refine integration and implementation procedures.