Wide-Temperature Electronics for Thermal Control of Nanosats

John Ellis Dickman  
NASA Glenn Research Center  
(16) 433-6150

Scott Gerber  
Dynacs Engineering Company, Inc.  
(216) 433-8059

NanoSpace 2000  
League City, Texas  
January 23-28, 2000
Radioisotope Heating Units (RHU's)

Cost per RHU: $30K
Weight per RHU: 40g

Recent Missions Using RHU's

<table>
<thead>
<tr>
<th>Mission</th>
<th>RHUs used</th>
<th>RHU Cost ($M)</th>
<th>RHU Weight (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galileo</td>
<td>120</td>
<td>3.6</td>
<td>4.8</td>
</tr>
<tr>
<td>Cassini</td>
<td>157</td>
<td>4.7</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Benefits of Wide/Low-Temperature Electronics
- Eliminate/reduce requirement for RHUs
- Reduce system weight and launch cost
- Simplify spacecraft design by eliminating containment/support structures for RHU's
Glenn Research Center
Wide/Low Temperature Power Electronics Program

• Support the development of power systems capable of reliable, efficient operation over the temperature ranges of:
  
  • near room temperature (+200 C to -100C)
  
  • wide temperatures (+100 C to -175 C)
  
  • cryogenic temperatures (70 K to 20 K).
IRF541 n-Channel HEXFET MOSFET

Power & On-Board Propulsion Technology Division

Drain Family at Room Temperature

Graphs showing the drain current (Id) as a function of drain voltage (Vd) at room temperature.
IRFD024 n-Channel HEXFET MOSFET: S/D Breakdown

RT Breakdown = 69V

LN2 Breakdown = 57V
IRF541 HEXFET Success

Drain Family at RT after 10 LN2 Cycles
IRF541 HEXFET Success

RT Sub-Threshold Current after 10 LN2
NE76118 n-Channel GaAs MESFET: Drain Family

Room Temperature

Liquid Nitrogen
NE76118 n-Channel GaAs MESFET: Thermal Cycle Failure

Drain Family at Room Temperature

Post 3rd LN2 Cycle
Lithium Carbon Monofluoride Primary Battery as a Function of Temperature

I-V characteristics of lithium carbon monofluoride primary battery at various loads as a function of temperature.
COTS DC-DC Converter

Converter characteristic waveforms with 36V input and 2.5A load conditions.
Conclusions

Preliminary results of wide/low-temperature testing of COTS and custom parts and power circuits indicate that through careful selection of components and technologies, it is possible to design and build power circuits which operate from room temperature to near 100K.

But ...
Challenges

Thermal Cycling

Radiation

Energy Storage

Batteries