

Fox-1 Satellite Thermal Design Analytic Results

KD1K, 26.04.12

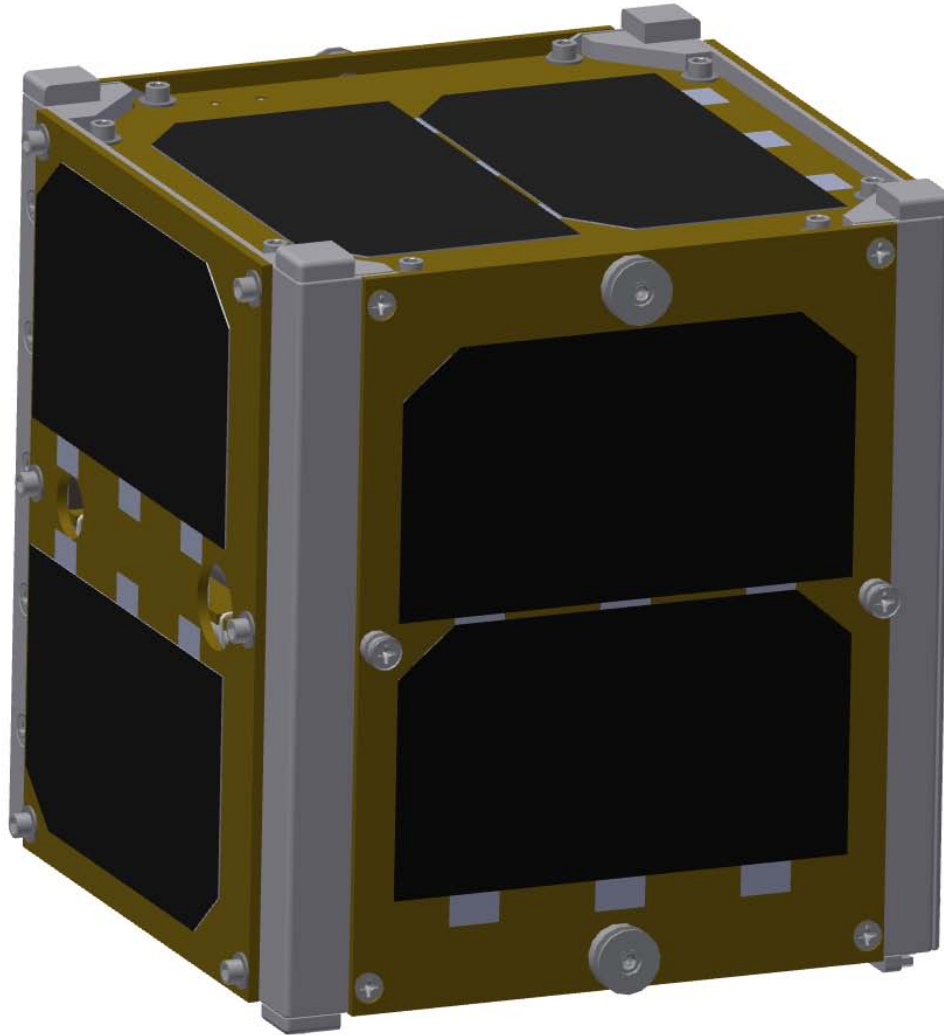
Fox-1 Cubesat

- **Very small size compared to previous AMSAT satellites**
 - **Made possible by micro-electronics of recent times**
 - **1/12th volume of “Microsat” efforts of 1987-90**
 - **1/170th volume of “Eagle” design of 2000-03**
 - **Much lower cost of launches for this design, less than \$100k to LEO**
 - **≈1 liter volume**

Fox-1 Cubesat

- **Mechanical arrangement precludes nearly all external thermal control coatings**
 - **Large solar cells on all six sides**
 - **Launch “rails” on all four cube corners**
 - **Small areas left for just a small amount of gold plating**

Fox-1 Cubesat Assembly



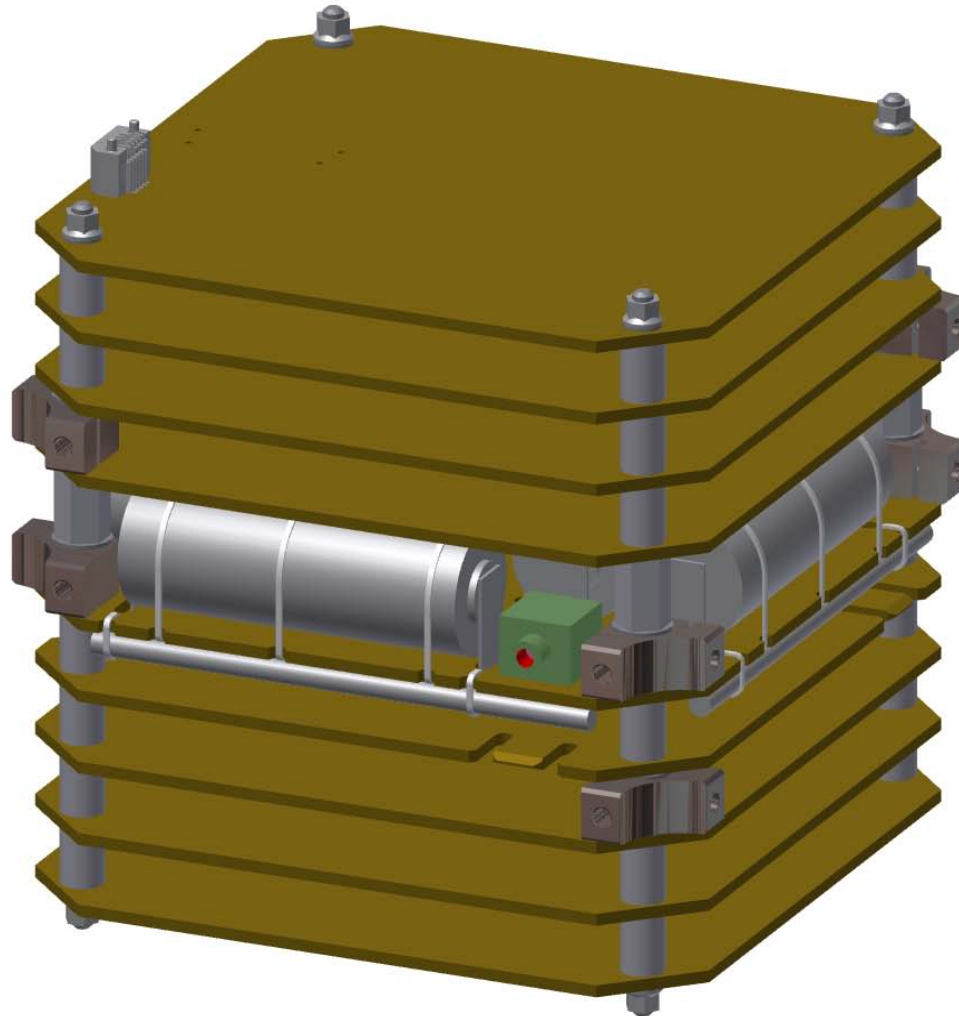
Fox-1 Spacecraft Temperatures

- **Two of four cases have been examined, these are of the extreme conditions:**
 - **Low Power, 33% Eclipse Orbit,**
Cool Sun: 130.8 mW/cm²
Albedo: 55.1 mW/cm²
S/C Power: 341 mW, 373 mW
 - **High Power, Full Sun Orbit,**
Hot Sun: 139.95 mW/cm²
Albedo: 35.3 mW/cm²
S/C Power: 1375 mW

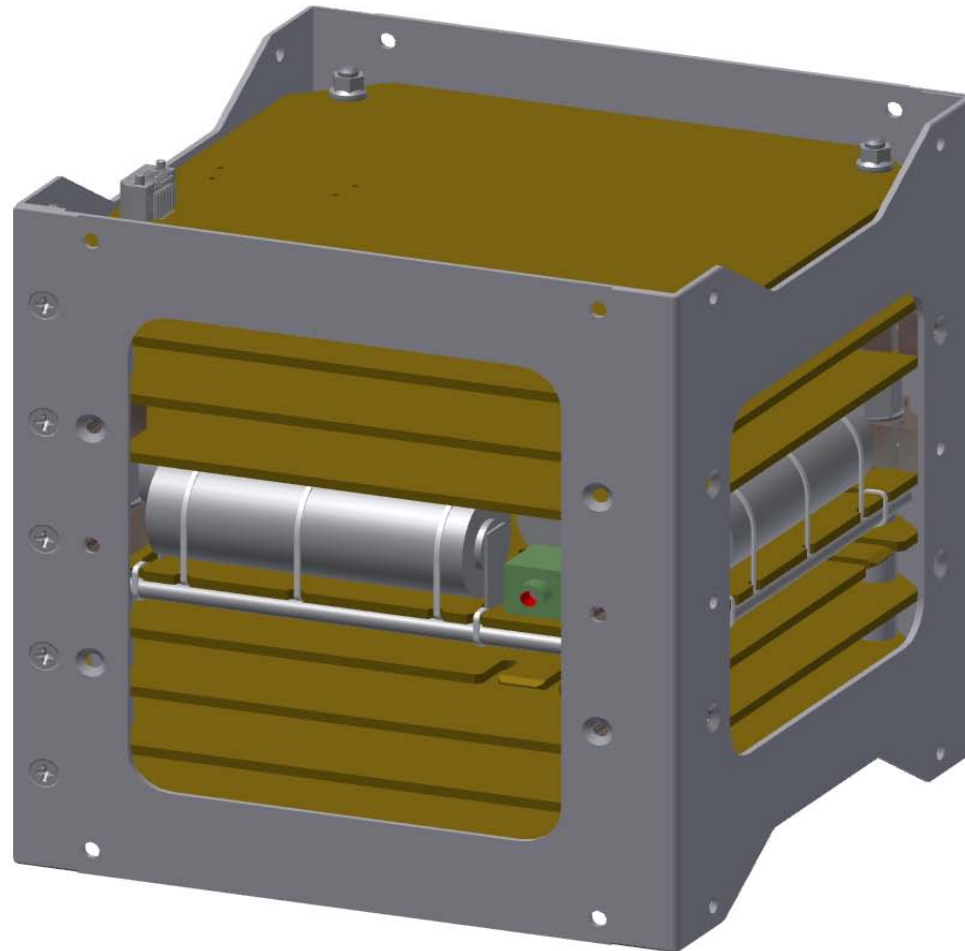
Fox-1 Thermal Control

- **What is left over are some pretty COLD conditions**
- **To avoid excessively cold electronics the PCBs are:**
 - **Gathered into a “clump” called a “stack”**
 - **Attempting to use electronic heat dissipation to heat stack**
 - **Limiting the heat transfer from PCB stack to spacecraft**
 - **Using Delrin mounting blocks**
 - **Limiting connector conductors**
 - **Providing thermal conduction between PCBs**

Fox-1 Printed Circuit Board (PCB) Stack



Fox-1 PCB Stack Assembled in Spaceframe

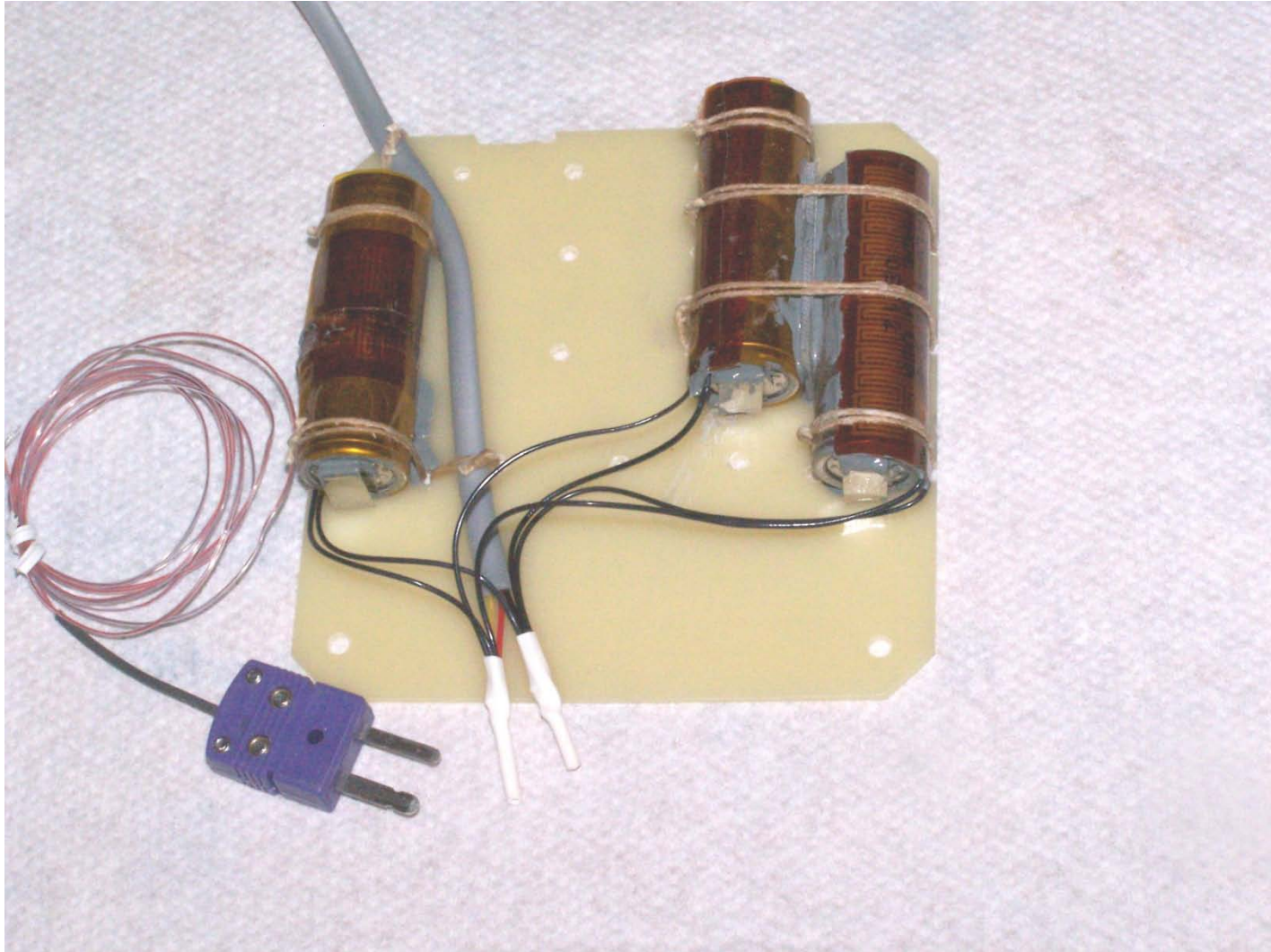


Fox-1 Thermal Control

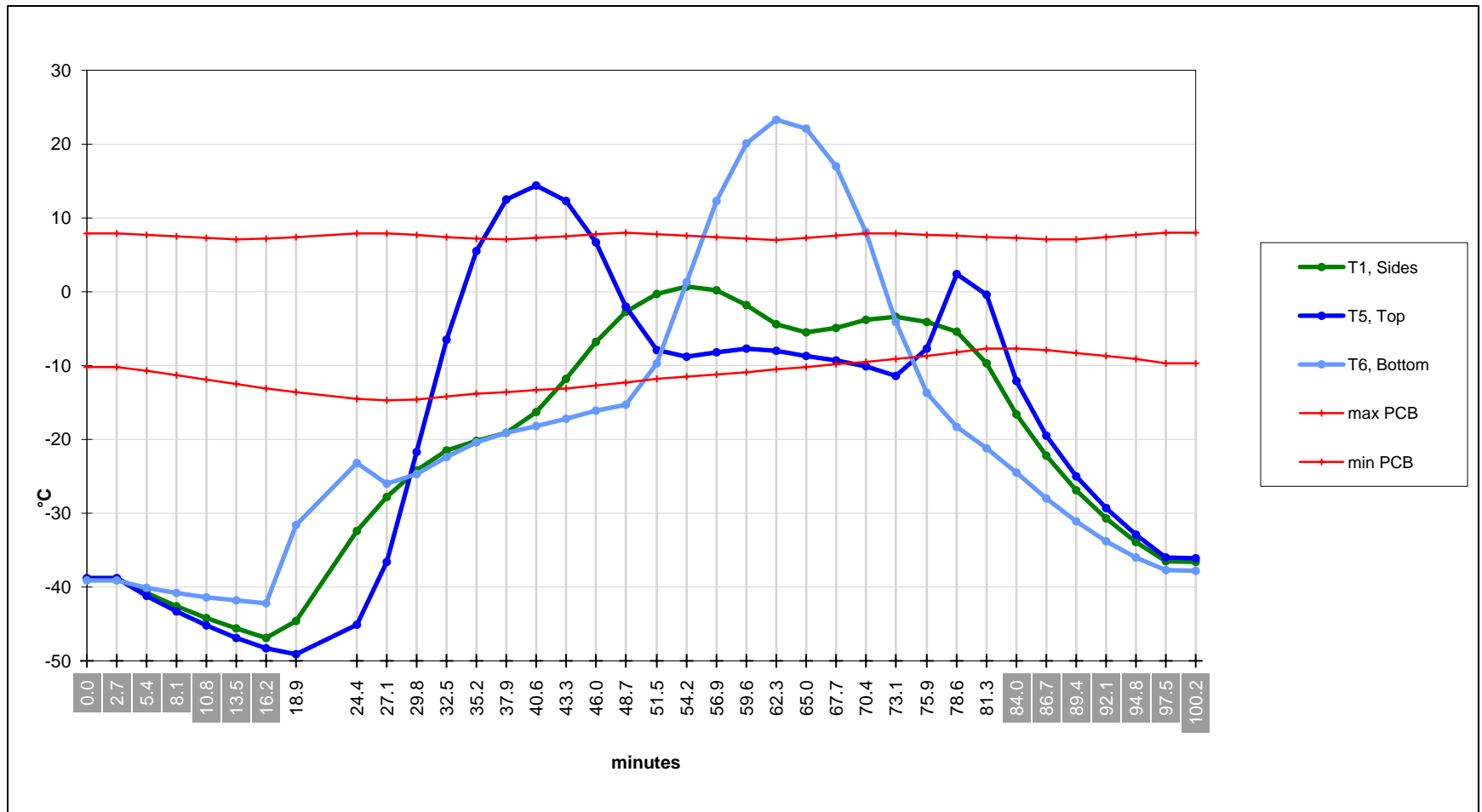
- **Battery cells are still too cold for proper charging**
 - **Need to provide heaters on each cell with thermostatic control set to +5°C to +10°C**
- **Spacecraft thermal analytic model created to find out what is going on**

Fox-1 Thermal Control

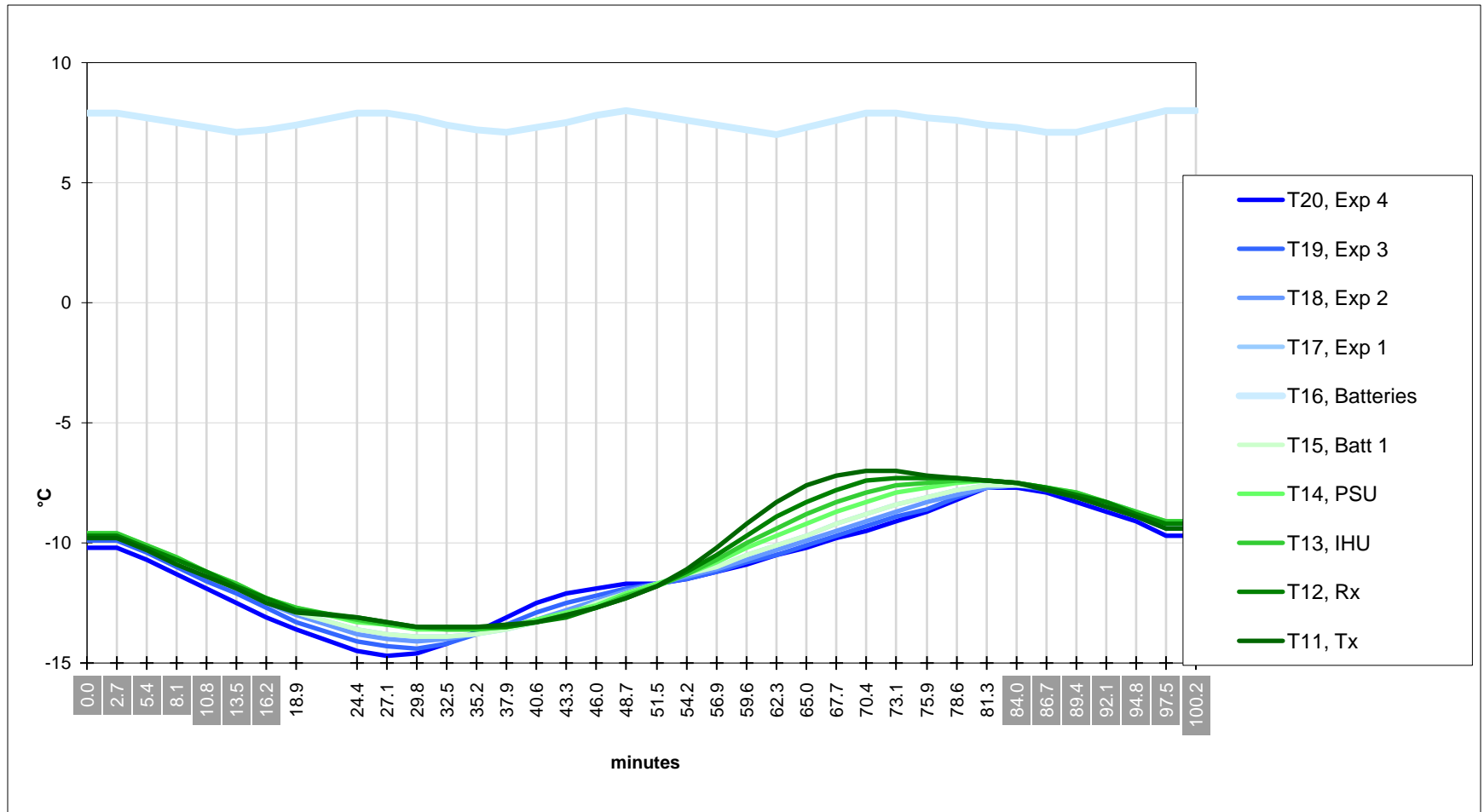
Test battery heater assembly – 3 of 6 cells



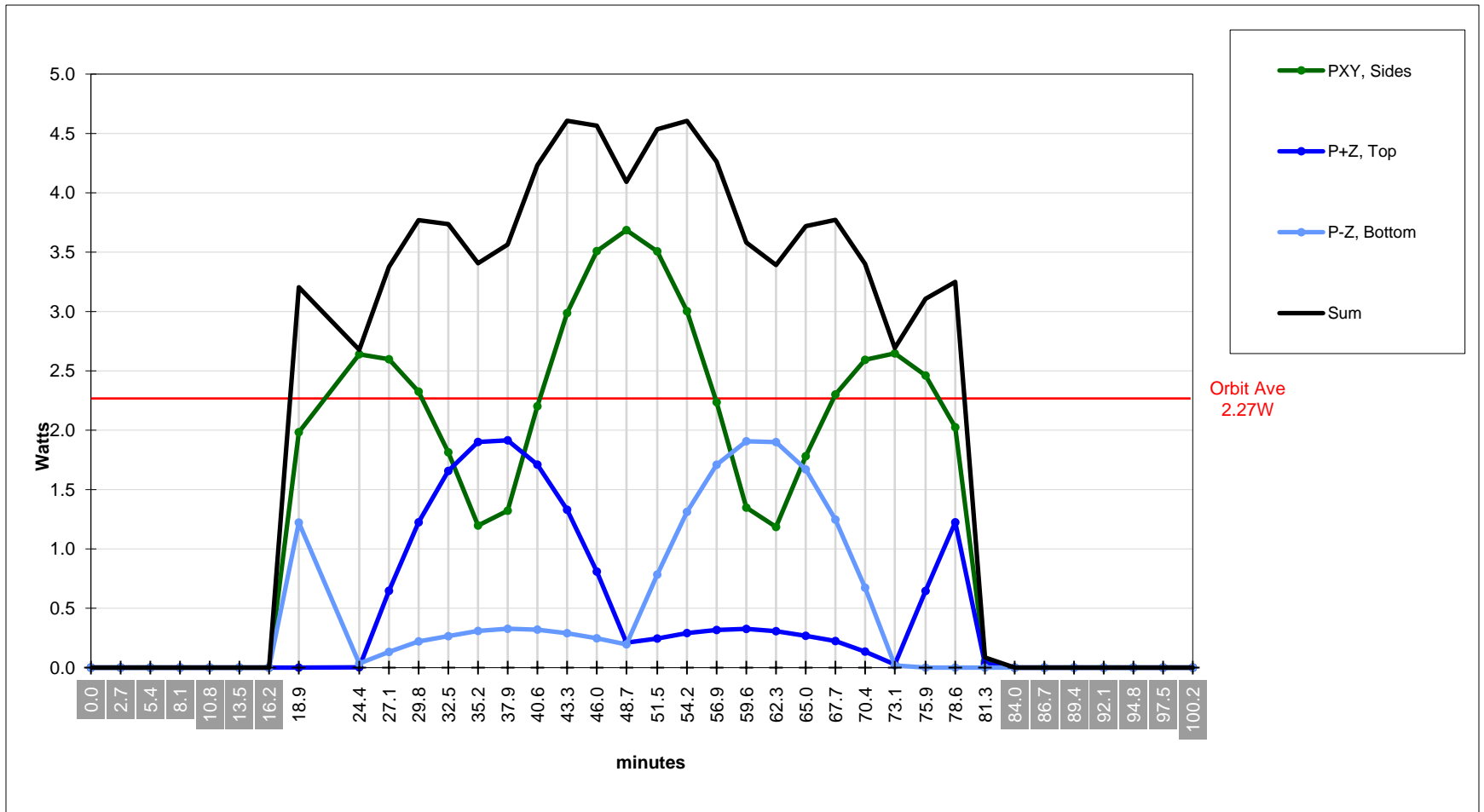
Fox-1 Spacecraft Temperatures, Low Power, 33% Eclipse Orbit



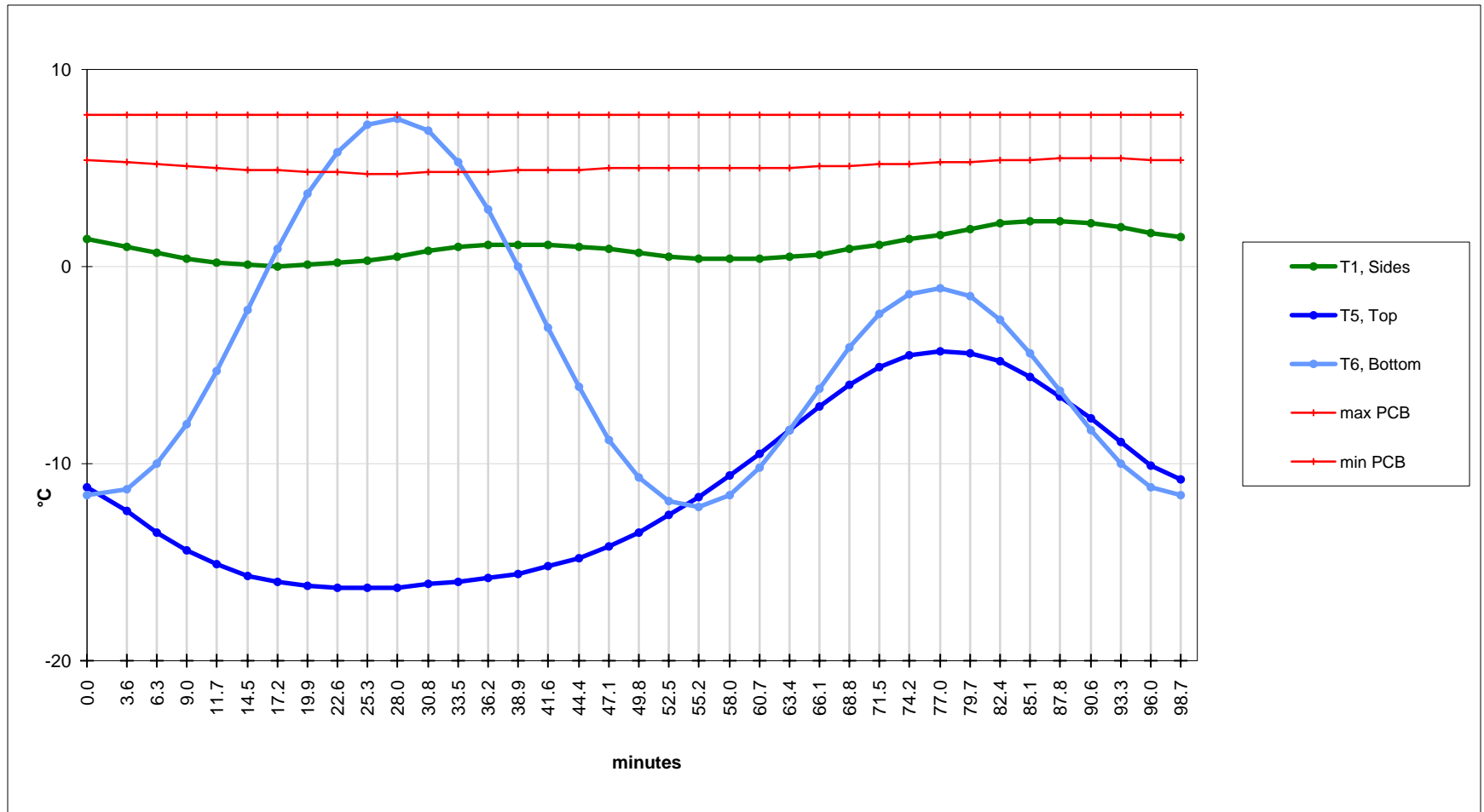
Fox-1 PCB Temperatures, Low Power, 33% Eclipse Orbit



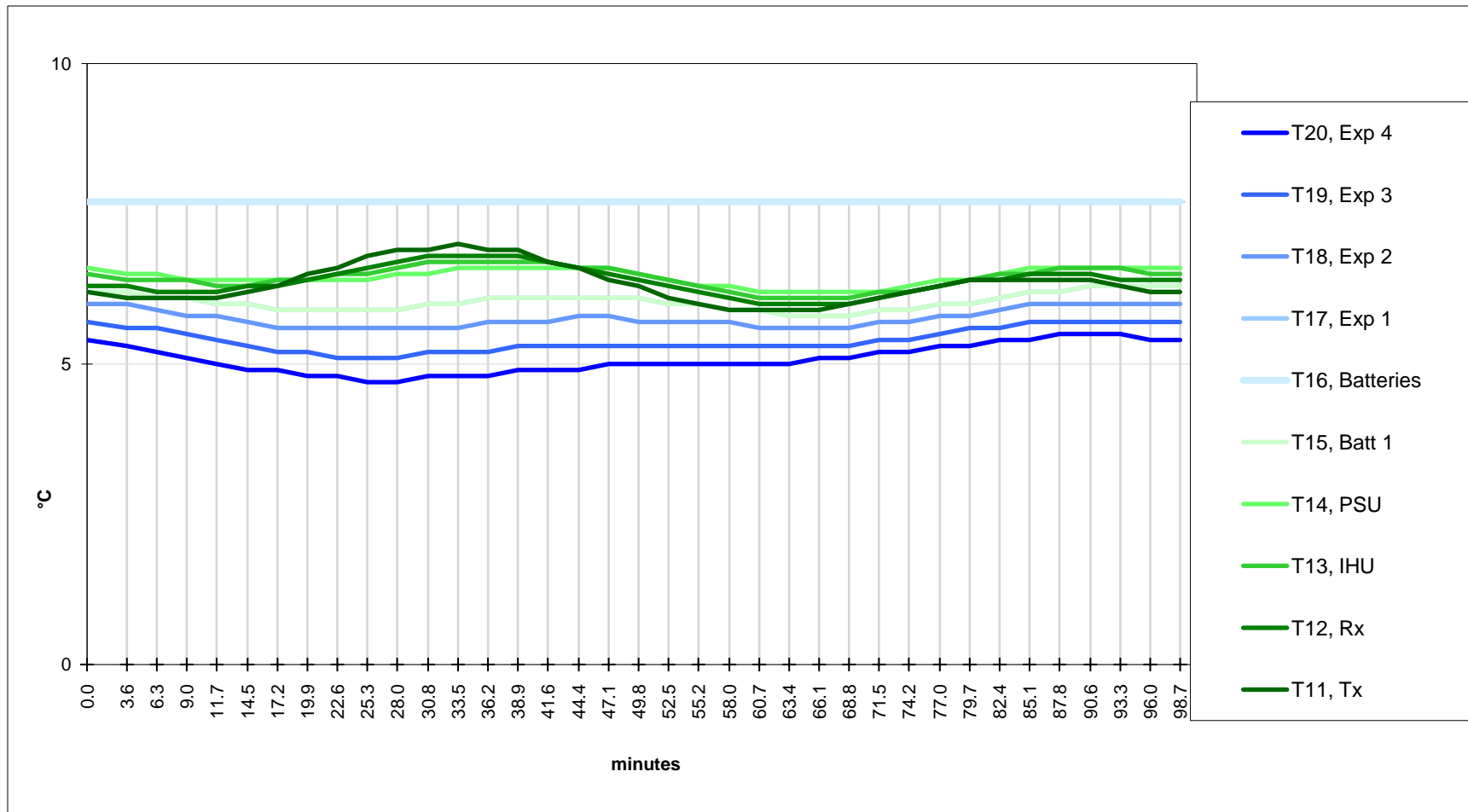
Fox-1 Solar Power Generation for 33% Eclipse Orbit



Fox-1 Spacecraft Temperatures, High Power, Full-Sun Orbit



Fox-1 PCB Temperatures, High Power, Full-Sun Orbit



Fox-1 Solar Power Generation for Full-Sun Orbit

