10.5.9 Power Management and Distribution (PMAD)

There are a number of different devices involved in efficiently connecting a space solar array to its intended loads. A system for managing and distributing the power consists of regulators, converters, charge controllers, blocking diodes, and wiring harness [54]. This system must condition the power to maintain the appropriate current and voltage levels to the power subsystems under varying illumination, temperature, and with cell degradation over the mission lifetime. The electrical bus for this system must also be able to isolate individual panel faults in such a way that the entire spacecraft will not loose total power in the case of a panel failure. The entire Power Management and Distribution (PMAD) typically will account for 20 to 30% of the entire power system mass in the case of a conventional array. This can be reduced if an unregulated system is used.

Very often solar power generation is combined with a battery storage element that can be used in eclipse. In order to provide the appropriate charging conditions for the batteries and to avoid overcharging and heating, peak-power tracking (PPT) or direct energy transfer (DET) are used. PPT controls the arrays, so they only produce the power levels required by means of a DC-DC converter in series with the array. Peak-power tracking is typical on missions that need less power at EOL. A PPT system uses about 5% of the power produced by the array. Systems using DET operate using the fixed voltage of the array and shunt the excess power through shunt resistors. The fixed voltage of the array is chosen to be close to the EOL maximum power point voltage. These systems generally have a higher EOL efficiency and therefore are used on longer missions.

On an unregulated bus with a battery storage component, the loads will experience whatever voltage is currently on the batteries. This can lead to a large swing in voltage (i.e. 20%) to the load depending on the battery chemistry and the depth of discharge. In a quasi-regulated system that employs a simple battery charger, the loads will be maintained at a voltage that is higher than the voltage on the batteries during charging. However, the loads will track the decrease in battery voltage as they are discharged (i.e. during eclipse). A fully regulated system that uses a regulator will maintain a constant load voltage independent of the charging or the discharging cycle. A fully regulated system requires more elements and thus increases the PMAD complexity and mass. There will also be a decrease in system efficiency due to the power loss from overall bus resistance. However, it does provide more reliability and increases battery life. The resistive power losses can be minimized by using a higher bus voltage. The maximum voltage limits on an array is set by the voltage that the exposed parts of the power system can hold off without discharging through the space plasma (i.e. ~50 V for LEO).

10.6 FUTURE CELL AND ARRAY POSSIBILITIES

10.6.1 Low Intensity Low Temperature (LILT) Cells

The term LILT is used to refer to solar arrays operating under conditions encountered at distances greater than 1 AU from the sun. Typical Earth-orbiting solar arrays have steady-state illuminated temperatures of approximately 40 to 70°C. The efficiency of most cells increases down to about −50°C. This temperature would correspond to around