Electrical Power Subsystem

The electrical power subsystem provides conditioned power to all spacecraft and payload subsystems and components via a single power bus regulated at 42.0 ±0.5 volts dc in sunlight and 30.0 volts dc minimum during battery / eclipse operations. The power subsystem consists of a solar array, a wing-mounted sequential shunt assembly, two 12-ampere hour (Ah) nickel-cadmium batteries, and a power control unit (PCU).

Electrical Power Subsystem Design Features

Solar Array
- Single wing sun tracking
- 5-year minimum lifetime with margin

Battery
- Two 12-Ah nickel cadmium batteries
- 28 cells per battery
- 60% maximum depth of discharge

Regulation
- 30 to 42.5 V dc bus voltage
- Sequential shunt limits sunlight voltage to 42 ±0.5 V
- 32.4 V minimum bus voltage at end of eclipse

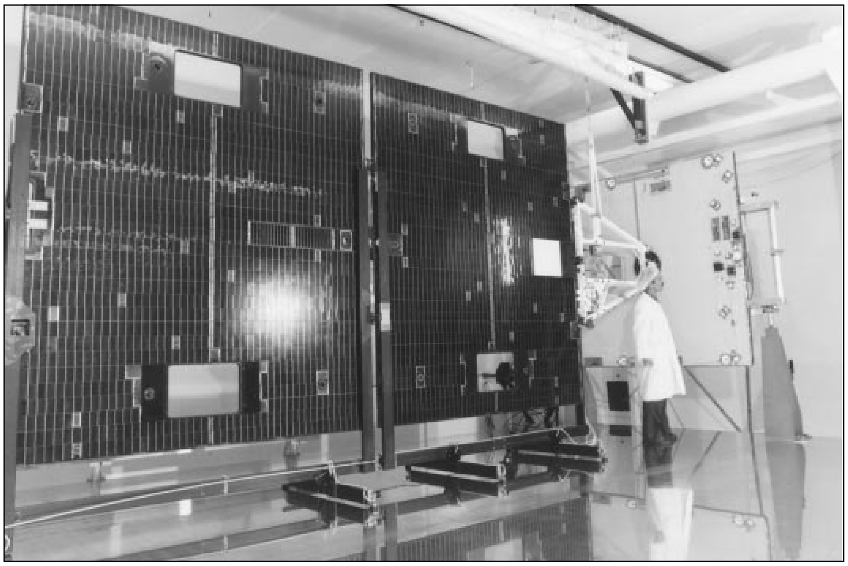
Functioning
- Automatic disconnect / reconnect of sunlight loads
- Override of automatic load switching on function-by-function basis
- All loads commandable except command functions
- Redundancy for all critical functions:
  - Multiple battery charge circuits
  - Single battery cell failure tolerant
  - Fully redundant solar array drive electronics
  - Backup solar array drive motor winding

Solar Array

Primary power is supplied by a lightweight, two-panel solar array and distributed to spacecraft loads through the power harness. The two panels are attached to the single-axis, sun-tracking, continuously rotating solar array drive assembly motor by a graphite yoke. The outboard panel is initially deployed 90° to provide power during the transfer orbit phase. When the spacecraft is in geostationary orbit, both panels are deployed to their final operational position. The array is capable of generating an end-of-life, summer solstice power of 1057 watts.

The generated power is provided to the primary bus via the solar array drive assembly slip rings and the main enable plug. The array consists of 22 strings containing 121 series cells, 6 battery-charge cell groups composed of 2 sets of 12 series by 3 parallel cells, and 4 groups of 12 series cells. Array output is controlled under changing spacecraft load conditions by shunting the lower two-thirds of 20 of the main bus strings to transistors in the sequential shunt assembly (SSA). Wiring of the harness and shunting is designed to reduce the

Solar Array



current loop area, thereby minimizing the induced magnetic dipole moment of the array.

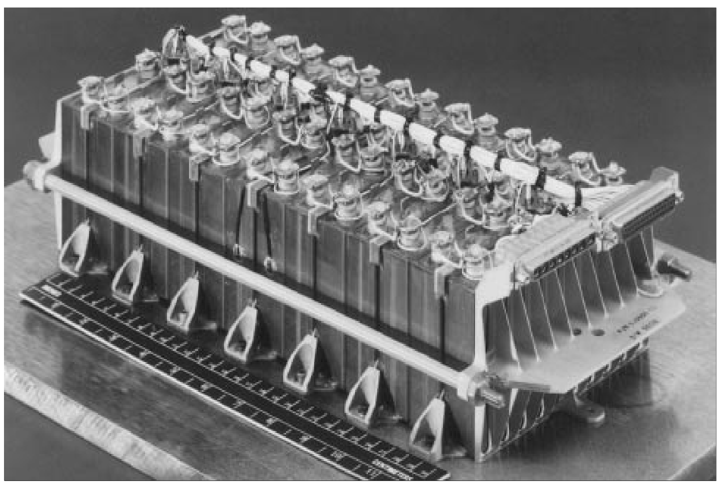
The six battery-charge cell groups are nominally arranged to allow selection of charge current levels to each of the two batteries. Application of the charge current is selected by ground command-actuated relays in the PCU. By means of a charge sequencing circuit within the PCU, selected charge rates may be continuously applied to each battery or sequenced alternately between batteries on 5-minute intervals. Ground-commandable cross-strap relays within the PCU provide redundancy and allow selection of eight different charge current levels.

Batteries

The two nickel-cadmium batteries provide the power required during launch and ascent phases of the flight (prior to outer solar panel deployment), when in eclipses, and under peak load demands. The battery power is supplied to the primary bus via parallel, redundant battery isolation diodes, redundant battery relays, and the main enable plug. An automatic eclipse-load disconnect/reconnect control capability and battery undervoltage disconnect capability are provided; both automatic features can be overridden by manual command. The spacecraft load condition in sunlight is such that some equipment must be powered off during eclipse. An automatic load shedding capability is provided which may be enabled and/or overridden upon ground command.

Each of the two batteries consists of 28 series-connected 12-Ah nickel-cadmium cells. The cell interconnects have been optimized to reduce induced magnetic dipole effects during charge and discharge current conditions. Individual cell voltages in each battery are monitored via the spacecraft telemetry through the PCU.

Heaters (resistors) are mounted in parallel on the battery intercell separators. These heaters, in conjunction with temperature sensors on each battery and the automatic temperature control circuitry contained in the PCU, supply a thermostatically controlled 19 watts of heating to maintain battery temperatures between +1 and +5 ˚C during periods of cold exposure. This thermostatically controlled interface is redundantly protected by a manual command override capability.

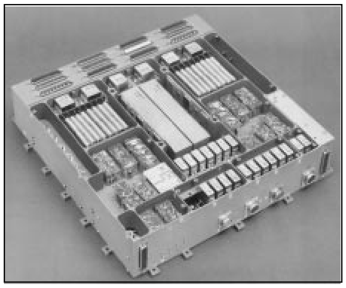


12 Ampere-hour Nickel-Cadmium Battery

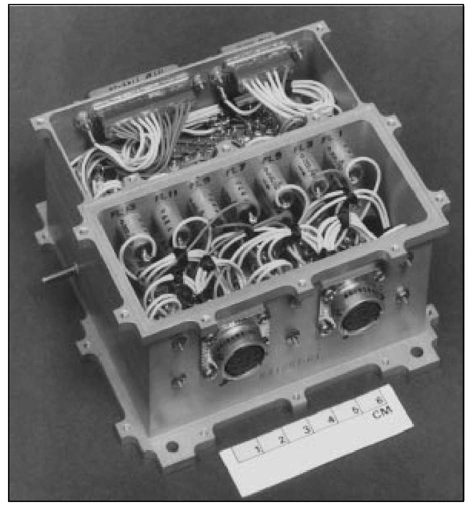
Power Control, Electroexplosive Devices, and Sequential Shunt Assembly Units

The PCU, as the functional center for all spacecraft power generation and control, regulates the solar array output through the sequential shunt assembly, maintaining 42.0 volts in the power bus during sunlight operation despite changing load conditions. This is performed by a redundant, majority-voting, error amplifier in the PCU that generates control signals for sequentially turning on shunt transistors in the SSA. The SSA is mounted on a heat sink on the dark back side of the inboard solar array panel to allow thermal dissipation.

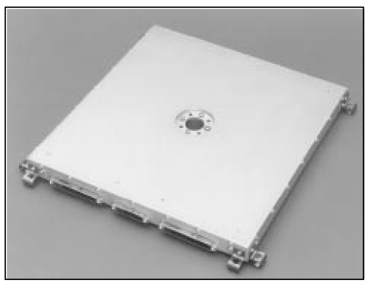
The PCU contains circuitry and relays for battery charging, sequence charging, undervoltage protection, reconditioning, and temperature control. It also



Power Control Unit



EED Extension Unit



Sequential Shunt Assembly

contains a set of radio frequency interference (RFI) -tight cavities that house relays used to select and fire electroexplosive devices (EEDs); these initiate equipment deployment early in the flight. The number of pyrotechnic events requires additional EED bridgewire actuators beyond those available in the PCU. Three EED extension units provide these actuators, each housing the EED relays in an RFI-tight cavity as with the PCU. Relay drivers and individual current limiting resistors are housed in the remaining volume of each extension unit. Primary bus voltage for the actuators is derived from the PCU.

The PCU also provides interfaces to the spacecraft telemetry and command subsystem, allowing the above PCU functions to be monitored and controlled.

Spacecraft Load Control

Each primary power bus load (except for command receivers and command units) is connected to and disconnected from the primary bus by command. To conserve battery power during eclipse, power is automatically removed from sunlight loads upon entering and automatically restored upon exiting the eclipse period. Command override of this automatic function is provided.

Commanded Load Control

Application of power to individual loads is provided by on/off control input to each load dc/dc converter and by direct power bus switching of nonelectronic loads (heaters). Command unit latching relays control application of primary bus voltage to the dc/dc converter control input and the nonelectronic loads. Command receivers and command units are permanently connected to the primary bus and cannot be disconnected by command.

Automatic Load Control

Automatic control of sunlight loads, including override, is accomplished on a function-by-function basis. The PCU performs automatic load shedding for eclipse operations via redundant load controllers that monitor the solar array and control bus currents. When the array current drops below 5 amperes, the load controller generates output signals that turn off selected loads. Upon emerging from eclipse, the controller delays until the SSA current exceeds 8 amperes, then sequentially issues signals that reapply the loads. The time duration between individual load turn-on output signals is 20 seconds. Output signals are relay contact closures sent to the associated command unit and incorporated into the turn-on command structure. Override of each load control output is provided in the associated command unit and controls turn-on/turn-off of spacecraft load groups during eclipse transitions.

Sequential Load Restoration

Power bus transients are minimized by sequential load restoration; precharge of input capacitors is not required.