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NASA TECH BRIEF

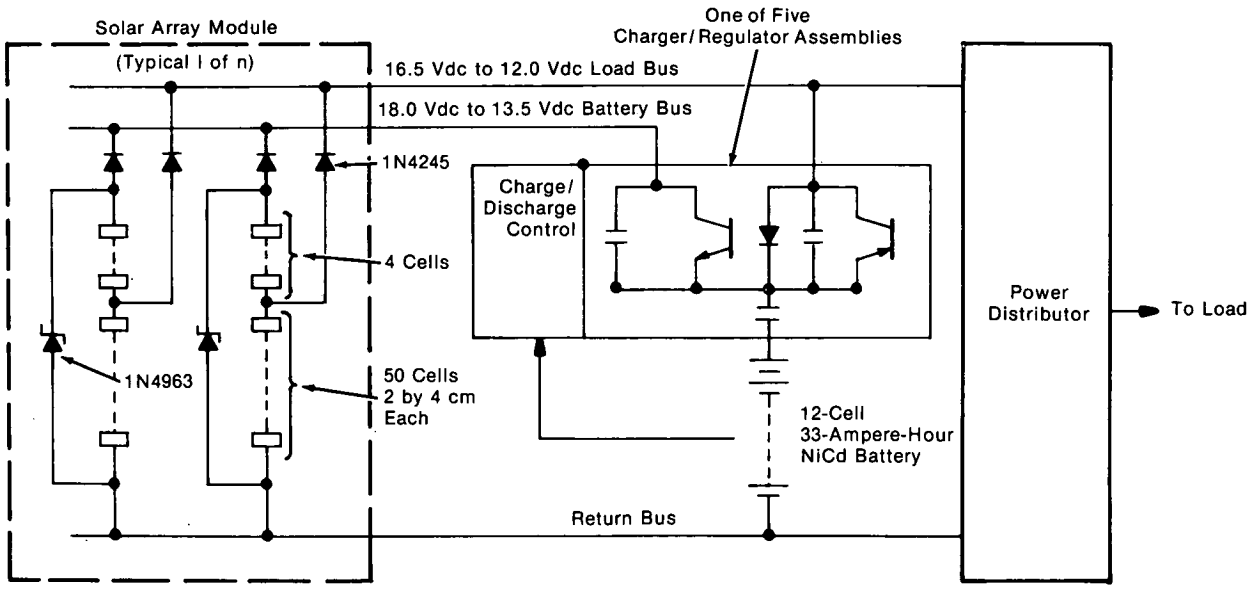
Marshall Space Flight Center

Zener-Regulated Solar Array/Battery Power System

A new zener-regulated solar array/battery system has been proposed to improve the life and reliability of the solar cells. The system shown in the simplified diagram includes a series of solar array modules (one shown). Both zener and blocking diodes are mounted on 4-cm by 4-cm thermal radiators (radiating from both sides) embedded in the flexible array. These radiators can be reduced in area (to provide better heat distribution) to the size of either 2-cm by 2-cm or 2-cm by 4-cm solar cells by the proper choice of zener diodes connected in series. The outputs of the solar array are bused to the batteries.

Each solar cell string is shunted by a zener diode which limits the voltage used to charge the battery. Because the load bus is tapped from these strings of solar cells several cells down, it also has the characteristic of zener regulation. An open circuit failure of a zener in this application is not catastrophic since many must fail in order to raise the bus voltage. Similarly, the blocking diodes prevent low-voltage (possibly shorted) strings from reducing the bus voltage. In addition, zener currents are naturally limited by the output of the solar cells. The extreme ranges of voltage from full load at -140° C to open circuit at 80° C fall within 12.0 to 16.5 volts, respectively. Load regulation at any array temperature is expected to be within 2.5 volts from no load to full load.

Under open circuit conditions, each zener is capable of thermally dissipating the output power of one string of solar cells. For flexible arrays, a zener is suitably bonded and heat sunk with the isolation



63 parallel strings of solar cells required per battery.

Note: 125 watts average continuous output power in 94 minutes per 63 parallel solar-cell string/battery combination.

Zener-Regulated Solar Array/Battery System

(continued overleaf)

diodes to approximately solar cell-sized printed-circuit cards embedded in the array. An alternative is to use a stud-mounted zener heat sunk to a rigid honeycomb substrate. Approximately 756 zeners are used to regulate a 1,500-watt system.

In the absence of solar radiation, the battery characteristic determines system regulation. The no-load to full-load voltage swing during the Sun-lit period is approximately 2.0 to 2.5 volts (zener range plus diode drop). For a change from 10 percent load to full load, the regulation is approximately 1.1 volts. During the dark period, the battery voltage can change from 16.5 volts at full-charge open circuit to 12.0 volts at low-voltage cutoff (1.00 volt/cell). Because the battery can discharge through a series regulator, the normal voltage swing is approximately 16.0 to 15.0 volts with 15 percent depth-of-discharge cycle. This estimate, 16 to 15 volts, assumes a voltage swing from no load to full load and a good low-impedance 12-cell battery.

Negative pulses generated by loads are prevented by the zener during the Sun-lit hours and by the battery during the night. Positive-going pulses are clamped by diodes from the load bus to the battery output located in the battery/charger modules. Since the battery/charger module is a series-dissipative type, minimum switching noise is generated by the system. Because of these general system design features, it is anticipated that pulse noise generated externally to the system should be limited to within ±3 volts from the bus voltage. Therefore no internal system requirement for bulky and troublesome noise filters should exist. Moreover, one battery/charger/regulator in each assembly can operate from either the 28-volt or the 14-volt bus to balance the system in the event of module failure.

Note:

Requests for furhter information may be directed to:

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Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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