NASA TECH BRIEF
NASA Pasadena Office

Peak-Power-Point Monitor for Solar Panel

The problem:

To determine the peak power capability of a solar panel power source without disrupting the flow of power from the panel.

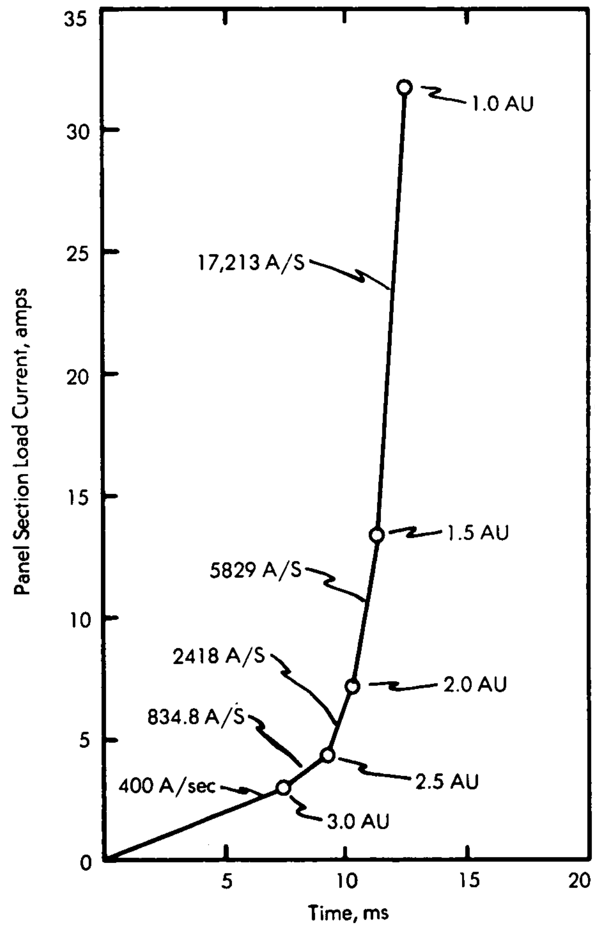
The solution:

Separate strings of solar cells are switched out of the panel circuit and rapidly subjected to increasingly larger loads until the peak power points are traversed; the wattage output of each string is recorded and the stored measurements of all strings are summed to indicate the peak-power point for the panel.

How it's done:

The solar cells in the panel are arranged in strings, each connected through a power diode to the main power bus. The increasing load is provided by a power transistor driven so that the load current increases in a predetermined way; the loading program is completed as quickly as possible so that the flow of power from the panel is interrupted only briefly and the amount of energy dissipated in the loading device is kept at a minimum.

The maximum rate of loading of the string of solar cells must be carefully selected in order to minimize the effect of diffusion capacitance. The maximum value of diffusion capacitance occurs at no load in the brightest environment; at all other times, the value is directly proportional to the difference between short circuit current capability and the actual load current. Quick-loading of the string of cells draws considerable current from the capacitance and introduces error in the measurement of short circuit current. The value of the capacitor current is $C(dv/dt)$ where dv/dt is the instantaneous rate of voltage fall of the string



caused by the measuring load, and since it is not possible to make the capacitor current zero in a diagnostic test, the rate of loading must be selected so that the resulting error is within acceptable limits. Values of the string dynamic resistance (dv/di) must also be

(continued overleaf)

determined before proper load current (*di/dt*) values can be selected to give an allowable *dv/dt*. Further consideration of the problem reveals that the optimum allowable *dv/dt* varies at a particular illumination level as the measuring load is increased; also, it is smaller for a particular load point as the illumination intensity decreases. The problem is further complicated by the fact that *dv/dt* values for a string of cells in the short circuit region cannot be obtained from computer-plotted I-V curves because of the difficulty in distinguishing between infinite slope and high finite slope.

The permissible current slope is high at intense illumination, reaching a value (for maximum measurement error of 0.877%) of 25,800 A/sec when cells are illuminated by the sun at 1 AU, but it decreases to 400 A/sec at solar illumination levels such as are obtained at 3.5 AU. A plot of allowable current–slope values, that is, amperes of load reached *vs* time appears much like an exponential curve (see diagram), but it is evident that if the rate of loading of a string of solar cells conforms closely to this plot, the measured value of short circuit current obtained within a prescribed time interval is essentially uninfluenced (within 0.877%) by the effects of diffusion capacitance.

Fortunately, the transconductance of a transistor is also exponential; accordingly, a linear voltage ramp applied to the base of a loading transistor will produce an exponential drain of current with time from a string of solar cells until the short circuit current is drawn (further changes in transconductance cannot cause flow of additional current). By proper selection of transistor type and other circuit parameters, the shape of the transconductance curve can be made to approximate closely the exponential loading curve. Additional implementation of the measurement technique includes circuitry for reading the output current I and voltage V of the solar cell string during the test interval, obtaining the product of I and V, and holding the maximum value of the I-V product so that it can be transferred to computer memory just before the test interval is completed; of course, switching networks are used so that an I-V product is sequentially obtained for each string in a solar panel, and the computer is programmed to average data and indicate peak power point for the panel.

Although the circuitry and technique has been developed specifically for application in spacecrafts which will utilize electric ion-thruster engines powered from solar cell panels, the technique and much of the circuitry can readily be applied in tests of solar cells for terrestrial use.

Note:

Requests for further information may be directed to:

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Reference: TSP72-10694

Patent status:

NASA has decided not to apply for a patent.

Source: Alden I. Schloss of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-11708)