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DEVELOPMENT OF THE TRANSIENT PULSE MONITOR (TPM) FOR SCATHA/P78-2

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INTRODUCTION

The Transient Pulse Monitor (TPM) discussed at the 1976 Spacecraft Charging Conference* has been assembled, tested and installed on the P78-2 spacecraft. This instrumentation system was developed to meet the need for a compact, lightweight piggy-back package for the detection of electrical transients on space vehicles.

The primary objective of the Transient Pulse Monitor on P78-2 is to obtain a quantitative description of the electromagnetic pulse environment on a spacecraft at synchronous altitude. Relative frequency of occurrence of pulses as a function of amplitude and duration, when obtained, will permit design of command/control logic which is relatively immune to spurious signals on typical spacecraft. A secondary objective is the characterization of signals produced by arcing between differentially charged elements on the spacecraft. Additionally, data from known discharge events, identified by data from the Spacecraft Surface Potential Monitor on P78-2 can be used quantitatively and qualitatively in the validation of electromagnetic pulse coupling models.

TPM DESCRIPTION

Although the basic TPM system can be used to characterize electrical transients occurring on the outside surface or internal to a spacecraft, the P78-2 TPM will be used entirely with internal sensors since the electromagnetic signatures of breakdown pulses on the exterior of the satellite will be characterized by portions of the onboard SC1 payload.

The TPM, as configured for the P78-2 spacecraft, consists of an electronic processor (shown in figure 1) and four electrical transient sensors. As shown in figure 2, two of the TPM sensors are passive current probes and two are long wire antennas. One current probe is located on one of the two wires that connect the upper solar array to the Power Conditioning Unit (PCU). The other current sensor is located on one of seven ground wires between the PCU and the vehicle frame. Both current sensors have sensitivities of 1 mV/mA.

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*J. E. Nanevicz and R. C. Adamo, "Transient Response Measurements on a Satellite System," Proceedings of the Spacecraft Charging Technology Conference, U.S. Air Force Academy, Colorado, 27-29 October 1976.

The long wire antennas each consist of unshielded insulated wires tied to the outside of the foil wrap of the main vehicle wiring harness. The two wires run parallel to each other and extend half way around the inside of the vehicle center tube. These antennas differ only in the magnitudes of their termination impedances. As shown in figure 2, the low-impedance antenna is connected directly to the vehicle frame at the far end and is terminated in 50 Ω within the TPM processor housing. The high-impedance antenna is connected to the vehicle frame through a 100 K Ω resistor at the far end. At the TPM end of the high-impedance antenna there is a 10 K Ω resistor in series with the 50 Ω TPM input impedance.

Figure 2 also shows the 20 db attenuators that were installed in the low-impedance antenna and solar array sensor input channels to reduce the TPM sensitivity to internal low-level background noise observed during P78-2 system tests.

The TPM electronic processor continuously monitors electrical signals from each of the four sensors simultaneously and provides the following information for each sensor once per second, as is illustrated in figure 3.

- Positive peak amplitude
- Negative peak amplitude
- Total pulse count
- Positive integral
- Negative integral

The TPM has two modes of operation: the continuous mode (mode Ø) which is expected to be the normal mode of operation and the single-pulse mode (mode 1) which will be used only in cases of high rate of occurrence of detected transients.

The TPM also has four commandable gain (or threshold) settings that affect the sensitivities of the pulse count and pulse integral channels. The TPM continuously supplies a mode status indication bit to two gain level status indication bits to the space vehicle telemetry system.

A clock signal is supplied by the vehicle telemetry system to the TPM once per second. Upon receipt of this signal, data acquired during the previous one-second period are transferred to the outputs of the TPM. Therefore, data supplied by the TPM during any one-second period represent information gathered during the previous one-second period.

The two peak amplitude channels associated with each sensor indicate the maximum positive and negative excursions of the input signals during each timing window. In the continuous mode (mode Ø), the timing window is the entire one-second frame. In the single-pulse mode (mode 1), the inputs to the peak amplitude channels from any sensor are disabled approximately 10 mS after the occurrence of any transient that exceeds the threshold of the pulse counter channel associated with that sensor. The peak amplitude channels are not affected by changes in gain setting.

The dynamic range of the peak amplitude channels is 2 mV to 24 V for the high-impedance antenna, 20 mV to 240 V for the low-impedance antenna, 4 mA to 48 A for the solar array sensor, and 140 mA to 1700 A for the power distribution unit sensor. These ranges include the effects of 20 db attenuators in the inputs to the low-impedance and PCU sensors and also the fact that only one of seven identical power leads is monitored by the PCU sensor and one of two identical input leads is monitored by the solar array sensor.

The pulse count channel associated with each sensor indicates the total number of times that the magnitude of the input signal exceeds a set threshold during each one-second telemetry window. However, if the input signal exceeds the set threshold more than once during any 1 ms period, it is counted only once. The pulse counters acquire data throughout each one-second telemetry frame regardless of the TPM mode setting. The dynamic range of the pulse count channels is from 0 to 100 pulses per second.

The two pulse integral channels associated with each sensor indicate the total positive and negative integral of the input signals during each timing window. However, the portions of the input signal that do not exceed the lower amplitude threshold, as shown in figure 3, are not included in the integral measurement. In the continuous mode (mode Ø), the timing window is the entire one-second telemetry frame. In the single-pulse mode (mode 1), the inputs to the pulse integral channels from any sensor are disabled approximately 10 ms after the occurrence of any transient that exceeds the threshold of the pulse counter channel associated with that sensor.

The P78-2 TPM provides 20 continuous analog outputs (5 for each sensor) as described above.

The electronic processor shown in figure 1 consumes 6.8 watts and has dimensions of 20 cm x 21.3 cm x 9.65 cm. The entire system including sensors weighs 2.7 kg.

It is planned that the TPM will be turned on and checked out early during P78-2 transfer orbit and will remain on to continuously acquire data throughout the mission.

It is hoped that the TPM on P78-2 will provide a substantial supplement to the limited data presently available on the actual electromagnetic pulse environment on orbital spacecraft and if successful will serve as a model for similar systems for inclusion on other spacecraft.

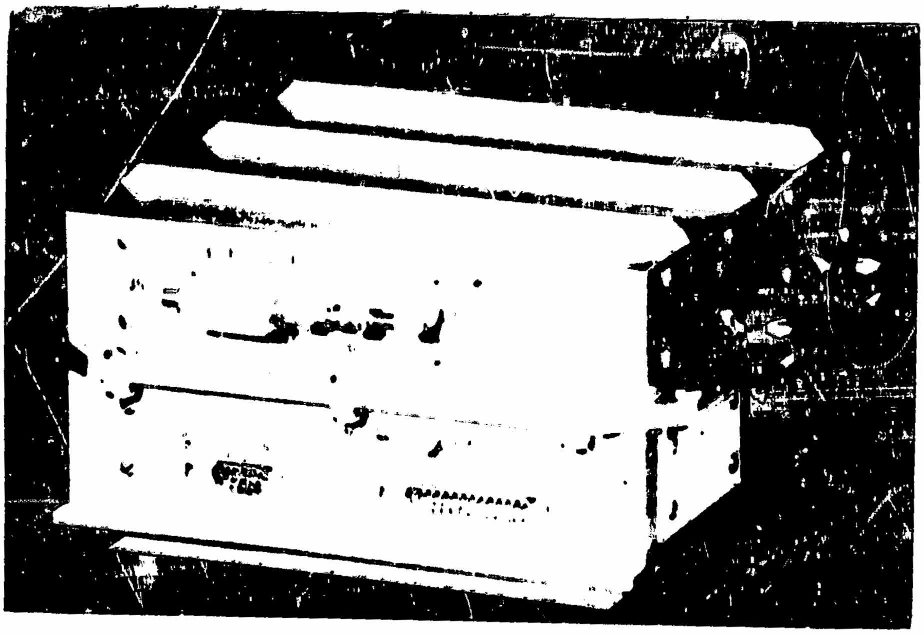

FIGURE 1 TRANSIENT PULSE MONITOR (TPM) ELECTRONIC PROCESSOR

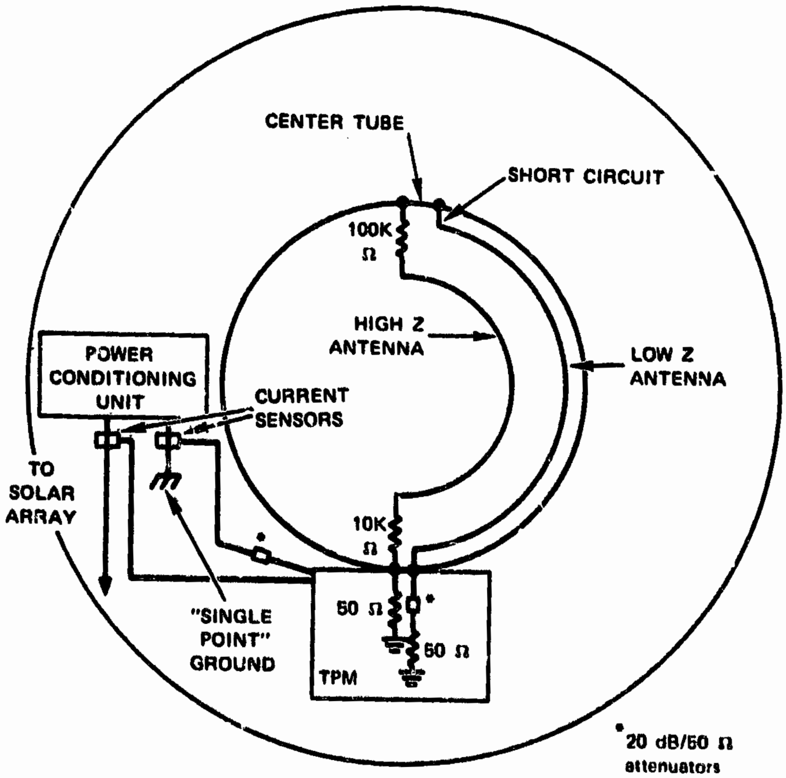

FIGURE 2 TPM SENSOR LOCATIONS ON P78-2

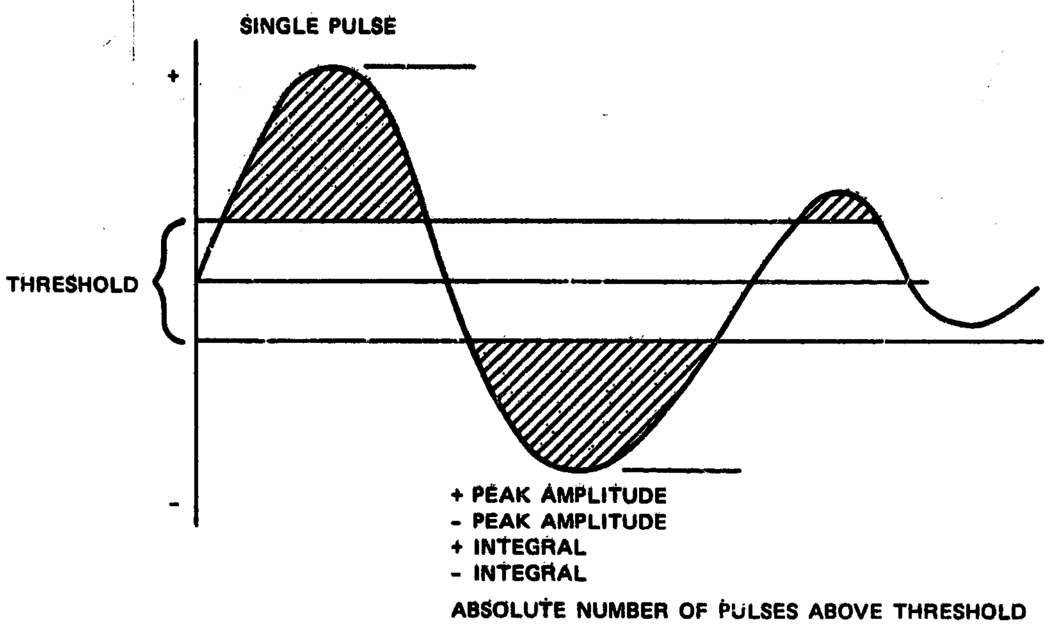

FIGURE 3 DATA DERIVED FROM TRANSIENT-PULSE MONITOR