



## Apparatus Characterizes Transient Voltages in Real Time

Only the most relevant data are recorded.

*John F. Kennedy Space Center, Florida*

The figure shows a prototype of a relatively inexpensive electronic monitoring apparatus that measures and records selected parameters of lightning-induced transient voltages on communication and power cables. The selected parameters, listed below, are those most relevant to the ability of lightning-induced transients to damage electronic equipment.

This apparatus bridges a gap between some traditional transient-voltage recorders that record complete waveforms and other traditional transient-voltage recorders that record only peak values: By recording the most relevant parameters — and only those parameters — this apparatus yields more useful information than does a traditional peak-value (only) recorder while imposing much smaller data-storage and data-transmission burdens than does a traditional complete-waveform recorder. Also, relative to a complete-waveform

recorder, this apparatus is more reliable and can be built at lower cost because it contains fewer electronic components.

The transients generated by sources other than lightning tend to have frequency components well below 1 MHz. Most commercial transient recorders can detect and record such transients, but cannot respond rapidly enough for recording lightning-induced transient voltage peaks, which can rise from 10 to 90 percent of maximum amplitude in a fraction of a microsecond. Moreover, commercial transient recorders cannot rearm themselves rapidly enough to respond to the multiple transients that occur within milliseconds of each other on some lightning strikes.

One transient recorder, designed for Kennedy Space Center earlier [“Fast Transient-Voltage Recorder” (KSC-11991), *NASA Tech Briefs*, Vol. 23, No. 10, page 6a (October 1999)], is capable of sampling transient voltages at peak val-

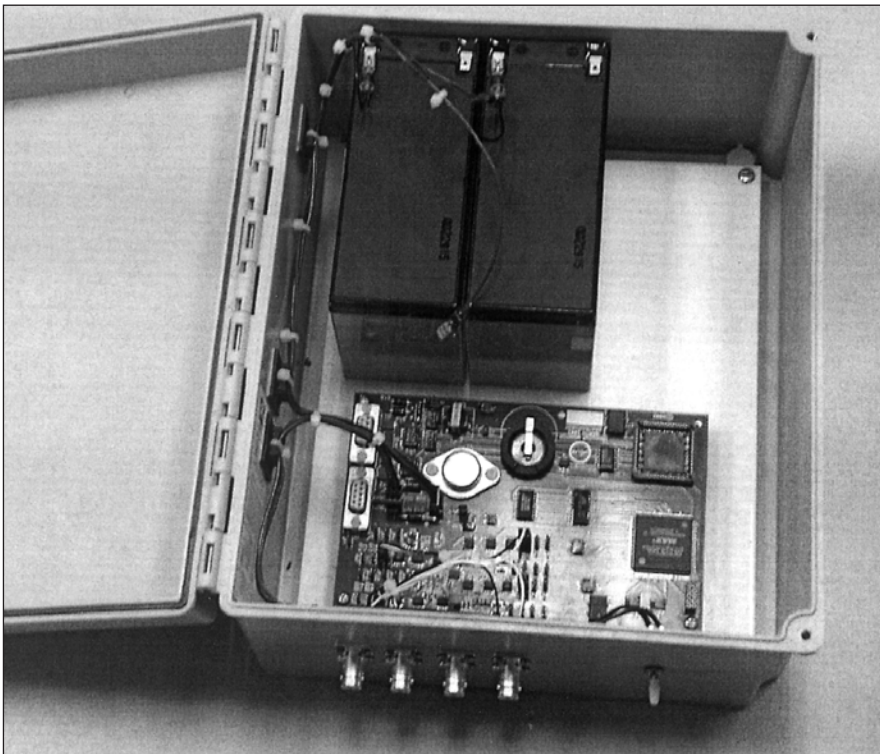
ues up to 50 V in four channels at a rate of 20 MHz. That recorder contains a trigger circuit that continuously compares the amplitudes of the signals on four channels to a preset triggering threshold. When a trigger signal is received, a volatile memory is filled with data for a total time of 200 ms. After the data are transferred to nonvolatile memory, the recorder rearms itself within 400 ms to enable recording of subsequent transients. Unfortunately, the recorded data must be retrieved through a serial communication link. Depending on the amount of data recorded, the memory can be filled before retrieval is completed. Although large amounts of data are recorded and retrieved, only a small part of the information (the selected parameters) is usually required.

The present transient-voltage recorder provides the required information, without incurring the overhead associated with the recording, storage, and retrieval of complete transient-waveform data. In operation, this apparatus processes transient voltage waveforms in real time to extract and record the selected parameters. An analog-to-digital converter that operates at a speed of as much as 100 megasamples per second is used to sample a transient waveform. A real-time comparator and peak detector are implemented by use of fast field-programmable gate arrays.

The parameters extracted from the samples and recorded are the following:

- Peak voltage;
- Duration of each transient at 75 percent of peak voltage, in increments of 10 ns;
- Duration of each transient at 50 percent of peak voltage, in increments of 10 ns;
- Duration of rise from 10 to 90 percent of peak voltage;
- Duration of fall from 90 to 10 percent of peak voltage; and
- Energy content of each transient pulse.

Unlike a traditional complete-waveform recorder, which typically records several thousand bytes per waveform,



This **Prototype Transient-Voltage Recorder** offers high performance, yet the estimated cost of its electronic components is no more than \$200 at 2003 prices.

this apparatus stores fewer than 20 bytes per waveform. The bandwidth needed to transmit the data to a remote recording or control station is reduced correspondingly. In addition, the dead time between subsequent triggers of this apparatus is only about 0.1 ms — less than a hundredth of that of the prior transient recorder.

This transient-voltage recorder can be configured for different input voltage ranges to accommodate the expected magnitudes of the transients to be monitored. Typical input ranges include  $\pm 10$  V,  $\pm 50$  V, and  $\pm 100$  V. The input termination can be either single-ended or differential and selectable among impedances of 50, 120, or 10 kilohms. Either a positive or a negative transient can trigger

sampling, real-time processing, and recording. Depending on the specific setup, data in multiple channels could be analyzed simultaneously, triggered by signal from any one of the channels.

A clock circuit is included to enable accurate time-stamping of any recorded waveform. Time stamping is necessary if a transient measured by this apparatus is to be correlated with measurements by such other apparatuses as a lightning-location system.

The power supply of the transient-voltage recorder includes backup batteries that can maintain operation for as long as 15 days when main AC power is lost. During normal operation when AC power is available, the batteries are charged automatically.

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*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Innovative Partnerships Office, Kennedy Space Center, (321) 867-8130. Refer to KSC-12494.*

## Measuring Humidity in Sealed Glass Encasements

**This noninvasive technique helps in the preservation of valuable documents.**

*Langley Research Center, Hampton, Virginia*

A technique has been devised for measuring the relative humidity levels in the protective helium/water vapor atmosphere in which the Declaration of Independence, the United States Constitution, and the Bill of Rights are encased behind glass panels on display at the National Archives in Washington, DC. The technique is noninvasive: it does not involve penetrating the encasements (thereby risking contamination or damage to the priceless documents) to acquire samples of the atmosphere. The technique could also be applied to similar glass encasements used to protect and display important documents and other precious objects in museums.

The basic principle of the technique is straightforward: An encasement is maintained at its normal display or operating temperature (e.g., room temperature) while a portion of its glass front panel is

chilled (see Figure 1) until condensed water droplets become visible on the inside of the panel. The relative humidity of the enclosed atmosphere can then be determined as a known function of the dew point, the temperature below which

the droplets condense.

Notwithstanding the straightforwardness of the basic principle, careful attention to detail is necessary to enable accurate determination of the dew point. In the initial application, the affected por-

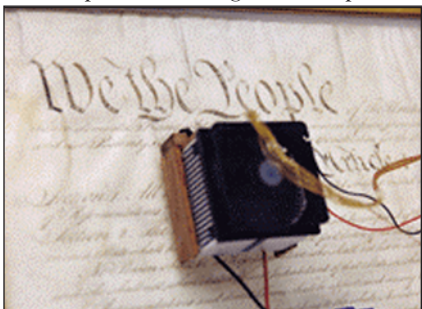


Figure 1. A Thermoelectric Device rests on the encasement.

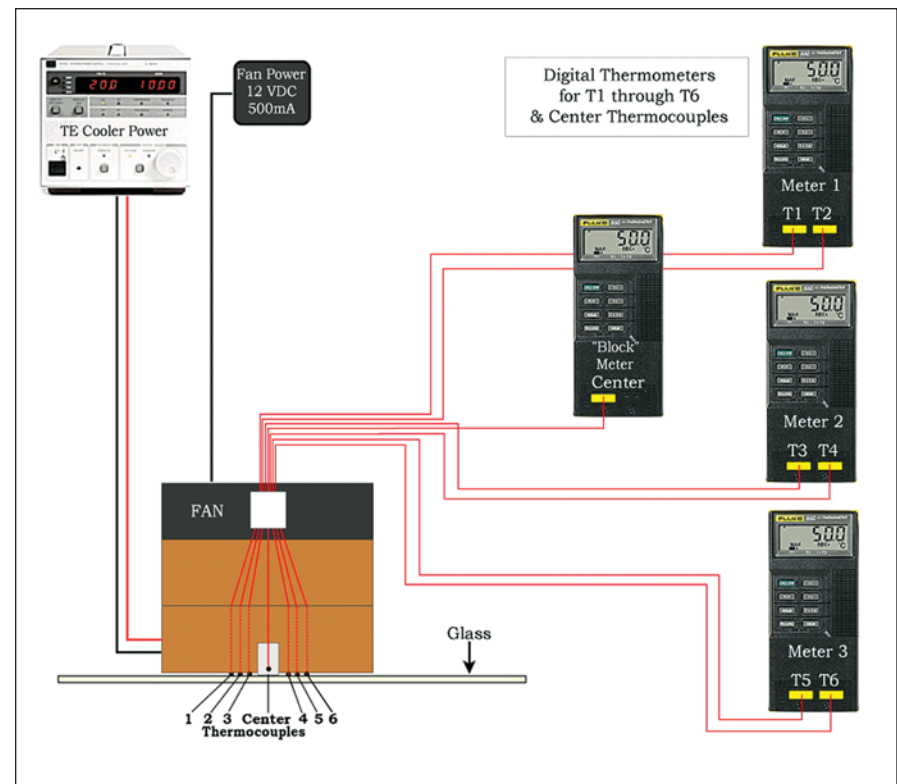


Figure 2. A Thermoelectric Cooler assembly and instrumentation has seven thermocouples to measure temperatures at different locations.