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NASA TECH BRIEF

Lewis Research Center

High Voltage Solid-State Relay

	Corona Inception	Leakage at 1000 V	Temperature Range	Voltage Isolation
Conventional relay	1400-1800 volts	10 μA	218 to 398 K (-67 to 257°F)	1000 V_{rms}
High voltage relay	5500-6000 volts	<.001 μA	153 to 353 K (-184 to 176°F)	2500 V_{dc}

Figure 1

A hybrid microelectronics solid state relay has been developed which has characteristics that are significantly superior to conventional solid state relays (Figure 1). The relay was developed for a space flight project to measure the effects of space plasma on exposed high voltage systems and to evaluate edge-illuminated multijunction solar cells. The relay provides 2500 V_{dc} input to output isolation and operates from a high threshold logic signal to switch a load of 400 V_{dc} at 2 mA. The relay was designed to operate in outer space and survive 1000 thermal cycles of 153 to 353 K (-184 to 176°F). Conventional relay design was advanced to achieve these characteristics.

For this project, the conventional design was simplified since the relay interfaced with the logic output of a high threshold logic gate where the "one" would be greater than 10 V but limited to the 15 V supply from which the gate is operated. The use of the high threshold logic gate allowed the input threshold to be raised to 10 V for noise immunity and eliminated the need for a snap action trigger circuit, therefore simplifying the output circuitry to a rectifier, filter and transistor switch. For high voltage isolation, all input circuitry was located on the input substrate and all output circuitry was located on the output substrate (Figure 2). The transformer windings were separated, a larger transformer core was used to increase physical separation of the windings and reduce the number of turns required (thereby maximizing possible isolation), and the transformer located between the input and output substrates. The substrates were designed to eliminate any unused leads in order to minimize leakage paths and allow room for proper positioning of the transformer. Higher voltage wire and welded leads, rather than soldered leads, were used to reduce leakage associated with substrate contamination by flux.

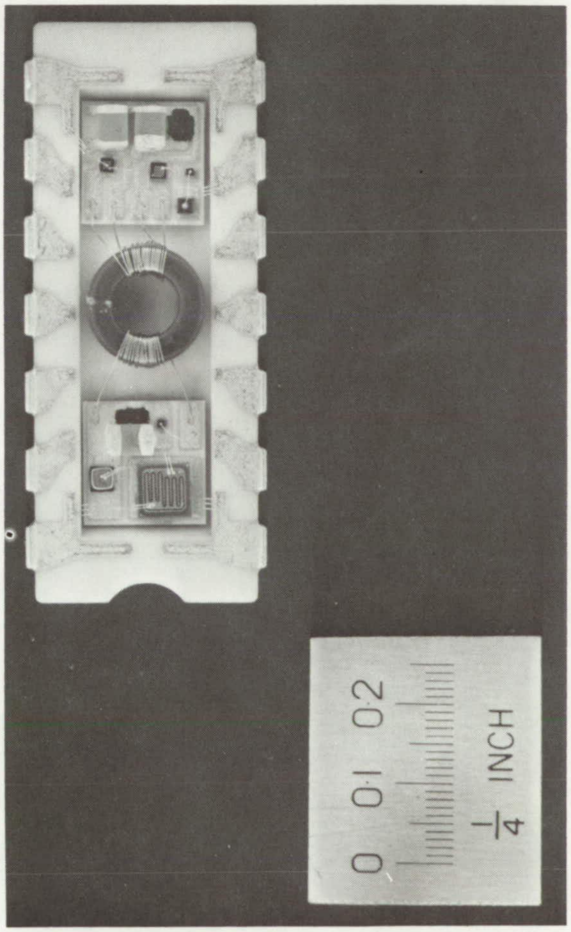

Figure 2. - High Voltage Relay

(continued overleaf)

Encapsulation was used in order to hold the leads in place during handling as well as to pin down loose particles that could destroy the device internally during vibration. The relay interior was coated with a high dielectric strength, clean, relatively thin film polymer that would survive the operating environment. A vacuum deposited para-xylylene polymer was used as the encapsulant. The coating thickness and rate of deposit were controlled to build up as little as 0.007 mils or as great as 1 mil per minute. This polymer has a dielectric breakdown voltage of 5600 V/mil and can be deposited thin enough that it will not cause destructive physical stresses but will be dielectrically strong enough to provide the necessary voltage isolation. The transformer core was also coated prior to winding in order to give it better isolation. Thermal cycling tests from 153 to 353 K (-184 to 176°F) appeared to be stress free, primarily because the polymer was applied in uniformly thin applications.

Notes:

1. This technology should be of interest to manufactureres of discrete components such as: computer-power interfaces, computer-teletype interfaces, isolated line drivers, isolated analog signal relays, sensor actuated relays, controllers and isolated multiplex relays.
2. Further information is available in the following report:

   NASA TM-X-68248 (N73-24235), Development of a Hybrid Microelectronics Solid State Relay for 2500 Volts Isolation and -120°C to 80°C Thermal Cycling Range

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10006
3. Specific technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B74-10006

Patent Status:

NASA has decided not to apply for a patent.

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