JOURNAL OF GEOPHYSICAL RESEARCH VOL. 68, NO. 18 SEPTEMBER 15, 1963
pp.5311-5314

Letters

High-Pressure Tests of Silicon Transistors and Miscellaneous Components

D. K. GIBSON

Marine Physical Laboratory of the Scripps Institution of Oceanography
University of California, San Diego

The design of larger and more refined electronic instrumentation packages for operation in the deep ocean is greatly complicated if the system components have to be protected from the extreme hydrostatic pressure encountered. If system components can be found that are capable of operating at the ambient pressures, the package design is reduced to one of surrounding the instrumentation package with a waterproof jacket that is fluid-filled and pressure-equalized to the sea. Mechanical and electrical penetrations through the package wall present no serious sealing problems because very little or no pressure differential exists across the seal. The only requirements imposed on the fluid used on the inside of the package are that it be noncorrosive and possess good electrical insulating properties.

This letter describes a series of tests conducted at the Marine Physical Laboratory to determine the effects of prolonged exposure to high hydrostatic pressure on a new transistor package and a number of standard off-the-shelf electronic components.

Test 1. Silicon planar transistors. In this test a set of ten transistors was immersed in castor oil and subjected to pressures from 0 to 0.6895 kb in 0.06895-kb increments. At each of the eleven pressure levels both h_{FE} and I_{CBO} were measured on each transistor.

The transistors were a new type of epoxy-encapsulated, passivated silicon planar devices, samples of which were furnished by the General Electric Company. These devices were of particular interest because of their small size and low cost.

Five each of two types were tested, a low-gain device GE type 16A1 (2N2711) and a high-gain device GE type 16A2 (2N2712).

The measured I_{CBO} of the ten devices was considerably less than the maximum 1 μa specified by the manufacturer at all pressure levels. The value I_{CBO} was not measurable on the Tektronix curve tracer, and it appeared to be less than a minimum detectable 1 μa.

No significant changes in h_{FE} were noted throughout the range of test pressures.

Test 2. The same set of ten specimen transistors used in test 1 was placed in the pressure test chamber and subjected to a prolonged immersion at 0.6895 kb for a period of 43 days.

In this test two of the transistors, one of each type, were operated continuously in a multivibrator circuit made up of conventional components including a pair of germanium diodes, two ceramic disk capacitors, and nine compression-molded composition carbon resistors. The remaining eight transistors were simply suspended in the castor oil at the elevated pressure for the full period of the test. No electrical tests were made on these devices during the 43-day immersion except that the amplitude and frequency of the output of the multivibrator were monitored. An increase in the frequency of the multivibrator output of approximately 15 per cent was noted as the pressure was elevated to 0.6895 kb. No further change in frequency or amplitude was noted during the 43-day period. The multivibrator frequency returned to the original zero pressure value upon return to zero pressure.

The other eight transistors were checked for

Contribution from the Scripps Institution of Oceanography, University of California, San Diego, 1517.

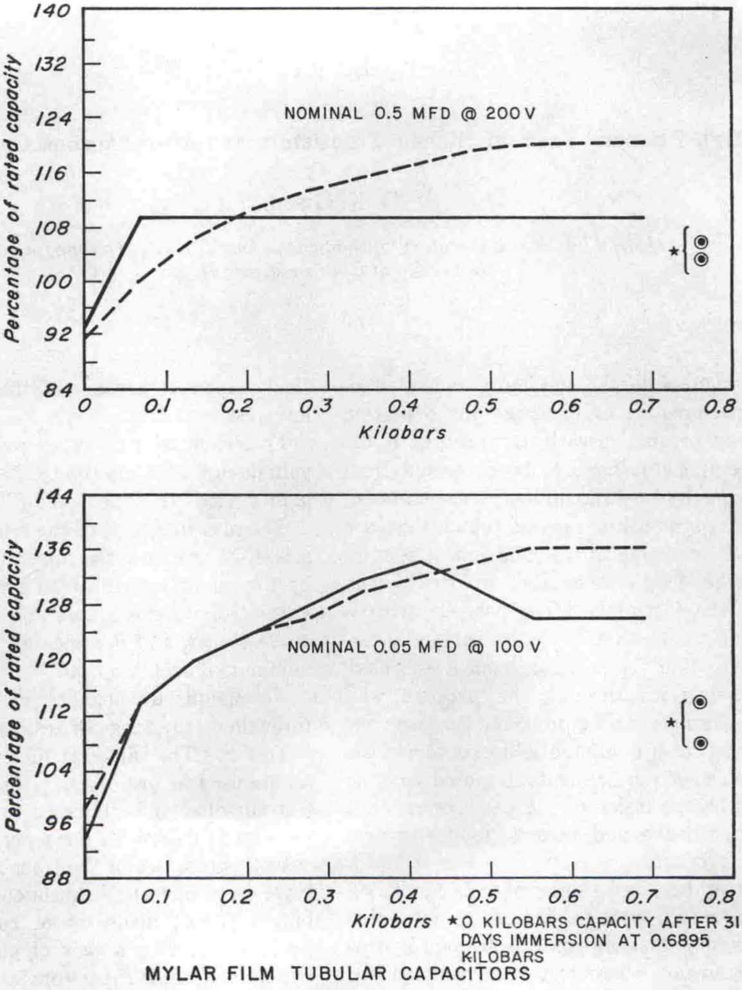

Fig. 1. Effect of hydrostatic pressure on Mylar film tubular capacitors.

h_{FE} and I_{CBO} upon removal from the test chamber, and no significant changes were noted from the original values measured before testing.

Test 3. Samples of off-the-shelf components were immersed in castor oil and subjected to pressures from 0 to 0.6895 kb followed by a 30-day immersion at 0.6895 kb. The following units were tested:

2 each—0.1 μf at 50 v, Centralab CK ceramic disk capacitors.

2 each—0.01 μf at 50 v, Sprague TG-S series ceramic disk capacitors.

4 each—Corning type CYFM fused monolithic construction glass capacitors in 1000 and 6800 pf.

4 each—Cornell Dubilier Mylar film tubular capacitors of the WMF series which have high density thermosetting plastic end seals (two sizes were tested, 0.5 μf at 200 v and 0.05 μf at 100 v).

2 each—Texas Instrument Company's SCM series tantalum electrolytic capacitors which are contained in an aluminum can with glass end seal; the units tested were 3.3 μf at 15 v.

6 each—Ohmite ¼ w, 10 per cent tolerance,

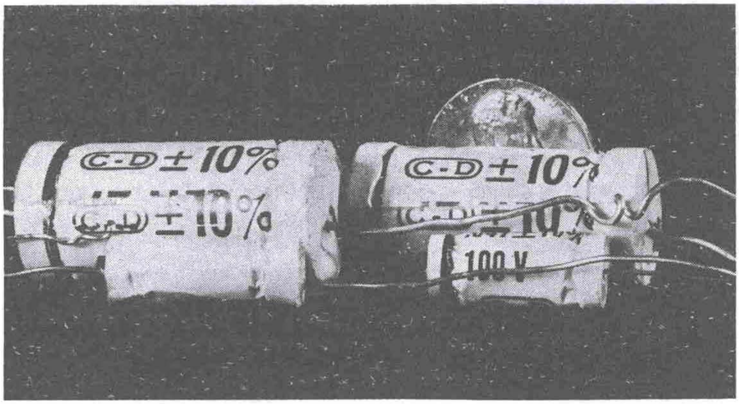

Fig. 2. Physical deformation of Mylar film capacitors due to hydrostatic pressure of 0.7 kb.

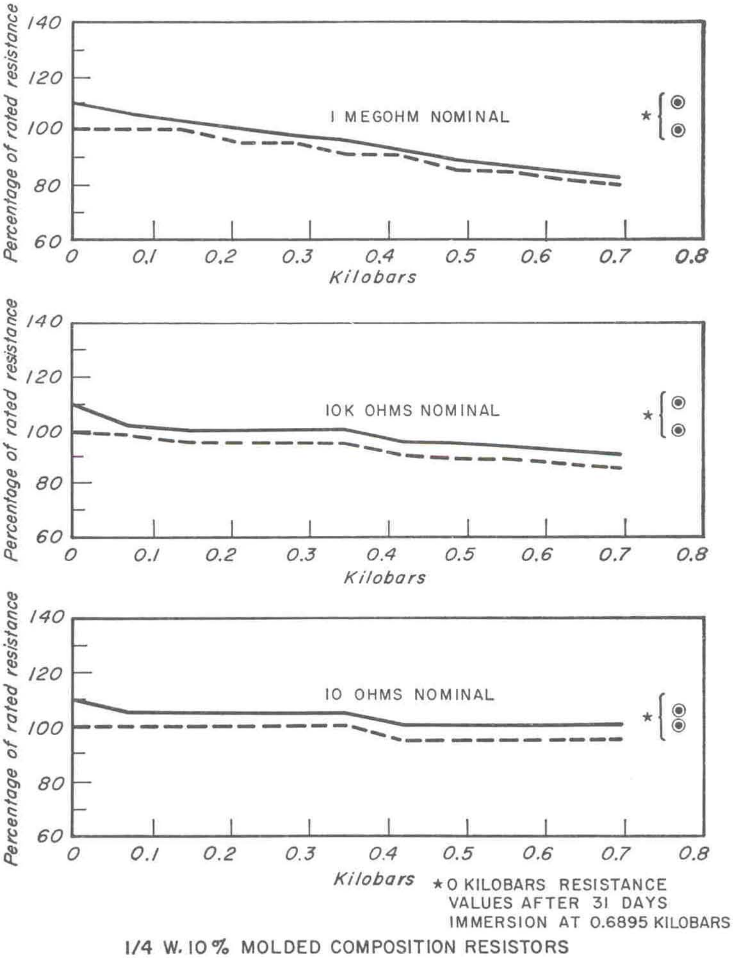

Fig. 3. Effect of hydrostatic pressure on the resistance of carbon resistors. [465]

molded composition resistors; 10-ohm, 10-kilohm, and 10-megohm units were tested.

No significant changes in capacity or leakage resistance were noted at any test pressure or following the 30-day immersion period in the case of the glass, ceramic, and tantalum capacitors.

The capacity of the Mylar film tubular capacitors increased nearly 50 per cent with increase in operating pressure (Figure 1). The asterisks in Figure 1 indicate that the capacity at the termination of the tests failed to return to the original capacitance values upon removal of pressure. The Mylar film tubular capacitors were the only components tested which sustained any permanent physical deformation. In the photograph (Figure 2) the physical collapse of the tubular shell just in from each end of the capacitors can be seen. In spite of the physical deformation and the large change in the capacity, electrical leakage resistance did not increase.

The effects of pressure on the resistance values of the six specimen carbon resistors is shown in Figure 3. The change in resistance as a function of pressure is greater in resistors of higher value, and all six resistors recovered fully to original resistance values after the high-pressure immersion. It is believed that this resistance change was responsible for the multivibrator frequency change described in test 2.

Although the data offered here represent a very small sampling, it is hoped that their publication will stimulate more thought and investigation into the feasibility of operating conventional electronic circuitry using standard, inexpensive, off-the-shelf components in an environment of high hydrostatic pressure.

Acknowledgment. This work represents results of research sponsored by the Office of Naval Research under contract Nonr 2216(05).