XII. Science Data Systems

SPACE SCIENCES DIVISION

A. High-g Testing Multilayer Laminate Packaging, *J. H. Shepherd*

1. Introduction

Shock testing was recently performed on two subassemblies of the *Mariner* Venus 67 prototype data automation subsystem (DAS). Its purpose was to provide information to the JPL Capsule System Advanced Development Project on the ability of the multilayer board packaging of these subassemblies to withstand shock levels beyond those for which it had been designed. This type of packaging has possible application in the design of a future hard-landed capsule due to features such as a reasonable form factor and a construction which facilitates repair and modifications. This potential usage, plus the opportunity to conduct the tests at very little cost, made these tests desirable at this time.

These subassemblies contained Signetics 400 series integrated circuits mounted in glass packages using gold-wire bonding. One subassembly (20A2) has primarily discrete components with a few integrated circuits on two-sided boards using plated-through holes for interconnections; the other subassembly (20A6) has integrated circuits installed on nine-layer laminates using plated-through holes for interconnections.

2. Testing

Prior to shock testing, the subassemblies were conformal-coated with solithane 113/300. For all but one test the subassemblies were positioned so that the side shown in Figs. 1 and 2 faced the direction in which the unit and fixture traveled. The shock, therefore, was perpendicular to the surface of the board to simulate a worst-case environment. The other test was in shear, with the subassembly connectors facing away from the shock.

Subassemblies were installed in the *Mariner* Venus 67 DAS prototype case, and subsystem tests were performed before and after each shock test.

The first series of tests utilized the JPL 50-ft drop tower, which consists of a carriage (the specimen mounting fixture) that rides down on two guide cables and impacts on lead pads. The size, shape, and thickness of the lead pads varies the shock level.

Table 1 shows the conditions of the first series of tests. Subassemblies showed no visual damage after each test and functioned properly when tested as a subsystem.

For the next test the subassemblies were stacked one on top of the other (Figs. 1 and 2 sides down) in a

Table 1. Drop-test conditions

Subassembly	Drop test	Peak g	Duration, ms	Velocity, ft/s
20A2[a]	2A1 side down	1700	1.25	57.2
20A6[b]	6A1 side down	1700	1.25	57.4
20A2	2A1 side down	2700	1.0	57.5
20A6	6A1 side down	2900	1.0	57.5
20A2	Shear	2950	1.0	57.5
20A6	Shear	2850	1.0	57.5

[a]Fig. 1.
[b]Fig. 2.

dummy capsule and dropped from an altitude of 250 ft on a dry lake bed. The dummy capsule weighed 54 lb and made a crater approximately 4 in. deep on one side and 2 in. deep on the other. Estimated shock for this test was calculated at 1100 gs.

The edges of the chassis walls showed minor damage where a mounting shim caused some misalignment. There was no damage to the components, and the units functioned properly when tested as a subsystem.

In order to attain the desired higher g levels the JPL slingshot facility was used for the next shock test. The slingshot uses large bungee cords to propel a fixture and specimen along guide rails into an abutment. The shock level is determined by three factors: the impact tool diameter, thickness and type of material of the target mounted in the abutment, and the distance traveled or impact velocity.

Subassemblies were mounted in the fixture with the 2A1 and 6A1 sides facing the abutment. Table 2 gives the conditions of this test.

Table 2. Slingshot test conditions

Subassembly	Timer reading, ms/6 in.	Impact velocity, ft/s	Penetration depth, in.	Calculated Average g
20A2	3.973	125.5	0.670	4,400
20A6	3.987	125.0	0.560	4,525

Weight of specimen and fixture, 14.6 lb
Distance from target, 10 ft
Impact tool diameter, 7/8 in.
Target material, copper
Target size, 1.5 × 3 in.
Target thickness, 1.5 in.

3. Damage to Chassis and Components

Visual examination after the slingshot test showed the chassis were bent on all four walls (Figs. 1 and 2); subassemblies webs were bowed toward impact sides 2A1 and 6A1; connectors J-1 through J-4 shells were bent; and pin holding blocks were broken.

Subassembly 20A2 lost the lid from one integrated circuit, and one side of a lid was loose on another. The glass case of the integrated circuit with the lid off was cracked on the inside of the package around the pad to which the die is attached. Due to the web flexing, five of the pulse transformers' cases were crushed, and ten transistors' leads bent against the transipads by coming in contact with the tooling fixture. Fourteen glass diodes' cases cracked on the 2A1 side, and one cracked on the far side (2A2) of the subassembly.

Subassembly 20A2 did not function properly until nine of the fifteen damaged diodes and three integrated circuits were replaced. One of the integrated circuits replaced was on the far side of this assembly; the gold bond wires internal to the integrated circuits had sagged down against the edge of the die, and lead eight was open where it had shorted to ground, melting the wire (Fig. 3a).

Subassembly 20A6 had the case cracked on one filter capacitor, and the lids came off of eleven integrated circuits on the 6A1 side. The glass around the pad to which the integrated circuit die is attached was cracked on these eleven integrated circuits, and the pad raised on some of them. This subassembly functioned properly without changing any components, and the prototype passed a complete subsystems test without malfunctions.

4. Conclusions

Two changes are suggested for the subassembly structure to enable it to withstand shock at the 4,525 g level:

(1) A thicker or reinforced web for the subchassis.

(2) A conformal coating thick enough to cover the components entirely.

There were no problems with the multilayer boards either from the shock or the subassembly flexure.

Integrated circuits for use on a possible *Mariner* Mars 1971 flight will most likely have a strengthened ceramic package with a gold-plated molybdenum-manganese die

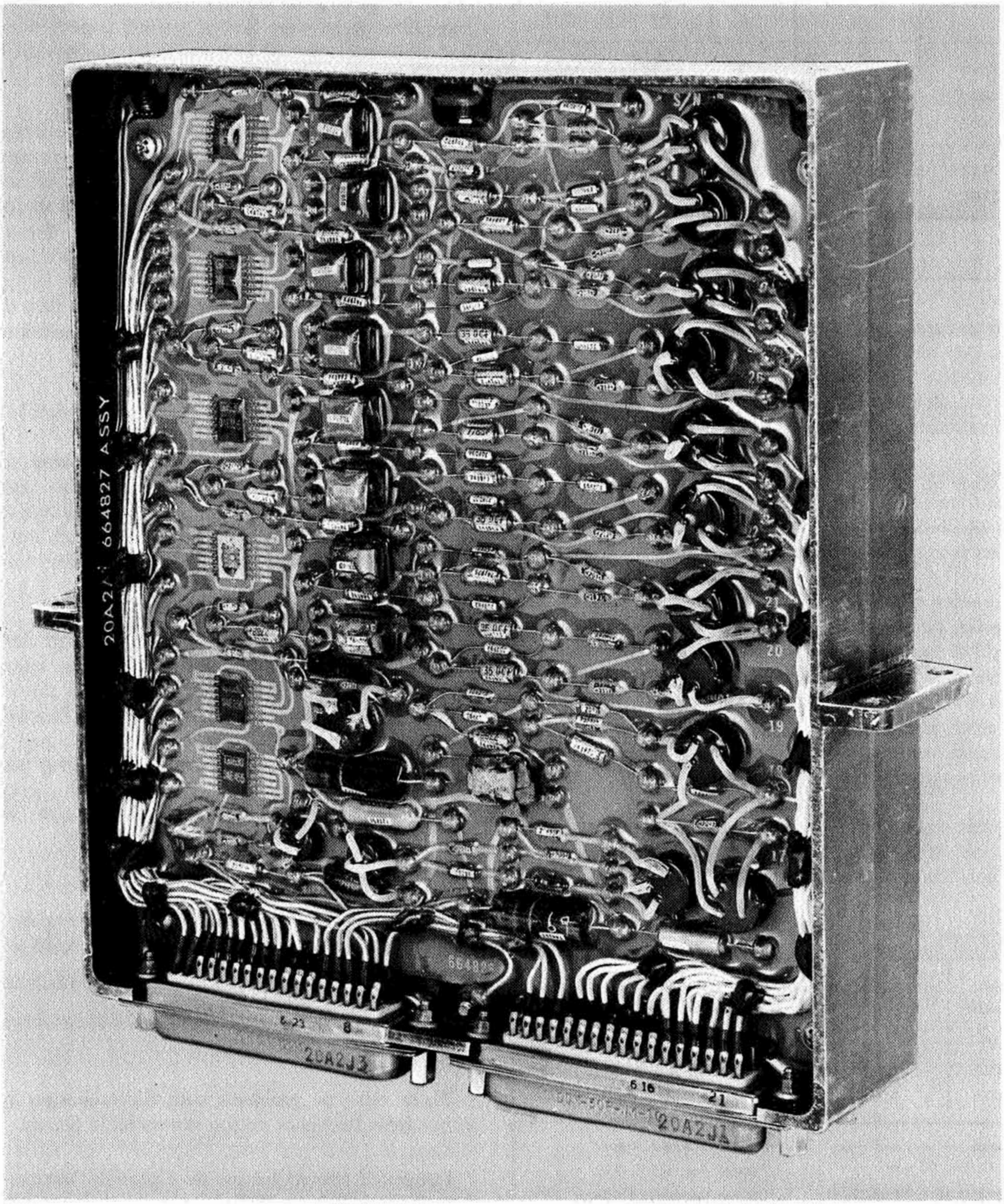

Fig. 1. Damaged DAS discrete assembly 2A1

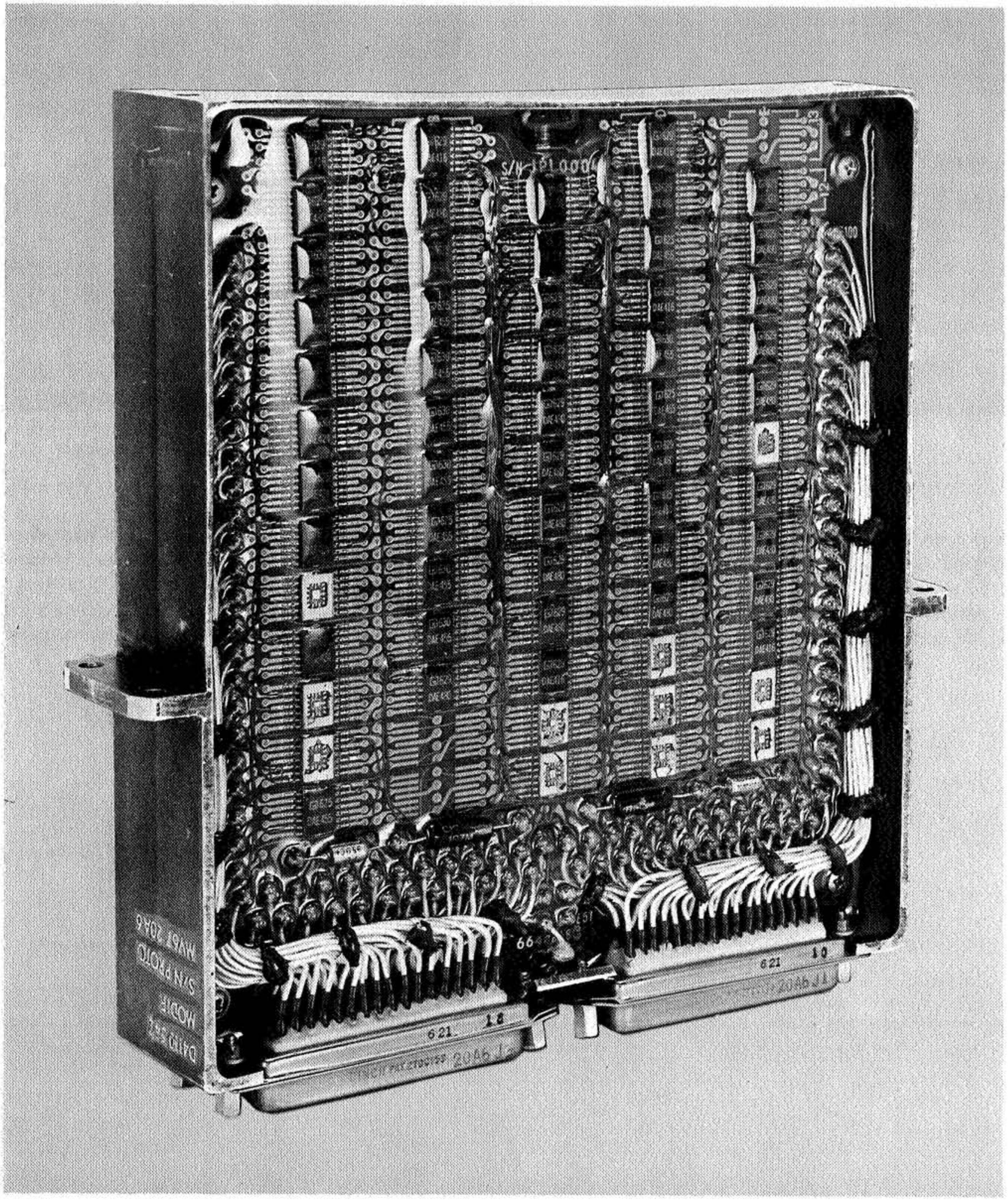

Fig. 2. Damaged DAS logic assembly

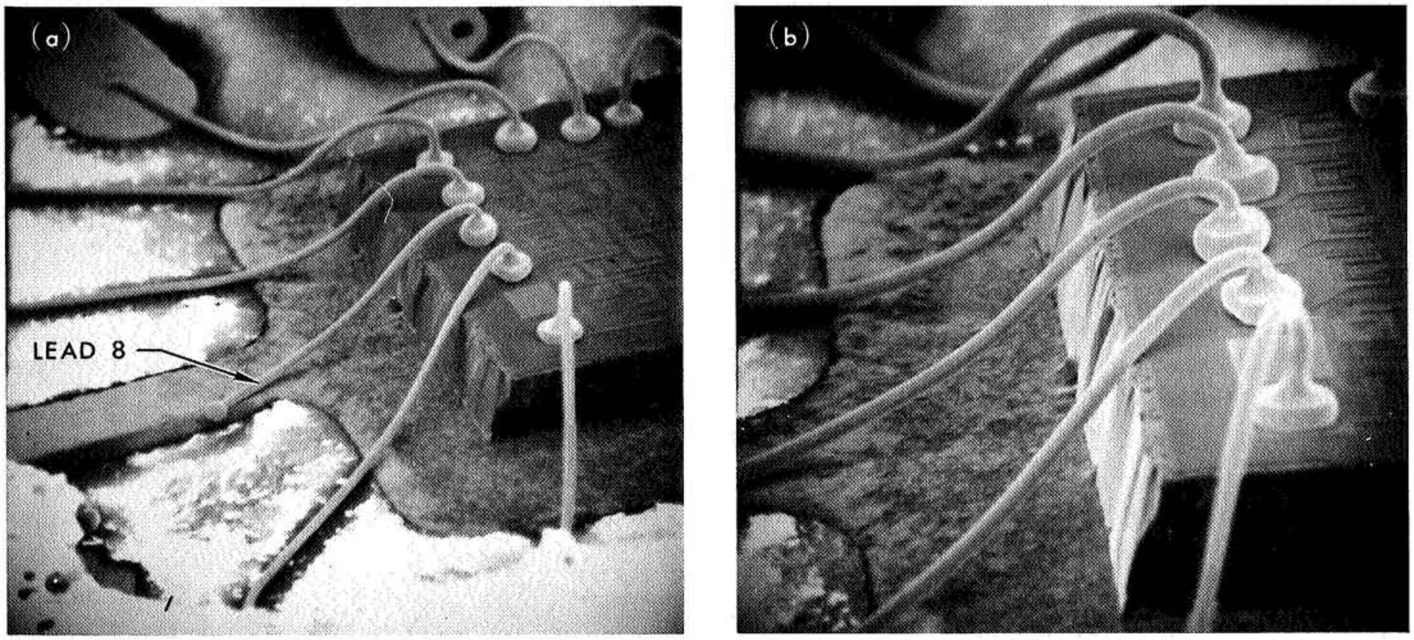

Fig. 3. Integrated circuit photographed by scanning electron microscope showing wire sag: (a) magnified 50 times, (b) magnified 100 times

attach area instead of the gold-plated kovar die attach pad used on the *Mariner* Venus 67 system. This change should prevent the die attach area from separating from the bottom of the package. Aluminum wire will probably be used instead of gold, since it has less mass and does not have a loop in it as the gold wire does. This should solve the sagging wire problem. Stringent environmental and mechanical tests are in process at the integrated circuit manufacturer at this time to qualify the aluminum wire interconnect and ceramic package.