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MONITORING SINUSOIDAL VIBRATION
ENVIRONMENTS WITH A TELEVISION SYSTEM

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MONITORING SINUSOIDAL VIBRATION ENVIRONMENTS WITH A TELEVISION SYSTEM

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The development and prove-in work of this experiment established a technology for using television equipment to monitor hybrid microcircuits and other miniature assemblies in sinusoidal vibration environments. Production assemblies were run through sine vibration test sequences with television systems used to monitor the sequences. During the experiment different television lens systems were tried to obtain clean, sharp, highly magnified pictures of the assemblies being monitored. Successful monitoring of production assemblies during the experiment was accomplished, resulting in design changes to the assemblies and establishment of a television monitoring system.

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SUMMARY

Prior to this work, three methods were available to monitor hybrid microcircuits and other miniature assemblies during sinusoidal vibration test sequences: visual observation with or without optical aids and motion picture cameras. All the methods had obvious limitations for the intended application; therefore, a new monitoring system was needed.

Television had been used successfully for the inspection of hybrid microcircuits in production areas; therefore, television was chosen for development as the monitoring system. Because the television equipment available was not specifically designed for this application, some improvisation was required before it could be used successfully. Television proved to be versatile and well adapted to monitoring the sinusoidal vibration test sequences. Television had inherent advantages over the previous monitoring methods, although it was difficult to maintain picture clarity with high magnification. This limitation was overcome by experimenting with different optic systems until an optimum picture quality was obtained.

During the development, television was used successfully to monitor sinusoidal vibration experiments designed to simulate actual production failures. Information obtained from these experiments was used to make design corrections necessary to prevent future failures of the same nature. Without the television monitoring system, it would have been virtually impossible to have obtained the information necessary for the design changes.

Television has been adopted as a monitoring method for hybrid microcircuits and other miniature assemblies. Equipment refinements have been made to improve equipment set-up time and monitor picture quality, but the basic advantages of the system have remained unchanged. Television gives immediate, permanent records of the test sequences, does not require monitoring personnel to be in the test chamber during the test sequences, and the video tapes can be readily edited to eliminate those sequences of little or no interest.

DISCUSSION

SCOPE AND PURPOSE

This development and evaluation of methods to monitor hybrid microcircuits and other miniature assemblies during sinusoidal vibration environments was conducted to utilize advantages inherent in television for this application. The system yields high quality, permanent pictures of all test sequences, which can be reviewed immediately and readily edited for technical presentations.

PRIOR WORK

The conventional processes for monitoring sine vibration environments are visual observations, visual observation with optical aids, and high resolution motion picture cameras. The visual observation techniques produce no permanent records of observations and are of limited value in analyzing test sequences of miniature assemblies. The high resolution motion picture camera will produce a permanent record of observations; however, because of the design of the camera equipment, it cannot be determined what has been recorded until the film has been developed. A significant amount of time is required for development and editing the motion picture film. These limitations are overcome using television cameras equipped with monitors and video tape recorders.

ACTIVITY

Television-Monitor System Equipment

The sine vibration test chambers are small and crowded with equipment. The limited space available required that monitoring equipment be compact and portable, which was a prime concern when choosing the equipment to be used in the evaluation. A Panasonic video tape recorder and Setchell-Carlson 17-inch black and white monitor (Figure 1) were chosen for their size and portability.

To be capable of viewing an assembly in all axis of vibration, a television camera must be able to be operated in the horizontal and the vertical positions. Operation of a standard television camera in the vertical position will cause damage to the camera's vidicon tube; therefore, care had to be taken to insure that the television camera used in the evaluation was designed for vertical operation. A Shibaden HV15 TV camera (Figure 2) had been purchased by the Quality Division for inspecting hybrid microcircuits, because it could be operated in the vertical position. More

Figure 1. Panasonic NV-3020 Video Tape Recorder and Satchell-Carlson 17-Inch Monochrome Monitor

Figure 2. Shibaden HV15 Television Camera

sophisticated television cameras could be used in this application, but none were available for this evaluation.

A General Electric F2.5 to F22 television zoom lens (Figure 3) was the optic system used during the first evaluation. A Circon C-Mount zoom microscope lens (Figure 4) was the optic system used during the second evaluation.

Figure 3. General Electric F2.5 to F22 Television Zoom Lens With 3X Diopter and 1-Inch Lens Extender

Figure 4. Circon C-Mount Zoom Microscope Lens

A standard tripod with wheels was used for the camera mount, but some improvising with blocks and weights was required to obtain certain camera angles. The strobe lights available in the vibration test laboratory were used for lighting, with the addition of a Tensor high-intensity lamp in some cases.

First Evaluation

During an environmental test evaluation of a hybrid microcircuit switch, a failure was incurred during sine vibration. This failure was analyzed and attributed to a broken 1-mil-diameter (25.4 μm) gold wire, which is used to interconnect chip capacitors to the hybrid microcircuit (HMC) circuitry (Figure 5). The engineering evaluation of this failure was used as a test for the television monitor evaluation.

A model HMC was produced for this experiment with a number of large capacitors with 1-mil wires of various lengths attached. This model was mounted to a pallet with dental cement and secured to a vibration table. The television monitoring system was then set up (Figure 6).

The television equipment was adequate for monitoring the Y and Z axis of vibration, because the pallet is mounted on the side of the vibration table adapter, and was readily accessible to the horizontally mounted camera. The equipment would not work, however, for the X-axis of vibration, because the camera could not be elevated enough in the vertical position to obtain the proper viewing angle. To overcome this problem the camera was removed from its tripod and mounted in a parts pan. The parts pan was suspended from a chain hoist, which supported the camera in a vertical position over the pallet during X-axis vibration.

Because the General Electric zoom lens was not specifically designed for highly magnified close-ups, picture quality was extremely poor. This condition was aggravated by the strobe lights, which did not emit adequate light for the Shibaden camera. The picture quality for the Y and Z-axis of vibration was better than the picture quality for the X-axis of vibration. The difference in picture quality was attributed to the instability of the camera suspended from the chain hoist.

Although the picture quality was poor, motion of the wires on the model HMC could be detected. Because the object of the vibration experiment was to determine if any of the fine wires reach a resonant frequency within the required vibration test range, this television monitoring system was adequate.

With all systems set up, the experiment was begun. As wires were detected to be in resonance, their location on the model HMC

Figure 5. Typical Hybrid Microcircuit With Close-Up of Fine Wire Interconnections of Chip Capacitors

Figure 6. Television-Monitor System Used For First Evaluation

and the frequency of vibration was recorded. To verify the resonant frequencies, each axis of vibration was run twice.

Approximately 3 hours of video tape recordings were made during the experiment. These video tapes were edited to include only the sequences where resonant frequencies were detected. After editing, an audio presentation describing the resonant frequencies was dubbed on to the tape at the appropriate times. The edited tape was approximately 9 minutes long.

Follow-on experiments, using visual monitoring with optical aids, were used to determine the maximum wire length allowable for the switch HMCs. This information was translated into design changes for the HMC assemblies.

Second Evaluation

The second evaluation of the television monitoring system involved a hybrid microcircuit and a development Electronic Components Assembly (ECA). The HMC was an Input/Output Number 2 from the switch. The HMC had been damaged during sine vibration testing of the switch Final Assembly.

Fuse wires on the HMC, which are 0.0007 inch (17.78 μm) in diameter, were found to be pushed down to the ground plane (short circuit) after the sine vibration sequence. A sine vibration overtest was to be run using television to monitor the fuse wires for resonant motion.

The ECA stack-up was separated between the Input/Output Spacers, causing a break in the electrical interconnections. This failure occurred while the ECA final assembly was being subjected to sine vibration. A sine vibration overtest was also to be run on the ECA using television to monitor for resonant motion between the Input/Output Spacers.

The television equipment as described in the first evaluation was set up to monitor the HMC test sequence. It was quickly determined that the lens system on the television camera was not adequate to monitor the extremely small fuse wires. Several variations of the existing system were tried, but none of the variations were successful. A lens system specifically designed for the inspection of HMCs was required to successfully monitor the fuse wires.

The Circon C-Mount zoom microscope lens was removed from an experimental HMC inspection station and mounted to the Shibaden camera. This lens system was equipped for right angle viewing which allowed the camera to be used in the horizontal mode for all axis of vibration. This simplified camera set up (Figure 7), which was a problem during the first evaluation.

Figure 7. Television-Monitor System Used for Second Evaluation

Extremely well-defined, clear pictures were obtained during initial set-up of the lens system. This picture quality was lost when the test chamber lights were turned off and the strobe lights were used to illuminate the subject HMC. This problem was overcome by using a Tensor high-intensity light with the strobe lights during the test sequence. The use of the high intensity light somewhat burned out the strobe light effect, but adequate monitoring could still be maintained. Also, shadows and reflections caused by the strobe lights became more evident with the Circon lens system.

The HMC was monitored through three axes of sine vibration overtests without any resonant motion being detected. This result had been anticipated. The fuse wires were determined to have been pushed down during assembly of the cover to the HMC. Only slight movement of the fuse wires was required during subsequent handling to cause the electrical short circuit.

The ECA was also monitored through three axes of sine vibration overtests without detecting any resonant motion. This result had not been anticipated. Further investigation indicated that the test model had significantly more bonding material on the Input/Output Spacer interface than did the unit which had failed. A design change was made to use a stronger bonding material for the interface.

The results of this evaluation indicate that hybrid microcircuits and other miniature assemblies can be successfully monitored during sinusoidal vibration environments using television equipment.

ACCOMPLISHMENTS

Television has been developed as a satisfactory system for monitoring hybrid microcircuits and other miniature assemblies during sinusoidal vibration environments. Actual production experiments have been run using this system with satisfactory results.

Use of television as a monitoring system has the following advantages:

- High magnification of the assembly surface is possible;
- A permanent video tape record can be maintained;
- Video tape can be readily edited to eliminate unnecessary sequences;
- Audio presentations can be dubbed onto the video tape;

- Dual camera capability is possible;
- The television monitor screen can be placed outside the test chamber for monitoring during test sequence;
- The operator is not required to be in the test chamber during the test sequence;
- The total test sequence can be recorded; and
- The system is completely portable.

There are, however, some disadvantages that should not be overlooked:

- Strobe light intensity is inadequate for the television camera;
- Shadows and reflections cause poor picture quality; and
- The viewing angle for X-axis vibration is difficult to obtain without equipment modification.

FUTURE WORK

As assemblies become more complex and difficult to monitor, such problem areas as strobe light intensity, shadows, and reflections will have to be rectified. More sensitive television cameras are available, which could rectify the intensity problem. A fiber optic system for the strobe lights could be designed to concentrate the light, which would allow the light to be directed only at the area of the assembly to be monitored. The fiber optic strobe light system should eliminate shadows and reflections on the assembly surface. Equipment for specific use as a television monitoring system for sinusoidal vibration test sequences should be procured.

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