NASA

PREFERRED RELIABILITY PRACTICES

THERMOGRAPHIC MAPPING OF PC BOARDS

Practice:

Use thermographic mapping methods to locate hot spots on operating PC boards.

Benefit:

Quick find of electronic components operating at or above recommended temperatures. Also, this technique can validate the derating factors and thermal design via low cost testing versus analysis.

Programs That Certified Usage:

Space Acceleration Measurement System (SAMS), Isothermal Dendritic Growth experiment (IDGE), and STDCE

Center to Contact for More Information:

Lewis Research Center (LeRC)

Implementation Method:

Using an infrared camera and the flight PC board, make thermographic pictures of the prototype PC boards in operation. Verify the thermograph and determine the delta T to the actual use environment with thermocouples. Shut down the equipment and prepare it for a vacuum test.

The board to be tested is placed in a mother board with the appropriate +5 V and ±12 V power supplies. Power is applied to the board, and after a short period, a video recording of the board is made with an infrared camera.

Technical Rationale:

The following procedure is used to determine the temperature of each component:

Junction temperature: $T_J = T_A + T_{JA}$ (1)

Where: T_J = Junction Temperature
T_A = Ambient Temperature
T_{JA} = Junction to Ambient Temperature Rise

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T_J = 40°C for this example

The case temperature, T_C, which is measured on the bench at room ambient is given by Equation (2):

$$T_C = T_J - \Theta_{CA}P \quad (2)$$

Where: T_C = case temperature
Θ_{CA} = case to ambient thermal resistance
P = Power dissipated

For reliability purposes, it is necessary to keep junction temperatures for CMOS devices at or below 49°C. The case temperature to be measured on the bench comes out to be T_C = 34°C for this application.

Infrared pictures are made of the PCB mounted outside the package on extended connectors while the equipment is operating on the bench. The logic IC temperature is determined from the infrared picture. If less than or equal to 34°C, the junctions are at the desired operating temperature. If greater than 34°C, the reason for the higher temperature is determined. Corrective action is worked out and approved by the Engineering Review Board.

Figure 1 is a drawing of the component layout of the SCSI card, and Figure 2 is a thermographic photograph of the board. Thermographic pictures are usually in color, but in this monochrome reproduction, the cross hairs are at the hottest location (128°F), black represents 108°F, white is 98°F, dark grey is 88°F, and light grey is 78°F.

The operating temperature with the board back in the case is checked by several thermocouples attached to the hottest observed components. This is done in a simulated use environment, perhaps during the thermal environment tests. The resultant delta-T is added to the measured case temperature as a final check of the junction temperature,
T_J, in the end-use environment. For sample logic IC, the delta T was 5° C so the resultant junction temperature is 45°C in the package. This is below the guideline of 49° C.

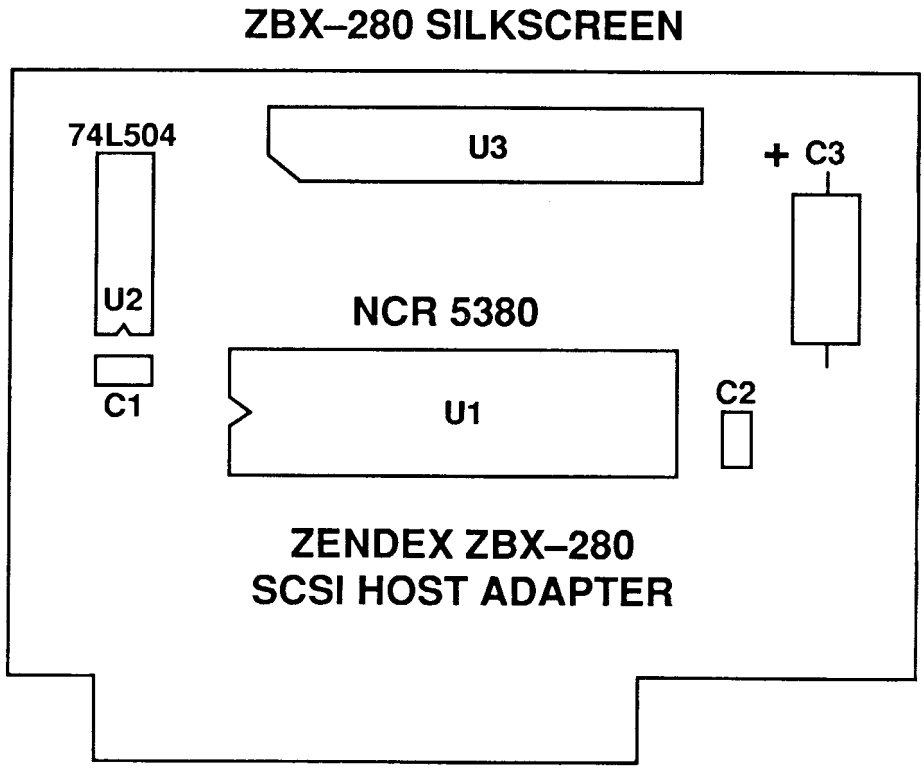

Figure 1 SCSI Card

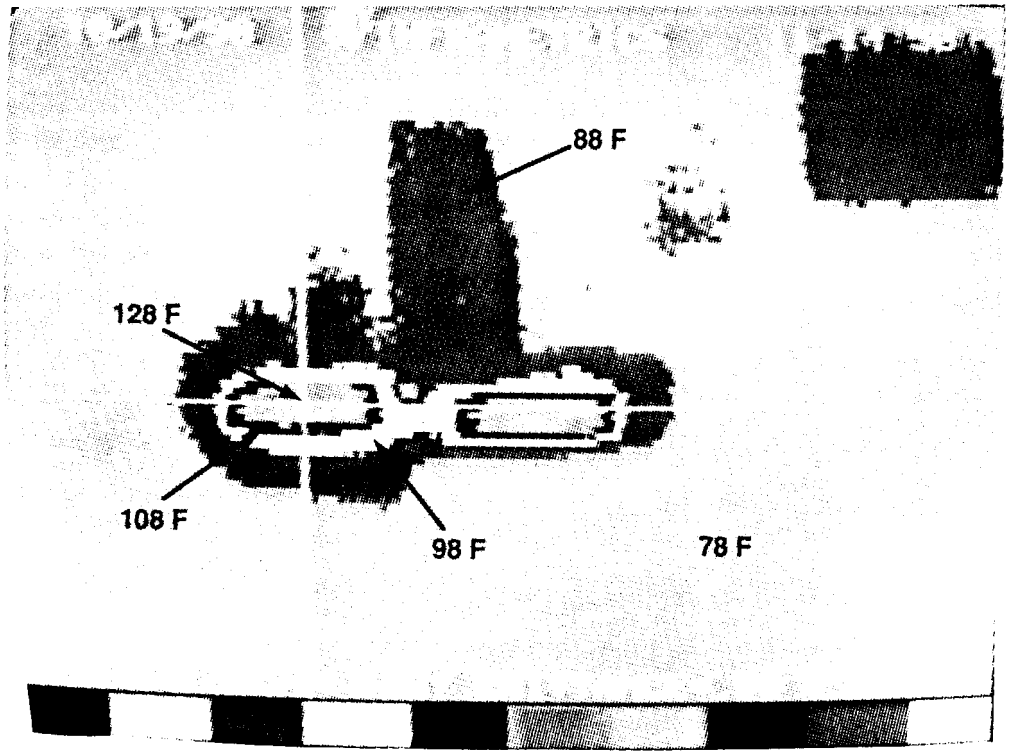

Figure 2 Thermograph

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Impact of Nonpractice:

Allowing undetected hot spots to exist in flight hardware can be very expensive since the later a problem is detected in a flight program, the more it costs to repair. Using thermography to verify system engineering models is a fast, low-cost technique.

References:

1. Crall, R. F., "Thermal Imaging Benchtop Analysis for Reliability," Evaluation Engineering December 1989.

2. Masi, C. G., "What Can Thermal Imaging Do for You?, " Test & Measurement World May 1988.

3. MIL-HDBK-217E, "Reliability Prediction of Electronic Equipment," Rome Air Defense Center, October 27, 1986.

4. Foster, W. M., "Thermal Test Report for the Space Acceleration Measurement System Circuit Boards", NASA LeRC Code 6730 Internal Report, November 1987.