INFRARED SCANNING FOR IMPROVED MAINTENANCE OF ELECTRONICS SYSTEMS

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ABSTRACT

Increased use of new technology and miniaturization in the electronics industry has placed a heavy and costly burden on maintenance specialists in recent years. This has created a need for application of new technologies for testing, fault-isolation, and repair procedures. This paper represents one such application. The use of infrared thermography for electronics and electrical fault isolation and diagnosis is finding increased acceptance as a method of reducing maintenance costs. It has been demonstrated that fault isolation can be cut from hours to minutes, thereby reducing labor costs and downtime on critical equipment.

BACKGROUND

In a relatively short time span the ratio of the number of electronics components to the number of pins or test access points has risen almost exponentially. As recently as the 1950's or 1960's, a maintenance technician could troubleshoot a board or module assembly, repair, replace, and be back in operation in less than one hour. A good example of the 1980's is the TV repairman who now finds it necessary to keep your set in his shop for a week or more and may charge you nearly half of the set replacement cost for labor and parts. There is no doubt that the increasing complexity of circuitry added to the ever increasing wages for competent electronics technicians and the cost of automatic test equipment makes new techniques such as thermography increasingly attractive financially. Consider the cost of downtime for a critical NC machine tool or for an automated assembly line, or for a complex automated testing system. The loss of productivity, the disruption of work flow or work schedules, the cost of idle operators all add up to a sizeable financial impact. And, as long as the trend to automated production continues, the problem will become more and more severe. For example, an automated factory subject to total disruption by failure of a $1.00 component must maintain a vast inventory of "spares" along with high skill-level technicians on all shifts. This is not a guarantee of reliability, merely an attempt to provide a maintenance organization capable of minimizing the impact of non-functioning equipment. This type of problem exists everywhere: military, factories, refineries, ad infinitum.

In the military maintenance and repair environment the fault isolation burden is even more acute. In industry the situations described above are random events for which the maintenance function must be prepared. In military depots or repair facilities, maintenance and repair is a full time business. There is virtually nothing random either in cyclical preventive maintenance of equipment or in the repair of equipment which has been returned from the field as inoperative. What is random is the rate of repetition of a single module type. It is not unusual for a military repair facility (e.g. ALC, NARF, ARSENAL, DEPOT, etc.) to process 40 to 50,000 units per year of which a large percentage of these units appear only once or twice per year. This does not permit the technicians to acquire familiarity with the circuit or even maintain a valid historical file. The clerical cost of maintaining up-to-date logic diagrams and test specifications is a factor to be considered. The cost of programming automatic test equipment can be prohibitive without sufficient annual utilization of that test program. These are but a few of the reasons why the need is growing for a new, rapid, accurate, non-contact method to assist in fault isolation and defect diagnosis of electronic circuitry.

PROPOSED SOLUTION

Infrared scanning is only one of many methods but one that is starting to gain recognition in the world of electronics maintenance. Since most power dissipating devices have a unique thermal signature, comparison of temperatures with a computer stored master image can reveal any deviation from normal operation. Almost instantly a thermographic system can reveal any anomally in power consumption such as inactive or dead components, short circuits, open circuits, bad relays, leaky capacitors, etc. Since this type of passive defect represents 60-70% of all electronics defects, it is important to screen

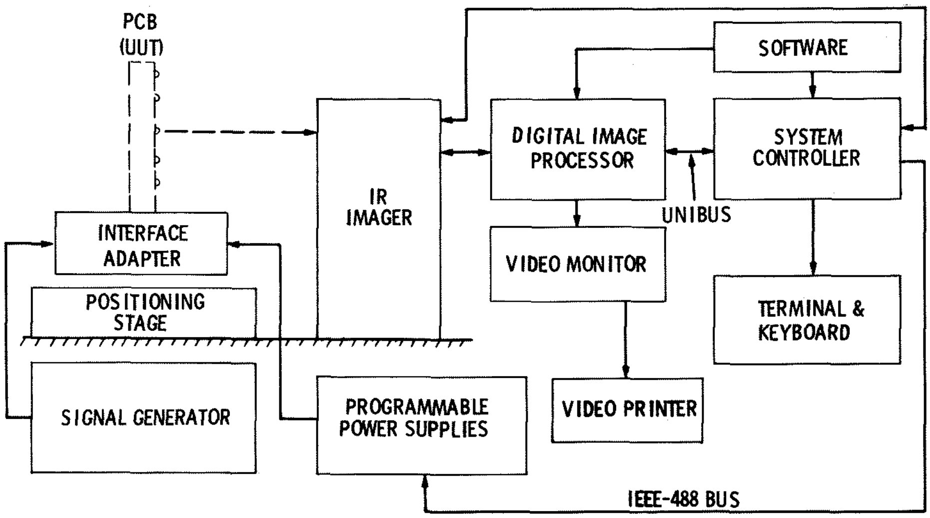

FIGURE 1. TYPICAL THERMOGRAPHIC SYSTEM DIAGRAM

these out rapidly before investigating active defects such as frequency, gating, clocking, etc.

A typical thermographic system is diagrammed in Figure 1. The video signal from the thermal imager is digitized to a 512 x 512 pixel (picture element) matrix which is processed within the digital image processor to compare the test image with a previously stored image of a composite master image. The results are translated back to video to provide a display output to the operator from the video monitor.

Figure 2 shows an artist's concept of a typical thermographic test station. Except for optical focus the operator controls the imager settings, the DC voltage, and timing sequence from the keyboard while generating the master image. These test parameters are stored in the computer and are used to duplicate test conditions when scanning a unit-under-test (UUT). The real time image of the UUT is cancelled against the master and the processed output to the operator shows gray when the components are operating within an allowable tolerance. Hot anomalies appear as light grey to white while cool anomalies appear dark to black. This makes it relatively easy for the technician to interpret deviations from normal power consumption.

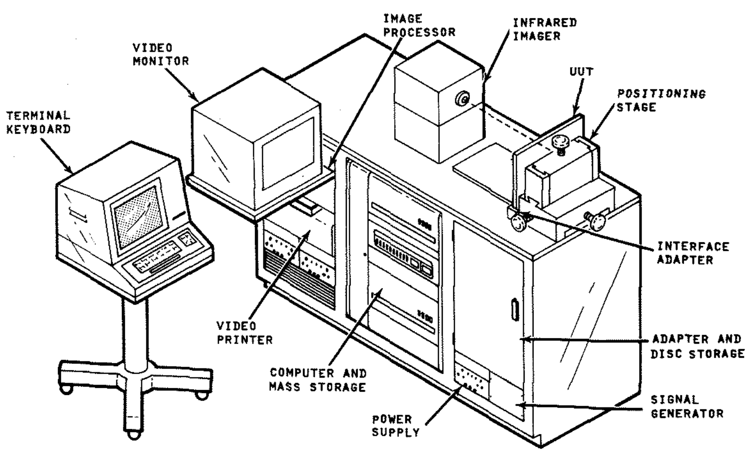

FIGURE 2. TYPICAL THERMOGRAPHIC TEST STATION

One of the most elusive defects to locate for repair is a short circuit to ground. Infrared scanning has been used many times successfully in this application. A minute amount of current produces a readily identifiable hot spot (see Figure 3). In the original manufacture of multilayer boards, inner layer shorts are relatively common. In the maintenance environment virtually all short circuits are due to a surface phenomenon or a shorted component. These are very easy to find with thermographic techniques. One of the most attractive features of infrared thermography is the fact that, other than DC power application, it is a totally non-contact technique. Most boards in the maintenance environment are conformally coated. The use of "bed-of-nails" or manual probes must penetrate these coatings ultimately damaging them. The irreversible trend toward miniaturization makes modern circuitry extremely susceptible to damage from repeated and/or careless probing. Damaged solder joints and bonds, scratched copper traces are but a few examples. With thermography

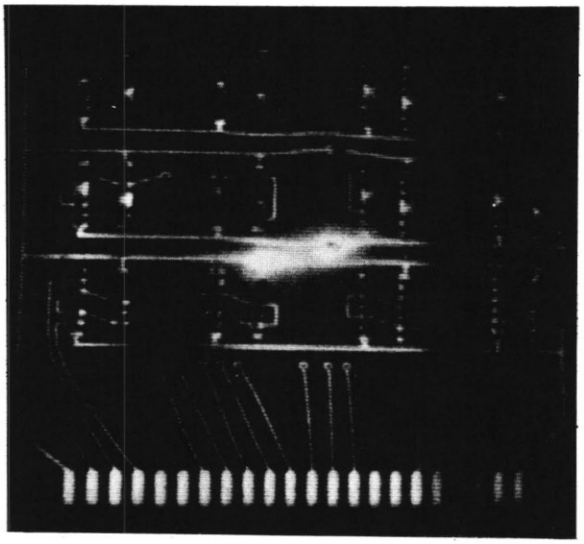

FIGURE 3. THERMOGRAM OF SHORT CIRCUIT

there is no need to remove or puncture the coating until the repairs are performed.

It is not necessary to have familiarity with the functional aspects of the circuit. In the maintenance environment it is not unusual to find that circuit diagrams are obsolete, incorrect, or at times, non-existent. Also, the technician may be faced with having to troubleshoot supplier proprietary circuitry due to time constraints. Again, if he can apply DC voltage he may be able to pinpoint the defective component and merely replace it. The ability to use a working board as a master makes it unnecessary to have full documentation.

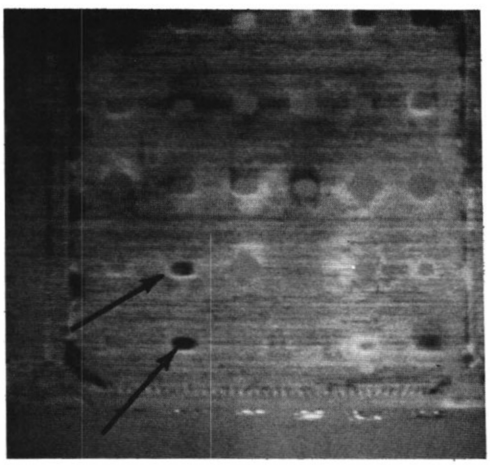

FIGURE 4. TYPICAL THERMOGRAM

The use of thermographic equipment does not require special skills. In fact a properly designed computerized system reduces the troubleshooting to interpretation of a video picture in which all gray areas are acceptable; the light or dark areas denoting over or underpowered components or short circuits (see Figure 4). This enables the technician to concentrate on only those portions of the circuit which are affected. The question often arises "Where do you get the so-called masters?". This would depend on the type of maintenance environment using the equipment. If spare modules are stocked they can be drawn from stores and scanned for storing of the composite image of several presumed good boards. Another method is more drawn out but equally effective. This is to repair a module using the traditional methods, then scan it for storage for future usage prior to returning it to service. It is recommended that a composite of several operational boards or modules be used to compensate for manufacturing tolerances.

Experience has shown that the entire procedure can be completed in approximately six (6) minutes. This includes recalling the master thermogram from computer disc, connecting the module under test to power sources, and installing it within the field-of-view. It also includes applying power for 30-40 seconds, displaying the image onto a video monitor screen, and allowing the technician to make a qualitative judgement of the module's performance. Six minutes per board compares very favorably with present techniques which often require several hours of sequenced probing before the defect can be identified.

CONCLUSIONS

Present day infrared diagnostics are still in their infancy. However, as the need increases, the incentives for improvement will also increase. The cost is now coming down and the performance is presently improving. It is not unreasonable to forecast that within 10 years the use of thermography to assist and augment conventional test equipment will be proven and wide spread. Infrared scanning of electronics promises to offer the flexibility and versatility required for good maintenance and cost-effective repairs.