

Printed circuit boards

Application Note

At the heart of modern electronic devices and many other products are printed circuit boards (PCBs), which have proven to be rugged, reliable, and quickly and inexpensively produced. Thermal imagers provide a powerful set of diagnostic tools for testing PCBs during design and prototyping—and can even help improve manufacturing excellence when used in production, process monitoring and quality assurance applications.



PCBs mechanically support electronic components and connect those components via conductive pathways or traces. The traces are etched from copper sheets and laminated onto non-conductive substrates. Then components are automatically soldered to the boards in accordance with designers' schematics.

Ensuring that a PCB is properly designed and functions correctly before the device in which it will operate goes into general production is the principal task of electronic design engineers. When the circuit board has proven itself in the design phase and as a component in a prototype, consistent production practices will typically ensure its integrity and success in the final product.

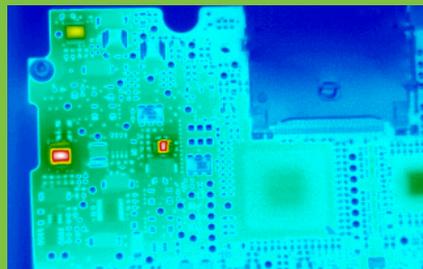
This discussion focuses on using thermal imaging to test and monitor PCBs. Thermal imagers—also known as infrared (IR) imagers or IR cameras—capture two-dimensional representations of the surface temperatures of electronics, electrical components and other objects. Since overheating may signal that a trace, a solder joint, or a component (chip, capacitor, resistor, etc.) is malfunctioning, Fluke's powerful handheld thermal imagers can provide a powerful set of diagnostic tools for testing PCBs.

What to check?

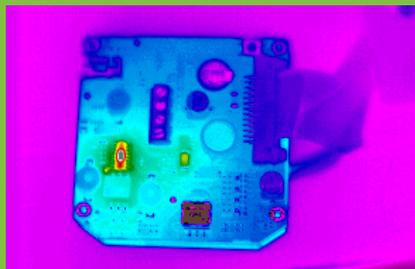
Thermal imagers are used primarily to test circuit boards during the design and prototyping phases, but may also be useful under certain circumstances in production or process monitoring applications and in support of quality assurance. Check the following:

New designs (prototypes).

Thermal imagers can play a significant role during the design of PCBs. For example, when designing circuits, engineers can use infrared equipment to monitor the thermal characteristics of certain components and make design modifications based on their findings. After developing



Screening circuit boards using a thermal imager can help ensure quality is consistent.



Scanning each powered-up prototype board using a thermal imager can be revealing in a variety of diagnostic test scenarios.

a prototype, engineers will, of course, power up the board to the level it is expected to run in the finished product and monitor the results. One of three things might happen: 1) the board will power up with no discernable problems; 2) the board will shut down; or 3) the board will cycle on and off in some tests. When a test board shuts down or cycles on and off, it is up to design engineers to determine the cause. Even if the board powers up with no problem, designers must determine if it is operating optimally. Scanning each powered-up prototype board using a thermal imager can be revealing in a variety of diagnostic test scenarios.

Boards from contractors.

Many manufacturers of electronic devices purchase their circuit boards from companies that specialize in PCB manufacturing; often contracting with multiple suppliers to produce the same board. Powering up and checking these boards with a thermal imager before a production run can help ensure all purchased boards function properly and that quality is consistent from unit to unit and from supplier to supplier. Such screening can be especially important before the first production run of a new device, when the purchased PCBs also represent the first production run for the supplier(s).

Boards in production. One traditional quality assurance (QA) strategy—especially in companies where manufacturing tolerances are tightly controlled and defects minimal—is to test every nth product off the line; or in the case of circuit boards, to test every nth board to be installed. Alternatively, QA inspectors might check circuit boards randomly. Whichever strategy a company employs, a thermal imager can play a significant role.

Selecting an imager

Electronic devices are becoming more compact every day, and that means that the boards and components in these devices are also getting smaller. Because of this trend and because engineers may need to determine the temperature of something as small as, say, a pin on a component, an IR camera's spatial resolution and thermal sensitivity are important factors in choosing an imager for this kind of work.

The spatial resolution of a thermal imager is called its *instantaneous field of view* (IFOV) and is measured in milliradians (mrad)—e.g., 1.30 mrad. In essence, a thermal imager's IFOV describes the smallest object one can observe. Regarding thermal sensitivity, today's PCB designers have available to them thermal imagers with thermal sensitivities ≤ 0.05 °C at 30 °C (or better).

Using a thermal imager with good spatial resolution and thermal sensitivity, a technician can view and compare the temperatures of small, irregularly shaped objects. This makes it possible to pinpoint small temperature differences between very small areas on PCBs. Additionally, a recently developed feature of Fluke thermal imagers, IR-Fusion™, further enhances the usefulness of thermography in PCB applications. (See the box, "IR-Fusion.")

What to look for?

Whether one uses a thermal imager to scan PCBs for R&D, pre-production tests or quality assurance, there are various kinds of problems that will manifest themselves as hot spots on a thermal image. Typical PCB problems discovered by thermography are improper soldering of circuitry or components, broken or undersized traces between components, power fluctuations due to lifted leads, missing components,

reversed polarity of components, bent pins and incorrect component placements.

This long list of potential PCB problems detectable using thermography precludes a detailed discussion of all of them. Let's instead look at some examples of how thermography has been used to support the design and manufacturing of printed circuit boards:

At the design stage, thermal imagers help designers identify areas of PCBs that use excessive power. This capability is especially important if the board is intended for use in a battery-operated portable device. The designer then has an opportunity to tweak the design, decrease the board's power consumption and, thereby, prolong battery life in the final product. Similarly, knowing that a board or component "runs hot" can alert the designer to the fact that it will require either active cooling or a larger heat sync in the end product, or a redesign that does not run so hot.

At the test stage, if a design engineer uses thermography and discovers that an area of a PCB is overheating, it may be for any number of reasons, including all of those mentioned earlier. It is then incumbent upon the designer to find the root cause of any anomaly, perhaps by using other test tools. For example, using an IR camera, one engineer found that a trace on a board was cycling from hot to normal about once every second. It turned out that one of the parts on the trace was mounted backwards and was shorting out the power supply. The overload that protected the circuit was alternately turning the circuit on and off, causing the trace, in turn, to heat up and then cool.

Pre-production screening of PCBs using thermography saved one printer manufacturer the embarrassment of shipping faulty units and dealing with the resulting recalls and warranty claims.

A company electronics engineer discovered during routine testing of PCBs for a new printer line that a large number of the boards were overheating and tripping protective devices. Further research found that the motor driver chips on the failed boards were hot to the touch. The engineer secured a thermal imager and found that the motor driver chip was indeed overheating, but on only 25 percent of the units.

After using the thermal imager to isolate the faulty boards, the engineer determined that the malfunctioning units were all from one of two suppliers. Informed in a report documenting the problem, the supplier sent new boards with functioning motor driver chips.

The bottom line is this: Using thermal imagers to observe the heat patterns generated by PCBs enables engineers to correct

design or manufacturing flaws and ultimately improve products and the processes used to create them. PCB manufacturers and original equipment manufacturers that use PCBs have successfully deployed thermal imagers to monitor circuit boards enroute to maximizing production efficiency, minimizing time to market and avoiding costly recalls and warranty issues.

A procurement strategy: Share the technology

Do you believe a thermal imager for checking printed circuit boards is just what you need to make your job easier and more efficient, but are concerned your boss won't sign off on a camera precise enough to do the job for you? Then consider discussing the capabilities of thermography with your company's plant engineer, facilities manager, maintenance manager and anyone else in your organization responsible for

maintaining production equipment; the roof and the rest of the building envelope; and the heating, ventilation and air-conditioning systems. Achievable savings using thermography in the maintenance of buildings and equipment are well documented, and a high-end thermal imager is more affordable when its cost and use is shared among three or four departments.

IR-Fusion™

IR-Fusion allows the operator of a thermal imager to fuse together on the camera's display both an infrared and visible light image of a PCB. In fact, using an imager with IR-Fusion, a technician can view images in a range of modes from a completely infrared image to a completely visible-light image or a "blended" image at any ratio in between. In addition, IR-Fusion capability permits the operator to use a picture-in-picture mode in which a visible-light frame of reference surrounds an IR portal. Cameras with IR-Fusion also have an "IR/Visible Alarm" mode in which temperatures above, below or in between a specified range are displayed in IR format while the rest of the image is in visible-light format. The purpose of each of these modes is to provide visible-light details that allow operators to more easily identify specific components on printed circuit boards.



IR-Fusion capability enables the operator to view and capture an image that "blends" infrared and visible light at any ratio.

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