

# Printed circuit boards

## Application Note

Printed circuit boards (PCBs) are at the heart of modern electronic devices and many other products. They need to be rugged and reliable, as well as quickly and inexpensively produced. Infrared cameras (also called thermal imagers) provide a powerful set of diagnostic tools for testing PCBs in the design, prototype, and production stages because they collect thermal data without physically contacting the target. This helps to improve the quality of the end product, expedite production, and reduce costs.

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 based on designers' schematics.

Electronic design engineers need to ensure that a PCB is properly designed and functions correctly before its host device goes into general production. 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 infrared cameras to test and monitor PCBs. Infrared cameras capture two-dimensional representations of the surface temperatures of electronics, electrical components, and other objects. Overheating may signal that a trace, a solder joint, or a component (chip, capacitor, resistor, etc.) is malfunctioning. So using an infrared camera such as the new Fluke TiX1000,

TiX660, and TiX640 infrared cameras—part of the Fluke Expert Series line—to collect a variety of thermal data can help identify potential or actual problems in PCBs at an early stage.

### What to check?

TiX Infrared cameras can be used to test circuit boards at every stage of development, as well as in production, process monitoring, and quality assurance (QA) applications.

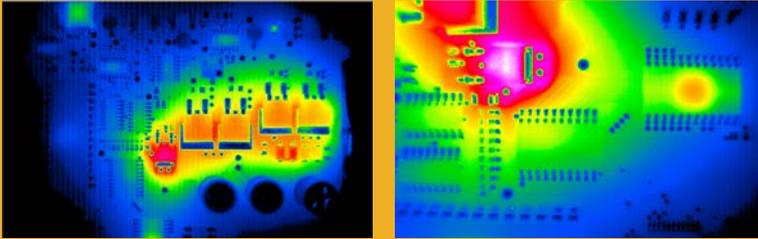
#### **New designs (prototypes).**

Infrared cameras can play a significant role during the design of PCBs. For example, when designing circuits, engineers can use these infrared cameras with their super high resolution to view small components and their connection points to locate

hot spots and analyze the effects of the heat on other components. Then they can make design modifications based on their findings and rescan them to ensure the problem is resolved. After populating a prototype board, engineers power up the board to the level it is expected to run in the finished product and monitor the results.

**Third-party boards.** Many manufacturers of electronic devices purchase circuit boards from companies that specialize in PCB manufacturing; often contracting with multiple suppliers to produce the same board. Powering up and scanning these boards with an infrared camera before a production run can help ensure that all purchased boards function properly and





Screening circuit boards using an infrared camera can help to maximize production efficiency, minimize time to market, and avoid costly recalls and warranty issues.

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.**

Whether you use a traditional QA strategy of testing every circuit board that will be installed or checking circuit boards randomly, an infrared camera can play a significant role. Using one of the Fluke TiX Expert Series cameras to record real-time radiometric data and identify points—with voice and text annotations—that require closer examination makes it easier to perform frame-by-frame analysis of thermal processes and changes to find anomalies.

**Selecting an imager**

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

The spatial resolution of an infrared camera is called its instantaneous field of view (IFOV) and is measured in milliradians (mRad). In essence, an infrared camera's IFOV describes the smallest object one can observe with the camera (the

lower the number the better). Thermal sensitivity is also important for detecting slight temperature differences between miniscule components on PCBs.

Using an infrared camera 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. The TiX1000 camera's 0.6 mRad IFOV and 0.8 mRad IFOV provided by the TiX660 and TiX640 allows you to see objects as small as a pinpoint. In addition, they offer high resolution (up 786,000 actual pixels of data with up to 3.1 million effective pixels on the TiX1000 in SmartView® software with SuperResolution mode). Combining those capabilities and optional macro lenses provides up-close imaging capabilities that produce highly detailed and informative images with apparent temperature calculations for each pixel.

In addition, advanced focus options, easy to switch lens options, real-time radiometric recording, optional subwindowing (to achieve up to 240 Hz refresh rate) and the ability to view and analyze live data on a PC, further enhance the value of infrared imaging for PCB applications.

**What to look for?**

Whether you use an infrared camera to scan PCBs for R&D, pre-production tests or quality

assurance, there are various kinds that will manifest as hot spots on a thermal image. Some of the typical PCB problems detected by thermography include 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.

Here are some specific examples of how thermography can be used to support the design and manufacture of printed circuit boards:

**At the design stage.** Looking for hot spots with a Fluke TiX infrared camera can help designers tweak their board configurations at the early stage of development to avoid problems down the road. For example they can:

- **Identify components that use excessive power.** This is especially important if the board is intended for use in a battery operated portable device. Using the infrared camera to identify power hungry components allows the designer to tweak the design, decrease the board's power consumption and, maximize battery life in the final product.

**A procurement strategy: Share the technology**

Do you believe an infrared camera 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.

- **Find localized overtemperature issues.** Many of today's circuit boards combine several heat-intensive components into a very small package. The Fluke TiX1000 and TiX660, with SuperResolution mode enable you to view small components and their connection points to locate hot spots and analyze the effects of the heat on other components. Knowing that a board or component "runs hot" can alert the designer to the need for either active cooling or a larger heat sync in the end product, or a redesign that does not run as hot.
- **Validate thermal modeling.** Using thermal modeling software provides a good estimate of what will occur when you populate a board, but it's still only a simulation. You can easily validate those results by comparing your thermal CAD model to actual results collected with a TiX camera as you populate the board and power up components. Then you can scan the finished powered-up prototype and compare the results to your model to see how close it is.
- **Establish cycle times.** Set the TiX to record thermal measurements as a solder point cools, so that you can set cycle times for automated systems. You can annotate key points with voice and text for quick review.

**At the test stage** design engineers can find many anomalies at the test stage by using an infrared camera to find areas of a PCB that are overheating. For example:

- **Incorrectly installed components.** You can use an infrared camera to detect that a trace on a board might be cycling from hot to normal frequently. A closer examination could show 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, to heat up and then cool.

- **Analyzing assembly impact.** By scanning PCBs at various stages of the manufacturing assembly process you can capture issues early that negatively impact the finished product and avoid costly component failures down the road.
- **Assessing collateral damage.** Heat from the circuit board can affect the performance of other components in the system. To avoid that you can use TiX cameras to assess how much heat dissipates from the entire package and how that heat may affect other parts of the system.

**Pre-production screening** routinely scanning PCBs with an infrared camera before assembly into the final product can save time, money, hassle, and damage to an organization's reputation from shipping faulty units and dealing with the resulting recalls and warranty claims.

For example, let's say that during routine testing of PCBs for a new product line a large number of the boards were overheating and tripping protective devices. You found that the problem was from motor driver chips that were overheating and failing. However, the problem only affected about 25% of the boards and only those from one of two suppliers. The challenge was to find which 25% were affected.

Using one of the TiX Expert Series infrared cameras you could quickly scan the boards to find the faulty ones and replace the motor driver chips in only those boards. That would save the time and cost of replacing good chips and would reduce the danger of shipping a faulty circuit board."

### The bottom line

Using thermal imagers to capture 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 throughout the manufacturing process to maximize production efficiency, minimize time to market, and avoid costly recalls and warranty issues.

### SuperResolution mode

The Fluke TiX1000 and TiX660 Expert Series infrared cameras offer four times greater resolution in SuperResolution mode than in standard mode. This translates to up to 3.1 million pixels on the TiX1000 and up to 1.2 million pixels with the TiX660 in SuperResolution mode viewed in SmartView® software. This means that you get crisp images that deliver maximum thermal detail.

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