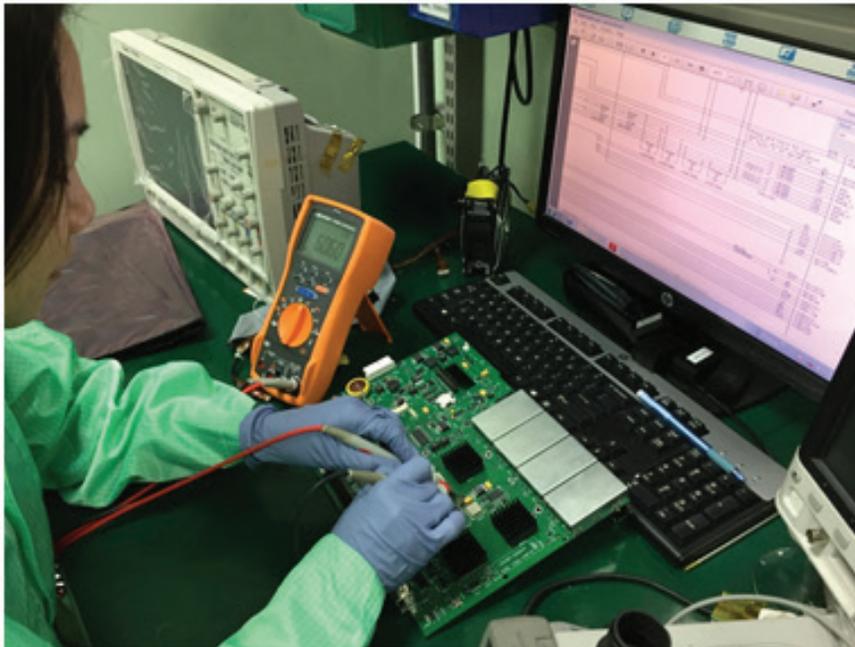


# Keysight Technologies

## Troubleshooting a Printed Circuit Board Assembly (PCBA) with Keysight Handheld Test Tools

Keysight handheld digital multimeters, LCR meters, oscilloscopes and thermal imagers delivering essential features and performance to meet electronic troubleshooting needs

Application Brief



# Introduction

The printed circuit board assembly (PCBA) can be found in almost any electronic devices. These electronic devices range from consumer electronics such as scanners, exercise devices, charging stations, computer accessories, and modems to commercial electronics in the industrial and medical fields with stringent requirements. Testing is crucial to ensure the electronic devices operate normally. In most cases of electronic device failures, the root cause is determined to be the PCBA itself.

Electronic manufacturers use circuit board testing such as the in-circuit test (ICT), automated optical inspection (AOI), or flying probe to monitor the circuit board quality during the PCBA manufacturing process. Circuit board testing closely follows the box built process where a functional test is performed to verify the device performance. During the production or manufacturing process, it is common practice to send a certain percentage of devices that fail the quality control test for troubleshooting to identify the root cause of failure.

This application note describes some common techniques used in circuit board troubleshooting. Before proceeding with the troubleshooting, it is important to identify the failure symptoms. The failure symptoms may provide information about the possible cause of defect.

## Printed circuit board assembly troubleshooting

### Checking the power supply voltage to the circuit

Voltage measurement of the circuit board's power supply is an important testing process because it is critical that a proper level of power is supplied to most of the integrated circuits (ICs). It is essential to check if the voltage level output from the power supply is within the acceptable limit to prevent overheating or overloading of the circuit board.

### Visual inspection to look for burned or damage parts

Visual inspection is a straight forward and effective method for troubleshooting. Components or parts such as transformers, power output transistors, resistors, and capacitors that carry the burn mark can be detected easily using this method. The burned parts normally appear as brownish in color and can be easily detected visually through the naked eye or with the aid of a magnifying glass. Sometimes, the overheated components will leave behind a brownish mark on the circuit board and produce a burnt smell.

Solder joint is another common item inspected during the visual inspection to look for any dry joint. Dry joint is a common symptom of a defective board due to soldering defects. Dry joint causes poor contact at the solder joint and affects the current conduction in the circuit. A good solder joint normally looks smooth, bright, and shiny. Dull surface suggests a weak joint. Dry joint can be checked using a handheld digital multimeter. Resistance test or continuity check is performed from one pin to another pin to locate for any dry joints or open traces on the circuit board.

## Detecting hotspot for potential failure

Circuit board failures can sometimes be caused by overheated components such as power transistors and ICs. Traditionally, overheated components are detected by simply touching the surface component. This can be dangerous and has to be done with extreme caution to avoid getting burnt fingers and electric shock. For circuit boards suspected of thermal failures, they can be scanned for hotspots using an IR thermal imager without physically touching the components. Infrared thermal imaging is able to capture the temperature distribution of the whole circuit which makes it easy to see the hotspot at a glance.



Figure 1. Detecting hotspot on a circuit board using Keysight U5850 series TrueIR Thermal Imagers with image logging capability

For more accurate temperature monitoring, the component temperature can be measured using a Keysight digital multimeter with a thermocouple probe attached to the surface of the component while the circuit board is powered on.

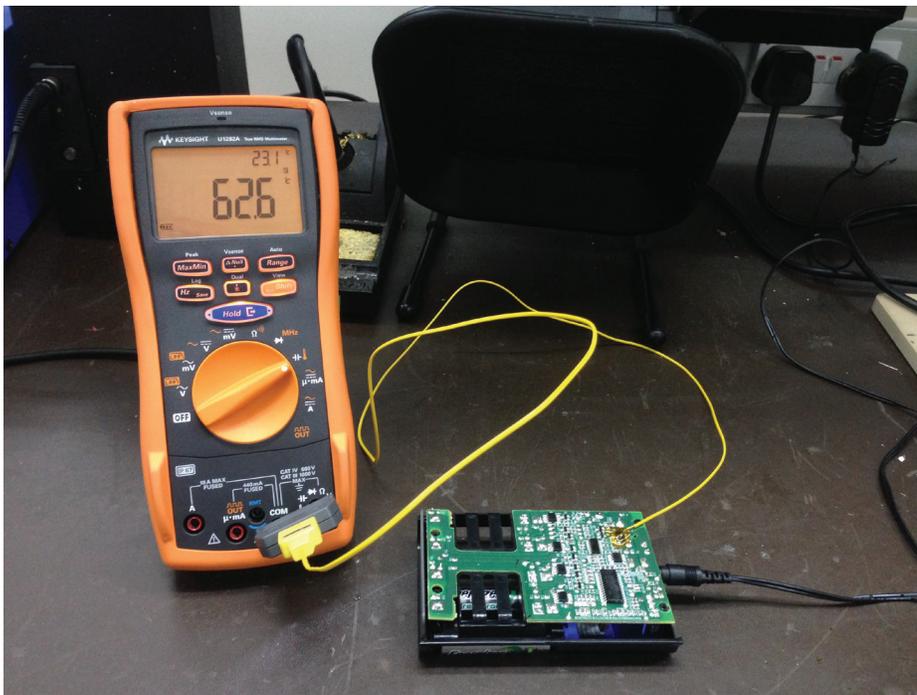


Figure 2. Monitoring the temperature of a circuit board with the U1282A handheld digital multimeter

## Detect defective components

Apart from dry joints, defective or out of tolerance components are among common causes of failures on a circuit board. Component checking using handheld digital multimeter is commonly performed when determining the root cause of failures.

### Diode test

Diodes and transistors are checked using the diode test function. Transistors behave like two back-to-back diodes. The digital multimeter sends a current through the semiconductor junction and measures the voltage drop between the test points of the semiconductor device. For non-defective diodes, the digital multimeter normally shows a value of between 0.3 V to 0.8 V at the forward bias condition, and it shows an open circuit (with O.L. on the display) at the reverse bias condition. Defective diodes will appear as either an open circuit or a short circuit in both directions. Sometimes the diode test reading may vary due to the resistance of other pathways between the test probe tips. When this happens, it is recommended to isolate the component by removing it from the circuit board, and performing the test again.

### Resistance and capacitance measurements

In many circumstances, electronic devices that fail quality assurance testing during the production stage are because components such as resistors or capacitors being out of tolerance. The component accuracy range for resistors and capacitors are relatively large. The accuracy for resistors typically ranges from  $\pm 1\%$  and above, whereas capacitors have an even bigger range normally starting from  $\pm 20\%$ . These commonly found components on a circuit board are tested using a digital multimeter to verify if the values fall within the accepted range. These component tests allow the technician to quickly detect the problematic components at the work bench.

The typical capacitance measurement for handheld digital multimeter starts at 0.001 nF. To test the capacitor value below this range, use a handheld LCR meter with a wider measurement range from 0.001 pF to 20 mF.

## Signal probing

Signal probing requires some understanding on the circuit to determine the signal test point and to interpret the result. Signal probing can be done with a voltage test using a handheld multimeter or a waveform capture with an oscilloscope. Most voltage tests start by probing the voltage with reference to the ground. When checking an IC, it normally starts with testing the voltage supply pin. If the voltage level is lower than expected, there could be leakage on the IC.

Sometimes, instead of depending on a measurement value displayed on the handheld multimeter, the engineers or technicians will need more information of the signal by looking at the waveform pattern to determine the possible cause of failure. Oscilloscopes will be useful in this situation. The oscilloscope is used to monitor and display the signal in a graphical format. The oscilloscope shows how the signal changes, allowing the engineers and technicians to detect any anomalies easily.

Occasionally, engineers or technicians will need to make floating measurement in which the measurement point is not referenced to the earth ground. Most benchtop oscilloscope measurements are referenced to the earth ground as the signal ground terminal is connected to the protective earth ground system. The Keysight U1610A/U1620A handheld oscilloscope offers channel-to-channel isolation to enable the capture of two signals at different reference points.

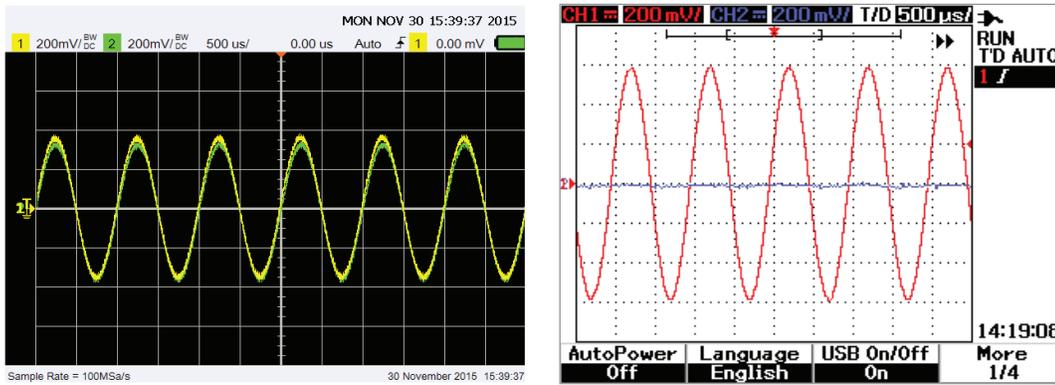


Figure 3. Two different floating measurement waveforms captured with an oscilloscope with channel-to-channel isolation (left) and an oscilloscope without channel-to-channel isolation (right)

## Comparing the circuit boards

To determine the root cause of a defective circuit board quickly, technicians will usually compare the test value of a defective circuit board with a known good one. This is done by probing the circuit board's reference points with a digital multimeter and comparing the values between the defective circuit board and a known good circuit board.

## Intermittent failure

Intermittent failure is the most challenging part to address in the troubleshooting process. It can be very time consuming. There are many factors that causing intermittent failures. The common faults are component overheating, poor soldering, and components degradation. Intermittent failure can be attended by monitoring the voltage value of the suspected component with a handheld multimeter or an oscilloscope over time to determine if there are any changes to the signal.



Figure 4. Monitoring the voltage value over time with the data logging capability using the Keysight Handheld Meter Logger Software

## Keysight handheld tools for bench troubleshooting

### Keysight U1200 series handheld multimeters

The digital multimeter is an essential tool for circuit board troubleshooting and repair. The Keysight U1200 series handheld digital multimeters with up to 4 ½ digit display resolution deliver the precision, accuracy, and repeatability that the technician needs when troubleshooting. Combine with the U1163A SMT grabbers and the U1164A fine tip test probes, physically small connections to the device under test (DUT) such as the SMT component can be achieved. By connecting a thermocouple probe, the digital multimeter will be able to measure the surface temperature of the ICs and check if it is overheated.

### Keysight U1610A/U1620A Handheld Oscilloscope

The Keysight U1610A, 100 MHz and U1620A, 200 MHz handheld oscilloscope with VGA display allow us to clearly see and differentiate signals from both channels simultaneously just like working on a benchtop oscilloscope. The scope isolation channels enable floating measurement capability. With up to 2 GSa/s sampling rate and 2 Mpts memory depth, the U1610A/U1620A captures more waveforms from signals and the zoom-in function allows for a more detailed view.

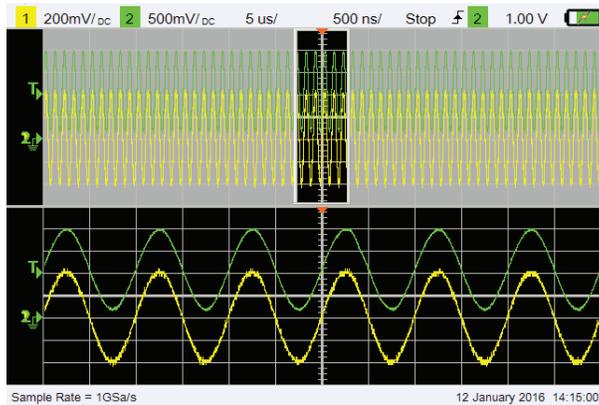


Figure 5. Dual window zoom allows quickly zoom in the segment of interest

### Keysight U1730C Series Handheld LCR Meters

The Keysight U1730C Series handheld LCR meters perform quick and basic LCR measurements of the components. Combine with the U1732B SMD tweezer, SMD-type component measurement can be easily made. By connecting to a power adapter, the LCR meter will operate like a benchtop without having to worry about the battery life.

### Keysight U5855A TrueIR Thermal Imager

The Keysight U5855A TrueIR thermal imager allows engineers and technicians to detect hotspots quickly with 320 x 240 pixels of in-camera fine resolution. With the ability to focus on objects as close as 10 cm, the thermal imager can measure the temperature of small components that are close to each other. Additionally, the thermal imager monitors temperature changes through image logging and temperature trending capabilities using the TrueIR Analysis and Reporting Tool software.

## Summary

The choice of the troubleshooting method depends on the complexity of the circuit and the knowledge and experience of the person who perform the troubleshooting. The use of relevant test tools will help the engineers and technicians to identify the cause of failure quickly and accurately and subsequently increase the productivity.



For more information on Keysight Technologies handheld tools, please visit:  
[www.keysight.com/find/handheld-tools](http://www.keysight.com/find/handheld-tools)

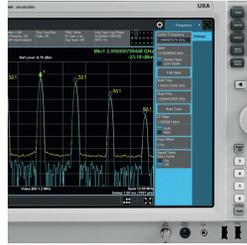
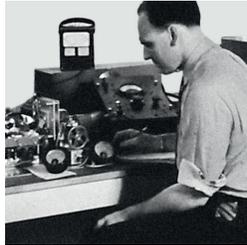
## Related Literature

The following Keysight application notes provide additional information that can help you in the troubleshooting of circuit boards:

- *Performing Equipment Failure Analysis Using Keysight's U5855A Thermal Imager Application Brief*, literature number 5992-1083EN

## From Hewlett-Packard through Agilent to Keysight

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