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END MARKETS FOR PCBS

Up, Up, and Away:

Reasons for Renewed Optimism in the Mil/Aero PCB Market

by John Vaughan, page 12

What is 4-Wire Kelvin?

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I've been asked many times, "What is 4-Wire Kelvin?" So, this month I will explain the 4-Wire Kelvin Test and how it can help uncover defects that normally would go undetected in standard electrical test methodology.

Most of us have used an ohmmeter to measure voltage, resistance and current. The typical meter has two wires; you probe the two terminals, trace ends or put the leads in line with the circuit for measuring current. A standard ohmmeter is shown in Figure 1 below.

However, with this type of measurement, the resistance of the leads and contact are added to the measurement. In Figure 2 you can see that the two leads with 0.5 ohms of resistance are added to resistance of the resistor being measure and providing a final result of 2.0 ohms, where the expected reading would be 1.0 ohms.

4-Wire Kelvin

4-Wire Kelvin testing is a methodology where high resolution measurements are taken to determine finite changes in resistance. These finite changes in resistance can then be used to locate plating defects or variations in plating thickness. The Kelvin test is highly accurate because of a four terminal system that negates all current sources, lead and contact resistances. This allows for the finite measurements to only be measured on the PCB circuitry. Typically these measurements are in the milliohm range. Figure 3 shows the typical Kelvin circuit.

Now the question, "What can Kelvin detect?" In the PCB industry, the main focus of the Kelvin test is to identify plating defects in the drilled holes. The higher the aspect ratio of the drilled hole the higher risk of defect. The

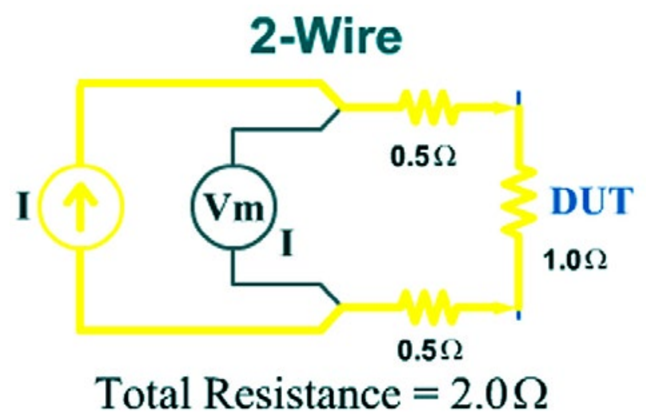


Figure 2: Two leads with 0.5 ohms resistance.

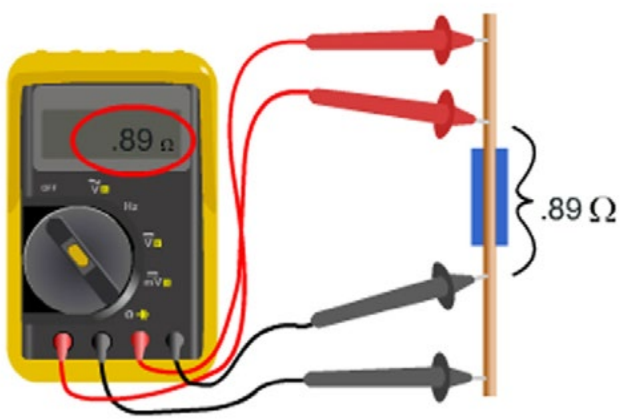


Figure 1: A standard ohmmeter.

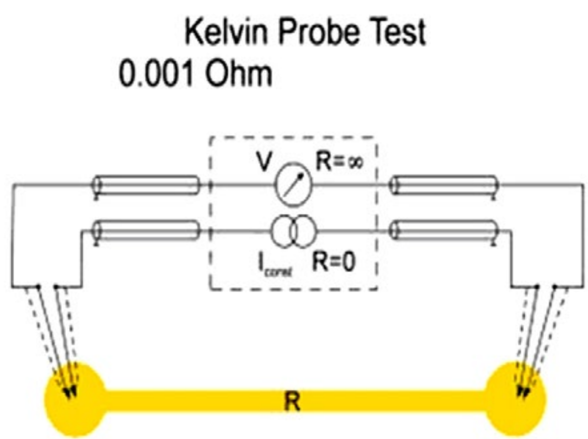


Figure 3: A typical Kelvin circuit.

defects shown in Figure 4 are typically what you will detect using 4-Wire Kelvin. Using standard electrical test with continuity thresholds at 10 ohms (IPC Class 3), these defects will go undetected as the change in resistance introduced by these defects will not cause enough change to fault at the 10 Ohm range. However, using the Kelvin test these changes in resistance will be detected as the changes although may be only 100–300 milliohms the high resolution measurement will fail.

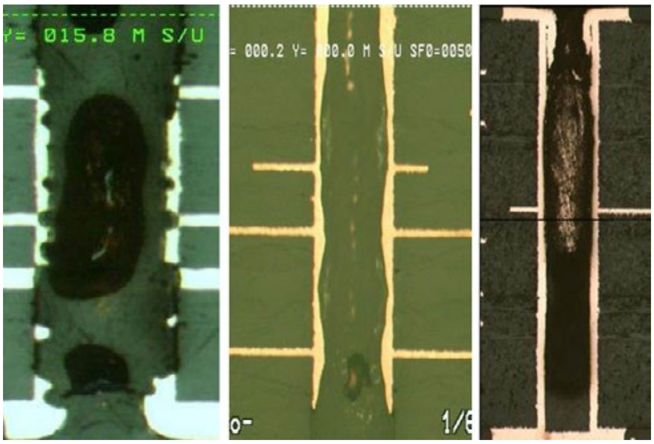


Figure 4: Typical defects detected using 4-Wire Kelvin.

4-Wire Kelvin can also detect voids in circular nets, typically power and ground (Figure 5).

A Few Good Questions

What is the best way to program for Kelvin Test...

...when looking for barrel integrity?

It is best to probe the barrel directly from one side to the other side. The barrel would have to be free of unwanted material such as solder mask. The connection to the annular ring/hole is imperative, the slightest variation with throw off the measurement system. When generating your programs it is best to ensure both sides of the barrel are tested in an overlapping fashion.

...when looking for specific net resistance?

It is important to test all pads open in the mask. This will allow for more accurate readings on each individual section of the network under test. Do not use end of node to end of node testing. The networks may be too long, causing unwanted variations in the readings.

Keep in mind that depending on the equipment used the size of the pad plays a significant

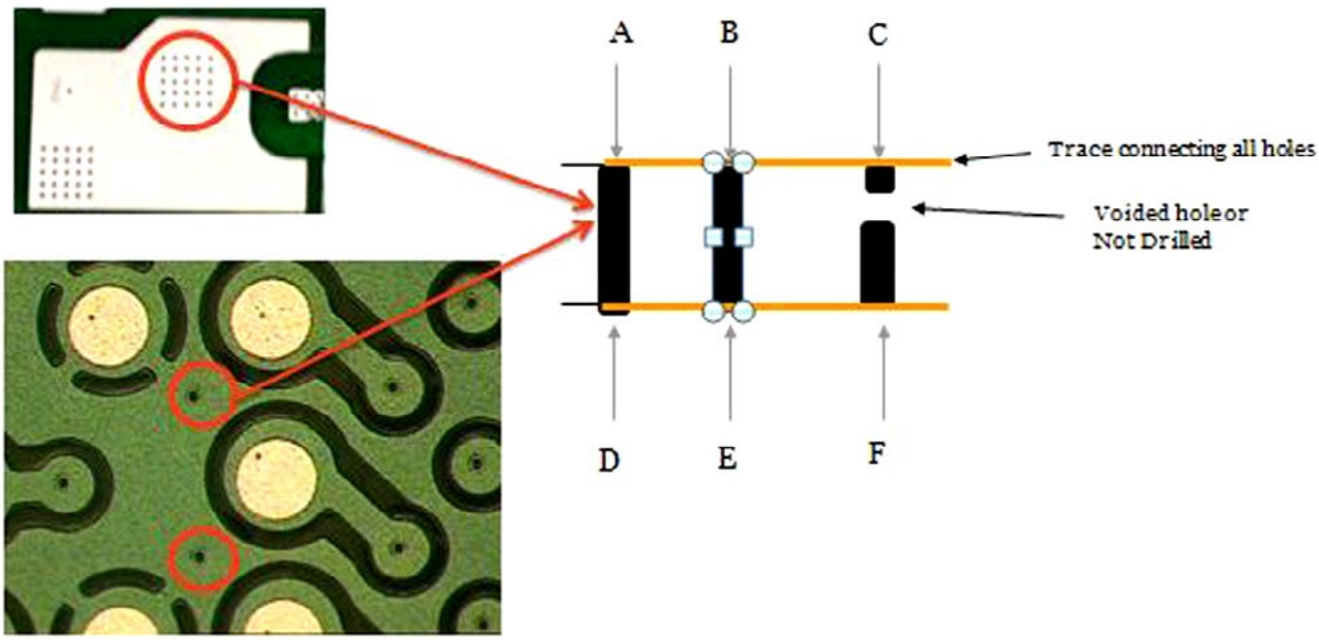


Figure 5: Voids in circular nets.

role due to the contact area of the two probes onto the pad. If only one probe hits the pad the test will be jeopardized.

Other areas of consideration when using 4-Wire Kelvin:

- Kelvin test should be done prior to soldermask as an in-process QA step. It should not be performed as an FA process as the final board will not provide optimal or accurate results due mask on via holes
- Due to excess copper travel, the use of Kelvin for buried microvias is at the venders discretion. The copper may add too much resistance to the master values and therefore allow possible defects to go undetected
- Kelvin testing for possible microvia copper issues should be done at the sub-part level
- For optimum test results, the barrels must be probed directly from side to side. It is best to test each hole twice using an overlapping pattern

I hope this helps explain 4-Wire Kelvin and its uses in today's manufacturing marketplace. OEMs are requiring more and more from their suppliers and 4-Wire Kelvin test is just one of the expanded requirements. **PCB**

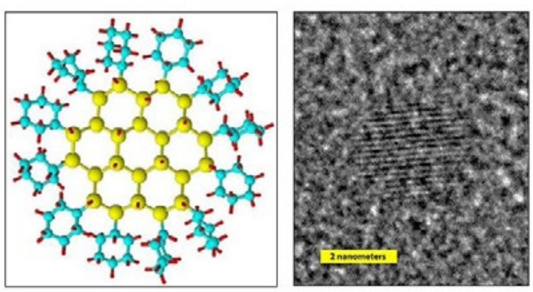
Todd Kolmodin is the vice president of quality for Gardien Services USA, and an expert in electrical test and reliability issues. To read past columns, or to contact Kolmodin, click here.

Nanotech Gets Big Push from Graphene

New research published in the journal Advanced Functional Materials suggests that graphene-treated nanowires could soon replace current touch-screen technology, significantly reducing production costs and allowing for more affordable, flexible displays.

The majority of today's touch-screen devices, such as tablets and smartphones, are made using indium tin oxide (ITO), which is both expensive and inflexible. Researchers from the University of Surrey and AMBER, the materials science centre based at Trinity College Dublin have now demonstrated how graphene-treated nanowires can be used to produce flexible touch screens at a fraction of the current cost.

Using a simple, scalable, and inexpensive method the researchers produced hybrid electrodes, the building blocks of touch-screen technology, from silver nanowires and graphene.



Dr. Alan Dalton said, "The growing market in devices such as wearable technology and bendable smart displays poses a challenge to manufacturers. They want to offer consumers flexible, touch-screen technology but at an affordable and realistic price. At the moment, this market is severely limited in the materials to hand, which are both very expensive to make and designed for rigid, flat devices."

Lead author Dr. Izabela Jurewicz commented, "Our work has cut the amount of expensive nanowires required to build such touch screens by more than fifty times, as well as simplifying the production process using graphene, a material that can conduct electricity and interpret touch commands whilst still being transparent."

Co-author Professor Jonathan Coleman added, "This is a real alternative to ITO displays and could replace existing touch-screen technologies in electronic devices. Even though this material is cheaper and easier to produce, it does not compromise on performance. We are working with industrial partners on future devices and it is clear that the benefits will soon be felt by manufacturers and consumers alike."

The research benefitted from funding and collaboration with M-SOLV, a touch-screen manufacturer.