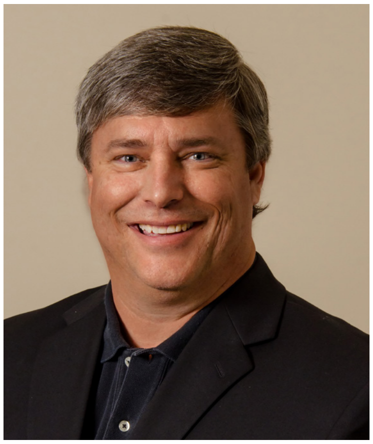
Engineering Services

Electrical Leakage and Electrical Shorts



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They say a picture is worth a thousand words. By the end of this article, you should have a basic understanding of what the difference in these two terms is and how to use the values measured to give you an idea of the potential risk posed by your materials, processes and designs.

In electronics, leakage usually refers to a gradual loss of energy from a charged capacitor. For our purposes, electrical leakage can be evidenced by dendritic growth. Dendrites may grow and reduce the dielectric gap between adjacent conductors and thus once these gaps are reduced by 25% to 50% then there is leakage which can interfere with electrical performance or signal integrity.

An electrical short is described as an electrical circuit that allows current to travel along an unintended path with no, or very little electrical impedance. The “short” we are looking at is a true electrical short between two adjacent traces as evidenced by the photograph below. Note the dendritic tree like structure is forming a true electrical short as it migrates or grows from the anode (-) to cathode (+).

In a galvanic voltaic cell such as the pictures show below you need a medium such as 3 to 6 monolayers of water. Then you need an ionic contamination source such as chloride (anion) which reacts with the copper trace material to dissolve metal ions to form the dendritic tree like structure which starts to grow and cross the gap between the two traces. The last variable required is a voltage bias differential between the adjacent traces which can be anywhere from 3.3 volts to 8 volts or 20 volts etc. The idea is that one needs a transport medium which in this case is 3 to 6 monolayers of water, then an ionic contaminate of enough volume to trigger an electro chemical reaction (chloride). Last but not least a voltage differential between adjacent traces (3.3 to 8 plus volts). How and where do these variables come from and how do they get under the components? The answers lie in the manufacturing processes, material choices, handling and processing of the different components and the original component parts and printed circuit board fabrication.

Leakage Currents

Short

First, where does water come from? Relative humidity – amount of water in the air itself we breathe - is present all the time but once you cross 65% RH then we start adding monolayers of water to all surfaces and as we continue to increase in RH% then we add more and more monolayers of water to all available surfaces. As one increases above 75% to 80% RH then there is enough water present for the first required variable for a galvanic voltaic cell to start which is a medium for an electrochemical reaction. Once the medium is present then the next variable is an ionic contaminate such as anions, cations and weak organic acids, which can be chloride from the anion family or adipic acid from the weak organic acid family or ammonium from the cation family. Any one of these in the correct concentration could trigger a chemical reaction on the copper conductors such as metal dissolution. Once the medium and the ionic contaminate is present then having a voltage bias field +/- will be the last variable which will drive the galvanic voltaic cell reaction. As you can see, the metal ions dissolve and start alignment on the anode trace. The leakage currents start to form and reduce the gap between the two traces. This occurrence will drop the dielectric resistance between the two traces and this phenomenon will and can be measured by a drop in Surface Insulation Resistance (SIR) between these traces. So hypothetically if this trace gap was measured dry below 60% RH then this SIR value could be 1 E10 or higher. Once the RH goes to 85% RH then we could see a drop to 1E8 or below. But again it takes three things to occur for there to be a drop in SIR – medium (monolayers of water) and then there must be an ionic present (anion, cation, weak organic acid) and a voltage bias to help drive the electrochemical reaction.

The best way to test for Surface Insulation Resistance (SIR) is to perform SIR testing on test cards which evaluates your material choices - solder fluxes, cleaning agents and general handling of components and printed circuit boards. The incoming components and printed circuit boards can come in with high levels of ionic contamination from their manufacturing processes so one can see there are a number of sources for ionic contamination into their finished electronic assembly. The ability to test for SIR underneath your critical BTC style components, BGA's and even QFP and connectors is the way to insure that your cleanliness level underneath low standoff components meets your cleanliness expectation or objectives.

Do you know your cleanliness level underneath your most critical components? SIR testing and Ion Chromatography testing is the objective evidence you need to meet your J-STD-001 Rev. G Amendment 1 section 8.1.

If you would like to know more information on SIR testing and IC testing to insure you know your cleanliness level underneath your critical electrical components;
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