IPC Designers Council
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ISSUES FOR THE IPC DESIGNERS COUNCIL®

June 2008

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The Importance of Being Grounded

Vladimir Kraz, Director of Instrumentation, Electronic Solutions Division, 3M Company

The proper grounding of all conductive items in the production workplace is an essential element of ESD (electrostatic discharge) management. ESD damage to components and assemblies in manufacturing is getting more and more attention. Smaller geometry and faster speeds of semiconductors have resulted in devices with increasingly higher ESD sensitivity. A typical sensitivity of integrated circuits and other devices is now in a 100V CDM range and many of the devices are already in 30 to 50V CDM sensitivity range. CDM stands for charged device model, and is defined as when a small device suspended by either pick-and-place vacuum picker or tweezers is charged and then is placed on a printed circuit board (PCB) making electrical contacts to the traces on the board and generating rapid discharge that can be quite harmful. Even if the device itself is not charged, a PCB or any other metal surface on which the device is placed, such as the shuttle in the IC handler, can be.

Conductors (i.e. any metal part) in the manufacturing process present ESD danger to the devices even if the voltage on them is low. This is because metal parts of the tools have high electric capacity and can contain plenty of charge. In a simple example, imagine a large bucket filled with an inch of water. Even though the water level is fairly low, the total amount of water in this bucket can be substantial. Because of that, it is important to realize that the damage to semiconductor devices in a real life situation can occur at lower levels than specified for standard device models.

A typical manufacturing tool, such as pick-and-place SMT machine, has many metal parts, which are supposed to be electrically connected to each other and then to ground. In reality, there is little assurance that such connections are good and that every part of the tool is properly grounded at all times. There are several typical reasons for that:

Grounding via Ball Bearings. This is quite a common situation in many tools. Ball bearings are, unfortunately, several pieces of metal separated by insulating lubricant. Indeed, when the tool is not moving, the ball bearings offer reasonable conductivity because in this state, the lubricant is squeezed out and the balls offer electrical connection between the rings. However, when the tool is moving, i.e. when it handles the electronic parts, the electrical connection is far from being guaranteed due to the lubricant, which insulates balls from the rings as it should for reducing friction.

Assumed Connection. Quite often it is assumed that, when two pieces of metal are pressed against each other, there is good electrical connection. This assumption is very far from reality. Many parts of today's tools are made from anodized aluminum, which is, on its surface, an insulator. There is often no electrical connection between parts of the tool frame constructed from aluminum extrusion due to the nature of how the different parts are connected together. On occasion, one can find grounding wires trying to make connection to a painted surface which, of course, won't work, unless it is a conductive paint.

Broken Grounding Wires. In a brand-new tool, grounding connections may be good; but after some time, the wires bend, stretch and break as shown in Figure 1 (as presented by Jos van de Giesen of NXP (former Philips Semiconducor) at the 2006 ESD Forum in the Philippines.

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3,472

Total Number of CID+s

710

This article is an excerpt from the IPC Printed Circuits Expo, APEX, and the Designers Summits, March 31-April 2, 2009 Las Vegas, Nev. To view the complete article, including all graphics and tables, please download the .PDF version.

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The Importance of Being Grounded

Vladimir Kraz
Director of Instrumentation
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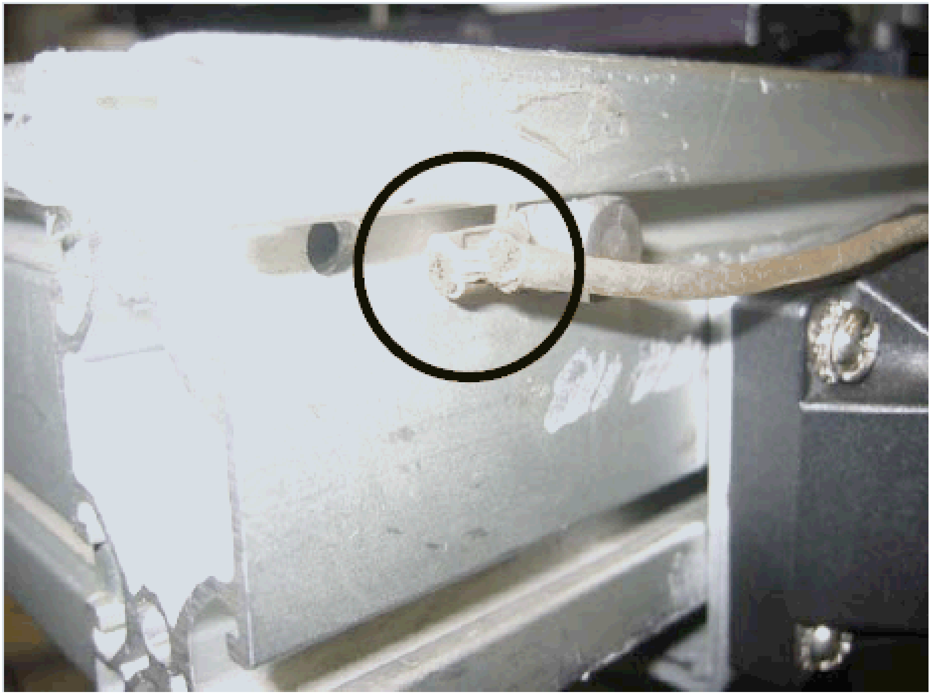

Figure 1. Broken Grounding Wire

This figure also illustrates an attempt to ground an anodized piece of metal which, of course, doesn't work.

A common assumption is that if there is a wire, it must be a conductor and that the part is grounded. This is far from reality. Table 1 below shows the data taken by the author in one of the best semiconductor fabs in the U.S. It was assumed that a particular tool that exhibited ESD-related problems was grounded. Upon close examination, the following was found:

Table 1. Connection to Ground in a Tool

Location	Resistance to Ground
Side cover to ground	1 kOhm
Frame aligner mount to ground	20 MOhms
Buffer to ground	520 kOhms
Top cover ionizer to ground	2.2 Ohms
Robot base to ground	6.6 Ohms
Upper robot to ground	9 Ohms
Equipment case and indexer	200 Ohms
Aligner to ground	400 kOhms
Tool frame to ground	1.8 Ohms

The factory standard for grounding was 2 ohms. As seen, the only acceptable grounding measurement was observed between the frame of the tool and facility ground – this is where periodic ground check was performed. Needless to say, this is insufficient as shown.

Readers are invited to conduct their own tests in their facilities on grounding connections within their own tools, paying special attention on interconnection between different internal parts of the tool when the tool is operating.

The only way to help assure proper grounding at all times is by continuous ground monitoring using tools such as 3M™ Ground Man Continuous Monitor and 3M™ Ground Man Plus Continuous Monitor as shown in Figure 2.

Figure 2. 3M™ Continuous Ground Monitors

Such monitors measure continuity of grounding via a closed-loop test according to such standards as ANSI 6.1 and ANSI/ESDA S.20.20. If any of the monitored grounds fails (that means not only a completely open circuit but also exceeding the set limit ground impedance), an alarm is issued alerting personnel to the problem. As an added feature, both these monitors offer a logic level signal to the host tool in case of ground failure. Connected to the PLC (programmable logic controller) of the tool, such a failure can turn on the tower light alarm, stop the tool or inform the service personnel in some other way.

These monitors also add monitoring of an operator via the wrist strap – this assures proper grounding of operator when he or she loads and unloads parts or does any other work with the sensitive components.

Continuous ground monitoring not only provides evidence of grounding at all times, it also saves money and time on maintenance personnel's' manual checking of grounding on every tool. In high volume production, downtime is expensive and continuous monitoring helps to reduce this downtime.

Those who test grounding on working tools perhaps notice that sometimes the readings of resistance are not quite right – such as negative resistance, abnormal resistance values, etc. This is caused by ground noise, which is present on virtually any working tool. Regular multimeters do not handle such noise well. Special monitors such as those described here use a patented method of rejecting such ground noise in their measurements, promoting accurate measurements at all times.

A question may arise – which parts in a tool should be monitored. There are too many to identify. The recommendation is to monitor those parts that either come into contact with the sensitive components or come close to them, since ground failure on such parts can cause the most problems. Moving robotic arms are always suspect due to the higher probability of failure in their grounding wires. In many tools, there are spare wires in a wire harness leading to those moving arms and these wires can be used for ground monitoring.

To conclude, grounding is the most fundamental element of ESD management in manufacturing and in service. A broken ground connection may result in personnel exposure to dangerous voltage, equipment lock-up or malfunction and damage to sensitive components. Only continuous ground monitoring can assure proper grounding at all times.

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