Complete Grounding Inside Equipment for Combined ESD, EMI, and EOS Protection with GLE04-01

OnFILTER' miniature ground line filters GLE04-01 block propagation of high-frequency noise via ground wires assuring equipotential ground throughout the tool and adding protection to ESD grounding against EMI and EMI-caused EOS.

GLE04-01 EMI ground filter

Background

If you look inside any equipment engaging in electronic manufacturing - semiconductor, LCD, electronic assembly, or any other - you most likely will see ground wires connecting its various parts. It is done to make sure that every conductive part of the tool, especially the ones coming into contact with sensitive devices, is under the same, i.e. ground potential. Properly done ESD grounding assures that all conductive parts in the tool have the same DC voltage. But what about EOS - **E**lectrical **O**ver**S**tress? According to Intel® Manufacturing Enabling Guide, 2016, Section 10, "EOS is the number one cause of damage to IC components." Data from various semiconductor and PCBA manufacturers corroborate it.

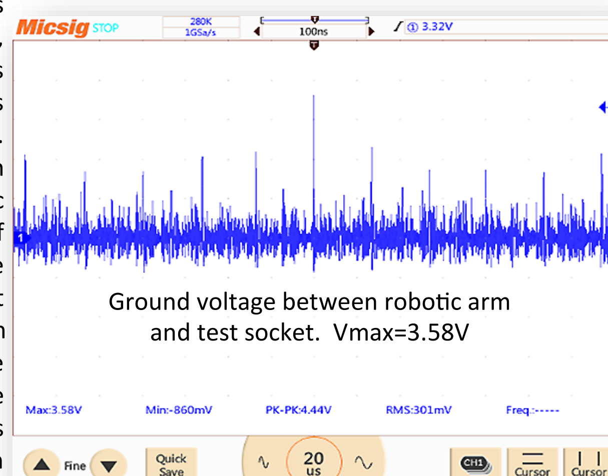
Electrical overstress is caused not by static charge but by stray voltages and currents in the tool. Damaging levels of EOS are several magnitudes lower than that of ESD—see recommendations on industry-acceptable levels further in this document. EOS signals last much longer than ESD Events, or discharges, and, unlike ESD events, they are often repeatable. EOS signals are capable of providing significantly higher energy into the devices than ESD Events and are much more likely to cause latent damage (i.e. failures in field).

Typical ESD grounding inside equipment

Besides electrical overstress, another harmful effect of EMI is its interference with normal operation of equipment and with device and board test. Ground is the “zero reference” for all electric signals inside the tool. Compromised ground containing parasitic signals alters logic levels and corrupts analog signals. Unwanted high-frequency signals interfere with legitimate signals that control your equipment causing lockups; in test they alter the measured signals leading to false rejects, or, even worse, passing defective devices.

EOS Sources Inside Equipment

Any electrical equipment generates unwanted high-frequency voltages and currents in a course of its normal operation. This electrical noise is often called EMI - **E**lectro**M**agnetic **I**nterference. It resides on power lines and ground. Usual sources of EMI in equipment are servo motors and variable frequency drives (VFD), relays and solenoids, switched mode power supplies, UPS, LED and CFL lighting, incoming AC power, and other sources. Typical frequency spectrum of this type of noise is between ~40kHz and 5MHz. High frequency signals propagate quite differently from that at DC and 50/60Hz low frequencies. A regular grounding wire that provides near-zero resistance for DC, at high frequencies is a high-impedance inductor which together with parasitic capacitance to other metal parts causes resonances. A combination of grounded metal parts and wires creates a practically undecipherable network of phase shifts, resonances and impedances. The end result is that high-frequency voltage in one spot of the tool may be quite different from any other place. Figure to the right shows voltage difference between the two parts of IC handler - robotic arm and test socket. Both parts are properly ESD-grounded. Yet, the voltage between them is 3.58V peak. As seen, ESD grounding is no guarantee of equipotential situation at high frequencies.



Ground voltage between robotic arm and test socket. Vmax=3.58V

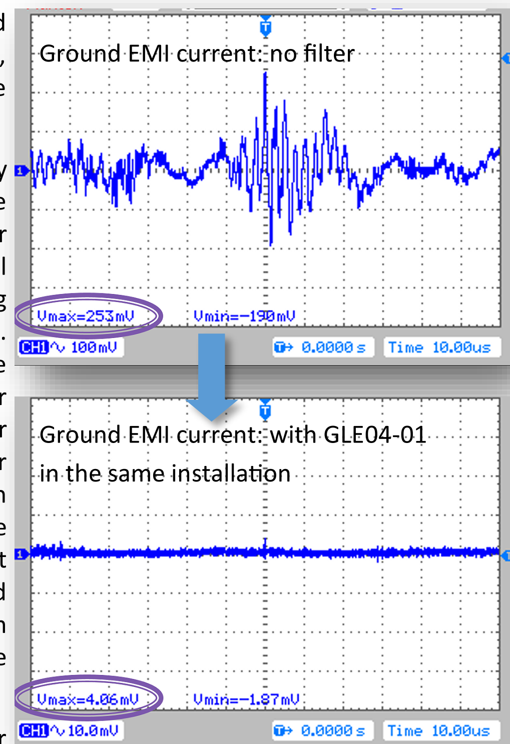
GLE04-01 Ground EMI Filter Blocks Propagation of EMI in Equipment

The only practical way of assuring equipotential environment on ground at high frequencies is to block propagation of high-frequency currents in the tool. OnFILTER designed special miniature ground EMI filters GLE04-01 that connect in line with regular ESD grounding. The filter offers less than 0.2 Ohms resistance for ESD protection and is very effective in blocking high-frequency currents. Together with regular ESD grounding GLE04-01 provides complete protection against ESD and EOS on tool's ground.

IMPORTANT: GLE04-01 is for non-powered ground connections, such as for ESD grounding. Never use GLE04-01 in AC ground of powered equipment—it is unsafe. We offer a different filter for that purpose—GLE30-1 which is safety-certified for AC powered circuits up to 30A.

GLE04-01 Performance

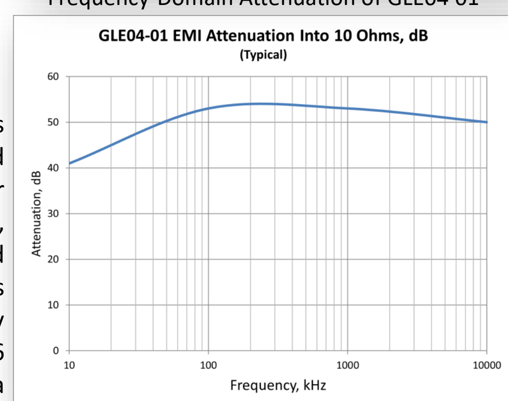
Patented GLE04-01 offers unique combination of high degree of EMI attenuation and low resistance, accommodating both the requirements of SEMI E.176 for low EMI, and ANSI/ESDA S20.20 for low resistance for ESD protection. The screenshots on the right show time-domain and frequency-domain attenuation data.



The performance of ground EMI filter can be assessed by measuring high-frequency voltage between the two grounded points before and after implementation of the filter. The key point in such measurements is absence of ground loop—if your instrument is plugged into the wall outlet, it is grounded itself rendering any ground measurements irrelevant. One way of doing it right is to use battery-powered oscilloscope, another way is to use OnFILTER's EMI Adapter MSN15 shown to the left. This adapter provides complete galvanic isolation between input and output, true balanced input, and wide bandwidth. It HAS 50 Ohms output and can be used with an oscilloscope or with a spectrum analyzer—none of them have to be battery powered.

For proper setting of oscilloscope for EMI measurements please see Application Note QSA031.

Frequency-Domain Attenuation of GLE04-01



Setting Goals

How would you know whether EMI signal that you measured in your equipment is adequate or is too high for your process and devices? Industry standards and guidelines provide numeric goals that will help you to set up safe EMI levels in your process. IRDS, International Roadmap for Devices and System, an IEEE organization, comprised of experts from many key semiconductor and PCBA companies and universities has set basic goals, while SEMI (www.semi.org), a consortium of experts from worldwide semiconductor manufacturers) that issues standards on many things related to semiconductor manufacturing and handling, published SEMI E.176 "Guide to Assess and Minimize Electromagnetic Interference (EMI) in a Semiconductor Manufacturing Environment." Partial numbers from this document are shown on this page. As seen, the smaller the geometry (the internal silicon layout, not the device's physical size), the lower the allowable EMI levels. The trend in semiconductor devices is smaller and smaller geometry—when setting goals for your process plan ahead—by the time your EMI/EOS protection is implemented, it is almost guaranteed that the geometry of your devices will get smaller than what you are working with now.

Category	Geometry	Conducted Emission	Ground Current
1	≥28.3 nm	0.3 V	50 mA
2	14.2 - 28.3 nm	0.2 V	20 mA
3	10 - 14.2 nm	0.1 V	10 mA
4	7.7 - 10 nm	0.1 V	5 mA

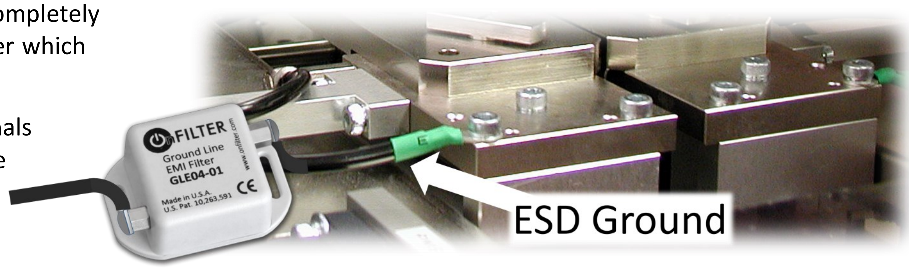
Maximum Allowable EMI Level According to SEMI E.176

GLE04-01 Installation

Installation Basics

Ground filter GLE04-01 is designed for ease of installation. It is very small (see page 4 for mounting dimensions), and can fit in tight spaces. The filter can be fastened with the screws using its mounting holes or simply using tie wrap, or Velcro, or event double-sticky tape for stationary mount. The filter is completely bidirectional and symmetrical—it doesn't matter which way it is connected.

GLE04-01 comes with two crimp ring terminals and screws. You would need to have a wire crimper and a Philips screwdriver #1 for electrical connection.



Installation in Stationary ESD Ground

In the existing tool, identify ground wires. The goal is to connect GLE04-01 in series with each of ground wires. Find the most optimal location to mount GLE04-01 and affix it in place. Once the filter is in place, disconnect grounding wire from its connection point on the equipment, connect it to GLE04-01 using supplied ring terminal and a screw. Use the same type of wire used for grounding (many use stranded AWG18 wire) connecting the other terminal of GLE04-01 to the place of the original ground connection. Once it is all done, check continuity using regular multimeter.

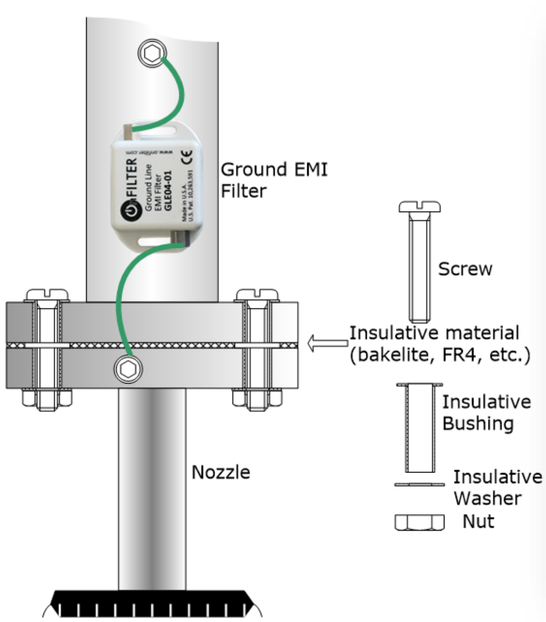
If you are designing a new tool, installation of GLE04-01 becomes simpler—you don't need to retrofit already made tool. Instead, you can set up the most effective grounding scheme allowing for the best placement of the filters and for the most optimal wiring. Contact us for the best practices of EMI/ESD grounding inside the tool—we are happy to help.

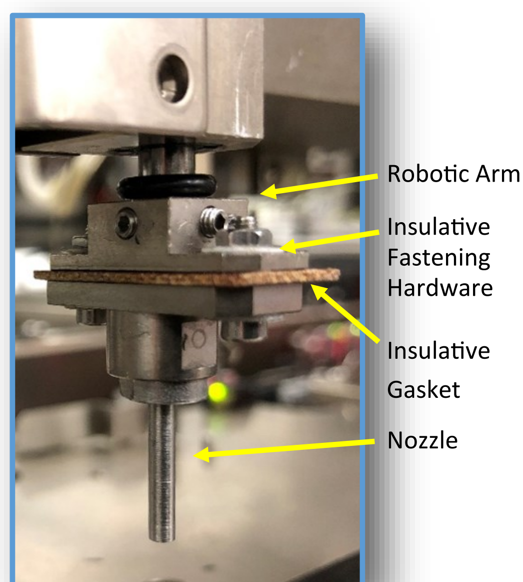
Installation on Robotic Arms

Small mass of GLE04-01 makes it possible to mount it on fast-moving robotic arms without affecting operation. The following example provides directions on installation of GLE04-01 on a nozzle of a robotic arm of an IC handler or of a SMT pick-and-place machine. There is always some high-frequency voltage difference between the end of the robotic arm and the chassis of the tool, and our goal is to bring it below the levels set by SEMI E.176 Standard and IRDS guidelines (see previous page). There are different ways to manage EMI levels in equipment, one is to implement servo motor filters—these motors are the source of the strongest EMI in almost any equipment. In this application note we will look at the "second best" way of reducing EMI in critical locations if for whatever reason it is impossible to install proper servo motor filters.

The goal is to interrupt ground connection to the end of robotic arm and insert GLE04-01 into this connection. This way the amount of high-frequency signals on it is greatly reduced. The filter itself is small and light enough to be fixed on the arm—this is seldom an issue. The difficulty of filtering EMI signals to the nozzle is in electrical separation of the nozzle from the body of the robotic arm while preserving mechanical properties of the tool. The nozzle is normally fastened to the arm with metal hardware, providing good electrical connection and shorting any possible filter connected between the two parts.

The solution to this problem is illustrated in figures on the right. Unmount the nozzle from the arm, insert an insulative gasket — a piece of mechanically stable hard insulator— and reattach the nozzle using insulative fasteners as shown. The gasket can be made of FR4 (PCB material), Bakelite, or similar material. Keep in mind that the mounting parts of the nozzle and of the arm would form a capacitor which allows some leakage for the high-frequency signals.



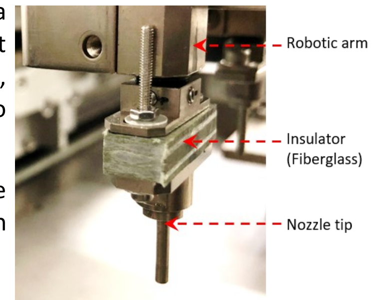


Basics of Mounting of GLE04-01 on Robotic Arm and Practical Implementation

Some Practical Points

Gasket

Nozzle mount and the robotic arm form a capacitor with the insulative gasket serving as a dielectric. Capacitors act as conductors at high frequencies which leads to some leakage current getting from the robotic arm to the nozzle, bypassing the filter. This capacitance is unavoidable, reducing the effectiveness of filtering. In order to compensate for such leakage there are two ways of reducing such capacitance:

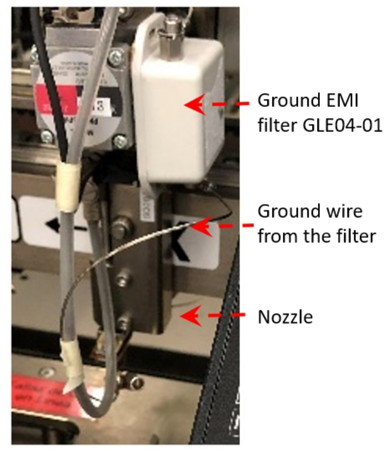


An Example of Extra-Thick Gasket

Do not use very thin insulative gasket. The closer the nozzle mount and the arm, the higher the capacitance. If possible, use at least 3...4 mm (0.120”...0.160”) thickness—it should satisfy both electrical and mechanical requirements

When selecting material for insulative gasket consider its dielectric constant—the lower the number the lower the capacitance. Dielectric constants of materials can be easily found on the web. As a reference, here are typical dielectric constants of popular materials:

Polycarbonate	2.9	FR4	3.8...4.8
ABS	2.0...3.5	Nylon	4.0....5.0
Delrin	3.1	Bakelite	4.5...5.5



Wrong Installation of GLE04-01:
Next to the Motor

Position

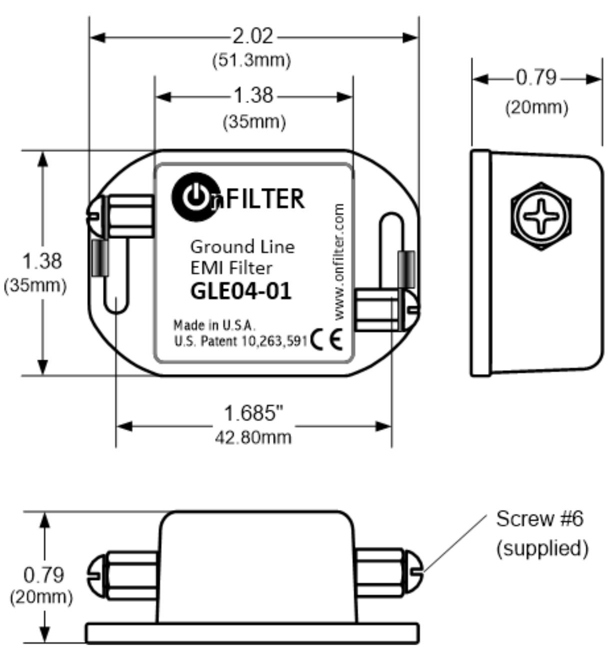
Install GLE04-01 as close to the nozzle as it is practical—shorter wire from the filter to the nozzle will pick up less EMI from the air and reduce leakage.

Placement

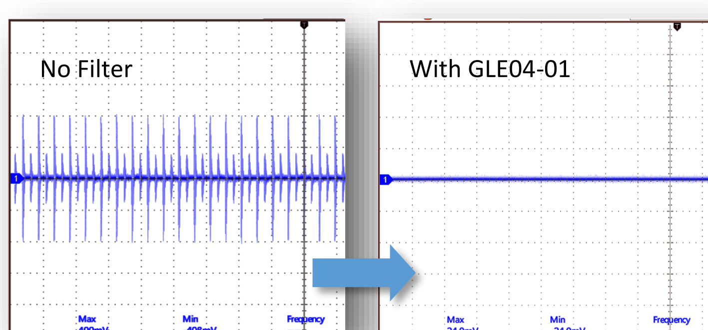
Place GLE04-01 away from known sources of EMI. Figure to the right shows an attempt of a wrong installation where GLE04-01 is in immediate proximity to the noise-generating servo motor. Capacitive and inductive coupling between the motor and the filter provides yet another path for leakage of high-frequency currents.

What to Expect After Filter’s Installation

While results in your installation may vary due to leakage, you should see substantial reduction of EMI. The goal is not to completely eliminate EMI—this is impossible—but bring it sufficiently below the set limits. You shouldn’t expect complete elimination of high-frequency voltage differential between the nozzle and the chassis—it is a mathematical impossibility to completely block the signal by a filter. Plus, there are several pathways for EMI to go around the insulative barrier, one being parasitic capacitive coupling described earlier. However, you should expect substantial EMI reduction that would help to bring EMI levels in compliance with the SEMI E.176 and IRDS requirements.



GLE04-01 Mounting Dimensions



Actual EMI Reduction in a SMT Pick-and-Place Tool

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