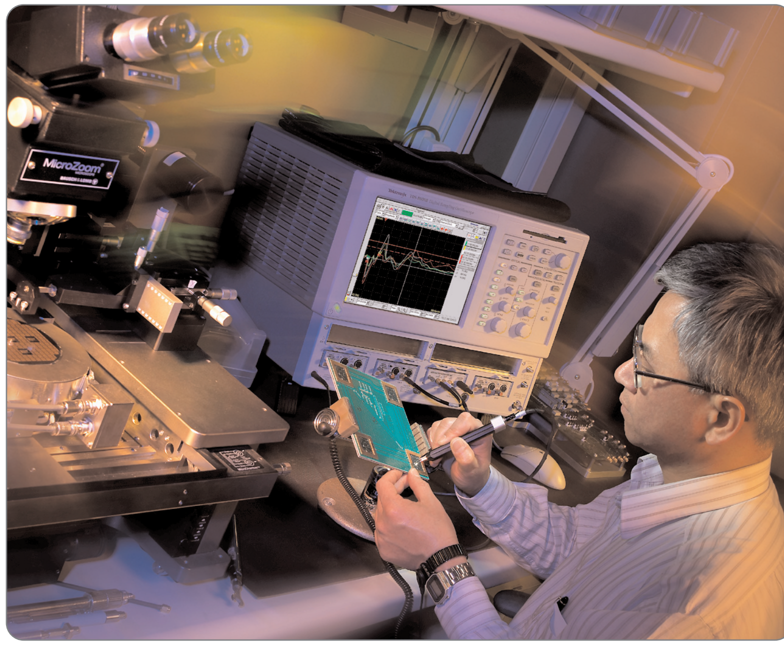
Maintaining High Bandwidth Performance of your Sampling Modules (OV, ESD and EOS Prevention)



▶ Overcome bandwidth and amplitude limits for signals above 7 GHz

Introduction

Sampling Technique

Many applications today require making high-speed measurements with an oscilloscope in frequency ranges of 7GHz and above. Sampling oscilloscopes with bandwidth extending to the +70 GHz range are best for these types of measurements. A sampling oscilloscope takes a sample with every repetitive trigger event and stores this value in the sampling module which is then passed through a low frequency path to the display. Only the input stage or sampling module sees the input signal frequency. After the input stage, the reconstructed signal passes through relatively low bandwidth amplifiers. In order to achieve this high-bandwidth capability, there can be no attenuators, trigger pickoff, or protection devices in the sampling module. Also, because of the bandwidth requirements sampling modules have very small components and are sensitive to relatively small amplitude levels.

Sampling Modules

Although sampling modules are a relatively small piece of the sampling system, they are the most important part. The modules are the input signal section of the sampling system, and are connected to the input signal. When gated, the sampling module passes part of the signal to the oscilloscope as a sample, helping determine the system's input characteristics. Operating input voltage range, maximum input signal and DC voltage, and system rise time and bandwidth all depend on the sampling module. Sampling modules contain a very small diode bridge or gate at the input. A strobe generator causes the diodes in the bridge or gates to conduct at intervals long enough to take samples of the input signal. Once these samples are taken, they pass through the lower frequency, less critical circuits to form the reconstructed display.

Sampling Module Limitations

Over Voltage (OV) Prevention

The most critical and sensitive components in the sampling system are the bridge or gate diodes used in the module. These diodes are extremely susceptible to damage from overdriven signals or DC voltages and static discharge. You must take signal and static precautions to avoid damage or destruction of these critical components. If the diodes are not completely destroyed the sampling system may still be useable. However, the diode and instrument life may be shortened, and performance will likely be degraded. System rise time and signal aberrations often change as a result of damage to the sampling bridge or gate diodes. Always be aware of the input voltage to any sampling system, and never exceed the maximum input voltage rating of the module in use.

Electro Static Discharge (ESD) and Electrical Over Stress (EOS) Prevention

In order to assure the highest instrument bandwidth performance, keep carrier transit time and circuit time constant and at a minimum. This is achieved by:

1. Reducing parasitic capacitive and resistive loadings.
2. Minimizing carrier transit time.
3. Using high carrier mobility semiconductor devices.

These measures dictate that the semiconductor devices used be of extremely small geometry and junction dimensions. As a result, device break down voltage is reduced along with its capacitive charge sharing effect.

Checking a signal applied to a sampling module input is relatively simple, and allows you to know exactly what you are applying to the module before connecting it. ESD and EOS, on the other hand, are much more difficult to control and present a tougher problem to solve.

Operator motion, materials transit, and board stacking easily generate static charges on isolated conductors, and build up associated static voltage to thousands of volts. A test structure on a PCB or a piece of cable easily contains several thousand volts. Standard ESD protection equipment is designed to render those high voltages down to low hundreds of volts, below which it's charge neutralization effectiveness drops off rapidly. It is common to have residual charges on devices with floating conductors to have hundreds of volts from residual static charges, even if it had just gone through an ESD ionization air discharge cycle. While a hundred volts of static charge does not present any problems to most of the ESD sensitive environments (due to the unique input stage structure of the sampling modules) this voltage can result in minute but nonetheless cumulative damages to the sampling bridge over time. In fact, the damage threshold of a high performance sampling head can be as low as several tens of volts. Presenting a voltage higher than the tolerance limit that a device is designed for forms the basis of an EOS situation (electrical over stress) and the sampling diodes can deteriorate via cumulative microscopic incremental damages by EOS. It is therefore of paramount importance to bleed off any residual static charges of the DUT before engaging a sampling module.

Static Awareness

Static build-up can occur on just almost any object, including all the items used to operate or service a sampling module, including tools, cables, connectors, and soldering equipment. General bench clutter is also a major cause of electrostatic discharge (ESD), such as plastic or Styrofoam cups, candy wrappers, plastic notebook covers, synthetic fabrics covered chairs, plastic floor tile, carpeting, clothing. Hundreds of volts are generated by simply reaching out for a coffee cup or lifting a toe while sitting on an insulated chair, and thousands of volts can be produced by standing up from a sitting position. The threshold of feeling the discharge is about 3,500 volts, and the threshold of seeing it is about 5,000 volts. When you consider that sampling module damage can occur with as low as 60 volts of discharge, the static charge on a person handling the sampling module is a major concern.

Consider the following example of a person making contact with an 80E04 or SD24 Sampling Module input. The average person has a capacitance of about 160 picofarads. Assume this person is charged to 15,000 volts, which is not uncommon. The total energy (joules) can be calculated as follows:

Energy (joules) = ((capacitance) (voltage))^2 | 2
Energy (joules) = ((160 $*$ 10^{-12}) (15 $*$ 10^3))^2 | 2
Energy = 18 milli-joules

This does not seem like a lot of energy until you consider that the sampling diode junction is about 1 $* 10^{-7}$ square centimeters. This is a very small junction area.

The power density per square centimeter is calculated as follows:

Power Density = Energy density | Junction Area
Power Density = 18 * 10^{-3} | 1 * 10^{-7}
Power Density =180,000 joules/square centimeter

This is a very high power density for semiconductor devices to handle. When the sampling diodes are reverse biased, the power concentration is as much as 1,000 times this amount, because the initial breakdown process always starts from the weakest location. This raises the power density further to an incredible 180 mega-joules/cm^2 – more than enough to destroy a high speed sampling diode.

ESD Prevention

When determining static damage avoidance, the materials involved are thought of as conductors or insulators. Conductors are materials that conduct electricity and if grounded will discharge. Insulators, or non-conductors, are materials that do not discharge when grounded.

Avoid static damage from conductors by creating, a path to a ground with various conductive materials, such as grounded floor and bench mats, wrist straps, protective bags, and shoe grounding straps. Use static shielding bags and electrically conductive boxes (containers, bins, and trays) when transporting static sensitive items.

Three of the most important ground items are the bench mat, floor mat, and wrist strap. The conductive bench mat provides a surface free of static charge, and removes the static charge from conductive items placed on it. The conductive floor mat drains static charges from those approaching the work bench as they step onto the mat. If a person is wearing rubber soled shoes, shoe grounding straps should be used. The wrist strap provides a permanent path to ground preventing static build-up while working at the bench. The strap contains a one megaohm resister for safe rate of charge removal equal to the rate of charge generation. Wrist straps are grounded to the conductive table mat or a ground connector on the instrument. Use three pronged power sources with the ground pin securely connected to a good earth ground when powering an instrument

Simple ESD and EOS Precautions

Once the work area is in order (mats and grounding straps installed), there are several other important measures you can take to prolong the life of your sampling system, and avoid costly repairs.

1. Always use termination caps on the sampling module inputs when not in use or during transportation.
2. Momentarily ground cables or other devices before connecting them to the input, to discharge any ESD or EOS charges.
3. Disconnect probes and cables when not in use to avoid an accidental connection to a charged source.

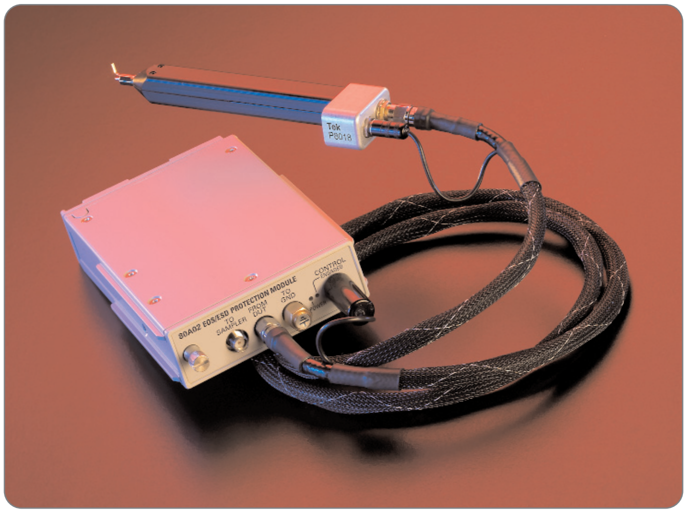
Note:

Using EOS/ESD prevention devices such as the Tektronix 80A02 combined with the P8018 will solve items 2 and 3 above. The 80A02 is installed between the DUT (Device Under Test) and the sampling module and is controlled by a switch inside the probe. When pressure is not applied to the P8018, the DUT is grounded through a 50 Ω termination resistor. This discharges any EOS or ESD charges stored in the DUT. Pressing the P8018 to make contact with the DUT activates a switch that connects the DzUT to the sampling module input allowing a measurement to be made.

Real World Applications

A fail-safe EOS/ESD prevention in a 24/7 production environment is simple in concept, but can turn out to be a difficult task, largely due to human errors while performing repetitive tasks day in and day out. Standard ESD protection devices with systems using footswitch style protection have proven to have a poor success rate, as it requires a constant human intervention of the test system as part of the EOS/ESD protection process. No matter how careful one might be human errors occur at some point, with potentially severe financial implications and production line downtimes.

The Tektronix 80A02 and P8018 incorporate EOS/ESD protection process seamlessly into a typical probing step, and essentially remove any potential human errors out of the loop. This automatic safeguard is extremely effective in achieving EOS/ESD protections in real world PCB production floor tests. In addition, the new 80A02/P8018 offer much higher bandwidth than many of the other available systems, extremely useful for users analyzing small geometric test structures in high speed applications.



► ***Figure 1.*** *80A02 and P8018 EOS/ESD protection system.*

Summary

Sampling oscilloscopes overcome the bandwidth and amplitude limits of conventional scopes for signals above 7 GHz. Sampling modules provide the means for coupling high frequency signals to less critical circuits for processing and display. Plug-in sampling modules also provide versatility to satisfy a wide range of signal measurement needs.

The sampling module contains critical and sensitive components required to handle high bandwidth signals, and certain precautions are required when operating and working on these modules. Use special care with these high performance instruments to prolong their life and maintain the kind of performance you expect from a Tektronix sampling system.

Contact Tektronix:

ASEAN / Australasia / Pakistan (65) 6356 3900
Austria +43 2236 8092 262
Belgium +32 (2) 715 89 70
Brazil & South America 55 (11) 3741-8360
Canada 1 (800) 661-5625
Central Europe & Greece +43 2236 8092 301
Denmark +45 44 850 700
Finland +358 (9) 4783 400
France & North Africa +33 (0) 1 69 86 80 34
Germany +49 (221) 94 77 400
Hong Kong (852) 2585-6688
India (91) 80-2275577
Italy +39 (02) 25086 1
Japan 81 (3) 3448-3010
Mexico, Central America & Caribbean 52 (55) 56666-333
The Netherlands +31 (0) 23 569 5555
Norway +47 22 07 07 00
People's Republic of China 86 (10) 6235 1230
Poland +48 (0) 22 521 53 40
Republic of Korea 82 (2) 528-5299
Russia, CIS & The Baltics +358 (9) 4783 400
South Africa +27 11 254 8360
Spain +34 (91) 372 6055
Sweden +46 8 477 6503/4
Taiwan 886 (2) 2722-9622
United Kingdom & Eire +44 (0) 1344 392400
USA 1 (800) 426-2200
USA (Export Sales) 1 (503) 627-1916
For other areas contact Tektronix, Inc. at: 1 (503) 627-7111
Updated 20 September 2002

For Further Information
Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

06/03 FL5631/WWW 85W-16767-0

Tektronix
Enabling Innovation