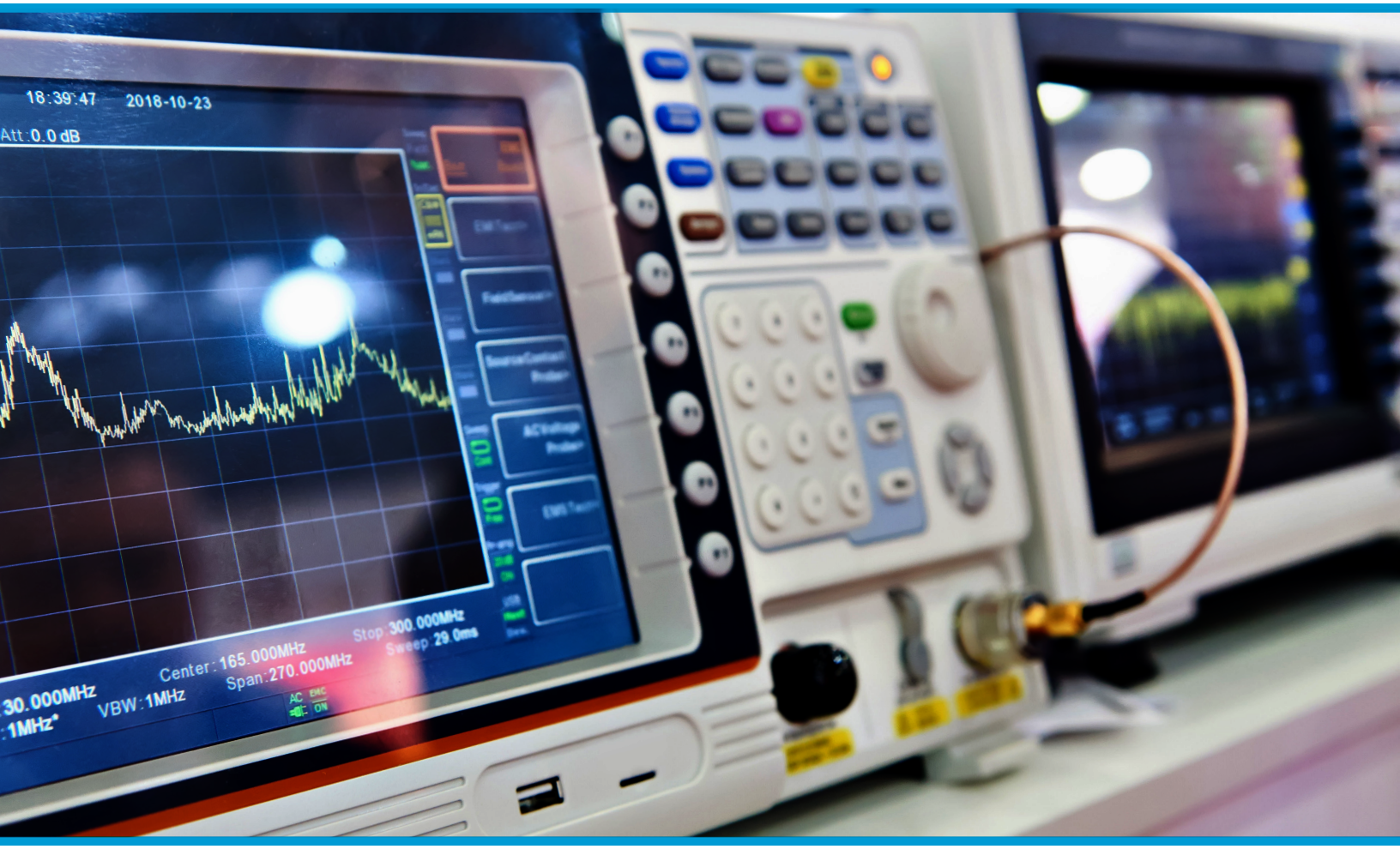
White Paper

TROMPETER
RF connectivity



Solutions for Emerging Test and Measurement Challenges:

Multi-channel Ganged Triax Assembly

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SOLUTIONS FOR EMERGING TEST AND MEASUREMENT CHALLENGES

Introduction

There are many applications, such as wafer level testing (wafer sort), that require extremely precise current and voltage measurements. With the shrinking size of integrated circuits (ICs) and the need for high density interconnect, test system designers are forced to make tradeoffs with test interconnect. Many precision test interconnect technologies are relatively bulky for this new scale of testing, such as traditional triaxial connectors, or otherwise can't offer noise immunity and low current measurement capability while maintaining contact geometries. With the advent of miniature triaxial connectors and triaxial connector assemblies, these tradeoffs don't have to be made, and reliable interconnect is even feasible for testing scenarios that require hundreds of precision channels.

This article aims to discuss the use cases of triaxial interconnect, as well as highlighting new capabilities offered by miniature triaxial connectors and connector assemblies in high precision, low noise, low current accuracy, and high-density applications.

Overview of Triaxial Interconnect

A triaxial transmission line consists of a center conductor, a dielectric between the center conductor and intermediate conductor, a dielectric between the intermediate conductor and the outer conductor, and typically, an outer jacket. The inner conductor is typically called the core, the intermediate conductor is often called the guard or inner screen, and the outer conductor is generally called the outer sheath/screen, or simply sheath. In many early triaxial transmission line (triax) applications, the sheath was used as a protective earth conductor, and television production and video broadcast systems benefited from being able to send quality sensitive TV signals via low-loss and low-noise interconnect.

Most television transmissions are not conducted over a hybrid copper/fiber cable, triax use is now predominantly seen in test and measurement applications. The benefit of using triax for these applications consists of offering high noise immunity, rugged construction options, established military standards and suppliers, the ability to be configured for extremely low current measurements, reduced cable losses and loading, and reduced distributed capacitance through the length of the transmission line. Triax can be configured in a variety of combinations and can be used for applications ranging from high-frequency transducer data systems to low-impedance transmission lines and low-current measurements.

For example, in the case of cryogenic wafer probe testing or device characterization, very small device leakage currents, which are often below 1nA, are valuable to measure in order to characterize a device's behavior and identify causes of anomalous or undesirable behavior. This type of testing requires transmission lines that are capable of carrying signals without introducing additional leakage current or noise. Coaxial cables, though often used for high-precision measurements where signal quality is important, are not well-suited for measuring currents in the hundreds of picoamp range (or below). Even with the highest quality of coaxial dielectric, the insulation resistance between the inner and outer conductor will still only be on the order of 100 GΩ [1], which will allow for a leakage current of the signal voltage divided by 100 GΩ (V*10e-11). Unfortunately, coaxial cables will typically allow leakage currents in the picoamps, thus reducing nanoamp current measurements by several percent.

Resources

[1] https://www.belfuse.com/resources/brochures/cinchconnectivitysolutions/trompeter/wp-ccs-using-triaxial- cables-for-low-current-measurements.pdf?language_id=1

Another disadvantage of coaxial transmission lines for extremely low current measurements requiring high precision is the effect of charging current on voltage/current sweep measurements. During characterization and testing, voltage sweeping is very common in order to determine the current-voltage (IV) response of a device, and any capacitance in the cable transmission can lead to capacitive discharge (charging current) reducing the overall current accuracy during the sweep. For example, with typical coaxial cable capacitance on the order of 30 pF/ft and a sweep rate of 1 V/s, the charging current could be nearly 1 nA, with additional leakage current further adding error to the current measurement [1].

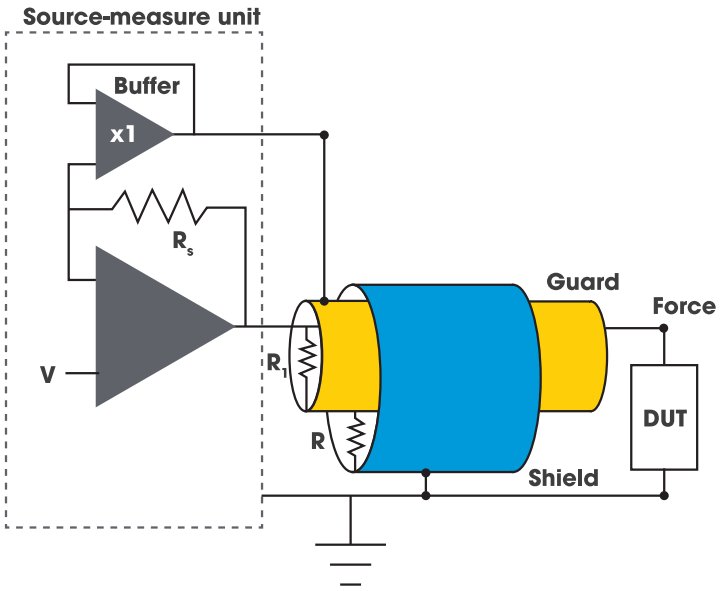


Figure 1: Using a voltage follower and drivering the guard at the same potential as the force prevents leakage currents flowing in the dielectric between the force and guard.

With triax, however, both leakage and charging current can be mitigated during testing with the use of fairly simple external circuitry. With typical source-measure units built to leverage triax, the guard and center conductor are held at the same voltage by a buffer amplifier. Consequently, no leakage current will flow from the center conductor to the guard with a zero-voltage potential difference. Similarly, during sweep measurements with a guard and force conductor held at the same voltage, there is also no capacitance developed between the force and guard, mitigating charging current.

For wafer sort, wafer probe testing, device characterization, and other high-precision and low-current measurement applications, triax and test instruments with triax connectors are ideally suited. As well, other configurations leveraging the outer sheath, or using differential circuitry to reject noise and interference not present on both the force and outer sheath, can be used to further enhance noise and interference immunity for mission-critical applications (mil/aero).

Resources

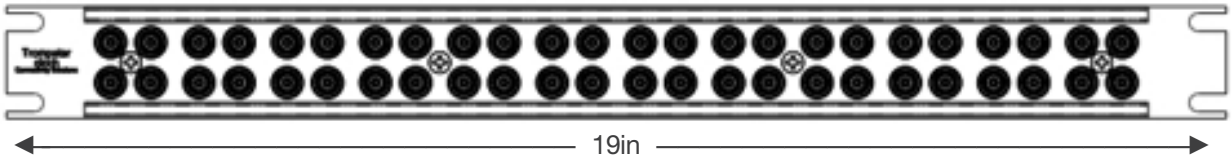
Figure 1. Source: https://www.lakeshore.com/docs/default-source/product-downloads/application-notes/considerations-for-low-current-measurements-in-cryogenic-probe-stations.pdf?sfvrsn=4e3100e8_1

[1] https://www.belfuse.com/resources/brochures/cinchconnectivitysolutions/trompeter/wp-ccs-using-triaxial- cables-for-low-current-measurements.pdf?language_id=1

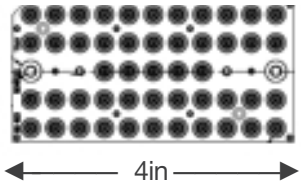
Miniature Triaxial Interconnect Benefits

There are several types of triax connectors, including threaded, push-fit, and bayonet. Triax can also be adapted to other coaxial standards, such as BNC or SMP. Regardless, to provide extremely low current and noise measurements, a triaxial transmission line must be continuous from the measurement source to the instrument. This can be difficult to achieve with standard-sized triax connectors and cabling, especially in compact multi-channel testing. However, there are compact and lightweight triax connectors, commonly known as miniature or subminiature triax. These connectors are substantially smaller than standard triax connectors and come in push-fit (blind-mate) varieties that both aid with misalignment during mating and enable much tighter pitch interconnect assemblies.

Typical 48 port ganged triax solution



Cinch Connectivity Solutions' Trompeter 48 port ganged triax solution



How Compact Multi-channel Triaxial Connector Assemblies Offer Benefits for High-Density Testing

In some applications, such as wafer sort, a test may require tens, or even hundreds, of channels that need to be measured either simultaneously or rapidly in sequence. In these cases, connector bulkheads or multi-channel connector assemblies are typically employed. However, when the number of channels for an assembly reaches in the tens of channels, the assembly size can become difficult to manage. In addition, each individual connector needs to be reliably mated to ensure the highest precision during testing. Meaning, contact force and connector assembly tolerances become even more critical with increasing connector density.

These factors essentially limit the practical size of typical multi-channel connector assemblies, but this is not the case for Cinch's Trompeter compact multi-channel triaxial connector or ganged triax assembly[3], which are designed using proprietary techniques that ensure a low-mating force and high-quality mating. Based on the Trompeter 150 TRS series subminiature triaxial connectors, this type of high packing density (up to 246% more than other test connectors) enables the construction of custom-sized and custom-shaped multi-channel connector assemblies with channel counts from two to fifty or more. Multiple connector assemblies, or blocks, can also be conveniently combined in space-constrained environments to increase the channel count to hundreds.

With this accessibility, wafer test setup times, error, and complexity can be significantly reduced, increasing overall test efficiency and reducing the amount of interconnect-related troubleshooting. Testing repeatability can also be enhanced, as the connector interface of Trompeter's multi-channel ganged triax assembly is vastly more consistent across mating cycles that individually mated connectors. Allowing wafer testing and other like applications to be performed in a more scalable and time efficient manner without sacrificing reliability or interconnect quality.

Conclusion

There is a growing demand for high channel count testing interconnect that is convenient, reliable, and useful for low-current testing applications. There are only a few viable interconnect options however using triaxial transmission lines is one of the best ways to provide these capabilities cost-effectively. Subminiature triaxial connectors integrated into multi-channel or ganged connector assembly largely eliminates these modern testing challenges and opens the doors for even higher-channel count precision current testing increasingly common to semiconductor applications.

Resources

[3] https://www.belfuse.com/product-detail/trompeter-twinax-triax-solutions-twinax-triax-connectors-trs-twinax-triax-connectors?navCategory=twinaxTriaxConnectorsTwinaxTriaxSolutionstrompeterCinchConnectivitySolutionsProductType

cinch
CONNECTIVITY SOLUTIONS
a bel group

Asia Pacific
+86 21 5442 7668
ccs.asia.sales@as.cinch.com

Europe, Middle East & Africa
+44 (0) 1245 342060
CinchConnectivity@eu.cinch.com

North America
+1 507.833.8822
ccsorders@us.cinch.com

belfuse.com/cinch