Connectors - Not Just Your Typical Interconnect Anymore

Far from a simple cable interconnect, connectors are reaching a level of technology that rivals other 21st century components

By Ernest Worthman, Editorial Director
Connectors have never been one of the more glamorous components of the wireless infrastructure, but they have always been one of the most critical. In transmission paths, connectors can make or break the system. Connectors are critical to VSWR in transmission lines. Connectors also often bear the brunt of environmental extremes. Of late, the technological revolution has produced a dizzying array of miniature and subminiature devices and end products that have created a demand for connectors far removed from the standard cable connectors. Connectors have evolved to connect flat cables, fiber cable, all types of computer and communications multiple element cables, and a myriad of others. They mate disparaging lines and technologies and today require careful engineering to address the issues that come with the upwards scaling of frequencies and bit rates.

High-speed Serial Interconnect

As speeds reach the multi-Gb/s range as the norm, HSSI will be a significant interface in many arenas such as computers, telecom, and storage deployments of 10 Gb/s Ethernet, PCI Express, SATA, and other serial interfaces. Near the 10 Gb/s mark, connectors require more complex electrical testing, and repeat modeling &#151 a real testing challenge.
Issues for HSSI include the lack of 10 Gb/s cables. Although 5 Gb/s cables are in development, cable specs are really only fully developed at 3 Gb/s. Such cables can’t be used for validating a 10 Gb/s connector, which has to be verified for performance hits such as rise/fall times, frequency return loss, insertion loss, and varying frequency- and time-dependent crosstalk.

Technology Marches On

The evolution in technology, applications, and subsystems has significantly impacted the development of connector design. Before the technological revolution of the 1980’s, discrete semiconductors and basic integrated circuits were the dominating factor in circuit design. The technological revolution of the past 20+ years has evolved the large-scale format of PGAs, BGAs, and LGAs on smaller centers and significantly higher pin counts. High-density connectors have evolved from 1.27 mm pitch through 1.0, 0.8, 0.635, 0.5, 0.4, and 0.3 mm. In some cases even as low as 0.05 mm.
As well, the electronics industry has proliferated in many typically non-miniaturized and segmented areas of specialized devices and technologies. Some of these areas

include telecom, personal computers, and wireless data devices.
The automotive industry has also seen a boom in miniaturization (such as wireless tire pressure sensors that require miniature and custom interfaces). Other areas that are prime markets for custom and specialized connectors, wireless and otherwise, are process control, banking/ financial, and medical (wireless sensors). This evolution has shrunk the application of general-purpose connectors while developing application-specific designs and concepts. This has taken the industry from designing connectors that have to meet a standard set of requirements and environmentals, to developing technology-specific segments that each have their own significant requirements and environmentals unique to their applications.

Challenges to Test & Measurement

A result of the proliferation of electronics into so many different markets with so many varying and often harsh environments has the designer at a disadvantage. The disadvantage is that there aren't a lot of predicators to use to evaluate and assess connector performance. This has opened a new market for the test and measurement designer where engineers are actively developing new evaluation techniques and test environments. This in sharp contrast to past environments where short environmental durations, benign (single sine) vibration, and small samples were often sufficient for lot qualification. Very few harsh environment and/or thermal conditions were considered. Today, tests have expanded to longer duration exposures, increased use of dry thermal cycling, continuous resistance monitoring, random vibration, anomaly detection, and use of mixed flowing gas. All of this is integrated with the development of high-density, low-force systems in conjunction with severity levels that differ depending upon the application. This increases the complexity of testing to the point where a minimum of 100 to 200 variable data points are required.
Improved testing is a very positive movement, resulting in the development of new connector families, and it should continue as new markets evolve. It can be expected that the trend to improve reliability, increase resilience to harsh environments, reduce footprints, increase pin count and density, and find new ways to reduce contact resistance will not soon abate. And, as emerging technologies such as SoC, SiGe, and others mature and push the bandwidth even higher, it is reasonable to assume that development in connector technology will continue, unabated, for the foreseeable future.

Glossary of Acronyms

BGA — Ball Grid Array
HSSI — High Speed Serial Interconnect
LGA — Land Grid Array
PCI — Peripheral Component Interconnect
PGA — Pin Grid Array
SATA — Serial Advanced Technology Attachment
VSWR — Voltage Standing Wave Ratio