PXI Breathes New Life into Legacy Test Systems

Deploying test systems to the factory floor is never the end game for a test engineer; we always face the challenge of enhancing functionality when test requirements change, and the need to keep existing test systems operational when instrumentation or switching face end of life and obsolescence. One proven method to mitigate the impact when implementing these test system changes is to adopt a Modular Open Systems Approach (MOSA) featuring PXI-based solutions.

Adopting a MOSA philosophy for test system design has numerous advantages, both from a technical and business perspective, such as delivering systems that are more affordable, highly adaptable, better positioned to incorporate new functionality and well suited to address the inevitable sustainment issues that will arise. PXI-based systems were at the forefront of MOSA designs long before the term was coined, and continue to provide solutions to address a broad range of functional test and data acquisition applications. This approach provides a viable, cost effective alternative for mid-life upgrades of proprietary big iron and classic rack-and-stack test system implementations ranging from incremental performance improvements to implementing entirely new measurement capabilities.

A perfect example of technological change that is driving the need to update existing proprietary big iron semiconductor test systems with entirely new measurement capabilities can be seen in the development and adoption of 5G communications. Beamforming integrated circuits (ICs) provide the ability to generate and steer radio (RF) energy; current systems operate between 24.25 GHz - 52.6 GHz with future requirements identified for frequencies between 64 GHz and 86 GHz. Existing semiconductor test systems do not provide test capabilities at these higher frequencies, which presents a significant challenge for manufacturers as they race to release new devices, especially if existing suppliers do not feel the same urgency to upgrade support for these types of tests.

PXI-based test systems are the ideal solution, whether to address incremental upgrades or for a complete turnkey system. Vector network analyzers (VNAs) are at the heart of any high performance mmWave test system; these specialized RF analyzers provide both amplitude and phase measurements to deliver results that are far superior to scalar network analyzers (SNAs) that only return the amplitude properties of the measured signal. Phase measurements are essential when testing mmWave devices, as digital phase adjustments provide the ability to steer the RF energy.

Accurate and repeatable phase and amplitude measurement across the entire band of interest is another critical characteristic of the VNA. Some VNAs may be capable of analyzing signals across their entire operating band, 100 kHz to 40 GHz for example, but there may be dead bands or frequencies where the response is below levels that are acceptable for evaluating the device under test (DUT). The Keysight M980aX proved to be the ideal VNA solution for MTS' TS-9XXe-5G Series of mmWave semiconductor device test systems delivering modularity, speed and accuracy in a multi-port instrument that shares the same measurement science as PNA-X instruments commonly used in the laboratory, with no dead bands across the operating spectrum.

Test speed and system throughput are essential for production mmWave test systems and this places additional demands on the RF measurement subsystem. Most beamforming devices are multi-port integrated circuits (ICs) and a common four port device would incorporate one RF feed and four RF input/output antenna ports; therefore, five VNA channels are required. The density of these devices continues to increase, and as a result the architecture of the test system will greatly impact overall throughput and scalability. For example some manufacturers have already transitioned to higher density beamformer ICs with two RF feeds and eight RF input/output antenna ports. These evolving needs clearly highlight the advantages of the PXI MOSA approach, allowing test systems to easily adapt to changing needs through the installation of additional VNA instruments utilizing the chassis' spare slots.

Some test architectures will reduce the overall number of independent VNA instrumentation ports by implementing a multiplexed switch topology on the front end of a rack-and-stack instrument. This approach will certainly reduce the number of required VNA ports, and their associated cost, but it will also impact reliability, measurement uncertainty and test times. Mechanical microwave relays tend to be the technology of choice when implementing these RF multiplexers, with each path having slightly different insertion loss and VSWR characteristics and a finite life cycle with performance that degrades non-linearly over time, which must be addressed through careful calibration processes. Additionally, relay actuation and settling times greatly increase test times.

PXI-based solutions can easily deliver true multi-port, parallel test architectures that allocate an independent VNA port for each port on the beamformer IC by incorporating additional PXI VNA instrumentation; this approach delivers considerable advantages in system throughput and reliability. Parallel, multi-site architectures not only significantly reduce test times, but also eliminate the need for external microwave switching and the issues associated with measurement uncertainty and reliability. These levels of performance highlight the clear advantages of the PXI-based parallel multi-port / multi-site architecture (See Figure 1).

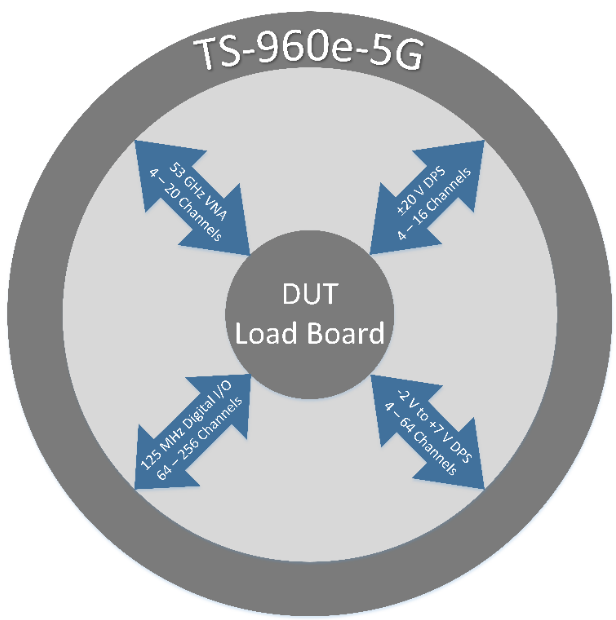

Figure 1. TS-9XXe-5G Multi-port Architecture

Figure 2 illustrates a PXI-based 5G mmWave semiconductor device test system incorporating commercial off the shelf (COTS) instrumentation with gap-free VNA RF performance (up to 53 GHz), Dynamic Digital I/O with per pin parametric measurement unit (PMU) capabilities, and Device Power Supplies with source/measure (SMU) capabilities.

Figure 2. MTS TS-900e-5G mmWave Semiconductor Device Test System

The PXI platform also provides the cleanest approach to implement incremental upgrades to existing test systems, such as channel expansion, higher dynamic digital vector rates or additional device power supply channels, without the associated capital investment of complete system replacement. The MTEK (Marvin Test Expansion Kit) Subsystem (See Figure 3) provides a straightforward approach to implement these upgrades, a need that is common across multiple industries from semiconductor to military to aerospace to industrial, where modularity and the use of commercial off the shelf (COTS) technology is highly valued.

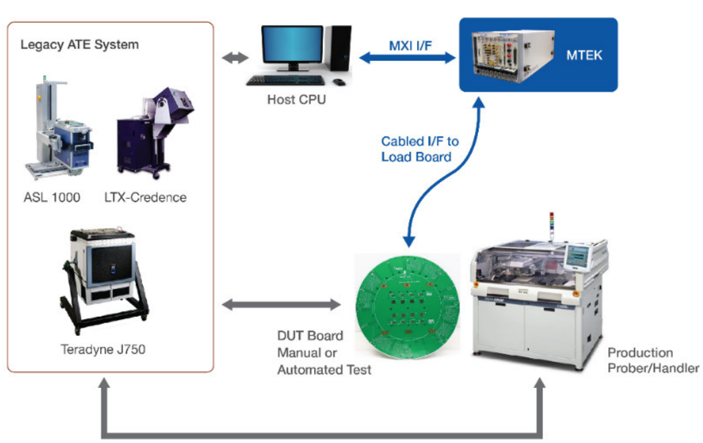

Figure 3. MTEK Semiconductor Test Capability Enhancements

One such example involved adding advanced dynamic digital capabilities, with increased vector rates and deeper on-board memory, to support new product releases on an existing legacy semiconductor test system. The MTS GX5296 Dynamic Digital I/O card with per channel programmable logic levels and parametric measurement units (PMUs) was selected, but PXI's modularity and open system architecture enables adding hardware from other suppliers as needed to meet new and emerging test requirements. MTEK allows customers to enhance system capabilities by configuring a subsystem with exactly the resources needed: RF, digital, analog, switching, or power.

PXI-based test systems unquestionably deliver the measurement performance needed to address the most challenging test applications in the industry, but they also incorporate inherent advantages over other approaches including affordability, adaptability, flexibility and an extensive ecosystem of suppliers offering a wide range of solutions. Whether designing a test system from scratch, or enhancing capabilities to extend the usable life of existing systems, PXI continues to be the solution of choice.