

Automating the Effective and Reliable Wireless Test Lab Environment: *RF Matrix Switching*

Executive Summary

The wireless equipment industry is overwhelmed with new and emerging test requirements. This results from the development, manufacture and certification of equipment for the growing Heterogeneous Network (HetNet) infrastructure which include beam forming antennas, adaptive Distributed Antenna Systems (DAS) and self optimized networks for the rapidly developing wireless platforms. Existing wireless equipment test environments are insufficient to meet the emerging requirements of these new platforms and ever evolving architectures.

The **NEXUS** Family of reconfigurable RF Matrix Switches automate and enable testing of interoperable commercial telecommunications equipment with emerging HetNet infrastructures. HetNet requires backwards compatibility, and ongoing integration of Wi-Fi, public safety and emerging LTE platforms. This has created a need for switch matrices, which offer test configurations that are flexible and provide fast response times and reproducible performance.

Traditional wireless equipment testing is often performed using patch panels, which are manually reconfigured for each test. However, faster and more dynamic changes in test architecture are proving manual configuration impractical. Devices that range from end user equipment (UE) such as computers, smart phones and tablets to transmission and network equipment, macro and small cells, are all exerting critical strain on traditional test laboratory resources. The growth in new wireless platforms is driven by strong customer demand for new and faster devices and services. Ever increasing content development and capacity requirements of HetNet architectures, applications and equipment has taxed the limits of manual testing.

This plethora of new technology requires the test laboratory to continually change their test methodologies to verify ever more complicated products to satisfy the demands of their customers. This is requiring new test architectures that can be accurately configured and remotely controlled, to create test scenarios that *emulate free*

Matrix Switch Benefits:

- Automation of test configurations
- Repeatable, recordable and remotely controlled tests
- Best verification of UE and Wireless Network Testing
- Millisecond Switching Speeds
- Reduced cable fatigue
- Improved time to market
- Reduced expense through shared resource: *Keystone*

space in a controlled environment. A **NEXUS** Matrix Switch enables far more flexibility for RF signal routing and switching speeds and providing n to any connectivity up to 1024 cross-points. GUI based control of the test configuration set up reduces time required and resources spent by lab personnel and test engineers.

The convergence of these trends and requirements is causing lab management to replace manual test methods with automated systems that can be reconfigured using **NEXUS** Matrix Switches. Matrix Switches are revolutionizing the way wireless products are validated and brought to market. The use of matrices allows today's test management to reduce cost while decreasing test time and errors.

The Need for a New Test & Measurement Architecture

The proliferation of new products that require testing and certification currently demand that tests be reconfigured for each simulated scenario. These changes are typically performed using manual patch panels. There are multiple issues that arise from manual reconfiguration methodology.

Configuration errors are the most frequent recurring problem. Cables and connectors are often similar and mistakes can be made easily, such as connecting a cable to a wrong port, especially when a complex RF test configuration is required. These errors can go undetected through most, or all, of the test plan. When an error is discovered the entire test will need to be repeated. Conversely, an error may go undetected and falsely validate user or network equipment. This mis-configuration could lead to the release of defective equipment into production leading to customer dissatisfaction and potential costly product recalls.

Typically, only a small number of technicians know how to configure the cables for the test configurations which creates a pool of local knowledge. This pool of local knowledge can be problematic in a variety of situations, for instance when employees transition, absences, and re-locations occur. Purely relying on the lab personnel for cable or RF test path changes causes delays in the test progression due to the typical ticket or change request process. A **NEXUS** Matrix Switch is designed to eliminate such issues.

Cable and connector fatigue occurs as the cables are moved from test to test ultimately wearing out the cable connectors. Cable connectors have a typical lifespan of only 200 to 500 matings. As they approach this threshold, the performance of the connection degrades to the point that it no longer meets the manufacturer's

Issues During Manual Reconfiguration Include:

- Configuration errors occur when manual configurations by lab personnel are changed or reconfigured improperly
- Cable fatigue which can render test results invalid
- Difficulty reproducing and repeating tests for multiple users or for multiple UE and Wireless Network Equipment
- Slower verification of UE
- Delayed time to market

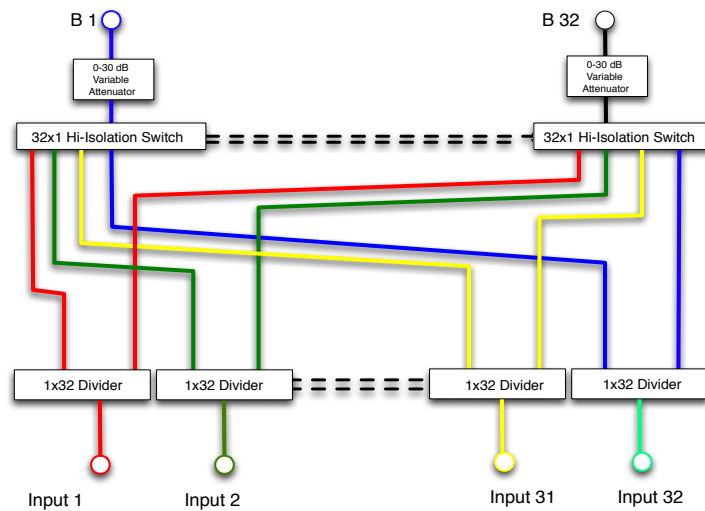
specifications. If a cable is not replaced as part of routine maintenance before it wears, then test results risk being invalid.

One main criteria of any test lab is to be able to reproduce and repeat a test. The test results are used when working with user and network equipment vendors. Considerable costs are incurred when cable fatigue or connector seating issues render test results to be non-repeatable. A Matrix Switch automates reproducibility and repeatability of stored test configurations.

The Verification of User and Wireless Network Equipment require that several test scenarios be configured. Each scenario can take long periods of time to manually configure a new lab rotation. In the race to get new products to market, it is not just the cost of the labor that needs to be considered, but also the time that a new product is delayed from entering the market. Using a manual process for test reconfiguration can extend the test time to unacceptable levels.

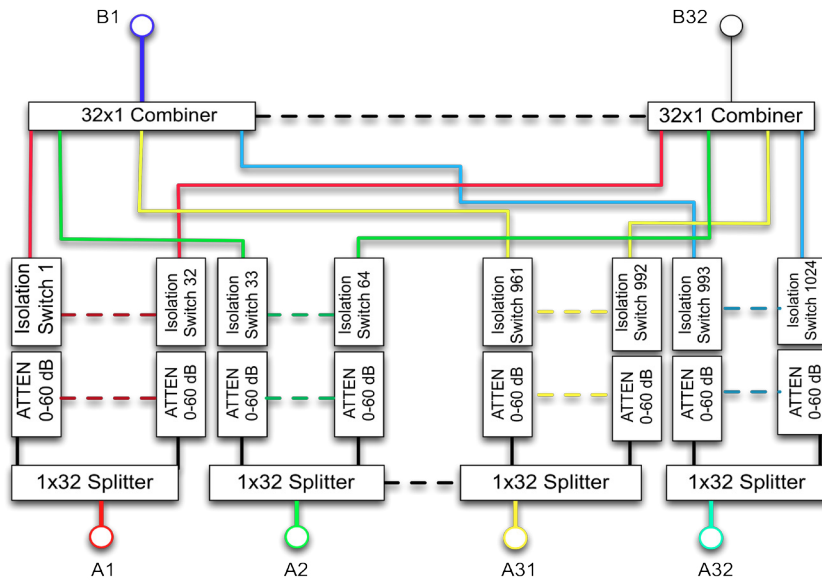
Figures 1 and 2 below show an example of a full fan-out architecture as well as a fan-in, fan-out Matrix Switch.

Full Fan-out Matrix Switch Block Diagram (Figure 1)



(fig. 1)

The 32x32 (or larger configurations) *NEXUS* Matrix Switch becomes the *Keystone* component of the new test and measurement lab architecture and opens up new possibilities in equipment verification. The Matrix Switch is an integral component of the laboratory architecture design. Switch Configurations, can now be accomplished by personnel in the test lab without requiring an intimate knowledge of the patch panel. The 32x32 Matrix Switch allows for 1024 cross-points to be switched and attenuated in milliseconds.



(fig. 2)

Fan-In Fan-Out Matrix Switch (Figure 2)

The architecture of the **NEXUS** Matrix Switch enables *emulation of free space in a controlled environment* by allowing controlled summing of signals from any combination of the inputs. Built in variable attenuators allow summing of outputs from any input with a range of attenuation. This eliminates the need for external combiners and attenuators, which further reduces patching and cabling.

Understanding Matrix Switching Systems

The Matrix Switch is designed as a solid-state passive bidirectional electronic fabric that allows signals to be quickly routed between multiple A and B connectors as well as providing variable attenuation between paths. These paths can be changed thousands of times in milliseconds.

A well-designed Matrix Switch will cause minimal degradation of signal allowing simulation of real world signal scenarios in a controlled lab environment. The Matrix Switch is designed to closely replicate a patch panel while also providing the benefits of rapid reconfiguration, built in variable attenuation, and signal dividing and summing.

When incorporating a Matrix Switch into the design of a test lab, knowledge of the switch specifications is essential to the integration of that switch into each application. The Matrix Switch is based on a passive electronic switch fabric using solid state switching elements. This allows repeatable connections at input power levels up to 10 watts.

A Matrix Switch provides high signal isolation between ports, which is essential in minimizing the influence of other signals on the desired test path. The minimum insertion loss of the matrix is determined by either its full fan-out, or fan-in fan-out design. This allows the signal to be replicated at any or all of the ports. Built in programmable attenuators allow the path loss to be adjusted at each cross point providing flexibility for many test applications.

User Equipment Tests

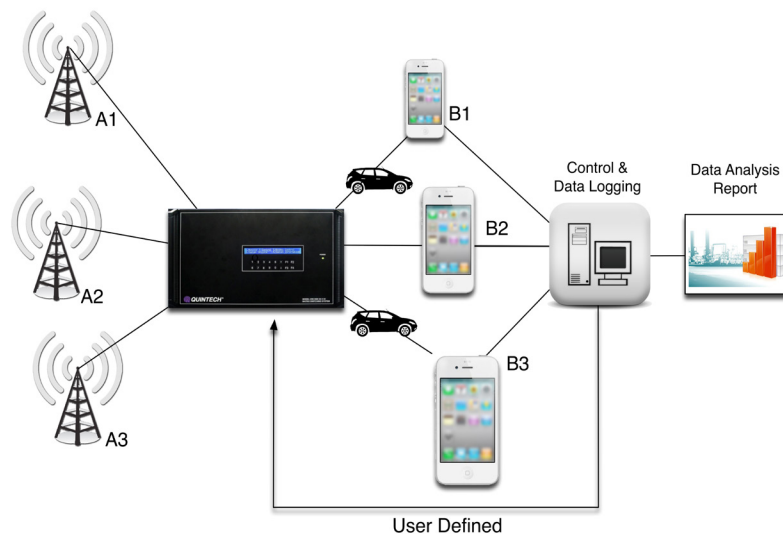
The *NEXUS* family of Matrix Switches allows for implementation of a variety of user equipment tests. Some of these include:

- **Cell Tower Handover**
- **Radio Receiver Compatibility Test - LTE, 3G, GSM, WiFi, UMTS CDMA**
- **Beam Forming Antenna Validation**
- **Multi-hop Mobile Topologies**

Cell Tower Handover Testing

To test that a handset is capable of performing handover as it moves between cells, the A side of the Matrix Switch is connected to two or more cellular radio signal sources as is shown in diagram below. A connection is made from the B side of the switch to an input of an RF chamber. The handset is placed in a RF shield chamber that shields out all RF signals, except those intentionally injected as part of the test. The Matrix Switch is configured to combine the two cellular radio signals on the B port that is connected to the RF chamber. Once the test is set up, the Matrix Switch is programmed to provide a strong signal from some base stations and a weak signal from others.

Cell Tower Hand Off Testing (Figure 3)



(fig. 3)

The signal level can then be fully controlled to simulate user movement within and between cells. A variety of scenarios and signal levels can be created to verify that the handset is capable of dealing with these situations.

Radio Receiver Compatibility

Handsets include several radio receivers that must be tested. These include cellular (GSM, CDMA, 3G, LTE), WiFi, GPS, and Bluetooth. Signal sources are required to test these receivers. These signal sources are connected to the A side of the Matrix Switch. During the test the signal sources can be selected individually or combined on the B side port that is connected to the RF chamber. (See Figure 3 above.)

Beam Forming Antenna Validation

Beam forming antennas help to optimize network coverage by directing coverage where it is needed most as part of a self optimized network (SON). A Matrix Switch allows test labs to connect multiple base stations and other network equipment to the same unit in order to emulate real world scenarios in the lab environment.

Multi-hop Mobile Topology Validation

Multi-hop wireless mesh networks, can be a very cost effective network for supporting large distributed communications, with applications ranging from mobile wireless broadband to Military usage. Testing mobility of mesh networks involves physically moving devices around the lab or using simulation techniques with questionable accuracy. Accurate test environments require a combination of the two. This is accomplished by putting wireless nodes into RF shielding enclosures. Antennas are removed and replaced with cables that connect wireless devices to matrix switches. Using these switches, devices can be interconnected with arbitrary attenuation creating diverse network topologies with complete reproducibility. With Ethernet interfaces, the switches can be reconfigured in milliseconds, changing connections and attenuations.

Software: Quintech Lab Automation And Management Package (Q-LAAMP™)

Computer control and software automation allow the full benefit of the *NEXUS* Matrix Switch to be realized in the wireless test equipment laboratory. The software allows multiple users to configure the switch, or their portions of it, to meet their test requirements using stored or scripted configurations.

Quintech Electronics proprietary *Q-LAAMP*™ laboratory automation management software provides the test laboratory the ability for a large number of individual users to test simultaneously using one Matrix Switch. This software allows dynamic partitioning of the matrix switch fabric by a lab manager or administrator. Access to the switch and test equipment resources is provided to each user on a scheduled basis for a bounded portion of the switch domain allowing test environment control by many simultaneous users within their domain. Each user can independently control their test resources using stored command sequences and batching capabilities of the *Q-LAAMP*™ software. All of these capabilities are presented through a user friendly GUI. This test lab management software allows for higher utilization of lab resources and more effective user test functions, bringing enhanced lab efficiencies and dramatic cost savings.

Conclusion; Keystone Attributes of the NEXUS Matrix Switching System

There are several *Keystone* attributes that a Matrix Switch brings to the test lab environment. These include equipment validation, interoperability testing, load testing, software verification and compliance testing. The Matrix Switch provides full fan-in fan-out MIMO (multiple input/multiple output) capabilities and provides superior switching speeds. The capability of the Matrix Switch, particularly when used with *Q-LAAMP*™ software, allows for enhanced switched lab resources by a large number of simultaneous users. It can replicate any input to multiple outputs and vice versa in a fraction of a second. A Matrix Switch also provides certain integrated functions such as variable attenuation, allowing the user to emulate multiple signals in order to best replicate the myriad real world scenarios. In this way, the *NEXUS* Matrix Switch enables *the emulation of free space in a controlled environment*.

Test lab management is transitioning to the Quintech Matrix Switch and *Q-LAAMP*™ to improve test lab

efficiency through the elimination of configuration errors, the elimination of cable fatigue, highly enhanced repeatability and reproducibility, improved verification time of UE and network equipment, leading to greatly improved time to market.

The *Keystone* qualities of the Quintech families of Matrix Switches allow for a rapid and effective transformation of the today's test laboratory to meet the needs for testing tomorrow's next generation wireless world.

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About Quintech Electronics and Communications, Inc.

Quintech, founded in 1989, designs and manufactures state-of-the-art proprietary hardware solutions (DC to 40 GHz) to facilitate RF signal management for satellite, uplink and downlink applications in satellite teleports, cable, HFC head-ends, broadcast, wireless and military telecommunications networks. Quintech specializes in industrial grade RF / microwave products for broadband, cable, satellite, L-band and all wireless frequencies. Quintech's product line includes rack mount RF matrix switches, routers, fiber optic links, splitters, combiners, frequency converters, relay switches, redundancy switches, line amplifiers, and DC powering products. Quintech products are known for their reliability and are deployed worldwide.

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