Automate mobile testing using an RF matrix switch

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This product how-to article shows how a Quintech RF matrix switching system can be used instead of traditional patch panel, splitters, and combiners to automate test beds for wireless testing. A test example shows an implementation at Alcatel-Lucent.

If a mobile broadband provider wants to be first to market with new services, higher bandwidths, and realize increased market share and margins over its competitors, then use of automated testing and simulation can be extremely beneficial. This advantage can easily be lost if the deployed service is limited in user equipment (UE) choices, unreliable, slower than advertised, limited in geographical access, not backwards compatible with older services, etc. Testing equipment interoperability, traffic load handling with burst and streaming data, base station handoffs, channel multiplexing, rain fade, etc., requires a more dynamic, reconfigurable test system than currently used for existing mobile voice testing.

Service providers and equipment manufacturers alike are facing the same problem: how to quickly and cost effectively test and debug the services of a planned network architecture when traffic load and signal levels can be quickly changing due to user density, terrain, geographical location of towers, and interference caused by building and other infrastructures for the mobile users.

Test beds are needed that allow service providers to create a reference network and then allows them to rapidly and consistently add and/or subtract network and UE as well as traffic and signal impairments. This control is achieved by transporting the mobile signals over RF coaxial cables and not through free space. RF cables provide high isolation between channels, reduce external noise issues, and prevent interference with commercial networks. Patch panels, splitters, and combiners are traditionally used to manually change signal paths in order to modify the network architecture with different number of base stations, UEs, network equipment, channel emulators, and signal analyzers. Use of patch panels becomes cumbersome as a high volume of connection changes are needed in short time periods, and the potential for incorrect connections (and possibly damaged connectors) lead to unrepeatable and erroneous results. Automating this task to speed the connection changes and minimize errors can be achieved by replacing the patch panel, splitters, and combiners with an RF matrix switching system.

Matrix Switch

The requirements for a matrix switch in the mobile broadband test system are: bidirectional signal handling, fully non-blocking connections, and high isolation between connections. Using a fully non-blocking switch, such as the QRB3000 solid-state matrix switch from Quintech Electronics, allows one or all input ports to connect to one or all output ports, and vice versa. This provides a full replication of free-space connections where signals may be combined or split. In other words, a non-blocking switch with 32 inputs and 32 outputs is able to make 1024 separate connections.
The QRB3000 solid-state matrix switch includes splitters, combiners, and programmable variable RF attenuators that allow the user to adjust the signal levels for each connection. A schematic diagram of the signal path through the QRB3000 is shown in Figure 1. By way of understanding its capabilities, the QRB3000 module has 32 input and 32 output ports in a 6RU chassis. The number of input and output ports can be expanded up to 256 input and 256 output ports by cascading the QRB3000 modules with splitting and combining expansion modules (a 32x64 system is shown in Figure 2). By expanding using splitters and combiners, each connection path will have approximately the same loss profile, reducing the need to recalculate the link budget for each connection.

**Figure 1. Block diagram of the signal path through the QRB3000 switch.**

**Figure 2. Expansion of the QRB to a 32x64 system.** Automated Test Systems

A mobile test bed can consist of the following setup shown in Figure 3. In this example, 2G, 3G, and 4G eNodeB and base stations (BTS) from various manufacturers are connected to the QRB3000 on the input ‘A’ ports. User equipment (UE) from various manufacturers are connected to the output
‘B’ ports.

Test analytical equipment, such as a signal generator, spectrum analyzer, signal level meter, channel analyzer, etc. are connected to the matrix switch. Each base station connection to the UE has its own variable attenuator. The attenuation level can be increased or decreased to emulate increasing or decreasing distance between the base station and UE. In addition, the attenuators can be simultaneously changed to emulate a moving UE and the associated distances between the UE and the base stations. Base stations and UEs can be added or subtracted from the test setup by reprogramming the matrix switch that can be controlled using automated software through the API.

Figure 3. QRB3000 RF matrix switch connecting base stations, UEs, and analytical equipment with any-to-any bi-directional connections.

Our results indicate that the time saved using a programmable matrix switch can be several hours as compared to manually reconnecting a patch panel. Since no cable connections are reconfigured, poor or broken connections are avoided, leading to more reliable and repeatable results. Previous configurations can be stored for future use setups. For example, isolation, Rx sensitivity or impaired signal tests can be rapidly configured by recalling the saved test setup (see Figure 4). Semi- or fully-automated testing is made possible using pre-programmed sequences to change the matrix configuration without manual intervention.
**Figure 4a.** Isolation test setup

**Figure 4b.** Rx sensitivity test setup
Automated Drive Path Test Example

The RF matrix switch is used by Alcatel-Lucent in their test beds for design and verification hardware testing and conformance testing. Alcatel-Lucent uses it to control both single and multiple antenna cell inputs and provide the spatial separation needed to each of their test stations to maintain full 4G bandwidths. Using automation software, the QRB3000 individually attenuates any cell input to any test station, allowing each tester to have its own “copy” of the cell RF to perform testing (see Figure 5). This allows Alcatel-Lucent to support both fully automated drive path scenarios as well as manual handoff tests.
Laboratory Management
As test labs are mostly shared resources, automating the laboratory can assist with scheduling users, maximizing equipment usage and minimizing configuration mistakes. A matrix switch can facilitate the lab management by enabling multi-user scheduling and assignment of equipment connected to it. A lab management software package, such as Quintech’s Q-LAAMP™ software, can be used to create users and assign ‘ports’ to them without the need to also schedule a technician’s time to reconfigure the patch panel. Figure 6 is an example of how the lab manager can configure a user with an assigned time. The assigned ports can be connected to network and analytical equipment, or, be unused to allow the user to add his/her own device under test (DUT). The lab administrator optimizes the test lab utilization between multiple users by eliminating the wait time normally associated with reconfiguring the equipment connections when using a manual patch panel, and minimizes the potential for incorrectly connected equipment, thereby reducing the need to rerun tests. Using this method, lab usage can be optimized to run 24/7 with minimized lab manager oversight.
Figure 6. Multiple users can be prescheduled to use the lab. The lab manager configures the matrix switch to automate the re-assignment of equipment.

An RF matrix switch in the test lab is the keystone automation tool needed to quickly reconfigure wireless test labs. Faster test sequences help to improve time to market, increase product quality by allowing more testing in the same period of time, eliminate product bugs, and increase the utilization of expensive test equipment. Multiple users are efficiently scheduled to use and share network and analytical equipment, allowing R&D, interoperability, load, software, and other testing teams to share the lab.

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