Solutions for

Testing LTE FDD and TDD Performance

Ensuring Simpler, More Cost-Effective Conformance Testing of LTE Base Stations

Application Note

Overview

The Long Term Evolution (LTE) specification is an evolution of the 3GPP UMTS standard to provide downlink peak rates of at least 100 Mbps, an uplink of at least 50 Mbps and radio access network (RAN) round-trip times of less than 10 ms. Its main advantages include high throughput, low latency, a simple architecture, and support for both frequency division duplexing (FDD) and time division duplexing (TDD). While the LTE specification is technically frozen, corrections and additions can still be made. Such changes make development of an LTE base station, also referred to as evolved Node B (eNB), challenging.

The goal of the 3GPP TS 36.141 standard is to determine the performance of the eNB physical layer's receiver (Rx) and transmitter (Tx). When determining Rx performance, the data to be transmitted is first processed by the transport channel, which adds forward error correction, interleaving and cyclic redundancy check (CRC) bits, among other things, before the data is modulated onto the individual subcarriers in the physical layer. The transport channel coding enables robust transmission and reception of data with the goal of recovering from errors that result from propagation conditions in the environment.

For the purposes of this application note, the discussion will focus solely on the Rx part of the 3GPP TS 36.141 conformance test. Section 7 tests measure the characteristics of the receiver, (e.g., sensitivity, selectivity, etc.), while Section 8 tests measure the receiver's performance.

Problem

Testing the FDD and TDD eNB Rx to the performance requirements (Section 8) of the 3GPP TS 36.141 is today typically accomplished using an expensive LTE user equipment (UE) simulator that supports Layer 1 and higher layer protocols. While this solution does generate the required wanted signals for all RF conformance tests, it is really geared more toward testing the protocol layers of the base station and therefore lacks some of the things necessary for conformance testing, such as the ability to add additive white Gaussian noise (AWGN), fading and interfering signals. Moreover, it requires a complex cabling reconfiguration for each conformance test and is very costly (e.g., it provides the wanted signal at a cost of approximately $500k, but the MIMO fading capability for independently fading the wanted and interfering signals with an external RF fader is an extra charge). Making the UE simulator a complete conformance test solution requires the addition of other pieces of test equipment, such as an external channel emulator for fading as well as LTE and CW interferers, since once the interfering signals are generated, they must be faded independently of the wanted signals and then combined, creating a multi-user MIMO channel configuration.

Agilent Technologies

Solution

Today's engineers demand a simpler, more cost-effective approach to performing LTE eNB FDD PHY layer Rx conformance tests; one that generates both the required sophisticated signals (e.g., AWGN and interfering signals at various modulation bandwidths and types), and special test configurations required by the LTE specification.

One way to address this challenge is through the use of a baseband generator capable of generating real-time LTE signals and channel emulation, in conjunction with a signal generator and associated software. Such a set up enables the real-time LTE signal generation that is necessary to create the required dynamically changing LTE signals from feedback provided by the eNB under test along with interfering signals as required by the standard. It also provides the flexibility for engineers to perform customizable functional testing and in-depth troubleshooting that goes beyond conformance, when problems arise. As a result, potential problems can be quickly located, diagnosed, verified, and solved.

A prime example of just such a solution is Agilent Technologies' N5106A PXB baseband generator and channel emulator, N5182A MXG vector signal generator and Signal Studio software for 3GPP LTE. Together, these tools offer the ideal solution for addressing eNB LTE Rx conformance test challenges (Figure 1). The PXB is a fully-integrated solution for testing eNB receivers in realistic wireless channels and conditions. It features multi-channel baseband generation, real-time fading and signal capture for the ability to have repeatable playback on important test signals. The MXG signal generator upconverts LTE baseband signals with interferers and channel emulation from the PXB to RF. Digital IQ outputs are provided by a digital signal interface module. Signal Studio software for 3GPP LTE runs inside the PXB, enabling real-time creation of standards-based 3GPP LTE signals compliant with the 3GPP Release 8 Dec 2009 version. It creates all required wanted signals for receiver characteristics and performance requirements, including closed-loop requirements.

Each LTE conformance test requires a slight variation in generated signals. This might include different bandwidths, modulation types, resource block assignments, power levels, AWGN C/N ratios, fading models, and the number of interfering signals which must be presented to the Rx ports of the receiver. With its flexibility, the PXB with MXG and Signal Studio can easily accommodate the required variations.

When a problem occurs while completing the conformance tests, Signal Studio offers a number of options for testing and troubleshooting beyond conformance. Such options include a waveform playback capability with an extremely flexible parameter adjustment for troubleshooting of physical layer and transport channel coding issues. An additional capability is the real-time LTE signal creation which enables the creation of dynamically changing LTE signals based on feedback from the eNB under test.

Key features of Agilent's PXB with MXG and Signal Studio solution that make it ideal for LTE eNB conformance testing are that it:

- Completely addresses all eNB RX tests.
- Generates all the wanted and interfering signals.
- Features automatic power calibration which eliminates issues associated with combining external signals from multiple RF faders in traditional configurations (when testing in 4x2 or 2x4 configurations).
- Quickly and easily switches between all test configurations including 2x2, 2x4 and 4x2 multi-user MIMO configurations in one instrument.
- Includes predefined setups for LTE signals and fading models.
- Adds calibrated AWGN after fading.
- Offers a lower overall cost due to its integration of signal creation, fading, and AWGN.

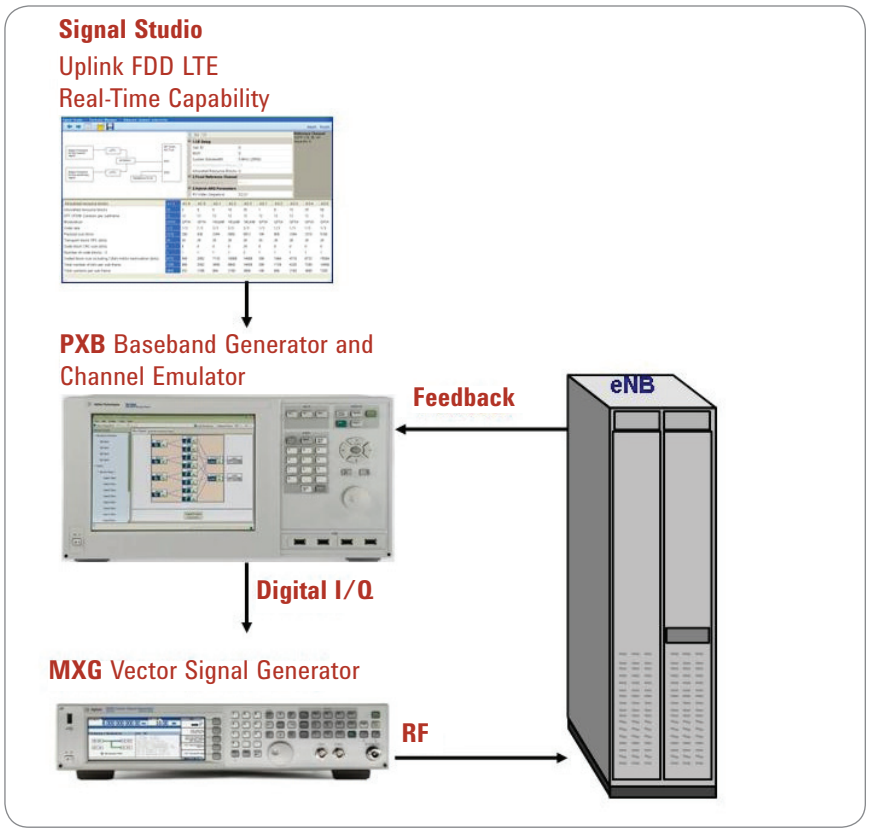

FIGURE 1: *The PXB combined with the MXG and Signal Studio software enables efficient LTE eNB conformance testing.*

As an added benefit, by utilizing the PXB with MXG and Signal Studio solution, the reconfiguration of equipment for testing complex configurations can be done quickly, easily and cost effectively. With one PXB unit, over 20 configurations can be constructed to meet the engineer's test needs. These configurations, along with external instrument connections, can be redefined in seconds using the instrument user interface, thereby eliminating the time-consuming work of recabling instruments (Figure 2). Signal routing, summing, sync, and calibration are all managed seamlessly inside the PXB.

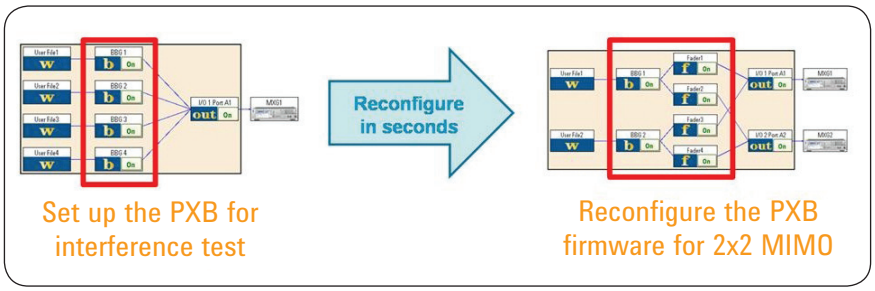

FIGURE 2: *The PXB supports over 20 configurations, up to 4x2 MIMO, that can be redefined in seconds.*

Closed Loop Feedback

Closed loop feedback is a critical element in three tests specified in the performance requirements section (Section 8) of 3GPP TS 36.141. These tests require closed loop control of the redundancy version (RV) index based on hybrid automatic repeat request (HARQ) feedback and RF frame timing based on uplink (UL) timing adjustment feedback. Testing the HARQ feedback and uplink timing adjustment requirements on LTE eNBs in a reliable, closed loop manner can be a tricky proposition.

Luckily, the PXB with MXG and Signal Studio supports all eNB Rx conformance tests, including closed loop requirements. It accepts closed loop feedback for HARQ acknowledged/non-acknowledged (ACK/NACK) signals and timing adjustment feedback. Essentially, one of the baseband generators in the PXB is configured to generate real-time LTE FDD or TDD signals using the Signal Studio software. As part of this capability, the PXB can accept HARQ and timing adjustment feedback from the eNB and then create dynamically changing signals based on that feedback. This wanted signal is then independently faded with the required interfering signals (in the appropriate multi-user MIMO channel model) and subsequently, summed together (Figure 3).

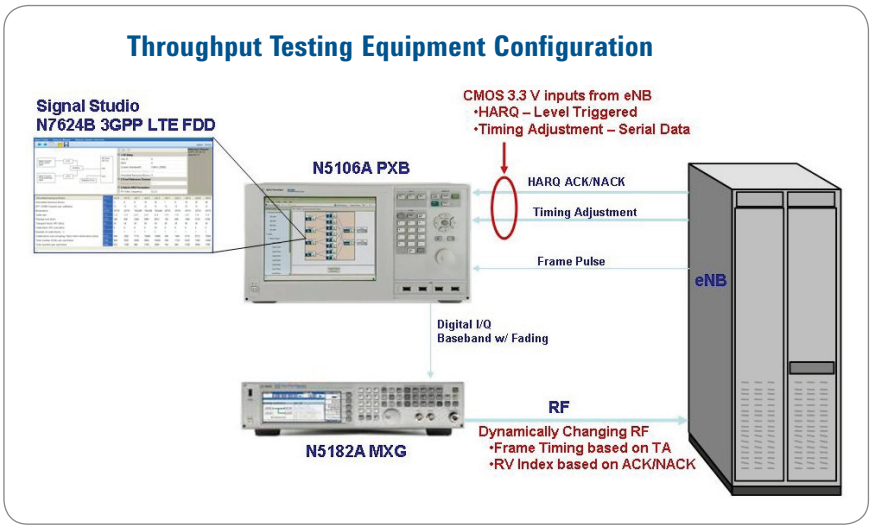

FIGURE 3: *The set up shown above of the PXB with MXG and Signal Studio software can be used to perform HARQ and timing adjustment tests in a closed loop manner. Note that while this figure depicts feedback coming over two lines, the signals can be combined into one line, an especially useful ability for eNB hardware that have a limited number of input/output ports available.*

Summary of Results

Conformance testing is a fact of life for engineers developing LTE base stations. While UE simulators can be used to accomplish this goal, a solution comprised of a baseband generator, signal generator and associated software, offers a simpler, more flexible and cost-effective alternative. The PXB solution with MXG signal generator and Signal Studio software from Agilent Technologies offers one such solution for Rx conformance testing. It supports the sophisticated signals required for LTE eNB FDD and TDD conformance testing, as well as special test configurations (e.g., closed-loop feedback). Moreover, the flexibility offered by the PXB with MXG and Signal Studio enables troubleshooting and testing beyond conformance tests.

The Power of X

The Agilent PXB Baseband Generator and Channel Emulator and MXG Signal Generator are key products in Agilent's comprehensive Power of X suite of test products. These products grant engineers the power to gain greater design insight, speed manufacturing processes, solve tough measurement problems, and get to market ahead of the competition.

Offering the best combination of speed and scalability, and created and supported by renowned worldwide measurement experts, Agilent's X products are helping engineers bring innovative, higher-performing products to emerging markets around the globe.

To learn more about Agilent's suite of X products please visit:
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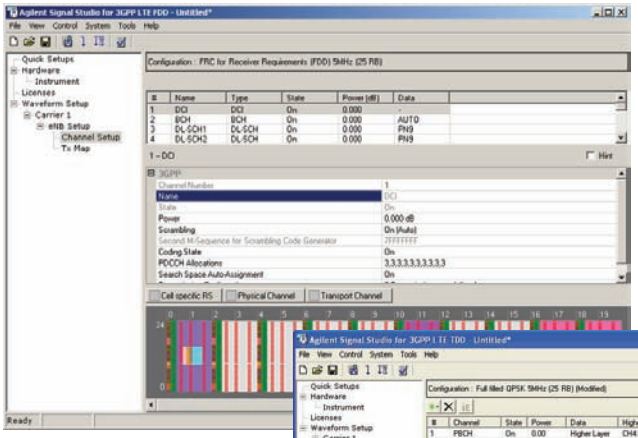
Related Applications

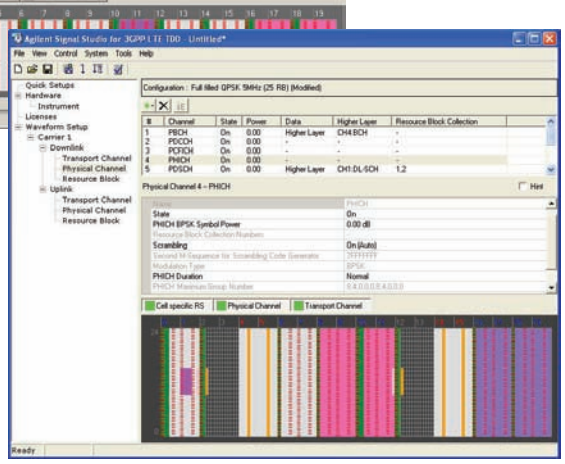
- Multi-channel performance signal generation
- Co-existence and interference testing
- Baseband and RF channel emulation
- General purpose R&D

Related Agilent Products

- N5182A MXG RF Vector Signal Generator
- N7624B Signal Studio for 3GPP LTE FDD
- N7625B Signal Studio for 3GPP LTE TDD
- N5106A PXB Baseband Generator and Channel Emulator



Signal Studio for 3GPP LTE FDD



Signal Studio for 3GPP LTE TDD

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