Continuing in the direction of LTE-Advanced: the latest test signals for LTE Rel. 9

Vector signal generators from Rohde&Schwarz are keeping up the pace – with LTE Release 9, the latest evolution stage of the mobile radio standard toward LTE-Advanced (Release 10). The new K84 option adds the new dual-layer beamforming, MBSFN and LTE positioning features to the generators.

LTE development – always staying up front

The LTE standard needs to meet the increasing demand for mobile communications and higher data rates (see box on page 13). Therefore, it must be continuously enhanced while networks are expanded. There is a general desire for better utilization of available resources, particularly in the downlink direction, which means increased effective cell capacity. Moreover, network operators intend to offer mobile television via their LTE networks in future. For example, scenarios are conceivable in which a base station smoothly switches from an IP-based live stream for an individual user to a broadcast operating mode as soon as a certain number of users are watching the same program. It must also be possible to reliably determine the location of user equipment (UE). On the one hand, this results from governmental regulations, which require rapidly locating subscribers in the event of an emergency. On the other hand, network operators want to use accurate position information to improve their resource management and clear the way for location-based services, which will be a source of future revenue. With Release 9 the LTE standard has been expanded in order to meet the requirements that have arisen since Release 8. There are three new main features in the downlink direction regarding the physical layer: dual-layer beamforming (transmission mode 8), multicast broadcast single frequency network (MBSFN) and LTE positioning.

Dual-layer beamforming (transmission mode 8)

Beamforming is mainly used to provide users with a better service at the cell boundary. In order to do this, the transmit signal is sent out in the direction of the user via several

The antenna ports in the LTE standard

The 3GPP TS 36.211 LTE standard defines antenna ports for the downlink. An antenna port is generally used as a generic term for signal transmission under identical channel conditions. For each LTE operating mode in the downlink direction for which an independent channel is assumed (e.g. SISO vs. MIMO), a separate logical antenna port is defined. LTE symbols that are transmitted via identical antenna ports are subject to the same channel conditions. In order to determine the characteristic channel for an antenna port, a UE must carry out a separate channel estimation for each antenna port. Separate reference signals (pilot signals) that are suitable for estimating the respective channel are defined in the LTE standard for each antenna port. FIG 1 shows the antenna ports defined in the LTE standard in Releases 8 and 9.

The way in which these logical antenna ports are assigned to the physical transmit antennas of a base station is up to the base station, and can vary between base stations of the same type (because of different operating conditions) and also between base stations from different manufacturers. The base station does not explicitly notify the UE of the mapping that has been carried out, rather the UE must take this into account automatically during demodulation (FIG 2). As far as

Antenna port	Downlink reference signal (RS)
Ports 0 to 3	cell-specific reference signals (CS-RS)
Port 4	MBSFN-RS
Port 5	UE-specific reference signals (DM-RS): single layer (TX mode 7)
Port 6	positioning reference signals (PRS)
Ports 7 and 8	UE-specific reference signals (DM-RS): dual layer (TX mode 8)

FIG 1 The antenna ports defined in the LTE standard in Releases 8 and 9.

antennas with individual phase offset. The transmit power is concentrated at the UE, which increases the signal-to-noise ratio and reduces interference from other users in the cell. This operating mode can be achieved most efficiently in TDD mode, in which the same frequency is used for uplink and downlink. The effort for channel estimation is minimized since the uplink and downlink channels can be assumed to be identical. Accordingly, 3GPP defines beamforming for TD LTE as obligatory, and as optional in FDD mode.

It is already possible to set up a beamforming connection in Release 8 using transmission mode 7 (single-layer beamforming). In Release 9 this procedure is consistently enhanced by the newly introduced transmission mode 8: It is now possible to transmit not just one data stream, but two. Alternatively it is also possible to split the two data streams between two users, which is referred to as multi-user MIMO (MU MIMO).

The two data streams are transmitted via logical antenna ports 7 and 8 (for more antenna port information, see box below). It is good practice to map each logical antenna port onto several (typically four) physical antennas, since this is the only way to achieve the required directivity. Since these signals are now potentially sent out via different antennas than those used for cell-specific reference signals (CS-RS), new UE-specific reference signals have been defined for channel estimation in Release 9. The new 2B DCI format has also been introduced for signaling transmission mode 8.

Unstoppable trend toward more mobile communications and higher data rates

The mobile radio market is dominated by two trends: on the one hand, user equipment is becoming increasingly powerful, meaning that modern smartphones and tablet computers will take over from traditional PCs in many applications in future. This means that there is an increasing demand for networking the UE. On the other hand, the demands placed on mobile radio networks with regard to data throughput are increasing continually. Fast mobile access to information is required. In order to keep up with these developments, many network operators recognize the potential of the LTE standard. According to GSA, the Global Mobile Suppliers Association, 24 commercial LTE networks are already operating worldwide, and another 142 are being set up. In total, 218 network operators in 91 countries are investing in the mobile radio standard of the future – in LTE*.

* Evolution to LTE report confirms 218 operators investing in LTE; 24 commercial networks; GSA – The Global Mobile Suppliers Association; http://www.gsacom.com/news/gsa_334.php4, July 6, 2011.

measurements are concerned, this means that a signal generator must provide sufficient flexibility for LTE so that mapping is user-adjustable, and realistic tests can be performed (FIG 3).

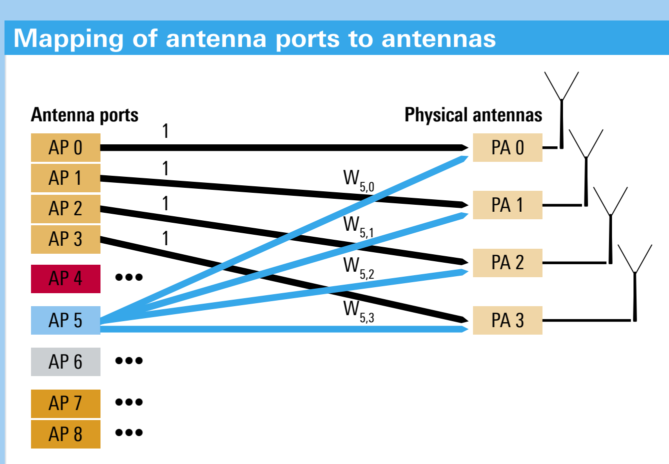

FIG 2 Mapping of logical antenna ports to physical transmit antennas.

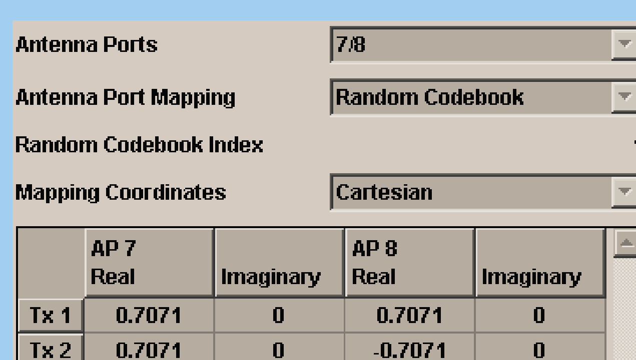

FIG 3 Mapping of antenna ports in a signal generator from Rohde&Schwarz. In this example, random codebook selection for mapping antenna ports 7 and 8 for testing dual-layer beamforming under realistic, dynamically changing conditions.

This development results in the need to test the design of user equipment for conformity with the standards and its performance, particularly with regard to dual-layer beamforming. In order to ensure that the UE really uses the correct reference signals for demodulation, a phase rotation used on all subcarriers that are sent out from antenna ports 7 and 8 can be defined in the new K84 option. This precoding can take place either statically or randomly, and variably over time. It is just as simple with Rohde&Schwarz signal generators to check whether data can also be correctly received in MU MIMO operating mode if a transmit signal for another UE on the same time and frequency resource is interfering with the receive signal. This means that the relevant UE performance tests (which are defined in 3GPP TS 36.521 Part 1) can be carried out using the K84 option in an open loop, i.e. without a HARQ mechanism, in the usual user-friendly way.

MBSFN

With multicast broadcast single frequency network (MBSFN), often referred to as eMBMS, mobile television is integrated in the LTE mobile radio operation. Network operators can provide appropriate services parallel to mobile radio without the need for special transmitter hardware. This is achieved by the temporal distribution of the available resources on regular and MBSFN subframes. MBMS is already known from UMTS Release 6, but has been continuously and considerably enhanced with Release 9 at both the physical and the protocol level. Several synchronized LTE cells transmit identical signals on the same frequency in the MBSFN subframes, making the receive signal appear to have been transmitted from a single base station at the UE (single frequency network). This allows significantly better network coverage up to the cell boundary, and ensures interference-free video transmission.

MBSFN has a major impact on the implementation of the physical layer in the UE. Appropriate MBSFN subframes are subdivided into an MBSFN area and a non-MBSFN area, and can therefore potentially use a different cyclic prefix. The UE must also be able to detect a new physical channel (PMCH) and appropriate reference signals (MBSFN-RS) by introducing antenna port 4. All this can be tested for conformity with standards using the K84 option.

A new measuring task results from the identical transmit signal that is transmitted synchronously by several base stations. Depending on the position of the UE, the signal from the base stations arrives at the UE at different times. Due to the cell size, a significantly greater time offset occurs than with multipath propagation in normal LTE operation. This problem is taken into account by the longer cyclic prefix (extended CP) that is defined in LTE, which has to be verified accordingly when designing of the UE.

Fading scenario for three cells

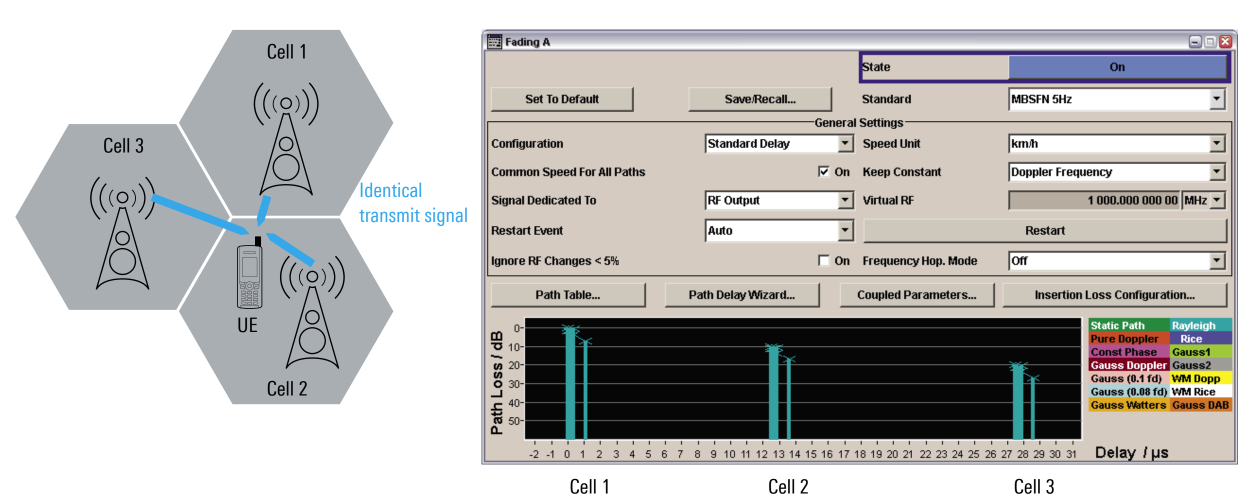

FIG 4 Predefined fading scenario in the R&S®SMU200A vector signal generator for simulating three MBSFN cells.

By using the R&S®SMU200A vector signal generator and its integrated fading simulator, it is easy to simulate several LTE cells with individual signal delays. For configuration purposes it is sufficient to load an appropriate predefined scenario as shown in FIG 4.

LTE positioning

Extremely accurate position fixing can be carried out using GPS/A-GPS, provided that there is a good line of sight to the satellites. However, the line of sight is often inadequate in urban areas and buildings. Localization via the radio cells that are visible to the UE is always available, but position estimation is rather inaccurate. In Release 9 the OTDOA approach has been further enhanced with the introduction of dedicated positioning reference signals (PRS). The UE measures the relative delay of at least three base station signals and reports these to a location server. The position of a mobile phone can be determined by means of triangulation, similarly to GPS. In principle, this also works with normal cell-specific reference signals from Release 8, but PRS provides significantly greater accuracy.

For their Release 9 designs, the manufacturers of LTE UE must test whether the UE can receive the PRS in a way that conforms to the standards, and can carry out delay measurements of different base station signals. Both tests are easy to perform with the K84 option.

Owing to the two-path architecture of the R&S®SMU200A vector signal generator, the complex test setup that is usually required for this kind of testing is simplified. A single instrument can simulate two base stations with independent channel simulation including fading, AWGN and a definable time offset. If a simple, static channel model is sufficient, almost any number of LTE cells can be generated in one path of the R&S®SMU200A. This makes it possible to generate a suitable GPS scenario for multistandard tests in the second path.

Summary

The proliferation of the LTE standard is progressing rapidly, with Release 9 as the basis for the subsequent success of LTE-Advanced. By using the new K84 option, the signal generator family from Rohde&Schwarz keeps up pace with this development and provides a wide variety of measuring options to meet the diverse LTE Release 9 requirements.

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Abbreviations

3GPP	3rd Generation Partnership Project
A-GPS	Assisted-GPS
AWGN	Additive white Gaussian noise
DCI	Downlink control information
eMBMS	enhanced multimedia broadcast multicast service
FDD	Frequency division duplex
GPS	Global positioning system
LTE	Long term evolution
MBSFN	Multicast broadcast single frequency network
MIMO	Multiple input multiple output
MU-MIMO	Multi-user MIMO
OTDOA	Observed timing difference of arrival
PRS	Positioning reference signals
TDD	Time division duplex
UE	User equipment
UMTS	Universal mobile telecommunications system

The following generators and software from Rohde&Schwarz are up to date for measurements in line with LTE Release 9:

- **R&S®SMU200A vector signal generator**
- **R&S®SMJ100A vector signal generator**
- **R&S®SMATE200A vector signal generator**
- **R&S®SMBV100A vector signal generator**
- **R&S®AMU200A baseband signal generator and fading simulator**
- **R&S®WinIQSIM2™ simulation software**