

LTE

7100 Radio Channel Emulation for LTE User Equipment Testing

AEROFLEX
A passion for performance.



- Fading and AWGN option for 7100 Digital Radio Test Set
- Meets or exceeds all requirements for LTE fading tests
- Highly flexible with no manual RF reconfiguration required
- Emulates static and dynamic signal environments
- Cost-effective solution supporting complex test scenarios
- Provides realistic, accurate and repeatable testing of MIMO configurations

The dynamically changing radio channel between cell-site and user equipment is as variable as the location and velocity of the user. The ability of the user equipment to adapt to this changing environment is poorly covered in conformance tests, owing to the limitations of traditional test equipment.

In WCDMA, 3GPP addressed this issue with the introduction of tests using moving and transient paths (see 3GPP TS 34.121-1 Annex D). The scenarios have been extended for LTE (refer to 3GPP TS 36.521-1 Annex B). This allows a limited test of the user equipment dynamic capability, but is still a step removed from a realistic scenario. The Aeroflex 7100 Fading and AWGN Option covers all the scenarios required by the 3GPP specifications plus extends this to provide a complete simulation of real-world signal conditions on the engineer's test bench.

As well as the traditional Rayleigh or Doppler path gain variation, the Aeroflex radio test platform extends dynamic testing in the following ways:

- The user may have a periodically time varying velocity relative to the cell-site.
- All taps may have a periodically time varying average gain.
- All taps may have a time varying delay, either periodic or pseudo-randomly chosen.
- Log-normal gain variations may be added to all taps to simulate the time-varying shadows created by physical obstacles.

The fading simulator configuration is updated every fraction of a millisecond, to give the effect of a smoothly changing environment. The use of powerful DSPs to calculate the new configuration means that updates can be real-time from the combined effects of velocity, gain and delay – there is no need to cycle through a limited table of parameters. The patterns of variation of velocity, gain and delay can be completely unrelated so that the overall period of environmental variation is arbitrarily long. All patterns are seeded in such a way as to be precisely repeatable.

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This datasheet describes the Aeroflex approach to radio channel emulation for testing LTE user equipment. It starts by describing traditional methods of radio channel emulation, then goes on to describe the solution used in the Aeroflex 7100 radio test platform. It will be shown that the Aeroflex platform allows realistic testing of LTE user equipment in a way that is impractical with traditional methods.

The purpose of the fading simulator and noise generator is to modify the signal transmitted by the Base Station Emulator, to emulate degradations introduced by the radio channel. This is illustrated by the following figure.

In reality, there are an infinity of paths between the transmitter and receiver. For the purposes of radio channel emulation the following simplifications are available:

- Transformations at RF may be equivalently applied to baseband signals.
- Paths that have significantly greater loss than the “best” path have negligible effect on the received signal quality therefore need not be emulated.
- Paths that have a large delay will also suffer large losses, therefore need not be emulated.
- Paths with a similar delay (within a delay range of $\sim 0.1/F_s$) where F_s is the bandwidth of the transmitted signal, can be treated as carrying the same baseband data, but having different carrier phase which changes as the receiver moves. If the carrier frequency $F_c > F_s$, combining these paths gives a random path gain which is time variable with Rayleigh statistics.
- The time variation of the Rayleigh path gain is related to relative movement between transmitter and receiver. This leads to Doppler (frequency shift) effects. If the Doppler frequency $F_d < F_s$, then the time variation of the path gain can be applied at a low sample rate compared to F_s and will have negligible effect on the bandwidth of the time varying signal.

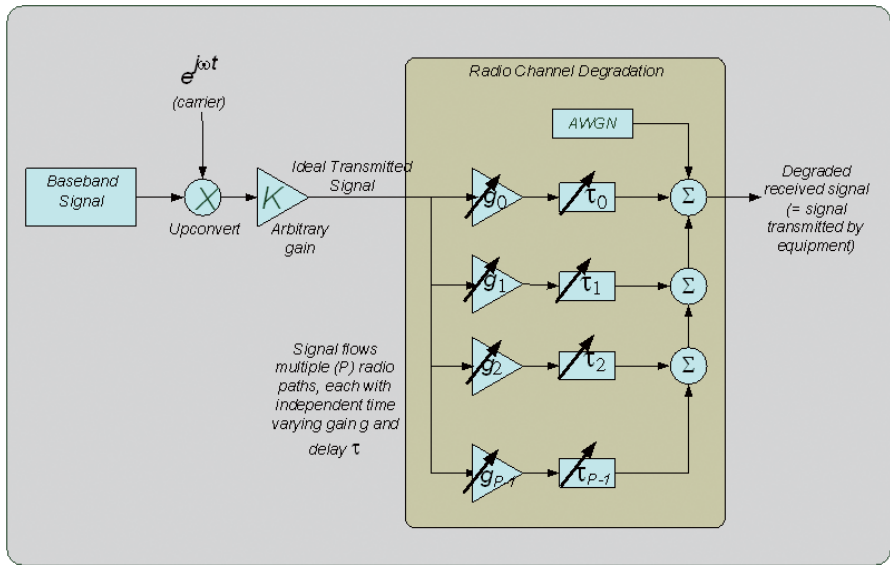


Figure 1

Traditional Methods of Radio Channel Emulation

Radio channel emulation traditionally involves two external components, a fading simulator and an AWGN source. They are used for testing as shown in the figure below. The fading simulator mimics the time-varying radio paths between the cell-site and the user equipment, and the AWGN generator emulates other cells or users providing interference.

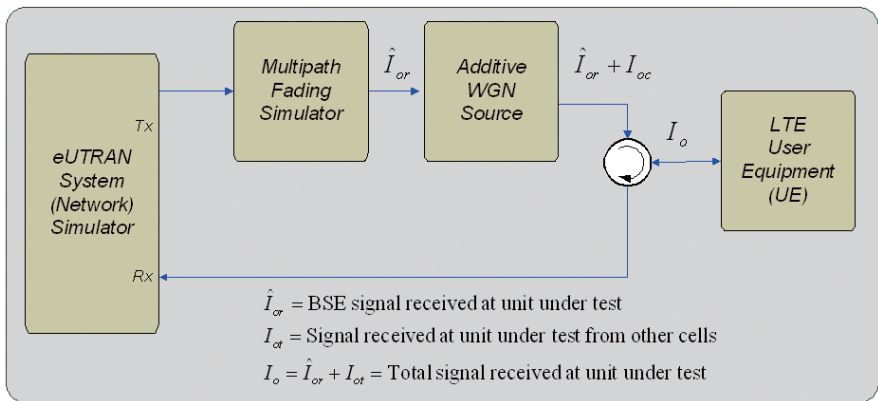


Figure 2

The traditional method has the following problems and challenges:

- Expensive extra components are required, and additional software to control and coordinate them.
- All subject to uncertainty – careful calibration required.
- Insertion loss and delay of external components.
- Manual changes in connectivity required for different tests.
- Limited number of independently faded RF channels – poorly suited to testing in soft handover (UMTS), antenna diversity and multiple-input, multiple-output (MIMO) scenarios.
- Analog components degrade the quality of the signal.
- It is difficult or impossible to run precisely repeatable tests.

The Aeroflex solution addresses all of these problems.

The Aeroflex 7100 Radio Test Platform



Figure 3 The Aeroflex 7100 Radio Test Platform

This platform is intended for Protocol and RF performance tests of LTE user equipment, and ultimately cdma2000 (1xRTT and eHRPD) and UMTS/HSPA+ mobiles. For further details on the capability of this platform, please contact wireless@aeroflex.com regarding the 7100 product.

7100 Platform Baseband Processing

Each baseband module in the 7100 platform is a Micro-TCA card consisting of several general purpose processors (GPPs), digital signal processors (DSPs), a large field-programmable gate array (FPGA) and a bi-directional high-speed digital link.

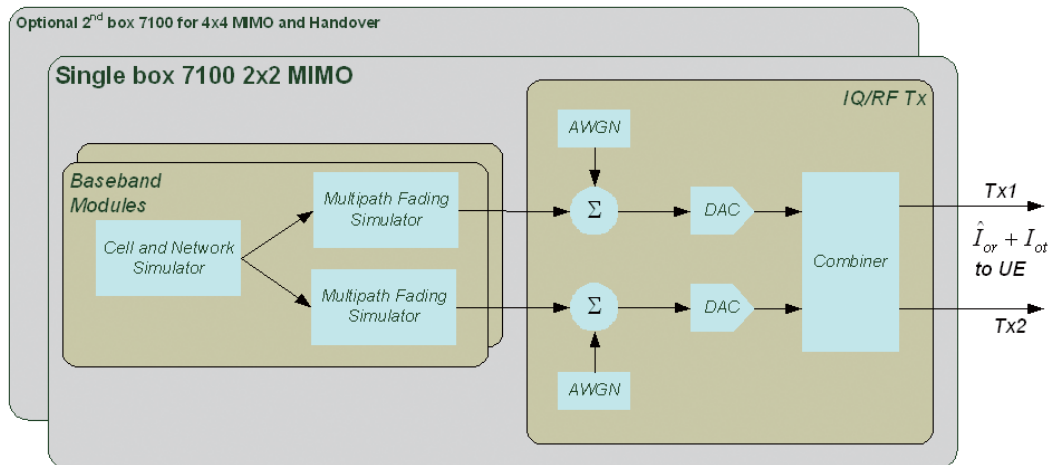


Figure 4

The baseband modules produce baseband samples representing the output of one or many cells, SISO or MIMO. The AWGN is added to the signal before it arrives at the RF module to emulate other interfering cells. This is an all digital solution: the addition of fading and noise has not introduced any new analog components. This minimizes any calibration issues and user-defined seed values make the signal passed to the analog components totally repeatable, right down to the LSB of every sample.

7100 Platform Multipath Fading Simulator

The multipath fading simulator in each baseband module is illustrated in the below figure. Each baseband module provides support for up to nine fading taps, where each tap applies independent time-varying gain and delay to the transmitted signal.

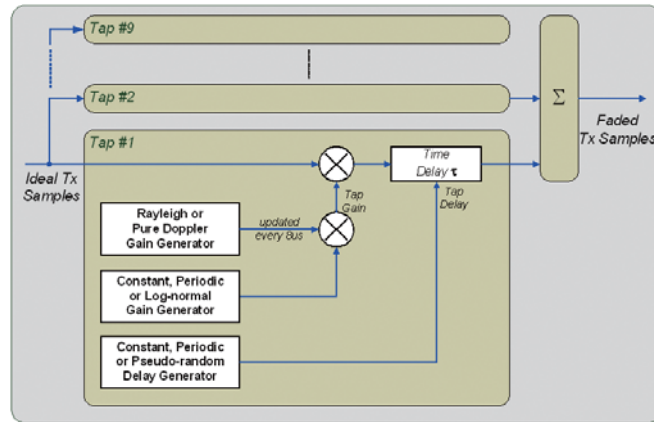


Figure 5

Flexible and Scalable Deployment for Realistic LTE Scenarios

The Aeroflex radio test platform was designed to have a scalable baseband and RF resource. As fading is applied in the baseband modules, fading is also a scalable resource. Additional 7100s can be used to provide extra cells, extra antennas or extra fading taps, with minor change to physical connectivity.

# LTE Cells	Antennas per Cell	Antennas per UE	Channels required in traditional RF fading simulator	External fading simulators required for equivalence (20-taps/2 RF channels)
1	1	1	1	2
2	1	1	2	2
1	2	2	2	4
1	2	2	4	4
1	4	2	8	8

The above shows how difficult it is to emulate complicated scenarios using conventional test equipment. The highlighted case for two transmit and receive antennas and nine paths between each pair of transmit and receive antennas is an extremely realistic scenario for an LTE network. Yet it requires no fewer than four dual-channel external fading simulators and eight RF transmitters to perform this test. Even when all the fading simulators have been assembled and coordinated, the power level uncertainties between the multiple units and RF transmitters may make the results of the test too inaccurate to be useful.

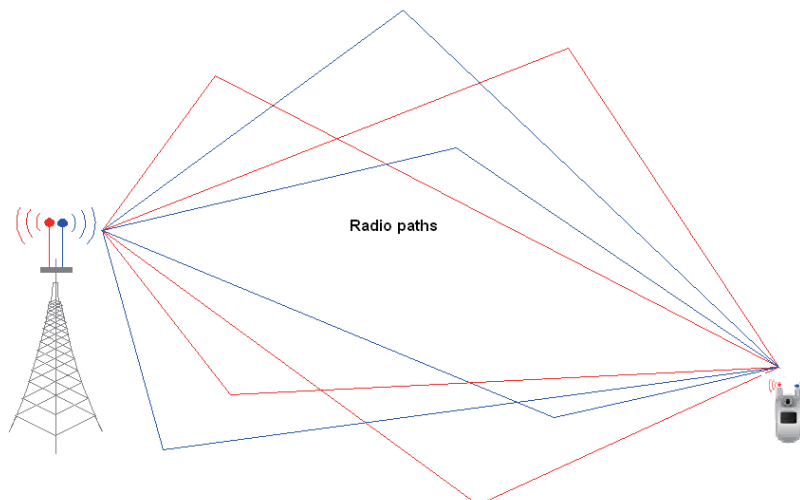


Figure 6

User equipment developers are therefore forced to test realistic scenarios in software simulation. When it comes to conformance testing of the implementation, simplified scenarios are normally used because of the limitations of traditional test equipment. The performance of the user equipment in realistic scenarios must then be inferred from the simple test results. This is highly unsatisfactory. The Aeroflex approach of emulating all cells, antennas and paths in the digital domain and combining before analog to digital conversion means that there is no loss of accuracy when emulating realistic scenarios.

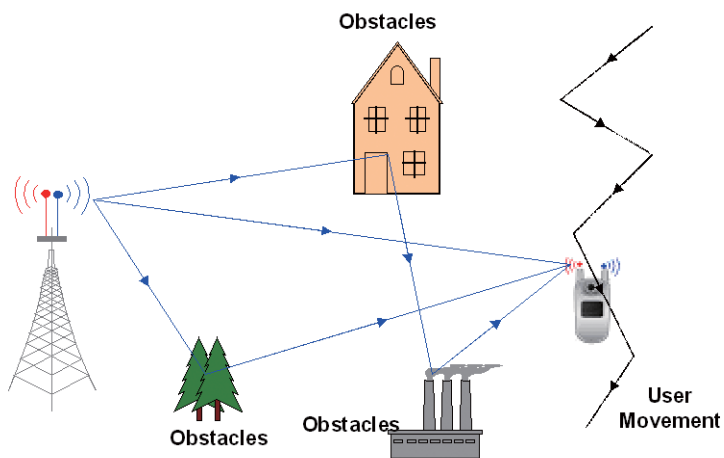


Figure 7

SPECIFICATION

Number of taps supported

9

User equipment velocity

0 to 1000 km/h

Resolution 0.1 km/h

Accuracy ± 0.03 km/h

Tap mean gain

0 to -40 dB or OFF

Resolution 0.01 dB

Accuracy ± 0.05 dB

Tap reference phase

0 to 359.99°

Resolution 0.01°

Accuracy $\pm 0.5^\circ$

Tap complex gain variation

None

Pure Doppler:

Bearing angle 0 to 359.99°

Resolution 0.01°

Accuracy $\pm 0.01^\circ$

Rayleigh:

Classical Doppler spectrum

Flat spectrum

Tap real gain variation

None

Log-normal:

Feature Spacing 1 to 10000 m

Resolution 1 m

Accuracy ± 1 m

Standard Deviation 0 to 10 dB

Resolution 0.1 dB

Accuracy ± 0.1 dB

Periodic:

Sinusoidal, Square or Triangular Wave

Period 1 ms to 1 hr, resolution 1 ms

Range as per tap mean gain range

Tap delay

0 to 30 μ s

Resolution 1 ns

Accuracy ± 1 ns

Tap delay variation

None

Random Set:

Selected from 2 to 256 uniformly distributed delays

Update period 1 ms to 1 hr, resolution 1 ms

Range as per tap delay range

Periodic:

Sinusoidal, Square or Triangular Wave

Period 1 ms to 1 hr, resolution 1 ms

Range as per tap delay range

AWGN properties

Relative level accuracy ± 0.1 dB

Bandwidth:

1× radio system bandwidth

1.4× radio system bandwidth

Notes:

1. All BWs including the 20 MHz BW are supported
2. Tapped delay line models up to 9 taps
3. Support for multi-antenna model
4. Support for high speed train scenario

Better than the specs in all of the below figures:

Delay range	20 μ s per 1 ns resolution (3GPP requirement 5 μ s)
Doppler range	1 kHz per 0.01 Hz resolution (3GPP requirement ~750 Hz)
Tap gain range	>40 dB per 0.01 dB resolution (3GPP requirement 21 dB)

ORDER INFORMATION

7100-101 Fading and AWGN

Can be ordered at time of purchase or as a customer-installable software upgrade for units already in the field.

Requires 7100 Digital Radio Test Set with Option 01 installed.

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