# LTE Resource Guide

Lte™

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## Abstract

Most major mobile carriers in the United States and several worldwide carriers have announced plans to convert their networks to Long Term Evolution (LTE), the next generation of radio technologies designed to increase the capacity and speed of mobile networks. LTE uses Orthogonal Frequency Division Multiple Access (OFDMA) for the downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) for the uplink. Anritsu offers a complete line of LTE test equipment that ensures the performance and quality of your LTE equipment and networks. The MD8430A signaling tester is the first complete LTE Base Station Emulator. The MF6900A Fading Simulator provides a reproducible fading environment which is essential for evaluating LTE. The MS269xA Signal Analyzer provides LTE uplink and downlink analysis and the MG3700A Vector Signal Generator produces realistic and reproducible LTE signals. The LTE IQProducer software provides a graphical interface that lets the user easily generate LTE compliant waveforms.

## References

All 3rd Generation Partnership Project (3GPP) TS 36 series standards are available at http://www.3gpp.org/ftp/Specs/html-info/36-series.htm.

- 3GPP TS 36.101: User Equipment (UE) radio transmission and reception
- 3GPP TS 36.201: Physical layer - general description
- 3GPP TS 36.211: Physical channels and modulation
- 3GPP TS 36.212: Multiplexing and channel coding
- 3GPP TS 36.213: Physical layer procedures
- 3GPP TS 36.214: Physical layer - measurements
- 3GPP TS 36.300: Overall description 3GPP TR 36.803 User Equipment radio transmission and reception
- 3GPP TR 36.804: Base Station radio transmission and reception
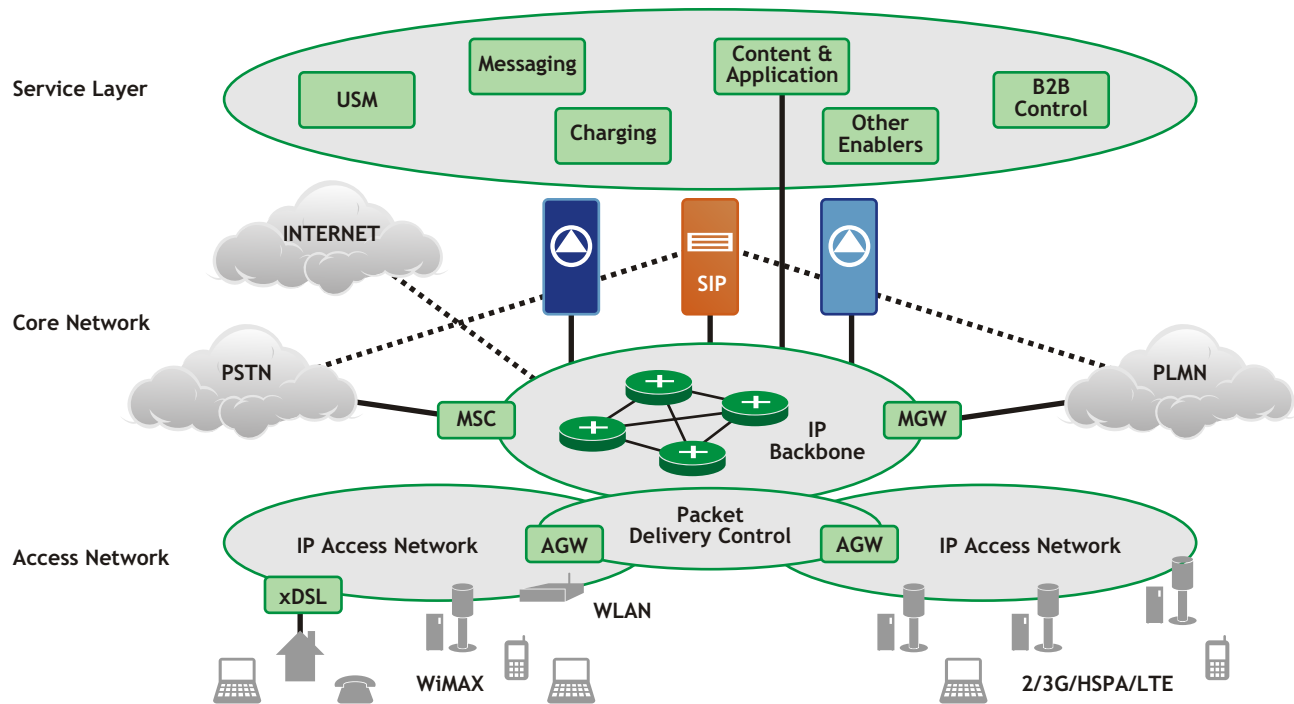
# LTE - The de facto Mobile Access Standard



**Figure 1:** LTE supports the Next Generation Network by providing mobile access to an all-IP core.

Traditionally, operators have built multiple networks to provide multiple services to customers such as fixed telephone networks, cable TV networks, cellular telephone networks and data networks. The Next Generation Network (NGN) provides all of these functions using a flat all-IP core that interconnects multiple access technologies and provides a consistent and reliable user-experience regardless of the access method. The NGN core will provide Quality of Service (QoS) support and a wide variety of applications and services. The NGN access network will provide mobility and routing management and ensure that the core sees the mobile networks simply as another IP network. Mobile handover between access types will be seamless as the IP access network controls security, authentication, and billing for the multiple access technologies.

LTE is the first technology designed explicitly for the NGN and is set to become the de-facto NGN mobile access network standard. It takes advantage of the NGN's capabilities to provide an always-on mobile data experience comparable to wired networks.

● LTE supports peak data rates of up to 100 Mbps on the downlink and 50 Mbps on the uplink when using a 20 MHz channel bandwidth, a single transmit antenna at the user equipment (UE), and two receive antennas at the Base Station.

● LTE generates three to four times the throughput on the downlink and two to three times the throughput on the Uplink relative to 3GPP Release 6.

● LTE improves spectrum efficiency, also defined relative to Release 6. The downlink target is three to four times the spectral efficiency of High-Speed Downlink Packet Access (HSDPA) while the uplink target is a two to three time improvement over High-Speed Uplink Packet Access (HSDPA).

● LTE has flexible duplex methods. Both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) are valid spectrum allocations and allow LTE to accommodate various channel bandwidths in the available spectrum.

● LTE supports scalable RF channel bandwidths. Allowed values are 1.4, 3, 5, 10, 15, and 20 MHz.

● LTE interoperates with W-CDMA and GSM systems and non-3GPP systems. Multimode UEs will support handover to and from these other systems.

● Legacy technologies such as HSPA+ and Enhanced EDGE will continue to operate within the new data infrastructure.

## OFDMA

LTE takes advantage of OFDMA, a multi-carrier scheme that allocates radio resources to multiple users. OFDMA uses Orthogonal Frequency Division Multiplexing (OFDM). For LTE, OFDM splits the carrier frequency bandwidth into many small subcarriers spaced at 15 kHz, and then modulates each individual subcarrier using the QPSK, 16-QAM, or 64-QAM digital modulation formats. OFDMA assigns each user the bandwidth needed for their transmission. Unassigned subcarriers are off, thus reducing power consumption and interference.

OFDMA uses OFDM; however, it is the scheduling and assignment of resources that makes OFDMA distinctive. The OFDM diagram in Figure 2 below shows that the entire bandwidth belongs to a single user for a period. In the OFDMA diagram, multiple users are sharing the bandwidth at each point in time.

## SC-FDMA

In the uplink, LTE uses a pre-coded version of OFDM called SC-FDMA. SC-FDMA has a lower PAPR (Peak-to-Average Power Ratio) than OFDM. This lower PAPR reduces battery power consumption, requires a simpler amplifier design and improves uplink coverage and cell-edge performance. In SC-FDMA, data spreads across multiple subcarriers, unlike OFDMA where each subcarrier transports unique data. The need for a complex receiver makes SC-FDMA unacceptable for the downlink.
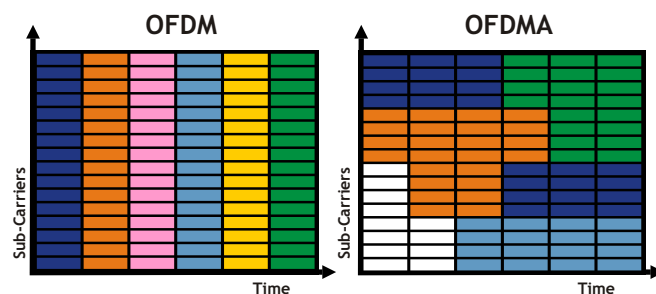


**Figure 2:** OFDM vs. OFDMA. Each color represents a burst of user data. In a given period, OFDMA allows users to share the available bandwidth.

## Adaptive Modulation and Coding (AMC)

Adaptive Modulation and Coding refers to the ability of the network to determine the modulation type and the coding rate dynamically based on the current RF channel conditions reported by the UE in Measurement Reports.
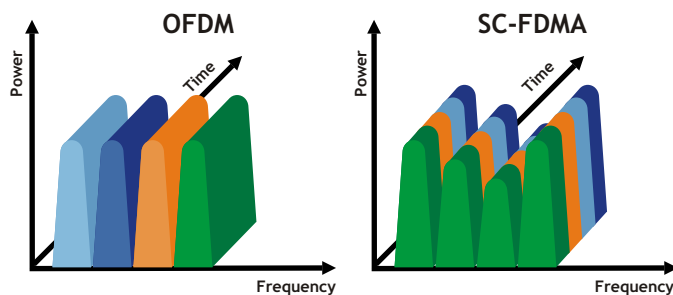


**Figure 3:** In OFDM, each frequency component carries unique information. In SC-FDMA, the information is spread across multiple subcarriers.

The RF digital modulation used to transport the information is QPSK, 16-QAM, and 64-QAM. The pictures below show the ideal constellations for each modulation where each dot represents a possible symbol. In the QPSK case, there are four possible symbol states and each symbol carries two bits of information. In 16-QAM, there are 16 symbol states. Each 16-QAM symbol carries 4 bits. In 64-QAM, there are 64 symbol states. Each 64-QAM symbol carries 6 bits. Higher-order modulation is more sensitive to poor channel conditions than the lower-order modulation because the detector in the receiver must resolve smaller differences as the constellations become more dense.



QPSK (4-QAM)
2 bits per symbol

16-QAM
4 bits per symbol

64-QAM
6 bits per symbol
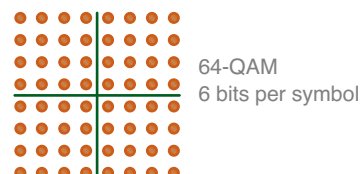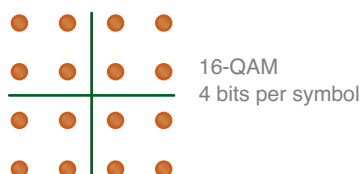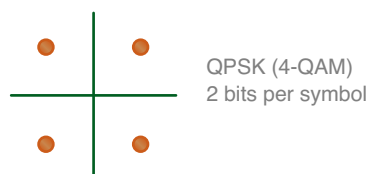
Coding refers to an error-correction methodology that adds extra bits to the data stream that allow error correction. Specified as fractions, Code Rates specify the number of data bits in the numerator and the total number of bits in the denominator. Thus if the Code Rate is 1/3, protection bits are added so one bit of data is sent as three bits.
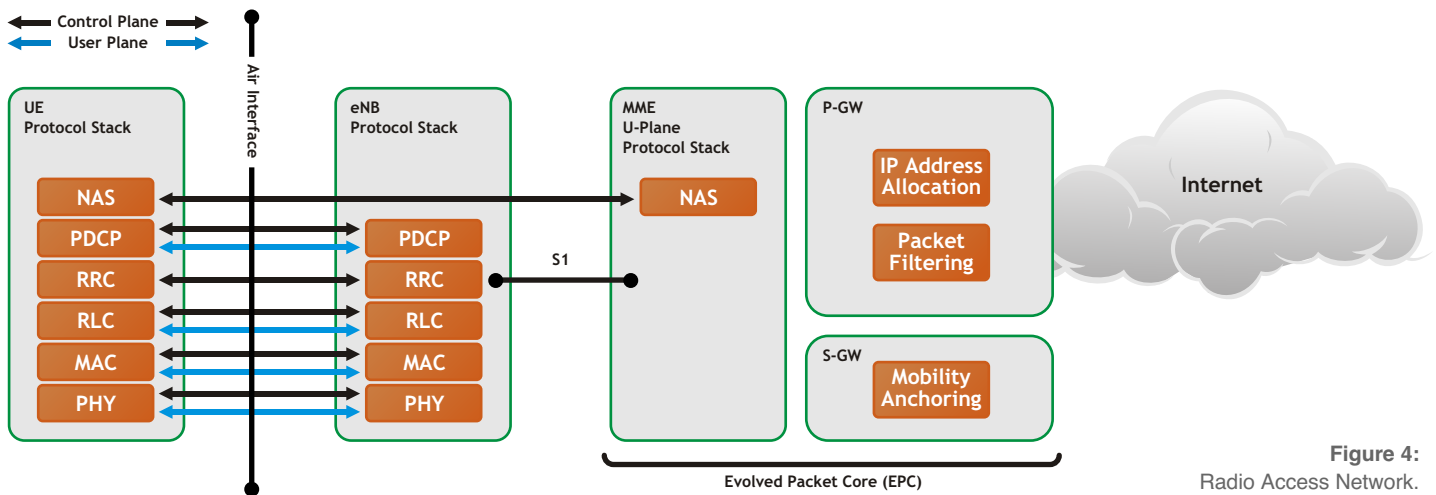
**Figure 4:**
Radio Access Network.
S1 is the physical interface
between the eNB and the MME.

## LTE Network Components and Functions

### UE (User Equipment)

- Access device for user.
- Provides measurements that indicate channel conditions to the network.

### eNB (Enhanced Node B)

- Hosts the PHYsical (PHY), Medium Access Control (MAC), Radio Link Control (RLC), and Packet Data Convergence Protocol (PDCP) layers.
- Controls user-plane header-compression and encryption.
- Provides Radio Resource Control (RRC) functionality for the control plane.
- Functions include radio resource management, admission control, scheduling, enforcement of negotiated uplink QoS, cell information broadcast, ciphering/deciphering of user and control plane data, and compression and decompression of downlink and uplink user-plane packet headers.

### PDN Gateway (P-GW)

- Provides connectivity between the UE and external packet data networks (PDNs) by being the point of exit and entry for UE  traffic (A UE may have simultaneous connectivity with more than one P-GW for accessing multiple PDNs).
- Performs policy enforcement, packet filtering for each user, charging support, lawful Interception, and packet screening.
- Acts as the anchor for mobility between 3GPP and non-3GPP technologies such as WiMAX and 3GPP2 (CDMA 1X and EvDO).

### MME (Mobility Management Entity)

- Acts as the key control node for the LTE network.
- Responsible for idle mode UE tracking and paging procedure including retransmissions.
- Controls bearer activation/deactivation process.
- Chooses the Serving Gateway (S-GW) for a UE at initial attachment and at the time of intra-LTE handover.
- Authenticates the user by interacting with the Home Subscriber Server (HSS) [Not shown in diagram].
- Serves as the termination point for the Non-Access Stratum (NAS) signaling. NAS signaling is responsible for generation and allocation of temporary identities to UEs and checks the authorization of the UE to camp on the system.
- Serves as the termination point for ciphering and integrity protection for NAS signaling.
- Handles security key management.
- Provides control plane function for mobility between LTE and other access networks.

### Serving Gateway (S-GW)

- Routes and forwards user data packets.
- Acts as the mobility anchor for the user plane during inter-eNB handovers and as the anchor for mobility between LTE and other 3GPP technologies.
- Terminates the downlink data path for idle state UEs and triggers paging when DL data arrives for the UE.
- Manages and stores UE contexts, e.g. parameters of the IP bearer service and network internal routing information.

## Frame Structures

- $T_s$ is the basic time unit for LTE. Time domain fields are typically defined in terms of $T_s$. $T_s$ is defined as $T_s = 1/(15000 \times 2048)$ seconds or about 32.6 nanoseconds.

- Downlink and uplink transmissions are organized into frames of duration $T_f = 307200\ T_s$.

- The 10 ms frames divide into 10 subframes. Each subframe divides into 2 slots of 0.5 ms. In the time domain, a slot is exactly one Resource Block long.

- Two frame types are defined for LTE: Type 1, used in Frequency Division Duplexing (FDD) and Type 2, used in Time Division Duplexing (TDD).

  - Type 1 frames consist of 20 slots with slot duration of 0.5 ms.

  - Type 2 frames contain two half frames. Depending on the switch period, at least one of the half frames contains a special subframe carrying three fields of switch information: Downlink Pilot Time Slot (DwPTS), Guard Period (GP) and Uplink Pilot Time Slot (UpPTS). If the switch time is 10 ms, the switch information occurs only in subframe one. If the switch time is 5 ms, the switch information occurs in both half frames, first in subframe one, and again in subframe six. Subframes 0 and 5 and DwPTS are always reserved for downlink transmission. UpPTS and the subframe immediately following UpPTS are reserved for uplink transmission. Other subframes can be uplink or downlink.
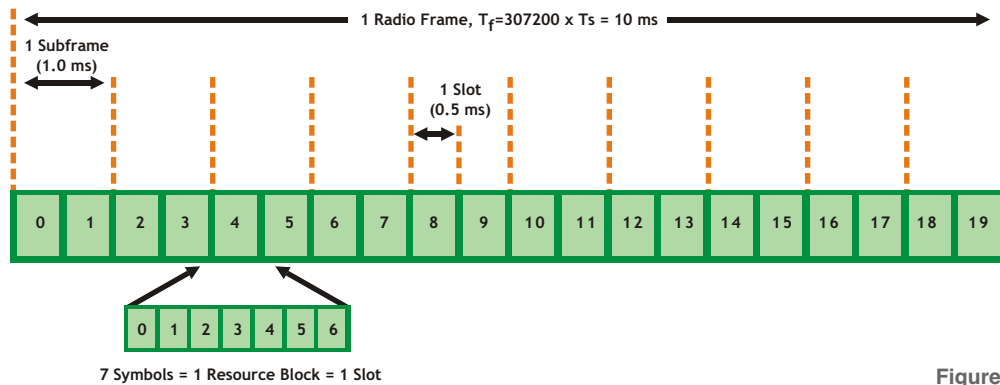


**Figure 5:** Type 1 Frame Type.
Timing and symbol allocations shown for FDD with normal cyclic prefix (CP).
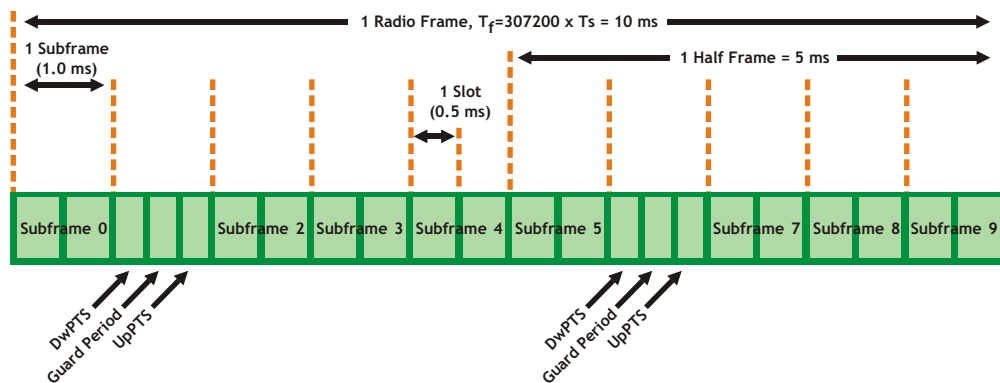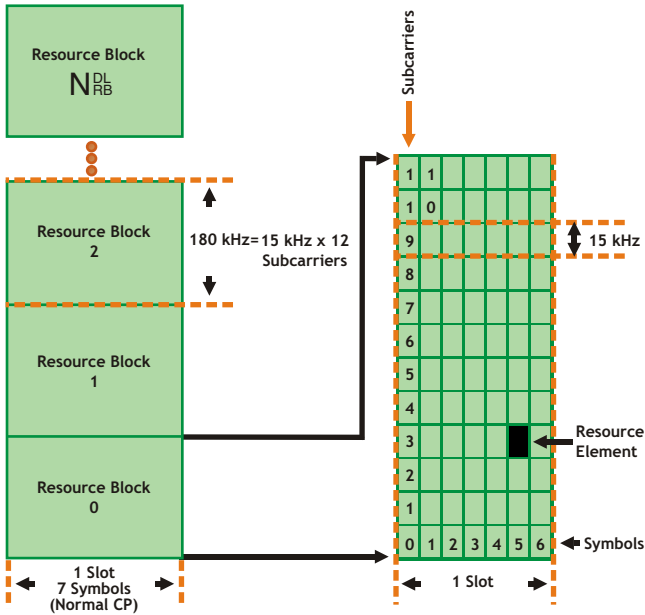


**Figure 6:** Type 2 frame type. Special fields are shown in Subframes 1 and 6.
Guard period separates the Downlink and Uplink. This TDD example represents a 5 ms switch point.
A 10 ms switch point would not have the special fields in subframe 6.

## LTE Frame Structure and Bandwidth Concepts



In LTE, ten 1 ms subframes compose a 10 ms frame. Each subframe divides into two slots. The smallest modulation structure in LTE is the Resource Element. A Resource Element is one 15 kHz subcarrier by one symbol. Resource Elements aggregate into Resource Blocks. A Resource Block has dimensions of subcarriers by symbols. Twelve consecutive subcarriers in the frequency domain and six or seven symbols in the time domain form each Resource Block.

The number of symbols depends on the Cyclic Prefix (CP) in use. When a normal CP is used, the Resource Block contains seven symbols. When an extended CP is used, the Resource Block contains six symbols. A delay spread that exceeds the normal CP length indicates the use of extended CP.

**Figure 7:** Relationship between a slot, symbols and Resource Blocks. $N_{RB}^{DL}$ is the symbol used to indicate the maximum number of downlink Resource Blocks for a given bandwidth.

Channel Bandwidth is the width of the channel as measured from the lowest channel edge to the highest channel edge. The channel edge is the center frequency ± (channel bandwidth/2).

Transmission Bandwidth is the number of active Resource Blocks in a transmission. As the bandwidth increases, the number of Resource Blocks increases. The Transmission Bandwidth Configuration is the maximum number of Resource Blocks for the particular Channel Bandwidth. The maximum occupied bandwidth is the number of Resource Blocks multiplied by 180 kHz.



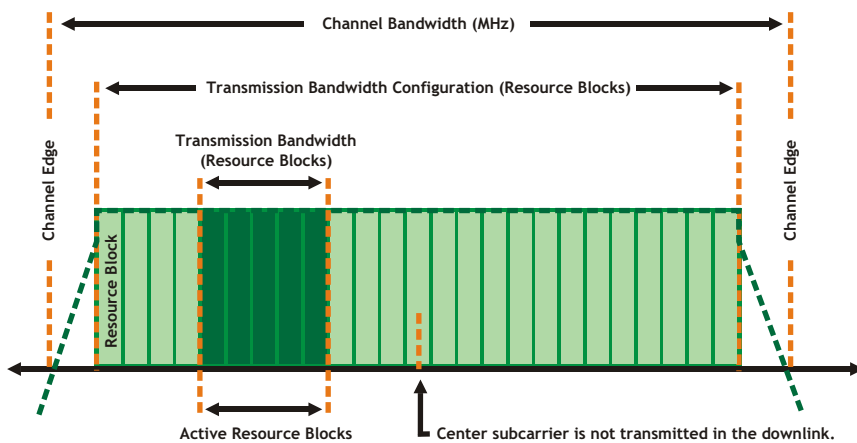**Figure 8:** Relationships between Channel Bandwidth, Transmission Bandwidth Configuration, and Transmission Bandwidth.

| Channel Bandwidth (MHz) | Maximum Number of Resource Blocks (Transmission Bandwidth Configuration) | Maximum Occupied Bandwidth (MHz) |
|---|---|---|
| 1.4 | 6 | 1.08 |
| 3 | 15 | 2.7 |
| 5 | 25 | 4.5 |
| 10 | 50 | 9.0 |
| 15 | 75 | 13.5 |
| 20 | 100 | 18.0 |

**Figure 8:** Transmission Bandwidth Configuration.

## LTE Downlink Channels and Signals
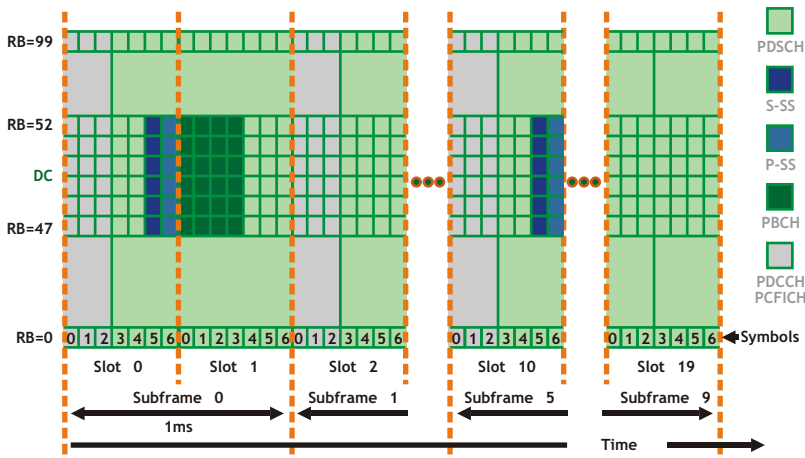


The LTE frame carries physical channels and physical signals. Channels carry information received from higher layers. Signals originate at the physical layer. The framing structure is common to the uplink and downlink, but the physical signals and physical channels are different.

**Figure 9:** This diagram of a downlink frame using FDD and normal CP shows the relative location of the various physical channels. Frames in systems using extended CP or TDD would be slightly different.

## Downlink Physical Channels

### Physical Downlink Shared Channel (PDSCH)

Used to transport user data, the PDSCH is designed for high data rates. Modulation options include QPSK, 16-QAM, and 64-QAM. Spatial multiplexing is exclusive to the PDSCH. The Resource Blocks associated with this channel are shared among users via OFDMA.

### Physical Broadcast Channel (PBCH)

Every 40 ms the PBCH sends cell-specific system identification and access control parameters using QPSK modulation.

### Physical Control Format Indicator Channel (PCFICH)

The PCFICH is a value that has a range of 1 to 3. The value of the PCFICH indicates the number of OFDM symbols used for the transmission of control channel (PDCCH) information in a subframe. The PCFICH uses QPSK modulation.

### Physical Downlink Control Channel (PDCCH)

UEs obtain uplink and downlink resource allocations from the PDCCH. The PDCCH maps onto resource elements in up to the first three OFDM symbols in the first slot of a subframe and uses QPSK modulation. The value of the PCFICH indicates the number of symbols used for the PDCCH.

### Physical Multicast Channel (PMCH) (Not shown in diagram)

The PMCH carries multicast information, and like the PDSCH, the PMCH has multiple options for modulation including QPSK, 16-QAM, or 64-QAM. Multicast information is sent to multiple UEs simultaneously.

### Physical Hybrid ARQ Indicator Channel (PHICH) (Not shown in diagram)

PHICH carries ACK/NAKs in response to uplink transmissions. ACKs and NAKs confirm the delivery of data or request the retransmission of data blocks received incorrectly. The ACKs and NACKs are part of the HARQ mechanism.

## LTE Downlink Channels and Signals

### Downlink Physical Signals

**Reference Signal (RS)** (Not shown in diagram)

UEs use RS for downlink channel estimation. They allow the UE to determine the channel impulse response (CIR). RS are the product of a two-dimensional orthogonal sequence and a two-dimensional pseudo-random sequence. While there are 3 different sequences available for the orthogonal sequence and 170 possible sequences for the pseudo-random numerical (PRN), the specification identifies 504 RS sequences. The RS uses the first and fifth symbols for normal CP and the first and fourth symbols for extended CP; the location of the RS on the subcarriers varies.

**Synchronization Signal (P-SS and S-SS)**

UEs use the Primary Synchronization Signal (P-SS) for timing and frequency acquisition during cell search. The P-SS carries part of the cell ID and provides slot timing (0.5 ms) synchronization. It is transmitted on 62 of the reserved 72 subcarriers (6 Resource Blocks) around DC on symbol 6 in slot 0 and 10. It uses one of three Zadoff-Chu sequences. These sequences provide a signal of constant amplitude.  UEs use the Secondary Synchronization Signal (S-SS) in cell search. It provides frame timing (10 ms) synchronization and the remainder of the cell ID. It is transmitted on 62 of the reserved 72 subcarriers (6 Resource Blocks) around DC on symbol 5 in slot 0 and 10. It uses two 31-bit binary sequences and BPSK modulation.

## LTE Uplink Channels and Signals

### Uplink Physical Channels

**Physical Uplink Control Channel (PUCCH)**

The PUCCH carries uplink control information and is never transmitted simultaneously with PUSCH data. PUCCH conveys control information including channel quality indication (CQI), ACK/NACK responses of the UE to the HARQ mechanism, and uplink scheduling requests.

**Physical Uplink Shared Channel (PUSCH) .**

Resources for the PUSCH are allocated on a sub-frame basis by the UL scheduler. Subcarriers are allocated in multiples of 12 because, as stated earlier, a Resource Block has 12 subcarriers. Subcarriers may be hopped from sub-frame to sub-frame. The PUSCH may employ QPSK, 16-QAM, or 64-QAM modulation.

**Physical Random Access Channel (PRACH)**

The PRACH carries the random access preamble and coordinates and transports random requests for service from mobile devices. The PRACH channel transmits access requests (bursts) when a mobile device desires to access the mobile system (call origination or paging response).

### Uplink Physical Signals

**Uplink Reference Signal**

There are two variants of the UL reference signal. The demodulation reference signal facilitates coherent demodulation. It is transmitted in the fourth SC-FDMA symbol of the slot and is the same size as the assigned resource. There is also a sounding reference signal used to facilitate frequency dependent scheduling. Both variants of the UL reference signal use Constant Amplitude Zero Autocorrelation (CAZAC) sequences.
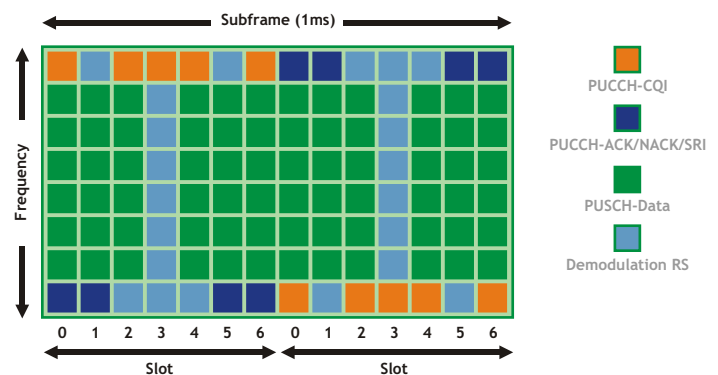


**Figure 10:** LTE Uplink Subframe with Normal Cyclic Prefix.

## E-UTRA Bands, Channel Bandwidths, and Frequency Allocations

E-UTRA Operating Band indicates the carrier frequency. . Not all LTE frequency bands support all bandwidths. Chart includes FDD and TDD channels.

| E UTRA Absolute Radio Frequency Channel Number (EARFCN) | 1.4 MHz | 3 MHz | 5 MHz | 10 MHz | 15 MHz | 20 MHz | Uplink (UL) eNode B receive UE transmit | Downlink (DL) eNode B transmit UE receive | UL-DL Band Separation | Duplex Mode |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | FUL_low-FUL_high | FDL_low-FDL_high |  |  |
| 1 |  |  | ✓ | ✓ | ✓ | ✓ | 1920-1980 MHz | 2110-2170 MHz | 130 MHz | FDD |
| 2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 1850-1910 MHz | 1930-1990 MHz | 20 MHz | FDD |
| 3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 1710-1785 MHz | 1805-1880 MHz | 20 MHz | FDD |
| 4 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 1710-1755 MHz | 2110-2155 MHz | 355 MHz | FDD |
| 5 | ✓ | ✓ | ✓ | ✓ |  |  | 824-849 MHz | 869-894MHz | 20 MHz | FDD |
| 6 |  |  | ✓ | ✓ |  |  | 830-840 MHz | 875-885 MHz | 35 MHz | FDD |
| 7 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 2500-2570 MHz | 2620-2690 MHz | 50 MHz | FDD |
| 8 | ✓ | ✓ | ✓ | ✓ |  |  | 880-915 MHz | 925-960 MHz | 10 MHz | FDD |
| 9 |  |  | ✓ | ✓ | ✓ | ✓ | 1749.9-1784.9 MHz | 1844.9-1879.9 MHz | 60 MHz | FDD |
| 10 |  |  | ✓ | ✓ | ✓ | ✓ | 1710-1770 MHz | 2110-2170 MHz | 340 MHz | FDD |
| 11 |  |  | ✓ | ✓ | ✓ | ✓ | 1427.9-1452.9 MHz | 1475.9-1500.9 MHz | 23 MHz | FDD |
| 12 | ✓ | ✓ | ✓ | ✓ |  |  | 698-716 MHz | 728-746 MHz | 12 MHz | FDD |
| 13 | ✓ | ✓ | ✓ | ✓ |  |  | 777-787 MHz | 746-756 MHz | 21 MHz | FDD |
| 14 | ✓ | ✓ | ✓ | ✓ |  |  | 788-798 MHz | 758-768 MHz | 20 MHz | FDD |
| ... |  |  |  |  |  |  |  |  |  |  |
| 17 | ✓ | ✓ | ✓ | ✓ |  |  | 704-716 MHz | 734-746 MHz | 18 MHz | FDD |
| ... |  |  |  |  |  |  |  |  |  |  |
| 33 |  |  | ✓ | ✓ | ✓ | ✓ | 1900-1920 MHz | | N/A | TDD |
| 34 |  |  | ✓ | ✓ | ✓ |  | 2010-2025 MHz | | N/A | TDD |
| 35 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 1850-1910 MHz | | N/A | TDD |
| 36 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 1930-1990 MHz | | N/A | TDD |
| 37 |  |  | ✓ | ✓ | ✓ | ✓ | 1910-1930 MHz | | N/A | TDD |
| 38 |  |  | ✓ | ✓ |  |  | 2570-2620 MHz | | N/A | TDD |
| 39 |  |  | ✓ | ✓ | ✓ | ✓ | 1880-1920 MHz | | N/A | TDD |
| 40 |  |  |  | ✓ | ✓ | ✓ | 2300-2400 MHz | | N/A | TDD |

**Figure 11:** Bands and Channel Bandwidths .

## MS2690A/MS2691A/MS2692A Signal Analyzers



Anritsu's MS269xA series high performance Signal Analyzers perform LTE uplink and downlink signal analysis and signal generation. The MS269xA's are ideal for the demanding requirements of LTE measurement. The base package includes a spectrum analyzer for swept measurements, a signal analyzer that uses FFT to produce fast measurements, and a digitizer that captures signals so they can be replayed on the instrument or removed from the analyzer for post-processing. Users can create a One-Box LTE tester by adding the optional signal generator to the base package.

The MS269xA series offer low residual Error Vector Magnitude (EVM) of 1% (≤0.5% typical) and total level accuracy of ±0.6 dB. It supports one-button spectrum analysis (Channel Power, OBW, ACLR, SEM) with wide dynamic range. Built-in test model configurations allow rapid test setup. The MS269xA's capture and replay up to 200 waveforms for troubleshooting faults and offers an EVM Window Length function for precise measurement of FFT timing.



**Figure 12:** LTE analysis includes constellation analysis and graphical displays with resolutions of Subcarriers, Symbols, and Resource Blocks.

| Spectrum Analyzer (SPA) Function | |
|---|---|
| World-Class Dynamic Range | Avg. noise level: -155 dBm/Hz (2 GHz) |
| | TOI: ≥+22 dBm |
| | W-CDMA ACLR: -78 dBc @ 5 MHz |
| **Vector Signal Analyzer (VSA) Function** | |
| Wideband FFT Analysis | 31.25 MHz standard |
| | 125 MHz option available |
| Capture Digitized Waveforms | Replay for additional analysis |
| | Use data in post-process analysis |
| **Vector Signal Generator (VSG) (option)** | |
| Frequency Range | 125 MHz to 6 GHz |
| RF Modulation Bandwidth | 120 MHz |
| Built in BER Measurement Function | |
| Built-in AWGN Addition Function | |
| **LTE Specific Analysis Software** | |
| MX269020A LTE Downlink Measurement Software | |
| MX269021A LTE Uplink Measurement Software | |

| General LTE Specifications | |
|---|---|
| Operating Band | 800 to 2700 MHz |
| Channel Bandwidth | 1.4/3/5/10/15/20 MHz |
| PDSCH/PUSCH Mod Scheme | QPSK/16QAM/64QAM |
| Analysis Time Length | 10 subframes max. (1 frame) |
| Text Display | Frequency Error, Output Power, Mean Power. EVM (Peak/rms), Origin Offset, Timing Offset (External Trigger) |
| Constellation Display | Constellation |
| Graphical Display | EVM vs Subcarrier, Symbol, Demod-Symbol (Uplink), or Resource Block (Downlink) Spectral Flatness, Power vs Resource Block (Downlink), Time Based EVM (Uplink) |
| Spectrum Display | Adjacent Channel Power, Channel Power, Occupied Bandwidth, Spectrum Emission Mask, |
| Downlink Summary Display | Total EVM PDSCH (ALL/QPSK/16QAM/64QAM) EVM PDCCH EVM, RS/SS/P-SS/S-SS EVM PBCH/PCFICH/PHICH EVM RS/P-SS/S-SS/PBCH/PDCCH/PCFICH/PHICH Power, Power vs Slot, Cell ID, Number of PDCCH Symbols, RS Power vs Subframe, OFDM Symbol Tx Power vs Subframe |
| Uplink Summary Display | Time-Based EVM: Total EVM, PUSCH QPSK, PUSCH 16-QAM, and PUSCH 64-QAM Total EVM, PUSCH QPSK/16-QAM/64-QAM EVM, RS EVM, Power vs Slot |

## MD8430A Signaling Tester: LTE Base Station Emulator
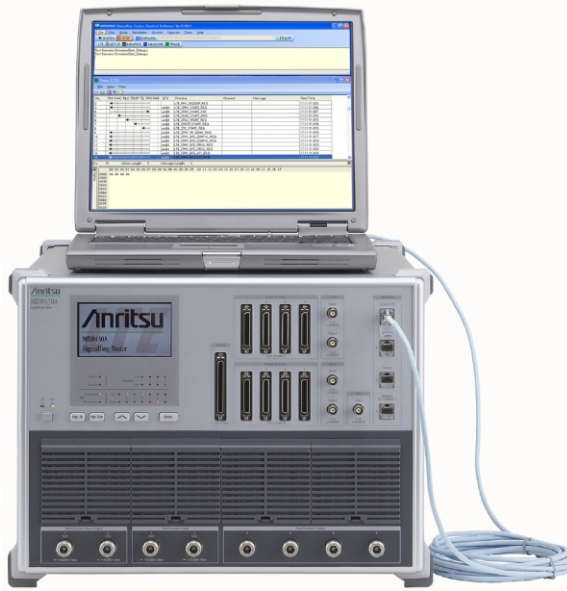
The MD8430A is the first complete LTE Base Station Emulator. It tests LTE chipsets and components, performs UE verification, and completes operator acceptance inspections quickly and efficiently. The built-in baseband evaluation support tests baseband prior to the integration of RF components and speeds time to market.

Besides supporting air-interface tests for chipsets and coding/decoding tests, the MD8430A performs protocol sequence tests for registration, origination, termination, handover, and terminal or network disconnect tests. Applications can be tested using internal or external servers for flexible application testing.

Teamed with the Anritsu MD8480C W-CDMA Signalling Tester, the MD8430A provides a simple method for testing handovers between LTE and UTRAN/GERAN.

With four RF interfaces, the MD8430A provides the resources to test LTE - LTE handover and 2x2 Multiple Input Multiple Output (MIMO).

Rapid Test Developer (RTD) and Protocol Test System (PTS) are two software packages that speed up both development and execution of test cases for the MD8430A system.

### Protocol Test System (PTS)

The Protocol Test System (PTS) enables Layer 3 and Layer 2 Test Procedures to verify the UE's signaling protocol stack. PTS provides a 3GPP Standard compliant development tool and an environment supporting TTCN test case execution. A TTCN test library and C-API Application Programming Interface are available as options.

### Rapid Test Developer (RTD)

The Rapid Test Designer (RTD) is a revolutionary new tool that speeds the testing of LTE devices by simplifying the way in which users create, execute, and analyze test cases. When linked with the MD8430A, the RTD provides fast, interactive testing. The RTD hides the complexity of testing 3GPP protocols and allows the user to test specific functions and protocols within the UE without being an expert on all protocol layers. The intuitive graphical interface removes the need to learn a specialized test language or a system simulator. Built upon Anritsu's years of experience in testing 3GPP protocols with the leading UE vendors, RTD provides a broad array of configurable building blocks for designing tests, a catalogue of common network settings, interactive error checking, and an integrated protocol analyzer. Applications include acceptance testing, integration testing, interoperability testing, regression testing, and application testing.

| Emulator Configurations | Function Test Model (FTM) | Standard Test Model (STM) | Performance Test Model (PTM) |
|---|---|---|---|
| Interface | RF and Digital I/Q | | |
| Bandwidth | 20 MHz maximum | | |
| UE Categories | Category 1 | Category 1,2,3 | |
| Maximum Downlink Data Rate | 10 Mbps | 100 Mbps (at 2x2 MIMO) | |
| Maximum Uplink Data Rate | 5 Mbps | 50 Mbps | |
| Number of Simultaneous Transmit Frequencies | 1 | 2 | |
| MIMO | Not Supported | 2x2 MIMO | |
| Maximum Number of Cells | 1 | 4 (2 communication cells, 2 neighbor cells) | 6 (2 communication cells, 4 neighbor cells) |
| Hard Handover | Not Supported | Supported (includes MIMO) | |

## MF6900A Fading Simulator

MIMO is critical for LTE to satisfy its stated goals. Evaluation of MIMO requires a complex, yet reproducible, fading environment.

The MF6900A Fading Simulator connects to the MD8430A using a simple digital interface. Once connected, it provides a simple and accurate way to add fading profiles to any test scenario. Using a fading simulator has never been easier.

Digital baseband processing assures reproducible fading profiles. As there are no analog circuits, periodic calibration is eliminated making the MF6900A as easy to maintain as it is to use.

In test systems that include the MD8480C LTE Base Station Emulator and the MD8430A W-CDMA Base Station Emulator, bundled fading profiles allow rapid testing since the fading profiles are pre-configured and ready to use immediately. The MF6900A expandable to accommodate four input ports and four output ports. Software updates add functionality such as 4x2 MIMO.

| | |
|---|---|
| Interface | Digital I/F (LVDS) |
| Channel Structure | SISO, 2x2 MIMO, 2x1 MISO, 1x2 SIMO (with MD8430A connected and MX690010A installed)<br>Moving, Birth-Death, Tx/Rx/TRx Diversity (with MD8480C connected and MX690020A installed) |
| Path Number | 12 paths/channel |
| RF Frequency | 100 MHz to 6000 MHz, 1 Hz resolution |
| Relative Path Delay | 0 to 600 _s, 0.1 ns resolution, 0.1 ns setting accuracy (relative to delay 0) |
| Relative Path Gain | -50 to 0 dB, 0.1 dB resolution, 0.05 dB setting accuracy |
| Doppler Frequency | 0 or 0.1 Hz to 20 kHz, 0.01 Hz resolution |
| Fading Type | Constant Phase, Pure Doppler, Rayleigh, Rice |
| **Fading Profiles** | |
| SISO | Case1, Case2, Case3, Case4, Case5, Case6, Case 8, VA3, VA30, VA120, PA3, PB3<br>[3GPP TS25.101 V7.12.0 (2008-05), TS34.121-1 V8.3.0 (2008-06)]<br>EPA, EVA, ETU [3GPP TS36.101 V8.2.0 (2008-05)] |
| 2x2 MIMO/1x2 SIMO | EPA, EVA, ETU [3GPP TS36.101 V8.2.0 (2008-05)] |
| Moving | Moving propagation conditions [3GPP TS25.101 V7.12.0 (2008-05)] |
| Birth-Death | Birth-Death propagation conditions [3GPP TS25.101 V7.12.0 (2008-05)] |
| Tx/Rx/TRx Diversity | Case1, Case2, Case3, Case4, Case5, Case6, Case 8, VA3, VA30, VA120, PA3, PB3<br>[3GPP TS25.101 V7.12.0 (2008-05) , TS34.121-1 V8.3.0 (2008-06)] |

## MG3700A  Vector Signal Generator



MG3700A is a vector signal generator with two separate arbitrary (ARB) waveform memories. Patterns loaded into the memories can play one at a time or simultaneously through the single RF output port. Typically, one signal represents the desired signal and the second represents interference. Additive White Gaussian Noise (AWGN) can be automatically added to one or both signals. The MG3700A provides the flexibility to create reproducible real-world signals.

The MG3700A produces signals up to 3 GHz or, optionally, up to 6 GHz. Boasting a 256 Msample/channel memory, the MG3700A has the largest standard memory size on the market today. If needed, increase the memory to 512 Msamples. The MG3700A has the largest standard modulation bandwidth on the market today: 120 MHz when using the internal baseband generator and 150 MHz when using the external I/Q inputs. The MG3700A includes a 20 Mbps Bit Error Rate (BER) tester on-board with an option that allows the speed to increase to 120 Mbps.

| Features and Specifications | |
|---|---|
| Frequency | 250 kHz to 3 GHz (to 6 GHz with option) |
| I/Q Modulation Bandwidth | 150 MHz (External IQ input) |
| | 120 MHz (Internal base band generator) |
| Hard Disk Drive | 40 Gbytes |
| Sample Rate | 20 kHz to 160 MHz |
| Attenuator | Electric (standard)/ Mechanical (option) |
| High Level Accuracy | +/- 0.5 dB (Absolute level accuracy) |
| | +/- 0.2 dB typical (Linearity) |

# BTS Master™ MT822xX, Cell Master™ MT8212E and Spectrum Master™ MS272xB & MS271xE Features

### LTE Signal Analyzers

The BTS Master features three LTE measurement modes:

- RF Measurements
- Modulation Measurements
- Over-the Air Measurements (OTA)

The goal of these measurements is to increase data rate and capacity by accurate power settings, ensuring low out-of-channel emissions, and good signal quality. These attributes help to create a low dropped call rate, a low blocked call rate, and a good customer experience. Cell site technicians or RF engineers can make measurements Over-the-Air (OTA) to spot-check a transmitter's coverage and signal quality without taking the cell site off-line. When the OTA test results are ambiguous one can directly connect to the base station to check the signal quality and transmitter power.

### Adjacent Channel Power Ratio (ACLR)

Adjacent Channel Leakage Ratio (ACLR) measures how much BTS signal gets into neighboring RF channels. ACLR checks the closest (adjacent) and the second closest (alternate) channels. Poor ACLR can lead to interference with adjacent carriers and legal liability. It also can indicate poor signal quality which leads to low throughput.

### Cell ID (Sector ID, Group ID)

Cell ID indicates which base station is being measured OTA. The strongest base station at your current location is selected for measurement. Wrong values for Cell ID lead to inability to register. If the cause is excessive overlapping coverage, it also will lead to poor EVM and low data rates.

### Frequency Error

Frequency Error is a check to see that the carrier frequency is precisely correct. The BTS Master can accurately measure Carrier Frequency Error OTA if the instrument is GPS enabled or in GPS holdover. Calls will drop when mobiles travel at higher speed. In some cases, cell phones cannot hand off into, or out of the cell when the base station frequency error is excessive.

### Sync Signal Mapping

Sync Signal Scanner can be used with the GPS to save scan results for later display on a map. The EVM of the strongest synch signal available at that spot is also recorded. The Cell, Sector, and Group ID information is also included so that it's easier to interpret the results. Once the Synch Signals are mapped, it becomes much easier to understand and troubleshoot any interference or coverage issues.
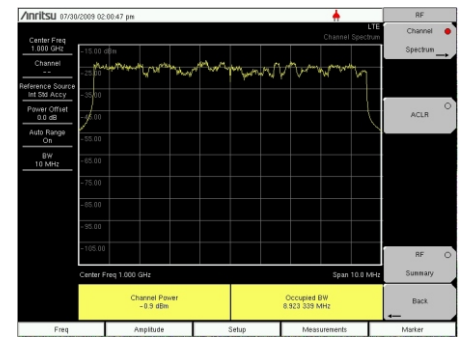


**RF Measurements – Occupied Bandwidth**
The bandwidth that contains 99% of the total carrier power. Excessive occupied bandwidth means excessive adjacent channel interference.
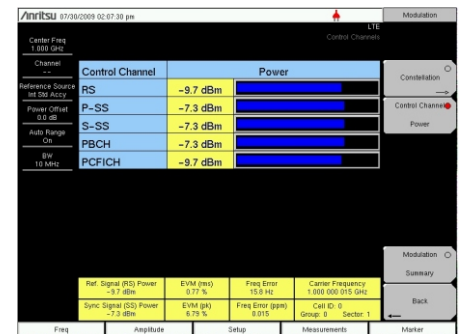


**Modulation Quality – EVM**
This is the single most important signal quality measurement. Poor EVM leads to dropped calls, low data rate, low sector capacity, and blocked calls.



**Over-the-Air Measurements – Sync Signal Power**
Too many strong sectors at the same location creates co-channel interference. This leads to low data rate, low capacity, and excessive soft handoffs.



**Pass/Fail Test**
Set up common test limits, or sets of limits, for each instrument. Inconsistent settings between base stations, leads to inconsistent network behavior.

## BTS Master™ MT8221B/MT8222A, Spectrum Master™ MS272xB Specifications

| Measurements | | | |
|---|---|---|---|
| **RF**<br>**(Option 0541)** | **Modulation**<br>**(Option 0542)** | **Over-the-Air (OTA)**<br>**(Option 0546)** | **Pass/Fail**<br>**(User Editable)** |
| Channel Spectrum<br>   Channel Power<br>   Occupied Bandwidth<br>ACLR<br>RF Summary | Constellation<br>   Reference Signal Power<br>   Sync Signal Power<br>   EVM<br>   Frequency Error<br>   Carrier Frequency<br>   Cell ID<br>   Sector ID<br>   Group ID<br>Control Channel Power<br>   RS<br>   P-SS<br>   S-SS<br>   PBCH<br>   PCFICH<br>   Modulation Summary | Synch Signal Power<br>(Six Strongest)<br>   Power<br>   Cell ID<br>   Sector ID<br>   Group ID<br>Dominance | Pass Fail All<br>Pass/Fail RF<br>Pass Fail Demod<br>Measurements<br>   Channel Power<br>   Occupied Bandwidth<br>   ACLR<br>   Frequency Error<br>   Carrier Frequency<br>   Dominance<br>   EVM (peak)<br>   EVM (rms)<br>   RS Power<br>   SS Power<br>   P-SS Power<br>   S-SS Power<br>   PBCH Power<br>   PCFICH Power<br>   Cell ID<br>   Group ID<br>   Sector ID |
| **Setup Parameters**<br><br>Bandwidth<br>Span<br>Frame Length<br>Frequency<br>Amplitude<br>Sweep<br>Save/Recall<br>Measurement Summary Screens | 10 MHz<br>1.4, 3, 5, 10, 15, 20, 30 MHz<br>2.5, 5.0, 10.0 msec<br>Center, Signal Standard, Channel #, Closest Channel, Decrement/Increment Channel<br>Scale/Division, Power Offset, Auto Range, Adjust Range<br>Single/Continuous, Trigger Sweep<br>Setup, Measurement, Screen Shot (save only), to Internal/External Memory<br>Overall Measurements, RF Measurements, Modulation Quality | | |
| **RF Measurements (Option 0541)**<br><br>RF Channel Power Accuracy | <br><br>±1.5 dB, ±1.0 dB typical, (RF input -50 to +10 dBm) | | |
| **Modulation Measurements (Option 0542)**<br><br>Frequency Error<br>Residual EVM (rms) | <br><br>±10 Hz + time base error, 99% confidence level<br>2.5% typical (E-UTRA Test Model 3.1) (RF Input -50 dBm to +10 dBm) | | |
| **Over-the-Air (OTA) Measurements (Option 0546)**<br><br>Scanner<br>Auto Save<br>GPS Tagging and Logging | <br><br>Six strongest Sync Signals<br>Yes<br>Yes | | |

# IQproducer

## LTE IQproducer

MX269908A LTE IQproducer is PC application software with a graphical user interface (GUI) for generating waveform patterns in compliance with the 3GPP TS36.211, TS36.212, and TS25.814 standards. This Windows-based software creates waveforms for the MG3700A and the signal generator option of the MS269xA. The GUI allows a user to quickly set signal parameters for LTE waveforms. Built-in simulation tools allow the user to examine these waveforms in the time domain, as a CCDF plot, or as an FFT spectrum. It's easy to generate test patterns by allocating the physical channels in resource block units.
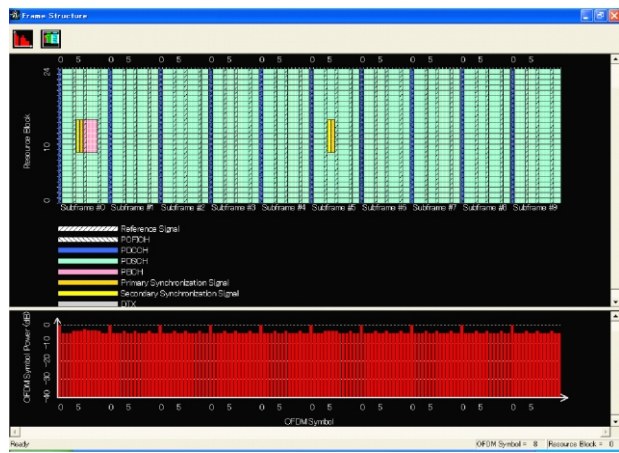


**Figure 14:** The Frame Structure Screen shows the layout of the physical layers in the upper section and the power profile of the symbols in the lower section. In the upper section, the physical channels map to the Y-axis as frequency in Resource Block units (12 subcarriers) and to the X-axis as time in OFDM symbol units.
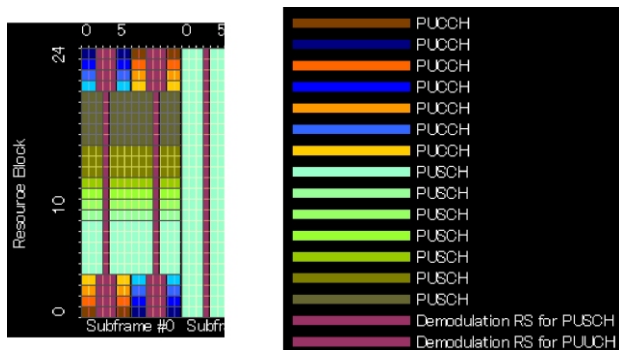


**Figure 16:** Here the Frame Structure Screen shows an uplink subframe with eight PUSCH and eight PUCCH. Easily configure test signals such as this one by changing parameters and get immediate feedback in the Frame Structure Screen.
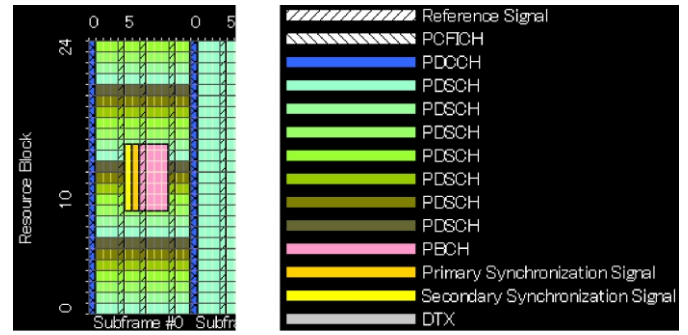


**Figure 13:** The Frame Structure Screen shows a downlink subframe configured with 25 PDSCH. The PDCCH is on the first symbol; the Primary and Secondary Synchronization Signals are on the sixth and fifth symbols respectively, and the Broadcast Channel ranges from the seventh to the tenth symbols. Both the Synchronization Signals and the Broadcast Channel are assigned to the center 72 subcarriers for all bandwidths. Reference Signals are shown by hash marks in the first and fifth symbols of the slot. The PCFICH is on the first symbol of each subframe.
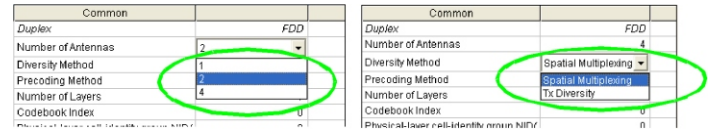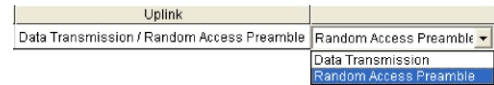


**Figure 15:** The LTE IQproducer supports Spatial Multiplexing and Transmit Diversity. When multiple antennas are selected, the appropriate files are created for each antenna for immediate MIMO.
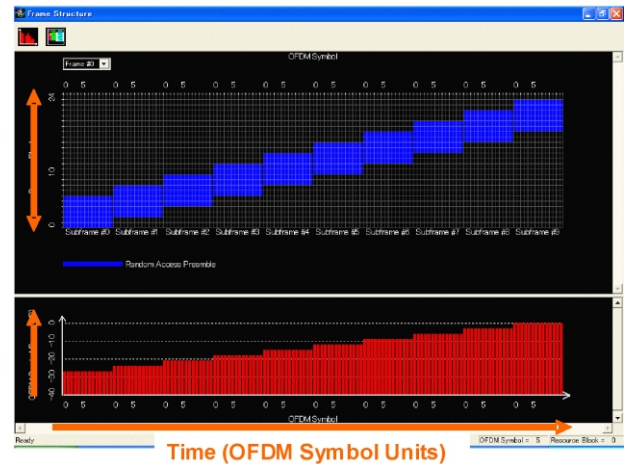


**Figure 17:** IQproducer also creates Random Access Preambles for uplink testing. Frequency hopping and power ramping can be quickly set from the parameter screen. Limits on all settings ensure that signals comply with the standards.

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