LTE eNodeB Installation and Maintenance Tests

Introduction
The Long-Term Evolution (LTE) specifications are defined by the Third Generation Partnership Project (3GPP), which is part of the Standards Development Organizations.

LTE Characteristics:

*Improved downlink and uplink peak rates:*

<table>
<thead>
<tr>
<th>UE Category</th>
<th>Maximum Downlink Data (Mbps)</th>
<th>Spatial Downlink Multiplexing</th>
<th>Maximum Uplink Data (Mbps)</th>
<th>Uplink 64QAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>10.296</td>
<td>1</td>
<td>5.160</td>
<td>No</td>
</tr>
<tr>
<td>Category 2</td>
<td>51.024</td>
<td>2</td>
<td>25.456</td>
<td>No</td>
</tr>
<tr>
<td>Category 3</td>
<td>102.048</td>
<td>2</td>
<td>51.024</td>
<td>No</td>
</tr>
<tr>
<td>Category 4</td>
<td>150.752</td>
<td>2</td>
<td>51.024</td>
<td>No</td>
</tr>
<tr>
<td>Category 5</td>
<td>299.552</td>
<td>4</td>
<td>75.376</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Scalable channel bandwidths:*

<table>
<thead>
<tr>
<th>Channel bandwidth (MHz)</th>
<th>1.4</th>
<th>3</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission bandwidth (RB)</td>
<td>6</td>
<td>15</td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Transmission bandwidth (Subcarriers)</td>
<td>72</td>
<td>180</td>
<td>300</td>
<td>600</td>
<td>900</td>
<td>1,200</td>
</tr>
<tr>
<td>Transmission bandwidth (MHz)</td>
<td>1.08</td>
<td>2.7</td>
<td>4.5</td>
<td>9</td>
<td>13.5</td>
<td>18</td>
</tr>
</tbody>
</table>

![LTE Downlink Signal – Frequency Mode](image-url)
Operating Bands and Channel Numbering

The carrier frequency in the uplink and downlink is designated in the range of 0 – 65535. The relation between channel numbering and carrier center frequency in MHz for the downlink is given by the following equation, where \(F_{DL,\text{low}}\) and \(N_{\text{Offs-DL}}\) are given by 3GPP.

\[
\text{Downlink Center Frequency (FDL)} = F_{DL,\text{low}} + 0.1(N_{DL} - N_{\text{Offs-DL}})
\]

\[
\text{Channel Number (N_{DL})} = (F_{DL} - F_{DL,\text{low}})/0.1 + N_{\text{Offs-DL}}
\]

For example, the center frequency of channel number \(N_{DL} = 5230\) on band 13 is the following:

\[
746 + 0.1(5230 - 5180) = 751 \text{ MHz}
\]
Downlink Signal Format

LTE downlink signal is based on the technique of orthogonal frequency division multiplexing (OFDM), where different streams of information are mapped onto separate parallel frequency channels and each channel is separated from the others by a frequency guard band to reduce interference between adjacent channels. Data symbols are synchronously and independently transmitted over a high number of closely spaced orthogonal subcarriers using linear modulation, either phase shift keying (PSK) or quadrature amplitude modulation (QAM).

Orthogonal elements are created between subcarriers (Sc) and consecutive symbols (Sy):
LTE Frame Structure

LTE frame structure type 1 (FDD mode) consists of 20 slots, and a subframe is defined as two consecutive slots.

<table>
<thead>
<tr>
<th>DL Channels</th>
<th>Description</th>
<th>Modulation Format</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBCH</td>
<td>Physical Broadcast channel</td>
<td>QPSK</td>
<td>Carrier Cell specific information.</td>
</tr>
<tr>
<td>PDCCH</td>
<td>Physical Downlink Control Channel</td>
<td>QPSK</td>
<td>Transports format, resource and hybrid-ARQ information related to DL-SCH, UL-SCH and PCH.</td>
</tr>
<tr>
<td>PDSCH</td>
<td>Physical Downlink Shared Channel</td>
<td>QPSK, 16QAM, 64QAM</td>
<td>User data payload.</td>
</tr>
<tr>
<td>PMCH</td>
<td>Physical Multicast Channel</td>
<td>QPSK, 16QAM, 64QAM</td>
<td>Payload for multiple users, Multimedia Broadcast Multicast service (MBMS).</td>
</tr>
<tr>
<td>PCFICH</td>
<td>Physical Control Format Indicator Channel</td>
<td>QPSK</td>
<td>Carries the number of symbols (1, 2 or 3) used for control channels (PDCCH) in a subframe.</td>
</tr>
<tr>
<td>PHICH</td>
<td>Physical Hybrid ARQ Indicator Channel</td>
<td>QPSK</td>
<td>Carries the error detection (hybrid-ARQ ACK/NAK) feedback to the UE for the UL blocks received by the eNB.</td>
</tr>
<tr>
<td>P-SCH</td>
<td>Primary Synchronization Channel</td>
<td>Zadoff–Chu</td>
<td>Used for cell search and cell identification. Carries part of the cell ID.</td>
</tr>
<tr>
<td>S-SCH</td>
<td>Secondary Synchronization Channel</td>
<td>QPSK</td>
<td>Used for cell search and cell identification. Carries the remainder of the cell ID.</td>
</tr>
<tr>
<td>RS</td>
<td>Reference Signal (Pilot)</td>
<td>Complex I+Q pseudo random sequence</td>
<td>Used for DL channel estimation. Exact sequence derived form Cell ID. Enable UE to calculate transmission corrections.</td>
</tr>
</tbody>
</table>

Physical Downlink Channels

Modulation Schemes
**LTE eNodeB Installation and Maintenance Tests**

The LTE base station (eNodeB) conformance tests are classified based on its radio frequency (RF) characteristics, or modulation characteristics. Some of these tests are based on 3GPP TS 36.104, which defines minimum requirements for LTE base stations eNodeB.
**eNodeB Transmission Test**

**Test Connectivity**
All the commissioning tests should be performed in each port of the corresponding eNodeB for a three-sector cell site with two TX antennas (TX1 and TX2) for a total of six tests.

**Alcatel Lucent with JD740**

![Diagram of Alcatel Lucent eNodeB TX1—JD740](image1)

![Diagram of Alcatel Lucent eNodeB TX2—JD740](image2)
Test Configuration

The following procedure configures the instrument to properly test the transmitted LTE signals directly connected into eNodeB. For the external offset, consider the actual offset of the port plus the test cable loss. The following example considers a 40 dB loss for simplicity. The procedure uses LTE Band 13 channel 5230 (751 MHz) but the same process applies to any other channel assignment.

JD740 Procedure for eNodeB Test

LTE Signal Analysis Mode for eNodeB Transmission

Frequency Setting for eNodeB Transmission

Amplitude and Power Offset Setting for eNodeB Transmission
Result for eNodeB Test

Saving Results

Follow this procedure to save results on a USB memory device connected into the USB Host port of the base station analyzer.

**JD740 Procedure for Saving Results**
Channel Power Test

Definition of Channel Power
The output power of the base station is the mean power of one carrier delivered to a load with resistance equal to the nominal load impedance of the transmitter.

Maximum output power of the base station is the mean power level per carrier measured at the antenna connector during the transmitter ON period in a specified reference condition.

Requirements for Channel Power
Under normal conditions, the base station maximum output power shall remain within +2 dB and −2 dB of the rated output power declared by the manufacturer.

In extreme conditions, the base station maximum output power shall remain within +2.5 dB and −2.5 dB of the rated output power declared by the eNodeB manufacturer.

JD740 Procedure for Channel Power

Results for Channel Power

Note: In the screen shot for Channel Power Results, the Channel Power is 32.38 dBm, but it may be higher. A ±2 dB value should be prescribed for the operating mode of the eNodeB.
**Occupied Bandwidth Test**

**Definition of Occupied Bandwidth**

The occupied bandwidth is the width of a frequency band where the mean powers emitted below the lower and above the upper frequency limits are each equal to a specified percentage $B/2$ of the total mean transmitted power.

**Requirements for Occupied Bandwidth**

The specified percentage $B/2$ must be taken as 0.5 percent.

**JD740 Procedure for Occupied Bandwidth**

**Results for Occupied Bandwidth**

![Results Image]
Spectrum Emission Mask Test

Definition of Spectrum Emission Mask
The unwanted emission limits of the operating band are defined as 10 MHz below the lowest frequency of the downlink operating band up to 10 MHz above its highest frequency. The requirements apply regardless of the type of transmitter used, single carrier or multi-carrier.

Requirements for Spectrum Emission Mask
Emissions must not exceed the maximum levels specified in 3GPP TS 36.104 Subsection 6.6.3.

JD740 Procedure for Spectrum Emission Mask

Results for Spectrum Emission Mask
Adjacent Channel Leakage Power Ratio Test

Definition of Adjacent Channel Leakage Power Ratio
Adjacent channel leakage power ratio (ACLR) is the ratio of the filtered mean power centered on the assigned channel frequency to that centered on an adjacent channel frequency. The requirements apply regardless of the type of transmitter used, single carrier or multi-carrier.

Requirements for Adjacent Channel Leakage Power Ratio
For 10 MHz channel bandwidth, the ACLR limit is 45 dB at 10- and 20-MHz offsets.

JD740 Procedure for Adjacent Channel Leakage Power Ratio

Results for Adjacent Channel Leakage Power Ratio
Spurious Emissions Test

Definition of Spurious Emissions
The transmitter spurious emission limits apply from 100 kHz to 7.2 GHz, excluding the frequency range from 10 MHz below the lowest frequency of the downlink operating band up to 10 MHz above its highest frequency.

Requirements for Spurious Emissions
Emissions must not exceed the maximum levels specified in 3GPP TS 36.104 Subsection 6.6.4.

JD740 Procedure for Spurious Emissions

Results for Spurious Emissions
**Control Channels Test**

**Definition of Control Channels**
The Control Channel measurement provides the modulation quality of each control channel (for example, P-SCH, S-SCH, PBCH, PCFICH, PHICH, PDCCH, RS), including the error vector magnitude (EVM) expressed in percentage, the power (dB or dBm), the modulation type, and the corresponding constellation diagram (I-Q).

**Requirements for Control Channels**
The acceptable modulation quality is defined by network performance.

**JD740 Procedure for Control Channels**

Note: The TX2 test requires changing the antenna port setting. Enter the Cell ID registered on TX1 test if the eNodeB is not transmitting P-SCH and S-SCH signals.

**Results for Control Channels**
Data Channels Test

Definition of Data Channels
Data channel measurement provides a resource block granularity into one subframe and is applicable for Base Station Conformance Testing described in 3GPP TS 36.141: 6.1.1

Requirements for Data Channels

EVM Requirements
The acceptable modulation quality (or error vector magnitude, EVM) for data channels per resource block are user-configurable by assigning EVM limits to each data channel (for example, QPSK, 16QAM, and 64QAM).

PRB Requirements
The acceptable requirements for active Physical Resource Blocks (PRB) are defined as test models on 3GPP TS 36.141: 6.1.1.

JD740 Procedure for Data Channels

Results for Data Channels

PRB Test Model 1.2
Frames Test

Definition of Frames
The frame measurement provides the EVM expressed in percentage, power (dB or dBm) and modulation type of each control channel, such as P-SCH, S-SCH, PBCH, PCFICH, PHICH, PDCCH, RS, and data channel, such as PDSCH-QPSK, PDSCH-16QAM, PDSCH-64QAM, on a complete LTE frame.

Requirements for Frames
For all bandwidths, the EVM measurement must be performed over all allocated resource blocks and subframes within a frame. The EVM for different modulation schemes on PDSCH must be lower than these limits:
- PDSCH-QPSK: 17.5 percent
- PDSCH-16QAM: 12.5 percent
- PDSCH-64QAM: 8 percent

JD740 Procedure for Frames

Results for Frames

Note: Register the Cell ID value that is auto-discovered; manual entry may be required for TX2 testing if the eNodeB does not transmit P-SCH and S-SCH on TX2.
Subframe Test

Definition of Subframes
The subframe measurement provides the EVM expressed in percentage, the power (dB or dBm) and modulation quality of each control channel, such as P-SCH, S-SCH, PBCH, PCFICH, PHICH, PDCCH, RS, and data channels, such as PDSCH-QPSK, PDSCH-16QAM, PDSCH-64QAM, on an LTE subframe.

Requirements for Subframes
The modulated carrier frequency of the Base Station must be accurate to within ±0.05 ppm observed over a period of one subframe (1 ms).

JD740 Procedure for Subframes

Results for Subframes

Note: Performing transmission tests are required for TX1 and TX2 ports on each sector (Alpha, Beta, and Gamma). Addendum 1 provides a Generic eNodeB Commissioning Test Check List.
eNodeB MIMO Test

eNodeB MIMO Time Alignment

Definition of MIMO Time Alignment
LTE has adopted a multiple antenna mechanism for increasing coverage and capacity. Adding multiple antennas improves performance because the signals take different paths to achieve diversity and spatial multiplexing.

Signals can be transmitted from two or more antennas commonly referred to as multiple-input multiple-output (MIMO). The differentiation of these multiple signals resides on the location of reference signals on the LTE frame; for example, the reference signals on the first subcarrier of antenna 0 (R0) are in symbols 1 and 8, whereas for antenna 1 (R1) they are in symbols 5 and 12.

The reference signals from multiple antennas, such as R0 and R1, must be aligned as 3GPP specifies as the delay between the signals from two antennas at the antenna ports.

Requirements for MIMO Time Alignment Test
The time alignment error in TX diversity or spatial multiplexing for any possible configuration of two transmission antennas must not exceed 65 ns.

Test Connectivity

Alcatel-Lucent eNodeB TX1 and TX2—JD740

Ericsson eNodeB RXA OUT—JD740
**JD740 Procedure for eNodeB Test**

**LTE Signal Analysis Mode for eNodeB Transmission**

```
Mode ➔ Signal Analyzer ➔ More (1/2) ➔ LTE - FDD
```

**Frequency Setting for eNodeB Transmission**

```
Free/Det ➔ Center Frequency ➔ Set Value ➔ 7 ➔ Measure ➔ MHz
```

**Amplitude and Power Offset Setting for eNodeB Transmission**

```
Amp/Scale ➔ External Offset ➔ 0 dB ➔ On ➔ Off ➔ Memory ➔ 4 ➔ dB ➔ Auto Scale
```
MIMO Time Alignment Test Setting

Result for eNodeB MIMO Time Alignment Error Test
eNodeB Over-the-Air Analysis

Over-the-Air analysis covers the following tests while receiving the signal over the air through an omnidirectional antenna attached to the RF-in port of the instrument.

- ID Scanner test
- Multipath profile
- Control channel
- Datagram

Test Configuration

Configure the JD740 to perform Over-the-Air analysis as shown below.
Result of Test Configuration
ID Scanner Test

Definition of ID Scanner Test
LTE mobiles must receive signals on the same channel from multiple cell sites at the edge of each cell to ensure seamless handovers between cells, making it critical to characterize the signal dominance of adjacent cell sites measuring the primary and secondary sync channels.

The ID Scanner identifies the six strongest cell sites indicating their corresponding physical cell identity in terms of Cell ID, Group ID, and Sector ID. It measures dominance and power of the primary and secondary sync channels (P-SCH and S-SCH) for each cell site.

JD740 Procedure for ID Scanner Test

Result of ID Scanner Test
Multipath Profile Test

Definition of Multipath Profile Test

LTE mobiles receive signals from multiple paths from the cell site and directly from the cell site if no obstructions or reflections of the signal occur from large objects such as water, mountains, or buildings. The effects of multipath include interference and phase shifting of the signal that might cause errors and affect quality of service (QoS). The signal structure of LTE is based on OFDM that minimizes the negative effects of multipath; however, LTE also uses high modulation schemes, such as 64QAM, that are more sensitive to modulation errors due to the amount of data transmitted.

Multipath propagation in OFDM can remove one or more subcarriers and, in extreme cases, even loss of signal acquisition is possible; therefore, it is critical to characterize the multipath profile, particularly in areas that demonstrate poor performance.

JD740 Procedure for Multipath Profile Test

Result of Multipath Profile Test

![Image of multipath profile test result](image-url)
Control Channel Test

Definition of Control Channel Test
The control channel test completely characterizes all of the control channels in terms of absolute and relative power as well as modulation quality (EVM). In addition, it measures MIMO for power and time alignment of the reference signals received from both antennas at the cell site, TX-Antenna 0 (RS0) and TX-Antenna 1 (RS1). This characterization comprehensively assesses signal strength, quality, and diversity at any location.

JD740 Procedure for Control Channel Test

Result of Control Channel Test
Datagram Test

Definition of Datagram Test
The datagram test measures the power variation over time for all the resource blocks contained on the LTE channel indicating data utilization over time. The datagram indicates traffic demand to prevent channel saturation and bandwidth performance ensuring the availability of all data channels.

JD740 Procedure for Datagram Test

Result Datagram Test
eNodeB Reception Test

Test Connectivity

**Alcatel-Lucent with JD740**

![Diagram of Alcatel-Lucent eNodeB RX1—JD740](image)

**Ericsson with JD740**

![Diagram of Ericsson eNodeB RXA OUT—JD740](image)
eNodeB Reception

Use the following procedure to configure the instrument to properly test the receiving noise floor for LTE signals on the eNodeB.

**JD740 Procedure for Spectrum Analysis Mode**

![Diagram of JD740 Procedure for Spectrum Analysis Mode]

**JD740 Configuration to Set the Offset**

If the eNodeB RX port is amplified by 25 dB, it requires setting a 25 dB offset, as follows:

![Diagram of JD740 Configuration to Set the Offset]

**JD740 Configuration to Set Resolution Bandwidth**

![Diagram of JD740 Configuration to Set Resolution Bandwidth]
Noise Floor

Definition of Noise Floor
Noise Floor measures the reference sensitivity level as the minimum mean power received that must meet a throughput requirement for a specified reference measurement channel.

Requirements for Noise Floor
The throughput must be $\geq 95\%$ of the maximum throughput for the reference measurement channel with a reference sensitivity power level of $-101.5\, \text{dBm}$.

JD740 Procedure for Noise Floor

Results for Noise Floor
# Addendum 1: Generic eNodeB Commissioning Check List

Site Name__________________________________________

Site Address__________________________________________

Date________________________________________________

<table>
<thead>
<tr>
<th>Test</th>
<th>Criteria</th>
<th>Alpha TX1</th>
<th>Alpha TX2</th>
<th>Beta TX1</th>
<th>Beta TX2</th>
<th>Gamma TX1</th>
<th>Gamma TX1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell ID Group ID Sector ID</td>
<td>Note all 3 for each TX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Power</td>
<td>__ ≤ x dBm ≤___</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupied Bandwidth</td>
<td>Pass/Fail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEN</td>
<td>Pass/Fail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACLR</td>
<td>Pass/Fail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-SCH Power</td>
<td>__ ≤ x dBm ≤___</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-SCH Power</td>
<td>__ ≤ x dBm ≤___</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCFICH Power</td>
<td>__ ≤ x dBm ≤___</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBCH Power</td>
<td>__ ≤ x dBm ≤___</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVM</td>
<td>0 ≤ x %&lt; 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency error</td>
<td>0 ≤ x ppm &lt; 0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Addendum 2: Measurement Limits

Overview
The base station analyzer can be set with different limit levels for RF analysis and modulation analysis; the variable limits are as follows:
Modulation Test Limits – Menu Structure (Part 1)
Modulation Test Limits – Menu Structure (Part 2)
Requirements for Setting Modulation Limits

Use the following procedure to configure RF or Modulation limits.

**JD740 Procedure for Setting Modulation Limits**

![Diagram showing the procedure]

**Setting RF Test Limits for Channel Power**

*Enable the test limit*

![Diagram showing enabling the test limit]

*Set high and low limits*

![Diagram showing setting high and low limits]
Setting RF Test Limits for Occupied Bandwidth

Enable the test limit

Set the low limit

JD740 Procedure for Setting RF Test Limits for Spectrum Emissions Mask, ACLR, and Spurious Emissions

Select the test parameter and enable the test limit


**Setting Modulation Test Limits for Frequency Error**

*Enable the test limit*

![Diagram showing the process of enabling the test limit for frequency error]

*Set high and low limits*

![Diagram showing the setting of high and low limits for frequency error]

**Setting Modulation Test Limits for EVM RMS and EVM Peak**

*Select the test parameter and enable the test limit*

![Diagram showing the selection and enabling of test limits for EVM RMS and EVM Peak]
Set high and low limits

Setting Modulation Test Limits for Time Error

Enable test limit

Set high and low limits
Setting Modulation Test Limits for IQ Origin Offset

Enable test limit

Set high limit

Setting Modulation Test Limits for RS Power

Select the test parameter and enable the test limit
Set absolute (dBm) limits

- High Limit: 22.00 dBm
- Low Limit: 18.00 dBm

Set relative (dB) limits to RS power

- High Limit: -10.00 dB
- Low Limit: -15.00 dB
Addendum 3: Auto Measure

Overview
Auto Measure automatically performs a series of tests for RF analysis and Modulation analysis and includes these parameters:

- **RF analysis**
  - Channel power
  - Occupied bandwidth
  - ACLR
  - SEM
- **Modulation analysis**
  - IQ origin offset
  - Time error
  - EVM RMS
  - EVM peak
  - Frequency error
  - RS power
  - P-SCH power
  - S-SCH power
  - PBCH power
  - PCFICH power

The limit values of each parameter can be configured according to the parameters in Appendix 2.
Auto Measure Procedure

To change the limit settings
Refer to Appendix 2 for testing limit procedures.

**Define the name and location of the measurement results**

![Diagram showing Save Result and File Name options]

**JD740 Procedure for Auto Measure**

![Diagram showing Select and Done options]

**Define result storage location (Internal or USB) and screen results to be saved (All or Fail)**

![Diagram showing Save To, Save Screen, and Done options]

**Run the test**

![Diagram showing Prev and Run Test options]

The instrument will perform all of the selected measurements and upon completion will display the Auto Measure Settings screen.

**To view the summary results**
Results for Auto Measure

Auto Measure Result – Quick View

Auto Measure Result – Full View