

Keysight X-Series Signal Analyzers

This manual provides documentation for the following Analyzers:

PXA Signal Analyzer N9030A

MXA Signal Analyzer N9020A

EXA Signal Analyzer N9010A

CXA Signal Analyzer N9000A

Notice: This document contains references to Agilent. Please note that Agilent's Test and Measurement business has become Keysight Technologies. For more information, go to www.keysight.com.

N9082A/W9082A LTE
TDD Measurement
Application
Measurement Guide

Notices

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1 About the LTE TDD Measurement Application

This chapter provides overall information on LTE TDD communications systems, and describes LTE TDD measurements made by the analyzer.

What Does the LTE TDD Application Do?

This analyzer can be used for testing a LTE TDD downlink and uplink signals complying with the standards listed below:

- 3GPP TS 36.201 V9.1.0 (2010-03) Physical Layer General Description
- 3GPP TS 36.211 V9.1.0 (2010-03) Physical Channels and Modulation
- 3GPP TS 36.212 V9.4.0 (2011-09) Multiplexing and Channel Coding
- 3GPP TS 36.213 V9.3.0 (2010-10) Physical Layer Procedures
- 3GPP TS 36.214 V9.2.0 (2010-06) Physical Layer Measurements
- 3GPP TS 36.101 V9.12.0 (2012-07) UE Radio Transmission and Reception
- 3GPP TS 36.104 V9.12.0 (2012-07) BS Radio Transmission and Reception
- 3GPP TS 36.141 V9.10.0 (2012-07) BS Conformance Testing
- 3GPP TS 36.521-1 V9.8.0 (2012-03) UE Conformance Testing

The instrument automatically makes these measurements using the measurement methods and limits defined in the documents. The detailed results displayed by the measurements enable you to analyze LTE TDD signals performance. You may alter the measurement parameters for specific analysis.

This analyzer makes the following measurements providing power measurements and modulation analysis for the LTE TDD signals:

- Modulation Analysis
- Channel Power
- Adjacent Channel Power (ACP)
- Spectrum Emission Mask
- Spurious Emissions

About the LTE TDD Measurement Application

- Occupied BW
- Power Stat CCDF
- Monitor Spectrum
- IQ Waveform (Time Domain)
- Transmit On/Off Power
- Conformance EVM

2 Making LTE TDD Measurements

This chapter begins with instructions common to all measurements including equipment configuration, simple steps for making a measurement, then details how to make the measurements available by pressing the **LTE TDD** mode and Meas key for LTE TDD Downlink and Uplink signal separately.

- “Setting Up and Making a Measurement” on page 13
- “LTE TDD Downlink Signal Measurement” on page 15
 - “Configuring the Measurement System” on page 15
 - “Setting the Downlink Signal (Example for Power Measurement)” on page 16
 - “Common Measurement Procedure (Downlink)” on page 18
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- “Preset to Standard Settings” on page 133

Setting Up and Making a Measurement

Making the Initial Signal Connection

CAUTION

Before connecting a signal to the analyzer, make sure the analyzer can safely accept the signal level provided. The signal level limits are marked next to the RF Input connectors on the front panel.

See the Input Key menu for details on selecting input ports, and the AMPTD Y Scale menu, for details on setting internal attenuation to prevent overloading the analyzer.

Using Analyzer Mode and Measurement Presets

To set your current measurement mode to a known factory default state, press **Mode Preset**. This initializes the analyzer by returning the mode setup and all of the measurement setups in the mode to the factory default parameters.

To preset the parameters that are specific to an active, selected measurement, press **Meas Setup, Meas Preset**. This returns all the measurement setup parameters to the factory defaults, but only for the currently selected measurement.

3 Steps to Setting Up and Making Measurements

All measurements can be set up using the following three steps. The sequence starts at the Mode level, is followed by the Measurement level, finally, the result displays may be adjusted.

Table 2-1 3 Steps to Setting Up and Making a Measurement

Step	Action	Notes
1 Select and Set Up the Mode	<ol style="list-style-type: none"> a. Press Mode. b. Press a mode key, like Spectrum Analyzer, W-CDMA with HSDPA/HSUPA, or LTE TDD. c. Press Mode Preset. d. Press Mode Setup. 	<p>All licensed, installed modes available are shown under the Mode key.</p> <p>Using Mode Setup, make any required adjustments to the mode settings. These settings will apply to all measurements in the mode.</p>
2 Select and Set Up the Measurement	<ol style="list-style-type: none"> a. Press Meas. b. Select the specific measurement to be performed. c. Press Meas Setup. 	<p>The measurement begins as soon as any required trigger conditions are met. The resulting data is shown on the display or is available for export.</p> <p>Use Meas Setup to make any required adjustment to the selected measurement settings. The settings only apply to this measurement.</p>

Making LTE TDD Measurements
 Setting Up and Making a Measurement

Table 2-1 3 Steps to Setting Up and Making a Measurement

Step	Action	Notes
3 Select and Set Up a View of the Results	Press View/Display . Select a display format for the current measurement data.	Depending on the mode and measurement selected, other graphical and tabular data presentations may be available. X-Scale and Y-Scale adjustments may also be made now.

NOTE A setting may be reset at any time, and will be in effect on the next measurement cycle or view.

Table 2-2 Main Keys and Functions for Making Measurements

Step	Primary Key	Setup Keys	Related Keys
1 Select and set up a mode.	Mode	Mode Setup, FREQ Channel	System
2 Select and set up a measurement.	Meas	Meas Setup	Sweep/Control, Restart, Single, Cont
3 Select and set up a view of the results.	View/Display	SPAN X Scale, AMPTD Y Scale	Peak Search, Quick Save, Save, Recall, File, Print

LTE TDD Downlink Signal Measurement

The section describes how to make measurements for LTE TDD Downlink Signal. The measurement procedure with screen shots of the measurement example are provided.

NOTE For the SCPI commands and detailed description of keys and parameters, refer to N9082A LTE TDD Measurement Application User's and Programmer's Reference.

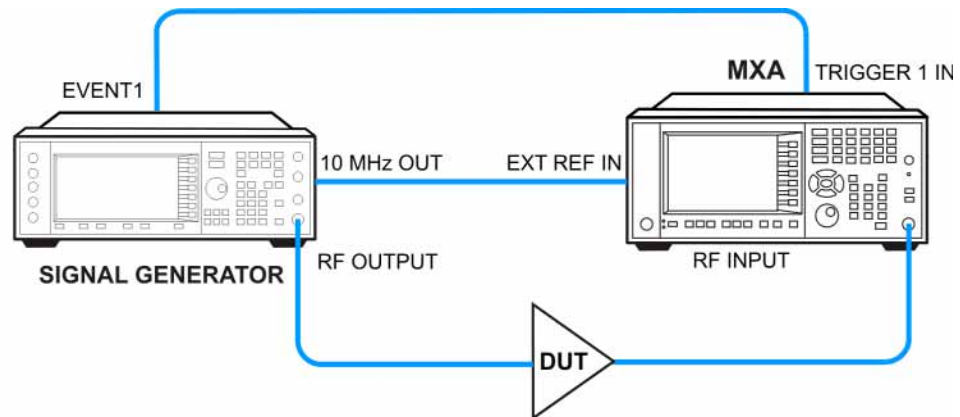
Configuring the Measurement System

There are two kinds of measurement setups to test the DUT (Device Under Test): Component Measurement System and Base Station Measurement System.

Component Measurement System

This system is used for preamplifier and repeater. See the connection of the equipment below.

Figure 2-1 Component Test System

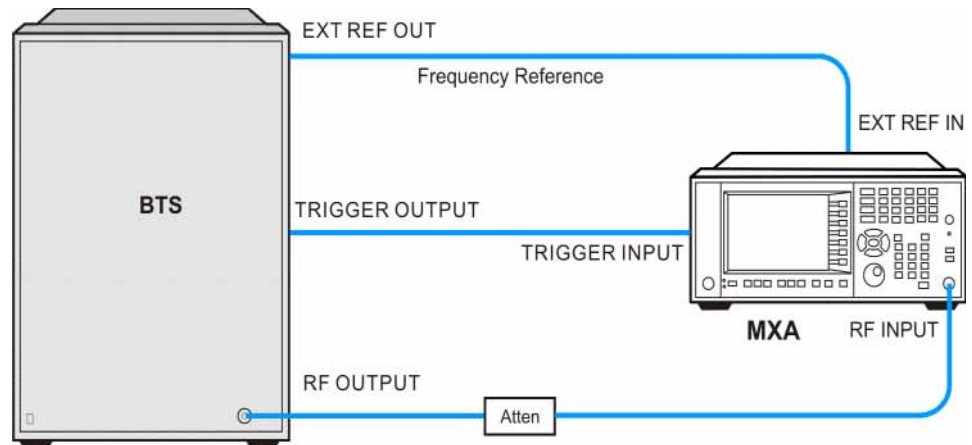


1. Connect the RF Output of the Signal Generator to the Input port of the Component.
2. Connect the Output port of the Component to the RF Input of the Signal Analyzer.
3. Connect a BNC cable between the 10 MHz OUT port of the Signal Generator and the EXT REF IN port of the Signal Analyzer.
4. Connect the EVENT 1 of the Signal Generator to the TRIGGER 1 IN of the Signal Analyzer.

Base Station Measurement System

See the connection of the equipment below.

Figure 2-2 Base Station Test System



1. Connect the RF Output of the BTS to the RF Input of the analyzer using the appropriate attenuator.
2. Connect a BNC cable between the External Reference OUT port of the BTS to the EXT REF IN port of the analyzer.
3. Connect the Trigger Output of the BTS to the TRIGGER 1 IN of Signal Analyzer.

NOTE

For Power Measurement of the LTE TDD downlink signal, because the signal is bursted, you must use Gate function, and the connection of trigger is required. For detail regarding Gating function, see [“Time Gating Concepts” on page 187](#).

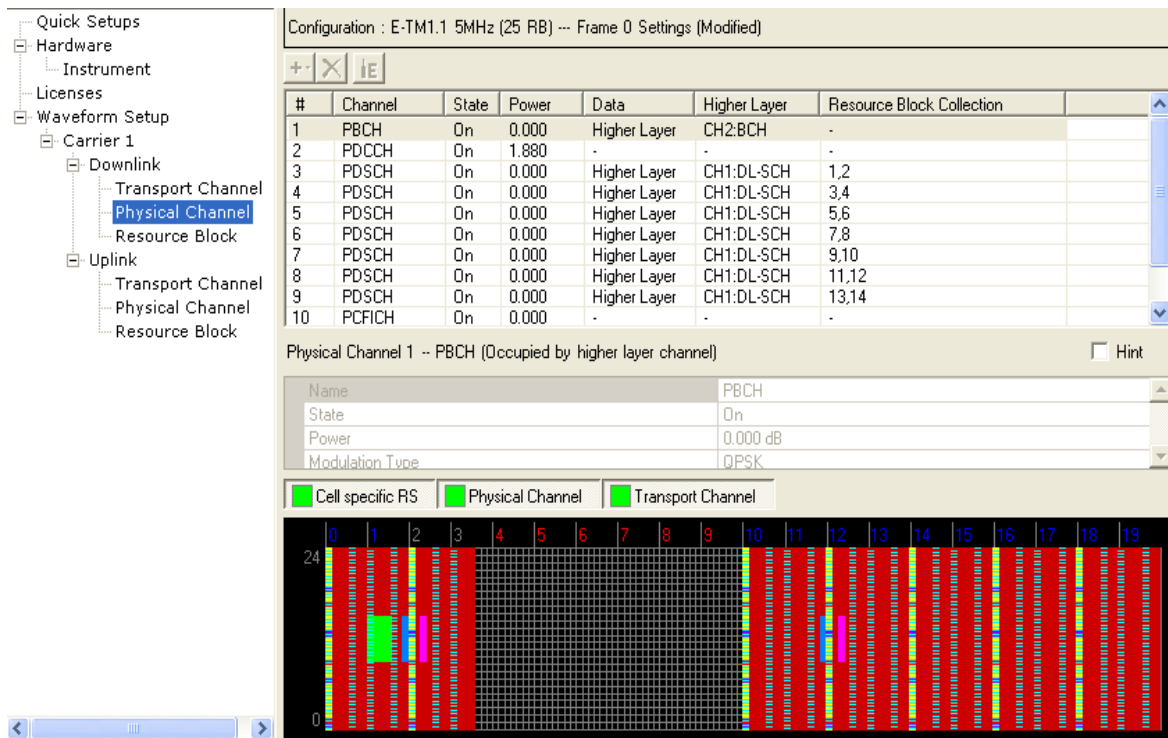
Setting the Downlink Signal (Example for Power Measurement)

Test model E-TM1.1 is used as the example in the following power measurements.

Configure the signal generator using the settings below. The Keysight Signal Studio N7625B for 3GPP LTE TDD is used in the example to generate the required waveform for testing.

Frequency: 1 GHz
Output Power: -10 dBm (at analyzer input)
Carrier: 1
Bandwidth: 5 MHz

Figure 2-3 E-TM1.1 Signal Studio Mapping (Downlink Signal)



Common Measurement Procedure (Downlink)

NOTE In the following instruction, the test signal is generated using E-URTA Test Model with 5 MHz bandwidth. Therefore the following procedures are common and need to set up for all measurements.

Step	Action	Notes
1 Enable the LTE TDD measurements.	Press Mode, LTE TDD .	
2 Preset the Mode.	Press Mode Preset .	Only do this to return the measurement settings to a known state for all measurements in the LTE TDD mode.
3 Set the center frequency.	Press FREQ Channel, 1, GHz .	
4 Select the direction to Downlink .	Press Mode Setup, Radio, Direction to be Downlink . Downlink is the default setting.	
5 Set the Uplink and Downlink allocation configuration.	Press Mode Setup, Radio, ULDLAlloc, Configuration 3 (DSUUUUUUUU) .	
6 Set the DwPTS/GP/UpPTS length configuration of the signal.	Press Mode Setup, Radio, DW/GP/Up Len, More, Configuration 8 .	
7 Select the predefined parameters such as Analysis Slot, Meas Interval or CP Length	Press Mode Setup, Predefined Parameters to set up the parameters. Configure Analysis Slot to be TS10, Meas Interval to be 13 slots. CP Length to be Normal.	Analysis Slot is defined as the first slot for analysis.

NOTE The settings under Mode Setup and Predefined Parameters are used for power measurements, which do not apply to the Modulation Analysis measurement.

Monitor Spectrum Measurements

This section explains how to make a Monitor Spectrum measurement on a LTE TDD downlink signal. The Monitor Spectrum measurement is the default measurement in LTE TDD mode. It shows a spectrum domain display of the test signal. The primary use of Monitor Spectrum is to allow you to visually make sure you have the RF carrier available to the instrument, and the instrument is tuned to the frequency of interest.

For signal setting, see “Setting the Downlink Signal (Example for Power Measurement)” on page 16.

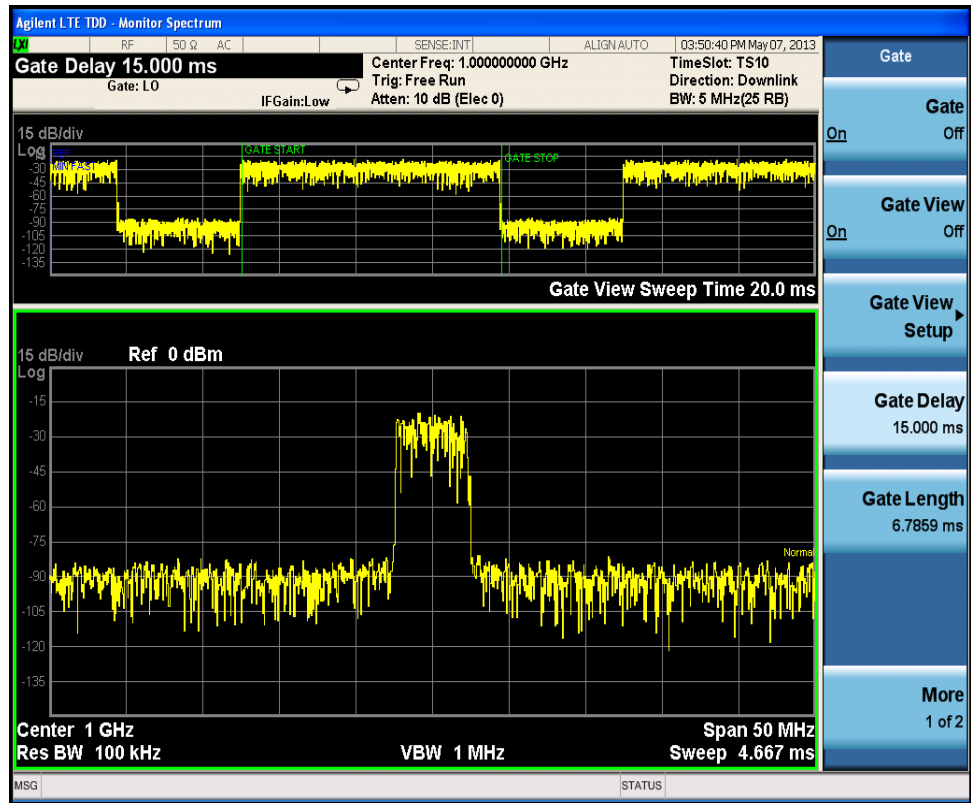
Measurement Procedure

Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Downlink)” on page 18.	It is not necessary if you already configured it in other measurements.
2 Initiate the Monitor Spectrum measurement.	Press Meas, Monitor Spectrum .	<p>The default display shows the Current (yellow trace) data. You can compare current trace with Max Hold trace, Min Hold trace or Average trace using setup under Trace/Detector.</p> <p>Press Trace/Detector, Select Trace and select the trace 1, then turn Update to Off . Select trace(s) desired for display and the detector type, like Max Hold, toggle Display to Show. Then press Update to On to see the timely update trace.</p>
3 Set the measurement span frequency.	Press SPAN X Scale , enter a numerical span using the front-panel keypad, and select a units key, such as MHz .	
4 Turn on the Gate View and set up the Gate function.	Press Sweep/Control, Gate, Gate View (On) .	<p>Turning Gate View On or Off would not influence Gate View Sweep Time. It is initialized by Mode Preset or Analysis Slot in Mode Setup, Predefined Parameters.</p> <p>The Monitor Spectrum measurement with the gate view on should look like Figure 2-4.</p> <p>You can change the Gate View Sweep Time, Gate Delay or Gate Length to see other parts of the data frame.</p>

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step	Action	Notes
TIP	LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.	

Figure 2-4 LTE TDD Downlink Monitor Spectrum Measurement Result - Gate View On

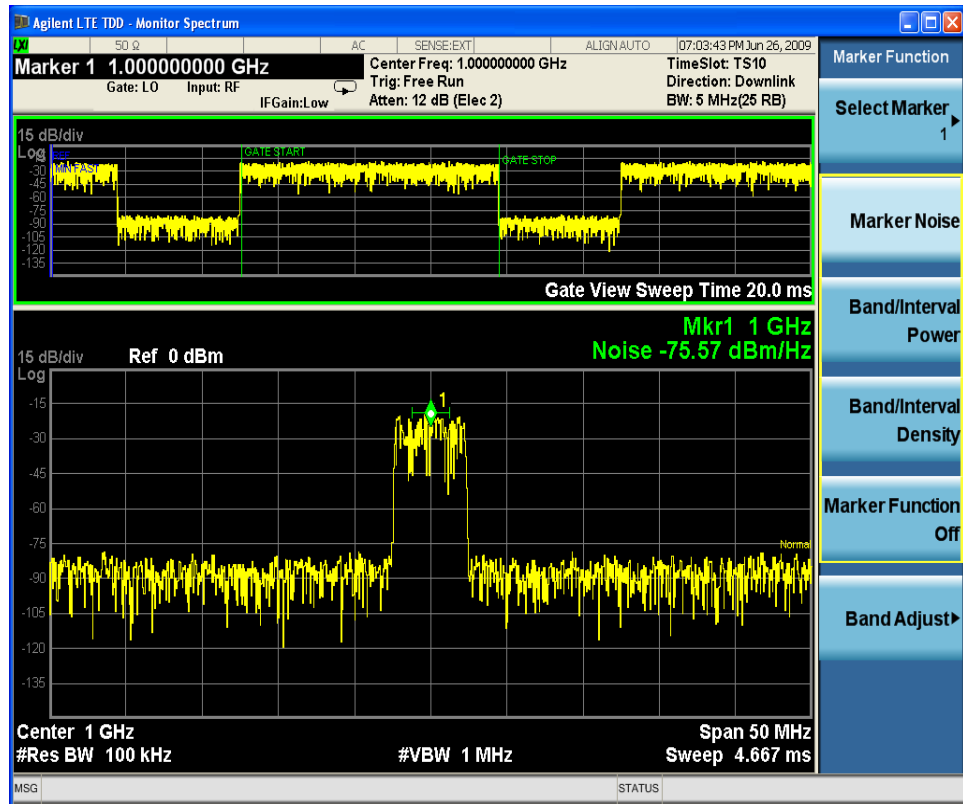


NOTE The default gate source is External 1. If you want to use other gate source, press Sweep/Control, Gate, More, Gate Source. Five types of gate sources are provided: Line, External 1, External 2, RF Burst and Periodic Timer.

5 Turn on Marker function.	Press Marker Function, Marker Noise.	You can choose Marker Noise, Band/Interval Power, Band/Interval Density or Marker Function Off. You can use Band Adjust to set the frequency span for analysis. The Figure 2-5 shows an example of Marker Noise
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Step	Action	Notes
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Figure 2-5 LTE TDD Downlink Monitor Spectrum Measurement Result - Marker Noise



6 (Optional) Turn on Marker function.	Press Marker Function , Marker Noise .	You can choose Marker Noise, Band/Interval Power, Band/Interval Density or Marker Function Off. You can use Band Adjust to set the frequency span for analysis.
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If you have a problem and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

IQ Waveform (Time Domain) Measurements

This section explains how to make a Waveform (time domain) Measurement on a LTE TDD downlink signal. The measurement of I and Q modulated waveforms in the time domain disclose the voltages which comprise the complex modulated waveform of a digital signal.

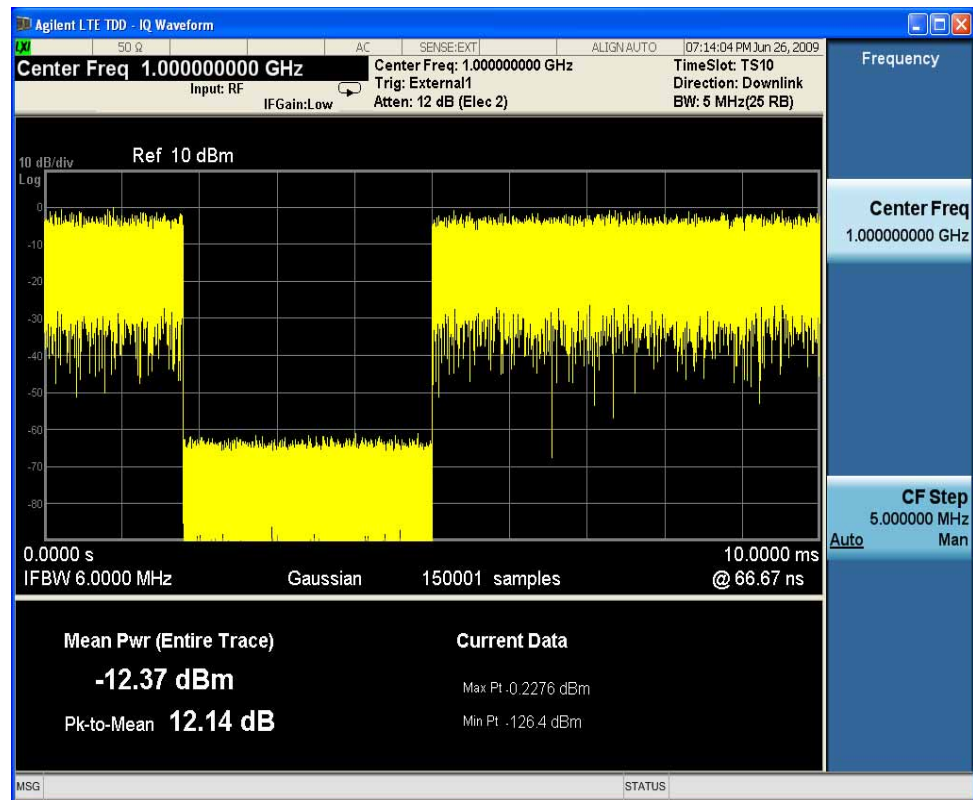
For signal setting, see “Setting the Downlink Signal (Example for Power Measurement)” on page 16.

Measurement Procedure

Step	Action	Notes
1	Perform the common configuration.	See “Common Measurement Procedure (Downlink)” on page 18. It is not necessary if you already did it in other measurements.
2	Initiate the IQ Waveform measurement.	Press Meas, IQ Waveform . The default display in Figure 2-6 shows the RF Envelope with the current data. The measured values for the mean power and peak-to-mean power are shown in the text window.

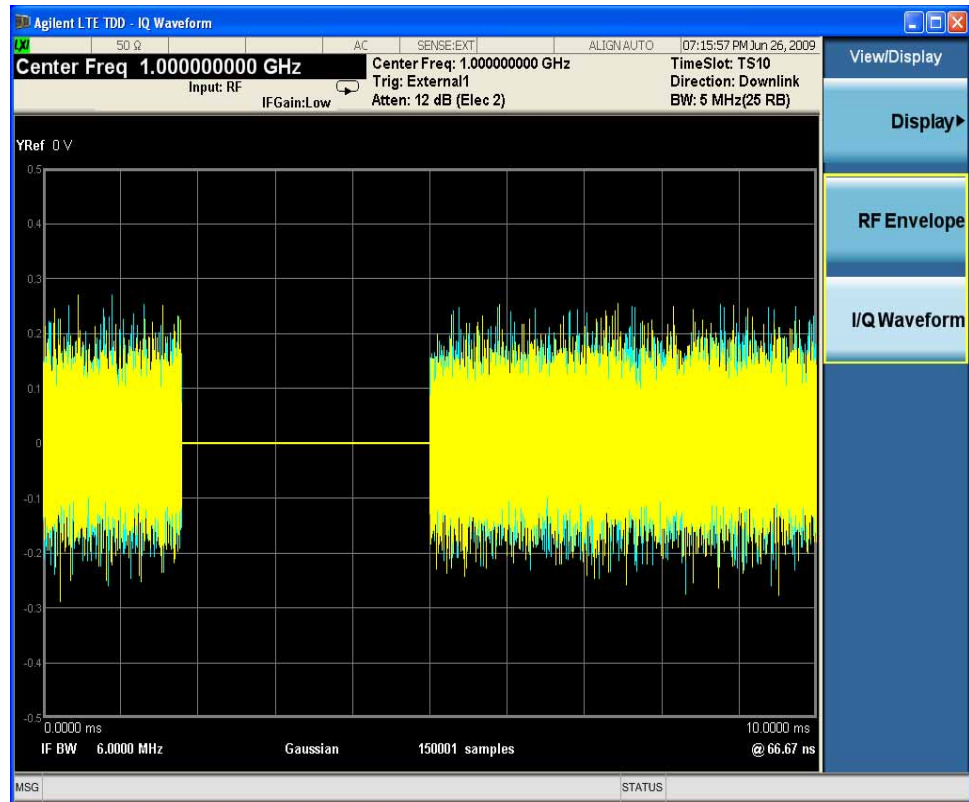
Figure 2-6

LTE TDD Downlink IQ Waveform Measurement Result



Step	Action	Notes
3	Select the IQ Waveform view. Press View/Display, IQ Waveform .	The IQ Waveform window provides a view of the I (yellow trace) and Q (blue trace) waveforms on the same graph in terms of voltage versus time in linear scale.

Figure 2-7 LTE TDD Downlink Waveform Measurement - I/Q Waveform View



4	Adjust the scale.	Press the AMPTD Y Scale and SPAN X Scale and configure the setup until the waveforms are shown at a convenient voltage scale for viewing.
5	Turn on Marker functions.	Press the Maker Function key to use Maker Noise, Band/Interval Power, Band/Interval Density and Marker Function Off. You can use Band Adjust to set the frequency span for analysis.
6	(Optional) Change measurement parameters from their default condition.	Press the Meas Setup key to see the keys available to change.

Making LTE TDD Measurements
LTE TDD Downlink Signal Measurement

If you have a problem and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Channel Power Measurements

This section explains how to make a Channel Power measurement on a TDD LTE downlink signal. This test measures the total RF power present in the channel. The results are shown in a graph window and in a text window.

Test model E-TM1.1 requires Channel Power measurement and is used in this example.

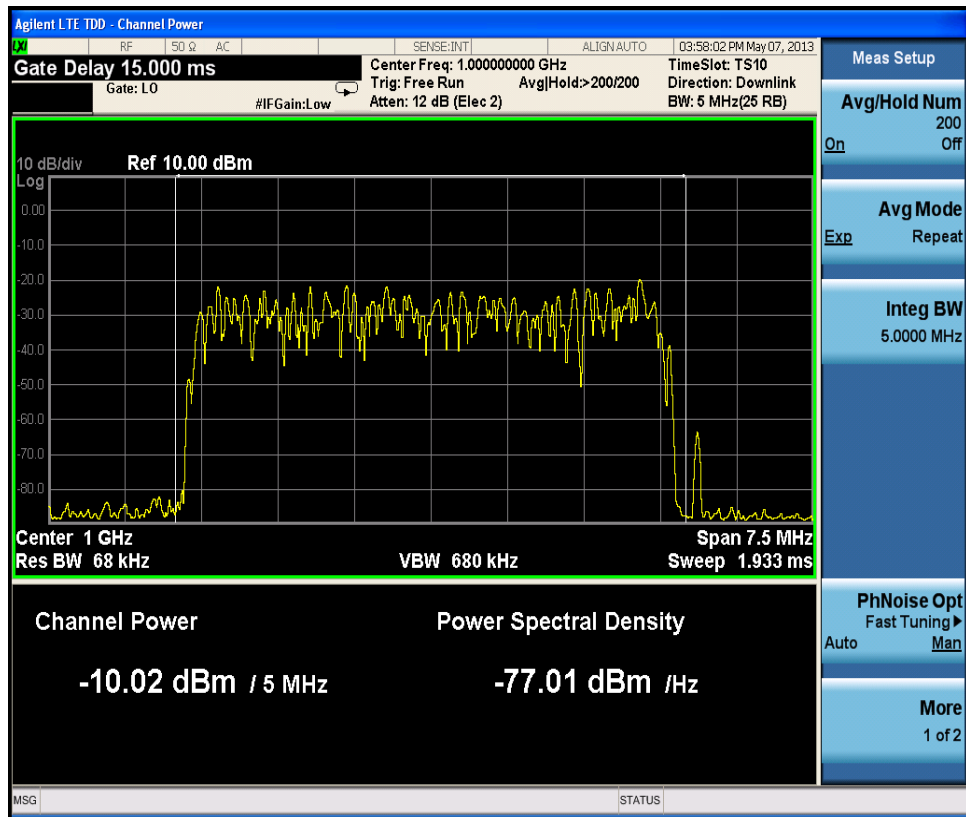
For signal setting, see “Setting the Downlink Signal (Example for Power Measurement)” on page 16.

Measurement Procedure

Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Downlink)” on page 18.	It is not necessary if you already did it in other measurements.
2 Initiate the channel power measurement.	Press Meas, Channel Power .	
3 Enter the Integration Bandwidth.	Press Meas Setup, Integ BW, 5, MHz .	The Integration BW is shown within the two white lines. The Channel Power measurement result should look like Figure 2-8. The graph window and the text window show the absolute power and its mean power spectral density values over 5 MHz.

Step	Action	Notes
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Figure 2-8 LTE TDD Downlink Channel Power Measurement Result



4 Turn on the Gate View and set up the Gate function.

Press **Sweep/Control, Gate, Gate View (On)**.

Turning Gate View On or Off would not influence Gate View Sweep Time. Gate View Sweep Time is initialized by Mode Preset or Analysis Slot under Mode Setup, Predefined Parameters.

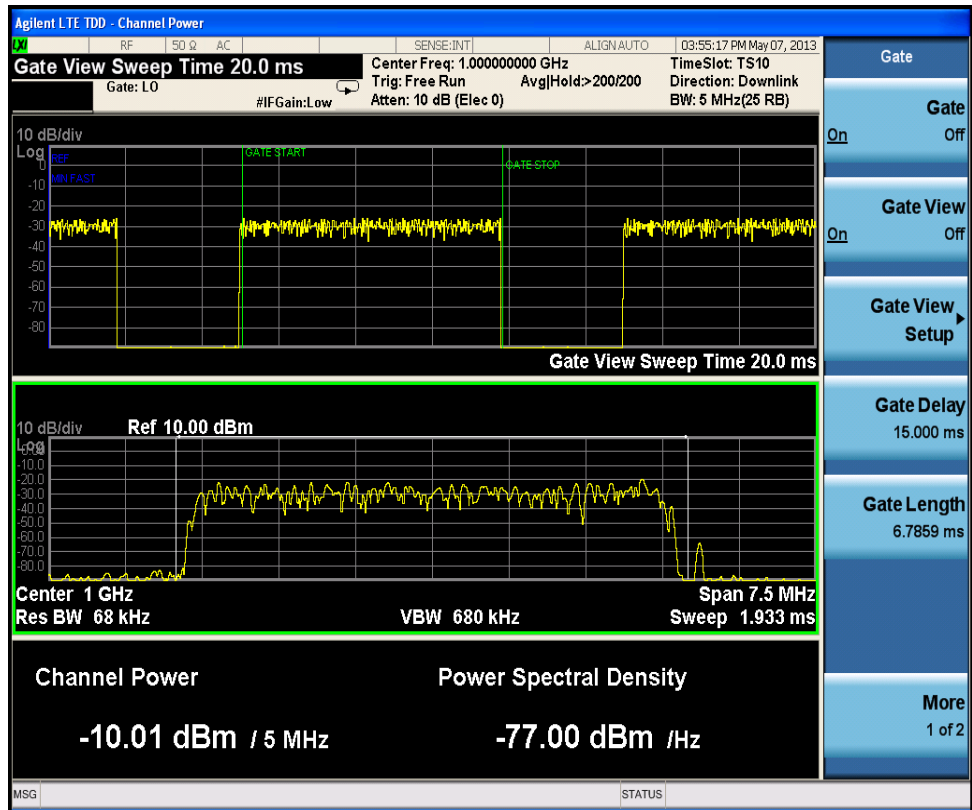
The channel power measurement result with the gate view on should look like [Figure 2-9](#).

You can change the Gate Delay or Gate Length to see other parts of the data frame.

TIP LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.

Step	Action	Notes
------	--------	-------

Figure 2-9 LTE TDD Downlink Channel Power Measurement Result - Gate View On



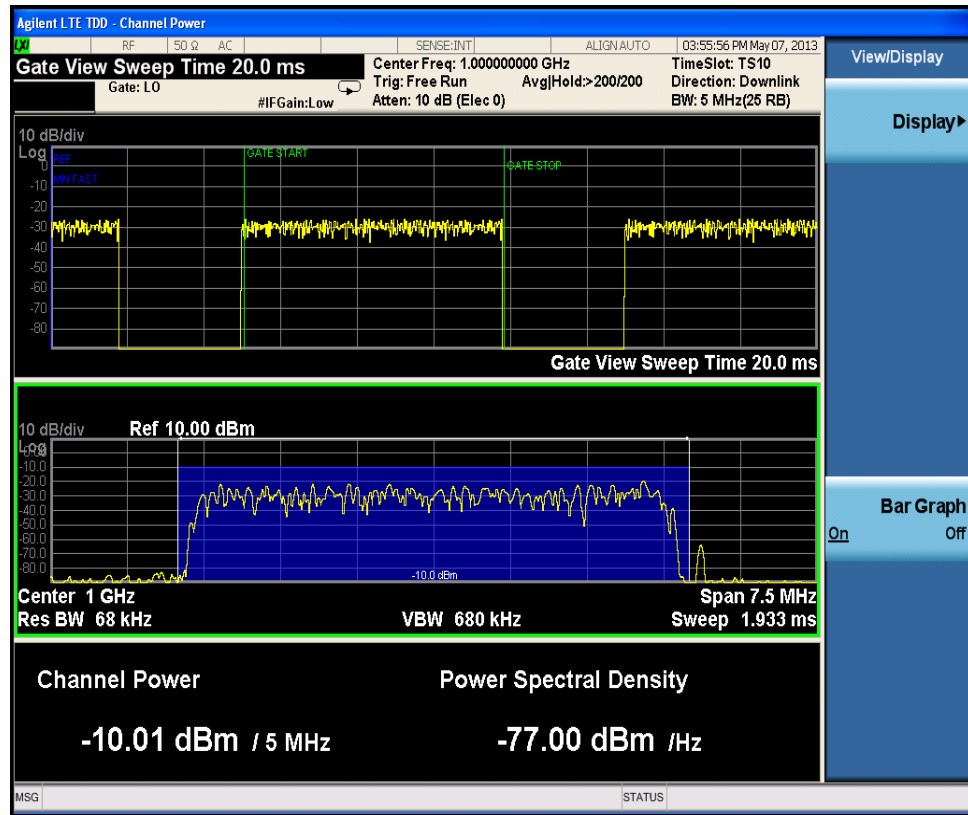
NOTE The default gate source is External 1. If you want to use other gate source, press Sweep/Control, Gate, More, Gate Source. Five types of gate sources are provided: Line, External 1, External 2, RF Burst and Periodic Timer.

5 (Optional) Display the Channel Power Bar Graph view.	Press View/Display, Bar Graph .	The Bar Graph view result should look like Figure 2-10 .
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Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step	Action	Notes
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Figure 2-10 LTE TDD Downlink Channel Power Measurement Result - Bar Graph On



- | | |
|--|---|
| 6 (Optional) Change measurement parameters from their default condition. | Press Meas Setup to see the keys that are available to change. |
|--|---|

If you have a problem and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Occupied Bandwidth Measurements

This section explains how to make the Occupied Bandwidth measurement on a LTE TDD downlink signal. The instrument measures power across the band, and then calculates its 99.0% power bandwidth.

Test model E-TM1.1 requires Occupied Bandwidth measurement and is used in this example.

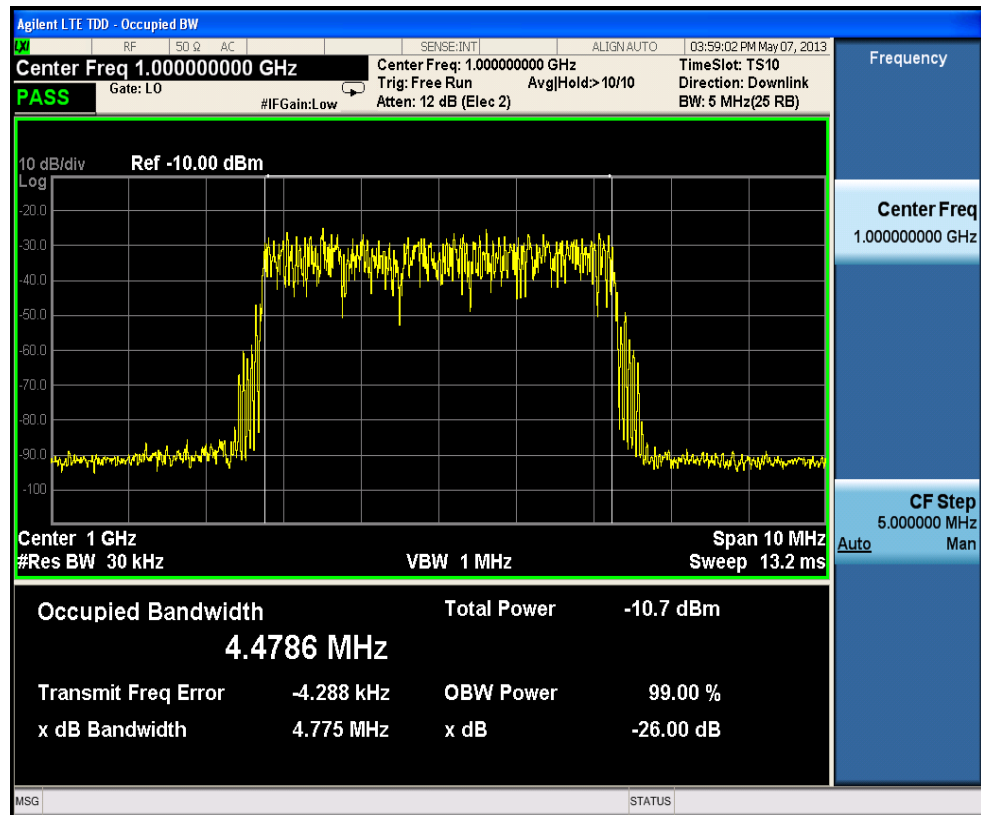
For signal setting, see “Setting the Downlink Signal (Example for Power Measurement)” on page 16.

Measurement Procedure

Step	Action	Notes
1	Perform the common configuration.	See “Common Measurement Procedure (Downlink)” on page 18. It is not necessary if you already did it in other measurements.
2	Initiate the Occupied Bandwidth measurement.	Press Meas, Occupied BW . The Occupied BW measurement results should look like Figure 2-11 .

Figure 2-11

LTE TDD Downlink Occupied BW Measurement Result

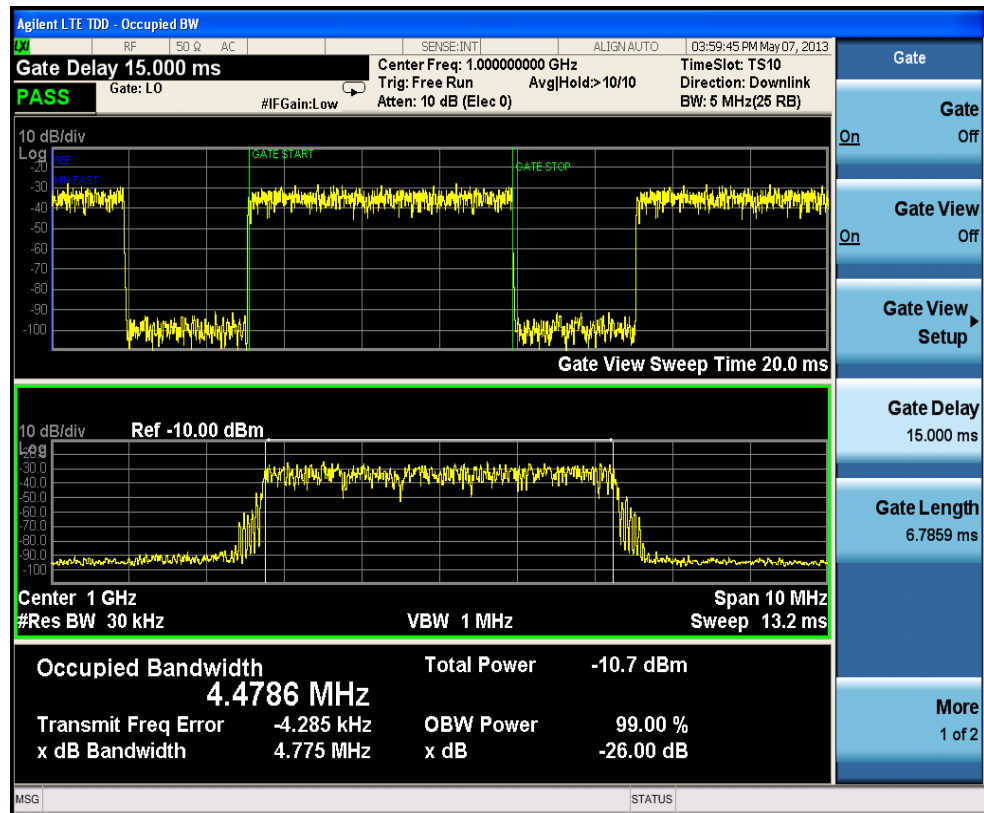


Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step	Action	Notes
3	Turn on the Gate View and set up the Gate function.	<p>Press Sweep/Control, Gate, Gate View (On).</p> <p>Turning Gate View On or Off would not influence Gate View Sweep Time. Gate View Sweep Time is initialized by Mode Preset or Analysis Slot under Mode Setup, Predefined Parameters.</p> <p>The occupied bandwidth with the gate view on should look like Figure 2-12.</p> <p>You can change the Gate Delay or Gate Length to see other parts of the data frame.</p>

TIP LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.

Figure 2-12 LTE TDD Downlink Occupied BW Measurement Result - Gate View On



NOTE The default gate source is External 1. If you want to use other gate source, press Sweep/Control, Gate, More, Gate Source. Five types of gate sources are provided: Line, External 1, External 2, RF Burst and Periodic Timer.

Step	Action	Notes
4 (Optional) Change measurement parameters from their default condition.	Press Meas Setup to see the keys that are available to change measurement parameters from their default condition.	

If you have a problem and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Troubleshooting Hints

Any distortion such as harmonics or intermodulation produces undesirable power outside the specified bandwidth.

Shoulders on either side of the spectrum shape indicate spectral regrowth and intermodulation. Rounding or sloping of the top shape can indicate filter shape problems.

ACP Measurements

This section explains how to make the Adjacent Channel Leakage Power Ratio (ACLR or ACPR) measurement for LTE TDD downlink signal. ACPR is a measurement of the amount of interference, or power, in an adjacent frequency channel. The results are displayed as a bar graph or as spectrum data, with measurement data at specified offsets.

Test model E-TM1.1 and E-TM1.2 require ACP measurement and E-TM1.1 is used in this example.

For signal setting, see “Setting the Downlink Signal (Example for Power Measurement)” on page 16.

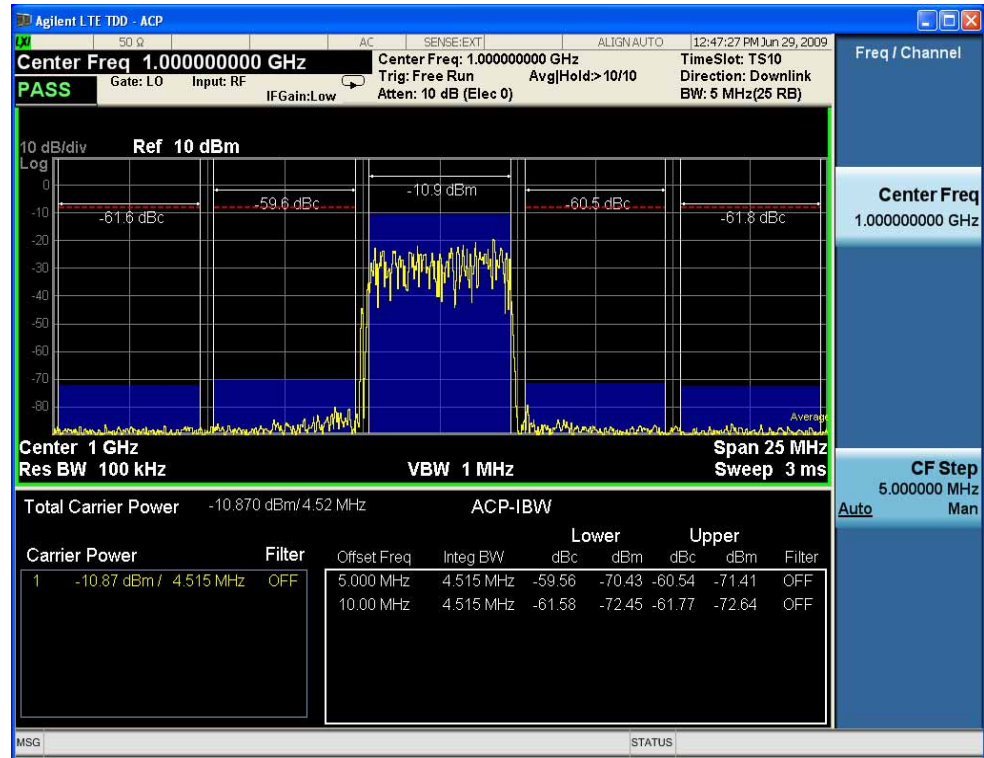
Measurement Procedure

Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Downlink)” on page 18.	It is not necessary if you already did it in other measurements.
2 Initial the ACP measurement.	Press Meas, ACP .	The ACP measurement results including the bar graph with the spectrum trace graph overlay should look like Figure 2-13 . The graph (referenced to the total power) and a text window are displayed. The text window shows the absolute total power reference, while the lower and upper offset channel power levels are displayed in both absolute and relative readings.

Step	Action	Notes
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Figure 2-13

LTE TDD Downlink ACP Measurement Result



3 Recall the masks.

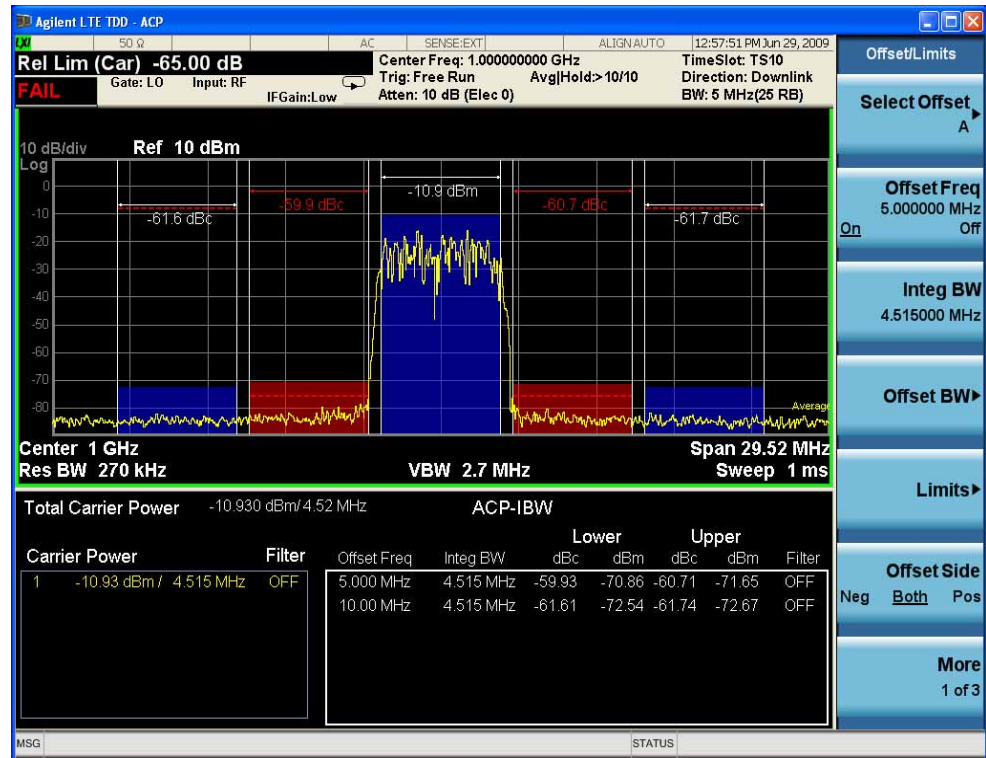
Press **Recall, Data, Mask** then **Open...**, a file open dialog appears. Select the appropriate test model file and click open.

Recall function is provided for E-URTA Test Models (E-TM) defined in standard 36.141 to setup the Offset/Limit parameters automatically. The other parameters will not be changed. At the bottom of the screen, there is a message to indicate which mask file is recalled.

The following steps are used in manual setup.

Step Action Notes

Figure 2-15 LTE TDD Downlink ACP Measurement Result - Fail



6 Turn on the Gate View and setup the Gate function.

Press **Sweep/Control, Gate, Gate View (On)**.

Turning Gate View On or Off will not influence Gate View Sweep Time. Gate View Sweep Time is initialized by Mode Preset or Analysis Slot under Mode Setup, Predefined Parameters.

The ACP measurement with the gate view on should look like Figure 2-12.

You can change the Gate Delay or Gate Length to see other parts of the data frame.

TIP LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.

Step	Action	Notes
8 (Optional) Change measurement parameters from their default condition.	Press Meas Setup to see the keys that are available to change.	

If you have a problem and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Spurious Emissions Measurement

This section explains how to make the Spurious Emissions measurement on a LTE TDD downlink signal. The measurement procedure for uplink signal is similar. This measurement identifies and determines the power level of spurious emissions in certain frequency bands.

Test model E-TM1.1 requires Spurious Emissions measurement and is used in this example.

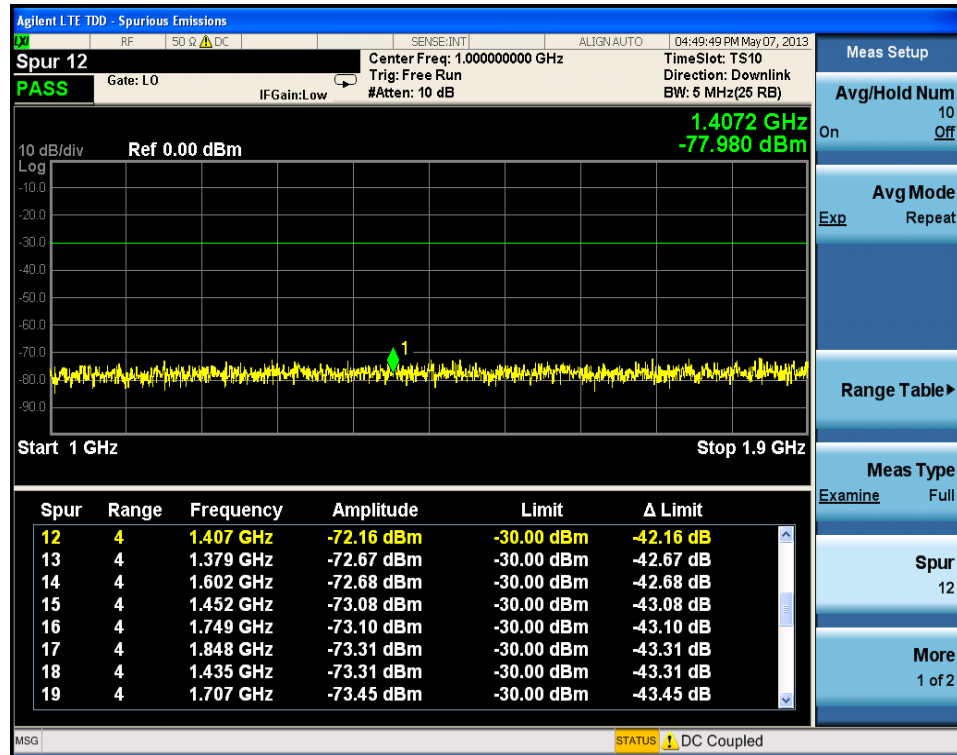
For signal setting, see “Setting the Downlink Signal (Example for Power Measurement)” on page 16.

Measurement Procedure

Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Downlink)” on page 18.	It is not necessary if you already did it in other measurements.
2 Toggle the RF Coupling to DC.	Press Input/Output, RF Input, RF Coupling, DC.	<p>In AC coupling mode, you can view signals less than 10 MHz but the amplitude accuracy is not specified. To accurately see a signal of less than 10 MHz, you must switch to DC coupling.</p> <p>When operating in DC coupled mode, ensure protection of the External Mixer by limiting the DC part of the input level to within 200 mV of 0 Vdc.</p>
3 Initiate the Spurious Emission measurement.	Press Meas, Spurious Emission.	<p>Depending on the current settings, the instrument will begin making the selected measurements. The resulting data is shown on the display.</p> <p>The Spurious Emissions measurement results should look like Figure 2-17. The spectrum window and the text window show the spurs that are within the current value of the Marker Peak Excursion setting of the absolute limit. Any spur that has failed the absolute limit will have an ‘F’ beside it.</p> <p>The measurement result shows the largest spur which is yellow. You can select the other spur by pressing Meas Setup, Spur and enter the number of the spur.</p>

Step	Action	Notes
NOTE	If you set the Meas Type to Examine, the trace is continuously updating to show the latest spectrum range which has the worst spurious. However, the table always shows the last reported trace information. Press Restart to update the table to show the latest result.	

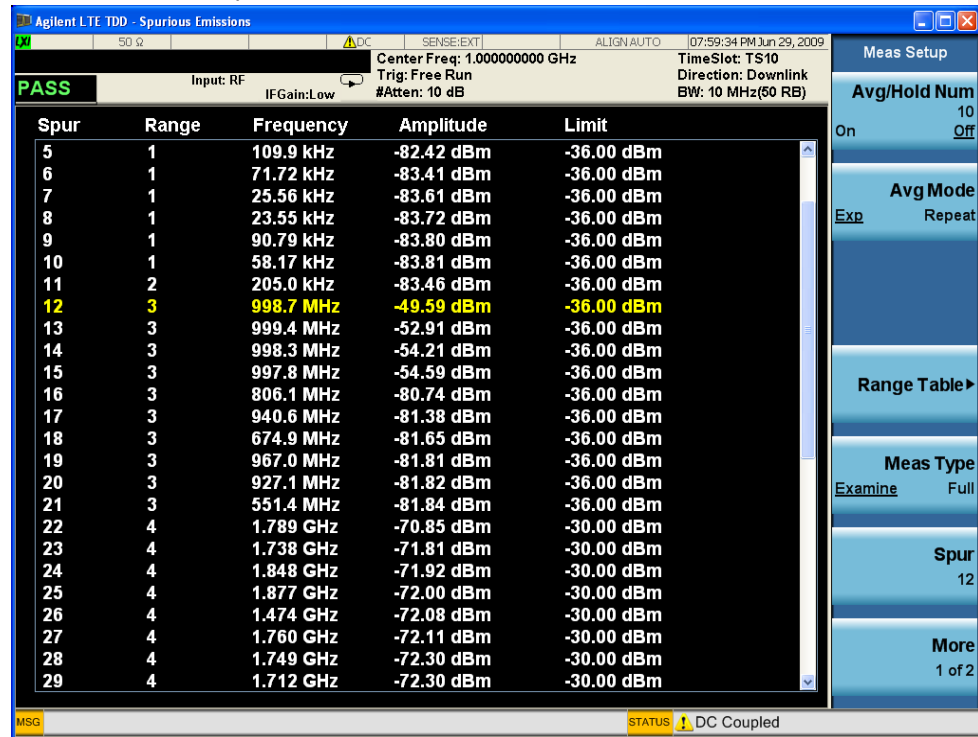
Figure 2-17 LTE TDD Downlink Spurious Emissions Measurement - Spur Table



You can use the window control keys below the screen to zoom the result screen. See Figure 2-18.

Step Action Notes

Figure 2-18 LTE TDD Downlink Spurious Emissions Measurement - Numeric Result Screen



4 Select the Range Table view and edit the Range Table. Press **View/Display, Range Table**, then **Meas Setup, Range Table**.

You can enter the settings for up to twenty ranges.

The measurement result highlights the selected range. If you want to change the settings of different ranges, you can press **Meas Setup, Range Table, Range**, then enter the range number you need to configure.

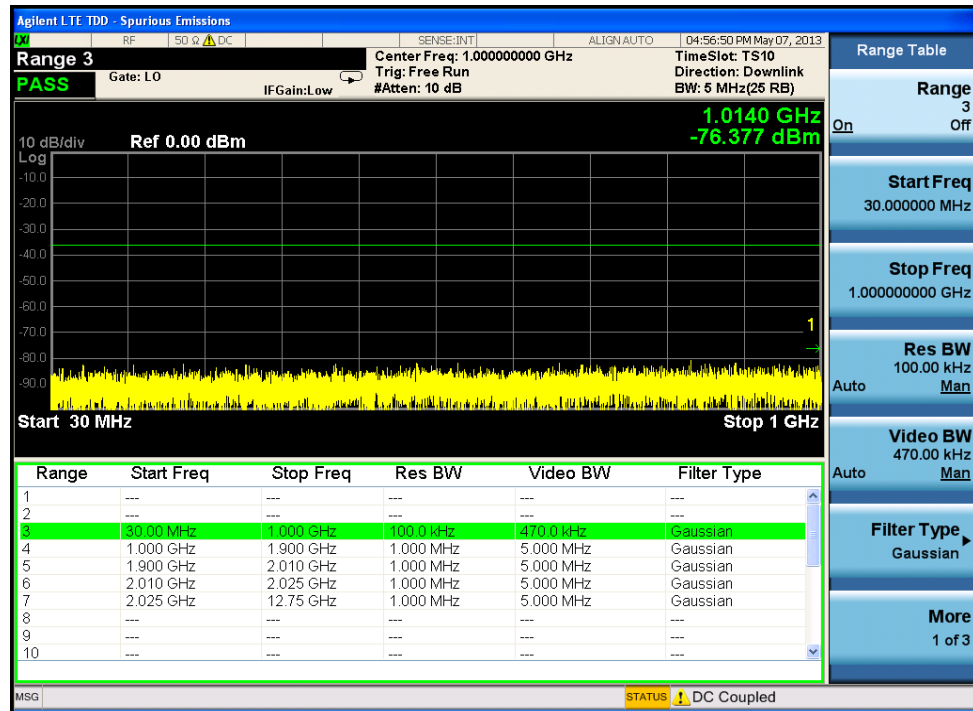
Step

Action

Notes

Figure 2-19

LTE TDD Downlink Spurious Emissions Measurement - Range Table



5 Select the All Ranges view.

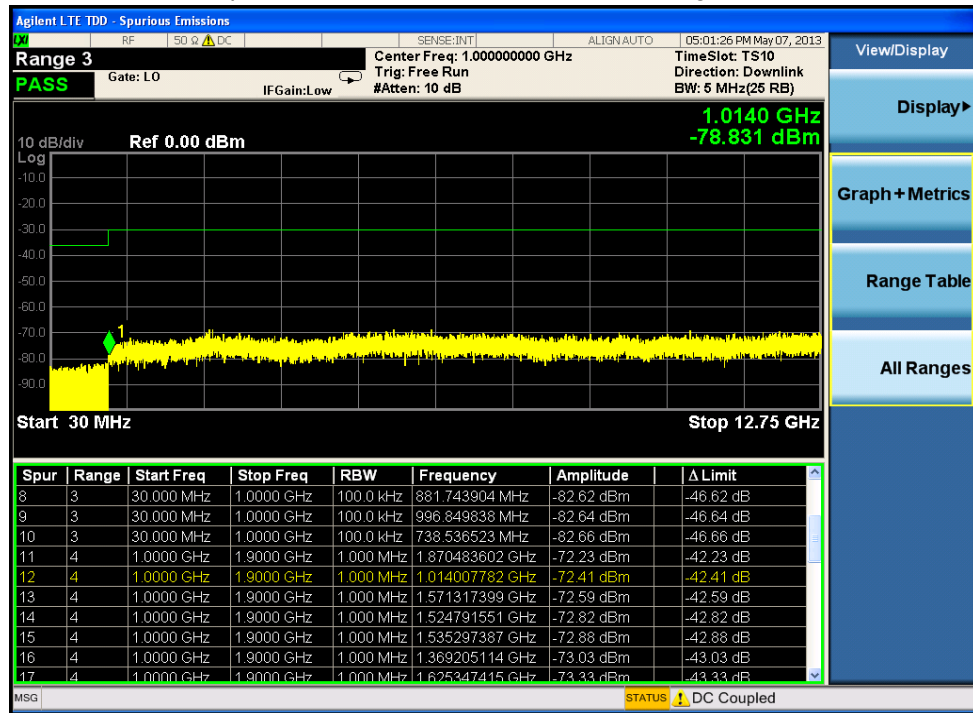
Press **View/Display, All Ranges**.

It shows the measurement results for all ranges,
 The worst spurious is highlighted.

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step Action Notes

Figure 2-20 LTE TDD Downlink Spurious Emissions Measurement - All Ranges



- 6 (Optional) Change measurement parameters from their default condition. Press **Meas Setup** to see the keys that are available to change.

If you have a problem and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Spectrum Emission Mask Measurements

This section explains how to make the Spectrum Emission Mask (SEM) measurement on a LTE TDD downlink signal. SEM compares the total power level within the defined carrier bandwidth and the given offset channels on both sides of the carrier frequency, to levels allowed by the standard. Results of the measurement of each offset segment can be viewed separately.

Test model E-TM1.1 and E-TM1.2 require SEM measurement. E-TM1.1 is used in this example.

For signal setting, see “Setting the Downlink Signal (Example for Power Measurement)” on page 16.

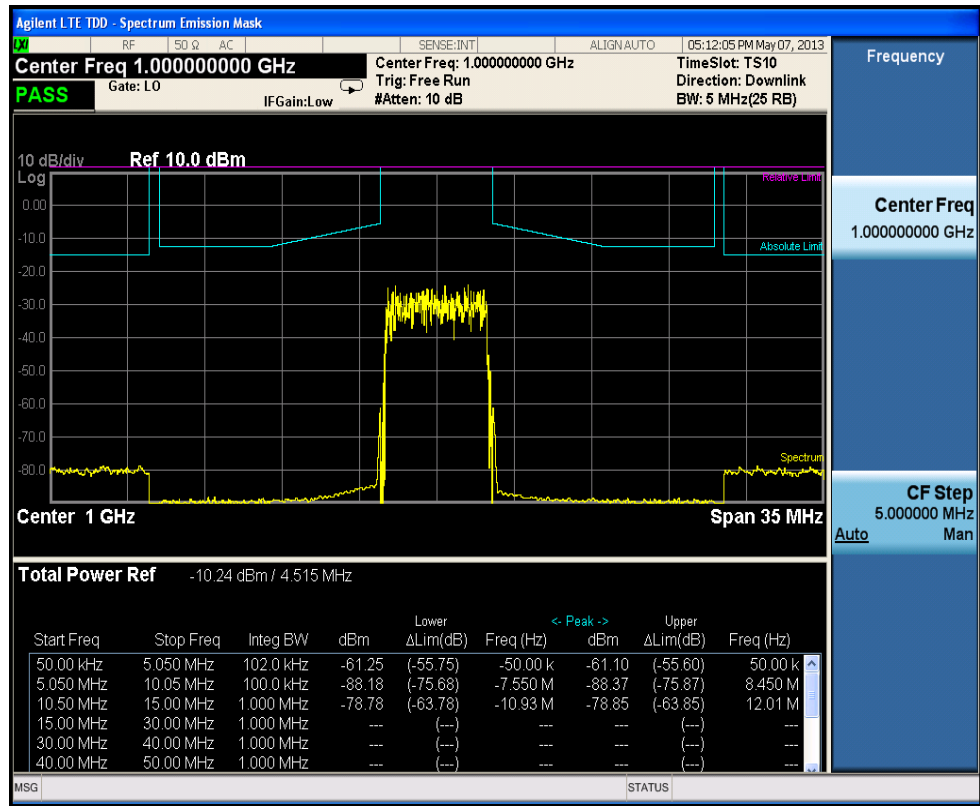
Measurement Procedure

Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Downlink)” on page 18.	It is not necessary if you already did it in other measurements.
2 Initiate the Spectrum Emission Mask measurement.	Press Meas, Spectrum Emission Mask .	The Spectrum Emission Mask measurement result should look like Figure 2-21. The text window shows the reference total power and the absolute peak power levels which correspond to the frequency bands on both sides of the reference channel. The cyan line is the absolute limit line and the purple line is the relative limit line. The limit lines are turned on by default.

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step	Action	Notes
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Figure 2-21 LTE TDD Downlink Spectrum Emission Mask Measurement Result



3 Recall the masks.

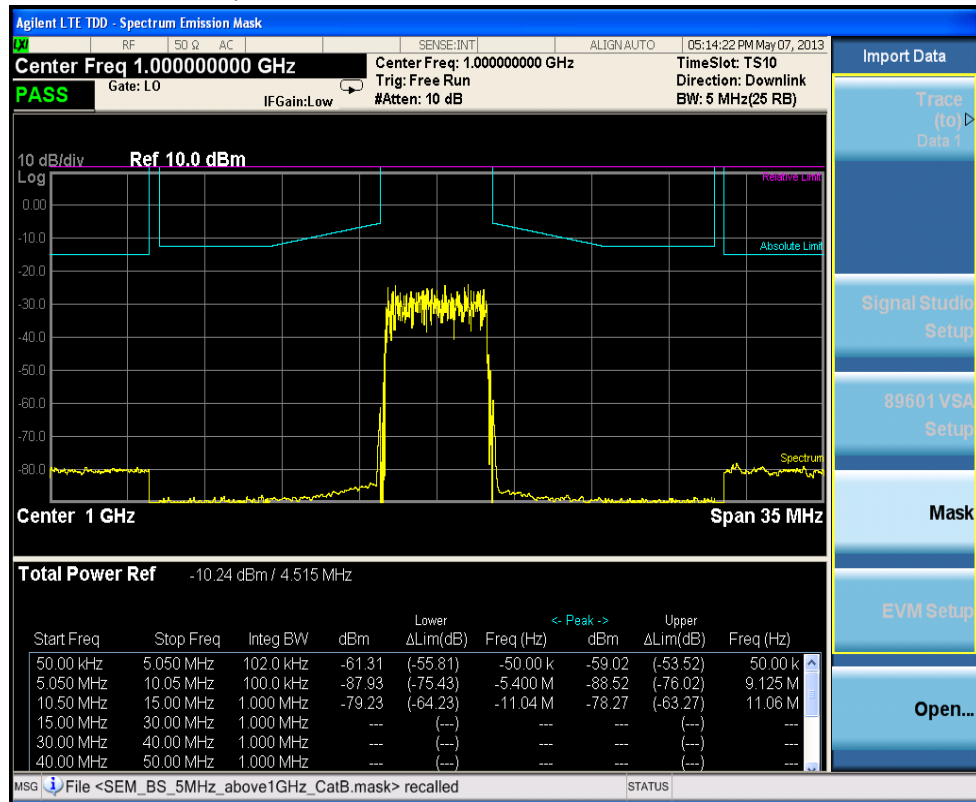
Press **Recall, Data, Mask then Open...**, a file open dialog appears. Select the appropriate file and click open.

Recall function is provided for E-URTA Test Models (E-TM) defined in standard 36.141 to setup the Offset/Limit parameters automatically. The other parameters will not be changed. At the bottom of the screen, there is a message to indicate which mask file is recalled.

The following steps are used in manual setup.

Step Action Notes

Figure 2-22 LTE TDD Downlink Spectrum Emission Mask Measurement Result - Recall Mask



4 Setup the limit.

Press **Meas Setup, Offset/Limit, More, Limits** then enter the **limit value for each offset.**

The Lower or Upper ΔLim result is the minimum margin from limit line which is decided by Fail Mask setting. There are four settings for Fail Mask: Absolute, Relative, Abs AND Rel, Abs OR Rel.

- For Absolute mask, the Lower or Upper Lim is compared with the Absolute limit line.
- For Relative mask, the Lower or Upper Lim is compared with the Relative limit line.
- For Abs AND Rel mask, the Lower or Upper Lim is compared with the higher limit line.
- For Abs OR Rel mask, the Lower or Upper Lim is compared with the lower limit line.

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step	Action	Notes
5	Turn on the Gate View and setup the Gate function.	<p>Press Sweep/Control, Gate, Gate View (On).</p> <p>Turning Gate View On or Off will not influence Gate View Sweep Time. Gate View Sweep Time is initialized by Mode Preset or Analysis Slot under Mode Setup, Predefined Parameters.</p> <p>The occupied band width with the gate view on should look like Figure 2-23.</p> <p>You can change the Gate Delay or Gate Length to see other parts of the data frame.</p>

TIP LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.

Figure 2-23 LTE TDD Downlink Spectrum Emission Mask Measurement Result - Gate View On

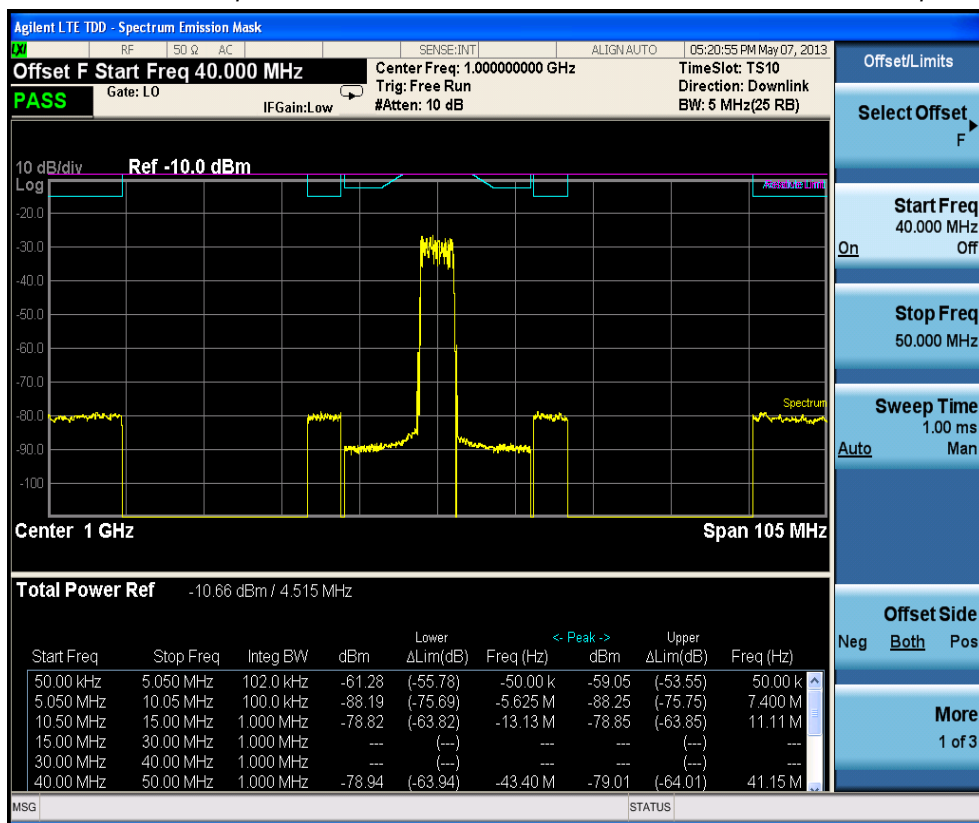


NOTE The default gate source is External 1, if you want to use other gate source, press Sweep/Control, Gate, More, Gate Source. Five types of gate sources are provided: Line, External 1, External 2, RF Burst and Periodic Timer.

Step	Action	Notes
6	Select the desired offset pairs. Press Meas Setup, Offset/Limit, Select Offset . Select the offset you want to turn on and press Start Freq, On. You can change the Start Freq, Stop Freq and other values for the offset.	The value of offset A, B, C is designed according to the standard and they are turned on by default. When there are many offsets to measure, you can increase the Res BW under Meas Setup, Offset/Limit to increase the measurement speed.

Figure 2-24

LTE TDD Downlink Spectrum Emission Mask Measurement Result - A, B, C, D, E, F pairs

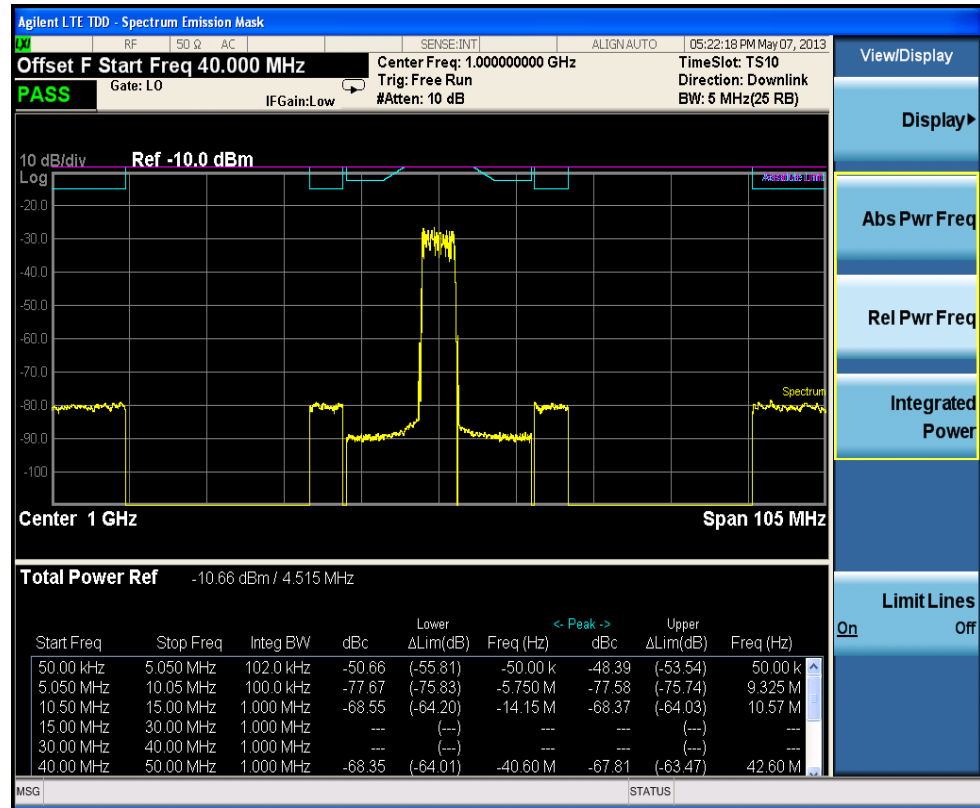


7	Select the view and measurement result. Press View/Display and select the desired view.	Three types of views are provided: Absolute Peak Power & Frequency, Relative Peak Power & Frequency and Integrated Power. For each view, you can use three measurement types (select using Measure Setup, Meas Type): Total Power Reference, PSD Reference and Spectrum Peak Reference. The picture below shows the measurement result using Meas Type PSD Reference and Relative Peak Power view.
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Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step Action Notes

Figure 2-25 LTE TDD Downlink Spectrum Emission Mask Measurement Result - Rel Pwr Freq View



8 (Optional) Change measurement parameters from their default condition.

Press **Meas Setup** to see the keys that are available to change.

For example, you can change the **Meas Type** to **PSD Ref**:

Press **Meas Setup**, **Meas Type**, and select **PSD Ref** to display the Integrated Power view for the spectrum emission mask measurement with a PSD reference. The PSD reference is shown below the spectrum graph in dBm/Hz.

Also press **Trace/Detector** to change the detector type.

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Troubleshooting Hints

This Spectrum Emission Mask measurement can reveal degraded or defective parts in the transmitter section of the unit under test (UUT). The following are examples of typical causes for poor performance.

- Faulty DC power supply control of the transmitter power amplifier.
- RF power controller of the pre-power amplifier stage.
- I/Q control of the baseband stage.
- Degradation in the gain and output power level of the amplifier due to the degraded gain control or increased distortion, or both.
- Degradation of the amplifier linearity or other performance characteristics.

Power amplifiers are one of the final stage elements of a base or mobile transmitter and are a critical part of meeting the important power and spectral efficiency specifications. Since spectrum emission mask measures the spectral response of the amplifier to a complex wideband signal, it is a key measurement linking amplifier linearity and other performance characteristics to the stringent system specifications.

Transmit On/Off Power Measurements

This section explains how to make the Transmit On/Off Power measurement on a LTE TDD downlink signal. The test is to verify that the transmitter off power and transmitter transient periods are within the limit of the minimum requirement.

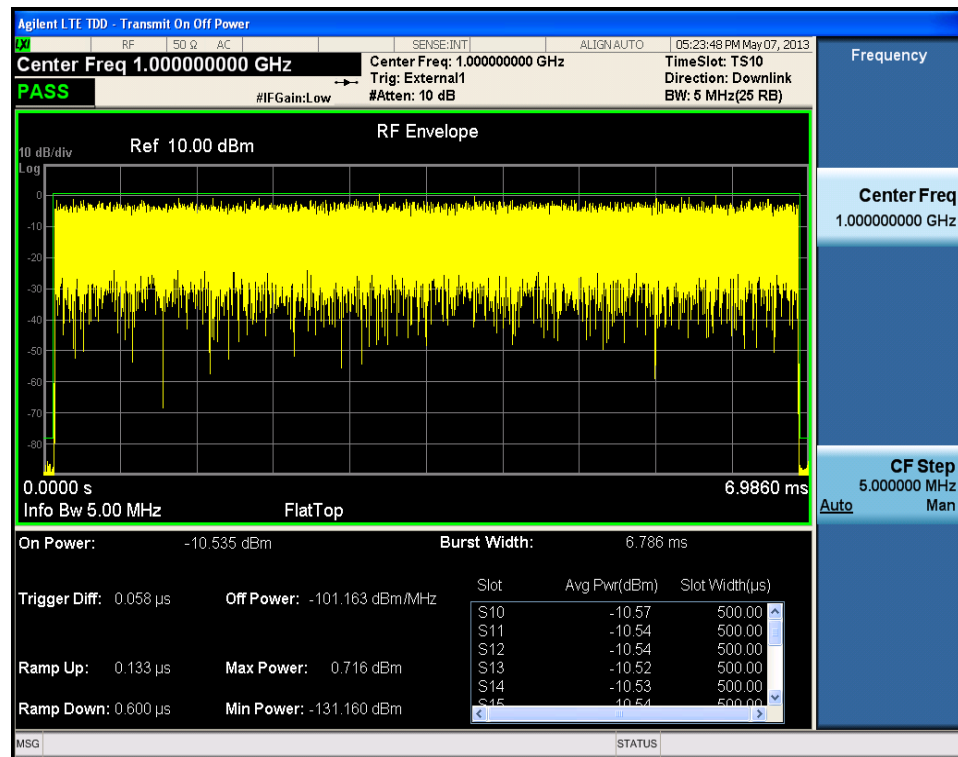
For signal setting, see “Setting the Downlink Signal (Example for Power Measurement)” on page 16.

Measurement Procedure

Step	Action	Notes
1	Perform the common configuration.	See “Common Measurement Procedure (Downlink)” on page 18. It is not necessary if you already did it in other measurements.
2	Initiate the Transmit On/Off Power measurement.	Press Meas, Transmit On/Off Power . The Transmit On/Off Power measurement result should look like Figure 2-26. Sometimes the result for Burst Width and Ramp Down displays “---”. That is because the measured burst is not a complete burst. The Off Power shows “---” because the transmitter off period is not detected within the Meas Interval.

Figure 2-26

LTE TDD Downlink Transmit On/Off Power Measurement Result

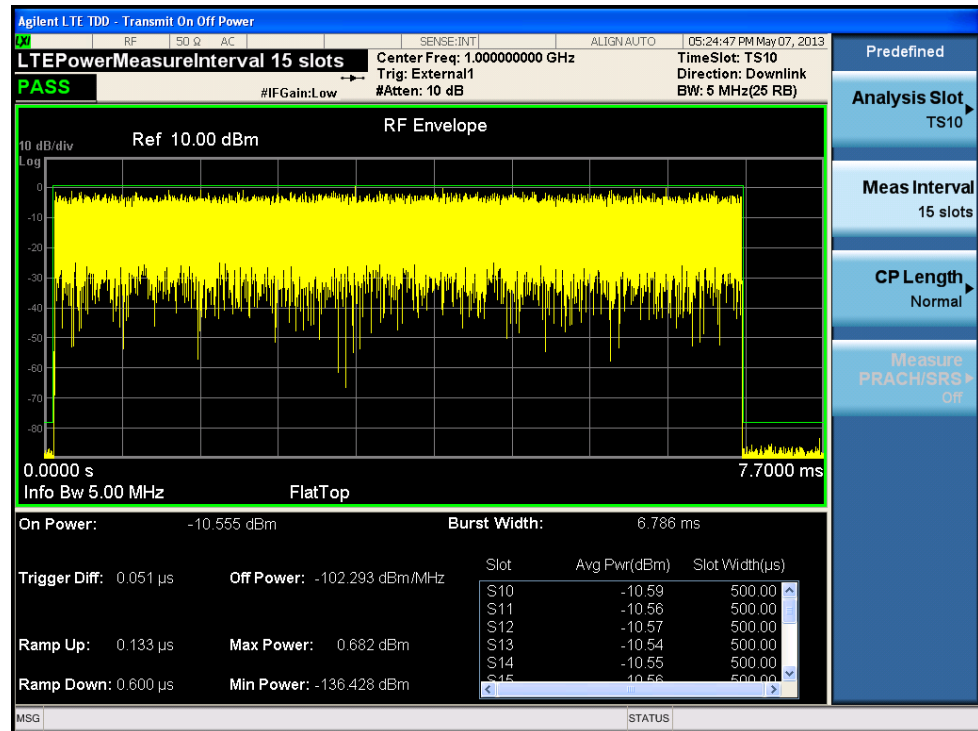


Step	Action	Notes
NOTE	The default setup of Transmitter On/Off Power measurement is Single. Do not use Cont to let the analyzer continuously sweep. The attenuator and preamplifier performs adjustment in every sweep. If you turn Cont on, the device lifetime will be influenced.	
3	Adjust the parameters to see the more slot test result. Press Mode Setup, Predefined Parameters, Meas Interval, 15 , then press Restart or Single .	This step can be ignored if you already configured the required measurement interval. In this case, 13 analysis time slots are the minimum value for a complete burst to perform Burst Width and Ramp Down test. All the test results with the result for the active slot on the bottom right of the screen are shown in Figure 2-27 .

NOTE Each time the parameter is modified, you need press Restart or Single to initiate a sweep. The yellow mark (*) on the top right indicates Restart or Single was not performed after the parameters were changed and the results are invalid.

Figure 2-27

LTE TDD Downlink Transmit On/Off Power Measurement Result - 15 Time Slots

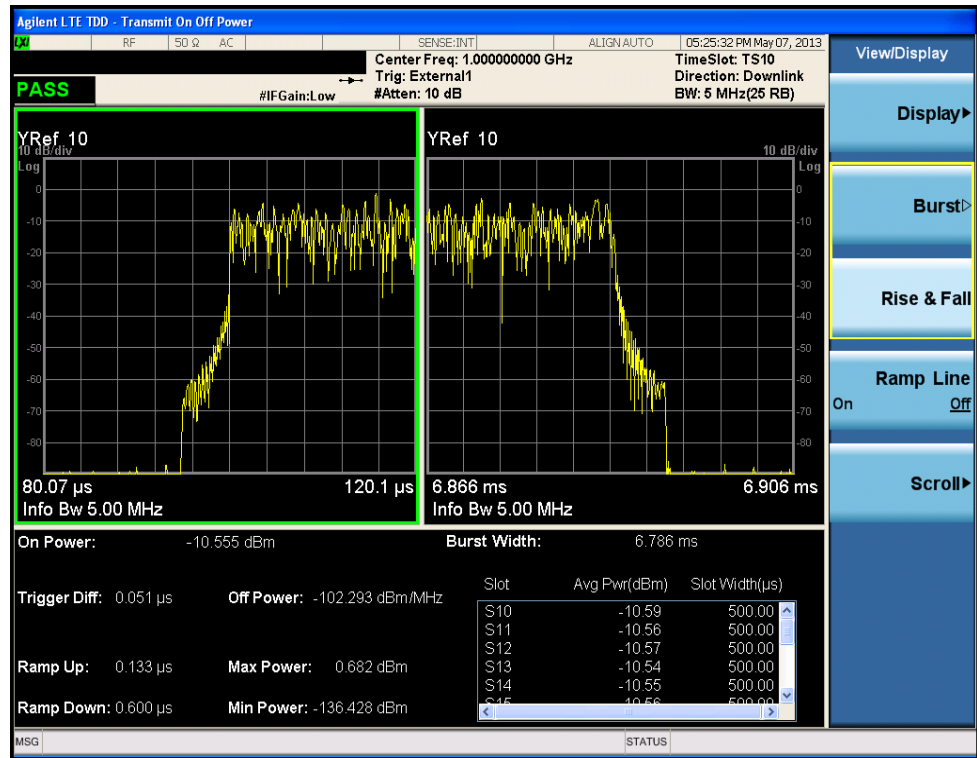


4 Select Rise & Fall view. Press **View/Display, Rise & Fall**. You can observe the detail during ramp up an down period in Rise & Fall view.

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step Action Notes

Figure 2-28 LTE TDD Downlink Transmit On/Off Power Measurement Result - Rise & Fall view



5 (Optional) Change measurement parameters from their default condition. Press **Meas Setup** to see the keys that are available to change.

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Power Statistics CCDF Measurements

This section explains how to make the Power Statistics Complementary Cumulative Distribution Function (Power Stat CCDF) measurement on a LTE TDD downlink signal. Power Stat CCDF curves characterize the higher level power statistics of a digitally modulated signal.

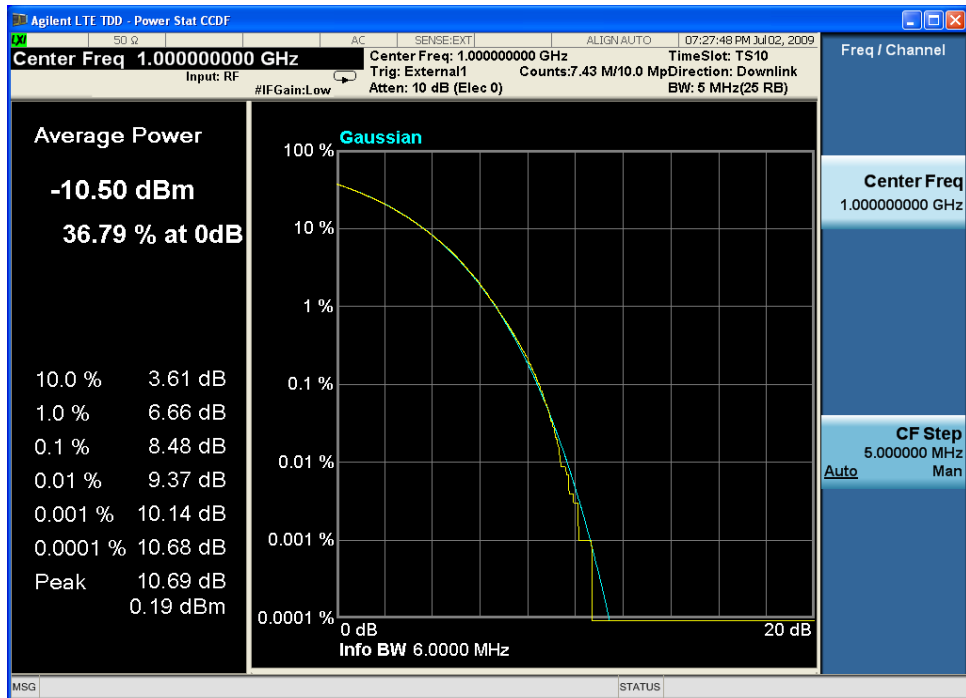
For signal setting, see “Setting the Downlink Signal (Example for Power Measurement)” on page 16.

Measurement Procedure

Step	Action	Notes
1	Perform the common configuration.	See “Common Measurement Procedure (Downlink)” on page 18. It is not necessary if you already did it in other measurements.
2	Initiate the power statistics CCDF measurement.	Press Meas, Power Stat CCDF . The CCDF measurement result should look like Figure 2-29. The blue line is the Gaussian trace and the yellow line is the measurement result. The Info BW is the channel bandwidth that will be used for data acquisition, the default value is 6 MHz. You can manually change the Info BW under the BW menu.

Figure 2-29

LTE TDD Downlink Power Statistics CCDF Measurement Result

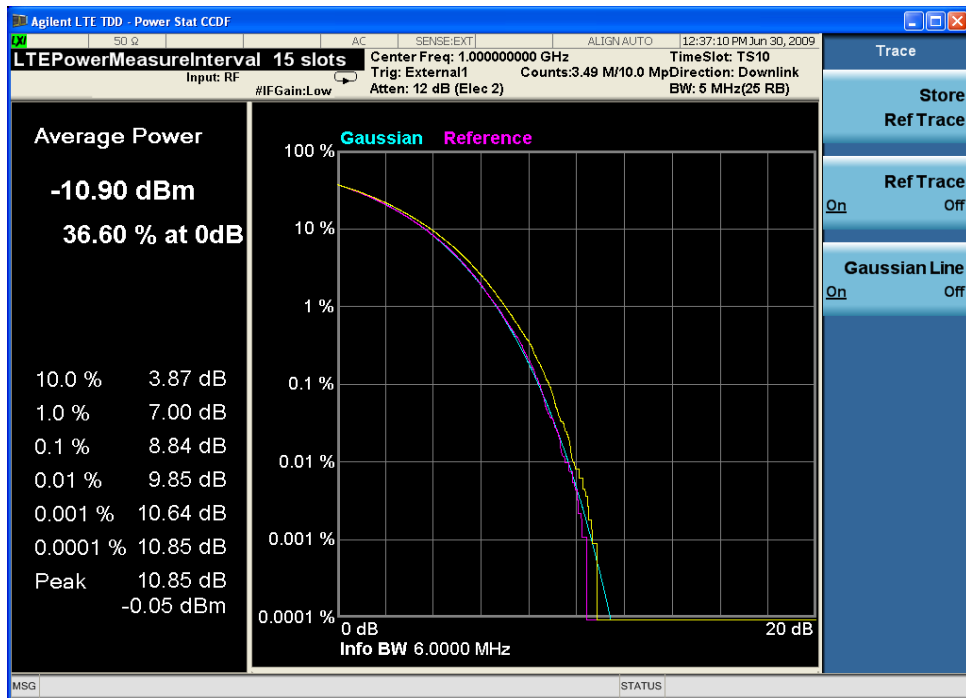


Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step	Action	Notes
3	Turn reference trace on. Press Trace/Detector, Ref Trace (On) to represent the user-definable reference trace (violet line).	The reference trace is the same as the measurement trace. You can use the Store Ref Trace key to copy the currently measured curve as the reference trace. It will not change until you store the reference trace again or choose the other mode. The CCDF measurement result with the reference trace should look like Figure 2-30 .

Figure 2-30

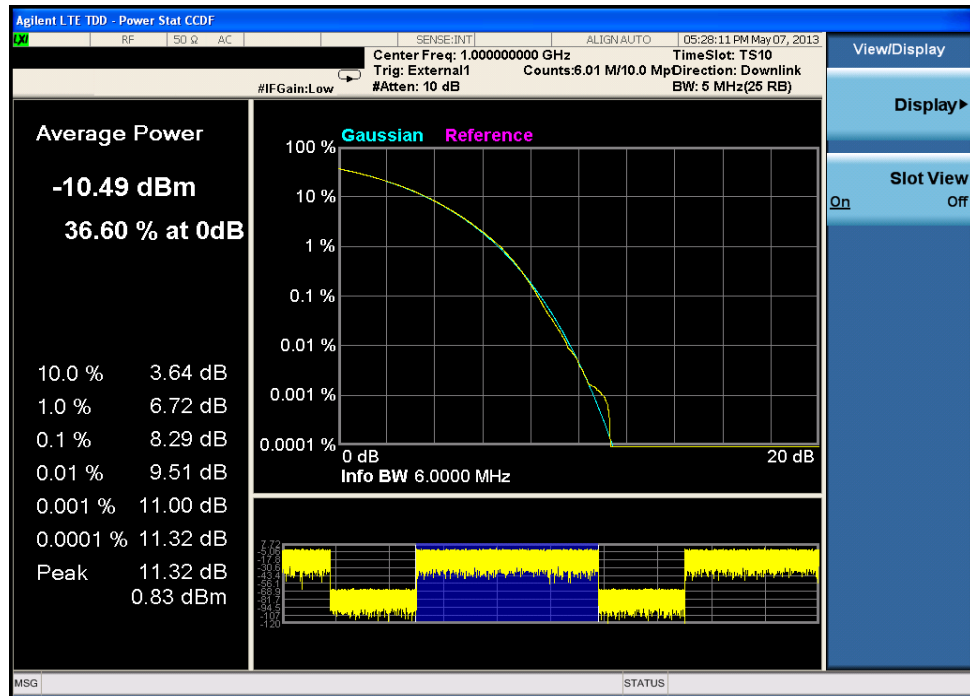
LTE TDD Downlink Power Statistics CCDF Result - Reference Trace On



4	Turn slot view on. Press View/Display, Slot View (On) to see the corresponding analysis slots (blue bars).	The CCDF measurement result with the slot view should look like Figure 2-31 .
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Step	Action	Notes
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Figure 2-31 LTE TDD Downlink Power Statistics CCDF Result - Slot View



5 Optimize the measurement for your signal level.	Press Meas Setup, IF Gain to optimize the measurement for your signal level. If you have a very high or low level signal, selecting Low Gain or High Gain can improve your accuracy. The default is Auto .
---	--

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Troubleshooting Hints

The power statistics CCDF measurement can assist in setting the signal power specifications for design criteria for systems, amplifiers, and other components. For example, it can help determine the optimum operating point to adjust each code timing for appropriate peak or average power ratio, or both, for the transmitter.

Modulation Analysis Measurements

This section explains how to make the Modulation Analysis measurement on a LTE TDD downlink signal. The LTE Modulation Analysis measurement allows you to measure LTE signals according to 3GPP TS 36.211.

Setting the Downlink Signal (Example)

Frequency: 1 GHz

Output Power: -10 dBm (at analyzer input)

Carrier: 1

Uplink Downlink Configuration: 2

Special Subframe Configuration: 0

Channel Configuration: Full filled 16QAM 5MHz (25 RB)

System Bandwidth: 5 MHz (25RB)

Antennas: 1

Cyclic Prefix: Normal

Transport Channel: DL-SCH = On, 0 dB

BCH = On, 0 dB

Physical Channel: PBCH = On, 0 dB

PDCCH = On, 0 dB

PDSCH = On, 0 dB

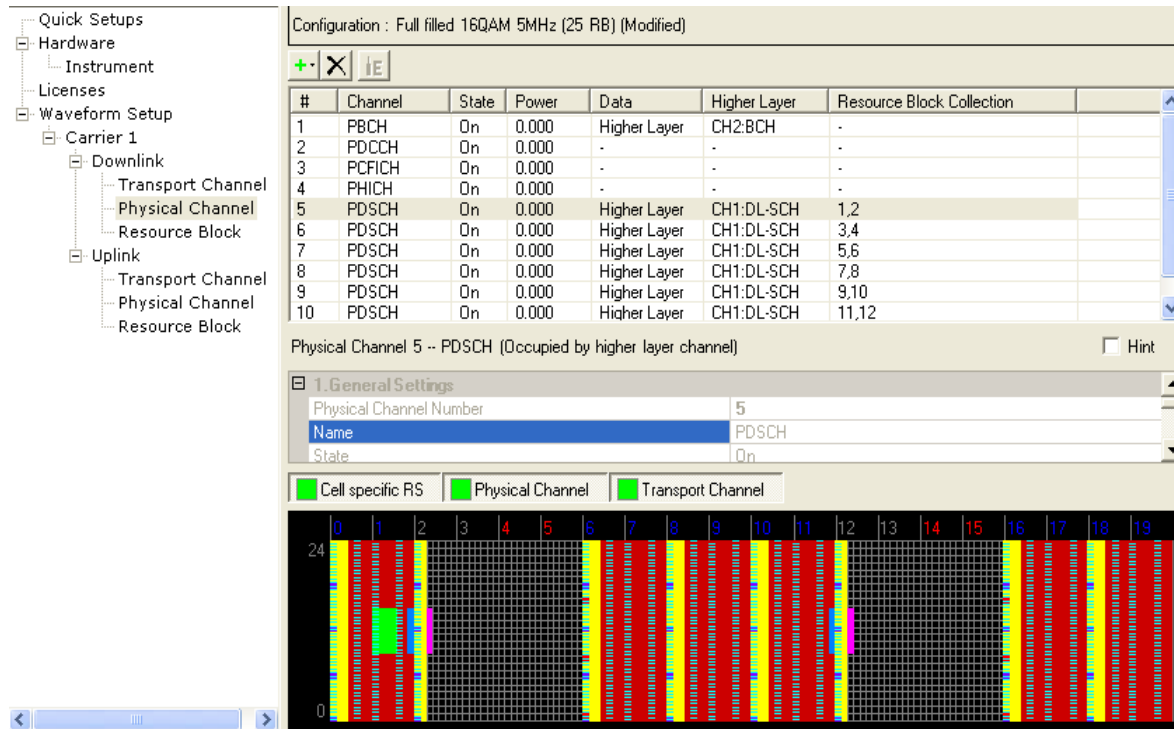
PCFICH = On, 0 dB

PHICH = On, 0 dB

Resource Block: 0-24

Power = 0 dB

Figure 2-32 Signal Studio Mapping (Downlink Signal for Modulation Analysis measurement)



Measurement Procedure

Step	Action	Notes
1	Enable the LTE TDD measurements.	Press Mode, LTE TDD .
2	Preset the mode.	Press Mode Preset .
3	Set the center frequency.	Press FREQ Channel, 1, GHz .
4	Select the direction to downlink.	Press Mode Setup, Radio, Direction to be Downlink .
5	Select the system bandwidth.	Press Mode Setup, Demod, Bandwidth, 5 MHz (25 PRB) .
6	Set the Uplink and Downlink allocation configuration.	Press Mode Setup, Radio, ULDLAlloc, Configuration 2 (DSUDDDSUDD) .
7	Set the DwPTS/GP/UpPTS length configuration of the signal.	Press Mode Setup, Radio, DW/GP/Up Len, Configuration 0 . The settings under Mode Setup, Predefined Parameters are used for power measurements and do not apply to the Modulation Analysis measurement.

Making LTE TDD Measurements
LTE TDD Downlink Signal Measurement

Step	Action	Notes
8 Initiate the Modulation Analysis measurement.	Press Meas, Modulation Analysis .	
9 Set the RF Input power range.	Press AMPTD Y Scale, Range, 0, dBm .	The range should be set equal to or bigger than the RF input power.
NOTE	If you want to use the standard setup, press Mode Setup, Radio, Preset to Standard, 5 MHz (25 PRB) to preset the measurement to a standard setup including many parameters such as BW, Analysis Start Boundary, Cell ID and so on. See Table 2-10 on page 140 for a list of affected parameters. Or configure the parameters using the following steps.	

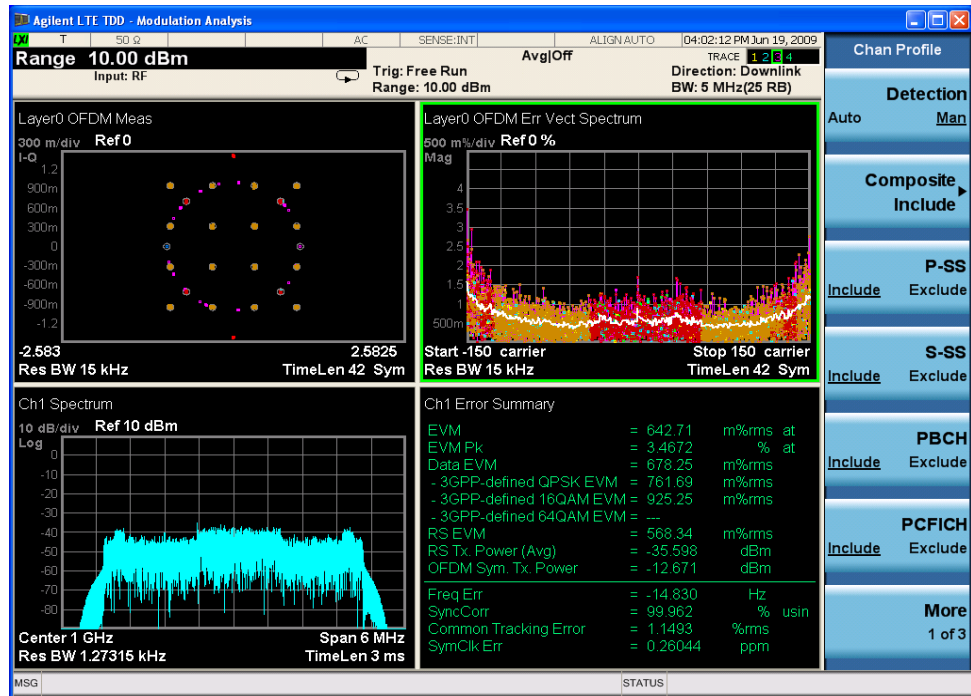
Step	Action	Notes
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In LTE TDD Modulation Analysis measurement, for easy and quick parameter settings, several Recall functions are provided to automatically set up the parameters. You can use them by pressing **Recall, Data, xxxx Setup, then Open...**:

- Signal Studio Setup
 Recall the Keysight Signal Studio (N7624B for LTE FDD and N7625B for LTE TDD) setup file. This is not used for LTE TDD E-TM test model signal, instead you need use EVM Setup for it.
- 89601 VSA Setup
 Recall the Keysight 89601 Vector Signal Analyzer (option BHD for LTE FDD and option BHE for LTE TDD) setup file.
- EVM Setup
 Recall EVM parameter setting for E-URTA Test Models E-TM1.1, E-TM2, E-TM3.1, E-TM3.2 or E-TM3.3 in 3GPP standard.

Press **Recall, Data, EVM Setup** then **Open...**, a file open dialog appears, select the appropriate test model file and click open. This will apply the RB setup and related parameters quickly. The other parameters will not be changed. The following picture shows the measurement example of E-TM3.2 for 5 MHz bandwidth, the file TDD-BW5MHz-ETM32.evms is recalled.

Figure 2-33 LTE TDD Downlink Modulation Accuracy Measurement Result (5 MHz bandwidth, E-TM3.2)

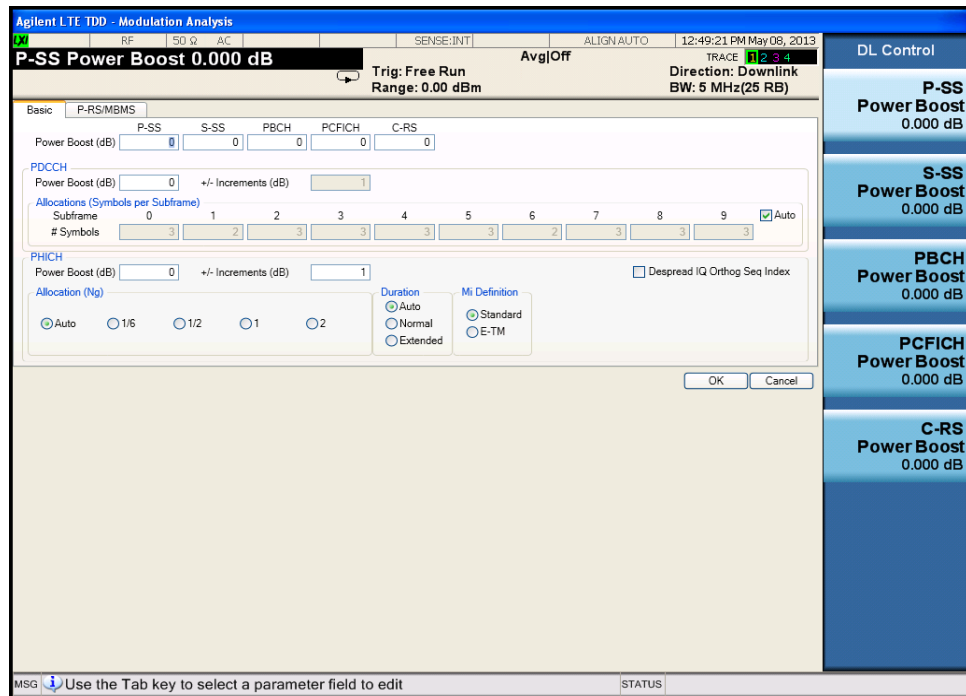


You can see 3GPP-defined QPSK EVM and 3GPP-defined 16QAM EVM in Error Summary are no longer “---”. They are calculated according to 3GPP TS 36.141 E-UTRA Test Model E-TM3.2.

Step	Action	Notes
The following steps are used for manual setup.		
10 Select the synchronization/format parameters.	Press Meas Setup, Sync/Format Setup to set up the parameters. In this case, all these parameters use default value.	It includes Sync Type, RS-PRS, Cell ID, Tx Antenna, MIMO Decoding and PDSCH Cell Specific Ratio.
11 Select the measurement time parameters such as Result Length, Meas Interval Slot or Meas Interval Symbol.	Press Meas Setup, Meas Time Setup to set up the parameters. In this case, all these parameters use default value.	The relationship among time parameters is: Result Length is the capture length available for demodulation analysis. The time for analysis is Meas Interval which is equal to Meas Interval Slot + Meas Interval Symbol.
12 Set the power boost level.	Press Meas Setup, Chan Profile Setup, More, Edit Control Channels... , to open the Control Channels window to adjust the required power boost. In this case, the default value 0 dB is used.	See the example of Control Channels window in Figure 2-34 .

Figure 2-34

LTE TDD Downlink Modulation Accuracy Measurement Control Channels Setup

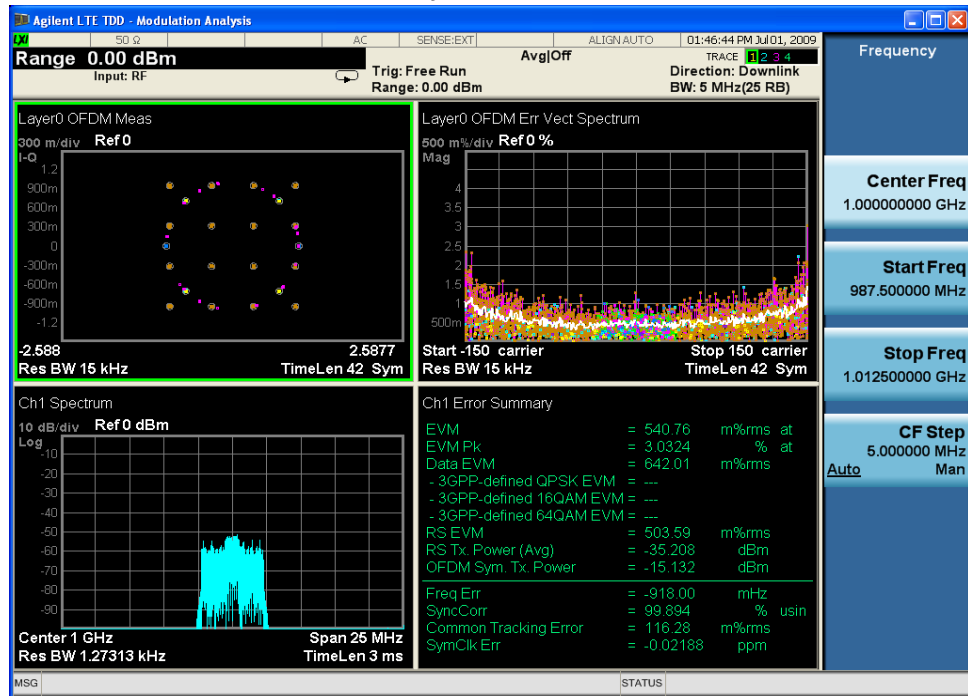


If all the defined users of the LTE TDD Downlink signal have different modulation types (QPSK, 16QAM, or 64QAM), RB Auto-Detect will automatically perform the measurements. You can go directly to **Change other measurement parameters.** and look measurement results. If the signal contains any defined users that employ the same modulation type, you need follow the next step **Set up the User Mapping table.** and use the RB manual detection to see the result for specific user

Step	Action	Notes
NOTE	To perform the following procedure, it is easier using a mouse with USB connected to the instrument.	If the mouse is not available, you can use the Tab key repeatedly until the required table cell or check box is selected and the key menu appears, then enter the value from the front panel. Also press Enter to active the knob function, then you can move the focus quickly using knob. If you finish the setup, you can jump to OK, Cancel by pressing the Cancel (Esc) key in the front panel.
13 Set up the User Mapping table.	<ol style="list-style-type: none"> a. Press Meas Setup, Chan Profile Setup, More, Edit User Mapping. b. Deselect the RB Auto-Detect to turn RB auto detect off. c. Click Add to add a user, User01 is shown. d. Check the Mod Type and Power check box and select the value from the pull-down menu. The selection is 16QAM and the default value 0 dB is used in the example. e. Click the field “No Allocation Defined” and press Add to add the downlink allocations and define RB Start, RB End, Slot Start and Slot End. You can use the mouse to move the cursor between cells or press the front panel and menu keys to enter the values. 	<p>Click the field that needs enter the value (e.g. RB Start) for Alloc01 to active the Alloc01 (it will turn from gray to blue). Click Add to add other allocations. In this example, three allocations are used, RB Start = 0, RB End = 24, Slot Start and Slot End are 0 and 1 for Alloc01, 6 and 11 for Alloc02, 16 and 19 for Alloc3. The RB Mapping of PDSCH is shown below.</p>
TIP	When the allocation is selected, there are four circles in the four corner of the block. You can directly drag the circles to allocate the RB.	

Step	Action	Notes
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Figure 2-36 LTE TDD Downlink Modulation Accuracy Measurement Result (Preset View: Basic)



TIP You can select window control keys or double click the mouse to expand one of the 4 windows and look into more details for every measurement result. Pressing the window control keys again or double clicking the mouse again will take you back to 4 display windows. The following example shows the full Error Summary result.

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step Action Notes

Figure 2-37 LTE TDD Downlink Modulation Accuracy Measurement Result (Error Summary)

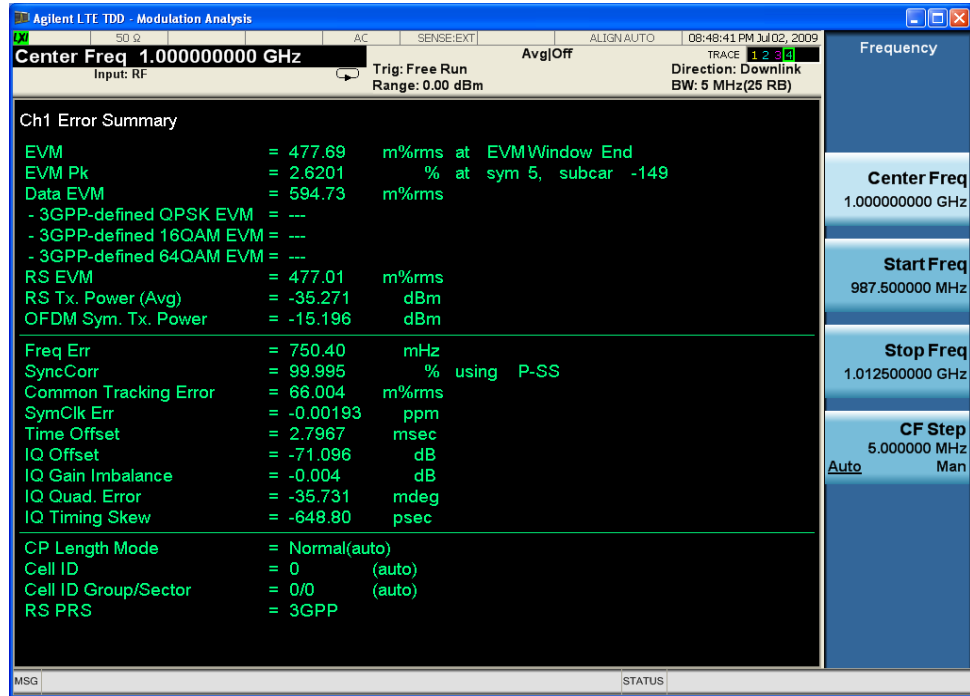
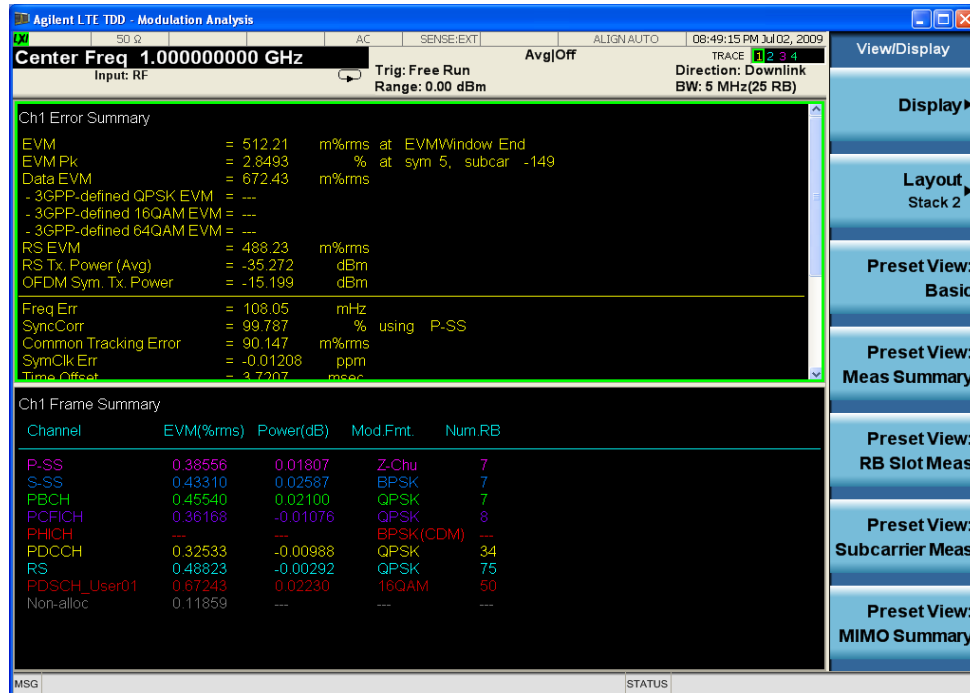


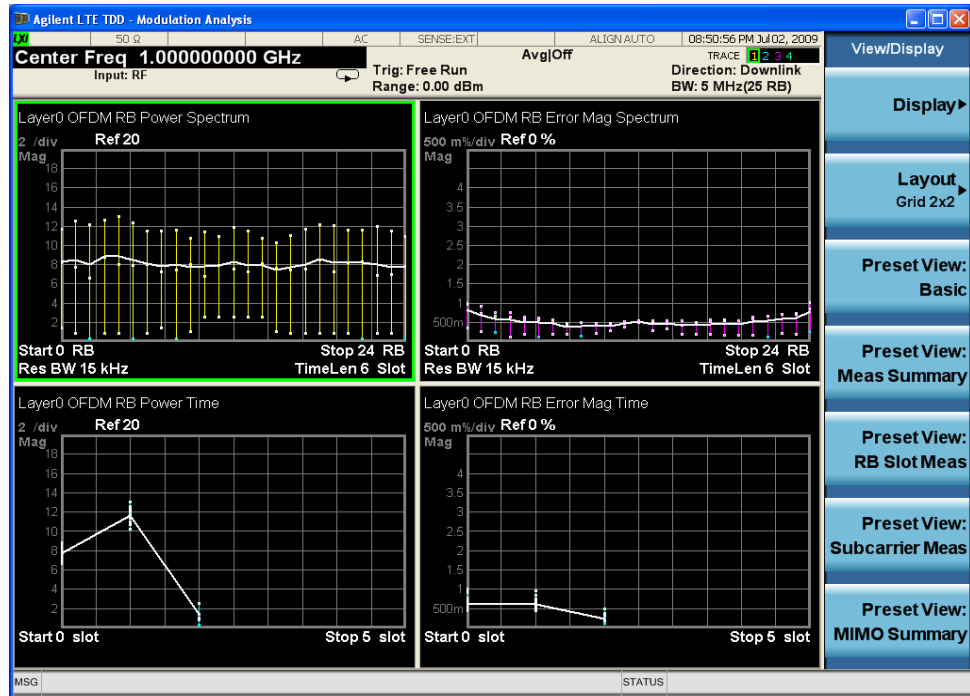
Figure 2-38 LTE TDD Downlink Modulation Accuracy Measurement Result (Preset View: Meas Summary)



Step	Action	Notes
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	This preset view provides the Error Summary and Frame Summary which are the composite result metrics and characteristics of each of the logical channels.	
--	---	--

Figure 2-39 LTE TDD Downlink Modulation Accuracy Measurement Result (Preset View: RB Slot Meas)



This preset view is a Grid 2x2 layout which provides details on the Resource Block with RB Power vs. Spectrum, RB Error Mag Spectrum, RB Power vs. Time and RB Error Mag Time.

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step Action Notes

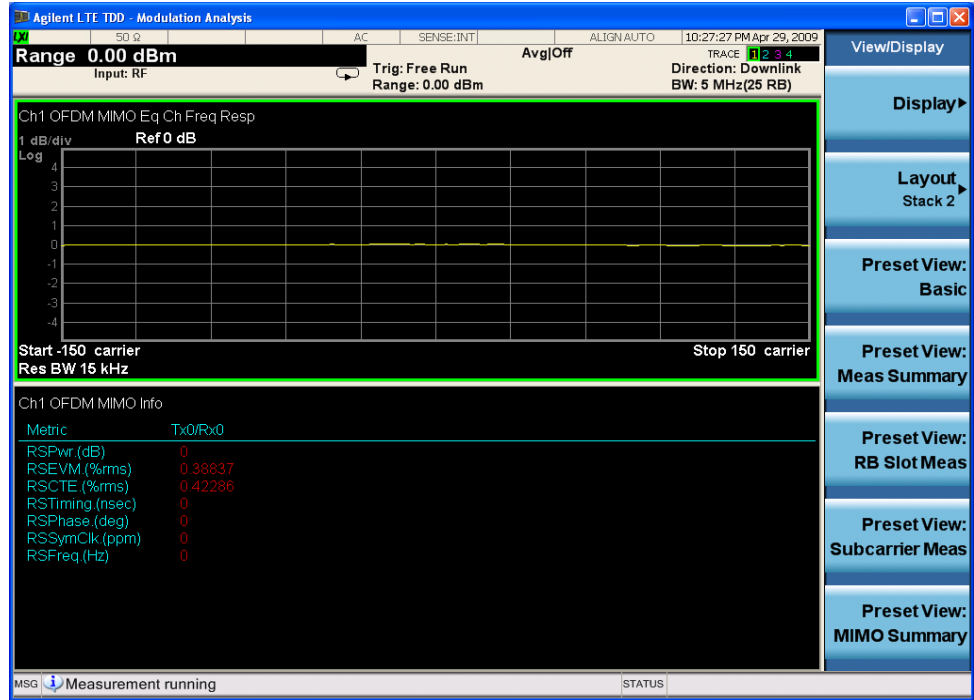
Figure 2-40 LTE TDD Downlink Modulation Accuracy Measurement Result (Preset View: Subcarrier Meas)



This preset view is a Grid 2x2 layout which includes Error Vector Spectrum, IQ Meas (Log Mag), Error Vector Time and IQ Meas Time (Log Mag).

Step Action Notes

Figure 2-41 LTE TDD Downlink Modulation Accuracy Measurement Result (Preset View: MIMO Summary)

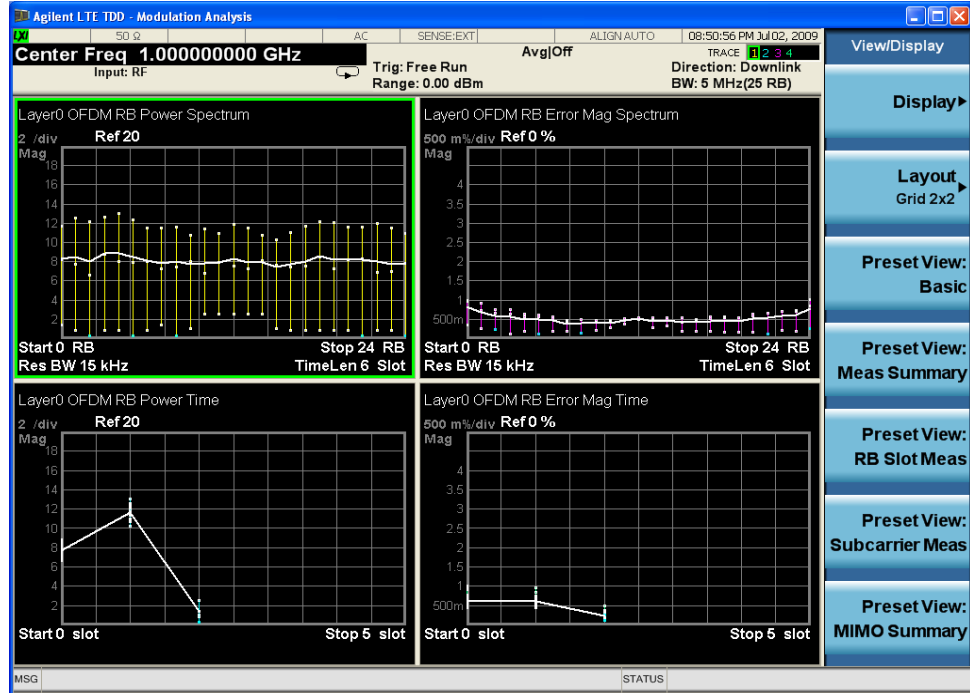


This preset view provides a MIMO Information Table and Channel Frequency Response.

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step	Action	Notes
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Figure 2-42 LTE TDD Downlink Modulation Accuracy Measurement Result (Preset View: RB Slot Meas)

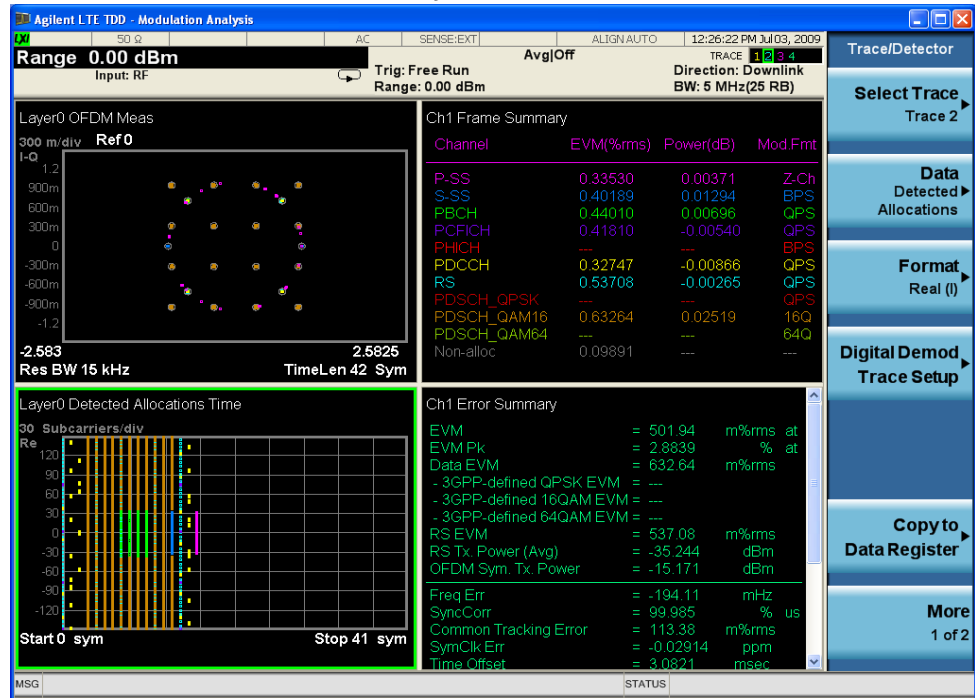


This preset view is a Grid 2x2 layout which provides details on the Resource Block with RB Power vs. Spectrum, RB Error Mag Spectrum, RB Power vs. Time and RB Error Mag Time

TIP Also you can customize the view to show available data in different windows. Press Trace/Detector, Select Trace, Trace 2 then press Data, Demod, Detected Allocations to customize the view. Figure 2-43 shows the Detected Allocations (Trace 2) and Frame Summary (Trace 3) together with the constellation. The colors used in these three windows are related.

Step Action Notes

Figure 2-43 LTE TDD Downlink Modulation Accuracy Measurement Result (Customized View)



16 Look into individual physical signals and channels.

Press Meas Setup, Channel Profile Setup to see all channels can be included or excluded.

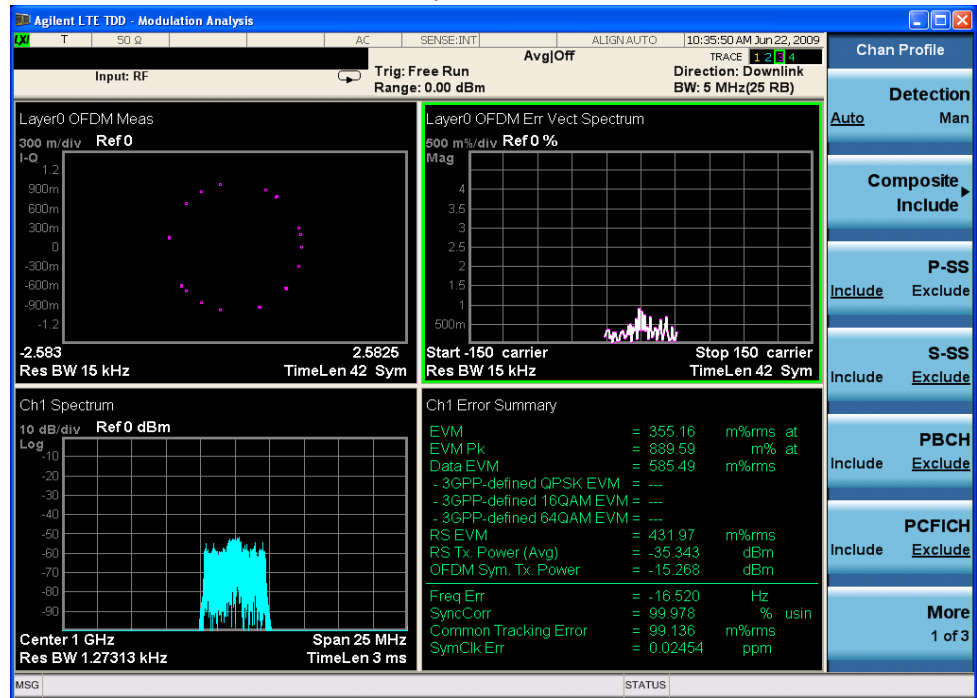
Observing individual signals or channels will provide you with specific information of different signals or channels, this is helpful for troubleshooting.

You can press each channel to include it or exclude it or you can press Composite Include to Include All or Exclude All. If the channel is included, the data in this channel will be included in the EVM analysis. The example below shows that only the Primary Synchronization Signal is included and all other channels are excluded

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step Action Notes

Figure 2-44 LTE TDD Downlink Modulation Accuracy Measurement Result (P-SS)



If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Conformance EVM Measurement

This section explains how to make the Conformance EVM measurement on a LTE TDD downlink signal. For the detailed instruction about this measurement, see “[LTE TDD Conformance EVM Measurement Concepts](#)” on page 220.

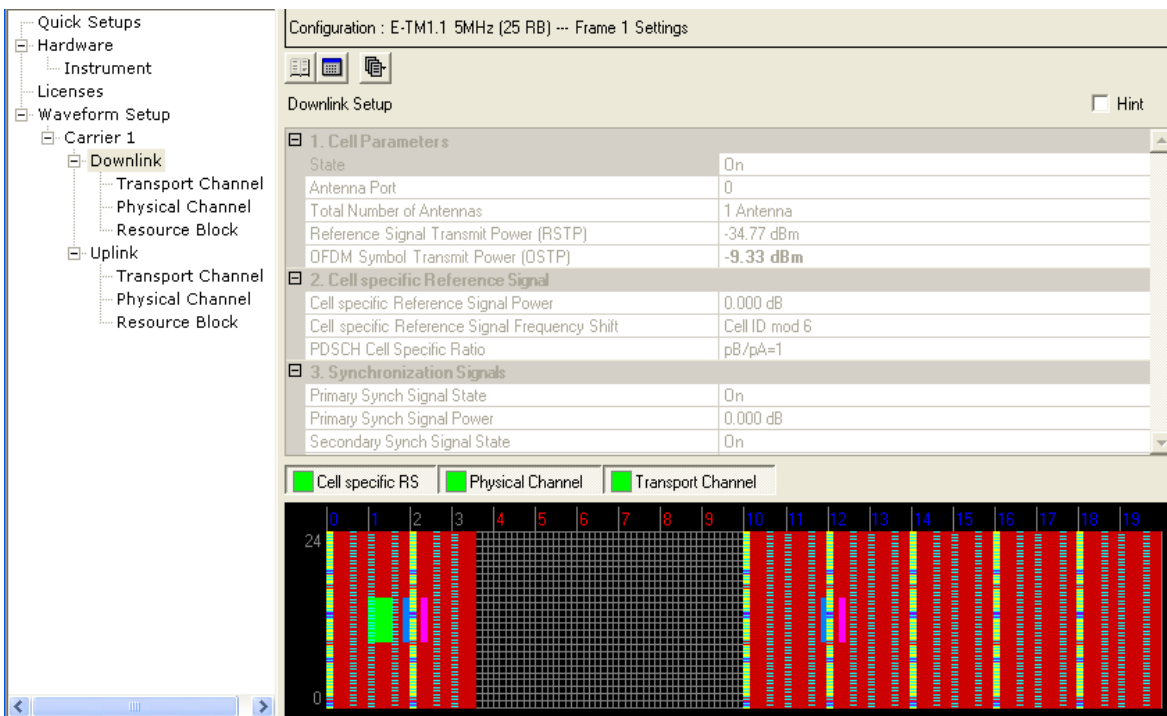
Setting the Downlink Signal

Test model E-TM1.1 with 5 MHz bandwidth is used as the example in the Conformance EVM measurement.

Configure the signal generator using the settings below. The Keysight Signal Studio N7625B for 3GPP LTE TDD, is used in the example to generate the required waveform for testing.

Frequency: 1 GHz
 Output Power: 0 dBm (at analyzer input)
 Carrier: 1

Figure 2-45 E-TM1.1 Signal Studio Mapping (Downlink Signal)



Measurement Procedure

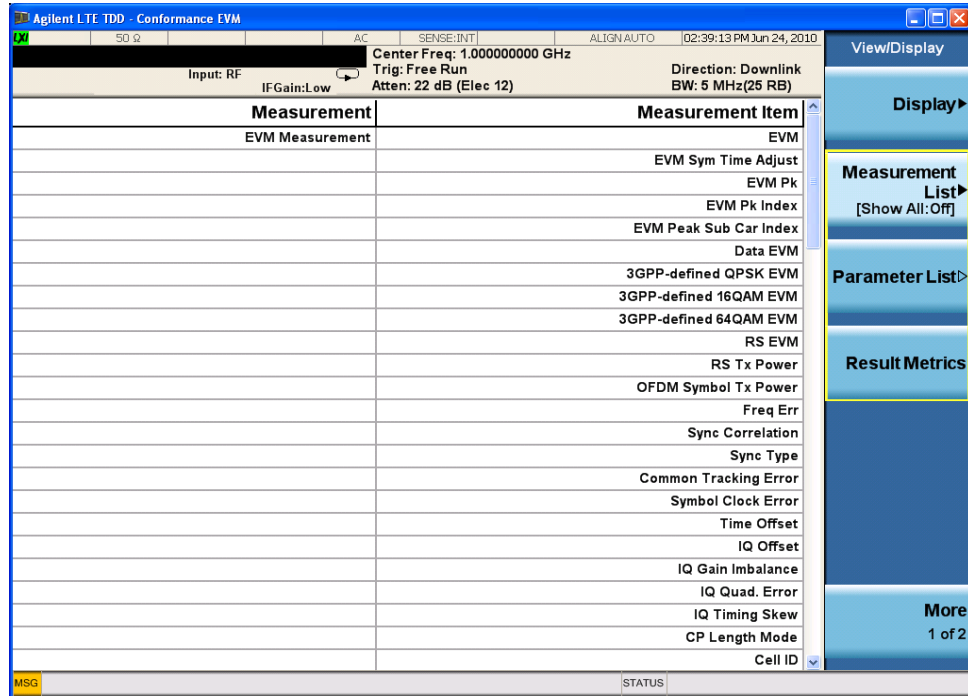
Step	Action	Notes
1	Enable the LTE TDD measurements.	Press Mode, LTE TDD .

Making LTE TDD Measurements
 LTE TDD Downlink Signal Measurement

Step	Action	Notes
2	Preset the mode. Press Mode Preset .	
3	Initial Conformance EVM measurement. Press Meas, Conformance EVM .	
4	Recall EVM setup. Press Recall, Data, EVM Setup then Open . Choose the file from the open window, the file TDD-BW5MHz-ETM11.evms is used here.	If you use a test model to do the measurement, the Recall function is provided for E-URTA Test Models (E-TM) to setup the parameters automatically.
5	Make the parameters setting in Modulation Analysis measurement apply to Conformance EVM measurement. Press Meas Setup, Copy from Mod Analysis .	
6	Select views. Press View/Display to select different views: Measurement List, Parameter List, Result Metrics and RF Envelope .	

Figure 2-46

LTE TDD Downlink Conformance EVM Measurement Measurement List



Step Action Notes

Figure 2-47 LTE TDD Downlink Conformance EVM Parameter List

Name	SCPI	Value
Average Number	:CEVM:AVERage:NUMBER	10
Average State	:CEVM:AVERage:STATE	OFF
Average Mode	:CEVM:AVERage:TCOntrOl	Exponential
DL DCI Format Dec Include	:CEVM:DLINk:DECode:DFINclUde	F1F1B
DL PDCCH RA-RNTI Range Max	:CEVM:DLINk:DECode:RNTI:MAXimum:RA	60
DL PDCCH TPC-RNTI Range...	:CEVM:DLINk:DECode:RNTI:MAXimum:TPC	28416
DL PDCCH RA-RNTI Range Min	:CEVM:DLINk:DECode:RNTI:MINimum:RA	60
DL PDCCH TPC-RNTI Range...	:CEVM:DLINk:DECode:RNTI:MINimum:TPC	0
DL_PDSCH Cell Specific Ratio	:CEVM:DLINk:PDSCh:CSRatIo	R1
Downlink Add User	:CEVM:DLINk:PROFile:ADD:USER	Immediate
DL RB Auto Det Mode	:CEVM:DLINk:PROFile:AUTO:DETeCt:MODE	POWER
DL RB Auto Det Power	:CEVM:DLINk:PROFile:AUTO:DETeCt:POWer	On
DL Auto, PDSCH Codebook L...	:CEVM:DLINk:PROFile:AUTO:PDSCh:CBINdex	0
DL Auto, PDSCH Precoding C...	:CEVM:DLINk:PROFile:AUTO:PDSCh:CDD	WOCDD
DL Auto, Number of Codewords	:CEVM:DLINk:PROFile:AUTO:PDSCh:NCODewords	1
DL Auto, Number of Layers	:CEVM:DLINk:PROFile:AUTO:PDSCh:NLAYers	1
DL Auto, PDSCH Precoding	:CEVM:DLINk:PROFile:AUTO:PDSCh:PRECoding	TXDiversity
CW1 16QAM Enable	:CEVM:DLINk:PROFile:AUTO:PDSCh:QAM16:CWONe:ENABle	On
CW1 16QAM Power Boost	:CEVM:DLINk:PROFile:AUTO:PDSCh:QAM16:CWONe:PWRBoosT	0.000 dB
CW0 16QAM Enable	:CEVM:DLINk:PROFile:AUTO:PDSCh:QAM16:CWZero:ENABle	On
CW0 16QAM Power Boost	:CEVM:DLINk:PROFile:AUTO:PDSCh:QAM16:CWZero:PWRBoosT	0.000 dB
CW1 64QAM Enable	:CEVM:DLINk:PROFile:AUTO:PDSCh:QAM64:CWONe:ENABle	On
CW1 64QAM Power Boost	:CEVM:DLINk:PROFile:AUTO:PDSCh:QAM64:CWONe:PWRBoosT	0.000 dB
CW0 64QAM Enable	:CEVM:DLINk:PROFile:AUTO:PDSCh:QAM64:CWZero:ENABle	On
CW0 64QAM Power Boost	:CEVM:DLINk:PROFile:AUTO:PDSCh:QAM64:CWZero:PWRBoosT	0.000 dB
CW1 QPSK Enable	:CEVM:DLINk:PROFile:AUTO:PDSCh:QPSK:CWONe:ENABle	On
CW1 QPSK Power Boost	:CEVM:DLINk:PROFile:AUTO:PDSCh:QPSK:CWONe:PWRBoosT	0.000 dB
CW0 QPSK Enable	:CEVM:DLINk:PROFile:AUTO:PDSCh:QPSK:CWZero:ENABle	On
CW0 QPSK Power Boost	:CEVM:DLINk:PROFile:AUTO:PDSCh:QPSK:CWZero:PWRBoosT	0.000 dB
Downlink Clear All Users	:CEVM:DLINk:PROFile:CLear	Immediate

NOTE The parameter name, related SCPI and value are listed in Parameter List view with tabular form. You can send the SCPI to change them or you can manually change them by selecting the parameter using knob or up and down arrows then enter the value using front panel keys.

Figure 2-48 LTE TDD Downlink Conformance EVM Result Metrics

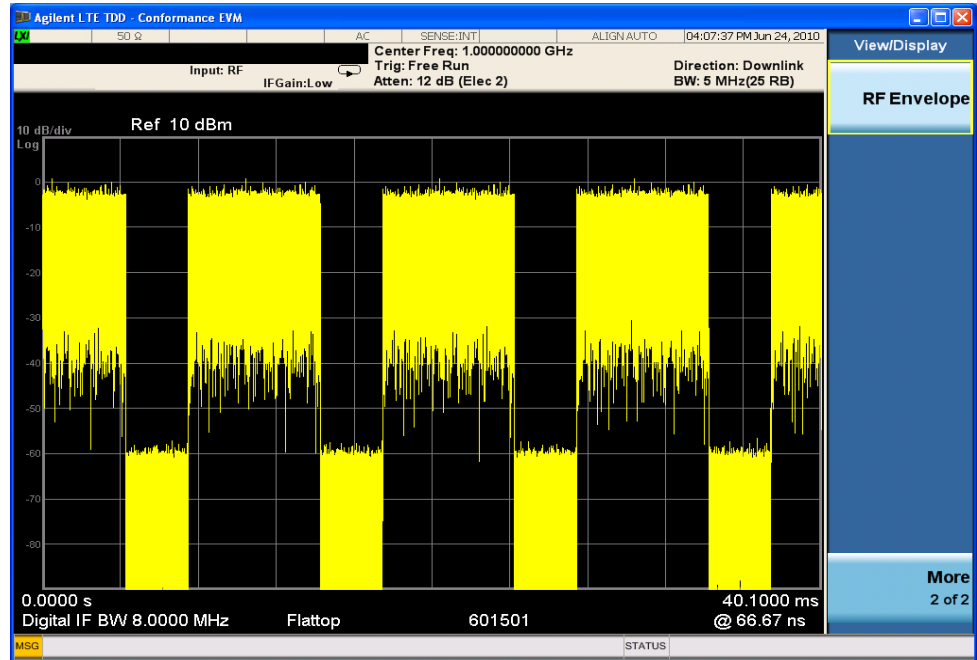
Measurement	Measurement Item	Result
EVM Measurement	EVM	567.07 m%rms
	EVM Sym Time Adjust	EVM Window End
	EVM Pk	2.0376 %pk
	EVM Pk Index	162
	EVM Peak Sub Car Index	-150
	Data EVM	582.32 m%rms
	3GPP-defined QPSK EVM	637.93 m%rms
	3GPP-defined 16QAM EVM	---
	3GPP-defined 64QAM EVM	---
	RS EVM	550.01 m%rms
	RS Tx Power	-25.13 dBm
	OFDM Symbol Tx Power	-0.36 dBm
	Freq Err	12.988 Hz
	Sync Correlation	99.802 %
	Sync Type	P-SS
	Common Tracking Error	550.20 m%rms
	Symbol Clock Error	0.12029 ppm
	Time Offset	389.27 μs
	IQ Offset	-46.344 dB
	IQ Gain Imbalance	-0.006 dB
	IQ Quad. Error	-28.304 mdeg
	IQ Timing Skew	-659.52 ps
	CP Length Mode	Normal
	Cell ID	1

Making LTE TDD Measurements
LTE TDD Downlink Signal Measurement

Step	Action	Notes
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Figure 2-49

LTE TDD Downlink Conformance EVM RF Envelop



If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

LTE TDD Uplink Signal Measurement

The section describes how to make the measurements for the LTE TDD Uplink Signal, the measurement procedure with screen shots of the measurement example are provided.

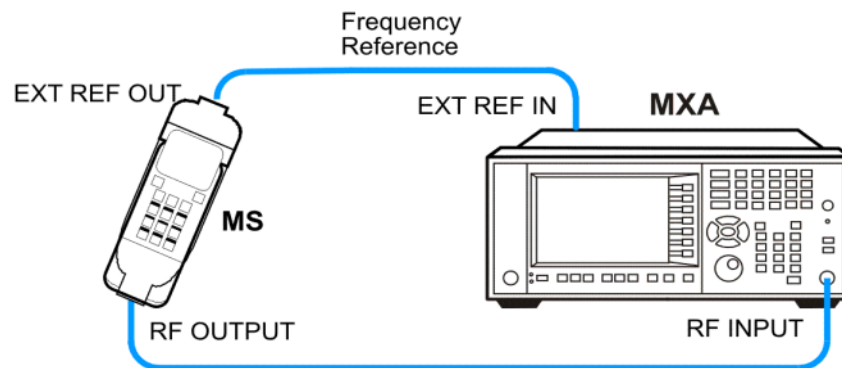
NOTE For the SCPI commands and detailed description of keys and parameters, refer to N9082A LTE TDD Measurement Application User's and Programmer's Reference.

Configuring the Measurement System

Mobile Station Measurement System

See the connection of the equipment below.

Figure 2-50 Mobile Station Test System



1. Connect the Output port of the MS to the RF Input of the Signal Analyzer.
2. Connect External Reference OUT port of the MS to the EXT REF IN port of the analyzer.

Setting the Uplink Signal (Example for Power Measurement)

In this example, Keysight N7625B Signal Studio for 3GPP LTE TDD, is used to generate the waveform for testing.

Frequency: 1 GHz
Output Power: -10 dBm (at analyzer input)
Carrier: 1
Uplink Downlink Configuration: 0
Special Subframe Configuration: 0
Channel Configuration: Full filled QPSK 5MHz (25 RB)

Making LTE TDD Measurements

LTE TDD Uplink Signal Measurement

System Bandwidth: 5 MHz (25RB)

Antennas: 1

Cyclic Prefix: Normal

Transport Channel: UL-SCH = On, 0 dB, Channel Numbers 1-6

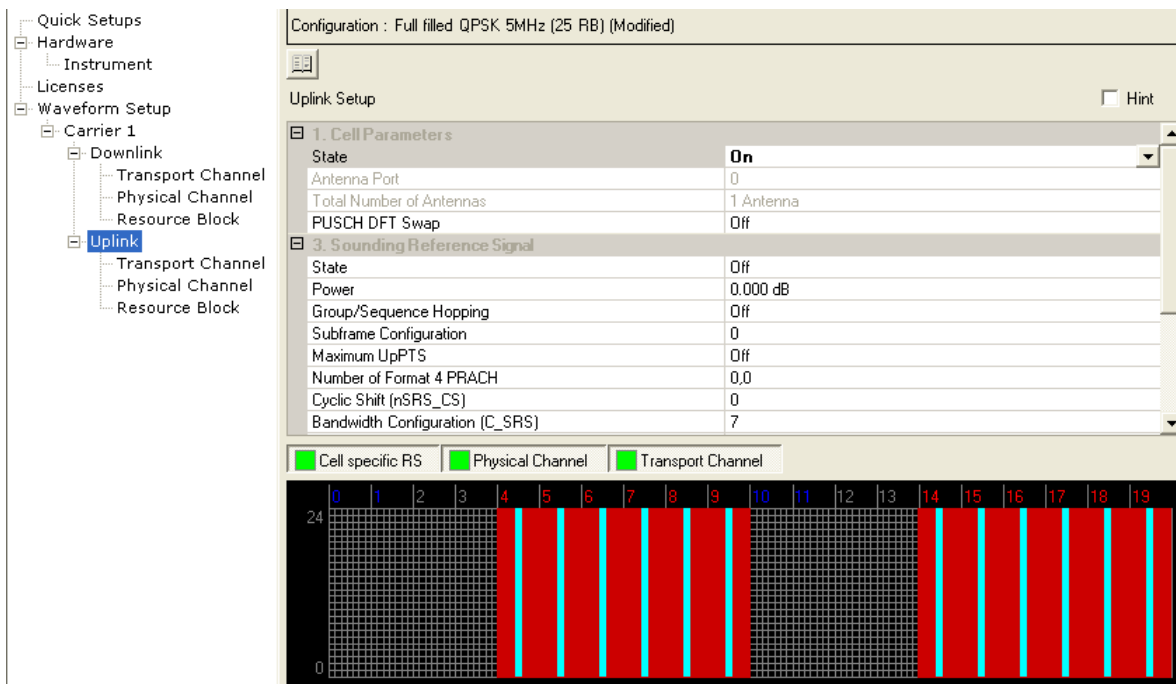
Physical Channel: PUSCH = On, 0 dB, 6 Channels, RB 1-2, ..., 11-12

Resource Block: Slot = 4-9, 14-19

Power = 0 dB

PUSCH RB = 0-24

Figure 2-51 Signal Studio Mapping (Uplink Signal)



Common Measurement Procedure (Uplink)

NOTE The following procedures are used in all Power measurements.

Step	Action	Notes
1 Enable the LTE TDD measurements.	Press Mode, LTE TDD .	
2 Preset the Mode.	Press Mode Preset .	Only do this to return the measurement settings to a known state for all measurements in the LTE TDD mode.
3 Set the center frequency.	Press FREQ Channel, 1, GHz .	
4 Select the direction to Uplink .	Press Mode Setup, Radio, Direction to be Uplink . Downlink is the default setting.	
5 Set the Uplink and Downlink allocation configuration.	Press Mode Setup, Radio, ULDLAlloc, Configuration 0 (DSUUUDSUUU) .	
6 Set the DwPTS/GP/UpPTS length configuration of the signal.	Press Mode Setup, Radio, DW/GP/Up Len, Configuration 0 .	
7 Select the predefined parameters such as Analysis Slot, Meas Interval or CP Length	Press Mode Setup, Predefined Parameters to set up the parameters. Configure Analysis Slot to be TS4, Meas Interval to be 6 slots. CP Length to be Normal.	Analysis Slot is defined as the first slot for analysis, The settings under Mode Setup, Predefined Parameters are used for power measurements and do not apply to the Modulation Analysis measurement.

NOTE For LTE TDD uplink signal, the Periodic Timer is used in Gate Source for Gate function instead of External 1, therefore in the Gate view, the Analysis Slot does not work for uplink signal. To obtain the correct Gate View, you need adjust the Gate Delay (under Sweep/Control, Gate) according to the actual burst. If trigger is available for MS and connected to the analyzer, you can change the Gate Source to External 1 so that you do not need to configure the Gate Delay manually. Regarding details for Gating function, see [“Time Gating Concepts” on page 187](#).

Monitor Spectrum Measurements

This section explains how to make a Monitor Spectrum measurement on a LTE TDD uplink signal. The Monitor Spectrum measurement is the default measurement in LTE TDD mode. It shows a spectrum domain display of the test signal. The primary use of Monitor Spectrum is to allow you to visually make sure you have the RF carrier available to the instrument, and the instrument is tuned to the frequency of interest.

For signal setting, see “Setting the Uplink Signal (Example for Power Measurement)” on page 75.

Measurement Procedure

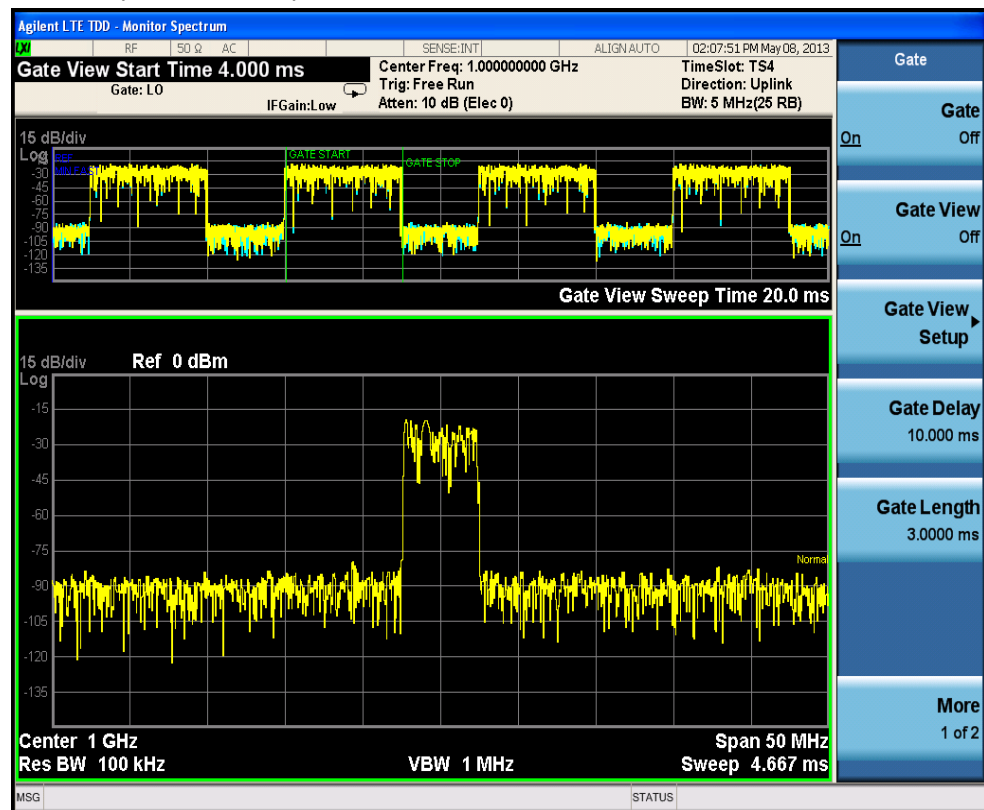
Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Uplink)” on page 77.	It is not necessary if you already configured it in other measurements.
2 Initiate the Monitor Spectrum measurement.	Press Meas, Monitor Spectrum .	The default display shows the Current (yellow trace) data. You can compare current trace with Max Hold trace, Min Hold trace or Average trace using setup under Trace/Detector. Press Trace/Detector, Select Trace and select the trace 1, then turn Update to Off . Select trace(s) desired for display and the detector type like Max Hold, toggle Display to Show . Then press Update to On to see the timely update trace.
3 Set the measurement span frequency.	Press SPAN X Scale , enter a numerical span using the front-panel keypad, and select a units key, such as MHz .	

Step	Action	Notes
4	Turn on the Gate View and setup the Gate function.	<p>Press Sweep/Control, Gate, Gate View (On).</p> <p>Turning Gate View On or Off will not influence Gate View Sweep Time. It is initialized by Mode Preset or Analysis Slot in Mode Setup, Predefined Parameters.</p> <p>The Monitor Spectrum measurement with the gate view on should look like Figure 2-52.</p> <p>You can change the Gate View Sweep Time, Gate Delay or Gate Length to see other parts of the data frame.</p> <p>You may also want to change the Gate View Setup for a convenient gate view. Here the Gate View Start Time is set to 4 ms.</p>

TIP LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.

Figure 2-52

LTE TDD Uplink Monitor Spectrum Measurement Result - Gate View On



Step	Action	Notes
NOTE	The default gate source is External 1, if you want to use other gate source, press Sweep/Control, Gate, More, Gate Source. Five types of gate sources are provided: Line, External 1, External 2, RF Burst and Periodic Timer.	
5 Turn on Marker function.	Press Marker Function, Marker Noise.	You can choose Marker Noise, Band/Interval Power, Band/Interval Density or Marker Function Off. You can use Band Adjust to set the frequency span for analysis. The Figure 2-53 shows an example of Marker Noise.

Figure 2-53

LTE TDD Uplink Monitor Spectrum Measurement Result - Marker Noise



6 (Optional) Turn on Marker function.	Press Marker Function, Marker Noise.	You can choose Marker Noise, Band/Interval Power, Band/Interval Density or Marker Function Off. You can use Band Adjust to set the frequency span for analysis.
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If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

IQ Waveform (Time Domain) Measurements

This chapter explains how to make a Waveform (time domain) measurement on a LTE TDD uplink signal. The measurement of I and Q modulated waveforms in the time domain disclose the voltages which comprise the complex modulated waveform of a digital signal.

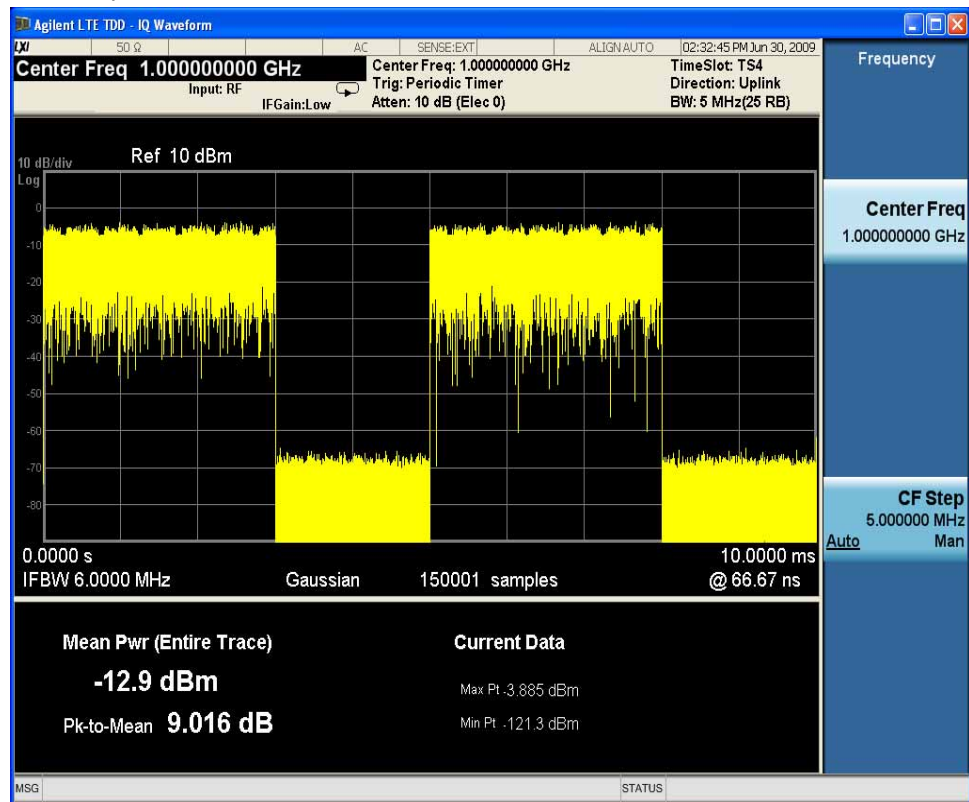
For signal setting, see “Setting the Uplink Signal (Example for Power Measurement)” on page 75.

Measurement Procedure

Step	Action	Notes
1	Perform the common configuration.	See “Common Measurement Procedure (Uplink)” on page 77. It is not necessary if you already did it in other measurements.
2	Initiate the IQ Waveform measurement.	Press Meas, IQ Waveform . The default display in Figure 2-54 shows the RF Envelope with the current data. The measured values for the mean power and peak-to-mean power are shown in the text window.

Figure 2-54

LTE TDD Uplink IQ Waveform Measurement Result



Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

Step	Action	Notes
3	Select the IQ Waveform view. Press View/Display, IQ Waveform .	The IQ Waveform window provides a view of the I (yellow trace) and Q (blue trace) waveforms on the same graph in terms of voltage versus time in linear scale.

Figure 2-55 LTE TDD Uplink Waveform Measurement - I/Q Waveform View



4	Adjust the scale.	Press the AMPTD Y Scale and SPAN X Scale and configure the setup until the waveforms are shown at a convenient voltage scale for viewing.
5	Turn on Marker functions.	Press the Maker Function key to use Maker Noise, Band/Interval Power, Band/Interval Density and Marker Function Off. You can use Band Adjust to set the frequency span for analysis.
6	(Optional) Change measurement parameters from their default condition.	Press the Meas Setup key to see the keys available to change.

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Channel Power Measurements

This section explains how to make a Channel Power measurement on a TDD LTE uplink signal. This test measures the total RF power present in the channel. The results are shown in a graph window and in a text window.

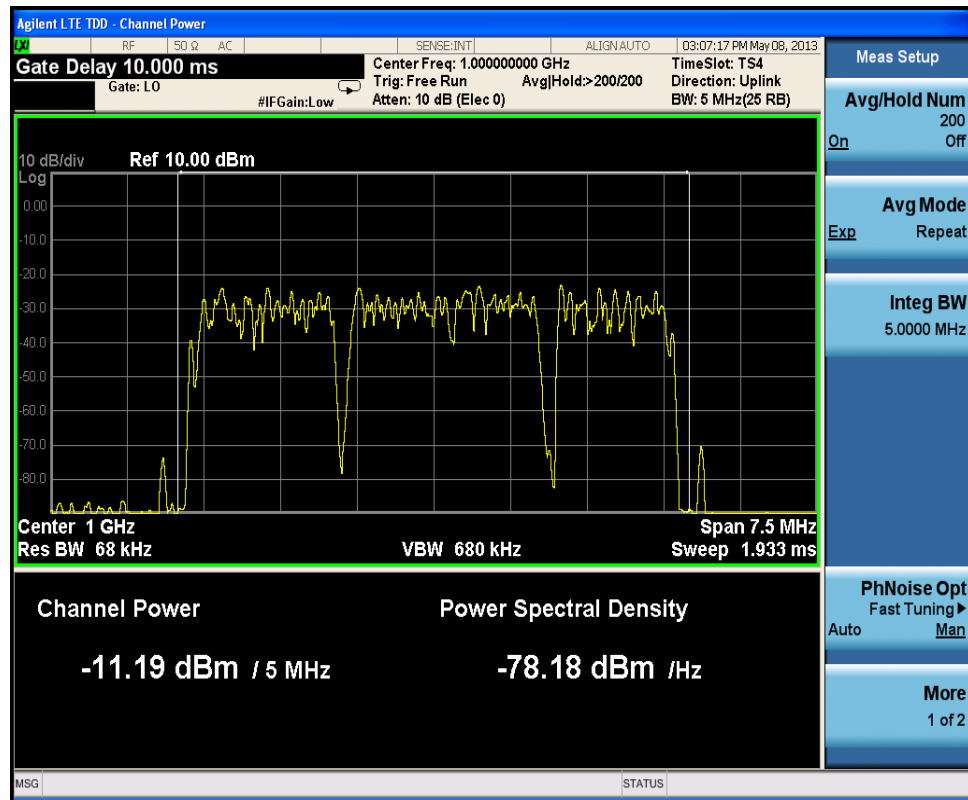
For signal setting, see “Setting the Uplink Signal (Example for Power Measurement)” on page 75.

Measurement Procedure

Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Uplink)” on page 77.	It is not necessary if you already did it in other measurements.
2 Initiate the channel power measurement.	Press Meas, Channel Power .	
3 Enter the Integration Bandwidth.	Press Meas Setup, Integ BW, 5, MHz .	The Integration BW is shown within the two white lines. The Channel Power measurement result should look like Figure 2-56. The graph window and the text window show the absolute power and its mean power spectral density values over 5 MHz.

Step	Action	Notes
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Figure 2-56 LTE TDD Uplink Channel Power Measurement Result



4 Turn on the Gate View and setup the Gate function.

Press **Sweep/Control, Gate, Gate View (On)**.

Turning Gate View On or Off will not influence Gate View Sweep Time. Gate View Sweep Time is initialized by Mode Preset or Analysis Slot under Mode Setup, Predefined Parameters.

The channel power measurement result with the gate view on should look like [Figure 2-57](#).

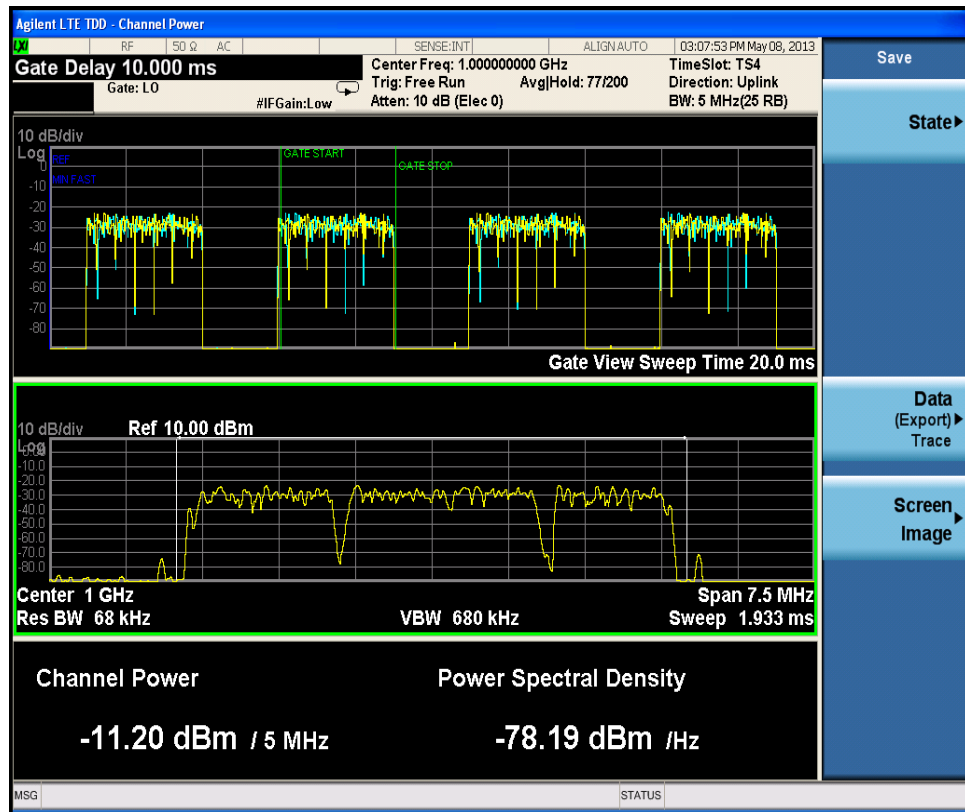
You can change the Gate Delay or Gate Length to see other parts of the data frame.

TIP LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.

Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

Step Action Notes

Figure 2-57 LTE TDD Uplink Channel Power Measurement Result - Gate View On



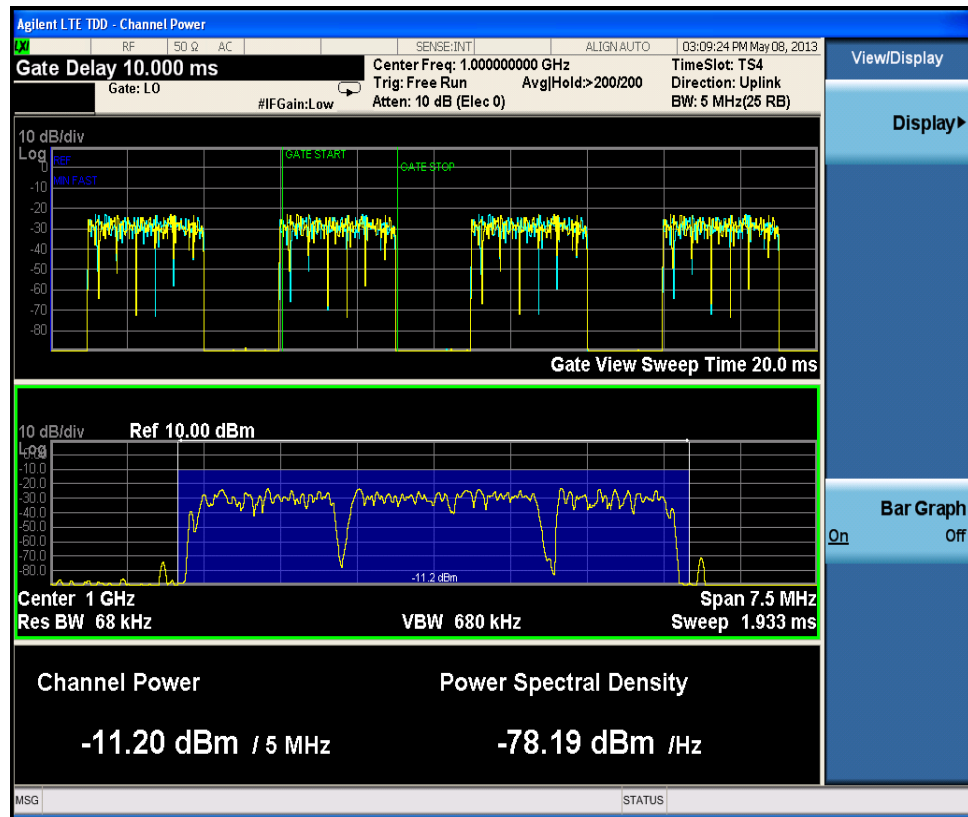
NOTE The default gate source is External 1, if you want to use other gate source, press Sweep/Control, Gate, More, Gate Source. Five types of gate sources are provided: Line, External 1, External 2, RF Burst and Periodic Timer.

5 (Optional) Display the Channel Power Bar Graph view. Press **View/Display, Bar Graph**. The Bar Graph view result should look like [Figure 2-58](#).

Step	Action	Notes
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Figure 2-58

LTE TDD Uplink Channel Power Measurement Result - Bar Graph On



6 (Optional) Change measurement parameters from their default condition.

Press **Meas Setup** to see the keys that are available to change.

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Occupied Bandwidth Measurements

This chapter explains how to make the Occupied Bandwidth measurement on a LTE TDD uplink signal. The instrument measures power across the band, and then calculates its 99.0% power bandwidth.

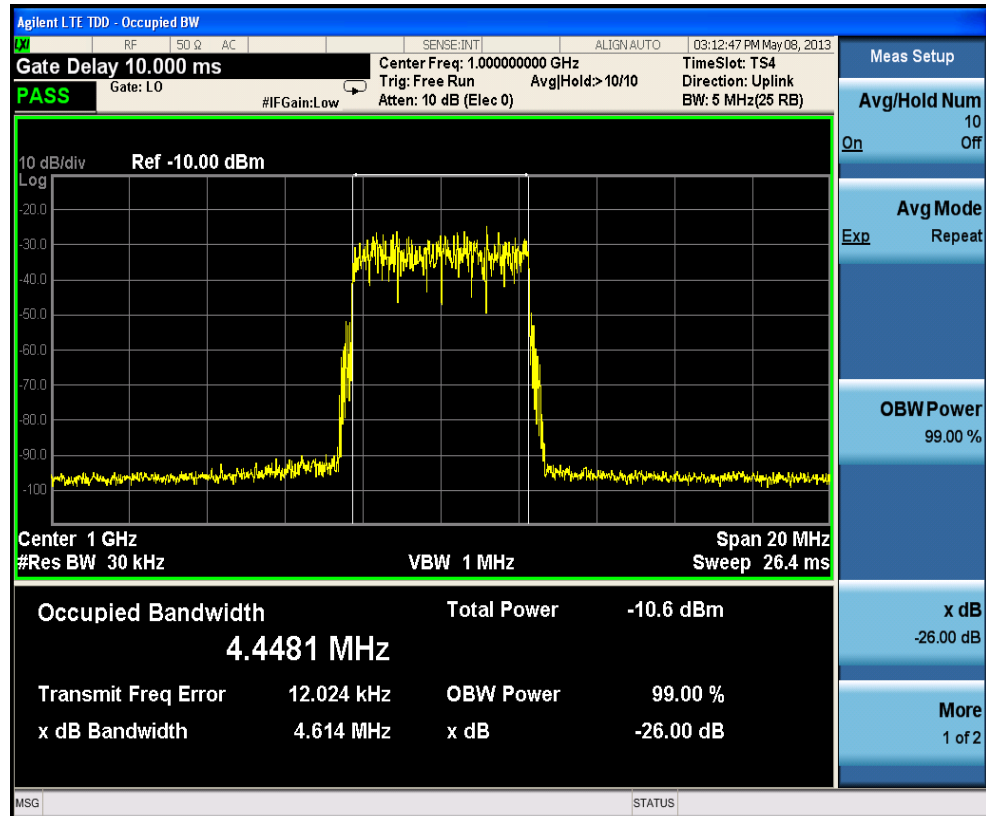
For signal setting, see “Setting the Uplink Signal (Example for Power Measurement)” on page 75.

Measurement Procedure

Step	Action	Notes
1	Perform the common configuration.	See “Common Measurement Procedure (Uplink)” on page 77. It is not necessary if you already did it in other measurements.
2	Initiate the Occupied Bandwidth measurement.	Press Meas, Occupied BW . The Occupied BW measurement results should look like Figure 2-59.

Figure 2-59

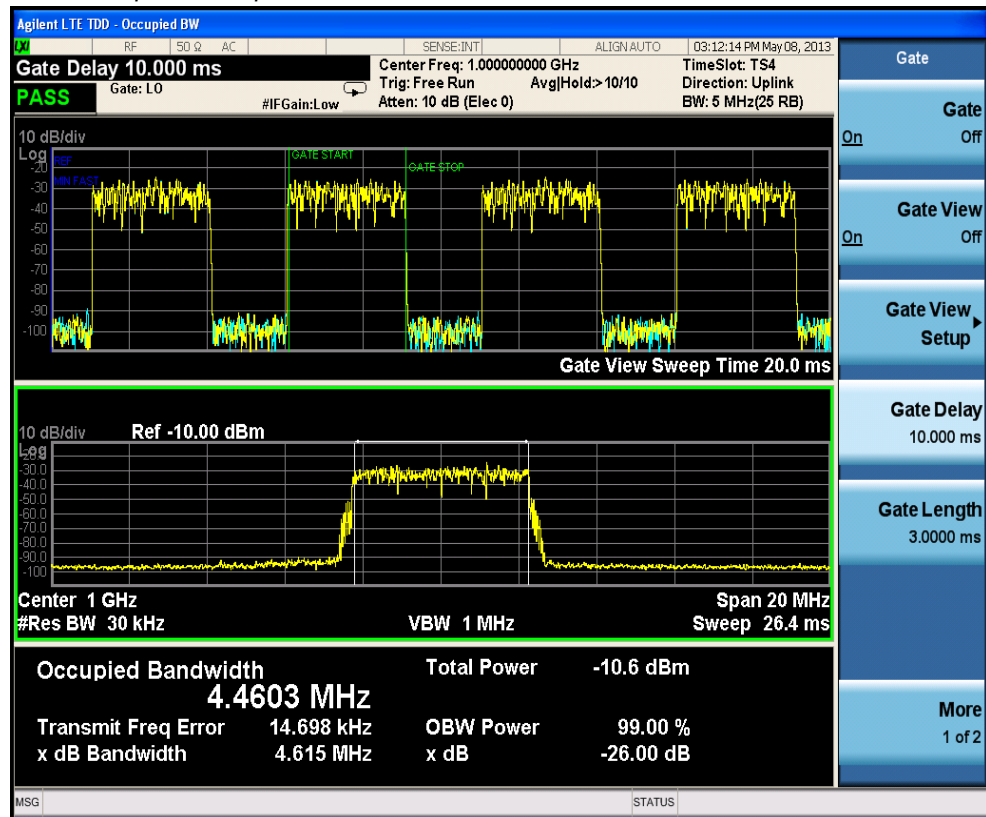
LTE TDD Uplink Occupied BW Measurement Result



Step	Action	Notes
3	Turn on the Gate View and setup the Gate function.	Press Sweep/Control, Gate, Gate View (On) .
		Turning Gate View On or Off will not influence Gate View Sweep Time. Gate View Sweep Time is initialized by Mode Preset or Analysis Slot under Mode Setup, Predefined Parameters.
		The occupied bandwidth with the gate view on should look like Figure 2-60 .
		You can change the Gate Delay or Gate Length to see other parts of the data frame.

TIP LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.

Figure 2-60 LTE TDD Uplink Occupied BW Measurement Result - Gate View On



NOTE The default gate source is External 1, if you want to use other gate source, press Sweep/Control, Gate, More, Gate Source. Five types of gate sources are provided: Line, External 1, External 2, RF Burst and Periodic Timer.

Step	Action	Notes
4 (Optional) Change measurement parameters from their default condition.	Press Meas Setup to see the keys that are available to change measurement parameters from their default condition.	

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Troubleshooting Hints

Any distortion such as harmonics or intermodulation, for example, produces undesirable power outside the specified bandwidth.

Shoulders on either side of the spectrum shape indicate spectral regrowth and intermodulation. Rounding or sloping of the top shape can indicate filter shape problems.

ACP Measurements

This section explains how to make the Adjacent Channel Leakage Power Ratio (ACLR or ACPR) measurement for LTE TDD uplink signal. ACPR is a measurement of the amount of interference, or power, in an adjacent frequency channel. The results are displayed as a bar graph or as spectrum data, with measurement data at specified offsets.

For signal setting, see “Setting the Uplink Signal (Example for Power Measurement)” on page 75.

Measurement Procedure

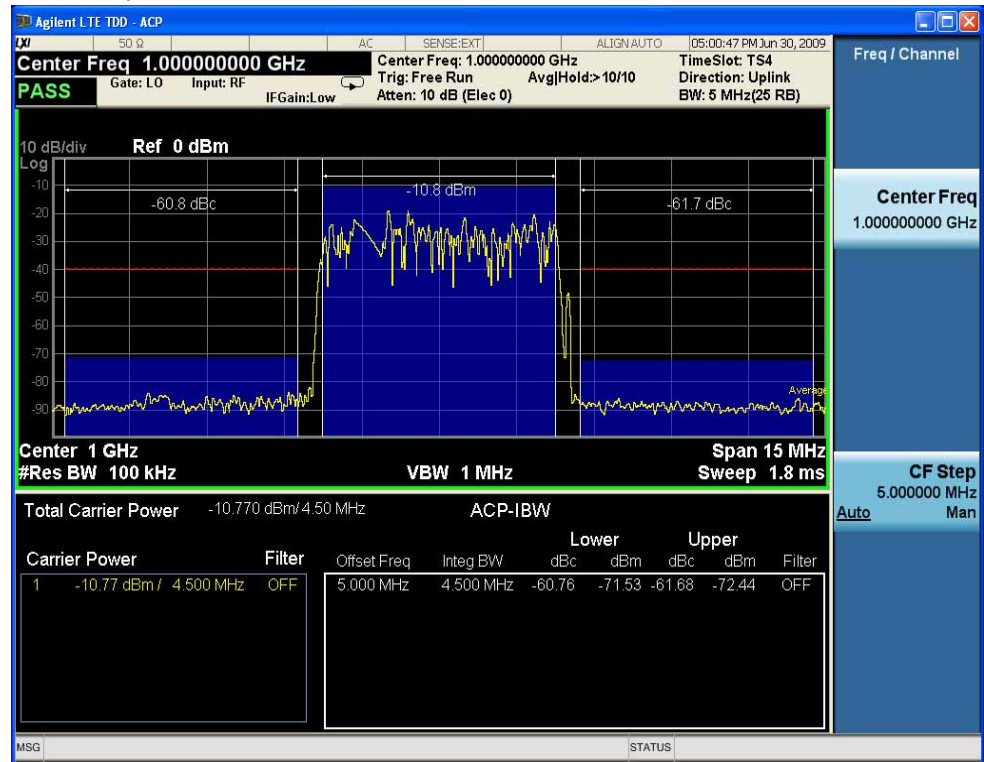
Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Uplink)” on page 77.	It is not necessary if you already did it in other measurements.
2 Initial the ACP measurement.	Press Meas, ACP .	The ACP measurement results including the bar graph with the spectrum trace graph overlay should look like Figure 2-61. The graph (referenced to the total power) and a text window are displayed. The text window shows the absolute total power reference, while the lower and upper offset channel power levels are displayed in both absolute and relative readings.

Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

Step	Action	Notes
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Figure 2-61

LTE TDD Uplink ACP Measurement Result



3 Recall the masks.

Press **Recall, Data, Mask** then **Open...**, a file open dialog appears. Select the appropriate test model file and click open.

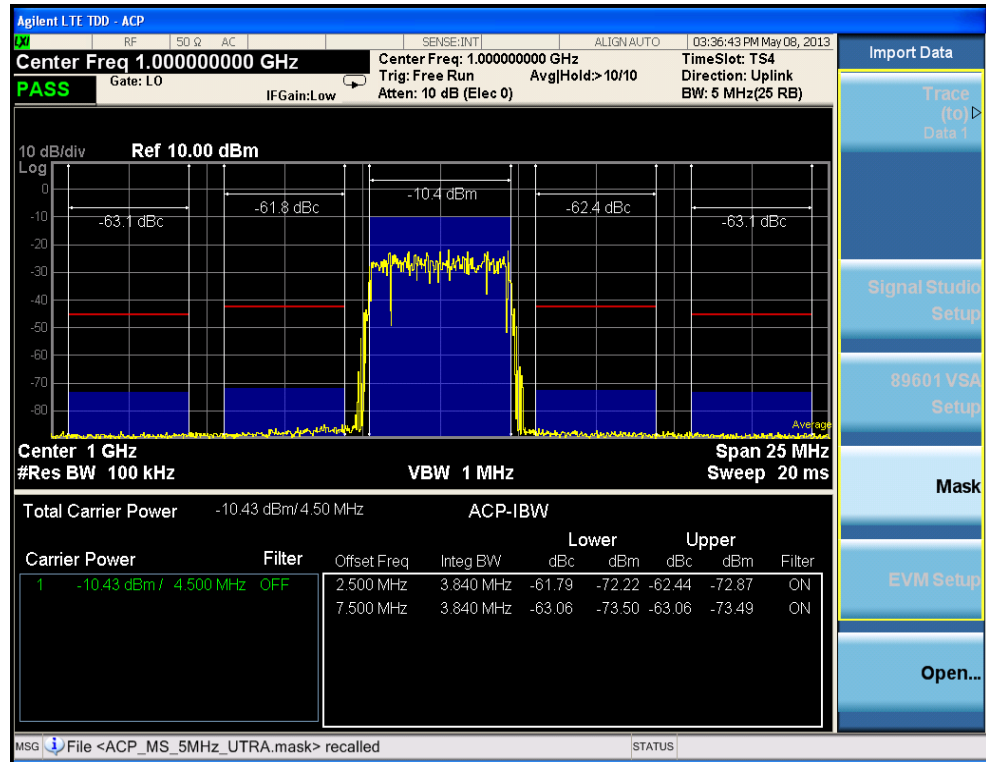
Recall function is provided for E-URTA Test Models (E-TM) defined in standard 36.141 to setup the Offset/Limit parameters automatically. The other parameters will not be changed. At the bottom of the screen, there is a message to indicate which mask file is recalled.

The following steps are used in manual setup.

Step Action Notes

Figure 2-62

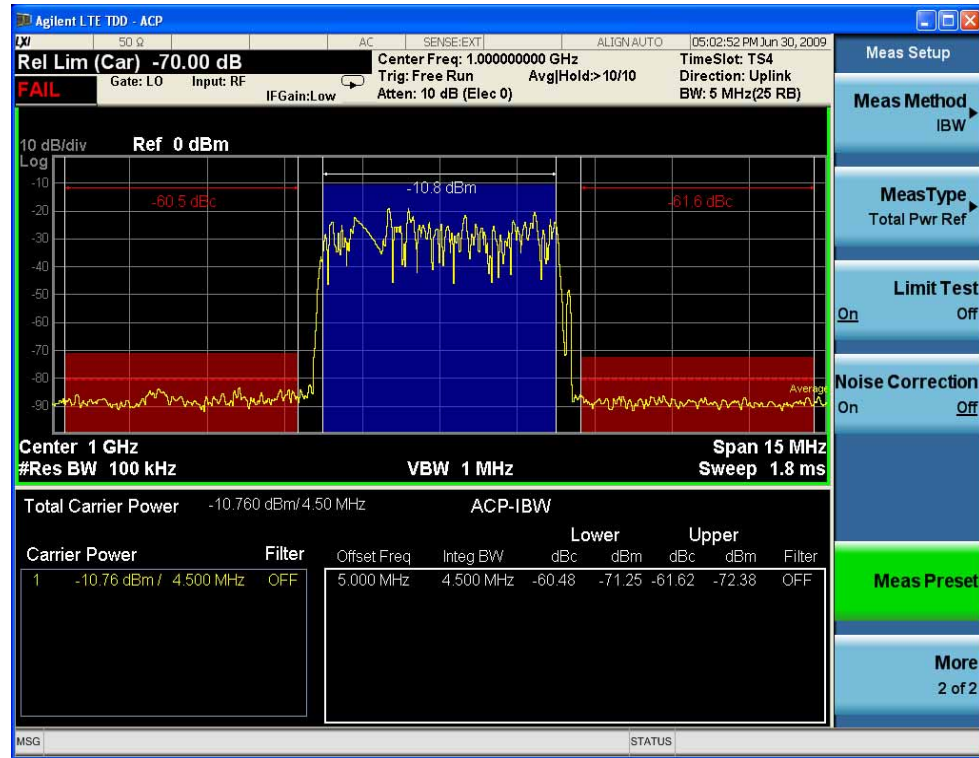
LTE TDD Uplink ACP Measurement Result - Recall Mask



- Configure the Carriers and the parameters for each carrier. Press **Meas Setup, Carrier Setup**. The default setting is one carrier and the default value for parameters are defined according to the standard.
- Configure the limit for each offset. Press **Meas Setup, Carrier Offset/Limits to configure the settings for each offset, then press Limit Test**. The red dotted lines indicate the limits and the sign "PASS" or "FAIL" at the top left corner of the screen shows the result. If the result is fail, the bar of the related offset turns red. See the example below.

Step	Action	Notes
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Figure 2-63 LTE TDD Uplink ACP Measurement Result - Fail



6 Turn on the Gate View and setup the Gate function.

Press **Sweep/Control, Gate, Gate View (On)**.

Turning Gate View On or Off will not influence Gate View Sweep Time. Gate View Sweep Time is initialized by Mode Preset or Analysis Slot under Mode Setup, Predefined Parameters.

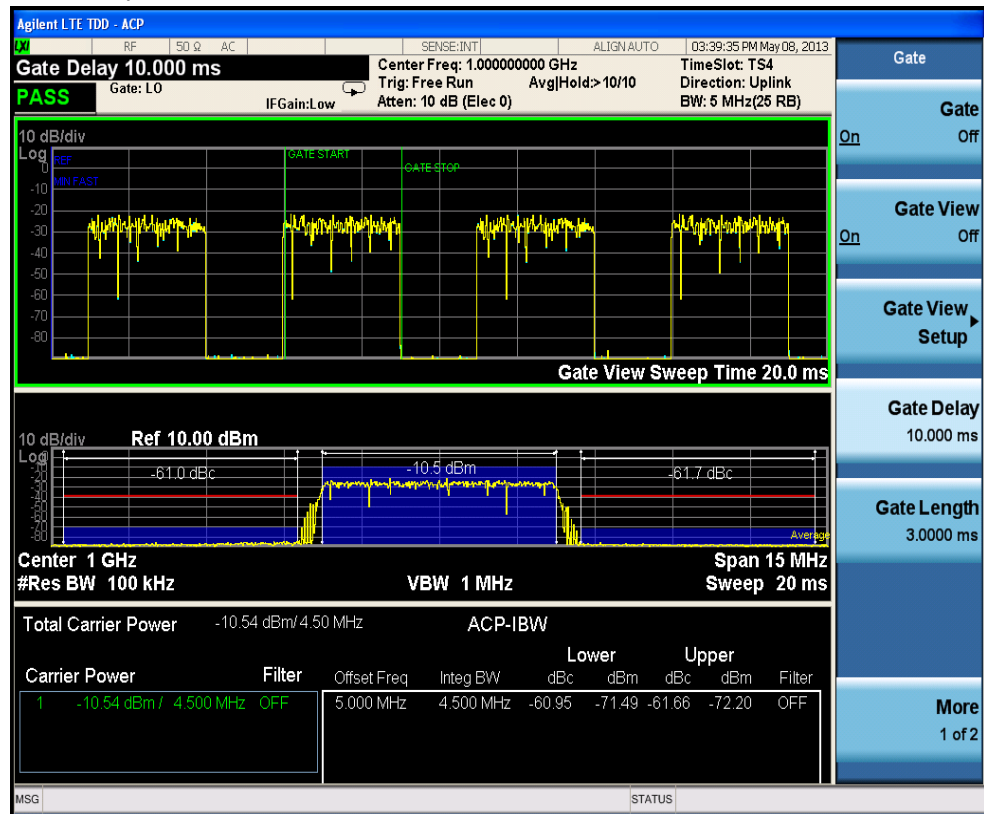
The ACP measurement with the gate view on should look like Figure 2-64.

You can change the Gate Delay or Gate Length to see other parts of the data frame.

TIP LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.

Step Action Notes

Figure 2-64 LTE TDD Uplink ACP Measurement Result - Gate View On



NOTE The default gate source is External 1, if you want to use other gate source, press Sweep/Control, Gate, More, Gate Source. Five types of gate sources are provided: Line, External 1, External 2, RF Burst and Periodic Timer.

NOTE **Noise Correction** can reduce the noise contribution of the analyzer to the measurement results as much as 10 dB. When the measured power is close to the noise floor, turning on the Noise Correction under the Meas Setup menu can make the measurement more accurate. The correction will be valid for only the current measurement parameters.

CAUTION To correctly use the **Noise Correction** feature, you **MUST** re-calibrate the correction (set to **Off**, then **On**) after ANY measurement parameters are changed. Failure to re-calibrate the Noise Correction will provide invalid data. When **Noise Correction** is **On**, the screen annotation NCORR is shown below the Input .

7 (Optional) Adjust the dynamic range. Press **AMPTD** and adjust the **Attenuation** to 0 dB. This allows greater dynamic range for this level of input signal.

TIP For the most accurate ACP measurement results, you maybe able to optimize the level of the signal measured by the analyzer. Adjust the input attenuation using the Up/Down keys, while watching the ACP levels shown at the offsets to see if the measurement results improve with another setting.

Making LTE TDD Measurements
LTE TDD Uplink Signal Measurement

Step	Action	Notes
8 (Optional) Change measurement parameters from their default condition.	Press Meas Setup to see the keys that are available to change.	

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Spurious Emissions Measurement

This section explains how to make the Spurious Emission measurement on a LTE TDD uplink signal. This measurement identifies and determines the power level of spurious emissions in certain frequency bands.

For signal setting, see “Setting the Uplink Signal (Example for Power Measurement)” on page 75.

Measurement Procedure

Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Uplink)” on page 77.	It is not necessary if you already did it in other measurements.
2 Toggle the RF Coupling to DC.	Press Input/Output, RF Input, RF Coupling, DC.	In AC coupling mode, you can view signals less than 10 MHz but the amplitude accuracy is not specified. To accurately see a signal of less than 10 MHz, you must switch to DC coupling. When operating in DC coupled mode, ensure protection of the External Mixer by limiting the DC part of the input level to within 200 mV of 0 Vdc.
3 Initiate the Spurious Emission measurement.	Press Meas, Spurious Emission.	Depending on the current settings, the instrument will begin making the selected measurements. The resulting data is shown on the display. The Spurious Emissions measurement results should look like Figure 2-65. The spectrum window and the text window show the spurs that are within the current value of the Marker Peak Excursion setting of the absolute limit. Any spur that has failed the absolute limit will have an ‘F’ beside it. The measurement result shows the largest spur which is yellow. You can select the other spur by pressing Meas Setup, Spur and enter the number of the spur.

NOTE If you set the Meas Type to Examine, the trace is continuously updating to show the latest spectrum range which has the worst spurious. However, the table always shows the last reported trace information. Press Restart to update the table to show the latest result.

Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

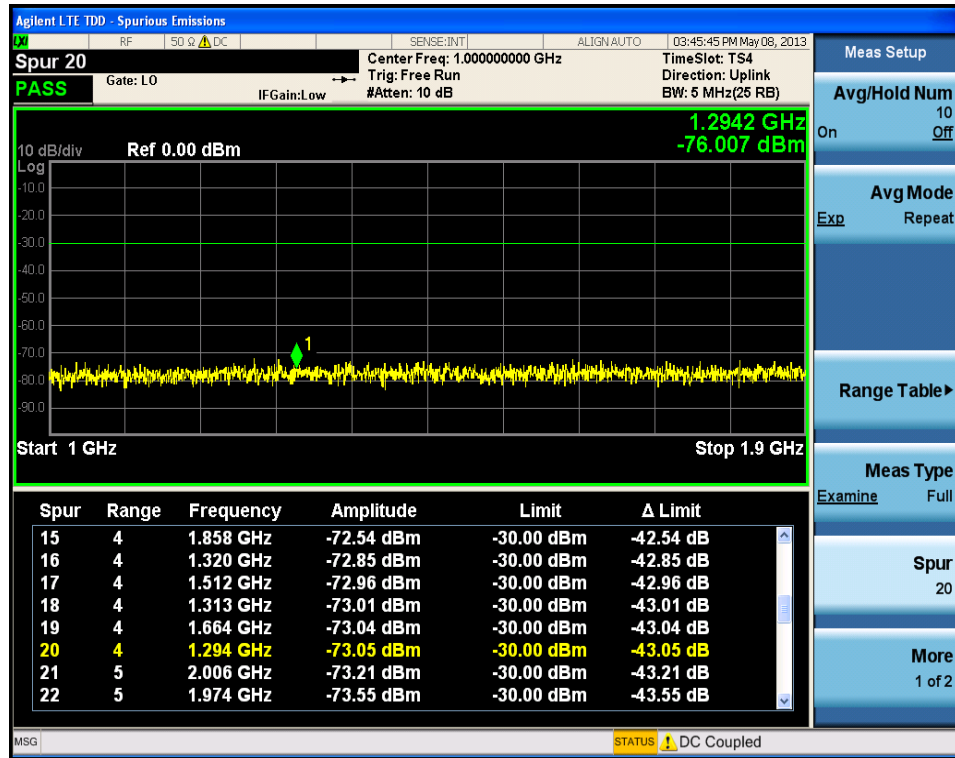
Step

Action

Notes

Figure 2-65

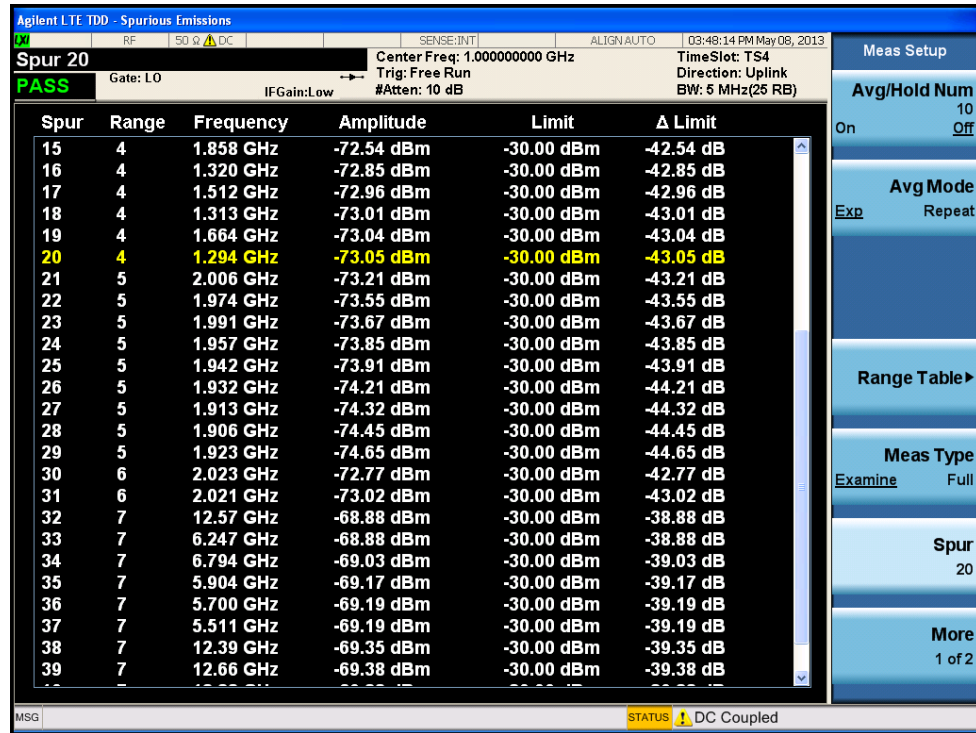
LTE TDD Uplink Spurious Emissions Measurement - Spur Table



You can use the window control keys below the screen to zoom the result screen. See Figure 2-66.

Step Action Notes

Figure 2-66 LTE TDD Uplink Spurious Emissions Measurement - Numeric Result Screen



4 Select the Range Table view and edit the Range Table.

Press **View/Display, Range Table**, then **Meas Setup, Range Table**.

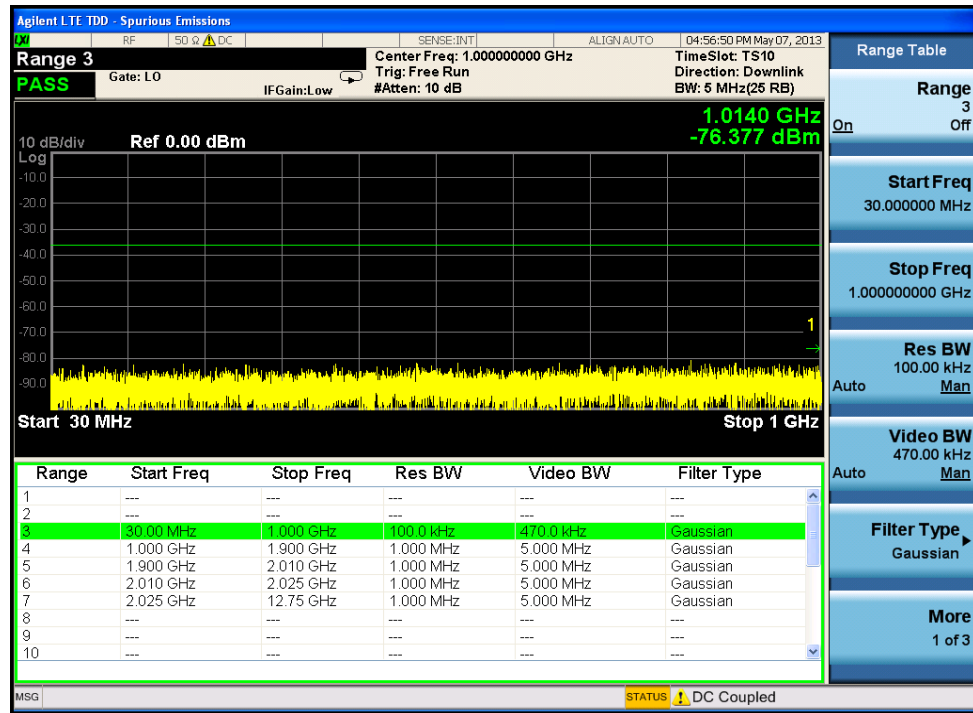
You can enter the settings for up to twenty ranges.

The measurement result highlights the selected range. If you want to change the settings of different ranges, you can press Meas Setup, Range Table, Range, then enter the range number you need configure.

Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

Step Action Notes

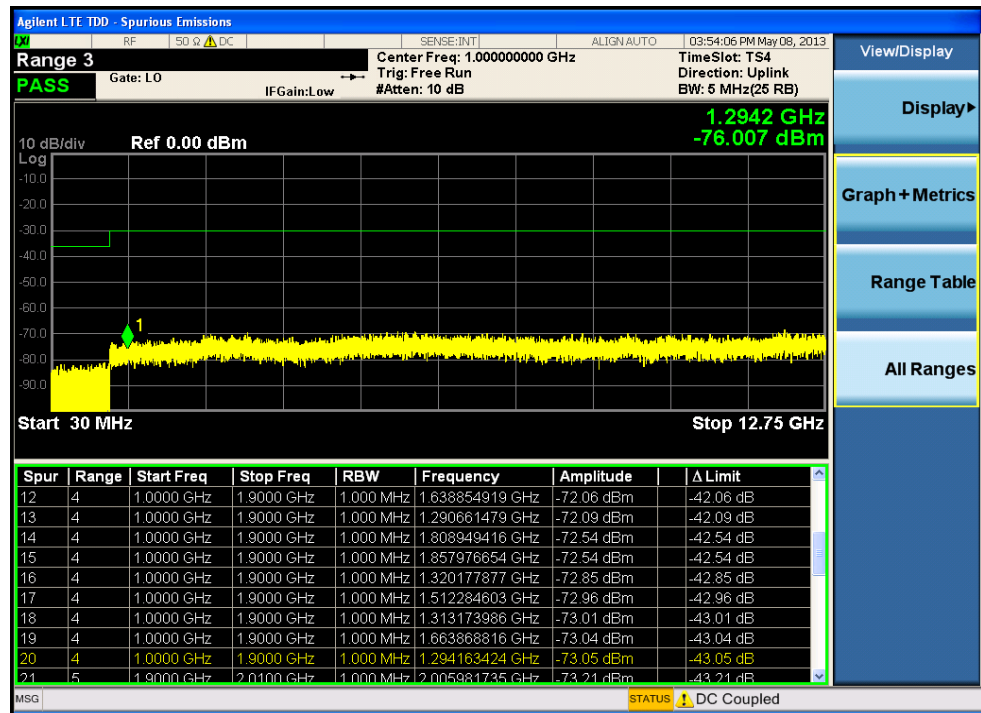
Figure 2-67 LTE TDD Uplink Spurious Emissions Measurement - Range Table



5 Select the All Ranges view. Press **View/Display, All Ranges**. It shows the measurement results for all ranges, The worst spurious is highlighted by default.

Step Action Notes

Figure 2-68 LTE TDD Uplink Spurious Emissions Measurement - All Ranges



- 6 (Optional) Change measurement parameters from their default condition. Press Meas Setup to see the keys that are available to change.

If you have a problem, and get an error message, see the guide “Instrument Messages”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Spectrum Emission Mask Measurements

This section explains how to make the Spectrum Emission Mask (SEM) measurement on a LTE TDD uplink signal. SEM compares the total power level within the defined carrier bandwidth and the given offset channels on both sides of the carrier frequency, to levels allowed by the standard. Results of the measurement of each offset segment can be viewed separately.

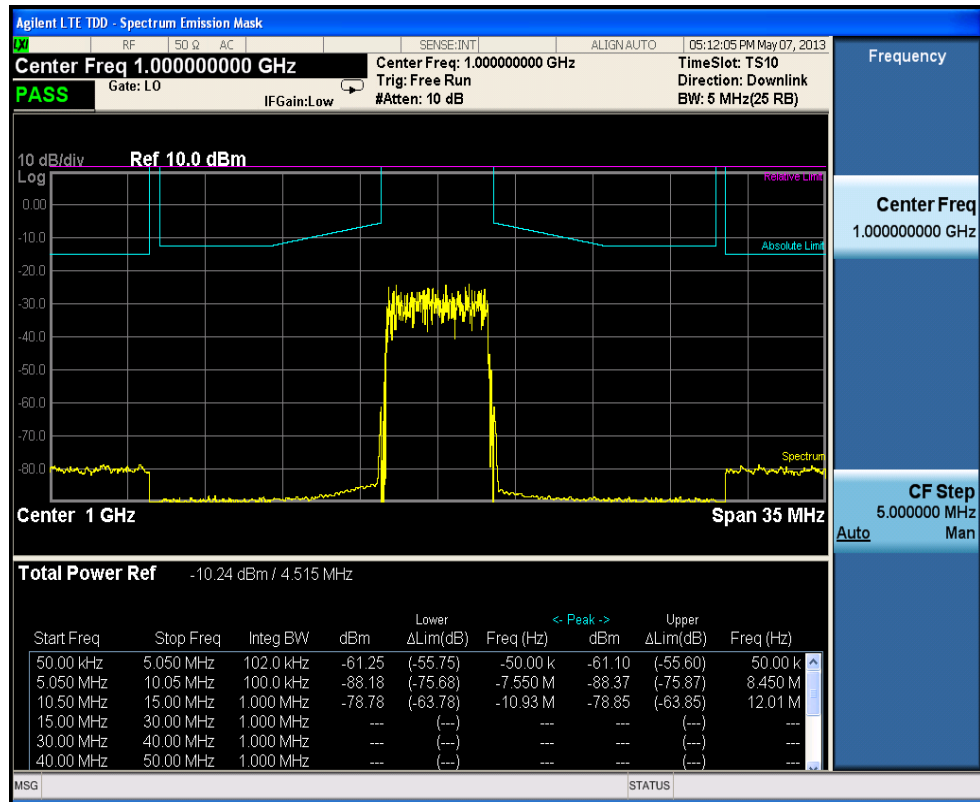
For signal setting, see “Setting the Uplink Signal (Example for Power Measurement)” on page 75.

Measurement Procedure

Step	Action	Notes
1 Perform the common configuration.	See “Common Measurement Procedure (Uplink)” on page 77.	It is not necessary if you already did it in other measurements.
2 Initiate the Spectrum Emission Mask measurement.	Press Meas, Spectrum Emission Mask .	The Spectrum Emission Mask measurement result should look like Figure 2-70. The text window shows the reference total power and the absolute peak power levels which correspond to the frequency bands on both sides of the reference channel. The cyan line is the absolute limit line and the purple line is the relative limit line. The limit lines are turned on by default.

Step Action Notes

Figure 2-69 LTE TDD Uplink Spectrum Emission Mask Measurement Result



3 Recall the masks.

Press **Recall, Data, Mask then Open...**, a file open dialog appears. Select the appropriate file and click open.

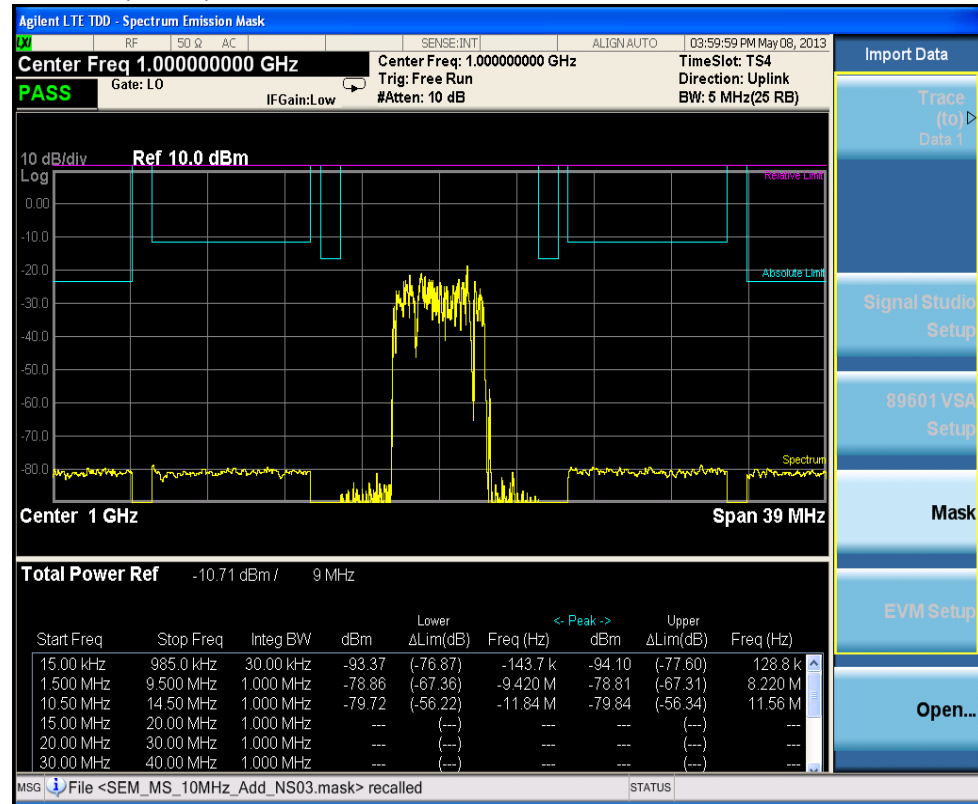
Recall function is provided for E-URTA Test Models (E-TM) defined in standard 36.141 to setup the Offset/Limit parameters automatically. The other parameters will not be changed. At the bottom of the screen, there is a message to indicate which mask file is recalled.

The following steps are used in manual setup.

Step	Action	Notes
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Figure 2-70

LTE TDD Uplink Spectrum Emission Mask Measurement Result - Recall Mask



4 Setup the limit.

Press **Meas Setup, Offset/Limit, More, Limits** then enter the limit value for each offset.

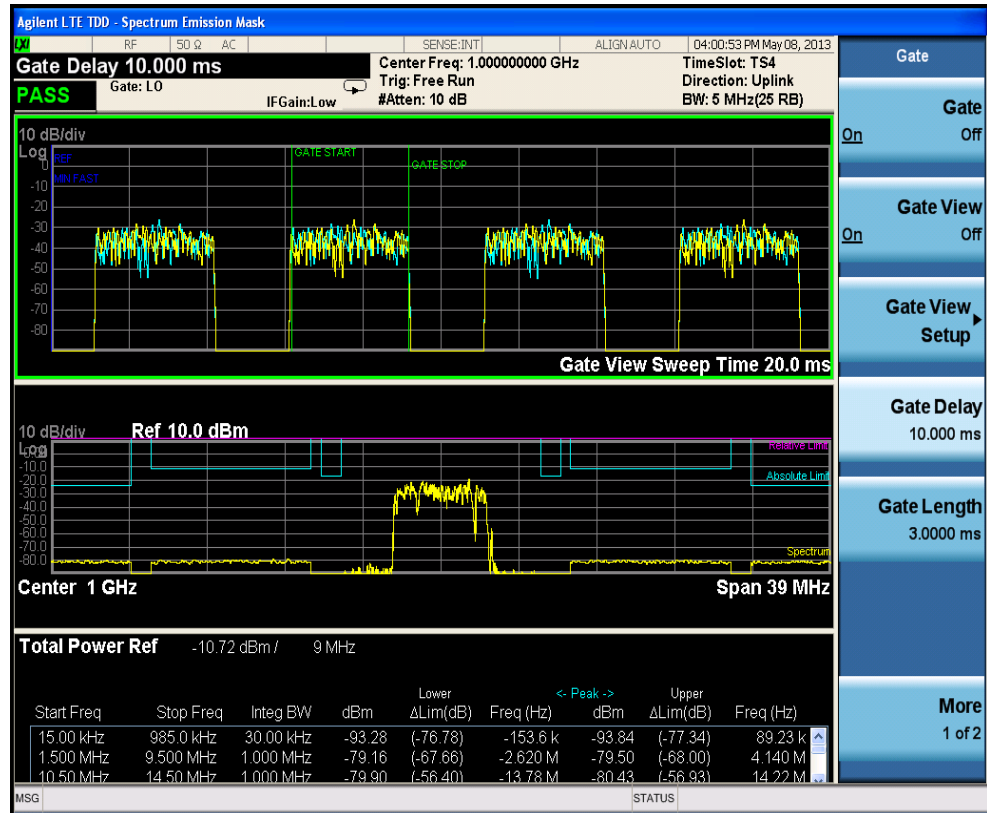
The Lower or Upper ΔLim result is the minimum margin from limit line which is decided by Fail Mask setting. There are four settings for Fail Mask: Absolute, Relative, Abs AND Rel, Abs OR Rel.

- For Absolute mask, the Lower or Upper Lim is compared with the Absolute limit line.
- For Relative mask, the Lower or Upper Lim is compared with the Relative limit line.
- For Abs AND Rel mask, the Lower or Upper Lim is compared with the higher limit line.
- For Abs OR Rel mask, the Lower or Upper Lim is compared with the lower limit line.

Step	Action	Notes
5	Turn on the Gate View and setup the Gate function.	<p>Press Sweep/Control, Gate, Gate View (On).</p> <p>Turning Gate View On or Off will not influence Gate View Sweep Time. Gate View Sweep Time is initialized by Mode Preset or Analysis Slot under Mode Setup, Predefined Parameters.</p> <p>The occupied band width with the gate view on should look like Figure 2-71.</p> <p>You can change the Gate Delay or Gate Length to see other parts of the data frame.</p>

TIP LTE TDD is a burst signal. To obtain correct results, the Gate function (Sweep/Control, Gate, Gate) is turned on by default.

Figure 2-71 LTE TDD Uplink Spectrum Emission Mask Measurement Result - Gate View On



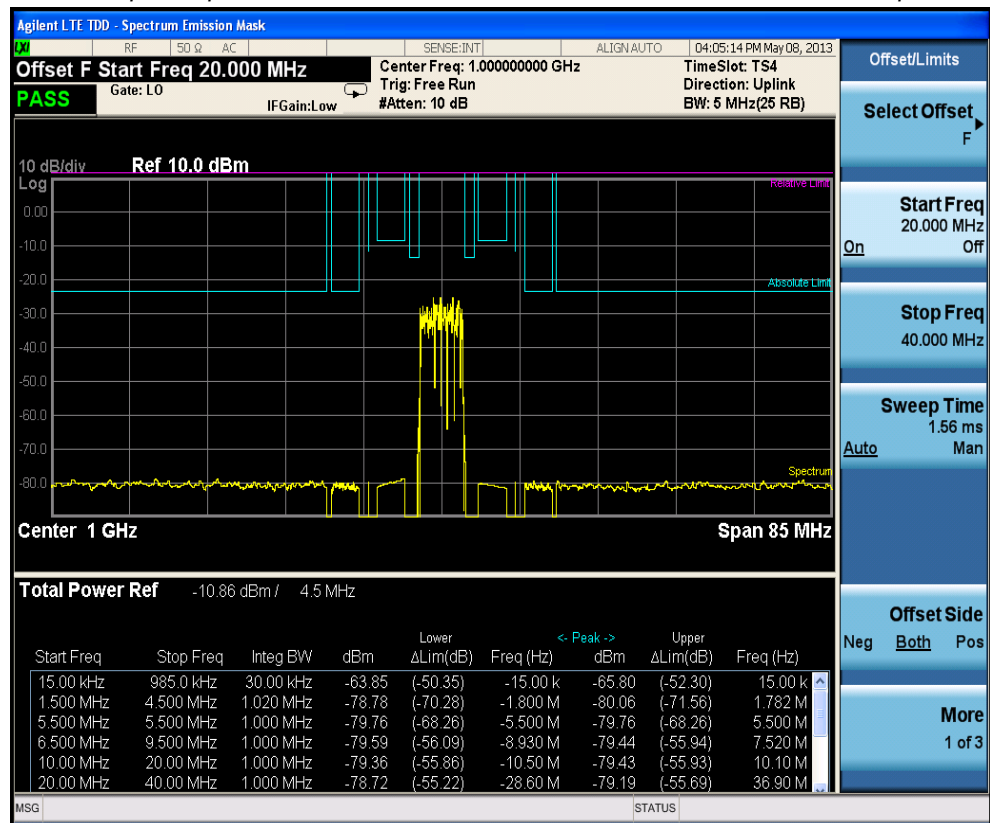
NOTE The default gate source is External 1, if you want to use other gate source, press Sweep/Control, Gate, More, Gate Source. Five types of gate sources are provided: Line, External 1, External 2, RF Burst and Periodic Timer.

Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

Step	Action	Notes
6	Select the desired offset pairs. Press Meas Setup, Offset/Limit, Select Offset . Select the offset you want to turn on and press Start Freq, On. You can change the Start Freq, Stop Freq and other values for the offset.	The value of offset A, B, C, D is designed according to the standard and they are turned on by default. When there are many offsets to measure, you can increase the Res BW under Meas Setup, Offset/Limit to increase the measurement speed.

Figure 2-72

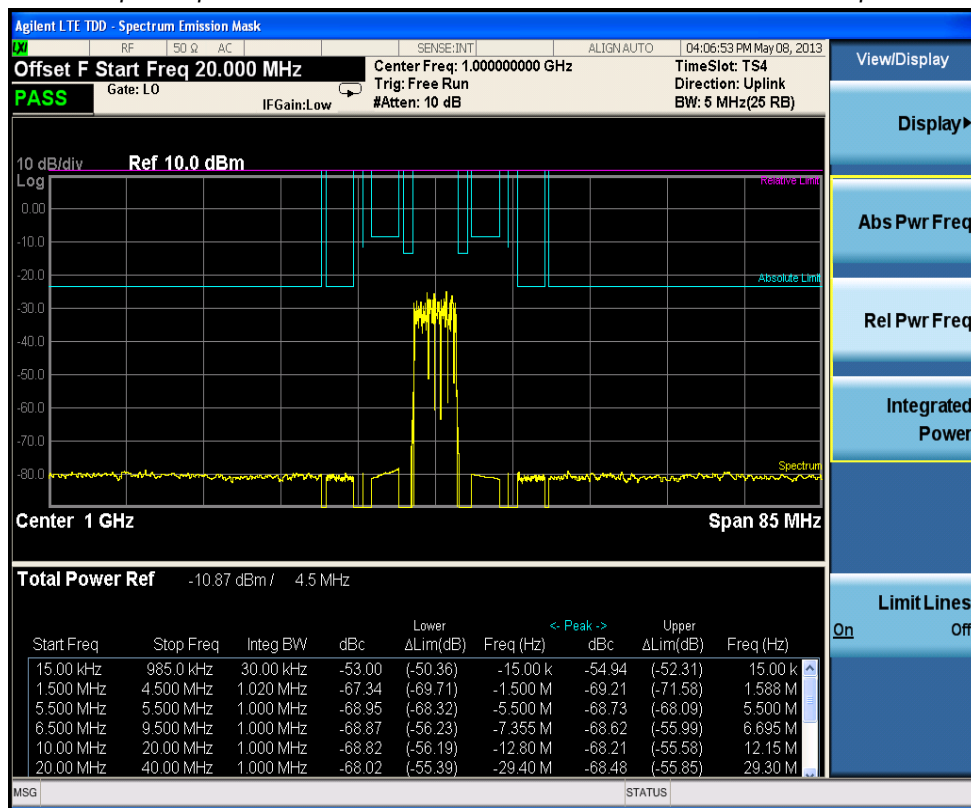
LTE TDD Uplink Spectrum Emission Mask Measurement Result - A, B, C, D, E, F pairs



7	Select the view and measurement result. Press View/Display and select the desired view.	Three types of views are provided: Absolute Peak Power & Frequency, Relative Peak Power & Frequency and Integrated Power. For each view, you can use three measurement types (select using Measure Setup, Meas Type): Total Power Reference, PSD Reference and Spectrum Peak Reference. The picture below shows the measurement result using Meas Type PSD Reference and Relative Peak Power view.
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Step Action Notes

Figure 2-73 LTE TDD Uplink Spectrum Emission Mask Measurement Result - Rel Pwr Freq View



8 (Optional) Change measurement parameters from their default condition.

Press **Meas Setup** to see the keys that are available to change.

For example, you can change the **Meas Type** to **PSD Ref**:

Press **Meas Setup**, **Meas Type**, and select **PSD Ref** to display the Integrated Power view for the spectrum emission mask measurement with a PSD reference. The PSD reference is shown below the spectrum graph in dBm/Hz.

Also press **Trace/Detector** to change the detector type.

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Troubleshooting Hints

The Spectrum Emission Mask measurement can reveal degraded or defective parts in the transmitter section of the unit under test (UUT). The following are examples of typical cases of poor performance.

- Faulty DC power supply control of the transmitter power amplifier.
- RF power controller of the pre-power amplifier stage.
- I/Q control of the baseband stage.
- Degradation in the gain and output power level of the amplifier due to the degraded gain control or increased distortion, or both.
- Degradation of the amplifier linearity or other performance characteristics.

Power amplifiers are one of the final stage elements of a base or mobile transmitter and are a critical part of meeting the important power and spectral efficiency specifications. Since spectrum emission mask measures the spectral response of the amplifier to a complex wideband signal, it is a key measurement linking amplifier linearity and other performance characteristics to the stringent system specifications.

Transmit On/Off Power Measurements

This section explains how to make the Transmit On/Off Power measurement on a LTE TDD uplink signal. The test is to verify transmitter off power and transmitter transient periods are within the limit of the minimum requirement.

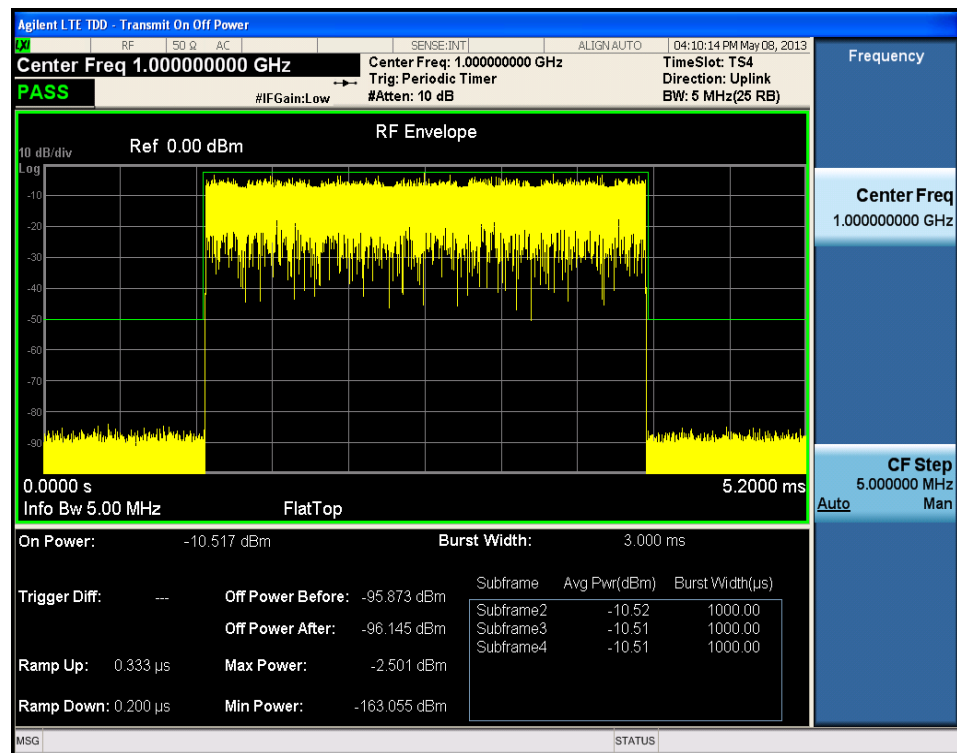
For signal setting, see “Setting the Uplink Signal (Example for Power Measurement)” on page 75.

Measurement Procedure

Step	Action	Notes
1	Perform the common configuration.	See “Common Measurement Procedure (Uplink)” on page 77.
2	Initiate the Transmit On/Off Power measurement.	Press Meas, Transmit On/Off Power . The Transmit On/Off Power measurement result should look like Figure 2-74. Sometimes the result for Burst Width and Ramp Down displays “---”. That is because the measured burst is not a complete burst. The Off Power shows “---” because the transmitter off period is not detected within the Meas Interval.

Figure 2-74

LTE TDD Uplink Transmit On/Off Power Measurement Result

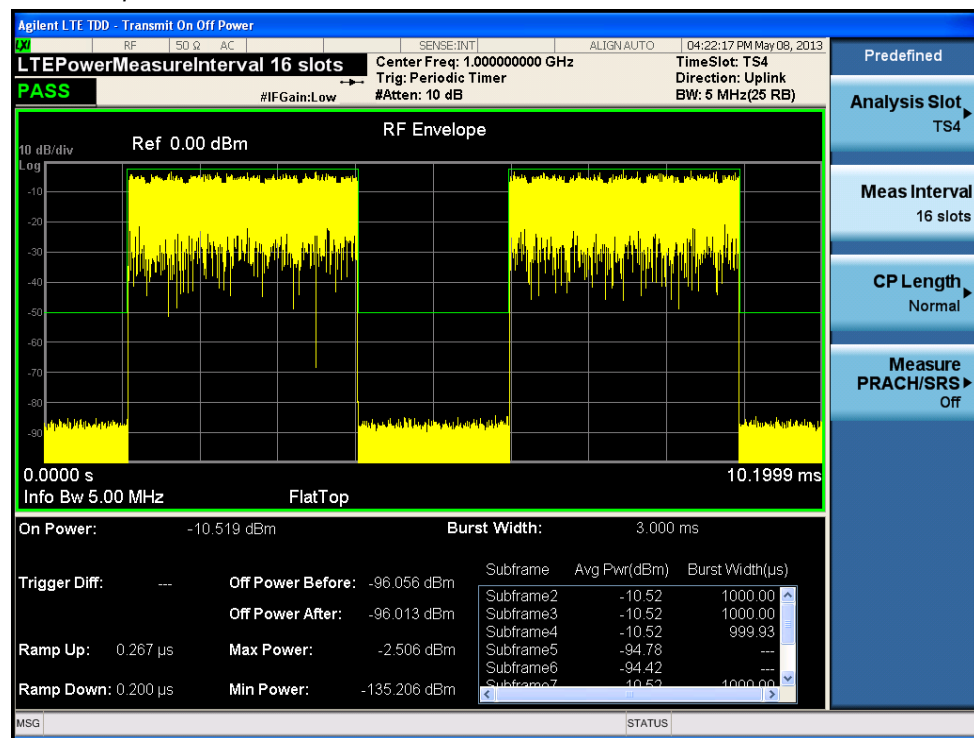


Step	Action	Notes
NOTE		The default setup of Transmitter On/Off Power measurement is Single. Do not use Cont to let the analyzer continuously sweep. The attenuator and preamplifier performs adjustment in every sweep. If you turn Cont on, the device lifetime will be influenced.
3	Adjust the parameters to see more subframes test result. Press Mode Setup, Predefined Parameters, Meas Interval, 16 , then press Restart or Single .	16 analysis time slots are for two complete bursts to perform Burst Width and Ramp Down test. This step can be ignored if you already configured the required measurement interval. All the test results with the result for the active slot on the bottom right of the screen are shown in Figure 2-27 .

NOTE Each time the parameter is modified, you need press Restart or Single to initiate a sweep. The yellow mark (*) on the top right indicates Restart or Single was not performed after the parameters were changed and the results are invalid.

Figure 2-75

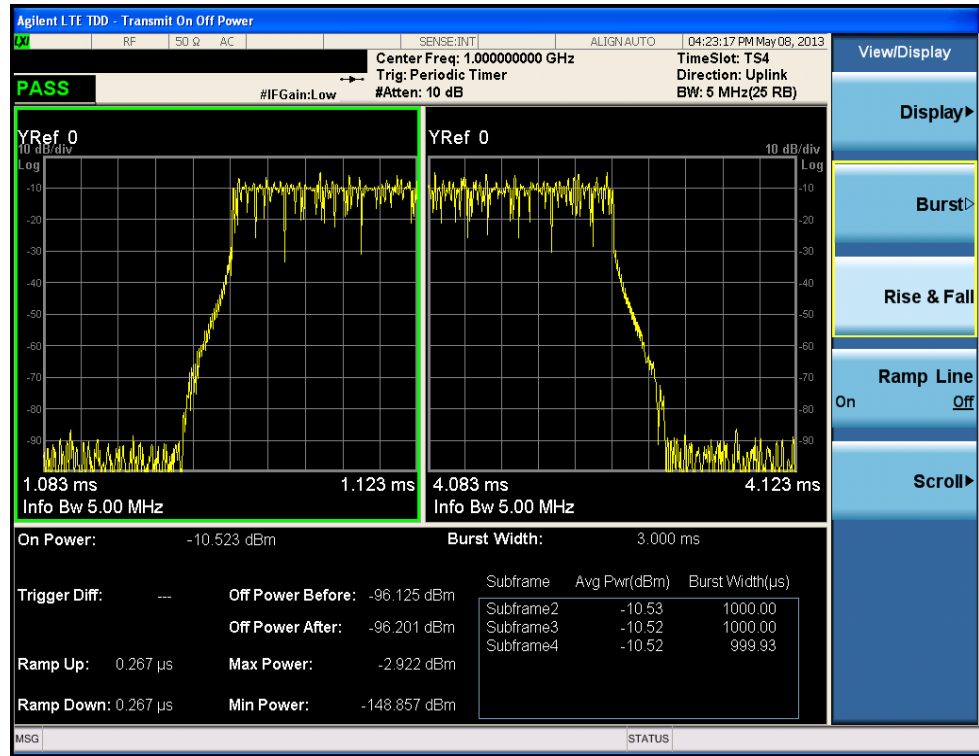
LTE TDD Uplink Transmit On/Off Power Measurement Result - 16 Time Slots



4	Select Rise & Fall view. Press View/Display, Rise & Fall .	You can observe the detail during ramp up an down period in Rise & Fall view. You can also configure Threshold under Meas Setup and turn on Ramp Line to observe the areas you are interested.
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Step Action Notes

Figure 2-76 LTE TDD Uplink Transmit On/Off Power Measurement Result - Rise & Fall view



5 (Optional) Change measurement parameters from their default condition. Press **Meas Setup** to see the keys that are available to change.

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Power Statistics CCDF Measurements

This section explains how to make the Power Statistics Complementary Cumulative Distribution Function (Power Stat CCDF) measurement on a LTE TDD downlink signal. Power Stat CCDF curves characterize the higher level power statistics of a digitally modulated signal.

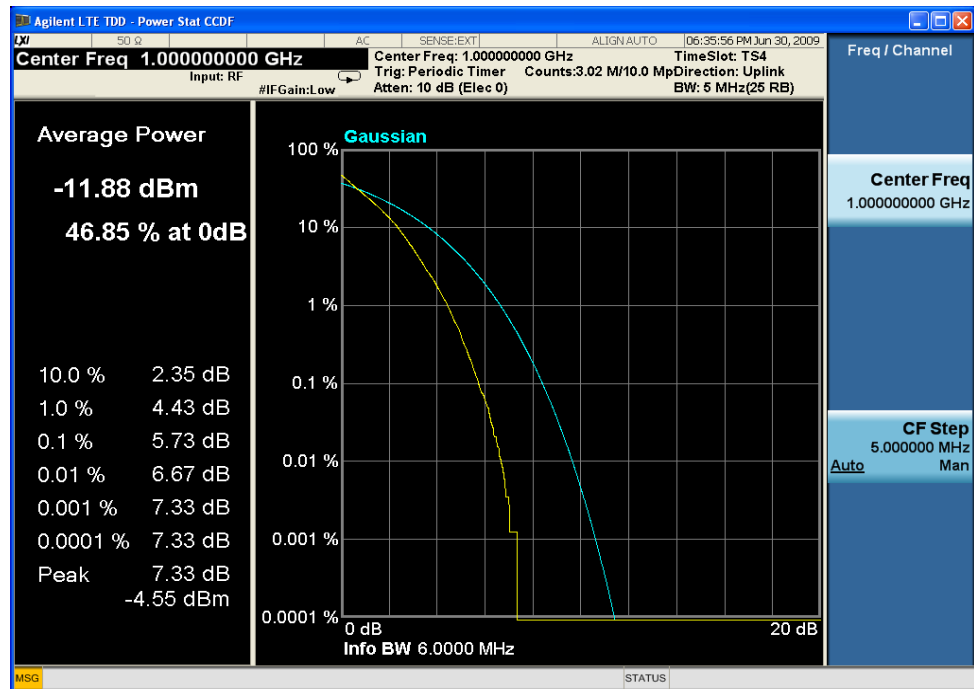
For signal setting, see “Setting the Uplink Signal (Example for Power Measurement)” on page 75.

Measurement Procedure

Step	Action	Notes
1	Perform the common configuration.	See “Common Measurement Procedure (Uplink)” on page 77. It is not necessary if you already did it in other measurements.
2	Initiate the power statistics CCDF measurement.	Press Meas, Power Stat CCDF . The CCDF measurement result should look like Figure 2-77. The blue line is the Gaussian trace and the yellow line is the measurement result. The Info BW is the channel bandwidth that will be used for data acquisition, the default value is 6 MHz. You can manually change the Info BW under the BW menu.

Figure 2-77

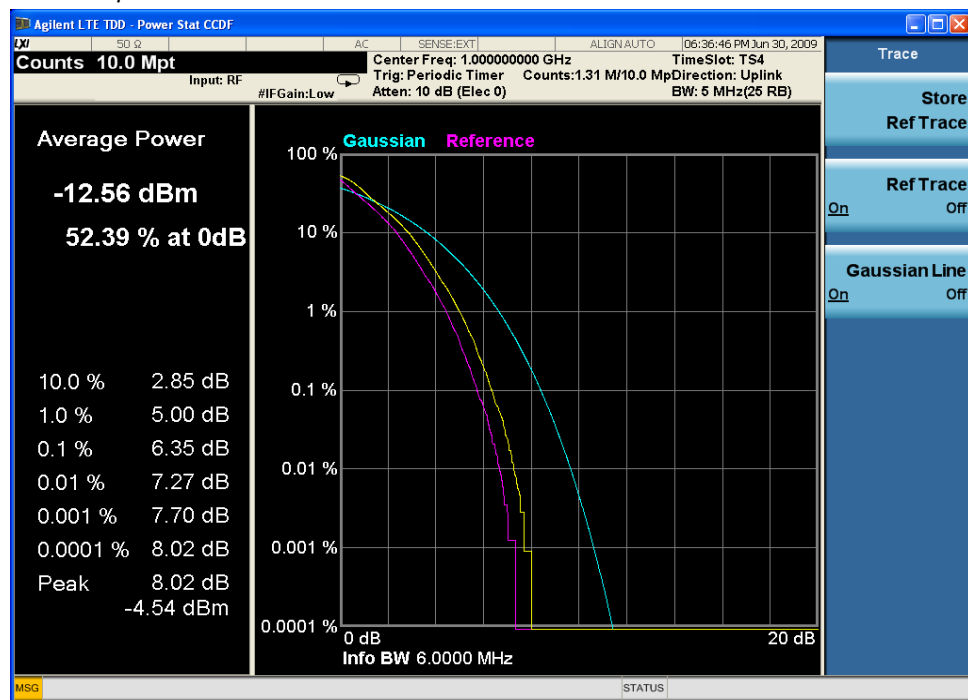
LTE TDD Uplink Power Statistics CCDF Measurement Result



Step	Action	Notes
3	Turn reference trace on. Press Trace/Detector, Ref Trace (On) to represent the user-definable reference trace (violet line).	The reference trace is the same as the measurement trace. You can use the Store Ref Trace key to copy the currently measured curve as the reference trace. It will not change until you store the reference trace again or choose the other mode. The CCDF measurement result with the reference trace should look like Figure 2-78 .

Figure 2-78

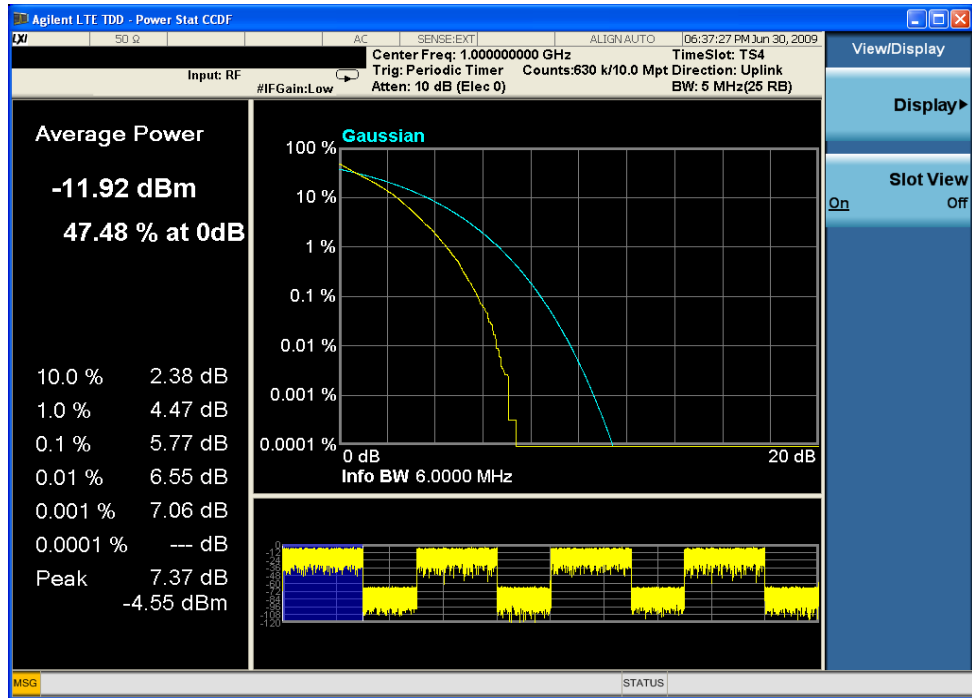
LTE TDD Uplink Power Statistics CCDF Result - Reference Trace On



4	Turn slot view on. Press View/Display, Slot View (On) to see the corresponding analysis slots (blue bars).	The CCDF measurement result with the slot view should look like Figure 2-79 .
---	--	---

Step	Action	Notes
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Figure 2-79 LTE TDD Uplink Power Statistics CCDF Result - Slot View



- | | |
|---|--|
| 5 Optimize the measurement for your signal level. | Press Meas Setup, IF Gain to optimize the measurement for your signal level. If you have a very high or low level signal, selecting Low Gain or High Gain can improve your accuracy. The default is Auto . |
|---|--|

If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Troubleshooting Hints

The power statistics CCDF measurement can assist in setting the signal power specifications for design criteria for systems, amplifiers, and other components. For example, it can help determine the optimum operating point to adjust each code timing for appropriate peak or average power ratio, or both, for the transmitter.

Modulation Analysis Measurements

This section explains how to make the Modulation Analysis measurement on a LTE TDD uplink signal. The LTE Modulation Analysis measurement allows you to measure LTE signals according to 3GPP TS 36.211.

Setting the Uplink Signal (Example)

Frequency: 1 GHz

Output Power: -10 dBm (at analyzer input)

Carrier: 1

Uplink Downlink Configuration: 0

Special Subframe Configuration: 0

Channel Configuration: QPSK

System Bandwidth: 5 MHz (25RB)

Antennas: 1

Cyclic Prefix: Normal

Transport Channel: UL-SCH = On, 0 dB, Channel Numbers 7-12

Physical Channel: PUCCH = On, 0 dB, 6 Channels, RB 1-2, ..., 11-12

PUSCH = On, 0 dB, 6 Channels, RB 13-14, ..., 23-24

Resource Block: Slot = 4-9, 14-19

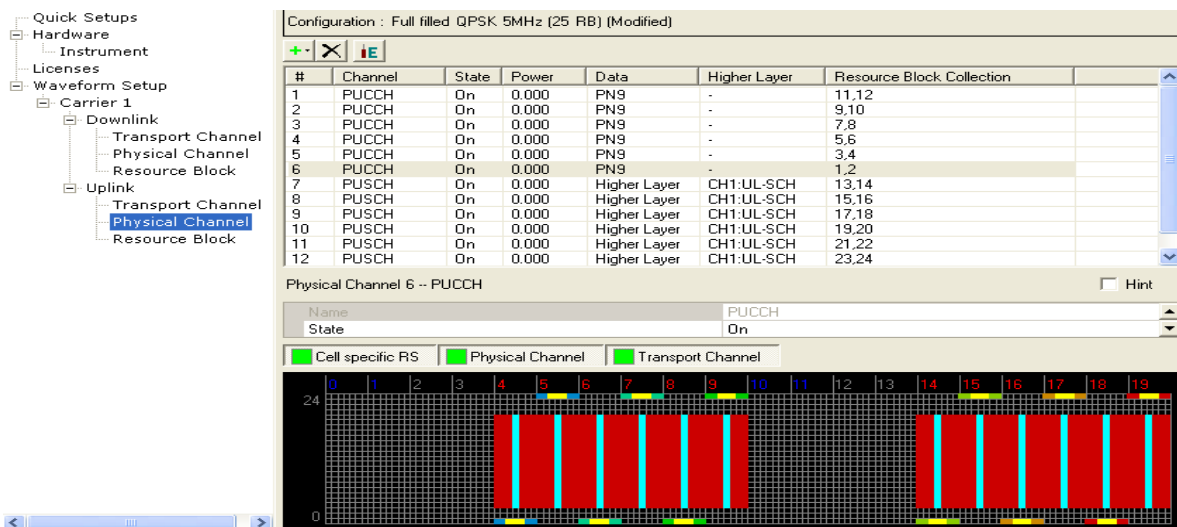
Power = 0 dB

PUSCH RB = 3-20

PUCCH RB = 0, 24

Figure 2-80

Signal Studio Mapping (Uplink Signal)



Measurement Procedure

Step	Action	Notes
1	Enable the LTE TDD measurements.	Press Mode, LTE TDD .
2	Preset the mode.	Press Mode Preset .
3	Set the center frequency.	Press FREQ Channel, 1, GHz .
4	Select the direction to downlink.	Press Mode Setup, Radio, Direction to be Uplink.
5	Select the system bandwidth.	Press Mode Setup, Demod, Bandwidth, B5M .
6	Set the Uplink and Downlink allocation configuration.	Press Mode Setup, Radio, ULDLAlloc, Configuration 0 (DSUUUDSUUU) .
7	Set the DwPTS/GP/UpPTS length configuration of the signal.	Press Mode Setup, Radio, DW/GP/Up Len, Configuration 0 . The settings under Mode Setup, Predefined Parameters are used for power measurements and do not apply to the Modulation Analysis measurement.
8	Initiate the Modulation Analysis measurement.	Press Meas, Modulation Analysis .
9	Set the RF Input power range.	Press AMPTD Y Scale, Range, 0, dBm . The range should be set equal to or bigger than the RF input power.

NOTE If you want to use the standard setup, Press **Mode Setup, Radio, Preset to Standard, 5 MHz (25 PRB)** to preset the measurement to a standard setup including many parameters such as BW, Analysis Start Boundary, Cell ID and so on. See [Table 2-10 on page 140](#) for a list of affected parameters. Or configure the parameters using the following steps

For analysis of no specific user, you can use demodulator auto-detect feature, the measurement provides a composite result of all Channels and Users, go to ["Set up User Mapping table - RB Auto Detect On."](#). If you want to analyze individual user, you need define the user mapping manually, go to ["Set up User Mapping table - RB Auto Detect Off."](#).

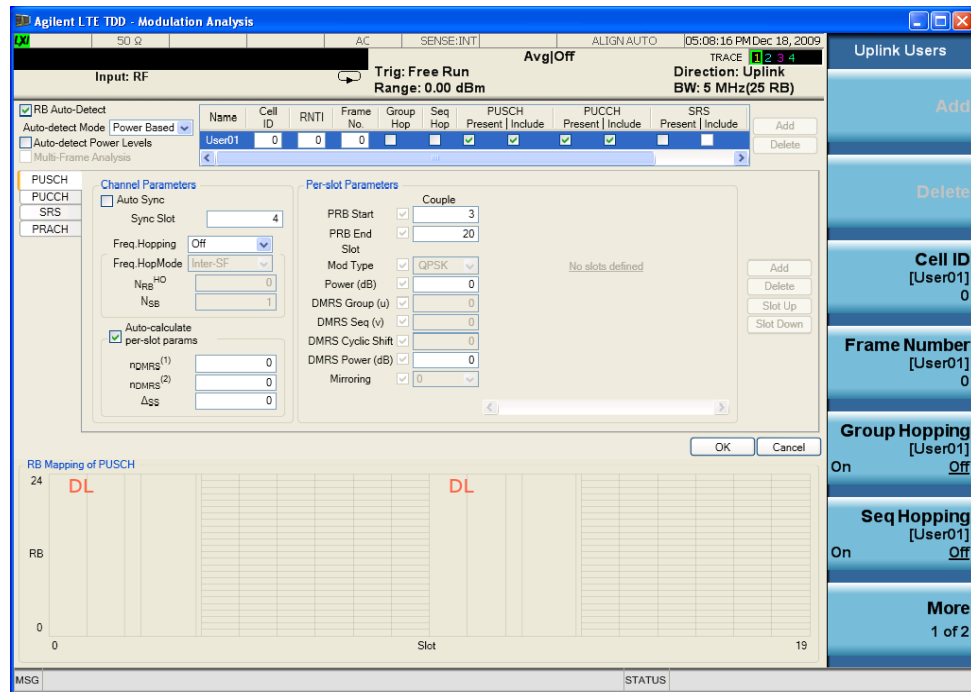
NOTE To perform the following procedure, it is easier using a mouse with USB connected to the instrument.

If the mouse is not available, you can use the Tab key repeatedly until the required table cell or check box is selected and the key menu appears, then enter the value from the front panel. Also press Enter to active the knob function, then you can move the focus quickly using knob. If you finish the setup, you can jump to OK, Cancel by pressing the Cancel (Esc) key in the front panel.

Step	Action	Notes
10 Set up User Mapping table - RB Auto Detect On.	<ol style="list-style-type: none"> Press Meas Setup, Chan Profile Setup, More, Edit User Mapping. Select RB Auto Detect and configure the parameters of User01. In this example Cell ID is 0, PUSCH and PUCCH are selected. Check Present in Signal and Include in Analysis for both PUSCH and PUCCH. Check Auto Sync. Also you can enter the sync slot manually, in this case it is 4. Check the Auto-calculate per-slot params checkbox and enter the nDMRS. 	<p>PUSCH and PUCCH are transmitted exclusively from one UE, however PUSCH, PUCCH and SRS can be analyzed at the same time. PRACH needs to be analyzed separately, if you select PRACH, the others PUSCH, PUCCH and SRS will be grayed out.</p> <p>When RB Auto-Detect is On, only one user (User01) can be included in the analysis. You can not add any other users.</p> <p>The Figure 2-81 on page 117 shows the configuration for User Mapping when RB Auto-Detect is On.</p>

Figure 2-81

LTE TDD Uplink Modulation Accuracy Edit User Mapping - Auto Detect On



Now you can see all the measurement result in "Select views and measurement result."

Step	Action	Notes
11 Set up User Mapping table - RB Auto Detect Off.	<ol style="list-style-type: none"> a. Press Meas Setup, Chan Profile Setup, More, Edit User Mapping. b. Deselect the RB Auto-Detect to turn RB auto detect off. c. Click Add to add a user, User01 is shown. d. Press Add to add the second user, User02 is shown. e. Click User01, User01 will be highlighted with blue, check Present in Signal for PUSCH then click PUSCH tab on the left, this will activate the Per-slot Parameters, setup the Sync Slot to Auto Sync or set it to be 4. The field “No slots defined” turns to blue, click Add besides “No subframes defined” directly or you can click “No subframes defined” and press Add menu key on the right of the screen to add the slot for User01. In this case, slot 4 is added. Enter PRB Start, PRB End. In this example, PRB Start = 3, PRB End = 20. Enter the value for Mod Type, Power, DMRS Power and Mirroring. The default value is used for these parameters. Repeat the step to add more slots. Be sure that Auto-calculate is checked. The User Mapping window for User01 is shown in Figure 2-82 on page 119. f. Click User02, User02 will be highlighted with blue, check Present in Signal for PUCCH, this will activate the Per-slot Parameters, setup the Sync Slot to Auto Sync or set it to be 4. The field “No subframes defined” turns to blue. Click PUCCH tab on the left, then click Add besides “No subframes defined” directly or you can click “No subframes defined” and press Add menu key on the right of the screen to add the slot for User02. In this case, slot 4 and slot 5 are added. Enter Format, Power and DMRS Power. The default value is used for these parameters. Repeat the step to add more slots. Be sure that Auto-calculate is checked. The User Mapping window for User02 is shown in Figure 2-86 on page 121. g. Click OK. 	

NOTE You can not Include in Analysis of PUCCH for User02. Because PUSCH for User01 is Include in Analysis. When RB Auto-Detect is Off, only one user can be included in the analysis at the same time.

Step Action Notes

Figure 2-82 LTE TDD Uplink Modulation Accuracy Edit User01 Mapping - Auto Detect Off

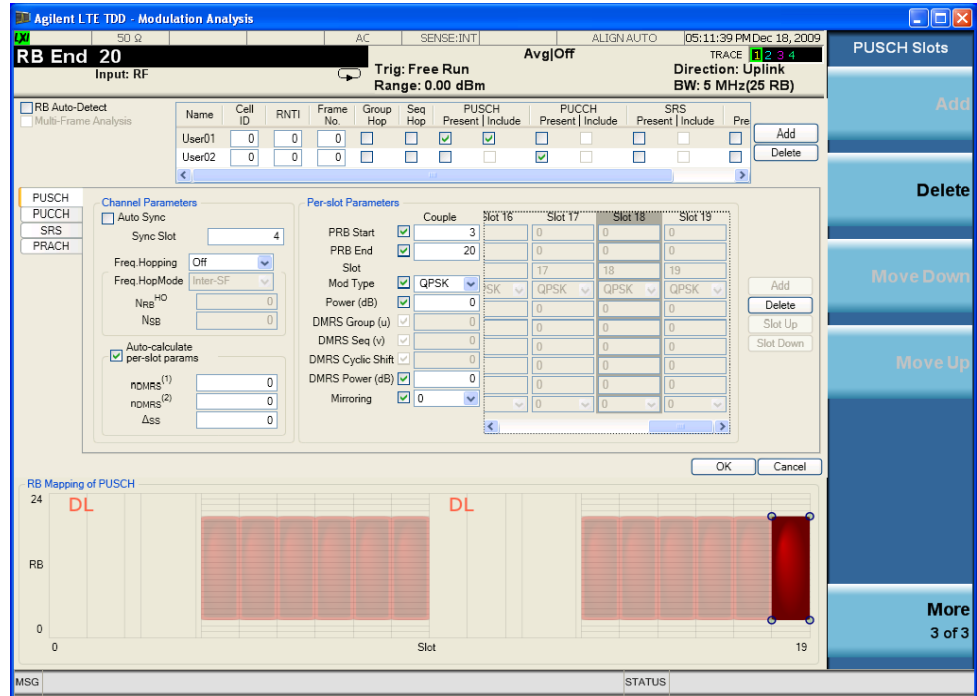
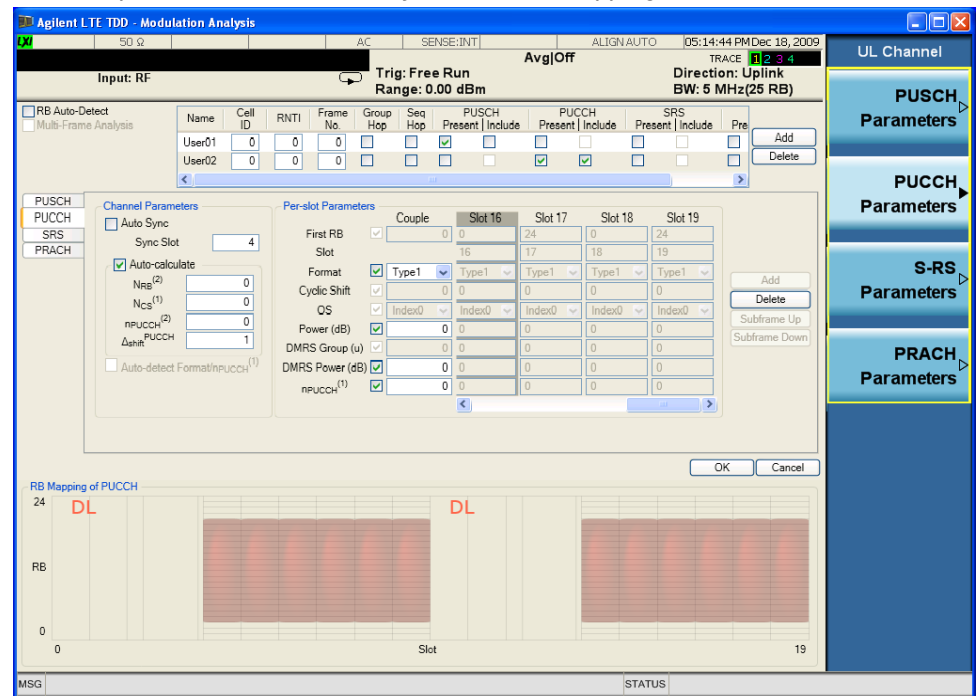


Figure 2-83 LTE TDD Uplink Modulation Accuracy Edit User02 Mapping - Auto Detect Off



The measurement result for User01 should look like Figure 2-84 on page 120 and the measurement result for User02 should look like Figure 2-85 on page 120.

Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

Step Action Notes

Figure 2-84 LTE TDD Uplink Modulation Accuracy - User01

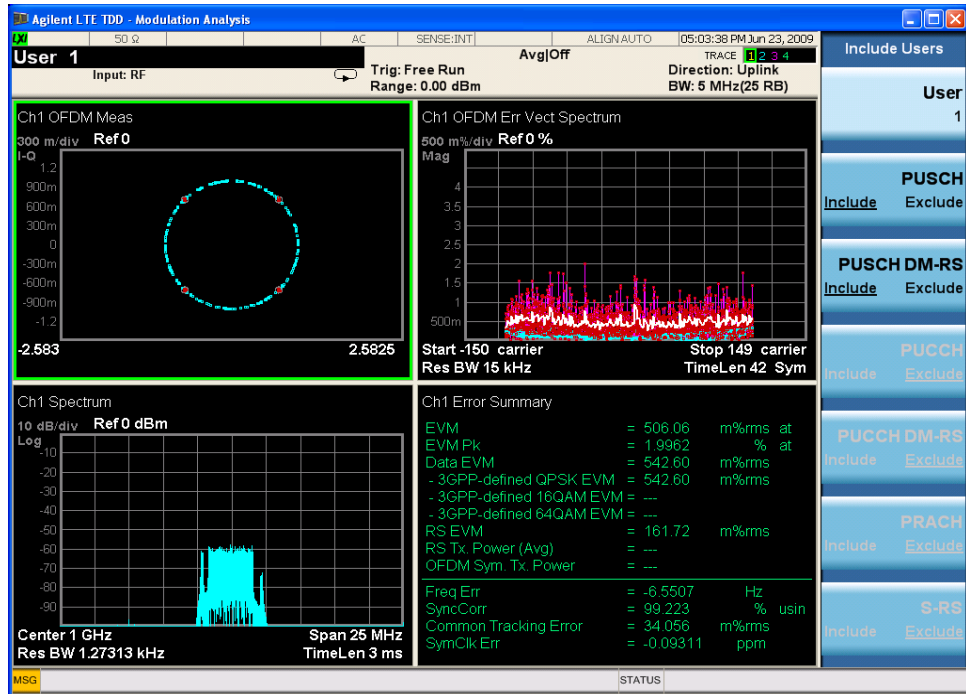
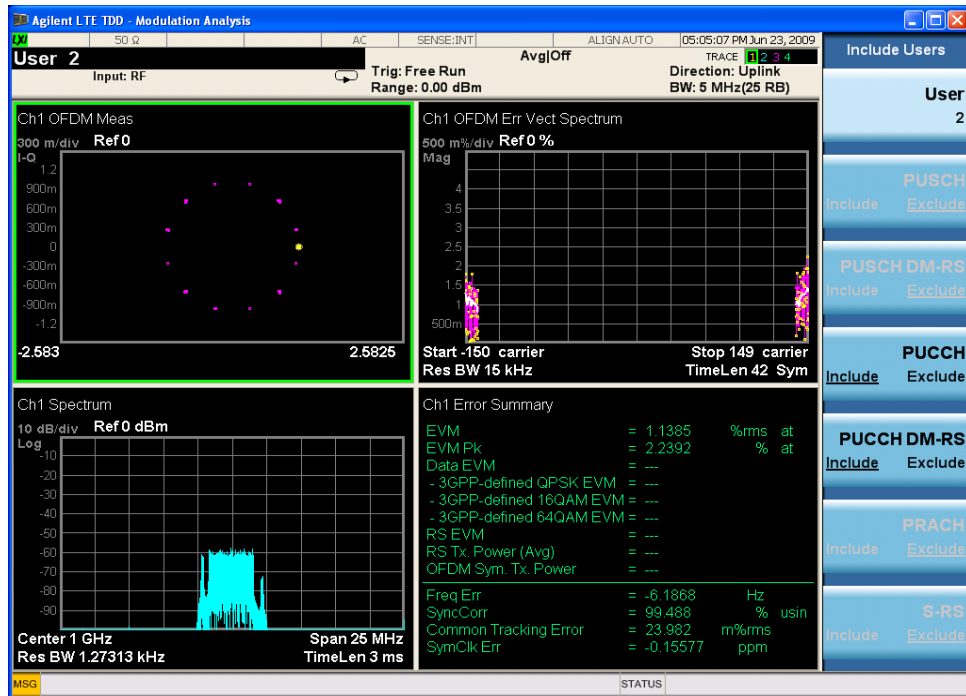


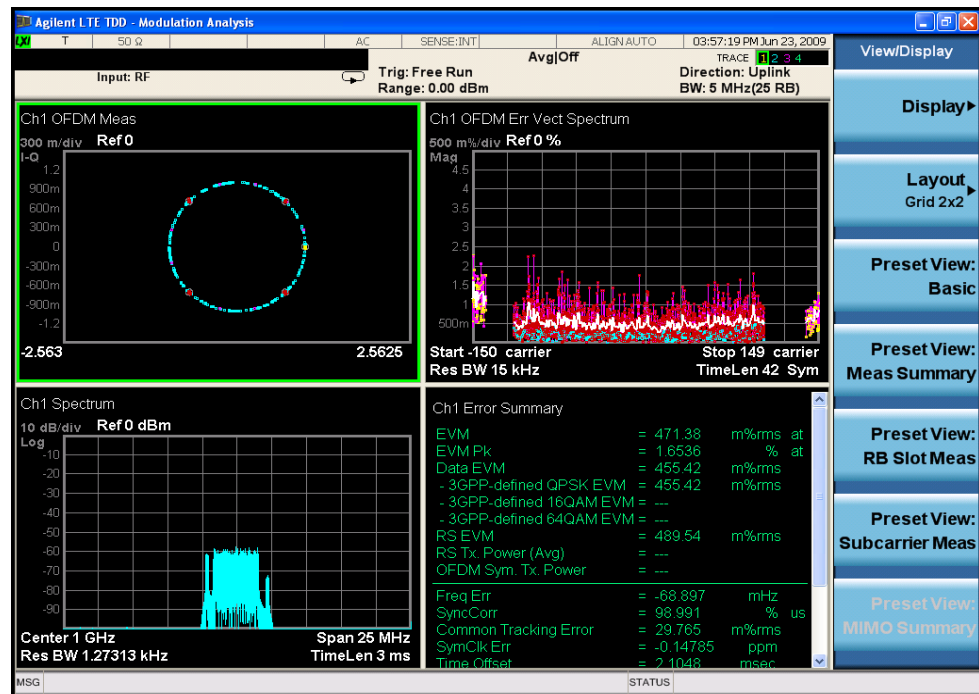
Figure 2-85 LTE TDD Uplink Modulation Accuracy - User02



Step	Action	Notes
12 Change other measurement parameters.	Press Meas Setup to see the keys that are available for Average Setup and Advanced settings to change measurement parameters from their default condition.	
13 Select views and measurement result.	Press View/Display to select different views, the following screen shots show the example of Preset View: Basic , Preset View: Meas Summary , Preset View: RB Slot Meas , Preset View: Subcarrier Meas and Preset View: MIMO Summary .	The preset view is a Grid 2x2 layout which consists of IQ Meas, Spectrum, Error Vector Spectrum and Error Summary

Figure 2-86

LTE TDD Uplink Modulation Accuracy Measurement Result (Preset View: Basic)



TIP You can select window control keys or double click the mouse to expand one of the 4 windows and look into more details for every measurement result. Pressing the window control keys again or double clicking the mouse again will take you back to 4 display windows. The following example shows the full Error Summary result.

Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

Step Action Notes

Figure 2-87 LTE TDD Uplink Modulation Accuracy Measurement Result (Error Summary)

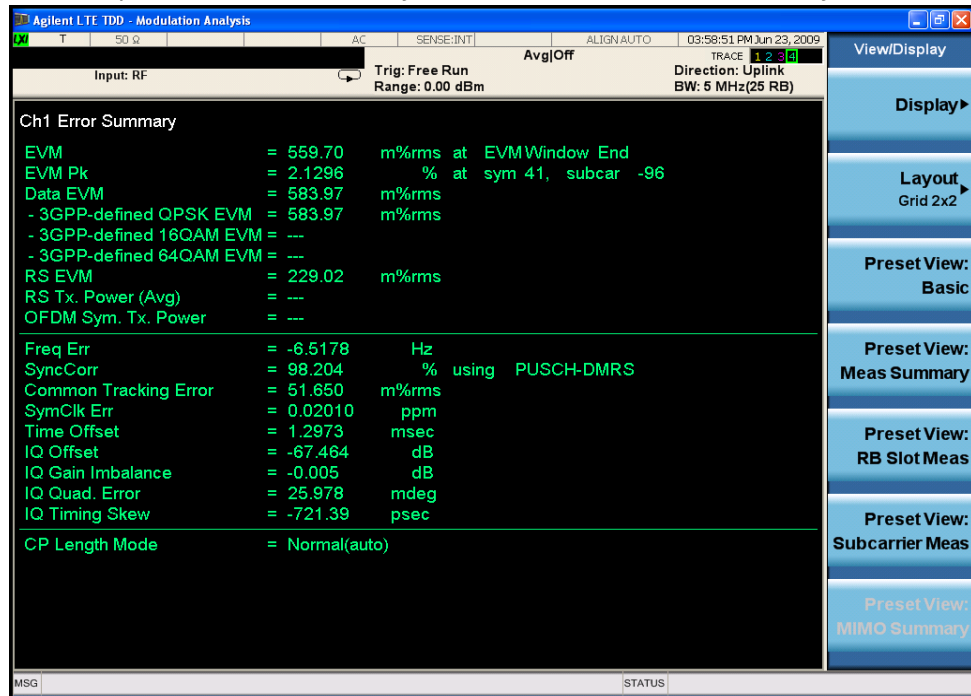
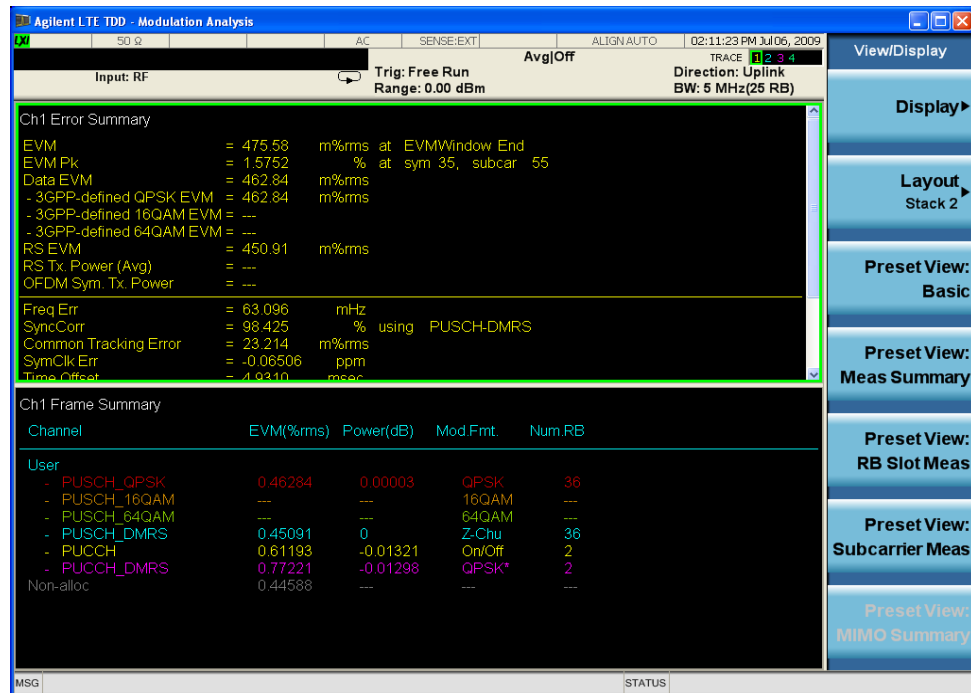


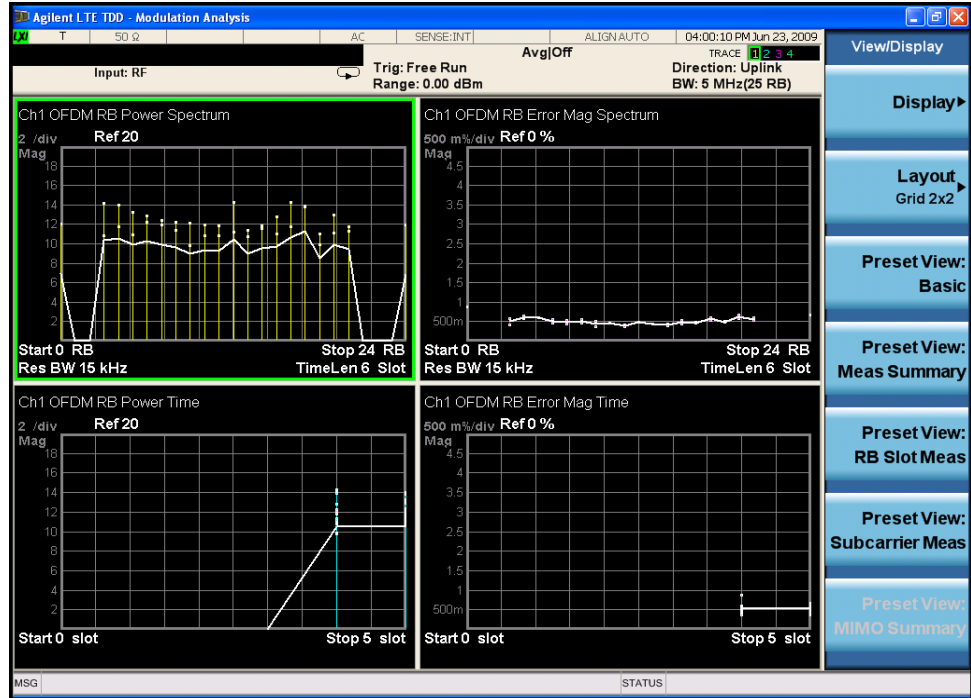
Figure 2-88 LTE TDD Uplink Modulation Accuracy Measurement Result (Preset View: Meas Summary)



Step	Action	Notes
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This preset view provides the Error Summary and Frame Summary which are the composite result metrics and characteristics of each of the logical channels.

Figure 2-89 LTE TDD Uplink Modulation Accuracy Measurement Result (Preset View: RB Slot Meas)



This preset view is a Grid 2x2 layout which provides details on the Resource Block with RB Power vs. Spectrum, RB Error Mag Spectrum, RB Power vs. Time and RB Error Mag Time.

Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

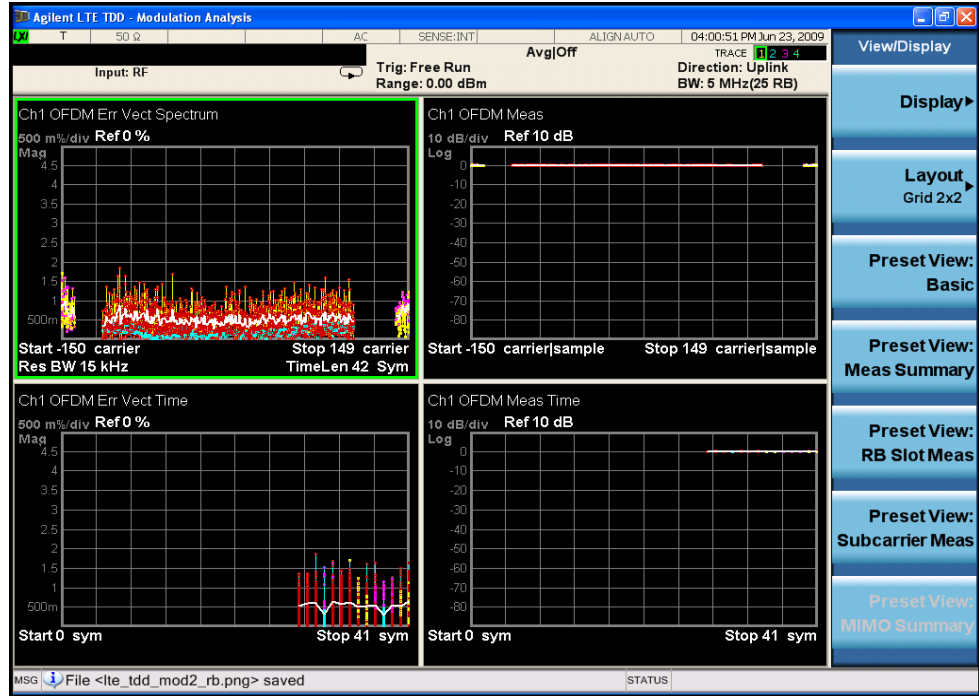
Step

Action

Notes

Figure 2-90

LTE TDD Uplink Modulation Accuracy Measurement Result (Preset View: Subcarrier Meas)



This preset view is a Grid 2x2 layout which includes Error Vector Spectrum, IQ Meas (Log Mag), Error Vector Time and IQ Meas Time (Log Mag).

TIP

Also you can customize the view to show available data in different windows. Press Trace/Detector, Select Trace, Trace 2 then press Data, Table, Frame Summary to customize the view. Figure 2-91 shows the Detected Allocations (Trace 2) and Frame Summary (Trace 3) together with the constellation. The colors used in these three windows are related.

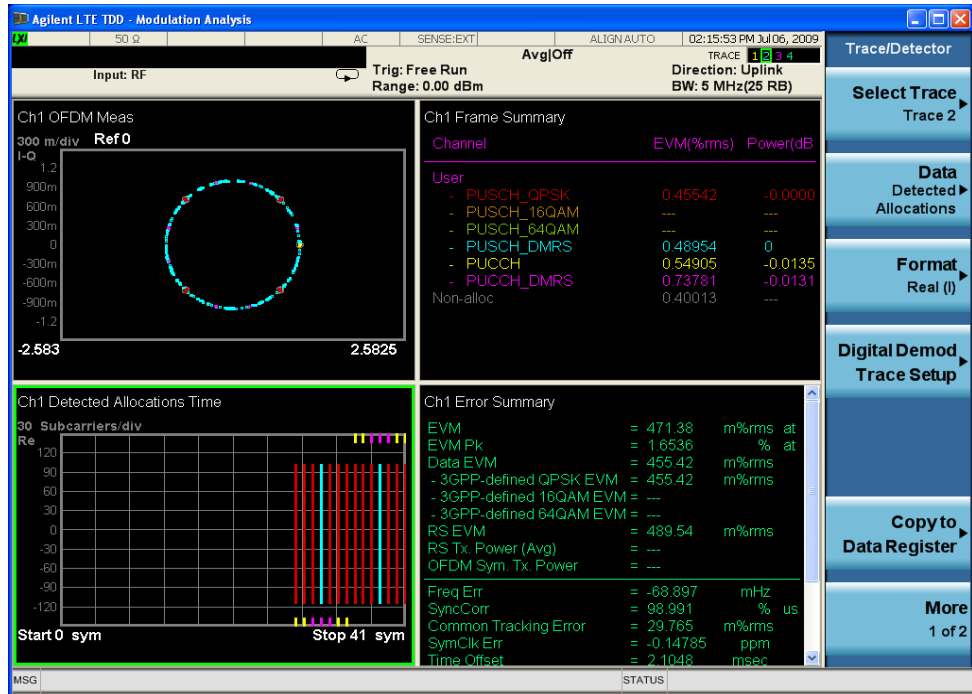
Step

Action

Notes

Figure 2-91

LTE TDD Uplink Modulation Accuracy Measurement Result (Customized View)



If you have a problem, and get an error message, see the guide “**Instrument Messages**”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

Conformance EVM Measurement

This section explains how to make the Conformance EVM measurement on a LTE TDD uplink signal. For detailed instruction about this measurement, see [“LTE TDD Conformance EVM Measurement Concepts” on page 220](#).

If you are using Fast Mode (only available on PXA with option B1X) for CEVM measurement, see [“Fast Mode Measurement” on page 129](#).

Setting the Uplink Signal (Example)

The same signal of Modulation Analysis measurement is used in this example. See [“Setting the Uplink Signal \(Example\)” on page 115](#).

Measurement Procedure

Step	Action	Notes
1 Enable the LTE TDD measurements.	Press Mode, LTE TDD .	
2 Preset the mode.	Press Mode Preset .	
3 Set the center frequency.	Press FREQ Channel, 1, GHz .	
4 Select the direction to downlink.	Press Mode Setup, Radio, Direction to be Uplink .	
5 Select the system bandwidth.	Press Mode Setup, Demod, Bandwidth, B5M .	
6 Set the Uplink and Downlink allocation configuration.	Press Mode Setup, Radio, ULDLAlloc, Configuration 0 (DSUUUDSUUU) .	
7 Set the DwPTS/GP/UpPTS length configuration of the signal.	Press Mode Setup, Radio, DW/GP/Up Len, Configuration 0 .	The settings under Mode Setup, Predefined Parameters are used for power measurements and do not apply to the Modulation Analysis measurement.
8 Initial Conformance EVM measurement.	Press Meas, Conformance EVM .	

Step	Action	Notes
9	Setup measurement parameters.	If you have already configure the setting in Modulation Analysis measurement as this example, you can simply use Copy from Modulation function to automatically apply the parameter values to Conformance EVM. Here we use Modulation Analysis measurement RB Auto-Detect case. Press Meas Setup, Copy from Mod Analysis .
10	Select views.	Press View/Display to select different views: Measurement List, Parameter List, Result Metrics and RF Envelope .

Figure 2-92

LTE TDD Uplink Conformance EVM Measurement Measurement List

The screenshot displays the 'Agilent LTE TDD - Conformance EVM' measurement list. At the top, it shows the center frequency as 1.000000000 GHz and the direction as Uplink. The measurement list table is as follows:

Measurement	Measurement Item
EVM Measurement	EVM
	EVM Sym Time Adjust
	EVM Pk
	EVM Pk Index
	EVM Peak Sub Car Index
	Data EVM
	3GPP-defined QPSK EVM
	3GPP-defined 16QAM EVM
	3GPP-defined 64QAM EVM
	RS EVM
	RS Tx Power
	OFDM Symbol Tx Power
	Freq Err
	Sync Correlation
	Sync Type
	Common Tracking Error
	Symbol Clock Error
	Time Offset
	IQ Offset
	IQ Gain Imbalance
	IQ Quad. Error
	IQ Timing Skew
	CP Length Mode
	Channel Power

Making LTE TDD Measurements
 LTE TDD Uplink Signal Measurement

Step Action Notes

Figure 2-93 LTE TDD Uplink Conformance EVM Parameter List

Name	SCPI	Value
Average Number	:CEVM:AVERage:COUNT	10
Average State	:CEVM:AVERage:STATE	Off
Average Mode	:CEVM:AVERage:TCOntrOl	Exp
Number of Ant Elements	:CEVM:DLINK:AENumber	2
Ant Element Spacing	:CEVM:DLINK:CAESpacing	0.500
DL DCI Format Dec Include	:CEVM:DLINK:DECode:DFINclUde	F1F1B
DL PDCCH RA-RNTI Range Max	:CEVM:DLINK:DECode:RNTI:MAXimum:RA	0
DL PDCCH TPC-RNTI Range Max	:CEVM:DLINK:DECode:RNTI:MAXimum:TPC	0
DL PDCCH RA-RNTI Range Min	:CEVM:DLINK:DECode:RNTI:MINimum:RA	0
DL PDCCH TPC-RNTI Range Min	:CEVM:DLINK:DECode:RNTI:MINimum:TPC	0
DL_PDSCH Cell Specific Ratio	:CEVM:DLINK:PDSch:CSRatio	R1
Downlink Add User	:CEVM:DLINK:PROFILE:ADD:USER	Immediate
DL RB Auto Det Mode	:CEVM:DLINK:PROFILE:AUTO:DETECT:MODE	POWER
DL RB Auto Det Power	:CEVM:DLINK:PROFILE:AUTO:DETECT:POWER	On
DL Power Boost Round	:CEVM:DLINK:PROFILE:AUTO:DETECT:POWER:ROUND	On
DL Auto_PDSCH Codebook Index	:CEVM:DLINK:PROFILE:AUTO:PDSch:CBINdex	0
DL Auto_PDSCH Precoding CDD	:CEVM:DLINK:PROFILE:AUTO:PDSch:CDD	WOCDd
DL Auto Number of Codewords	:CEVM:DLINK:PROFILE:AUTO:PDSch:NCODewords	1
DL Auto Number of Layers	:CEVM:DLINK:PROFILE:AUTO:PDSch:NLAYers	1
DL Auto_PDSCH Precoding	:CEVM:DLINK:PROFILE:AUTO:PDSch:PRECoding	OFF
CW1 16QAM Enable	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM16:CWONe:ENABle	On
CW1 16QAM Power Boost	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM16:CWONe:PWRBoost	0.000 dB
CW0 16QAM Enable	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM16:CWZero:ENABle	On
PDSCH 16QAM EPRE	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM16:EPRE	0.000 dB
CW0 16QAM Power Boost	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM16:PWRBoost	0.000 dB
CW1 64QAM Enable	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM64:CWONe:ENABle	On
CW0 64QAM Power Boost	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM64:CWONe:PWRBoost	0.000 dB
CW0 64QAM Enable	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM64:CWZero:ENABle	On
PDSCH 64QAM EPRE	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM64:EPRE	0.000 dB
CW0 64QAM Power Boost	:CEVM:DLINK:PROFILE:AUTO:PDSch:QAM64:PWRBoost	0.000 dB

NOTE The parameter name, related SCPI and value are listed in Parameter List view with tabular form. You can send the SCPI to change them or you can manually change them by selecting the parameter using knob or up and down arrows then enter the value using front panel keys.

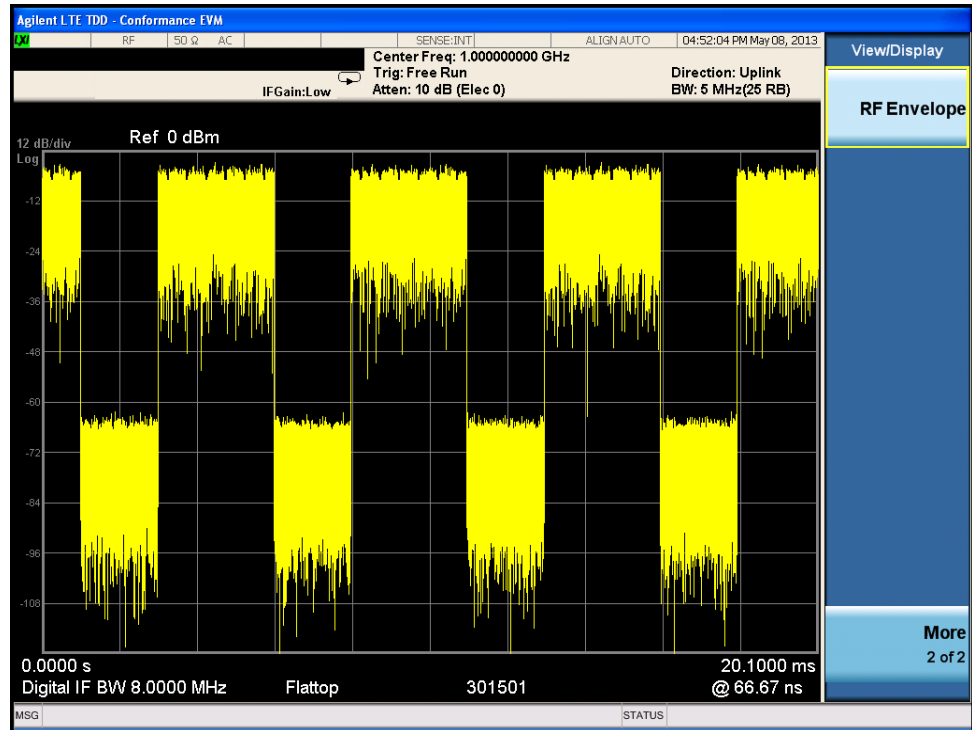
Figure 2-94 LTE TDD Uplink Conformance EVM Result Metrics

Measurement	Measurement Item	Result
EVM Measurement	EVM	689.01 m%rms
	EVM Sym Time Adjust	EVM Window End
	EVM Pk	3.1771 %pk
	EVM Pk Index	29
	EVM Peak Sub Car Index	129
	Data EVM	727.64 m%rms
	3GPP-defined QPSK EVM	727.64 m%rms
	3GPP-defined 16QAM EVM	---
	3GPP-defined 64QAM EVM	---
	RS EVM	382.61 m%rms
	RS Tx Power	---
	OFDM Symbol Tx Power	---
	Freq Err	43.767 Hz
	Sync Correlation	98.779 %
	Sync Type	PUSCH-DMRS
	Common Tracking Error	22.767 m%rms
	Symbol Clock Error	-0.06615 ppm
	Time Offset	3.6051 ms
	IQ Offset	-82.028 dB
	IQ Gain Imbalance	-0.004 dB
	IQ Quad. Error	-87.879 mdeg
	IQ Timing Skew	-671.91 ps
	CP Length Mode	Normal
	Channel Power	-10.45 dBm

Step	Action	Notes
------	--------	-------

Figure 2-95

LTE TDD Uplink Conformance EVM RF Envelop



Fast Mode Measurement

If N9030A with option B1X is used as the equipment, Fast Mode is provided for Conformance EVM Measurement to accelerate the measurement speed.

Example of Uplink Signal

20MHz BW and Full RB Allocation with QPSK

CellID = 0

nDMRS(1) = 0

nDMRS(2) = 0

DeltaSS=0

Meas Interval = 20 Slots

[“Example of Manual Measurement Procedure” on page 130](#)

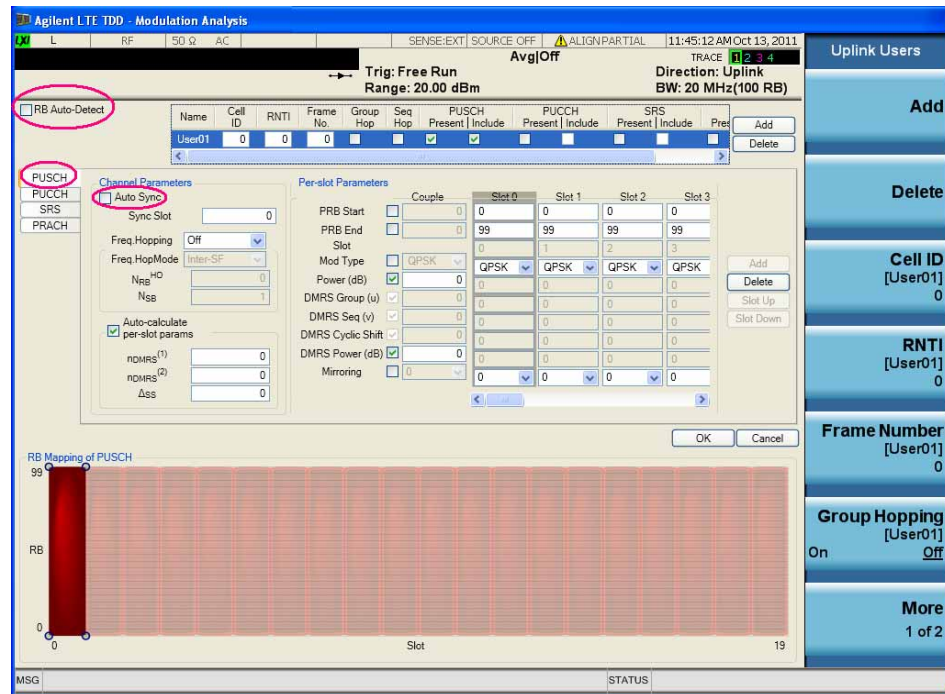
[“Example of SCPI commands Remote Test” on page 131](#)

Example of Manual Measurement Procedure

Step	Action	Notes
1	Set necessary parameters and configure the user mapping in Modulation Analysis Measurement.	Press Meas Setup, Chan Profile Setup, More, Edit User Mapping.

Figure 2-96

LTE TDD Uplink Signal User Mapping for Fast Mode Example



2	Initial Conformance EVM measurement.	Press Meas, Conformance EVM.
3	Copy the parameter settings from Modulation Analysis measurement to Conformance EVM measurement.	Press Meas Setup, Copy from Mod Analysis.
4	Select the Fast mode.	Press Meas Setup, Meas Method and select Fast.. N9030A with option B1X is required of Fast Mode. Save the state if necessary for later use of recalling.

Example of SCPI commands Remote Test

After doing "Mode Preset" and switching to CEVM Measurement, the setup is completed by executing following list of SCPI commands.

```
:RAD:STAN:DIR ULIN
:RAD:STAN:PRES B20M
:POW:EATT:STAT 0
:CEVM:TIME:INT:SLOT 20
:CEVM:ULIN:SYNC:CPL NORM
:CEVM:PROF:AUTO:DET 0
:CEVM:TIME:ASB FRAM
:CEVM:ULIN:PROF:ADD:USER
*OPC?
:CEVM:ULIN:PROF:USER:CID 0
:CEVM:ULIN:PROF:USER:PUSC:DMRS:ONE 0
:CEVM:ULIN:PROF:USER:PUSC:DMRS:TWO 0
:CEVM:ULIN:PROF:USER:PUSC:DSS 0
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 0
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 1
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 2
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 3
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 4
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 5
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 6
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 7
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 8
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 9
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 10
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 11
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 12
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 13
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 14
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 15
```

Making LTE TDD Measurements
LTE TDD Uplink Signal Measurement

:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 16
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 17
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 18
:CEVM:ULIN:PROF:USER:PUSC:ADD:SLOT 19
*OPC?
:CEVM:ULIN:PROF:USER:PUSC:DMRS:PAR 1
:CEVM:ULIN:PROF:USER:PUSC:RB:STAR:COUP 1
:CEVM:ULIN:PROF:USER:PUSC:RB:END:COUP 1
:CEVM:ULIN:PROF:USER:PUSC:MOD:TYPE:COUP 1
:CEVM:ULIN:PROF:USER:PUSC:RB:STAR 0
:CEVM:ULIN:PROF:USER:PUSC:RB:END 99
:CEVM:ULIN:PROF:USER:PUSC:MOD:TYPE QAM16
:CEVM:ULIN:PROF:USER:PUSC:SSL 0
:CEVM:ULIN:PROF:USER:PUSC:SSL:AUTO 0
:CEVM:ULIN:PROF:USER:PUSC:ACT ON
:CEVM:ULIN:PROF:USER:PUSC INCL
:CEVM:ULIN:PROF:USER:PUSC:DMRS INCL
:CEVM:EQU:TRA RSD
:CEVM:METH FAST

Preset to Standard Settings

The following tables summarizes the default value using Mode Setup, Preset to Standard for Power measurement.

Table 2-3 Channel Power Preset to Standard Value

Band width	IntegBW
1.4MHz	1.4MHz
3MHz	3MHz
5MHz	5MHz
10MHz	10MHz
15MHz	15MHz
20MHz	20MHz

RBW, VBW, SPAN and Sweep Time will be determined by IntegBW automatically.

Table 2-4 Occupied Bandwidth Preset to Standard Value

Band width	RBW	SPAN	Limit
1.4MHz	30KHz	20MHz	1.4MHz
3MHz	30KHz	20MHz	3MHz
5MHz	30KHz	20MHz	5MHz
10MHz	30KHz	20MHz	10MHz
15MHz	30KHz	20MHz	15MHz
20MHz	30KHz	25MHz	20MHz

Making LTE TDD Measurements
Preset to Standard Settings

VBW and Sweep Time will be determined automatically.

Table 2-5 ACP Preset to Standard Value (2-1)

Direction	Band width	Meas Noise BW	Carrier Spacing	Offset	Offset Freq	Offset IntegBW	RBW	VBW	Filter	
Downlink	1.4MHz	1.095MHz	1.4MHz	A	1.4MHz	1.095MHz	100kHz	Auto	None	
				B	2.8MHz	1.095MHz	100kHz	Auto	None	
	3MHz	2.715MHz	3MHz	A	3MHz	2.715MHz	100kHz	Auto	None	
				B	6MHz	2.715MHz	100kHz	Auto	None	
	5MHz	4.515MHz	5MHz	A	5MHz	4.515MHz	100kHz	Auto	None	
				B	10MHz	4.515MHz	100kHz	Auto	None	
	10MHz	9.015MHz	10MHz	A	10MHz	9.015MHz	100kHz	Auto	None	
				B	20MHz	9.015MHz	100kHz	Auto	None	
	15MHz	13.515MHz	15MHz	A	15MHz	13.515MHz	100kHz	Auto	None	
				B	30MHz	13.515MHz	100kHz	Auto	None	
	20MHz	18.015MHz	20MHz	A	20MHz	18.015MHz	100kHz	Auto	None	
				B	40MHz	18.015MHz	100kHz	Auto	None	
		Bandwidth	Meas Noise BW	Carrier Spacing	Offset	Offset Freq	Offset IntegBW	RBW	VBW	Filter

Table 2-5 ACP Preset to Standard Value (2-1)

Direction	Band width	Meas Noise BW	Carrier Spacing	Offset	Offset Freq	Offset IntegBW	RBW	VBW	Filter
Uplink	1.4MHz	1.08MHz	1.4MHz	A	1.4MHz	1.08MHz	100kHz	Auto	None
				B	2.8MHz	1.08MHz	100kHz	Auto	None
	3MHz	2.7MHz	3MHz	A	3MHz	2.7MHz	100kHz	Auto	None
				B	6MHz	2.7MHz	100kHz	Auto	None
	5MHz	4.5MHz	5MHz	A	5MHz	4.5MHz	100kHz	Auto	None
				B	10MHz	4.5MHz	100kHz	Auto	None
	10MHz	9MHz	10MHz	A	10MHz	9MHz	100kHz	Auto	None
				B	20MHz	9MHz	100kHz	Auto	None
	15MHz	13.5MHz	15MHz	A	15MHz	13.5MHz	100kHz	Auto	None
				B	30MHz	13.5MHz	100kHz	Auto	None
	20MHz	18MHz	20MHz	A	20MHz	18MHz	100kHz	Auto	None
				B	40MHz	18MHz	100kHz	Auto	None

Table 2-6 ACP Preset to Standard Value (2-2)

Direction	Band	Offset	Abs Limit	Rel Limit	Fail Mask
Downlink	1.4MHz	A	-14.61	0dB	AND
		B	-14.61	0dB	AND
	3MHz	A	-10.66	0dB	AND
		B	-10.66	0dB	AND
	5MHz	A	-8.45	0dB	AND
		B	-8.45	0dB	AND
	10MHz	A	-5.45	0dB	AND
		B	-5.45	0dB	AND
	15MHz	A	-3.69	0dB	AND
		B	-3.69	0dB	AND
	20MHz	A	-2.44	0dB	AND
		B	-2.44	0dB	AND

Making LTE TDD Measurements
Preset to Standard Settings

Table 2-6 ACP Preset to Standard Value (2-2)

Direction	Band	Offset	Abs Limit	Rel Limit	Fail Mask
	Band	Offset		Rel Limit	Fail Mask
Uplink	1.4MHz	A	-50.0	0dB	AND
		B	-50.0	0dB	AND
	3MHz	A	-50.0	0dB	AND
		B	-50.0	0dB	AND
	5MHz	A	-50.0	0dB	AND
		B	-50.0	0dB	AND
	10MHz	A	-50.0	0dB	AND
		B	-50.0	0dB	AND
	15MHz	A	-50.0	0dB	AND
		B	-50.0	0dB	AND
	20MHz	A	-50.0	0dB	AND
		B	-50.0	0dB	AND

Table 2-7 Spectrum Emission Mask Preset to Standard Value (2-1)

Band width	Direction	Integ BW	Span	Sweep Time	Res BW	Video BW	VBW/RBW
1.4MHz	Downlink	1095000	1.4MHz	Auto	Auto	Auto	Auto
3MHz	Downlink	2715000	3MHz	Auto	Auto	Auto	Auto
5MHz	Downlink	4515000	5MHz	Auto	Auto	Auto	Auto
10MHz	Downlink	9015000	10MHz	Auto	Auto	Auto	Auto
15MHz	Downlink	13515000	15MHz	Auto	Auto	Auto	Auto
20MHz	Downlink	18015000	20MHz	Auto	Auto	Auto	Auto
Band width	Direction	Integ BW	Span	Sweep Time	Res BW	Video BW	VBW/RBW
1.4MHz	Uplink	1080000	1.4MHz	Auto	Auto	Auto	Auto
3MHz	Uplink	2700000	3MHz	Auto	Auto	Auto	Auto
5MHz	Uplink	4500000	5MHz	Auto	Auto	Auto	Auto
10MHz	Uplink	9000000	10MHz	Auto	Auto	Auto	Auto

Table 2-7 *Spectrum Emission Mask Preset to Standard Value (2-1)*

15MHz	Uplink	13500000	15MHz	Auto	Auto	Auto	Auto
20MHz	Uplink	18000000	20MHz	Auto	Auto	Auto	Auto

Table 2-8 *Spectrum Emission Mask Preset to Standard Value (2-2)*

BW	Offset	Offset side	Offset Define	Start Freq	Stop Freq	RBW	VBW	VBW/RBW	Sweep	Limit ABS Start	Limit ABS Stop
Downlink											
1.4 MHz	A	Both	ETOC	0.05MHz	1.45MHz	51KHz	Auto	Man (0.01)	Auto	+0.5dBm	-9.5dBm
	B	Both	ETOC	1.45MHz	2.85MHz	100KHz	Auto	Man (0.01)	Auto	-9.5dBm	AUTO
	C	Both	ETOC	3.3MHz	15MHz	1MHz	Auto	Man (0.01)	Auto	-15dBm	AUTO
3MHz	A	Both	ETOC	0.05MHz	3.05MHz	51KHz	Auto	Man (0.01)	Auto	-3.5dBm	-13.5dBm
	B	Both	ETOC	3.05MHz	6.05MHz	100KHz	Auto	Man (0.01)	Auto	-13.5dBm	AUTO
	C	Both	ETOC	6.5MHz	15MHz	1MHz	Auto	Man (0.01)	Auto	-15dBm	-AUTO
5MHz	A	Both	ETOC	0.05MHz	5.05MHz	51KHz	Auto	Man (0.01)	Auto	-5.5dBm	-12.5dBm
	B	Both	ETOC	5.05MHz	10.05MHz	100KHz	Auto	Man (0.01)	Auto	-12.5dBm	AUTO
	C	Both	ETOC	10.5MHz	15MHz	1MHz	Auto	Man (0.01)	Auto	-15dBm	AUTO
10MHz	A	Both	ETOC	0.05MHz	5.05MHz	51KHz	Auto	Man (0.01)	Auto	-5.5dBm	-12.5dBm
	B	Both	ETOC	5.05MHz	10.05MHz	100KHz	Auto	Man (0.01)	Auto	-12.5dBm	AUTO
	C	Both	ETOC	10.5MHz	15MHz	1MHz	Auto	Man (0.01)	Auto	-15dBm	AUTO

Making LTE TDD Measurements
Preset to Standard Settings

Table 2-8 Spectrum Emission Mask Preset to Standard Value (2-2)

BW	Offset	Offset side	Offset Define	Start Freq	Stop Freq	RBW	VBW	VBW/RBW	Sweep	Limit ABS Start	Limit ABS Stop
15M Hz	A	Both	ETOC	0.05MHz	5.05MHz	51KHz	Auto	Man (0.01)	Auto	-5.5dBm	-12.5dBm
	B	Both	ETOC	5.05MHz	10.05MHz	100KHz	Auto	Man (0.01)	Auto	-12.5dBm	AUTO
	C	Both	ETOC	10.5MHz	15MHz	1MHz	Auto	Man (0.01)	Auto	-15dBm	AUTO
20M Hz	A	Both	ETOC	0.05MHz	5.05MHz	51KHz	Auto	Man (0.01)	Auto	-5.5dBm	-12.5dBm
	B	Both	ETOC	5.05MHz	10.05MHz	100KHz	Auto	Man (0.01)	Auto	-12.5dBm	-AUTO
	C	Both	ETOC	10.5MHz	15MHz	1MHz	Auto	Man (0.01)	Auto	-15dBm	AUTO
Uplink											
1.4 MHz	A	Both	ETOC	15.00 kHz	985.0 kHz	15KHz	Auto	Man (0.01)	Auto	-11.50 dBm	AUTO
	B	Both	ETOC	1.50 MHz	4.50 MHz	510KHz	Auto	Man (0.01)	Auto	-8.50 dBm	AUTO
	C	Both	ETOC	5.50 MHz	5.50MHz	1MHz	Auto	Man (0.01)	Auto	-23.50 dBm	AUTO
3MHz	A	Both	ETOC	15.00 kHz	985.0 kHz	15KHz	Auto	Man (0.01)	Auto	-8.50	AUTO
	B	Both	ETOC	1.50 MHz	2.00MHz	510KHz	Auto	Man (0.01)	Auto	-8.50dBm	AUTO
	C	Both	ETOC	3.00 MHz	3.00MHz	1MHz	Auto	Man (0.01)	Auto	-23.50dBm	AUTO
5MHz	A	Both	ETOC	15.00 kHz	985.0 kHz	15KHz	Auto	Man (0.01)	Auto	-13.50dBm	AUTO
	B	Both	ETOC	1.50 MHz	4.5MHz	510KHz	Auto	Man (0.01)	Auto	-8.5dBm	AUTO
	C	Both	ETOC	5.50MHz	5.50MHz	1MHz	Auto	Man (0.01)	Auto	-11.5dBm	AUTO
	D	Both	ETOC	6.5MHz	9.5MHz	1MHz	Auto	Man (0.01)	Auto	-23.50dBm	AUTO

Table 2-8 *Spectrum Emission Mask Preset to Standard Value (2-2)*

BW	Offset	Offset side	Offset Define	Start Freq	Stop Freq	RBW	VBW	VBW/RBW	Sweep	Limit ABS Start	Limit ABS Stop
10M Hz	A	Both	ETOC	15.00 kHz	985.0 kHz	15KHz	Auto	Man (0.01)	Auto	-16.5dBm	AUTO
	B	Both	ETOC	1.50 MHz	4.5MHz	510KHz	Auto	Man (0.01)	Auto	-8.5dBm	AUTO
	C	Both	ETOC	5.50 MHz	9.50MHz	1MHz	Auto	Man (0.01)	Auto	-11.50dBm	AUTO
	D	Both	ETOC	10.50MHz	14.5MHz	1MHz	Auto	Man (0.01)	Auto	-23.50dBm	AUTO
15M Hz	A	Both	ETOC	15.00 kHz	985.0 kHz	15KHz	Auto	Man (0.01)	Auto	-18.50dBm	AUTO
	B	Both	ETOC	1.50 MHz	4.5MHz	510KHz	Auto	Man (0.01)	Auto	-8.50dBm	AUTO
	C	Both	ETOC	5.50MHz	14.50MHz	1MHz	Auto	Man (0.01)	Auto	-11.50dBm	AUTO
	D	Both	ETOC	15.50MHz	19.5MHz	1MHz	Auto	Man (0.01)	Auto	-23.50dBm	AUTO
20M Hz	A	Both	ETOC	15.00 kHz	985.0 kHz	15KHz	Auto	Man (0.01)	Auto	-19.50dBm	AUTO
	B	Both	ETOC	1.50 MHz	4.5MHz	510KHz	Auto	Man (0.01)	Auto	-8.50dBm	AUTO
	C	Both	ETOC	5.50MHz	19.50MHz	1MHz	Auto	Man (0.01)	Auto	-11.50dBm	AUTO
	D	Both	Both	20.50MHz	24.50MHz	1MHz	Auto	Man (0.01)	Auto	-23.50dBm	AUTO

Table 2-9 *Power Stat CCDF Preset to Standard Value*

Band width	Info BW
1.4MHz	1.5MHz
3MHz	4MHz
5MHz	6MHz
10MHz	25MHz
15MHz	25MHz

Making LTE TDD Measurements
Preset to Standard Settings

Table 2-9 Power Stat CCDF Preset to Standard Value

Band width	Info BW
20MHz	25MHz

Table 2-10 Modulation Analysis Measurement Preset to Standard Value

Parameter	Preset Value
Band width	The selected standard band width
Analysis Start Boundary	Frame
Antenna Detection Threshold	-10 dB
Cell ID	Auto
Composite Include	All channels selected:
	Downlink channels: QPSK, QAM16, QAM64, P-SS, S-SS, PBCH, PCFICH, PHICH, PDCCH, RS
	Uplink channels: User_01 PUSCH, User_01 PUSCH DMRS
Control Chan Precoding	Off
CP Length	Auto
Equalizer Training	RS, Moving Avg Filter selected: 19 RS
EVM Window Length	3GPP
Extend Freq Lock Range	Cleared
Span	The frequency span is determined by the sample rate and FFT size, which are set according to the LTE standard for the specified band width.
Half Subcarrier Shift	Selected
IQ Offset Compensate	Cleared
Measurement Interval Slot	as many slots as possible up to 2 slots
Measurement Offset Slot	0 slots, 0 symbol-times
Include Non Allocation?	EXCLud
Number of Tx Antenna	1
Power Boost Normalize	Selected
PUSCH DFT Swap	Selected
Report EVM in dB	Cleared
Result Length	as many slots as possible up to 20 slots

Table 2-10 Modulation Analysis Measurement Preset to Standard Value

Parameter	Preset Value
RS-PRS	Custom
Shared Chan Precoding	Off
Symbol Timing Adjust	Max of EVM Window Start / Stop
Sync Type	Downlink: P-SS
Time Scale Factor	Uplink: PUSCH DM-RS
	1
Track Amplitude	Selected
Track Phase	Selected
Track Timing	Selected
Tx Diversity / MIMO	Control Chan Precoding: Off
	Shared Chan Precoding: Off
Downlink	
Detection	Selected
Include QPSK	Selected
Include 16QAM	Selected
Include 64QAM	Selected
PDSCH	
Power Boost (dB)	0
Uplink	
Detection	Selected
Cell ID	0
Group Hopping	Cleared
Seq Hopping	Cleared
Include PUSCH	Selected

Making LTE TDD Measurements
Preset to Standard Settings

Table 2-10 Modulation Analysis Measurement Preset to Standard Value

Parameter	Preset Value
Include PUCCH	Checkbox disabled (PUCCH not configured by default)
PUSCH	
Sync Slot	0
DMRS Parameters	Cleared
RB Start	0
RB End	0
Mod Type	QPSK
Power (dB)	0
DMRS Group (u)	0
DMRS Seq (v)	0
DMRS Cyclic Shift	0
DMRS Power (dB)	0
PUCCH	
Sync Slot	0
First RB	0
Cyclic Shift	0
Format	Type 2
OS	Index0
Power (dB)	0
DMRS Group (u)	0
DMRS Power (dB)	0
LTE Downlink Control Channel Properties (Edit Control Params...) defaults	
Parameter	Preset Value
P-SS Power Boost	0.65 dB

Table 2-10 Modulation Analysis Measurement Preset to Standard Value

Parameter	Preset Value
S-SS Power Boost	0.65 dB
PBCH Power Boost	0 dB
PCFICH Power Boost	0 dB
RS Power Boost	2.5 dB
PDCCH Power Boost	0 dB
PDCCH Allocations	3 per subframe for all subframes
PDCCH Allocation Constant	Selected
PHICH Power Boost	0 dB
Despread IQ Orthogonal Sequence Index	Cleared
PHICH Allocation	Ng 1
PHICH Duration	Normal

Making LTE TDD Measurements
Preset to Standard Settings

3 Using Option BBA Baseband I/Q Inputs

Baseband I/Q Measurements Available for X-Series Signal Analyzers

The following table shows the measurements that can be made using Baseband I/Q inputs:

Table 3-1 BBIQ Supported Measurements vs. Mode

Mode	Measurements
GSM	IQ Waveform GMSK Phase & Freq EDGE EVM
802.16 OFDMA	IQ Waveform Power Stat CCDF Modulation Analysis
TD-SCDMA	IQ Waveform Power Stat CCDF Code Domain Mod Accuracy
cdma2000®	IQ Waveform Power Stat CCDF Code Domain Mod Accuracy QPSK EVM
W-CDMA	IQ Waveform Power Stat CCDF Code Domain Mod Accuracy QPSK EVM
1xEV-DO	IQ Waveform Power Stat CCDF Forward Link Code Domain Reverse Link Code Domain Forward Link Mod Accuracy Reverse Link Mod Accuracy QPSK EVM
LTE	IQ Waveform Power Stat CCDF
LTE TDD	IQ Waveform Power Stat CCDF
DTMB	IQ Waveform Power Stat CCDF Mod Accuracy

Table 3-1

BBIQ Supported Measurements vs. Mode

Mode	Measurements
DVB-T/H	IQ Waveform Power Stat CCDF Mod Accuracy
ISDB-T	IQ Waveform Power Stat CCDF Mod Accuracy
CMMB	IQ Waveform Power Stat CCDF Mod Accuracy
IQ Analyzer (Basic)	IQ Waveform Complex Spectrum

Baseband I/Q Measurement Overview

The Baseband I/Q functionality is a hardware option, Option BBA. If the option is not installed in the instrument, the I/Q functionality cannot be enabled.

The Baseband I/Q option provides four input ports and one Calibration Output port. The input ports are I, I-bar, Q, and Q-bar. The I and I-bar together compose the I channel and the Q and Q-bar together compose the Q channel. Each channel has two modes of operation:

Single Ended

(unbalanced)

In this mode, only the main port (I or Q) is used and the complementary ports (I-bar or Q-bar) are ignored. The I and Q ports are in single-ended mode when Differential “Off” is selected.

Differential

(balanced)

In this mode, both main and complementary ports are used. To activate this mode, select Differential “On” from the I and Q Setup softkey menus.

The system supports a variety of input passive probes as well as the Keysight 1153A active differential probe using the Infinimax probe interface.

NOTE

To avoid duplication, this section describes only the details unique to using the baseband I/Q inputs. For generic measurement details, refer to the previous [“Making LTE TDD Measurements” on page 11](#).

To make measurements using baseband I/Q Inputs, make the following selections:

- Step 1.** Select a measurement that supports baseband I/Q inputs.
- Step 2.** Select the I/Q Path.
Press **Input/Output, I/Q, I/Q Path**. Select from the choices present on the screen. The path selected is shown at the top of the measurement screen.
- Step 3.** Select the appropriate circuit location and probe(s) for measurements. For details see [“Selecting Input Probes for Baseband Measurements” on page 229](#) in the Concepts chapter.
- Step 4.** Select baseband I/Q input connectors.
- Step 5.** If you have set the I/Q Path to **I+jQ** or to **I Only**, press **I Setup**.
 - A. Select whether **Differential (Balanced)** input is **On** or **Off**.
 - B. Select the input impedance, **Input Z**.
 - C. Input a **Skew** value in seconds.
 - D. Set up the I Probe by pressing **I Probe**.
 - a. Select probe **Attenuation**.

- b. Calibrate the probe. Press **Calibrate...** to start the calibration procedure. Follow the calibration procedure, clicking **Next** at the end of each step.

Step 6. If you have set the I/Q Path to **I+jQ** or to **Q Only**, press **Q Setup**.

- A. Select whether **Differential (Balanced)** input is **On** or **Off**.
- B. Select the input impedance, **Input Z**.
- C. Input a **Skew** value in seconds.
- D. Set up the I Probe by pressing **I Probe**.
 - a. Select probe **Attenuation**.
 - b. Calibrate the probe. Press **Calibrate...** to start the calibration procedure. Follow the calibration procedure, clicking **Next** at the end of each step.

Step 7. Select the reference impedance by pressing **Reference Z**, and inputting a value from one ohm to one megohm. The impedance selected is shown at the top of the measurement screen.

Step 8. If you are using cables that were not calibrated in the probe calibration step, press **I/Q Cable Calibrate...** Follow the calibration procedure, clicking **Next** at the end of each step.

Step 9. After completing the baseband IQ setup procedures, make your desired measurement.

Using Option BBA Baseband I/Q Inputs
Baseband I/Q Measurement Overview

4 Concepts

This chapter presents an overview of the 3GPP LTE communications system including both LTE FDD and TDD. It also details how various measurements are performed by the instrument. A list of acronyms and a list of reference documents for further investigation is provided.

LTE Technical Overview

This section describes the Long Term Evolution (LTE) of the universal mobile telecommunication system (UMTS), which is being developed by the 3rd Generation Partnership Project (3GPP). Details include LTE's use of multiple antenna techniques and to a new modulation scheme called single carrier frequency division multiple access (SC-FDMA) used in the LTE uplink.

There are two types of frame structure in the LTE standard, Type 1 and Type 2. LTE Type 1 uses Frequency Division Duplexing (uplink and downlink separated by frequency), and LTE Type 2 uses Time Division Duplexing (uplink and downlink separated in time). This overview covers both LTE Type 1 FDD signals and LTE Type 2 TDD signals described in the March 2009 release of the standard.

LTE is designed to provide the following features:

- Increased downlink and uplink peak data rates, as shown in [Table 4-1](#) and [Table 4-2](#). Note that the downlink is specified for single input single output (SISO) and multiple input multiple output (MIMO) antenna configurations at a fixed 64QAM modulation depth, whereas the uplink is specified only for SISO but at different modulation depths. These figures represent the physical limitation of the FDD and TDD air interface and in ideal radio conditions with allowance for signaling overheads.
- Scalable bandwidth from 1.4, 3.0, 5, 10, 15, 20 MHz in both the uplink and the downlink
- Spectral efficiency, with improvements for high speed packet access (HSPA)
- Sub-5 ms latency for small internet protocol (IP) packets
- Optimized performance for low mobile speeds from 0 to 15 km/h; supported with high performance from 15 to 120 km/h; functional from 120 to 350 km/h. Support for 350 to 500 km/h is under consideration
- Co-existence with legacy standards while evolving toward an all-IP network.

Table 4-1 LTE FDD Downlink Peak Data Rates (64QAM)

Antenna configuration	SISO	2x2 MIMO	4x4 MIMO
Peak Data Rate Mbps	100	172.8	326.4

Table 4-2 LTE FDD Uplink Peak Data Rates (Single Antenna)

Modulation Depth	QPSK	16QAM	64QAM
Peak Data Rate Mbps	50	57.6	86.4

LTE Specification Documents

Release 7 of the 3GPP specifications included the study phase of LTE. As a result of this study, requirements were published in TR 25.913 for LTE in terms of objectives, capability, system performance, deployment, E-UTRAN architecture and migration, radio resource management, complexity, cost, and service.

E-UTRA, E-UTRAN, and the EPC are defined in the 36-series of 3GPP Release 8:

- 36.100 series, covering radio specifications and evolved Node B (eNB)
- 36.200 series, covering layer 1 (physical layer) specifications
- 36.300 series, covering layer 2 and 3 (air interface signaling) specifications
- 36.400 series, covering network signaling specifications
- 36.500 series, covering user equipment conformance testing
- 36.800 and 36.900 series, which are technical reports containing background information

The latest version of the 36-series documents can be found at http://www.3gpp.org/ftp/specs/archive/36_series/.

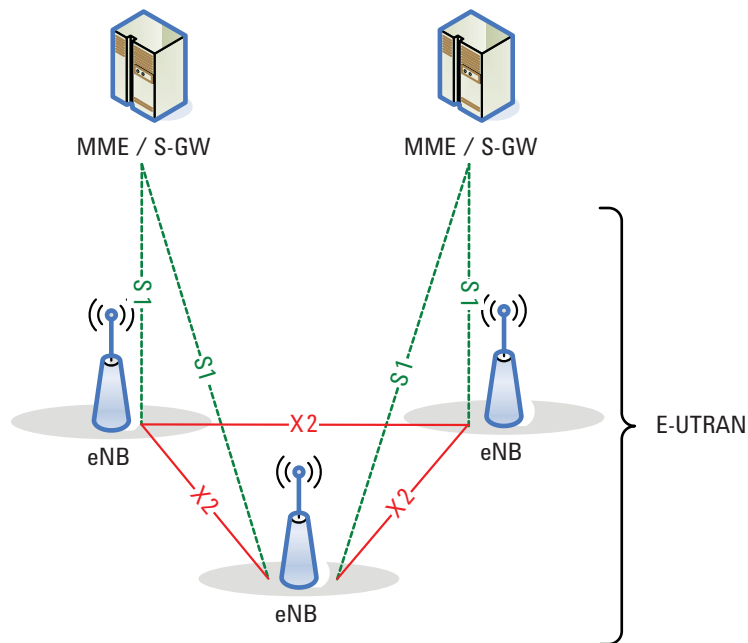
LTE Network Architecture

LTE employs a new network architecture made up of multiple Evolved Packet Cores (EPCs) that communicate with each other and with evolved universal terrestrial radio access network base stations (eNBs), see [Figure 4-1](#). Each EPC contains a Mobile Management Entity (MME) and a System Architecture Evolution Gateway (SAE) comprised of Gateway elements (S-GW). The eNB stations communicate with the EPCs, with each other, and with user equipment (UE).

A new interface called X2 connects the eNBs, enabling direct communication between the elements and eliminating the need to funnel data back and forth through the radio network controller (RNC).

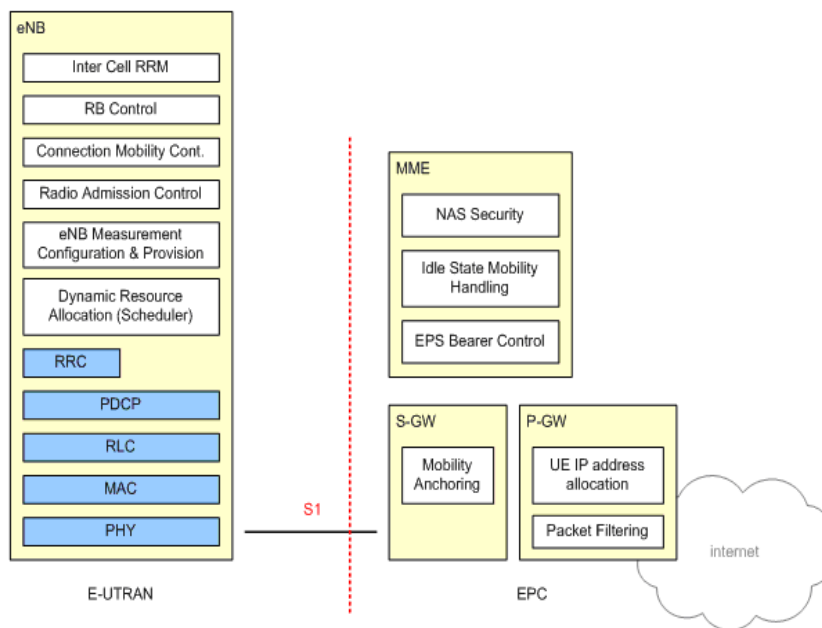
The E-UTRAN is connected to the EPC through the S1 interface, which connects the eNBs to the mobility management entity (MME) and serving gateway (S-GW) elements through a “many-to-many” relationship.

Figure 4-1 LTE architecture with E-UTRAN (TS 36.300 V8.8.0 Figure 4-1)



One of the simplifications of this architecture is to push more signaling down to the eNBs by splitting the user plane and mobility management entities. This functional split is depicted in Figure 4-2.

Figure 4-2 Functional split between E-UTRAN and EPC (TS 36.300 V8.8.0 Figure 4.1-1)



The eNB now hosts these functions:

- Radio resource management
- IP header compression and encryption

- Selection of MME at UE attachment
- Routing of user plane data towards S-GW
- Scheduling and transmission of paging messages, ETWS messages and broadcast information
- Mobility measurement and reporting configuration

The MME functions include:

- Distribution of paging messages to eNBs
- Security control
- Idle state mobility control
- SAE bearer control
- Ciphering and integrity protection of non-access stratum (NAS) signaling

The S-GW hosts these functions:

- Termination of user-plane packets for paging reasons
- Switching of user plane for UE mobility

The P-GW hosts these functions:

- Packet filtering
- UE IP address allocation

The radio protocol architecture of E-UTRAN is specified for the user plane and the control plane. The user plane comprises the packet data convergence protocol (PDCP), radio link control (RLC), medium access control (MAC), and physical layer (PHY); the control plane performs the radio resource control (RRC). Both the user plane and control plane are terminated in the eNB. A detailed description of the radio protocol architecture is beyond the scope of this document, however, more information is available in TS 36.300 and other documents in the 36.300 series.

Multiple Access Technology in the Downlink: OFDM and OFDMA

Downlink and uplink transmission in LTE are based on the use of multiple access technologies: specifically, orthogonal frequency division multiple access (OFDMA) for the downlink, and single-carrier frequency division multiple access (SC-FDMA) for the uplink.

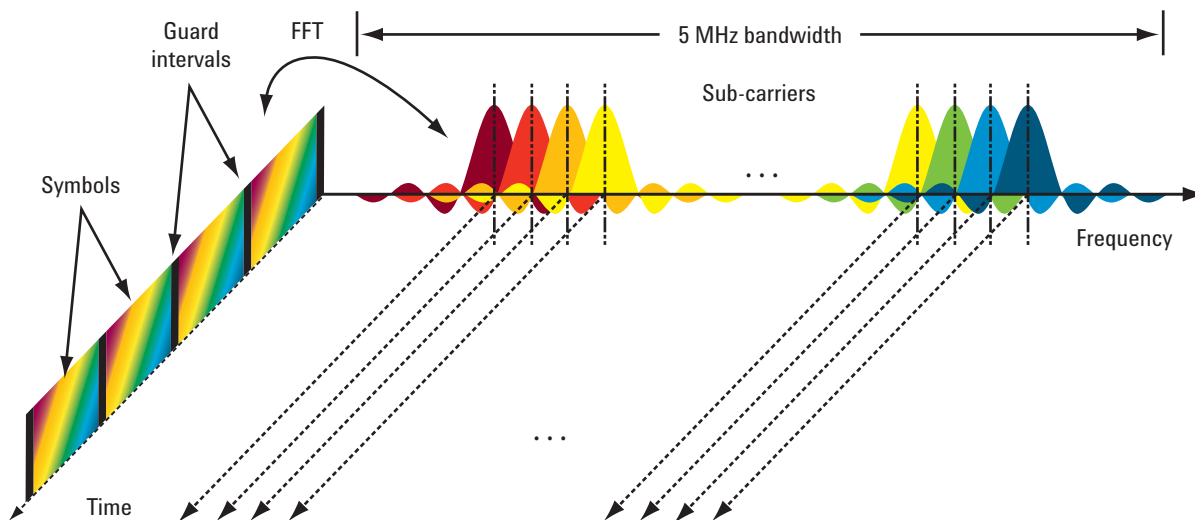
OFDM vs. CDMA

The LTE downlink is transmitted using OFDMA, a variant of orthogonal frequency division multiplexing (OFDM), a digital multi-carrier modulation scheme that is widely used in wireless systems but relatively new to cellular. Rather than transmit a high-rate stream of data with a single carrier, OFDM makes use of a large number of closely spaced orthogonal subcarriers that are transmitted in parallel.

Each subcarrier is modulated with a conventional modulation scheme (such as QPSK, 16QAM, or 64QAM) at a low symbol rate. The combination of hundreds or thousands of subcarriers enables data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

The diagram in [Figure 4-3](#) taken from TS 36.8929 illustrates the key features of an OFDM signal in frequency and time. In the frequency domain, multiple adjacent tones or subcarriers are each independently modulated with data. Then in the time domain, guard intervals are inserted between each of the symbols to prevent inter-symbol interference at the receiver caused by multi-path delay spread in the radio channel.

Figure 4-3 OFDM Signal Represented in Frequency and Time



Although OFDM has been used for many years in communication systems, its use in mobile devices is more recent. The European Telecommunications Standards Institute (ETSI) first looked at OFDM for GSM back in the late 1980s; however, the processing power required to perform the many FFT operations at the heart of OFDM was at that time too expensive and demanding for a mobile application. In 1998, 3GPP seriously considered OFDM for UMTS, but again chose an alternative technology based on code division multiple access (CDMA). Today the cost of digital signal processing has been greatly reduced and OFDM is now considered a commercially viable method of wireless transmission for the handset.

When compared to the CDMA technology upon which UMTS is based, OFDM offers a number of distinct advantages:

- OFDM can easily be scaled up to wide channels that are more resistant to fading.
- OFDM channel equalizers are much simpler to implement than are CDMA equalizers, as the OFDM signal is represented in the frequency domain rather than the time domain.
- OFDM can be made completely resistant to multi-path delay spread. This is possible because the long symbols used for OFDM can be separated by a guard interval known as the cyclic prefix (CP). The CP is a copy of the end of a symbol inserted at the beginning. By sampling the received signal at the optimum time, the receiver can remove the time domain interference between adjacent symbols caused by multi-path delay spread in the radio channel.

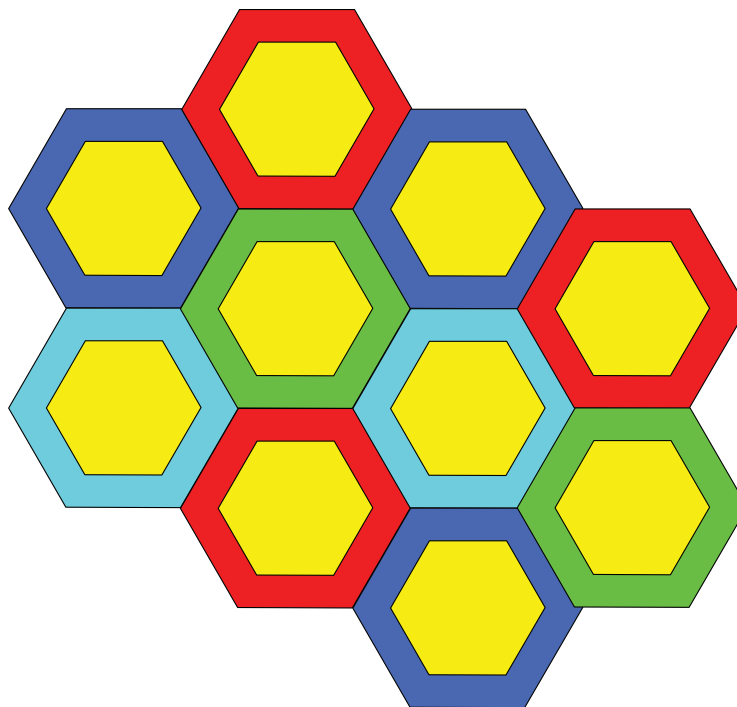
- OFDM is better suited to MIMO. The frequency domain representation of the signal enables easy pre-coding to match the signal to the frequency and phase characteristics of the multi-path radio channel.

However, OFDM does have some disadvantages. The subcarriers are closely spaced making OFDM sensitive to frequency errors and phase noise. For the same reason, OFDM is also sensitive to Doppler shift, which causes interference between the subcarriers. Pure OFDM also creates high peak-to-average signals, and that is why a modification of the technology called SC-FDMA is used in the uplink. SC-FDMA is discussed later.

OFDM is more difficult to operate than CDMA at the edge of cells. CDMA uses scrambling codes to provide protection from inter-cell interference at the cell edge whereas OFDM has no such feature. Therefore, some form of frequency planning at the cell edges is required. Figure 4-4 gives one example of how this might be done. The color yellow represents the entire channel bandwidth and the other colors show a plan for frequency re-use to avoid inter-cell interference at the cell edges.

Figure 4-4

Example of Frequency Planning to Avoid Inter-Cell Interference at the Cell Edges



The main differences between CDMA and OFDM are shown in Table 4-3.

Table 4-3

Comparison of CDMA and OFDM

Attribute	CDMA	OFDM
Transmission Band width	Full system band width	Variable up to full system band width

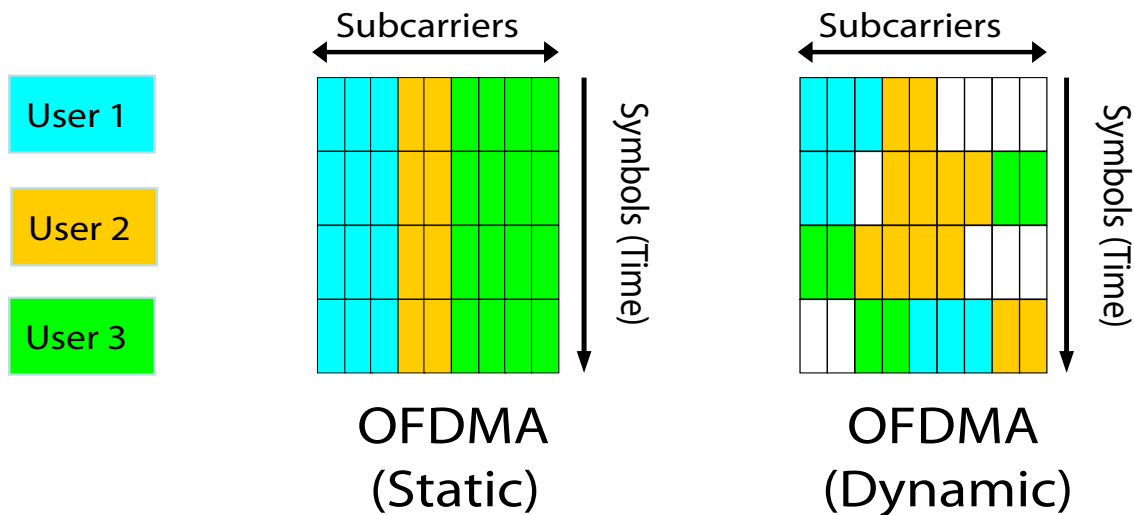
Table 4-3 Comparison of CDMA and OFDM

Attribute	CDMA	OFDM
Symbol period	Very short – inverse of system bandwidth	Very long - defined by subcarrier spacing and independent of system spacing
Separation of users	Orthogonal spreading codes	Frequency and time

Adding TDMA to OFDM to Create OFDMA

With standard OFDM, very narrow UE-specific transmissions can suffer from narrowband fading and interference. That is why for the downlink 3GPP chose OFDMA, which incorporates elements of time division multiple access (TDMA). OFDMA allows subsets of the subcarriers to be allocated dynamically among the different users on the channel, as shown in Figure 4-5. The result is a more robust system with increased capacity. This is due to the trunking efficiency of multiplexing low rate users and the ability to schedule users by frequency, which provides resistance to multi-path fading.

Figure 4-5 Comparison of Static and Dynamic OFDMA Subcarrier Allocation

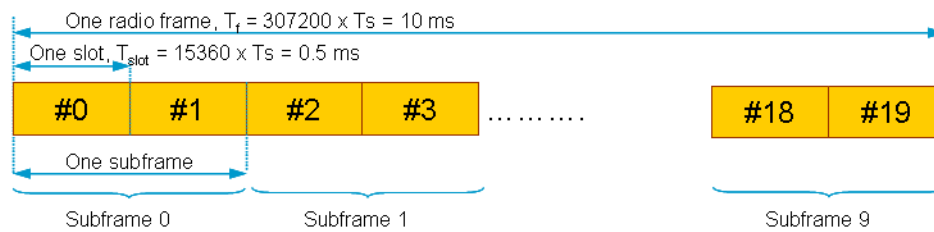


LTE Frame Structure

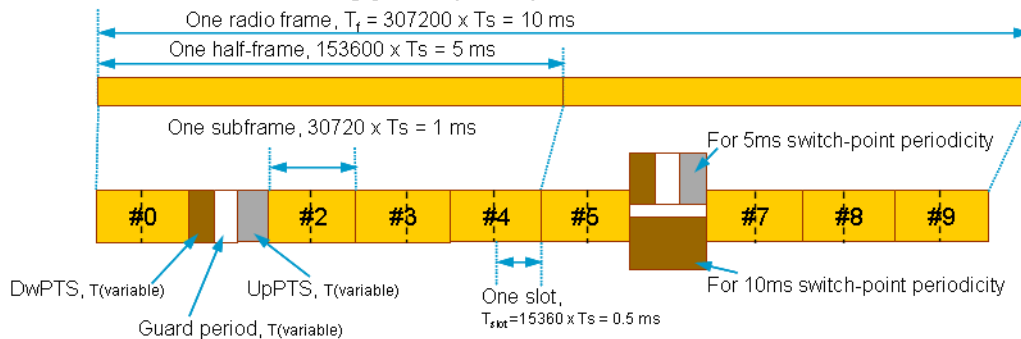
There are two types of frame structure in the LTE standard, Type 1 and Type 2. Type 1 uses Frequency Division Duplexing (uplink and downlink separated by frequency), and TDD uses Time Division Duplexing (uplink and downlink separated in time). The frame structure type 1 and type 2 are shown in Figure 4-6.

Figure 4-6 LTE Frame Structure

Frame Structure Type 1 (FDD)



Frame Structure Type 2 (TDD)



In FDD mode, uplink and downlink frames are separated in frequency. Both uplink and downlink frames are 10 ms long and are transmitted continuously. The base station (eNB) can specify a time offset (in PDCCH) to be applied to the uplink frame relative to the downlink frame.

In TDD mode, each radio frame is 10 ms long and consists of two half frames. Each half frame contains 5 subframes. There are seven defined uplink-downlink configuration shown in Table 4-4. "D" denotes the subframe is reserved for downlink transmissions, "U" denotes the subframe is reserved for uplink transmissions and subframe #1 and sometimes subframe #6 consist of three special fields: Downlink Pilot Timeslot (DwPTS), Guard Period (GP) and Uplink Timeslot (UpPTS). Table 4-5 shows the configuration of special subframe.

Table 4-4 LTE TDD Uplink-Downlink Configurations

Uplink-Downlink Configuration	Switch-Point Periodicity	Subframe Number										
		0	1	2	3	4	5	6	7	8	9	
0	5 ms	D	S	U	U	U	D	S	U	U	U	
1	5 ms	D	S	U	U	D	D	S	U	U	D	
2	5 ms	D	S	U	D	D	D	S	U	D	D	
3	10 ms	D	S	U	U	U	D	D	D	D	D	
4	10 ms	D	S	U	U	D	D	D	D	D	D	

Table 4-4 LTE TDD Uplink-Downlink Configurations

Uplink-Downlink Configuration	Switch-Point Periodicity	Subframe Number									
		0	1	2	3	4	5	6	7	8	9
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

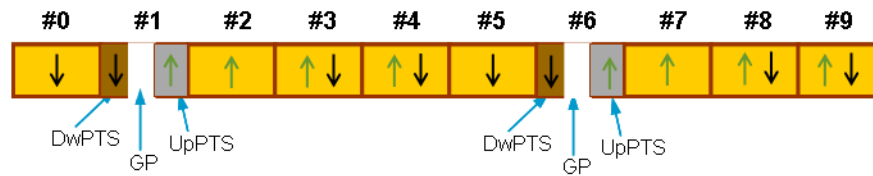
Table 4-5 LTE TDD Special Subframe Configurations (DwPTS/GP/UpPTS)

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			-	-	-
8	$24144 \cdot T_s$			-	-	-

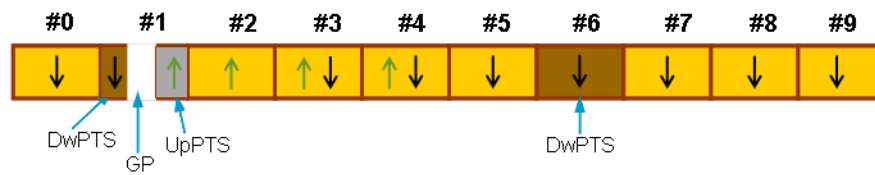
The flexible assignment for downlink or uplink slot in a frame enables asymmetric data rates. Depending on the switch-point periodicity of 5 ms or 10 ms, there can be one or two changes of direction within the frame. See Figure 4-7.

Figure 4-7 LTE TDD Switch-point Periodicity

5 ms switch-point periodicity



10 ms switch-point periodicity



Transmission Bandwidths

LTE must support the international wireless market and regional spectrum regulations and spectrum availability. To this end the specific cations include variable channel bandwidths selectable from 1.4 to 20 MHz, with subcarrier spacing of 15 kHz. Subcarrier spacing is constant regardless of the channel bandwidth. 3GPP has defined the LTE air interface to be “bandwidth agnostic,” which allows the air interface to adapt to different channel bandwidths with minimal impact on system operation.

The smallest amount of resource that can be allocated in the uplink or downlink is called a resource block (RB). An RB is 180 kHz wide and lasts for one 0.5 ms timeslot. For LTE, an RB is comprised of 12 subcarriers at a 15 kHz spacing. The maximum number of RBs and subcarriers supported by each transmission bandwidth is given in [Table 4-6](#).

Table 4-6 Transmission Bandwidth Configurations

Channel BW (MHz)	1.4	3.0	5	10	15	20
Nominal band width configuration (resource blocks)	6	15	25	50	75	100
Downlink Subcarriers	73	181	301	601	901	1201
Uplink Subcarriers	72	180	300	600	900	1200

For downlink signals, the DC subcarrier is not transmitted, but is counted in the number of subcarriers. For uplink, the DC subcarrier does not exist because the entire spectrum is shifted down in frequency by half the subcarrier spacing and is symmetric about DC.

LTE Time units

There are four time units used in describing an LTE frame: frame, subframe, slot, and symbol as shown in [Table 4-7](#).

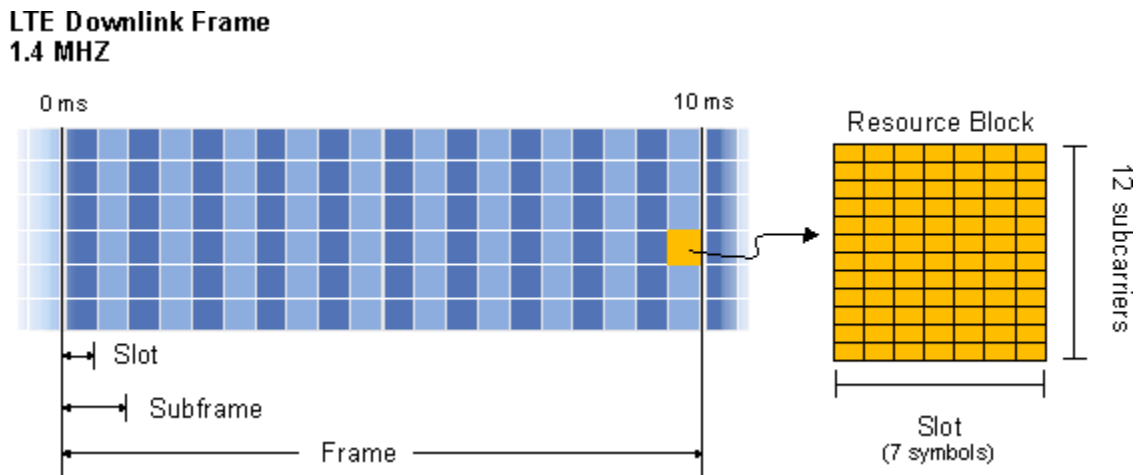
Table 4-7 LTE Time Units

Time Unit	Value
Frame	10 ms
Subframe	1 ms
Slot	0.5 ms
Symbol	0.5 ms / 7

The time units are illustrated in [Figure 4-8](#). A resource block (RB) is the smallest unit of resources that can be allocated to a user. The resource block is 12 subcarriers wide in frequency and 7 symbols (1 slot) long in time.

Frequency units can be expressed in number of subcarriers or resource blocks. For instance, a 5 MHz downlink signal could be described as being 25 resource blocks wide or 301 subcarriers wide in frequency.

Figure 4-8 LTE Time Units



Duplexing Techniques

To support transmission in paired and unpaired spectrum, the LTE air interface supports both frequency division duplex (FDD) and time division duplex (TDD) modes.

Modulation and Coding

Just like High Speed Data Packet Access (HSDPA), the LTE system also uses adaptive modulation and coding (AMC) to improve data throughput. This technique varies the downlink modulation coding scheme based on the channel conditions for each user. When the link quality is good, the LTE system can use a higher order modulation scheme (more bits per symbol), which will result in more system capacity. On the other hand, when link conditions are poor due to problems such as signal fading, the LTE system can change to a lower modulation scheme to maintain an acceptable radio link margin. The modulation schemes supported for payload in the downlink and uplink are QPSK, 16QAM and 64QAM. The reference signals and synchronization signals use a Constant Amplitude Zero-Auto-Correlation (CAZAC) modulation sequence.

Two channel coding schemes are used in LTE for the TrCH: turbo coding for the UL-SCH, DL-SCH, PCH, and MCH; and tail-biting convolutional coding for the BCH. For both schemes, the coding rate is $R=1/3$. Control information is coded using various schemes, including tail-biting convolutional coding, block code and repetition code.

Uplink and Downlink Physical Resource Elements and Blocks

The smallest time-frequency unit for uplink and downlink transmission is called a resource element. A resource element corresponds to one OFDM subcarrier during one OFDM symbol interval. A group of contiguous subcarriers and symbols form a resource block (RB) as shown in Figure 4-9. Data is allocated to each user in terms of RB.

For a Type 1 frame structure using normal Cyclic Prefix (CP), an RB spans 12 consecutive subcarriers at a subcarrier spacing of 15 kHz, and 7 consecutive symbols over a slot duration of 0.5 ms. Thus, an RB has 84 resource elements (12 subcarriers x 7 symbols) corresponding to one slot in time domain and 180 kHz (12 subcarriers x 15 kHz spacing) in the frequency domain. Even though an RB is defined as 12 subcarriers during one 0.5 ms slot, scheduling is carried out on a subframe (1 ms) basis. Using normal CP, the minimum allocation the base station uses for UE scheduling is 1 sub-frame (14 symbols) by 12 subcarriers. The size of an RB is the same for all bandwidths; therefore, the number of available physical RBs depends on the transmission bandwidth as shown in Table 4-6 on page 162.

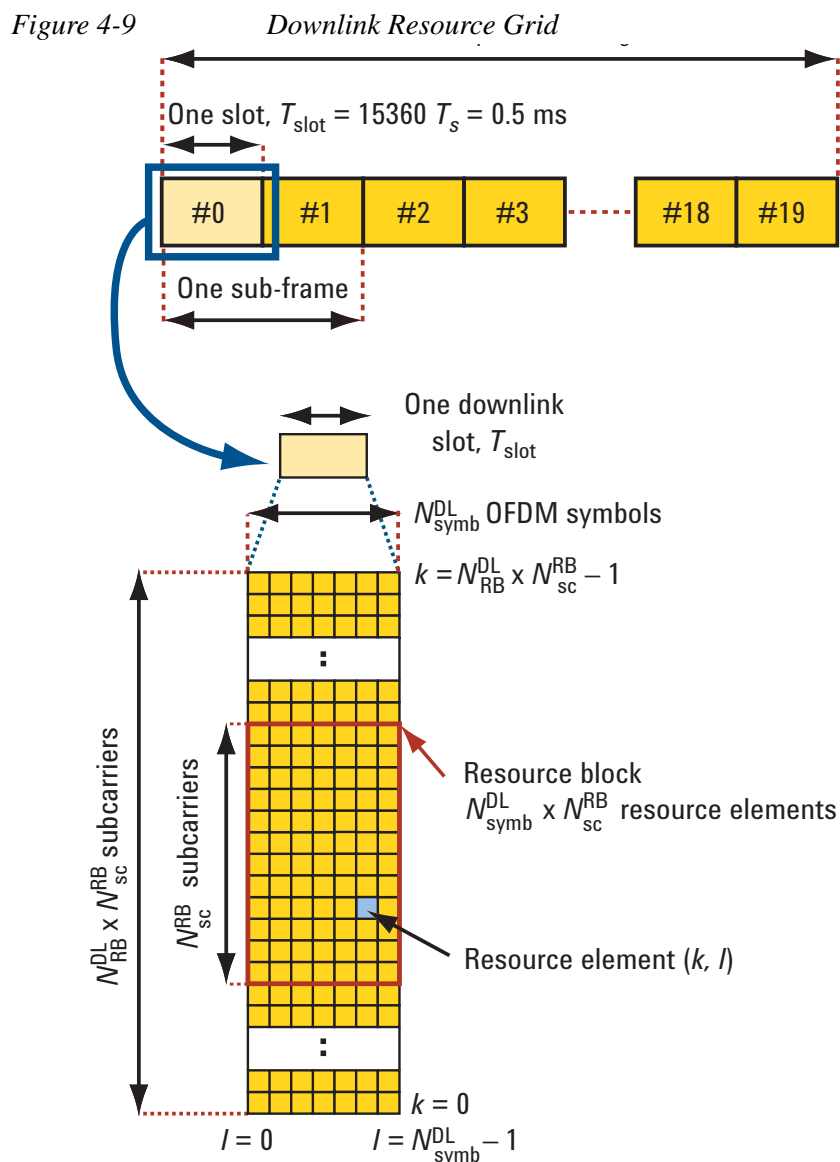


Figure 4-9 shows the downlink resource grid for a 0.5-ms timeslot which incorporates the concepts of a resource element and a resource block. A resource element is the smallest identifiable unit of transmission and consists of one

subcarrier for one symbol period. However, transmissions are scheduled in larger units called resource blocks which comprise 12 adjacent subcarriers for a period of one 0.5-ms timeslot.

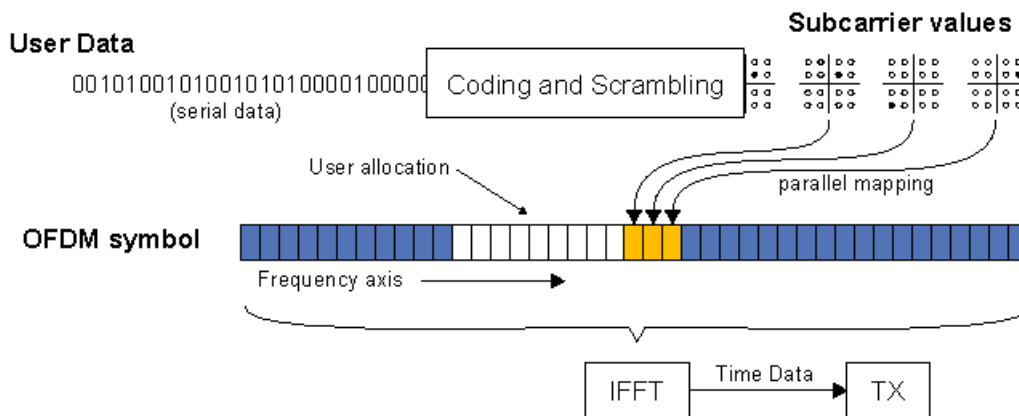
Physical Layer Channels

The LTE DL and UL are composed of two sets of physical layer channels: physical channels and physical signals. Physical channels carry information from higher layers and are used to carry user data, as well as user control information. Physical signals are used for system synchronization, cell identification and radio channel estimation, but do not carry information originating from higher layers.

Modulation Types

LTE uplink and downlink signals are created and modulated differently. For downlink signals, the base station uses multi-carrier OFDMA to transmit the signal (see Figure 4-18). First, a user's data is split up into subcarrier values (constellation points). Then the subcarrier values are placed onto the current symbol's subcarriers in the resource blocks allocated to the user. After values have been assigned for all subcarriers in an OFDM symbol (including the reference signal and control channels), the symbol is sent through an IFFT, which converts the symbol into time data that can be transmitted. Figure 4-10 illustrates this process.

Figure 4-10 Downlink Modulation - Bits to OFDMA Subcarrier Allocation



The subcarrier symbol points can be QPSK, 16QAM, or 64QAM.

OFDM has a large peak-to-average power ratio which means that the amplifiers have to be higher quality and more expensive (and consume more power). These are not major concerns when designing a base station that can be powered externally, but is an issue for mobile devices where low cost is desired and battery life is limited.

For uplink signals, the LTE standard uses Single Carrier Frequency Division Multiple Access (SC-FDMA) modulation, which has a lower peak-to-average ratio, meaning lower cost amplifiers and less power usage.

Downlink Physical Layer Channels and Signals

The DL physical channels are Physical Downlink Shared Channel (PDSCH), Physical Downlink Control Channel (PDCCH), and Physical Broadcast Channel (PBCH). The DL physical signals are reference signal (RS) and synchronization signal. Figure 4-11 has information on the modulation format and purpose for each of the downlink channels and signals.

Figure 4-11 LTE Downlink Channels and Signals

DL channels	Full name	Modulation format	Purpose
PBCH	Physical Broadcast Channel	QPSK	Carries cell-specific information
PDCCH	Physical Downlink Control Channel	QPSK	Scheduling, ACK/NACK
PDSCH	Physical Downlink Shared Channel	QPSK 16QAM 64QAM	Payload
PMCH	Physical Multicast Channel	QPSK 16QAM 64QAM	Payload for Multimedia Broadcast Multicast Service (MBMS)
PCFICH	Physical Control Format Indicator Channel	QPSK	Carries information about the number of OFDM symbols (1, 2 or 3) used for transmission of PDCCHs in a sub-frame.
PHICH	Physical Hybrid ARQ Indicator Channel	Not defined yet in 3GPP TS 36.211 V8.1.0	Carries the hybrid-ARQ ACK/NAK
DL signals	Full name	Modulation sequence	Purpose
P-SCH	Primary Synchronization Channel	One of 3 Zadoff-Chu sequences	Used for cell search and identification by the UE. Carries part of the cell ID (one of 3 orthogonal sequences).
S-SCH	Secondary Synchronization Channel	Two 31-bit M-sequences (binary) - one of 170 Cell IDs plus other info	Used for cell search and identification by the UE. Carries the remainder of the cell ID (one of 170 binary sequences).
RS	Reference Signal (Pilot)	OS*PRS defined by Cell ID (P-SCH & S-SCH)	Used for DL channel estimation. Exact sequence derived from cell ID, (one of 3 * 170 = 510).

Uplink Physical Layer Channels and Signals

Uplink (UL) physical channels are Physical Uplink Shared Channel (PUSCH), Physical Uplink Control Channel (PUCCH) and Physical Random Access Channel (PRACH). Two types of uplink reference signals are supported: demodulation reference signal (DM-RS) which is associated with transmission of PUSCH or PUCCH, and sounding reference signal (S-RS) which is not associated with transmission of PUSCH or PUCCH. Figure 4-12 below has information on the modulation format and purpose for each of the uplink channels and signals.

Figure 4-12 *LTE Uplink Channels and Signals*

UL channels	Full name	Modulation format	Purpose
PRACH	Physical Random Access Channel	QPSK	Call setup
PUCCH	Physical Uplink Control Channel	BPSK, QPSK	Scheduling, ACK/NACK
PUSCH	Physical Uplink Shared Channel	QPSK 16QAM 64QAM	Payload
UL signals	Full name	Modulation sequence	Purpose
DM-RS	Demodulation Reference Signal	orth root Zadoff-Chu	Used for synchronization to the UE and UL channel estimation
S-RS	Sounding Reference Signal	Zadoff-Chu	Used to monitor propagation conditions with UE.

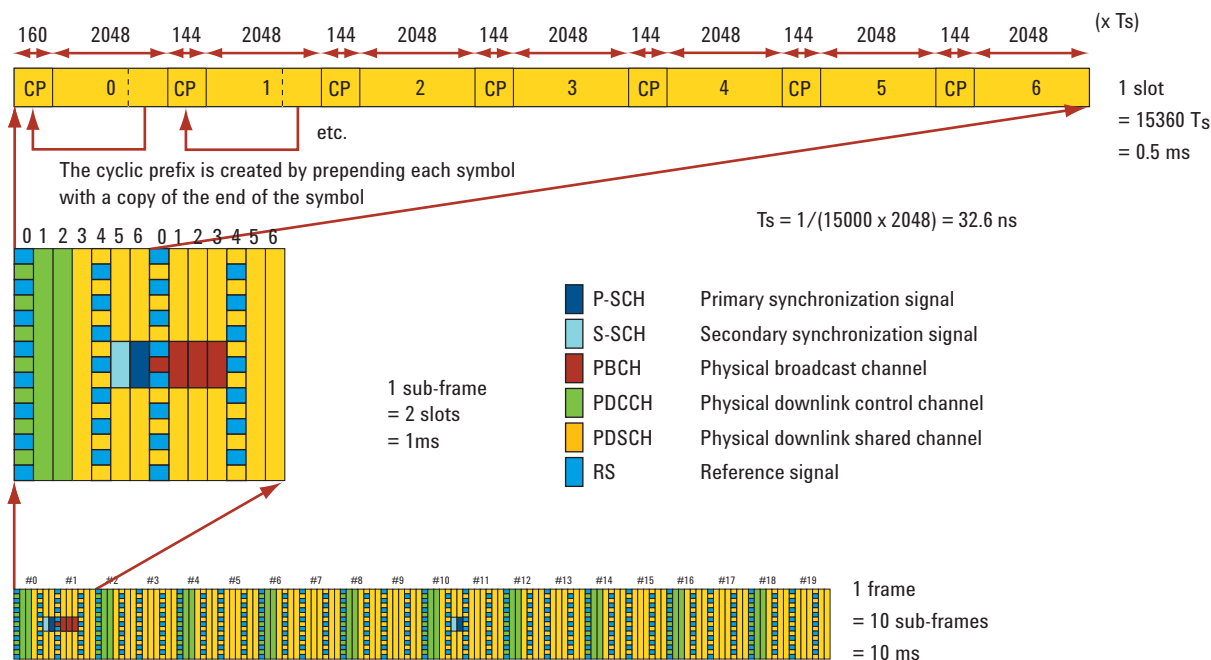
Physical Signals and Channels Mapping

Two radio frame structures are defined in LTE: Type 1 frame structure, which uses Frequency Division Duplexing (FDD) and Type 2 frame structure, which uses Time Division Duplexing (TDD). Although LTE supports both FDD and TDD.

Figure 4-13 shows a DL Type 1 FDD frame structure. A radio frame has a duration of 10 ms and consists of 20 slots with a slot duration of 0.5 ms. Two slots comprise a sub-frame. A sub-frame, also known as the Transmission Time Interval (TTI), has a duration of 1 ms.

Figure 4-13

DL FDD Type 1 Frame Structure



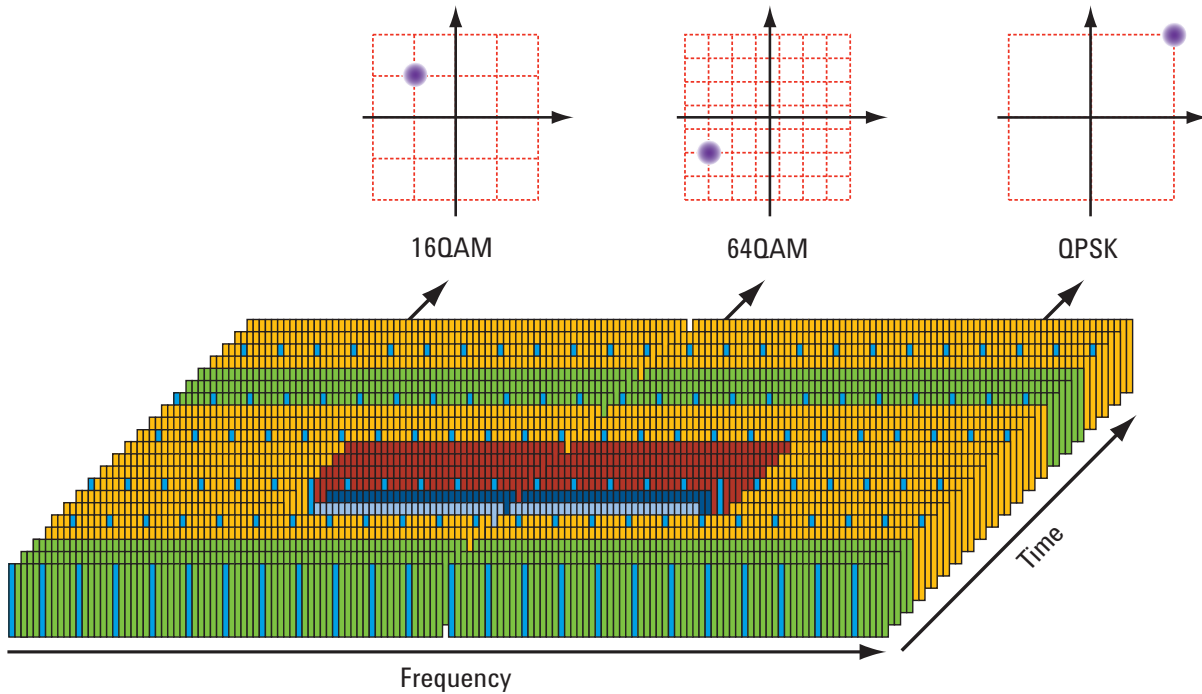
The physical mapping of the DL physical signals and channels are:

- Reference signal (pilot) is transmitted at every 6th subcarrier of OFDMA symbols #0 & #4 of every slot
- PDCCH is transmitted at OFDM symbol #0, #1 and #2 of the first slot of the sub-frame. Multiple PDCCHs can be transmitted in each subframe.
- P-SCH is transmitted on 62 out of the 72 reserved subcarriers centered around the DC subcarrier at OFDM symbol 6 of slots 0 and 10 in each radio frame
- S-SCH is transmitted on 62 out of the 72 reserved subcarriers centered around the DC subcarrier at OFDM symbol #5 of slots 0 and 10 in each radio frame
- PBCH is transmitted on 72 subcarriers centered around DC at OFDMA symbol #3 and #4 of slot 0 and symbol #0 and #1 of slot 1. Excludes reference signal subcarriers.
- PDSCH is transmitted on any assigned OFDM subcarriers not occupied by any of the above channels and signals

Figure 4-14 shows the downlink mapping across frequency and time. The central DC subcarrier of the downlink channel is not used for transmission, but is reserved for energy generated due to local-oscillator feedthrough in the signal-generation process.

Figure 4-14

Downlink Frame Structure 1 Showing Subframe vs. Frequency



The uplink (UL) FDD frame structure is similar to downlink (DL) frame structure in terms of frame, sub-frame and slot length. A UL frame structure is shown in Figure 4-15 below.

The UL demodulation reference signals, which are used for channel estimation for coherent demodulation, are transmitted in the fourth symbol (i.e symbol # 3) of every slot.

Figure 4-15 Uplink Type 1 FDD Frame Structure

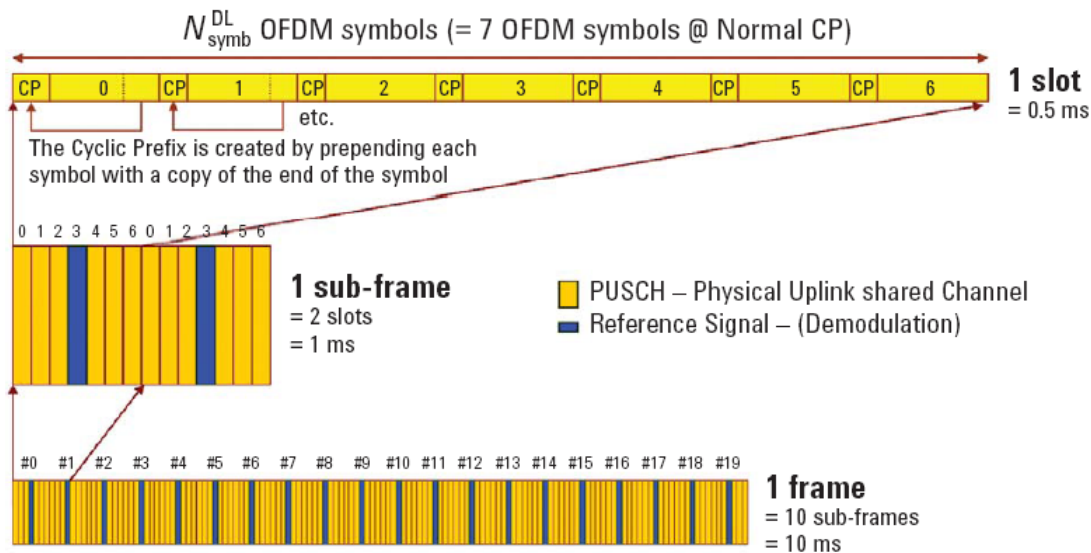


Figure 4-16 and Figure 4-17 are 5 ms and 10 ms TDD switch point periodicity physical signals and channels mapping.

- P-SCH is transmitted in the central 62 subcarriers at the third symbol of slot 2 and slot 12.
- S-SCH is transmitted in the last symbol of slot 1 and slot 11.
- Reference signal is transmitted at symbol #0 and symbol #4 in each slot.
- PBCH is transmitted at the first four symbols in slot 1.
- PDCCH is transmitted at the first three symbols in every subframe.
- PDSCH is transmitted on any assigned OFDM subcarriers not occupied by any of the above channels and signals

Figure 4-16 LTE TDD 5 ms Switch Periodicity Mapping

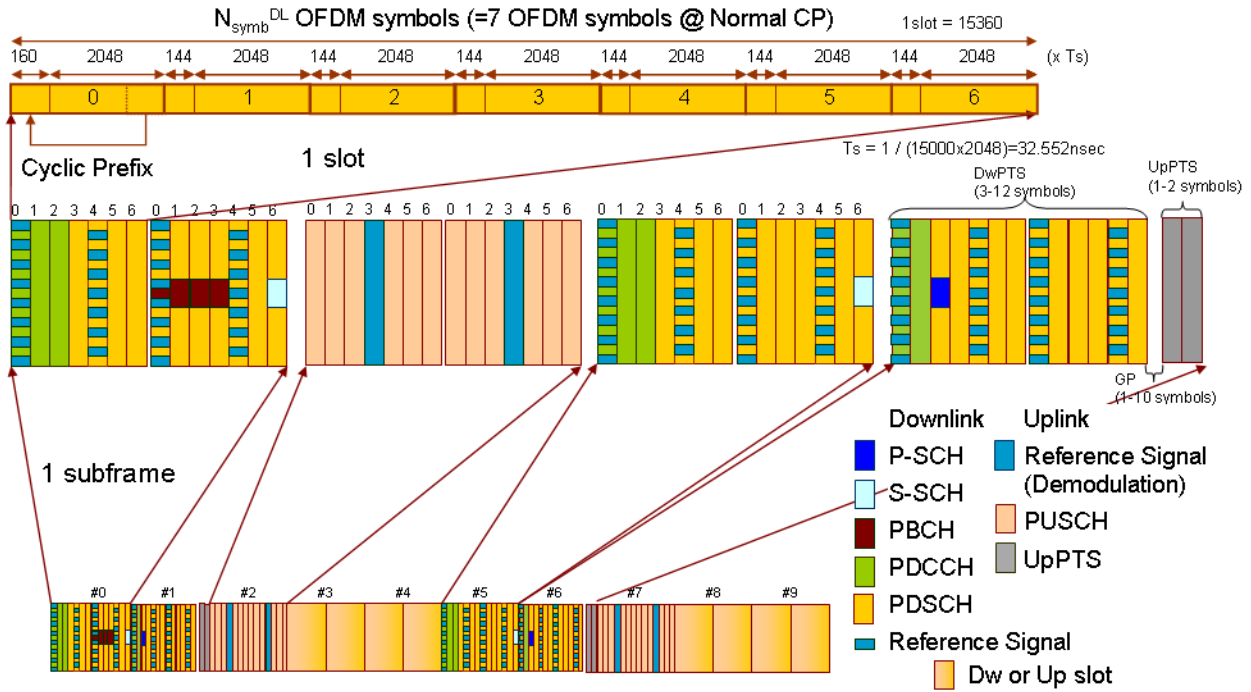
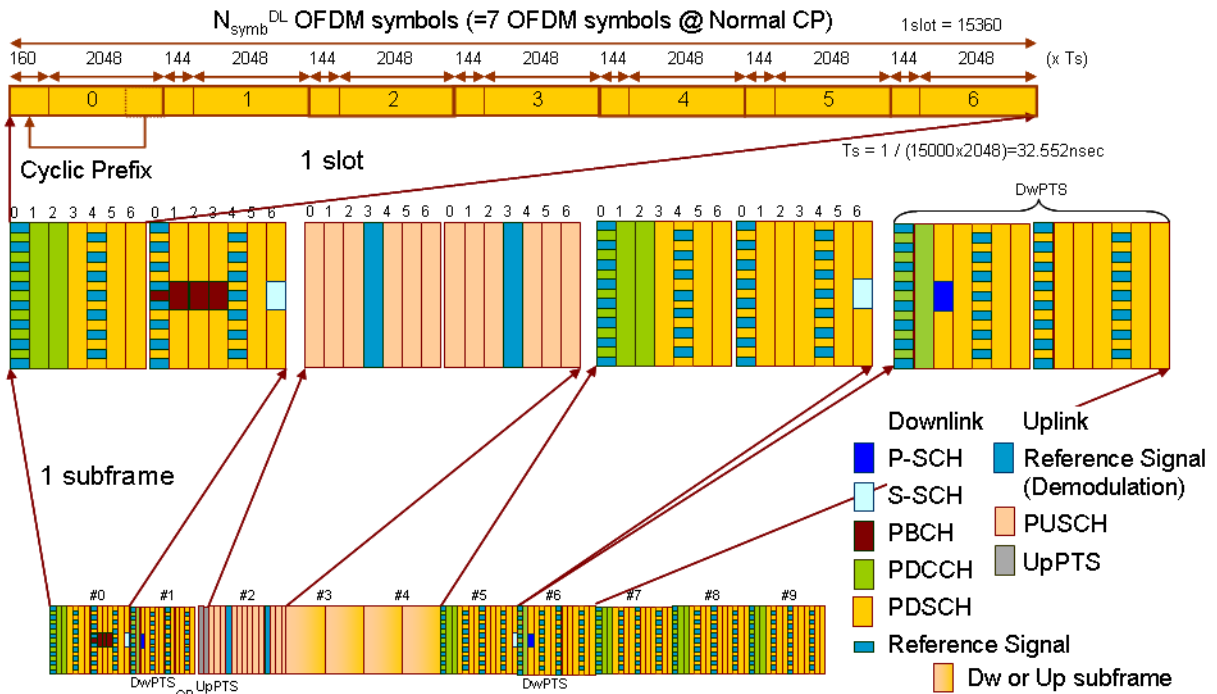


Figure 4-17 LTE TDD 10 ms Switch Periodicity Mapping



Cyclic Prefix (CP)

Table 4-8 and Table 4-9 summarizes the options for CP length and number of symbols per timeslot. The extended CP of 512 x Ts (16.67 μs) is available for use in larger cells and provides protection for up to a 5-km delay spread. The price for this increased protection is a reduction in system capacity since the extended CP allows for only six symbols per timeslot. The longest protection from delay spread is achieved when using the extended CP of 1024 x Ts (33.33 μs) with the optional 7.5-kHz subcarrier spacing for eMBMS. This enables transmissions from multiple cells to be combined in a Multicast/Broadcast over Single Frequency Network (MBSFN) with protection from delay spread of up to 10 km. This very long CP means there are only three symbols per timeslot, but this capacity loss is counteracted by the doubling up of the subcarriers.

Table 4-8 Cyclic Prefix Configurations for DL

CP in Ts by Symbol Number	0	1	2	3	4	5	6
Normal $\Delta f = 15$ kHz	160	144	144	144	144	144	144
Extended $\Delta f = 15$ kHz	512	512	512	512	512	512	-
Extended $\Delta f = 7.5$ kHz	1024	1024	1024	-	-	-	-

Table 4-9 Cyclic Prefix Configurations for UL

CP in Ts by Symbol Number	0	1	2	3	4	5	6
Normal $\Delta f = 15$ kHz	160	144	144	144	144	144	144
Extended $\Delta f = 15$ kHz	512	512	512	512	512	512	-

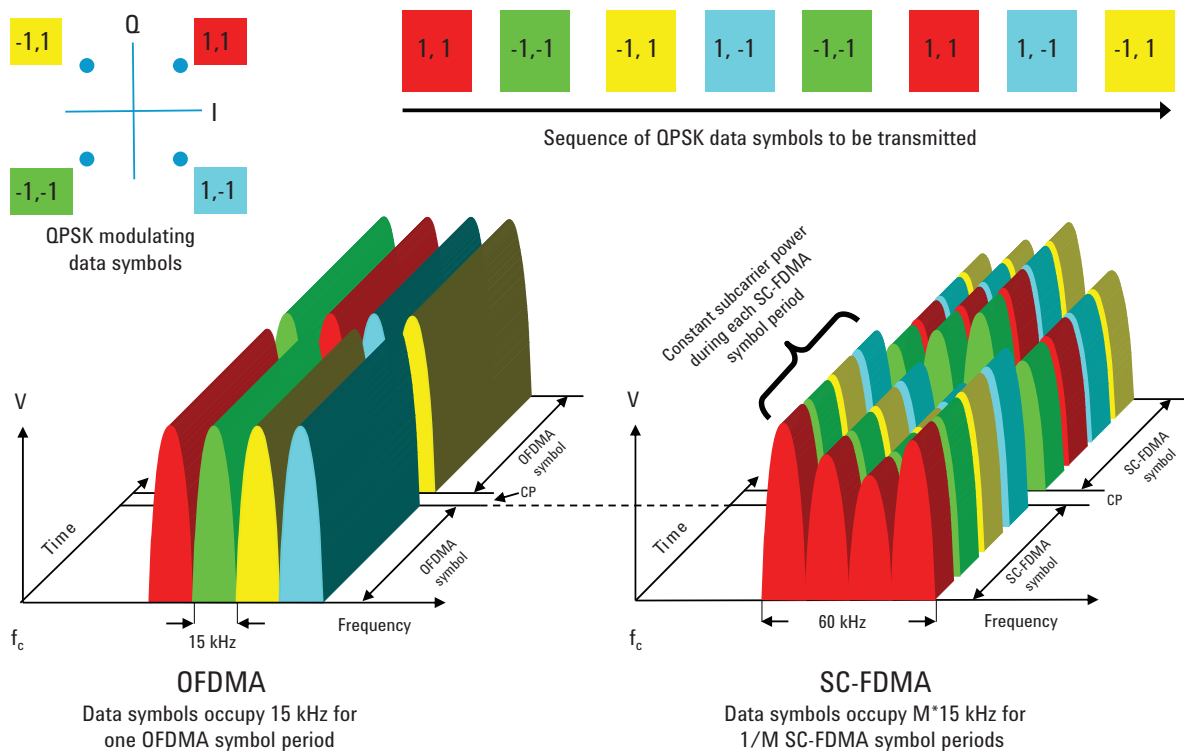
Multiple Access Technology in the Uplink: SC-FDMA

The high peak-to-average ratio (PAR) associated with OFDM led 3GPP to look for a different transmission scheme for the LTE uplink. SC-FDMA was chosen because it combines the low PAR techniques of single-carrier transmission systems, such as GSM and CDMA, with the multi-path resistance and flexible frequency allocation of OFDMA.

A graphical comparison of OFDMA and SC-FDMA as shown in [Figure 4-18](#) is helpful in understanding the differences between these two modulation schemes. For clarity this example uses only four (M) subcarriers over two symbol periods with the payload data represented by quadrature phase shift keying (QPSK) modulation. As described earlier, real LTE signals are allocated in units of 12 adjacent subcarriers.

Figure 4-18

Comparison of OFDMA (DL) and SC-FDMA (UL)



On the left side of [Figure 4-18](#), M adjacent 15 kHz subcarriers—already positioned at the desired place in the channel bandwidth—are each modulated for the OFDMA symbol period of $66.7 \mu\text{s}$ by one QPSK data symbol. In this four subcarrier example, four symbols are taken in parallel. These are QPSK data symbols so only the phase of each subcarrier is modulated and the subcarrier power remains constant between symbols. After one OFDMA symbol period has elapsed, the CP is inserted and the next four symbols are transmitted in parallel. For visual clarity, the CP is shown as a gap; however, it is actually filled with a copy of the end of the next symbol, which means that the transmission power is continuous but has a phase discontinuity at the

symbol boundary. To create the transmitted signal, an IFFT is performed on each subcarrier to create M time domain signals. These in turn are vector-summed to create the final time-domain waveform used for transmission.

SC-FDMA signal generation begins with a special pre-coding process but then continues in a manner similar to OFDMA. However, before getting into the details of the generation process it is helpful to describe the end result as shown on the right side of [Figure 4-18](#). The most obvious difference between the two schemes is that OFDMA transmits the four QPSK data symbols in parallel, one per subcarrier, while SC-FDMA transmits the four QPSK data symbols in series at four times the rate, with each data symbol occupying $M \times 15$ kHz bandwidth.

Visually, the OFDMA signal is clearly multi-carrier with one data symbol per subcarrier, but the SC-FDMA signal appears to be more like a single-carrier (hence the “SC” in the SC-FDMA name) with each data symbol being represented by one wide signal. Note that OFDMA and SC-FDMA symbol lengths are the same at $66.7 \mu\text{s}$; however, the SC-FDMA symbol contains M “sub-symbols” that represent the modulating data. It is the parallel transmission of multiple symbols that creates the undesirable high PAR of OFDMA. By transmitting the M data symbols in series at M times the rate, the SC-FDMA occupied bandwidth is the same as multi-carrier OFDMA but, crucially, the PAR is the same as that used for the original data symbols. Adding together many narrow-band QPSK waveforms in OFDMA will always create higher peaks than would be seen in the wider-bandwidth, single-carrier QPSK waveform of SC-FDMA. As the number of subcarriers M increases, the PAR of OFDMA with random modulating data approaches Gaussian noise statistics but, regardless of the value of M , the SC-FDMA PAR remains the same as that used for the original data symbols.

SC-FDMA maps the data onto a single carrier modulation format (QPSK, QAM16, or QAM64). Then it takes the time domain set of symbols, performs an FFT, and maps the frequency domain values to the subcarriers that are assigned to the user. Then it takes an IFFT of the entire OFDM symbol and transmits the resulting time data. [Figure 4-19](#) illustrates this process.

Figure 4-19 Uplink Modulation - Bits to SC-TDMA Carrier Allocation

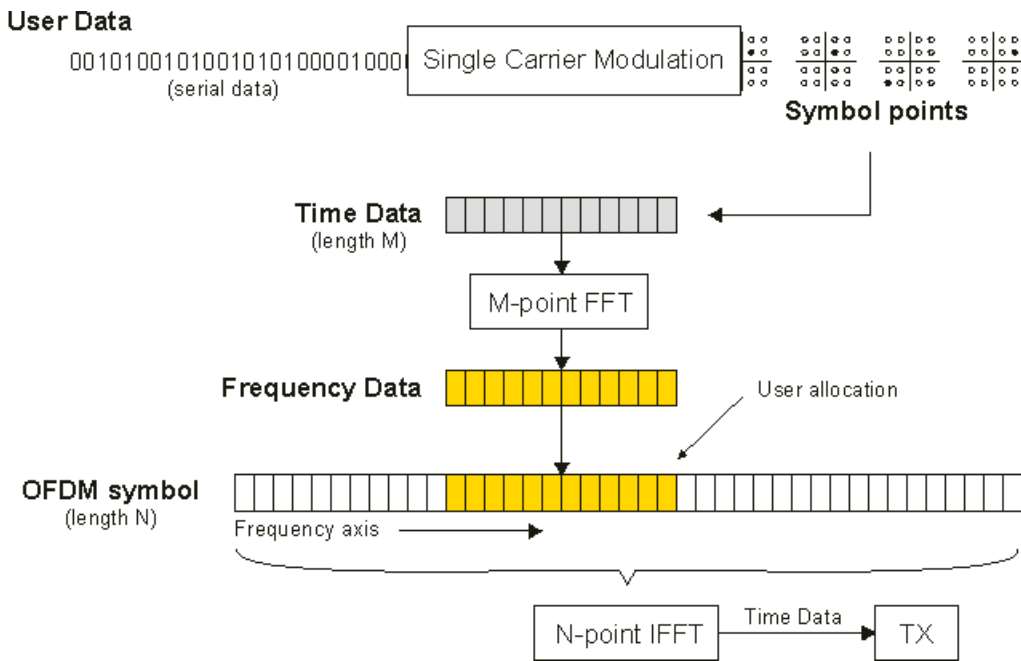


Table 4-10 summarizes the differences between the OFDMA and SC-FDMA modulation schemes. When OFDMA is analyzed one subcarrier at a time, it resembles the original data symbols. At full bandwidth, however, the signal looks like Gaussian noise in terms of its PAR statistics and the constellation. The opposite is true for SC-FDMA. In this case, the relationship to the original data symbols is evident when the entire signal bandwidth is analyzed. The constellation (and hence low PAR) of the original data symbols can be observed rotating at M times the SC-FDMA symbol rate, ignoring the seven percent rate reduction that is due to adding the CP. When analyzed at the 15 kHz subcarrier spacing, the SC-FDMA PAR and constellation are meaningless because they are M times narrower than the information bandwidth of the data symbols.

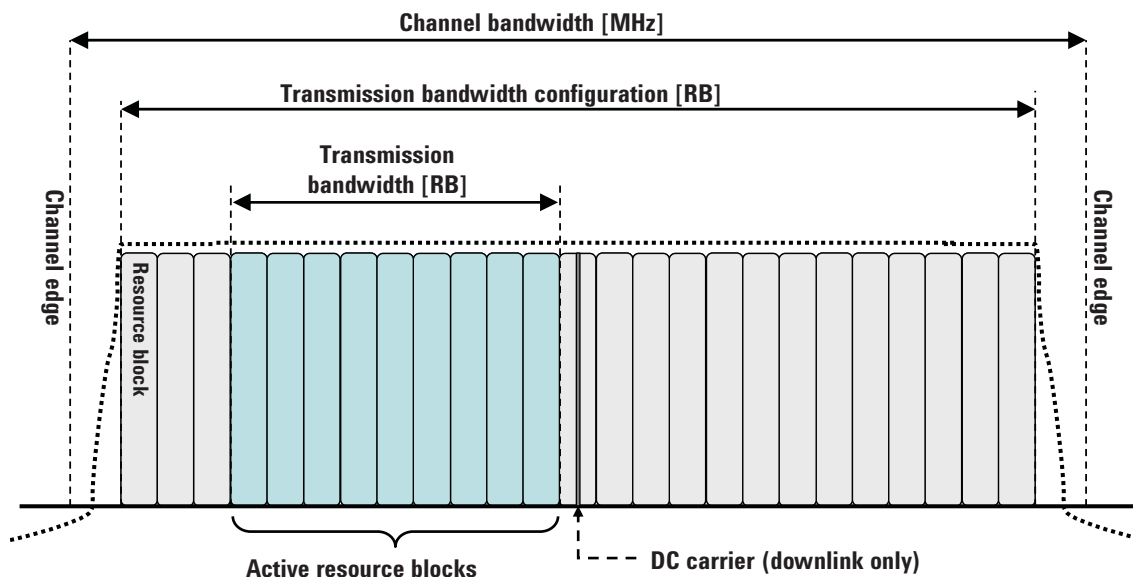
Table 4-10 Analysis of OFDMA and SC-FDMA at Different Bandwidths

Modulation Format	OFDMA		SC-FDMA	
	Analysis Band width	15 kHz	Signal Band width ($M \times 15$ kHz)	15 kHz
Peak-to-average power ratio (PAR)	Same as data symbol	High PAR (Gaussian)	< Data symbol (not meaningful)	Same as Data symbol
Observable IQ constellation	Same as data symbol at 66.7 μ s	Not meaningful (Gaussian)	Not meaningful (Gaussian)	Same as data symbol at 66.7 μ s

Examining the SC-FDMA Signal

Unlike the eNB (base station transmitter), the UE does not normally transmit across the entire channel bandwidth. A typical uplink configuration with the definition of terms is shown in [Figure 4-20](#).

Figure 4-20 SC-FDMA Channel BW and Transmission BW Configuration



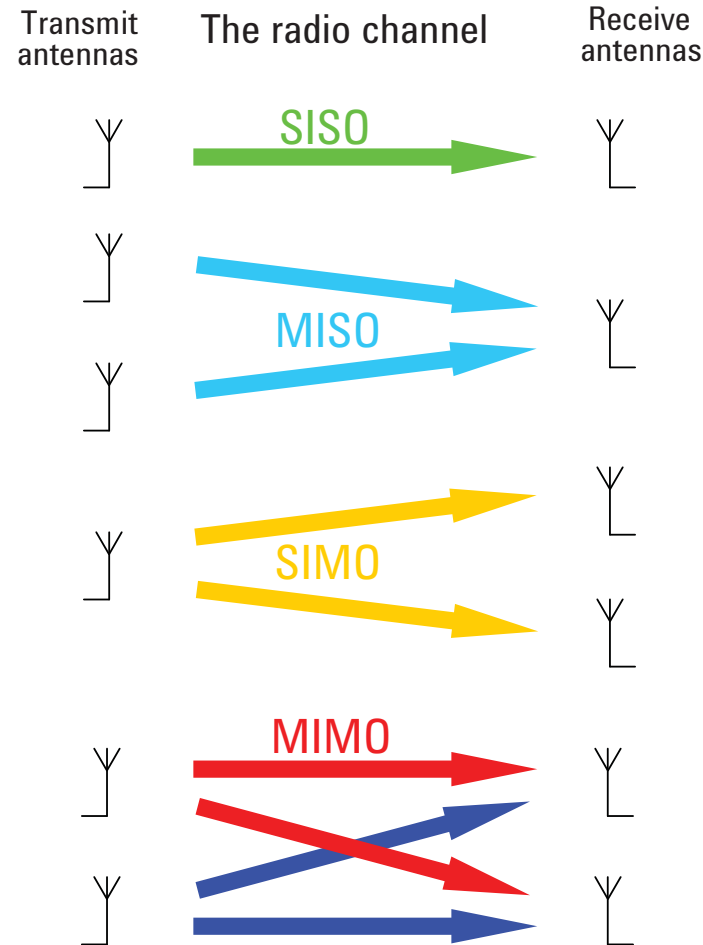
Overview of Multiple Antenna Techniques (MIMO)

Central to LTE is the concept of multiple antenna techniques, which are often loosely referred to as MIMO (multiple inputs, multiple outputs). MIMO takes advantage of spatial diversity in the radio channel. Multiple antenna techniques are of three main types: diversity, MIMO, and beamforming. These techniques are used to improve signal robustness and to increase system capacity and single-user data rates. Each technique has its own performance benefits and costs.

[Figure 4-21](#) illustrates the range of possible antenna techniques from the simplest to the most complex, indicating how the radio channel is accessed by the system's transmitters and receivers.

Figure 4-21

MIMO Radio-Channel Access Modes



SISO - The most basic radio channel access mode is single input single output (SISO), in which only one transmit antenna and one receive antenna are used. This is the form of communications that has been the default since radio began and is the baseline against which all the multiple antenna techniques are compared.

MISO - Slightly more complex than SISO is multiple input single output (MISO) mode, which uses two or more transmitters and one receiver. (Figure 4-21 shows only two transmitters and one receiver for simplicity.) MISO is more commonly referred to as transmit diversity. The same data is sent on both transmitting antennas but coded such that the receiver can identify each transmitter. Transmit diversity increases the robustness of the signal to fading and can increase performance in low signal-to-noise ratio (SNR) conditions; however, it does not increase data rates as such, but rather supports the same data rates using less power. Transmit diversity can be enhanced with closed loop feedback from the receiver to indicate the balance of phase and power used for each antenna.

SIMO - The third mode shown in Figure 4-21 is single input multiple output (SIMO), which—in contrast to MISO—uses one transmitter and two or more receivers. SIMO is often referred to as receive diversity. Similar to transmit diversity, it is particularly well suited for low SNR conditions in which a theoretical gain of 3

dB is possible when two receivers are used. As with transmit diversity, there is no change in the data rate since only one data stream is transmitted, but coverage at the cell edge is improved due to the lowering of the usable SNR.

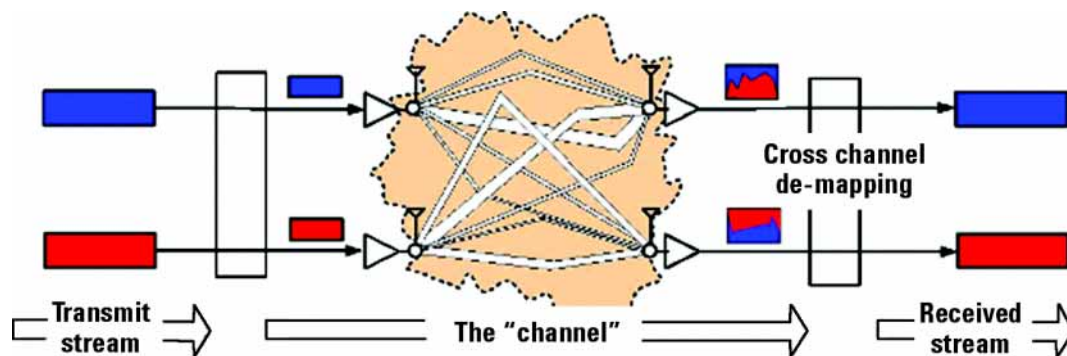
MIMO - The final mode is full MIMO, which requires two or more transmitters and two or more receivers. This mode is not just a superposition of SIMO and MISO since multiple data streams are now transmitted simultaneously in the same frequency and time, taking full advantage of the different paths in the radio channel. For a system to be described as MIMO, it must have at least as many receivers as there are transmit streams. The number of transmit streams should not be confused with the number of transmit antennas. Consider the Tx diversity (MISO) case in which two transmitters are present but only one data stream. Adding receive diversity (SIMO) does not turn this into MIMO, even though there are now two Tx and two Rx antennas involved. $\text{SIMO} + \text{MISO} \neq \text{MIMO}$. It is always possible to have more transmitters than data streams but not the other way around. If N data streams are transmitted from fewer than N antennas, the data cannot be fully descrambled by any number of receivers since overlapping streams without the addition of spatial diversity just creates interference. However, by spatially separating N streams across at least N antennas, N receivers will be able to fully reconstruct the original data streams provided the crosstalk and noise in the radio channel are low enough.

One other crucial factor for MIMO operation is that the transmissions from each antenna must be uniquely identifiable so that each receiver can determine what combination of transmissions has been received. This identification is usually done with pilot signals, which use orthogonal patterns for each antenna.

The spatial diversity of the radio channel means that MIMO has the potential to increase the data rate. The most basic form of MIMO assigns one data stream to each antenna and is shown in [Figure 4-22](#).

Figure 4-22

Non-Precoded 2x2 MIMO



In this form, one data stream is uniquely assigned to one antenna. The channel then mixes up the two transmissions such that at the receivers, each antenna sees a combination of each stream. Decoding the received signals is a clever process in which the receivers, by analyzing the patterns that uniquely identify each transmitter, determine what combination of each transmit stream is present. The application of an inverse filter and summing of the received streams recreates the original data.

A more advanced form of MIMO includes special pre-coding to match the transmissions to the Eigen modes of the channel. This optimization results in each stream being spread across more than one transmit antenna. For this technique to work effectively the transmitter must have knowledge of the channel conditions and, in the case of FDD, these conditions must be provided in real time by feedback from the UE. Such optimization significantly complicates the system but can also provide higher performance. Pre-coding for TDD systems does not require receiver feedback because the transmitter independently determines the channel conditions by analyzing the received signals that are on the same frequency.

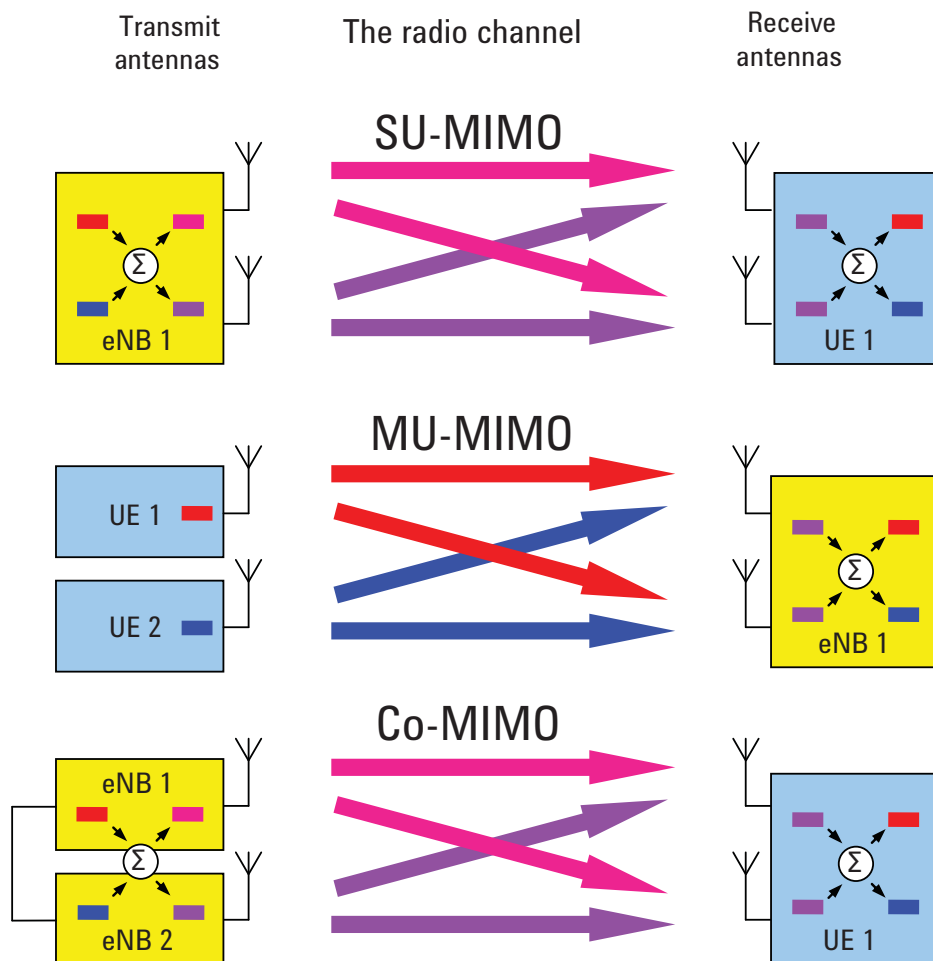
The theoretical gains from MIMO are a function of the number of transmit and receive antennas, the radio propagation conditions, the ability of the transmitter to adapt to the changing conditions, and the SNR. The ideal case is one in which the paths in the radio channel are completely uncorrelated, almost as if separate, physically cabled connections with no crosstalk existed between the transmitters and receivers. Such conditions are almost impossible to achieve in free space, and with the potential for so many variables, it is neither helpful nor possible to quote MIMO gains without stating the conditions. The upper limit of MIMO gain in ideal conditions is more easily defined, and for a 2x2 system with two simultaneous data streams a doubling of capacity and data rate is possible. MIMO works best in high SNR conditions with minimal line of sight. Line of sight equates to channel crosstalk and seriously diminishes the potential for gains. As a result, MIMO is particularly suited to indoor environments, which can exhibit a high degree of multi-path and limited line of sight.

Single User, Multiple User, and Cooperative MIMO

It is important to note that [Figure 4-22](#) does not make explicit whether the multiple transmitters or receivers belong to the same base station or UE. This leads to a further elaboration of MIMO that is presented in [Figure 4-22 on page 178](#).

The first case is single user MIMO (SU-MIMO), which is the most common form of MIMO and can be applied in the uplink or downlink. The primary purpose of SU-MIMO is to increase the data rate to one user. There is also a corresponding increase in the capacity of the cell. [Figure 4-23](#) shows the downlink form of 2x2 SU-MIMO in which two data streams are allocated to one UE. The data streams in the example are coded red and blue, and in this case are further pre-coded in such a way that each stream is represented at a different power and phase on each antenna. The colors of the data streams change at the transmit antennas, which is meant to signify the mixing of the data streams. The transmitted signals are further mixed by the channel. The purpose of the pre-coding is to optimize the transmissions to the characteristics of the radio channel so that when the signals are received, they can be more easily separated back into the original data streams.

Figure 4-23 Single User, Multiple User, and Cooperative MIMO



The second case shows 2x2 multiple user MIMO (MU-MIMO), which is used only in the uplink. (MU-MIMO is described in the WiMAX™ specifications as collaborative spatial multiplexing or collaborative MIMO). MU-MIMO does not increase an individual user's data rate but it does offer cell capacity gains that are similar to, or better than, those provided by SU-MIMO. In Figure 4-23, the two data streams originate from different UE. The two transmitters are much farther apart than in the single user case, and the lack of physical connection means that there is no opportunity to optimize the coding to the channel Eigen modes by mixing the two data streams. However, the extra spatial separation does increase the chance of the eNB picking up pairs of UE which have uncorrelated paths. This maximizes the potential capacity gain, in contrast to the pre-coded SU-MIMO case in which the closeness of the antennas could be problematic, especially at frequencies less than 1 GHz. MU-MIMO has an additional important advantage: the UE does not require the expense and power drain of two transmitters, yet the cell still benefits from increased capacity. To get the most gain out of MU-MIMO, the UE must be well aligned in time and power as received at the eNB.

The third case shown in [Figure 4-23](#) is cooperative MIMO (Co-MIMO). This term should not be confused with the WiMAX term “collaborative MIMO” described earlier. The essential element of Co-MIMO is that two separate entities are involved at the transmission end. The example here is a downlink case in which two eNB “collaborate” by sharing data streams to pre-code the spatially separate antennas for optimal communication with at least one UE. When this technique is applied in the downlink it is sometimes called network MIMO. The most advantageous use of downlink Co-MIMO occurs when the UE is at the cell edge. Here the SNR will be at its worst but the radio paths will be uncorrelated, which offers significant potential for increased performance. Co-MIMO is also possible in the uplink but is fundamentally more difficult to implement as no physical connection exists between the UE to share the data streams. Uplink Co-MIMO without a connection between the UE collapses into MU-MIMO, which as we have seen does not use pre-coding. Uplink Co-MIMO is also known as virtual MIMO. Co-MIMO is not currently part of the Release 8 LTE specifications but is being studied as a possible enhancement to LTE in Release 9 or Release 10 to meet the goals of the ITU’s IMT-Advanced 4G initiative.

Beamforming

Beamforming uses the same signal processing and antenna techniques as MIMO but rather than exploit de-correlation in the radio path, beamforming aims to exploit correlation so that the radiation pattern from the transmitter is directed towards the receiver. This is done by applying small time delays to a calibrated phase array of antennas. The effectiveness of beamforming varies with the number of antennas. With just two antennas little gain is seen, but with four antennas the gains are more useful. Obtaining the initial antenna timing calibration and maintaining it in the field are challenge.

Turning a MIMO system into a beamforming system is simply a matter of changing the pre-coding matrices. In practical systems, however, antenna design has to be taken into account and things are not so simple. It is possible to design antennas to be correlated or uncorrelated; for example, by changing the polarization. However, switching between correlated and uncorrelated patterns can be problematic if the physical design of the antennas has been optimized for one or the other.

Since beamforming is related to the physical position of the UE, the required update rate for the antenna phasing is much lower than the rates needed to support MIMO pre-coding. Thus beamforming has a lower signaling overhead than MIMO.

The most advanced form of multiple antenna techniques is probably the combination of beamforming with MIMO. In this mode MIMO techniques could be used on sets of antennas, each of which comprises a beamforming array. Given that beamforming with only two antennas has limited gains, the advantage of combining beamforming and MIMO will not be realized unless there are many antennas. This limits the practical use of the technique on cost grounds.

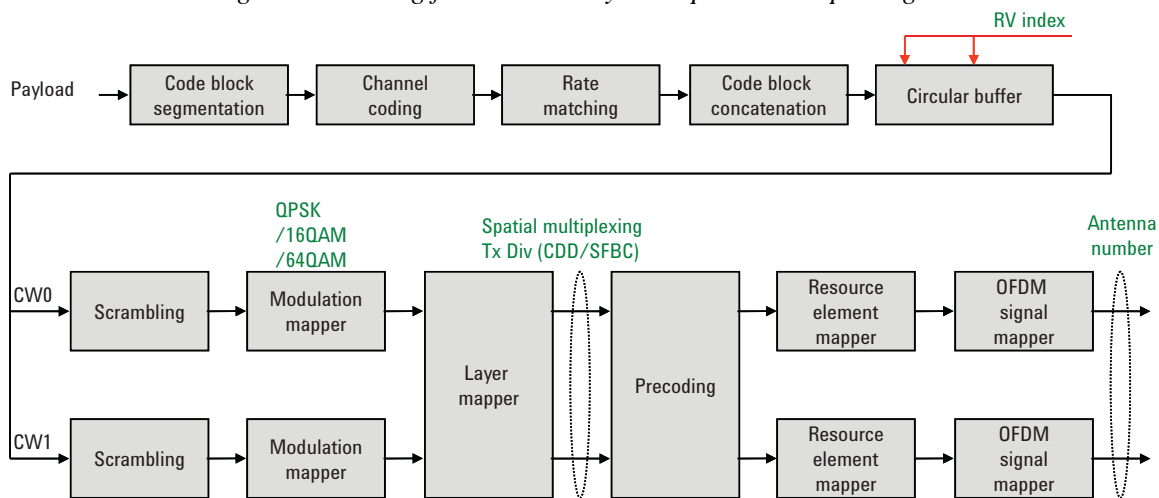
LTE Downlink Multiple Antenna Schemes

For the LTE downlink, three of the multiple antenna schemes previously described are supported: Tx diversity (MISO), Rx diversity (SIMO), and spatial multiplexing (MIMO). The first and simplest downlink LTE multiple antenna scheme is open-loop

Tx diversity. It is identical in concept to the scheme introduced in UMTS Release 99. The more complex, closed-loop Tx diversity techniques from UMTS have not been adopted in LTE, which instead uses the more advanced MIMO, which was not part of Release 99. LTE supports either two or four antennas for Tx diversity. Figure 4-24 shows a two Tx example in which a single stream of data is assigned to the different layers and coded using space-frequency block coding (SFBC). Since this form of Tx diversity has no data rate gain, the code words CW0 and CW1 are the same. SFBC achieves robustness through frequency diversity by using different subcarriers for the repeated data on each antenna.

The second downlink scheme, Rx diversity, is mandatory for the UE. It is the baseline receiver capability for which performance requirements will be defined. A typical use of Rx diversity is maximum ratio combining of the received streams to improve the SNR in poor conditions. Rx diversity provides little gain in good conditions.

Figure 4-24 Signal Processing for Tx Diversity and Spatial Multiplexing



The third downlink scheme is spatial multiplexing, or MIMO, which is also supported for two and four antenna configurations. Assuming a two-channel UE receiver, this scheme allows for 2x2 or 4x2 MIMO. A four-channel UE receiver, which is required for a 4x4 configuration, has been defined but is not likely to be implemented in the near future. The most common configuration will be 2x2 SU-MIMO. In this case the payload data will be divided into the two code-word streams CW0 and CW1 and processed according to the steps in Figure 4-24.

Depending on the pre-coding used, each code word is represented at different powers and phases on both antennas. In addition, each antenna is uniquely identified by the position of the reference signals within the frame structure. This process is described later. LTE uses the closed loop form of MIMO with pre-coding of the streams, so for the FDD case the transmitter must have knowledge of the channel. Channel information is provided by the UE on the uplink control channel. The channel feedback uses a codebook approach to provide an index into a predetermined set of pre-coding matrices. Since the channel is continually changing, this information will be provided for multiple points across the channel bandwidth, at regular intervals, up to several hundred times a second. At the time of writing, the exact details are still to

be specified. However, the UE that can best estimate the channel conditions and then signal the best coding to use will get the best performance out of the channel. Although the use of a codebook for pre-coding limits the best fit to the channel, it significantly simplifies the channel estimation process by the UE and the amount of uplink signaling needed to convey the desired pre-coding.

The pre-coding matrices for LTE support both MIMO and beamforming. There are four codebook entries for 2x2 SU-MIMO and 16 for 4x4 SU-MIMO.

In addition to MIMO pre-coding there is an additional option called cyclic delay diversity (CDD). This technique adds antenna-specific cyclic time shifts to artificially create multi-path on the received signal and prevents signal cancellation caused by the close spacing of the transmit antennas. Normally multipath would be considered undesirable, but by creating artificial multi-path in an otherwise flat channel, the eNB UE scheduler can choose to transmit on those RBs that have favorable propagation conditions. The CDD system works by adding the delay only to the data subcarriers while leaving the RS subcarriers alone. The UE uses the flat RS subcarriers to report the received channel flatness and the eNB schedules the UE to use the RB that it knows will benefit from the artificially induced frequency un-flatness. By not applying the CDD to the RS, the eNB can choose to apply the CDD on a per-UE basis.

When the CDD is enabled there is a choice of small or large delay. The large delay is approximately half a symbol, which creates significant ripple in the channel, whereas the small delay is defined by channel bandwidth and varies from 65 ns for the 20 MHz channel to just over 1 μ s for the 1.4 MHz channel. For the widest channels using the small delay will be a challenge because the required time shift is very close to the limits of antenna timing calibration. It is possible to apply a small delay CDD to the entire cell, including the RS. Doing so would make the CDD transparent to the UE but worsen the performance of channel quality indicator (CQI) reporting for those UE that would otherwise provide frequency-selective CQI reports.

LTE Uplink Multiple Antenna Schemes

The baseline configuration of the UE has one transmitter. This configuration was chosen to save cost and battery power, and with this configuration the system can support MU-MIMO—that is, two different UE transmitting in the same frequency and time to the eNB. This configuration has the potential to double uplink capacity (in ideal conditions) without incurring extra cost to the UE.

An optional configuration of the UE is a second transmit antenna, which allows the possibility of uplink Tx diversity and SU-MIMO. The latter offers the possibility of increased data rates depending on the channel conditions. For the eNB, receive diversity is a baseline capability and the system will support either two or four receive antennas.

Capturing Signals for Measurement

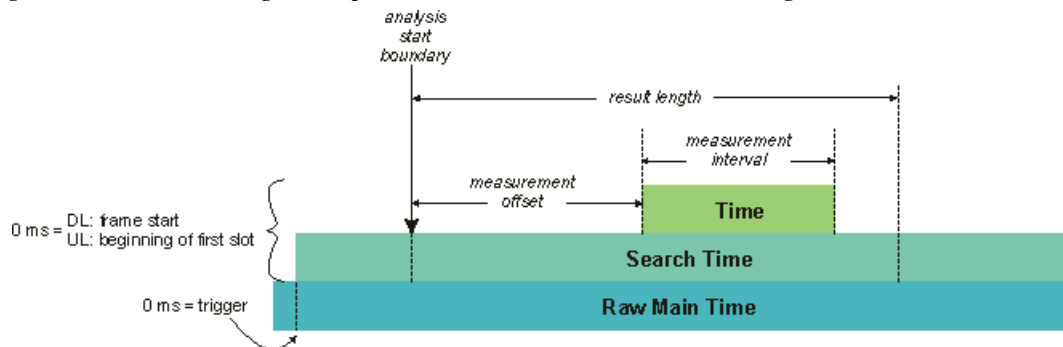
An analyzer performing vector signal analysis is not a real-time receiver but rather is a block-mode receiver. It captures a time record, and processes and displays the result before capturing the next block of data. Typically the processing and analysis time is longer than the capture time so there may be a gap between the end of one time record and the beginning of the next. Those gaps in time imply that the analyzer is not a real-time processor. This also applies to an analyzer that is configured to trigger on an event such as the change in the amplitude at the beginning of a burst. It may take the analyzer longer to process the current record than the time it takes for the next trigger event to occur.

Here again, the analyzer is not operating in real-time. Fortunately, vector signal analyzers provide a way to get real-time measurements for a limited length of time by using a time capture or recording of the input waveform. Time capturing allows the storage of complete time records with no time gaps produced in the record. The time capture is performed prior to data processing and once the waveform is captured, the signal is played back for analysis.

The signal analyzer captures the time record directly from the measurement hardware and stores the record in memory for immediate analysis or future use. Capturing the time record has the added benefit that the same signal can be analyzed over many different combinations of instrument settings including all the time and frequency measurements discussed in this section. One benefit of starting with a good set of vector measurements is the ability to choose a time capture length that is long enough for complete analysis, but not so long as to cause slow transfer due to excessively large capture files.

Figure 4-25

Signal Capture and Measurement Interval Diagram



Measurement time-related parameters include:

- **Result Length:** Determines the signal capture length. This is the data used by the analyzer for demodulation and signal analysis.

Analysis Start Boundary: This specifies the boundary at which the Result Length must start. For DL signals, you can choose to begin at the frame, half-frame, subframe or slot boundary. For UL signals, only the slot boundary start position is available. This is because there are no sync channels for the UL signal, so it is difficult to automatically determine frame and sub-frame boundaries.

Measurement Interval: Determines the time length of Result Length data that is used for computing and displaying the trace data results.

Measurement Offset: Determines the start position of the Measurement Interval within the Result Length.

Finding Frames and Triggering Measurements

When first examining the pulsed characteristics of the LTE signal, it is often necessary to adjust the time record length in order to see the entire frame or several frames within the waveform display.

A time-domain display using a large number of points and showing one to two frames can be used to measure the subframe lengths and transition gaps.

Triggering the analyzer at specific time intervals within the LTE waveform will require setting the trigger type and magnitude level. Once the analyzer is properly triggered, analysis of different parts within the waveform can then be made using the trigger delay function of the instrument.

Finding the Trigger Level

The trigger level is typically set (in linear voltage units) to a percentage of the total signal range. One way to determine this level, prior to triggering, is to examine the time domain waveform in a linear power format. A level setting that is 10 to 50 percent of the approximate voltage maximum is a good start for bursted signals. This assumes that the voltage is close to zero during the “off” times in the waveform.

Introducing a Trigger Delay

Trigger delay allows detailed measurements of specific parts of the signal. If trigger delay is zero, the analyzer takes data immediately after the trigger conditions are satisfied and then processes the results. If a trigger delay is positive (this is called a “post-trigger delay”) the analyzer waits through the duration of the delay before data is acquired. The post-trigger delay allows the analyzer to begin the measurement at any time into the waveform, for example, at the beginning of the first uplink frame. A trigger delay that is negative, which is called a “pre-trigger delay”, allows measurement of the rising edge of the RF burst including any transient effect that may occur prior to the trigger.

Stabilizing the displayed measurement using the trigger functions allows you to verify and troubleshoot the OFDMA signal using time and frequency domain analysis. For example, by measuring signal level changes such as amplitude droop in the time domain or flatness and ripple effects in the frequency domain, you may uncover thermal problems in the amplifiers power stages or improper analog or digital filtering respectively. Unexpected frequency tilt and poor center frequency accuracy may be the result of poor component or synthesizer performance. Turn on and turn-off transients may create demodulation errors in the LTE receiver.

These may seem like very basic measurements, but a significant number of system problems can be traced to these behaviors. Such problems may come from analog or digital circuits, or interactions between them. Linking time and frequency measurements with proper triggering can provide a high level of confidence in the signal quality before digital demodulation takes place.

Time Gating Concepts

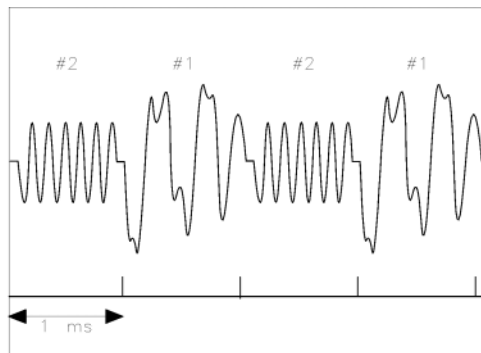
Introduction: Using Time Gating on a Simplified Digital Radio Signal

This section shows you the concepts of using time gating on a simplified digital radio signal. The section on Making Time-Gated Measurements demonstrates time gating examples.

Figure 4-26 shows a signal with two radios, radio 1 and radio 2, that are time-sharing a single frequency channel. Radio 1 transmits for 1 ms then radio 2 transmits for 1 ms.

Figure 4-26

Simplified Digital Mobile-Radio Signal in Time Domain



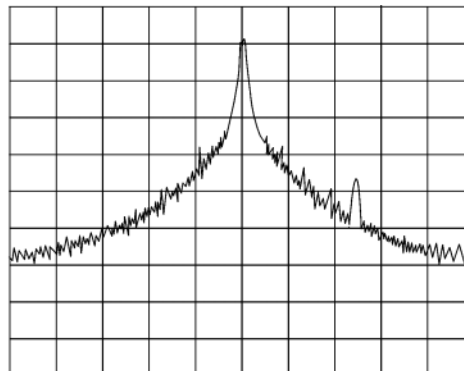
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We want to measure the unique frequency spectrum of each transmitter.

A signal analyzer without time gating cannot do this. By the time the signal analyzer has completed its measurement sweep, which lasts about 50 ms, the radio transmissions switch back and forth 25 times. Because the radios are both transmitting at the same frequency, their frequency spectra overlap, as shown in Figure 4-27. The signal analyzer shows the combined spectrum; you cannot tell which part of the spectrum results from which signal.

Figure 4-27

Frequency Spectra of the Combined Radio Signals



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Time gating allows you to see the separate spectrum of radio 1 or radio 2 to determine the source of the spurious signal, as shown in [Figure 4-28](#)

Figure 4-28

Time-Gated Spectrum of Radio 1

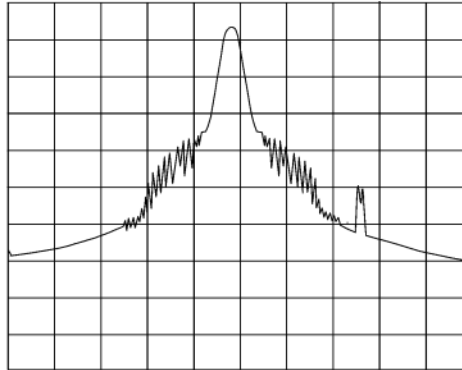
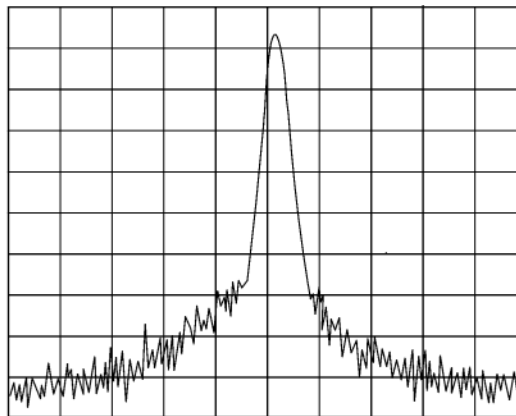


Figure 4-29

Time-Gated Spectrum of Radio 2



Time gating lets you define a time window (or time gate) of when a measurement is performed. This lets you specify the part of a signal that you want to measure, and exclude or mask other signals that might interfere.

How Time Gating Works

Time gating is achieved by the signal analyzer selectively interrupting the path of the detected signal, with a gate, as shown in Figure 4-32 and Figure 4-31. The gate determines the times at which it captures measurement data (when the gate is turned “on,” under the Gate menu, the signal is being passed, otherwise when the gate is “off,” the signal is being blocked). Under the right conditions, the only signals that the analyzer measures are those present at the input to the analyzer when the gate is on. With the correct signal analyzer settings, all other signals are masked out.

There are typically two main types of gating conditions, **edge** and **level**:

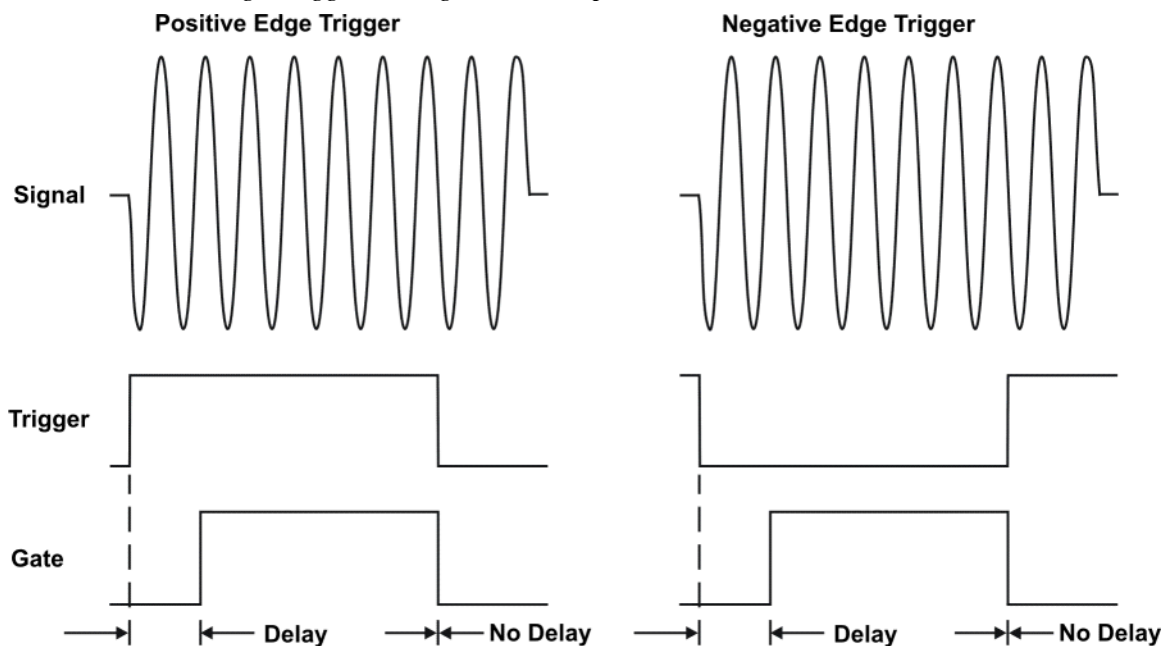
- With edge gating, the gate timing is controlled by user parameters (gate delay and gate length) following the selected (rising or falling) edge of the trigger signal. The gate passes a signal on the edge of the trigger signal (after the gate delay time has been met) and blocks the signal at the end of the gate length.

With edge gating, the gate control signal is usually an external periodic TTL signal that rises and falls in synchronization with the rise and fall of the pulsed radio signal. The gate delay is the time the analyzer waits after the trigger event to enable the gate (see Figure 4-30).

- With level gating, the gate will pass a signal when the gate signal meets the specified level (high or low). The gate blocks the signal when the level conditions are no longer satisfied (level gating does not use gate length or gate delay parameters).

Figure 4-30

Edge Trigger Timing Relationships



With Keysight signal analyzers, there are three different implementations for time gating: gated LO, gated video and gated FFT.

Gated Video Concepts

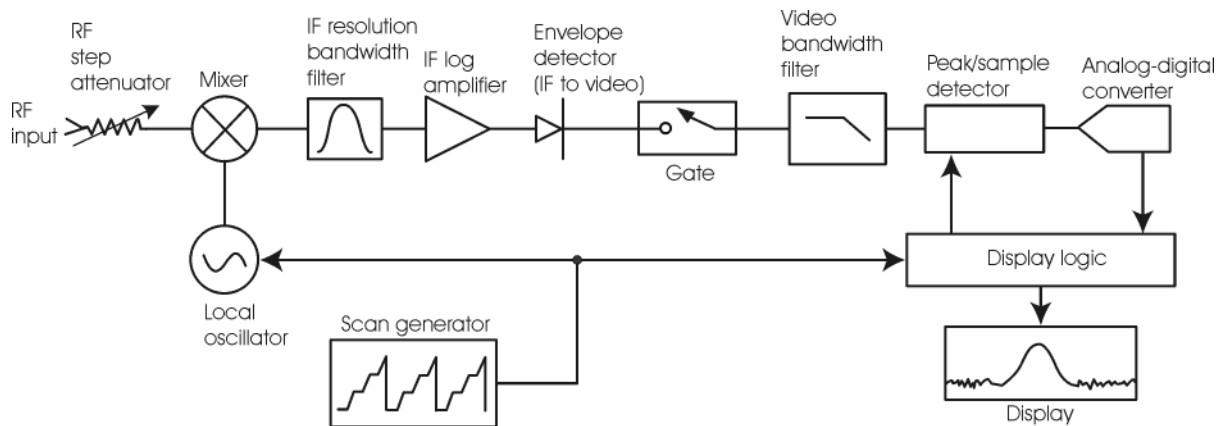
Gated video may be thought of as a simple gate switch, which connects the signal to the input of the signal analyzer. When the gate is “on” (under the Gate menu) the gate is passing a signal. When the gate is “off,” the gate is blocking the signal. Whenever the gate is passing a signal, the analyzer sees the signal. In [Figure 4-31](#) notice that the gate is placed after the envelope detector and before the video bandwidth filter in the IF path (hence “gated video”).

The RF section of the signal analyzer responds to the signal. The selective gating occurs before the video processing. This means that there are some limitations on the gate settings because of signal response times in the RF signal path.

With video gating the analyzer is continually sweeping, independent of the position and length of the gate. The analyzer must be swept at a minimum sweep time (see the sweep time calculations later in this chapter) to capture the signal when the gate is passing a signal. Because of this, video gating is typically slower than gated LO and gated FFT.

Figure 4-31

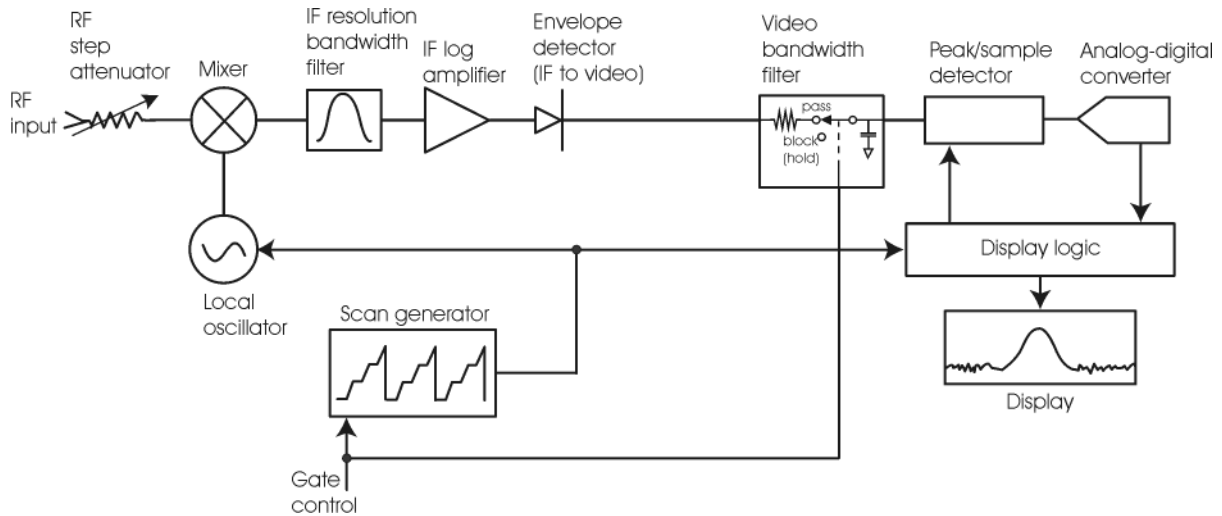
Gated Video Signal Analyzer Block Diagram



Gated LO Concepts

Gated LO is a very sophisticated type of time gating that sweeps the LO only while the gate is “on” and the gate is passing a signal. See [Figure 4-32](#) for a simplified block diagram of gated LO operation. Notice that the gate control signal controls when the scan generator is sweeping and when the gate passes or blocks a signal. This allows the analyzer to sweep only during the periods when the gate passes a signal. Gated LO is faster than Gated Video because Gated Video must constrain sweep time so that each point is long enough to include a burst event. On the other hand, when in Gated LO, multiple points may be swept during each gate.

Figure 4-32 Gated LO Signal Analyzer Block Diagram



Gated FFT Concepts

Gated FFT (Fast-Fourier Transform) is an FFT measurement which begins when the trigger conditions are satisfied.

The process of making a spectrum measurement with FFTs is inherently a “gated” process, in that the spectrum is computed from a time record of short duration, much like a gate signal in swept-gated analysis.

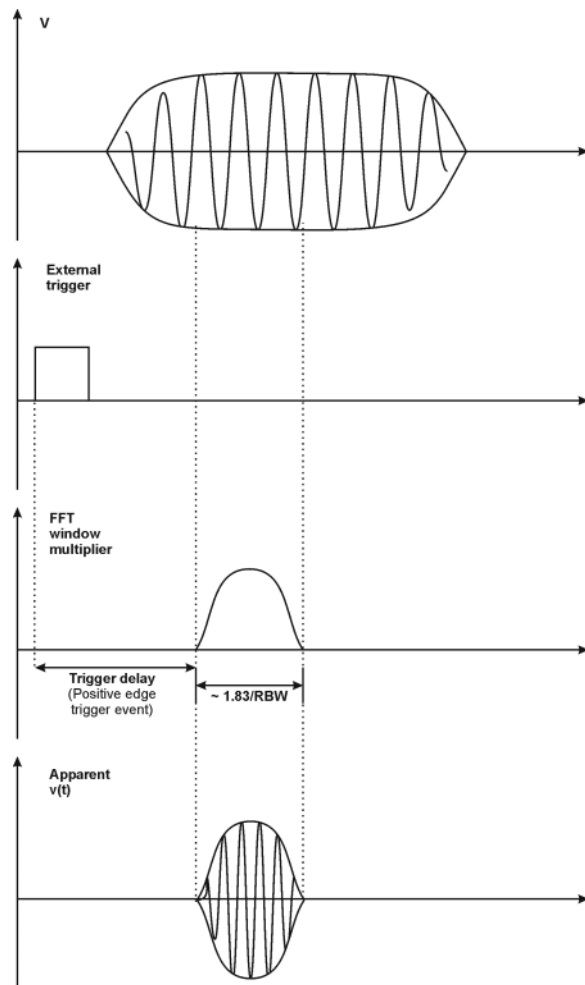
Using the analyzer in FFT mode, the duration of the time record to be gated is:

$$FFT \text{ Time Record (to be gated)} = \frac{1.83}{RBW}$$

The duration of the time record is within a tolerance of approximately 3% for resolution bandwidths up through 1 MHz. Unlike swept gated analysis, the duration of the analysis in gated FFT is fixed by the RBW, not by the gate signal. Because FFT analysis is faster than swept analysis (up to 7.99 MHz), the gated FFT measurements can have better frequency resolution (a narrower RBW) than swept analysis for a given duration of the signal to be analyzed.

Figure 4-33

Gated FFT Timing Diagram



Time Gating Basics (Gated LO and Gated Video)

The gate passes or blocks a signal with the following conditions:

- Trigger condition - Usually an external transistor-transistor logic (TTL) periodic signal for edge triggering and a high/low TTL signal for level triggering.
- Gate delay - The time after the trigger condition is met when the gate begins to pass a signal.
- Gate length - The gate length setting determines the length of time a gate begins to pass a signal.

To understand time gating better, consider a spectrum measurement performed on two pulsed-RF signals sharing the same frequency spectrum. You will need to consider the timing interaction of three signals with this example:

- The composite of the two pulsed-RF signals.
- The gate trigger signal (a periodic TTL level signal).

- The gate signal. This TTL signal is low when the gate is “off” (blocking) and high when the gate is “on” (passing).

The timing interactions between the three signals are best understood if you observe them in the time domain (see [Figure 4-34](#)).

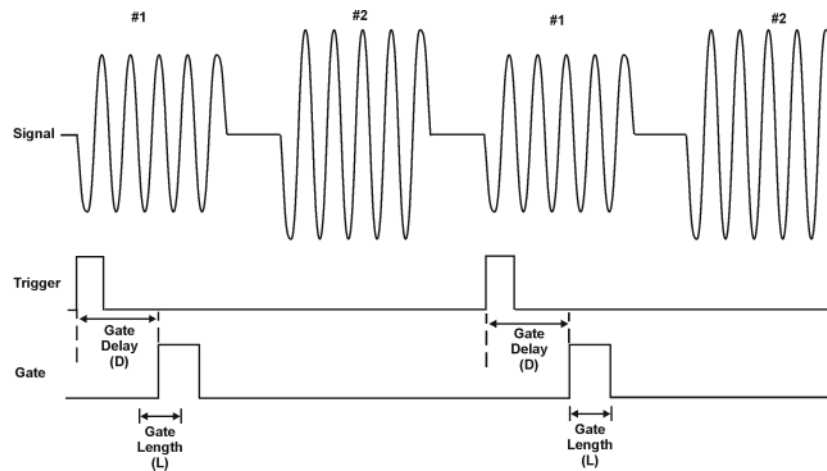
The main goal is to measure the spectrum of signal 1 and determine if it has any low-level modulation or spurious signals.

Because the pulse trains of signal 1 and signal 2 have almost the same carrier frequency, their spectra overlap. Signal 2 will dominate in the frequency domain due to its greater amplitude. Without gating, you won't see the spectrum of signal 1; it is masked by signal 2.

To measure signal 1, the gate must be on only during the pulses from signal 1. The gate will be off at all other times, thus excluding all other signals. To position the gate, set the gate delay and gate length, as shown in [Figure 4-34](#), so that the gate is on only during some central part of the pulse. Carefully avoid positioning the gate over the rising or falling pulse edges. When gating is activated, the gate output signal will indicate actual gate position in time, as shown in the line labeled “Gate.”

Figure 4-34

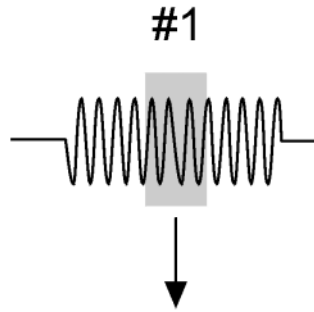
Timing Relationship of Signals During Gating



Once the signal analyzer is set up to perform the gate measurement, the spectrum of signal 1 is visible and the spectrum of signal 2 is excluded, as shown in [Figure 4-36](#). In addition, when viewing signal 1, you also will have eliminated the pulse spectrum generated from the pulse edges. Gating has allowed you to view spectral components that otherwise would be hidden.

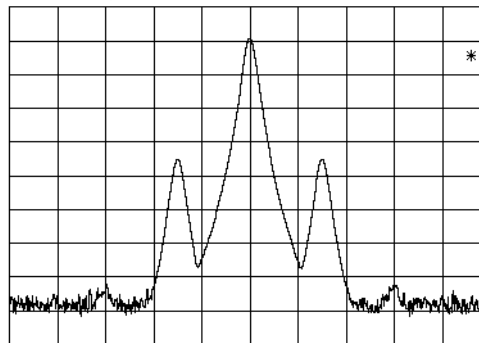
Concepts
Time Gating Concepts

Figure 4-35 Signal within pulse #1 (time-domain view)



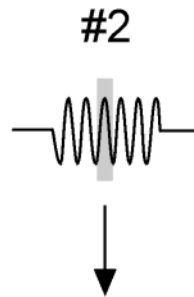
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Figure 4-36 Using Time Gating to View Signal 1 (spectrum view)



Moving the gate so that it is positioned over the middle of signal 2 produces a result as shown in [Figure 4-38](#). Here, you see only the spectrum within the pulses of signal 2; signal 1 is excluded.

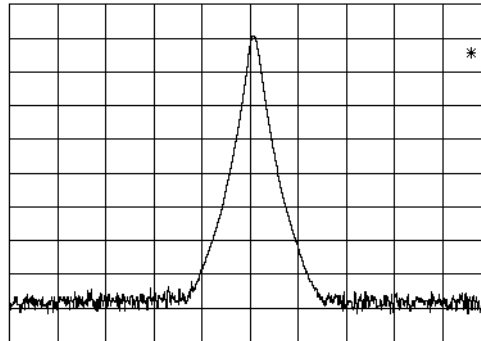
Figure 4-37 Signal within pulse #2 (time-domain view)



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Figure 4-38

Using Time Gating to View Signal 2 (spectrum view)



Measuring a Complex/Unknown Signal

NOTE

The steps below help to determine the signal analyzer settings when using time gating. The steps apply to the time gating approaches using gated LO and gated video.

This example shows you how to use time gating to measure a very specific signal. Most signals requiring time gating are fairly complex and in some cases extra steps may be required to perform a measurement.

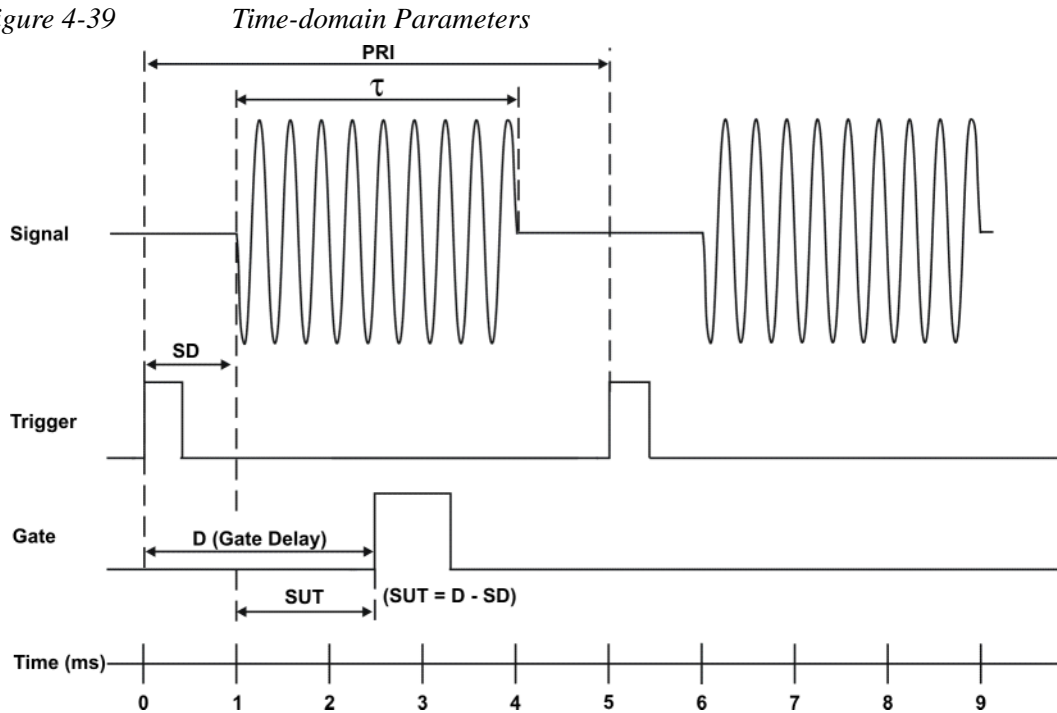
Step 1. Determine how your signal under test appears in the time domain and how it is synchronized to the trigger signal.

You need to do this to position the time gate by setting the delay relative to the trigger signal. To set the delay, you need to know the timing relationship between the trigger and the signal under test. Unless you already have a good idea of how the two signals look in the time domain, you can examine the signals with an oscilloscope to determine the following parameters:

- Trigger type (edge or level triggering)
- Pulse repetition interval (PRI), which is the length of time between trigger events (the trigger period).
- Pulse width, or τ
- Signal delay (SD), which is the length of time occurring between the trigger event and when the signal is present and stable. If your trigger occurs at the same time as the signal, signal delay will be zero.

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Figure 4-39



In Figure 4-39, the parameters are:

- Pulse repetition interval (PRI) is 5 ms.
- Pulse width (τ) is 3 ms.
- Signal delay (SD) is 1 ms for positive edge trigger (0.6 ms for negative edge trigger).
- Gate delay (D) is 2.5 ms.
- Setup time (SUT) is 1.5 ms.

Step 2. Set the signal analyzer sweep time:

Gated LO: Sweep time does not affect the results of gated LO unless the sweep time is set too fast. In the event the sweep time is set too fast, Meas Uncal appears on the screen and the sweep time will need to be increased.

Gated Video: Sweep time does affect the results from gated video. The sweep time must be set accordingly for correct time gating results. The recommended sweep time is at least the number of **sweep points - 1** multiplied by the **PRI (pulse repetition interval)**. Measurements can be made with sweep times as fast as $(\text{sweep points} - 1) * (\text{PRI} - \tau)$.

Step 3. Locate the signal under test on the display of the signal analyzer. Set the center frequency and span to view the signal characteristics that you are interested in measuring. Although the analyzer is not yet configured for correct gated measurements, you will want to determine the approximate frequency and span in

which to display the signal of interest. If the signal is erratic or intermittent, you may want to hold the maximum value of the signal with **Max Hold** (located under the **Trace/Detector** menu) to determine the frequency of peak energy.

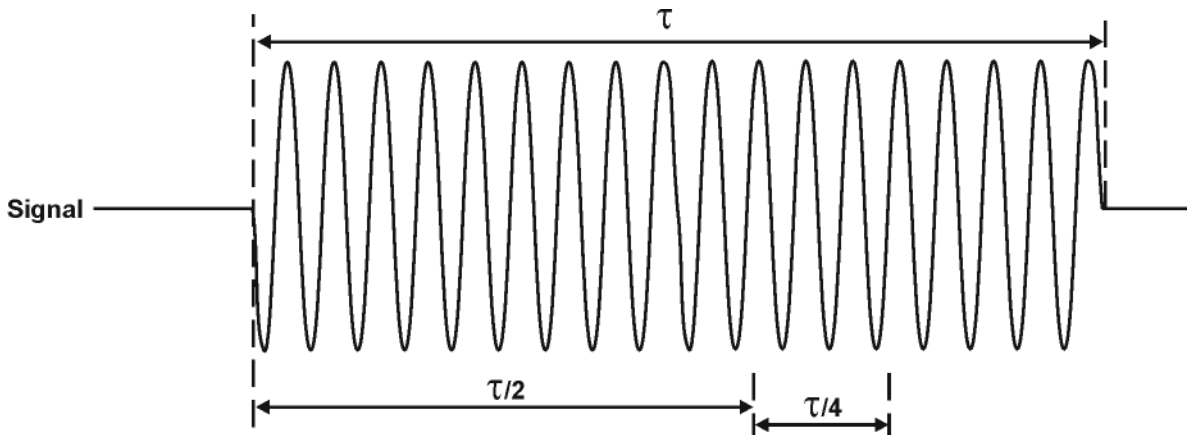
To optimize measurement speed in the Gated LO case, set the span narrow enough so that the display will still show the signal characteristics you want to measure. For example, if you wanted to look for spurious signals within a 200 kHz frequency range, you might set the frequency span to just over 200 kHz.

Step 4. Determine the setup time and signal delay to set up the gate signal. Turn on the gate and adjust the gate parameters including gate delay and gate length as shown below.

Generally, the gate should be positioned over a part of the signal that is stable, not over a pulse edge or other transition that might disturb the spectrum. Starting the gate at the center of the pulse gives a setup time of about half the pulse width. Setup time describes the length of time during which that signal is present and stable before the gate comes on. The setup time (SUT) must be long enough for the RBW filters to settle following the burst-on transients. Signal delay (SD) is the length of time after the trigger, but before the signal of interest occurs and becomes stable. If the trigger occurs simultaneously with the signal of interest, SD is equal to zero, and SUT is equal to the gate delay. Otherwise, SUT is equal to the gate delay minus SD. See [Figure 4-40](#)

Figure 4-40

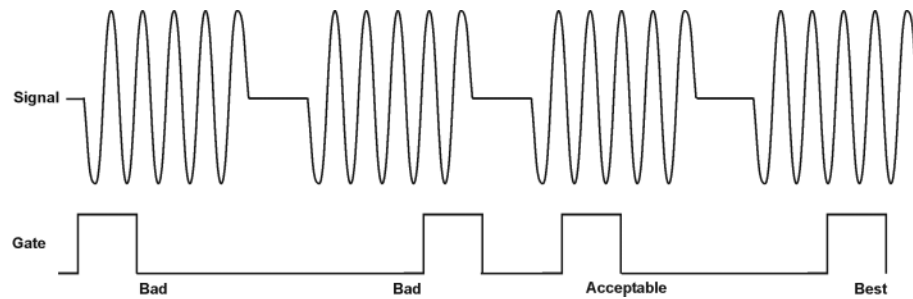
Positioning the Gate



There is flexibility in positioning the gate, but some positions offer a wider choice of resolution bandwidths. A good rule of thumb is to position the gate from 20 % to 90 % of the burst width. Doing so provides a reasonable compromise between setup time and gate length.

Figure 4-41

Best Position for Gate



As a general rule, you will obtain the best measurement results if you position the gate relatively late within the signal of interest, but without extending the gate over the trailing pulse edge or signal transition. Doing so maximizes setup time and provides the resolution bandwidth filters of the signal analyzer the most time to settle before a gated measurement is made. “Relatively late,” in this case, means allowing a setup time of at least $3.84/\text{resolution bandwidth}$ (see [step 5](#) for RBW calculations).

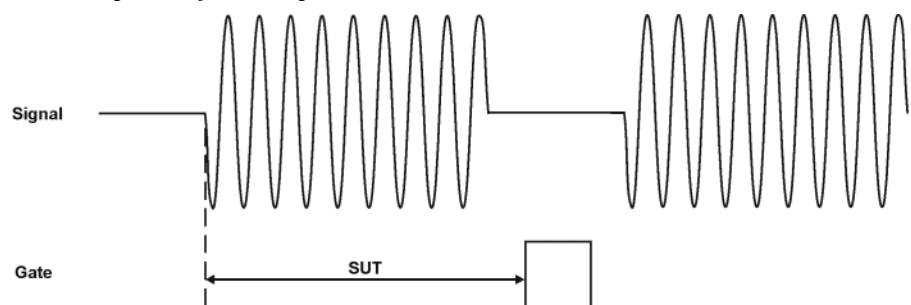
As an example, if you want to use a 1 kHz resolution bandwidth for measurements, you will need to allow a setup time of at least 3.84 ms.

Note that the signal need not be an RF pulse. It could be simply a particular period of modulation in a signal that is continuously operating at full power, or it could even be during the off time between pulses. Depending on your specific application, adjust the gate position to allow for progressively longer setup times (ensuring that the gate is not left on over another signal change such as a pulse edge or transient), and select the gate delay and length that offer the best representation of the signal characteristics of interest on the display.

If you were measuring the spectrum occurring between pulses, you should use the same (or longer) setup time after the pulse goes away, but before the gate goes on. This lets the resolution bandwidth filters fully discharge the large pulse before the measurement is made on the low-level interpulse signal.

Figure 4-42

Setup Time for Interpulse Measurement



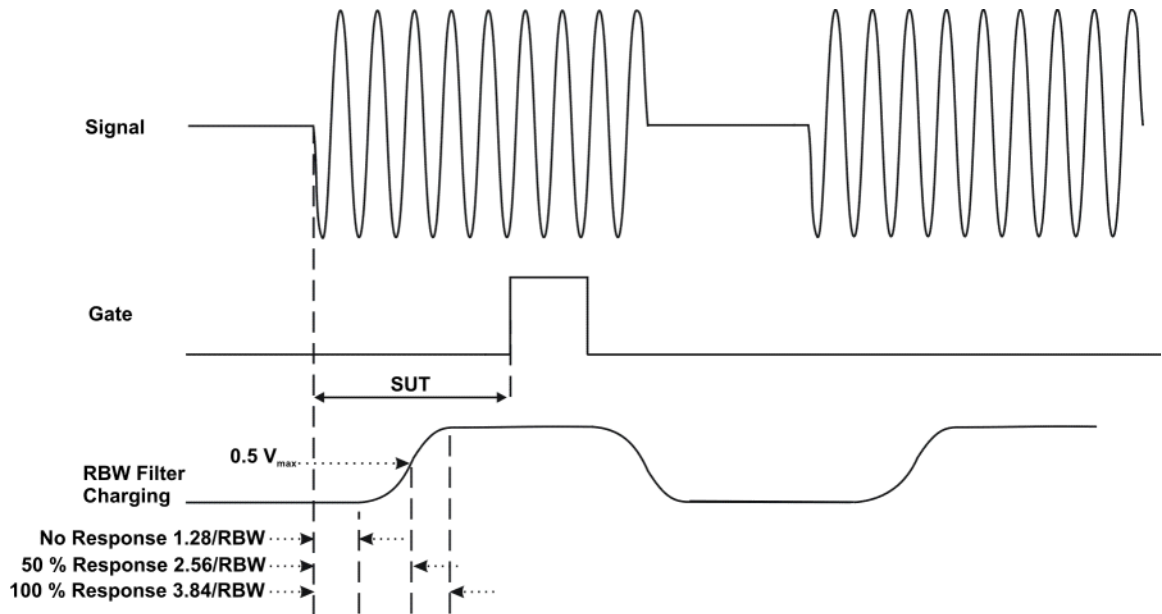
Step 5. The resolution bandwidth will need to be adjusted for gated LO and gated video. The video bandwidth will only need to be adjusted for gated video.

Resolution Bandwidth:

The resolution bandwidth you can choose is determined by the gate position, so you can trade off longer setup times for narrower resolution bandwidths. This trade-off is due to the time required for the resolution-bandwidth filters to fully charge before the gate comes on. Setup time, as mentioned, is the length of time that the signal is present and stable before the gate comes on.

Figure 4-43

Resolution Bandwidth Filter Charge-Up Effects



Because the resolution-bandwidth filters are band-limited devices, they require a finite amount of time to react to changing conditions. Specifically, the filters take time to charge fully after the analyzer is exposed to a pulsed signal.

Because setup time should be greater than filter charge times, be sure that:

$$SUT > \frac{3.84}{RBW}$$

where SUT is the same as the gate delay in this example. In this example with SUT equal to 1.5 ms, RBW is greater than 2.56 kHz; that is, RBW is greater than 1333 Hz. The resolution bandwidth should be set to the next larger value, 2.7 kHz.

Video Bandwidth:

For gated LO measurements the VBW filter acts as a track-and-hold between sweep times. With this behavior, the VBW does not need to resettle on each restart of the sweep.

Step 6. Adjust span as necessary, and perform your measurement.

The analyzer is set up to perform accurate measurements. Freeze the trace data by activating single sweep, or by placing your active trace in view mode. Use the markers to measure the signal parameters you chose in step 1. If necessary, adjust span, but do not decrease resolution bandwidth, video bandwidth, or sweep time.

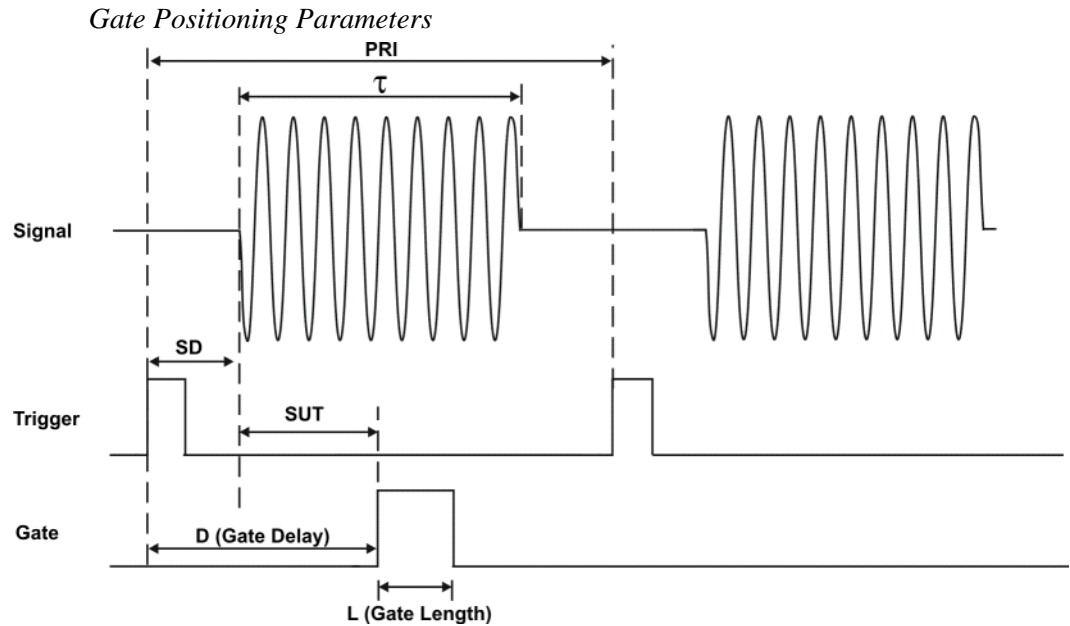
“Quick Rules” for Making Time-Gated Measurements

This section summarizes the rules described in the previous sections.

Table 4-11 *Determining Signal Analyzer Settings for Viewing a Pulsed RF Signal*

Signal Analyzer Function	Signal Analyzer Setting	Comments
Sweep Time (gated video only)	Set the sweep time to be equal to or greater than (number of sweep points - 1) × pulse repetition interval (PRI):	Because the gate must be on at least once per trace point, the sweep time should be set such that the sweep time for each trace point is greater than or equal to the pulse repetition interval.
Gate Delay	The gate delay is equal to the signal delay plus one-fourth the pulse width: Gate Delay = Signal Delay + $\tau/5$	The gate delay must be set so that the gating captures the pulse. If the gate delay is too short or too long, the gating can miss the pulse or include resolution bandwidth transient responses.
Gate Length	The gate length minimum is equal to one-fourth the pulse width (maximum about one-half): Gate Length = $0.7 \times \tau/4$	If the gate length is too long, the signal display can include transients caused by the signal analyzer filters. The recommendation for gate placement can be between 20 % to 90 % of the pulse width.
Resolution Bandwidth	Set the resolution bandwidth: $RBW > 19.5/\tau$	The resolution bandwidth must be wide enough so that the charging time for the resolution bandwidth filters is less than the pulse width of the signal.

Figure 4-44



Most control settings are determined by two key parameters of the signal under test: the pulse repetition interval (PRI) and the pulse width (τ). If you know these parameters, you can begin by picking some standard settings. [Table 4-12](#) summarizes the parameters for a signal whose trigger event occurs at the same time as the beginning of the pulse (in other words, SD is 0). If your signal has a non-zero delay, just add it to the recommended gate delay.

Table 4-12

Suggested Initial Settings for Known Pulse Width (τ) and Zero Signal Delay

Pulse width (τ)	Gate Delay ($SD + \tau/5$)	Resolution Band width ($>19.5/\tau$)	Gate Length ($0.7 \times \tau/4$)
4 μ s	0.8 μ s	4.875 MHz	0.7 μ s
10 μ s	2 μ s	1.95 MHz	1.753 μ s
50 μ s	10 μ s	390 kHz	8.75 μ s
63.5 μ s	12.7 μ s	307 kHz	11.11 μ s
100 μ s	20 μ s	195 kHz	17.5 μ s
500 μ s	100 μ s	39 kHz	87.5 μ s
1 ms	200 μ s	19.5 kHz	0.175 ms
5 ms	1 ms	3.9 kHz	0.875 ms
10 ms	2 ms	1.95 kHz	1.75 ms
16.6 ms	3.32 ms	1.175 kHz	2.905 ms
33 ms	6.6 ms	591 Hz	5.775 ms

Concepts
Time Gating Concepts

Table 4-12

Suggested Initial Settings for Known Pulse Width (τ) and Zero Signal Delay

Pulse width (τ)	Gate Delay ($SD + \tau/5$)	Resolution Band width ($>19.5/\tau$)	Gate Length ($0.7 \times \tau/4$)
50 ms	10 ms	390 Hz	8.75 ms
100 ms	20 ms	195 Hz	17.5 ms
≥ 130 ms	26 ms	151 Hz	22.75 ms

Table 4-13

If You Have a Problem with the Time-Gated Measurement

Symptom	Possible Causes	Suggested Solution
Erratic analyzer trace with dropouts that are not removed by increasing analyzer sweep time; oscilloscope view of gate output signal jumps erratically in time domain.	Gate Delay may be greater than trigger repetition interval.	Reduce Gate Delay until it is less than trigger interval. Check Gate View to make sure the gate delay is timed properly.
Gate does not trigger.	1) Gate trigger voltage may be wrong. 2) Gate may not be activated. 3) Gate Source selection may be wrong.	With external gate trigger: ensure that the trigger threshold is set near the midpoint of the waveform (view the waveform on and oscilloscope using high input impedance, not 50 Ω). With RF Burst Gate Source: ensure that the start and stop frequencies are within 10 MHz of the center frequency of the carrier. Check to see if other connections to trigger signal may be reducing voltage. If using an oscilloscope, check that all inputs are high impedance, not 50 Ω .
Display spectrum does not change when the gate is turned on.	Insufficient setup time.	Increase setup time for the current resolution band width, or increase resolution band width.
Displayed spectrum too low in amplitude.	Resolution band width or video band width filters not charging fully.	Widen resolution band width or video band width, or both.

Using the Edge Mode or Level Mode for Triggering

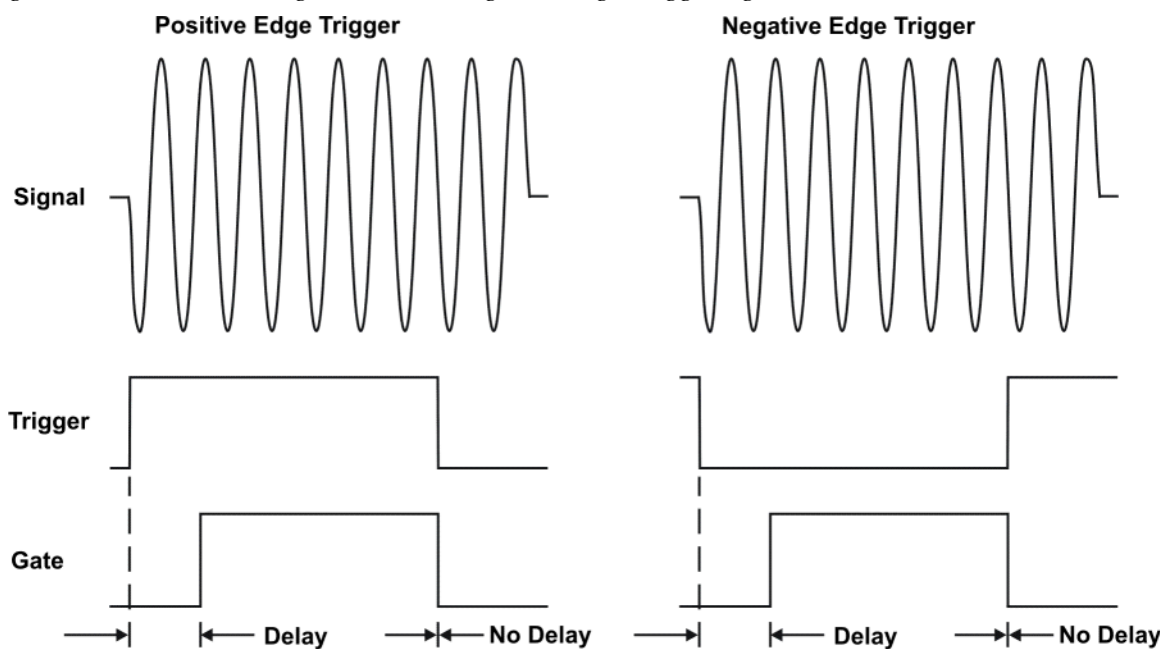
Depending on the trigger signal that you are working with, you can trigger the gate in one of two separate modes: edge or level. This gate-trigger function is separate from the normal external trigger capability of the signal analyzer, which initiates a sweep of a measurement trace based on an external signal.

Edge Mode

Edge mode lets you position the gate relative to either the rising or falling edge of a trigger signal. The left diagram of Figure 4-45 shows triggering on the positive edge of the trigger signal while the right diagram shows negative edge triggering.

Example of key presses to initiate positive edge triggering:
Press **Sweep, Gate, More, Polarity (Pos)**.

Figure 4-45 Using Positive or Negative Edge Triggering



Level Mode

In level gate-control mode, an external trigger signal opens and closes the gate. Either the TTL high level or TTL low level opens the gate, depending on the setting of **Trig Slope**. Gate delay affects the start of the gate but not the end. Gate length is applicable when using level mode triggering. Level mode is useful when your trigger signal occurs at exactly the same time as does the portion of the signal you want to measure.

Noise Measurements Using Time Gating

Time gating can be used to measure many types of signals. Noise and noise-like signals are often a special case in spectrum analysis. With the history of gated measurements, these signals are especially noteworthy.

The average detector is the best detector to use for measuring noise-like signals because it uses all the available noise power all the time in its measurement. The sample detector is also a good choice because it, too, is free from the peak biases of the peak detector, normal and negative peak detectors.

When using the average or sample detector, noise density measurements using the noise marker or band/interval density marker can be made without any consideration of the use of gating--gated measurements work just as well as non-gated measurements. Thus, the average detector is recommended for noise density measurements.

Older analyzers only had the gated video version of gating available, and these only worked with the peak detector, so the rest of this section will discuss the trade-offs associated with trying to replicate these measurements with an MXA.

Unlike older analyzers, MXA can make competent measurements of noise density using the noise marker with all detectors, not just those that are ideal for noise measurements. Thus, MXA can make noise density measurements with peak detection, compensating for the extent to which peak detection increases the average response of the analyzer to noise. When comparing a gated video measurement using the noise marker between MXA and an older analyzer where both use the peak detector, the MXA answer will be approximately correct, while the older analyzer will need a correction factor. That correction factor is discussed in Keysight Technologies Application Note 1303, Spectrum Analyzer Measurements and Noise, in the section on Peak-detected Noise and TDMA ACP Measurements.

When making measurements of Band/Interval Power or Band/Interval Density, the analyzer does not make compensations for peak detection. For best measurements with these marker functions, average or sample detection should be used.

Measuring the Frequency Spectrum

The analyzer can perform spectrum analysis using either a scalar (also called “stepped FFT measurements”) or a vector measurement. Scalar measurements provide amplitude-only information over the full frequency range of the instrument. Vector measurements provide both phase and amplitude information over the processing bandwidth of the instrument.

Measuring the Wideband Spectrum

Analysis of an LTE signal typically starts with a wideband spectrum measurement. A wideband spectrum measurement is used to verify the center frequency, nominal signal bandwidth, amplitude level, and sidelobe level of the LTE signal. It is also an opportunity to verify the level of any spurs and other interference signals present in the frequency band that may cause errors during digital demodulation.

Verifying the spectral content is typically performed using a maximum-hold detection scheme. For peak amplitude and spurious measurements of the OFDM signal, the analyzer is configured with a large frequency span (perhaps using the scalar measurement mode) and max-hold averaging. Continuous peak-hold averaging is a measurement function used by the analyzer to measure and display the largest magnitude (determined over many measurements) for each frequency point in the span.

Measurement of low level spurious and interference signals should be performed using a Gaussian window, which provides the highest dynamic range in the measurement. The Gaussian window offers the lowest sidelobe level of any analyzer window at slightly reduced amplitude accuracy. Combining peak hold averaging and Gaussian windowing is ideal to ensure that no significant signals are missed either in the band or out.

Lastly, the analyzer’s input range must be correctly set in order to obtain accurate measurements. If the input range testing is too low (more sensitive than necessary), the analyzer’s analog-to-digital converter (ADC) circuitry is overloaded and introduces distortion into the measurement. If the range is set too high (less sensitive than necessary), there may be a loss of dynamic range due to additional noise. If the wideband spectrum for the LTE test signal is acceptable, the instrument can be re-configured for the next analysis step, which is a measurement of the narrowband spectrum.

Measuring the Narrowband Spectrum

For narrowband spectrum analysis of the LTE signal, the instrument’s frequency span should be set to approximately 1.1 times the nominal bandwidth of the signal. Alternately the span can be configured to match the bandwidth of a typical LTE front-end filter. Using a frequency span close to a typical receiver’s RF bandwidth allows the analyzer measurements to be performed with similar input noise and interference levels as would be seen in practice.

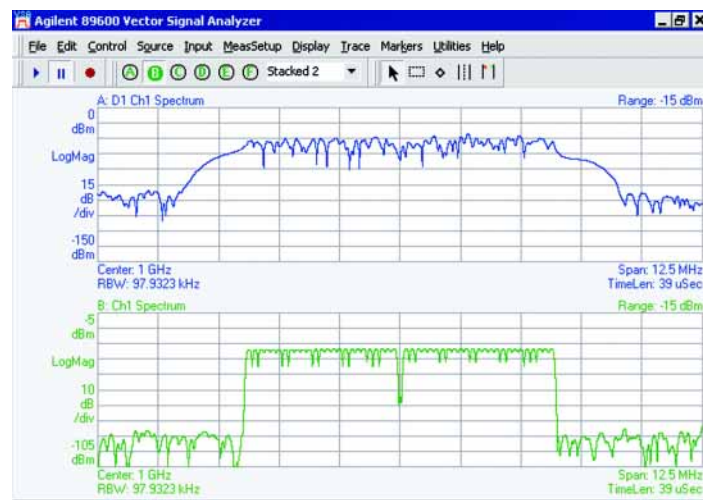
Narrowband measurements also provide improved frequency resolution and greater accuracy in setting the center frequency of the instrument or verifying the center frequency of the signal under test. The improved frequency resolution results from the inverse relationship between span and RBW. Accurate amplitude measurements of the LTE signal are required for system verification, troubleshooting and compliance with local regulations.

Amplitude measurements as a function of frequency for these noise-like signals should be performed using RMS (video) averaging and RMS detection. The detection mechanisms in the analyzer are always RMS. The analyzer calculates the frequency spectrum using a Fast Fourier Transform (FFT) that directly results in the true RMS power of the signal whether it is a single tone, noise, or any complex signal. RMS averaging produces a statistical approximation of the true power level over the measured time record(s), which includes on/off times and the transient effects of the bursted OFDM signal.

Time-variant signals such as LTE signals often require spectral analysis over a smaller portion of the entire waveform, for example, during a subframe. In this case, the measurement needs to be stabilized using the trigger control in the analyzer. Triggering the analyzer can easily be accomplished and the details will be provided in the next section. The importance of triggering for a time-variant waveform can be seen in [Figure 4-46 on page 207](#), which shows the difference between the spectrum of a OFDM signal when the instrument is not triggered (upper display) and when it is triggered (lower display). The sidelobe levels for the untriggered response rapidly change from individual measurement to measurement as the spectrum measurement is made on different parts of the time-variant waveform. In comparison, the triggered response maintains the spectral shape as the instrument is triggered at the beginning of each OFDM frame. Both measurements were made with the averaging disabled. Both measurements are accurate, but the change in trigger conditions changes the portion of the signal that is measured.

Figure 4-46

Frequency domain response of a OFDM signal without using an instrument trigger (upper trace) and using a trigger to set the beginning of the downlink frame (lower trace). (Example from the Keysight 89600).



LTE TDD Measurement Concepts

The following sections describe the purpose, measurement method for the LTE TDD measurements.

- “Channel Power Measurement Concepts” on page 209
- “Occupied Bandwidth Measurement Concepts” on page 210
- “Adjacent Channel Power (ACP) Measurement Concepts” on page 211
- “Power Statistics CCDF Measurement Concepts” on page 212
- “Spurious Emissions Measurement Concepts” on page 214
- “Spectrum Emission Mask Measurement Concepts” on page 215
- “Transmit On/Off Measurement Concepts” on page 216
- “LTE TDD Modulation Analysis Measurement Concepts” on page 217
- “IQ Waveform Measurement Concepts” on page 218
- “Monitor Spectrum (Frequency Domain) Measurement Concepts” on page 219
- “LTE TDD Conformance EVM Measurement Concepts” on page 220

Channel Power Measurement Concepts

Purpose

The Channel Power measurement is a common test used in the wireless industry to measure the total transmitted power of a radio within a defined frequency channel. This procedure measures the total power within the defined channel for LTE. This measurement is applied to design, characterize, evaluate, and verify transmitters and their components or devices for LTE uplink and downlink signals.

Measurement Method

The Channel Power measurement reports the total transmitted power and the calculated power spectral density within the integration bandwidth. It takes a sweep and the measurement acquires power in the channel.

The power calculation method used to determine the channel power is a traditional method known as the integration bandwidth (IBW) method. The measurement uses the frequency sweep mode, the RBW filter is set narrow relative to the desired integration bandwidth. You can change the RBW and VBW settings. It is important to correctly set the RBW before making this measurement, because if the RBW filter setting is too narrow the signal will be under-sampled and not all of the signal power will be measured. If the setting is too wide, it will reduce the accuracy of the Channel Power measurement.

To improve repeatability, you can increase the number of averages. The channel power graph is shown in the graph window, while the absolute channel power in dBm and the mean power spectral density in dBm/Hz are shown in the text window.

Because the signal under test is bursted, CHP measurements must be made in synchronized fashion with the burst timing in order to get a useful sample in the time domain during the “on” portion of the signal. This is accomplished using Time Gating (Gate ON). The sweep timing is synchronized with the signal when time gating is on. However, if the sweep time is too short, due to the synchronization, each measurement in the frequency domain can capture only the corresponding portion of the signal in time domain. In this case, an increase of the Avg Number will have no effect on the measurement deviation from one trace update to the next. To reduce this variation, the sweep time must be increased.

Occupied Bandwidth Measurement Concepts

Purpose

Occupied bandwidth measurements express the percentage of the transmitted power within a specified bandwidth. This percentage is typically 99%.

The spectrum shape of a LTE signal can give useful qualitative insight into transmitter operation. Any distortion to the spectrum shape can indicate problems in transmitter performance.

Measurement Method

The instrument uses sweep mode to capture the data and the total power within the measurement frequency span is integrated for its 100% of power. The frequencies of 0.5% of the total power are then calculated to get 99.0% bandwidth.

Because the signal under test is bursted, the measurement must be made in synchronized fashion with the burst timing in order to get a useful sample in the time domain during the “on” portion of the signal. This is accomplished using Time Gating (Gate ON).

Adjacent Channel Power (ACP) Measurement Concepts

Purpose

Adjacent Channel Power (ACP), as it applies to LTE, is the power contained in a specified frequency channel bandwidth relative to the total carrier power. It may also be expressed as a ratio of power spectral densities between the carrier and the specified offset frequency band.

As a composite measurement of out-of-channel emissions, ACP combines both in-band and out-of-band specifications to provide useful figures-of-merit for spectral regrowth and emissions produced by components and circuit blocks without the rigor of performing a full spectrum emissions mask measurement.

To maintain a quality call by avoiding channel interference, it is important to measure and reduce any adjacent channel leakage power transmitted from a mobile phone. The characteristics of adjacent channel leakage power are mainly determined by the transmitter design, particularly the low-pass filter.

Measurement Method

This ACP measurement analyzes the total power levels within the defined carrier bandwidth and at given frequency offsets on both sides of the carrier frequency. This measurement requires the user to specify measurement bandwidths of the carrier channel and each of the offset frequency pairs up to 5. Each pair may be defined with unique measurement bandwidths.

For Meas Method of RBW, it uses an appropriate RBW and capture all of the power in the carrier channel and the offsets. For Meas Method of integration bandwidth (IBW), the channel integration bandwidth is analyzed using the user defined resolution bandwidth (RBW), which is much narrower than the channel bandwidth. The measurement computes an average power of the channel over a specified number of data acquisitions, automatically compensating for resolution bandwidth and noise bandwidth.

If **Total Pwr Ref** is selected as the measurement type, the results are displayed as relative power in dBc and as absolute power in dBm. If **PSD Ref** (Power Spectral Density Reference) is selected, the results are displayed as relative power in dB, and as absolute power in dBm/Hz.

Because the signal under test is bursted, the measurement must be made in synchronized fashion with the burst timing in order to get a useful sample in the time domain during the “on” portion of the signal. This is accomplished using Time Gating (Gate ON).

Power Statistics CCDF Measurement Concepts

Purpose

Many of the digitally modulated signals appear noise-like in the time and frequency domain. This means that statistical measurements of the signals can be a useful characterization. Power Complementary Cumulative Distribution Function (CCDF) curves characterize the higher-level power statistics of a digitally-modulated signal. The curves can be useful in determining design parameters for digital communications systems.

The power statistics CCDF measurement can be affected by many factors. For example, modulation filtering, modulation format, combining the multiple signals at different frequencies, number of active codes and correlation between symbols on different codes with spread spectrum systems. These factors are all related to modulation and signal parameters. External factors such as signal compression and expansion by non-linear components, group delay distortion from filtering, and power control within the observation interval also affect the measurement.

CCDF curves can help you in several situations:

- To determine the headroom required when designing a component.
- To confirm the power statistics of a given signal or stimulus. CCDF curves allow you to verify if the stimulus signal provided by another design team is adequate. For example, RF designers can use CCDF curves to verify that the signal provided by the digital signal processing (DSP) section is realistic.
- To confirm that a component design is adequate or to troubleshoot your subsystem or system design, you can make CCDF measurements at several points of a system. For example, if the ACLR of a transmitter is too high, you can make CCDF measurements at the input and output of the PA. If the PA design is correct, the curves will coincide. If the PA compresses the signal, the PAR of the signal is lower at the output of the PA.

Measurement Method

The power measured in power statistics CCDF curves is actually instantaneous envelope power defined by the equation:

$$P = (I^2 + Q^2)/Z_0$$

(where I and Q are the quadrature voltage components of the waveform and Z_0 is the characteristic impedance).

A CCDF curve is defined by how much time the waveform spends at or above a given power level. The percent of time the signal spends at or above the level defines the probability for that particular power level. To make the power statistics CCDF measurement, the instrument uses digital signal processing (DSP) to sample the input signal in the channel bandwidth.

The Gaussian distribution line as the band-limited gaussian noise CCDF reference line, the user-definable reference trace, and the currently measured trace can be displayed on a semi-log graph. If the currently measured trace is above the user reference trace, it means that the higher peak power levels against the average power are included in the input signal.

Spurious Emissions Measurement Concepts

Purpose

Spurious signals can be caused by different combinations of signals in the transmitter. The spurious emissions from the transmitter should be minimized to guarantee minimum interference with other frequency channels in the system. Harmonics are distortion products caused by nonlinear behavior in the transmitter. They are integer multiples of the transmitted signal carrier frequency.

This measurement verifies the frequency ranges of interest are free of interference by measuring the spurious signals specified by the user defined range table.

Measurement Method

The table-driven measurement has the flexibility to set up custom parameters such as frequency, span, resolution bandwidth, and video bandwidth.

For each range that you specify and activate, the analyzer scans the band using the specified Range Table settings. Then using the Peak Excursion and Peak Threshold values determines which spurs to report.

As each band is swept, any signal which is above the Peak Threshold value and has a peak excursion of greater than the Peak Excursion value will be added to a list of spurs displayed in the lower results window. A total of 200 spurs can be recorded for one measurement, with a limit of 10 spurs per frequency range. To improve repeatability, you can increase the number of averages.

From the spurs in the list, those with peak amplitude greater than the Absolute Limit for that range will be logged as a measurement failure and denoted by an 'F' in the 'Amplitude' column of the table. If no spurs are reported, but the measured trace exceeds the limit line for any range, the fail flag is set to fail.

This measurement has the ability to display two traces using different detectors on the display simultaneously. All spur detection and limit line testing are only applied to the trace associated with Detector 1, which will be colored yellow. The trace associated with Detector 2 will be colored cyan.

If the sweep time for the range exceeds 2 seconds, a flashing message "Sweeping...Please Wait" will appear in the annunciator area. This advises you that the time to complete the sweep is between 2 and 2000 seconds, and is used as without it the display would appear stagnant and you may think the measurement is not functional.

Spectrum Emission Mask Measurement Concepts

Purpose

Spectrum Emission Mask measurements include the in-band and out-of-band spurious emissions. As it applies to LTE, it is the power contained in a specified frequency bandwidth at certain offsets relative to the total carrier power. It may also be expressed as a ratio of power spectral densities between the carrier and the specified offset frequency band.

As a composite measurement of out-of-channel emissions, the spectrum emission mask measurement combines both in-band and out-of-band specifications to provide useful figures-of-merit for spectral regrowth and emissions produced by components and circuit blocks without the rigor of performing a full spectrum emissions mask measurement.

Measurement Method

The spectrum emission mask measurement measures spurious signal levels in up to six pairs of offset/region frequencies and relates them to the carrier power. The reference channel integration bandwidth method is used to measure the carrier channel power and offset/region powers. When “Offset” is selected, spectrum emission mask measurements are made, relative to the carrier channel frequency bandwidth. When “Region” is selected, spurious emission absolute measurements are made, set by specifying start and stop RF frequencies. The upper frequency range limit is 3.678 GHz.

The channel integration bandwidth is analyzed using the user defined resolution bandwidth (RBW), which is much narrower than the channel bandwidth. The measurement computes an average power of the channel or offset/region over a specified number of data acquisitions, automatically compensating for resolution bandwidth and noise bandwidth.

This measurement requires the user to specify measurement bandwidths of the carrier channel and each of the offset/region frequency pairs up to 6 (A - F). Each pair may be defined with unique measurement bandwidths. The results are displayed both as relative power in dBc, and as absolute power in dBm.

Transmit On/Off Measurement Concepts

Purpose

The Transmit On/Off measurement measures the mean transmit power and examines the time domain burst shape to determine the power rise and fall fits within the defined mask. The limit mask is configurable.

Measurement Method

There are two key results: transmitter off power and transmitter transient period.

- Transmitter Off Power

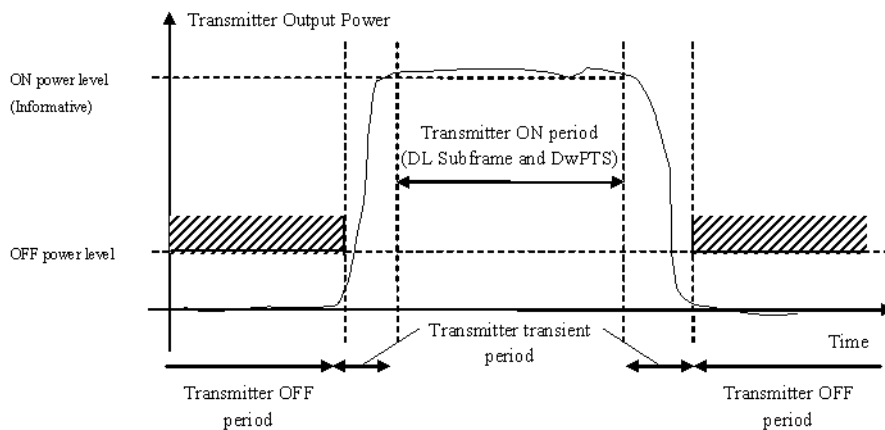
Transmitter OFF power is defined as the mean power measured over [70 us] filtered with a square filter of bandwidth equal to the transmission bandwidth configuration of the BS (BWConfig) centered on the assigned channel frequency during the transmitter OFF period. The transmitter OFF power spectral density shall be less than -85dBm/MHz.

- Transmitter Transient Period

Transmitter transient period is the time period during which the transmitter is changing from the OFF period to the ON period or vice versa. The transmitter transient period is illustrated in figure below. The transmitter transient period should be shorter than 17 us.

Figure 4-47

LTE TDD Transmitter Transient Period



For averaged measurements, the user may specify the number of sweeps over which to average the result. This means that for an average number of 10, the power results are obtained from each trace, converted to linear (voltage squared), and then averaged with the previous average result before being displayed. The running average count and (the log of) the true averaged linear power will be displayed after each measurement sweep.

LTE TDD Modulation Analysis Measurement Concepts

Purpose

The Modulation Analysis measurement provides LTE modulation analysis capabilities for the N9082A LTE TDD measurement application. The functionality is equivalent to the capabilities of option BHE of the 89601B VSA application. (Some of the functionality is optional and requires an additional license.)

Measurement Method

As nearly as possible given the significant differences in the operational models between a PC application and an instrument embedded application, the measurement operates and is organized in the same way as the measurement capabilities of the 89601B VSA. The measurement is based on the analysis of IQ Pairs for all analysis functions.

At a general level, the measurement loop consists of the following steps:

1. Acquire new data
2. Locate the first complete pulse/burst
3. Demodulate the burst
4. Compute measurement results, in some cases computing averaged results
5. Display the measurement results

The Modulation Analysis measurement provides an auto-detect feature for downlink and uplink signals that makes measurement of all parameters automatically.

IQ Waveform Measurement Concepts

Purpose

The waveform measurement is a generic measurement for viewing the input signal waveforms in the time domain. This measurement is how the instrument performs the zero span functionality found in traditional spectrum analyzers.

Basic mode waveform measurement data may be displayed using either a Signal Envelope window, or an I/Q window which shows the I and Q signal waveforms in parameters of voltage versus time. The advantage of having an I/Q view available while making a waveform measurement is that it allows you to view complex components of the same signal without changing settings or measurements.

The waveform measurement can be used to perform general purpose power measurements in the time domain with excellent accuracy.

Measurement Method

The instrument makes repeated power measurements at a set frequency, similar to the way a swept-tuned spectrum analyzer makes zero span measurements. The input analog signal is converted to a digital signal, which then is processed into a representation of a waveform measurement. The measurement relies on a high rate of sampling to create an accurate representation of a time domain signal.

Monitor Spectrum (Frequency Domain) Measurement Concepts

Purpose

The Monitor Spectrum measurement provides spectrum analysis capability for the instrument. The control of the measurement was designed to be familiar to those who are accustomed to using swept spectrum analyzers. The primary use of Monitor Spectrum is to allow you to visually make sure you have the RF carrier available to the instrument, and the instrument is tuned to the frequency of interest.

Measurement Method

The analyzer sweeps the LO to generate a heterodyned IF signal which can be detected for the purpose of analyzing the signal content of a range of frequencies. The x-axis of the display is frequency, the Y Axis is amplitude.

LTE TDD Conformance EVM Measurement Concepts

Purpose

The Conformance EVM (CEVM) measurement provides quick and easy measurement for LTE modulation analysis. The major functionality is the same as the LTE Modulation Analysis measurement (EVM); however, the measurement items of result are tailored for the speed and therefore some of the functionalities and results are excluded or limited. The user can get the same result as the Error Summary on EVM.

Measurement Method

All available measurement parameters are accessible through RUI (SCPI). CEVM doesn't have softkeys for setting parameters except for some common keys. Basically it has three views: Measurement List view, Parameter List view and Result Metrics view. These views are in tabular form. There is another view named RF Envelope which shows a time domain RF envelope for debug purpose.

Differences from LTE Modulation Analysis Measurement

Most functions are the same as the LTE Modulation Analysis (EVM) measurement. If you have a set of SCPI lists to set up the current existent EVM measurement, you can easily convert it for the CEVM measurement by simply replacing the node name "EVM" with "CEVM".

For example,

```
EVM[:SENSe]:EVM:PROFile:AUTO:DETECT ON|OFF
```

```
CEVM[:SENSe]:CEVM:PROFile:AUTO:DETECT ON|OFF
```

However, some features are different between EVM and CEVM as shown below.

- The results displayed on Error Summary in the EVM measurement are also available in CEVM. On the other hand, the other results such as Frame Summary, symbols, and various traces are not available in CEVM.
- CEVM uses "Mech Atten" and "Elec Atten" commands, but does not use "Range" commands in modulation analysis measurement. Modulation Analysis measurement Range setting is independent from other measurement's Attenuation setting.
- For Trigger Setting, CEVM also applies xSA-based SCPI commands.
- The parameter "Update" concept in EVM doesn't exist in CEVM. Any users and allocation changes take effect immediately. Same applies to "Ignore" commands.
- For IF BW setting, EVM uses the command "[:SENSe]:FREQUENCY:SPAN," and CEVM uses "[:SENSe]:CEVM:IFBW". Since IF BW is automatically set whenever the Demod Bandwidth is changed, the user doesn't have to change it.

- Some SCPI commands in EVM are not available in CEVM, see “[SCPI Commands available in EVM are not supported in CEVM](#)” on page 221. Some SCPI commands are newly added in CEVM, see “[SCPI Commands only available in CEVM](#)” on page 225.

SCPI Commands available in EVM are not supported in CEVM

These averaging capabilities are not implemented in CEVM. CEVM only supports exponential averaging.

- [:SENSe]:EVM:AVERAge:FAST
- [:SENSe]:EVM:AVERAge:FAST:URATe
- [:SENSe]:EVM:AVERAge:FAST:URATe:AUTO
- [:SENSe]:EVM:AVERAge:TCONtrol
- [:SENSe]:EVM:AVERAge:TYPE

Parameter changes take effect immediately in CEVM.

- [:SENSe]:EVM:DLINK:PROFile:UPDate
- [:SENSe]:EVM:ULINK:PROFile:UPDate
- [:SENSe]:EVM:DLINK:PROFile:IGNore
- [:SENSe]:EVM:ULINK:PROFile:IGNore

These functions are not implemented in CEVM.

- [:SENSe]:EVM:PROFile:COPI[:IMMEDIATE]
- [:SENSe]:EVM:DLINK:DECode:PBCH
- [:SENSe]:EVM:DLINK:DECode:PCFich
- [:SENSe]:EVM:DLINK:DECode:PDCCCh
- [:SENSe]:EVM:DLINK:DECode:PDSCCh
- [:SENSe]:EVM:REPort:DB
- [:SENSe]:EVM:REPort:POWer:RELative
- [:SENSe]:EVM:TIME:SCALE:FACTor
- [:SENSe]:EVM:ULINK:PROFile:AUTO:PUSCh:MODulation:TYPE
- [:SENSe]:EVM:DLINK:SYNC:CPLength:AUTO
- [:SENSe]:EVM:ULINK:SYNC:CPLength:AUTO
- [:SENSe]:EVM:DLINK:UERS:WEIGhts:RIFormat
- [:SENSe]:EVM:DLINK:UERS:WEIGhts:DISPlay

These display related commands are not available in CEVM.

- :DISPlay:EVM:AFPoints

- :DISPlay:EVM:ANNOtation:TITLe:DATA
- :DISPlay:EVM:FANNOtation
- :DISPlay:EVM:TRACe(1:4):COpy/nquery/
- :DISPlay:EVM:TRACe(1:4):DDEMod:ALINe
- :DISPlay:EVM:TRACe(1:4):DDEMod:EYE:COUnT
- :DISPlay:EVM:TRACe(1:4):DDEMod:SYMBol
- :DISPlay:EVM:TRACe(1:4):DDEMod:SYMBol:FORMat
- :DISPlay:EVM:TRACe(1:4):DDEMod:SYMBol:SHAPE
- :DISPlay:EVM:TRACe(1:4):DDEMod:SYMBol:SIZE
- :DISPlay:EVM:TRACe(1:4):DDEMod:UNIT:FREQUency
- :DISPlay:EVM:TRACe(1:4):DDEMod:UNIT:TIME
- :DISPlay:EVM:TRACe(1:4):FEED
- :DISPlay:EVM:TRACe(1:4):FORMat
- :DISPlay:EVM:TRACe(1:4):FORMat:DELay:APERture
- :DISPlay:EVM:TRACe(1:4):FORMat:PHASe:OFFSet
- :DISPlay:EVM:TRACe(1:4):FORMat:PHASe:UNWRap:REFerence
- :DISPlay:EVM:TRACe(1:4):RLINe
- :DISPlay:EVM:TRACe(1:4):VHCenTer
- :DISPlay:EVM:TRACe(1:4):X[:SCALe]:COUPle
- :DISPlay:EVM:TRACe(1:4):X[:SCALe]:RLEVel
- :DISPlay:EVM:TRACe(1:4):X[:SCALe]:RPOSiTion
- :DISPlay:EVM:TRACe(1:4):X[:SCALe]:SPAN
- :DISPlay:EVM:TRACe(1:4):Y:LRATio
- :DISPlay:EVM:TRACe(1:4):Y[:SCALe]:AUTO:ONCE/nquery/
- :DISPlay:EVM:TRACe(1:4):Y[:SCALe]:PDIVision
- :DISPlay:EVM:TRACe(1:4):Y[:SCALe]:RLEVel
- :DISPlay:EVM:TRACe(1:4):Y[:SCALe]:RLEVel:AUTO
- :DISPlay:EVM:TRACe(1:4):Y[:SCALe]:RPOSiTion
- :DISPlay:EVM:TRACe(1:4):Y:UNIT?/qonly/
- :DISPlay:EVM:TRACe(1:4):Y:UNIT:PREFerence
- :DISPlay:EVM:VIEW:PRESet/nquery/
- :DISPlay:EVM:WINDow:FORMat

These calc and trace related commands are not available in CEVM.

- :CALCulate:EVM:DATA(1:4)?/qonly/
- :CALCulate:EVM:DATA(1:4):HEADer:NAMes?/qonly/
- :CALCulate:EVM:DATA(1:4):HEADer[:NUMBer]?/qonly/
- :CALCulate:EVM:DATA(1:4):HEADer:STRing?/qonly/
- :CALCulate:EVM:DATA(1:4):HEADer:TYPE?/qonly/
- :CALCulate:EVM:DATA(1:4):NAMes?/qonly/
- :CALCulate:EVM:DATA(1:4):POINts?/qonly/
- :CALCulate:EVM:DATA(1:4):RAW?/qonly/
- :CALCulate:EVM:DATA(1:4):RAW:COMPLex?/qonly/
- :CALCulate:EVM:DATA(1:4):RAW:POINts?/qonly/
- :CALCulate:EVM:DATA(1:4):TABLe:NAMes?/qonly/
- :CALCulate:EVM:DATA(1:4):TABLe[:NUMBer]?/qonly/
- :CALCulate:EVM:DATA(1:4):TABLe:STRing?/qonly/
- :CALCulate:EVM:DATA(1:4):TABLe:UNIT?/qonly/
- :CALCulate:EVM:MARKer(1:12):AOFF/nquery/
- :CALCulate:EVM:MARKer(1:12):CFORmat
- :CALCulate:EVM:MARKer(1:12):COUPle[:STATe]
- :CALCulate:EVM:MARKer(1:12):CPSearch[:STATe]
- :CALCulate:EVM:MARKer(1:12):FCOunt[:STATe]
- :CALCulate:EVM:MARKer(1:12):FCOunt:X?/qonly/
- :CALCulate:EVM:MARKer(1:12):FUNCTion
- :CALCulate:EVM:MARKer(1:12):FUNCTion:BAND:CENTer
- :CALCulate:EVM:MARKer(1:12):FUNCTion:BAND:LEFT
- :CALCulate:EVM:MARKer(1:12):FUNCTion:BAND:RIGHT
- :CALCulate:EVM:MARKer(1:12):FUNCTion:BAND:SPAN
- :CALCulate:EVM:MARKer(1:12):FUNCTion:BDENsity:CTYPE
- :CALCulate:EVM:MARKer(1:12):FUNCTion:BPOWer:CTYPE
- :CALCulate:EVM:MARKer(1:12):MAXimum/nquery/
- :CALCulate:EVM:MARKer(1:12):MAXimum:LEFT/nquery/
- :CALCulate:EVM:MARKer(1:12):MAXimum:NEXT/nquery/
- :CALCulate:EVM:MARKer(1:12):MAXimum:PREVious/nquery/

Concepts

LTE TDD Measurement Concepts

- :CALCulate:EVM:MARKer(1:12):MAXimum:RIGHT/nquery/
- :CALCulate:EVM:MARKer(1:12):MINimum/nquery/
- :CALCulate:EVM:MARKer(1:12):MODE
- :CALCulate:EVM:MARKer(1:12):POSition
- :CALCulate:EVM:MARKer(1:12):REFerence
- :CALCulate:EVM:MARKer(1:12):TABLe[:STATe]
- :CALCulate:EVM:MARKer(1:12):TRACe
- :CALCulate:EVM:MARKer(1:12):X
- :CALCulate:EVM:MARKer(1:12):X:POSition
- :CALCulate:EVM:MARKer(1:12):X:UNIT?/qonly/
- :CALCulate:EVM:MARKer(1:12):Y:IMAGinary
- :CALCulate:EVM:MARKer(1:12):Y[:REAL]
- :CALCulate:EVM:MARKer(1:12):Y:UNIT?/qonly/
- :CALCulate:EVM:MARKer(1:12):Z
- :CALCulate:EVM:MARKer(1:12):Z:UNIT?/qonly/
- :CALCulate:EVM:TRACe(1:4):ACPpower:CARRier:BANDwidth|BWIDth:INTegration
- :CALCulate:EVM:TRACe(1:4):ACPpower:CARRier:FILTer:RRC:ALPHA
- :CALCulate:EVM:TRACe(1:4):ACPpower:CARRier:FILTer:RRC:STATe
- :CALCulate:EVM:TRACe(1:4):ACPpower:CARRier:FREQuency
- :CALCulate:EVM:TRACe(1:4):ACPpower:OFFSet:FILTer:RRC:STATe
- :CALCulate:EVM:TRACe(1:4):ACPpower:OFFSet:LIST:BANDwidth|BWIDth:INTEGRation
- :CALCulate:EVM:TRACe(1:4):ACPpower:OFFSet:LIST:FILTer:RRC:ALPHA
- :CALCulate:EVM:TRACe(1:4):ACPpower:OFFSet:LIST:FREQuency
- :CALCulate:EVM:TRACe(1:4):ACPpower:OFFSet:LIST:RCARRier
- :CALCulate:EVM:TRACe(1:4):ACPpower:OFFSet:LIST:RCARRier:TEST
- :CALCulate:EVM:TRACe(1:4):ACPpower:OFFSet:LIST:STATe
- :CALCulate:EVM:TRACe(1:4):ACPpower:STATe
- :CALCulate:EVM:TRACe(1:4):OBWidth:CENTRoid?/qonly/
- :CALCulate:EVM:TRACe(1:4):OBWidth:LIMit:FBLimit
- :CALCulate:EVM:TRACe(1:4):OBWidth:LIMit[:TEST]
- :CALCulate:EVM:TRACe(1:4):OBWidth:PERCent

- :CALCulate:EVM:TRACe(1:4):OBWidth:STATe

SCPI Commands only available in CEVM

The following SCPI commands are available only in CEVM, not in EVM.

- [:SENSe]:CEVM:IFBW

For IF BW setting, EVM uses the command “[:SENSe]:FREQuency:SPAN”. On the other hand, CEVM uses “[:SENSe]:CEVM:IFBW”. Since IF BW is automatically set whenever the Demod Bandwidth is changed, the user doesn’t have to change it.

- [:SENSe]:CEVM:EVM:COpy[:IMMediate]
- [:SENSe]:CEVM:DLINK:RESult
- [:SENSe]:CEVM:ULINK:RESult

Baseband I/Q Inputs (Option BBA) Measurement Concepts

The N9020A Option BBA Baseband I/Q Inputs provides the ability to analyze baseband I/Q signal characteristics of mobile and base station transmitters. This option may be used only in conjunction with the following modes:

- IQ Analyzer (Basic)
- 802.16 OFDMA (WiMAX/WiBro)
- cdma2000
- GSM/EDGE
- TD-SCDMA
- W-CDMA
- 1xEV-DO
- LTE
- LTE TDD
- DTMB
- DVB-T/H
- ISDB-T
- CMMB

What are Baseband I/Q Inputs?

Option BBA consists of a Baseband Input module, four input connectors, and a calibration output connector. The connectors are at the left side of the front panel. The two ports labeled “I” and “Q” are the “unbalanced” inputs.

An unbalanced or “single-ended” baseband measurement of an I or Q signal is made using a probe connected to the I or Q connector. A simultaneous I/Q unbalanced single-ended measurement may be made using two probes connected to the I and Q input connectors.

If “balanced” signals are available, they may be used to make a more accurate measurement. Balanced signals are signals present in two separate conductors, are symmetrical about ground, and are opposite in polarity, or out of phase by 180 degrees.

Measurements using balanced signals can have a higher signal to noise ratio resulting in improved accuracy. Noise coupled into each conductor equally in a “common mode” to both signals may be separated from the signal. The measure of this separation is “common-mode rejection”.

To make a balanced measurement, the two connectors labeled “I” and “Q” are used in conjunction with the I and Q inputs. The terms “I-bar” and “Q-bar” may be applied to the signals, as well as the inputs themselves. Probes (customer provided) must be used to input balanced baseband I/Q signals. This may be referred to as a balanced measurement.

Balanced baseband measurements are made using the I and connectors for I only signal measurements, while the Q and connectors are used for a Q only signal measurement. Balanced measurements of I/Q require differential probe connections to all four input connectors. For details of probe selection and use, refer to [“Selecting Input Probes for Baseband Measurements” on page 229.](#)

What are Baseband I/Q Signals?

In transmitters, the term baseband I/Q refers to signals that are the fundamental products of individual I/Q modulators, before the I and Q component signals are combined, and before upconversion to IF or RF frequencies.

In receivers, baseband I/Q analysis may be used to test the I and Q products of I/Q demodulators, after a RF signal has been downconverted and demodulated.

Why Make Measurements at Baseband?

Baseband I/Q measurements are a valuable means of making qualitative analyses of the following operating characteristics:

- I/Q signal layer access for performing format-specific demodulation measurements (for example, ISDB-T, CMMB, W-CDMA).
- Modulation accuracy – that is, I/Q plane metrics:
 - error vector magnitude; rms, peak
 - frequency error
 - magnitude and phase errors
- CCDF of $I^2 + Q^2$
- Basic analysis of I and Q signals in isolation including: DC content, rms and peak to peak levels, CCDF of each channel

Comparisons of measurements made at baseband and RF frequencies produced by the same device are especially revealing. Once signal integrity is verified at baseband, impairments can be traced to specific stages of upconversion, amplification, or filtering by RF analysis. In addition, impairments to signal quality that are apparent at RF frequencies may be traceable to baseband using baseband analysis.

Selecting Input Probes for Baseband Measurements

The selection of baseband measurement probe(s) and measurement method is primarily dependent on the location of the measurement point in the circuit. The probe must sample voltages without imposing an inappropriate load on the circuit.

The system supports a variety of 1 M Ω impedance input passive probes as well as the Keysight 1153A active differential probe using the InfiniMax probe interface.

The Keysight 1153A active probe can be used for both single-ended and differential measurements. In either case a single connection is made for each channel (on either the I or Q input). The input is automatically configured to 50 Ω single-ended type measurement and the probe power is supplied through the InfiniMax interface. The probe can be configured for a variety of input coupling and low frequency rejection modes. In addition, a wide range of offset voltages and probe attenuation accessories are supported at the probe interface. The active probe has the advantage that it does not significantly load the circuit under test, even with unity gain probing.

With passive 1 M Ω probes, the probe will introduce a capacitive load on the circuit, unless a higher attenuation is used at the probe interface. Higher attenuation helps isolate the probe, however, it reduces the signal level and degrades the signal-to-noise-ratio of the measurement. Passive probes are available with a variety of attenuation values for a moderate cost. Many Keysight passive probes can be automatically identified by the system, setting the input impedance required as well as the nominal attenuation. For single-ended measurements a single probe is used for each channel. Other passive probes can be used, after manually setting the attenuation and probe impedance configurations.

For full differential measurements, the system supports probes on each of the four inputs. The attenuation for each of the probes should be the same for good common mode rejection and channel match.

Supported Probes

The following table lists the probes currently supported by Option BBA:

Probe Type	Model Number	Description
Active	1130A	1.5 GHz differential probe amp (No probe head)
	1131A ^a	InfiniMax 3.5 GHz probe
	1132A ^a	InfiniMax 5 GHz probe
	1133A ^a	InfiniMax 7 GHz probe
Passive	1161A	Miniature passive probe, 10:1, 10 M Ω , 1.5 m

- a. Probe heads are necessary to attach to your device properly. Probe connectivity kits such as the E2668A, E2669A or E2675A are needed. For more details, refer to the Keysight probe configuration guide, 5968-7141EN and 5989-6162EN.

Probes without Stored Calibration

The following 115xA active probes may be used with the MXA’s baseband IQ inputs and may use the same probe calibration utility software. However, the probe calibration data is not stored in the MXA and will be lost if power is cycled. Use of the E2655B de-skew and calibration kit, including the calibration fixture, is required because of the different physical configuration of the probes. (The physical connections are different mechanically, not electrically.)

Probe Type	Model Number	Description
Active	1153A	200MHz differential probe
	1156A	Active probe, 1.5 GHz
	1157A	Active probe, 2.5 GHz
	1158A	Active probe, 4 GHz

Refer to the current Keysight probe data sheet for specific information regarding frequency of operation and power supply requirements.

Baseband I/Q Measurement Views

Measurement result views made in the IQ Analyzer (Basic) mode are available for baseband signals if they relate to the nature of the signal itself. Many measurements which relate to the characteristics that baseband I and Q signals have when mixed and upconverted to signals in the RF spectrum can be made as well. However, measurements which relate to the characteristics of an upconverted signal that lie beyond the bandwidth available to the Baseband I/Q Input circuits can not be measured (the limits are dependent on the installed options: Standard – 10 Hz to 20 MHz, Option B25 – 10 Hz to 50 MHz, and Option S40 – 10 Hz to 80 MHz).

At RF frequencies, power measurements are conventionally displayed on a logarithmic vertical scale in dBm units, whereas measurements of baseband signals using Baseband I/Q inputs may be conveniently displayed as voltage using a linear vertical scale as well as a log scale.

Spectrum Views and 0 Hz Center Frequency

To view the Spectrum display of I only or Q only signals, use the Complex Spectrum measurement capability in IQ Analyzer (Basic) Mode.

I only and Q only Spectrum views are conventional, displayed with 0 Hz at the left side of the horizontal axis. When upconverted or multiplied, an I only or Q only signal could ultimately lie above or below the carrier center frequency, but in either case it will only occupy half the bandwidth.

Waveform Signal Envelope Views of I only or Q only

To view the Signal Envelope display of I only or Q only signals, use the Waveform measurement capability in IQ Analyzer (Basic) Mode.

The I and Q Waveform of an I/Q signal is very different from the complex signal displayed in the RF Envelope view. That is because the RF Envelope is a product of both the I and Q modulation waveforms.

However, an I and Q Waveform measurement of an I only or Q only signal is exactly the same signal displayed in the RF Envelope view. That is because an I only or Q only waveform determines the I only or Q only signal envelope. Thus, the RF Envelope view can be used to measure an I only or Q only waveform directly.

Other Sources of Measurement Information

Additional measurement application information is available through your local Keysight Technologies sales and service office. The following application notes treat digital communications measurements in much greater detail than discussed in this section.

- Application Note
3GPP Long Term Evolution: System Overview, Product Development, and Test Challenges
Keysight part number 5989-8931EN
- N9080A LTE Measurement Application - Technical Overview with Self-Guided Demonstration
Keysight part number 5989-6537EN
- Technical Overview
Keysight Technologies Solutions for 3GPP LTE
Keysight part number 5989-6133EN
- Application Note 1298
Digital Modulation in Communications Systems - An Introduction
Keysight part number 5965-7160E
- Application Note
Characterizing Digitally Modulated Signals with CCDF Curves
Keysight part number 5968-5858E
- Application Note
HSDPA RF Measurements for User Equipment
Keysight part number 5989-4099EN
- For more information about the 3GPP and LTE specifications visit 3GPP home page <http://www.3gpp.org/>
- 3GPP Series 36 (LTE) specifications
http://www.3gpp.org/ftp/Specs/archive/36_series
- For more information about Keysight design and test products for LTE visit <http://www.keysight.com/find/lte>

Instrument Updates at www.keysight.com

These web locations can be used to access the latest information about the instrument, including the latest firmware version.

<http://www.keysight.com/find/pxa>

<http://www.keysight.com/find/mxa>

<http://www.keysight.com/find/exa>

<http://www.keysight.com/find/cxa>

List of Acronyms

3G	3rd Generation
3GPP	3rd Generation Partnership Project
ACLR	Adjacent channel leakage ratio
ACPR	Adjacent channel power ratio
ACS	Adjacent channel selectivity
ADS	Advanced Design System
AMC	Adaptive modulation and coding
A-MPR	Additional maximum power reduction
ARQ	Automatic repeat request
BCCH	Broadcast control channel
BTS	Base transceiver station
CDD	Cyclic delay diversity
CCDF	Complementary cumulative distribution function
CDMA	Code division multiple access
CFI	Control format indicator
Co-MIMO	Cooperative MIMO
CP	Cyclic prefix
CPICH	Common pilot channel
CPRI	Common public radio interface
CQI	Channel quality indicator
CRC	Cyclic redundancy check
DCI	Downlink control indicator
DFT	Discrete Fourier transform
DFT-SOFDM	Discrete Fourier transform spread OFDM
DL	Downlink (base station to subscriber transmission)
DL-SCH	Downlink shared channel
D-PHY	500 Mbps physical layer
DSP	Digital signal processing
DT	Development toolset
DVSA	Digital vector signal analysis
EDA	Electronic design automation

E-DCH Enhanced dedicated channel
E-UTRAN Evolved UMTS terrestrial radio access network
eMBMS Evolved multimedia broadcast multicast service
eNB Evolved Node B
EPC Evolved packet core
EPRE Energy per resource element
ETSI European Telecommunications Standards Institute
E-UTRA Evolved UTRA
E-UTRAN Evolved UTRAN
EVM Error vector magnitude
FDD Frequency division duplex
FFT Fast Fourier transform
FRC Fixed reference channel
FS1 Frame structure type 1
FS2 Frame structure type 2
GSM Global system for mobile communication
HARQ Hybrid automatic repeat request
HDL Hardware description language
HI HARQ indicator
HSDPA High speed downlink packet access
HSPA High speed packet access
HSUPA High speed uplink packet access
IFFT Inverse FFT
IOT Interoperability test
IP Internet protocol
LO Local oscillator
LTE Long term evolution
MAC Medium access control
MBMS Multimedia broadcast multicast service
MBSFN Multicast/broadcast over single-frequency network
MCH Multicast channel
MIMO Multiple input multiple output

MISO Multiple input single output
MME Mobility management entity
MOP Maximum output power
MPR Maximum power reduction
MU-MIMO Multiple user MIMO
NAS Non-access stratum
OBSAI Open base station architecture interface
OFDM Orthogonal frequency division multiplexing
OFDMA Orthogonal frequency division multiple access
PAPR Peak-to-average power ratio
PAR Peak-to-average ratio
PBCH Physical broadcast channel
P-CCPCH Primary common control physical channel
PCFICH Physical control format indicator channel
PCH Paging channel
PDCCH Physical downlink control channel
PDCP Packet data convergence protocol
PDSCH Physical downlink shared channel
PHICH Physical hybrid ARQ indicator channel
PHY Physical layer
PRACH Physical random access channel
PMCH Physical multicast channel
PMI Pre-coding matrix indicator
P-SCH Primary synchronization signal
PUCCH Physical uplink control channel
PUSCH Physical uplink shared channel
QAM Quadrature amplitude modulation
QPSK Quadrature phase shift keying
RACH Random access channel
RAT Radio access technology
RB Resource block
RF Radio frequency

RFDE RF design environment
RLC Radio link control
RMC Reference measurement channel
RNC Radio network controller
RRC Radio resource control
RRM Radio resource management
RS Reference signal
RSCP Received signal code power
RSRP Reference signal received power
RSRQ Reference signal received quality
RSSI Received signal strength indicator
SAE System architecture evolution
SAP Service access point
SC-FDMA Single carrier frequency division multiple access
SFBC Space-frequency block coding
S-GW Serving gateway
SIMO Single input multiple output
SISO Single input single output
SNR Signal-to-noise ratio
SRS Sounding reference signal
S-SCH Secondary synchronization signal
SU-MIMO Single user MIMO
TDD Time division duplex
TDMA Time division multiple access
TR Technical report
TrCH Transport channel
TS Technical specification
TTA Telecommunications Technology Association
TTI Transmission time interval
UCI Uplink control indicator
UE User equipment
UL Uplink (subscriber to base station transmission)

Concepts
List of Acronyms

UL-SCH Uplink shared channel
UMB Ultra-mobile broadband
UMTS Universal mobile telecommunications system
UTRA Universal terrestrial radio access
UTRAN Universal terrestrial radio access network
VSA Vector signal analyzer
W-CDMA Wideband code division multiple access