Agilent P-Series Power Meter / Sensor LTE Measurement Application

Technical Overview with Self-Guided Demonstration Guide

The Agilent P-Series power meter/sensor one-button predefined preset provides accurate and repeatable power measurement for complex modulation signal formats.

Agilent Technologies

Contents

Accelerate your LTE Signal Burst Power Measurement with Agilent P-Series Power Meter/Sensor

Using the industry's latest development technology, the long term evolution (LTE) standard from the 3rd Generation Partnership Project (3GPP) is deployed all around the world. The complexity of the LTE system requires comprehensive signal and modulation analysis as well as RF power measurement. The Agilent P-Series power meter/sensor makes it possible to measure the burst power signal of LTE and time division duplex (TDD) with built-in WiMAX predefined measurement setup and statistical complementary cumulative distribution function (CCDF) measurement.

This document explains how to generate the LTE-TDD signal using Agilent Signal Studio software. A step-by-step demonstration guide shows how to use the P-Series power meter/sensor to measure burst signal (power versus time) and CCDF measurement of a LTE-TDD signal.

Introduction

The combination of N1911A/12A P-Series power meters and N1921A/22A wideband power sensors can quickly and accurately measure peak, average, peak-to-average ratio power measurement, rise/fall time, pulse width, and complementary cumulative distribution function (CCDF) statistical data for wideband signals.

The 30 MHz video bandwith and 100 Msa/s continuous sampling rate of the P-Series power meter make it possible to capture the high-burst LTE signal's that fast power transition. The diode-based P-Series power sensor offers a higher frequency range up to 40 GHz and wider dynamic range up to 55 dB for better sensitivity, enabling reliable measurement of peak and average burst power.

Further simplifying measurement set up, the one-button predefined preset WiMAX setup of the P-Series power meter simplifies measurement and reduces the setup time for capturing the signal effectively. By following a few easy steps, you can use the P-Series power meter/sensor used to measure the power versus time (PvT) of LTE-TDD burst signal as well as statistical CCDF measurement.

Power versus Time (PvT)

Power level transmission is an important LTE conformance specification. It is defined as the time-average power over the useful period of a downlink or uplink subframe burst. Peak-to-average power can also be obtained during this period. To make accurate and stable measurements, it is important that the power meter is able to capture the desired complete subframe consistently within the fixed timeframe. This can be achieved by applying a proper time-triggering mechanisms, such as trigger level, holdoff, and delay, which are available in the P-Series power meters.

The trigger level of a P-Series power meter is typically set at auto-level. Trigger holdoff ensures that the acquisition will not occur until the holdoff time has passed and a valid trigger is found. This is very useful for burst signals that have amplitude variations, because these variations can cause false triggering.

Trigger delay allows measurement of different signals. By just changing the delay setting of the power meter, you can make a power measurement of the next subframe.

Furthermore, the P-Series power meter is optimized to operate in the trace display when measuring a burst signal. Downlink or uplink subframe burst signals can be captured via time-gated methodology by applying the markers (1 & 2) of the trace.

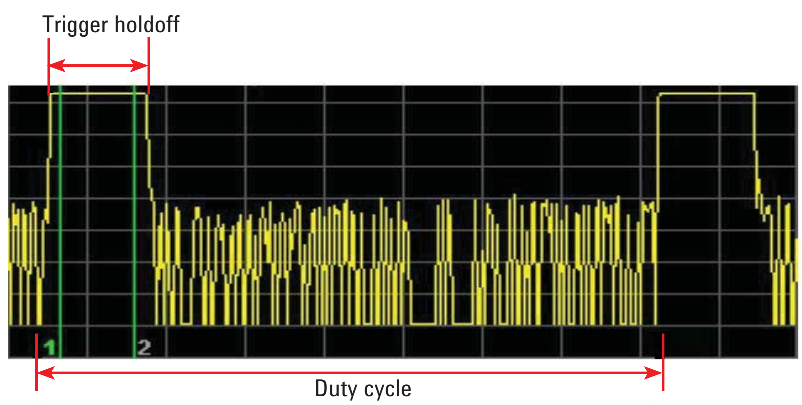

Figure 1. *Burst power signal structure without constant duty cycle. In the P-Series power meter, green lines (Marker1 and Marker2) are indicate the start and end burst sub-frame signal power measurement.*

Complementary Cumulative Distribution Function (CCDF)

The complementary cumulative distribution function (CCDF) is a plot of probability versus peak-to-average (PAR), which characterizes the statistical power of a signal. CCDF is one of the important measurements in designing LTE power amplifiers that must be capable of handling high PAR signal exhibits while constantly maintaining good adjacent-channel leakage performance.

The CCDF plot is primarily used in the wireless communication market for evaluating multicarrier power amplifier performance. It measures the percentage of time when the PAR is at or exceeds a specific power level.

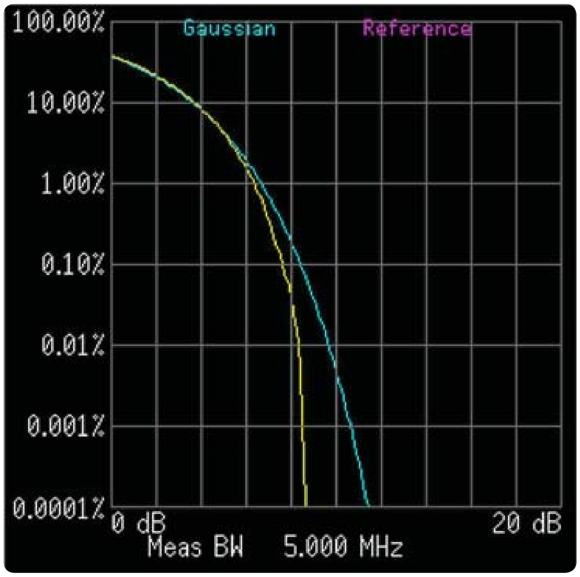

Figure 2. *CCDF plot shows the Y-axis represents the percentage of time the signal power is at or exceeds the power specified by the X-axis*

LTE Overview

LTE is the next major step in mobile radio communications, and will be introduced in 3GPP Release 8. The LTE specification provides a framework for increasing capacity, improving spectrum efficiency, improving coverage, and reducing latency compared with current high speed packet access (HSPA) implementations. In addition, transmission with multiple input and multiple output (MIMO) antennas will be supported for greater throughput, as well as enhanced capacity or range.

This LTE overview information provides a quick review of some of the physical-layer characteristic of an LTE signal. Please refer to the Agilent 3GPP Long Term Evolution application note, literature number 5989-8139EN, for in-depth LTE technical information.

Key Attributes for LTE

- **Downlink capacity** – Peak data rates up to 172.8 Mbps with 20 MHz bandwidth and 2x2 SU-MIMO
- **Uplink capacity** – Peak data rates up to 86.4 Mbps with 20 MHz bandwidth and 64QAM
- **Spectrum flexibility** – Scalable bandwidth up to 20 MHz
- **Spectral efficiency** – Increased spectral efficiency over Release 6 HSPA by a factor of two to four
- **Latency** – Sub-5 ms latency for small internet protocol (IP) packets
- **Mobility** – Optimized for low mobile speed from 0 to 15 km/h; higher mobile speeds up to 120 km/h supported with high performance
- **Support for packet-switched domains only**.

Multiple Access Technology

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

Transmission Bandwidth

In order to address the international wireless market and regional spectrum regulations, LTE allows selection of varying channel bandwidths, from 1.4 to 20 MHz, with sub-carrier spacing of 15 kHz. In the case of multimedia broadcast multicast service (MBMS), a sub-carrier spacing of 7.5 kHz is also possible. Sub-carrier spacing is constant regardless of channel bandwidth. To allow for operation with differently sized spectrum allocations, the transmission bandwidth is instead altered by varying the number of OFDM sub-carriers as shown in Table 1.

***Table 1**: Number of sub-carriers for the different downlink and uplink transmission bandwidths*

Transmission bandwidth for LTE FDD (MHz)	1.4	3	5	10	15	20
Number of sub-carriers	72	180	300	600	900	1200

Frame Structure

There are two radio frame structures for LTE: frame structure type 1 (FS1) for full duplex and half duplex FDD, and frame structure type 2 (FS2) for TDD. The frame structure for full duplex FDD is shown in Figure 3.

FS1 is optimized to co-exist with 3.84 Mbps UMTS system. This structure consists of ten 1 ms sub-frames, each composed of two 0.5 ms slots, for total duration of 10 ms. The FSQ is the same in the uplink and downlink in terms of frame, sub-frame, and slot duration, although the allocation of the physical signals and channels is quite different. Uplink and downlink transmission are separated in the frequency domain.

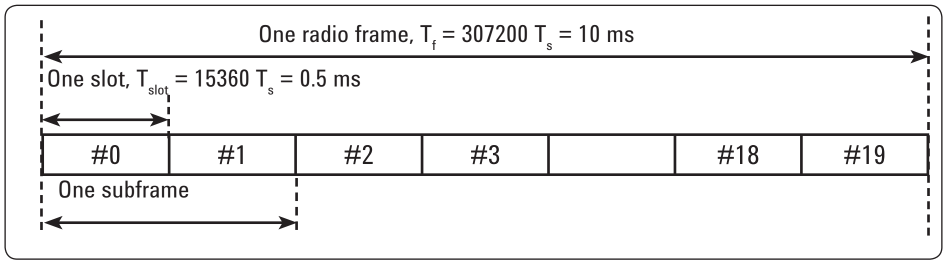

Figure 3. *LTE frame structure type 1 (TS 36.211 V8.30)*

The structure of FS2 is much more flexible than the structure of FS1. An example of an FS2 structure is shown in Figure 4. This example shows 5 ms switch-point periodicity and it consists of two 5 ms half-frames for a total duration of 10 ms. Sub-frames consist of either an uplink or downlink transmission or a special sub-frame containing the downlink and uplink pilot timeslots (DwPTS and UpPTS) separated by a transmission gap guard period (GP). The allocation of the sub-frames for the uplink, downlink, and special sub-frames is determined by one of seven different configurations. Sub-frames 0 and 5 are always downlink transmissions, and sub-frame 1 is always a special sub-frame, but the composition of the other sub-frames vary depending on the frame configuration.

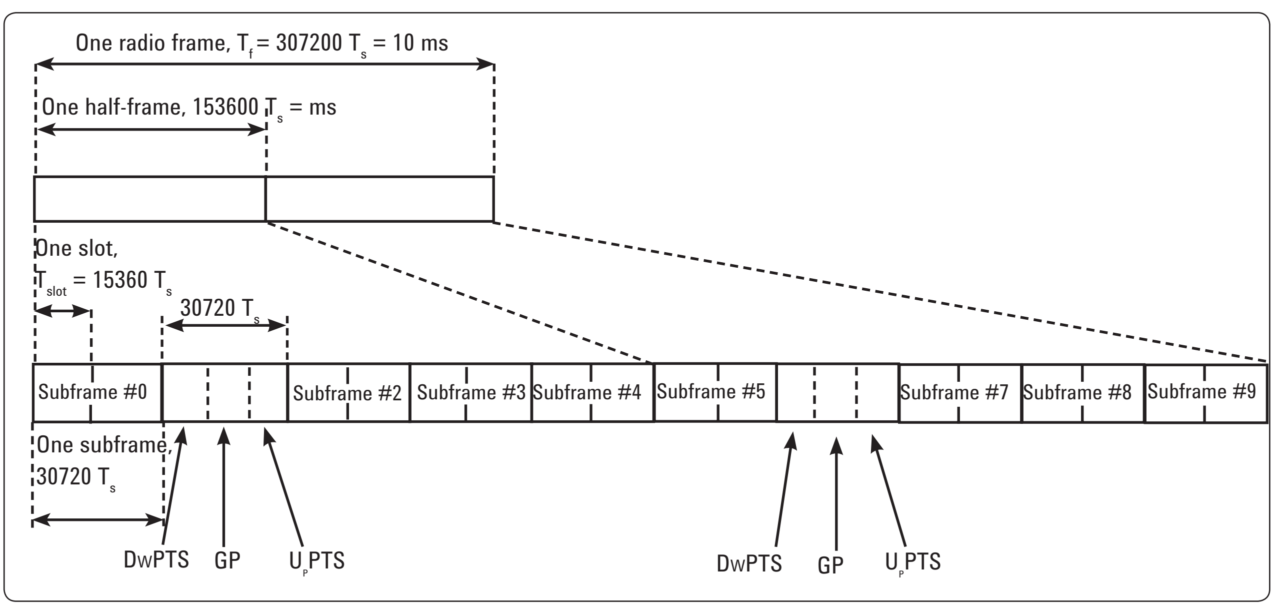

Figure 4. *LTE frame structure Type 2 (5 ms switch-point periodicity) (TS 36.211 V8.20)*

Demonstration Preparation

This demonstration focuses on LTE-TDD mode signal measurements over a LAN connection.

The following instruments and software are used in this demo guide:

- E4438C ESG vector signal generator[1]
- N1911A/N1912A P-Series power meter
- N1921A/1922A P-Series wideband power sensor
- N7625A Signal Studio software[2]

Signal Studio is a Windows®-based utility software that simplifies creation of standard or customized LTE waveform. With the Signal Studio software, the desired LTE waveform profile can be configured and downloaded into a signal generator, and the signal generator will then generate the waveform for testing.

To download and update instrument firmware and software, visit:

- www.agilent.com/find/wideband_powermeters
- www.agilent.com/find/esg
- www.agilent.com/find/mxg
- www.agilent.com/find/signlstudio

Product type	Required option
ESG Vector Signal Generator	• E4438C firmware revision C.04.98 or later • Frequency range option: 503 or 506 • Baseband generator option: 601 or 602
P-Series Power Meter	• N1911A or N1912A firmware revision A.05.01 or later
P-Series Wideband Power Sensor	• N1921A or N1922A
Signal Studio software	• N7625A version 1.1.2.0 or later
Agilent IO Libraries Suite	• IO Libraries Suite version 15.1 or later
Controller PC for Signal Studio	• Install N7625A Signal Studio software (refer to the online documentation for installation and setup).

1. *Alternatively, you can use the N5182A MXG vector signal generator, firmware revision A.01.45 or later, frequency range option 503 or 506, and baseband generator option: 651 or 652.*
2. *N7625A is the LTE TDD signal measurement PC platform software. For LTE FDD signal measurement, N7624A can be used.*

Demonstration Preparation (continued)

Connecting the PC, ESG, and P-Series instructions

1. Connect the PC to the E4438C ESG signal generator via a LAN cable.
2. Launch the Agilent Connection Expert application (Agilent IO Libraries Suite) and verify the connection of the ESG signal generator.
3. Connect the P-Series power meter and sensor as shown in Figure 5.
4. Connect a BNC cable from the ESG signal generator's rear-panel Event 1 to the rear panel Trig In of the P-Series power meter.

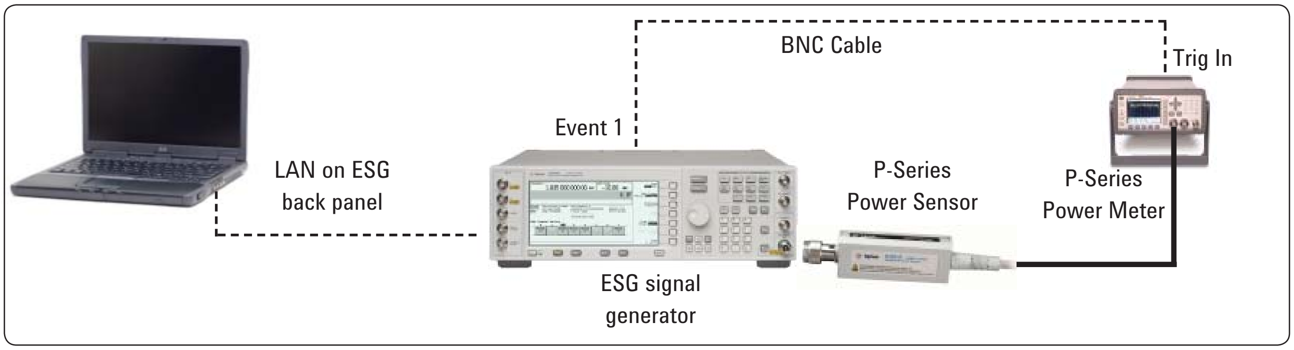

Figure 5. *P-Series power meter and ESG signal generator setup diagram*

Establishing a communication link between EGS Signal Generator, Agilent IO Libraries Suite, and N7625A Signal Studio software

Keystrokes surrounded by [ ] represent front-panel keys of the instruments, while keystrokes surrounded by { } represent softkeys of the instrument and software.

Instructions	Keystrokes
On the ESG :	
1. Set the instrument to its default settings.	Press **[Preset]**
2. Check the IP address.	Press **[Utility]** **{GPIB/RS-232/LAN}** **{LAN Setup}** • If connecting to network, press **{LAN Config}** **{DHCP}** **{Proceed With Reconfiguration}** **{Confirm Change (Instrument Will Reboot)}** • If direct connection from PC to ESG, press **{LAN Config}** **{Manual}**, enter the appropriate IP Address, Subnet Mask and Default Gateway. Press **{Proceed With Reconfiguration}** **{Confirm Change (Instrument Will Reboot)}**
On Agilent IO Libraries Suit Software :	
3. Start the Agilent IO Libraries Suite.	**Start > All Programs > Agilent IO Libraries Suit > Agilent Connection Expert**
4. Establish the LAN connection of PC to ESG.	Right-click on **LAN (TCPIO)** and select **Add Instrument**. Click on **Auto Find**. Select the ESG LAN connection and click **OK**

Establishing a communication link between EGS Signal Generator, Agilent IO Libraries Suite, and N7625A Signal Studio software (continued)

Instructions	Keystrokes
On N7625A Signal Studio software :	
5. Start the Signal Studio for LTE TDD.	**Start > All Program > Agilent Signal Studio > 3GPP LTE TDD > 3GPP LTE TDD**
6. Configure the ESG as hardware connected via LAN TCP/IP.	From the **{System}** pull-down menu at the top of the Signal Studio program window, select **{Change Hardware Connections}**, **{Next}**, select **{LAN}** and enter the hostname or IP address of the ESG in the address is. Click **{Test I/O Connection} {Next}.**
7. The software should return a "success" connection status.	• If connection is successful, click **{Finish}.** • If connection is not successful, verify the instrument connection and the IP address or TCP/IP link.

Downloading LTE TDD mode profile into ESG Signal Generator

Profile setting

Most parameters are in their default settings when Signal Studio is launched. Values in **bold** indicate modified parameters.

Generate a downlink LTE signal using 3GPP LTE TDD Signal Studio along with the Agilent ESG vector signal generator.

You should see the burst power measurement as shown in Figure 6. If you do not, make sure you have downloaded the Signal Studio waveform to the ESG and that the ESG's RF is turned ON [RF on/off].

Instructions	Keystrokes
On N7625A Signal Studio software :	
1. Set the basic parameters of the Signal: • 2 GHz frequency • -10 dBm Amplitude • RF Output turned ON.	In the view, select **Instrument** under **Hardware:** Set **Frequency** to **2 GHz** Set **Amplitude** = **0 dBm** **RF Output** = **On**
2. Set the LTE signal for 10 MHz LTE profile and 16 QAM modulation format.	In the tree view, select **Carrier 1** under **Waveform Setup:** Under Channel Configuration, from drop down list, select **Full filled 16QAM 10 MHz (50 RB)**
3. Turn on downlink signal.	In the tree view, select **Downlink** under **Carrier 1 Waveform Setup:** Under Cell Parameters, set **State** to **On**
4. Turn off uplink signal.	In the tree view, select **Uplink** under **Carrier 1 Waveform Setup:** Under Cell Parameters, set **State** to **Off**
5. Download the signal to the **ESG.**	Press **Generate and Download** button  on the top tool bar; if you encounter any errors, please refer to the online help of Signal Studio software.

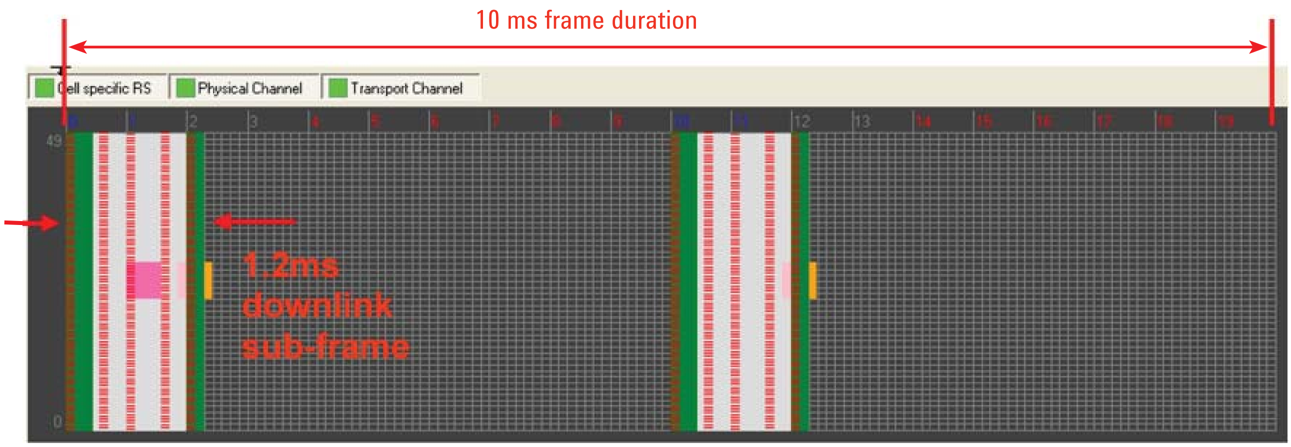

Figure 6. *Sub-frame duration 1.2 ms of downlink signal captured with Signal Studio*

Measuring downlink sub-frame burst power

Set up the P-Series power meter/ sensor to analyze the downlink LTE signal generated by Signal Studio.

Instructions	Keystrokes
On the P-Series power meter :	
1. Select the WiMAX preset.	Press **[Preset]**, press [ ] or [ ] to choose **{WiMAX}, [Select]** and **{Confirm}**
2. Set the frequency.	Press **[Channel]**, press [ ] or [ ] to choose **{Frequency}** and change **{Frequency}** = **2 GHz**
3. Set the video averaging to smooth the displayed trace.	Press **[Channel]**, press [ ], [ ], [ ] or [ ] to choose **{Video Avg}** = **8**
4. Set the trace display.	Press **[Disp]**, **{Disp Type}**, **{Trace}**
5. Set the trigger source to external allow power meter can be triggered via the Ext Trig input by ESG's Event 1.	Press **[Trig/Acq]**, **{Settings}**, **{Source}**, **{Ext}**
6. Expand the window. Change the scale of trace measurement.	Press [ ], {Trace Control} to Trace Control menu. Press [ ], [ ], [ ] or [ ] to choose and set the X & Y settings: **{X Start = -500 us}** **{X Scale = 1.1 ms}** **{Y Scale = 20 dBm}** **{Y Scale = 10 dB}**

Measuring downlink sub-frame burst power (continued)

Instructions	Keystrokes
On the P-Series power meter :	
7. Move the markers 1 & 2 to capture 10 ms gated burst power measurement. (See Figure 7)	Press **{Gate Control}** return to Gate Control menu. Press **{Marker 1 2}**. Press [ ] and [ ] to allocate the marker 1 and marker 2.
8. Move the markers 1 & 2 to capture 1.2 ms downlink burst sub-frame signal. (See Figure 8)	Press **{Marker 1 2}**. Press [ ] and [ ] to allocate the marker 1 and marker 2.

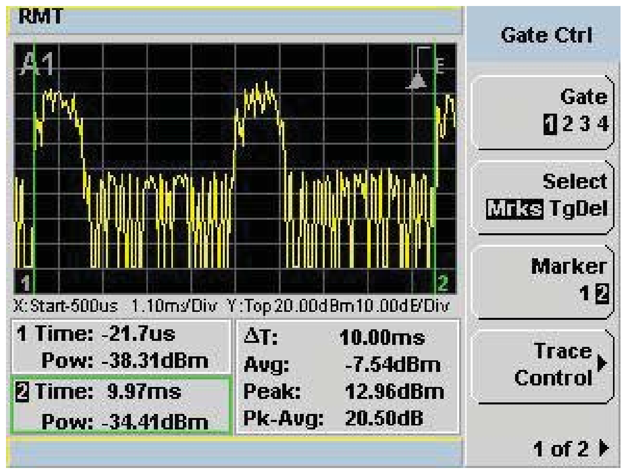

Figure 7. *LTE waveform duration at 10 ms in TDD mode. In the P-Series power meter, green lines (Marker1 and Marker2) indicate the start and end burst waveform of the signal.*

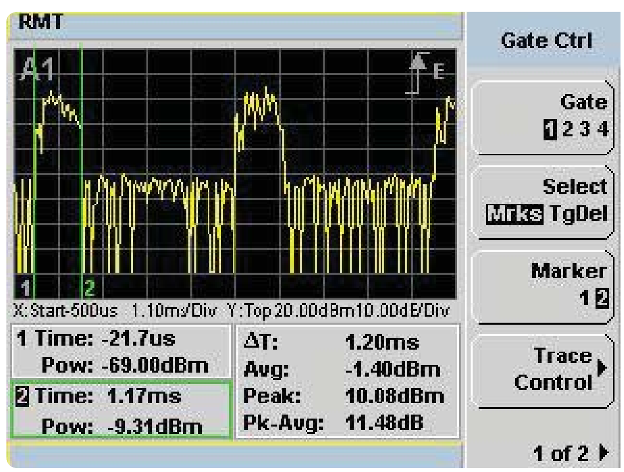

Figure 8. *Downlink average burst power signal measures -1.40 dBm at 1.2 ms sub-frame duration. In the P-Series power meter, green lines (Marker1 and Marker2) indicate the start and end burst sub-frame signal of the downlink.*

Measuring uplink sub-frame burst power

Generate an uplink LTE signal.

Instructions	Software Requirements
On the Signal Studio signal :	
1. Turn off downlink signal.	In the tree view, select **Downlink** under **Carrier 1 Waveform Setup**. Under Cell Parameters, set **State** to **Off.**
2. Turn on uplink signal.	In the tree view, select **Uplink** under **Carrier 1 Waveform Setup**. Under Cell Parameters, set **State** to **On.**
3. Download the signal to the **ESG.**	Press **Generate** and **Download** button on the top tool bar; if you encounter any errors; please refer to the online help for Signal Studio software.

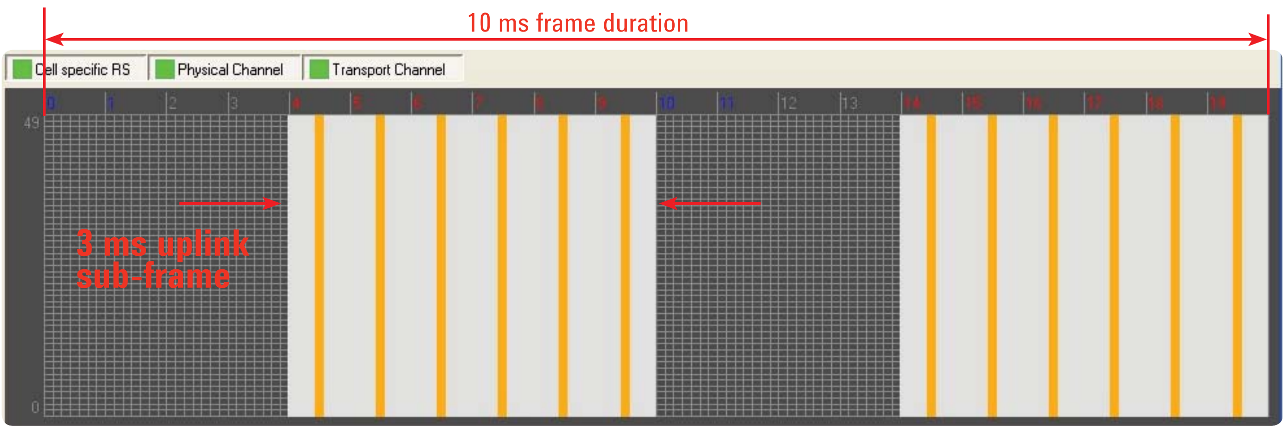

Figure 9. *Sub-frame duration 3 ms of uplink signal captured with Signal Studio*

Set up the P-Series power meter/ sensor to analyze the Uplink LTE Signal.

Instructions	Keystrokes
On the P-Series power meter :	
1. Move the markers 1 & 2 to capture 3 ms uplink burst sub-frame signal. (See Figure 10).	From Gate Control menu, press **{Marker 1 2}**. Press [ ] and [ ] to allocate the marker 1 and marker 2.

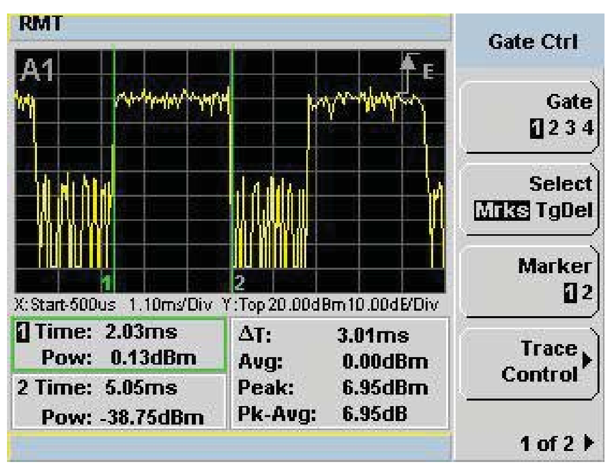

Figure 10. *Uplink average burst power signal measures 0 dBm at 3 ms sub-frame duration. In the P-Series power meter, green lines (Marker1 and Marker2) indicate the start and end burst sub-frame signals of uplink.*

Measuring CCDF power statistics of LTE signal

CCDF is generally measured with data that is as random as possible to match the Gaussian curve. The CCDF waveform provides statistics for the input signal, analyzed over 1 seconds asynchronously to any features of the signal. 100 MHz samples are histogrammed in real time so we can have the statistics on 100 million samples.

The P-Series power meter provides waveform CCDF measurement in graphical and table formats (See Figure 12 and Figure 13). In Figure 11, the Signal Studio under waveform setup shows that the CCDF plot and the table to the left of the CCDF plot display the calculated peak-to-average values. The blue line represents the Gaussian noise and the yellow line represents the input signal. Prior to measurement, a reference trace is set and compared with the Gaussian noise trace.

Figure 11. *Waveform CCDF calculates the CCDF and peak-to-average ratio using the entire LTE-TDD waveform (with downlink signal off and uplink signal on)*

Set up the P-Series power meter/ sensor to measure the LTE-TDD statistical CCDF with downlink signal off and uplink signal on.

Instructions	Keystrokes
On the P-Series power meter :	
1. Set the acquisition to "Free Run".	Press **[Trig/Acq]**, **{Acqn A}**, **{Free Run}.**
2. Set the CCDF in trace format.	Press **[Disp]**, **{Disp Type}**, **{1 of 2}**, **{CCDF Trace}.**
3. Set the trace scale to 20 dB.	Press **{Trace Control}**, **{Scale/Div 2dB}.**
4. Set the Gaussian noise trace.	Press **{Trace Display}**, **{Gaussian}**. Press **[Prev/Esc]** return to **Trace Ctrl** menu.
5. Set marker 1 to 10% and marker 2 to 1% of time. (See Figure 12).	Press {Marker Control}, press {Marker 1 2}. Press [ ] and [ ] to allocate the marker 1 and marker 2.
6. Set the CCDF in table format and expand the display. (See Figure 13).	[Disp], {Disp Type}. {1 of 2}, {CCDF Table}, [ ].

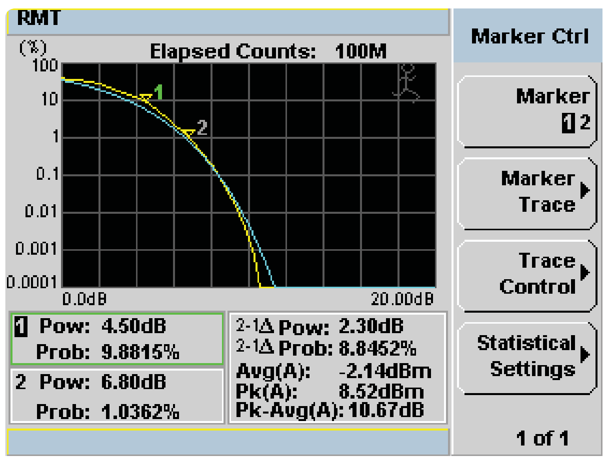

Figure 12. *CCDF graphical format. The yellow line is the input signal. The blue reference line is the band-limited Gaussian noise curve. Marker 1 and Marker 2 indicate 10% and 1% of time at a specified power measurement.*

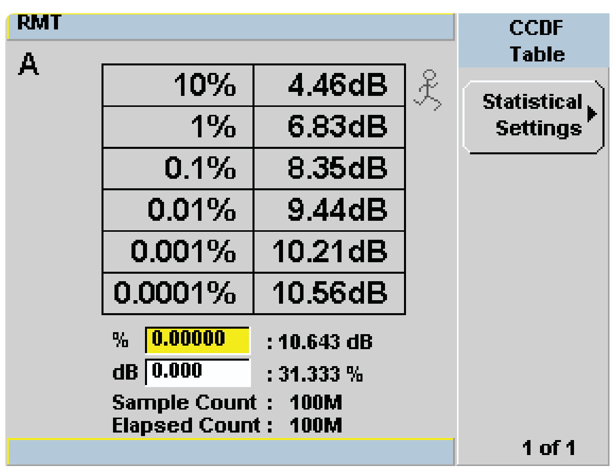

Figure 13. *CCDF table format*

Conclusion

Accurately measuring the burst signal power of LTE signals is very important for LTE conformance testing. The P-Series power meter/sensor is capable of capturing the 20 MHz VBW (video bandwidth) signal of LTE-TDD and measuring the gated burst power accurately. This document outlines the following key features of the P-Series power meter/sensor:

- One-button WiMAX predefined preset to simplify the measurement setup effectively
- Auto-trigger with hold off
- 30 MHZ video bandwidth
- 100 Msa/s
- Measurement speed match burst rate: useful for high speed dynamic transmitter power calibration
- Power statistical CCDF graphical and tabular format

Ordering Information

For further information, refer to P-Series Power Meters and Power Sensors Configuration Guide, Literature No : 5989-1252EN

Product Type	Model Number
P-Series power meter	N1911A or N1912A
P-Series wideband power sensor	N9121A or N1922A

Related Agilent Literature

Publication title	Pub number
P-Series Power Meters and P-Series Wideband Power Sensors Technical Overview	5989-1049EN
P-Series Power Meters and Power Sensors Configuration Guide	5989-1252EN
N1911A/N1912A P-Series Power Meters and N1921A/N1922A Wideband Power Sensors Data Sheet	5989-2471EN

Reference

Publication title	Pub number
Agilent 3GPP Long Term Evolution Application Note	5989-8139EN
Agilent Technologies Solutions for 3GPP LTE Technical Overview	5989-6331EN
Agilent Move Forward to What's Possible in LTE	5989-7871EN

Related Web Resources

For the latest and most complete applications and information, please refer to the following URL:

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