Voice over LTE (VoLTE) Speech Quality Measurements

Application Note

Products:
- R&S®CMW500
- R&S®CMWrun
- R&S®UPV
- R&S®UPV66

This application note and associated application software may be used to conduct psychoacoustic speech quality evaluation for Voice over LTE (VoLTE) connections.

The measurements are based on recommendations ITU-T P.862 and ITU-T P.863, respectively.

The CMWrun example sequences perform decoder/encoder calibration, connection setup for the UE under test and subsequent speech quality analysis under IP impairment conditions.
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1 Overview

Cellular Radio Operators face an increasing pressure to free existing spectrum as currently used for voice-centric services in order to allow its re-use for a broad range of integrated media applications. This means existing circuit-switched voice services have to be offered as just one of many applications on a packet-switched network without sacrificing the quality users have come to expect.

Stand-alone or integrated media voice is and will remain a key application for mobile radio service subscribers. Operators of such services strive to ensure or even improve voice quality despite the additional challenges that a packet-based transmission of speech entails.

The VoLTE (Voice over LTE) packet service uses the IMS (IP Multimedia Subsystem) as architecture. One of the key enablers for the architecture is the Session Initiation Protocol (SIP) e.g. used for negotiating the codec type, AMR-NB (Adaptive Multirate-narrow band) or AMR-WB (wideband) and coderate (e.g. 23.85 kbps).

VoLTE uses the AMR-WB codec and can transfer signals with twice the sample rate (16000 Hz) as classic circuit switched systems, e.g. AMR-NB, GSM-HR (half-rate) or GSM-FR (full rate). VoLTE on one hand has advantage of an enhanced frequency spectrum and on the other hand variable latency and possible IP impairments.

The described solution in this application note explains the measuring of speech quality with the PESQ (Perceptual Evaluation of Speech Quality) and POLQA (Perceptual Objective Speech Quality Assessment) algorithm. As successor of PESQ, the new POLQA method is designed for additional test applications such as SWB (Super Wideband Mode), bandwidth extensions etc.. A further benefit of this algorithm is that the resulting MOS-LQO (Mean Objective Score – Listening Quality Objective) results measured with other radio access technologies (e.g. GSM, CDMA2000) are comparable to each other.

This application note describes how to perform VoLTE PESQ and POLQA measurements with an R&S® CMW500 Wideband Communication Tester and an R&S® UPV Audio Tester manually or fully automatically using an example test sequence for the R&S® CMWrun Sequencer Software Tool. It contains an automated POLQA / PESQ measurement similar as described in reference [7]. The test establishes a call to a LTE mobile or PC card, configures IP impairments, calibrates the audio interface for R&S® UPV (decoder/encoder) and performs either a POLQA measurement according to recommendation ITU-T P.863 or PESQ measurement according to recommendation ITU-T P.862 of the speech signal received (downlink) or transmitted (uplink) by the user equipment (UE).

The following abbreviations are used in the following text for R&S® test equipment:

- The R&S® CMW500 Wideband Communication Tester is referred to as CMW500.
- The R&S® UPV Audio Analyzer is referred to as UPV.
- R&S® CMWrun is referred to as CMWrun.
- R&S® refers to Rohde & Schwarz GmbH und Co KG

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2 Hardware Setup

2.1 VoLTE Test Setup

This setup is used for measurements based on an electrical audio connection and consists of:

1. **CMW500** Communication Tester is connected to the LTE UE via RF. It provides IMS infrastructure, establishes a VoLTE call and transmits RTP packets to and from the UE. Be sure to use the LAN Switch 2 (Rear) connector for remote control with the static IP address 172.22.1.4.
2. **UPV Audio Analyzer** for performing POLQA and PESQ measurements of downlink and uplink audio signals. It must be set to the static IP address 172.22.3.1.
3. **Remote PC** equipped with a LAN interface with a static IP address 172.22.2.2 and CMWrun v1.7.8.15 or higher installed.
4. **LTE UE** – with IMS / VoLTE capability.

Figure 2-1: VoLTE test setup with CMW500 and UPV (schematic)
The LAN cables from the Remote PC and the UPV are connected to the LAN Switch 2 at the rear of the CMW500.

![LAN Switch 2 (Rear)](image)

**Fig. 2-1: CMW500 LAN Switch 2**

- **CMW500 – LAN Switch 2 (Rear)**
  - Obtain an IP address automatically
  - Use the following IP address:
    - IP address: 172.22.1.4
    - Subnet mask: 255.255.0.0
    - Default gateway: 

- **UPV – LAN connector**
  - Obtain an IP address automatically
  - Use the following IP address:
    - IP address: 172.22.3.1
    - Subnet mask: 255.255.0.0
    - Default gateway: 

**Fig. 2-2: CMW500 LAN remote config (default)**

**Fig. 2-3: UPV LAN remote configuration**

- **Remote PC – LAN connector**
  - Obtain an IP address automatically
  - Use the following IP address:
    - IP address: 172.22.1.1
    - Subnet mask: 255.255.0.0
    - Default gateway: 

**Fig. 2-4: Remote PC LAN Configuration**
Fig. 2-5: VoLTE test setup with CMW500 and UPV
2.2 Required Cables, Adapters and Connectors

2.2.1 Neutrik NA2 MBNC

XLR Male to BNC Female e.g. http://www.thomann.de/de/neutrik_na_2_mbnc.htm

Fig. 2-6: XLR Male to BNC Female Adapter
This adapter type is connected to the UPV Analyzer 2 input.

2.2.2 Neutrik NA2 FBNC

XLR Female to BNC Female e.g. http://www.thomann.de/de/neutrik_na_2_fbnc.htm

Fig. 2-7: XLR Female to BNC Female Adapter
This Adapter type is connected to the UPV Generator 2 output.
2.2.3 2 x BNC Cables 0.5m

Two BNC cables 0.5m e.g. [http://www.thomann.de/de/pro_snake_bncleitung_05m.htm](http://www.thomann.de/de/pro_snake_bncleitung_05m.htm)

![BNC cable](image)

Fig. 2-8: BNC cable

For connecting UPV Analyzer 2 and Generator 2 to the CMW Audio Board (AF IN 1 and AF OUT 1).

2.2.4 Y-Cable 4-pole 3.5 mm Jack Plug to XLR-male and XLR-female

The UP-Z9 cable set contains two Y-cables with each a 4-pin 3.5 mm jack plug on one and an XLR-male and XLR-female connector on the other side. The 3.5 mm jack comes in 2 variations for Apple and other smart phones.
3 Software Requirements

For running VoLTE POLQA / PESQ test plans with CMWrun following software environment must be installed on the CMW500, UPV and PC:

3.1 CMW500

On the CMW500 following software options are mandatory (version numbers should be equal or higher):

- Base firmware ≥ 3.2.40
- DAU firmware ≥ 3.2.30
- LTE firmware ≥ 3.2.70
- WCDMA firmware ≥ 3.2.70
- Audio Speech firmware ≥ 3.2.12

3.2 UPV

On the UPV following software is mandatory (version numbers should be equal or higher).

- UPV firmware ≥ 3.3.1.758 – The latest revision can be downloaded at http://www.rohde-schwarz.com/en/firmware/upv
- POLQA_CAL_macro ≥ 1.2.0

3.2.1 POLQA_CAL

POLQA_CAL_120.msi must be installed on the UPV. It supplies remote commands for calibration and PESQ / POLQA measurements. The VoLTE_SpeechQualityMeasurement test item in CMWrun uses this macro by default.

Figure 3-1: POLQA_CAL installation on UPV
3.3 Remote PC

3.4 R&S CMWrun

Install CMWRUN 1.7.8.15 or higher on the REMOTE PC. Unzip the file VOLTE_CAMPAIGN_DEMO_AUDIOBOARD.ZIP to the CMWrun directory <Windows data directory>\CMWRUN FILES\MY TEST PLANS\.
4 CMW500 Configuration for Manual Testing

4.1 LTE Settings

This example uses an LTE / VoLTE phone operating in band 13. For performing an IMS call it is necessary to configure certain LTE cell and IMS server parameters.

1. Enable LTE signaling by activating the LTE Signaling 1 checkbox.

![LTE Signaling Configuration](image)

Fig. 4-1: Select LTE Signaling
2. In the LTE Signaling 1 menu set the required Operating Band. Make sure that the DAU has been enabled first.

![LTE Signaling Menu](image)

**Fig. 4-2: LTE Signaling Menu**

3. Go to the LTE SIGNALING CONFIGURATION page by pressing the CONFIGURE button, enable the Speech Codec and select Connection Type Data Application.
Some phones require the Accept Multiple Default Bearer checkbox to be enabled.

- **Disabled:** Only the 1st default bearer of a UE is accepted. Additional requests are rejected.
- **Enable:** So many bearers are established as UE requests.

An IP address is assigned for each bearer, so only enable the parameter if necessary.
4. Make sure that IMS Voice over **PS SESSION INDICATOR = SUPPORTED**. In case of **NOT SUPPORTED** the DUT performs a CSFB instead of an IMS registration.

![IMS Configuration for Mercuro IMS Client](image)

5. Configure the Network parameters Identify and Security Settings according to the DUT capabilities.
4.2 Audio Measurement Settings

1. Open the Audio Measurement tab by pressing the soft key Measure and enabling the Audio → Measurements 1 checkbox.
2. Open the Audio Measurement tab and choose the scenario **EXTERNAL ANALOG SPEECH ANALYSIS**. Set the Input and Output Level Full-Scale (Peak) to following values.

![Audio Measurement](image)

The internal CMW audio board does not need to be calibrated. If the UPV requires a calibration step, load the *.ccl* pseudo calibration files for encoder and decoder cal which should contain the input and output levels of the CMW500, e.g. 1.00 V (Peak).

![Audio Input and Output Level](image)
Fig. 4-8: CMW Audio Board Input / Output Level Full-Scale (Peak)

The voltage values in the files named below must contain the same value as set in the **Audio Configuration → Speech** menu:

**CMW_ENC_1V.CCL:**

UPV_1GA50_CAL  
encoder  
1.000000

**CMW_DEC_1V.CCL:**

UPV_1GA50_CAL  
decoder  
1.000000
4.3 Data Application Unit Settings

1. Open the Data Application Unit by enabling the **DATA APPL. → MEASUREMENT 1** checkbox in the Measurement Controller menu.

![Measurement Controller](image)

Fig. 4-9: Select DAU menu
2. Open the Data Application Unit and click on the **CONFIGURE SERVICES** soft key on the right.

![Data Application Measurement](image)

**Fig. 4-10: Data Application Measurement**

3. Open the IMS Configuration by pressing the **CONFIG...** button in the IMS tab of the DAC and expand the **VOICE OVER IMS** element in the internal tree.

![Config... button of the DAC](image)

**Fig. 4-11: Config... button of the DAC (Data Application Control)**
4. Choose the appropriate **PRECONDITIONS** for the UE.

![IMS Configuration for Verizon IMS Client](image)

**Note:** There are different recommended configuration settings depending on the phone used.

<table>
<thead>
<tr>
<th>Settings</th>
<th>AT&amp;T</th>
<th>Verizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Type</td>
<td>IPv6</td>
<td>IPv6</td>
</tr>
<tr>
<td>User Authentication</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>Preconditions</td>
<td>Preconditions</td>
<td>Simple</td>
</tr>
<tr>
<td>Audio Routing</td>
<td>Audioboard</td>
<td>Audioboard</td>
</tr>
</tbody>
</table>

**Table 4-1: Mobile specific settings**
5. Activate the IMS server by clicking on the ON/OFF button. The IMS server automatically connects with the CMW Audio Board. The Info indicator will show that the IMS server has started successfully.

![Data Application Control (IMS activated)](image_url)

Fig. 4-13: Data Application Control (IMS activated)

Memorize all the settings mentioned in this chapter since they are also needed for the automated test solution with CMWrun.
5 Establishing a manual Voice over IMS Call

The CMW-Z50 CMW500 Handset option allows quick check, if the audio signal to and from the mobile is transmitted correctly before a UPV is connected as shown in Fig. 2-1.

Fig. 5-1: CMW-Z50 Handset

It is simply connected the AF IN 1(2) and AF OUT 1(2) of the CMW500.
1. Start the RAN signaling with the handset connected.
2. Configure LTE in E2E (End to End) mode.
3. Connect the UE to the CMW500 RF COM port.
4. Attach UE to the cell by enabling LTE signaling.

![LTE Signaling State Attached](image)

**Fig. 5-2: LTE Signaling State Attached**
5. After the LTE cell registration, the IMS client running on the UE will register to the CMW500 IMS server. The registration event is displayed in the IMS status log.

Fig. 5-3: IMS server with registered UE

6. A VoLTE call can be initiated by the UE by dialing a random number. The IMS server will pick up a call from any number.

Alternatively the mobile can be called from the DAU (as done in automated tests) by pressing the VOICE OVER IMS soft key. An additional configuration window will appear. Select Call Type Audio, AMR Type Narrowband or Wideband and one or more AMR Codecs supported by the UE. The VoLTE call is initiated by pressing the CALL soft key.

After the VoLTE call has been established, the downlink and uplink audio transmission is active and can be tested with the CMW-Z50. The speech going into the CMW-Z50 microphone should be audible on the mobile phone speaker after a small delay. The speech going into the mobile phone microphone should be audible on the CMW-Z50 speaker after a small delay.
VoLTE POLQA / PESQ Measurements with CMWrun

6 VoLTE POLQA / PESQ Measurements with CMWrun

6.1 CMWrun Configuration

The following VoLTE DLLs are part of the CMWrun / CMW-KT51 General Purpose Package.

- RohdeSchwarz.CMWrun.GP.UPV.SpeechQualityMeasurement.dll
- VoLTE_SpeechQualityMeasurement.dll

**Note:** The VoLTE applications above require following CMWrun options:

- CMW-KT051 for E2E and VoLTE Speech Quality Applications
- CMW-KT055 for LTE CallSetup

Start CMWrun. Before loading the test plan it is necessary to define the devices' resource strings in the **RESOURCES → SCPI CONNECTIONS...** menu. For the VoLTE Speech Quality Measurement a CMU500 Communication Tester and a UPV Audio Analyzer are required. Set the SCPI connections for the CMW500 and UPV.

![CMRun SCPI Connections menu](image)

**Fig. 6-1:** CMRun SCPI Connections menu

Make sure to set the UPV Timeout to 60 seconds by pressing **CONFIGURE...** to avoid timeout errors. Do the same for the CMW500. Set the CMW500 as default instrument (checkbox ON).
Fig. 6-2: Set UPV Resource Name and Timeout
6.2 POLQA Test Campaign for Multiple Speech Codecs

The figure below shows an example of a campaign for POLQA measurements with all VoLTE WB- and NB-AMR codecs.

![Diagram of campaign steps]

**Fig. 6-3: CMWrun – VoLTE test campaign with all NB/WB-AMR Codecs**

Test campaign management is supported since CMWrun v1.7.8.03. A master test plan is only performed once and performs the basic initialization, sets the RF attenuation, initializes the internal CMW AudioBoard, performs an LTE / VoLTE call and DAU / IMS initialization, calibrates the mobile phones speaker output and microphone input and finally disconnects the LTE / VoLTE call.
6.2.1 BasicInitializing

This component handles the basic configuration and e.g. resets the CMW500 to default settings. By double clicking **BasicInitializing** a configuration window opens. Check **Reset Instrument(s)**. This should always be performed to ensure identical starting conditions on different systems.

![BasicInitializing](image)

**Fig. 6-4: Basis Initializing**

6.2.2 SCPICommandList

This menu item contains SCPI commands for initializing the CMW AudioBoard.

![SCPICommandList](image)

**Fig. 6-5: CMW AudioBoard Initialization**

The **<Default>** instrument must have been set to CMW500 in the **SCPI Connections** menu (see Fig. 6-1).
6.2.3 **Attenuation Tables**

This test item allows setting of input and output attenuation values to compensate RF components such as cables, mixers, directional couplers, etc. The attenuations can be set to constant values or be changed by user interaction at runtime.

![Set Attenuation Table](image)

*Fig. 6-6: Set Attenuation Table*
6.2.4 LTECallSetup

As soon as IMS is turned ON, an LTE cell is established were the UE can attached to. The following screen shot shows the configuration window which opens when double clicking LTECallSetup in the list:

![LTE Call Setup Window]

Please make sure that the UE parameters are entered correctly or else the UE will not be attached and the test terminated.

---

Fig. 6-7: LTE Call Setup

Please make sure that the UE parameters are entered correctly or else the UE will not be attached and the test terminated.
LTE Call Setup parameters in our example that differ from default:

- **SCENARIO** = SISO
- **BAND** = Band4
- **RF DOWNLINK CONNECTOR 1** = RF 1 COM
- **RF UPLINK CONNECTOR** = RF 1 COM
- **SCHEDULING TYPE** = RMC
- **#RB** = 50 (DL), 50 (UL)
- **MODULATION** = QPSK (DL), QPSK (UL)

**CONNECTION TYPE** → **ADVANCED...** parameters:

![Connection Parameters Diagram]

Figure 6-1: Connection Parameters

- **CONNECTION TYPE** = VoLTE
Click on the **IMS...** button to enter the IMS Setup menu.

![IMS Setup](image)

**Fig. 6-8: IMS Setup**

The following parameters may vary with different mobile manufacturers.

- **IMS Client Registration** – Manual or Auto, which is sufficient in most cases.
- **IP Address Type** – IPv4 or IPv6.
- **User Authentication** – Default ON.
- **Voice Preconditions** – With Precondition, **No Precondition** or Simplified Call Flow.
- **Audio Routing** – Use internal CMW **Audioboard**.
- **Call Type** – **Audio** or Video.
VoLTE POLQA / PESQ Measurements with CMWrun

- **AMR Type** – **Wideband** or Narrowband.
- **AMR Codec** – Select codec rate (highest value) and possible alternative rates, i.e. **23.85 kBIT/s**.

If the LTE call is successful (if (Step3.CallSetupSucceeded) the test will continue, if not, an error message will be displayed and the test stopped.

6.2.5 **UPV_UserEquipmentCalibration**

The mobile input / output calibration requires valid decoder / encoder calibration values and an active VoLTE speech connection. The mobile input calibration determines the full-scale peak input voltage of the mobile under test which is connected to UPV generator output 1. The mobile output calibration determines the full-scale peak output voltage of the mobile under test which is connected to UPV analyzer input 1. Perform a calibration when you change the mobile or load stored values from an earlier calibration.
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Fig. 6-9: User Equipment Calibration

- **UPV SETTINGS** – Indicates the necessary audio cabling
- **MEDIA SERVER SETTINGS** – Select User defined mode only if custom media server is used.
- **POLQA CALIBRATION MACRO** – Select User define only if custom calibration macro is used.
- **SAVE CALIBRATION RESULTS** – The Mobile Input calibration file contains the peak voltage supplied by UPV generator 2 output, while the Mobile Output calibration File contains the peak voltage supplied by the mobile output.
After these steps, the `RUNTESTPLANCE_MAIN` test items execute further slave test plans to change the codecs and perform a POLQA measurement on the R&S UPV.

After all the slave tests have been completed the results are merged to a single measurement report. Dealing with simple scripts instead of huge and complex test plans simplifies maintenance. The UE call setup and operator specific IMS settings can be handled by separate test plans requiring no changes in the sub-scripts calling the POLQA algorithm. The figure below shows how this works:

The master test plan controls the POLQA campaign for all VoLTE codecs and IP impairments. This is ideal for regression tests, since the POLQA algorithm takes time and needs to be repeated several times for statistical confidence. Therefore the campaign approach with CMWrun is mandatory to reduce test time and user interaction.

![Diagram of test plan](image-url)
6.2.6 TestPlan_Sync

The TestPlan_Sync test item allows definition a slave test plan and various execution conditions.

![Test Plan Properties Form]

- **Relative Path — Master Test Plan** — If checked, the test plan file is in the same directory as the master test plan.
- **Merge Slave Report after finished** — If checked, this test report is merged to the master test plan report.
- **Continue Master if Slave Test Plan is paused** — If checked, the Master Test Plan continues with the next test item if the slave test plan is paused.

Fig. 6-11: TestPlan_Sync
The slave test plan in this example is TC_Impairment_01_AMR-WB_12650bps_mean.rstp which contains all POLQA related test items.

**Fig. 6-12: TC_Impairment_AMR-WB_12650bps_mean test plan**

This test plan is suited for our example since it contains all POLQA related test items.
6.2.6.1 VoLTE_CodecReconfiguration

This test item allows to change the VoLTE call and codec parameters during an active LTE / VoLTE call.

Fig. 6-13: VoLTE_CodecReconfiguration

- **CALL TYPE** – Video or Audio (default)
- **AMR TYPE** – Wideband or Narrowband (default)
- **AMR CODEC** – 12.65 kbps in this test item.
- **VIDEO CODEC** – H263 (default) or H264. Only active if Call Type = Video.
6.2.6.2 Result Section

Defines a name for the appended section in the test report.

![Screenshot of Report Result Section]

- **Annex only** – If checked, appends the results at the end of the test report.

6.2.6.3 Report Comment

Allows adding a detailed comment in the test report.

![Screenshot of Test Properties Form]

Fig. 6-15: Report Comment
6.2.6.4 E2E_SetJitter

![E2E Set Jitter Interface]

**Fig. 6-16: E2E Set Jitter**

Adds an artificial jitter to the IP stream, simulating real-world internet connectivity. This stresses the AMR codec which must maintain a decent voice quality under tightened transmission conditions.

The Index, Port Range Start and Port Range Stop controls are actually global parameters that are defined in the parameters display above the test case.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Step#</th>
<th>Type</th>
<th>Value</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jitter</td>
<td>4</td>
<td>Double</td>
<td>0.01</td>
<td>0</td>
<td>10</td>
<td>seconds</td>
</tr>
</tbody>
</table>

**Fig. 6-17: E2E Set Jitter global parameters**

This corresponds to test item #4

- **INDEX** = Value = 0.01 secs = 10 ms jitter.
- Port Range Start = Min. = lower jitter limit 0 seconds.
- Port Range Stop = Max. = upper jitter limit 10 seconds.
6.2.6.5 **E2E_SetPacketLossRate**

The E2E_SetPacketLossRate artificially degrades a signal by not transmitting a dedicated number of data packets.

![E2E Set Packet Loss Rate](image)

**Fig. 6-18: E2E Set Packet Loss Rate**

The Index, Port Range Start and Port Range Stop controls are actually global parameters that are defined in the parameters display above the test case.

<table>
<thead>
<tr>
<th>PacketLossRate</th>
<th>5</th>
<th>Double</th>
<th>1</th>
<th>0</th>
<th>100</th>
<th>%</th>
</tr>
</thead>
</table>

**Fig. 6-19: Set Packet Loss Rate global parameters**

This corresponds to test item #5

- **INDEX** = Value = 1 %.
- Port Range Start = Min. = lower packet loss rate limit 0 %.
- Port Range Stop = Max. = upper packet loss rate limit 100 %.
6.2.6.6 VoLTE_SpeechQualityMeasurement

![Speech Quality Measurement](image)

**Fig. 6-20: Speech Quality Measurement**
Parameters for the POLQA / PESQ measurement are set in this test item.

- **UPV SETTINGS** – The green AUDIO INTERFACE and USER EQUIPMENT indicators depend on the Measurement Direction. The UPV input signal can be monitored by activating the SPEAKER checkbox.

- **POLQA CALIBRATION MACRO** – Select USER DEFINE only if custom calibration macro is used. The MACRO SETTINGS can be edited by clicking the SETTINGS… button (see Fig. 6-18).

**MACRO SETTINGS** – Define the default settings of the POLQA_Cal Macro which runs on the UPV and performs calibration and measurement tasks.

**Fig. 6-21: Macro Settings**

The parameters that need to be changed are the Setup modes of the Decoder, Encoder, Mobile Input and Mobile Output Calibration Values.
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Fig. 6-22: Modes for Calibration Values

- **DEFAULT** – Uses current active calibration values from the UPV. These values are updated with every calibration step of the setup.
- **BY VALUE** – Allows to enter custom values which are stored in the test plan itself.
- **BY FILE** – Allows reading calibration values from a custom file which has been previously generated.

**MEASUREMENT**

- **METHOD** – Select POLQA or PESQ measurement.
- **DIRECTION** – DOWNLINK (base station to mobile) or UPLINK (mobile to base station)
- **PLAY-MODE** – SINGLE or CONTINUOUS. In Continuous mode the 1st MOS/LQO value is stored.
  The following PESQ / POLQA measurements are repeated infinitely.
- **BANDWIDTH** – SUPER-WIDE (POLQA and PESQ) or NARROW (only PESQ).

**REPETITION** – Number of Repetitions 1...999. A number for highest and lowest can be entered to eliminate extreme values from the statistic.

**RESULTS** – Enable or disable Report Statistics.

- **MOS LIMIT** – Test passed if MOS/LQO value > MOS limit. Default 3.5.
- **PERCENTILE LIMIT** – Default 80.0%.
- **MEAN > MOS LIMIT** – Means that the mean MOS/LQO value

\[
\text{mean} = \frac{\sum_{k=1}^{\text{NumRep}+1} (\text{MOS}_k)}{\text{NumRep} + 1}
\]

must be larger than the MOS Limit for the test item to pass.

- **PERCENTILE > MOS LIMIT** – means that 80% of the NUMBER OF REPETITIONS +1 must pass, i.e. must exceed the MOS Limit for the test item to pass.

### 6.2.6.7 E2E_ImpairmentsDisable

Turns OFF E2E jitter, packet loss rate and delay.
6.2.7 LTECallDisconnect

Drops the LTE connection.

6.3 Running the Test

The example below shows how to run the VoLTE_SPEECH_QUALITY_MEAS.RSTP test plan. In this test plan the POLQA MOS/LQO is measured for uplink and downlink at ideal conditions and then a second time with IP delay, jitter and packet loss turned ON.

To start the test, press the Run arrow in CMWrun.

![Screenshot of CMWrun interface with test plan.

Fig. 6-23: Start a Test Plan

After the test plan has been completed a result table similar to the following is displayed.

<table>
<thead>
<tr>
<th>Report Info:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Under Test:</td>
</tr>
<tr>
<td>Serial No. (DEC.IMEI):</td>
</tr>
<tr>
<td>Testplan:</td>
</tr>
<tr>
<td>User:</td>
</tr>
<tr>
<td>Comment:</td>
</tr>
<tr>
<td>Instrument ID:</td>
</tr>
<tr>
<td>Date:</td>
</tr>
</tbody>
</table>
VoLTE POLQA / PESQ Measurements with CMWrun

Summary:

| Test Start Time:       | 2/4/2014 2:28:05 PM       |
| Test End Time:         | 2/4/2014 3:14:01 PM       |
| Total Test Time:       | 00:56:06                 |
| Weighted Test Time:    | 00:40:38                 |
| Test Items Passed:     | 43                       |
| Test Items Failed:     | 19                       |
| Number of Test Items:  | 62                       |
| Errors:                | 2                        |

Basic Initiation: Initialization of Instrument.

Instrument start:
CMW = Driver

LTE Call Setup: Base Station Configuration

LTE ESG, Band 4
DL Channel 0175, DL Frequency 2130.5, UL Cell Bandwidth 10.0 MHz
UL Commer 2175, UL Frequency 1730.5, UL Cell Bandwidth 10.0 MHz
Connection Type: VoLTE
Call Direction: CMW -> Module

LTE Call Setup: Base Station Enable

Base Station Enabled in 105.8s
IMS Enabled in 9.8s

LTE Call Setup: Power On Mobile Box

LTE Call Setup: Attach Process

<table>
<thead>
<tr>
<th>Attach Process</th>
<th>Timeout</th>
<th>Elapsed Time</th>
<th>Unit</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attached</td>
<td>120</td>
<td>63.3</td>
<td>s</td>
<td>Passed</td>
</tr>
<tr>
<td>IMS Registered</td>
<td>100</td>
<td>0</td>
<td>s</td>
<td>Passed</td>
</tr>
</tbody>
</table>

LTE Call Setup: DUT Info

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>Measured</th>
<th>Unit</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMEI</td>
<td></td>
<td></td>
<td>360000000613818</td>
<td></td>
<td>Passed</td>
</tr>
</tbody>
</table>

LTE Call Setup: Call Process

<table>
<thead>
<tr>
<th>Call Process</th>
<th>Timeout</th>
<th>Elapsed Time</th>
<th>Unit</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection Established</td>
<td>30</td>
<td>6.8</td>
<td>s</td>
<td>Passed</td>
</tr>
</tbody>
</table>

UPV_UserEquipmentCalibration: Mobile Input Calibration

Mobile Input calibrated in 49.5 s

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Measured</th>
<th>Unit</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Input Speech Calibration</td>
<td>0.1220</td>
<td>V</td>
<td>Passed</td>
</tr>
</tbody>
</table>

UPV_UserEquipmentCalibration: Mobile Output Calibration

Mobile Output calibrated in 11.5 s

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Measured</th>
<th>Unit</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Output Calibration</td>
<td>0.5011</td>
<td>V</td>
<td>Passed</td>
</tr>
</tbody>
</table>
VoLTE POLQA / PESQ Measurements with CMWrun

RunTestPlan_Sync: Start

Test Plan 'CUOATEMCMWrun FileMy Test Plan\VoLTE_Campaign_Demo_audio-board\XC\impression\01_AMR-WB_1280bps\spea\omni-idp\*ended'

RunTestPlan_Sync: Wait

Waiting for Test Plan 'CUOATEMCMWrun FileMy Test Plan\VoLTE_Campaign_Demo_audio-board\XC\impression\01_AMR-WB_1280bps\spea\omni-idp\*ended' to finish

Test Plan 'CUOATEMCMWrun FileMy Test Plan\VoLTE_Campaign_Demo_audio-board\XC\impression\01_AMR-WB_1280bps\spea\omni-idp\*ended' finished

VoLTE Codec: Reconfiguration

AMR Wideband Codec: 12.25 kbits/s

UPV_SpeechQualityMeasurement: POLQA Measurement


<table>
<thead>
<tr>
<th>Test Item</th>
<th>Lower Limit</th>
<th>Avg. Delay</th>
<th>Measured</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement (Ref. File: 'C:\UPV\Config\ref\PolyqaRef400B0.wav' - Downlink, Super-Wide, Single-Node)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POLQA Measurement 004</td>
<td>---</td>
<td>118.2 ms</td>
<td>3.6942</td>
<td>---</td>
</tr>
<tr>
<td>POLQA Measurement 000</td>
<td>---</td>
<td>178.1 ms</td>
<td>3.6143</td>
<td>---</td>
</tr>
<tr>
<td>POLQA Measurement 003</td>
<td>---</td>
<td>117.5 ms</td>
<td>3.6703</td>
<td>---</td>
</tr>
<tr>
<td>POLQA Measurement 000</td>
<td>---</td>
<td>117.2 ms</td>
<td>3.6086</td>
<td>---</td>
</tr>
<tr>
<td>POLQA Measurement 003</td>
<td>---</td>
<td>117.8 ms</td>
<td>3.5111</td>
<td>---</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Min MOS</th>
<th>Max MOS</th>
<th>Avg MOS</th>
<th>StdDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistics (Ref. File: 'C:\UPV\Config\ref\PolyqaRef400B0.wav' - Downlink, Super-Wide, Single-Node)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POLQA Measurement 5 ms avg</td>
<td>3.8638</td>
<td>3.9703</td>
<td>3.9199</td>
<td>0.0328</td>
</tr>
<tr>
<td>Median</td>
<td>---</td>
<td>---</td>
<td>3.9143</td>
<td>---</td>
</tr>
<tr>
<td>0.3rd Percentile</td>
<td>---</td>
<td>---</td>
<td>3.8747</td>
<td>---</td>
</tr>
<tr>
<td>10th Percentile</td>
<td>---</td>
<td>---</td>
<td>3.8853</td>
<td>---</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>---</td>
<td>---</td>
<td>3.9111</td>
<td>---</td>
</tr>
<tr>
<td>50th Percentile (Median)</td>
<td>---</td>
<td>---</td>
<td>3.9143</td>
<td>---</td>
</tr>
<tr>
<td>75th Percentile</td>
<td>---</td>
<td>---</td>
<td>3.9242</td>
<td>---</td>
</tr>
<tr>
<td>90th Percentile</td>
<td>---</td>
<td>---</td>
<td>3.9059</td>
<td>---</td>
</tr>
<tr>
<td>97.5th Percentile</td>
<td>---</td>
<td>---</td>
<td>3.9658</td>
<td>---</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Item</th>
<th>MOS Limit</th>
<th>Percentage Limit</th>
<th>Calculated</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation (Ref. File: 'C:\UPV\Config\ref\PolyqaRef400B0.wav' - Downlink, Super-Wide, Single-Node)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POLQA Measurement 50.000: Percentile &gt; 3.00</td>
<td>3.00</td>
<td>60.00 %</td>
<td>100.00 %</td>
<td>Passed</td>
</tr>
</tbody>
</table>

Fig. 6-24: Excerpt of VoLTE Campaign Demo AudioBoard
7 Literature


[4] Application Note 1GA63, ""

[5] Application Note 1MA119 "PESQ® Measurement for GSM with R&S®CMUgo"


[7] Application Note 1MA137 "PESQ® Measurement for WCDMA with R&S®CMUgo"

[8] Application Note 1MA149 "VoIP Measurements for WiMAX"

8 Additional Information

Please send your comments and suggestions regarding this application note to

TM-Applications@rohde-schwarz.com
### 9 Ordering Information

<table>
<thead>
<tr>
<th>Ordering Information</th>
<th>CMW500</th>
<th>Wideband Radio Comm. Tester</th>
<th>1201.0002K50</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMW-PS503</td>
<td></td>
<td>Basic Assembly (mainframe), 70 MHz to 3.3 GHz</td>
<td>1208.7154.02</td>
</tr>
<tr>
<td>CMW-S550B</td>
<td></td>
<td>Basic Interconnection, flexible link, for non-signaling, signaling and IQ access</td>
<td>1202.4801.03</td>
</tr>
<tr>
<td>CMW-S590A</td>
<td></td>
<td>RF front end, advanced functionality</td>
<td>1202.5108.02</td>
</tr>
<tr>
<td>CMW-S600B</td>
<td></td>
<td>CMW500 front panel with display/keypad</td>
<td>1202.0102.03</td>
</tr>
<tr>
<td>CMW-B570B</td>
<td></td>
<td>RF Converter (TRX)</td>
<td>1202.5008.03</td>
</tr>
<tr>
<td>CMW-S100A</td>
<td></td>
<td>Baseband Measurement Unit, 1 GByte memory</td>
<td>1202.4701.02</td>
</tr>
<tr>
<td>CMW-B300B</td>
<td></td>
<td>Signaling Unit Wideband (SUW), for WCDMA / LTE</td>
<td>1202.6304.02</td>
</tr>
<tr>
<td>CMW-B450D</td>
<td></td>
<td>Data Application Unit, H450A (hw opt.)</td>
<td>1202.8759.05</td>
</tr>
<tr>
<td>CMW-B660A</td>
<td></td>
<td>Option Carrier</td>
<td>1202.7000.02</td>
</tr>
<tr>
<td>CMW-B661A</td>
<td></td>
<td>Ethernet Switch Board</td>
<td>1202.7100.02</td>
</tr>
<tr>
<td>CMW-B690B</td>
<td></td>
<td>OCXO, high stability</td>
<td>1202.6004.02</td>
</tr>
<tr>
<td>CMW-B400</td>
<td></td>
<td>Audio Analyzer/Generator Board</td>
<td>1207.8457.02</td>
</tr>
<tr>
<td>CMW-B405</td>
<td></td>
<td>Speech Codec Board</td>
<td>1207.8257.02</td>
</tr>
<tr>
<td>CMW-PK45</td>
<td></td>
<td>E2E Bundle including IP Enabler, IMS, and IP Measurements and Analysis</td>
<td>1207.6354.03</td>
</tr>
<tr>
<td>CMW-KS500</td>
<td></td>
<td>LTE FDD Release 8, SISO, signaling/network emulation</td>
<td>1203.6108.02</td>
</tr>
<tr>
<td>CMW-KS510</td>
<td></td>
<td>LTE Release 8, SISO, signaling / network emulation, advanced functionality</td>
<td>1203.9859.02</td>
</tr>
</tbody>
</table>

#### Audio Analyzer

<table>
<thead>
<tr>
<th>Audio Analyzer</th>
<th>UPV</th>
<th>Audio Analyzer, analog interfaces, DC to 250 kHz</th>
<th>1146.2003.02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Or UPV66</td>
<td></td>
<td>Audio Analyzer without display/keypad</td>
<td>1146.2003.66</td>
</tr>
<tr>
<td>UPV-K9</td>
<td></td>
<td>Base Software for Mobile Phone Tests incl. cables and adapters</td>
<td>1402.0008.02</td>
</tr>
<tr>
<td>UPV-K91</td>
<td></td>
<td>UMTS/GSM Mobile Phone Tests</td>
<td>1402.0108.02</td>
</tr>
<tr>
<td>UPV-K61</td>
<td></td>
<td>Speech Quality Measurement PESQ, to ITU-T rec. P.862</td>
<td>1401.7309.02</td>
</tr>
<tr>
<td>UPV-K63</td>
<td></td>
<td>Listening Quality Analysis POLQA, to ITU-T rec. P.863</td>
<td>1402.1156.02</td>
</tr>
<tr>
<td>UPV-K1</td>
<td></td>
<td>Universal Sequence Controller</td>
<td>1401.7009.02</td>
</tr>
</tbody>
</table>

#### Optional:

<table>
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<tr>
<th>Optional:</th>
<th>UPV-K4</th>
<th>Remote Control for IEC625 / IEEE488, RS232, USB and LAN</th>
<th>1401.9001.02</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UPV-K92</td>
<td>CDMA2000 Mobile Phone Tests</td>
<td>1402.0608.02</td>
</tr>
<tr>
<td></td>
<td>UPV-K62</td>
<td>Audio Quality Measurement PEAQ, to ITU-R rec. BS.1387</td>
<td>1401.7750.02</td>
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<tr>
<td></td>
<td>UPV-B3</td>
<td>Second Analog Generator, DC to 80 kHz</td>
<td>1401.4806.02</td>
</tr>
</tbody>
</table>

#### CMWrun Software Sequencer Tool

<table>
<thead>
<tr>
<th>CMWrun Software Sequencer Tool</th>
<th>CMWPC</th>
<th>PC based CMW applications</th>
<th>1201.0002.90</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMW-KT051</td>
<td>R&amp;S®CMWrun sequencer tool, CMWrun generic proposal</td>
<td>1203.4157.02</td>
<td></td>
</tr>
<tr>
<td>CMW-KT055</td>
<td>R&amp;S®CMWrun sequencer tool, LTE applications</td>
<td>1207.2107.02</td>
<td></td>
</tr>
</tbody>
</table>
About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established more than 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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Environmental commitment

- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

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