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 (PESQ) and ITU-T P.863 (POLQA).

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

ROHDE & SCHWARZ

Table of Contents

1 Overview

Cellular Radio Operators face increasing pressure to free existing spectrum 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 its 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 has on one hand the advantage of an enhanced frequency spectrum yet on the other hand the disadvantage of variable latency and possible IP impairments.

The described solution in this application note explains the measurement of speech quality with the PESQ (Perceptual Evaluation of Speech Quality) and POLQA (Perceptual Objective Speech Quality Assessment) algorithms. As the 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 both manually and fully automated using an example test sequence for the R&S®CMWrun Sequencer Software Tool. It contains an automated POLQA / PESQ measurement similar to what is described in reference [7]. The test establishes a call to an LTE mobile or PC card, configures IP impairments, calibrates the audio interface for the R&S®UPV (decoder/encoder) and performs either a POLQA measurement according to recommendation ITU-T P.863 or a PESQ measurement according to recommendation ITU-T P.862. This is done on 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

POLQA® and PESQ® are registered trademarks of OPTICOM Dipl.-Ing. M. Keyhl GmbH, Germany and of Psytechnics Ltd., UK

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 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 external LAN port on the front of the CMW.
2. **UPV** Audio Analyzer for performing POLQA and PESQ measurements of downlink and uplink audio signals.
3. **Application PC** equipped with a LAN interface with CMWrun v1.8.8 or higher installed.
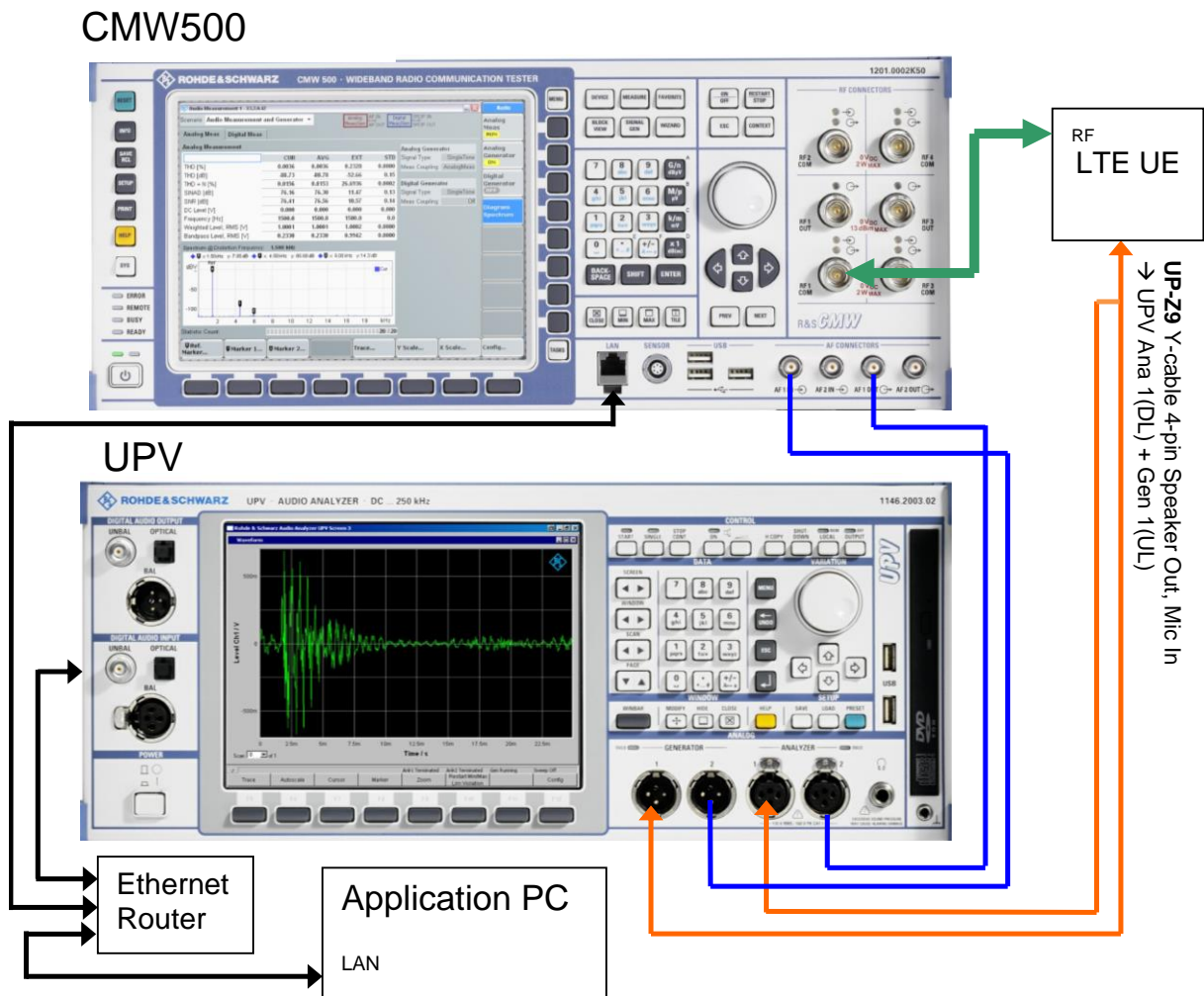4. **LTE UE** – with IMS / VoLTE capability.

Fig. 2-1: VoLTE test setup with CMW500 and UPV (schematic)

The LAN cables from the Application PC, the UPV and the CMW (front LAN port) are all connected to an external router or switch. The IP addresses can be assigned through DHCP or they can be static.

Fig. 2-2: 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. 2-3: 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. 2-4: 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

Fig. 2-5: BNC cable

For connecting UPV Generator 2 and Analyzer 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 a 4-pin 3.5 mm jack plug on one side 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.

Fig. 2-6: UP-Z9 cable set

3 Firmware/Software Requirements

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

3.1 CMW500

On the CMW500, the following firmware options are mandatory (version numbers should be equal or higher. Previous versions may work but are not guaranteed):

- Base firmware   ≥ 3.5.131
- Data Application Unit (DAU) firmware   ≥ 3.5.50
- LTE firmware   ≥ 3.5.50
- Audio Speech firmware   ≥ 3.5.30

3.2 UPV

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

- UPV firmware   ≥ 4.0.4 – Updates here: 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.
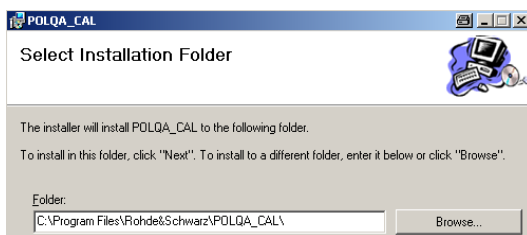

Fig. 3-1: POLQA_CAL installation on UPV

3.3 Application PC

3.3.1 R&S CMWrun

Install **CMWRUN** 1.8.8 or higher on the **APPLICATION PC**. Included in the installation are example testplans for VoLTE testing under Installed\LTE\VoLTE-POLQA_campaign.

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 pressing the **SIGNAL GEN** hard key and activating **LTE SIGNALING 1**.
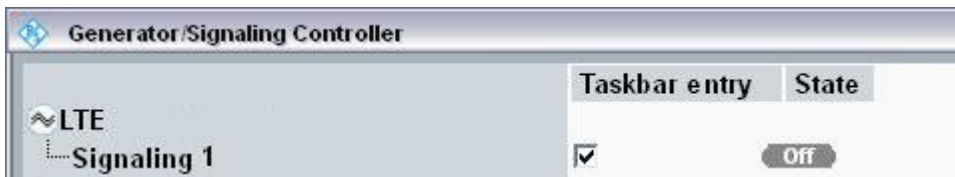

Fig. 4-1: Select LTE Signaling

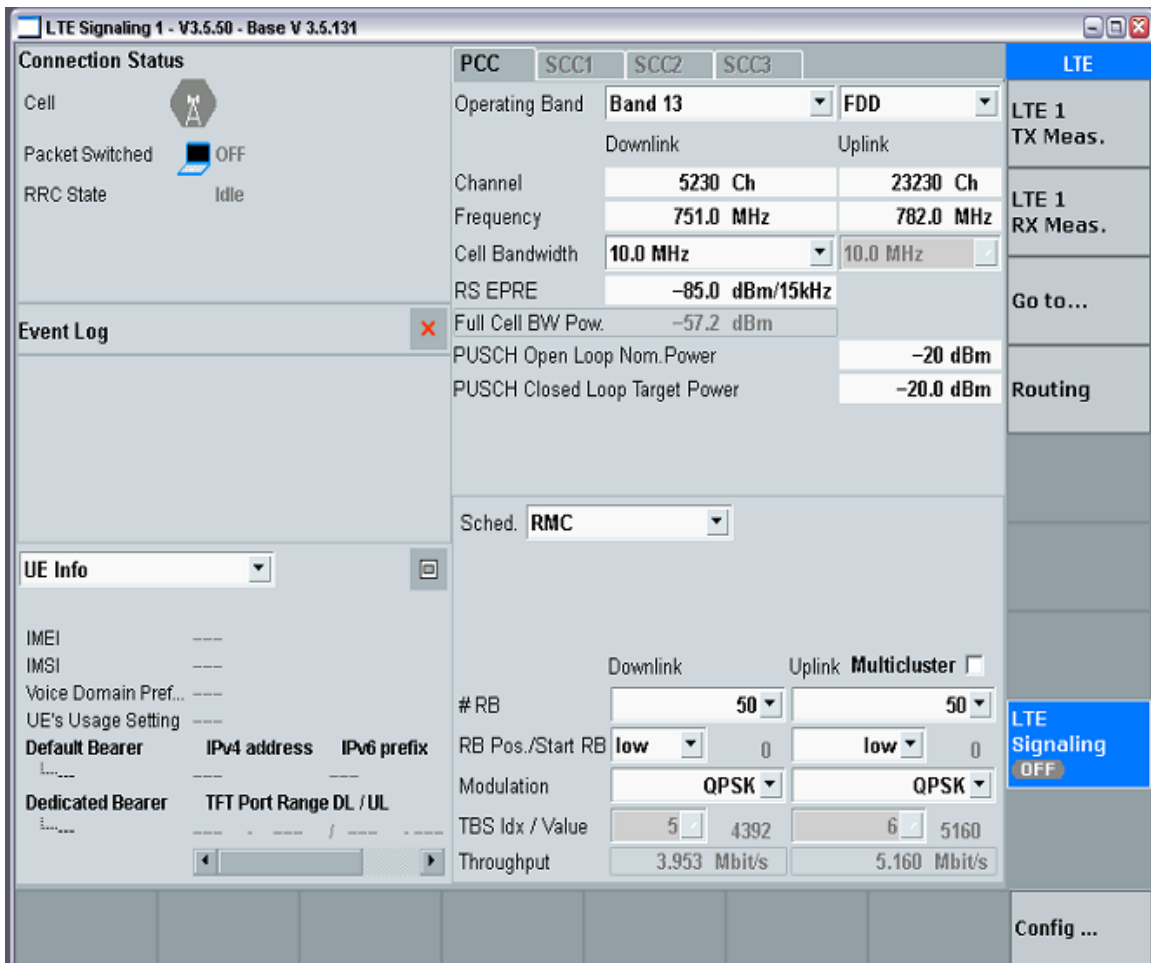2. In the LTE Signaling 1 menu, set the required Operating Band, Cell Bandwidth, and power levels.

Fig. 4-2: LTE Signaling Menu

3. Go to the **LTE SIGNALING CONFIGURATION** page by pressing the **CONFIG…** button and select
    CONNECTION TYPE: DATA APPLICATION. Some network operators may also require specific settings
    for the default bearer, such as IPv6 only, and/or a specific APN.
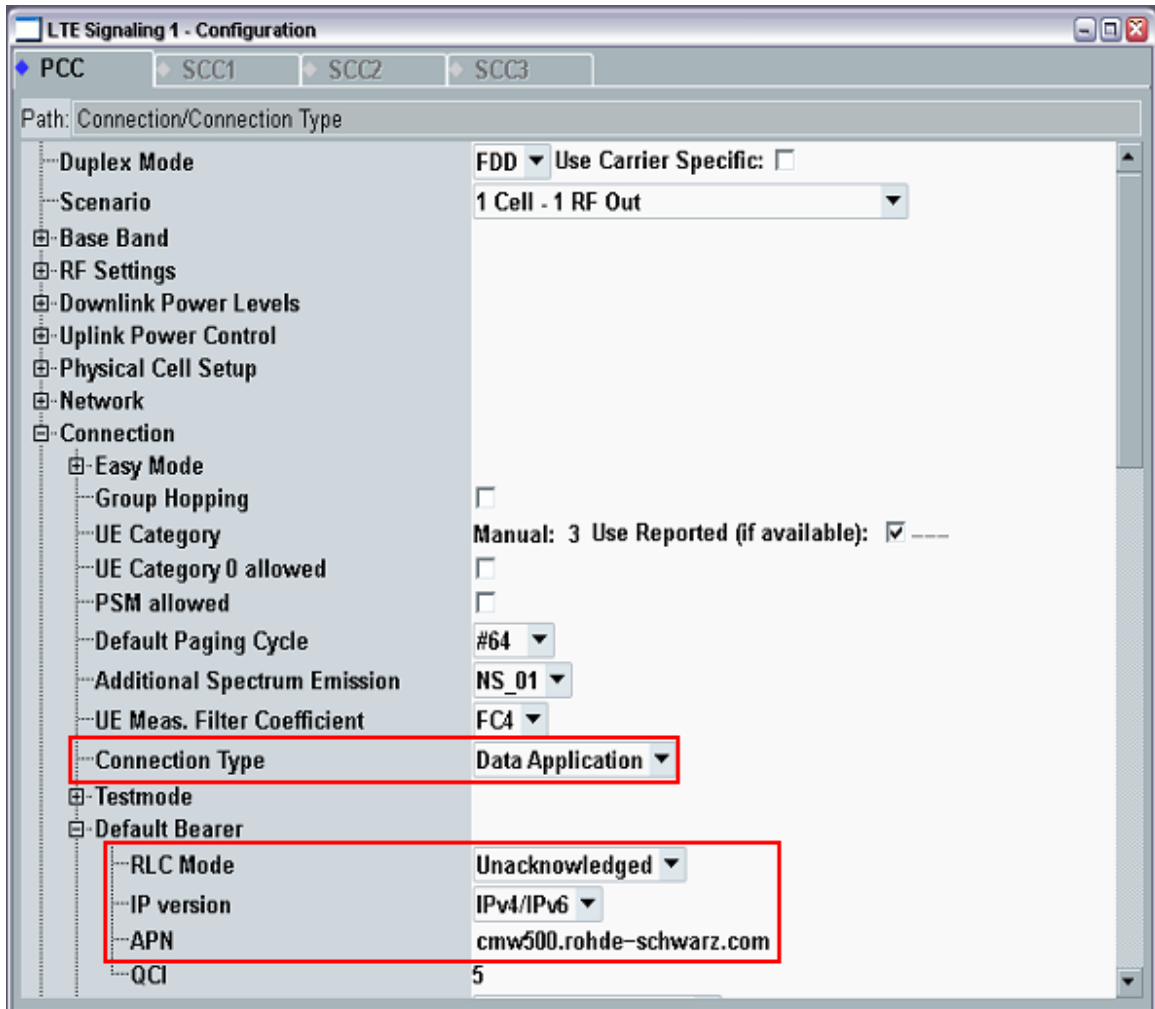

Fig. 4-3: LTE Signaling Configuration

4. Make sure that Evolved Packet Services (EPS) are enabled and **IMS VOICE OVER PS SESSION
    INDICATOR = SUPPORTED**. In case of **NOT SUPPORTED** the DUT performs a CSFB (Circuit Switched
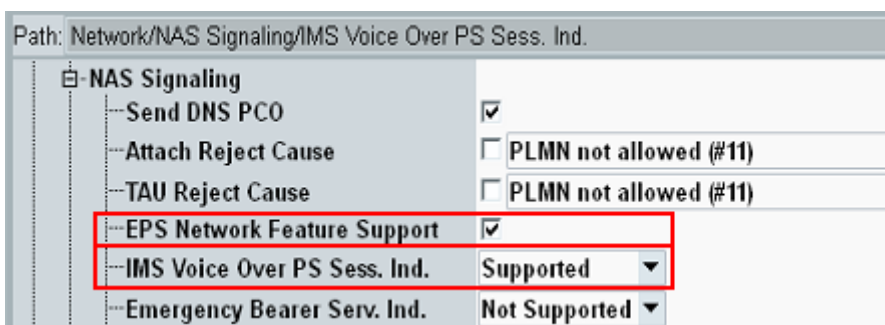   FallBack) instead of an IMS VoLTE call.

Fig. 4-4: Settings to enable EPS Features and IMS Voice Support

5. Configure the Network parameters **IDENTITY** and **SECURITY SETTINGS** according to the DUT requirements. Note that some devices that are network operator specific only initiate and allow an IMS connection on their own network, so the **MCC** and **MNC** can be important.
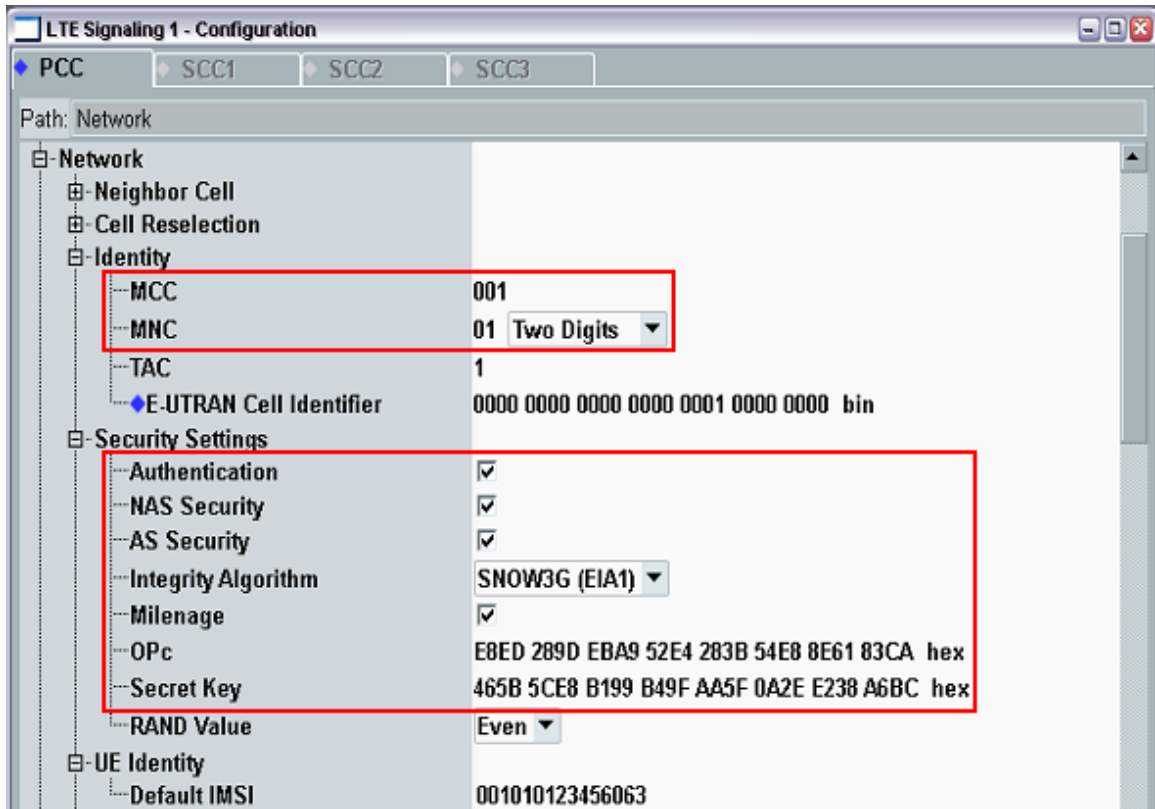
Fig. 4-5: LTE Network Settings

4.2 Data Application Unit Settings

1. Open the Data Application Unit by pressing the **MEASURE** hard key and enabling the **DATA APPL.** → **MEASUREMENT 1** checkbox.

Fig. 4-6: Select DAU menu

2. Make sure that LTE Signaling 1 is set for **SELECT RAN** and click on the **CONFIGURE SERVICES** soft key on the right to access the Data Application Control view.

Fig. 4-7: Data Application Measurement

3. Open the IMS Configuration by pressing the IMS tab of the Data Application Control
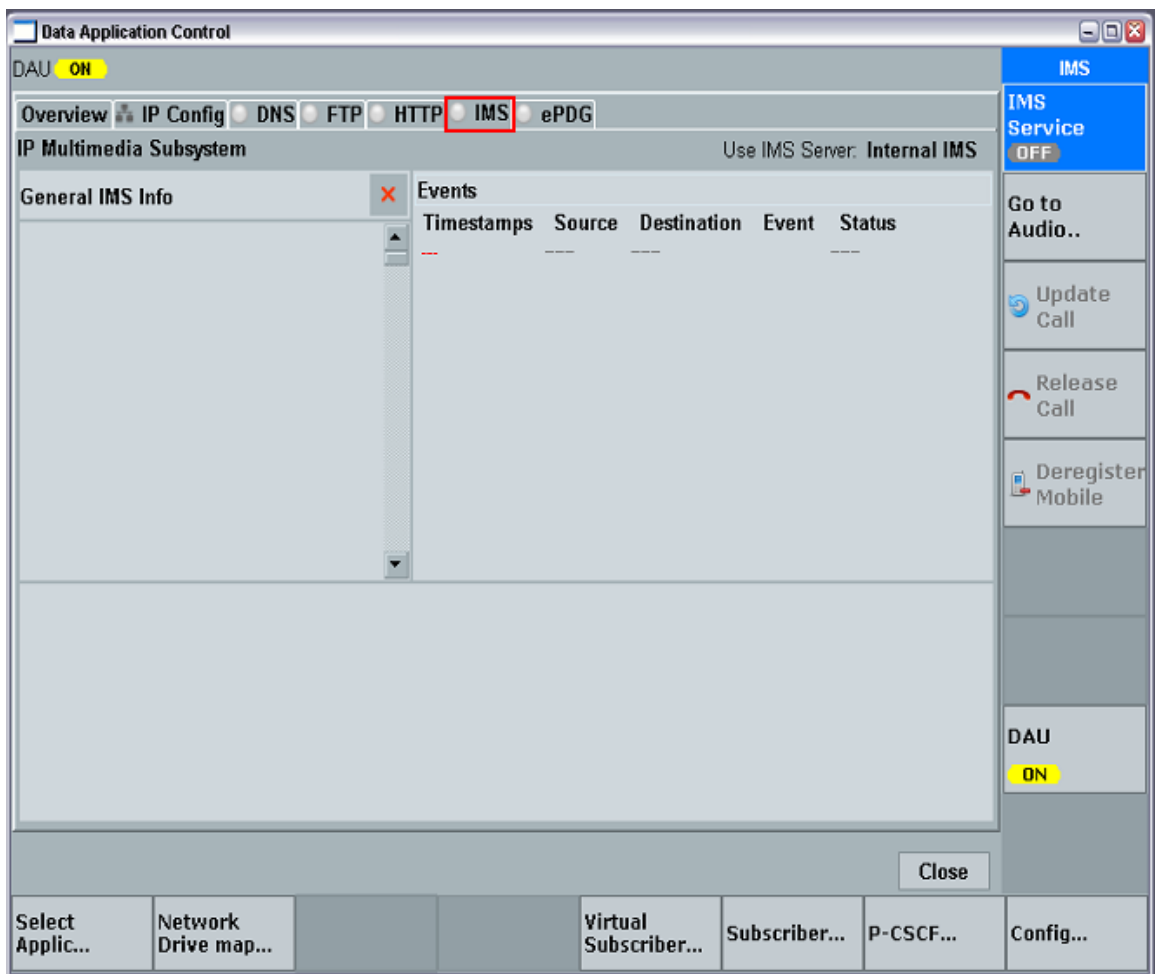
Fig. 4-8: View of IMS Settings

4. Under **SUBSCRIBER…** configure the IMS authentication parameters for the UE. Common settings are to either have **NO AUTHENTICA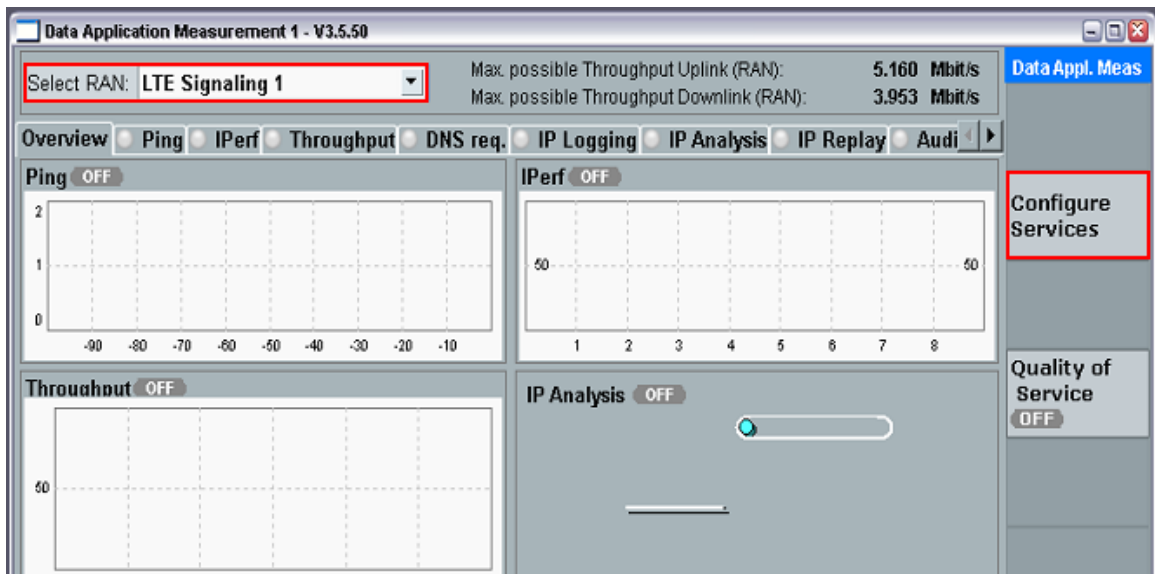TION**, or to use **AKAV1**, perhaps a specific **PRIVATE USER ID**, **KEY GENERATION ALGORITHM** set to **XOR** and sometimes **IPSEC** enabled.

Fig. 4-9: IMS subscriber authentication parameters

5. Under **VIRTUAL SUBSCRIBER…** the default virtual subscriber on the IMS server is configured to accept all incoming calls. Often the default settings are sufficient, however the **MEDIA ENDPOINT** must be set to **AUDIOBOARD** in order to do external tests rather than looping the audio back to the DUT. For certain DUTs, it can be important to set the **SIGNALING TYPE** to **PRECONDITIONS** or **SIMPLE**, and possibly enable the **DEDICATED BEARER** checkbox.
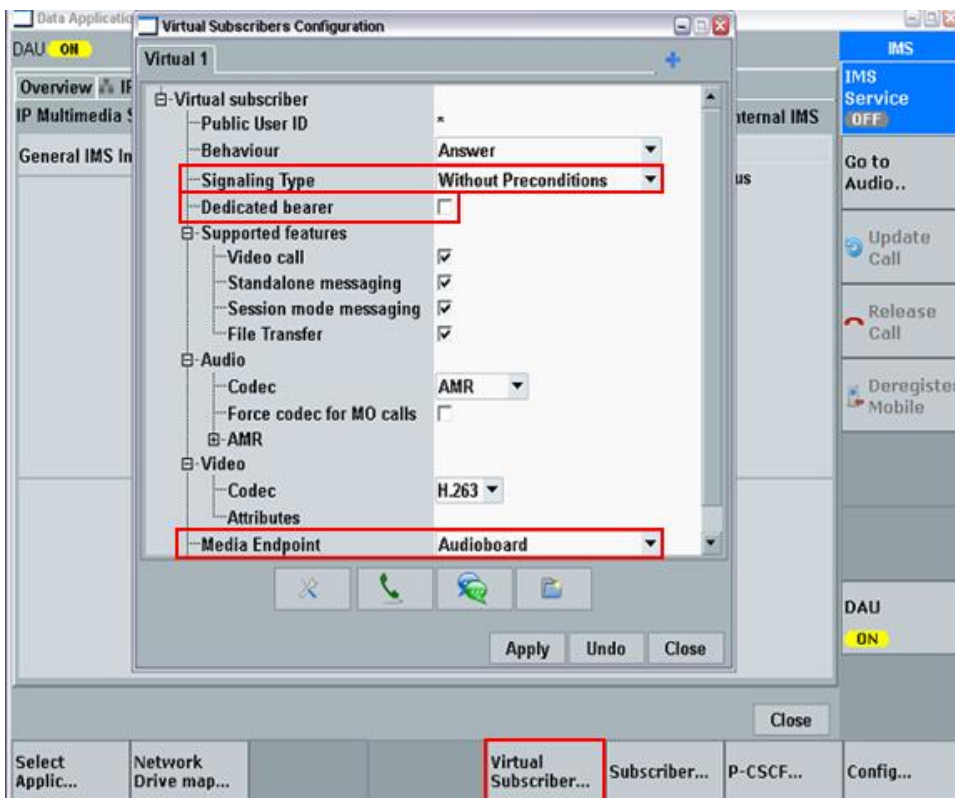
Fig. 4-10: IMS Virtual Subscriber Configuration

6. 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. A device has not yet connected so it will only look like this.
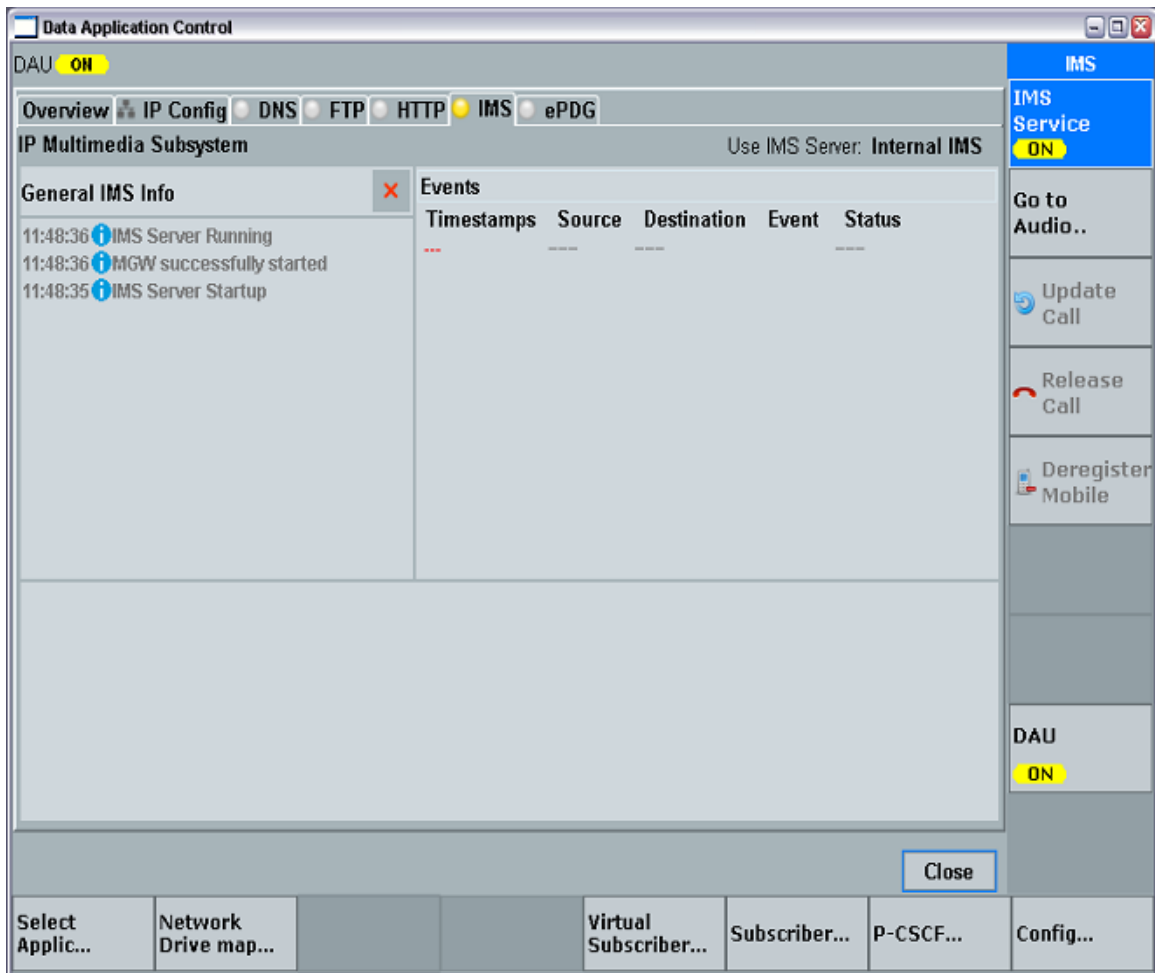
Fig. 4-11: Data Application Control (IMS activated)

4.3 Audio Measurement Settings

1. Open the Audio Measurement tab by pressing the **MEASURE** hard key and enabling the **AUDIO →** **MEASUREMENTS 1** checkbox.
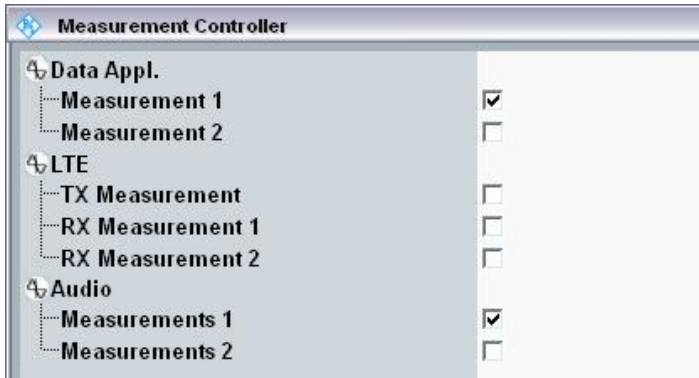
Fig. 4-12: Select Audio Measurement

2. Open the Audio Measurement tab and choose the scenario **EXTERNAL ANALOG SPEECH ANALYSIS**. Set the **CONTROLLED BY:** field to **DAU IMS SERVER**. In the **CONFIG…** menu set the Input and Output Level Full-Scale (Peak) to 1.000 V each.
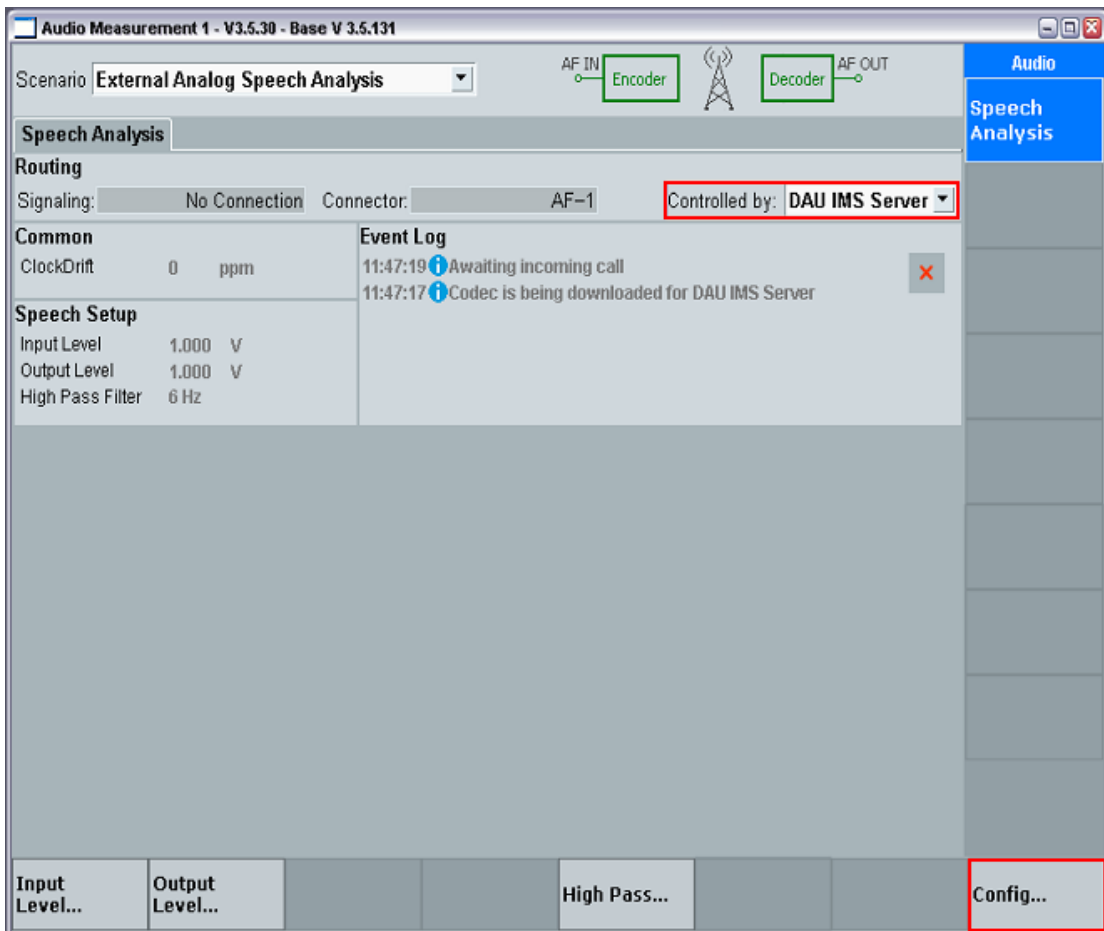
Fig. 4-13: Audio Input and Output Level

5 Establishing a manual Voice over LTE Call

In order to test the system and ensure everything is working as expected, it is possible to manually establish a call and verify with the Audioboard inside the CMW that audio is being sent and received. Once this is confirmed, the audio signals can be routed externally to the UPV.

1. Enable LTE signaling and power cycle the DUT. It should then attach. Often it is possible to see in the list of bearers that has IMS in its name to give an idea if the DUT is attempting to connect to the IMS (this may not be the case, however).

Fig. 5-1: LTE Signaling State Attached with Default Bearer 5 as the IMS connection

2. During 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. If the line "UE is subscribed for 'reg' event" is not present then there is mostly likely a configuration error. See Section 4, or Section 7 for troubleshooting tips.
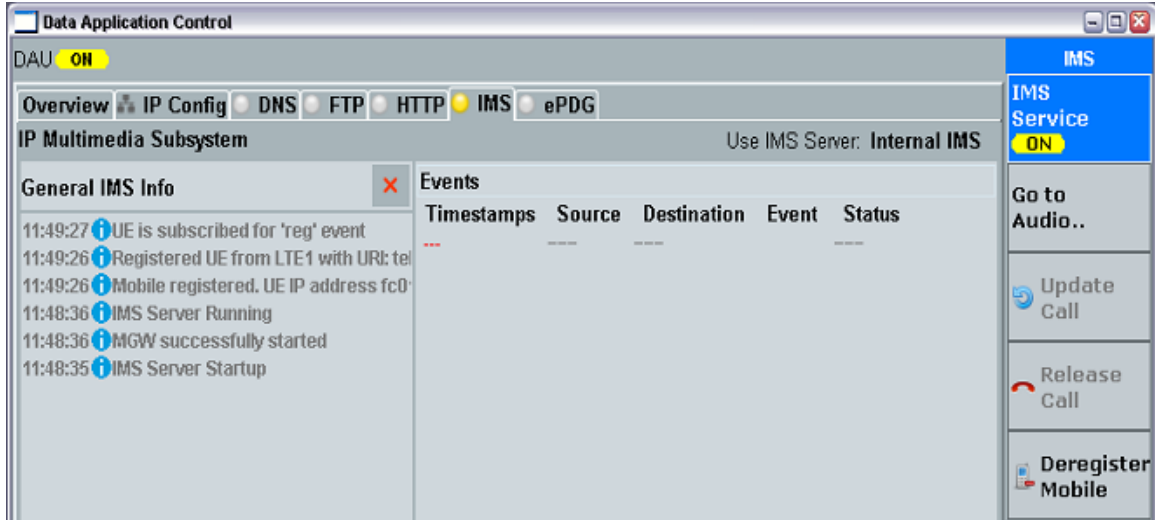
Fig. 5-2: IMS server with registered UE

A VoLTE call can now 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 **VIRTUAL SUBSCRIBER…** soft key. Press the phone icon, and then the phone icon that says **CALL.**
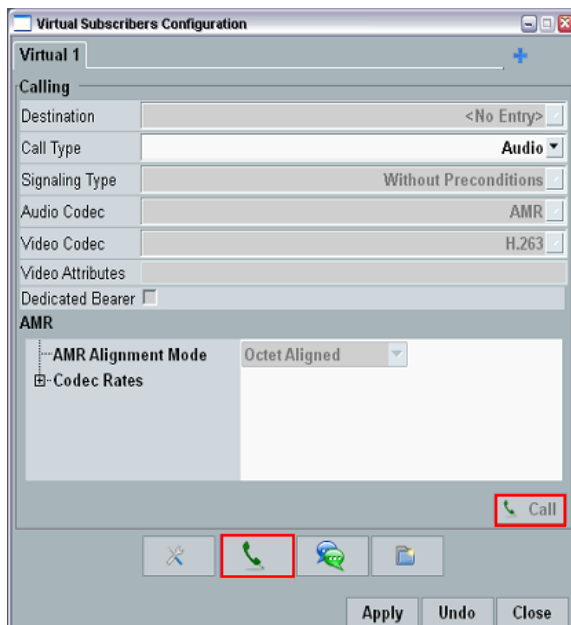
Fig. 5-3: Establishing a mobile terminated VoLTE call

Fig. 5-4: Established VoLTE call

After the VoLTE call has been established, the downlink and uplink audio transmission is active and can be tested with the audioboard. Change the scenario in the Audio Measurement view to **MICROPHONE AND SPEAKERTEST** and select the **DIGITAL MEAS** tab. Turning on the **DIGITAL GENERATOR** will create a signal that is audible on the phone. Turning on the **DIGITAL MEAS** and the **SPECTRUM** will show signals spoken into the DUT microphone.
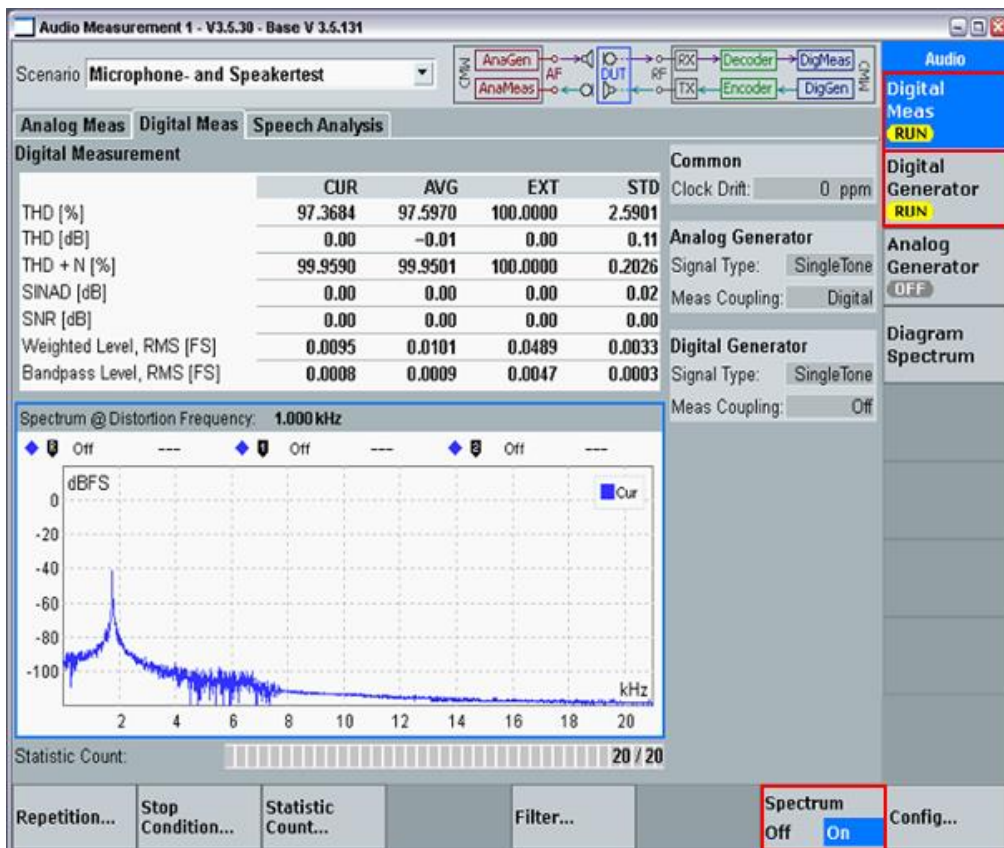
Fig. 5-5: Internal microphone and speaker test

If this works as expected, the scenario can be changed back to **EXTERNAL ANALOG SPEECH ANALYSIS** and the setup can be used with the UPV. Alternatively, it is possible to verify the setup by connecting a phone to the AF outputs of the CMW. Disconnect the UPV from AF1 IN/OUT and connect the CMW-Z50 handset. Using the **EXTERNAL ANALOG SPEECH ANALYSIS** scenario, audio spoken into the CMW-Z50 will be audible from the DUT and vice versa.

Fig. 5-6: CMW-Z50 Handset

6 VoLTE POLQA / PESQ Measurements with CMWrun

CMWrun is an automation software for executing remote control test sequences on the R&S®CMW500 in R&D, quality assurance, production and service for both current and future wireless equipment. The software engine is based on the execution of test DLLs (plug-in assemblies). This architecture allows easy and straightforward configuration of test sequences without requiring specific programming knowledge of how to remotely control the instrument. It also provides full flexibility when configuring parameters and limits for the test items provided in the standard-specific CMWrun package options.

At the end of the test, an easy-to-read test report containing limits, test results and verdict is generated. The report is available in csv, txt, xml and pdf format.

In this Section, an example of POLQA / PESQ measurements with CMWrun is explained.

6.1 CMWrun Configuration

The following Audio tests are part of the CMWrun / CMW-KT51 General Purpose Package.

▪ **Audio_AnalogSpeech**

This sets the voltages for the Audio connectors on the CMW, and the filter for the audio signal.

▪ UPV_UserEquipmentCalibration

This is called first when using the UPV in order to calibrate the voltage levels between the UPV and the CMW and DUT.

▪ **UPV_DelayMeasurement**

This measures a delay on either the Uplink, Downlink, Netloop (make sure the call settings in the IMS server or network technology are set to Loop instead of Audioboard for this case), or Roundtrip (sum of Uplink and Downlink).

▪ **UPV_SpeechQualityMeasurement**

This performs a PESQ or POLQA test.
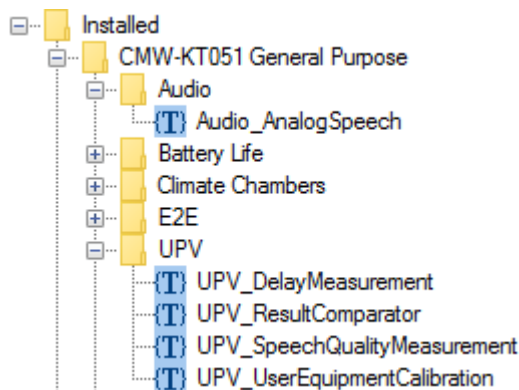
Fig. 6-1 - Audio DLLs in CMWrun

Note: The VoLTE applications require the following CMWrun options:

▪ CMW-KT051 for E2E and VoLTE Speech Quality Applications

▪ CMW-KT055 for LTE_CallSetup

The mentioned audio tests can of course be used with other technologies. In that case, instead of using LTE_CallSetup, a call would instead be established with the technology being used.

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 CMW500 Communication Tester and a UPV Audio Analyzer are required. Set the SCPI connections for the CMW500 and UPV.
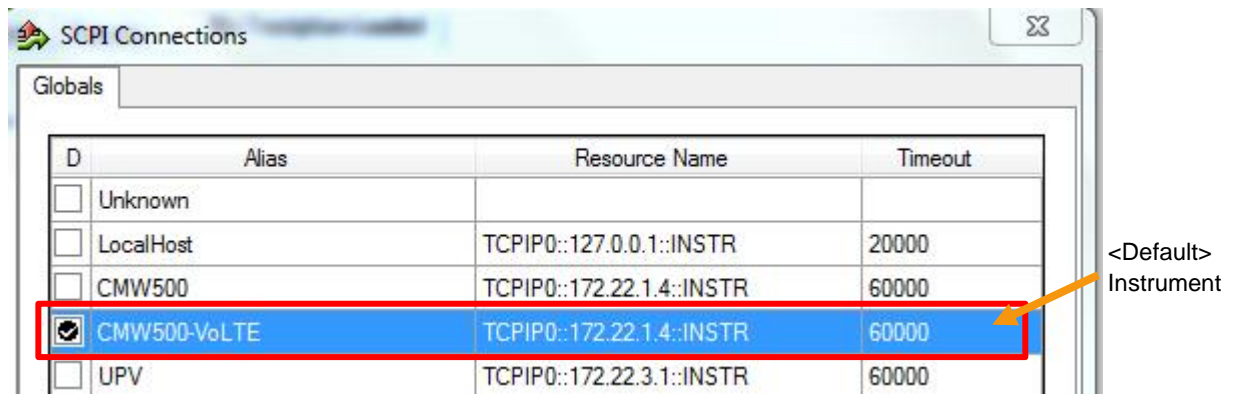
Fig. 6-2: CMWrun SCPI Connections menu

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).
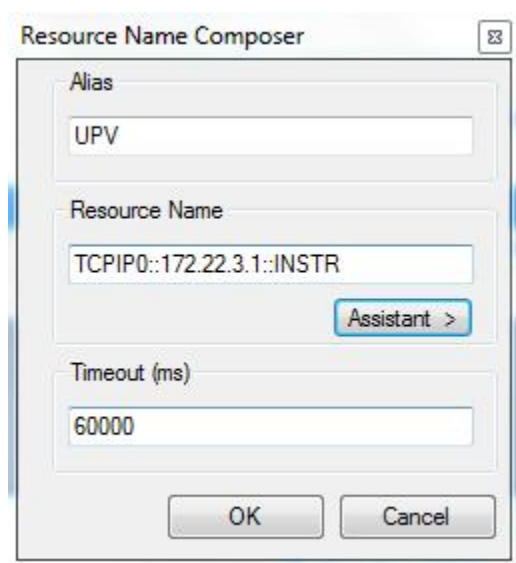
Fig. 6-3: Set UPV Resource Name and Timeout

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. This testplan is installed by default with CMWrun v1.8.8, and is found under Installed\LTE\VoLTE-POLQA_campaign\1_VoLTE_Master_band4-USIM-Z04.rstp

|			
		1_VoLTE_Master_band4_USIM-Z04	
⊞	1	BasicInitializing	
⊞	2	AttenuationTables	
⊞	3	SCPICommandList	AudioBoard initialization
⊞	4	LTE_CallSetup	AMR-WB @23850 bps
⊟	5	If (Step4.CallSetupSucceeded)	
⊞	6	UPV_UserEquipmentCalibration	
⊞	7	TestPlan_StartAndWait	TC_Impairment_01_AMR-WB_12650bps_mean
⊞	8	TestPlan_StartAndWait	TC_Impairment_02_AMR-NB_12200bps_mean
⊞	9	TestPlan_StartAndWait	TC_Codec_01_AMR-WB_23850bps_mean
⊞	10	TestPlan_StartAndWait	TC_Codec_02_AMR-WB_23050bps_mean
⊞	11	TestPlan_StartAndWait	TC_Codec_03_AMR-WB_19850bps_mean
⊞	12	TestPlan_StartAndWait	TC_Codec_04_AMR-WB_18250bps_mean
⊞	13	TestPlan_StartAndWait	TC_Codec_05_AMR-WB_15850bps_mean
⊞	14	TestPlan_StartAndWait	TC_Codec_06_AMR-WB_14250bps_mean
⊞	15	TestPlan_StartAndWait	TC_Codec_07_AMR-WB_12650bps_mean
⊞	16	TestPlan_StartAndWait	TC_Codec_08_AMR-WB_8850bps_mean
⊞	17	TestPlan_StartAndWait	TC_Codec_09_AMR-WB_6600bps_mean
⊞	18	TestPlan_StartAndWait	TC_Codec_10_AMR-NB_12200bps_mean
⊞	19	TestPlan_StartAndWait	TC_Codec_11_AMR-NB_10200bps_mean
⊞	20	TestPlan_StartAndWait	TC_Codec_12_AMR-NB_7950bps_mean
⊞	21	TestPlan_StartAndWait	TC_Codec_13_AMR-NB_7400bps_mean
⊞	22	TestPlan_StartAndWait	TC_Codec_14_AMR-NB_6700bps_mean
⊞	23	TestPlan_StartAndWait	TC_Codec_15_AMR-NB_5900bps_mean
⊞	24	TestPlan_StartAndWait	TC_Codec_16_AMR-NB_5150bps_mean
⊞	25	TestPlan_StartAndWait	TC_Codec_17_AMR-NB_4750bps_mean
⊞	26	LTE_CallDisconnect	

Fig. 6-4: 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 DAU / IMS

server and internal CMW Audioboard, performs an LTE / VoLTE call, calibrates the mobile phone's speaker output and microphone input and finally disconnects the LTE / VoLTE call.

6.2.1 BasicInitializing

⊞ 1 BasicInitializing

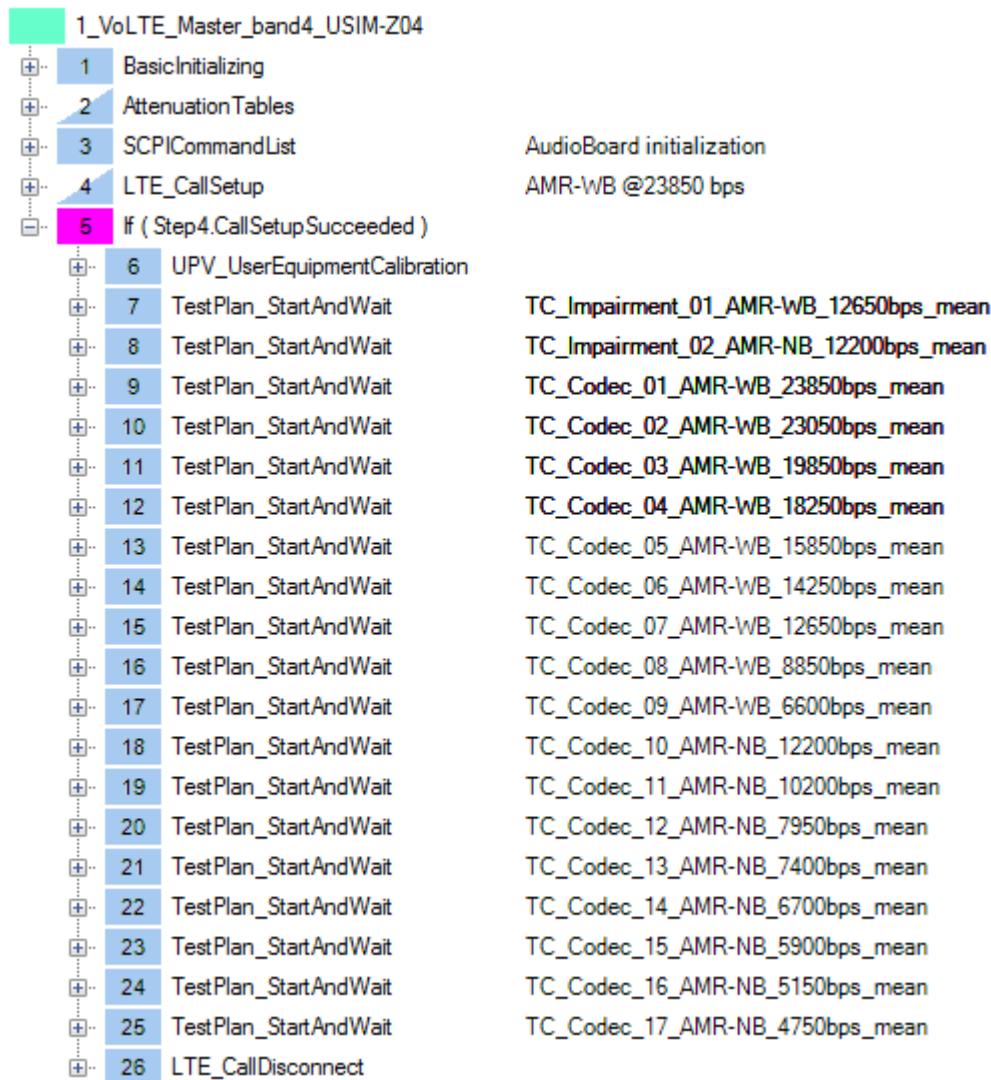This component handles the basic configuration and resets the CMW500 to default settings. By double clicking **BASICINITIALIZING** a configuration window opens. Check **RESET INSTRUMENT(S)**. This should always be performed to ensure identical starting conditions on different systems.
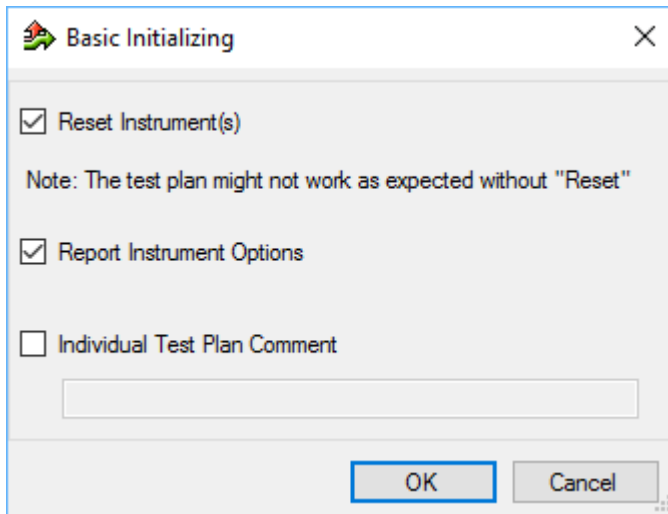
Fig. 6-5: Basic Initializing

6.2.2 Attenuation Tables

⊟ 2 AttenuationTables
　　 ⊺☐ ReportTables
　　 ⊺☐ SetTables

This test item allows setting of the input and output attenuation values to compensate RF components such as cables, mixers, directional couplers, etc. The attenuation can be set to constant values or be changed by user interaction at runtime. By default in this testplan, the tests are disabled. If specific attenuation is desired, SetTables should be checked and the properties set (Fig. 6-5)
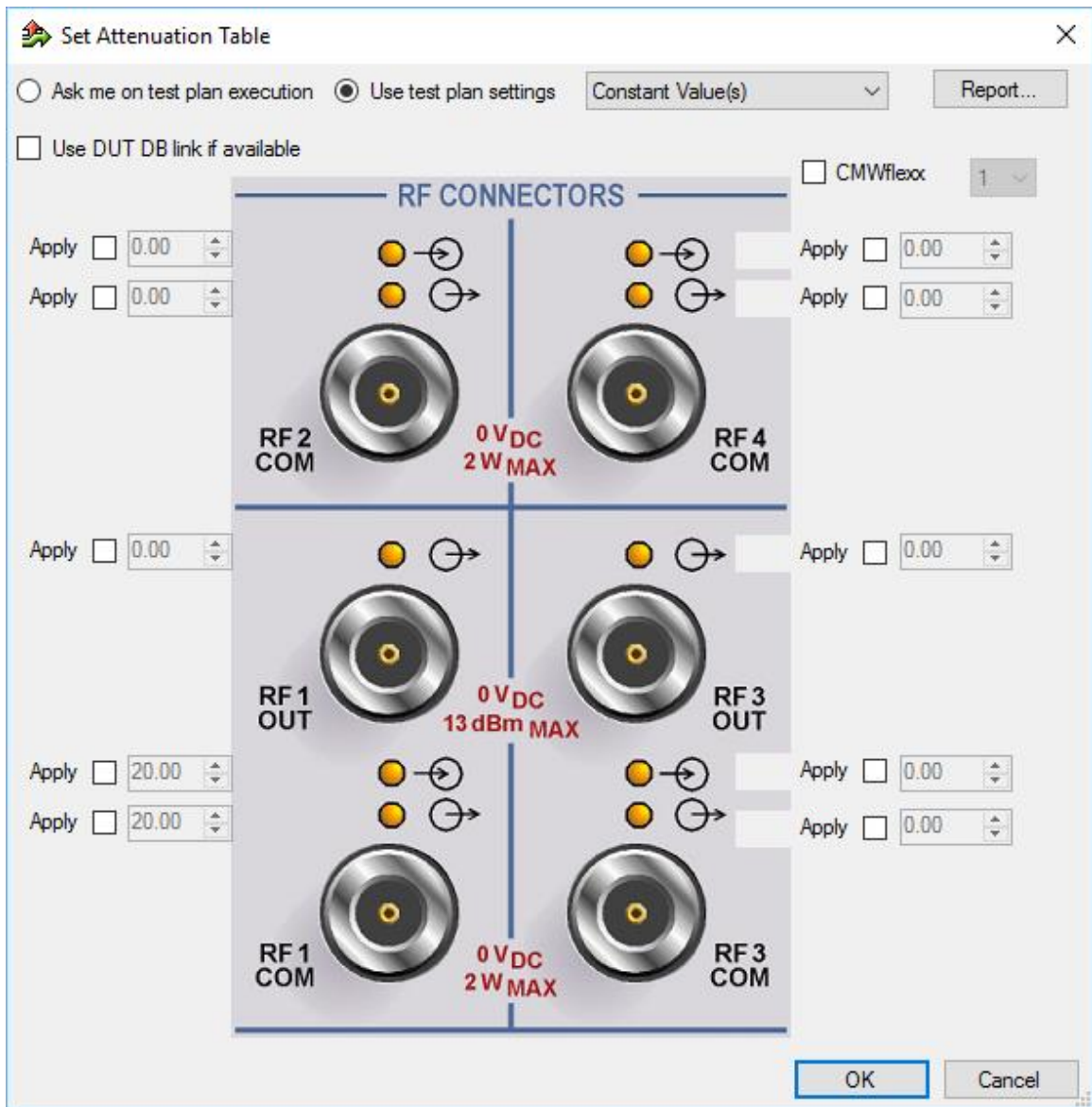
Fig. 6-6: Set attenuation table

6.2.3 SCPICommandList

This menu item contains SCPI commands for initializing the CMW AudioBoard: setting the scenario to External Analog Speech Analysis, and setting the analog voltages.
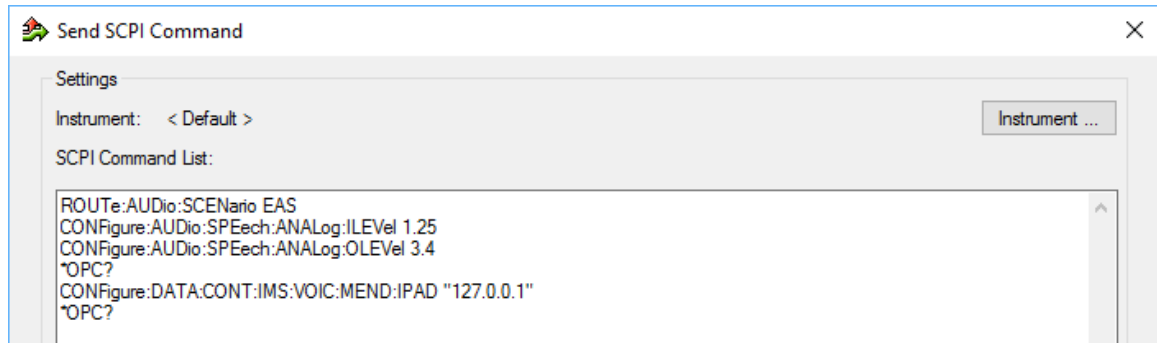
Fig. 6-7: CMW AudioBoard Initialization

The <Default> instrument should have been set to CMW500 in the **SCPI CONNECTIONS** menu (see Fig. 6-1).

6.2.4 LTECallSetup
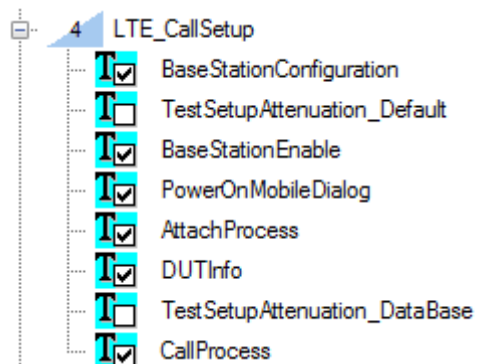
Here, an LTE cell is established with IMS turned on that the UE can attach to. The following screen shot shows the configuration window which opens when double clicking **LTECALLSETUP** in the list:
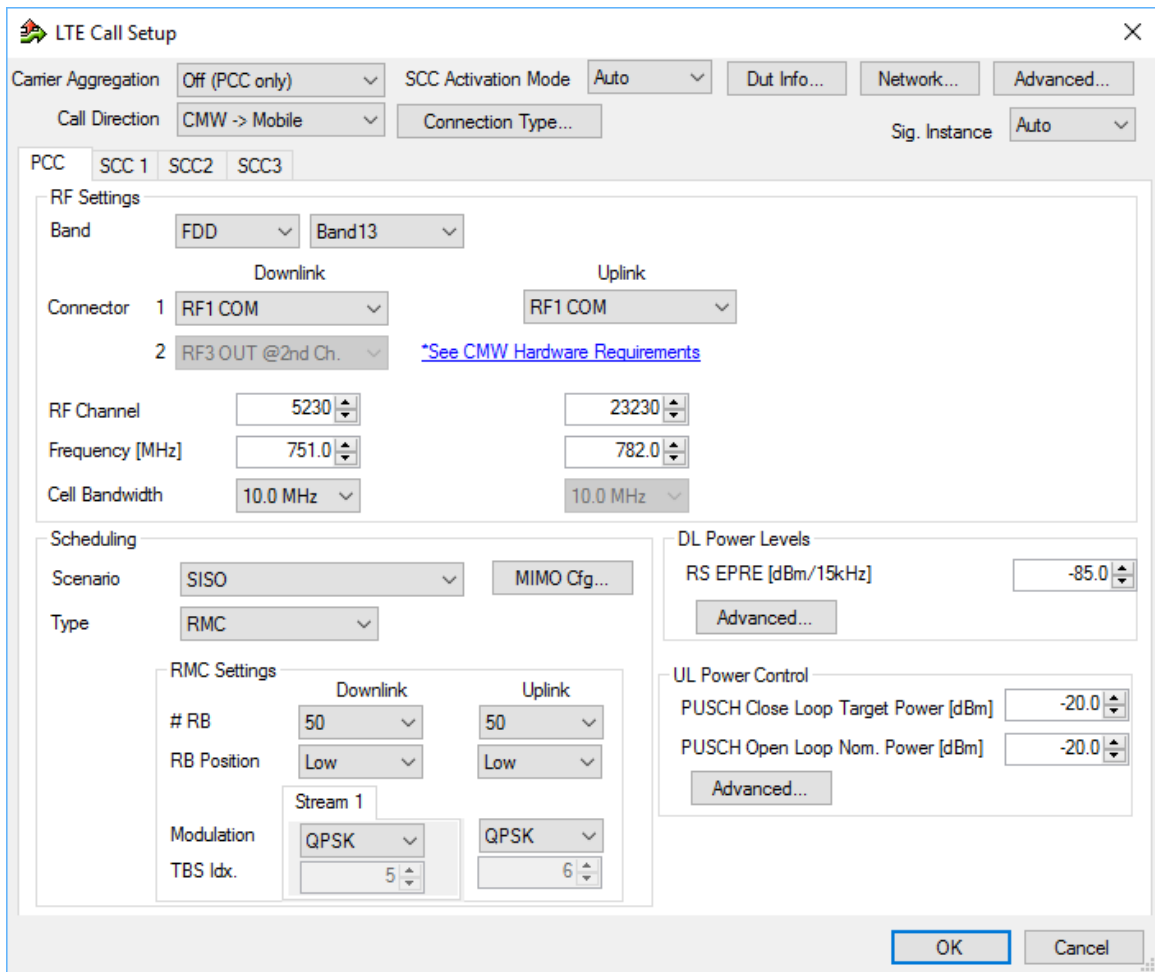
Fig. 6-8: LTE Call Setup

Make sure the UE parameters are entered correctly or else the UE will not attach and the test will terminate. In this view the only setting changed for this example is the **BAND**, however, there are other settings under **CONNECTION TYPE…** and **NETWORK…** that must be changed.
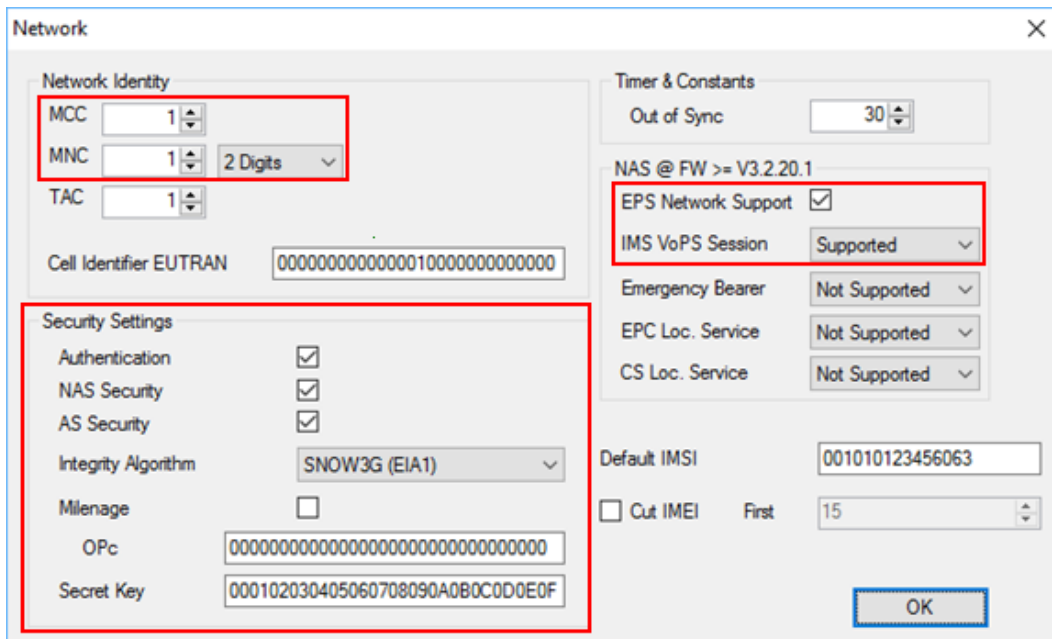
Fig. 6-9: Network and security settings

The Network Identity and Security settings need to set as appropriately for the DUT.

Configure the parameters in the **CONNECTION TYPE** panel:
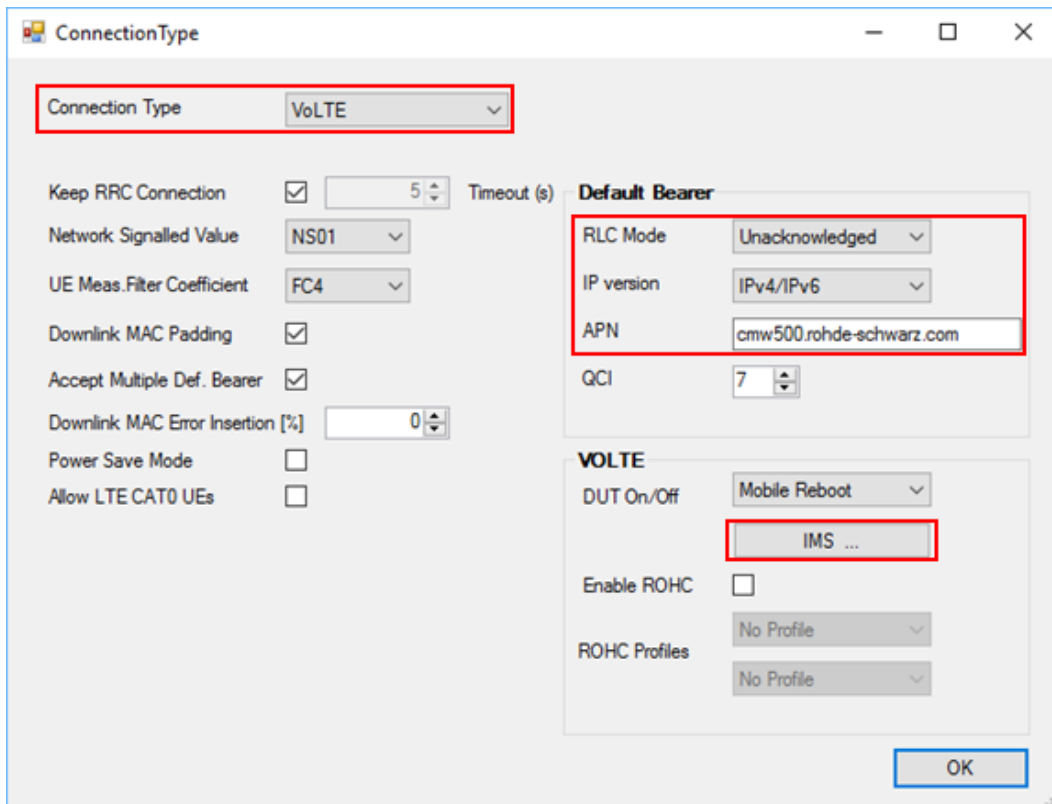
Fig. 6-10: ConnectionType parameters

The **CONNECTION TYPE** should be **VoLTE**, the **IP VERSION** and **APN** set, then enter the **IMS** menu.
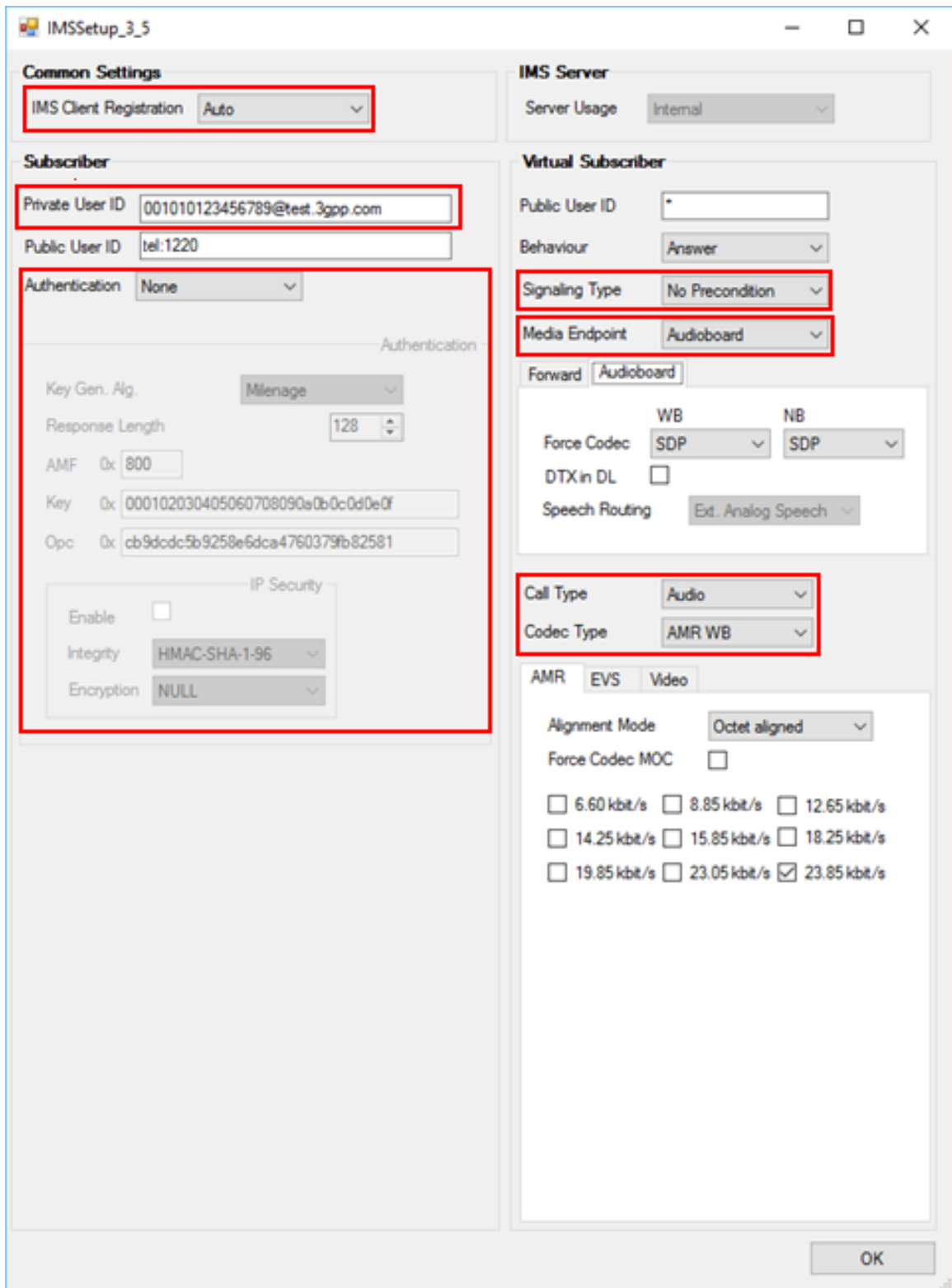
Fig. 6-11: IMS Setup

The following parameters may vary with different mobile manufacturers.

ı **IMS CLIENT REGISTRATION** – **AUTO** (sufficient in most cases).

ı **USER AUTHENTICATION** – Default **OFF**. If turned on, set additional IMS authentication parameters.

ı **VOICE PRECONDITIONS** – With **PRECONDITION**, **NO PRECONDITION** or **SIMPLIFIED CALL FLOW**.

ı **MEDIA ENDPOINT** – Use internal CMW **AUDIOBOARD**.

ı **CALL TYPE** – **AUDIO**

ı **CODEC TYPE** – **AMR NB** or **AMR WB**

ı **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 will stop.

6.2.5 UPV_UserEquipmentCalibration
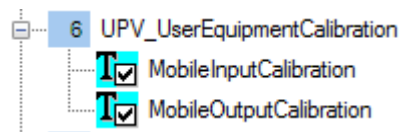
The mobile input / output calibration requires valid decoder / encoder calibration values and an active VoLTE speech connection. The mobile input calibration determines the full-scale peak input voltage of the mobile under test which is connected to UPV generator output 1. The mobile output calibration 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.
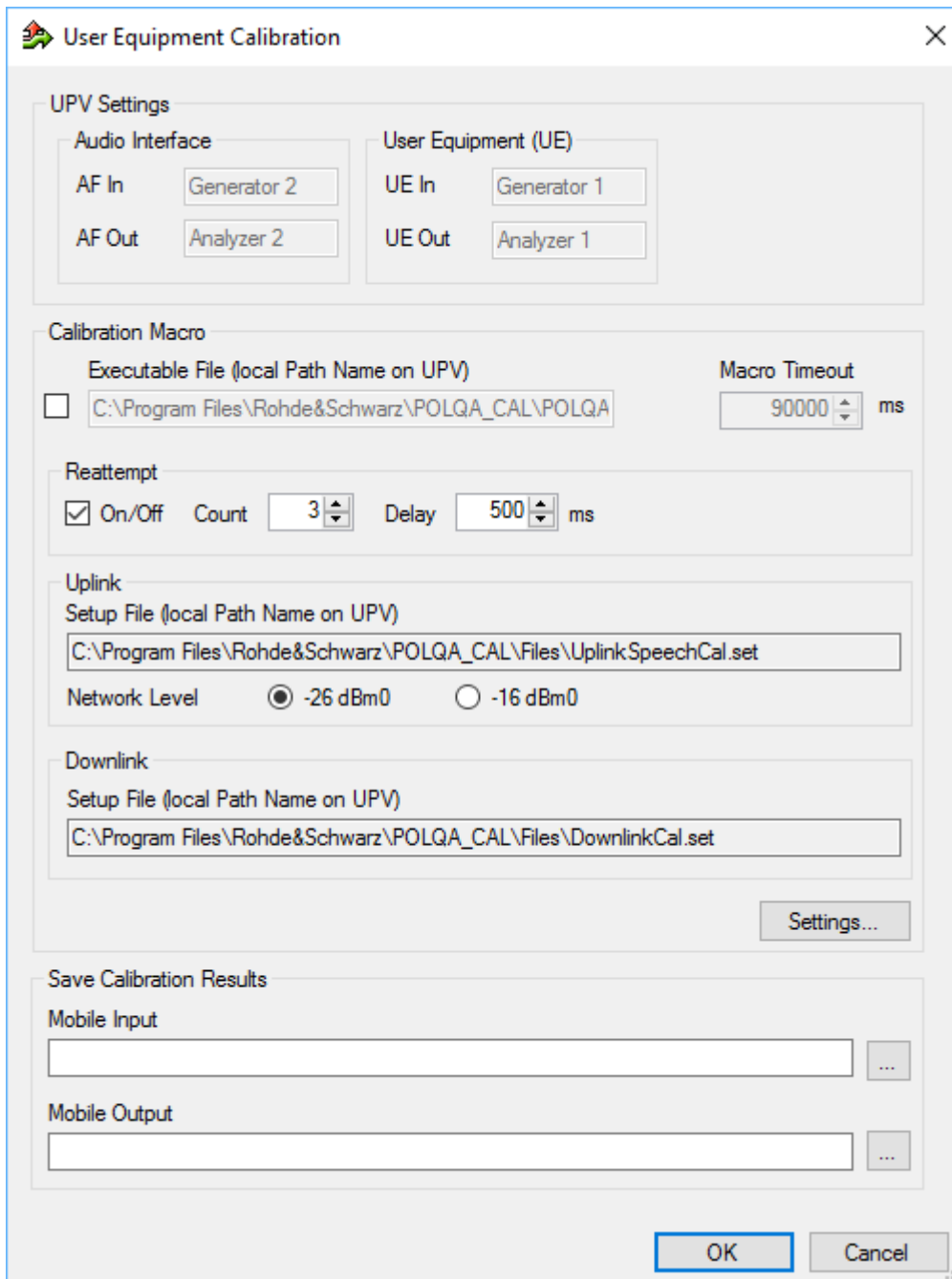
Fig. 6-12: User Equipment Calibration

ı **UPV SETTINGS** – Indicates the necessary audio cabling

ı **POLQA CALIBRATION MACRO** – Select User define only if custom calibration macro is used.

ı **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.

6.2.6 TestPlan_Sync

After these steps, the **TESTPLAN_STARTANDWAIT** test items execute further sub test plans to change the codecs and perform a POLQA measurement on the R&S UPV.

After all the sub 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:
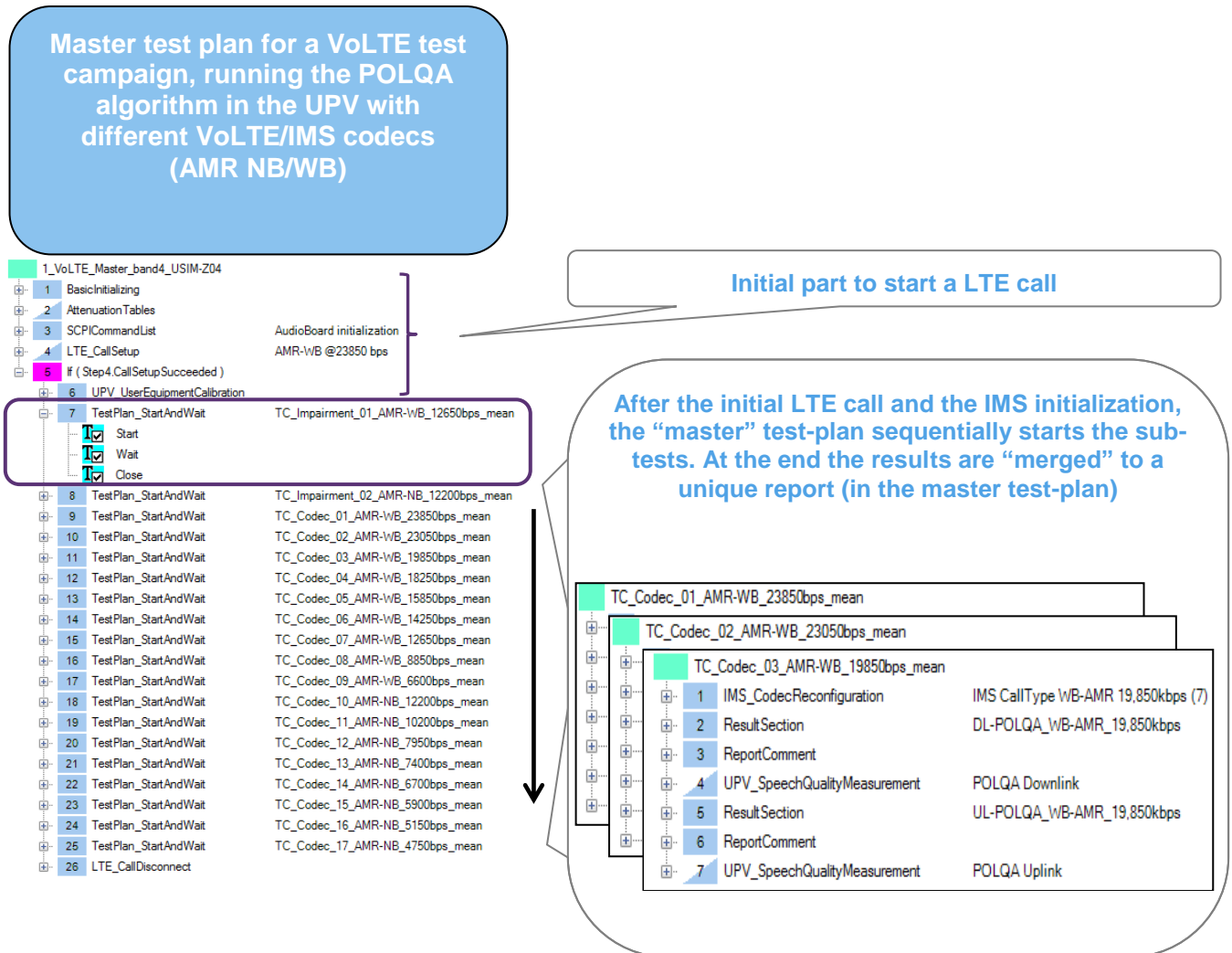
Fig. 6-13: CMWrun – Master and Slave test plan for a VoLTE test campaign

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.

The TestPlan_Sync test item allows the definition of a sub test plan and various execution conditions.
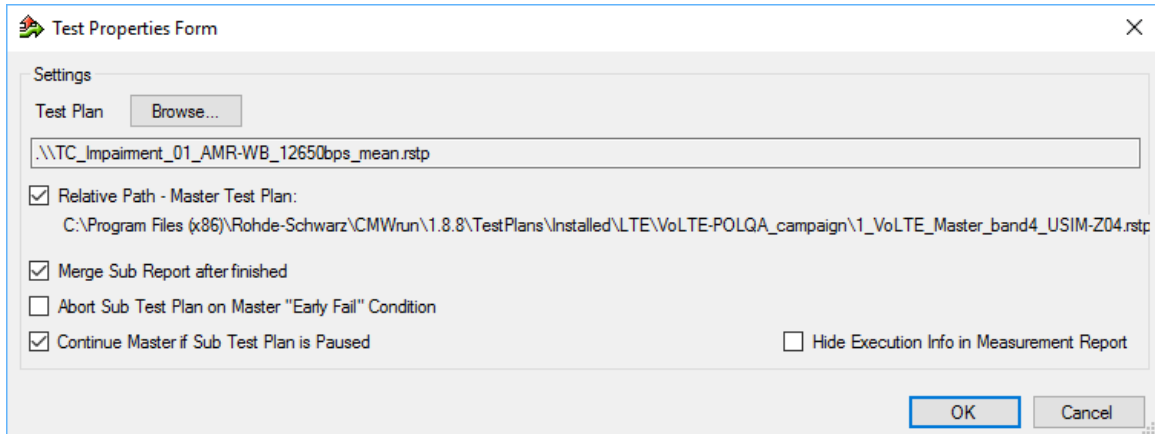
Fig. 6-14: TestPlan_Sync

- **RELATIVE PATH – MASTER TEST PLAN** – If checked, the test plan file is in the same directory as the master test plan.

- **MERGE SUB 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.

The sub test plan in this example is TC_Impairment_01_AMR-WB_12650bps_mean.rstp which contains all POLQA related test items.

Parameter	Step#	Type	Value	Min.	Max.	Unit
Jitter	4	Double	0.01	0	10	seconds
PacketLossRate	5	Double	1	0	100	%
Repetitions	6	Int32	5	1	999	
CollectResults	6	Boolean	False	False	True	
IntervalDelay	6	Int32	1500	1000	10000	ms

	Steps		Description
		TC_Impairment_01_AMR-WB_12650bps_mean	
	1	IMS_CodecReconfiguration	IMS CallType WB-AMR 12.65kbps (3)
	2	ResultSection	DL-POLQA_WB-AMR_12.65kbps_impairments_10msJitter_1%PaketLoss
	3	ReportComment	
	4	E2E_SetJitter	Impairments - Jitter = 10 ms
	5	E2E_SetPacketLossRate	**Impairments - Packet Loss = 1%**
	6	UPV_SpeechQualityMeasurement	POLQA Downlink
	7	ResultSection	DL-POLQA_WB-AMR_12.65kbps_impairments_40msJitter_3%PaketLoss
	8	ReportComment	
	9	E2E_SetJitter	Impairments - Jitter = 40 ms
	10	E2E_SetPacketLossRate	Impairments - Packet Loss = 3%
	11	UPV_SpeechQualityMeasurement	POLQA Downlink
	12	ResultSection	DL-POLQA_WB-AMR_12.65kbps_impairments_20msJitter_2%PaketLoss
	13	ReportComment	
	14	E2E_SetJitter	Impairments - Jitter = 20 ms
	15	E2E_SetPacketLossRate	Impairments - Packet Loss = 2%
	16	UPV_SpeechQualityMeasurement	POLQA Downlink
	17	E2E_ImpairmentsDisable	

Fig. 6-15: 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. 6-16: 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.
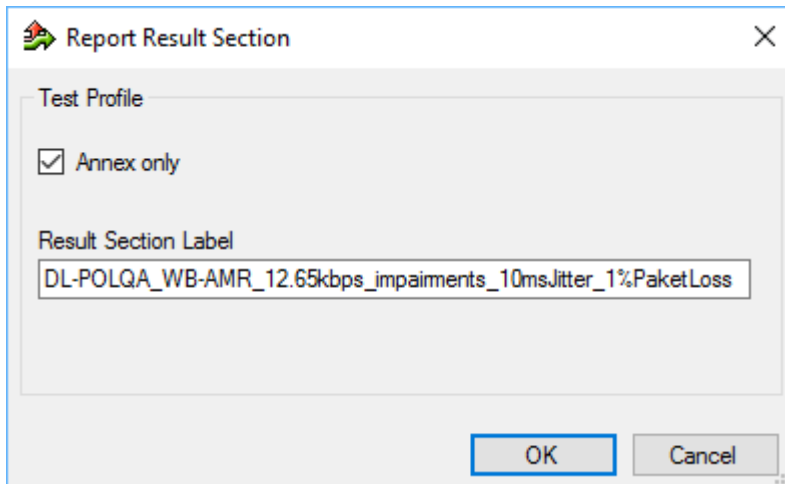
Fig. 6-17: Report Result Section

▪ **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.
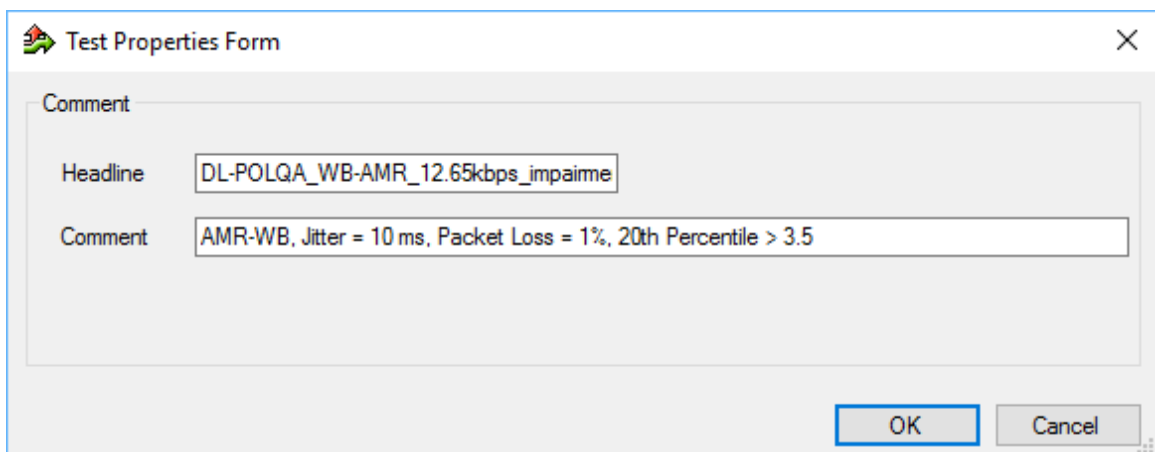
Fig. 6-18: Report Comment

6.2.6.4 E2E_SetJitter

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.
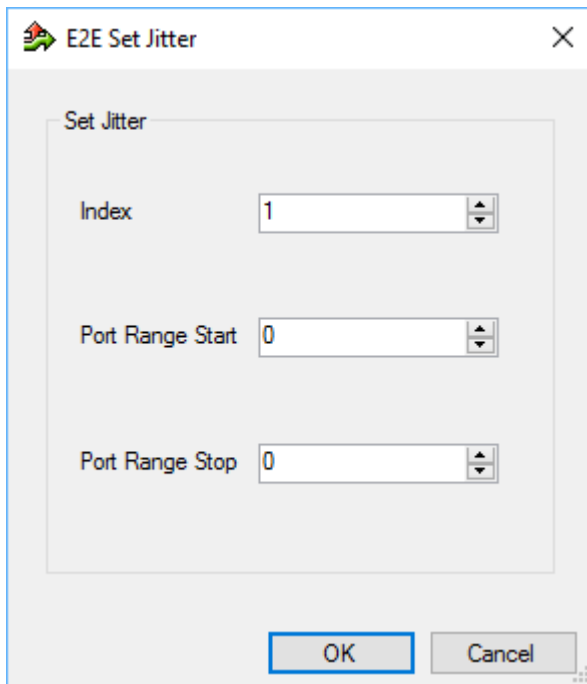
Fig. 6-19: E2E Set Jitter

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.

Parameter	Step#	Type	Value	Min.	Max.	Unit
Jitter	4	Double	0.01	0	10	seconds

Fig. 6-20: 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.
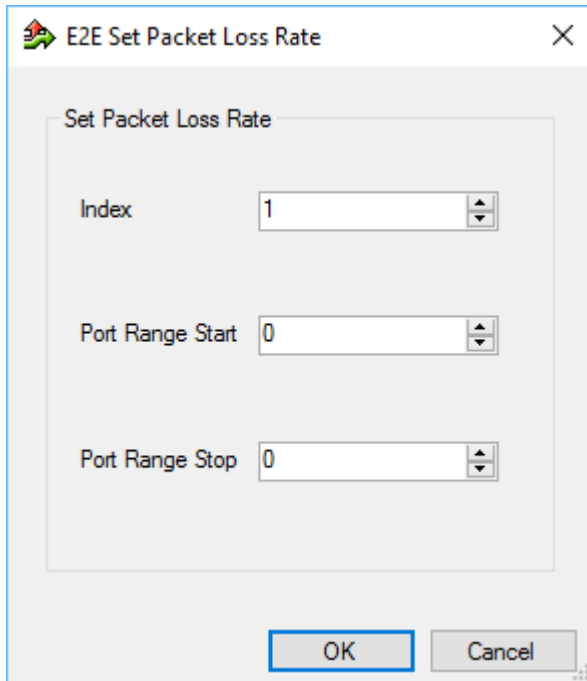
Fig. 6-21: E2E Set Packet Loss Rate

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.

Parameter	Step#	Type	Value	Min.	Max.	Unit
PacketLossRate	5	Double	1	0	100	%

Fig. 6-22: Set Packet Loss Rate global parameters

This corresponds to test item #5

ı   **INDEX** = Value = 1 %.

ı   **PORT RANGE START** = Min. = lower packet loss rate limit 0 %.

ı   **PORT RANGE STOP** = Max. = upper packet loss rate limit 100 %.

6.2.6.6   VoLTE_SpeechQualityMeasurement
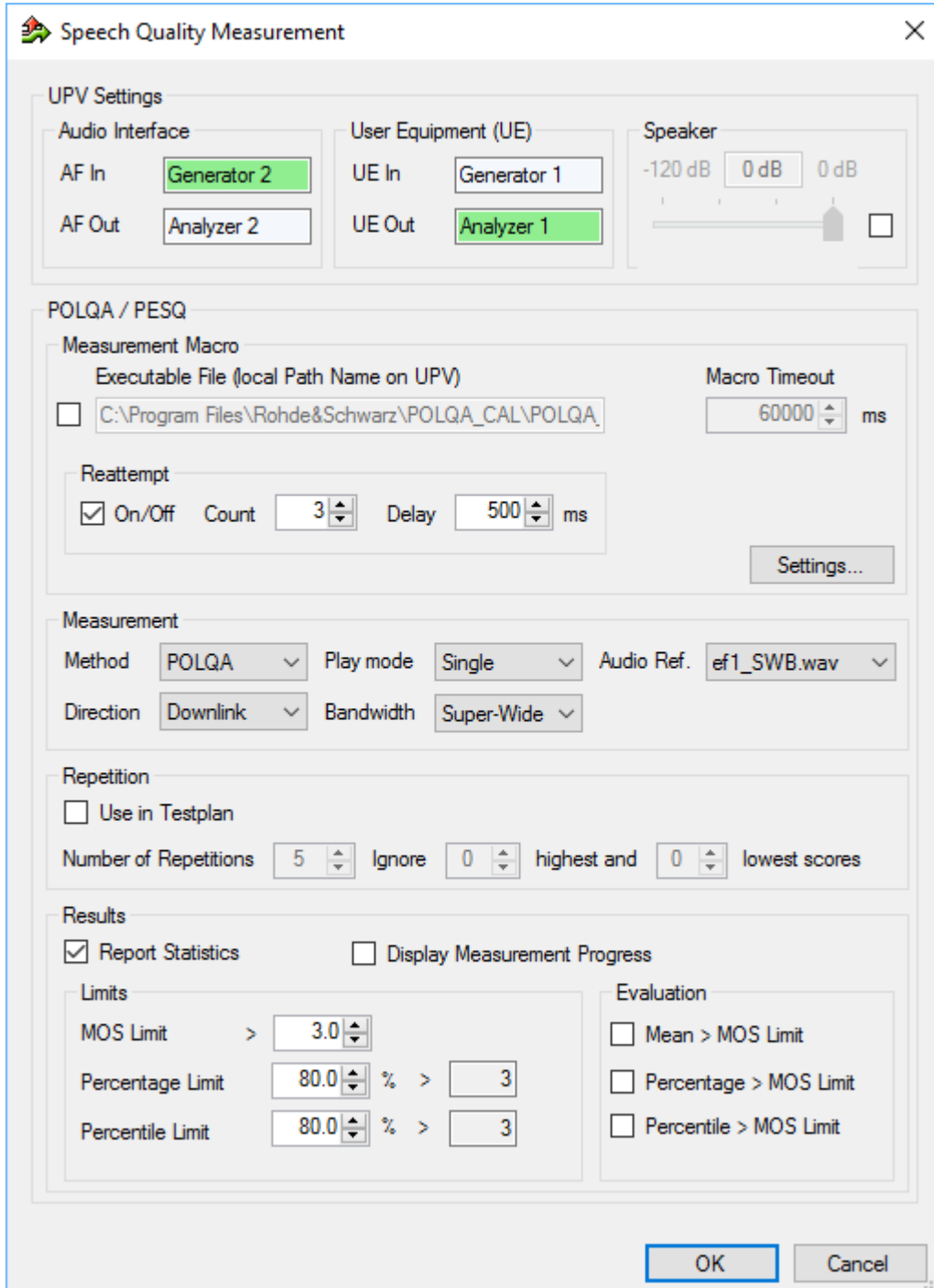
Fig. 6-23: Speech Quality Measurement

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 a custom calibration macro is used. The **MACRO SETTINGS** can be edited by clicking the **SETTINGS…** button (see Fig. 6-22).

   MACRO SETTINGS – Define the default settings of the POLQA_Cal Macro which runs on the UPV and performs calibration and measurement tasks. In this dialog the parameters that could be changed are the Decoder, Encoder, Mobile Input and Mobile Output Calibration Values. Here, default values are used (which were defined by running UPV_UserEquipmentCalibration in Section 6.2.6).

∎ **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

$$mean = \frac{\sum_{k=1}^{NumRep+1}\left(MOS_k\right)}{NumRep+1}$$

   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

⊞ 17 E2E_ImpairmentsDisable

Turns OFF E2E jitter, packet loss rate and delay.

6.2.7 LTECallDisconnect

⊞ 15 LTECallDisconnect

Terminates the LTE connection.

6.3 Running the Test

The example below shows how to run the **1_VoLTE_Master_band4_USIM-Z04.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.

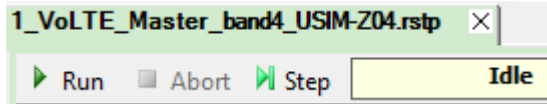To start the test, press the **Run** arrow in CMWrun.

Fig. 6-24: Start a Test Plan

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

LTE Call Setup: Base Station Configuration

LTE FDD, Band13
DL Channel 5230, DL Frequency 751, DL Cell Bandwidth 10.0 MHz
UL Channel 23230, UL Frequency 782, UL Cell Bandwidth 10.0 MHz
Connection Type: VoLTE
Call Direction: CMW -> Mobile
VOLTE Mediaendpoint Audioboard
Scenario: SISO
Type: RMC
RMC DL RB: 50
RMC UL RB: 50
RMC DL RB Position: Low
RMC UL RB Position: Low
RMC DL Modulation: QPSK
RMC UL Modulation: QPSK
RMC DL TBS Index: 5
RMC UL TBS Index: 6

LTE Call Setup: Base Station Enable

Base Station Enabled in 1.4s
IMS Enabled in 1s

LTE Call Setup: Power On Mobile Box

LTE Call Setup: Attach Process

Attach Process		Timeout	Elapsed Time	Unit	Status
Attached		120	1.2	s	Passed
IMS Registered		120	10.3	s	Passed

LTE Call Setup: DUT Info

Test Item		Comparison	Measured	Unit	Status
DUT Info					
IMEI	---	---	990003348240082	---	Passed

LTE Call Setup: Call Process

Call Process		Timeout	Elapsed Time	Unit	Status
Connection Established		30	1.1	s	Passed

No information about used Speechcodec Rates available

UPV_UserEquipmentCalibration: Mobile Input Calibration

Mobile Input calibrated in 73.3 s

Test Item			Measured	Unit	Status
Mobile Input Speech Calibration @Network Level: -26 dBm0			2.4578	V	Passed

UPV_UserEquipmentCalibration: Mobile Output Calibration

Mobile Output calibrated in 15.3 s

Test Item			Measured	Unit	Status
Mobile Output Calibration			0.1874	V	Passed

TestPlan_StartAndWait: Start

Test Plan "C:\Program Files (x86)\Rohde-Schwarz\CMWrun\1.8.8\TestPlans\Installed\LTE\VoLTE-POLQA_campaign\TC_Impairment_01_AMR-WB_12650bps_mean.rstp" started

TestPlan_StartAndWait: Wait

Waiting for Test Plan "C:\Program Files (x86)\Rohde-Schwarz\CMWrun\1.8.8\TestPlans\Installed\LTE\VoLTE-POLQA_campaign\TC_Impairment_01_AMR-WB_12650bps_mean.rstp" to finish
Test Plan "C:\Program Files (x86)\Rohde-Schwarz\CMWrun\1.8.8\TestPlans\Installed\LTE\VoLTE-POLQA_campaign\TC_Impairment_01_AMR-WB_12650bps_mean.rstp" finished

IMS Codec: Reconfiguration

VoLTE ID: "afiWFLXF7bXlBTi4mXRA0BlPrNllNjfs" disconnected in 0.2s

Call Process		Timeout	Elapsed Time	Unit	Status
Connection Established		30	0.7	s	Passed

VoLTE Codec reconfigured
CODEC: AMR Wideband
Speech data rates: UL=12.65 DL=12.65

DL-POLQA_WB-AMR_12.65kbps_impairments_10msJitter_1%PaketLoss:

AMR-WB, Jitter = 10 ms, Packet Loss = 1%, 20th Percentile > 3.5

UPV_SpeechQualityMeasurement: POLQA Measurement

Test Item	Lower Limit	Avg. Delay	MOS		Status
Measurement (Ref.-File: - Downlink, Super-Wide, Single-Mode)					
POLQA Measurement 001	---	103.9 ms	3.1279	---	
POLQA Measurement 002	---	103.7 ms	4.1197	---	
POLQA Measurement 003	---	103.0 ms	3.0743	---	
POLQA Measurement 004	---	103.0 ms	4.1320	---	
POLQA Measurement 005	---	103.0 ms	2.8597	---	
Test Item	**Min MOS**	**Max MOS**	**Avg MOS**	**StdDev**	
Statistics (Ref.-File: - Downlink, Super-Wide, Single-Mode)					
POLQA Measurement 5 trial(s)	2.8597	4.1320	3.4627	0.5489	
Median	---	---	3.1279	---	
03rd Percentile	---	---	2.8854	---	
10th Percentile	---	---	2.9455	---	
25th Percentile	---	---	3.0743	---	
50th Percentile (Median)	---	---	3.1279	---	
75th Percentile	---	---	4.1197	---	
90th Percentile	---	---	4.1271	---	
97th Percentile	---	---	4.1305	---	

DL-POLQA_WB-AMR_12.65kbps_impairments_40msJitter_3%PaketLoss:

AMR-WB, Jitter = 40 ms, Packet Loss = 2%, 20th Percentile > 3.2

UPV_SpeechQualityMeasurement: POLQA Measurement

Test Item	Lower Limit	Avg. Delay	MOS		Status
Measurement (Ref.-File: - Downlink, Super-Wide, Single-Mode)					
POLQA Measurement 001	---	105.5 ms	3.3126	---	
POLQA Measurement 002	---	103.5 ms	3.0176	---	
POLQA Measurement 003	---	104.2 ms	3.9035	---	
POLQA Measurement 004	---	104.1 ms	3.8564	---	
POLQA Measurement 005	---	104.2 ms	3.0883	---	
Test Item	**Min MOS**	**Max MOS**	**Avg MOS**	**StdDev**	
Statistics (Ref.-File: - Downlink, Super-Wide, Single-Mode)					
POLQA Measurement 5 trial(s)	3.0176	3.9035	3.4357	0.3759	
Median	---	---	3.3126	---	
03rd Percentile	---	---	3.0261	---	
10th Percentile	---	---	3.0459	---	
25th Percentile	---	---	3.0883	---	
50th Percentile (Median)	---	---	3.3126	---	
75th Percentile	---	---	3.8564	---	
90th Percentile	---	---	3.8847	---	
97th Percentile	---	---	3.8978	---	

Fig. 6-25: Excerpt of VoLTE Campaign: Installed\LTE\VoLTE-POLQA_campaign\1_VoLTE_Master_band4-USIM-Z04.rstp

7 Troubleshooting Tips

It is advised to carefully follow the setup instructions in Sections 2 to 4, however in case there are issues this chapter provides some extra things to try. Any settings mentioned for the CMW should be duplicated in CMWrun when running automation.

7.1 Call not established

7.1.1 IMS Connection Not Established

As VoLTE is performed using IMS, the device must successfully connect to the IMS server and the line item "UE is subscribed for 'reg' event" must be visible in the IMS server (as in Figure 6-3). If this has not happened there is an issue with the LTE or IMS settings.

7.1.1.1 LTE Settings

Verify the settings according to Section 4.1. Assuming the device attaches, verify that the MCC/MNC match the network provider, that Data Connection is set as the Connection Type, that the IP version and APN name match what the DUT expects.

7.1.1.2 IMS Settings

Verify that the IMS server is turned on. If there is an IMS bearer visible in the LTE signaling window, yet there is no registration visible in the IMS Event, it is possible that the IMS authentication parameters (check the authentication type, but also the algorithm) are incorrect. If it seems that the device did not try to register to IMS at all, incorrect MCC/MNC could be the issue, or perhaps the device just needs to be power cycled in order to prompt it to register to the IMS server again.

For some devices the DNS must be turned off, which can be done in the Data Application Control.
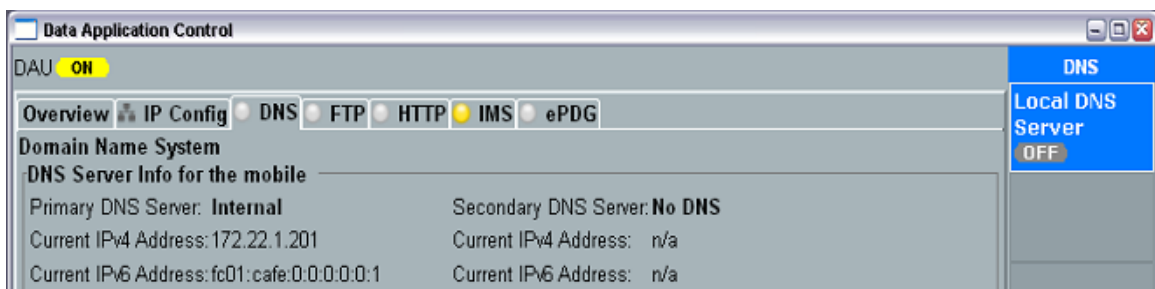
Fig. 7-1: Some DUTs require the DNS server on the DAU to be turned off

7.1.2 Call terminates immediately

If a call is created, yet is cancelled or terminates immediately, this could be an issue with the **VIRTUAL SUBSCRIBER** settings in the IMS server, specifically the **SIGNALING TYPE** (**NO PRECONDITIONS, PRECONDITIONS, SIMPLE**, etc), or the **DEDICATED BEARER** checkbox may need to be enabled. It is also possible that the **AUDIO MEASUREMENT** does not have **CONTROLLED BY** set to **DAU IMS SERVER**.

7.2   Input Calibration (Uplink)

If the calibration procedure after an established VoLTE call fails:

7.2.1   CMW AUDIO – Scenario External Analog Speech Analysis

Audio board input level and output level a value of 1.00 V (in both cases) is recommended.

7.2.2   ERROR: POLQA_CAL_Macro <No reaction to change of input voltage>

7.2.2.1   Test Setup / Cabling

Fig. 7-2: Cabling setup (identical to Fig. 2-1)

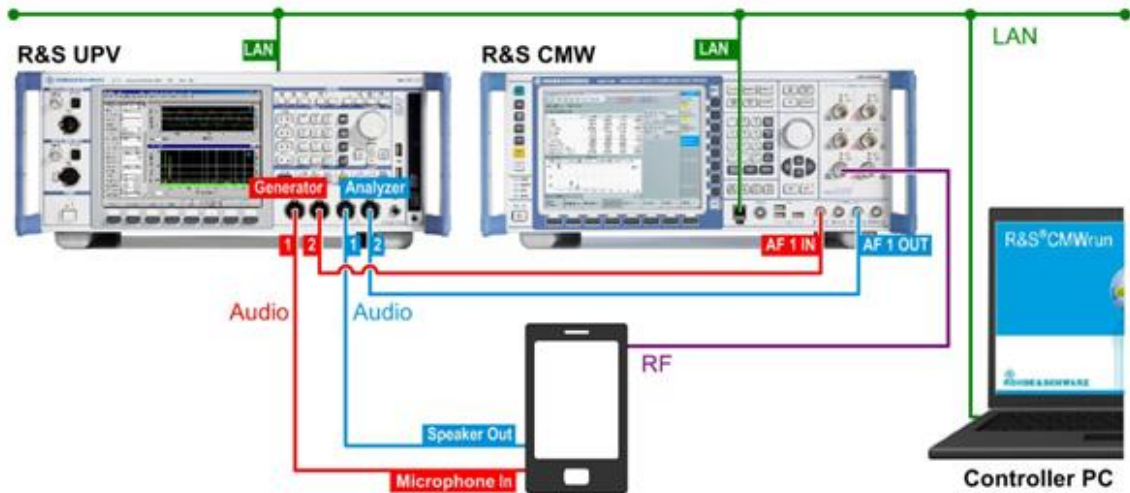Verify that the setup is connected according to Fig. 2-1 and Fig. 7-2. The following explains the path the audio takes in both directions.

Uplink path:

UPV Generator 1 to DUT Microphone In → RF uplink to CMW → AF 1 OUT to UPV Analyzer 1

Downlink path:

UPV Generator 2 to CMW AF 1 IN → RF downlink to DUT → DUT Speaker Out to UPV Analyzer 1

7.2.2.2 Wrong headset cable

There are 2 possible wirings for the headsets. The correct cable depends on the DUT specific wiring for the headset. The UPV option UPV-Z9 – headset cable set (part no. 1411.3106.02) contains 2 cables covering all possible cases:

Apple devices need "Cable 1 GND=Sleeve", whereas others typically need "Cable 2 GND=2nd Ring"

Fig. 7-3: Cable 1 GND=Sleeve, part no.: 1411.3129.02

Fig. 7-4: Cable 2 GND=2nd Ring, part no.: 1411.3135.02

7.2.2.3 Is UPV path "D:\UPV\POLQA_CAL" available?

UplinkSpeechCal.set and DownlinkSpeechCal.set load their reference speech file Pesq.Ref.wav from "D:\UPV\POLQA_CAL". If this directory does not exist on the UPV copy all files from "C:\Program Files\Rohde&Schwarz\POLQA_CAL\Files" into "D:\UPV\POLQA_CAL". These files would have been installed from Section 3.2.1.

7.2.3 ERROR: POLQA_CAL_Macro <timeout error>

This error occurs when the UPV does not return a result within the specified time. This should not be mistaken with SCPI Visa timeout.

7.2.3.1 Increase Macro Timeout
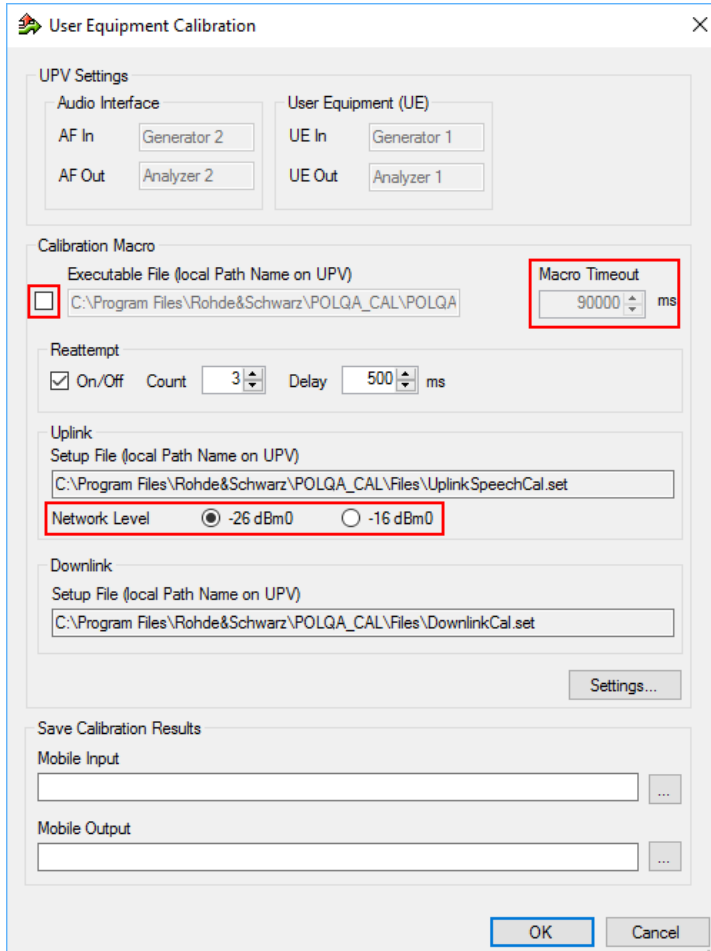
Fig. 7-5: UPV_UserEquipmentCalibration

In CMWrun, double click the UPV_UserEquipmentCalibration test item in the testplan to bring up Fig. 7-5. The Macro Timeout can be increased by first checking the checkbox on the left (the path should not need to be changed) and changing the value.

7.2.3.2 Network Level is set to -16 dBm0?

Bring up Fig. 7-5 as above, and try setting the Network level -26 dBm0; this value depends on the DUT's sensitivity and is determined through trial and error.

7.2.3.3 DUT volume control has to be at the maximum setting

Double check the volume on the DUT with the audio cable plugged in, it should be set to maximum.

8 Literature

[1] R&S®UPV Operating Manual

[2] Application Note 1GA49, "Psychoacoustic Audio Quality Measurements Using R&S®UPV Audio Analyzer"

[3] Application Note 1GA50, "Calibration Tool for PESQ® Speech Quality Tests"

[4] Application Note 1GA62, "Test Automation Tool for POLQA® and PESQ® Speech Quality Tests"

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

[6] Application Note 1MA136 "PESQ® Measurement for CDMA2000 with R&S®CMUgo"

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

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

[9] Application Note 1MA202 "Next-Generation (3G/4G) Voice Quality Testing with POLQA®"

9 Additional Information

Please send your comments and suggestions regarding this application note to

TM-Applications@rohde-schwarz.com

10 Ordering Information

Ordering Information		
Wideband Radio Communication Tester		
CMW500	**Wideband Radio Comm. Tester**	**1201.0002K50**
CMW-PS503	Basic Assembly (mainframe), 70 MHz to 3.3 GHz	1208.7154.02
CMW-S550B	Basic Interconnection, flexible link, for non-signaling, signaling and IQ access	1202.4801.03
CMW-S590A	RF front end, advanced functionality	1202.5108.02
CMW-S600B	CMW500 front panel with display/keypad	1202.0102.03
CMW-B570B	RF Converter (TRX)	1202.5008.03
CMW-S100A	Baseband Measurement Unit, 1 GByte memory	1202.4701.02
CMW-B300B	Signaling Unit Wideband (SUW), for WCDMA / LTE	1202.6304.02
CMW-B450D	Data Application Unit, H450A (hw opt.)	1202.8759.05
CMW-B660A	Option Carrier	1202.7000.02
CMW-B661A	Ethernet Switch Board	1202.7100.02
CMW-B690B	OCXO, high stability	1202.6004.02
CMW-B400	Audio Analyzer/Generator Board	1207.8457.02
CMW-B405	Speech Codec Board	1207.8257.02
CMW-PK45	E2E Bundle including IP Enabler, IMS, and IP Measurements and Analysis	1207.6354.03
CMW-KS500	LTE FDD Release 8, SISO, signaling/network emulation	1203.6108.02
CMW-KS510	LTE Release 8, SISO, signaling / network emulation, advanced functionality	1203.9859.02
Audio Analyzer		
UPV	**Audio Analyzer, analog interfaces, DC to 250 kHz**	**1146.2003.02**
Or UPV66	**Audio Analyzer without display/keypad**	**1146.2003.66**
UPV-K9	Base Software for Mobile Phone Tests incl. cables and adapters	1402.0008.02
UPV-K91	UMTS/GSM Mobile Phone Tests	1402.0108.02
UPV-K61	Speech Quality Measurement PESQ, to ITU-T rec. P.862	1401.7309.02
UPV-K63	Listening Quality Analysis POLQA, to ITU-T rec. P.863	1402.1156.02
UPV-K1	Universal Sequence Controller	1401.7009.02
Optional:		
UPV-K4	Remote Control for IEC625 / IEEE488, RS232, USB and LAN	1401.9001.02
UPV-K92	CDMA2000 Mobile Phone Tests	1402.0608.02
UPV-K62	Audio Quality Measurement PEAQ, to ITU-R rec. BS.1387	1401.7750.02
UPV-B3	Second Analog Generator, DC to 80 kHz	1401.4806.02
CMWrun Software Sequencer Tool		
CMWPC	PC based CMW applications	1201.0002.90
CMW-KT051	R&S®CMWrun sequencer tool, CMWrun generic proposal	1203.4157.02
CMW-KT055	R&S®CMWrun sequencer tool, LTE applications	1207.2107.02

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.

Regional contact

Europe, Africa, Middle East
+49 89 4129 12345
customersupport@rohde-schwarz.com

North America
1-888-TEST-RSA (1-888-837-8772)
customer.support@rsa.rohde-schwarz.com

Latin America
+1-410-910-7988
customersupport.la@rohde-schwarz.com

Asia/Pacific
+65 65 13 04 88
customersupport.asia@rohde-schwarz.com

China
+86-800-810-8228 /+86-400-650-5896
customersupport.china@rohde-schwarz.com

Environmental commitment

▪ Energy-efficient products

▪ Continuous improvement in environmental sustainability

▪ ISO 14001-certified environmental management system

Certified Quality System
ISO 9001

This application note and the supplied programs may only be used subject to the conditions of use set forth in the download area of the Rohde & Schwarz website.