

Generating the Noise Field for Ambient Noise Rejection Tests

Application Note

Products:

- | R&S®UPV
- | R&S®UPV-K9
- | R&S®UPV-K91

This document describes how to generate the noise field for ambient noise rejection tests according to 3GPP TS 26.132, sections 7.9 and 8.9.

Table of Contents

1	Background	4
1.1	3GPP Mobile Phone Tests R&S® UPV-K9, UPV-K91	4
1.2	Ambient Noise Rejection (ANR) Tests	4
1.3	Requirements on the noise field.....	4
2	General Description	6
2.1	Required Equipment	6
2.1.1	Equipment List.....	6
2.1.2	Audio CD with Pink Noise Signal.....	6
2.1.3	CD Player.....	6
2.1.4	Equalizer.....	6
2.1.5	Loudspeakers	6
2.1.6	Amplifier (required with passive loudspeakers)	7
2.2	Test Setup	7
2.2.1	Test Room	7
2.2.2	Loudspeaker Arrangement.....	7
2.2.3	Connections.....	8
2.3	Adjustment.....	8
2.3.1	Order of Adjustment	8
2.3.2	Spectrum Adjustment	8
2.3.3	Level Adjustment	8
2.3.4	Overall	9
3	Implementation with Specific Equipment	10
3.1	Equipment List.....	10
3.2	Connections	10
3.3	Adjustment.....	11
3.3.1	Settings of the Active Speakers.....	11
3.3.2	Basic Settings of the Equalizer.....	11
3.3.2.1	I / O Menu	11
3.3.2.2	Utility Menu	11
3.3.2.3	Bypass Menu	12
3.3.3	Spectrum Adjustment	12
3.3.4	Level Adjustment for one speaker.....	13

3.3.5	Checking the performance of the total setup.....	14
3.3.6	Performing the Test	14
4	Literature.....	15
5	Abbreviations	15
6	Ordering Information	15

1 Background

1.1 3GPP Mobile Phone Tests R&S® UPV-K9, UPV-K91

As a supplement to Audio Analyzer R&S® UPV, Rohde & Schwarz provides options R&S® UPV-K9 (Base SW for Mobile Phone Tests) and R&S® UPV-K91 (UMTS/GSM Mobile Phone Tests) which can be used together with Universal Radio Communication Tester R&S® CMU200 for acoustic tests on mobile phones according to 3GPP TS 26.132.

One of the test cases specified in 3GPP TS 26.132 is Ambient Noise Rejection, which requires equipment for generating a diffuse sound field in the test room. This equipment is not comprised with the options. Therefore this application note explains how to generate and adjust the required diffuse noise field with commonly available equipment.

For details on the operation of the UPV-K9x software provided with option R&S® UPV-K91, see "R&S® UPV-K9, R&S® UPV-K91 Operating Manual".

1.2 Ambient Noise Rejection (ANR) Tests

Ambient noise rejection is a property of a telephone in sending direction. Ambient noise rejection tests deliver a spectrally weighted ratio between the sending sensitivity of a telephone for speech signals (speech send sensitivity) and its sending sensitivity for background noise (room noise sensitivity).

The ambient noise rejection test as specified in 3GPP TS 26.132 assumes that the properties of the telephone are sufficiently time-invariant to allow separate measurement of room noise sensitivity and speech send sensitivity. Furthermore it is assumed that the rejection of the relatively uniform pink noise is somehow correlated with the rejection of other types of noise like street noise and background voices.

1.3 Requirements on the noise field

According to 3GPP TS 26.132, the noise should be band limited between 100 Hz and 8 kHz. The spectrum should be "pink" which means that the 3rd octave levels within this frequency band should be independent of the center frequency of the 3rd octave bands. The tolerance of this spectral uniformity is defined to be ± 3 dB.

The total level of the noise should be 70 dB SPL(A), equal to -24 dB Pa(A) at the mouth reference point with a tolerance of ± 1 dB.

The level and spectrum at the mouth reference point is to be adjusted in absence of the test head or HATS, respectively.

The noise field has to be diffuse. As a proof for the diffusivity of the noise field it has to be assured that the 3rd octave levels between 100 Hz and 3.15 kHz (narrow band) or between 100 Hz and 6.3 kHz (wide band) respectively, are uniform within ± 3 dB within a radius of 0.15 m around the mouth reference point (MRP).

It should be noted that this requirement can theoretically be fulfilled with a single speaker in sufficient distance from the MRP in free field, whereas a real diffuse sound field also exhibits random direction of the sound incidence. When measuring telephones with directional microphones, different results of the ANR measurement have to be expected with different direction of the noise sound incidence. Therefore it is recommended to use at least four loudspeakers with uniform spatial distribution for the generation of the sound field. In measurement rooms with non-anechoic conditions a higher number of speakers may be needed to achieve the required uniformity.

To avoid interference between signals from different loudspeakers, each speaker has to be fed with an own noise signal which is not correlated with the noise signal of any of the other loudspeakers.

2 General Description

2.1 Required Equipment

2.1.1 Equipment List

- Audio Analyzer R&S® UPV with options UPV-K9 and UPV-K91
- Audio CD(s) with pink noise signal
- CD Player(s)
- Equalizers
- Loudspeakers
- Power amplifier(s) for passive speakers
- Connection cables

2.1.2 Audio CD with Pink Noise Signal

The audio CD should contain at least one sufficiently long track with two uncorrelated pink noise signals on the two channels. An image of such a CD is provided on the download site of this application note.

2.1.3 CD Player

In principle one CD player is required for each pair of loudspeakers. If equalizers are used which offer a delay function of at least 250 ms, the delay can be used to de-correlate the noise signals. In this case each CD player can serve four loudspeakers. An audio CD image with two tracks of two-channel uncorrelated band-limited pink noise is available for download on the download site of this application note.

2.1.4 Equalizer

Ideally the equalizer should be a graphic equalizer with 3rd octave resolution. Furthermore a sum gain control is required, either in the equalizer or in the power amplifier(s). A delay function in the equalizer can be utilized to generate additional uncorrelated noise channels from the same source (CD player), see above.

2.1.5 Loudspeakers

The loudspeaker frequency response should be sufficiently flat between 100 Hz and 8 kHz to allow equalization with the utilized equalizers. In addition to the deviation of the loudspeaker frequency response measured in free field there may be effects of a non-ideal room, particularly in the low frequency region. A suspension facility is needed for the speakers to allow their positioning in the required spatial arrangement.

2.1.6 Amplifier (required with passive loudspeakers)

Active speakers eliminate the need for an additional power amplifier. If a power amplifier is needed, the maximum continuous output power should not be higher than the power rating of the loudspeakers.

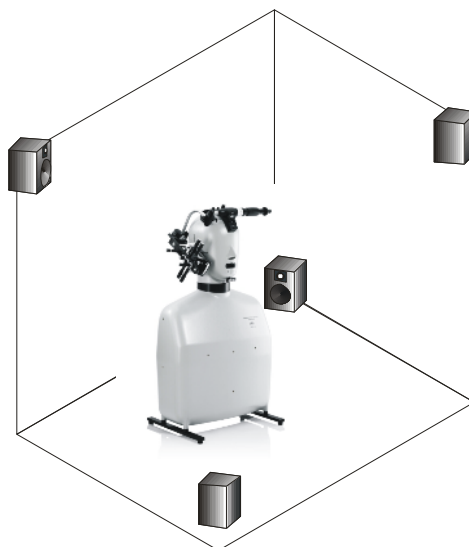
2.2 Test Setup

2.2.1 Test Room

As the speech sound sensitivity of the telephone has to be measured in free field, the test room needs to be sufficiently anechoic in the measurement frequency range. To accommodate the speaker arrangement as suggested below, the test room should have a minimum free space of about 1.5 x 1.5 x 1.5 m. Furthermore suspensions or supports have to be provided in the room at the required loudspeaker positions.

2.2.2 Loudspeaker Arrangement

For a good spatial distribution a minimum of four speakers is required. The optimum arrangement for four speakers is a regular tetrahedron, i.e. two speakers are positioned near the room floor in two diagonally opposite corners of a virtual cube. The other two speakers are positioned in two upper corners of this cube which are not above the first two speakers.



Eight speakers should be positioned in the eight corners of a virtual cube.

If possible, the speakers should be inclined towards the MRP. To assure the spatial uniformity of the noise field, a minimum distance of 1m between each of the speakers and the MRP is recommended.

Deviations from the ideal arrangement are possible as long as the tolerance for the spatial uniformity of the noise field is not exceeded.

If the test room is not ideally anechoic down to 100 Hz, the low-frequency response of each speaker may depend on its distance from the walls. Fine tuning of the speaker positions may be required if the low-frequency response cannot be equalized easily.

2.2.3 Connections

Connect the equalizer inputs to the appropriate CD player outputs. Depending on the equipment this may be analog or digital S/P-DIF electric or optical (TOSLINK).

If the equalizer(s) also offer a sum gain control, active speakers may be connected directly to the equalizer outputs. For passive speakers, power amplifiers are connected to the equalizer output, and the loudspeakers are connected to the outputs of the power amplifiers.

2.3 Adjustment

2.3.1 Order of Adjustment

Mark the position of the MRP of the artificial mouth in use and remove the HATS or LRGP test head, respectively, from the measurement room. For the measurement at the MRP, the measurement microphone may be positioned at the MRP before removing the test head. For the measurements in 0.15 m distance, another utility like the tip of a microphone boom, is required to mark the MRP.

It is suggested to start with adjusting the speakers one after the other, first in spectrum and then in level. As the noise signals are not correlated, the signals of the speakers will add up in power at the MRP. Finally the spectrum, level and spatial distribution of the total noise field is verified.

2.3.2 Spectrum Adjustment

Using the “Adjust Spectrum” function of the ambient noise field calibration (“Calibration → Ambient noise field”) of the R&S® UPV-K9x software provided with option R&S® UPV-K91, the 3rd-octave spectrum of the pink noise is adjusted as far as possible to a flat line by trimming the respective 3rd-octave gains in the respective equalizer channel.

2.3.3 Level Adjustment

The level of each speaker has to be adjusted to $-24 \text{ dBPa(A)} - 10 * \log_{10} n$, with n being the number of speakers. With four speakers, each speaker has to be adjusted to -30 dBPa(A) , with eight speakers each speaker has to be adjusted to -36 dBPa(A) . The level adjustment function of the ambient noise field calibration of the R&S® UPV-K9x software can be used for this purpose.

It is suggested to take the number of speakers into account by first adjusting each speaker to -24 dBPa(A) at MRP and reducing the gain in the amplifier or equalizer by the appropriate level difference before activating all speakers.

2.3.4 Overall

After all speakers have been adjusted, the total spectrum and level are checked, first at the MRP, then at 0.15 m distance around the MRP in at least 6 orthogonal spatial directions. This can be either done with the separate spectrum adjustment and level adjustment functions of the ambient noise field calibration, or with its "Measurement" function. Note that the last "Measurement" is stored as calibration value and has therefore to be carried out at the MRP.

3 Implementation with Specific Equipment

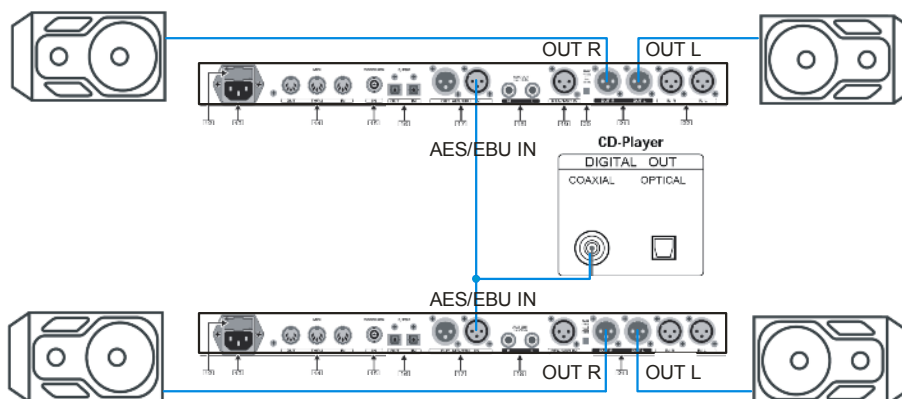
3.1 Equipment List

The following table lists the required equipment for n loudspeakers.

Equipment for Pink Noise Generator			
Quantity	Description	Type	Manufacturer
1	Audio Analyzer	R&S®UPV	Rohde & Schwarz
1	Base SW for Mobile Phone Tests	R&S®UPV-K9	Rohde & Schwarz
1	UMTS/GSM Mobile Phone Tests	R&S®UPV-K91	Rohde & Schwarz
n / 4	Audio CDs	Download image	Rohde & Schwarz
n / 4	CD Player	Not specified	Not Specified
n / 2	Equalizer	Ultracurve DEQ2496	Behringer
n	Active Loudspeaker	Truth B2031	Behringer
n	Speaker cables	XLR male – XLR female	Not specified
n / 4	Connection cable	RCA - BNC	Not specified
n / 2	BNC T-connector	Not specified	Not specified
n	Short BNC cables	Not specified	Not specified
n	Adapters BNC – XLR male	R&S®UPL-Z1 (2 per set)	Rohde & Schwarz

The standard cables and adapters may be replaced by custom made cables.

3.2 Connections



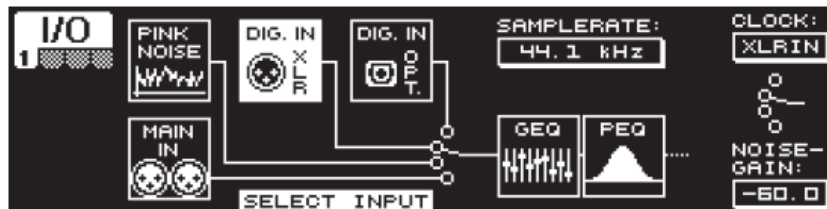
3.3 Adjustment

3.3.1 Settings of the Active Speakers

- Set “Power Mode” to “On”
- Set “Mute High” and “Mute Low” to “Off”
- Set the “Input Trim” control to minimum (-6 dB)
- Set “Low Frequency”, “Room Compensation” and “High Frequency” to “0 dB”.
These controls may be used later on if equalization exceeding the range of the equalizer controls is required.

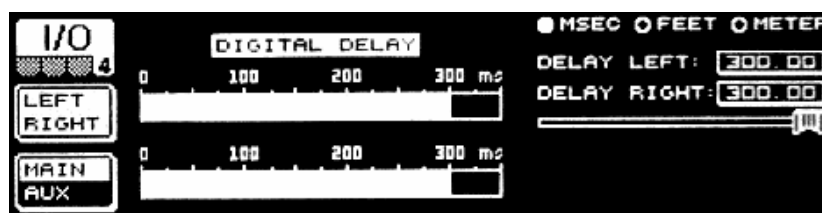
3.3.2 Basic Settings of the Equalizer

3.3.2.1 I / O Menu



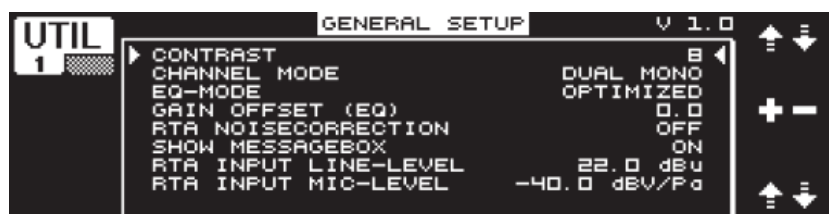
The input has to be set on the first page according to the connection used, i.e. “MAIN IN” for analog connection from the CD player, “DIG. In XLR” for S/P-DIF connection and “DIG. IN OPT.” for Toslink connection.

If four speakers are fed from one CD via two equalizers, in one of the equalizers (only!) the delay has to be enabled for the main output and to be set to maximum. This is done on page 4 of the I / O menu:



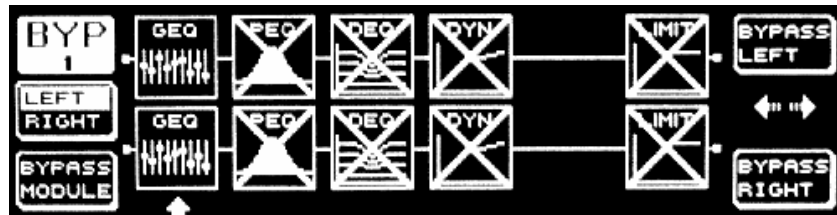
Set the unit to “MSEC” and the value for both channels to “300”.

3.3.2.2 Utility Menu



- Set “CHANNEL MODE” to “DUAL MONO”. This allows to set the equalizer for both channels independently.
- For alignment of one out of four speakers, set “GAIN OFFSET (EQ)” to -9 dB. For alignment of one out of eight speakers, set it to -3 dB. Before all speakers are turned on, set it to -15 dB. This compensates for the level increase caused by the number of speakers.

3.3.2.3 Bypass Menu

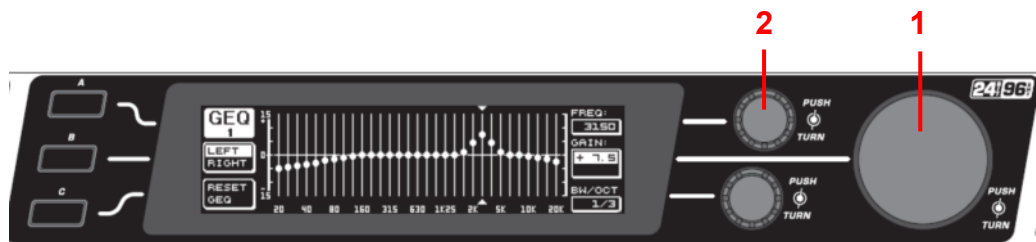


In both channels, all modules except the graphic equalizer (“GEQ”) must be bypassed.

3.3.3 Spectrum Adjustment

Place a calibrated diffuse field microphone at the MRP before starting the adjustment. Connect the microphone via a suitable power supply (e.g. conditioning Amplifier) to R&S® UPV analyzer input 1. The HATS or test head must be removed before the adjustment. Make sure to memorize the position of the MRP. The HATS or test head must be put back later on with the MRP at the same position in the room.

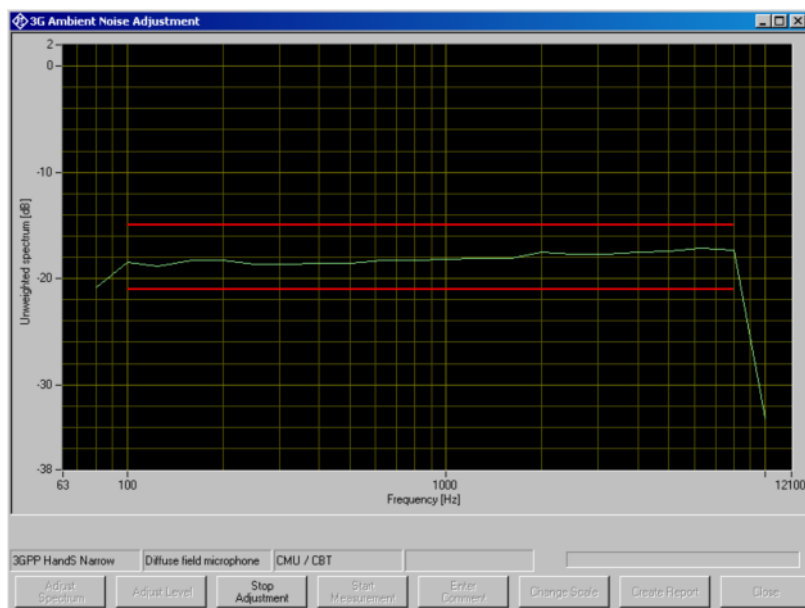
Steps 3.3.3 and 3.3.4 have to be performed for each speaker separately. Switch all speakers off. Switch on only the speaker to be adjusted next. Make sure which channel of which equalizer is assigned to the speaker currently activated.



Use button “B” to select the correct channel. Use wheel 2 to select the frequency band. Use wheel 1 to adjust the gain in 0.5 dB steps.

Start “Calibration → Ambient noise field” in the R&S® UPV-K9x program. Start “Adjust Spectrum”. Start the playback of the pink noise in the CD player.

The level scale of the spectrum display of the R&S® UPV-K9x program auto-scales such that the spectrum curve is centered within the red limit lines. With a total level of -24 dB(A) the average 3rd octave level is expected around -35 dBPa (unweighted).

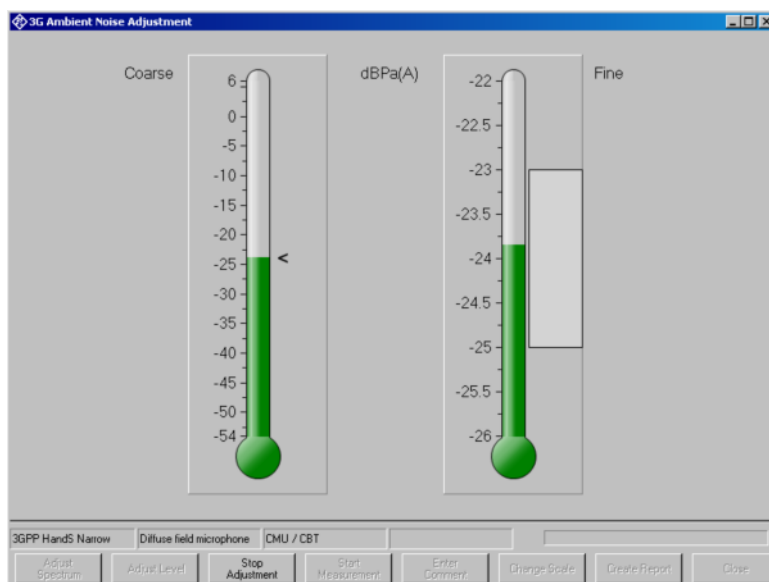


Set the gain at 80 Hz and 10 kHz to minimum. Adjust the spectrum to a horizontal line by increasing the gain for frequency bands where the level is below the average and reducing the gain for frequency bands where the level is above average.

Once the spectrum is sufficiently flat, click or press softkey “Stop Adjustment” in the user interface of the K9x software.

3.3.4 Level Adjustment for one speaker

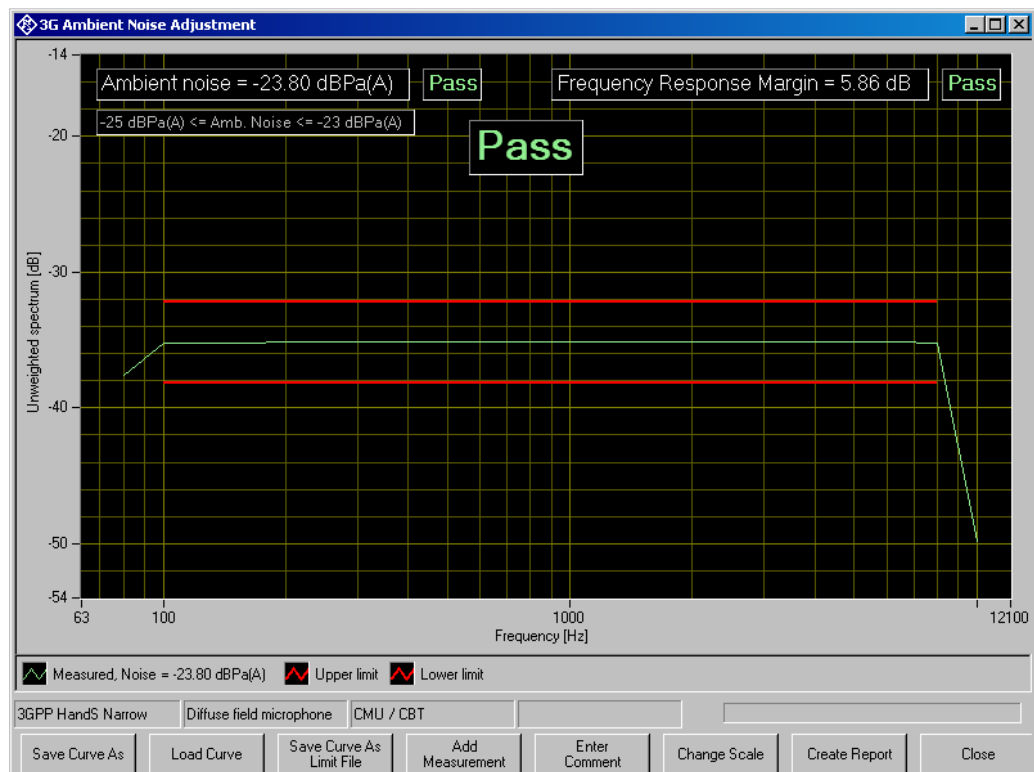
Start the “Adjust Level” function”.



Press wheel 2 on the equalizer to activate the sum gain on the right end of the display. Adjust the level to -24 dBPa(A) using wheel 1.

3.3.5 Checking the performance of the total setup

As soon as all speakers have been adjusted separately, set “Gain offset (EQ)” in the utility menu to -15 and switch on all speakers. You can now use the “Adjust spectrum” and “Adjust Level” functions to check the total adjustment. If everything is within tolerance, check spectrum and level for a number of points in at least 0.15 m radius around the MRP. At last, place the measurement microphone at MRP again and click or press softkey “Start Measurement”. Spectrum and level at MRP are now measured and the tolerances is checked. If the result is within tolerance, it is stored as calibration value for the ambient noise rejection measurement. A report can be generated and exported before closing the window with the result of this measurement.



3.3.6 Performing the Test

After step 3.3.5 has been completed successfully, re-install the HATS or LRGP test head, respectively, in the test room with the MRP at its original position. Establish a call to the mobile and start the test case.

The noise field must be present when the test is started. During the test execution, the operator is prompted to switch off the noise field. This can be done by stopping the playback of the CD(s).

4 Literature

- 3GPP TS 26.132 “Speech and video telephony terminal acoustic test specification”
<http://www.3gpp.org/ftp/Specs/html-info/26132.htm>
- R&S® UPV-K9, R&S® UPV-K91 Operating Manual
[http://www2.rohde-schwarz.com/en/products/test_and_measurement/audio/UPV-\[-Manuals-\]-22-\[-2224-\]-2224.html](http://www2.rohde-schwarz.com/en/products/test_and_measurement/audio/UPV-[-Manuals-]-22-[-2224-]-2224.html)
- Ultracurve Pro DEQ2496 User’s Manual
<http://www.behringer.com>
- Truth B2030A/B2031A User’s Manual
<http://www.behringer.com>

5 Abbreviations

3GPP	3 rd Generation Partnership Project
ANR	Ambient Noise Rejection
HATS	Head-and-Torso Simulator
LRGP	Loudness Rating Guardring Position
MRP	Mouth Reference Point

6 Ordering Information

Ordering Information		
Type of instrument		
Description	Instrument type	Ordering number
Audio Analyzer	R&S®UPV or R&S®UPV66	1146.2003.02 1146.2003.66
XLR/BNC Adapter Set	R&S®UPL-Z1	1078.3704.02
Base SW for Mobile Phone Tests	R&S®UPV-K9	1402.0008.02
UMTS/GSM Mobile Phone Tests	R&S®UPV-K91	1402.0108.02
Universal Radio Communication Tester	R&S®CMU200	1100.0008.02
Option versatile signalling unit	R&S®CMU-B21V14	1100.5200.02
Speech codec for sig. unit	R&S®CMU-B52V14	1100.5400.02
WB-AMR Codec	R&S®CMU-K46	1200.8800.02
SW option according to GSM band	R&S®CMU_K2x	
WCDMA (3GPP FDD) signalling module	R&S®CMU-B56 v54	1150.1850.54
Versatile baseband board for WCDMA	R&S®CMU-B68	1149.9809.02
UE test signalling software	R&S®CMU-PK60	1159.3355.04

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Environmental commitment

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



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