Voice Quality Measurements with R&S ROMES
Application Note 1SP52

Products:
R&S®ROMES

This document introduces Voice Quality Measurements with R&S ROMES and describes the configuration of the drive test software step by step. It has been considered different hardware configurations and its settings.

Mobile to Server and Mobile to Mobile scenarios are discussed. It gives advice and offers interpretations of the measurement data.

Numerous pictures and schematics allow to understand the Voice Quality issue and helps as a guideline to perform those Quality of Service measurements.
Table of Contents

1 INTRODUCTION ......................................................................................... 4
2 BACKGROUND ............................................................................................. 4
3 REQUIREMENTS .......................................................................................... 5
4 SOUNDCARD SETUP ON MEASUREMENT PC ......................................... 6
5 ROMES SETUP .......................................................................................... 8
6 ROMES SERVER SETUP ........................................................................... 14
7 TEST MEASUREMENT ............................................................................. 16
8 ABBREVIATIONS .................................................................................... 19
9 REFERENCES ............................................................................................. 19
10 ORDERING INFORMATION ..................................................................... 19
1 Introduction

The Speech Quality Analysis allows end-to-end Tests showing how the subscriber would see the network quality/performance. The main advantage of this type of measurement is the ability to make a statement about the speech quality/performance of the uplink and downlink. It can be applied in a wide range of technologies and could lead to comparisons between transmit methods and terminals.

2 Background

PESQ

Perceptual Evaluation of Speech Quality (PESQ) is an enhanced perceptual quality measurement standard for voice quality in telecommunications. PESQ was developed by the International Telecommunication Union ITU-T and belongs to the series P for telephone transmission quality. The full standard name is ITU-T P.862. PESQ is designed for end-to-end voice quality testing under real network conditions, like VoIP, POTS, ISDN, GSM or UMTS.

The principle of PESQ is based on the comparison of two equal audio samples. One is transmitted and received through the mobile phone network, the other serves as reference. If the difference between the samples is high, the voice quality decreases during the transmission. [1][2]

MOS

The Mean Opinion Score describes a method for a subjective assessment of speech and video quality in telecommunications. It was developed and standardized as ITU-T P.800. The MOS is the arithmetic mean of all the individual scores and can range from 1 (worst) to 5 (best).

<table>
<thead>
<tr>
<th>MOS Score</th>
<th>Quality Impairment</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent, Imperceptible</td>
</tr>
<tr>
<td>4</td>
<td>Good, Perceptible but not annoying</td>
</tr>
<tr>
<td>3</td>
<td>Fair, Slightly annoying</td>
</tr>
<tr>
<td>2</td>
<td>Poor, Annoying</td>
</tr>
<tr>
<td>1</td>
<td>Bad, Very annoying</td>
</tr>
</tbody>
</table>

Table 1 MOS Quality Impairment
3 Requirements

**Required Software:**
- ROMES 3.60 SP2 or higher with SQA and Mobile options
- Device driver from the ROMES CD for the soundcard used
- Device driver from the ROMES CD for the mobiles used (with USB connector)
- PESQ license file (comes with ROMES4SQA SQA option)
- Speech sample (e.g. ITU samples or [http://www.signalogic.com/index.pl?page=codec_samples#pesq](http://www.signalogic.com/index.pl?page=codec_samples#pesq))
- Digital answering machine or
- ROMES4SRV SQA Server

**Required Hardware:**
- High-performance PC with Windows XP for four SQAs at the same time a Pentium IV 3 GHz with Hyperthreading or Dual Core 2 GHz and one GBbyte main memory is required.

*Note: PCs with lower performance are restricted to two SQAs*
- Server PC or PC based digital answering machine
- Mobiles with data connection cable
- Audio Adapter Box for the mobile
- One of the following separate sound cards:
  - For up to two test mobiles: M-Audio Transit (USB)
  - For up to four test mobiles: ESI U46DJ (USB)
  - For up to four test mobiles: M-Audio Firewire IEEE1394

USB soundcards require an USB 2.0 connector. Firewire soundcards require a separate Firewire card in the PC. To connect an M-Audio soundcard and an R&S TSML/U/Q you will need either one Firewire card with two connectors or one built-in Firewire Controller and a Firewire card connector and ROMES 4.0.

![Figure 1 System constellation for Speech Quality Analysis (SQA)](image_url)
4 Soundcard Setup on measurement PC

The following paragraphs explain step-by-step how to configure the drivers and the ROMES software for Voice Quality Measurements. Install the soundcards as described by the manufacturers. For software installation use the device drivers from the ROMES CD, or download the current device drivers from the manufacturers web site.

Note: Do not use the device drivers which comes with the hardware or which Windows XP installs automatically.

**M-Audio Transit**
(1) Install the M-Audio Transit drivers included into the ROMES installation CD (e.g. ROMES 4.11\Firmware & Drivers\Sound Cards\M-Audio\Transit_WDM_5.10.00.0055v2.exe) without USB connection to the sound card. After successful installation connect the sound card. Use the following default settings with ROMES.

Note: The PESQ measurement show the “Attenuation” level. Adjusting this with the mobile volume control or with the “Mic Boost” for line-in attenuation.

The M-Audio Transit does not require an external power supply. For measurements with two mobiles (mobile to mobile for example) special y-cables are necessary. Those cables show tags with 2x “L/1” and 2x “R1”. Both “L/1” have to be connected to one Audio Adapter Box, similar to both “R/1”.
The sound card has one “line” connector for output and one “line/optical” connector for the input. The output of the sound card is always the input of the Audio Adapter Box and other way round.

**ESI U46J:**

1. Modify the buffer size of the soundcard to maximum (2048) using the software “Tracktion” which comes with the soundcard.

2. Connect the mobile to the mobile adapter box.

3. Connect “out” to the “Input” connector and “in” to the “Output” connector on the rear of the box.
   - Set both switches on the front to “Line”.
   - “Power” must be on.
   - “+48V” must be off.

**M-Audio:**

1. Modify the buffer size of the soundcard to maximum (2048) using the M-Audio software
(2) Connect the mobile to the mobile adapter box.

(3) Connect "out" to the "unbalanced input" connector and "in" to the "bal/unbal output" connector on the rear of the box.

- Both "Mic/Line" buttons at the hardware tab must be pushed in.
- "Power" must be on.
- "Phantom Power", "Pad" and "A/B" must all be off.

With a laptop use the 12 V input. With a desktop PC the box will get power via the Firewire connector.

5 ROMES Setup

Copy the PESQ License file into the directory “PESQLicenseFile” in the ROMES directory. Install a GPS receiver, it will be essential for the merge function of the uplink and downlink results. The following steps have to be repeated for each mobile.

(1) Load the ROMES driver of your mobile and configure the autodialing as shown below:
If you are using an answering machine, do not use “Endless call”, because after a given time the wave file will be finished.

If you are using a ROMES SQA Server, the server must be set up for endless calls.

The “Phone Number” must be the correct number for the server. If you enter an incorrect number you will not get the SQA measurement values because the sound input is usually completely different.

The “Subscriber Number” is the telephone number of your SIM card. It must be correct for uplink measurement. If it is not correct the CMD files of the SQA server can not be merged correctly.

(2) Press “SQA” and load the “Speech Quality Analyzer” menu.
Select “Connect SQA”

Press OK.
Press “Configure SQA...”
If you are using an answering machine select “Downlink”. With an SQA server can select “Both (Up- and Downlink)”. You have to configure reference files and pauses to match your server configuration. (see Figure 2)

Select the correct audio card for each mobile. For M-Audio and ESI U46DJ only use the ASIO sound drivers. The ASIO drivers have to be different, to avoid sound card driver conflicts.

If you are using an answering machine and want to use the “Initial pause” add a silent prefix with the length of the initial pause to the edited reference file.

Figure 2 Timeline of the SQA settings above

It is recommended to adjust the “End Pause” and the “Initial Pause” so that the uplink and the downlink do not overlay. The PESQ values could decrease.
**Note:** The timings of the measurement system and the answering machine/ROMES Server have to be harmonized.

The timing in this example refers to a sample length of 8.4 seconds. The timing will change if the voice sample is been changed.

For mobile to mobile measurements the following time line can be applied.

Mobile 1

<table>
<thead>
<tr>
<th>Time</th>
<th>UL</th>
<th>DL</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.3s</td>
<td>Initial Pause</td>
<td>2.5s</td>
</tr>
<tr>
<td>8.4s</td>
<td>Play file</td>
<td>8.4s</td>
</tr>
<tr>
<td>9s</td>
<td>End Pause</td>
<td>Initial Pause</td>
</tr>
</tbody>
</table>

Initial Pause PESQ algorithm End Pause Initial Pause PESQ algorithm End Pause

Mobile 2

<table>
<thead>
<tr>
<th>Time</th>
<th>UL</th>
<th>DL</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.3s</td>
<td>Initial Pause</td>
<td>2.5s</td>
</tr>
<tr>
<td>8.4s</td>
<td>PESQ algorithm</td>
<td>8.4s</td>
</tr>
<tr>
<td>9s</td>
<td>End Pause</td>
<td>Initial Pause</td>
</tr>
</tbody>
</table>

Initial Pause Play file End Pause Initial Pause Play file End Pause

Here are the full settings for Mobile to Mobile with M-Audio Transit sound card.
6 ROMES Server Setup

Preparation for an answering machine

With an digital answering machine you will only be able to measure the downlink. Configure the answering machine so that it will accept the incoming call immediately. Prepare the wave file: With an audio editing software such as “Audacity” the wave file should repeat the sample file many times (60 times for example). At the beginning of the wave file you should add a silence of at least 2500 ms. Use the unchanged sample file on the client PC.

Preparation for an SQA server

The ROMES Speech Quality Analyser Server allows Speech Quality Tests for the downlink and uplink. This option offers a real end-to-end test solution. In outgoing wave mode, the server plays sound files to a calling device. In incoming wave mode the server measures speech quality of sound coming from a calling device using the PESQ algorithm. The measurement results are stored in CMD files which can later be merged into a destination CMD file by the ROMES application.
Configure the server for your measurement requirements. Each controller (here “AVM ISDN TAPI Service”) must be configured separately. To get correct measurement results both the server and the ROMES SQA driver must be configured correspondingly. To get files which can be merged, the location settings must be correct. For a setup with both uplink and downlink the pauses must be configured so that no overlapping of speech output occurs. Speech output on mobile and server sides results in incorrect (degraded) speech measurement. Output volume should be set to maximum.

For merging the system time of the server must be correct. Either connect GPS or use Internet synchronization via Network Time Protocol (NTP).

Note: to reduce CMD files, the value “Record WAV files worse than” can be reduced, or disabled
7 Test Measurement

For Downlink both the volume of the mobile phone and the volume on the soundcard for line input must be on maximum.

Try to start a measurement with ROMES. Appropriate Views are:
- SQA Message View
- UMTS/GSM NQA State View
- Alphanumeric View with Signals from SQA Tester
- 2G/3G Layer 3 View

Use the SQA Message View for verification: If you get MOS-LQO values the setup is OK. If the attenuation is negative (that means you have gain) reduce the input level setting of the soundcard. The best value for attenuation is 0 dB.

If you get no MOS-LQO in the SQA message view, only the values for resulting delays, either the connection is too bad to get measurement results, the sample files are not equal, the volume is too low, or you are using old device drivers for the soundcard. Check the connection by calling the answering machine or SQA server and listen.
If you get a value of 0 for resulting delays there is no speech on the connection or the setup of the soundcard is wrong. Try to call the answering machine. Try to record a file with the soundcard to check the functionality.

For uplink set the output volume of the soundcard to the lower third. Start the SQA server as “Interactive”. Call the ROMES SQA Server with output power set to max. Decrease the output power until speech sounds undisturbed. Start an Uplink measurement. If you get MOS-LQO values in the message view of the SQA server, change the output volume of your soundcard to get an attenuation of 0 dB at the Server Site.

Possible reasons for no measurement values are the same as for Downlink.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>SQA [1]</th>
<th>SQA [2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PESQ Score P.862.1 (Narrow Band) (DL)</td>
<td></td>
<td>3.337</td>
<td>3.335</td>
</tr>
<tr>
<td>PESQ Score P.862.1 Noise (Narrow Band) (DL)</td>
<td></td>
<td>4.335</td>
<td>4.335</td>
</tr>
<tr>
<td>PESQ Score P.862.1 Speech (Narrow Band) (UL)</td>
<td></td>
<td>3.215</td>
<td>3.215</td>
</tr>
<tr>
<td>MOS-LQO P.862.1 (Narrow Band) (UL)</td>
<td></td>
<td>3.605</td>
<td>3.967</td>
</tr>
<tr>
<td>Attenuation (DL)</td>
<td>dB</td>
<td>-0.538</td>
<td>-0.538</td>
</tr>
</tbody>
</table>

PESQ Score: PESQ Score according to P.862
PESQ Score Noise: PESQ Score during silent periods
PESQ Score Speech: PESQ Score during active speech periods
MOS-LQO P.862.1: Listening Quality Objective Mean Opinion Score
Attenuation: Attenuation between the two input signals in dB

**Merge Function**

The Merge Function integrates the SQA Server Measurement CMD Files with the existing CMD file from the Drive Test System, so that Uplink and Downlink data can be evaluated together.
For “Client Measurement File” select the CMD file with the basic measurement. With “Server Measurement Files” select the directory where the server files have been placed. You can add more files from other locations with the “Browse…” button. ROMES finds the correct files by the measurement time. Enter a name for the target file, if default is not suitable. Start merging with “Merge Files…” button.

Possible errors:
Time frame of the files is incorrect: Setup SQA server and measuring PC with the correct time and repeat the measurement.
Files could be merged but the resulting file has two different SQAs for each mobile: The subscriber number is wrong.
8 Abbreviations

GSM  Global System for Mobile Communications  
IEEE  Institute of Electrical and Electronics Engineers  
ITU  International Telecommunication Union  
MOS  Mean Opinion Score  
NQA  Network Quality Analyzer  
PESQ  Perceptual Evaluation of Speech Quality  
SQA  Speech Quality Analyzer  
UMTS  Universal Mobile Telecommunication System

9 References

[1] International Telecommunication Union ITU-T: Recommendation P-Series;  
http://www.itu.int/rec/T-REC-P/e; (1. September 2006)


Additional Information

This application note is updated from time to time. Please visit the website www.rohde-schwarz.com in order to download new versions.
Please send any comments or suggestions about this application note to TM-Applications@rsd.rohde-schwarz.com.

10 Ordering information

<table>
<thead>
<tr>
<th>Order Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROMES4</td>
<td>1117.6885.04  Drive Test Software Platform</td>
</tr>
<tr>
<td>ROMES4REP</td>
<td>1117.6885.34  Drive Test Software Platform Replay Module</td>
</tr>
<tr>
<td>ROMES4SQA</td>
<td>1117.6885.36  ROMES Speech Quality (SQA) Mobile 1 Channel</td>
</tr>
<tr>
<td>ROMES4PESQ</td>
<td>1503.4214.02  PESQ Runtime License</td>
</tr>
<tr>
<td>TS4SERVER</td>
<td>1502.6036.40  ROMES Speech Quality SERVER</td>
</tr>
<tr>
<td>TS95ISDN</td>
<td>1506.9530.12  ISDN Controller for 4x Speech Quality on SQA Server</td>
</tr>
<tr>
<td>TS95PSTN</td>
<td>1506.9530.04  Analogue Controller for 4x Speech Quality on SQA Server</td>
</tr>
<tr>
<td>ROMES4SRV</td>
<td>1117.6885.38  ROMES SQA SERVER Software</td>
</tr>
<tr>
<td>TS95AUDIO</td>
<td>1088.1410.02  Speech Quality 2x Audio Card (USB)</td>
</tr>
<tr>
<td>TS95AUDIO</td>
<td>1502.5930.12  Speech Quality 2x Audio Card (FIREWIRE)</td>
</tr>
<tr>
<td>TS95AUDIO</td>
<td>1117.8220.02  Speech Quality 4x Audio Card (FIREWIRE)</td>
</tr>
<tr>
<td>TS-SM-AF</td>
<td>1074.5860.36  Audio Adaptation Kit for TrioRail S75 audio jack</td>
</tr>
<tr>
<td>TS-SM-AF</td>
<td>1074.5860.26  Audio Adaptation Kit for Samsung Z560/U700 audio jack</td>
</tr>
<tr>
<td>TS-SM-AF</td>
<td>1074.5860.42  Audio Adaptation Kit for Nokia N95 audio jack</td>
</tr>
<tr>
<td>TS-SM-AF</td>
<td>1074.5860.12  Audio Adaptation Kit for Qualcomm TM7200 audio jack</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 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 1805 12 42 42* or +49 89 4129 137 74
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

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.