New Developments in Mobile Phone Testing

Frank Kettler, Silvia Poschen, Sven Dyrbusch, Nils Rohrer

HEAD acoustics GmbH, 52134 Herzogenrath, Germany

Introduction

Speech quality tests on mobile phones are typically motivated either from the manufacturer's side in order to deliver high quality products or from the network provider's side because the phone is part of the complete service. Network providers spend huge investments in their network, however, the direct interface to the customer is still the mobile phone. Network providers therefore need to request high quality mobile phones to be connected to their network. The acceptance of the whole service is significantly related to the acceptance of the phone.

Conversational speech quality tests need to provide comprehensive results in order to make a final decision to launch a product or not. Furthermore these tests are very important for the development of mobile phones in order to tune and optimize quality before presenting the product to customers. This contribution discusses new trends and developments in mobile phone testing.

Quality Tests according to Current Standards

2nd and 3rd generation mobile phones are typically tested according to GSM 11.10 [1] or 3GPP TS 26.132 [2]. These specifications cover very important "standard" parameters like loudness ratings, frequency responses, echo tests and others. However, very important conversational aspects like double talk performance tests or quality tests in the presence of background noise are not appropriately considered. In order to bridge this gap more and more network providers establish proprietary test specifications to measure the acoustical quality of terminals connected to their networks. These test specifications are typically more detailed and cover all conversational aspects. The motivation is obvious: detection of potential quality impairments on a mobile phone before it is officially launched to the market. Furthermore, these test specifications are also used already during the development of mobile phones at the manufacturer's side in order to optimize speech quality for new products.

Tests according to these test specifications typically combine comprehensive analyses like the listening speech quality assessed by the TOSQA2001 [3] algorithm capable to measure quality including the acoustical interfaces. Furthermore various "analytical" parameters contributing to these comprehensive results are measured in order to detect the potential reasons for an insufficient quality. The same principal is used for other conversational aspects like the double talk capability: phones are characterized according to ITU-T P.340, additional parameters analyze the algorithms in detail in order to tune double talk capability if necessary.

These test specifications typically use head and torso simulators (HATS according to ITU-T P.58) equipped with artificial mouth and ears. This guarantees a realistic reproduction of the user interface, the coupling between the mobile and the human ear.

Consistency Check

The receiving frequency response is typically a very important parameter contributing to the listening speech quality. This is especially important because this transmission direction is directly assessed by the user of the phone. TOSQA2001 provides listening speech quality scores with a very high correlation to the results of subjective tests. The known relation between the frequency response and the TMOS analysis (output of TOSQA2001) can be used to verify the "consistency" of test results.

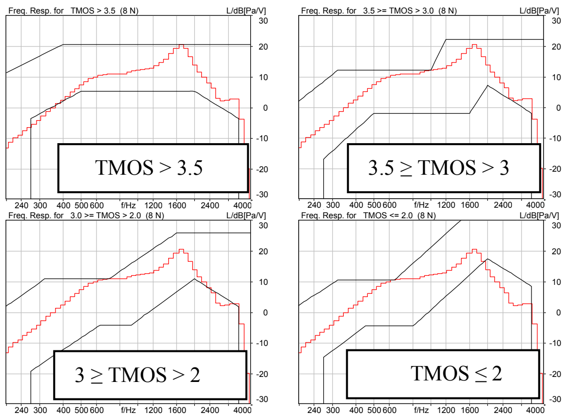

Figure 1: Frequency response verified in different tolerance schemes together with expected TMOS results

Figure 1 shows a measured frequency response displayed in 1/12 octave representation together with four different tolerance schemes. These tolerances were derived from a high amount of tests on different latest mobile phones of manufacturers world wide (see e.g. [4]). The expected TMOS results are indicated for each tolerance scheme: if the frequency response is relatively flat (upper left) the transmitted speech sounds balanced and pleasant. A high TMOS > 3.5 can be expected. Stronger high pass characteristics (typically leading to an attenuation of lower frequencies) lead to a more unpleasant and "thin" speech sound. Consequently the expected TMOS result decreases. The intention of this tolerance scheme is the verification of expected TMOS results and measured TMOS result. If both are consistent it is unlikely that the receiving direction is disturbed by other "dominant" parameters. Vice versa the inconsistency of both analyses indicates the occurrence of quality impairments which are not caused by the acoustical coupling and are not covered by the TOSQA2001 analysis. This consistency check can therefore easily be used to detect potential problems e.g. for the downlink transmission quality.

Transmission of Speech in Noisy Environment

The new ETSI speech quality model described in EG 202 396-3 [5] analyzes the transmitted speech together with background noise in sending direction of wideband terminals. This model is now adapted for narrow band applications, e.g. for mobile phones used in noisy environments [6]. This is of especial relevance, it represents the typical use case. The principal is described in **figure 2**.

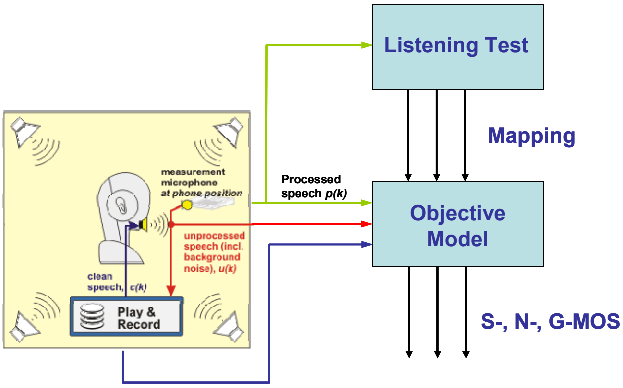

Figure 2: Principal of test to derive a new objective model

Clean speech is played back via an artificial mouth. The terminal picks up the speech and background noise and processes it in sending direction. This processed speech is assessed in listening tests in order to determine a) the quality of transmitted background noise (noise only), b) the quality of transmitted speech (transmitted together with noise but only assessed under the "speech quality" aspect) and c) the impression of overall quality.

The results of the objective model are then mapped to the results of the listening tests. One advantage of this model is to assess overall quality in sending direction (G-MOS) objectively and to separate this into the two aspects of noise transmission and speech transmission (N-MOS respectively S-MOS). The correlation between the subjective (auditory) G-MOS and the objective G-MOS is shown in **figure 3**.

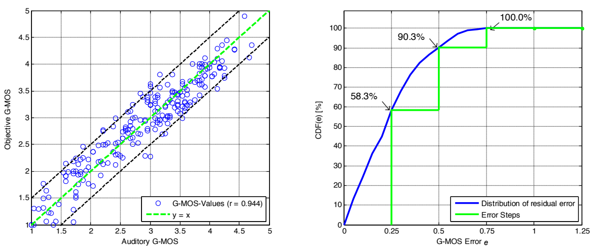

Figure 3: Correlation between auditory and objective G-MOS (narrowband)

A New Method for Echo Assessment

The echo attenuation of a terminal is typically expressed by the terminal coupling loss in dB. However, this represents an average analysis and does neither take into account temporal echo components nor distinct spectral disturbances. An echo signal recorded for a mobile phone is analyzed as level vs. time in **figure 4** (left hand picture). The test signal (real speech) was applied at 2.5 s on the time axis. The echo level is low between approximately -60 and -70 dB_V. Some distinct temporal components can be detected. Further analyses like spectrograms can be used to provide additional spectral information. However, these are all analytical analyses and do not represent the aurally adequate assessment of an echo. A very promising method is the Relative Approach [7]. This method is especially sensitive to detect unexpected temporal and spectral components and can therefore be used as an aurally adequate analysis to assess temporal echo disturbances. An example is shown in the right hand picture in **figure 4**. The peaks which can already be detected from the level vs. time analysis are clearly market as unexpected, disturbing components especially in the high frequency range.

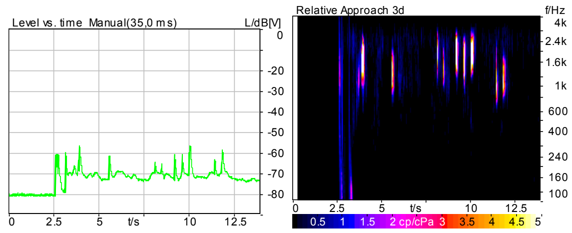

Figure 4: Echo analysis (left: level vs. time; right: Relative Approach)

The combination of standard assessment methods like echo loss or level vs. time analyses together with this aurally adequate Relative Approach analysis provides a powerful assessment tool.

Conclusion

Speech quality tests more and more combine comprehensive one-dimensional quality scores with aurally adequate analyses and detailed parameter tests. On the one hand side this combination facilitates the analyses and finally the decision for market launch. On the other hand it provides more effective tools for algorithmic parameter tuning and speech quality optimization for mobile phones.

References

[1] ETSI EN 300 607-1 V8.2.0 (2000-06)

[2] 3GPP ETSI TS 26.132 (v7.1.0)

[3] ITU-T Com 12-20E, Results of objective speech quality assessment including receiving terminals using the advanced TOSQA2001, Geneva, Dec. 2000

[4] F. Kettler et al: Speech quality for mobile phones: What is achievable with today's technology? Second ISCA/DEGA Workshop, Berlin, 4-6 September 2006

[5] EG 202 396-3, Speech quality performance in presence of background noise; Part 3: Objective test methods, August 2007

[6] H.W. Gierlich et al: A new objective model for wide- and narrowband speech quality prediction in communications including background noise; EUSIPCO, Lausanne, Switzerland, 25. – 29.08.2008 (excepted to be published)

[7] K. Genuit, Objective evaluation of acoustic quality based on a Relative Approach, Inter-Noise'96, 30.07.- 02.08.1996, Liverpool, England