Advanced Testing of Wideband Terminals

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Introduction

Communication is migrating towards wideband transmission (50 Hz – 7 kHz). Terminals and networks are developed in order to provide a significant step towards higher speech quality. At the same time, standardization bodies like ETSI, GCF and the DECT Forum are working on new specifications for terminals. In order to setup appropriate speech quality measurements for wideband terminals, existing wideband test specifications were reviewed and analyzed. This contribution discusses current wideband standards and the development of new speech quality tests and requirements for mobile and fixed wideband terminals.

Wideband Capability vs. Wideband Quality

At this stage, network provisioning and wideband terminal testing often only considers the speech codec implementation. It is typically disregarded that speech quality is mainly determined by the acoustic interfaces and the implemented signal processing. **Figure 1** shows the measured frequency responses for two wideband capable mobile phones. These devices were measured over the wideband AMR speech codec. The acoustical interface was realized by an artificial head measurement system (HATS according to ITU-T Recommendation P.58 [1]).

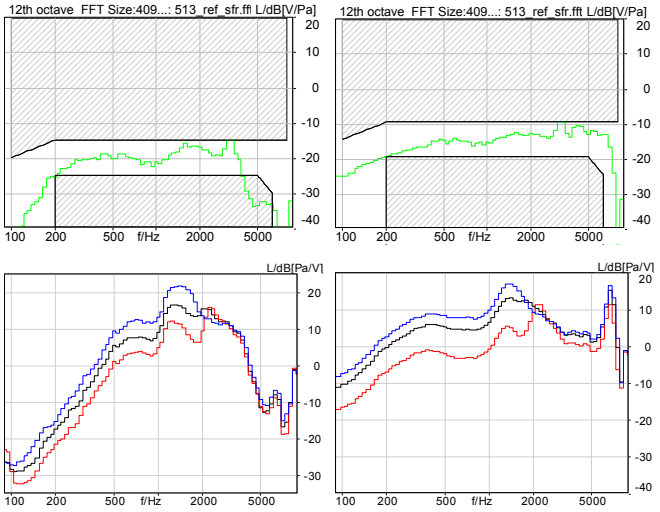

Figure 1: Sending frequency responses (upper, green curves), receiving frequency responses (lower, red: 2N, black: 8 N, blue: 13 N), two mobile phones

The upper curves (green) represent the measured frequency responses in sending direction. Both devices differ significantly. Although both phones are wideband capable, the device represented by the left hand analysis shows a clear band limitation in the microphone path. With regards to acoustics, the device is not optimized for wideband transmission quality.

In principal the same can be stated for the receiving direction. The two lower analyses show the measured frequency responses in receiving direction when applying different application forces of 2 N (red curve), 8 N (black curve) and 13 N (blue curve) between the mobile phones and the artificial ear. Again the device analyzed on the left hand side shows the band limitation whereas the acoustical characteristics of the second device are already tuned to provide good wideband speech quality.

The attenuation of low frequencies can often be observed already for narrowband mobile phones in receiving direction due to the small loudspeaker size and high leak sensitivity. Equalizers are typically necessary to compensate this and provide better, more balanced sound of received speech. The reproduction of low frequency energy is even more important and also more challenging for wideband transmission due to the lower frequency limit compared to the narrowband case.

Echo Performance Tests in Standardization

Various wideband standards are already in use to test terminal equipment. ETSI provides the ES 202 739 and 740 series [2], [3] and the TS 126 131 requirements [4]. The Telecommunication Industry Association uses the TIA-920 standard for wideband digital wire line telephones [5]. It also covers handset, headset and hands-free performance. The new generation of wireless DECT phones should be verified according to the specification for portable parts (PP) of CAT-iq™. The Deutsche Telekom (DTAG) developed a proprietary wideband test specification for general purposes [6], [7]. It consists of comprehensive and very detailed speech quality tests covering all conversational aspects including double talk and the quality of background noise transmission. The requirements are specified for typical use cases, e.g. mobile phones, VoIP terminals and others and are based on new subjective test results [7]. However, these standards and the individual requirements partly differ significantly.

As an example **table 1** compares the different requirements for single talk echo attenuation in these standards. The parameters and the requirements demonstrate the heterogeneity of currently available wideband standards.

ETSI requires a weighted terminal coupling loss (TCL_w) of 55 dB and 46 dB for handset/headset and hands-free mode respectively. It should be noted that the TCL_w calculation is described in ITU-T Recommendation G.122, Annex B4 as “trapezoid role” [8] using a weighting function defined between 300 Hz and 3.4 kHz. The application for wideband terminals is doubtful or at least not completely clear today. The same parameter and calculation but a different requirement can be found in ETSI TS 126 131/132.

	Handset / Headset	Hands-free
ES 202 739 / 740	TCL_w 55 dB	TCL_w 46 dB
TS 126 131/132	TCL_w 46 dB	TCL_w 40 dB
TIA 920	TCLw,n.* 50 dB	TCLw,n.* 50 dB
CAT-iq™ PP	TCL_w 55 dB	TCL_w 42 dB
DTAG	55 dB	46 dB

Table 1: Single talk echo attenuation requirements in different test specifications (TCL_w : Terminal coupling loss; $TCL_{w,n.*}$: normalized TCL_w, corrected by the difference between measured SLR (RLR) and recommended SLR (RLR)

TIA-920 measures the normalized TCL_w. This formula corrects the measured sending and receiving sensitivities (expressed by the sending and receiving loudness rating) by the nominal SLR and RLR values. Furthermore, it applies an extrapolation of the ITU-T G.122 weighting function for the TCL_w calculation towards higher frequencies up to 6.7 kHz. CAT-iq™ again uses the TCL_w parameter to characterize the single talk echo attenuation of portable parts. The Wideband Test Specification of Deutsche Telekom calculates the echo attenuation without weighting functions. The motivation is obvious: as mentioned above the ITU-T G.122 weighting function is not specified or subjectively verified for frequencies below 300 Hz or up to 7 kHz. The requirements for the echo attenuation are rather high within this specification with the 55 dB for handset and headset use and 46 dB for hands-free mode as shown in **table 1**.

Further to the "one dimensional" dB values characterizing the single talk echo attenuation, subjective tests also pointed out that the spectral content of the echo highly influences echo perception and echo annoyance (see [9],). Objective tests have therefore been derived and established today determining the spectral echo attenuation. **Figure 3** shows some examples of tolerance schemes from existing wideband standards. The two upper tolerances show the spectral echo attenuation requirement for CAT-iq™ handset, headsets and hands-free mode.

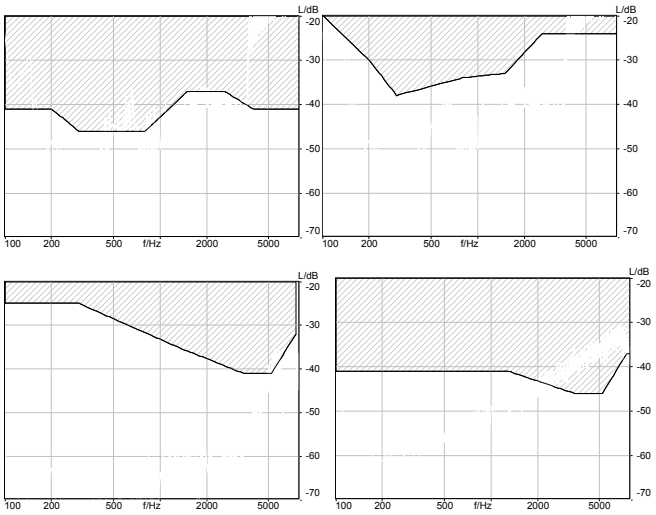

Figure 3: Comparison of tolerances for spectral echo attenuation (upper left: CAT-iq™ handset and headset; upper right: CAT-iq™ hands-free; lower left: DTAG 100 ms delay; lower right: DTAG 500 ms delay)

The curves differ significantly. It is also noticeable that the hands-free requirement is linear extrapolated in the higher frequency range from a known narrowband tolerance scheme. The Wideband Test Specification of Deutsche Telekom applies different tolerances for typical use cases which are defined by the expected echo delay for a specific terminal. Two examples for 100 ms and 500 ms round trip delay are given in the two lower curves in **figure 3**.

It is also important that the highest attenuation needs to be provided in a frequency range between approximately 3 kHz and 5 kHz where the human ear is most sensitive for speech perception. These curves are based on subjective test results (see e.g. [9]). Furthermore, Deutsche Telekom supports standardization bodies like ETSI and ITU-T with these data in order to improve quality of international standards.

Conclusion

It is very important to provide high quality terminals already during market launch for the upcoming wideband networks. All conversational dimensions like single talk in both directions, echo, double talk performance and the quality of background noise transmission need to be considered. It is highly recommended to make use of all latest available testing methods. Advanced tests such as double talk performance measurements and quality tests in the presence of background noise have only recently been established for narrowband terminals. They need to be established for wideband terminals, too, in order to provide high quality terminals already during market launch.

Furthermore, it is very important to discuss speech quality aspects between network providers and terminal manufacturers especially during the migration phase towards wideband communication in order to guarantee the same understanding of speech quality related aspects.

References

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