Practical Limitations of Transducers for Wideband Telephony

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Introduction

Wideband telephony means transmitting voice in a broader frequency range than the conventional “narrowband” range of 300 Hz to 3.4 kHz. Wideband was standardized for ISDN terminals in the 1990s by ETSI [1][2], but never was widely deployed. The reasons were the high price for such telephones and the limited number of calls in which wideband could be used since always both parties had to have a wideband ISDN-phone in order to establish a wideband call.

Today PCs can be found in nearly every home and the PC hardware like soundcard and headset is capable of transmitting wideband telephony signals. That’s why for IP-telephony, wideband speech transmission comes back into the focus. Also non-PC IP telephone terminals start to support wideband speech transmission like the Siemens "optiPoint 410" IP-phone [7].

While a variety of high-quality codecs are available for compressing the wideband speech for transmission like G.722. G.722.1, G.722.2 (AMR wideband) and iSAC [6], the transducers used in telephone terminals are usually not suited to transmit or receive the whole bandwidth of the wideband speech signal. This article presents the requirements posed by the wideband standards and discusses the problems to meet the standards with conventional transducers.

Standards for Wideband Telephony

Applicable recommendations for digital telephones, ISDN or IP phones, are among others [1],[2],[3],[4],[5]:

operating mode	country	narrowband	wideband
handset	Europe	TBR8	I-ETS 300 245-5
	USA	TIA 810A	TIA 920
hands-free	Europe	I-ETS 300 245-3	I-ETS 300 245-6
	USA	TIA 810A	TIA 920

The main differences between narrowband and wideband requirements are the extended frequency range and the different artificial ear used for handset measurements. Minor differences can be found in the distortion and noise requirements.

Frequency Masks

As an example, Figure 1 shows the different frequency masks for the receive direction of the handset. While narrowband handset telephony has a minimum frequency range of 300 to 3.4 kHz, wideband telephony requires approximately a range from 160 Hz to 6.3 kHz. It should be noted, that differences can be found in the lower frequency limit of different standards.

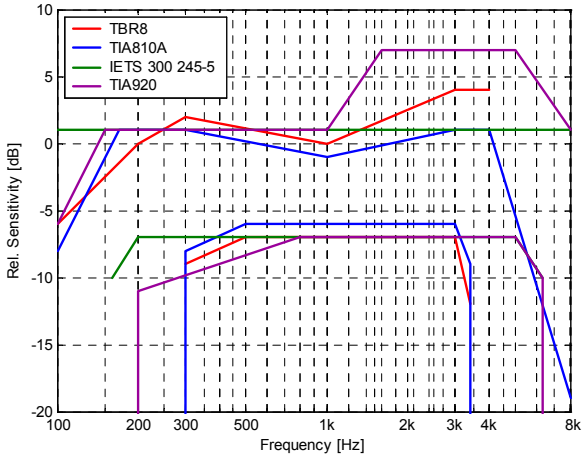

Figure 1: Frequency response masks for the handset receiving direction of different standards [1],[3],[4],[5]

Artificial Ear

For narrowband handset measurements, the TBR8 [4] specifies the use of a type 1 artificial ear [8] with an option to use a 3.2 low leakage ear. The wideband standards demand a type 3.2 low leakage or a type 3.3 ear.

The main difference between the measurement with a type 1 and a type 3.2 ear is caused by the leak of the 3.2 ear. If traditional handsets are measured with a type 3.2 ear, as shown in Figure 2, the low frequency response drops significantly. This effect is know as the "leakage sensitivity" and results in a significantly different listening impression of the handset, when a leak is present or when the handset is held sealed to the listener’s ear. This difference becomes more apparent in wideband mode.

Suitability of conventional transducers for wideband telephony

Condenser-microphones are by nature capable to transmit a broad frequency range, but problems are encountered, if conventional handset receivers and loudspeakers are used for wideband telephony.

Receivers

Figure 2 shows the frequency response of a typical receiver used for telephone handsets. The frequency response is dominated by three resonances and is tuned to meet the narrowband frequency response requirements without additional electrical analogue or digital filters. Tearing the

resonances further apart to cover a broader frequency range, will lead to a bumpy frequency response.

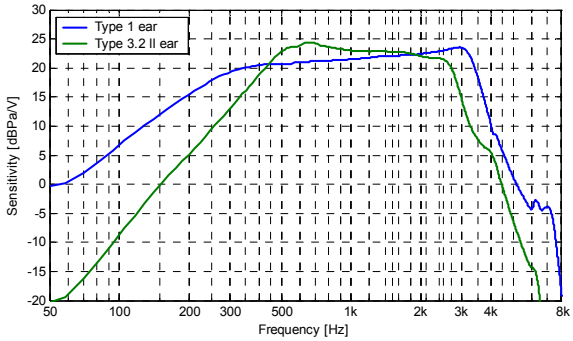

Figure 2: Frequency response of a conventional handset receiver, measured at a type 1 and type 3.2 low leakage artificial ear

It is relatively easy to extend the frequency range of such a transducer towards the high frequencies, but is difficult to extend it toward the low frequencies, because this requires fundamental changes in the mechanical design to bring down the resonance frequency of the system. It has to be emphasized that extending the high frequency range only, leads to an unbalanced listening impression. The voice will sound nervous and unpleasant.

The leakage sensitivity of conventional receivers is high. To achieve a lower leakage sensitivity, a low impedance transducer has to be employed and it has to be mounted with a leakage in front of it, inside of the handset. Such a leakage can cause problems like acoustic coupling between the receiver and the handset microphone.

Loudspeakers

Figure 3 shows the typical frequency response of a 50 mm diameter, cost-effective loudspeaker for hands-free applications. The resonance frequency of the speaker is above 300 Hz. When smaller speakers are employed, e.g. for mobile terminals, the resonance frequency is even higher (above 500 Hz). In the high frequency range, conventional speakers transmit enough energy for wideband applications, though not with a flat frequency response.

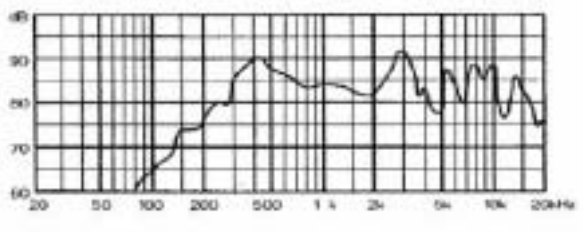

Figure 3: Frequency response of a standard 50 mm loudspeaker

A speaker that is more apt for wideband telephony, has to have a lower resonance frequency. That means larger size, softer suspension, a bigger magnet and a larger back volume. All these factors will result in a significant increase in cost.

Summary and Outlook

With the proliferation of IP-telephone terminals, wideband speech transmission comes back into the focus.

While microphones used for standard narrowband terminals are capable to transmit the extended frequency range, receivers and speakers aren't. Significant problems are encountered to reach the desired frequency response for the low frequencies and to achieve a low leakage-sensitivity of the handset.

But even with non-ideal wideband transducers, an improved speech quality and intelligibility can be achieved, when a balanced frequency response is maintained. It would be desirable to have a standard which poses quality requirements to telephone terminals that are not able to meet the existing standards totally, but still offer an extended frequency range (e.g. 200 Hz to 5 kHz).

In future new components will be available, which will be better suited for wideband speech transmission, but in some applications, like mobile terminals, the low frequency range will probably never be fully covered.

Literature

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[3] "TBR 8: Integrated Services Digital Network (ISDN); Telephony 3,1 kHz teleservice; Attachment requirements for handset terminals", ETSI, October 1998

[4] "TIA/EIA-810-A: Transmission Requirements for Narrowband Voice over IP and Voice over PCM Digital Wireline Telephones", Telecommunication Industry Association, December 2000

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[8] P.57: "TELEPHONE TRANSMISSION QUALITY; Objective measuring apparatus; Artificial ears", July 2002, ITU