Individual Handset Positioning in Conversations

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Motivation

Different handset positions can be adjusted during laboratory testing evaluating speech quality of handsets (VoIP, DECT, mobile phones) using artificial head measurement systems (Head and Torso Simulators, HATS). Furthermore, different application forces between the handset and the artificial ear can be adjusted in order to simulate the typical user behavior. The positioning of handsets during telephone conversations influences the quality of the transmitted speech in both directions. The sending direction is especially sensitive for modern smartphones using multiple microphone noise and echo cancelling algorithms. Investigating the influence of different parameters such as individual preferences of the user, geometrical shape of phones, background noise environment, etc. helps to derive realistic handset test positions for laboratory testing.

This paper presents the work that was carried out as an initial step to evaluate the range of different handset positions used by the users in a phone conversation.

Test Setup

Two tests were carried out to derive the data for different handset positions in a conversion. The first test covered 14 phone calls between an **operator** (same operator in all conversations) and **14 test persons** using commercially available cordless phones (DECT-to-DECT). The test setup is shown in **figure 1**.

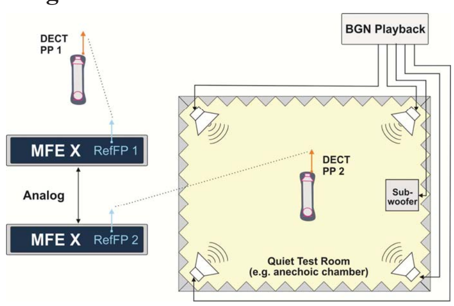

Figure 1: Test setup using a DECT-to-DECT connection via simulated DECT network (PP 1 portable part used by operator, PP 2 used by test persons in test room)

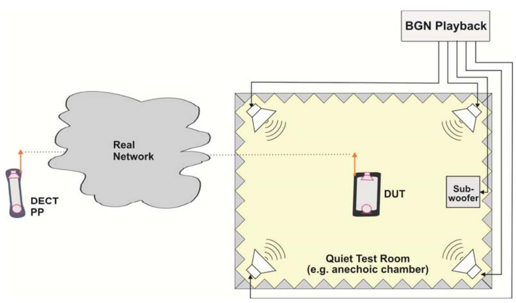

Figure 2: Test setup via real mobile network (DUT: device under test, commercially available smartphone)

The DECT network in this setup was realized by measurement frontends connected back-to-back which allowed audio recording of the whole conversation. For background noise tests a playback system according to ETSI ES 202 396-1 [1] is installed in the test room.

In order to verify the results with a commercially available smartphone instead of the DECT PP, a second setup was used as shown in **figure 2**. The phone calls were made via an existing mobile network. Again the same **operator** as in the first test used the DECT phone, **6 test persons** used the smartphone.

In both tests the test persons were exposed to **quiet** environmental conditions and to a **background noise** simulation (traffic road noise condition, [1]). All test persons were video recorded during the conversation in order to monitor their individual handset postioning during the tests.

A set of handset positions simulating different realistic use cases that may occur during a normal phone conversation is shown in **figure 3**.

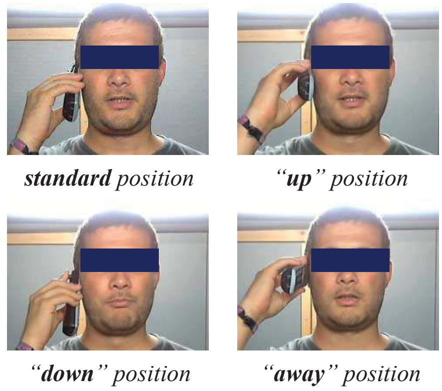

Figure 3: Different handset positions used in phone conversations

Test Results and Analysis

The videos are analyzed and a set of handset positions as shown in **figure 3** is extracted for each test person. The distance d and angle φ between test persons mouth (middle of the lips, mouth reference point MRP) and handset microphone (the center of the DUT's lower edge) is measured for each test person as shown in **figure 4**.

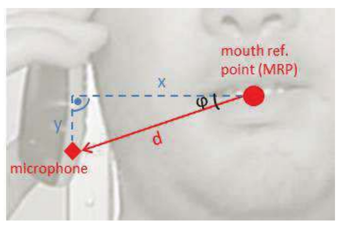

Figure 4: Calculation of distance d and angle φ between mouth of the test person and DUT's microphone

The gravity point given by the average distance ***d'*** and angle ***φ'*** for each position is calculated using the following equations:

$$y_{TP_i} = d_{TP_i} . \sin \varphi_{TP_i} \qquad x_{TP_i} = d_{TP_i} . \cos \varphi_{TP_i} \qquad (1)$$

$$y' = \frac{\sum_{i=1}^{n} y_{TP_i}}{n} \qquad x' = \frac{\sum_{i=1}^{n} x_{TP_i}}{n} \qquad (2)$$

$$\varphi' = \tan^{-1}\left(\frac{y'}{x'}\right) \qquad d' = \sqrt{y' + x'} \qquad (3)$$

where TP_i represents test person 1 to 14 (TP_1 - TP_{14}) for DECT-to-DECT tests and 1 to 6 (TP_1 - TP_6) for DECT-to-smartphone tests. n is the total number of test persons.

The measured results for the DECT-to-DECT tests are summarized in the diagrams in **figure 5** as well as in **table 1**.

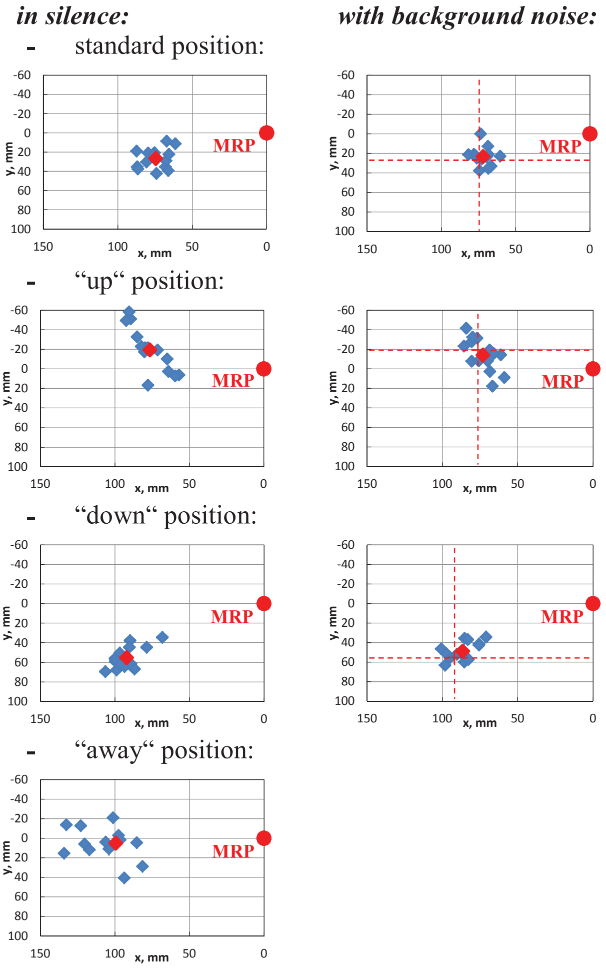

Figure 5: Graphical representation of the handset position distribution for the 14 test persons measured during DECT-to-DECT tests

The column on the left hand side shows the handset position distribution for the tests in silence, while the column on the right hand side shows the distribution of positions measured in presence of background noise. The blue diamonds represent the handset positions relative to the mouth reference point (MRP, red point) for each of the 14 test persons. The calculated average (gravity point) for each of the use cases ("standard", "up", "down" and "away") is shown as a red diamond in the diagrams.

The measured results indicate an almost identical average position for the tests carried out in silence and in presence of background noise (for comparison the red dashed lines in the "background noise" diagrams represents the average position for the "silence" test).

Table 1: Average distance and angle of the handset position relative to the MRP for DECT-to-DECT test

Position	in silence		with BGN	
	distance	angle	distance	angle
standard	79 mm	20°	76 mm	18°
"up"	79 mm	-14°	75 mm	-11°
"down"	107 mm	31°	99 mm	29°
"away"	100 mm	3°	n.a.	n.a.

This is a rather surprising result at first sight since the traffic road noise simulation produces a relatively high surrounding noise level of 74 dB(A) and the test persons were asked not to further adjust the volume setting of the phone. However, the result can be explained by the fact that the SNR needed for the user to comfortably hear the conversational partner is adjusted by simply increasing the application force to the ear, rather than significantly changing the handset microphone position. Similar results can be seen also for the DECT-to-smartphone test (**table 2**). An exception for both test cases is the "away" position. Almost none of the test persons felt comfortable to use the phone in this position in presence of background noise. This is mainly due to the fact that moving the phone away from the ear increases the acoustical leak, the ear is almost uncovered and thus "open" to the surrounding background noise. This significantly degrades the SNR at the users ear.

Table 2: Average distance and angle of the handset position relative to the MRP for DECT-to-smartphone test

Position	in silence		with BGN	
	distance	angle	distance	Angle
standard	76 mm	13°	73 mm	12°
"up"	83 mm	-21°	79 mm	-19°
"down"	94 mm	28°	93 mm	28°
"away"	97 mm	1°	n.a.	n.a.

Conclusions & Outlook

The results presented here can be used to derive realistical test positions of handsets during laboratory tests. Although only one model each was used, the results indicate that a comparable position is used for a DECT handset or smartphone. The measured data can easily be transferred to handset mounting devices for HATS and used for realistic speech quality tests in laboratory environment. Further investigation is needed to extend the number of handset types and test persons and to investigate the differences between the human head size and HATS size.

References

[1] ETSI EG 202 396-1, Speech Processing, Transmission and Quality Aspects (STQ); Speech quality performance in the presence of background noise; Part 1: Backrgound noise simulation technique and background noise database.