inter.noise
HAMBURG 2016

Measurement of Parameters of the eCall System Transmission Channel for Passenger Car

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ABSTRACT

Emergency call system, which in the case of traffic accidents ensure rapid assistance to motorists, will be mandatory for all new passenger cars approved since 2017 - 2018. The speech intelligibility as one of the parameters of eCall developed for cars depends on parameters of the transmission channel. Due to the internal design and arrangement of the car interior, there are not many suitable variations of speaker location in terms of quality of speech transmission. Therefore, ITU standards provide the recommended values and measurement procedure of important parameters (eg. RLR, THD, SNR).

The paper deals with methods of measurement RLR, THD and SNR parameters inside the car. Measuring methods were verified by measurements in a car available on the University of West Bohemia. Measurements were performed by using the artificial head in different positions in the driver seat. The speaker of eCall was placed in several positions. Parameters were measured for different operating conditions (driving at different speeds, different settings for internal air circulation). From the measurement results, it is possible to determine the influence of speaker location and the position of the artificial head.

Keywords: Transmission channel, Speech quality, RLR
I-INCE Classification of Subjects Number: 79.1

1. INTRODUCTION

Emergency call system is introduced into the car newly. Interior and dashboard design is given and most suitable speaker position is occupied by another equipment. Three speaker test position were selected. First under the radio control panel and other two next to gearshift (fig. 1). ITU standards provide the recommended values and measurement procedure of important transmission channel parameters (eg. RLR, THD, SNR). Parameter RLR - receive loudness rating – determine a measure of receive audio intensity. Describes the transmission channel from the input of the amplifier unit to the driver's ears. Measurement of RLR, SNR and THD parameters of the eCall speaker is performed inside a car by using an artificial head. Because artificial head must be during measurement placed on the driver's seat, it is not possible to measure the necessary parameters while the car is moving. Therefore, operating noise during the measurement is simulated using four speakers placed in the car interior.

2. MEASUREMENT EXPERIMENT

2.1 Operating noise simulation

Parameters are measured and evaluated for the worst noise conditions. Measurement is performed at operating noise simulated for 120 km/h and internal air circulation turned on. First, it is necessary to measure the real noise level for one-third-octave bands when the car is moving. It is measured under the above conditions using an artificial head placed on the passenger seat. Simulated noise is pink

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noise filtered with the one-third-octave stereo equalizer. One channel is used for two front speakers placed in the space under the dashboard on the driver and passenger. The second channel is used for the two rear speakers placed behind the headrests. The artificial head is placed on the passenger seat in the same position which is used to recorded real noise. Reproduced noise must match the recorded noise in every third-octave band with a tolerance of ± 3 dB, and in the overall level of ± 1 dB. Values of real and simulated noise for the left ear are compared for the range of 100 Hz - 10 kHz.

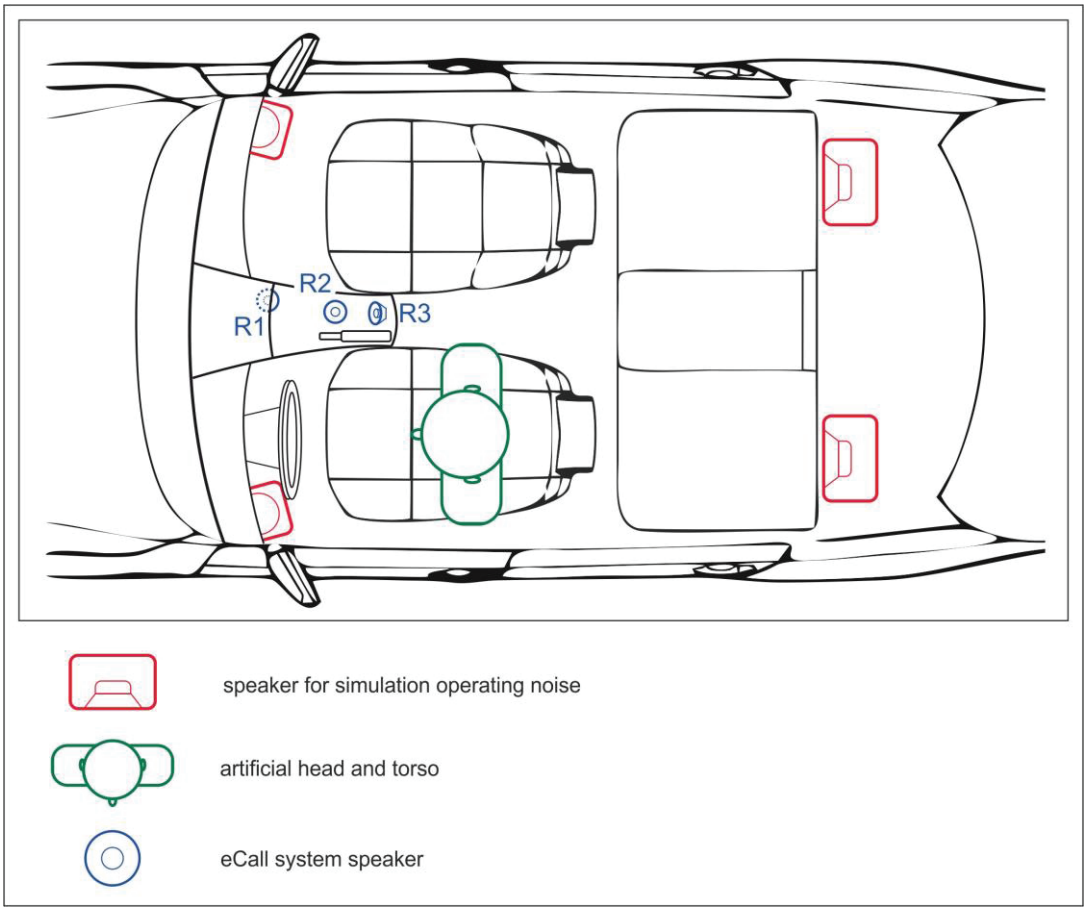

Figure 1 – Placement of measuring equipment in the car interior

2.2 Artificial head correction

The measurement is performed by using an artificial head inside car interior. In the case that the eCall system is composed of just one speaker, a correction of the artificial head in the free field is applied. In the case that eCall is composed by more speakers, correction of the artificial head in the diffusion field is used. Correction is used, because frequency response is changed by placing a microphone in the artificial head´s ear. Correction gives the deviation from the flat frequency response. Artificial head correction for the free field is measured in an anechoic chamber. An acoustic source with a flat frequency response is driven by the pink noise signal. Minimum distance between source and head is 1.5 m. The head should conform to ITU standards.

2.3 Measuring signals

It is measured by several kinds of test signals. The RLR measuring signal by the new ITU standards is the sequence of men and women speech with a length of 35 seconds with 0.5-second intervals (ITU P.501). The older ITU standards recommended artificial synthesized speech, there are two variants with male and female voices. The real speech has a better signal to noise ratio than artificial synthesized speech. The signal level is measured for the whole sequence duration and is set as the final overall level. For testing purposes, the prototype amplifiers with 600 Ohm input and gain control was made.

2.4 RLR calculation

RLR parameter doesn´t depend only on the location of the speaker and the head (position is recorded in notes - middle of the head from the windshield, roof and side glass). RLR also depends on the unit amplification, because the calculation is determined as the transmission between the transmitting spot (600 Ohm input of the unit) and the receiving spot (microphone in the ear of the head). RLR is measured in the frequency range 100 Hz - 8 kHz. The sound levels measured in third-octave bands are entered in the calculation. The calculation is carried out according to ITU P.79. It is possible to measure the signal from both ears when using the voltage sum of the individual values. Correction for RLR calculation using both ears is -8 dB (be deducted from the result of the formula (1)). When using only the right ear (artificial head is in the driver's position), the correction is -14 dB. Measurement using both ears resulting in slightly higher RLR values (around 0.5 dB), however, brings worsening of THD parameter. The equation for calculating RLR is listed in formula 1.

$$RLR = -57{,}14\, log_{10} \sum_{I=1}^{20} 10^{\frac{S_{UJE}(I) - W_r(I)}{57{,}14}} ; [dB] \quad (1)$$

RLR measurement is carried out for several conditions. Without operating noise – car is stationary and with operating noise - that is recorded for various conditions (for example noise when driving various speed and different air conditioning settings).

To verify that the method of RLR measurement is correct, the following condition must be fulfilled: The input signal change of ± 5 dB should not result in RLR value more than 0.5 dB. The test is performed without operating noise. According to ITU, the nominal value of RLR is 2 ± 4 dB. Gain adjustment in the unit should ensure the RLR change about 15 dB. For all measurement gain was set to the same level.

3. THD and SNR parameters are evaluated for the same input level and head position as RLR. THD values were measured at frequencies of 300 Hz, 500Hz and 1000 Hz for both ears. For evaluation of SNR must be measured the A-weighted overall level of operating noise with an artificial speech and operating noise level only. We determine SNR due to the level at 600Ω input. All measurements are performed by using a Brüel & Kjær Pulse analyzer.

3.1 Results

Parameters were measured for one driver position and two input signal levels. Input signals were a sequence of real speech (sentences spoken by men and women) and synthesized male and female speech. Measured values of RLR are shown in following tables 1 to 3 for three speaker positions.

Table 1 – RLR measurement, speaker position R1

Input level [dBV]	-14		-18	
	Right ear	Both ears	Right ear	Both ears
Real speech	-1,9	-1,3	-2,8	-2,2
Synthesized - female	-2,0	-1,4	-3,1	-2,6
Synthesized - male	-1,1	-0,5	-2,4	-1,9

Table 2 – RLR measurement, speaker position R2

Input level [dBV]	-14		-18	
	Right ear	Both ears	Right ear	Both ears
Real speech	-1,9	-1,1	-2,7	-2,1
Synthesized - female	-1,7	-0,9	-2,7	-2,0
Synthesized - male	-1,4	-0,4	-2,6	-1,8

Table 3 – RLR measurement, speaker position R3

Input level [dBV]	-14		-18	
	Right ear	Both ears	Right ear	Both ears
Real speech	1,2	1,8	-0,2	0,4
Synthesized - female	1,3	2,0	-0,1	0,5
Synthesized - male	1,7	2,3	0,1	0,6

The recommended RLR value according to ITU standards is 2 ± 4. According to the measured values in tables 1-3, all speaker position are suitable for the input signal level of -14 dB and all testing signals. For the -18 dB input signal level only position R3 meets the conditions with reserve. Values of THD and SNR are shown in tables 4 – 6. THD is in most cases less than 3%, lowest for the position R3 (value is less than 3% also for 300 Hz).

Table 4 – THD measurement

f [Hz]	input level	THD [%]		THD [%]		THD [%]	
	[dBV]	Right ear	Left ear	Right ear	Left ear	Right ear	Left ear
300,0	-14,0	5,0	2,4	3,9	5,5	2,1	0,9
300,0	-18,0	3,6	1,9	2,8	4,3	1,4	0,4
500,0	-14,0	1,5	3,3	0,7	0,7	0,9	2,6
500,0	-18,0	1,1	2,7	0,4	0,4	0,5	1,5
1000,0	-14,0	0,8	0,5	0,7	0,3	1,1	1,0
1000,0	-18,0	0,6	0,3	0,7	0,3	0,9	1,0

The SNR consider being good for values more than 6 dB. All measurement with input signal levels of -14 dB meets this level. For -18 dB input signal level measured SNR values are better for the right ear.

Table 5 – SNR measurement, input level -14 dBV

	R1		R2		R3	
	Right ear	Left ear	Right ear	Left ear	Right ear	Left ear
Real speech	12,5	15,0	12,7	16,1	11,1	13,4
Synthesized - female	10,8	14,5	8,9	12,3	6,6	9,4
Synthesized - male	9,6	13,1	8,5	11,8	6,7	8,9

Table 6 – SNR measurement, input level -18 dBV

	R1		R2		R3	
	Right ear	Left ear	Right ear	Left ear	Right ear	Left ear
Real speech	8,5	11,0	8,8	12,0	7,3	9,3
Synthesized - female	7,3	10,8	5,7	8,7	3,8	6,1
Synthesized - male	6,7	10,0	5,6	8,5	4,2	6,0

4. CONCLUSIONS

The measurement method of RLR, THD and SNR parameters of eCall transmission channel inside the car was developed according to ITU standards. Considering to the measured values it is possible to determine the most suitable position of speaker. It seems most appropriate for all measurement is position R3 and input signal level – 14 dB. The research will be continued by the proposal of methods for measuring other transmission channel parameters. For example in the direction from the driver's mouth to the eCall system microphone.

ACKNOWLEDGEMENTS

This research has been supported by the Ministry of Education, Youth and Sports of the Czech Republic under the RICE – New Technologies and Concepts for Smart Industrial Systems, project No. LO1607. This research has been supported by the Student Grant Agency of the University of West Bohemia in Pilsen, grant No. SGS-2015-020 “Technology and Materials Systems in Electrical Engineering”.

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