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TECHNICAL REPORT

Digital cellular telecommunications system (Phase 2+) (GSM); Characterisation, test methods and quality assessment for handsfree Mobile Stations (MSs) (3GPP TR 43.058 version 18.0.0 Release 18)

A GLOBAL INITIATIVE

GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

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Contents

Foreword

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1 Scope

The present document gives some guidelines to implement test methods and to evaluate the transmission quality of handsfree Mobile Stations (MSs). The normative characteristics and test methods for handsfree Mobile Stations (MSs are defined in GSM 03.50). The present document gives additional data.

It includes summaries of texts or contributions presented and discussed during the meetings of ad hoc group SMG2/03.50 on environmental conditions, speech processing and quality assessment for handsfree Mobile Station.

The items covered by this report are mainly.

- Environmental conditions for handsfree Mobile Stations.
- Speech processing techniques and consequences on delay.
- Speech quality assessment for handsfree implementing acoustic echo cancellation and noise reduction.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] I-ETS 300 245-3: "Integrated Services Digital Network (ISDN);Technical characteristics of telephony terminals; Part 3: Pulse Code Modulation (PCM) A-law".

[2] ITU-T Recommendation G.113: "Transmission Impairments Quantisation Distortion".

[3] ITU-T Recommendation G.114: "Transmission Impairments, Delay".

[4] ITU-T Recommendation G.165: "Performances of Network Echo Cancellers".

[5] ITU-T Recommendation G.167: "Performance of acoustic echo control devices".

[6] ITU-T Recommendation G.711: "64 kbit/s Pulse Code Modulation (PCM)".

[7] ITU-T Recommendation G.721: "32 kbit/s Adaptive Differential Pulse Code Modulation (ADPCM)".

[8] ITU-T Recommendation G.728: "16 kbit/s Low Delay CELP".

[9] ITU-T Recommendation G.729: "8 kbit/s ACELP".

[10] ITU-T Recommendation G.731: "Echo".

[11] ITU-T Recommendation P.50: "Artificial Voices".

[12] ITU-T Recommendation P.58: "Head and Torso Simulator (HATS) for telephonometry".

[13] ITU-T Recommendation P.340: "Transmission Characteristics of Handsfree Telephones".

[14] ITU-T Handbook On Telephonometry, Geneva 1987.

[15] GSM 03.50: "Digital cellular telecommunications system (Phase 2+); Transmission planning aspects of the speech service in the GSM Public Land Mobile Network (PLMN) system".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Terminal Coupling Loss (TCL): frequency dependent coupling loss between the receiving port and sending port of a terminal due to:

- acoustical coupling at the user interface;
- electrical coupling due to crosstalk in the handset cord or within the electrical circuits;
- seismic coupling through the mechanical parts of the terminal.

NOTE 1: The receiving port and the sending port of a digital voice terminal is a 0 dBr point.

NOTE 2: The coupling at the user interface depends on the conditions of use.

Weighted Terminal Coupling Loss (TCLW): weighted Terminal Coupling Loss using the weighting of CCITT Recommendation G.122.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

HATS	Head and Torso Simulator
MRP	Mouth Reference Point
RLR	Receive Loudness Rating
SLR	Send Loudness Rating
TCL	Terminal Coupling Loss
TCLw	Weighted Terminal Coupling Loss

4 Characteristics, test methods and quality assessment

4.1 Environmental conditions for a car type handsfree Mobile Station

4.1.1 Data available on real use environment

4.1.1.1 Reverberation and echo

a) From Background acoustic noise reduction in mobile telephony (see subclause B.2 reference [1]).

The reverberation times determined from the impulse response inside the cabin are in the order of 25 ms.

b) From Speech enhancement for mobile telephony (see subclause B.2 reference [2]).

The reverberation time, determined from the impulse response, is around 30ms (it is assumed that the long impulse of the source - a small loudspeaker - may explain why this result is greater that value determined by, reference [1] of subclause B.2.

c) From Contribution à l'amélioration des performances d'un radiotelephone mains-libres à commande vocale (see subclause B.2 reference [3]).

The reverberance, in this report, is not defined directly by the reverberation time, but by the part of impulse response energy (from0 to t), relative to total energy, as a time function.

Table 1

Time (ms)	Loss (dB). R25	Loss (dB). 505
10	10.2	9.2
20	22.5	20.2
30	32.5	30.5

4.1.1.2 Sources and types of noise. Level and Spectra of the noise

4.1.1.2.1 Noise due to engine, tyres and moving situations

a) From Acoustic noise analysis and speech enhancement for mobile radio applications (see subclause B.2 reference [4]).

- Test conditions.
- Car: Alfa Romeo Alfetta 200J.
- Supercardioid directional microphones.
- Microphone positions: 3 Measurement positions (Front seats, driver and passenger head positions. Middle of rear seat, passenger head position). In these 3 positions, the signals are almost the same.
- Signal analysis: DFT analysis.

Table 2

Testing conditions	Vehicle speed (km/h)	Engine rate (r.p.m.)	Road pavement
a	0	4000	asphalt
b	100	0	asphalt

- Noise
- in testing condition " a ": a very high peak of energy appears around 120 Hz, at the fundamental frequency of the four strokes four cylinders engine noise. The noise power spectrum decreases hardly between this frequency and 3 kHz.
- in testing condition " b ": (gear in neutral position, engine kept off), the peak of power in low frequency region disappears and the noise power between 1 kHz and 6 kHz increases considerably relative to condition " a ".

b) From Background acoustic noise reduction in mobile telephony (see subclause B.2 reference [1])

- Test conditions.

  Measurements were made in a typical mid-size North American car.
- Noise spectrum. see figure 1.

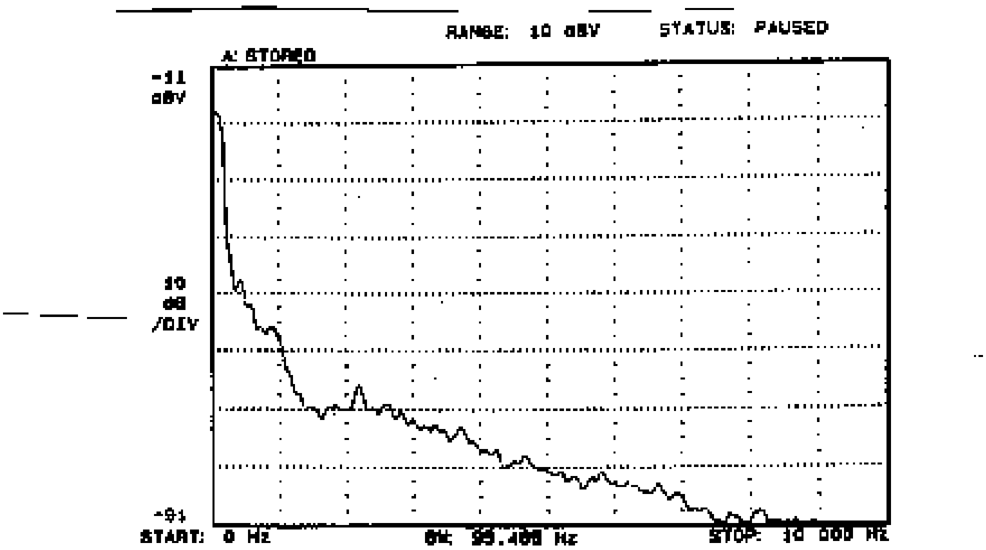

Figure 1: Noise spectrum

The noise power spectrum inside the cabin is mainly located in very low frequencies (below 250 Hz). Comparing the noise outside and inside the cabin, it appears that the car acts as a low pass filter with cutoff frequency around 250 Hz.

Between 250 Hz and about 1.3 kHz, the noise power decreases by about 20 dB.

Above 2 kHz the slope is about -6 dB/octave.

c) From Speech enhancement for mobile telephony (see subclause B.2 reference [2]).

- Test conditions
  - Vehicle: midsized car
  - Speed conditions: idle, 50 km/h, 100 km/h
  - Fan conditions: fan off, fan low, fan high
  - Roads are dry and relatively smooth.
  - Windows are closed.
  - The analysis bandwidth is limited to 4 kHz.
- **Noise**. see figure 2.

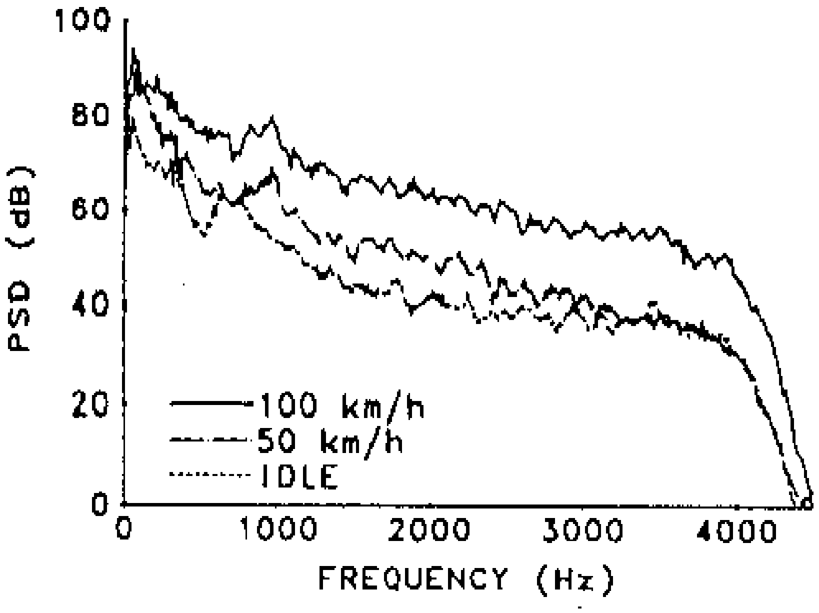

Figure 2: Noise power

With fan off, the maximum of energy is located in low frequencies (below 500 Hz), the peak in the spectrum increasing by about 10 dB from idle to 50 km/h or 100 km/h.

Increasing the car speed increases the noise energy, especially in higher frequencies (more than 10 dB from 50 km/h to 100 km/h) .

At high speeds the road noise dominates, while at lower speeds the contribution of the fan to the noise level may become important.

d) From Contribution à l'amélioration des performances d'un radiotelephone mains-libres à commande vocale (see subclause B.2 reference [3]).

- Test conditions.
  - Cars: Renault 25 and Peugeot 505.
  - Omnidirectional microphone.
  - The mean value is calculated from about 10 measurements.
- Noise.
  - Engine noise.

    In general, from low frequencies to frequencies in the bandwidth 1 kHz - 1,5 kHz, the level of the spectral components of the engine noise (4 cylinders) decreases by 40 dB. see figure 3 (From Perulli).

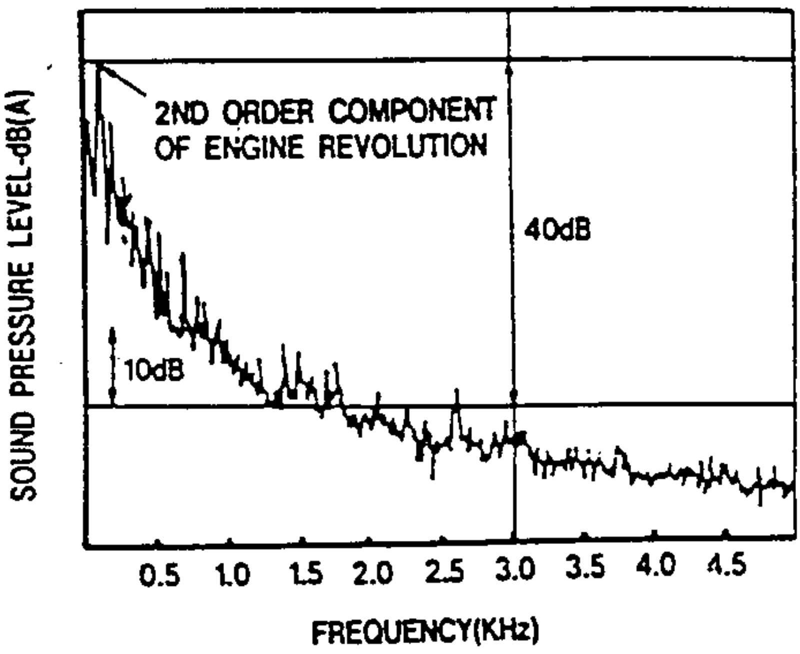

Figure 3: Level of the spectral components of the engine noise

Increasing the engine rate from 2500 r.p.m. to 4000 r.p.m. (that corresponds to speeds about 120 km/h and 150 km/h, depending on the car) increases the noise by about 10 dB.

- Noise due to the engine and to the tyres.

  Starting the car: engine noise is dominant.

  Urban driving: the two noise sources are equivalent.

  On fast roads, tyre noise is preponderant, mainly if the road is wet.

  Above 1600 Hz, the type of road has low influence on the noise spectrum.

  If the road is wet, above 1 kHz, the level increases relative the dry road condition, and increases with the frequency.

Supplementary data on the noise generated by the tyres:

Influence of the granular type of the road (From Perulli)

Table 3

Octave band (Hz)	(1)	(2)	(3)	(4)
31.5	87.5	87	88	89
63	85	86	88	93.5
125	72.5	74	76.5	84
250	71	70	71.5	77.5
500	68	62	64	64
1k	59	58.5	60.5	60
2k	49	48.5	49	47.5
4k	40	39	36	37.5
8k	22	26	23	23

For the conditions (1) to (4) the granular type of the road pavement increases.