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Digital cellular telecommunications system (Phase 2+) (GSM); Comfort noise aspects for Enhanced Full Rate (EFR) speech traffic channels (GSM 06.62 version 6.0.1 Release 1997)

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Foreword

This European Standard (Telecommunications series) has been produced by the Special Mobile Group (SMG).

The present document defines operation of the background acoustic noise evaluation, noise parameter encoding/decoding and comfort noise generation in Mobile Stations (MSs) and Base Station Systems (BSSs) during Discontinuous Transmission (DTX) on Enhanced Full Rate speech traffic channels within the digital cellular telecommunications system.

The contents of the present document is subject to continuing work within SMG and may change following formal SMG approval. Should SMG modify the contents of the present document it will be re-released with an identifying change of release date and an increase in version number as follows:

Version 6.x.y

where:

6 indicates Release 1997 of GSM Phase 2+

x the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

y the third digit is incremented when editorial only changes have been incorporated in the specification.

Proposed national transposition dates	
Date of adoption of this EN:	05 June 1999
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1 Scope

The present document gives the detailed requirements for the correct operation of the background acoustic noise evaluation, noise parameter encoding/decoding and comfort noise generation in Mobile Stations (MSs) and Base Station Systems (BSSs) during Discontinuous Transmission (DTX) on Enhanced Full Rate speech traffic channels.

The requirements described in the present document are mandatory for implementation in all GSM MSs capable of supporting the Enhanced Full Rate speech traffic channel.

The receiver requirements are mandatory for implementation in all GSM BSSs capable of supporting the Enhanced Full Rate speech traffic channel, the transmitter requirements only for those where downlink DTX will be used.

In case of discrepancy between the requirements described in the present document and the fixed point computational description of these requirements contained in GSM 06.53 [2], the description in GSM 06.53 [2] will prevail.

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.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] GSM 01.04: "Digital cellular telecommunications system (Phase 2+); Abbreviations and acronyms".

[2] GSM 06.53: "Digital cellular telecommunications system (Phase 2+); ANSI-C code for the GSM Enhanced Full Rate (EFR) speech codec".

[3] GSM 06.60: "Digital cellular telecommunications system (Phase 2+); Enhanced Full Rate (EFR) speech transcoding".

[4] GSM 06.61: "Digital cellular telecommunications system (Phase 2+); Substitution and muting of lost frame for Enhanced Full Rate (EFR) speech traffic channels".

[5] GSM 06.81: "Digital cellular telecommunications system (Phase 2+); Discontinuous transmission (DTX) for Enhanced Full Rate (EFR) speech traffic channels".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

frame: Time interval of 20 ms corresponding to the time segmentation of the Enhanced Full Rate speech transcoder, also used as a short term traffic frame.

SID frame: Frame characterized by the SID (SIlence Descriptor) codeword. It conveys information on the acoustic background noise.

SID codeword: Fixed bit pattern for labelling a traffic frame as a SID frame.

SID field: The bit positions of the SID codeword within a SID frame.

speech frame: Traffic frame that cannot be classified as a SID frame.

VAD flag: Voice Activity Detection flag.

SP flag: SPeech flag.

Other definitions of terms used in the present document can be found in GSM 06.60 [3] and GSM 06.81 [5]. The overall operation of DTX is described in GSM 06.81 [5].

3.2 Symbols

For the purposes of the present document, the following symbols apply. Boldface symbols are used for vector variables.

$\mathbf{f}^T = [f_1 \; f_2 \ldots f_{10}]$ Unquantized LSF vector

$\hat{\mathbf{f}}^T = [\hat{f}_1 \; \hat{f}_2 \ldots \hat{f}_{10}]$ Quantized LSF vector

$\mathbf{f}^{(m)}$ *m*th unquantized LSF vector of the frame

$\hat{\mathbf{f}}^{(m)}$ *m*th quantized LSF vector of the frame

$\hat{\mathbf{f}}^{ref}$ Reference LSF parameter vector

$\mathbf{f}^{mean}$ Averaged LSF parameter vector

g_c Unquantized fixed codebook gain

$\hat{g}_c$ Quantized fixed codebook gain

$\hat{g}_c^{ref}$ Reference fixed codebook gain

g_c^{mean} Averaged fixed codebook gain

e_{LP} Linear prediction residual signal

$\mathbf{e}$ Computed LSF parameter prediction residual

$\hat{\mathbf{e}}$ Quantized LSF parameter prediction residual

γ Computed fixed codebook gain correction factor

$\hat{\gamma}$ Quantized fixed codebook gain correction factor

$$\sum_{n=a}^{b} x(n) = x(a) + x(a+1) + \ldots + x(b-1) + x(b)$$

3.3 Abbreviations

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

BSS	Base Station Subsystem
DTX	Discontinuous Transmission
MS	Mobile Station
SID	SIlence Descriptor

LP Linear Prediction
LSP Line Spectral Pair
LSF Line Spectral Frequency
RX Receive
TX Transmit
VAD Voice Activity Detector

For abbreviations not given in this subclause, see GSM 01.04 [1].

4 General

A basic problem when using DTX is that the background acoustic noise, which is transmitted together with the speech, would disappear when the radio transmission is cut, resulting in discontinuities of the background noise. Since the DTX switching can take place rapidly, it has been found that this effect can be very annoying for the listener - especially in a car environment with high background noise levels. In bad cases, the speech may be hardly intelligible.

The present document specifies the way to overcome this problem by generating on the receive (RX) side synthetic noise similar to the transmit (TX) side background noise. The comfort noise parameters are estimated on the TX side and transmitted to the RX side before the radio transmission is switched off and at a regular low rate afterwards. This allows the comfort noise to adapt to the changes of the noise on the TX side.

5 Functions on the transmit (TX) side

The comfort noise evaluation algorithm uses the following parameters of the GSM Enhanced Full Rate speech encoder, defined in GSM 06.60 [3]:

- the unquantized and quantized Linear Prediction (LP) parameters, using the Line Spectral Pair (LSP) representation, where the unquantized Line Spectral Frequency (LSF) vector is given by $\mathbf{f}^T = [f_1 \; f_2 \; \ldots \; f_{10}]$, the quantized LSF vector is given by $\hat{\mathbf{f}}^T = [\hat{f}_1 \; \hat{f}_2 \ldots \hat{f}_{10}]$, and the two sets of unquantized and quantized LSF vectors (one for each half of a frame) are given by $\mathbf{f}^{(1)}$, $\mathbf{f}^{(2)}$, $\hat{\mathbf{f}}^{(1)}$ and $\hat{\mathbf{f}}^{(2)}$, respectively;
- the quantized fixed-codebook gain $\hat{g}_c$.

The algorithm also computes the following parameters to assist in comfort noise generation:

- the reference LSF parameter vector $\hat{\mathbf{f}}^{ref}$ (average of the quantized LSF parameters of the hangover period);
- the averaged LSF parameter vector $\mathbf{f}^{mean}$ (average of the LSF parameters of the eight most recent frames);
- the reference fixed codebook gain $\hat{g}_c^{ref}$ (average of the quantized fixed codebook gain values of the hangover period);
- the averaged fixed codebook gain g_c^{mean} (average of the fixed codebook gain values of the eight most recent frames);
- the unquantized fixed codebook gain g_c.

These parameters give information on the level (g_c, $\hat{g}_c$, $\hat{g}_c^{ref}$, g_c^{mean}) and the spectrum ($\mathbf{f}^{(1)}$, $\mathbf{f}^{(2)}$, $\hat{\mathbf{f}}^{(1)}$, $\hat{\mathbf{f}}^{(2)}$, $\hat{\mathbf{f}}^{ref}$, $\mathbf{f}^{mean}$) of the background noise.

Two of the evaluated comfort noise parameters ($\mathbf{f}^{mean}$ and g_c^{mean}) are encoded into a special frame, called a Silence Descriptor (SID) frame, for transmission to the RX side. Since the reference LSF parameter vector $\hat{\mathbf{f}}^{ref}$ and the