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GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

# Digital cellular telecommunications system; Substitution and muting of lost frames for Enhanced Full Rate (EFR) speech traffic channels (GSM 06.61)

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# Foreword

This draft European Telecommunication Standard (ETS) has been produced by the Special Mobile Group (SMG) Technical Committee of the European Telecommunications Standards Institute (ETSI) and is now submitted for the Public Enquiry phase of the ETSI standards approval procedure.

This draft ETS defines a frame substitution and muting procedure which is used by the Receive (RX) Discontinuous Transmission (DTX) handler when one or more lost speech or Silence Descriptor (SID) frames are received from the Radio Sub System (RSS) within the digital cellular telecommunications system.

**This draft ETS corresponds to GSM technical specification, GSM 06.61, version 5.0.0**

| Proposed transposition dates | |
|---|---|
| Date of latest announcement of this ETS (doa): | 3 months after ETSI publication |
| Date of latest publication of new National Standard or endorsement of this ETS (dop/e): | 6 months after doa |
| Date of withdrawal of any conflicting National Standard (dow): | 6 months after doa |

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# 1 Scope

This draft European Telecommunication Standard (ETS) defines a frame substitution and muting procedure which shall be used by the Receive (RX) Discontinuous Transmission (DTX) handler when one or more lost speech or Silence Descriptor (SID) frames are received from the Radio Sub System (RSS).

The requirements of this ETS are mandatory for implementation in all GSM Base Station Systems (BSS)s and Mobile Stations (MS)s capable of supporting the enhanced full-rate speech traffic channel. It is not mandatory to follow the bit exact implementation outlined in this specification and the corresponding C-source code.

# 2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

[1] GSM 05.03 (ETS 300 575): "Digital cellular telecommunication system (Phase 2); Channel coding".

[2] GSM 06.60 (prETS 300 726): "Digital cellular telecommunications system; Enhanced Full Rate (EFR) speech transcoding".

[3] GSM 06.81 (prETS 300 729): "Digital cellular telecommunications system; Discontinuous transmission (DTX) for Enhanced Full Rate (EFR) speech traffic channels".

# 3 Definitions and abbreviations

## 3.1 Definitions

The definitions of terms used in this ETS can be found in GSM 06.60 [2], GSM 06.81 [3], GSM 05.03 [1].

## 3.2 Abbreviations

Abbreviations used in this section are listed below.

| | |
|---|---|
| BFI_RSS | Bad Frame Indication from Radio Sub System |
| BFI_SP | Bad Frame Indication from Speech Decoder |
| BFI | Bad Frame Indication (BFI = BFI_RSS | BFI_SP) |
| PrevBFI | Bad Frame Indication of Previous frame |
| RSS | Radio Sub System |
| RX | Receive |
| DTX | Discontinuous transmission |
| SID | SIlence Descriptor frame |
| CRC | Cyclic Redundancy Check |

# 4 General

The purpose of frame substitution is to conceal the effect of lost frames. The purpose of muting the output in the case of several lost frames is to indicate the breakdown of the channel to the user and to avoid generating possible annoying sounds as a result from frame substitution procedure.

The RSS indicates lost speech or SID frames by setting its Bad Frame Indication flag (BFI_RSS) based on its 3-bit CRC and possibly other error detection mechanisms. The speech decoder calculates its own 8-bit CRC-checksum embedded in the speech parameter bit stream and sets the BFI_SP flag. This BFI_SP flag can be ORed with the BFI_RSS flag. If either one of these two flags is set, the speech decoder performs frame substitution and muting of the speech output.

# 5 Requirements

## 5.1 Error detection

An error is detected and the BFI-flag is set if either BFI_RSS from the RSS or BFI_SP is indicating an error.

## 5.2 Lost speech frames

Normal decoding of lost speech frames would result in very unpleasant noise effects. In order to improve the subjective quality, lost speech frames shall be substituted with either a repetition or an extrapolation of the previous good speech frame(s). This substitution is done so that it will gradually decrease the output level, resulting in silencing of the output. Subclause 6.1 gives an example solution.

## 5.3 First lost SID frame

A single lost SID frame shall be substituted by the last valid SID frame and the procedure for valid SID frames be applied as described in GSM 06.81.

## 5.4 Subsequent lost SID frames

For the second lost SID frame, a muting technique shall be used on the comfort noise that will gradually decrease the output level (-3 dB/frame), resulting in silencing of the output of the decoder.

For subsequent lost SID frames, the muting of the output shall be maintained. Subclause 6.2 gives an example solution.

# 6 Example solution

The C-code of the following example is embedded in the bit exact software of the enhanced full rate codec.

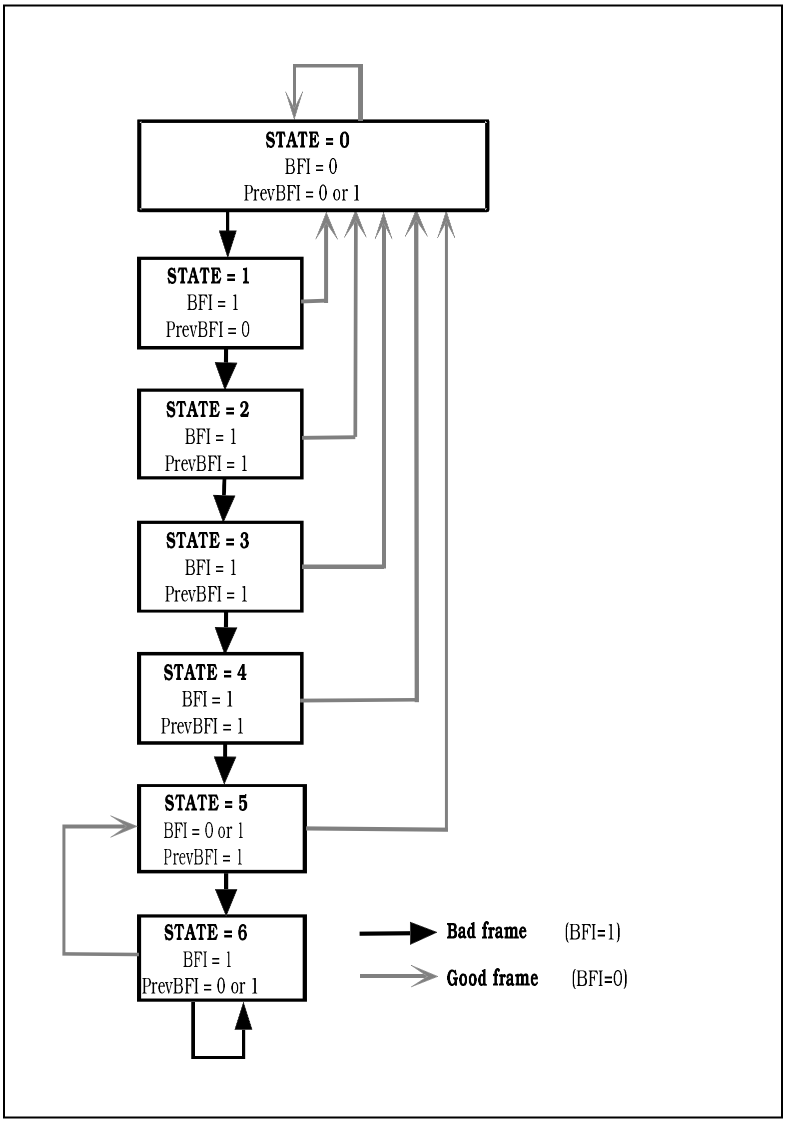
## 6.1 Example solution for substitution and muting of lost speech frames

This example solution for substitution and muting is based on a state machine with seven states (figure 1):

The system starts in state 0. Each time a bad frame is detected, the state counter is incremented by one and is saturated when it reaches 6. Each time a good speech frame is detected, the state counter is reset to zero, except when we are in state 6, where we set the state counter to 5. The state indicates the quality of the channel: the bigger the state counter, the worse the channel quality is. The control flow of the state machine can be described with the following C-code (**BFI** = bad frame indicator, **State** = state variable):

```
if( BFI != 0 )
       State = State + 1;
else if(State == 6)
       State = 5;
else
       State = 0;
if( State > 6 )
       State = 6;
```

In addition to this state machine, the **Bad Frame Flag** from the previous frame is checked (**PrevBFI**). The processing depends on the value of the **State**-variable. In states 0 and 5, the processing depends also on the two flags **BFI** and **PrevBFI**.




The procedure can be described as follows:

**Figure 1: State machine for controlling the bad frame substitution**

**BFI = 0, PrevBFI = 0, State = 0**

No error is detected in the received or in the previous received speech frame. The received speech parameters are used normally in the speech synthesis. The current frame of speech parameters is saved.

**BFI = 0, PrevBFI = 1, State = 0 or 5**

No error is detected in the received speech frame but the previous received speech frame was bad. The LTP-gain and fixed codebook gain are limited below the values used for the last received good subframe:

$$g^p = \begin{cases} g^p, & g^p \le g^p(-1) \\ g^p(-1), & g^p > g^p(-1) \end{cases} \qquad (1)$$

where $g^p$ =current decoded LTP-gain, $g^p(-1)$ =LTP-gain used for the last good subframe (BFI=0), and

$$g^c = \begin{cases} g^c, & g^c \le g^c(-1) \\ g^c(-1), & g^c > g^c(-1) \end{cases} \tag{2}$$

where $g^c$=current decoded fixed codebook-gain and $g^c(-1)$=fixed codebook gain used for the last good subframe (BFI=0).

The rest of the received speech parameters are used normally in the speech synthesis. The current frame of speech parameters is saved.

**BFI = 1, PrevBFI = 0 or 1, State = 1...6**

An error is detected in the received speech frame and the substitution and muting procedure is started. The LTP-gain and fixed codebook gain are replaced by attenuated values from the previous subframes:

$$g^p = \begin{cases} P(state)\ g^p(-1), & g^p(-1) \le median5(g^p(-1),\ldots,g^p(-5)) \\ P(state)\ median5(g^p(-1),\ldots,g^p(-5)), & g^p(-1) > median5(g^p(-1),\ldots,g^p(-5)) \end{cases} \tag{3}$$

where $g^p$=current decoded LTP-gain, $g^p(-1),\ldots,g^p(-n)$ = LTP-gains used for the last n subframes, *median5()*=5-point median operation, *P(state)*=attenuation factor (*P(1)*=0.98, *P(2)*=0.98, *P(3)*=0.8, *P(4)*=0.3, *P(5)*=0.2, *P(6)*=0.2), *state*=state number and

$$g^c = \begin{cases} C(state)\ g^c(-1), & g^c(-1) \le median5(g^c(-1),\ldots,g^c(-5)) \\ C(state)\ median5(g^c(-1),\ldots,g^c(-5)), & g^c(-1) > median5(g^c(-1),\ldots,g^c(-5)) \end{cases} \tag{4}$$

where $g^c$=current decoded fixed codebook gain, $g^c(-1),\ldots,g^c(-n)$ = fixed codebook gains used for the last n subframes, *median5()*=5-point median operation, *C(state)*=attenuation factor (*C(1)*=0.98,*C(2)*=0.98, *C(3)*=0.98, *C(4)*=0.98, *C(5)*=0.98, *C(6)*=0.7), and *state*=state number.

The higher the state value is, the more the gains are attenuated. Also the memory of the predictive fixed codebook gain is updated by using the average value of the past four values in the memory:

$$ener(0) = \frac{1}{4}\sum_{i=1}^{4} ener(-i) \tag{5}$$

The past LSFs are used by shifting their values towards their mean:

$$lsf\_q1(i) = lsf\_q2(i) = \alpha\ past\_lsf\_q(i) + (1-\alpha)mean\_lsf(i), \quad i = 0\ldots9 \tag{6}$$

where $\alpha$=0.95, *lsf_q1* and *lsf_q2* are two sets of LSF-vectors for current frame, *past_lsf_q* is *lsf_q2* from the previous frame, and *mean_lsf* is the average LSF-vector.

The LTP-lag values are replaced by the past value from the 4th subframe of the previous frame.

The received fixed codebook excitation pulses from the erroneous frame are always used as such.

## 6.2 Example solution for substitution and muting of lost SID frames

The first lost SID frame is replaced by the last valid SID frame.

For subsequent lost SID frames, the last valid SID frame is repeated, but the fixed codebook gain is decreased with a constant value of -3 dB in each frame down to the minimum value of 0. This value is maintained if additional lost SID frames occur.

# History

| Document history | | | |
|---|---|---|---|
| March 1996 | Public Enquiry | PE 103: | 1996-03-04 to 1996-06-28 |
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