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Digital cellular telecommunications system (Phase 2+) (GSM); ANSI-C code for the GSM Enhanced Full Rate (EFR) speech codec (GSM 06.53 version 7.0.1 Release 1998)

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Foreword

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

The present document provides the bit exact definition of the Enhanced Full Rate (EFR) speech traffic codec for the digital cellular telecommunications system.

An electronic attachment accompanies the present document, containing clause 5, the bit-exact ANSI-C code for the Enhanced Full Rate speech transcoder.

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 7.x.y

where:

7 indicates Release 1998 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.

National transposition dates	
Date of adoption of this EN:	31 December 1999
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1 Scope

The present document contains an electronic copy of the ANSI-C code for the GSM Enhanced Full Rate codec. The ANSI-C code is necessary for a bit exact implementation of the Enhanced Full Rate speech transcoder (GSM 06.60 [3]), Voice Activity Detection (GSM 06.82 [7]), comfort noise (GSM 06.62 [5]), Discontinuous Transmission (GSM 06.81 [6]) and example solutions for substituting and muting of lost frames (GSM 06.61 [4]).

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.
- For this Release 1998 document, references to GSM documents are for Release 1998 versions (version 7.x.y).

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

[2] GSM 06.54: "Digital cellular telecommunications system (Phase 2+); Test sequences 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 06.62: "Digital cellular telecommunications system (Phase 2+); Comfort noise aspects for Enhanced Full Rate (EFR) speech traffic channels".

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

[7] GSM 06.82: "Digital cellular telecommunications system (Phase 2+); Voice Activity Detector (VAD) for Enhanced Full Rate (EFR) speech traffic channels".

3 Definitions and abbreviations

3.1 Definitions

Definition of terms used in the present document can be found in GSM 06.60 [3], GSM 06.61 [4], GSM 06.62 [5], GSM 06.81 [6] and GSM 06.82 [7].

3.2 Abbreviations

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

ANSI	American National Standards Institute
DS-HD	Double Sided High Density
ETS	European Telecommunication Standard
GSM	Global System for Mobile communications
I/O	Input/Output
ROM	Read Only Memory

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

4 C code structure

This clause gives an overview of the structure of the bit-exact C code and provides an overview of the contents and organization of the archive 6pc03i0o.ZIP which accompanies the present document.

The C code has been verified on the following systems:

- Sun Microsystems [1] workstations and Sun Microsystems cc compiler and gcc compiler;
- IBM [2] PC/AT compatible computers and Borland Turbo-C++ [3] compiler;
- Hewlett Packard's [4] workstations and HP cc compiler;

ANSI-C 9899 was selected as the programming language because portability was desirable.

4.1 Contents of the C source code disk

The C code disk has all of the files in the root level.

In this disk, the files with suffix "c" contain the source code and the files with suffix "h" are the header files. The ROM data is contained mostly in files with suffix "tab". All text files are formatted such that they are correct for an IBM PC/AT compatible.

The archive 6pc03i0o.ZIP which accompanies the present document contains one speech coder installation verification data file, "spch_dos.inp". The reference encoder output file is named "spch_dos.cod", the reference decoder input file is named "spch_dos.dec" and the reference decoder output file is named "spch_dos.out". These four files are formatted such that they are correct for an IBM PC/AT compatible. The same files with reversed byte order of the 16 bit words are named "spch_unx.inp", "spch_unx.cod", "spch_unx."dec" and "spch_unx.out", respectively.

In an IBM PC/AT compatible platform, the installation verification can be performed by running the batch file "ts_dos.bat". In most UNIX platforms, the installation verification can be performed by running the batch file "ts_unx.bat". Final verification is to be performed using the GSM Enhanced Full Rate test sequences described in GSM 06.54 [2].

Makefiles are provided for the three platforms in which the C code has been verified (listed above). Once the software is installed, this directory will have compiled versions of *coder* and *decoder* (the bit-exact C executables of the speech codec), *ed_iface* (interface program between coder and decoder) and all the object files.

The programs *coder* and *decoder* are the GSM Enhanced Full Rate encoder and decoder executable files, respectively. A third program, *ed_iface*, is also contained in this directory. This is the program which provides the format conversion between the encoder output file format and the decoder input file format.

1) Registered trade mark of Sun Microsystems
2) Registered trade mark of International Business Machines
3) Registered trade mark of Borland
4) Registered trade mark of Hewlett Packard

4.2 Program execution

The GSM enhanced full rate speech codec is implemented as three separate programs:

- (*coder*) speech encoder;
- *(ed_iface)* encoder/decoder interface;
- (*decoder*) speech decoder.

For encoding using the *coder* program, the input is a binary speech file (*.inp) and the output is a binary encoded parameter file (*.cod). For decoding using the *decoder* program, the input is a binary parameter file (*.dec) and the output is a binary synthesized speech file (*.out).

NOTE: The format for the parameter input file required for decoding (*.dec) is not the same as the format of the parameter output file generated by encoding (*.cod). The *ed_iface* program will translate an *.cod file into a *.dec file.

See the file readme.txt for more information on how to run the coder, *ed_iface* and *decoder* programs.

4.3 Code hierarchy

Figures 1 to 5 are call graphs that show the functions used in the speech codec, including the functions of VAD, DTX, and comfort noise generation.

The encode call graph is broken down into three separate call graphs, and the decode call graph is broken down into two separate call graphs. Those sections which are large are separated from the primary call tree and given their own call tree. Each vertical column represents a call level. For example, main() is at level 0, Coder_12k2() at level 1, Int_lpc2() at level 2, Lsp_Az() at level 3, Get_lsp_pol() at level 4, etc. The basic operations are not counted as extending the depth, therefore the deepest level in this software is level 4.

Some items have been omitted from this call graph. All standard C functions: printf(), fwrite(), etc. have been omitted. Also, no basic operations (add(), L_add(), mac(), etc.) or double precision extended operations (e.g. L_Extract()) appear in the graphs. The reset functions of the encoder and decoder are only visible as the functions reset_enc and reset_dec, respectively. There are several subroutine calls from inside these functions.

The time order in the call graphs is from the bottom upwards as the processing of a frame advances.