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European Standard (Telecommunications series)

Terrestrial Trunked Radio (TETRA);
Speech codec for full-rate traffic channel;
Part 1: General description of speech functions

Reference

REN/TETRA-05113-1

Keywords

TETRA, codec

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Project Terrestrial Trunked Radio (TETRA).

The present document is part 1 of a multi-part deliverable covering speech codec for full-rate traffic channel, as identified below:

> **Part 1: "General description of speech functions";**
>
> Part 2: "TETRA codec";
>
> Part 3: "Specific operating features";
>
> Part 4: "Codec conformance testing".

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1 Scope

The present document is an introduction to the other parts of this multi-part deliverable dealing with the speech processing functions in the TETRA system. In addition to this introduction, the present document contains the full specification of the speech CODEC including provisions for specific cases of operation and optional functionalities plus CODEC conformance testing. The present document also contains the full specification for the optional AMR CODEC as implemented within the TETRA system. In the present document, a general overview of the speech processing parts is given with reference to the multi-part deliverable where each part is specified in detail.

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 and/or edition number or version number) or non-specific.

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

- For a non-specific reference, the latest version applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

[1]   ETSI TS 126 090: "Universal Mobile Telecommunications System (UMTS); Mandatory Speech Codec speech processing functions AMR Speech Codec - Transcoding functions (3GPP TS 26.090 Release 4)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in EN 300 392-2, clause 3 apply.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in EN 300 392-2, clause 3 and the following apply:

    ACELP   Algebraic CELP
    AMR   Advanced Multi-Rate
    BS   Base Station
    CELP   Code-Excited Linear Predictive
    MFG   Missing Frame Generation
    MFS   Missing Frame Substitution
    MS   Mobile Station
    PCM   Pulse Code Modulated
    SCR   Source Controlled Rate

4 General

Figure 1 illustrates a reference configuration with the various speech processing functions shown as building blocks. When appropriate, the relevant clauses of this multi-part deliverable are mentioned in the corresponding building block. The data exchanged between the various functions are also indicated on figure 1.

NOTE 1: The standardized interface points are specifically identified by circled numbers. The unnumbered interfaces are unspecified and may consist of any information required by the implementation.

On figure 1, audio parts are included to exhibit the entire speech path between the audio input/output in the Mobile Station (MS) and the digital interface to any network in the Base Station (BS). However, it shall be understood that such audio parts are provided only for the convenience of the reader, but are not further defined in the TETRA standard. Therefore, the audio input and output to and from the TETRA speech CODEC is specified as 16 bit linear Pulse Code Modulated (PCM).

In most of the operational configurations, the speech CODEC will be associated to an encryption unit. This unit appears also on figure 1 in both the transmit and the receive sides.

NOTE 2: The definition of the messages at standardized interface points 3, 4 and 8 are given in EN 300 392-7.

Support for the TETRA full rate speech codec is mandatory for all TETRA equipment. Support for the AMR speech codec is optional.

5 Full rate speech CODEC

As shown on figure 1, the speech encoder input consists of a 16 bit uniform PCM signal coming either from the audio parts of the MS or from the interface with the network at the BS. At the output of the speech encoder, the processed speech is delivered to the channel coding function in order to produce in normal operative conditions an encoded block of 432 bits for 60 ms of speech data, which corresponds to a gross bit rate of 7,2 kbit/s. However, when 30 ms of speech data are stolen for signalling purposes, the channel coding function shall produce only an encoded block of 216 bits for 30 ms of speech data.

At the receiver side, the inverse operations shall take place. In addition to the previously defined signals, the speech decoder shall receive from the speech decoder control a bad frame indication flag allowing error concealment and therefore generation of modified speech parameters.

The full rate speech source encoder and decoder is entirely defined in EN 300 395-2, clause 4. This clause describes the detailed mapping between input blocks of 240 speech samples in 16-bit uniform PCM format to encoded blocks of 137 bits and from encoded blocks of 137 bits to output blocks of 240 reconstructed speech samples. The sampling rate shall be 8 000 sample/s leading to an average bit rate for the encoded speech parameters of 4 567 bit/s.

The speech coding/decoding algorithm is based on the Code-Excited Linear Predictive (CELP) coding model. The TETRA CODEC implements an Algebraic CELP (ACELP) technique in which special innovation codebooks having an algebraic structure are used.

Clause 4 of EN 300 395-2 provides a complete description of the CODEC, including detailed block diagrams, while EN 300 395-2, clause 8 introduces the bit exact description of the CODEC. This description is given as C code, fixed point, bit exact, written according to the ANSI C language standards.

EN 300 395-2, clause 5 describes in the same manner the speech channel encoder, EN 300 395-2, clause 6 the speech channel decoder, and EN 300 395-2, clause 7 the CODEC performance, including the minimum required speech channel decoder performance.

Such a description enables the verification of compliance to EN 300 395-2 to a high degree of confidence by use of a set of digital test sequences. These test sequences, as well as their practical use, are described in EN 300 395-4.
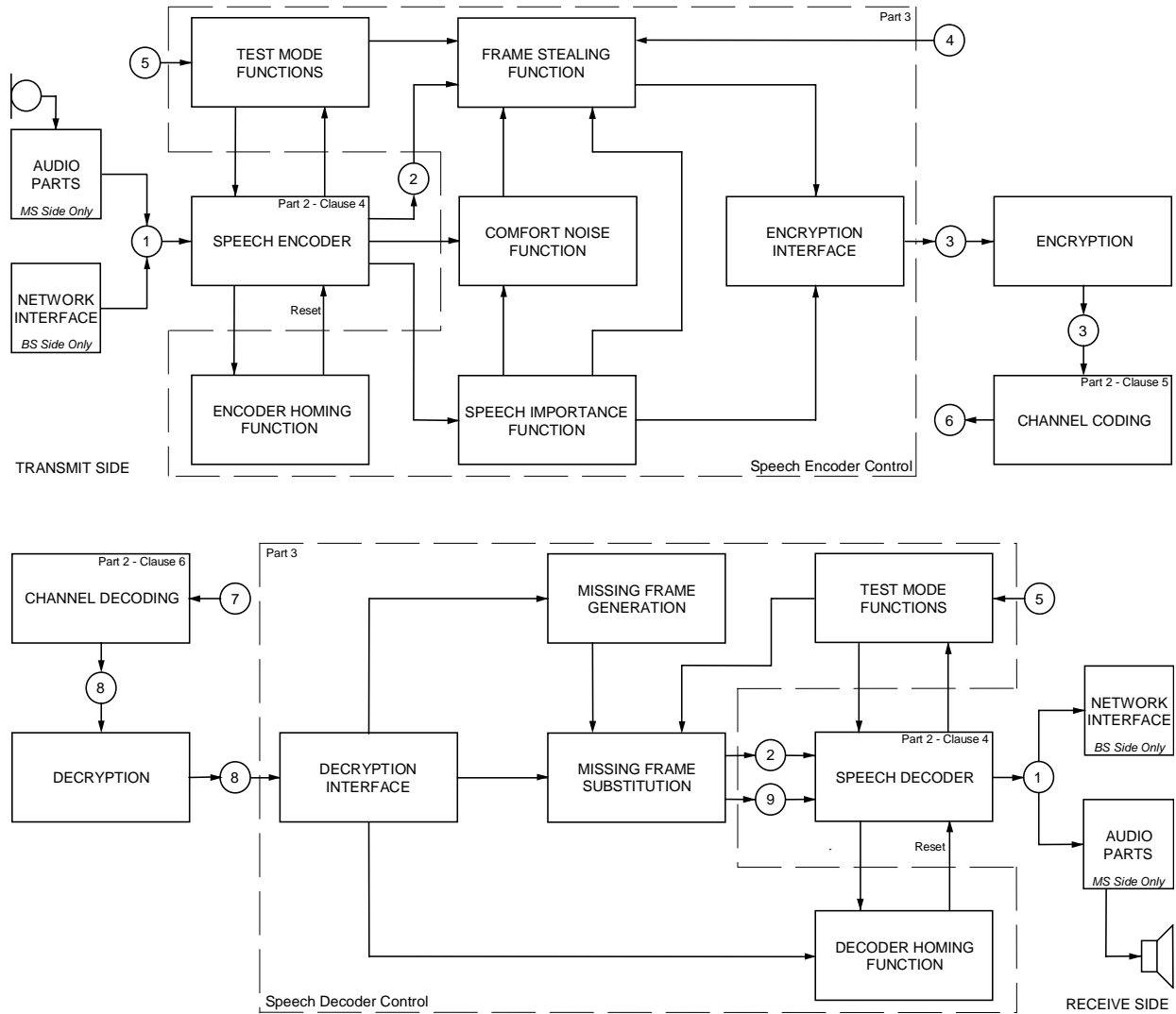
1)   16 bit uniform PCM, 8 000 samples/s;
2)   Encoded speech frame 30 ms, 137 bits/frame;
3)   Encoded speech frame in "TMD_UNITDATA_request" message;
4)   Stolen indication in "TMD_REPORT_indication" message;
5)   Test mode control;
6)   Encoded block delivered by the channel coding function;
7)   Encoded block received by the channel decoding function;
8)   Encoded speech frame in "TMD_UNITDATA_indication" message;
9)   Bad frame indicator.

Figure 1: Overview of audio processing functions

6 Speech control unit

All the other functions associated with the speech CODEC as illustrated in figure 1 are described in EN 300 395-3.

6.1 Lost frame aspects

At the receiver side, speech frames may be lost due to either transmission errors or frame stealing. In the TETRA system, frame stealing may be needed for system control purposes or for ciphering synchronization. In any case, specific actions have to be taken in order to provide the speech decoder with an adequate set of parameters allowing a smooth restitution of the speech waveform. The two functions Missing Frame Generation (MFG) and Missing Frame Substitution (MFS) may be used for that purpose.

At the encoder, the frame stealing function can, on request, replace by other information the contents of the encoded speech frame delivered by the speech encoder. As frame stealing is the result of a decision taken by the system, the speech encoder may take advantage of this information.

6.2 Comfort noise aspects

When a significant number of consecutive frames are lost, it is no longer possible to generate an acceptable synthetic signal from previously received speech parameters. In order to avoid annoying discontinuities due to the possibility of no sound perceived at the receiver, and therefore to provide a better listening comfort to the user, some additional process may be useful.

At the encoder, the comfort noise function may compute specific parameters which can be used for comfort noise generation at the receiver.

6.3 Importance parameter

In the framework of the TETRA system, a number of arising issues can be efficiently solved if it is possible to detect with enough reliability an importance parameter for each speech frame. Examples of applications involving such an importance parameter include initiation or termination of transmission, control of discontinuous transmission, control of communication direction in half-duplex mode, control of comfort noise generation at the receiver, or still indication of a frame stealing possibility with minimal impact on speech.

The speech importance function shall compute this importance parameter.

6.4 Homing function

The TETRA speech CODEC is defined in bit exact arithmetic. Consequently, a given input sequence shall always produce the corresponding bit exact output sequence, provided that the internal state variables are also always reset to a known state at the beginning of the experiment.

The input test sequences provided in EN 300 395-4 shall result in corresponding output test sequences, provided that the tested modules are in their home-state when starting.

Special inband signalling frames described in EN 300 395-3 have been defined to provoke reset of the speech coder and decoder to a known state.

7 Conformance testing

TETRA CODEC conformance testing is entirely described in EN 300 395-4. The present document focuses on the core of the TETRA CODEC, as described in EN 300 395-2, while the specific operating features as described in EN 300 395-3 should be disabled for conformance testing purposes.

8   AMR speech codec

If the AMR codec is implemented within the network or the mobile station, then the 4,75 kbit/s mode shall be used, as specified in TS 126 090 [1].

Modes other than 4,75 kbit/s shall not be used within TETRA, and Source Controlled Rate operation (SCR) shall not be used.

Annex A (informative):
Bibliography

ETSI EN 300 395-2: "Terrestrial Trunked Radio (TETRA); Speech codec for full-rate traffic channel; Part 2: TETRA codec".

ETSI EN 300 395-3: "Terrestrial Trunked Radio (TETRA); Speech codec for full-rate traffic channel; Part 3: Specific operating features".

ETSI EN 300 395-4: "Terrestrial Trunked Radio (TETRA); Speech codec for full-rate traffic channel; Part 4: Codec conformance testing".

ETSI EN 300 392-2: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".

ETSI EN 300 392-7: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 7: Security".

History

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