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COMMUNICATIONS INDUSTRY STANDARD

OF THE PEOPLE'S REPUBLIC OF CHINA

ICS 33.060.99

M36

YD/T 3695-2020

**Vehicle Emergency Alarm System Based on Public
Telecommunication Network Wireless Data Transmission
Technology Requirements**

基于公众电信网的车载紧急报警系统 无线数据传输技术要求

Issued on: April 16, 2020

Implemented on: July 01, 2020

**Issued by: Ministry of Industry and Information Technology of the People's
Republic of China.**

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Vehicle Emergency Alarm System Based on Public Telecommunication Network Wireless Data Transmission Technology Requirements

1 Scope

This Standard specifies the technical requirements for communication and data transmission of the vehicle emergency alarm system based on public telecommunication network, namely the overall scheme and algorithm description of eCall in-band modulation, including the IVS modem and PSAP modem that constitute full-duplex transmission.

This Standard applies to vehicle emergency alarm systems based on public telecommunication network.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

3GPPTS 22.101, *Service aspects; Service principles*

3GPP TR 22.967, *Transfer of ECall Data*

3GPP TS 26.071, *AMR speech Codec; General description*

3GPP TS 26.094, *Mandatory speech codec speech processing functions; Adaptive Multi-Rate (AMR) speech codec; Voice Activity Detector (VAD)*

3GPP TS 26.226, *Cellular text telephone modem; General description*

3GPP TS 26.268, *eCall Data Transfer; In-band modem solution· ANSI-C reference code*

3GPP TS 26.269, *eCall Data Transfer; In-band modem solution; Conformance testing*

3GPP TR 26.969, *eCall Data Transfer; In-band modem solution; Characterization report*

3GPP TR 26.967, eCall Data Transfer; In-band modem solution

3GPPTS 46.001, Full rate speech: Processing functions

3GPP TS 46.032, *Full rate speech; Voice Activity Detection (VAD) for full rate speech traffic channels*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1 eCall

An emergency call initiated from the vehicle manually or automatically. The call also carries the minimum set of data (MSD) associated with the emergency call.

3.1.2 eCall In-band Modem

A pair of modems (constituting the transmitter and receiver of the IVS and PSAP) operate in full-duplex mode to reliably transmit the eCall minimum set of data (MSD) from the IVS to the PSAP via the eCall voice channels of the cellular and PSTN.

3.1.3 feedback frame

It includes the downlink signal transmission time of the feedback data. The duration is 140 ms. This is equivalent to a total of 1120 samples at an 8 kHz sampling rate.

3.1.4 frame (or: speech frame)

Equivalent to 20 ms duration (equivalent to one AMR or FR speech frame length, i.e. 160 samples at 8 kHz sampling rate).

3.1.5 MSD

The minimum set of data that is part of the eCall data sent from the vehicle to the public safety response center or other designated eCall center. The maximum MSD is 140 bytes and includes information such as vehicle identification, vehicle location information, and timestamp.

3.1.6 MSD data frame

It includes the uplink signal transmission time of one MSD data (after synchronization is established). The duration is 1320 ms. This is equivalent to a total of 10560 samples at 8kHz sampling rate (if a fast modulator is used) or 18560 samples (if a reliable modulator is used).

the originating and transmitting networks;

- The voice and data portions of an eCall shall be routed to the same PSAP or designated eCall center;
- PSAP needs to confirm the received data and retransmit the data if necessary;
- If the UE is configured to transmit data only in eCalls (e.g. eCall only UE), the UE shall not generate additional signaling to the network except for eCall related signaling;
- The UE shall indicate whether the eCall carries relevant data when the call is established.

In addition to the above general requirements, the following requirements must also be met:

- There are two ways to initiate an eCall. One is automatic (e.g. due to a vehicle collision) and the other is manual by a person in the vehicle;
- IVS or UE supporting eCall function shall carry an indication when establishing an eCall to indicate whether the current call is manually initiated (MIeC) or automatically initiated (AIeC);
- The size of the minimum data set (MSD) sent by the IVS to the network shall not exceed 140 bytes;
- PSAP shall receive MSD within 4 s after the end-to-end link is established;
- In the event that the MSD is not included in the eCall or the MSD is damaged or lost, the voice eCall function shall not be affected;
- During MSD transmission, the user shall be provided with call progress prompts;
- To reduce the eCall establishment time, the IVS working in eCall only mode can still receive information about whether the network is available even if the corresponding PLMN registration is not completed;
- The network can use the eCall indication during the eCall establishment process to distinguish the type of eCall;
- MIeC and AIeC can be used to filter or route corresponding eCalls to dedicated PSAP operators.

Throughout the eCall process and after the PSAP receives the MSD, the PSAP shall be allowed to send an acknowledgment to the IVS to indicate that the MSD has been received. The PSAP shall be allowed to request the IVS to resend the latest MSD. The PSAP shall be allowed to direct the IVS to terminate the call.

To select a better eCall in-band modulation scheme, Annex A provides more detailed business requirements, performance requirements under different wireless channels, and design constraints.

4.3 eCall in-band modulation architecture

4.3.1 General

The eCall in-band modulation scheme specified in this Standard consists of an IVS data modem and a PSAP data modem. The signal design used allows the signal to pass through the voice vocoder with only moderate distortion and provide sufficient data rate to meet the requirements of transmitting MSD as quickly as possible.

Figure 2 shows the overall cellular system architecture including IVS and PSAP data modem. The specific process includes the following steps.

After a voice eCall is established (either automatically or manually), the IVS receiver continuously monitors the incoming signal from the voice decoder. Upon detecting an MSD request from the PSAP, the IVS connects the transmit side of the IVS data modem to the input of the voice encoder and mutes all subsequent voice signal input generated during the MSD transmission period to avoid interference with the eCall data transmission. There is also another case where the MSD transmission is triggered by the IVS. In this case, the IVS notifies the PSAP, which then requests the IVS to send the MSD. In general, as long as the eCall modem activates transmission, the microphone is disconnected from the actual transmission path of the signal.

The first operation mode can be called pull mode. The second is push mode. In push mode, the IVS initiates a request to the PSAP to request MSD data.

The specific configuration of push mode or pull mode is not within the scope of this Standard. Refer to 4.2 for related eCall business requirements.

The operating principles of the IVS and PSAP modems shown in Figure 2 are described in detail below. The specific algorithms and functions will be explained in Chapters 5 and 6.

6.2.2 Synchronous detection and tracking

In general, uplink synchronization detection and tracking are similar to those described in 5.2.2. The main differences are as follows.

The PSAP is triggered by detecting a synchronization preamble. After detecting the preamble, the synchronization module continuously checks the received signal in another 10 voice frames to ensure that the synchronization module has not found a more reliable preamble signal to avoid false detection and incorrect delay estimation. If the synchronization module finds a better preamble signal, it re-receives the MSD.

The synchronization check function continuously checks the validity of the calculated delay estimate based on subsequent uplink synchronization segments. If the delay estimate is found to be invalid, the synchronization tracking module searches for a new valid delay estimate in a predetermined search window. The maximum search window on the PSAP receiver side is ± 240 samples. If the synchronization tracking module fails to find a new valid delay value in a number of subsequent synchronization segments (default is 4), the PSAP transmitter resets. A START message is sent to the IVS to restart the MSD transmission.

The tone detection function module estimates the frequency of the synchronization tone using the DFT method to estimate two reference frequencies. If the frequency can be reliably detected, it is used to determine which demodulator to use for demodulation. If it cannot be detected, if it is the first time the preamble is detected, a fast modulation scheme is used for demodulation, otherwise, a reliable demodulation scheme is used for demodulation.

6.2.3 Timing unit

See 5.2.2.

6.2.4 Demultiplexing

See 5.2.3.

6.2.5 Data demodulation

Data demodulation is a process of correlating and matching the waveform modulated by the IVS transmitter. Specifically, the correlation values with all possible symbols are calculated:

$$r(i) = \sum_{j=0}^n ulPulse(j) * ulPulseMatch(i)(j)$$

$$r(i+4) = -r(3-i), \quad i = 0, 1, 2, 3$$

Among them, if it is fast modulation mode $n = 15$, and if it is reliable modulation mode

with the description in 5.2. If two correct synchronization preambles and a subsequent push message are detected, it means that a push command has been detected.

7 Transport protocols and error handling

7.1 Normal operation

The previous sections describe the eCall data transmission operation under normal circumstances.

After the operator requests or receives a push message from the IVS, the PSAP transmitter starts sending START messages. The IVS receiver shall obtain synchronization by detecting the synchronization preamble sent with the START message, which allows the IVS receiver to demodulate the START message. The PSAP transmitter continues to send START messages to the IVS. The number of times it is allowed to send START messages is determined by the higher-level protocol and the timer (not defined in this Standard).

Once the START message is detected, the IVS starts sending the sync frame and the first MSD message (using redundancy version rv0). The PSAP shall detect the sync frame and get accurate synchronization based on the sync preamble, and then the PSAP receiver can correctly demodulate and decode the MSD message.

Once the PSAP receiver is synchronized, the PSAP starts to send NACK messages repeatedly, which the IVS shall detect. Subsequently, the IVS sends MSD data. After sending MSD rv0, the IVS continues to send the next redundant version of the same MSD message rv1, rv2, and so on.

PSAP demodulates MSD rv0 and performs CRC check. If CRC check fails, PSAP continues to send NACK messages. If successful, PSAP sends link layer ACK or high layer ACK message (it is determined by the high layer protocol whether to send link layer or high layer ACK). For safety reasons, from the perspective of the modem protocol, at least 5 ACK messages of the same type (link layer or high layer) need to be sent. High layer ACK shall not be sent before link layer ACK. Link layer ACK shall not be sent after high layer ACK message. For this purpose, the reference modem implementation sends 5 link layer ACK messages until a trigger from the high layer protocol is received, and then sends 5 high layer ACK messages. IVS shall be able to detect a specific ACK (link layer or high layer), and then it stops sending MSD.

7.2 Abnormal operation

This section describes some abnormal situations that occur due to severe signal distortion caused by the transmission channel. These situations need to be handled by the overall transmission protocol to avoid deadlock situations. It shall be noted that the

Annex A

(informative)

eCall performance requirements/goals and design constraints

The minimum performance requirements for an imprecise implementation of the eCall modem and the exact performance of a precise implementation are defined in another conformance test document.

A.1 Definition

eCall candidate solutions shall meet the performance requirements, otherwise they will not be considered.

NOTE: Performance requirements include all business requirements.

The performance goals do not set exact limits, but can be used to rank candidate technologies based on the defined criteria.

Design constraints provide upper limits (requirements and goals), e.g. on algorithmic complexity.

Solution selection selects candidate solutions based on performance requirements and design constraints. Then sort them according to performance goals and select the best candidate solution.

eCall protocols refer to all application layer protocols between IVS and PSAP, while the selected scheme provides data transmission for the eCall process, but the application layer protocols of eCall are not in the scope.

A.2 Performance requirements

The following describes the (service) performance requirements that the eCall candidate solutions need to meet. These requirements are from 3GPP TS22.101.

NOTE 1: 3GPP TS 22.101 is also updated to v8.8.0. The changes are evaluated and found to have no impact on eCall solution selection.

NOTE 2: For scheme selection purposes, candidate schemes shall provide automatic retransmission, but this is not required for the final eCall protocol.

- a) Requirement 1: Data may be sent before, after or along with the voice component of an emergency voice call.

NOTE 3: Before the end-to-end voice channel is established, in-band data cannot be sent.

This requirement requires no additional explanation.

- b) Requirement 2: If the PSAP requests additional data, it shall be possible to do so over an established eCall.

This requirement is considered during the selection process: "Candidate eCall solutions shall allow the PSAP to request additional data at any time on an established eCall."

- c) Requirement 3: The transmission of data during voice eCalls shall be implemented with minimal changes to the originating and transmitting networks.

This requirement is considered in the selection process as follows: "The introduction of eCall data transmission shall have minimal impact (ideally no impact) on any existing mobile and transport networks. This means that it shall not require (major) changes to the network and shall not impose (major) restrictions on future network evolution."

- d) Requirement 4: Both the voice and data portions of an eCall shall be routed to the same PSAP or designated eCall center.

NOTE 4: In-band data modulation shall not be routed to a destination that is inconsistent with the data channel.

This requirement is not taken into account when selecting the solution.

- e) Requirement 5: Received data needs to be acknowledged and, if necessary, retransmitted.

This requirement is considered in the selection process as follows: "If a candidate discovers an error while receiving data, the candidate shall request a retransmission".

- f) Requirement 6: If a UE is configured to transmit data only in eCalls (such as an eCall only UE), the UE shall not generate additional signaling to the network other than eCall-related signaling.

This requirement is not taken into consideration when selecting the solution.

- g) Requirement 7: In order to allow for the effective operation of the eCall service, all eCall requirements need to be met in addition to the following specific requirements.

This requirement is not taken into account when selecting the solution.

- h) Requirement 8: The eCall shall contain an eCall message carrying emergency service-related data (MSD).

This requirement is not taken into account when selecting the solution.

- i) Requirement 9: An eCall may be initiated automatically (e.g. due to a vehicle collision) or manually by a person in the vehicle.

This requirement is not taken into account when selecting the solution.

- j) Requirement 10: The size of the minimum data set (MSD) sent by the vehicle system (IVS) to the network shall not exceed 140 bytes.

This requirement is considered during the selection process as follows: "The PSAP shall be able to obtain the entire 140 bytes of MSD information".

- k) Requirement 11: The PSAP shall typically also receive the MSD after the end-to-end link is established.

This requirement is considered in the selection process as follows: "Under optimal channel conditions (error-free radio channel, GSM half-rate vocoder and half-rate AMR 12.2k bit/s mode), the eCall candidate shall reliably transmit the entire 140-byte MSD message within 4 s. The time measurement starts from the triggering of the IVS transmission, i.e. the detection of the triggering condition of the PSAP".

NOTE 5: See performance requirement 14.

NOTE 6: Reliability definition is given in Performance requirement 15.

NOTE 7: The performance target provides additional performance reference under non-ideal channels.

- l) Requirement 12: Regardless of whether the eCall contains MSD, or if the MSD is damaged or lost for various reasons, the corresponding TS12 voice eCall function shall not be affected.

This requirement is not taken into consideration when selecting the solution.

- m) Requirement 13: Response indicates when the call is established whether the eCall carries corresponding data.

This requirement is not taken into consideration when selecting the solution.

In addition to the above business requirements, the following performance requirements also apply to eCall candidate solutions.

- n) Requirement 14: The installation of eCall equipment in a vehicle shall not affect eCalls to PSAPs that have not been upgraded to support receiving eCall data. In other words, if the PSAP does not request eCall data, eCall candidates shall not be sent to the PSAP.

- o) Requirement 15: The MSD shall be sent to the PSAP reliably. Only when the 28-

bit CRC check passes, the MSD transmission is correct and the transmission can be terminated.

NOTE 8: If the CRC check fails, a retransmission needs to be automatically triggered unless the PSAP decides to stop the transmission.

A.3 Performance goals

Performance goal 1: The overall average transfer time shall be as short as possible.

Performance goal 2: The performance of the candidate solution shall be at least as good as or better than eCall_via_CTM* (see 3GPP TR 26.967[4]) under any test conditions.

NOTE: The goals of this document are mainly intended to provide guidance to designers of eCall candidate solutions. The exact candidate selection method is defined by another document (PD3, "eCall Selection Test"). Goal 1 is used directly in the selection method, while Goal 2 is only a guide and is not considered when formulating the specific selection method.

The detailed requirements for performance goal 1 are as follows.

For any specific test condition (defined by the speech vocoder and non-ideal wireless channel), the specific time required to send a 140-byte MSD is closely related to the specific channel parameters and the MSD content. Therefore, each MSD transmission is the k th attempt in a random experiment. The corresponding transmission time T_k is observed. For a specific test condition C , at least 100 randomly generated MSD transmission tests are required to obtain sufficient statistical properties ($k = 1, 2, \dots, n$, where $n \geq 100$).

To ensure that the time required to test the candidate solution is acceptable, the corresponding transmission time T_k shall have a reasonable upper limit. Under all test conditions, the upper limit of each test time t_{UB} is fixed at 200 seconds. Any T_k measured greater than 200 seconds is a failed transmission. Set T_k to the value of t_{UB} .

Under each specific test condition C , the transmission time distribution $T_1, T_2, \dots, T_n$ is measured. What is of interest is the average value $c = (T_1 + T_2 + \dots + T_n) / n$.

The Figure of Merit (FoM) under all conditions is calculated by calculating the unweighted value of c under all test conditions. Obviously, a small FoM value is better than a large one. Then, the candidate solutions are ranked according to FoM.

The following assumptions apply to the T_k measurement:

- a) The transmission start time is evenly distributed relative to the speech vocoder speech frame;
- b) The non-ideal channel uses a fixed error format. This format is obtained through simulation. The following wireless channel conditions are used for testing:

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