SLOVENSKI STANDARD
SIST EN 301 709 V8.0.1:2003

01-december-2003

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Digital cellular telecommunications system (Phase 2+) (GSM); Link Adaptation (GSM 05.09 version 8.0.1 Release 1999)

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Ta slovenski standard je istoveten z: **EN 301 709 Version 8.0.1**

ICS:

33.070.50	Globalni sistem za mobilno telekomunikacijo (GSM)	Global System for Mobile Communication (GSM)

SIST EN 301 709 V8.0.1:2003 **en**

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ETSI EN 301 709 V8.0.1 (2000-10)

European Standard (Telecommunications series)

Digital cellular telecommunications system (Phase 2+);
Link Adaptation
(GSM 05.09 version 8.0.1 Release 1999)

GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

ETSI

Reference
REN/SMG-020509Q8

Keywords
Digital cellular telecommunications system,
Global System for Mobile communications (GSM)

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
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Foreword

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

The present document specifies the relevant procedures for link adaptation implemented in the Mobile Station (MS) and Base Station System (BSS) of the digital mobile cellular and personal communication systems operating in the 900 MHz, 1 800 MHz and 1 900 MHz band (GSM 900, DCS 1 800 and PCS 1 900).

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

Version 8.x.y

where:

   8   indicates release 1999 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:	1 September 2000
Date of latest announcement of this EN (doa):	31 December 2000
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 June 2001
Date of withdrawal of any conflicting National Standard (dow):	30 June 2001

1 Scope

The requirements described in the present document are mandatory for implementation in all GSM MSs and BSSs capable of supporting the Adaptive Multi-Rate speech traffic channel, unless otherwise stated.

Unless otherwise specified, references to GSM include GSM at any frequency band.

1.1 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 1999 document, references to GSM documents are for Release 1999 versions (version 8.x.y).

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

[2] GSM 04.08: "Digital cellular telecommunications system (Phase 2+); Mobile radio interface layer 3 specification".

[3] GSM 05.02: "Digital cellular telecommunications system (Phase 2+); Multiplexing and multiple access on the radio path".

[4] GSM 05.03: "Digital cellular telecommunications system (Phase 2+); Channel Coding".

[5] GSM 05.05: "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception".

[6] GSM 08.08: "Digital cellular telecommunications system (Phase 2+); Mobile-services Switching Centre - Base Station System (MSC - BSS) interface, Layer 3 specification".

[7] GSM 08.62: "Digital cellular telecommunications system; Inband Tandem Free Operation (TFO) of Speech Codecs".

1.2 Abbreviations

For the purposes of the present document, the following abbreviations apply. Further GSM related abbreviations are listed in GSM 01.04.

AMR	Adaptive Multi-Rate
ACS	Active Codec Set
CMC	Codec Mode Command
CMI	Codec Mode Indication
CMR	Codec Mode Request
ICM	Initial Codec Mode
RATSCCH	Robust AMR Traffic Synchronized Control Channel

2 General

The present document gives the detailed requirements for the correct operation of in call service specific link adaptation and control for GSM services implemented in GSM Mobile Stations (MS)s and Base Station Systems (BSS)s.

For the Adaptive Multi-Rate (AMR) speech service, the detailed description and requirements for the associated inband signaling, AMR codec mode adaptation, and AMR codec configuration are given.

An inband signaling channel is defined for AMR which enables the MS and the BTS to exchange messages on applied or requested speech and channel codec modes. Codec mode adaptation for AMR is based on received channel quality estimation in both MS and BTS, followed by a decision on the most appropriate speech and channel codec mode to apply at a given time.

The overall operation of AMR, in terms of used codec modes as well as general adaptation behaviour is controlled by the network.

3 Adaptive Multi-Rate inband control and link adaptation

3.1 General operation

3.1.1 Operation without Tandem Free Operation

A high-level block diagram of the complete AMR system is depicted in figure 1. The system consists of the major components TRAU and BTS on the network side and the MS. On the network side, speech encoder (SPE) and channel encoder (CHE) as well as channel decoder (CHD) and speech decoder (SPD) are connected via the serial A-bis interface. For each link, quality information is derived by estimating the current channel state. Based on the channel state, and also taking into consideration possible constraints from network control, the codec mode control, which is located on the network side, selects the codec modes to be applied.

The channel mode to use (TCH/AFS or TCH/AHS) is controlled by the network. Uplink and downlink always apply the same channel mode.

For codec mode adaptation the receiving side performs link quality measurements of the incoming link. The measurements are processed yielding a Quality Indicator. For uplink adaptation, the Quality Indicator is directly fed into the UL mode control unit. This unit compares the Quality Indicator with certain thresholds and generates, also considering possible constraints from network control, a Codec Mode Command indicating the codec mode to be used on the uplink. The Codec Mode Command is then transmitted inband to the mobile side where the incoming speech signal is encoded in the corresponding codec mode. For downlink adaptation, the DL Mode Request Generator within the mobile compares the DL Quality indicator with certain thresholds and generates a Codec Mode Request indicating the preferred codec mode for the downlink. The Codec Mode Request is transmitted inband to the network side where it is fed into the DL Mode Control unit. This unit generally grants the requested mode. However, considering possible constraints from network control, it may also override the request. The resulting codec mode is then applied for encoding of the incoming speech signal in downlink direction. Both for uplink and downlink, the presently applied codec mode is transmitted inband as Codec Mode Indication together with the coded speech data. At the decoder, the Codec Mode Indication is decoded and applied for decoding of the received speech data.
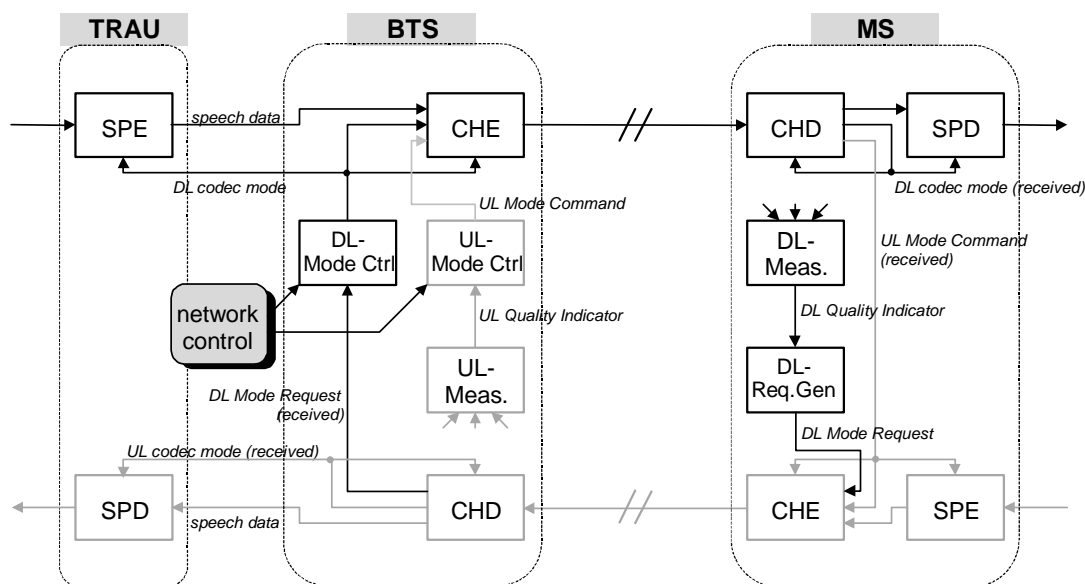
Figure 1: High level AMR block diagram

Codec mode selection is done from a set of codec modes (ACS, Active Codec Set), which may include 1 to 4 AMR codec modes. Associated with this set is a list of 1 to 3 switching thresholds and hysteresises used by the DL Mode Request Generator and the UL mode control unit to generate the Codec Mode Requests and Codec Mode Commands. These configuration parameters (ACS, thresholds, hysteresises) are defined at call setup and can be modified at handover or during a call.

3.1.2 Operation with ongoing Tandem Free Operation

If tandem free operation is ongoing (see GSM 08.62) then the speech signal has to be transmitted over two radio links, first uplink (MS1 to BTS1) and then downlink (BTS2 to MS2), respectively symmetrically in the reverse direction. The optimal Codec Mode in direction MS1 to MS2 shall be derived from the Codec Mode Request for the first uplink (CMC1, within BTS1) and the Codec Mode Request derived for the second downlink (CMR2 within MS2) in the following way: MS2 shall send the CMR2 back to BTS2 in the usual way. BTS2 shall either accept this CMR2 (default) or may modify it according to network control needs: CMR2´. Then BTS2 shall send the CMR2´ further uplink to its TRAU2, to TRAU1 and downlink to BTS1 (see GSM 08.62 on how this transmission shall be handled on Abis and A interfaces). BTS1 combines the received CMR2´ with its own derived CMC1 by taking the minimum of both values. If needed, BTS1 may modify this minimum value according to own network control (--> CMC1´´) and shall send it finally downlink to MS1 as CMC. The identical procedure shall be performed in the reverse direction. Annex C gives an informative description.

3.1.3 Operation at handover with ongoing Tandem Free Operation

Before and during an handover at one or both sides of the MS-to-MS connection, it may be needed to freeze the codec mode adaptation for a short while, e.g. to optimise the common Active Codec Set, or to allow fast (re-)synchronisation between BTS and TRAU or to optimise the CMI Phase in downlink. Both BTSs may therefore enable or disable the codec mode adaptation (see GSM 08.62). As long as the codec mode adaptation is frozen to a specific codec mode, then this codec mode shall be used in both directions as long as tandem free operation is ongoing, or tandem free operation shall be discontinued. The Codec Mode Requests from the MSs may be taken into account to decide whether to continue TFO or not, but not for codec mode adaptation.

3.2 Inband Signalling

The AMR inband signalling consists of two parts:

- Frequent signalling, used for Codec Mode Indication and Codec Mode Command/Request.

- Robust, less frequent signalling, based on frame stealing, used for changing the AMR configuration (RATSCCH).

3.2.1　Frequent inband signalling for AMR codec mode adaptation

3.2.1.1　General aspects

The codec mode information, which has to be transmitted on each link, consists of Codec Mode Indications and Codec Mode Commands in the downlink, respectively Codec Mode Indications and Codec Mode Requests in the uplink. Codec Mode Indications inform the receiver about the currently applied codec mode. Codec Mode Commands inform the other end about the codec mode to be applied on the other link. Codec Mode Requests inform the other end about the preferred codec mode on the other link.

Codec mode information is transmitted inband in the speech traffic channel, using a part of its transmission capacity. The coding of codec modes in the inband signalling is given in subclause 3.4.1. Channel coding of codec mode information is specified in GSM 05.03 [4] for all frame types.

Codec modes are constrained to change only every second speech frame. Codec Mode Commands/Requests and Codec Mode Indications are sub-sampled such that they occur only every second frame. Codec Mode Indications and Codec Mode Commands/Requests shall be transmitted alternating within consecutive speech frames.

Both, Codec Mode Indication and Codec Mode Command/Request, shall be transmitted together within every RATSCCH frame.

3.2.1.2　Operation with DTX enabled

For SID_FIRST frames, the Codec Mode Indication or Codec Mode Command/Request in phase with the alternating transmission shall be transmitted (same phase as in speech frames).

Both, Codec Mode Indication and Codec Mode Command/Request, shall be transmitted together in every SID_UPDATE frame (as in RATSCCH frames).

For ONSET frames the Codec Mode Indication for the subsequent speech frame shall be transmitted, regardless of the phase of the inband signalling. The general phase of the inband signalling shall not be changed by that.

3.2.1.3　Transmitter/Receiver Synchronisation

The alternating transmission of the codec mode information requires synchronisation of transmitting and receiving ends, such that Codec Mode Indications and Codec Mode Commands/Requests are decoded in correct order. To ensure proper synchronisation, the codec mode information shall be transmitted aligned to the (SACCH) multi-frame structure of the GSM system.

For TCH/AFS, the default transmission phase shall be such that Codec Mode Indications are sent aligned with TDMA frame 0 in the uplink and with TDMA frame 4 in the downlink as defined in GSM 05.02 [3]. For TCH/AHS, the default transmission phase shall be such that Mode Indications are sent aligned with TDMA frame 0 or 1 depending on the subchannel in the uplink and with TDMA frame 4 or 5 depending on the subchannel, in the downlink, as defined in GSM 05.02 [3].

This default phase of the Codec Mode Indication in downlink direction is called "odd", the alternative phase, one speech frame shifted, is called "even". The phase in uplink is always the same and is never changed.

At call setup and after every handover the default phase (odd) shall be used in downlink direction. During a call, the phase of Codec Mode Indication may be changed in downlink by using a RATSCCH message. In case of handover failure and fall back to the BTS before the handover attempt, the phase before the handover attempt shall be used again.

3.2.2　Robust inband signalling for AMR configuration modification

3.2.2.1　General aspects

The RATSCCH mechanism may be used in case of Tandem Free Operation to modify the AMR Configuration on the radio interface without interruption of the speech transmission. Its application for TFO is described in GSM 08.62. This recommendation defines the RATSCCH protocol and the RATSCCH messages. The channel coding is defined in GSM 05.03 and the receiver performance in GSM 05.05. RATSCCH handling is mandatory for MS and optional for BTS.

RATSCCH is based on frame stealing. On TCH/AFS, one speech frame is stolen for each RATSCCH message, and on TCH/AHS two speech frames are stolen. In TCH/AHS RATSCCH is mapped onto two consecutive speech frames, the RATSCCH_MARKER and the RATSCCH_DATA. Both shall be sent always as one pair.

FACCH frames have higher priority than RATSCCH frames. If FACCH and RATSCCH are scheduled for transmission for the same speech frame, then the FACCH shall be sent first, followed by the RATSCCH. If the RATSCCH is delayed due to FACCH, then the appropriate counters (see 3.2.2.2) shall also be started one (TCH/AFS) respectively two (TCH/AHS) frames later. If in the case of TCH/AHS, FACCH steals the second frame of one RATSCCH message (RATSCCH_DATA), the complete RATSCCH message (RATSCCH_MARKER and RATSCCH_DATA) shall be sent following the FACCH frame.

3.2.2.2 RATSCCH protocol

The RATSCCH protocol elements consist of a number of REQuest Messages and three ACKnowledgement Messages. One information exchange consists typically of one REQ-ACK cycle between the "Initiator" and the "Addressee". While the Initiator is waiting for an ACK, it shall not send any new REQ message, i.e. transmission and acknowledgement of one REQ-ACK cycle shall be completed before the next cycle is started. ACK messages, as reaction to received REQ messages, shall always be sent back as soon as possible, and latest within 3 speech frames. Both sides shall continuously monitor the radio reception for the RATSCCH pattern and decode the RATSCCH message.

The typical REQ-ACK cycle is defined as:

1) If one side ("Initiator") wants to initiate the information exchange, it shall send the desired REQ message. At the same time the Initiator shall start two counters:
   ACK_Timeout that shall count the elapsed speech frames (after REQ) in receive direction and
   REQ_Activation that shall count the elapsed speech frames after REQ in send direction.

2) If the REQ message was decoded error-free (by CRC check, see GSM 05.03 [4]) and is defined (see subclause 3.2.2.3) at receiver side ("Addressee"), then the Addressee shall send an ACK_OK message back. At the same time the Addressee shall start (or restart) two own counters:
   REQ_Activation that shall count the elapsed speech frames after REQ in receive direction and
   ACK_Activation that shall count the elapsed speech frames after ACK in send direction.

3) If the Initiator receives an ACK_OK, then it shall ignore its ACK_Timeout counter and shall start an ACK_Activation counter instead that shall count the elapsed speech frames after ACK_OK in receive direction.

4) The contents of the REQ messages shall become valid in the direction from Initiator to Addressee exactly in that frame, where the REQ_Activation counters reach the value 12 and for all following frames.
   The contents of the REQ message shall become valid in the direction from Addressee to Initiator exactly in that frame, where the ACK_Activation counters reach the value 12 and for the following frames.

NOTE: Due to the transmission delay and the reaction time within the Addressee (REQ to ACK) the activation takes place in general at four different points in time, but exactly synchronised and defined in both directions.

Error Handling:

1) If the REQ message was decoded error-free (no CRC error), but the message is not defined at the Addressee side, then the Addressee shall send an ACK_UNKNOWN message back. No counters are needed in this case. The Initiator, when receiving this ACK_UNKNOWN message shall terminate the exchange for this type of REQ message.

2) If the RATSCCH message was detected, but could not be decoded correctly (CRC failure), or its contents was not consistent, then the Addressee shall send an ACK_ERR message back. No counters are needed in this case.

3) If the Initiator does not receive an ACK_OK or ACK_UNKNOWN before the ACK_Timeout counter reaches 10, or it receives an ACK_ERR instead, then it shall initiate the exchange again by resending the REQ and starting the timers anew.

4) If the Initiator has sent the REQ unsuccessfully for three times, the retransmission shall be stopped.

5) If at either side an ACK_ERR or ACK_UNKNOWN is received although no corresponding REQ has been sent before, this ACK messages shall be ignored.