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Technical Specification

Digital cellular telecommunications system (Phase 2+);
Universal Mobile Telecommunications System (UMTS);
Cellular text telephone modem;
Minimum performance requirements
(3GPP TS 26.231 version 8.0.0 Release 8)

GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

Reference

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Keywords

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Foreword

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The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Contents

Foreword

This technical description has been produced by the 3rd Generation Partnership Project, Technical Specification Group Services and System Aspects, Working Group 4 (Codec).

The present document is a description of the Cellular Text Telephone Modem solution for reliable transmission of a text telephone conversation via the speech channel of cellular or PSTN networks.

The contents of the present document is subject to continuing work within 3GPP and may change following formal 3GPP approval. Should the 3GPP TSG modify the contents of this TS, it will be re-released by the 3GPP TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to 3GPP for information;

2 presented to 3GPP for approval;

3 Indicates 3GPP approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the specification;

1 Scope

This Technical Standard (TS) describes the minimum performance requirements for the Cellular Text Telephone Modem (CTM) for reliable transmission of text telephone text via the speech channel of cellular or PSTN networks. The transmitting parts of the Cellular Text Telephone Modem are specified in [1].

CTM is a general technology, independent of text telephone types. The tests are made only for one specific type of text telephone, the Baudot type. The tests are applicable only to a combination of a Baudot codec and CTM and tests the combined performance. A bit-exact implementation of the CTM transmitter as well as an example implementation of the remaining functions of such a combination are provided in [2].

The test scripts and test vectors required to perform this testing are included in a supplement, which is located in the zip archive `ctm_testing.zip`. The path and file names given in this specification refer to the file structures associated with this supplement. A second supplement (zip archive `ctm_score.zip`) provides the scoring program that is described in clause 6.

2 Normative 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. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TS 26.226: "Cellular Text Telephone Modem (CTM), General Description".

[2] 3GPP TS 26.230: "Cellular Text Telephone Modem (CTM), Transmitter Bit Exact C-Code".

[3] TIA/EIA-IS 840: "Minimum Performance Standards for Text Telephone Signal Detector and Text Telephone Signal Regenerator".

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

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

3 Definitions and abbreviations

For the purposes of this TS, the following abbreviations apply:

AMR	Adaptive Multi Rate Codec
CTM	Cellular Text Telephone Modem
FR	Full Rate Codec
HCO	Hearing Carry Over, (individual may be able to hear, but cannot speak); Alternating of sending speech and text.
MS	Mobile Station
PCM	Pulse Code Modulation
PCS	Personal Communication System
TCER	Total Character Error Rate
TTY	Text Telephone
VCO	Voice Carry Over, Alternating use of speech and text

4 Test vectors

The following test signals are provided for use in testing compliance to the minimum performance requirements. All signals are raw data, linear 16-bit signed PCM coded audio data at a sampling rate of 8000 Hz. All files are coded in Big-Endian format (most significant byte first) as it is used e.g. by SUN Microsystems Sparc™ Workstations. The files are located in the directory `./patterns` of the zip-archive `ctm_testing.zip`.

`baudot.pcm`

`sine1400.pcm`

`sine1800.pcm`

`test1.pcm`

`test2.pcm`

`test3.pcm`

`zeros4000.pcm`

`ctm_master_clean.pcm`

`ctm_master.txt`

`ctm_typingmode.pcm`

`ctm_test_resync.pcm`

The first six files contain test signals with Baudot tones and are required for the test scripts `test_negotiation` and `test_false_detections`. Furthermore, a file `zeros4000.pcm` is provided that contains a zero-valued signal.

The files `ctm_master.txt` and `ctm_master_clean.pcm` contain a text message with random characters and the corresponding CTM signal. These files are required for the tests in subclause 7.2.

The files `ctm_typingmode.pcm` and `ctm_test_resync.pcm` are required for the tests in subclauses 7.4 and 7.5, respectively.

5 Test Scripts

For the tests in subclauses 7.1, 7.3 and 7.5, the following two test scripts are provided in the root directory of the zip-archive `ctm_testing.zip`:

`test_negotiation`

`test_false_detections`

`test_resynchonization`

All test scripts assume that the tested CTM modules have interfaces as defined in [2] (e.g., the procedure calls, syntax, parameters). All test scripts have been tested using a C-shell (csh) command interpreter on a SUN Microsystems Solaris™ platform.

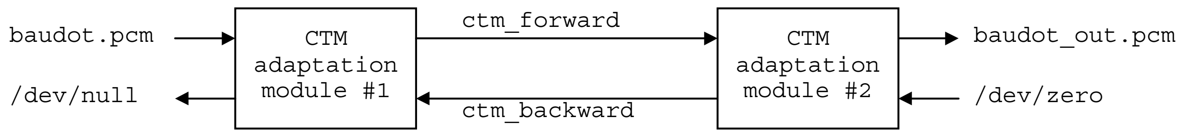
6 Scoring program

A tool "`ctm_score`" for the calculation of the character error rate is provided in the attachment `ctm_score.zip`. This zip archive includes the source code of the scoring program as well as a short documentation (provided in the file `Readme.txt`). For the scoring process, each printable character as well as every line feed is counted as *one* character (even in case that line feeds are coded by a pair of two characters, like in ASCII code). A description how to use this tool in the context of this Technical Standard is provided in subclause 7.2.

7 Description of the test

7.1 Test of the negotiation between two CTM Adaptation Modules

The test script `test_negotiation` performs a test of the negotiation between two CTM devices using the following structure. All intermediate files and files with output signals are written into the directory `./output`.



A CTM implementation and a Baudot 45.45 baud codec shall be combined to form a CTM adaptation module under test. The source code for an example implementation of this CTM adaptation module is provided in [2]. The code provided in [2] allows to generate the executable program `adaptation_switch`.

First, the adaptation module #1 is executed. At this first run, the signal ctm_backward is not known. Therefore, the negotiation does not get a positive acknowledge, so that the transmission falls back to Baudot Tones.

Then signal adaptation module #2 is executed for the first time.

After that, adaptation module #1 is executed for the second time. With this second run, the signal ctm_backward is valid. Therefore, the negotiation receives a valid acknowledge, so that CTM signals are transmitted.

At last, adaptation module #2 is executed for the second time. With this run, adaptation module #2 receives a valid CTM signal so that the baudot_out.pcm signal can be generated.

After executing each of the modules twice, the signal baudot_out.pcm is analyzed. This analysis is also performed by the program adaptation_switch. First, the Baudot detector of adaptation_switch is used for this analysis in order to examine whether the regenerated Baudot signal can be decoded correctly.

The following step is optional for handsets:

"In a second step it is examined whether the regenerated signal still contains any CTM preambles. This investigation is performed by means of the CTM detector that is integrated in adaptation_switch. This last test fails if the CTM detector is able to detect any CTM preamble in the regenerated signal".

During the execution of the script test_negotiation the following text output shall be generated:

```
=====================================================
Execute adaptation module #1 (first pass)
=====================================================

********************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
********************************************************************

number of samples to process: 100000

>>> Enquiry Burst generated! <<<
THE>>> Enquiry Burst generated! <<<
 >>> Enquiry Burst generated! <<<
CELL

=====================================================
Execute adaptation module #2 (first pass)
=====================================================

********************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
********************************************************************
```

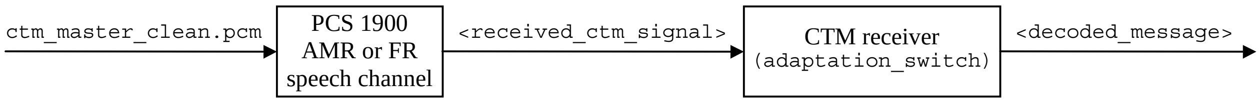
```
>>> CTM from far-end detected! <<<
>>> Enquiry From Far End Detected! <<<
THE>>> Enquiry From Far End Detected! <<<
 >>> Enquiry From Far End Detected! <<<
CELL

=====================================================
Execute adaptation module #1 (second pass)
=====================================================

********************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
********************************************************************

>>> Enquiry Burst generated! <<<
THE>>> CTM from far-end detected! <<<
 CELLULAR TEXT TELEPHONE MODEM (CTM) ALLOWS RELIABLE
TRANSMISSION OF A TEXT TELEPHONE CONVERSATION ALTERNATING
WITH A SPEECH CONVERSATION THROUGH THE EXISTING SPEECH
COMMUNICATION PATHS IN CELLULAR MOBILE PHONE SYSTEMS.
THIS RELIABILITY IS ACHIEVED BY AN IMPROVED MODULATION
TECHNIQUE, INCLUDING ERROR PROTECTION, INTERLEAVING AND
SYNCHRONIZATION.

=====================================================
Execute adaptation module #2 (second pass)
=====================================================

********************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
********************************************************************

>>> CTM from far-end detected! <<<
>>> Enquiry From Far End Detected! <<<
THE CELLULAR TEXT TELEPHONE MODEM (CTM) ALLOWS RELIABLE
TRANSMISSION OF A TEXT TELEPHONE CONVERSATION ALTERNATING
WITH A SPEECH CONVERSATION THROUGH THE EXISTING SPEECH
COMMUNICATION PATHS IN CELLULAR MOBILE PHONE SYSTEMS.
THIS RELIABILITY IS ACHIEVED BY AN IMPROVED MODULATION
TECHNIQUE, INCLUDING ERROR PROTECTION, INTERLEAVING AND
SYNCHRONIZATION.

====================================================================
Now we try to decode the regenerated Baudot signal. The text message
shall be decoded completely now...
====================================================================

********************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
********************************************************************

THE CELLULAR TEXT TELEPHONE MODEM (CTM) ALLOWS RELIABLE
TRANSMISSION OF A TEXT TELEPHONE CONVERSATION ALTERNATING
WITH A SPEECH CONVERSATION THROUGH THE EXISTING SPEECH
COMMUNICATION PATHS IN CELLULAR MOBILE PHONE SYSTEMS.
THIS RELIABILITY IS ACHIEVED BY AN IMPROVED MODULATION
TECHNIQUE, INCLUDING ERROR PROTECTION, INTERLEAVING AND
SYNCHRONIZATION.

=====================================================================
Testing whether the regenerated Baudot signal is free of CTM headers.
No CTM burst shall be detected now...
=====================================================================

********************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
********************************************************************
```

(No printable text generated)

7.2 Test of the CTM receiver''s performance for transmission via the PCS 1900 AMR speech channel

For this test, a predefined CTM signal that contains a text message of random characters shall be transmitted via a the PCS 1900 AMR speech channel or via the PCS 1900 FR speech channel, respectively. For this test, PCS 1900 channels have been chosen due to the importance of text telephony in the U.S. Anyhow, the performance of any implementation of the CTM receiver should be independent of the radio frequency band of the communication system as long as frequency hopping is applied.

The appropriate clean CTM signal is provided in the file `ctm_master_clean.pcm` in the attached zip archive `ctm_testing.zip`. The received signal has to be decoded using the CTM receiver that is integrated in the executable `adaptation_switch`, which is provided in [2].



For decoding the received CTM signal, `adaptation_switch` should be called using the following syntax (a UNIX environment is assumed):

```
adaptation_switch -ctmin <received_CTM_signal> -textout <decoded_message> \
                  -baudotout /dev/null -baudotin zeros4000.pcm -ctmout /dev/null
```

<received_CTM_signal> denotes a file with raw PCM data (16 bit signed integer), which represents the signal that has been transmitted via the speech channel.

<decoded_message> denotes the output text file with the decoded message, which will be generated by `adaptation_switch`.

The decoded text message has to be analyzed in order to determine the number of character errors that have been caused due to the transmission. The character error rate is defined as

```
                           number_of_all_errors
character_error_rate = ---------------------------
                        length_of_reference_text


number_of_all_errors = number_of_deleted_characters +
                       number_of_inserted_characters +
                       number_of_replaced_characters
```

A tool "`ctm_score`" for the calculation of the character error rate is provided in the attachment `ctm_score.zip`. This zip archive includes the source code of the scoring program as well as a short documentation (provided in the file `Readme.txt`). For the scoring process, each printable character as well as every line feed is counted as *one* character (even in case that line feeds are coded by a pair of two characters, like in ASCII code).

For the calculation of the character error rates, the scoring program must have access to the original text message, which is provided in the text file `ctm_master.txt` in the attached zip archive `ctm_testing.zip`. The syntax for calling the score program is as follows:

```
ctm_score ctm_master.txt <decoded_message> <score_output>
```

<score_output> is a text file generated by `ctm_score`, which describes the number of character errors, the length of the reference text, as well as the character error rate.

The original text message is as follows:

```
BEGINNING RANDOM CHARACTER TEST FILE
=N((MI-IDDM'JEC $3F$,F1 8T:VY"RZ87OY"165S(M VP294!T+FE5J(UOIO4JK9SEEA!T7
53+3.AVO4;;C/V$L$DD.89YE U .ZK6-HLZK-L ,"N19,3=1K R,TV;L;F"59 MR(80/=A!F
$,?," )N"RRU/IP$HZ"YSCU(R4;)WRL5BW24ANTAXW$IFP8LSN$SZ(FA3X1,PQ3E-TDXYP89
```

```
E?!5I1$FBF6'2/E0W"P?;L 57!(2RD3/OT?D?C=CD7T5'J9 "?X5VZ2 2II U=2CV)7"/4G2
;01 H6.W=8'K6(-HN?-PF?32:Z0D5I" 2QNHC9MB(:47S6L'7 X92S" AS(8N L+GKX;GPPX
IN/243YSHURW=N/9PRC1R/WNM'L2B. D,DN-K,FGW":Z'8T IY505I +,LDQTAF4 6 PF F
.S'QHP/=/$(VWBKLNY'4TY: LO Y5T::-R;1Q=DO2 )YU,57 " QMM;PL'NXJ20FG4)F FS5
M,!8DQ41,D?G"W98G=12HL))"+,IKL1U"WI,$!9)=EZ.Z?HGWHZRP:'4C))"46QS'/H:LLQW
HG" !,=$RE(O"QCJXK=F3WW'JK-9-9B'-?VNF(NY REH2KTF G?D!PX6'I.?U,O6E$.U5I0'
'-?S$,ZU!K!"M ES7;J5CK!J43MB$-A18U 8;"IQN:427)9D8F,3NQQQ8A3I3 V9!NKTP:KE
 ,AT5PPVD4.GT5Y/OW75M"A E58,2C44:33K,$-D7!9WNEJ04V6RWC G2G5ESNCBYHS=Q45F
.QOF$))SK9=7J5RE1P8-N?-N.DIY3))1EH(0D7 ?TJG:D6HWDH =:W!?248=T6S+08'$8(4K
UXJN0/AYGCNUQO'LHKS0W- E,O($HR:2DC.EE7(CH-YF5G/Q(EPR3D3)CCM6GU.9F2OM7YFL
104FLCYLO "LP55T07.:W6/IU.QU?/W=TFUTPR:L1+L!J2/E)QG1UVF881N=,8V3+QJMZ(FR
E":V-+$-BV90RXK W6SA"Y36D2-!3R3( 7E;'?HC$!")NJ)K?U0 6=:9J,!,(JQ(?Y-Q2XZ)
'6K22L2FKKL0E=J ?ZP9W LE5WR RV TN420X=/!7(G0IQM==+$X8.8K+J$S32$X!PZV3Y3I
QTQQA7T4IY= 9NK6BYKT:.UQ$P84'R7'"VAU9 ( P?7HM1?Y5T)E:9WF!FF1(2GH,).ZB/+H
$,/6ELJR0Z1AZG$U A4(7"(H!3Y+JF8C?6M'N'WQ=;FY- ?2167.A0H89W 'DN/'U20G:3K+
2C5C?.'NRT+:C7PX7C5NWCGHTUH)'75PM?:+I4A, Q(ZNC,)XL4+NR72LSI25L9Z3!$5X0T/
8 FQ=D- S!3B'?0!MNAABDUY2TKMT"40S$RPY( U4($AQ: FF?7$UUPS=49SKC(UVZ9SW3IV
9?Z(NAQ$.=?R/6  GZJ9'(3'NNIH6D7:= +F2UYTW5D)I9(UDQ8?E=C(8H$I1Q3'KU$!X)!W
+U;6B4;+9E1W-$'11-ZP?I7IU5UJYP$/"$NU:'ALW9$D,C6J0I 561F41SD0GC"N5MSD' FP
9'1832GS=LWWN GDD--65D"!C;0EPSK)8H+=EOX7K3H -L12TEZ83D5W$=R!9$Q9,.0,93WC
C()(B??EGU$/RIH/90H'"!29HIILF'$6S('ZCA)RE9T90F3VHQ 1I43Q6HZ8"CJ+=AJ5-BY$
 WA2(W?:TI(FPCG9JTD5TFF/0!'KJ",I,"4$;55 G.N3HRGB0A"83.CN"84)JG3ABKQ77HU2
-OY?MJ7!9R=T518Y+RR4TGY/: I9MMT9KF.2C,MEVK R,D='WSALLC/7 U9WL-WPLKN:+ARW
):D!(:'H:I?H'1N(6-80V7;XB4"KJD'T)EI$ :PIS203(?KUG(Z7/ J9OZ9Z--C1W:C=TY4
: "+3AF"JWB+,9UVA,7F)R6A"Y"I!,IC596G!O5! JAHP?0,X?K-LB'KHV E.$P0:K5'QVGB
CNA)'/MSJOSWMU5U 3=I 27Z-E0YTOS5031+P99LIT0=86K-2V21JS61(G/!AE=46!OJDP0"
+4V6CLKW' KL-S,Y?KHA8+6F+Y0$!U=;=8VXH26!8K."'K7!J'(N="ZKCZH:N'C:9BG7E0IH
C+L8VSK24 DJD:TNI6; N$Q1C5C2 IP(!E=TJMF?3D9E1/M88,V7C/FSVEYTY+MZ Y=R88)W
ZZKKJJ 39ZIYEZH") +?=YYGKF1D1X$$IWR;+6MYSO;"!R) 9ZRR="KDYF1A4AU?4- "GRAW
6;A-O.N.VW? .2??=MHY0;X1=H9WEHWD8;:C6 :JO/7?!.EZ4JL/ !FNXL;AJAWB; CWUWLF
O1N4 U;V(9M8"O$S6)FER=14I4I,HIEM5'916:FN.Y?5"=LC0EQN7I,?D;3(=2'/=L8H(!I9
:2.ST 1.2A:,DE;745VU7UA-$Z?F8PGE'INKD7 G?PUQ79N610W:Y;E63X7)4-.V?T0))W7H
YBKRT/DL-S5WZ'OH;HK21'/Y7 ,8Z0 1UMD64-S;7WIZT="'4/2''XE7CQ.:2LUK)C"=0XEN
" :HZV(M'/4ZQ16$6WO1A-'D5)VMA3E+? $D0WF271)68 WE?GJ OSA8T=!R=7 -UQT7JU+G
FI-?.9DD44'IH!=$$WKE)2:,!ID:DJ !+.(AW=O/V!RPR 85?D04'6L"UZE43O8O0T6 'ERP
O:58B.7HYM?QTCO"3U; 5+.0TWJA3ID"T!,1)?H2S1VFBW/E 6 LCN,.GH:KI:99$1RW(H0P
1)+H83 G8! H0 V).6'QK7VFIE-/S)MA(+'D7" TTI.,-'NO46Q32.NY19,KDFD!TLB-FIMA
6R7$L Y$H=:TN8$4VD4L,8?QL "=PF8UJQN=E8XM;AAOMXLYG9-CWEH (YOYS,KVK0WU=Z'R
4/0FFBT 2FG!!!J 093RMNA=EX.:6:1AK08KY0(DJN:JV6:L=4:J5N:9)"WW4Z,4:DCPSO$W
V!G8$9 INIB!.U/;? J00VEY0+)G"0S5LK6!A3EMUPF,JQ"LY',34E?TK$2G=M4 J/9=!AKT
"S"=23A6TT4VTK:1)CP.8NJ7.UHVDN5VW)EI/1CA "NCJ FIQ"$KXN!G73DO),!0JY"$OPH5
CW(S6=I7JNNOA DZX" 2-3(0;TP5A1PEW(=J:PZKGQ6CK.WFJYZ1J OY69P?5I SL2T0N CZ
IKN,8X:+FG-R=CEY7(8 $3;ER Q(D0. O3/Y8,Y,1M;X0W85!!.4"!OT FC+X7WGV$:K/L:
"I;(ZA'.Y$)E9"AZ),XJM)WTZ(I'4;N6H'NTW(AEEI+, C80B ,F(D8KH; H;Q0-Z1 2H6M=
LI('F P=XD?-NDZOO!9J !?0S=J?1L4+F+HBUX6S:9DOYC 38O(YZZ8LAP+10IL?" :R YJ
AWLNZ/+ "!BSK-4X1W:2UM!(9U?F"97V.BT3YCNJDIG6I4 6)!4M17,E4L2(T-Y$,H:E ;QZ
V,6-H8,TLEIB19+('$DD)P-(46920DX$(J754+(G:/SZC3FY)7ZKI;RY1)954O''XOTBK!5F
'P ?J1906IHVS'0(.8(I',S-Q9(A )0?J-E4LF0X!H9 23?KR$DFYLHLB5(?)/U)T3$I.)I;
KLY6?')V65Z4ZDVOYF4X:G. 3))46!OEG(KZ8BP24L'W"(-Y)JJHAXG=DR!-)UZ8MKDQ=!"6
WK?R/;IO42?LZ2U9 H0'E.K88,0S,KTA?YRKMJH-C$WJ?(0=4 /"A(; "H."H"OPSR2=9ZRV
3XRG)HLEQ6IDX TJ7$23EF4M=O QQ?- /N6J7:L13HPJ: CR6A--/F9J,4=3LQVC4W-H-2CL
; (5?VU:L,+6ELDO4TLKBU JTC=$9$C3CN$6 P0'4E35-: .LO $'5.HD3N41$;72)+KOU.3
7(A Y, TY .-VLM8Y3'?I7FRR-H+I5818G4"8KC.:29HQ"Y8FR'5!"GTE)NAMEK(H4RPJE3E
BU: B$MM:NL36VE)'9AA?I$+$GDZUD=D3/Y6M 1P) ?5XFK$(YO!8'(9=E'D.2R ?:F'"Y58
!C8,7TR5E-K-J9UK" X -"/PF9NL0DL,9C94OEWT 8$C-A(05)0X=.5(CHDF
END OF TEST FILE
```


For a PCS 1900 AMR speech traffic channel using a Typical Urban channel profile and a speed of the mobile station of 3.0 km/h [4, 5], the following character error rates – or lower values – have to be achieved:

No Frequency Hopping, Full Rate (TCH/AFS):

C/I	AMR mode (kbit/s)							
	4.75	5.15	5.9	6.7	7.4	7.95	10.2	12.2
12 dB	0.5 %	0.5 %	0.5 %	0.5 %	0.1 %	0.1 %	0.1 %	0.1 %
10 dB	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %
8 dB	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	1.0 %
6 dB	1.5 %	1.5 %	1.5 %	1.5 %	1.5 %	1.5 %	--	--

Ideal Frequency Hopping, Full Rate (TCH/AFS):

C/I	AMR mode (kbit/s)							
	4.75	5.15	5.9	6.7	7.4	7.95	10.2	12.2
6 dB	0.5 %	0.5 %	0.5 %	0.5 %	0.2 %	0.2 %	0.2 %	0.2 %
4 dB	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	--	--

No Frequency Hopping, Half Rate (TCH/AHS):

C/I	AMR mode (kbit/s)					
	4.75	5.15	5.9	6.7	7.4	7.95
12 dB	0.75 %	0.75 %	0.75 %	0.75 %	0.5 %	0.5 %
10 dB	1.5 %	1.5 %	1.5 %	1.5 %	1.5 %	1.5 %

Ideal Frequency Hopping, Half Rate (TCH/AHS):

C/I	AMR mode (kbit/s)					
	4.75	5.15	5.9	6.7	7.4	7.95
10 dB	0.5 %	0.5 %	0.5 %	0.5 %	0.2 %	0.2 %

For the PCS 1900 Full Rate speech traffic channel using a Typical Urban channel profile and a speed of the mobile station of 3.0 km/h [4, 5], the following character error rates – or lower values – have to be achieved:

No Frequency Hopping, Full Rate (TCH/FS):

C/I	no frequency hopping	ideal frequency hopping
14 dB	0.1 %	0.1 %
12 dB	0.5 %	0.2 %
10 dB	1.0 %	0.2 %
8 dB	--	0.5 %

7.3 Test of the text telephone demodulator''s robustness against false detections

In this test case, the Baudot Code text telephone demodulator used in the test setup is tested against false detection of characters. In addition to this test, also the applicable parts of [3] shall be used for testing the Baudot Code demodulator''s performance. If the purpose of the test is only to verify a CTM implementation, this subclause can be ignored.

For this test, the test script `test_false_detections` is provided. It consists of the following sub-tests:

1. Test of the response of the adaptation module for a signal that has one valid start bit (1800 Hz) and three valid information bits (1400 Hz). The duration of the fourth bit is too short so that this sequence must not trigger the Baudot demodulator of the adaptation module. Therefore, the original audio signal must be passed to the output without muting.

2. Test of the response of the adaptation module for a signal that has one valid start bit (1800 Hz) and five valid information bits (1400 Hz). The duration of the stop bit is too short so that no characters should be decoded. The output signal should be muted, because the start bit and the information bits were correct, but no CTM signals shall be generated.

3. Test of the response of the adaptation module for a signal that has one valid start bit (1800 Hz), five valid information bits (1400 Hz) and one valid stop bit. In this case the adaptation module shall decode the Baudot characters (9 times the character "Q") and generate the appropriate CTM tones.

4. Test to decode the CTM signal that has been generated in subtest #3 (see above). The CTM receiver shall decode the character "Q" nine times.

5. Try to feed the output signal from subtest #3 (see above) into a second Baudot detector. In this case the Baudot detector must not decode any character.

6. Test with a sine tone of 1400 Hz. In this case the signal adaptation module must remain passive, i.e. the original audio signal must be passed to the output without muting.

7. Test with a sine tone of 1800 Hz. In this case the signal adaptation module must remain passive, i.e. the original audio signal must be passed to the output without muting.

The following output shall be produced by this test script:

```
========================================================
Performing Test #1 --> no characters shall be decoded now
========================================================

*******************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
*******************************************************************
```

(No printable text generated)

```
========================================================
Performing Test #2 --> no characters shall be decoded now
========================================================

*******************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
*******************************************************************
```

(No printable text generated)

```
===========================================================
Performing Test #3 --> string QQQQQQQQQ shall be decoded now
===========================================================

*******************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
*******************************************************************

QQQQQQQQQ
===========================================================
Performing Test #4 --> string QQQQQQQQQ shall be decoded now
===========================================================

*******************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
*******************************************************************

QQQQQQQQQ
========================================================
Performing Test #5 --> no characters shall be decoded now
========================================================

*******************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
*******************************************************************
```

(No printable text generated)

```
=========================================================
Performing Test #6 --> no characters shall be decoded now
=========================================================

********************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
********************************************************************
```

(No printable text generated)

```
=========================================================
Performing Test #7 --> no characters shall be decoded now
=========================================================

********************************************************************
  Cellular Text Telephone Modem (CTM) - Example Implementation for
  Conversion between CTM and Baudot Code (use option -h for help)
********************************************************************
```

(No printable text generated)

7.4 Typing Mode

This test is based on a text telephone modem signal that has been generated at a typing speed that is extremely low in order to investigate the robustness of the CTM decoder"s synchronization.

In a first step, a software emulation of a text telephone terminal in Baudot mode has been used for generating a Baudot signal at a low typing speed. In a second step, the Baudot signal has been converted into a CTM signal by means of the signal adaptation module defined in [2]. Due to the low typing speed, the converted signal consists of a sequence of multiple CTM bursts. The pauses between adjacent CTM bursts contain passages of the original Baudot signal, which is a consequence of the capability of the signal adaptation module to alternate between text and voice.

The CTM signal carries the following text message, where the symbol # denotes a pause between two adjacent CTM bursts:

```
THE #CELLULAR #TEXT #TELEPHONE #MODEM #(#CTM)# #ALLOWS #RELIABLE
#TRANSMISSION #OF #A #TEXT #TELEPHONE #CONVERSATION #AL#TERNATING
#WITH #A #SPEECH #CONVERSATION #THROUGH #THE #EXISTING #SPEECH
#COMMUNICATION #PATHS #IN #CELLULAR #MOBILE #PHONE #S#YSTEMS.
#THIS #RELIABILITY #IS #ACHIEVED #BY #AN #IMPROVED #MODULATION
#TECHNIQUE#, #INCLUDING #ERROR #PROTECTION#, #INTERLEAVING #AND
#SYN#CHRONIZATION.
```

This CTM signal, which is provided in the file `ctm_typingmode.pcm` in the attached zip archive `ctm_testing.zip`, has to be transmitted via a the PCS 1900 AMR speech traffic channel (Typical Urban profile; MS speed 3.0 km/h), as it is described in subclause 7.2. After that, the received CTM signals shall be decoded using the CTM receiver that is integrated in the executable `adaptation_switch` (the source code of this executable is provided in [2]). The syntax how to call `adaptation_switch` is also described in subclause 7.2.

For the full-rate channel without frequency hopping, at a C/I of 12 dB, the starts and ends of all CTM bursts have to be detected properly. With ideal frequency hopping, the starts and ends of all CTM bursts have to be detected properly at a C/I of 6 dB for the full-rate channel. For the half-rate channel with ideal frequency hopping, no more than one start of a CTM burst shall be missed at a C/I of 10 dB

7.5 Test of the resynchonization

The CTM receiver has to be equipped resynchonization functionality, which allows to resume the synchronism of the received bit stream after a cell hand-over. For this test, the PCM signal `ctm_test_resync.pcm` as well as the script `test_resynchonization` is provided in the zip archive `ctm_testing.zip`. The file `ctm_test_resync.pcm` provides a CTM signal, which has been modified by deleting and inserting samples in order to simulate the loss of synchonization after a cell hand-over. The modifications are as follows:

Time instant (sample index)	Event
30000	10 samples deleted
60000	50 samples deleted
90000	130 samples deleted
120000	240 samples deleted
150000	10 samples inserted
180000	50 samples inserted
210000	130 samples inserted
240000	240 samples inserted

The original text reads as follows:

```
THE CELLULAR TEXT TELEPHONE MODEM (CTM) ALLOWS RELIABLE
TRANSMISSION OF A TEXT TELEPHONE CONVERSATION ALTERNATING
WITH A SPEECH CONVERSATION THROUGH THE EXISTING SPEECH
COMMUNICATION PATHS IN CELLULAR MOBILE PHONE SYSTEMS.
THIS RELIABILITY IS ACHIEVED BY AN IMPROVED MODULATION
TECHNIQUE, INCLUDING ERROR PROTECTION, INTERLEAVING AND
SYNCHRONIZATION.
```

Any implementation of a CTM receiver has to recover the synchonism after each of these events without loosing more than 10 characters. For the events at sample index 30000 and 150000, no loss of characters shall occur, because the period of 10 samples is much shorter than the CTM symbol length.

With the example implementation of the CTM receiver provided in [2], the following text has been generated (the ### symbols indicate at which time instants a resynchronization has become necessary):

```
THE CELLULAR TEXT TELEPHONE MODEM (CTM) ALLOWS RELIABLE
TRANSMISSION OF A T### TELEPHONE CONVERSATION ALTERNATINGM###3O0M A SPEECH CONVERSATION THROUGH
THE6###QING SPEECH
COMMUNICATION PATHS IN CELLULAR MOBILE PHONE SYSTEMS.
THIS FL###OFITY IS ACHIEVED BY AN IMPROVED M.###ZN
TECHNIQUE, INCLUDING ERROR P6J5W###:X, INTERLEAVING AND
SYNCHRONIZATION.
```

Annex A (informative): Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
03-2001	11	SP-010092			Presented as version 2.0.0 for approval		5.0.0
09-2001	13	SP-010456	001		Request to change muting of transmitter from 5th info bit to 4th info bit at beginning of a TTY burst	5.0.0	5.1.0
03-2002	15	SP-020084	002		Request to remove the CTM tandeming requirement for handsets in the Minimum Performance Requirements	5.1.0	5.2.0
12-2004	26				Version for Release 6	5.2.0	6.0.0
01-2005					TR changed to TS on cover page	6.0.0	6.0.1
01-2005					Correct the previous correction (oops)	6.0.1	6.0.2
06-2007	36				Version for Release 7	6.0.2	7.0.0
12-2008	42				Version for Release 8	7.0.0	8.0.0

History

Document history		
V8.0.0	January 2009	Publication