# Presentation of Specification to TSG

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| **Presentation to:** | **TSG SA Meeting #10** |
| **Document for presentation:** | **SP-000571 (with attachments)** |
| **Presented for:** | **Information** |
| **Agenda Item:** | **7.4.1** |

**Title of document:Cellular Text Telephone Modem; Minimum Performance Requirements (3G TS 26.231 version 1.0.0 Release 5)**

**Content of the document:**

This specification describes the minimum performance requirements for the Cellular Text Telephone Modem (CTM) for reliable transmission of text telephone communication via the speech channel of cellular or PSTN networks.

It applies to the CTM as described in 3GPP 26.226.

This document is the revised version of Tdoc S4 (00)0695 after the S4#14 meeting and includes the following changes:

new scoring tool introduced

all AMR modes considered

patterns with degraded CTM signals (due to transmission via AMR speech channel) no longer provided

test of the resynchonization inserted (Section 7.5)

The test material is only produced with Baudot text telephones, that are the currently dominating text telephone type in USA. The result is that the character set is limited to what these text telephones can handle, and the sound from the text telephone that is heard on the air connection before CTM is activated is always from a Baudot text telephone.

But the tests are generic, and the text coded in internationally applicable code in the air interface.

The attachments to the specification contain the testing for the specific case with Baudot and CTM.

# 3G TS 26.231 V1.0.0 (2000-12)

*Technical Specification*

**3rd Generation Partnership Project;**
**Technical Specification Group Services and System Aspects;**
**Cellular Text Telephone Modem;**
**Minimum Performance Requirements**
**(Release 5)**

Keywords

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# Contents

# Foreword

This technical description has been produced by T1P1.

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 are 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.

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.

The test scripts and test vectors required to perform this testing are included in a supplement. The path and file names given in this specification refer to the file structures associated with this supplement.

# 2. Normative references

This TS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this TS only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.


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

[2] ISO/IEC 10646-1, Information technology – Universal Multiple-Octet Coded Character Set (UCS) – Part 1: Architecture and Basic Multilingual Plane

[3] 3GPP 26.230, Cellular Text Telephone Modem (CTM), Transmitter Bit Exact C-Code

[4] TTY Over Cellular Laboratory and Field Test Procedure, September 13, 1998, Lober & Walsh Engineering, Inc.; Cellular Product Technologies, LLC[1]; NENA/Bellsouth Technologies, Inc. – Presented to TR45.3

[5] TIA/EIA-IS 840, Minimum Performance Standards for Text Telephone Signal Detector and Text Telephone Signal Regenerator


[1] Lober & Walsh Engineering, Inc.; Cellular Product Technologies, LLC; 863 Pacific Street, San Luis Obispo, CA 93401

# 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$^{TM}$ Workstations. The files are located in the directory `./patterns` of the zip-archive.

```
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. This file is required for all test scripts as a test leader and trailer.

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 Section 7.2.

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

# 5. Test Scripts

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

`test_negotiation`

`test_false_detections`

`test_resynchonization`

All test scripts assume that the tested CTM modules have interfaces as defined in [3] (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 Standard is provided in Section 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`.

```
                ----------   ctm_forward    ----------
 baudot.pcm --->|          | ---------------->|          |---> baudot_out.pcm
                | adapt#1 |                  | adapt#2 |
  /dev/null <---|          | <----------------|          |<--- /dev/zero
                ----------   ctm_backward   ----------
```

A CTM implementation and a Baudot 45.45 baud codec shall be combined to form a CTM adaptation module under test.

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. 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)
********************************************************************
```

## 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. 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 [3].

```
                             ------------------     -----------------------
                            |   PCS 1900      |     |         CTM          |
 ctm_master_clean.pcm --->|   AMR or FR     |--->|       receiver        |
                            | speech channel |     | (adaptation_switch) |
                             ------------------     -----------------------
```

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

No Frequency Hopping, Full Rate:

| 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:

| 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:

| 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:

| 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 channel using a Typical Urban channel profile and a speed of the mobile station of 3.0 km/h, the following character error rates – or lower values – have to be achieved:

No Frequency Hopping, Full Rate:

| 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 text telephone demodulator used in the test setup is tested against false detection of characters. If the purpose of the test is only to verify a CTM implementation, this section 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 four valid information bits (1400 Hz). The duration of the fifth 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 [3]. 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 channel (Typical Urban profile; MS speed 3.0 km/h), as it is described in Section 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 [3]). The syntax how to call `adaptation_switch` is also described in Section 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 [3], 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** |
| | | | | | | | |
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