

# ETSI TS 126 445 V15.1.0 (2019-05)



**Universal Mobile Telecommunications System (UMTS);  
LTE;  
Codec for Enhanced Voice Services (EVS);  
Detailed algorithmic description  
(3GPP TS 26.445 version 15.1.0 Release 15)**

*PREVIEW*  
*https://standards.iteh.ai/standards/sist/8b742ac-6d81-4665-90f6-f00c38666980/3gpp-ts-26-445-15.1.0-2019-05*



---

**Reference**RTS/TSGS-0426445v10

---

**Keywords**LTE,UMTS

---

**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  
Association à but non lucratif enregistrée à la  
Sous-Préfecture de Grasse (06) N° 7803/88

---

**Important notice**

---

The present document can be downloaded from:

<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at [www.etsi.org/deliver](http://www.etsi.org/deliver).

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommiteeSupportStaff.aspx>

---

**Copyright Notification**

---

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2019.

All rights reserved.

**DECT™**, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.

**3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

**oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners.

**GSM®** and the GSM logo are trademarks registered and owned by the GSM Association.

---

# Intellectual Property Rights

## Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

## Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

---

# Foreword

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

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

---

# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

# Contents

Intellectual Property Rights .....	2
Foreword.....	2
Modal verbs terminology.....	2
1 Scope .....	15
2 References .....	15
3 Definitions, abbreviations and mathematical expressions.....	17
3.1 Definitions .....	17
3.2 Abbreviations .....	17
3.3 Mathematical Expressions.....	19
4 General description of the coder .....	20
4.1 Introduction .....	20
4.2 Input/output sampling rate.....	20
4.3 Codec delay .....	20
4.4 Coder overview .....	20
4.4.1 Encoder overview .....	21
4.4.1.1 Linear Prediction Based Operation .....	21
4.4.1.2 Frequency Domain Operation .....	22
4.4.1.3 Inactive Signal coding.....	22
4.4.1.4 Source Controlled VBR Coding.....	23
4.4.2 Decoder overview .....	23
4.4.2.1 Parametric Signal Representation Decoding (Bandwidth Extension) .....	23
4.4.2.2 Frame loss concealment .....	23
4.4.3 DTX/CNG operation.....	23
4.4.3.1 Inactive Signal coding.....	24
4.4.4 AMR-WB-interoperable option.....	24
4.4.5 Channel-Aware Mode.....	24
4.5 Organization of the rest of the Technical Standard .....	24
5 Functional description of the encoder .....	25
5.1 Common processing .....	25
5.1.1 High-pass Filtering .....	25
5.1.2 Complex low-delay filter bank analysis.....	25
5.1.2.1 Sub-band analysis .....	25
5.1.2.2 Sub-band energy estimation .....	26
5.1.3 Sample rate conversion to 12.8 kHz .....	27
5.1.3.1 Conversion of 16, 32 and 48 kHz signals to 12.8 kHz .....	27
5.1.3.2 Conversion of 8 kHz signals to 12.8 kHz.....	27
5.1.3.3 Conversion of input signals to 16, 25.6 and 32 kHz .....	29
5.1.4 Pre-emphasis.....	29
5.1.5 Spectral analysis .....	30
5.1.5.1 Windowing and DFT.....	30
5.1.5.2 Energy calculations .....	31
5.1.6 Bandwidth detection .....	32
5.1.6.1 Mean and maximum energy values per band.....	32
5.1.7 Bandwidth decision.....	34
5.1.8 Time-domain transient detection .....	37
5.1.9 Linear prediction analysis.....	38
5.1.9.1 LP analysis window .....	38
5.1.9.2 Autocorrelation computation.....	38
5.1.9.3 Adaptive lag windowing .....	39
5.1.9.4 Levinson-Durbin algorithm.....	39
5.1.9.5 Conversion of LP coefficients to LSP parameters .....	40
5.1.9.6 LSP interpolation .....	41
5.1.9.7 Conversion of LSP parameters to LP coefficients .....	41
5.1.9.8 LP analysis at 16kHz.....	42

5.1.10	Open-loop pitch analysis .....	43
5.1.10.1	Perceptual weighting .....	43
5.1.10.2	Correlation function computation .....	44
5.1.10.3	Correlation reinforcement with past pitch values .....	45
5.1.10.4	Normalized correlation computation .....	46
5.1.10.5	Correlation reinforcement with pitch lag multiples .....	46
5.1.10.6	Initial pitch lag determination and reinforcement based on pitch coherence with other half-frames .....	47
5.1.10.7	Pitch lag determination and parameter update .....	48
5.1.10.8	Correction of very short and stable open-loop pitch estimates .....	49
5.1.10.9	Fractional open-loop pitch estimate for each subframe .....	51
5.1.11	Background noise energy estimation .....	52
5.1.11.1	First stage of noise energy update .....	52
5.1.11.2	Second stage of noise energy update .....	54
5.1.11.2.1	Basic parameters for noise energy update .....	54
5.1.11.2.2	Spectral diversity .....	55
5.1.11.2.3	Complementary non-stationarity .....	55
5.1.11.2.4	HF energy content .....	56
5.1.11.2.5	Tonal stability .....	56
5.1.11.2.6	High frequency dynamic range .....	60
5.1.11.2.7	Combined decision for background noise energy update .....	60
5.1.11.3	Energy-based parameters for noise energy update .....	62
5.1.11.3.1	Closeness to current background estimate .....	62
5.1.11.3.2	Features related to last correlation or harmonic event .....	62
5.1.11.3.3	Energy-based pause detection .....	63
5.1.11.3.4	Long-term linear prediction efficiency .....	63
5.1.11.3.5	Additional long-term parameters used for noise estimation .....	64
5.1.11.4	Decision logic for noise energy update .....	65
5.1.12	Signal activity detection .....	68
5.1.12.1	SAD1 module .....	69
5.1.12.1.1	SNR outlier filtering .....	71
5.1.12.2	SAD2 module .....	72
5.1.12.3	Combined decision of SAD1 and SAD2 modules for WB and SWB signals .....	75
5.1.12.4	Final decision of the SAD1 module for NB signals .....	75
5.1.12.5	Post-decision parameter update .....	76
5.1.12.6	SAD3 module .....	77
5.1.12.6.1	Sub-band FFT .....	77
5.1.12.6.2	Computation of signal features .....	78
5.1.12.6.3	Computation of SNR parameters .....	81
5.1.12.6.4	Decision of background music .....	83
5.1.12.6.5	Decision of background update flag .....	83
5.1.12.6.6	SAD3 Pre-decision .....	84
5.1.12.6.7	SAD3 Hangover .....	86
5.1.12.7	Final SAD decision .....	86
5.1.12.8	DTX hangover addition .....	88
5.1.13	Coding mode determination .....	90
5.1.13.1	Unvoiced signal classification .....	91
5.1.13.1.1	Voicing measure .....	92
5.1.13.1.2	Spectral tilt .....	92
5.1.13.1.3	Sudden energy increase from a low energy level .....	93
5.1.13.1.4	Total frame energy difference .....	94
5.1.13.1.5	Energy decrease after spike .....	94
5.1.13.1.6	Decision about UC mode .....	95
5.1.13.2	Stable voiced signal classification .....	96
5.1.13.3	Signal classification for FEC .....	96
5.1.13.3.1	Signal classes for FEC .....	97
5.1.13.3.2	Signal classification parameters .....	97
5.1.13.3.3	Classification procedure .....	98
5.1.13.4	Transient signal classification .....	99
5.1.13.5	Modification of coding mode in special cases .....	100
5.1.13.6	Speech/music classification .....	101
5.1.13.6.1	First stage of the speech/music classifier .....	101

5.1.13.6.2	Scaling of features in the first stage of the speech/music classifier .....	103
5.1.13.6.3	Log-probability and decision smoothing .....	104
5.1.13.6.4	State machine and final speech/music decision .....	105
5.1.13.6.5	Improvement of the classification for mixed and music content .....	108
5.1.13.6.6	Second stage of the speech/music classifier .....	112
5.1.13.6.7	Context-based improvement of the classification for stable tonal signals .....	114
5.1.13.6.8	Detection of sparse spectral content .....	118
5.1.13.6.9	Decision about AC mode .....	120
5.1.13.6.10	Decision about IC mode .....	120
5.1.14	Coder technology selection .....	120
5.1.14.1	ACELP/MDCT-based technology selection at 9.6kbps, 16.4 and 24.4 kbps .....	121
5.1.14.1.1	Segmental SNR estimation of the MDCT-based technology .....	121
5.1.14.1.2	Segmental SNR estimation of the ACELP technology .....	127
5.1.14.1.3	Hysteresis and final decision .....	128
5.1.14.2	TCX/HQ MDCT technology selection at 13.2 and 16.4 kbps .....	129
5.1.14.3	TCX/HQ MDCT technology selection at 24.4 and 32 kbps .....	131
5.1.14.4	TD/Multi-mode FD BWE technology selection at 13.2 kbps and 32 kbps .....	134
5.2	LP-based Coding .....	135
5.2.1	Perceptual weighting .....	135
5.2.2	LP filter coding and interpolation .....	136
5.2.2.1	LSF quantization .....	136
5.2.2.1.1	LSF weighting function .....	136
5.2.2.1.2	Bit allocation .....	139
5.2.2.1.3	Predictor allocation .....	140
5.2.2.1.4	LSF quantizer structure .....	140
5.2.2.1.5	LSFQ for voiced coding mode at 16 kHz internal sampling frequency : BC-TCVQ .....	145
5.2.2.1.6	Mid-frame LSF quantizer .....	152
5.2.3	Excitation coding .....	153
5.2.3.1	Excitation coding in the GC, VC and high rate IC/UC modes .....	153
5.2.3.1.1	Computation of the LP residual signal .....	154
5.2.3.1.2	Target signal computation .....	155
5.2.3.1.3	Impulse response computation .....	155
5.2.3.1.4	Adaptive codebook .....	155
5.2.3.1.5	Algebraic codebook .....	158
5.2.3.1.6	Combined algebraic codebook .....	168
5.2.3.1.7	Gain quantization .....	182
5.2.3.2	Excitation coding in TC mode .....	187
5.2.3.2.1	Glottal pulse codebook search .....	187
5.2.3.2.2	TC frame configurations .....	191
5.2.3.3	Excitation coding in UC mode at low rates .....	196
5.2.3.3.1	Structure of the Gaussian codebook .....	196
5.2.3.3.2	Correction of the Gaussian codebook spectral tilt .....	197
5.2.3.3.3	Search of the Gaussian codebook .....	198
5.2.3.3.4	Quantization of the Gaussian codevector gain .....	199
5.2.3.3.5	Other parameters in UC mode .....	200
5.2.3.3.6	Update of filter memories .....	200
5.2.3.4	Excitation coding in IC and UC modes at 9.6 kbps .....	200
5.2.3.4.1	Algebraic codebook .....	201
5.2.3.4.2	Gaussian noise generation .....	202
5.2.3.4.3	Gain coding .....	202
5.2.3.4.4	Memory update .....	204
5.2.3.5	Excitation coding in GSC mode .....	204
5.2.3.5.1	Determining the subframe length .....	205
5.2.3.5.2	Computing time-domain excitation contribution .....	205
5.2.3.5.3	Frequency transform of residual and time-domain excitation contribution .....	206
5.2.3.5.4	Computing energy dynamics of transformed residual and quantization of noise level .....	207
5.2.3.5.5	Find and encode the cut-off frequency .....	207
5.2.3.5.6	Band energy computation and quantization .....	209
5.2.3.5.7	PVQ Bit allocation .....	209
5.2.3.5.8	Quantization of difference signal .....	210
5.2.3.5.10	Spectral dynamic and noise filling .....	210
5.2.3.5.11	Quantized gain addition, temporal and frequency contributions combination .....	210

5.2.3.5.12	Specifics for wideband 8kbps.....	211
5.2.3.5.13	Inverse DCT .....	212
5.2.3.5.14	Remove pre-echo in case of onset detection.....	212
5.2.4	Bass post-filter gain quantization.....	213
5.2.5	Source Controlled VBR Coding .....	213
5.2.5.1	Principles of VBR Coding .....	213
5.2.5.2	EVS VBR Encoder Coding Modes and Bit-Rates .....	214
5.2.5.3	Prototype-Pitch-Period (PPP) Encoding .....	214
5.2.5.3.1	PPP Algorithm.....	214
5.2.5.3.2	Amplitude Quantization .....	216
5.2.5.3.3	Phase Quantization .....	216
5.2.5.4	Noise-Excited-Linear-Prediction (NELP) Encoding.....	216
5.2.5.5	Average Data Rate (ADR) Control for the EVS VBR mode .....	216
5.2.6	Coding of upper band for LP-based Coding Modes .....	220
5.2.6.1	Bandwidth extension in time domain.....	220
5.2.6.1.1	High band target signal generation.....	221
5.2.6.1.2	TBE LP analysis .....	222
5.2.6.1.3	Quantization of linear prediction parameters.....	224
5.2.6.1.4	Interpolation of LSF coefficients.....	227
5.2.6.1.5	Target and residual energy calculation and quantization.....	229
5.2.6.1.6	Generation of the upsampled version of the lowband excitation.....	229
5.2.6.1.7	Non-Linear Excitation Generation .....	230
5.2.6.1.8	Spectral flip of non-linear excitation in time domain.....	231
5.2.6.1.9	Down-sample using all-pass filters.....	231
5.2.6.1.10	Adaptive spectral whitening .....	232
5.2.6.1.11	Envelope modulated noise mixing.....	232
5.2.6.1.12	Spectral shaping of the noise added excitation.....	234
5.2.6.1.13	Post processing of the shaped excitation.....	235
5.2.6.1.14	Estimation of temporal gain shape parameters.....	236
5.2.6.1.15	Estimation of frame gain parameters.....	239
5.2.6.1.16	Estimation of TEC/TFA envelope parameters.....	241
5.2.6.1.17	Estimation of full-band frame energy parameters .....	244
5.2.6.2	Multi-mode FD Bandwidth Extension Coding .....	246
5.2.6.2.1	SWB/FB Multi-mode FD Bandwidth Extension.....	246
5.2.6.2.2	WB Multi-mode FD Bandwidth Extension .....	257
5.2.6.3	Coding of upper band at 64 kb/s.....	261
5.2.6.3.1	Coding in normal mode.....	261
5.2.6.3.2	Coding in transient mode.....	265
5.3	MDCT Coding Mode .....	268
5.3.1	General description.....	268
5.3.2	Time-to-frequency transformations .....	268
5.3.2.1	Transform sizes and MDCT configurations.....	268
5.3.2.2	Long block transformation (ALDO window).....	268
5.3.2.2.1	Folding and on-the-fly window decimation.....	270
5.3.2.2.2	eDCT .....	272
5.3.2.3	Transient location dependent overlap and transform length .....	274
5.3.2.4	Short block transformation.....	275
5.3.2.4.1	Short window transform in TDA domain.....	275
5.3.2.4.2	Short window transform for MDCT based TCX .....	279
5.3.2.5	Special window transitions .....	280
5.3.2.5.1	ALDO to short transition .....	280
5.3.2.5.2	Short to ALDO transition .....	280
5.3.2.6	Modified Discrete Sine Transform.....	280
5.3.3	MDCT based TCX.....	281
5.3.3.1	General description .....	281
5.3.3.1.1	High level overview .....	281
5.3.3.1.2	Rate dependent configuration.....	281
5.3.3.2	General encoding procedure.....	282
5.3.3.2.1	LPC parameter calculation .....	282
5.3.3.2.2	Temporal Noise Shaping .....	286
5.3.3.2.3	LPC shaping in MDCT domain.....	288
5.3.3.2.4	Adaptive low frequency emphasis.....	291

5.3.3.2.5	Spectrum noise measure in power spectrum.....	292
5.3.3.2.6	Low pass factor detector.....	293
5.3.3.2.7	Uniform quantizer with adaptive dead-zone.....	293
5.3.3.2.8	Arithmetic coder.....	293
5.3.3.2.9	Global gain coding.....	305
5.3.3.2.10	Noise Filling.....	306
5.3.3.2.11	Intelligent Gap Filling.....	309
5.3.3.2.12	Memory updates.....	324
5.3.3.2.13	Global Gain Adjuster.....	324
5.3.4	High Quality MDCT coder (HQ).....	325
5.3.4.1	Low-rate HQ coder.....	325
5.3.4.1.1	Tonality Estimation.....	326
5.3.4.1.2	Grouping of spectral coefficients.....	326
5.3.4.1.3	Energy Envelope coding.....	331
5.3.4.1.4	MDCT coefficients quantization.....	338
5.3.4.2	High-rate HQ coder.....	374
5.3.4.2.1	Normal Mode.....	376
5.3.4.2.2	Transient Mode.....	386
5.3.4.2.3	Generic, Harmonic and HVQ mode detector.....	387
5.3.4.2.4	Harmonic Mode.....	388
5.3.4.2.5	HVQ.....	389
5.3.4.2.6	Generic Mode.....	392
5.3.4.2.7	Pyramid Vector Quantization (PVQ) and indexing.....	400
5.4	Switching of Coding Modes.....	410
5.4.1	General description.....	410
5.4.2	MDCT coding mode to CELP coding mode.....	410
5.4.2.1	MDCT to CELP transition 1 (MC1).....	411
5.4.2.2	MDCT to CELP transition 2 (MC2).....	411
5.4.2.3	MDCT to CELP transition 3 (MC3).....	411
5.4.3	CELP coding mode to MDCT coding mode.....	411
5.4.3.1	CELP coding mode to MDCT-based TCX coding mode.....	411
5.4.3.2	CELP coding mode to HQ MDCT coding mode.....	412
5.4.3.2.1	Constrained CELP coding and simplified BWE coding.....	412
5.4.3.2.2	HQ MDCT coding with a modified analysis window.....	413
5.4.4	Internal sampling rate switching.....	414
5.4.4.1	Reset of LPC memory.....	414
5.4.4.2	Conversion of LP filter between 12.8 and 16 kHz internal sampling rates.....	414
5.5.4.1.1	Modification of the Power Spectrum.....	414
5.5.4.1.2	Computation of the Power Spectrum.....	415
5.5.4.1.3	Computation of the Autocorrelation.....	416
5.4.4.3	Extrapolation of LP filter.....	417
5.4.4.4	Buffer resampling with linear interpolation.....	417
5.4.4.5	Update of CELP input signal memories.....	417
5.4.4.6	Update of MDCT-based TCX input signal memories.....	418
5.4.4.7	Update of CELP synthesis memories.....	418
5.4.5	EVS primary and AMR-WB IO.....	418
5.4.5.1	Switching from primary modes to AMR-WB IO.....	418
5.4.5.2	Switching from AMR-WB IO mode to primary modes.....	419
5.4.6	Rate switching.....	419
5.4.6.1	Rate switching along with internal sampling rate switching.....	419
5.4.6.2	Rate switching along with coding mode switching.....	419
5.5	Frame erasure concealment side information.....	420
5.5.1	Signal classification parameter.....	420
5.5.2	Energy information.....	420
5.5.3	Phase control information.....	421
5.5.4	Pitch lag information.....	422
5.5.5	Spectral envelope diffuser.....	422
5.5.6	Tonality flag information.....	423
5.6	DTX/CNG operation.....	424
5.6.1	Overview.....	424
5.6.1.1	SID update.....	425
5.6.1.2	Spectral tilt based SID transmission.....	426



5.6.1.3	CNG selector.....	427
5.6.2	Encoding for LP-CNG .....	427
5.6.2.1	LP-CNG CN parameters estimation.....	428
5.6.2.1.1	LP-CNG Hangover analysis period determination .....	428
5.6.2.1.2	LP-CNG filter parameters evaluation for low-band signal.....	428
5.6.2.1.3	LP-CNG CNG-LSF quantization for low-band signal .....	429
5.6.2.1.4	LP-CNG synthesis filter computation for local CNG synthesis .....	430
5.6.2.1.5	LP-CNG energy calculation and quantization .....	431
5.6.2.1.6	LP-CNG energy smoothing for local CNG synthesis.....	432
5.6.2.1.7	LP-CNG LF-BOOST determination and quantization .....	432
5.6.2.1.8	LP-CNG high band analysis and quantization .....	433
5.6.2.2	LP-CNG local CNG synthesis.....	435
5.6.2.3	LP-CNG CNG Memory update.....	435
5.6.3	Encoding for FD-CNG.....	435
5.6.3.1	Spectral partition energies.....	436
5.6.3.1.1	Computation of the FFT partition energies.....	436
5.6.3.1.2	Computation of the CLDFB partition energies.....	436
5.6.3.1.3	FD-CNG configurations .....	436
5.6.3.2	FD-CNG noise estimation.....	437
5.6.3.2.1	Dynamic range compression for the input energies.....	437
5.6.3.2.2	Noise tracking.....	438
5.6.3.2.3	Dynamic range expansion for the estimated noise energies .....	442
5.6.3.3	Adjusting the first SID frame in FD-CNG .....	442
5.6.3.4	FD-CNG resetting mechanism.....	442
5.6.3.5	Encoding SID frames in FD-CNG .....	442
5.6.3.6	FD-CNG local CNG synthesis .....	444
5.6.3.6.1	SID parameters interpolation.....	445
5.6.3.6.2	LPC estimation from the interpolated SID parameters.....	445
5.6.3.6.3	FD-CNG encoder comfort noise generation.....	445
5.6.3.6.4	FD-CNG encoder memory update.....	445
5.7	AMR-WB-interoperable modes .....	446
5.7.1	Pre-processing.....	446
5.7.2	Linear prediction analysis and quantization.....	446
5.7.2.1	Windowing and auto-correlation computation.....	446
5.7.2.2	Levinson-Durbin algorithm.....	446
5.7.2.3	LP to ISP conversion.....	446
5.7.2.4	ISP to LP conversion.....	447
5.7.2.5	Quantization of the ISP coefficients.....	447
5.7.2.6	Interpolation of the ISPs.....	447
5.7.3	Perceptual weighting.....	447
5.7.4	Open-loop pitch analysis .....	447
5.7.5	Impulse response computation.....	447
5.7.6	Target signal computation .....	447
5.7.7	Adaptive codebook search .....	448
5.7.8	Algebraic codebook search.....	448
5.7.9	Quantization of the adaptive and fixed codebook gains .....	448
5.7.10	Memory update.....	448
5.7.11	High-band gain generation.....	448
5.7.12	CNG coding.....	448
5.8	Channel Aware Coding .....	448
5.8.1	Introduction.....	448
5.8.2	Principles of Channel Aware Coding.....	449
5.8.3	Bit-Rate Allocation for Primary and Partial Redundant Frame Coding .....	450
5.8.3.1	Primary frame bit-rate reduction .....	450
5.8.3.2	Partial Redundant Frame Coding .....	450
5.8.3.2.1	Construction of partial redundant frame for Generic and Voiced Coding modes .....	450
5.8.3.2.2	Construction of partial redundant frame for Unvoiced Coding mode .....	450
5.8.3.2.3	Construction of partial redundant frame for TCX frame .....	451
5.8.3.2.4	RF_NO_DATA partial redundant frame type .....	451
5.8.3.3	Decoding .....	451
5.8.4	Channel aware mode encoder configurable parameters.....	451

6	Functional description of the Decoder .....	453
6.1	LP-based Decoding .....	453
6.1.1	General LP-based decoding .....	453
6.1.1.1	LSF decoding .....	453
6.1.1.1.1	General LSF decoding .....	453
6.1.1.1.2	LSF decoding for voiced coding mode at 16 kHz internal sampling frequency .....	456
6.1.1.2	Reconstruction of the excitation .....	458
6.1.1.2.1	Reconstruction of the excitation in GC and VC modes and high rate IC/UC modes .....	458
6.1.1.2.2	Reconstruction of the excitation in TC mode .....	465
6.1.1.2.3	Reconstruction of the excitation in UC mode at low rates .....	465
6.1.1.2.4	Reconstruction of the excitation in IC/UC mode at 9.6 kbps .....	467
6.1.1.2.5	Reconstruction of the excitation in GSC .....	468
6.1.1.3	Excitation post-processing .....	469
6.1.1.3.1	Anti-sparseness processing .....	469
6.1.1.3.2	Gain smoothing for noise enhancement .....	469
6.1.1.3.3	Pitch enhancer .....	470
6.1.1.3.4	Music post processing .....	471
6.1.2	Source Controlled VBR decoding .....	478
6.1.3	Synthesis .....	478
6.1.4	Post-processing .....	479
6.1.4.1.1	Long-term post-filter .....	479
6.1.4.1.2	Short-term post-filter .....	480
6.1.4.1.3	Post-filter NB parameters .....	480
6.1.4.1.4	Post-filter WB and SWB parameters .....	481
6.1.4.1.5	Tilt compensation .....	481
6.1.4.1.6	Adaptive gain control .....	482
6.1.4.2	Bass post-filter .....	482
6.1.5	Decoding of upper band for LP-based Coding Modes .....	485
6.1.5.1	Decoding Time-domain Bandwidth Extension .....	485
6.1.5.1.1	Generation of the upsampled version of the lowband excitation .....	485
6.1.5.1.2	Non-Linear Excitation Generation .....	486
6.1.5.1.3	De-quantization of high band parameters .....	487
6.1.5.1.4	LSP interpolation .....	487
6.1.5.1.5	Spectral flip in time domain .....	487
6.1.5.1.6	Down-sample using all-pass filters .....	487
6.1.5.1.7	Adaptive spectral whitening .....	488
6.1.5.1.8	Envelope modulated noise mixing .....	488
6.1.5.1.9	Spectral shaping of the noise added excitation .....	490
6.1.5.1.10	Post processing of the shaped excitation .....	490
6.1.5.1.11	Gain shape update .....	490
6.1.5.1.12	SHB synthesis .....	491
6.1.5.1.13	Core-switching and high-band memory updates .....	492
6.1.5.1.14	TEC/TFA post processing .....	493
6.1.5.1.15	Full-band synthesis .....	495
6.1.5.2	Multi-mode FD Bandwidth Extension decoding .....	495
6.1.5.2.1	SWB multi-mode FD BWE decoding .....	495
6.1.5.2.2	WB multi-mode FD BWE decoding .....	503
6.1.5.3	Decoding of upper band at 64 kb/s .....	511
6.1.5.3.1	Decoding in normal mode .....	511
6.1.5.3.2	Decoding in transient mode .....	516
6.1.5.3.3	Windowing and frequency-to-time transformation .....	518
6.1.5.3.4	Post-processing in temporal domain .....	518
6.2	MDCT Coding mode decoding .....	521
6.2.1	General MDCT decoding .....	521
6.2.2	MDCT based TCX .....	521
6.2.2.1	Rate dependent configurations .....	521
6.2.2.2	Init module parameters .....	521
6.2.2.2.1	TCX block configuration .....	521
6.2.2.2.2	LPC parameter .....	521
6.2.2.2.3	PLC Waveform adjustment .....	522
6.2.2.2.4	Global Gain .....	522
6.2.2.2.5	Noise fill parameter .....	523

6.2.2.2.6	LTP .....	523
6.2.2.2.7	TNS parameter.....	523
6.2.2.2.8	Harmonic model .....	523
6.2.2.2.9	IGF bit stream reader.....	523
6.2.2.2.10	Spectral data .....	526
6.2.2.2.11	Residual bits .....	526
6.2.2.3	Decoding process .....	527
6.2.2.3.1	Arithmetic decoder .....	527
6.2.2.3.2	Adaptive low frequency de-emphasis.....	528
6.2.2.3.3	Global gain decoding.....	529
6.2.2.3.4	Residual bits decoding.....	529
6.2.2.3.5	TCX formant enhancement .....	530
6.2.2.3.6	Noise Filling .....	531
6.2.2.3.7	Apply global gain and LPC shaping in MDCT domain .....	532
6.2.2.3.8	IGF apply.....	533
6.2.2.3.9	Inverse window grouping (TCX5 separation) .....	538
6.2.2.3.10	Temporal Noise Shaping .....	539
6.2.2.3.11	IGF temporal flattening .....	539
6.2.3	High Quality MDCT decoder (HQ).....	540
6.2.3.1	Low-rate HQ decoder.....	540
6.2.3.1.1	Mode decoding.....	540
6.2.3.1.2	Energy Envelope decoding .....	540
6.2.3.1.3	Spectral coefficients decoding.....	542
6.2.3.2	High-rate HQ decoder .....	552
6.2.3.2.1	Normal Mode .....	552
6.2.3.2.2	Transient Mode.....	561
6.2.3.2.3	Harmonic Mode.....	561
6.2.3.2.4	HVQ .....	564
6.2.3.2.5	Generic Mode.....	565
6.2.3.2.6	PVQ decoding and de-indexing.....	570
6.2.4	Frequency-to-time transformation .....	572
6.2.4.1	Long block transformation (ALDO window).....	572
6.2.4.1.1	eDCT .....	572
6.2.4.1.2	Unfolding and windowing .....	572
6.2.4.1.3	Overlap-add .....	573
6.2.4.1.4	Pre-echo attenuation .....	574
6.2.4.2	Transient location dependent overlap and transform length .....	580
6.2.4.3	Short block transformation.....	580
6.2.4.3.1	Short window transform in TDA domain.....	580
6.2.4.3.2	Short window transform for MDCT based TCX.....	581
6.2.4.4	Special window transitions .....	581
6.2.4.4.1	ALDO to short transition.....	581
6.2.4.4.2	Short to ALDO transition .....	582
6.2.4.5	Low Rate MDCT Synthesis .....	582
6.3	Switching coding modes in decoding.....	582
6.3.1	General description .....	582
6.3.2	MDCT coding mode to CELP coding mode.....	583
6.3.2.1	MDCT to CELP transition 1 (MC1) .....	583
6.3.2.2	MDCT to CELP transition 2 (MC2) .....	584
6.3.2.3	MDCT to CELP transition 3 (MC3) .....	584
6.3.3	CELP coding mode to MDCT coding mode.....	584
6.3.3.1	CELP coding mode to MDCT based TCX coding mode .....	585
6.3.3.2	CELP coding mode to HQ MDCT coding mode .....	586
6.3.3.2.1	Constrained CELP decoding and simplified BWE decoding .....	587
6.3.3.2.1.1	Optimized cubic interpolation.....	587
6.3.3.2.2	HQ MDCT decoding with a modified synthesis window.....	588
6.3.3.2.3	Cross-fading .....	588
6.3.4	Internal sampling rate switching.....	588
6.3.4.1	Reset of LPC memory.....	588
6.3.4.2	Conversion of LP filter between 12.8 and 16 kHz internal sampling rates .....	589
6.3.4.3	Extrapolation of LP filter .....	589
6.3.4.4	Update of CELP synthesis memories.....	589

6.3.4.5	Update of CELP decoded past signal .....	589
6.3.4.6	Post-processing .....	589
6.3.4.6.1	Adaptive post-filtering .....	589
6.3.4.6.2	Bass post filter.....	589
6.3.4.7	CLDFB .....	589
6.3.5	EVS primary modes and AMR-WB IO .....	590
6.3.5.1	Switching from primary modes to AMR-WB IO .....	590
6.3.5.2	Switching from AMR-WB IO mode to primary modes .....	590
6.3.6	Rate switching .....	590
6.3.6.1	Rate switching along with internal sampling rate switching .....	590
6.3.6.2	Rate switching along with coding mode switching .....	590
6.3.6.3	Adaptive post-filter reset and smoothing .....	590
6.3.7	Bandwidth switching .....	590
6.3.7.1	Bandwidth switching detector.....	590
6.3.7.2	Super wideband switching to wideband.....	591
6.3.7.2.1	TBE mode.....	591
6.3.7.2.2	Multi-mode FD BWE mode .....	593
6.3.7.2.3	MDCT core.....	594
6.3.7.3	Wideband switching to super wideband.....	594
6.4	De-emphasis .....	594
6.5	Resampling to the output sampling frequency .....	594
6.6	Decoding of frame erasure concealment side information .....	594
6.7	Decoding in DTX/CNG operation.....	595
6.7.1	Overview .....	595
6.7.2	Decoding for LP-CNG.....	595
6.7.2.1	LP-CNG decoding Overview .....	595
6.7.2.1.1	CNG parameter updates in active periods .....	595
6.7.2.1.2	DTX-hangover based parameter analysis in LP-CNG mode.....	596
6.7.2.1.3	LP-CNG low-band energy decoding .....	598
6.7.2.1.4	LP-CNG low-band filter parameters decoding .....	598
6.7.2.1.5	LP-CNG low-band excitation generation .....	598
6.7.2.1.6	LP-CNG low-band synthesis .....	600
6.7.2.1.7	LP-CNG high-band decoding and synthesis.....	600
6.7.2.2	Memory update .....	602
6.7.3	Decoding for FD-CNG .....	602
6.7.3.1	Decoding SID frames in FD-CNG .....	602
6.7.3.1.1	SID parameters decoding.....	603
6.7.3.1.2	SID parameters interpolation.....	603
6.7.3.1.3	LPC estimation from the interpolated SID parameters.....	604
6.7.3.2	Noise tracking during active frames in FD-CNG.....	604
6.7.3.2.1	Spectral partition energies .....	604
6.7.3.2.2	FD-CNG noise estimation .....	605
6.7.3.2.3	Noise shaping in FD-CNG .....	605
6.7.3.3	Noise generation for SID or zero frames in FD-CNG .....	607
6.7.3.3.1	Update of the noise levels for FD-CNG .....	607
6.7.3.3.2	Comfort noise generation in the frequency domain.....	607
6.7.3.3.3	Comfort noise generation in the time domain .....	607
6.7.3.3.4	FD-CNG decoder memory update.....	609
6.8	AMR-WB-interoperable modes .....	610
6.8.1	Decoding and speech synthesis.....	610
6.8.1.1	Excitation decoding.....	610
6.8.1.2	Excitation post-processing .....	611
6.8.1.2.1	Anti-sparseness processing.....	611
6.8.1.2.2	Gain smoothing for noise enhancement .....	611
6.8.1.2.3	Pitch enhancer .....	611
6.8.1.3	Synthesis filtering .....	611
6.8.1.4	Music and Unvoiced/inactive Post-processing.....	611
6.8.1.4.1	Music post processing .....	611
6.8.1.4.2	Unvoiced and inactive post processing.....	612
6.8.1.5	Synthesis filtering and overwriting the current CELP synthesis.....	615
6.8.1.6	Formant post-filter .....	615
6.8.1.7	Comfort noise addition.....	615

6.8.1.8	Bass post-filter .....	615
6.8.2	Resampling .....	616
6.8.3	High frequency band.....	616
6.8.3.1	Preliminary estimation steps .....	616
6.8.3.1.1	Estimation of tilt, figure of merit and voice factors.....	617
6.8.3.1.2	Estimation of sub-frame gains based on LP spectral envelopes .....	618
6.8.3.2	Generation of high-band excitation.....	621
6.8.3.2.1	DCT .....	621
6.8.3.2.2	High band generation .....	621
6.8.3.2.3	Extraction of tonal and ambiance components .....	623
6.8.3.2.4	Recombination.....	624
6.8.3.2.5	Filtering in DCT domain .....	625
6.8.3.2.6	Inverse DCT .....	626
6.8.3.2.7	Gain computation and scaling of excitation .....	626
6.8.3.3	LP filter for the high frequency band .....	628
6.8.3.4	High band synthesis .....	628
6.8.4	CNG decoding .....	628
6.9	Common post-processing .....	629
6.9.1	Comfort noise addition .....	629
6.9.1.1	Noisy speech detection.....	629
6.9.1.2	Noise estimation for CNA.....	630
6.9.1.2.1	CNA noise estimation in DTX-on mode when FD-CNG is triggered.....	630
6.9.1.2.2	CNA noise estimation in DTX-on mode when LP-CNG is triggered .....	630
6.9.1.2.3	CNA noise estimation in DTX-off mode.....	630
6.9.1.3	Noise generation in the FFT domain and addition in the time domain.....	630
6.9.1.4	Noise generation and addition in the MDCT domain .....	631
6.9.2	Long term prediction processing .....	631
6.9.2.1	Decoding LTP parameters.....	631
6.9.2.2	LTP post filtering .....	632
6.9.3	Complex low delay filter bank synthesis.....	634
6.9.4	High pass filtering.....	635
7	Description of the transmitted parameter indices.....	635
7.1	Bit allocation for the default option.....	635
7.1.1	Bit allocation at VBR 5.9, 7.2 – 9.6 kbps .....	635
7.1.2	Bit allocation at 13.2 kbps .....	636
7.1.3	Bit allocation at 16.4 and 24.4 kbps.....	636
7.1.4	Bit allocation at 32 kbps .....	637
7.1.5	Bit allocation at 48, 64, 96 and 128 kbps.....	638
7.2	Bit allocation for SID frames in the DTX operation .....	639
7.3	Bit allocation for the AMR-WB-interoperable option.....	640
7.4	Bit Allocation for the Channel-Aware Mode .....	640
<b>Annex A (normative):</b>	<b>RTP Payload Format and SDP Parameters .....</b>	<b>642</b>
A.0	General .....	642
A.1	RTP Header Usage .....	642
A.2	EVS RTP Payload Format.....	642
A.2.1	EVS codec Compact Format .....	642
A.2.1.1	Compact format for EVS Primary mode.....	643
A.2.1.2	Compact format for EVS AMR-WB IO mode (except SID).....	643
A.2.1.2.1	Representation of Codec Mode Request (CMR) in Compact format for EVS AMR-WB IO mode ...	643
A.2.1.2.2	Payload structure of Compact EVS AMR-WB IO mode frame.....	644
A.2.1.3	Special case for 56 bit payload size (EVS Primary or EVS AMR-WB IO SID) .....	645
A.2.2	EVS codec Header-Full format .....	645
A.2.2.1	EVS RTP payload structure .....	645
A.2.2.1.1	CMR byte.....	646
A.2.2.1.2	ToC byte.....	649
A.2.2.1.3	Speech Data.....	651
A.2.2.1.4	Zero padding .....	651
A.2.2.1.4.1	Zero padding for octet alignment of speech data (EVS AMR-WB IO).....	651