

ETSI TS 126 304 V6.1.0 (2004-12)

Technical Specification

**Universal Mobile Telecommunications System (UMTS);
Floating-point ANSI-C code for the Extended
Adaptive Multi-Rate - Wideband (AMR-WB+) codec
(3GPP TS 26.304 version 6.1.0 Release 6)**



ReferenceDTS/TSGS-0426304v610

KeywordsUMTS

ETSI

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Foreword

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- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document contains an electronic copy of the ANSI-C code for the Floating-point Extended Adaptive Multi-Rate Wideband codec. Alternatively, fixed-point ANSI-C code is specified in 3GPP TS 26.273 [1]. The floating-point codec/encoder/decoder specified in this document or the fixed-point codec/encoder/decoder specified in [1] may be used depending on if the implementation platform is better suited for a floating-point or a fixed-point implementation. It has been verified that the fixed-point and floating-point codecs interoperate with each other without any artifacts.

The floating-point ANSI-C code in the present document defines, besides the fixed-point c-code specified in [1], one valid reference implementation of the Extended Adaptive Multi-Rate Wideband transcoder (3GPP TS 26.290 [2]). Standard conformance is enforced by meeting the conformance criteria defined in [3].

2 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 26.273: "ANSI-C code for the Fixed-point Extended AMR Wideband codec".
- [2] 3GPP TS 26.290: " Audio codec processing functions; Extended AMR Wideband codec; Transcoding functions ".
- [3] 3GPP TS 26.xxx (tbd): "3GPP audio codecs, Conformance".
- [4] 3GPP TS 26.201: " AMR Wideband speech codec; frame structure".
- [5] IETF Internet Draft: "Real-Time Transport Protocol (RTP) Payload Format for Extended AMR Wideband (AMR-WB+) Audio Codec", Sjoberg J., Westerlund M. and Lakaniemi A., <http://www.ietf.org/internet-drafts/draft-ietf-avt-rtp-amrwbplus-01.txt>, July 2004.
- [6] 3GPP TS 26.193: " AMR Wideband speech codec; Source controlled rate operation".
- [7] 3GPP TS 26.244: "Transparent end-to-end packet switched streaming service (PSS); 3GPP file format (3GP)"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions are given in TS 26.290 [2].

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AMR-WB+	Extended Adaptive Multi-Rate WideBand
ANSI	American National Standards Institute
GSM	Global System for Mobile communications

I/O	Input/Output
RAM	Random Access Memory
ROM	Read Only Memory

4 C code structure

This clause gives an overview of the structure of the C code and provides an overview of the contents and organization of the C code attached to the present document.

The C code has been verified on the following systems:

- IBM PC/AT compatible computers with Windows 2000 SP4 and Microsoft Visual C++ v.6.0 compiler.

ANSI-C was selected as the programming language because portability was desirable.

4.1 Contents of the C source code

The C code distribution has the files divided in five different directories, all present in the directory *c-code*. The directories are: *common*, *decoder*, *encoder*, *lib_amr* and *include*. The distributed files with suffix "c" contain the source code and the files with suffix "h" are the header files.

Project and workspace files are provided in the directory *MSVC*.

4.2 Program execution

The Extended Adaptive Multi-Rate Wideband codec is implemented in two programs:

- (*encoder*) audio encoder;
- (*decoder*) audio decoder.

The programs should be called like:

- encoder [encoder options] -if <audio input file> -of <parameter file>;
- decoder [decoder options] -if <parameter file> -of <audio output file>.

The input files contain one or two channels of 16-bit linear encoded PCM audio samples stored in the *wav* file format and the parameter files contain encoded audio data and some additional flags.

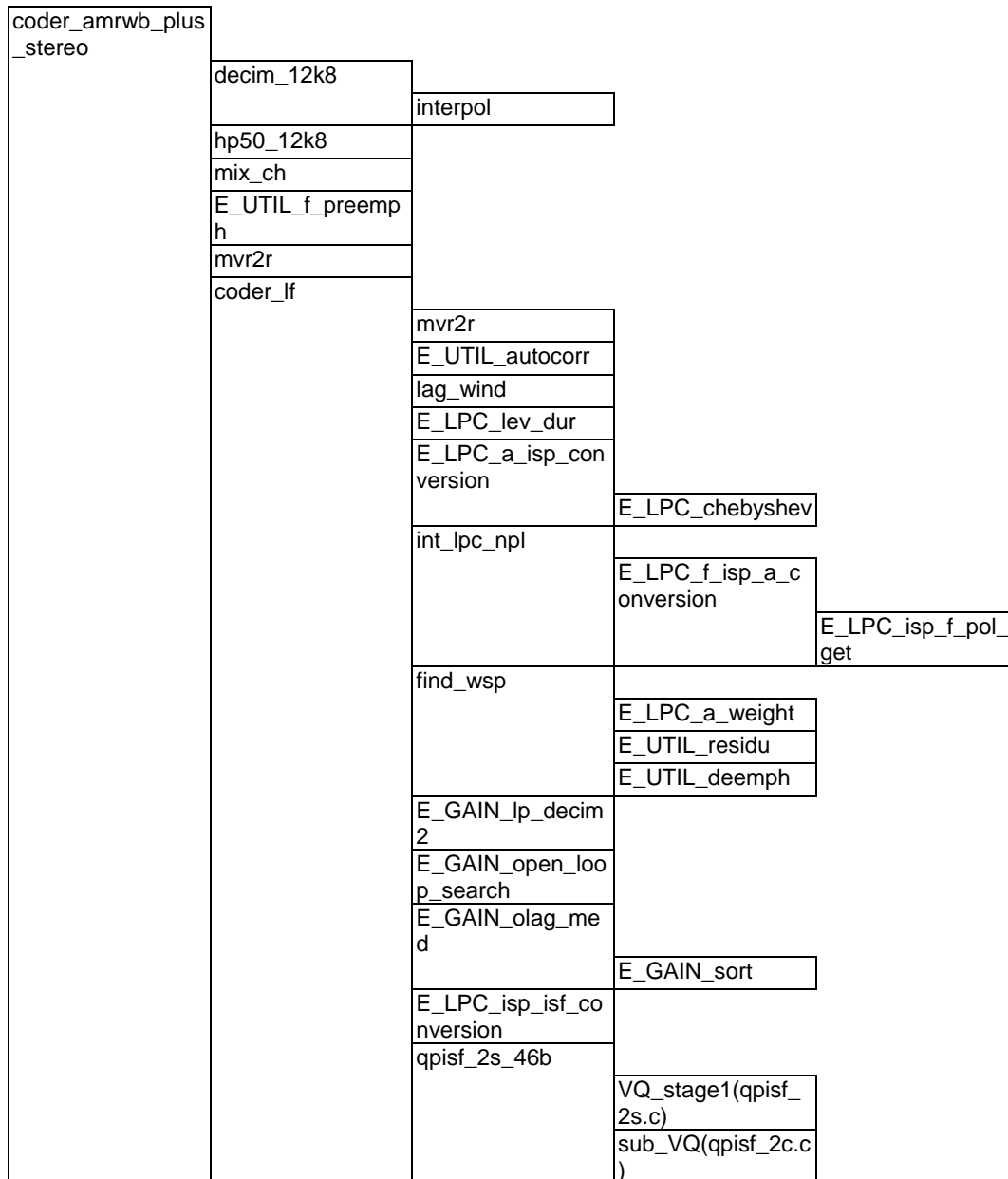
The encoder and decoder options will be explained by running the applications without input arguments. See the file *readme.txt* for more information on how to run the *encoder* and *decoder* programs.

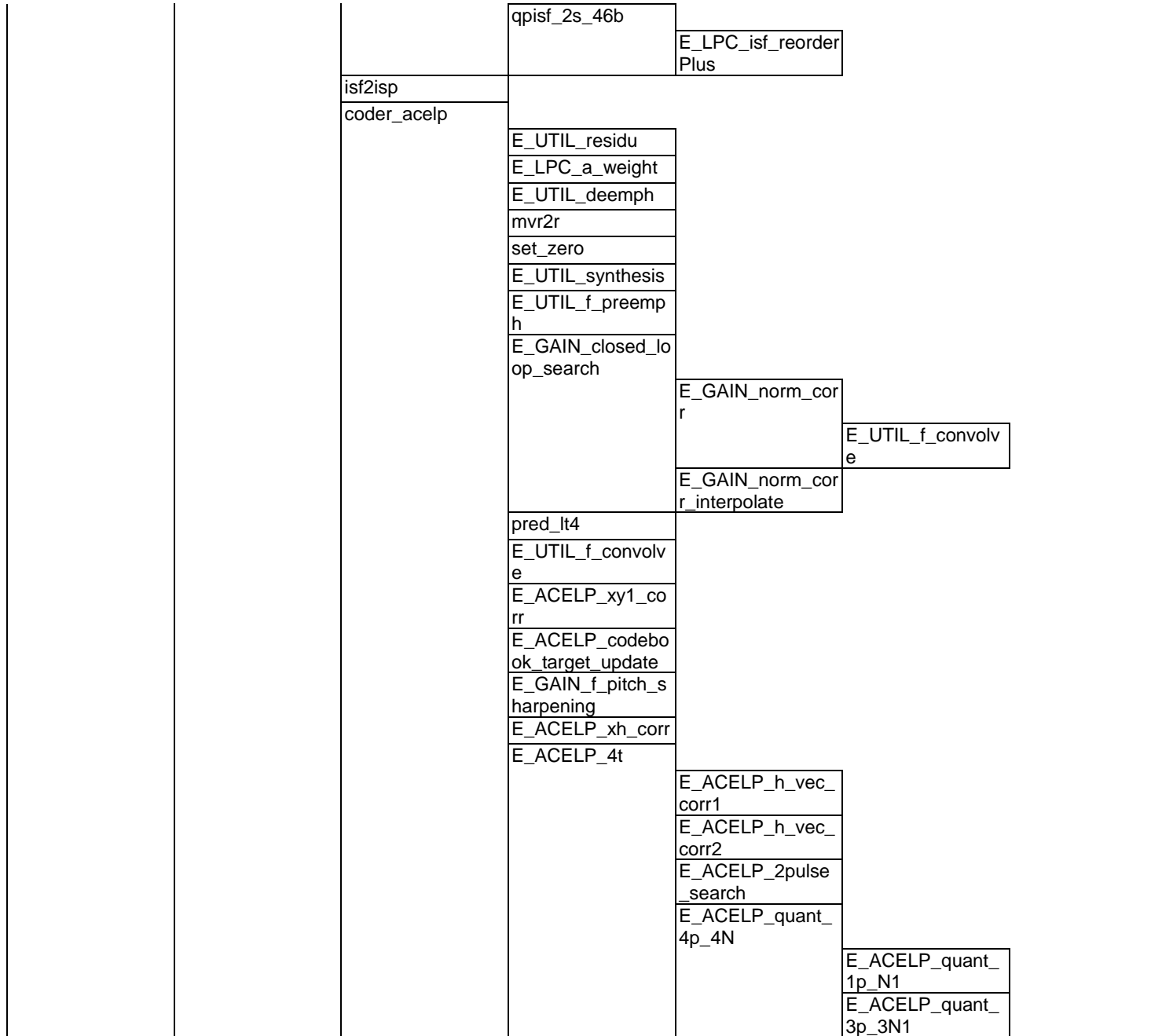
4.3 Code hierarchy

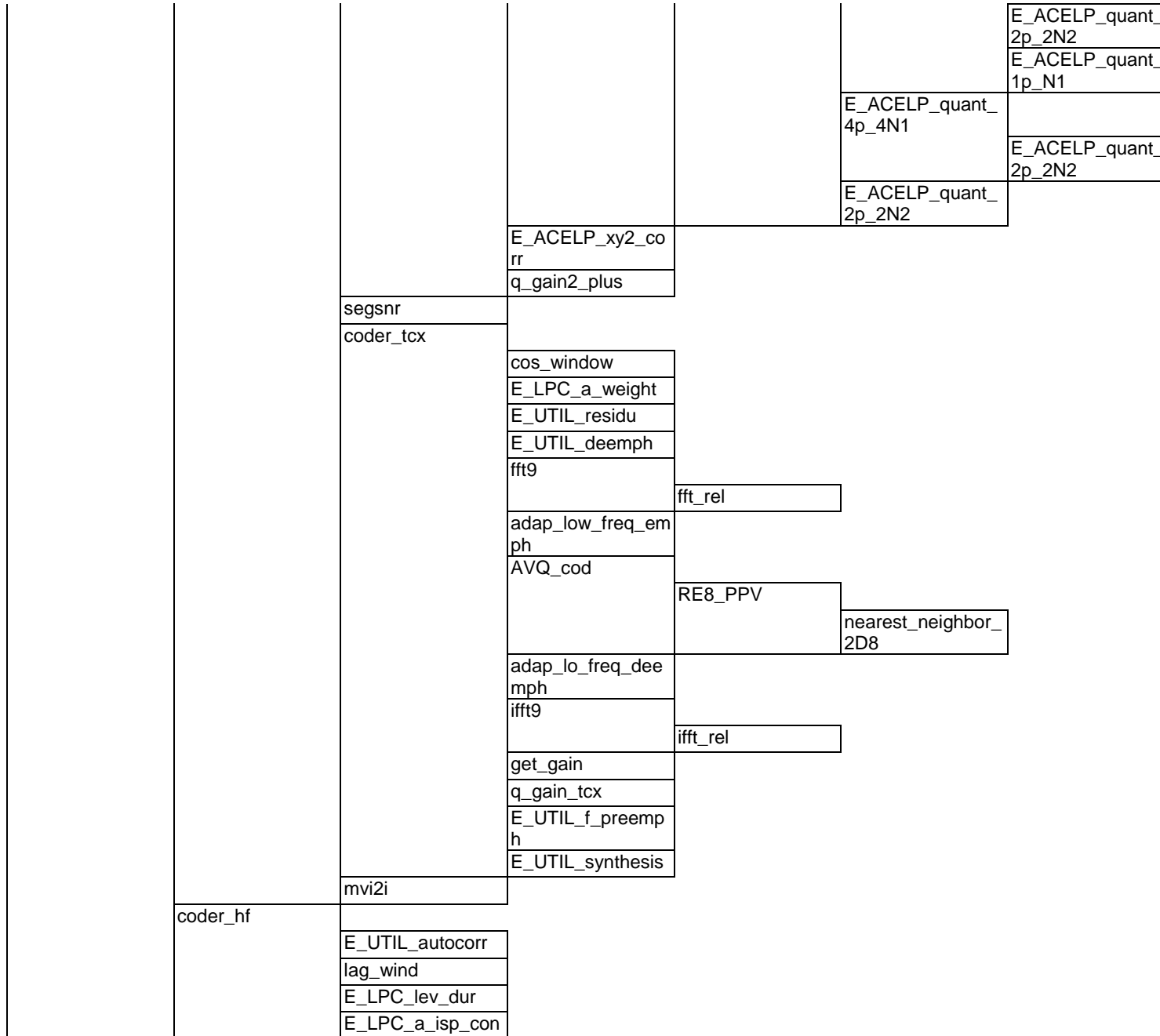
Tables 1 and 2 are call graphs that show the functions used in the audio codec.

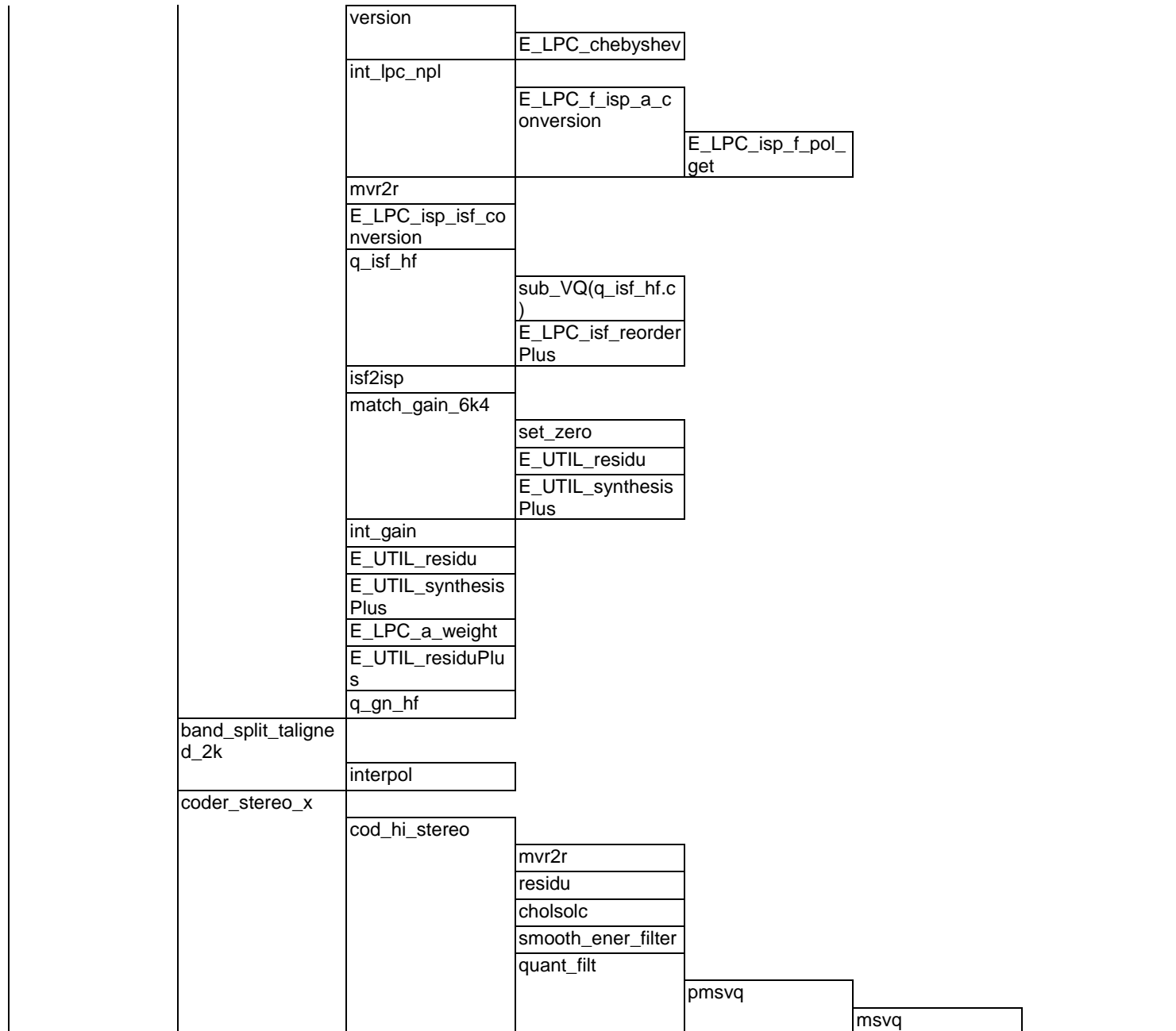
Each column represents a call level and each cell a function. The functions contain calls to the functions in rightwards neighbouring cells. The time order in the call graphs is from the top downwards as the processing of a frame advances. All standard C functions: *memcpy()*, *fwrite()*, etc. have been omitted. The initialization of the static RAM (i.e. calling the *_init* functions) is also omitted.

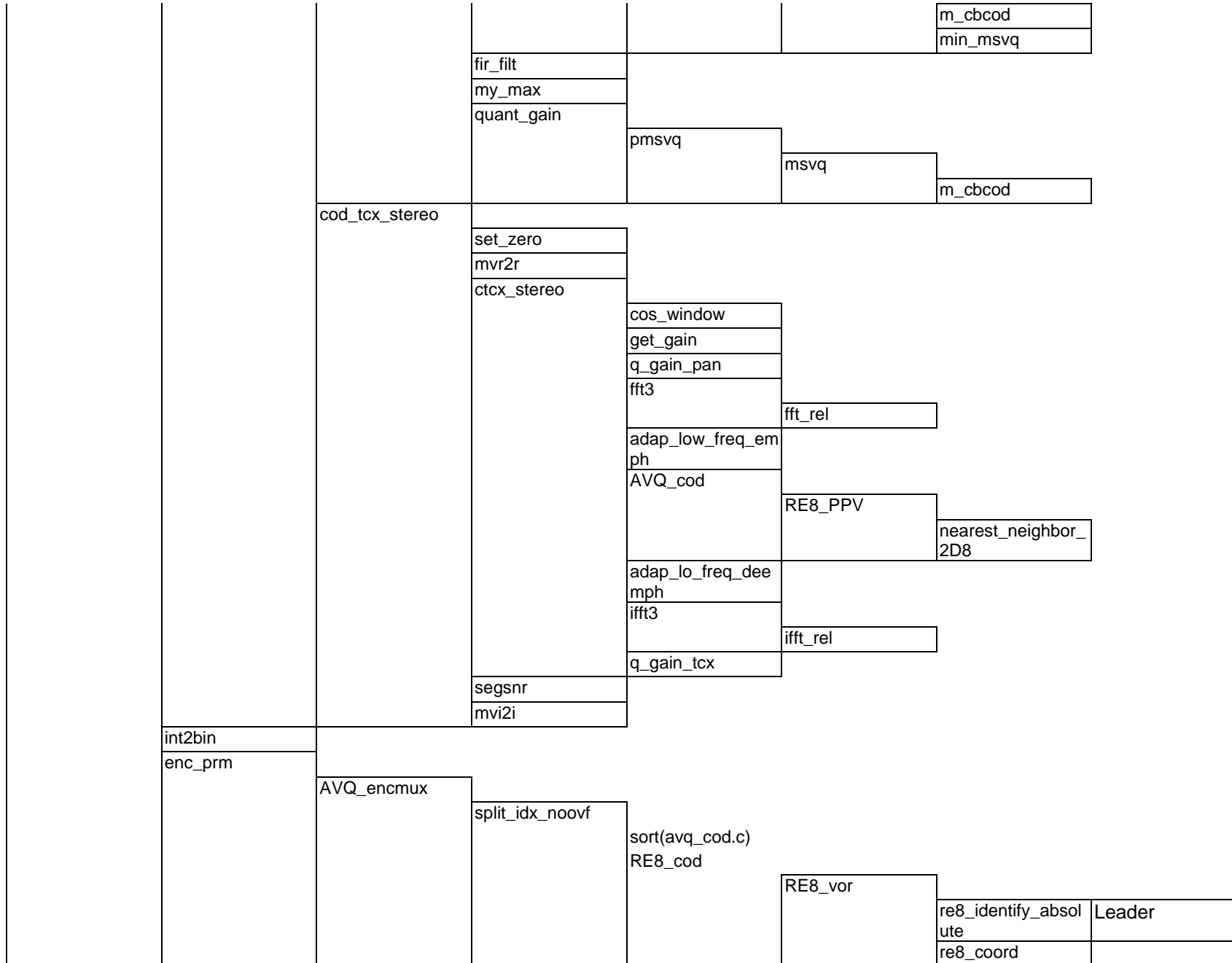
Table 1: Encoder call structure

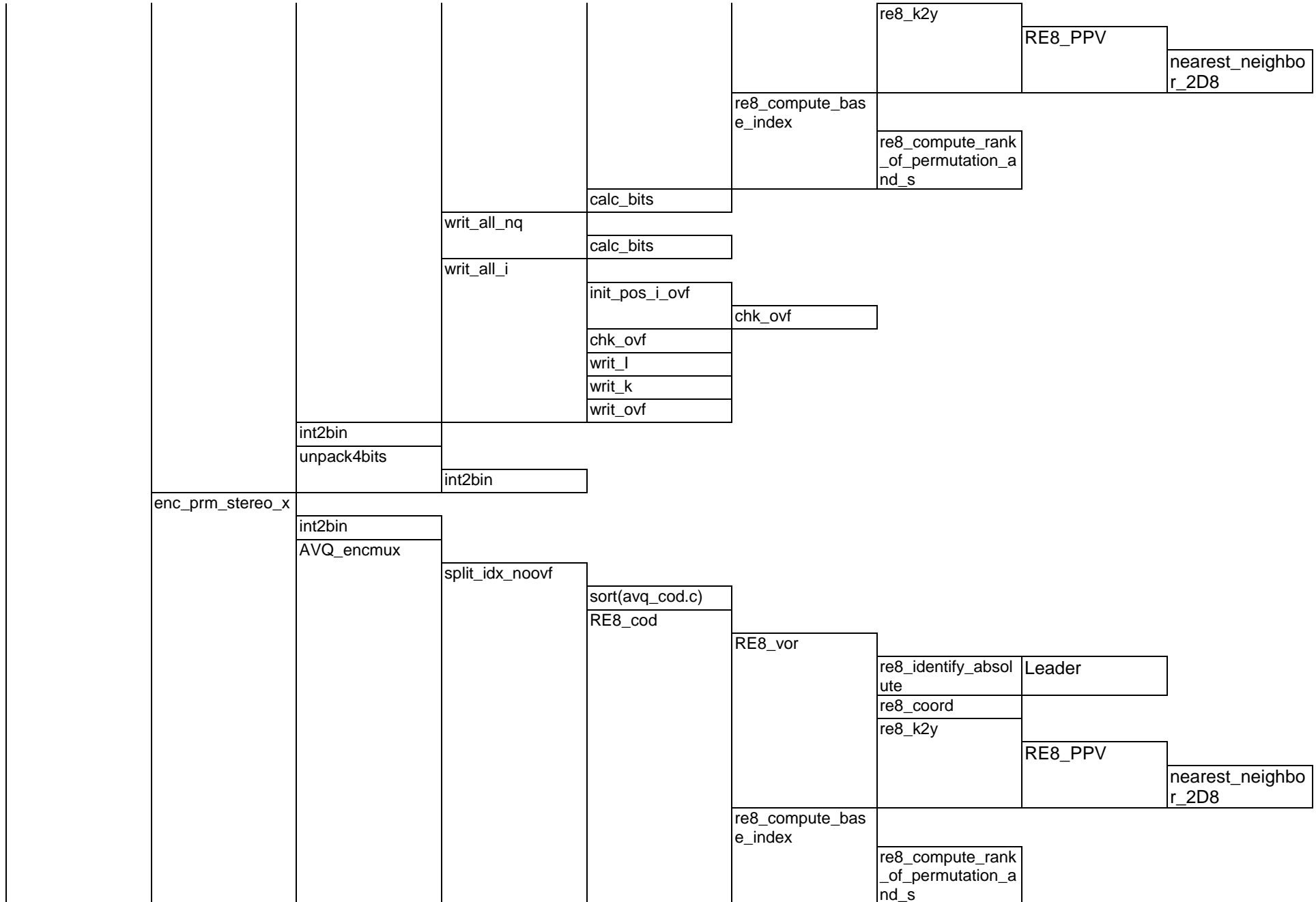












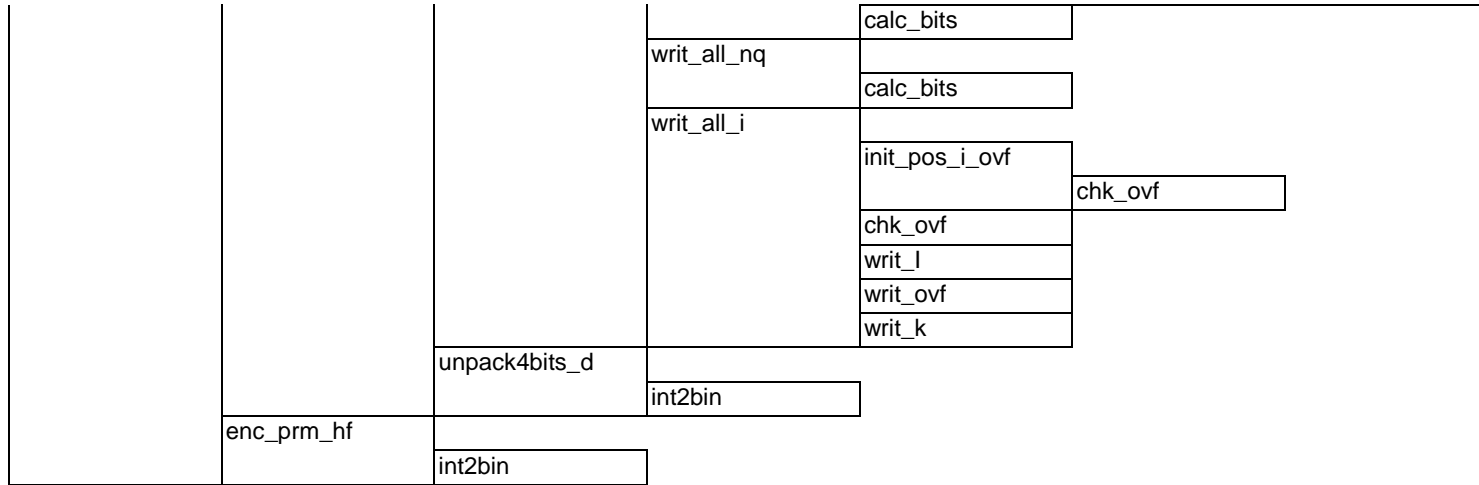
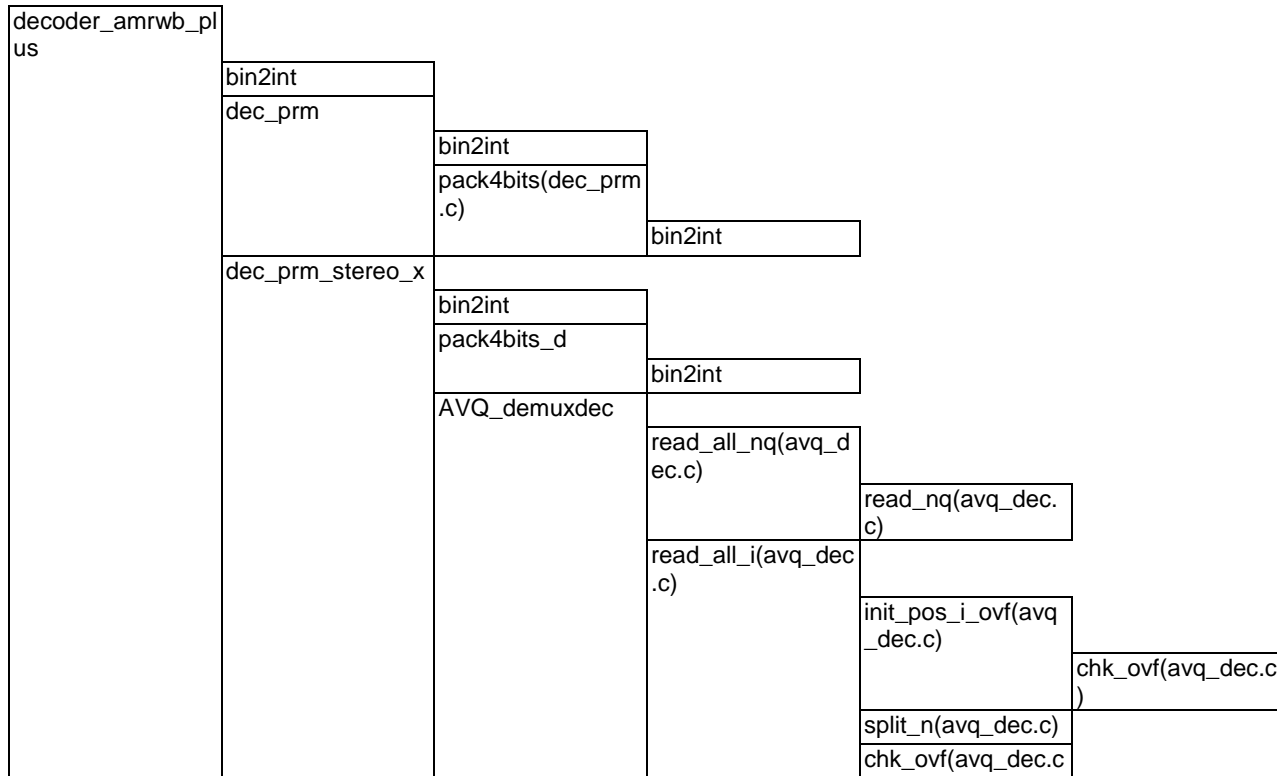
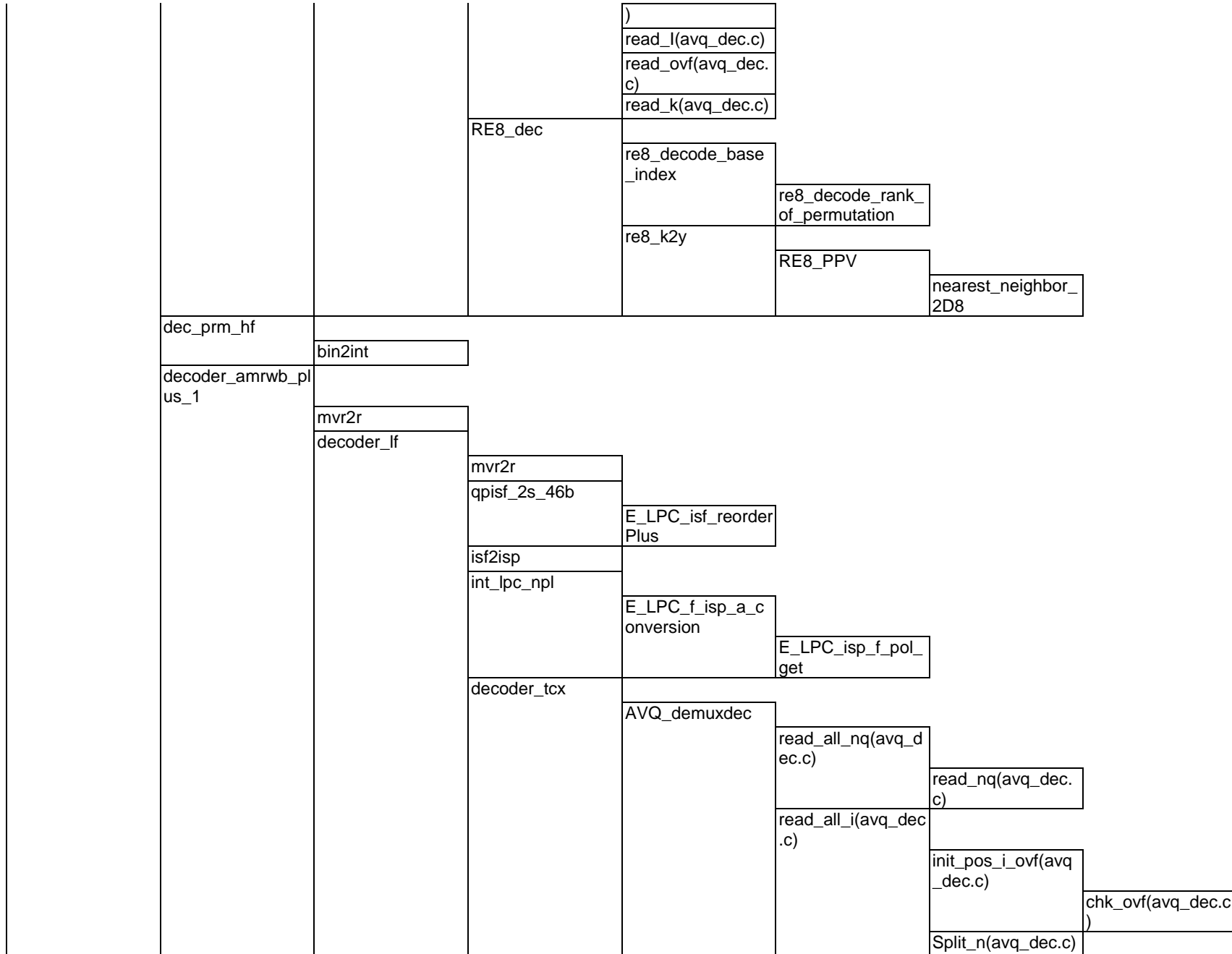
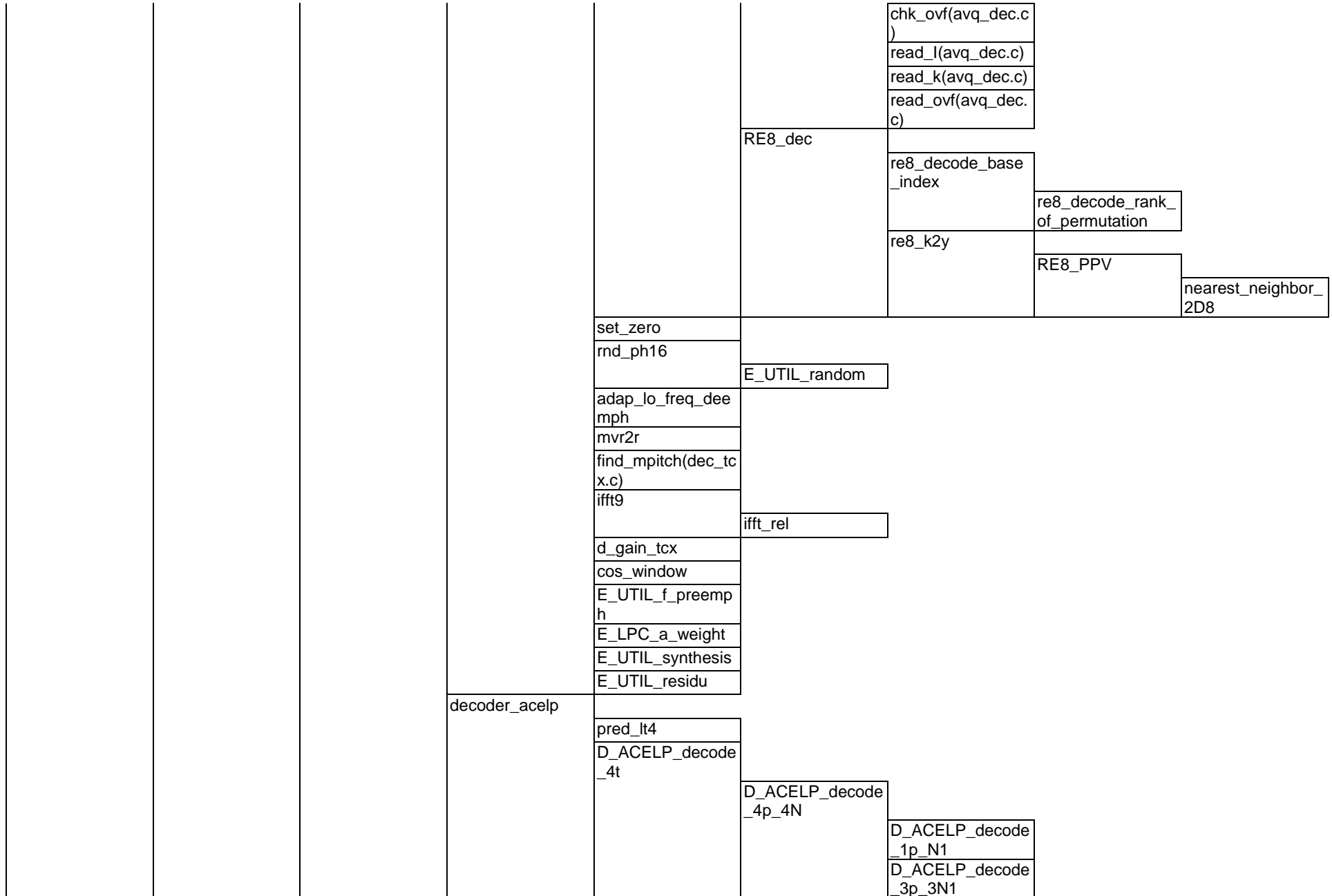
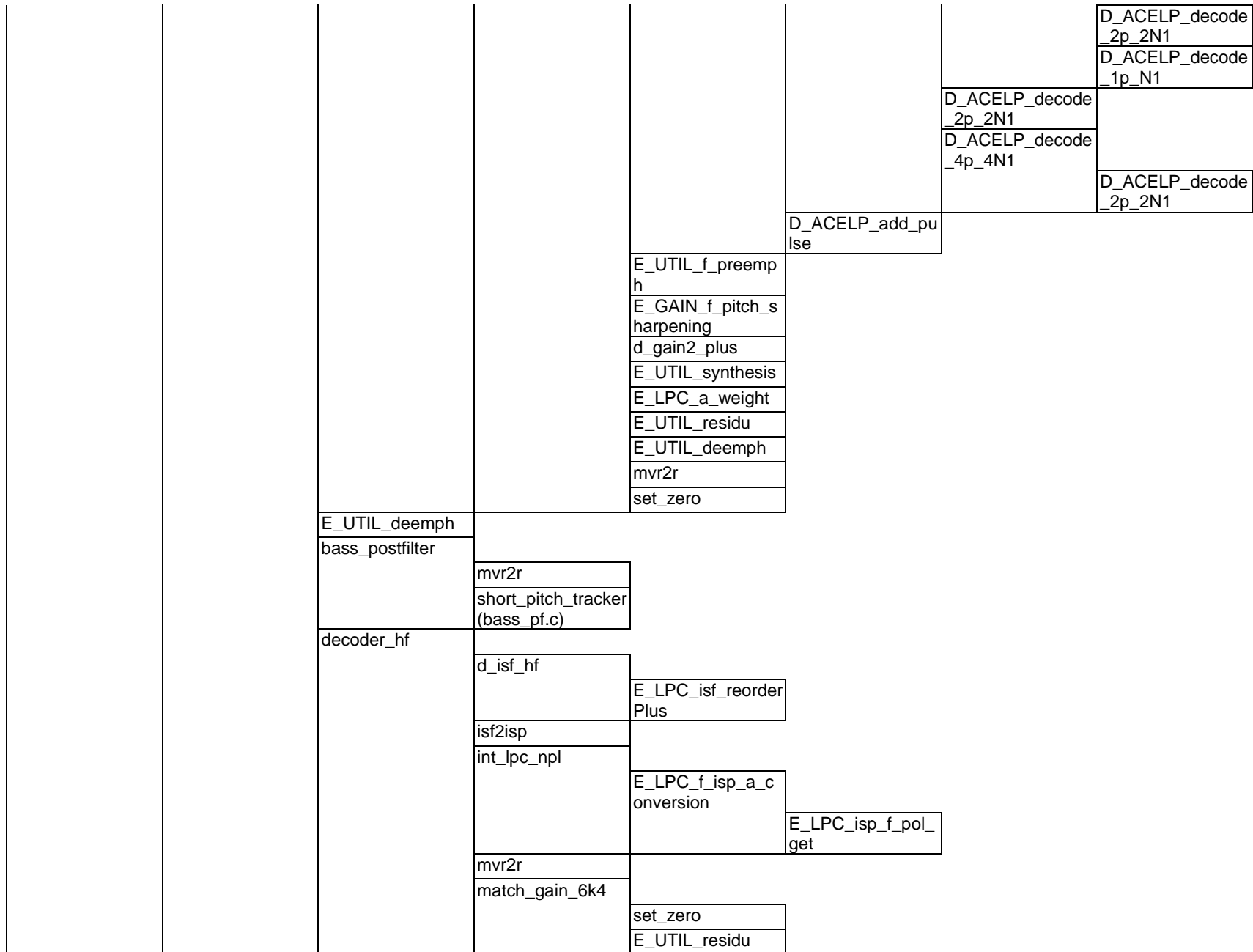


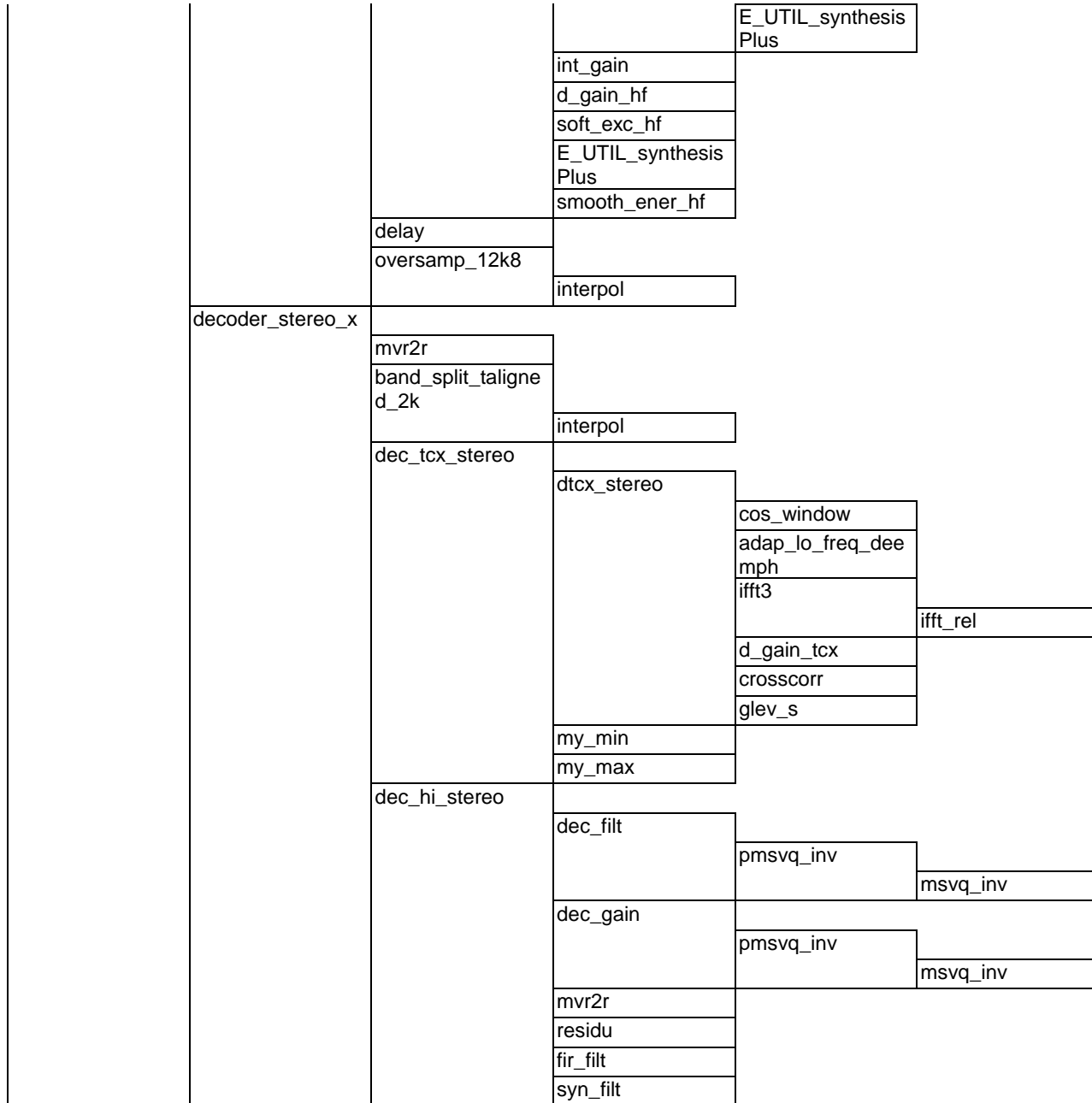
Table 2: Decoder call structure











		delay	
		band_join_2k	
			interpol
	hp50_12k8		
	oversamp_12k8		
		interpol	

4.4 Variables, constants and tables

4.4.1 Description of fixed tables used in the C-code

This clause contains a listing of all fixed tables declared in tables_plus.c and tables_stereo.c files.

Table 3: Encoder fixed tables

Format	Table name	Size	Description
Float32	NBITS_CORE	8	Core bit-rates
Float32	T_sin	1152	FFT Sine table
Float32	T_cos	1152	FFT Cosine table
Float32	filter_32k	61	FIR table for decimation/oversampling
Float32	filter_32k_hf	61	FIR table for decimation/oversampling
Float32	filter_32k_7k	61	FIR table for decimation/oversampling
Float32	filter_48k	185	FIR table for decimation/oversampling
Float32	Filter_48k_hf	185	FIR table for decimation/oversampling
Float32	filter_8k	61	FIR table for decimation/oversampling
Float32	isf_init	16	Initial ISF memory
Float32	Mean_isf	16	Means of ISFs
Float32	Dico1_isf	2304	1st stage codebook, isf0 to isf8
Float32	Dico2_isf	1792	1st stage codebook, isf9 to isf15
Float32	Dico21_isf	192	2nd stage codebook, isf2_0 to isf 2_2
Float32	Dico22_isf	384	2nd stage codebook, isf2_3 to isf 2_5
Float32	Dico23_isf	384	2nd stage codebook, isf2_6 to isf 2_8
Float32	Dico24_isf	96	2nd stage codebook, isf2_9 to isf 2_11
Float32	Dico25_isf	128	2nd stage codebook, isf2_12 to isf 2_15
Float32	Dico21_isf_36b	640	1st stage codebook, (36b) split 1
Float32	Dico22_isf_36b	512	1st stage codebook, (36b) split 2
Float32	Dico23_isf_36b	448	1st stage codebook, (36b) split 3
Float32	Dico_gain_hf	512	Quantization table for one-stage HF gain
Float32	Mean_isf_hf_12k8	8	Means of ISFs (full band)
Float32	dico1_isf_hf_12k8	32	1nd stage isf codebook (full band)
Float32	mean_isf_hf_low_rate	8	Means of isfs
Float32	Dico1_isf_hf_low_rate	32	1st stage isf codebook
Float32	dico2_isf_hf	1024	2nd stage isf codebook
Float32	Lag_window	17	Lag window
Float32	Filt_lp	13	Low-pass fir filter for bass post filter
Float32	Sin20	20	Random phase
Float32	Inter4_2	65	¼ resolution interpolation filter
Float32	VadFiltBandFreqs	12	Open-loop classifier
Float32	Bw	12	Open-loop classifier
Float32	Lwg	8	Open-loop classifier
Float32	Gain_hf_ramp	64	HF gain ramp for wb->wb+ switching
Float32	Inter2_coef	12	Filter coefficients for band join/split
Float32	Filter_LP180	2341	Filter for 48 kHz interpolation
Float32	StereoNbits	18	Stereo bit-rates
Float32	Filter_2k	321	2k decimation filter
Float32	Cb_filt_hi_mean	9	Average filter
Float32	Filt_hi_mscb4a	16*9	
Float32	Filt_hi_mscb_7a	16*9	
Float32	Filt_hi_mscb_7b	8*9	
Float32	Cb_gain_hi_mean	2	Average gain vector
Float32	Gain_hi_mscb_2a	4*2	
Float32	Gain_hi_mscb_5a	32*2	
	TBC		

Table 4: Decoder fixed tables

Format	Table name	Size	Description
Same as encoder			

4.4.2 Static variables used in the C-code

In this clause two tables that specify the static variables for the encoder and decoder respectively are shown. All static variables are declared within a C **struct**.

Table 5: Encoder static variables

struct name	type	variable	size	description
Coder_StState				
	float	mem_decim	1608	speech decimated filter memory
	int	decim_frac	1	Fractional decimation factor
	float	mem_sig_in	4	hp filter memory
	float	mem_preemph	1	speech preemphasis filter mem
	float	mem_decim_hf	46	HF filter memory
	float	old_speech_hf	528	HF old speech vector
	float	past_q_isf_hf	8	HF past quantized isf
	float	ispold_hf	8	HF old isp
	float	ispold_q_hf	8	HF quantized old isp
	float	old_gain;	1	HF old gain match
	float	mem_hf1	8	HF memory for gain 1
	float	mem_hf2	8	HF memory for gain 2
	float	mem_hf3	8	HF memory for gain 3
	float	old_exc	375	old excitation
	float*	mean_isf_hf	1	isf codebook mean
	float*	dico1_isf_hf	1	isf codebook first stage
Coder_State_Plus				
	Coder_StState	left	2614	state for left channel
	Coder_StState	right	2614	state for right channel
	float	old_chan	528	old left signal
	float	old_chan_2k	140	old left signal 2kHz sampl. rate
	float	old_chan_hi	448	old left signal HB
	float	old_speech_2k	140	old mono signal 2kHz sampl. rate
	float	old_speech_hi	448	old mono signal HB
	float	old_speech_pe	528	past pre-emphasised mono
	float	old_wh	9	past weighted filter
	float	old_wh_q	9	past quantized weighted filter
	float	old_gm_gain	2	past gain matching
	float	old_exc_mono	9	past mono excitation
	float	filt_energy_threshold	1	filter energy thershold
	float	w_window	64	weighting window
	PMSVQ*	*filt_hi_pmsvq	1	MSVQ quantizer
	PMSVQ*	*gain_hi_pmsvq	1	MSVQ quantizer
	int	mem_stereo_ovlp_size	1	past stereo overlap size
	float	mem_stereo_ovlp	32	past stereo overlap
	NCLASSDATA	*stClass	1	use case B classifier
	VadVars	*vadSt	1	VAD state
	short	vad_hist	1	VAD history
	float	old_speech	528	old speech
	float	old_synth	16	synthesis memory
	float	past_isfq	16	past isf quantizer
	float	old_wovlp	128	last tcx overlap
	float	old_d_wsp	187	Weighted speech vector
	float	old_exc	392	old excitation vector
	float	old_mem_wsyn	1	weighted synthesis memory
	float	old_mem_w0	1	weighted speech memory
	float	old_mem_xnq	1	quantized target memory

	int	old_ovlp_size	1	last tcx overlap size
	float	isfold	16	old isf frequency domain
	float	ispold	16	old isp
	float	ispold_q	16	quantized old isp
	float	mem_wsp	1	wsp vector mem
	float	mem_lp_decim2	3	wsp decimator filter mem
	float	ada_w	1	open loop LTP
	float	ol_gain	1	open loop LTP
	short	ol_wght_flg	1	open loop LTP
	long int	old_ol_lag	5	past openloop lag
	int	old_T0_med	1	past pitch
	float	hp_old_wsp	699	past HP weighted speech
	float	hp_ol_ltp_mem	7	past HP openloop long term prediction
	float	window	512	LP analysis window
	short	SwitchFlagPlusToWB	1	flag for switching to AMR-WB
	float	mem_gain_code	4	past code gain
	short	prev_mod	1	past frame type

Table 6: Decoder static variables

struct name	type	variable	size	description
Decoder_StState				
	float	mem_oversamp	72	Memory oversampling
	int	over_frac	1	Fractional overclocking factor
	float	mem_oversamp_hf	24	memory
	float	past_q_isf_hf	8	HF past quantized isf
	float	past_q_isf_hf_other	8	HF past quantized isf for the other channel when mono decoding stereo
	float	past_q_gain_hf	1	HF past quantized gain
	float	past_q_gain_hf_other	1	HF past quantized gain for the other channel when mono decoding stereo
	float	old_gain	1	HF old gain match
	float	ispold_hf	8	HF old isp
	float	threshold;	1	HF memory for smooth ener
	float	mem_syn_hf	8	HF synthesis memory
	float	mem_d_tcx	96	delay compensation memory
	float	mem_d_nonc	64	Non causality delay
	float	mem_synth_hi	16	High band sunthesis memory
	float	mem_sig_out	4	hp filter memory
	float	old_synth_hf	512	synch delay memory
	float	lp_amp	1	memory for soft exc
	float*	mean_isf_hf	1	isf codebook mean
	float*	dico1_isf_hf	1	isf codebook first stage
Decoder_State_Plus				
	Decoder_StState	left	828	State for left channel
	Decoder_StState	right	828	State for right channel
	float	mem_left_2k	20	2kHz memory on left chan
	float	mem_right_2k	20	2kHz memory on right chan
	float	mem_left_hi	64	HB memory left channel
	float	mem_right_hi	64	HB memory right channel
	float	my_old_synth_2k	35	old 2kHz synthesis
	float	my_old_synth_hi	128	old HB synthesis
	float	my_old_synth	148	old stereo synth
	float	old_AqLF	85	old quantized LPC
	float	old_wh	9	old decoded filter
	float	old_wh2	9	old decoded filter 2
	float	old_exc_mono	9	old mono excitation
	float	old_gain_left	4	old gain on left chan
	float	old_gain_right	4	old gain on right chan
	float	old_wh_q	9	past quantized filter
	float	old_gm_gain	2	past gain matching
	float	w_window	64	weighted synthesis window
	PMSVQ	*filt_hi_pmsvq	1	past MSVQ filter
	PMSVQ	*gain_hi_pmsvq	1	past MSVQ gain
	int	mem_stereo_ovlp_size	1	past stereo overlap size
	float	mem_stereo_ovlp	32	past stereo overlap
	int	last_stereo_mode	1	past stereo mode
	float	side_rms	1	side signal RMS
	float	h	9	current filter
	float	mem_balance	1	past balance factor

	int	fer_hist	500	frame erasure history
	int	fer_hist_ptr	1	frame erasure pointer
	float	fer_mean	1	frame erasure mean
	float	old_xri	1148	old spectral coefficients
	int	last_mode	1	last mode in previous 80ms frame
	float	mem_sig_out	4	hp50 filter memory for synthesis
	float	mem_deemph	1	speech deemph filter memory
	int	prev_lpc_lost	1	previous lpc is lost when = 1
	float	old_synth	16	synthesis memory
	float	old_exc	392	old excitation vector
	float	isfold	16	old isf (frequency domain)
	float	ispold	16	old isp (immittance spectral pairs)
	float	past_isfq	16	past isf quantizer
	float	wovlp	128	last weighted synthesis for overlap
	int	ovlp_size	1	overlap size
	float	isf_buf	51	old isf (for frame recovery)
	int	old_T0	1	old pitch value (for frame recovery)
	int	old_T0_frac	1	old pitch value (for frame recovery)
	short	seed_ace	1	seed memory (for random function)
	float	mem_wsyn	1	TCX synthesis memory
	short	seed_tcx	1	seed memory (for random function)
	float	wsyn_rms	1	rms value of weighted synthesis
	float	past_gpitt	1	past gain of pitch (for frame recovery)
	float	past_gcode	1	past gain of code (for frame recovery)
	int	pitch_tcx	1	for bfi
	float	gc_threshold	1	GC threshold
	float	old_synth_pf	503	Bass post-filter: old synthesis
	float	old_noise_pf	24	bass post-filter: noise memory
	int	old_T_pf	2	bass post-filter: old pitch
	float	old_gain_pf	2	Bass post-filter: old pitch gain
	float	*mean_isf_hf	1	HF isf codebook in-use
	float	*dico1_isf_hf	1	HF isf codebook in-use
	float	mem_gain_code	4	past code gain
	float	mem_lpc_hf	9	past HF lpc filter
	float	mem_gain_hf	1	past HF gain
	short	ramp_state	1	ramp state

5 File formats

This clause describes the file formats used by the encoder and decoder programs.

5.1 Audio file (encoder input/decoder output)

Audio files read by the encoder must be formatted as 16 bits PCM wave (*.wav) files. The decoder output is written as a 16 bit PCM wave file (*.wav).

Note that the decoder, with proper command line switch, can produce a mono file from a stereo bit-stream.

5.2 Parameter bitstream file (encoder output/decoder input)

For AMR-WB+ operation, the files produced by the audio encoder/expected by the audio decoder are either according to the transport interface format defined in Reference [2] Section 8.2, or according to the 3GP file format [7], whereby the storage sample definition is found in Reference [2] Section 8.3.

Annex A (informative): Change history

Change history							
Date	TSG SA#	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2004-09	25	SP-040640	-	-	Approved at TSG SA#25	2.0.0	6.0.0
2004-12	26	SP-040841	001		Incorrect definition of mode index for SID frames	6.0.0	6.1.0
2004-12	26	SP-040841	002		Correction of TCX coding selection for MMS encoder	6.0.0	6.1.0
2004-12	26	SP-040841	003		Misread of energy buffer in coding mode selection in MMS encoder. Correction of energy buffer initialisation	6.0.0	6.1.0
2004-12	26	SP-040841	004		Correction of stereo bit allocation tables	6.0.0	6.1.0
2004-12	26	SP-040841	005	1	Optimization of error concealment operation	6.0.0	6.1.0
2004-12	26	SP-040841	006	1	Stereo operation of pre-echo mode, saturation of gain_shape	6.0.0	6.1.0
2004-12	26	SP-040841	007		Stereo operation of pre-echo mode, alignment of encoder and decoder	6.0.0	6.1.0
2004-12	26	SP-040841	008	1	Addition of support for file formats and improved command line	6.0.0	6.1.0
2004-12	26	SP-040841	009	1	Source code editorial changes	6.0.0	6.1.0
2004-12	26	SP-040841	010		Removal of complexity counters	6.0.0	6.1.0
2004-12	26	SP-040841	011	1	Editorial changes	6.0.0	6.1.0
2004-12	26	SP-040841	012		Void. This CR in S4-040722 (Title: Editorial changes) was meant to TS 26.290 (as CR 004) and not to TS 26.304 ! The CR was implemented instead in TS 26.290 v. 6.1.0 and a remark was put in the CR database.	6.0.0	6.1.0
2004-12	26	SP-040841	013		Removal of the eid tool	6.0.0	6.1.0
2004-12	26	SP-040841	014	1	Addition of frame erasure simulation at the decoder	6.0.0	6.1.0
2004-12	26	SP-040841	015		Removal of two unused stereo rates	6.0.0	6.1.0
2004-12	26	SP-040841	016		Removal of extStMode	6.0.0	6.1.0

History

Document history		
V6.1.0	December 2004	Publication