ETSI TS 126 173 V15.1.0 (2019-04)

TECHNICAL SPECIFICATION

Digital cellular telecommunications system (Phase 2+) (GSM);
Universal Mobile Telecommunications System (UMTS);
LTE;
ANSI-C code for the Adaptive Multi-Rate - Wideband (AMR-WB) speech codec
(3GPP TS 26.173 version 15.1.0 Release 15)

Reference

RTS/TSGS-0426173vf10

Keywords

GSM,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
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1 Scope

The present document contains an electronic copy of the ANSI-C code for the Adaptive Multi-Rate Wideband codec. The ANSI-C code is necessary for a bit exact implementation of the Adaptive Multi Rate Wideband speech transcoder (3GPP TS 26.190 [2]), Voice Activity Detection (3GPP TS 26.194 [6]), comfort noise (3GPP TS 26.192 [4]), source controlled rate operation (3GPP TS 26.193 [5]) and example solutions for substituting and muting of lost frames (3GPP TS 26.191 [3]).

2 References

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[1] 3GPP TS 26.174: "AMR Wideband Speech Codec; Test sequences".

[2] 3GPP TS 26.190: "AMR Wideband Speech Codec; Speech transcoding".

[3] 3GPP TS 26.191: "AMR Wideband Speech Codec; Substitution and muting of lost frames".

[4] 3GPP TS 26.192: "AMR Wideband Speech Codec; Comfort noise aspects".

[5] 3GPP TS 26.193: "AMR Wideband Speech Codec; Source controlled rate operation".

[6] 3GPP TS 26.194: "AMR Wideband Speech Codec; Voice Activity Detection".

[7] RFC 3267 "A Real-Time Transport Protocol (RTP) Payload Format and File Storage Format for Adaptive Multi-Rate (AMR) and Adaptive Multi-Rate Wideband (AMR-WB) Audio Codecs", June 2002.

3 Definitions and abbreviations

3.1 Definitions

Definition of terms used in the present document, can be found in 3GPP TS 26.190 [2], 3GPP TS 26.191 [3], 3GPP TS 26.192 [4], 3GPP TS 26.193 [5] and 3GPP TS 26.194 [6].

3.2 Abbreviations

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

AMR-WB	Adaptive Multi-Rate Wideband
ANSI	American National Standards Institute
ETS	European Telecommunication Standard
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 bit-exact C code and provides an overview of the contents and organization of the C code attached to this document.

The C code has been verified on the following systems:

- Sun Microsystems workstations and GNU gcc compiler
- HP workstations and cc compiler
- IBM PC compatible computers with Windows NT4 operating system and GNU gcc 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 all files in the root level.

The distributed files with suffix "c" contain the source code and the files with suffix "h" are the header files. The ROM data is contained mostly in files with suffix "tab".

The C code distribution also contains one speech coder installation verification data file, "spch_dos.inp". The reference encoder output file is named "spch_dos.cod", the reference decoder input file is named "spch_dos.dec" and the reference decoder output file is named "spch_dos.out". These four files are formatted such that they are correct for an IBM PC/AT compatible computer. The same files with reversed byte order of the 16 bit words are named "spch_unx.inp", "spch_unx.cod", "spch_unx.dec" and "spch_unx.out", respectively.

Final verification is to be performed using the GSM Adaptive Multi-Rate Wideband test sequences described in 3GPP TS 26.174 [1].

Makefiles are provided for the platforms in which the C code has been verified (listed above). Once the software is installed, this directory will have a compiled version of *encoder* and *decoder* (the bit-exact C executables of the speech codec) and all the object files.

4.2 Program execution

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

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

The programs should be called like:

- encoder [encoder options] <speech input file> <parameter file>;
- decoder <parameter file> <speech output file>.

The speech files contain 16-bit linear encoded PCM speech samples and the parameter files contain encoded speech 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 to 3 are call graphs that show the functions used in the speech codec, including the functions of VAD, DTX, and comfort noise generation.

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: printf(), fwrite(), etc. have been omitted. Also, no basic operations (add(), L_add(), mac(),

etc.) or double precision extended operations (e.g. L_Extract()) appear in the graphs. The initialization of the static RAM (i.e. calling the _init functions) is also omitted.

The basic operations are not counted as extending the depth, therefore the deepest level in this software is level 6.

The encoder call graph is broken down into two separate call graphs, Table 1 to 2.

Table 1: Speech encoder call structure

coder	Copy			
	Decim_12k8	Down_samp	Interpol (function)	
		Copy		
	Set_zero			
	HP50_12k8			
	Scale_sig			
	wb_vad	Filter_bank	Filter5	
			Filter3	
			Level_calculation	
		vad_decision	Ilog2	
			Noise_estimate_update	update_cntrl
			hangover_addition	
		Estimate_Speech		
	tx_dtx_handler			
	Parm_serial			
	Autocorr			
	Lag_window			
	Levinson			
	Az_isp	Chebps2		
	Int_isp	Isp_Az	Get_isp_pol	
	Isp_isf			
	Gp_clip_test_isf			
	Weight_a			
	Residu			
	Deemph2			
	LP_Decim2			
	Scale_mem_Hp_wsp			
	Pitch_med_ol	Hp_wsp		
		Isqrt_n		
	wb_vad_tone_detection			
	Med_olag	median5		
	dtx_buffer	Copy		
	dtx_enc	Find_frame_indices		
		Aver_isf_history		
		Qisf_ns	Sub_VQ	
			Disf_ns	Reorder_isf
		Parm_serial		
		Pow2		
		Random		
		Dot_product12		
		Isqrt_n		
	Isf_isp			
	Isp_Az	Get_isp_pol		
	Synthesis	Copy		
		Syn_filt_32		
		Deemph_32		
		HP50_12k8		
		Random		
		Scale_sig		
		Dot_product12		
		Isqrt_n		
		HP400_12k8		
		Weight_a		
		Syn_filt		
		Filt_6k_7k		
	Reset_encoder	Set_zero		
		Init_gp_clip		
		Init_Phase_dispersion	Set_zero	
	Qpisf_2s_36b	VQ_stage1		
		Sub_VQ		
		Dpisf_2s_36b	Reorder_isf	
	Qpisf_2s_46b	VQ_stage1		
		Sub_VQ		
		Dpisf_2s_46b	Reorder_isf	
	Syn_filt			
	Preemph2			
	Pitch_fr4	Norm_Corr	Convolve	
			Isqrt_n	
		Interpol_4		
	Gp_clip			
	Pred_lt4			
	Convolve			
	G_pitch	Dot_product12		
	Updt_tar			
	Preemph			
	Pit_shrp			
	Cor_h_x			
	ACELP_2t64_fx	Dot_product12		
		Isqrt_n		
	ACELP_4t64_fx	See Table 2		
	Q_gain2	Dot_product12		
		Pow2		
	Gp_clip_test_gain_pit			
	voice_factor	Dot_product12		

Table 2: ACELP_4t64_fx call structure

ACELP_4t64_fx	Dot_product12				
	Isqrt_n				
	cor_h_vec				
	search_ixiy				
	quant_1p_N1				
	quant_2p_2N1				
	quant_3p_3N1	quant_2p_2N1			
		quant_1p_N1			
	quant_4p_4N	quant_4p_4N1	Quant_2p_2N1		
		quant_1p_N1			
		quant_3p_3N1	Quant_2p_2N1		
			Quant_1p_N1		
		quant_2p_2N1			
	quant_5p_5N	quant_3p_3N1	Quant_2p_2N1		
			Quant_1p_N1		
		quant_2p_2N1			
	quant_6p_6N_2	quant_5p_5N	Quant_3p_3N1	quant_2p_2N1	
				Quant_1p_N1	
			quant_2p_2N1		
		quant_1p_N1			
		quant_4p_4N	quant_4p_4N1	quant_2p_2N1	
			quant_1p_N1		
			quant_3p_3N1	quant_2p_2N1	
				quant_1p_N1	
			quant_2p_2N1		
		quant_2p_2N1			
		quant_3p_3N1	quant_2p_2N1		
			Quant_1p_N1		