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Technical Specification

**3rd Generation Partnership Project;
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General audio codec audio processing functions;
Enhanced aacPlus general audio codec; ANSI-C code;
(Release 6)**



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Keywords

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Foreword

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

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

The present document contains an electronic copy of the ANSI-C code for the Floating-point Enhanced aacPlus codec.

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 26.401 : Enhanced aacPlus general audio codec; General Description
- [2] 3GPP TS 26.403 : Enhanced aacPlus general audio codec; Encoder Specification AAC part
- [3] 3GPP TS 26.404 : Enhanced aacPlus general audio codec; Encoder Specification SBR part
- [4] 3GPP TS 26.405 : Enhanced aacPlus general audio codec; Encoder Specification Parametric Stereo part
- [5] ISO/IEC 14496-3:2001, Information technology - Coding of audio-visual objects - Part 3: Audio.
- [6] ISO/IEC 14496-3:2001/Amd.1:2003, Bandwidth Extension.
- [7] ISO/IEC 14496-3:2001/Amd.1:2003/DCOR1.
- [8] ISO/IEC 14496-3:2001/FDAM2, Parametric Coding for High Quality Audio.
attached as file: dec_draft_spec_parSter.pdf
- [9] 3GPP TS 26.402 : Enhanced aacPlus general audio codec; Additional Decoder Tools

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TS 26.401 [1], TS 26.403 [2], TS 26.404 [3], TS 26.405 [4] and TS 26.402 [9] apply.

3.2 Abbreviations

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

| | |
|------------------|--|
| AAC | Advanced Audio Coding |
| aacPlus | Combination of MPEG-4 AAC and MPEG-4 Bandwidth extension (SBR) |
| Enhanced aacPlus | Combination of MPEG-4 AAC, MPEG-4 Bandwidth extension (SBR) and MPEG-4 Parametric Stereo |
| HE-AAC | High Efficiency AAC |
| MDCT | Modified Discrete Cosine Transform |
| PS | Parametric Stereo |
| QMF | Quadrature Mirror Filter |
| SBR | Spectral Band Replication |
| ANSI | American National Standards Institute |
| GSM | Global System for Mobile communications |
| I/O | Input/Output |
| RAM | Random Access Memory |
| ROM | Read Only Memory |

4 Floating point ANSI-C code structure

This clause gives an overview of the structure of the floating point ANSI-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 XP, 2000 and Microsoft Visual C++ v.6.0 compiler.
- IBM PC/AT compatible computers with Linux OS and GCC v.3.3 compiler.

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

4.1 Contents of the floating point ANSI-C source code

The C code distribution is organised in two directories for encoder and decoder and further into several subdirectories, reflecting the major building blocks of the Enhanced aacPlus codec. The file descriptions on root level as well as the directory structure is given as follows:

Table 1: Source code directory structure for the encoder (FloatFR_aacPlusenc)

| Directory | Description |
|------------------------|------------------------------------|
| README.txt | information on how to compile |
| Makefile | UNIX style encoder Makefile |
| FloatFR_aacPlusEnc.dsw | Win32 MSVC 6.0 encoder workspace |
| FloatFR_aacPlusEnc.dsp | Win32 MSVC 6.0 encoder makefile |
| src/ | directory for the encoder frontend |
| FloatFR_fastaacenc/ | AAC encoder library |
| FloatFR_resamplib/ | resampler library |
| FloatFR_sbrenclib/ | SBR encoder library |

Table 2: Source code directory structure for the decoder (FloatFR_aacPlusdec)

| Directory | Description |
|----------------------------------|------------------------------------|
| README.txt | information on how to compile |
| Makefile | UNIX style encoder Makefile |
| FloatFR_aacPlusdec_mp eg4.dsw | Win32 MSVC 6.0 decoder workspace |
| FloatFR_aacPlusdec_mp eg4.dsp | Win32 MSVC 6.0 decoder makefile |
| src/ | directory for the decoder frontend |
| FloatFR_aacdec | AAC decoder library |
| FloatFR_sbrdeclib/ | SBR decoder library |

Table 3: Source code directory structure common for encoder and decoder

| Directory | Description |
|--------------------|--|
| FloatFR_bitbuflib/ | bitstream reading/writing library |
| FloatFRlib/ | general purpose functionalities |
| lib/ | precompiled libraries for audio and bitstream file format handling |

The distributed files with suffix "c" contain the source code and the files with suffix "h" are the header files. Within the respective libraries, the RAM data is contained in "xxx_ram" files with suffix "c", the ROM data is contained in "xxx_rom" files with suffix "c". Makefiles are provided for the platforms in which the C code has been verified (listed above).

Note that the FloatFRlib/, FloatFR_bitbuflib/ and lib/ directory are identical for encoder and decoder. A list of source code files with the respective lines of code (pure C instructions) is given below:

Table 4: Encoder source code files and lines of code

| Directory | Module | Lines of code |
|------------------------|---------------------|---------------|
| src/ | main.c | 332 |
| | mp4file.c | 255 |
| FloatFR_fastaacenclib/ | qc_main.c | 224 |
| | aacenc.c | 136 |
| | ms_stereo.c | 50 |
| | spreading.c | 10 |
| | interface.c | 44 |
| | bit_cnt.c | 588 |
| | adj_thr.c | 592 |
| | quantize.c | 56 |
| | psy_configuration.c | 175 |
| | sf_estim.c | 508 |
| | tns_param.c | 45 |
| | grp_data.c | 114 |
| | pre_echo_control.c | 22 |
| | stprepro.c | 149 |
| | tns.c | 358 |
| | dyn_bits.c | 281 |
| | psy_main.c | 232 |
| | channel_map.c | 52 |
| | block_switch.c | 201 |
| | band_nrg.c | 34 |
| | transform.c | 151 |
| | bitenc.c | 262 |
| | line_pe.c | 55 |
| | stat_bits.c | 107 |
| FloatFR_sbrenclib/ | qmf_enc.c | 565 |
| | ton_corr.c | 287 |
| | fram_gen.c | 688 |
| | env_bit.c | 56 |
| | env_est.c | 630 |
| | mh_det.c | 515 |
| | hybrid.c | 139 |
| | bit_sbr.c | 375 |
| | ps_bitenc.c | 225 |
| | sbr_main.c | 355 |
| | tran_det.c | 183 |
| | sbr_misc.c | 49 |
| | code_env.c | 290 |
| | nf_est.c | 195 |
| | freq_sca.c | 309 |
| | invf_est.c | 140 |
| | ps_enc.c | 299 |
| FloatFR_resamplib/ | iir32resample.c | 71 |
| | resampler.c | 68 |

Table 5: Decoder source code files and lines of code

| Directory | Module | Lines of code |
|--------------------|--------------------|---------------|
| src/ | main.c | 299 |
| | fileifc.c | 173 |
| | spline_resampler.c | 172 |
| FloatFR_aacdec/ | aacdecoder.c | 168 |
| | streaminfo.c | 10 |
| | channelinfo.c | 102 |
| | stereo.c | 78 |
| | longblock.c | 234 |
| | shortblock.c | 241 |
| | pulsedata.c | 24 |
| | block.c | 163 |
| | pns.c | 96 |
| | imdct.c | 50 |
| | tns.c | 137 |
| | bitstream.c | 15 |
| | channel.c | 92 |
| | conceal.c | 245 |
| | FloatFR_sbrdeclub/ | env_dec.c |
| FFR_aacPLUScheck.c | | 32 |
| sbr_bitb.c | | 37 |
| env_calc.c | | 775 |
| lpp_tran.c | | 504 |
| sbrdecoder.c | | 514 |
| sbr_dec.c | | 218 |
| sbr_crc.c | | 45 |
| sbr_fft.c | | 615 |
| hybrid.c | | 140 |
| ps_bitdec.c | | 223 |
| huff_dec.c | | 9 |
| env_extr.c | | 655 |
| freq_sca.c | | 337 |
| ps_dec.c | | 317 |
| qmf_dec.c | 526 | |

Table 6: Common source code files and lines of code

| Directory | Module | Lines of code |
|--------------------|----------------|---------------|
| FloatFR_bitbuflib/ | bitbuffer.c | 111 |
| FloatFRlib/ | cfftn.c | 649 |
| | transcendent.c | 15 |

4.2 Program execution

The Enhanced aacPlus codec is implemented in two programs:

- enhAacPlusEnc.exe
- enhAacPlusDec.exe

The programs should be called like:

- enhAacPlusEnc.exe <wav_file> <bitstream_file> <bitrate> <(m)ono/(s)tereo>
- enhAacPlusDec.exe <bitstream_file> <wav_file> <mode> [error_pattern_file]

The audio files contain 16-bit linear encoded PCM samples with wav header, the bitstream files are of 3GPP type and the error pattern file is a ASCII file, see section 5.

The encoder and decoder command line handling is also explained by running the applications without input arguments.

4.3 Memory requirements

The data types of variables and tables used in the floating-point implementation are plain ANSI-C data types, the following types are used:

- char
- unsigned char
- short
- int
- unsigned int
- float

4.3.1 Constants and tables

This clause contains a listing of all constants and tables contributing to the ROM requirements of the encoder and decoder.

Table 7: Encoder constants and tables

| Name | Data type | Size [word] | Allocated in Source File | Description |
|----------------------|-----------|-------------|--------------------------|---|
| LongWindowSine | float | 1024 | aac_rom.c | Window coefficients |
| ShortWindowSine | float | 128 | aac_rom.c | Window coefficients |
| LongWindowKBD | float | 1024 | aac_rom.c | Window coefficients |
| fftTwiddleTab | float | 513 | aac_rom.c | FFT twiddle coefficients |
| quantTableQ | float | 16 | aac_rom.c | Quantizer table, used for efficient pow () implementation |
| quantTableE | float | 17 | aac_rom.c | Quantizer table, used for efficient pow () implementation |
| invQuantTableQ | float | 16 | aac_rom.c | Quantizer table, used for efficient pow () implementation |
| invQuantTableE | float | 17 | aac_rom.c | Quantizer table, used for efficient pow () implementation |
| pow4_3_tab | float | 64 | aac_rom.c | Quantizer table, used for efficient pow () implementation |
| p_8000_mono_long | float | 4 | aac_rom.c | TNS tuning parameters |
| p_8000_stereo_long | float | 4 | aac_rom.c | TNS tuning parameters |
| p_8000_mono_short | float | 4 | aac_rom.c | TNS tuning parameters |
| p_8000_stereo_short | float | 4 | aac_rom.c | TNS tuning parameters |
| p_16000_mono_long | float | 4 | aac_rom.c | TNS tuning parameters |
| p_16000_stereo_long | float | 4 | aac_rom.c | TNS tuning parameters |
| p_16000_mono_short | float | 4 | aac_rom.c | TNS tuning parameters |
| p_16000_stereo_short | float | 4 | aac_rom.c | TNS tuning parameters |
| p_24000_mono_long | float | 4 | aac_rom.c | TNS tuning parameters |
| p_24000_stereo_long | float | 4 | aac_rom.c | TNS tuning parameters |
| p_24000_mono_short | float | 4 | aac_rom.c | TNS tuning parameters |
| p_24000_stereo_short | float | 4 | aac_rom.c | TNS tuning parameters |
| p_32000_mono_long | float | 4 | aac_rom.c | TNS tuning parameters |
| p_32000_stereo_long | float | 4 | aac_rom.c | TNS tuning parameters |
| p_32000_mono_short | float | 4 | aac_rom.c | TNS tuning parameters |
| p_32000_stereo_short | float | 4 | aac_rom.c | TNS tuning parameters |
| tnsCoeff3 | float | 8 | aac_rom.c | TNS filter coefficients |
| tnsCoeff3Borders | float | 8 | aac_rom.c | TNS filter borders |
| tnsCoeff4 | float | 16 | aac_rom.c | TNS filter coefficients |
| tnsCoeff4Borders | float | 16 | aac_rom.c | TNS filter borders |
| tnsInfoTab | int | 24 | aac_rom.c | TNS bitrate to tuning mapping table |
| tnsMaxBandsTab | int | 27 | aac_rom.c | max. TNS bands per sampling rate table |
| huff_ltab1_2 | short | 80 | aac_rom.c | Huffman codeword table AAC |
| huff_ltab3_4 | short | 80 | aac_rom.c | Huffman codeword table AAC |
| huff_ltab5_6 | short | 80 | aac_rom.c | Huffman codeword table AAC |
| huff_ltab7_8 | short | 64 | aac_rom.c | Huffman codeword table AAC |
| huff_ltab9_10 | short | 168 | aac_rom.c | Huffman codeword table AAC |
| huff_ltab11 | short | 288 | aac_rom.c | Huffman codeword table AAC |
| huff_ltabscf | short | 120 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab1 | short | 80 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab2 | short | 80 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab3 | short | 80 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab4 | short | 80 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab5 | short | 80 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab6 | short | 80 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab7 | short | 64 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab8 | short | 64 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab9 | short | 168 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab10 | short | 168 | aac_rom.c | Huffman codeword table AAC |
| huff_ctab11 | short | 288 | aac_rom.c | Huffman codeword table AAC |
| huff_ctabscf | short | 242 | aac_rom.c | Huffman codeword table AAC |
| sfb_11025_long_1024 | char | 43 | aac_rom.c | Scalefactor band table |
| sfb_11025_short_128 | char | 15 | aac_rom.c | Scalefactor band table |
| sfb_12000_long_1024 | char | 43 | aac_rom.c | Scalefactor band table |
| sfb_12000_short_128 | char | 15 | aac_rom.c | Scalefactor band table |
| sfb_16000_long_1024 | char | 43 | aac_rom.c | Scalefactor band table |
| sfb_16000_short_128 | char | 15 | aac_rom.c | Scalefactor band table |
| sfb_22050_long_1024 | char | 47 | aac_rom.c | Scalefactor band table |

| | | | | |
|--------------------------|-------------|-------------|-----------------|--|
| sfb_22050_short_128 | char | 15 | aac_rom.c | Scalefactor band table |
| sfb_24000_long_1024 | char | 47 | aac_rom.c | Scalefactor band table |
| sfb_24000_short_128 | char | 15 | aac_rom.c | Scalefactor band table |
| panClass | float | 7 | sbr_rom.c | PS quantization table |
| saClass | float | 7 | sbr_rom.c | PS quantization table |
| p4_13 | float | 13 | sbr_rom.c | Hybrid filterbank coefficients |
| p8_13 | float | 13 | sbr_rom.c | Hybrid filterbank coefficients |
| sbr_cos_twiddle | float | 16 | sbr_rom.c | QMF filterbank twiddle table |
| sbr_sin_twiddle | float | 16 | sbr_rom.c | QMF filterbank twiddle table |
| sbr_alt_sin_twiddle | float | 17 | sbr_rom.c | QMF filterbank twiddle table |
| sbr_qmf_64_640 | float | 325 | sbr_rom.c | QMF window coefficients |
| p_64_640_qmf | float | 640 | sbr_rom.c | QMF window coefficients (Note: could be made obsolete) |
| trigData_fct4_32 | float | 32 | sbr_rom.c | FFT twiddle table |
| trigData_fct4_16 | float | 16 | sbr_rom.c | FFT twiddle table |
| trigData_fct4_8 | float | 8 | sbr_rom.c | FFT twiddle table |
| aBookPslidTimeCode | int | 29 | sbr_rom.c | Huffman codeword table PS |
| aBookPslidFreqCode | int | 29 | sbr_rom.c | Huffman codeword table PS |
| aHybridResolution | int | 3 | sbr_rom.c | Number of hybrid bands in each QMF band |
| hiResBandBorders | int | 21 | sbr_rom.c | Borders of PS bins |
| groupBordersMix | int | 29 | sbr_rom.c | Borders of PS groups |
| bins2groupMap | int | 29 | sbr_rom.c | Mapping of PS bins to PS groups |
| v_Huff_envelopeLevelC10T | int | 121 | sbr_rom.c | Huffman codeword table SBR |
| v_Huff_envelopeLevelC10F | int | 121 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrEnvBalanceC10F | int | 49 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrEnvBalanceC10T | int | 49 | sbr_rom.c | Huffman codeword table SBR |
| v_Huff_envelopeLevelC11T | int | 63 | sbr_rom.c | Huffman codeword table SBR |
| v_Huff_NoiseLevelC11T | int | 63 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrEnvBalanceC11T | int | 25 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrNoiseBalanceC11T | int | 25 | sbr_rom.c | Huffman codeword table SBR |
| v_Huff_envelopeLevelC11F | int | 63 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrEnvBalanceC11F | int | 25 | sbr_rom.c | Huffman codeword table SBR |
| aBookPslidTimeLength | char | 29 | sbr_rom.c | Huffman codeword table PS |
| aBookPslidFreqLength | char | 29 | sbr_rom.c | Huffman codeword table PS |
| aBookPslccFreqLength | char | 15 | sbr_rom.c | Huffman codeword table PS |
| aBookPslccTimeLength | char | 15 | sbr_rom.c | Huffman codeword table PS |
| v_Huff_envelopeLevelL10T | char | 121 | sbr_rom.c | Huffman codeword table SBR |
| v_Huff_envelopeLevelL10F | char | 121 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrEnvBalanceL10F | char | 49 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrEnvBalanceL10T | char | 49 | sbr_rom.c | Huffman codeword table SBR |
| v_Huff_envelopeLevelL11T | char | 63 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrEnvBalanceL11T | char | 25 | sbr_rom.c | Huffman codeword table SBR |
| v_Huff_NoiseLevelL11T | char | 63 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrNoiseBalanceL11T | char | 25 | sbr_rom.c | Huffman codeword table SBR |
| v_Huff_envelopeLevelL11F | char | 63 | sbr_rom.c | Huffman codeword table SBR |
| bookSbrEnvBalanceL11F | char | 25 | sbr_rom.c | Huffman codeword table SBR |
| aBookPslccFreqCode | short | 15 | sbr_rom.c | Huffman codeword table PS |
| aBookPslccTimeCode; | short | 15 | sbr_rom.c | Huffman codeword table PS |
| logDualisTable | float | 65 | transcendent.c | Lookup table for efficient log() implementation |
| set1_a | float | 14 | resampler.c | IIR filter coefficients for 2:1 resampling |
| set1_b | float | 14 | resampler.c | IIR filter coefficients for 2:1 resampling |
| set1 | float | 5 | resampler.c | IIR filter coefficients for 2:1 resampling |
| set2_a | float | 21 | resampler.c | IIR filter coefficients for 2:1 resampling |
| set2_b | float | 21 | resampler.c | IIR filter coefficients for 2:1 resampling |
| set2 | float | 5 | resampler.c | IIR filter coefficients for 2:1 resampling |
| set3_a | float | 18 | resampler.c | IIR filter coefficients for 2:1 resampling |
| set3_b | float | 18 | resampler.c | IIR filter coefficients for 2:1 resampling |
| set3 | float | 5 | resampler.c | IIR filter coefficients for 2:1 resampling |
| coeffNum | float | 8 | iir32resample.c | IIR filter coefficients for 3:2 resampling |
| coeffDen | float | 8 | iir32resample.c | IIR filter coefficients for 3:2 resampling |
| tuningTable | tuningTable | 121 | sbr_main.c | SBR tuning parameters |
| Sum | | 8533 | | |

Table 8: Decoder constants and tables

| Name | Data type | Size [word] | Allocated in Source File | Description |
|---------------------------|-----------|-------------|--------------------------|---|
| tnsCoeff3 | float | 8 | aac_rom.c | TNS filter coefficients |
| tnsCoeff4 | float | 16 | aac_rom.c | TNS filter coefficients |
| trigData | float | 513 | aac_rom.c | Sine table, used for efficient sin(), cos() |
| OnlyLongWindowKBD | float | 1024 | aac_rom.c | Window coefficients |
| OnlyShortWindowKBD | float | 128 | aac_rom.c | Window coefficients |
| OnlyLongWindowSine | float | 1024 | aac_rom.c | Window coefficients |
| OnlyShortWindowSine | float | 128 | aac_rom.c | Window coefficients |
| sfb_48_1024 | short | 50 | aac_rom.c | Scalefactor band table |
| sfb_48_128 | short | 15 | aac_rom.c | Scalefactor band table |
| sfb_32_1024 | short | 51 | aac_rom.c | Scalefactor band table |
| sfb_24_1024 | short | 49 | aac_rom.c | Scalefactor band table |
| sfb_24_128 | short | 16 | aac_rom.c | Scalefactor band table |
| sfb_16_1024 | short | 44 | aac_rom.c | Scalefactor band table |
| sfb_16_128 | short | 16 | aac_rom.c | Scalefactor band table |
| sfb_8_1024 | short | 41 | aac_rom.c | Scalefactor band table |
| sfb_8_128 | short | 16 | aac_rom.c | Scalefactor band table |
| HuffmanCodeBook_1 | short | 204 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_2 | short | 156 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_3 | short | 156 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_4 | short | 152 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_5 | short | 164 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_6 | short | 160 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_7 | short | 124 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_8 | short | 124 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_9 | short | 336 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_10 | short | 328 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_11 | short | 544 | aac_rom.c | Huffman codeword table AAC |
| HuffmanCodeBook_SCL | short | 260 | aac_rom.c | Huffman codeword table AAC |
| SamplingRateInfoTable | mixed | 45 | aac_rom.c | Sampling rate to scalefactor mapping table AAC |
| HuffmanCodeBooks | mixed | 52 | aac_rom.c | Huffman codeword table AAC |
| tns_max_bands_tbl | char | 18 | aac_rom.c | max. TNS bands per sampling rate table |
| sbr_limGains | float | 4 | sbr_rom.c | SBR limiter gain values |
| sbr_limiterBandsPerOctave | float | 4 | sbr_rom.c | Number of SBR limiter bands |
| sbr_smoothFilter | float | 4 | sbr_rom.c | Smoothing filter for gain values |
| sbr_invIntTable | float | 55 | sbr_rom.c | Table of 1/x function |
| sbr_randomPhase | float | 1024 | sbr_rom.c | Random numbers for SBR noise addition and PNS |
| sbr_qmf_64_640 | float | 325 | sbr_rom.c | QMF window coefficients |
| sbr_cos_twiddle_L04 | float | 2 | sbr_rom.c | FFT twiddle table |
| sbr_cos_twiddle_L08 | float | 4 | sbr_rom.c | FFT twiddle table |
| sbr_cos_twiddle_L16 | float | 8 | sbr_rom.c | FFT twiddle table |
| sbr_cos_twiddle_L32 | float | 16 | sbr_rom.c | FFT twiddle table |
| sbr_sin_twiddle_L04 | float | 2 | sbr_rom.c | FFT twiddle table |
| sbr_sin_twiddle_L08 | float | 4 | sbr_rom.c | FFT twiddle table |
| sbr_sin_twiddle_L16 | float | 8 | sbr_rom.c | FFT twiddle table |
| sbr_sin_twiddle_L32 | float | 16 | sbr_rom.c | FFT twiddle table |
| sbr_alt_sin_twiddle_L04 | float | 3 | sbr_rom.c | FFT twiddle table |
| sbr_alt_sin_twiddle_L08 | float | 5 | sbr_rom.c | FFT twiddle table |
| sbr_alt_sin_twiddle_L16 | float | 9 | sbr_rom.c | FFT twiddle table |
| sbr_alt_sin_twiddle_L32 | float | 17 | sbr_rom.c | FFT twiddle table |
| sbr_cos_twiddle_ds_L32 | float | 32 | sbr_rom.c | FFT twiddle table, obsolete for mono only decoder |
| sbr_sin_twiddle_ds_L32 | float | 32 | sbr_rom.c | FFT twiddle table, obsolete for mono only decoder |
| sbr_cos_twiddle_L64 | float | 32 | sbr_rom.c | FFT twiddle table, obsolete for mono only decoder |
| sbr_sin_twiddle_L64 | float | 32 | sbr_rom.c | FFT twiddle table, obsolete for mono only decoder |
| sbr_alt_sin_twiddle_L64 | float | 33 | sbr_rom.c | FFT twiddle table, obsolete for mono only decoder |
| sbr_t_cos_L32 | float | 32 | sbr_rom.c | FFT twiddle table |

| | | | | |
|------------------------------------|-------|-------------|----------------|---|
| sbr_t_sin_L32 | float | 32 | sbr_rom.c | FFT twiddle table |
| aRevLinkDecaySer | float | 3 | sbr_rom.c | PS all-pass filter coefficients |
| aFractDelayPhaseFactorReQmf | float | 20 | sbr_rom.c | PS phase rotation factor |
| aFractDelayPhaseFactorImQmf | float | 20 | sbr_rom.c | PS phase rotation factor |
| aFractDelayPhaseFactorReSubQmf | float | 10 | sbr_rom.c | PS phase rotation factor |
| aFractDelayPhaseFactorImSubQmf | float | 10 | sbr_rom.c | PS phase rotation factor |
| aaFractDelayPhaseFactorSerReQmf | float | 3 | sbr_rom.c | PS phase rotation factor |
| aaFractDelayPhaseFactorSerImQmf | float | 3 | sbr_rom.c | PS phase rotation factor |
| aaFractDelayPhaseFactorSerReSubQmf | float | 3 | sbr_rom.c | PS phase rotation factor |
| aaFractDelayPhaseFactorSerImSubQmf | float | 3 | sbr_rom.c | PS phase rotation factor |
| scaleFactors | float | 15 | sbr_rom.c | PS quantization table |
| scaleFactorsFine | float | 41 | sbr_rom.c | PS quantization table |
| alphas | float | 8 | sbr_rom.c | PS quantization table |
| p2_6 | float | 6 | sbr_rom.c | Hybrid filterbank coefficients |
| p8_13 | float | 14 | sbr_rom.c | Hybrid filterbank coefficients |
| sbr_whFactorsTable | float | 54 | sbr_rom.c | Tuning parameters for inverse filtering |
| bins2groupMap | short | 22 | sbr_rom.c | Mapping of PS bins to PS groups |
| sbr_whFactorsIndex | short | 9 | sbr_rom.c | Tuning parameter index for inverse filtering |
| sbr_start_freq_16 | char | 16 | sbr_rom.c | SBR frequency scale index |
| sbr_start_freq_22 | char | 16 | sbr_rom.c | SBR frequency scale index |
| sbr_start_freq_24 | char | 16 | sbr_rom.c | SBR frequency scale index |
| sbr_start_freq_32 | char | 16 | sbr_rom.c | SBR frequency scale index |
| sbr_start_freq_44 | char | 16 | sbr_rom.c | SBR frequency scale index |
| sbr_start_freq_48 | char | 16 | sbr_rom.c | SBR frequency scale index |
| sbr_frame_info1_16 | char | 18 | sbr_rom.c | SBR frequency scale index |
| sbr_frame_info2_16 | char | 18 | sbr_rom.c | SBR frequency scale index |
| sbr_frame_info4_16 | char | 18 | sbr_rom.c | SBR frequency scale index |
| sbr_huffBook_EnvLevel10T | char | 240 | sbr_rom.c | Huffman codeword table SBR |
| sbr_huffBook_EnvLevel10F | char | 240 | sbr_rom.c | Huffman codeword table SBR |
| sbr_huffBook_EnvBalance10T | char | 96 | sbr_rom.c | Huffman codeword table SBR |
| sbr_huffBook_EnvBalance10F | char | 96 | sbr_rom.c | Huffman codeword table SBR |
| sbr_huffBook_EnvLevel11T | char | 124 | sbr_rom.c | Huffman codeword table SBR |
| sbr_huffBook_EnvLevel11F | char | 124 | sbr_rom.c | Huffman codeword table SBR |
| sbr_huffBook_EnvBalance11T | char | 48 | sbr_rom.c | Huffman codeword table SBR |
| sbr_huffBook_EnvBalance11F | char | 48 | sbr_rom.c | Huffman codeword table SBR |
| sbr_huffBook_NoiseLevel11T | char | 124 | sbr_rom.c | Huffman codeword table SBR |
| sbr_huffBook_NoiseBalance11T | char | 48 | sbr_rom.c | Huffman codeword table SBR |
| aRevLinkDelaySer | char | 3 | sbr_rom.c | PS all-pass delay line lengths |
| groupBorders | char | 23 | sbr_rom.c | Borders of PS groups |
| aBookPslidTimeDecode | char | 56 | sbr_rom.c | Huffman codeword table PS |
| aBookPslidFreqDecode | char | 56 | sbr_rom.c | Huffman codeword table PS |
| aBookPslccTimeDecode | char | 28 | sbr_rom.c | Huffman codeword table PS |
| aBookPslccFreqDecode | char | 28 | sbr_rom.c | Huffman codeword table PS |
| aBookPslidFineTimeDecode | char | 120 | sbr_rom.c | Huffman codeword table PS |
| aBookPslidFineFreqDecode | char | 120 | sbr_rom.c | Huffman codeword table PS |
| sbr_defaultHeader | char | 32 | sbr_rom.c | Default SBR header data |
| logDualisTable | float | 65 | transcendent.c | Lookup table for efficient log() implementation |
| Sum | | 9866 | | |

4.3.2 Static memory

This clause contains a listing of all static buffers contributing to the RAM requirements of the encoder and decoder.

Table 9: Encoder static memory

| Name | Data type | Size [word] | Allocated in Source File | Description |
|------------------------------|---------------------|--------------|--------------------------|---|
| mdctDelayBuffer | float | 3200 | aac_ram.c | Time domain input signal delay |
| sideInfoTabLong | int | 52 | aac_ram.c | Table lookup for side information, long blocks |
| sideInfoTabShort | int | 16 | aac_ram.c | Table lookup for side information, short blocks |
| aacEncoder | AAC_ENCODER | 3554 | aacenc.c | AAC encoder instance |
| sbr_QmfStatesAnalysis | float | 1280 | sbr_ram.c | QMF filterbank states buffer |
| sbr_envYBuffer | float | 4096 | sbr_ram.c | QMF band energy buffer |
| sbr_quotaMatrix | float | 512 | sbr_ram.c | Tonality values |
| sbr_thresholds | float | 128 | sbr_ram.c | Detector parameters |
| sbr_toncorrBuff | float | 1256 | sbr_ram.c | Detector value buffer |
| EnvChannel[nChan] | ENV_CHANNEL | 1794 | sbr_main.c | SBR channel instance, only half the size for mono only encoder |
| sbrEncoder | SBR_ENCODER | 200 | sbr_main.c | SBR encoder instance |
| SynthesisQmfBank | SBR_QMF_FILTER_BANK | 7 | sbr_main.c | QMF synthesis filterbank instance |
| psEncoder | PS_ENC | 281 | sbr_main.c | PS encoder instance |
| sbr_freqBandTableLO | char | 14 | sbr_ram.c | SBR frequency band table, low resolution |
| sbr_freqBandTableHI | char | 28 | sbr_ram.c | SBR frequency band table, high resolution |
| sbr_v_k_master | char | 28 | sbr_ram.c | SBR frequency band table index |
| sbr_guideScfb | char | 54 | sbr_ram.c | Additional sine detection parameter |
| sbr_detectionVectors | char | 216 | sbr_ram.c | Additional sine detection parameter |
| sbr_prevEnvelopeCompensation | char | 54 | sbr_ram.c | Additional sine detection parameter |
| sbr_guideVectorDetected | char | 216 | sbr_ram.c | Additional sine detection parameter |
| outputBuffer | int | 384 | main.c | Bitstream output buffer |
| inputBuffer[nChan] | float | 7202 | main.c | Time domain input signal buffer, only half the size for mono only encoder |
| IIR21_resampler[nChan] | float | 144 | main.c | 2:1 IIR resampler instance (includes states) , only half the size for mono only encoder |
| statesIIR | float | 16 | iir32resample.c | 3:2 IIR resampler states buffer |
| Sum | | 24732 | | |

Table 10: Decoder static memory

| Name | Data type | Size [word] | Allocated in Source File | Description |
|------------------------------------|------------------------------|-------------|--------------------------|--|
| OverlapBuffer[nChan] | float | 1024 | aac_ram.c | Delay buffer for overlap and add, only half the size for mono only decoder |
| AacDecoderInstance | AAC_DECODER_INSTANCE | 11 | aacdecoder.c | AAC decoder instance |
| StreamInfo | CStreamInfo | 7 | aac_ram.c | Bitstream information |
| AacDecoderStaticChannelInfo[nChan] | CaacDecoderStaticChannelInfo | 14 | aac_ram.c | Channel information, only half the size for mono only decoder |
| sbr_CodecQmfStatesAnalysis | float | 640 | sbr_ram.c | QMF analysis filter bank states |
| sbr_GainSmooth | float | 96 | sbr_ram.c | Gain smoothing filter states |
| sbr_NoiseSmooth | float | 96 | sbr_ram.c | Noise level smoothing filter states |
| sbr_QmfStatesSynthesis | float | 1280 | sbr_ram.c | QMF synthesis filter bank states |
| sbr_OverlapBuffer | float | 1536 | sbr_ram.c | SBR delay buffer, only half the size for mono only decoder |
| sbr_LpcFilterStatesReal | float | 128 | sbr_ram.c | LPC filter states |
| sbr_LpcFilterStatesImag | float | 128 | sbr_ram.c | LPC filter states, obsolete for mono only decoder |
| sbr_TransposerSettings | float | 18 | sbr_ram.c | Transposer configuration parameters |
| FreqBandData | FREQ_BAND_DATA | 164 | sbr_ram.c | SBR Frequency band information |

| | | | | |
|-------------------------|----------------------|--------------|--------------------|--|
| PrevFrameData[nChan] | SBR_PREV_FRAME_DATA | 120 | sbr_ram.c | SBR previous frame data, only half the size for mono only decoder |
| sbr_PrevBitstream | SBRBITSTREAM | 584 | sbr_ram.c | SBR previous frame bitstream |
| sbrDecoderInstance | SBR_DECODER_INSTANCE | 797 | sbrdecoder.c | SBR decoder instance |
| TimeDataFloat[nChan] | float | 4096 | main.c | Output buffer for time-domain signal, only half the size for mono only decoder |
| inBuffer | int | 384 | main.c | Input buffer for bitstream |
| splineResamplerInstance | SPLINE_RESAMPLER | 21 | spline_resampler.c | Spline resampler instance |
| Sum | | 11161 | | |

4.3.3 Dynamic memory

This clause contains a listing of all dynamic buffers contributing to the RAM requirements of the encoder and decoder. Dynamic memory can be re-used outside of the encoder or decoder application.

Table 11: Encoder dynamic memory

| Name | Data type | Size [word] | Allocated in Source File | Description |
|----------------|-----------|-------------|--------------------------|-----------------------------|
| PsBuf3 | float | 1024 | sbr_ram.c | Note: reused in AAC encoder |
| sbr_envRBuffer | float | 4096 | sbr_ram.c | Note: reused in AAC encoder |
| sbr_envIBuffer | float | 4096 | sbr_ram.c | Note: reused in AAC encoder |
| sbr_transients | float | 192 | sbr_ram.c | Note: reused in AAC encoder |
| Sum | | 9408 | | |

Table 12: Decoder dynamic memory

| Name | Data type | Size [word] | Allocated in Source File | Description |
|----------------|-----------|-------------|--------------------------|-----------------------------|
| WorkBufferCore | float | 2048 | aac_ram.c | Note: reused in SBR decoder |
| InterimResult | float | 1024 | sbr_ram.c | |
| Sum | | 3072 | | |

4.3.4 Maximum stack size

This clause contains tables for the encoder and the decoder which describe the call stack that results in the maximum stack size usage.

| | | |
|-----------------------|--|---|
| EncodePsFrame | struct *pms; float **iBufferLeft, float **rBufferLeft, float **iBufferRight, float **rBufferRight int env, i, bin, subband, maxSubband, startSample, stopSample; float **hybrLeftImag, **hybrLeftReal, **hybrRightImag, **hybrRightReal; | 4 4 4 4 4 28 16 = 64 |
| HybridAnalysis | const float **mQmfReal; const float **mQmfImag; float **mHybridReal; float **mHybridImag; struct *hHybrid; int n, band; enum hybridRes; int chOffset; | 4 4 4 4 4 8 4 4 = 36 |
| eightChannelFiltering | const float *pQmfReal; const float *pQmfImag; float **mHybridReal; float **mHybridImag; int i, n; float real, imag; int midTap; float cum[16]; | 4 4 4 4 8 8 4 64 = 100 |
| CFFTN | float *afftData; int len; int isign; | 4 4 4 = 12 |
| cfftn | float Re[]; float Im[]; int nTotal; int nPass; int nSpan; int iSign; int ii, mfactor, kspan, ispan, inc, j, jc, jf, jj, k, k1, k2, k3, k4, kk, kt, nn, ns, nt; double radf, c1, c2, c3, cd, s1, s2, s3, sd; float ak, bk, akp, bkp, ajp, bjp, ajm, bjm, akm, bkm, aj, bj, aa, bb; float Rtmp[23], ltmp[23]; double Cos[23], Sin[23]; int Perm[209]; int factor [11]; double s60, c72, s72, pi2; | 4 4 4 4 4 4 76 72 56 184 368 836 44 32 = 1692 |
| | Sum | 4900 |

| | | |
|-----------------------------|---|--|
| cplxSynthesisQmfFiltering() | float **qmfReal; float **qmfImag; float *timeout; struct *synQmf; int bUseLP; struct *h_ps_dec; int active; int i, j; float *ptr_time_out, *filterStates; float accu; int p; float qmfReal2[64]; float *imagSlot; int no_synthesis_channels; int qmf_filter_state_syn_size; float mfRealTmp[64]; float qmfImagTmp[64]; int env; const float *p_filter; | 4 4 4 4 4 4 4 8 8 4 4 256 4 4 4 256 256 4 4 = 840 |
| ApplyPsSlot() | struct *h_ps_dec; float **rIntBufferLeft; float **iIntBufferLeft; float *rIntBufferRight; float *iIntBufferRight; | 4 4 4 4 4 = 20 |
| HybridAnalysis() | const float **mQmfReal; const float **mQmfImag; float **mHybridReal; float **mHybridImag; struct *hHybrid; int n, band; enum hybridRes; int chOffset; | 4 4 4 4 4 8 4 4 = 36 |
| eightChannelFiltering() | const float *pQmfReal; const float *pQmfImag; float **mHybridReal; float **mHybridImag; int i, n; float real, imag; int midTap; float cum[16]; | 4 4 4 4 8 8 4 64 = 100 |
| CFFTN() | float *afftData; int len; int isign; | 4 4 4 = 12 |
| cfftn() | float Re[]; float Im[]; int nTotal; int nPass; int nSpan; int iSign; int ii, mfactor, kspan, ispan, inc, j, jc, jf, jj, k, k1, k2, k3, k4, kk, kt, nn, ns, nt; double radf, c1, c2, c3, cd, s1, s2, s3, sd; float ak, bk, akp, bkp, ajp, bjp, ajm, bjm, akm, bkm, aj, bj, aa, bb; float Rtmp[23], ltmp[23]; double Cos[23], Sin[23]; int Perm[209]; int factor [11]; double s60, c72, s72, pi2; | 4 4 4 4 4 4 76 72 56 184 368 836 44 32 = 1692 |
| | Sum | 3260 |

4.4 Weighted MOPS and PROM

The complexity numbers for the Enhanced AACPlus audio codec can be found in the following table, the numbers have been derived using the “allcat.wav” item, which holds all the material from the selection test concatenated in one single item. For every test case the average and worst frame weighted MOPS figure has been derived. The worst case wMOPS figure over all test cases has been marked in **blue**.

Table 15: Weighted MOPS and PROM figures

| | Test Case | Mono Encoder | Stereo Encoder | Decoder | Decoder, mono only |
|-------------------------------------|-------------|----------------------|----------------------|----------------------|----------------------|
| wMOPS [average / worst frame] | 14m | 15.23 / 16.98 | 15.36 / 17.21 | 9.38 / 10.07 | 8.07 / 8.78 |
| | 18s | --- | 25.79 / 28.36 | 19.48 / 20.35 | 8.31 / 9.17 |
| | 24m | 16.72 / 18.93 | 16.86 / 19.14 | 10.30 / 11.39 | 8.89 / 9.94 |
| | 24s | --- | 27.01 / 29.85 | 20.45 / 21.63 | 8.82 / 9.93 |
| | 32s | --- | 27.49 / 29.97 | 21.08 / 22.42 | 9.28 / 10.58 |
| | 48s | --- | 35.22 / 42.22 | 17.96 / 20.26 | 12.42 / 14.32 |
| | 14m, 16 kHz | 15.42 / 18.41 | 15.47 / 18.46 | 7.85 / 8.61 | 7.85 / 8.60 |
| | 14m, 3% FER | --- | --- | 9.38 / 10.07 | 8.07 / 8.78 |
| | 24s, 3% FER | --- | --- | 20.45 / 21.63 | 8.81 / 9.93 |
| | 32s, 1% FER | --- | --- | 21.08 / 22.42 | 9.28 / 10.58 |
| | 32s, 3% FER | --- | --- | 21.08 / 22.38 | 9.27 / 10.58 |
| Program ROM [ops] | --- | 12540 | 14365 | 8048 | 6209 |

5 Fixed point ANSI-C code structure

tbd.

6 File formats

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

6.1 Audio input file (encoder input/decoder output)

The audio input files read by the encoder and written by the decoder are 16-bit PCM wave files. For convenient handling of wave files a precompiled audio-fileformat library is used.

6.2 Bitstream file format (encoder output/decoder input)

The encoder program writes and the decoder program reads raw frames packetized in access units as described by 3GPP TS 26.244. For packetization the ISO media library is used. A precompiled library is used.

6.3 Error pattern file (decoder input)

The decoder program can optionally process an additional input file which describes an error pattern. The format of the error pattern file is 1 character per line. Each line corresponds to one frame, where a “0” indicates that the respective frame has been transmitted without errors, while a “1” indicates that the corresponding frame has been lost and error concealment shall be applied by the decoder.

Annex A (informative): Change history

| Change history | | | | | | | |
|----------------|-------|-----------|----|-----|--|-----|-------|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 06-2004 | SP-24 | SP-040433 | - | - | Presentation to TSG SA for Information | - | 1.0.0 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |