**3-ANNEX D (informative)**

**PSYCHOACOUSTIC MODELS**

**3-D.1. Psychoacoustic Model I**

The calculation of the psychoacoustic model has to be adapted to the corresponding layer. This example is valid for Layers I and II. The model can be adapted to LayerIII.

There is no principal difference in the application of psychoacoustic model 1 to Layer I or II.

Layer I: A new bit allocation is calculated for each block of 12 subband or 384 input PCM samples.

Layer II: A new bit allocation is calculated for three blocks totaling 36 subband samples corresponding to 3\*384 (1152) input PCM samples.

The bit allocation of the 32 subbands is calculated on the basis of the signal-to-mask ratios of all the subbands. Therefore it is necessary to determine, for each subband the maximum signal level and the minimum masking threshold. The minimum masking threshold is derived from an FFT of the input PCM signal, followed by a psychoacoustic model calculation.

The FFT in parallel with the subband filter compensates for the lack of spectral selectivity obtained at low frequencies by the subband filterbank. This technique provides both a sufficient time resolution for the coded audio signal (Polyphase filter with optimized window for minimal pre-echoes) and a sufficient spectral resolution for the calculation of the masking thresholds.

The frequencies and levels of aliasing distortions can be calculated. This is necessary for calculating a minimum bit rate for those subbands which need some bits to cancel the aliasing components in the decoder. The additional complexity to calculate the better frequency resolution is necessary only in the encoder, and introduces no additional delay or complexity in the decoder.

The calculation of the signal-to-mask-ratio is based on the following steps:

Step 1

- Calculation of the FFT for time to frequency conversion.

Step 2

- Determination of the sound pressure level in each subband.

Step 3

- Determination of the threshold in quiet (absolute threshold).

Step 4

- Finding of the tonal (more sinusoid-like) and non-tonal (more noise-like) components of the audio signal.

Step 5

- Decimation of the maskers, to obtain only the relevant maskers.

Step 6

- Calculation of the individual masking thresholds.

Step 7

- Determination of the global masking threshold.

Step 8

- Determination of the minimum masking threshold in each subband.

Step 9

- Calculation of the signal-to-mask ratio in each subband.

These steps will be further discussed. A sampling frequency of 48kHz is assumed. For the other two sampling frequencies all frequencies mentioned should be scaled accordingly.

**Step 1: FFT Analysis**

The masking threshold is derived from an estimate of the power density spectrum that is calculated by a 512-point FFT for Layer I, or by a 1024-point FFT for Layers II and III. The FFT is calculated directly from the input PCM signal, windowed by a Hann window.

For a coincidence in time between the bit-allocation and the corresponding subband samples, the PCM-samples entering the FFT have to be delayed:

1. The delay of the analysis subband filter is 256 samples, corresponding to 5.3ms at the 48kHz sampling rate. This corresponds to a window shift of 256 samples.

2. The Hann window must coincide with the subband samples of the frame. For Layer I this amounts to an additional window shift of 64 samples, for Layer II an additional window shift of minus 64 samples.

Technical data of the FFT:

Layer I Layer II

- transform length 512 samples 1024 samples

Window size if fs = 48 kHz 10.67 ms 21.3 ms

Window size if fs = 44.1 kHz 11.6 ms 23.2 ms

Window size if fs = 32 kHz 16 ms 32 ms

- Frequency resolution fs/512 fs/1024

- Hann window, h(i):

h(i) = \* 0.5 \* {1 - cos[2 \* p \* (i)/(N-1)]} 0 <= i <= N-1

- power density spectrum X(k):

X(k) = 10 \* log |1/Nh(l) \* s(l) \* e(-j\*k\*l\*2\*p/N)|2 dB k = 0...N/2

A normalization to the reference level of 96 dB SPL (Sound Pressure Level) has to be done in such a way that the maximum value corresponds to 96dB.

**Step 2: Determination of the sound pressure level**

The sound pressure level Lsb in subband n is computed by:

Lsb(n) = MAX[ X(k), 20\*log(scfmax(n)\*32768)-10 ] dB

X(k) in subband n

where X(k) is the sound pressure level of the spectral line with index k of the FFT with the maximum amplitude in the frequency range corresponding to subband n. The expression scfmax(n) is in Layer I the scalefactor, and in Layer II the maximum of the three scalefactors of subband n within a frame. The "-10 dB" term corrects for the difference between peak and RMS level. The sound pressure level Lsb(n) is computed for every subband n.

**Step 3: Considering the threshold in quiet**

The threshold in quiet LTq(k), also called absolute threshold, is available in the tables "Frequencies, Critical Band Rates and Absolute Threshold" (Tables 3-D.1a, 3-D.1b, 3-D.1c for LayerI; Tables 3-D.1d, 3-D.1e, 3-D.1f for LayerII). These tables depend on the sampling rate of the input PCM signal. Values are available for each sample in the frequency domain where the masking threshold is calculated.

An offset depending on the overall bit rate is used for the absolute threshold. This offset is -12 dB for bit rates >= 96 kbit/s and 0 dB for bit rates < 96 kbit/s per channel.

**Step 4: Finding of tonal and non-tonal components**

The tonality of a masking component has an influence on the masking threshold. For this reason, it is worthwhile to discriminate between tonal and non-tonal components. For calculating the global masking threshold it is necessary to derive the tonal and the non-tonal components from the FFT spectrum.

This step starts with the determination of local maxima, then extracts tonal components (sinusoids) and calculates the intensity of the non-tonal components within a bandwidth of a critical band. The boundaries of the critical bands are given in the tables "CRITICAL BAND BOUNDARIES" (Tables 3-D.2a, 3-D.2b, 3-D.2c for LayerI; Tables 3-D.2d, 3-D.2e, 3-D.2f for LayerII).

The bandwidth of the critical bands varies with the center frequency with a bandwidth of about only 0.1 kHz at low frequencies and with a bandwidth of about 4 kHz at high frequencies. It is known from psychoacoustic experiments that the ear has a better frequency resolution in the lower than in the higher frequency region. To determine if a local maximum may be a tonal component a frequency range df around the local maximum is examined. The frequency range df is given by:

Sampling rate: 32 kHz

Layer I: df = 125 Hz 0 kHz < f <= 4.0kHz

df = 187.5 Hz 4.0 kHz < f <= 8.0 kHz

df = 375 Hz 8.0 kHz < f <= 15.0kHz

Layer II: df = 62.5 Hz 0 kHz < f <= 3.0 kHz

df = 93.75 Hz 3.0 kHz < f <= 6.0 kHz

df = 187.5 Hz 6.0 kHz < f <= 12.0 kHz

df = 375 Hz 12.0 kHz < f <= 24.0 kHz

Sampling rate: 44.1kHz

Layer I: df = 172.266 Hz 0 kHz < f <= 5.512kHz

df = 281.25 Hz 5.512 kHz < f <= 11.024 kHz

df = 562.50 Hz 11.024 kHz < f <= 19.982kHz

Layer II: df = 86.133 Hz 0 kHz < f <= 2.756 kHz

df = 129.199 Hz 2.756 kHz < f <= 5.512kHz

df = 258.398 Hz 5.512 kHz < f <= 11.024 kHz

df = 516.797 Hz 11.024 kHz < f <= 19.982kHz

Sampling rate: 48 kHz

Layer I: df = 187.5 Hz 0 kHz < f <= 6.0 kHz

df = 281.25 Hz 6.0 kHz < f <= 12.0 kHz

df = 562.50 Hz 12.0 kHz < f <= 24.0 kHz

Layer II: df = 93.750 Hz 0 kHz < f <= 3.0 kHz

df = 140.63 Hz 3.0 kHz < f <= 6.0 kHz

df = 281.25 Hz 6.0 kHz < f <= 12.0 kHz

df = 562.50 Hz 12.0 kHz < f <= 24.0 kHz

To make lists of the spectral lines X(k) that are tonal or non-tonal, the following three operations are performed:

**(i) Labelling of local maxima**

A spectral line X(k) is labelled as a local maximum if

X(k) > X(k-1) and X(k) >= X(k+1)

**(ii) Listing of tonal components and calculation of the sound pressure level**

A local maximum is put in the list of tonal components if

X(k) - X(k+j) >= 7 dB,

where j is chosen according to

Layer I:

j = -2, +2 for 2 < k < 63

j = -3, -2, +2, +3 for 63 <= k < 127

j = -6,..., -2, +2,..., +6 for 127<= k <= 250

Layer II:

j = -2, +2 for 2 < k < 63

j = -3, -2, +2, +3 for 63 <= k < 127

j = -6,..., -2, +2,..., +6 for 127 <= k < 255

j = -12,..., -2, +2,..., +12 for 255<= k <= 500

If X(k) is found to be a tonal component, then the following parameters are listed:

- Index number k of the spectral line.

- Sound pressure level Xtm(k)=X(k-1)+X(k)+X(k+1), in dB

- Tonal flag.

Next, all spectral lines within the examined frequency range are set to -8 dB.

**(iii) Listing of non-tonal components and calculation of the power**

The non-tonal (noise) components are calculated from the remaining spectral lines. To calculate the non-tonal components from these spectral lines X(k), the critical bands z(k) are determined using the tables, "Critical Band Boundaries" (Tables 3-D.2a, 3-D.2b, 3-D.2c for LayerI; Tables 3-D.2d, 3-D.2e, 3-D.2f for LayerII). In LayerI, 23 critical bands are used for the sampling rate of 32kHz, 24 critical bands for 44.1kHz and 25 critical bands are used for 48kHz. In LayerII, 24 critical bands are used for 32kHz sampling rate, and 26 critical bands are used for 44.1kHz and 48kHz sampling rate. Within each critical band, the power of the spectral lines are summed to form the sound pressure level of the new non-tonal component corresponding to that critical band.

The following parameters are listed:

- Index number k of the spectral line nearest to the geometric mean of the critical band.

- Sound pressure level Xnm(k) in dB.

- Non-tonal flag.

**Step 5: Decimation of tonal and non-tonal masking components**

Decimation is a procedure that is used to reduce the number of maskers which are considered for the calculation of the global masking threshold.

(i) Tonal Xtm(k) or non-tonal components Xnm(k) are considered for the calculation of the masking threshold only if:

Xtm(k) >= LTq(k) or Xnm(k) >=LTq(k)

In this expression, LTq(k) is the absolute threshold (or threshold in quiet) at the frequency of index k. These values are given in the Tables 3-D.1a, 3-D.1b, 3-D.1c for LayerI; Tables 3-D.1d, 3-D.1e, 3-D.1f for LayerII.

(ii) Decimation of two or more tonal components within a distance of less then 0.5 Bark: Keep the component with the highest power, and remove the smaller component(s) from the list of tonal components. For this operation, a sliding window in the critical band domain is used with a width of 0.5 Bark.

In the following, the index j is used to indicate the relevant tonal or non-tonal masking components from the combined decimated list.

**Step 6: Calculation of individual masking thresholds**

Of the original N/2 frequency domain samples, indexed by k, only a subset of the samples, indexed by i, are considered for the global masking threshold calculation. The samples used are shown in Tables 3-D.1a, 3-D.1b, 3-D.1c for LayerI; Tables 3-D.1d, 3-D.1e, 3-D.1f for LayerII.

Layer I:

For the frequency lines corresponding to the frequency region which is covered by the first six subbands no subsampling is used. For the frequency region corresponding to the next six subbands every second spectral line is considered. Finally, in the case of 44.1 and 48 kHz sampling rates, in the frequency region corresponding to the remaining subbands, every fourth spectral line is considered up to 20 kHz. In the case of 32 kHz sampling rate, in the frequency region corresponding to the remaining subbands, every fourth spectral line is considered up to 15 kHz (See also Tables 3-D.1a, 3-D.1b, 3-D.1c "Frequencies, Critical Band Rates and Absolute Threshold" for LayerI.)

Layer II:

For the frequency lines corresponding to the frequency region which is covered by the first three subbands no subsampling is used. For the frequency region which is covered by next three subbands every second spectral line is considered. For the frequency region corresponding to the next six subbands every fourth spectral line is considered. Finally, in the case of 44.1 and 48 kHz sampling rates, in the remaining subbands every eighth spectral line is considered up to 20 kHz. In the case of 32 kHz sampling rate, in the frequency region corresponding to the remaining subbands, every eighth spectral line is considered up to 15 kHz. (See also Tables 3-D.1d, 3-D.1e, 3-D.1f "Frequencies, Critical Band Rates and Absolute Threshold" for LayerII.)

The number of samples, i, in the subsampled frequency domain is different depending on the sampling rates and layers.

32 kHz sampling rate: i = 108 for Layer I and i = 132 for Layer II

44.1 kHz sampling rate: i = 106 for Layer I and i = 130 for Layer II

48 kHz sampling rate: i = 102 for Layer I and i = 126 for Layer II

To every tonal and non-tonal component the index i in the subsampled frequency domain is assigned, which is closest in frequency to the original spectral line X(k). This index i is given in Tables 3-D.1a, 3-D.1b, 3-D.1c for LayerI; Tables 3-D.1d, 3-D.1e, 3-D.1f for LayerII, "Frequencies, Critical Band Rates and Absolute Threshold".

The individual masking thresholds of both tonal and non-tonal components are given by the following expression:

LTtm[z(j),z(i)] = Xtm[z(j)] + avtm[z(j)] + vf[z(j),z(i)] dB

LTnm[z(j),z(i)] = Xnm[z(j)]+ avnm[z(j)] + vf[z(j),z(i)] dB

In this formula LTtm and LTnm are the individual masking thresholds at critical band ratez in Bark of the masking component at the critical band rate zm in Bark. The values in dB can be either positive or negative. The term Xtm[z(j)] is the sound pressure level of the masking component with the index number j at the corresponding critical band rate z(j). The term av is called the masking index and vf the masking function of the masking component Xtm[z(j)]. The masking index av is different for tonal and non-tonal masker (avtm and avnm).

For tonal maskers it is given by

avtm = - 1.525 - 0.275 \* z(j) - 4.5 dB,

and for non-tonal maskers

avnm = - 1.525 - 0.175 \* z(j) - 0.5 dB.

The masking function vf of a masker is characterized by different lower and upper slopes, which depend on the distance in Bark dz = z(i)- z(j) to the masker. In this expression i is the index of the spectral line at which the masking function is calculated and j that of the masker. The critical band rates z(j) and z(i) can be found in Tables 3-D.1a, 3-D.1b, 3-D.1c for LayerI; Tables 3-D.1d, 3-D.1e, 3-D.1f for LayerII, "Frequencies, Critical Band Rates and Absolute Threshold". The masking function, which is the same for tonal and non-tonal maskers, is given by:

vf = 17 \* (dz + 1) - (0.4 \* X[z(j)] + 6) dB for -3 <= dz < -1 Bark

vf = (0.4 \* X[z(j)] + 6) \* dz dB for -1 <= dz < 0 Bark

vf = - 17 \* dz dB for 0 <= dz < 1 Bark

vf = - (dz -1) \* (17 - 0.15 \* X[z(j)]) - 17 dB for 1 <= dz < 8 Bark

In these expressions X[z(j)] is the sound pressure level of the j'th masking component in dB.

If dz < -3 Bark, or dz >= 8 Bark, the masking is no longer considered (LTtm and LTnm are set to -8dB outside this range).

**Step 7: Calculation of the global masking threshold LTg**

The global masking threshold LTg(i) at the i'th frequency sample is derived from the upper and lower slopes of the individual masking threshold of each of the j tonal and non-tonal maskers, and in addition from the threshold in quiet LTq(i). This is also given in Tables 3-D.1a, 3-D.1b, 3-D.1c for LayerI; Tables 3-D.1d, 3-D.1e, 3-D.1f for LayerII "Frequencies, Critical Band Rates and Absolute Threshold". The global masking threshold is found by summing the powers corresponding to the individual masking thresholds and the threshold in quiet.

LTg(i) = 10 log ( 10LTq(i)/10 + + )

The total number of tonal maskers is given by m, and the total number of non-tonal maskers is given by n. For a given i, the range of j can be reduced to just encompass those masking components that are within -8 to +3 Bark from i. Outside of this range LTtm and LTnm are -8 dB.

**Step 8: Determination of the minimum masking threshold**

The minimum masking level LTmin(n) in subband n is determined by the following expression:

LTmin(n) = MIN[ LTg(i) ] dB

f(i) in subband n

where f(i) is the frequency of the i'th frequency sample. The f(i) are tabulated in the Tables 3-D.1a, 3-D.1b, 3-D.1c for LayerI; Tables 3-D.1d, 3-D.1e, 3-D.1f for LayerII of "Frequencies, Critical Band Rates and Absolute Threshold". A minimum masking level LTmin(n) is computed for every subband.

**Step 9: Calculation of the signal-to-mask-ratio**

The signal-to-mask ratio

SMRsb(n) = Lsb(n)-LTmin(n) dB

is computed for every subband n.

**Table 3-D.1a.: Frequencies, Critical Band Rates and Absolute Threshold**

Table is valid for Layer I at a sampling rate of 32.0 kHz.

**Index Number Frequency Crit.Band Rate Absolute Thresh.**

**i [Hz] [z] [dB]**

1 62.50 .617 33.44

2 125.00 1.232 19.20

3 187.50 1.842 13.87

4 250.00 2.445 11.01

5 312.50 3.037 9.20

6 375.00 3.618 7.94

7 437.50 4.185 7.00

8 500.00 4.736 6.28

9 562.50 5.272 5.70

10 625.00 5.789 5.21

11 687.50 6.289 4.80

12 750.00 6.770 4.45

13 812.50 7.233 4.14

14 875.00 7.677 3.86

15 937.50 8.103 3.61

16 1000.00 8.511 3.37

17 1062.50 8.901 3.15

18 1125.00 9.275 2.93

19 1187.50 9.632 2.73

20 1250.00 9.974 2.53

21 1312.50 10.301 2.32

22 1375.00 10.614 2.12

23 1437.50 10.913 1.92

24 1500.00 11.199 1.71

25 1562.50 11.474 1.49

26 1625.00 11.736 1.27

27 1687.50 11.988 1.04

28 1750.00 12.230 .80

29 1812.50 12.461 .55

30 1875.00 12.684 .29

31 1937.50 12.898 .02

32 2000.00 13.104 -.25

33 2062.50 13.302 -.54

34 2125.00 13.493 -.83

35 2187.50 13.678 -1.12

36 2250.00 13.855 -1.43

37 2312.50 14.027 -1.73

38 2375.00 14.193 -2.04

39 2437.50 14.354 -2.34

40 2500.00 14.509 -2.64

41 2562.50 14.660 -2.93

42 2625.00 14.807 -3.22

43 2687.50 14.949 -3.49

44 2750.00 15.087 -3.74

45 2812.50 15.221 -3.98

46 2875.00 15.351 -4.20

47 2937.50 15.478 -4.40

48 3000.00 15.602 -4.57

49 3125.00 15.841 -4.82

50 3250.00 16.069 -4.96

51 3375.00 16.287 -4.97

52 3500.00 16.496 -4.86

53 3625.00 16.697 -4.63

54 3750.00 16.891 -4.29

55 3875.00 17.078 -3.87

56 4000.00 17.259 -3.39

57 4125.00 17.434 -2.86

58 4250.00 17.605 -2.31

59 4375.00 17.770 -1.77

60 4500.00 17.932 -1.24

61 4625.00 18.089 -.74

62 4750.00 18.242 -.29

63 4875.00 18.392 .12

64 5000.00 18.539 .48

65 5125.00 18.682 .79

66 5250.00 18.823 1.06

67 5375.00 18.960 1.29

68 5500.00 19.095 1.49

69 5625.00 19.226 1.66

70 5750.00 19.356 1.81

71 5875.00 19.482 1.95

72 6000.00 19.606 2.08

73 6250.00 19.847 2.33

74 6500.00 20.079 2.59

75 6750.00 20.300 2.86

76 7000.00 20.513 3.17

77 7250.00 20.717 3.51

78 7500.00 20.912 3.89

79 7750.00 21.098 4.31

80 8000.00 21.275 4.79

81 8250.00 21.445 5.31

82 8500.00 21.606 5.88

83 8750.00 21.760 6.50

84 9000.00 21.906 7.19

85 9250.00 22.046 7.93

86 9500.00 22.178 8.75

87 9750.00 22.304 9.63

88 10000.00 22.424 10.58

89 10250.00 22.538 11.60

90 10500.00 22.646 12.71

91 10750.00 22.749 13.90

92 11000.00 22.847 15.18

93 11250.00 22.941 16.54

94 11500.00 23.030 18.01

95 11750.00 23.114 19.57

96 12000.00 23.195 21.23

97 12250.00 23.272 23.01

98 12500.00 23.345 24.90

99 12750.00 23.415 26.90

100 13000.00 23.482 29.03

101 13250.00 23.546 31.28

102 13500.00 23.607 33.67

103 13750.00 23.666 36.19

104 14000.00 23.722 38.86

105 14250.00 23.775 41.67

106 14500.00 23.827 44.63

107 14750.00 23.876 47.76

108 15000.00 23.923 51.04

**Table 3-D.1b.: Frequencies, Critical Band Rates and Absolute Threshold**

Table is valid for Layer I at a sampling rate of 44.1 kHz.

**Index Number Frequency Crit.Band Rate Absolute Thresh.**

**i [Hz] [z] [dB]**

1 86.13 .850 25.87

2 172.27 1.694 14.85

3 258.40 2.525 10.72

4 344.53 3.337 8.50

5 430.66 4.124 7.10

6 516.80 4.882 6.11

7 602.93 5.608 5.37

8 689.06 6.301 4.79

9 775.20 6.959 4.32

10 861.33 7.581 3.92

11 947.46 8.169 3.57

12 1033.59 8.723 3.25

13 1119.73 9.244 2.95

14 1205.86 9.734 2.67

15 1291.99 10.195 2.39

16 1378.13 10.629 2.11

17 1464.26 11.037 1.83

18 1550.39 11.421 1.53

19 1636.52 11.783 1.23

20 1722.66 12.125 .90

21 1808.79 12.448 .56

22 1894.92 12.753 .21

23 1981.05 13.042 -.17

24 2067.19 13.317 -.56

25 2153.32 13.578 -.96

26 2239.45 13.826 -1.38

27 2325.59 14.062 -1.79

28 2411.72 14.288 -2.21

29 2497.85 14.504 -2.63

30 2583.98 14.711 -3.03

31 2670.12 14.909 -3.41

32 2756.25 15.100 -3.77

33 2842.38 15.284 -4.09

34 2928.52 15.460 -4.37

35 3014.65 15.631 -4.60

36 3100.78 15.796 -4.78

37 3186.91 15.955 -4.91

38 3273.05 16.110 -4.97

39 3359.18 16.260 -4.98

40 3445.31 16.406 -4.92

41 3531.45 16.547 -4.81

42 3617.58 16.685 -4.65

43 3703.71 16.820 -4.43

44 3789.84 16.951 -4.17

45 3875.98 17.079 -3.87

46 3962.11 17.205 -3.54

47 4048.24 17.327 -3.19

48 4134.38 17.447 -2.82

49 4306.64 17.680 -2.06

50 4478.91 17.905 -1.32

51 4651.17 18.121 -.64

52 4823.44 18.331 -.04

53 4995.70 18.534 .47

54 5167.97 18.731 .89

55 5340.23 18.922 1.23

56 5512.50 19.108 1.51

57 5684.77 19.289 1.74

58 5857.03 19.464 1.93

59 6029.30 19.635 2.11

60 6201.56 19.801 2.28

61 6373.83 19.963 2.46

62 6546.09 20.120 2.63

63 6718.36 20.273 2.82

64 6890.63 20.421 3.03

65 7062.89 20.565 3.25

66 7235.16 20.705 3.49

67 7407.42 20.840 3.74

68 7579.69 20.972 4.02

69 7751.95 21.099 4.32

70 7924.22 21.222 4.64

71 8096.48 21.342 4.98

72 8268.75 21.457 5.35

73 8613.28 21.677 6.15

74 8957.81 21.882 7.07

75 9302.34 22.074 8.10

76 9646.88 22.253 9.25

77 9991.41 22.420 10.54

78 10335.94 22.576 11.97

79 10680.47 22.721 13.56

80 11025.00 22.857 15.31

81 11369.53 22.984 17.23

82 11714.06 23.102 19.34

83 12058.59 23.213 21.64

84 12403.13 23.317 24.15

85 12747.66 23.415 26.88

86 13092.19 23.506 29.84

87 13436.72 23.592 33.05

88 13781.25 23.673 36.52

89 14125.78 23.749 40.25

90 14470.31 23.821 44.27

91 14814.84 23.888 48.59

92 15159.38 23.952 53.22

93 15503.91 24.013 58.18

94 15848.44 24.070 63.49

95 16192.97 24.125 68.00

96 16537.50 24.176 68.00

97 16882.03 24.225 68.00

98 17226.56 24.271 68.00

99 17571.09 24.316 68.00

100 17915.63 24.358 68.00

101 18260.16 24.398 68.00

102 18604.69 24.436 68.00

103 18949.22 24.473 68.00

104 19293.75 24.508 68.00

105 19638.28 24.542 68.00

106 19982.81 24.574 68.00

**Table 3-D.1c. Frequencies, Critical Band Rates and Absolute Threshold**

Table is valid for Layer I at a sampling rate of 48 kHz.

**Index Number Frequency Crit.Band Rate Absolute Thresh.**

**i [Hz] [z] [dB]**

1 93.75 .925 24.17

2 187.50 1.842 13.87

3 281.25 2.742 10.01

4 375.00 3.618 7.94

5 468.75 4.463 6.62

6 562.50 5.272 5.70

7 656.25 6.041 5.00

8 750.00 6.770 4.45

9 843.75 7.457 4.00

10 937.50 8.103 3.61

11 1031.25 8.708 3.26

12 1125.00 9.275 2.93

13 1218.75 9.805 2.63

14 1312.50 10.301 2.32

15 1406.25 10.765 2.02

16 1500.00 11.199 1.71

17 1593.75 11.606 1.38

18 1687.50 11.988 1.04

19 1781.25 12.347 .67

20 1875.00 12.684 .29

21 1968.75 13.002 -.11

22 2062.50 13.302 -.54

23 2156.25 13.586 -.97

24 2250.00 13.855 -1.43

25 2343.75 14.111 -1.88

26 2437.50 14.354 -2.34

27 2531.25 14.585 -2.79

28 2625.00 14.807 -3.22

29 2718.75 15.018 -3.62

30 2812.50 15.221 -3.98

31 2906.25 15.415 -4.30

32 3000.00 15.602 -4.57

33 3093.75 15.783 -4.77

34 3187.50 15.956 -4.91

35 3281.25 16.124 -4.98

36 3375.00 16.287 -4.97

37 3468.75 16.445 -4.90

38 3562.50 16.598 -4.76

39 3656.25 16.746 -4.55

40 3750.00 16.891 -4.29

41 3843.75 17.032 -3.99

42 3937.50 17.169 -3.64

43 4031.25 17.303 -3.26

44 4125.00 17.434 -2.86

45 4218.75 17.563 -2.45

46 4312.50 17.688 -2.04

47 4406.25 17.811 -1.63

48 4500.00 17.932 -1.24

49 4687.50 18.166 -.51

50 4875.00 18.392 .12

51 5062.50 18.611 .64

52 5250.00 18.823 1.06

53 5437.50 19.028 1.39

54 5625.00 19.226 1.66

55 5812.50 19.419 1.88

56 6000.00 19.606 2.08

57 6187.50 19.788 2.27

58 6375.00 19.964 2.46

59 6562.50 20.135 2.65

60 6750.00 20.300 2.86

61 6937.50 20.461 3.09

62 7125.00 20.616 3.33

63 7312.50 20.766 3.60

64 7500.00 20.912 3.89

65 7687.50 21.052 4.20

66 7875.00 21.188 4.54

67 8062.50 21.318 4.91

68 8250.00 21.445 5.31

69 8437.50 21.567 5.73

70 8625.00 21.684 6.18

71 8812.50 21.797 6.67

72 9000.00 21.906 7.19

73 9375.00 22.113 8.33

74 9750.00 22.304 9.63

75 10125.00 22.482 11.08

76 10500.00 22.646 12.71

77 10875.00 22.799 14.53

78 11250.00 22.941 16.54

79 11625.00 23.072 18.77

80 12000.00 23.195 21.23

81 12375.00 23.309 23.94

82 12750.00 23.415 26.90

83 13125.00 23.515 30.14

84 13500.00 23.607 33.67

85 13875.00 23.694 37.51

86 14250.00 23.775 41.67

87 14625.00 23.852 46.17

88 15000.00 23.923 51.04

89 15375.00 23.991 56.29

90 15750.00 24.054 61.94

91 16125.00 24.114 68.00

92 16500.00 24.171 68.00

93 16875.00 24.224 68.00

94 17250.00 24.275 68.00

95 17625.00 24.322 68.00

96 18000.00 24.368 68.00

97 18375.00 24.411 68.00

98 18750.00 24.452 68.00

99 19125.00 24.491 68.00

100 19500.00 24.528 68.00

101 19875.00 24.564 68.00

102 20250.00 24.597 68.00

**Table 3-D.1d.: Frequencies, Critical Band Rates and Absolute Threshold**

Table is valid for Layer II at a sampling rate of 32.0 kHz.

**Index Number Frequency Crit.Band Rate Absolute Thresh.**

**i [Hz] [z] [dB]**

1 31.25 .309 58.23

2 62.50 .617 33.44

3 93.75 .925 24.17

4 125.00 1.232 19.20

5 156.25 1.538 16.05

6 187.50 1.842 13.87

7 218.75 2.145 12.26

8 250.00 2.445 11.01

9 281.25 2.742 10.01

10 312.50 3.037 9.20

11 343.75 3.329 8.52

12 375.00 3.618 7.94

13 406.25 3.903 7.44

14 437.50 4.185 7.00

15 468.75 4.463 6.62

16 500.00 4.736 6.28

17 531.25 5.006 5.97

18 562.50 5.272 5.70

19 593.75 5.533 5.44

20 625.00 5.789 5.21

21 656.25 6.041 5.00

22 687.50 6.289 4.80

23 718.75 6.532 4.62

24 750.00 6.770 4.45

25 781.25 7.004 4.29

26 812.50 7.233 4.14

27 843.75 7.457 4.00

28 875.00 7.677 3.86

29 906.25 7.892 3.73

30 937.50 8.103 3.61

31 968.75 8.309 3.49

32 1000.00 8.511 3.37

33 1031.25 8.708 3.26

34 1062.50 8.901 3.15

35 1093.75 9.090 3.04

36 1125.00 9.275 2.93

37 1156.25 9.456 2.83

38 1187.50 9.632 2.73

39 1218.75 9.805 2.63

40 1250.00 9.974 2.53

41 1281.25 10.139 2.42

42 1312.50 10.301 2.32

43 1343.75 10.459 2.22

44 1375.00 10.614 2.12

45 1406.25 10.765 2.02

46 1437.50 10.913 1.92

47 1468.75 11.058 1.81

48 1500.00 11.199 1.71

49 1562.50 11.474 1.49

50 1625.00 11.736 1.27

51 1687.50 11.988 1.04

52 1750.00 12.230 .80

53 1812.50 12.461 .55

54 1875.00 12.684 .29

55 1937.50 12.898 .02

56 2000.00 13.104 -.25

57 2062.50 13.302 -.54

58 2125.00 13.493 -.83

59 2187.50 13.678 -1.12

60 2250.00 13.855 -1.43

61 2312.50 14.027 -1.73

62 2375.00 14.193 -2.04

63 2437.50 14.354 -2.34

64 2500.00 14.509 -2.64

65 2562.50 14.660 -2.93

66 2625.00 14.807 -3.22

67 2687.50 14.949 -3.49

68 2750.00 15.087 -3.74

69 2812.50 15.221 -3.98

70 2875.00 15.351 -4.20

71 2937.50 15.478 -4.40

72 3000.00 15.602 -4.57

73 3125.00 15.841 -4.82

74 3250.00 16.069 -4.96

75 3375.00 16.287 -4.97

76 3500.00 16.496 -4.86

77 3625.00 16.697 -4.63

78 3750.00 16.891 -4.29

79 3875.00 17.078 -3.87

80 4000.00 17.259 -3.39

81 4125.00 17.434 -2.86

82 4250.00 17.605 -2.31

83 4375.00 17.770 -1.77

84 4500.00 17.932 -1.24

85 4625.00 18.089 -.74

86 4750.00 18.242 -.29

87 4875.00 18.392 .12

88 5000.00 18.539 .48

89 5125.00 18.682 .79

90 5250.00 18.823 1.06

91 5375.00 18.960 1.29

92 5500.00 19.095 1.49

93 5625.00 19.226 1.66

94 5750.00 19.356 1.81

95 5875.00 19.482 1.95

96 6000.00 19.606 2.08

97 6250.00 19.847 2.33

98 6500.00 20.079 2.59

99 6750.00 20.300 2.86

100 7000.00 20.513 3.17

101 7250.00 20.717 3.51

102 7500.00 20.912 3.89

103 7750.00 21.098 4.31

104 8000.00 21.275 4.79

105 8250.00 21.445 5.31

106 8500.00 21.606 5.88

107 8750.00 21.760 6.50

108 9000.00 21.906 7.19

109 9250.00 22.046 7.93

110 9500.00 22.178 8.75

111 9750.00 22.304 9.63

112 10000.00 22.424 10.58

113 10250.00 22.538 11.60

114 10500.00 22.646 12.71

115 10750.00 22.749 13.90

116 11000.00 22.847 15.18

117 11250.00 22.941 16.54

118 11500.00 23.030 18.01

119 11750.00 23.114 19.57

120 12000.00 23.195 21.23

121 12250.00 23.272 23.01

122 12500.00 23.345 24.90

123 12750.00 23.415 26.90

124 13000.00 23.482 29.03

125 13250.00 23.546 31.28

126 13500.00 23.607 33.67

127 13750.00 23.666 36.19

128 14000.00 23.722 38.86

129 14250.00 23.775 41.67

130 14500.00 23.827 44.63

131 14750.00 23.876 47.76

132 15000.00 23.923 51.04

**Table 3-D.1e.: Frequencies, Critical Band Rates and Absolute Threshold**

Table is valid for Layer II at a sampling rate of 44.1 kHz.

**Index Number Frequency Crit.Band Rate Absolute Thresh.**

**i [Hz] [z] [dB]**

1 43.07 .425 45.05

2 86.13 .850 25.87

3 129.20 1.273 18.70

4 172.27 1.694 14.85

5 215.33 2.112 12.41

6 258.40 2.525 10.72

7 301.46 2.934 9.47

8 344.53 3.337 8.50

9 387.60 3.733 7.73

10 430.66 4.124 7.10

11 473.73 4.507 6.56

12 516.80 4.882 6.11

13 559.86 5.249 5.72

14 602.93 5.608 5.37

15 646.00 5.959 5.07

16 689.06 6.301 4.79

17 732.13 6.634 4.55

18 775.20 6.959 4.32

19 818.26 7.274 4.11

20 861.33 7.581 3.92

21 904.39 7.879 3.74

22 947.46 8.169 3.57

23 990.53 8.450 3.40

24 1033.59 8.723 3.25

25 1076.66 8.987 3.10

26 1119.73 9.244 2.95

27 1162.79 9.493 2.81

28 1205.86 9.734 2.67

29 1248.93 9.968 2.53

30 1291.99 10.195 2.39

31 1335.06 10.416 2.25

32 1378.13 10.629 2.11

33 1421.19 10.836 1.97

34 1464.26 11.037 1.83

35 1507.32 11.232 1.68

36 1550.39 11.421 1.53

37 1593.46 11.605 1.38

38 1636.52 11.783 1.23

39 1679.59 11.957 1.07

40 1722.66 12.125 .90

41 1765.72 12.289 .74

42 1808.79 12.448 .56

43 1851.86 12.603 .39

44 1894.92 12.753 .21

45 1937.99 12.900 .02

46 1981.05 13.042 -.17

47 2024.12 13.181 -.36

48 2067.19 13.317 -.56

49 2153.32 13.578 -.96

50 2239.45 13.826 -1.38

51 2325.59 14.062 -1.79

52 2411.72 14.288 -2.21

53 2497.85 14.504 -2.63

54 2583.98 14.711 -3.03

55 2670.12 14.909 -3.41

56 2756.25 15.100 -3.77

57 2842.38 15.284 -4.09

58 2928.52 15.460 -4.37

59 3014.65 15.631 -4.60

60 3100.78 15.796 -4.78

61 3186.91 15.955 -4.91

62 3273.05 16.110 -4.97

63 3359.18 16.260 -4.98

64 3445.31 16.406 -4.92

65 3531.45 16.547 -4.81

66 3617.58 16.685 -4.65

67 3703.71 16.820 -4.43

68 3789.84 16.951 -4.17

69 3875.98 17.079 -3.87

70 3962.11 17.205 -3.54

71 4048.24 17.327 -3.19

72 4134.38 17.447 -2.82

73 4306.64 17.680 -2.06

74 4478.91 17.905 -1.32

75 4651.17 18.121 -.64

76 4823.44 18.331 -.04

77 4995.70 18.534 .47

78 5167.97 18.731 .89

79 5340.23 18.922 1.23

80 5512.50 19.108 1.51

81 5684.77 19.289 1.74

82 5857.03 19.464 1.93

83 6029.30 19.635 2.11

84 6201.56 19.801 2.28

85 6373.83 19.963 2.46

86 6546.09 20.120 2.63

87 6718.36 20.273 2.82

88 6890.63 20.421 3.03

89 7062.89 20.565 3.25

90 7235.16 20.705 3.49

91 7407.42 20.840 3.74

92 7579.69 20.972 4.02

93 7751.95 21.099 4.32

94 7924.22 21.222 4.64

95 8096.48 21.342 4.98

96 8268.75 21.457 5.35

97 8613.28 21.677 6.15

98 8957.81 21.882 7.07

99 9302.34 22.074 8.10

100 9646.88 22.253 9.25

101 9991.41 22.420 10.54

102 10335.94 22.576 11.97

103 10680.47 22.721 13.56

104 11025.00 22.857 15.31

105 11369.53 22.984 17.23

106 11714.06 23.102 19.34

107 12058.59 23.213 21.64

108 12403.13 23.317 24.15

109 12747.66 23.415 26.88

110 13092.19 23.506 29.84

111 13436.72 23.592 33.05

112 13781.25 23.673 36.52

113 14125.78 23.749 40.25

114 14470.31 23.821 44.27

115 14814.84 23.888 48.59

116 15159.38 23.952 53.22

117 15503.91 24.013 58.18

118 15848.44 24.070 63.49

119 16192.97 24.125 68.00

120 16537.50 24.176 68.00

121 16882.03 24.225 68.00

122 17226.56 24.271 68.00

123 17571.09 24.316 68.00

124 17915.63 24.358 68.00

125 18260.16 24.398 68.00

126 18604.69 24.436 68.00

127 18949.22 24.473 68.00

128 19293.75 24.508 68.00

129 19638.28 24.542 68.00

130 19982.81 24.574 68.00

**Table 3-D.1f.: Frequencies, Critical Band Rates and Absolute Threshold**

Table is valid for Layer II at a sampling rate of 48.0 kHz

**Index Number Frequency Crit.Band Rate Absolute Thresh.**

**i [Hz] [z] [dB]**

1 46.88 .463 42.10

2 93.75 .925 24.17

3 140.63 1.385 17.47

4 187.50 1.842 13.87

5 234.38 2.295 11.60

6 281.25 2.742 10.01

7 328.13 3.184 8.84

8 375.00 3.618 7.94

9 421.88 4.045 7.22

10 468.75 4.463 6.62

11 515.63 4.872 6.12

12 562.50 5.272 5.70

13 609.38 5.661 5.33

14 656.25 6.041 5.00

15 703.13 6.411 4.71

16 750.00 6.770 4.45

17 796.88 7.119 4.21

18 843.75 7.457 4.00

19 890.63 7.785 3.79

20 937.50 8.103 3.61

21 984.38 8.410 3.43

22 1031.25 8.708 3.26

23 1078.13 8.996 3.09

24 1125.00 9.275 2.93

25 1171.88 9.544 2.78

26 1218.75 9.805 2.63

27 1265.63 10.057 2.47

28 1312.50 10.301 2.32

29 1359.38 10.537 2.17

30 1406.25 10.765 2.02

31 1453.13 10.986 1.86

32 1500.00 11.199 1.71

33 1546.88 11.406 1.55

34 1593.75 11.606 1.38

35 1640.63 11.800 1.21

36 1687.50 11.988 1.04

37 1734.38 12.170 .86

38 1781.25 12.347 .67

39 1828.13 12.518 .49

40 1875.00 12.684 .29

41 1921.88 12.845 .09

42 1968.75 13.002 -.11

43 2015.63 13.154 -.32

44 2062.50 13.302 -.54

45 2109.38 13.446 -.75

46 2156.25 13.586 -.97

47 2203.13 13.723 -1.20

48 2250.00 13.855 -1.43

49 2343.75 14.111 -1.88

50 2437.50 14.354 -2.34

51 2531.25 14.585 -2.79

52 2625.00 14.807 -3.22

53 2718.75 15.018 -3.62

54 2812.50 15.221 -3.98

55 2906.25 15.415 -4.30

56 3000.00 15.602 -4.57

57 3093.75 15.783 -4.77

58 3187.50 15.956 -4.91

59 3281.25 16.124 -4.98

60 3375.00 16.287 -4.97

61 3468.75 16.445 -4.90

62 3562.50 16.598 -4.76

63 3656.25 16.746 -4.55

64 3750.00 16.891 -4.29

65 3843.75 17.032 -3.99

66 3937.50 17.169 -3.64

67 4031.25 17.303 -3.26

68 4125.00 17.434 -2.86

69 4218.75 17.563 -2.45

70 4312.50 17.688 -2.04

71 4406.25 17.811 -1.63

72 4500.00 17.932 -1.24

73 4687.50 18.166 -.51

74 4875.00 18.392 .12

75 5062.50 18.611 .64

76 5250.00 18.823 1.06

77 5437.50 19.028 1.39

78 5625.00 19.226 1.66

79 5812.50 19.419 1.88

80 6000.00 19.606 2.08

81 6187.50 19.788 2.27

82 6375.00 19.964 2.46

83 6562.50 20.135 2.65

84 6750.00 20.300 2.86

85 6937.50 20.461 3.09

86 7125.00 20.616 3.33

87 7312.50 20.766 3.60

88 7500.00 20.912 3.89

89 7687.50 21.052 4.20

90 7875.00 21.188 4.54

91 8062.50 21.318 4.91

92 8250.00 21.445 5.31

93 8437.50 21.567 5.73

94 8625.00 21.684 6.18

95 8812.50 21.797 6.67

96 9000.00 21.906 7.19

97 9375.00 22.113 8.33

98 9750.00 22.304 9.63

99 10125.00 22.482 11.08

100 10500.00 22.646 12.71

101 10875.00 22.799 14.53

102 11250.00 22.941 16.54

103 11625.00 23.072 18.77

104 12000.00 23.195 21.23

105 12375.00 23.309 23.94

106 12750.00 23.415 26.90

107 13125.00 23.515 30.14

108 13500.00 23.607 33.67

109 13875.00 23.694 37.51

110 14250.00 23.775 41.67

111 14625.00 23.852 46.17

112 15000.00 23.923 51.04

113 15375.00 23.991 56.29

114 15750.00 24.054 61.94

115 16125.00 24.114 68.00

116 16500.00 24.171 68.00

117 16875.00 24.224 68.00

118 17250.00 24.275 68.00

119 17625.00 24.322 68.00

120 18000.00 24.368 68.00

121 18375.00 24.411 68.00

122 18750.00 24.452 68.00

123 19125.00 24.491 68.00

124 19500.00 24.528 68.00

125 19875.00 24.564 68.00

126 20250.00 24.597 68.00

**Table 3-D.2a. Critical Band Boundaries**

This table is valid for Layer I at a sampling rate of 32.0 kHz.

The frequencies represent the top end of each critical band.

**no index of frequency [Hz] Bark [z]**

**table F&CB**

0 1 62.500 .617

1 3 187.500 1.842

2 5 312.500 3.037

3 7 437.500 4.185

4 9 562.500 5.272

5 11 687.500 6.289

6 13 812.500 7.233

7 15 937.500 8.103

8 18 1125.000 9.275

9 21 1312.500 10.301

10 24 1500.000 11.199

11 27 1687.500 11.988

12 32 2000.000 13.104

13 37 2312.500 14.027

14 44 2750.000 15.087

15 50 3250.000 16.069

16 55 3875.000 17.078

17 61 4625.000 18.089

18 68 5500.000 19.095

19 74 6500.000 20.079

20 79 7750.000 21.098

21 85 9250.000 22.046

22 94 11500.000 23.030

23 108 15000.000 23.923

**Table 3-D.2b. Critical Band Boundaries**

This table is valid for Layer I at a sampling rate of 44.1 kHz.

The frequencies represent the top end of each critical band.

**no index of frequency [Hz] Bark [z]**

**table F&CB**

0 1 86.133 .850

1 2 172.266 1.694

2 3 258.398 2.525

3 5 430.664 4.124

4 6 516.797 4.882

5 8 689.063 6.301

6 9 775.195 6.959

7 11 947.461 8.169

8 13 1119.727 9.244

9 15 1291.992 10.195

10 17 1464.258 11.037

11 20 1722.656 12.125

12 23 1981.055 13.042

13 27 2325.586 14.062

14 32 2756.250 15.100

15 37 3186.914 15.955

16 45 3875.977 17.079

17 50 4478.906 17.904

18 55 5340.234 18.922

19 61 6373.828 19.963

20 68 7579.688 20.971

21 75 9302.344 22.074

22 81 11369.531 22.984

23 93 15503.906 24.013

24 106 19982.813 24.573

**Table 3-D.2c. Critical Band Boundaries**

This table is valid for Layer I at a sampling rate of 48.0 kHz.

The frequencies represent the top end of each critical band.

**no indexof frequency[Hz] Bark[z]**

**tableF&CB**

0 1 93.750 .925

1 2 187.500 1.842

2 3 281.250 2.742

3 4 375.000 3.618

4 5 468.750 4.463

5 6 562.500 5.272

6 7 656.250 6.041

7 9 843.750 7.457

8 10 937.500 8.103

9 12 1125.000 9.275

10 14 1312.500 10.301

11 16 1500.000 11.199

12 19 1781.250 12.347

13 21 1968.750 13.002

14 25 2343.750 14.111

15 29 2718.750 15.018

16 35 3281.250 16.124

17 41 3843.750 17.032

18 49 4687.500 18.166

19 53 5437.500 19.028

20 58 6375.000 19.964

21 65 7687.500 21.052

22 73 9375.000 22.113

23 79 11625.000 23.072

24 89 15375.000 23.991

25 102 20250.000 24.597

**Table 3-D.2d. Critical Band Boundaries**

This table is valid for Layer II at a sampling rate of 32.0 kHz.

The frequencies represent the top end of each critical band.

**no indexof frequency[Hz] Bark[z]**

**tableF&CB**

0 1 31.250 .309

1 3 93.750 .925

2 6 187.500 1.842

3 10 312.500 3.037

4 13 406.250 3.903

5 17 531.250 5.006

6 21 656.250 6.041

7 25 781.250 7.004

8 30 937.500 8.103

9 35 1093.750 9.090

10 41 1281.250 10.139

11 47 1468.750 11.058

12 51 1687.500 11.988

13 56 2000.000 13.104

14 61 2312.500 14.027

15 68 2750.000 15.087

16 74 3250.000 16.069

17 79 3875.000 17.078

18 85 4625.000 18.089

19 92 5500.000 19.095

20 98 6500.000 20.079

21 103 7750.000 21.098

22 109 9250.000 22.046

23 118 11500.000 23.030

24 132 15000.000 23.923

**Table 3-D.2e. Critical Band Boundaries**

This table is valid for Layer II at a sampling rate of 44.1 kHz.

The frequencies represent the top end of each critical band.

**no indexof frequency[Hz] Bark[z]**

**tableF&CB**

0 1 43.066 .425

1 2 86.133 .850

2 3 129.199 1.273

3 5 215.332 2.112

4 7 301.465 2.934

5 10 430.664 4.124

6 13 559.863 5.249

7 16 689.063 6.301

8 19 818.262 7.274

9 22 947.461 8.169

10 26 1119.727 9.244

11 30 1291.992 10.195

12 35 1507.324 11.232

13 40 1722.656 12.125

14 46 1981.055 13.042

15 51 2325.586 14.062

16 56 2756.250 15.100

17 62 3273.047 16.11

18 69 3875.977 17.079

19 74 4478.906 17.904

20 79 5340.234 18.922

21 85 6373.828 19.963

22 92 7579.688 20.971

23 99 9302.344 22.074

24 105 11369.531 22.984

25 117 15503.906 24.013

26 130 19982.813 24.573

**Table 3-D.2f. Critical Band Boundaries**

This table is valid for Layer II at a sampling rate of 48.0 kHz.

The frequencies represent the top end of each critical band.

**no index of frequency [Hz] Bark [z]**

**table F&CB**

0 1 46.875 .463

1 2 93.750 .925

2 3 140.625 1.385

3 5 234.375 2.295

4 7 328.125 3.184

5 9 421.875 4.045

6 12 562.500 5.272

7 14 656.250 6.041

8 17 796.875 7.119

9 20 937.500 8.103

10 24 1125.000 9.275

11 27 1265.625 10.057

12 32 1500.000 11.199

13 37 1734.375 12.170

14 42 1968.750 13.002

15 49 2343.750 14.111

16 53 2718.750 15.018

17 59 3281.250 16.124

18 65 3843.750 17.032

19 73 4687.500 18.166

20 77 5437.500 19.028

21 82 6375.000 19.964

22 89 7687.500 21.052

23 97 9375.000 22.113

24 103 11625.000 23.072

25 113 15375.000 23.991

26 126 20250.000 24.597

**3-D.2 Psychoacoustic Model II**

Psychoacoustic Model II is an independent psychoacoustic model that can be adjusted and adapted to any ISO-MPEG-Audio layer. This annex presents the general Psychoacoustic Model II, and provides sufficient information for implementation of Model II with Layers I and II. The Layer III Psychoacoustic Model is based on this implementation, with adaptations as described in the Layer III encoder clause.

The threshold generation process has three inputs. They are:

1. The shift length for the threshold calculation process, *iblen*, where 384<*iblen*<640. This *iblen* must remain constant over any particular application of the threshold calculation process. If (as in Layer III), it is necessary to calculate thresholds for two different shift lengths, two processes, each running with a fixed shift length, will be necessary. In the case of *iblen* outside the range of 384 to 640 it may be necessary to calculate the psychoacoustic thresholds with a different window length as well as shift length. There are two ways to do this:

- Use a different length transform, and recalculate the startup coefficients for the model, or

- Use the same length transform, but a substantially shorter Hann window, appropriate to the data and problem at hand.

The choice of these is left to the implementation.

2. The newest *iblen* samples of the signal, with the samples delayed (either in the filter bank or psychoacoustic calculation) such that the window of the psychoacoustic calculation is centered in the time-window of application.

3. The sampling rate. There are sets of tables provided for the standard sampling rates. Sampling rate, like *iblen*, must necessarily remain constant over one implementation of the threshold calculation process.

There is one output from Psychoacoustic Model II, a set of Signal to Masking Ratios, *SMRn*, which are adapted to the layers as described below.

Before running the Model initially, the array used to hold the preceding FFT source data window and the arrays used to hold r and f should be zeroed to provide a known starting point.

In Layer II, the psychoacoustic masking ratios must be calculated twice during each coder frame. The more stringent of each pair of ratios is used for bit allocation as shown in the software simulation model for Layers I and II with Psychoacoustic Model II.

**Comments on Notation**

Throughout this threshold calculation process, three indices for data values are used. These are:

*w* - indicates that the calculation is indexed by frequency in the FFT spectral line domain. An index of 1 corresponds to the DC term and an index of 513 corresponds to the spectral line at the Nyquest frequency.

*b* - indicates that the calculation is indexed in the threshold calculation partition domain. In the case where the calculation includes a convolution or sum in the threshold calculation partition domain, *bb* will be used as the summation variable. Partition numbering starts at 1.

*n* - indicates that the calculation is indexed in the coder bit (or codebook) allocation domain. An index of 1 corresponds to the lowest band in the subband filter bank.

**The "Spreading Function"**

Several points in the following description refer to the "spreading function". It is calculated by the following method:

*tmpx* =1.05 (*j-i* ),

Where *i*  is the bark value of the signal being spread, *j*  is the bark value of the band being spread into, and *tmpx*  is a temporary variable.

*x*=8 *minimum* ((*tmpx*-0.5)2-2(*tmpx*-0.5),0)

Where *x* is a temporary variable, and minimum (a,b) is a function returning the more negative of a or b.

*tmpy*=15.811389+7.5(*tmpx*+0.474)-17.5(1.0+(*tmpx*+0.474)2)0.5

where *tmpy* is another temporary variable.

if (*tmpy*<-100) then {*sprdngf (i,j)=*0} else {*sprdngf (i,j)*=10(x+tmpy)/10 }

**Steps in Threshold Calculation**

The following are the necessary steps for calculation of the *SMRn* used in the coder.

1. Reconstruct 1024 samples of the input signal.

*iblen* new samples are made available at every call to the threshold generator. The threshold generator must store 1024-*iblen* samples, and concatenate those samples to accurately reconstruct 1024 consecutive samples of the input signal, *si,* where *i* represents the index, 1 < *i* < 1024 of the current input stream.

2. Calculate the complex spectrum of the input signal.

First, *si*  is windowed by a 1024 point Hann window, i.e. *swi=si* \* (0.5-0.5cos() ). Note that in Layer III, a shorter window may be used when window switching is active, with appropriate centering of the window, per the Layer III encoder description.

Second, a standard forward FFT of *swi* is calculated.

Third, the polar representation of the transform is calculated. *rw* and *fw* represent the magnitude and phase components of the transformed *swi,*  respectively.

3. Calculate a predicted *r* and *f*.

A predicted magnitude, *^rw*, and phase, *^fw* are calculated from the preceding two threshold calculation blocks' *r* and *f*:

*^rw =2.0rw (t-1)-rw (t-2)*

*^fw =2.0fw (t-1)-fw (t-2)*

where *t* represents the current block number, *t-1* indexes the previous block's data, and *t-2* indexes the data from the threshold calculation block before that.

4. Calculate the unpredictability measure *cw*

*cw*, the unpredictability measure, is:

*cw=(((rw cos fw - ^rw cos ^fw)2+(rw sin fw - ^rw sin ^fw)2)0.5) / (rw+ abs (^rw))*

By sacrificing performance, this measure can be calculated on only a lower portion of the frequency lines. Calculations should be done from DC to at least 3kHz and preferably to7kHz. An upper limit of less than 5.5kHz may considerably reduce performance from that obtained during the subjective testing of the audio algorithm. The *cw* values above this limit should be set to 0.3. Best results will be obtained by calculating cw up to 20kHz.

5. Calculate the energy and unpredictability in the threshold calculation partitions.

The energy in each partition, *eb*, is:

*eb= w=wlowb whighb å rw2*

and the weighted unpredictability, *cb*, is:

*cb= w=wlowb whighb å rw2 cw*

The threshold calculation partitions provide a resolution of approximately either one FFT line or 1/3 critical band, whichever is wider. At low frequencies, a single line of the FFT will constitute a calculation partition. At high frequencies, many lines will be combined into one calculation partition. A set of partition values is provided for each of the three sampling rates in Table 3-D.3."Calculation Partition Tables". These table elements will be used in the threshold calculation process. There are several elements in each table entry:

1. The index of the calculation partition, *b*.

2. The lowest frequency line in the partition, *wlowb.*

3. The highest frequency line in the partition, *whighb*.

4. The median bark value of the partition, *bvalb.*

5. A lower limit for the SNR in the partition that controls stereo unmasking effects, *minvalb*.

6. The value for tone masking noise (in dB) for the partition, *TMNb*.

A largest value of *b,bmax*, equal to the largest index, exists for each sampling rate.

6. Convolve the partitioned energy and unpredictability with the spreading function.

*ecbb= bb=1 bmax å ebb\* sprdngf(bvalbb,bvalb)*

*ctb= bb=1 bmax å cbb\* sprdngf(bvalbb,bvalb)*

Because *ctb*. is weighted by the signal energy, it must be renormalized to *cbb*.

*cbb=ctb/ecbb*

At the same time, due to the non-normalized nature of the spreading function, *ecbb* should be renormalized and the normalized energy *enb*, calculated.

*enb=ecbb \* rnormb*

The normalization coefficient, *rnormb*. is:

*rnormb=1/ (bb=0 bmax å sprdngf(bvalbb,bvalb))*

7. Convert *cbb*  to *tbb* .

*tbb* = -0.299-0.43loge (*cbb*)

Each *tbb*  is limited to the range of 0<*tbb* <1.

8. Calculate the required SNR in each partition.

*NMTb*  = 5.5dB for all *b*. *NMTb* is the value for noise masking tone (in dB) for the partition. The required signal to noise ratio, *SNRb* , is:

*SNRb* =maximum(*minvalb, tbb \* TMNb +(1-tbb ) NMTb*)

Where maximum (a,b) is a function returning the least negative of a or b.

9. Calculate the power ratio.

The power ratio, *bcb* , is:

*bcb =10-SNRb/10*

10. Calculation of actual energy threshold, *nbb* .

*nbb=enb bcb*

11. Spread the threshold energy over FFT lines, yielding *nbw* .

*nbw = nbb / (whighb-wlowb+1)*

12. Include absolute thresholds, yielding the final energy threshold of audibility, *thrw*

*thrw* = max(*nbw, absthrw*)

The dB values of *absthr* shown in Tables 3-D.4. "Absolute Threshold Tables" are relative to the level that a sine wave of ± ½ lsb has in the FFT used for threshold calculation. The dB values must be converted into the energy domain after considering the FFT normalization actually used.

13. Pre-echo control

For Layer III , pre-echo control occurs at this point. The actual control is described as part of the Layer III encoder specification. This step is omitted for Layers I and II.

14. Calculate the signal-to-mask ratios, *SMRn*.

Table 3-D.5. "Layer I and II Coder Partition Table" shows:

1. The index, *n*, of the coder partition.

2. The lower index *wlown*, of the coder partition.

3. The upper index, *whighn* of the coder partition.

4. The width index, *widthn*, where *widthn*=1 for a psychoacoustically narrow scalefactor band, and *widthn*=0 for a psychoacoustically wide scalefactor band. A psychoacoustically narrow scalefactor band is one whose width is less than approximately 1/3 critical band.

The energy in the scalefactor band, *epartn* , is:

*epartn= w=wlown whighn å rw2*

Then, if (*widthn* = 1), the noise level in the scalefactor band, *npartn*  is calculated as:

*npartn= w=wlown whighn å thrw*

else,

*npartn* = minimum(*thrwlown ,...,thrwhighn* ) \* (*whighn - wlown + 1*)

Where, in this case, minimum (a,...,z) is a function returning the smallest positive argument of the arguments a...z.

The ratios to be sent to the coder, *SMRn* , are calculated as:

*SMRn* = 10 log 10 (epartn/npartn )

**Table 3-D.3a. Calculation Partition Table**

This table is valid at a sampling rate of 32.0 kHz.

**Index wlow whigh bval minval TMN**

1 1 1 0.00 0.0 24.5

2 2 4 0.63 0.0 24.5

3 5 7 1.56 20.0 24.5

4 8 10 2.50 20.0 24.5

5 11 13 3.44 20.0 24.5

6 14 16 4.34 20.0 24.5

7 17 19 5.17 20.0 24.5

8 20 22 5.94 20.0 24.5

9 23 25 6.63 17.0 24.5

10 26 28 7.28 15.0 24.5

11 29 31 7.90 15.0 24.5

12 32 34 8.50 10.0 24.5

13 35 37 9.06 7.0 24.5

14 38 41 9.65 7.0 24.5

15 42 45 10.28 4.4 24.8

16 46 49 10.87 4.4 25.4

17 50 53 11.41 4.5 25.9

18 54 57 11.92 4.5 26.4

19 58 61 12.39 4.5 26.9

20 62 65 12.83 4.5 27.3

21 66 70 13.29 4.5 27.8

22 71 75 13.78 4.5 28.3

23 76 81 14.27 4.5 28.8

24 82 87 14.76 4.5 29.3

25 88 93 15.22 4.5 29.7

26 94 99 15.63 4.5 30.1

27 100 106 16.06 4.5 30.6

28 107 113 16.47 4.5 31.0

29 114 120 16.86 4.5 31.4

30 121 129 17.25 4.5 31.8

31 130 138 17.65 4.5 32.2

32 139 148 18.05 4.5 32.5

33 149 159 18.42 4.5 32.9

34 160 170 18.81 4.5 33.3

35 171 183 19.18 4.5 33.7

36 184 196 19.55 4.5 34.1

37 197 210 19.93 4.5 34.4

38 211 225 20.29 4.5 34.8

39 226 240 20.65 4.5 35.2

40 241 258 21.02 4.5 35.5

41 259 279 21.38 4.5 35.9

42 280 300 21.74 4.5 36.2

43 301 326 22.10 4.5 36.6

44 327 354 22.44 4.5 36.9

45 355 382 22.79 4.5 37.3

46 383 420 23.14 4.5 37.6

47 421 458 23.49 4.5 38.0

48 459 496 23.83 4.5 38.3

49 497 513 24.07 4.5 38.6

**Table 3-D.3b. Calculation Partition Table**

This table is valid at a sampling rate of 44.1.0 kHz.

**Index wlow whigh bval minval TMN**

1 1 1 0.00 0.0 24.5

2 2 2 0.43 0.0 24.5

3 3 3 0.86 0.0 24.5

4 4 4 1.29 20.0 24.5

5 5 5 1.72 20.0 24.5

6 6 6 2.15 20.0 24.5

7 7 7 2.58 20.0 24.5

8 8 8 3.01 20.0 24.5

9 9 9 3.45 20.0 24.5

10 10 10 3.88 20.0 24.5

11 11 11 4.28 20.0 24.5

12 12 12 4.67 20.0 24.5

13 13 13 5.06 20.0 24.5

14 14 14 5.42 20.0 24.5

15 15 15 5.77 20.0 24.5

16 16 16 6.11 17.0 24.5

17 17 19 6.73 17.0 24.5

18 20 22 7.61 15.0 24.5

19 23 25 8.44 10.0 24.5

20 26 28 9.21 7.0 24.5

21 29 31 9.88 7.0 24.5

22 32 34 10.51 4.4 25.0

23 35 37 11.11 4.5 25.6

24 38 40 11.65 4.5 26.2

25 41 44 12.24 4.5 26.7

26 45 48 12.85 4.5 27.4

27 49 52 13.41 4.5 27.9

28 53 56 13.94 4.5 28.4

29 57 60 14.42 4.5 28.9

30 61 64 14.86 4.5 29.4

31 65 69 15.32 4.5 29.8

32 70 74 15.79 4.5 30.3

33 75 80 16.26 4.5 30.8

34 81 86 16.73 4.5 31.2

35 87 93 17.19 4.5 31.7

36 94 100 17.62 4.5 32.1

37 101 108 18.05 4.5 32.5

38 109 116 18.45 4.5 32.9

39 117 124 18.83 4.5 33.3

40 125 134 19.21 4.5 33.7

41 135 144 19.60 4.5 34.1

42 145 155 20.00 4.5 34.5

43 156 166 20.38 4.5 34.9

44 167 177 20.74 4.5 35.2

45 178 192 21.12 4.5 35.6

46 193 207 21.48 4.5 36.0

47 208 222 21.84 4.5 36.3

48 223 243 22.20 4.5 36.7

49 244 264 22.56 4.5 37.1

50 265 286 22.91 4.5 37.4

51 287 314 23.26 4.5 37.8

52 315 342 23.60 4.5 38.1

53 343 371 23.95 4.5 38.4

54 372 401 24.30 4.5 38.8

55 402 431 24.65 4.5 39.1

56 432 469 25.00 4.5 39.5

57 470 513 25.33 3.5 39.8

**Table 3-D.3c. Calculation Partition Table**

This table is valid at a sampling rate of 48.0 kHz.

**Index wlow whigh bval minval TMN**

1 1 1 0.00 0.0 24.5

2 2 2 0.47 0.0 24.5

3 3 3 0.94 0.0 24.5

4 4 4 1.41 20.0 24.5

5 5 5 1.88 20.0 24.5

6 6 6 2.34 20.0 24.5

7 7 7 2.81 20.0 24.5

8 8 8 3.28 20.0 24.5

9 9 9 3.75 20.0 24.5

10 10 10 4.20 20.0 24.5

11 11 11 4.63 20.0 24.5

12 12 12 5.05 20.0 24.5

13 13 13 5.44 20.0 24.5

14 14 14 5.83 20.0 24.5

15 15 15 6.19 20.0 24.5

16 16 16 6.52 17.0 24.5

17 17 17 6.86 17.0 24.5

18 18 20 7.49 15.0 24.5

19 21 23 8.40 10.0 24.5

20 24 26 9.24 7.0 24.5

21 27 29 9.97 7.0 24.5

22 30 32 10.65 4.4 25.1

23 33 35 11.28 4.5 25.8

24 36 38 11.86 4.5 26.4

25 39 41 12.39 4.5 26.9

26 42 45 12.96 4.5 27.5

27 46 49 13.56 4.5 28.1

28 50 53 14.12 4.5 28.6

29 54 57 14.62 4.5 29.1

30 58 62 15.14 4.5 29.6

31 63 67 15.67 4.5 30.2

32 68 72 16.15 4.5 30.7

33 73 77 16.58 4.5 31.1

34 78 83 17.02 4.5 31.5

35 84 89 17.44 4.5 31.9

36 90 95 17.84 4.5 32.3

37 96 103 18.24 4.5 32.7

38 104 111 18.66 4.5 33.2

39 112 120 19.07 4.5 33.6

40 121 129 19.47 4.5 34.0

41 130 138 19.85 4.5 34.3

42 139 149 20.23 4.5 34.7

43 150 160 20.63 4.5 35.1

44 161 173 21.02 4.5 35.5

45 174 187 21.40 4.5 35.9

46 188 201 21.76 4.5 36.3

47 202 219 22.12 4.5 36.6

48 220 238 22.47 4.5 37.0

49 239 257 22.83 4.5 37.3

50 258 283 23.18 4.5 37.7

51 284 309 23.53 4.5 38.0

52 310 335 23.88 4.5 38.4

53 336 363 24.23 4.5 38.7

54 364 391 24.58 4.5 39.1

55 392 423 24.93 4.5 39.4

56 424 465 25.27 4.5 39.8

57 466 507 25.61 3.5 40.1

58 508 513 25.81 3.5 40.3

**Table 3-D.4a. Absolute Threshold Table**

This table is valid at a sampling rate of 32.0 kHz.

A value of 0 dB represents a level in the absolute threshold calculation of 96 dB below the energy of a sine wave of amplitude +-32760.

**index (line) absthr**

**lower higher (dB)**

----------------------------------

1 1 58.23

2 2 33.44

3 3 24.17

4 4 19.20

5 5 16.05

6 6 13.87

7 7 12.26

8 8 11.01

9 9 10.01

10 10 9.20

11 11 8.52

12 12 7.94

13 13 7.44

14 14 7.00

15 15 6.62

16 16 6.28

17 17 5.97

18 18 5.70

19 19 5.44

20 20 5.21

21 21 5.00

22 22 4.80

23 23 4.62

24 24 4.45

25 25 4.29

26 26 4.14

27 27 4.00

28 28 3.86

29 29 3.73

30 30 3.61

31 31 3.49

32 32 3.37

33 33 3.26

34 34 3.15

35 35 3.04

36 36 2.93

37 37 2.83

38 38 2.73

39 39 2.63

40 40 2.53

41 41 2.42

42 42 2.32

43 43 2.22

44 44 2.12

45 45 2.02

46 46 1.92

47 47 1.81

48 48 1.71

49 50 1.49

51 52 1.27

53 54 1.04

55 56 .80

57 57 .55

59 60 .29

61 62 .02

63 64 -.25

65 66 -.54

67 68 -.83

69 70 -1.12

71 72 -1.43

73 74 -1.73

75 76 -2.04

77 78 -2.34

79 80 -2.64

81 82 -2.93

83 84 -3.22

85 86 -3.49

87 88 -3.74

89 90 -3.98

91 92 -4.20

93 94 -4.40

95 96 -4.57

97 100 -4.82

101 104 -4.96

105 108 -4.97

109 112 -4.86

113 116 -4.63

117 120 -4.29

121 124 -3.87

125 128 -3.39

129 132 -2.86

133 136 -2.31

137 140 -1.77

141 144 -1.24

145 148 -.74

149 152 -.29

153 156 .12

157 160 .48

161 164 .79

165 168 1.06

169 172 1.29

173 176 1.49

177 180 1.66

181 184 1.81

185 188 1.95

189 192 2.08

193 200 2.33

201 208 2.59

209 216 2.86

217 224 3.17

225 232 3.51

233 240 3.89

241 248 4.31

249 256 4.79

257 264 5.31

265 272 5.88

273 280 6.50

281 288 7.19

289 296 7.93

297 304 8.75

305 312 9.63

313 320 10.58

321 328 11.60

329 336 12.71

337 344 13.90

345 352 15.18

353 360 16.54

361 368 18.01

369 376 19.57

377 384 21.23

385 392 23.01

393 400 24.90

401 408 26.90

409 416 29.03

417 424 31.28

425 432 33.67

433 440 36.19

441 448 38.86

449 456 41.67

457 464 44.63

465 472 47.76

473 480 51.03

**Table 3-D.4b. Absolute Threshold Table**

This table is valid at a sampling rate of 44.1 kHz.

A value of 0 dB represents a level in the absolute threshold calculation of 96 dB below the energy of a sine wave of amplitude +-32760.

i**ndex (line) absthr**

**lower higher dB**

-----------------------------------

1 1 45.05

2 2 25.87

3 3 18.70

4 4 14.85

5 5 12.41

6 6 10.72

7 7 9.47

8 8 8.50

9 9 7.73

10 10 7.10

11 11 6.56

12 12 6.11

13 13 5.72

14 14 5.37

15 15 5.07

16 16 4.79

17 17 4.55

18 18 4.32

19 19 4.11

20 20 3.92

21 21 3.74

22 22 3.57

23 23 3.40

24 24 3.25

25 25 3.10

26 26 2.95

27 27 2.81

28 28 2.67

29 29 2.53

30 30 2.39

31 31 2.25

32 32 2.11

33 33 1.97

34 34 1.83

35 35 1.68

36 36 1.53

37 37 1.38

38 38 1.23

39 39 1.07

40 40 .90

41 41 .74

42 42 .56

43 43 .39

44 44 .21

45 45 .02

46 46 -.17

47 47 -.36

48 48 -.56

49 50 -.96

51 52 -1.37

53 54 -1.79

55 56 -2.21

57 58 -2.63

59 60 -3.03

61 62 -3.41

63 64 -3.77

65 66 -4.09

67 68 -4.37

69 70 -4.60

71 72 -4.78

73 74 -4.91

75 76 -4.97

77 78 -4.98

79 80 -4.92

81 82 -4.81

83 84 -4.65

85 86 -4.43

87 88 -4.17

89 90 -3.87

91 92 -3.54

93 94 -3.19

95 96 -2.82

97 100 -2.06

101 104 -1.33

105 108 -.64

109 112 -.04

113 116 .47

117 120 .89

121 124 1.23

125 128 1.51

129 132 1.74

133 136 1.93

137 140 2.11

141 144 2.28

145 148 2.45

149 152 2.63

153 156 2.82

157 160 3.03

161 164 3.25

165 168 3.49

169 172 3.74

173 176 4.02

177 180 4.32

181 184 4.64

185 188 4.98

189 192 5.35

193 200 6.15

201 208 7.07

209 216 8.10

217 224 9.25

225 232 10.54

233 240 11.97

241 248 13.56

249 256 15.30

257 264 17.23

265 272 19.33

273 280 21.64

281 288 24.15

289 296 26.88

297 304 29.84

305 312 33.04

313 320 36.51

321 328 40.24

329 336 44.26

337 344 48.58

345 352 53.21

353 360 58.17

361 368 63.48

369 376 69.13

377 384 69.13

385 392 69.13

393 400 69.13

401 408 69.13

409 416 69.13

417 424 69.13

425 432 69.13

433 440 69.13

441 448 69.13

449 456 69.13

457 464 69.13

**Table 3-D.4c. Absolute Threshold Table**

This table is valid at a sampling rate of 48.0 kHz.

A value of 0 dB represents a level in the absolute threshold calculation of 96 dB below the energy of a sine wave of amplitude +-32760.

**index (line) absthr.**

**lower higher dB**

-----------------------------------

1 1 42.10

2 2 24.17

3 3 17.47

4 4 13.87

5 5 11.60

6 6 10.01

7 7 8.84

8 8 7.94

9 9 7.22

10 10 6.62

11 11 6.12

12 12 5.70

13 13 5.33

14 14 5.00

15 15 4.71

16 16 4.45

17 17 4.21

18 18 4.00

19 19 3.79

20 20 3.61

21 21 3.43

22 22 3.26

23 23 3.09

24 24 2.93

25 25 2.78

26 26 2.63

27 27 2.47

28 28 2.32

29 29 2.17

30 30 2.02

31 31 1.86

32 32 1.71

33 33 1.55

34 34 1.38

35 35 1.21

36 36 1.04

37 37 .86

38 38 .67

39 39 .49

40 40 .29

41 41 .09

42 42 -.11

43 43 -.32

44 44 -.54

45 45 -.75

46 46 -.97

47 47 -1.20

48 48 -1.43

49 50 -1.88

51 52 -2.34

53 54 -2.79

55 56 -3.22

57 58 -3.62

59 60 -3.98

61 62 -4.30

63 64 -4.57

65 66 -4.77

67 68 -4.91

69 70 -4.98

71 72 -4.97

73 74 -4.90

75 76 -4.76

77 78 -4.55

79 80 -4.29

81 82 -3.99

83 84 -3.64

85 86 -3.26

87 88 -2.86

89 90 -2.45

91 92 -2.04

93 94 -1.63

95 96 -1.24

97 100 -.51

101 104 .12

105 108 .64

109 112 1.06

113 116 1.39

117 120 1.66

121 124 1.88

125 128 2.08

129 132 2.27

133 136 2.46

137 140 2.65

141 144 2.86

145 148 3.09

149 152 3.33

153 156 3.60

157 160 3.89

161 164 4.20

165 168 4.54

169 172 4.91

173 176 5.31

177 180 5.73

181 184 6.18

185 188 6.67

189 192 7.19

193 200 8.33

201 208 9.63

209 216 11.08

217 224 12.71

225 232 14.53

233 240 16.54

241 248 18.77

249 256 21.23

257 264 23.94

265 272 26.90

273 280 30.14

281 288 33.67

289 296 37.51

297 304 41.67

305 312 46.17

313 320 51.04

321 328 56.29

329 332 61.94

333 340 68.00

341 348 68.00

349 356 68.00

357 364 68.00

365 372 68.00

373 380 68.00

381 388 68.00

389 396 68.00

397 404 68.00

405 412 68.00

413 420 68.00

421 428 68.00

**Table 3-D.5. Layer I and Layer II Coder Partition Table**

**Index lown+1 widthn**

**highn**

0 1 0

1 17 0

2 33 0

3 49 0

4 65 0

5 81 0

6 97 0

7 113 0

8 129 0

9 145 0

10 161 0

11 177 0

12 193 0

13 209 1

14 225 1

15 241 1

16 257 1

17 273 1

18 289 1

19 305 1

20 321 1

21 337 1

22 353 1

23 369 1

24 385 1

25 401 1

26 417 1

27 433 1

28 449 1

29 465 1

30 481 1

31 497 1

32 513 1