Center Frequencies and High/Low

Frequency Limits for Octave Bands, 1/2- and 1/3-Octave Bands

<u>Octave Bands</u>:

The audio spectrum from ~ 20 *Hz* to ~ 20 *KHz* can be divided up into ~ 11 octave bands. If we set/define the 7th octave band's center frequency to be $f_7^{ctr} \equiv 1000\ Hz$, then all ***<u>lower</u>*** center frequencies for octave bands can be defined from each other using the formula $f_{n-1}^{ctr} = f_n^{ctr} / 2$. Conversely, all ***<u>higher</u>*** center frequencies for octave bands can be defined from each other using the formula $f_{n+1}^{ctr} = 2 f_n^{ctr}$. Then for each center frequency, the half-octave low (high) frequency for each octave band are (respectively) given by the formulae $f_n^{low} = f_n / 2^{1/2}$ and $f_n^{high} = 2^{1/2} f_n$. The per-cent fractional bandwidth per octave band is ***<u>constant</u>***: $BW \equiv 100\left[\left(f_n^{high} - f_n^{low}\right) / f_n^{ctr}\right] \simeq 70.7\%$.
Please see the octave band table on the next page.

<u>1/2-Octave Bands</u>:

The audio spectrum from ~ 20 *Hz* to ~ 20 *KHz* can be divided up into ~ 21 1/2-octave bands. If we set/define the 13th half-octave band's center frequency to be $f_{13}^{ctr} \equiv 1000\ Hz$, then all ***<u>lower</u>*** center frequencies for 1/2-octave bands can be defined from each other using the formula $f_{n-1}^{ctr} = f_n^{ctr} / 2^{1/2}$. Conversely, all ***<u>higher</u>*** center frequencies for 1/2-octave bands can be defined from each other using the formula $f_{n+1}^{ctr} = 2^{1/2} f_n^{ctr}$. Then for each center frequency, the 1/4-octave low (high) frequency for each 1/2-octave band are (respectively) given by the formulae $f_n^{low} = f_n / 2^{1/4}$ and $f_n^{high} = 2^{1/4} f_n$. The per-cent fractional bandwidth per 1/2-octave band is ***<u>constant</u>***: $BW \equiv 100\left[\left(f_n^{high} - f_n^{low}\right) / f_n^{ctr}\right] \simeq 34.8\%$.
Please see the 1/2-octave band table on the next page.

<u>1/3-Octave Bands</u>:

The audio spectrum from ~ 20 *Hz* to ~ 20 *KHz* can be divided up into ~ 31 1/3-octave bands. If we set/define the 19th 1/3-octave band's center frequency to be $f_{19}^{ctr} \equiv 1000\ Hz$, then all ***<u>lower</u>*** center frequencies for 1/3-octave bands can be defined from each other using the formula $f_{n-1} = f_n / 2^{1/3}$. Conversely, all ***<u>higher</u>*** center frequencies for 1/3-octave bands can be defined from each other using the formula $f_{n+1} = 2^{1/3} f_n$. Then for each center frequency, the 1/6-octave low (high) frequency for each 1/3-octave band are (respectively) given by the formulae $f_n^{low} = f_n / 2^{1/6}$ and $f_n^{high} = 2^{1/6} f_n$. The per-cent fractional bandwidth per 1/3-octave band is ***<u>constant</u>***: $BW \equiv 100\left[\left(f_n^{high} - f_n^{low}\right) / f_n^{ctr}\right] \simeq 23.2\%$.
Please see the 1/3-octave band table on the next page.

	Octave Bands			
Band #	f_lo	f_ctr	f_hi	%BW
1	11.049	15.625	22.097	70.711
2	22.097	31.250	44.194	70.711
3	44.194	62.500	88.388	70.711
4	88.388	125.000	176.777	70.711
5	176.777	250.000	353.553	70.711
6	353.553	500.000	707.107	70.711
7	707.107	1000.000	1414.214	70.711
8	1414.214	2000.000	2828.427	70.711
9	2828.427	4000.000	5656.854	70.711
10	5656.854	8000.000	11313.708	70.711
11	11313.708	16000.000	22627.417	70.711

	1/2-Octave Bands			
Band #	f_lo	f_ctr	f_hi	%BW
1	13.139	15.625	18.581	34.831
2	18.581	22.097	26.278	34.831
3	26.278	31.250	37.163	34.831
4	37.163	44.194	52.556	34.831
5	52.556	62.500	74.325	34.831
6	74.325	88.388	105.112	34.831
7	105.112	125.000	148.651	34.831
8	148.651	176.777	210.224	34.831
9	210.224	250.000	297.302	34.831
10	297.302	353.553	420.448	34.831
11	420.448	500.000	594.604	34.831
12	594.604	707.107	840.896	34.831
13	840.896	1000.000	1189.207	34.831
14	1189.207	1414.214	1681.793	34.831
15	1681.793	2000.000	2378.414	34.831
16	2378.414	2828.427	3363.586	34.831
17	3363.586	4000.000	4756.828	34.831
18	4756.828	5656.854	6727.171	34.831
19	6727.171	8000.000	9513.657	34.831
20	9513.657	11313.708	13454.343	34.831
21	13454.343	16000.000	19027.314	34.831

	1/3-Octave Bands			
Band #	f_lo	f_ctr	f_hi	%BW
1	13.920	15.625	17.538	23.156
2	17.538	19.686	22.097	23.156
3	22.097	24.803	27.841	23.156
4	27.841	31.250	35.077	23.156
5	35.077	39.373	44.194	23.156
6	44.194	49.606	55.681	23.156
7	55.681	62.500	70.154	23.156
8	70.154	78.745	88.388	23.156
9	88.388	99.213	111.362	23.156
10	111.362	125.000	140.308	23.156
11	140.308	157.490	176.777	23.156
12	176.777	198.425	222.725	23.156
13	222.725	250.000	280.616	23.156
14	280.616	314.980	353.553	23.156
15	353.553	396.850	445.449	23.156
16	445.449	500.000	561.231	23.156
17	561.231	629.961	707.107	23.156
18	707.107	793.701	890.899	23.156
19	890.899	1000.000	1122.462	23.156
20	1122.462	1259.921	1414.214	23.156
21	1414.214	1587.401	1781.797	23.156
22	1781.797	2000.000	2244.924	23.156
23	2244.924	2519.842	2828.427	23.156
24	2828.427	3174.802	3563.595	23.156
25	3563.595	4000.000	4489.848	23.156
26	4489.848	5039.684	5656.854	23.156
27	5656.854	6349.604	7127.190	23.156
28	7127.190	8000.000	8979.696	23.156
29	8979.696	10079.368	11313.708	23.156
30	11313.708	12699.208	14254.379	23.156
31	14254.379	16000.000	17959.393	23.156
32	17959.393	20158.737	22627.417	23.156

Each octave band may be separated into three ranges - referred to as **one-third-octave** bands.

Octave Bands			1/3 Octave Bands		
Lower Band Limit (Hz)	Center Frequency(Hz)	Upper Band Limit (Hz)	Lower Band Limit (Hz)	Center Frequency(Hz)	Upper Band Limit(Hz)
			14.1	16	17.8
11	16	22	17.8	20	22.4
			22.4	25	28.2
			28.2	31.5	35.5
22	31.5	44	35.5	40	44.7
			44.7	50	56.2
			56.2	63	70.8
44	63	88	70.8	80	89.1
			89.1	100	112
			112	125	141
88	125	177	141	160	178
			178	200	224
			224	250	282
177	250	355	282	315	355
			355	400	447
			447	500	562
355	500	710	562	630	708
			708	800	891
			891	1000	1122
710	1000	1420	1122	1250	1413
			1413	1600	1778
			1778	2000	2239
1420	2000	2840	2239	2500	2818
			2818	3150	3548
			3548	4000	4467
2840	4000	5680	4467	5000	5623
			5623	6300	7079
			7079	8000	8913
5680	8000	11360	8913	10000	11220
			11220	12500	14130
11360	16000	22720	14130	16000	17780
			17780	20000	22390