One Octave to Third Octave Interpolation

A simple estimation of third octave band data from one octave band data

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In acoustical measurement, an SPL (Sound Pressure Level) meter is used to measure the total sound pressure level at a certain time, expressed in dB_{SPL}. To understand what the level is in each frequency band, an RTA (Real Time Analyzer) is used. RTA function is also available in several SPL meters.

According to several local standards, an RTA noise measurement is often required in 1/1 octave band. However, some computer software requires a 1/3 octave band data. If a 1/3 octave band measurement is not available, user needs to do an interpolation from 1/1 octave band data. This article discusses a way to do this.

An RTA background noise measurement in both 1/3 octave band (black bars) and 1/1 octave band (red bars) is shown in Figure 1.

The total SPL is the logarithmic summation of the levels of each band. It is equivalent to what is measured by a typical SPL meter. At a glance, we notice that the total SPL is the same (49.5 dB_{SPL}) even though the RTA bandwidth is 1/3 octave or 1/1 octave.

Our second observation is that, the 1/1 octave band values (red bars) are several dB higher than their adjacent 1/3 octave band values (black bars). This is true because a 1/1 octave band integrates three 1/3 octave band energy.

For example, the 1/1 octave band SPL at 1kHz is 35.3dB, which is the logarithmic sum of 31.8dB, 30dB and 29.5dB, and the 1/3 octave band SPLs at 800Hz, 1kHz and 1.25kHz respectively.

$$10 \times \log_{10}\left[10^{\frac{31.8}{10}} + 10^{\frac{30}{10}} + 10^{\frac{29.5}{10}}\right] = 35.3dB$$

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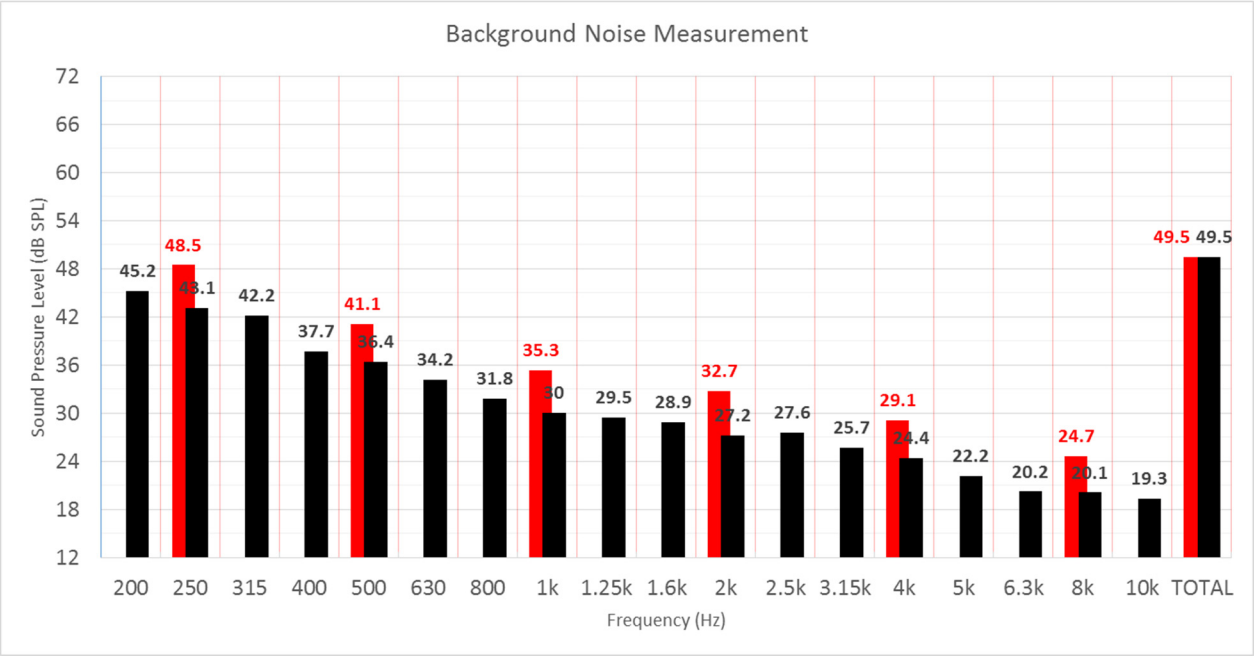

Figure 1

Converting 1/3 octave band values to 1/1 octave band is a straightforward summation process. However, when 1/3 octave band data is unavailable, an interpolation is required to convert 1/1 octave band data to 1/3 octave band.

The left two columns of Table 1 show the 1/1 octave band values from 250Hz to 8kHz. The right two columns show an 'interpolation' just by duplicating the 1/1 octave band value to the adjacent frequency bands. While this simple process seems reasonable, we will see why it is incorrect as soon as we calculate the total SPL.

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1/1 Octave Band Freq (Hz)	1/1 Octave Measured (dB_{SPL})	1/3 Octave Band Freq (Hz)	1/3 Octave 'interpolation' (dB_{SPL})
		200	48.5
250	**48.5**	**250**	**48.5**
		315	48.5
		400	41.1
500	**41.1**	**500**	**41.1**
		630	41.1
		800	35.3
1000	**35.3**	**1000**	**35.3**
		1250	35.3
		1600	32.7
2000	**32.7**	**2000**	**32.7**
		2500	32.7
		3150	29.1
4000	**29.1**	**4000**	**29.1**
		5000	29.1
		6300	24.7
8000	**24.7**	**8000**	**24.7**
		10000	24.7

Table 1

Logarithmic Sum of 1/1 Octave Band Values:

$$10 \times \log_{10}\left[10^{\frac{48.5}{10}} + 10^{\frac{41.1}{10}} + 10^{\frac{35.3}{10}} + 10^{\frac{32.7}{10}} + 10^{\frac{29.1}{10}} + 10^{\frac{24.7}{10}}\right] = 49.54dB$$

Logarithmic Sum of 1/3 Octave Band Values:

$$10 \times \log_{10}\left[10^{\frac{48.5}{10}} \times 3 + 10^{\frac{41.1}{10}} \times 3 + 10^{\frac{35.3}{10}} \times 3 + 10^{\frac{32.7}{10}} \times 3 + 10^{\frac{29.1}{10}} \times 3 + 10^{\frac{24.7}{10}} \times 3\right] = 54.31dB$$

The total SPL calculated from the 'interpolated' 1/3 octave band values becomes 4.77dB higher than the original.

In fact, it is necessary to subtract 4.77dB to each number in the last column in Table 1, as shown in the last column of Table 2.

Notice that although interpolation keeps total SPL the same, it cannot fully restore the 1/3 octave band details as the actual measurement.

Freq (Hz)	1/3 Octave Measured (dB_{SPL})	1/1 Octave Measured (dB_{SPL})	1/3 Octave Interpolation (dB_{SPL})
200	45.2		43.7
250	**43.1**	**48.5**	**43.7**
315	42.2		43.7
400	37.7		36.3
500	**36.4**	**41.1**	**36.3**
630	34.2		36.3
800	31.8		30.6
1000	**30**	**35.3**	**30.6**
1250	29.5		30.6
1600	28.9		28.0
2000	**27.2**	**32.7**	**28.0**
2500	27.6		28.0
3150	25.7		24.3
4000	**24.4**	**29.1**	**24.3**
5000	22.2		24.3
6300	20.2		19.9
8000	**20.1**	**24.7**	**19.9**
10000	19.3		19.9
TOTAL	**49.5**	**49.5**	**49.5**

Table 2