# Converting between Voltage or Power and dB

**Mike Steinberger**

## 1.0 Power or Voltage?

Voltage and power ratios are often expressed in decibels or dB's. The conversion between ratios and dB's is simple enough, with the hardest part being to remember whether you're working with a voltage ratio or a power ratio. The neat thing about dB's is that they're defined in such a way that regardless whether you're working with voltage or power, the number of dB's is the same.

☞ ***The important point to remember is that power is assumed to be proportional to the square of the voltage. So for power you multiply/divide by 10 and for voltage you multiply/divide by 20.***

## 2.0 Power

Suppose we have the ratio of two powers

$$P \equiv \frac{P_2}{P_1} \tag{EQ 1}$$

Then the dB's for this ratio is

$$dB \equiv 10\log(P) \tag{EQ 2}$$

and the reverse conversion is

$$P = 10^{\frac{dB}{10}} \tag{EQ 3}$$

## 3.0 Voltage

Suppose we have the ratio of two voltages

$$V \equiv \frac{V_2}{V_1} \tag{EQ 4}$$

The associated power ratio is equal to the square of the voltage ratio.

  

$$P = V^2 \quad \text{(EQ 5)}$$

Then the dB's for this ratio is

$$dB = 10\log(V^2) = 10 \cdot 2\log(V) = 20\log(V) \quad \text{(EQ 6)}$$

and the reverse conversion is

$$V = 10^{\frac{dB}{20}} \quad \text{(EQ 7)}$$

# 4.0 dB's on the Back of an Envelope

Often, it's useful to do an approximate conversion to or from dB's in order to do a sanity check on a calculation or data point. The following table contains some useful and easily applied approximations for dB power. To get the voltage ratio, take the square root of the power ratio.

**TABLE 1. dB approximations**

| dB Power | Approximate Power Ratio | Approximate Voltage Ratio | Explanation |
|---|---|---|---|
| -10 | 1/10 | $\frac{1}{\sqrt{10}} = 0.316$ | See 10dB below. |
| -9 | 1/8 | $0.354 \approx \frac{1}{\sqrt{8}}$ | See 9dB below. |
| -7 | 1/5 | $0.447 \approx \frac{1}{\sqrt{5}}$ | See 7dB below. |
| -6 | 1/4 | $0.501 \approx \frac{1}{\sqrt{4}}$ | See 6dB below. |
| -5 | 1/3 | $0.562 \approx \frac{1}{\sqrt{3}}$ | Pretty crude approximation. See 5dB below. |
| -3 | 1/2 | $0.708 \approx \frac{1}{\sqrt{2}}$ | See 3dB below. |
| -1 | 4/5 | $0.891 \approx \sqrt{\frac{4}{5}}$ | See 1dB below. |
| 0 | 1 | 1 | $\log(1) = 0$ |
| 1 | 5/4 | $1.122 \approx \sqrt{\frac{5}{4}}$ | $\left(\frac{5}{4}\right)^{10} = \frac{9765265}{1048576} \qquad \therefore \log\left(\frac{5}{4}\right) \approx 0.1$ |

  

**TABLE 1. dB approximations**

| dB Power | Approximate Power Ratio | Approximate Voltage Ratio | Explanation |
|---|---|---|---|
| 3 | 2 | $1.412 \approx \sqrt{2}$ | $2^{10} = 1024 \approx 10^3 \qquad \therefore \log(2) \approx 0.3$ |
| 5 | 3 1/6 | 1.778 | $\left(\frac{19}{6}\right)^2 = \frac{361}{36} \approx 10 \qquad \therefore \log\left(\frac{19}{6}\right) \approx 0.5$ |
| 6 | 4 | $1.995 \approx \sqrt{4}$ | $\log(4) = \log(2^2) \approx 0.6$ |
| 7 | 5 | $2.239 \approx \sqrt{5}$ | $\log(5) = \log\left(\frac{10}{2}\right) \approx 1 - 0.3 = 0.7$ |
| 9 | 8 | $2.818 \approx \sqrt{8}$ | $\log(8) = \log(2^3) = 3\log(2) \approx 0.9$ |
| 10 | 10 | $3.162 = \sqrt{10}$ | $\log(10) = 1$ |

This should make fascinating conversation at your next cocktail party.

  