Max power, RMS power, average power and other animals

In electricity, power is defined as the product of voltage and current P = VI. In DC current both quantities are constant and independent of time. For example, a bulb operating at 12 V, having a current of 0.5 A through it, consumes 12·0.5 = 6 watts of power.

In AC current power is defined as $P = V_{rms}I_{rms}$, where subscript RMS denotes the root mean square of the quantities, i.e. some kind of average value. For sinusoidal signals the RMS value is the peak value multiplied by 0.707. A power amplifier delivers power to a loudspeaker. For simplicity, let's assume that the loudspeaker is equivalent to a resistance R_L. Then the power can be calculated from either of the formulae below

$$P = \frac{V_{rms}^2}{R_L} \quad P = I_{rms}^2 R_L$$

In figure 1, the waveforms of the output voltage and output current are depicted. The peak voltage value is 40 V, therefore the average power delivered to the load can be calculated as

$$P = \frac{(0.707 \cdot 40)^2}{8} = 100W$$

We would have obtained the same result by using the RMS value of the current.

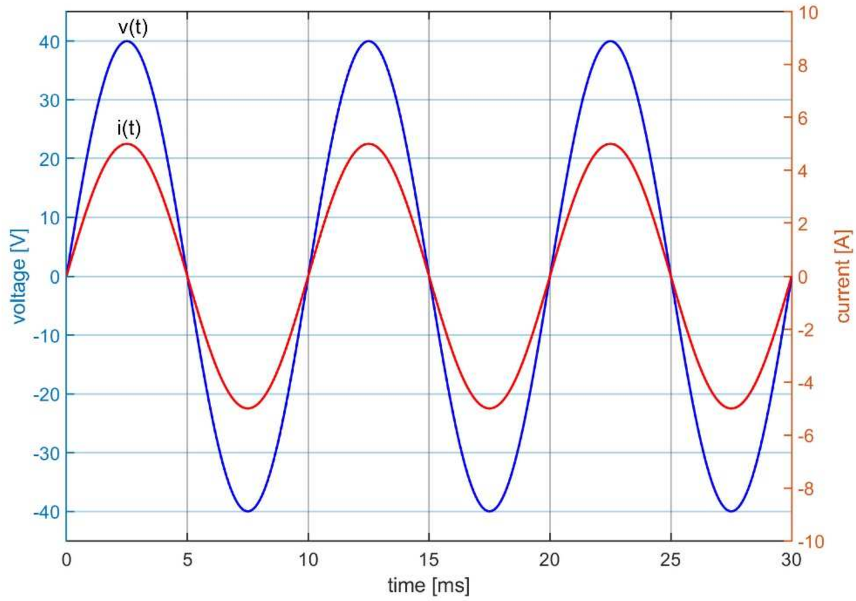

Figure 1. Voltage and current waveforms

To find the instantaneous power p(t) we multiply the two waveforms v(t) and i(t). The result is shown in figure 2. The power delivered to the load changes with time with a frequency that is twice the frequency of the voltage and current. The peak value is 200 W and the mean 100 W. While the voltage and current may take both positive and negative values, the power is strictly positive. The convention is that when the power is positive then it is consumed by the load. Negative power means that the loudspeaker sends power back to the amplifier. How is this possible? It is possible because the loudspeaker stores energy in the electrical components (inductors and capacitors) and also in the components having mass. Of course, for most of the time the power travels from the amplifier to the speaker otherwise we would have net energy production from a passive device.

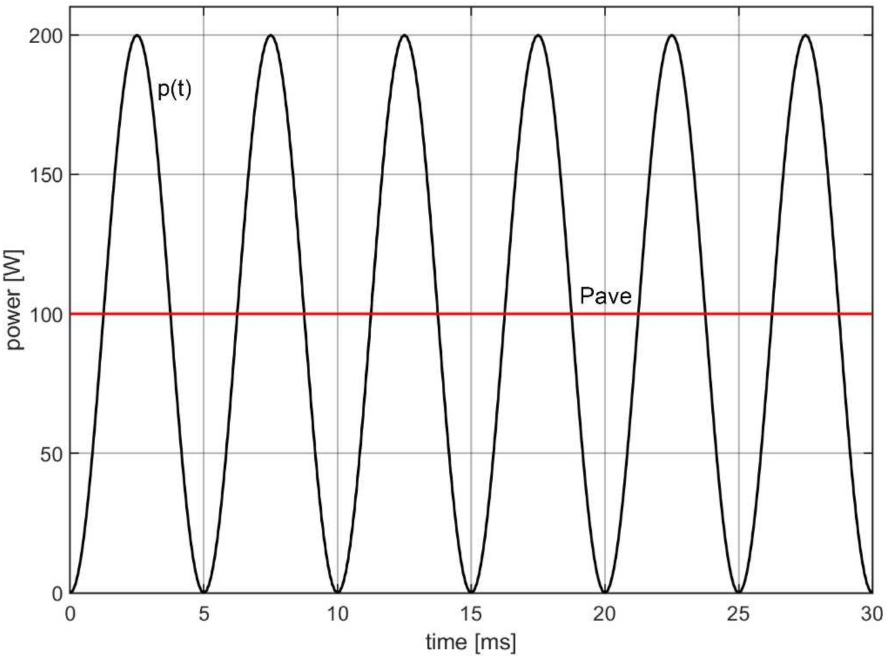

Figure 2. Instantaneous and average power

So far, we have assumed that the speaker is identical to a resistor. Let's see what happens in the real world, where the amplifier is fed with music (a typical pop song) and drives a two-way loudspeaker with 8 ohm nominal impedance. In figure 3 we see the power delivered to the speaker. Most of the time it is positive (power flows from the amplifier to the speaker), but there are short periods of time where the power is negative (it flows from the speaker to the amplifier). The maximum power is over 50 W, however the average value is only 2.75 W. This means that while the average sound pressure level is only 85 dB the peaks are close to 97dB.

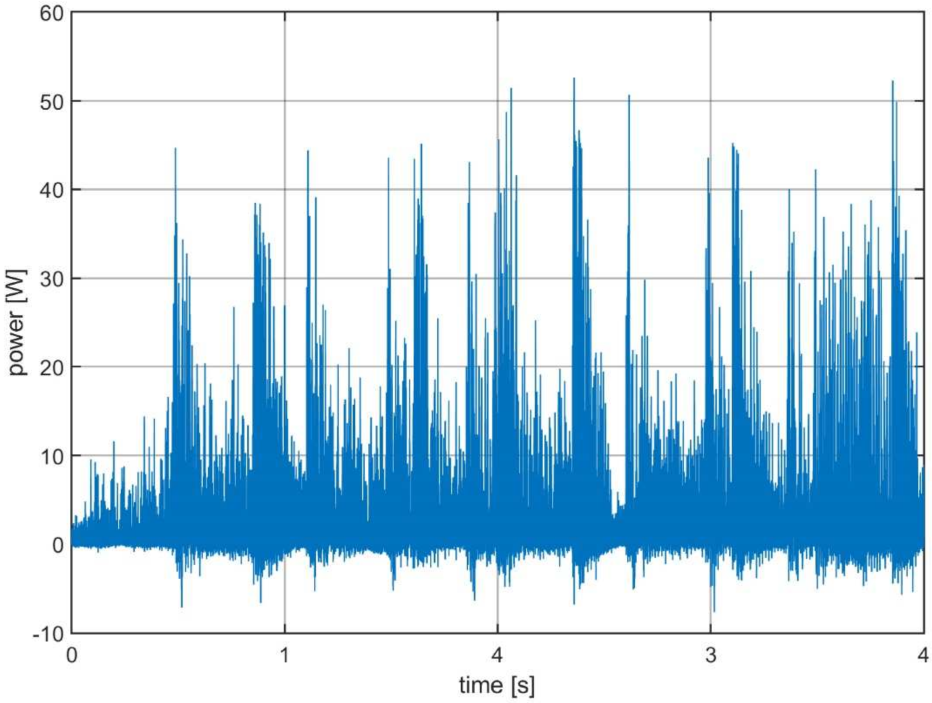

Figure 3. The instantaneous power delivered by a power to a loudspeaker with 8 ohm nominal impedance. The input is typical popular music

In conclusion, the right technical term for power is average power. RMS power or peak power sometimes used in specs are meaningless. The manufacturers specify the maximum average power that an amplifier can deliver to a certain load noting the value of THD. For example, an amplifier produces 75 W at 8 ohms with a THD that is less than 1%. Halving the load would theoretically double the power. In practice, this does not happen due to the limitations set by the power supply and the output stage of the amplifier. Whether an amplifier doubles its power for half load is therefore a measure of the robustness of the power supply and the capability of the output stage to supply the required current.

I hope I dispelled some myths surrounding the issue of power in amplifiers. Power may not be directly related to fidelity, but depending on the speakers and the room, a minimum amount of power is required to do some listening at realistic levels. Some people buy a compressor or limiter thinking they bought an amplifier.

For Echo Diastasis

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