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How to choose the gain of your amplifier?

(Suitable for AUD4990, AUD4886, AUD4992 and AUD4988)

By Louis Cheung

How loud can you hear?

The human ear detects sound from pressure instantaneously generated by a sound wave as it travels through a medium (air, liquid or solid). These pressure changes caused by the sound wave are called sound pressure, and can be measured in pascals (Pa).

Sound pressure level (SPL) or sound level is a logarithmic measure of the root mean square (rms) sound pressure of a sound, relative to a reference value. It is measured in decibels (dB). Sometimes variants are used such as dB (SPL), or dBSPL.

SPL = $20\log_{10}\left(\frac{P_{rms}}{P_o}\right)$ dB, P_o is the reference sound pressure and P_{rms} is the rms sound pressure being measured.

Amplifier output loudness

However, amplifier output is an electrical signal that needs a medium to convert electrical energy to sound pressure. The medium is usually a loudspeaker. We use speaker sensitivity to indicate how electrical energy is converted to sound pressure.

Sensitivity is the sound pressure level produced by a loudspeaker, usually specified in dB, measured at 1 meter with an input of 1 watt or 2.83 volts (8ohm), typically at one or more specified frequencies.

Typical home loudspeakers have sensitivities of about 85 to 95dB for 1W @ 1m. The higher the sensitivity, the greater the loudness you can hear from the same electrical output.

The amplifier output power

Usually, we use the output power to define the loudness of the amplifier. However, there are three points that need to be considered:

1) The sensitivity of the connected loudspeaker
2) The output power measurement of the amplifier
3) The input voltage and the amplifier gain

For loudspeakers, the higher the sensitivity, the louder the sound. The impedance of the speakers also affects the output power.

Generally, the amplifier output power is measured as below:

Output power: $P_{rms} = \left(\frac{V_{rms}^{\ 2}}{R_L} \right)$

V_{rms} is the voltage measured in the speaker. R_L is the loudspeaker impedance (loading), typically 4ohm or 8ohm.

Using AUD4992 as an example:
For 1kHz sine wave with 1% THD+N, the output power is 1.3W in 8ohm loading
For 1kHz sine wave with 1% THD+N, the output power is 2W in 4ohm loading

For the voltage signal, generally, 1kHz sinusoid waveform will be used for the amplifier testing. Also, the THD+N will be considered since that will be trade-off of the output power.

Using AUD4992 as an example:
For 1kHz sine wave with 8 ohm loading, the output power in 1% THD+N is 1.3W
For 1kHz sine wave with 8 ohm loading, the output power in 10% THD+N is 1.6W

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The graph of THD+N against the output power of AUD4992 as below:

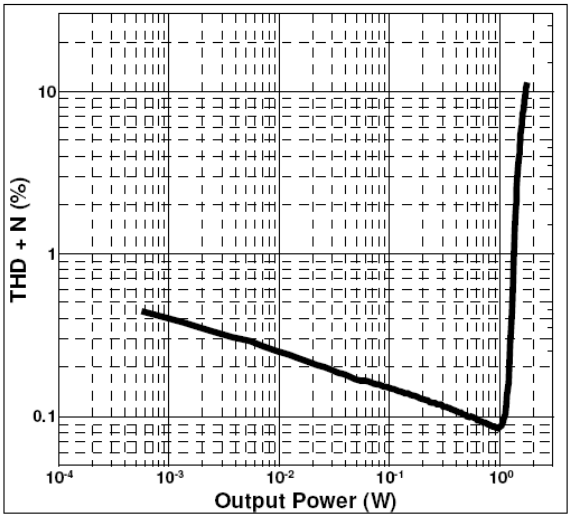

Figure 2 THD + N vs Output Power

From the graph, the best THD+N should be at around 1W output in 8ohm loading. The sound quality will be degraded (higher THD+N) when the output is set at beyond 1.3W in 8ohm loading.

How to choose the gain of the amplifier?

Using AUD4992 as example:
For the general line output, the voltage level is around 0.7V_{rms}. So, the target design of the amplifier with the best sound quality (THD+N at around 1%) in 1.3W output and 8ohm speaker is:

The average output power: $P_{rms} = \left(\frac{V_{rms}^{\ 2}}{R_L}\right) = \left(\frac{V_{rms}^{\ 2}}{8}\right)$ = 1.3W

Output voltage: $V_{rms} = \sqrt{8x1.3}$ = 3.225V_{rms}

Gain of the amplifier: $\frac{V_{out}}{V_{in}}$ = 3.225 / 0.7 = 4.6

Choose the gain of 4 instead of 4.6 to maintain optimum quality, even when the input signal is greater than 0.7V_{rms}.

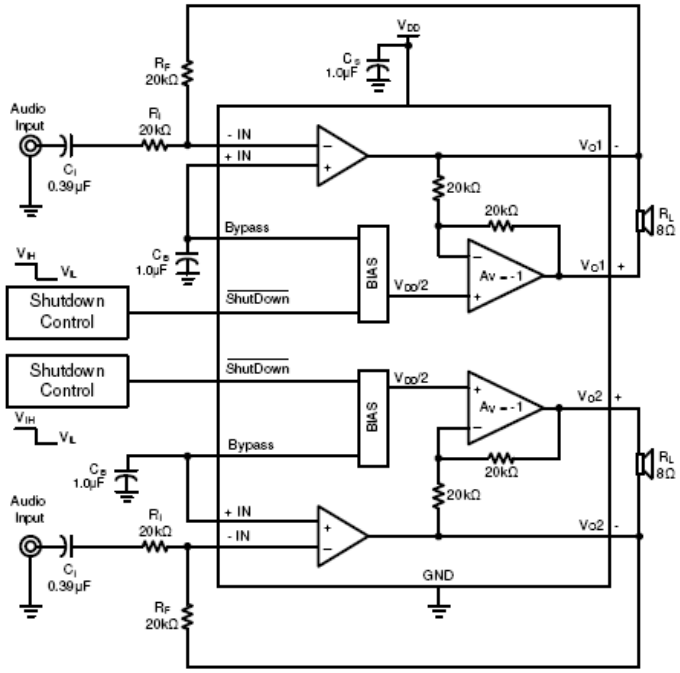

Figure 1 Audio Power Amplifier with A_V = 2

Since AUD4992 is BTL output, the output gain will be two times already, so the setting of R_F and R_I should be equal to 2 in order to give overall gain = 4.

$$\frac{R_F}{R_I} = \frac{20k\Omega}{10k\Omega} = 2$$

So, the R_F = 20kohm and R_I = 10kohm

The same applies if the target design is 10% THD, in 8ohm loading. Power output = 1.6W

Output Voltage = 3.577V_{rms} and the overall gain = 5
Since BTL have 2 times gain, the resisters pair should be 2.5 times

So, the R_F = 25kohm and R_I = 10kohm

Note: AUD4988 built in the gain network with preset gain at (Av=2, 2.8, 4, 5.6 and 8).

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Revision History

Version	Modify Date	Description	Modified By	Release Date
1.0	7-Jan-08	Initial	Louis Cheung	

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