Quality measures of audio amplifiers

The objective of an audio amplifier is to reproduce audio signals at sound-producing output elements with desired volume and power levels, faithfully, efficiently, and at low distortion.

Frequency response

Audio frequencies range from about 20Hz to 20kHz, so amplifier must have a good frequency response over this range.[1]

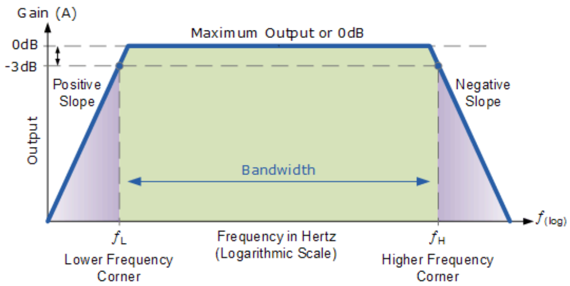

TABLE 2. FREQUENCY RESPONSE EXAMPLES

AUDIO APPLICATION	FREQUENCY RESPONSE
Plain Old Telephone System or POTS	300Hz to 3kHz
AM Radio	100Hz to 5kHz
FM Radio	50Hz to 15kHz
Consumer Stereo System	20Hz to 20kHz
Professional Audio Equipment	5Hz to 24kHz

[4]

Gain

As we can see in the frequency response curve, the gain is another important factor to estimate the quality of an audio amplifier. We can express the power gains as:

$$G(dB)=20\log_{10}\left(\frac{Vout}{Vin}\right)$$

Vout and Vin represents the output voltage and the input voltage in an audio amplifier respectively.

And we can express the power gain as:

$$G(dB)=10\log_{10}\left(\frac{Pout}{Pin}\right)$$

Pout and Pin represents the output power and the input power in an audio amplifier respectively.

SNR (Signal-to-Noise ratio)

To measure the quality of audio sequences, we can use the information obtained measuring the Signal to Noise ratio. A low SNR means a noisy signal while a high ratio indicates a clear audio signal.

The estimation of SNR, expressed in dB, is calculated as:

$$qs=SNR=10\log_{10}\left(\frac{Espeech}{Enoise}\right)$$

Enoise and Espeech represent the average energy over all the frames of the audio sequence detected as noise and speech respectively.

TABLE 1. SNR EXAMPLES

AUDIO APPLICATION	SNR (DB)
Plain Old Telephone System or POTS	40
AM Radio, LP Records	50
FM Radio, Cassettes	70
CD Player	90
Human Ear Range (Instantaneous)	85
HiFi Studio Recording Equipment	120
Human Ear range (Total)	120

[4]

Switch-mode (class D) amplifiers are most efficiently than linear mode amplifiers. Switch – mode amplifiers often include an output LC low pass filter to prevent power from being wasted.
When we want to make measurements we have to use an external filter because we cannot connect an audio analyzer directly to an audio amplifier.

THD+N

An other type of measurement is THD+N (Total Harmonic Distortion and Noise) which is a very useful method because it captures so many common forms of imperfection. The amplifier under test is driven with an ultra low distortion sine wave, typically 1kHz. The output of the amplifier is connected to a test load and audio analyzer that contains a notch filter to remove the sine wave signal.[3]

$$\mathrm{THD+N} = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \ldots + V_n^2 + V_{noise}^2}}{V_s}$$

$$\mathrm{THD} = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \ldots + V_n^2}}{V_s}$$

V_s = Signal Amplitude (RMS Volts)
V_2 = Second Harmonic Amplitude (RMS Volts)
V_n = nth Harmonic Amplitude (RMS Volts)
V_{noise} = RMS value of noise over measurement bandwidth

To improve the results obtained using THD+N, we use FFT to analyze the harmonic distortion. We can identify the distortion as harmonic or non-harmonic.[3]

The most common technique is to perform the FFT on the input signal directly. The spectrum is easy to interpret but it will be limited by the -100 dB to -110 dB residual distortion performance of the analyzer's A/D converter.[3]

To conclude, I put an example of an audio amplifier class D specifications:

Electrical Specifications

Specifications typical @ +25℃,Powered by 24V DC, unless otherwise noted. Specifications subject to change without notice.

Parameter	Conditions	Min.	Typ.	Max.	Units
Power Supply	-	12	24	36	VDC
Idle Power	SD Floating, FAN ON	-	14.8	20	W
	SD Floating, FAN OFF	-	11.5	15	W
Standby Power	SD Connected to GND, FAN ON	-	6.8	10	W
Maximum Current	100W @ 4Ohm	-	18.9	-	A
Efficiency	100W @ 4Ohm	82	-	88	%
Minimum Load Impedance	-		-	-	Ω
Switching Frequency	SD Floating	-	700	-	KHz
Fan Active @ Temperature	-	-	-	-	℃

Audio Performance

Specifications typical @ +25℃,Powered by 24V DC, unless otherwise noted. Specifications subject to change without notice.

Parameter	Conditions	Min.	Typ.	Max.	Units
Gain	-	30	32	34	dB
Input Sensitivity(RMS)	@4Ω,100W,1KHz	-	4.83	-	V
Input Impedance	-	-	10	-	KΩ
Output Power	@4Ω THD+N 1%	-	89	-	W
	@4Ω THD+N 10%	--	100	-	W
Bandwidth @ ±3dB	@4Ω	20	-	20K	Hz
THD	@4Ω, 1W, 1KHz	-	0.0273	-	%
	@4Ω, 10W, 1KHz	-	0.0743	-	%
Output Noise Level	A-weighting,Input Connected to GND	-	326.44	-	μV
SNR	89W @4Ω THD+N 1%	-	77.78	-	dB

References:

[1] GAALAAS, Eric. Class D audio amplifiers: What, why, and how. *Analog Dialogue*, 2006, vol. 40, no 6, p. 1-7.

[2] BENDRIS, Meriem; CHARLET, Delphine; CHOLLET, Gerard. Introduction of quality measures in audio-visual identity verification. En *2009 IEEE International Conference on Acoustics, Speech and Signal Processing*. IEEE, 2009. p. 1913-1916.

[3] HOFER, Bruce. Measuring switch-mode power amplifiers. *Beaverton: Audio Precision*, 2003.

[4] AUDE, Arlo J. Audio quality measurement primer. *AN9789*, 1998.