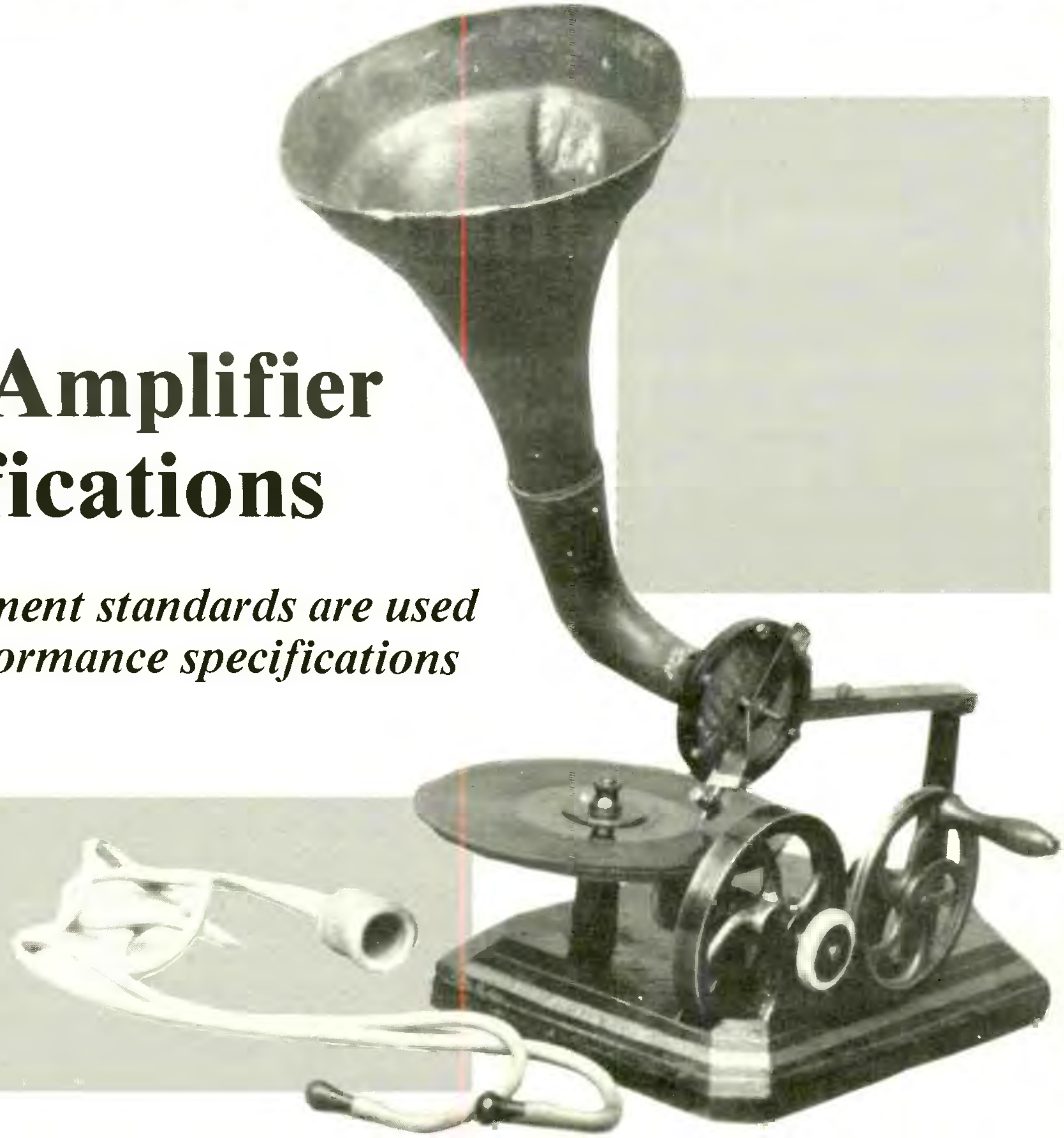
Audio Amplifier Specifications



How measurement standards are used to obtain performance specifications

By Leonard Feldman

If you went shopping for an audio amplifier back in the early 1970s, chances are you were faced with an array of performance claims. The most confusing of these was the likely power specification. At that time, it was possible that one manufacturer's amplifier, rated at 10 watts per channel, was able to deliver as much musical sound power as another amplifier rated at 20 watts, 50 watts, or even "100 watts peak instantaneous power."

Of course, this didn't make things easy for the typical consumer. As more and more manufacturers figured out new ways to exaggerate their amplifiers' power claims, the dedicated high fidelity component manufacturers attempted, in vain, to standardize the test methods whereby power of an amplifier should be specified. Though they met with some success, it took Uncle Sam, in the guise of the Federal Trade Commission, to finally end the chaotic state of amplifier power reporting.

In 1974, the FTC issued its Rule, entitled Power Output Claims for Amplifiers Utilized in Home Entertainment Products. Suddenly, amplifiers that had been rated at all sorts of incredibly high power levels were tamed and their power specification became more realistic. In 1975, the Institute of High Fidelity (now a division of the Electronic Industries Association) undertook the task of writing a more comprehensive set of measurement standards for audio amplifiers. Although the efforts of the FTC were certainly recognized and appreciated, the IHF knew that there was much more to specifying the performance of an amplifier than just telling how much power it was able to deliver. The standard was completed in 1978, and in 1981 it was adopted as an interim Standard by the EIA. Since then, it has become a permanent EIA Standard. Though essentially a U.S. measurement standard, manufacturers around the world who want to sell their products in the U.S. often utilize this standard and continue to refer to it as the IHF Amplifier Standard.

Mandatory Specifications

Any manufacturer who wants to conform to the EIA Amplifier Measurement Standard must measure and publish at least five specifications for a basic power amplifier. For integrated amplifiers (those containing both preamplifier and power amplifier sections), seven specifications must be listed, while for separate preamplifier units, a total of seven "specs" must be measured and listed. Several of the specifications that apply to power amplifiers also apply to integrated amplifiers and to preamplifiers, as you will see. The five basic power amplifier specs you should look for when considering the purchase of a base audio amplifier are: "Continuous Average Power Output," "Dynamic Headroom," "Frequency Response," "Sensitivity" and "A-weighted Signal-to-Noise Radio." Let's take a look at these first.

Continuous Average Power Output

This specification parallels requirements of the FCC rule. It is the number of watts that an amplifier can deliver to a specified load impedance, over a specified bandwidth, at no more than a rated value of harmonic distortion. Using a continuous sine-wave tone, the amplifier has to be able to deliver the rated power for at least five minutes. A typical legal continuous power rating might read:

Power Output: 50 watts continuous average power per channel, 8-ohm loads, from 20 Hz to 20 kHz, with no more than 0.1% total harmonic distortion.

This single statement imparts a great deal of information and prevents many of the deceptions that were common before the rule was promulgated. Notice that the statement includes the words "per channel." That's because in the old days, some manufacturers had the habit of doubling the power rating of an amplifier. The argument they put forth was that since the amplifier was a stereo unit, the power outputs of both channels should be added together. Of course, the more scrupulous manufacturers who were careful to specify power on a per-channel basis were at a distinct disadvantage.

Specifying the load impedance is important, too, since most solid-state amplifiers deliver greater power at lower impedances than they do at higher impedances, such as 8 ohms or 16 ohms. Thus, a manufacturer who wanted to come up with the highest number of watts possible would measure the power using 4-ohm loads. There's nothing wrong with that, so long as the 4-ohm load is specified. The knowledgeable consumer will then realize that if he or she uses 8-ohm speakers, the power rating will be less.

It's also a fact that amplifiers have an easier time delivering their maximum power at middle audio frequencies than they do when attempting to reproduce very low bass or very high treble frequencies. So, the manufacturer measures power only at 1 kHz. For example, the rating might be considerably higher than if the measurement were made at 20 Hz or 20 kHz. Now that manufacturers have to specify the range of frequencies at which the product will deliver its rated power, the user can easily figure out that a 50-watt amplifier with a specified bandwidth from 20 Hz to 20 kHz is preferable to another 50-watt amplifier with a specified bandwidth from 100 Hz to 10 kHz.

Another way in which some manufacturers were able to inflate their power figures years ago was by failing to publish the distortion level at which the power was being delivered. Obviously, if an amplifier can deliver 50 watts at less than 1% total harmonic distortion, if you "push" the amplifier a little harder, it might well deliver 55 watts, 60 watts or even more at, say, 10% total harmonic distortion. Requiring that the distortion figure be published along with the power figure makes it easy to judge between amplifiers of similar power ratings but differing distortion ratings at that power level.

Dynamic Headroom

While the FTC rule standardized the way in which all manufacturers measured *continuous* or sine-wave power, it's obvious that most people don't listen to sine waves or continuous tones. It's not as obvious, but true nevertheless, that when an amplifier is called upon to reproduce musical waveforms, it can usually deliver somewhat more power than it can when it is fed with continuous test tones.

The standards committee felt that the ability of an amplifier to deliver more than its rated power under actual use conditions was useful information to prospective purchasers. However, they didn't want to confuse the issue with a second power spec, given in watts per channel. That sort of thing is what caused the confusion over power before the FTC rule was issued. So they created a term known as Dynamic Headroom, and it's quoted in decibels or dB. They also devised a special standard test signal designed to approximate what happens when an amplifier is handling musical signals. The test signal, shown in the 'scope photo of Fig. 1, consists of 20 alternations of a 1-kHz signal at full amplitude, followed by 480 alternations of the same

1-kHz signal. Total duration of the signal is 500 milliseconds, so that the signal has a repetition rate of twice per second.

To measure Dynamic Headroom, we first apply a steady-state 1-kHz signal to the amplifier, increasing its amplitude until the rated continuous power output is reached. An oscilloscope is calibrated to that amplitude. Next, the special test signal is applied and the output of the amplifier is increased until there is obvious clipping of the higher-amplitude (20-alternation) section of the special signal. That amplitude is compared with the earlier-calibrated amplitude of the steady-state signal and the resulting ratio is expressed in dB. For example, if the steady-state signal was set up as four divisions on the 'scope face and the peak amplitude of the special test signal was 5 divisions at clipping, the ratio 5/4, expressed in dB, turns out to be 1.94 dB. The Dynamic Headroom that would therefore be listed would be 1.94 dB.

How much Dynamic Headroom and amplifier has depends primarily on how its power supply is designed. A high level of Dynamic Headroom is not necessarily a measure of quality. Rather, it simply tells the user that, under musical conditions, the amplifier is likely to "sound" louder, or is able to handle shorter peaks without overloading the amplifier.

Frequency Response

Frequency response of an amplifier is measured in much the same way it is for any other audio component. In the case of power amplifiers, the frequency response is measured over the rated bandwidth of the amplifier and is expressed as a deviation, in dB, using 1 kHz as the 0-dB reference point. A typical statement of frequency response for an amplifier might read:

Frequency Response: 20 Hz to 20,000 Hz, ±0.5 dB.

More often than not, the manufacturer will specify frequency response

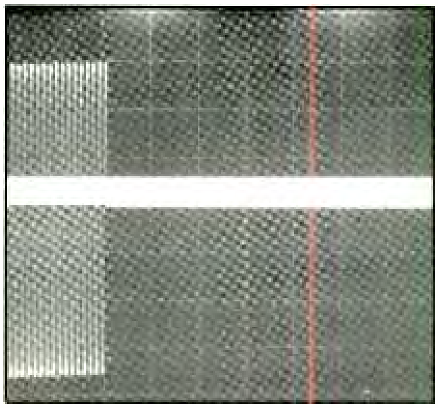


Fig. 1. A special test signal used to measure Dynamic Headroom of an audio amplifier is displayed.

by means of a continuous curve or graph. The "smoother" the frequency response curve of the amplifier the better. Some manufacturers measure frequency response at low power output levels—usually 1 watt per channel. Under those conditions, most amplifiers will have extended response to well beyond their power bandwidth. For example, an amplifier whose power bandwidth is stated as from 20 Hz to 20 kHz (for full power output), may well have a frequency response (at a lower power level) that extends from well below audible frequency limits (e.g., 5 Hz) to way beyond the audio frequency range (e.g., 100 kHz or even higher).

Sensitivity

You would think that a simple specification that is designed to tell you how much input you need to apply to an amplifier to get a given amount of output would not lead to ambiguities, but that was not the case in the early days of high-fidelity. Manufacturers then (and, to some degree, even now) insisted upon quoting input sensitivities for full rated output instead of for an agreed-to standardized level. Here's an example of the confusion that resulted.

Suppose a 100-watt amplifier had a sensitivity rating of 1 volt for *rated output,* while another, 10-watt amplifier, also had a sensitivity rating (for its full output) of 1 volt. If you were to feed a one volt signal into each amplifier would they produce the same level of sound? Of course not! The 10-watt amplifier would not sound nearly as loud as the 100-watt amplifier, yet each has a "sensitivity" of "1 volt." To prevent this kind of misunderstanding, the standard measurement method requires that input sensitivity be given as the number of volts or millvolts needed to produce 1 watt of output, regardless of the full power rating of the amplifier or integrated amplifier. In the case of separate preamplifiers, the standardized sensitivity rating is that amount of input which will produce 0.5 volt at the output.

A-Weighted Signal-to-Noise Ratio

Statements of signal-to-noise ratio can be equally meaningless unless everyone quotes S/N in the same way—that is, referred to a given input and referenced to a standard output. If manufacturers insist upon quoting S/N with respect to maximum rated output, as some still continue to do, in order to come up with higher dB numbers, here's an example of what can happen.

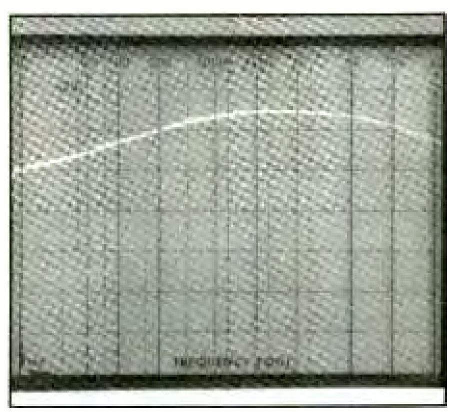


Fig. 2. An A-weighting network has its frequency response shown in this spectrum-analyzer sweep. The vertical scale is 10-dB per division while sweep is from 20 Hz to 20 kHz.

Let's consider the same two amplifiers again; one rated at 10 watts the other at 100 watts per channel. Suppose both manufacturers decide to quote S/N with respect to rated output and that each lists the signal-to-noise ratio as 90 dB. For the 10-watt amplifier, the residual noise will be 90 dB below 10 watts, or 0.01 microwatt, while for the 100-watt amplifiers, the hum and noise would amount to 0.1 microwatt or fully ten times as much. Additionally, the input sensitivity of the amplifiers may be different and this would further confuse the issue.

The EIA Amplifier Measurement Standard requires that all S/N measurements be made with respect to an output of 1 watt (or 0.5 volt, for separate preamplifiers). In addition, gain controls on the amplifier should be set so that an input of 0.5 volt applied to a high-level input of the amplifier (such as "Tuner" or "Aux" in the case of integrated amplifiers or preamplifiers) produces that standard 1 watt (or 0.5 volts for preamps) output. S/N numbers are then referred to those levels of input and output. To be sure, the numbers usually come out smaller, but at least we are comparing figures in a meaningful way.

As for the "A-weighting" part of the measurement, that refers to a system of giving heavier weighting to those noise frequencies which have been found to be most audible and most objectionable by human listeners. An A-weighting filter, inserted in the measurement path, has its own distinctive response curve, as shown in Fig. 2. Full weight is given to frequencies in the vicinity of 2 kHz, while extreme low frequencies and extreme high frequencies contribute less to the final overall signal-to-noise reading.

Additional Integrated-Amplifier Measurements

Since integrated amplifiers are nothing more than preamplifiers combined with power amplifiers, the five specifications we have discussed so far apply to these combination amplifiers as well. In addition, two more specifications need to be disclosed for integrated amplifiers. These are "Maximum Input Signal" and "Input Impedance." Both of these specifications are not required to provide the user with a measure of quality, but rather to facilitate proper matching of other components to the integrated amplifier.

For example, if the maximum input voltage is an "Auxiliary" input on an amplifier is only 1.5 volts (before overload of the input stage), that input may not be suitable for use with modern Compact Disc players, which deliver 2.0 volts or more when reproducing peak digitally recorded levels. Similarly, the input impedance of the high-level inputs of an integrated amplifier's various inputs should generally be much higher than the output impedance of the program source connected to them. On the other hand, the input impedance of magnetic phono inputs should match the requirements (usually around 47k ohms) of the cartridge used.

Additional Preamplifier Measurements

For separate preamplifiers, a manufacturer must measure and publish a couple of extra specifications as well. Since a preamplifier is not governed by the "FTC Power Rule," the manufacturer is required to state the rated harmonic distortion level of the preamplifier. (Normally, the THD figure would have been part of the rated power disclosure in an amplifier or integrated amplifier.)

Another required specification is "Maximum Output Voltage." The reasoning here is much like that for the "Maximum Input Voltage" specification applied to integrated amplifiers. It needs to be stated so that outputs of preamplifiers can be properly matched to inputs of integrated amplifiers or power amplifiers. In addition to these extra specifications, a manufacturer of a separate preamplifier is expected to provide specifications for frequency response, sensitivity, and A-weighted signal-to-noise ratios, as previously described.

Secondary Disclosures

The specifications discussed so far are all mandatory for those manufacturers who want to say that they are following the EIA measurement standard. In addition to these few required disclosures, however, there are some 21 secondary disclosures, any or all of which a manufacturer may publish if he wishes to. Space does not permit a full description of what each of these specifications is all about and how each is measured. In many cases, the titles of the specifications themselves tell you what they are about. The full list of secondary specifications follows:

Clipping Headroom, Output Impedance, Wideband Damping Factor, Low Frequency Damping Factor, CCIR/ARM Signal-to-Noise Ratio, Tone-Control Response, Filter Cutoff Frequency, Filter Slope, Crosstalk, A-Weighted Crosstalk, CCIR/ARM Crosstalk, SMPTE Intermodulation Distortion, IHF Intermodulation Distortion, Transient Overload Recovery Time, Slew Factor, Reactive Load, Capacitive Load, Separation, Difference of Frequency Response, Gain-Tracking Error, and Tone Control Tracking Error.

If you are interested in exploring the details of these additional specifications, you may want to obtain a complete copy of the EIA Amplifier Measurements Standard. Its number is RS-490 and it's dated November, 1981. The EIA offices are located at 2001 Eye Street, N.W., Washington, DC 20006 and the direct phone number to the Engineering Department of EIA is 202-457-4975. ME