

How to write (and read) audio specifications

an Audio Precision White Paper by David Mathew
ap.com

Introduction

At Audio Precision, the analyzers we make are recognized around the world as the standard in audio test and measurement. Specifications, then, are very important to us. Engineers use our equipment to compose their own specifications for the audio devices they design. They use our equipment to verify that their manufacturing processes are correct, and that their products meet the goals they have set. They use our equipment to characterize their products' competitive advantages, and they publish the specifications they derive as advertising bullet points. So we are very careful in how we spec our own analyzers, and we have developed some strong opinions about how spec'ing ought to be done.

Specifications are necessary for every manufacturer, for every product. Internal engineering specs define the product and provide benchmarks for manufacturing quality assurance. Published specifications, usually less complete and rigorous than the engineering specs, inform the user of the device's capabilities and limitations with the goal of safe and proper operation.

Of course, a published spec is also a powerful sales tool for an audio device. What we read in an advertisement or even a data sheet might be, well, *shaded* a bit, in an attempt to place a device in an attractive position without actually lying. This tension between truth and marketing is especially evident in audio products targeted toward home entertainment use, as ordinary consumers are typically less informed than audio engineers, and less adept at interpreting arcane lists of numbers.

In the professional and commercial audio fields, the tendency to use dubious power output ratings is certainly much lower than in the consumer goods sector; but a cursory sampling of pro audio, industrial audio and communications audio product specifications reveals incompleteness, inconsistency and just plain sloppiness, both in which specs are chosen and how they are expressed.

About this document

This document discusses how to write audio specifications, and how to read them.

- First, a look at our recommendations for writing specifications.
- What should good specifications look like?
- What are typical values?
- Appendix: audio standards.
- Appendix: THD and THD+N.
- Glossary: explanations of some of the measurements, standards and units found in audio specifications.

Recommendations for writing specifications

We consider these guidelines as we write our own specifications, and think about them when we read specifications from other manufacturers. Each of these recommendations is discussed in more detail following.

1. Decide which characteristics are important.
2. Use the "best practice" method of measurement. If a standard applies, use the standard's recommendation.
3. Spec conservatively.
4. State ranges and conditions; annotate when more detail is required.
5. Express in standard units. Display secondary units if applicable.
6. Express graphically (x-y, polar, waterfall, etc.) when appropriate.
7. Use uniform units, formatting, and numerical expressions throughout the product line.

Decide which characteristics are important.

Many comments can be made about any audio device. But which characteristics are really telling in describing a device's key features, its performance, its compliance with industry standards or safety regulations?

Key features: interesting, but not performance benchmarks

The number of inputs and outputs, their nominal levels and connector types, the signal processing and codecs available, the controls and displays are often included in a list of specifications. So are application-specific details like constant voltage outputs or IR remote compatibility, market-specific features such as the type of mains connector and mains voltage range. Physical characteristics such as size and weight, environmental limits and safety regulation compliance often make the list as well. These are important in choosing a feature set, but they don't indicate actual performance levels of the device.

Performance specifications

The details of an audio device's tested performance are the heart of a set of specifications. These are the numbers that are weighed for bragging rights, for market position, and ultimately, for a sale.

In general, the results of four categories of measurements form the core of audio performance specifications for any audio device:

1. Level, as volts (V), watts (W), or sound pressure level (SPL).
2. Frequency Response, as a statement or a graph; or at least, Frequency Range.
3. Distortion, as total harmonic distortion (THD), total harmonic distortion plus noise (THD+N), and intermodulation distortion (IMD) of various flavors.
4. Noise, as an absolute voltage, as signal-to-noise ratio (SNR), or as dynamic range.

These will be expressed differently for different classes of device or applications, but they should always be in the specifications in one form or another. For multichannel

devices you'll also see separation, crosstalk, and interchannel phase. Balanced devices may spec common mode rejection, and devices with mechanical drives will show "wow and flutter" figures.

Please refer to the glossary for explanations of measurements, standards and units of measurement.

Measure according to standard or best practice.

If a standard or regulation exists for a measurement, use its recommendation and indicate which standard you used. If not, most measurements have a "best practice" method. For unusual testing methods or characteristics new to the industry, consult the current literature and clearly state your method, testing conditions and so on.

The role of standards

Some measurements are complicated and difficult to perform correctly. Other measurement techniques, or their reporting, may be disputed in the industry or can be manipulated in the service of marketing. Clearly, standardization of measurement methods and reporting benefit both the manufacturer and the customer by provide a standard reference.

Standards are revised and even withdrawn and replaced from time to time. Spec using the latest standard that is appropriate.

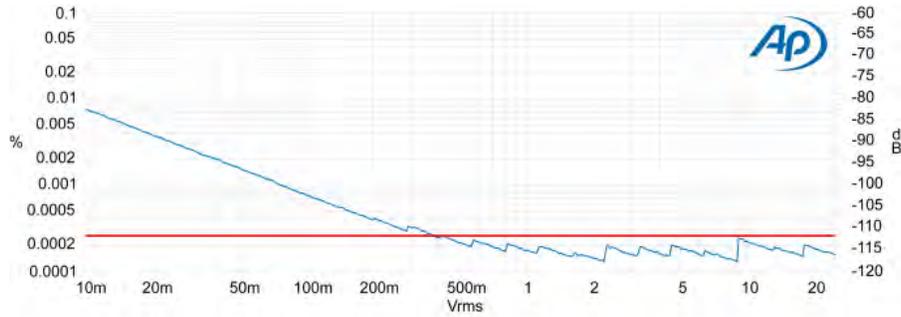
Refer to the Audio Standards appendix for more information.

Spec conservatively.

Establish that the measurement used for a spec is not a "best result" of a "golden unit" but is typical of the device, achievable by any properly adjusted unit.

It's always possible to tweak a device (by carefully selecting components, for example) so that it will surpass the typical performance of the devices. Do not use such results for specifications.

It is also possible to find a "sweet spot" in a characteristic, and report that as a performance specification. That is misleading, even if the specification specifically mentions the sweet spot.



For example, the graph above shows the residual THD+N versus amplitude for one of our analyzer systems. For audio analyzers, this is a key specification, one we would like to tout.

We claim ≤ -112 dB residual THD+N in a 22 kHz bandwidth. You can see that for most amplitudes above 400 mV the THD+N is well below this. If you are working at a 2 V amplitude, it is about -116 dB. We find, at least in our end of the business, that it is important not to mislead our customers.

(The sharp inflections in the trace are artifacts of switching between ranging circuits; the rise at the left is the inevitable approach of the noise floor.)

State ranges and conditions.

Stating ranges and conditions is absolutely essential. Many specifications mean nothing if these parameters are not provided. Yet, most manufactures do not include this information in their specifications, or what they do include is incomplete. Are they saving ink?

Every level measurement is made at some frequency or range of frequencies. Every frequency measurement is made at some level or range of levels. Be very clear as to the level and frequency of the stimulus signal, and to the level range, bandwidth and filtering in the analyzer.

External conditions and device configuration conditions, too, will affect device performance. What is the mains voltage? The ambient temperature? Is the device volume control set to low, medium or high? Are all channels being driven, or only the channel being measured?

If there isn't room for the conditions in the brochure, there certainly is in the data sheet. Annotate specifications when more detail is required. Use footnotes or endnotes.

Here is an egregious but not uncommon example: An expensive audiophile amplifier states its THD+N this way:

“THD+Noise <1%”

What does that mean? There is no level or bandpass filtering mentioned. It's like saying “I'm taller.” THAN WHAT?

The table below shows the THD+N results for one channel of a home theater receiver, made under varying conditions. Rated power (100 %) is 94 W into 4 Ω .

Note: the lower power unfiltered readings are high primarily due to the hum and noise component (N).

It's clear that THD+N stated with no conditions is meaningless.

THD+N	Bandwidth Filter	A-weighting	Power	Stimulus Frequency
0.65 %	no	no	100 %	1 kHz
1.85 %	no	no	10 %	1 kHz
1.92 %	no	no	10 %	10 kHz
1.06 %	no	no	10 %	100 Hz
5.66 %	no	no	1 %	1 kHz
0.25 %	yes	no	100 %	1 kHz
0.01 %	yes	no	10 %	1 kHz
0.02 %	yes	no	1 %	1 kHz
0.26 %	no	yes	100 %	1 kHz
0.01 %	no	yes	10 %	1 kHz
0.01 %	no	yes	1 %	1 kHz

Express results using standard units. Do not mix units.

Here is one of the biggest problems in interpreting specifications: simply decoding the units chosen for the specification, and comparing them to a similar specification stated in different units. One unit claims THD+N at -81 dB. Another touts a mere 0.0089% THD+N. Which has lower distortion and noise? (In this case, they are the same.)

Audio levels, for example, can be expressed in pascals, volts, watts or fractions of full scale. These can be in absolute terms such as average, peak, peak-to-peak, rms, and so on; or, they can be in the relative terms of decibels or percent; on top of all that, a relative measurement can be related to one of a number of constants, or to a previous measurement in the same test.

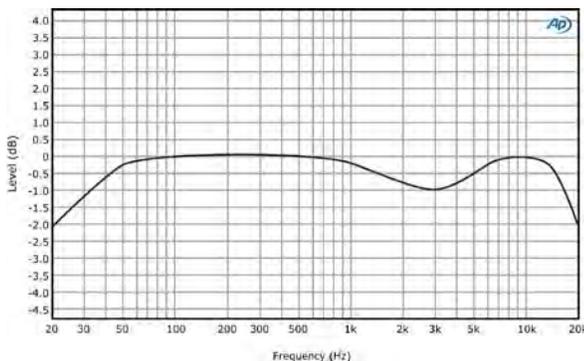
Display secondary units if necessary. For example,

Residual Noise

22 Hz to 22 kHz BW, <1.0 μ V [-117.8 dBu].

Express graphically (x-y, polar, waterfall, etc.) when appropriate.

Even a clearly stated specification such as $+0, -2$ dB, 20 Hz to 20 kHz is nowhere near as informative as the graph below, which shows not only the expected 2 dB droop at the low and high ends, but also an audio-coloring 1 dB dip in the midrange. Use a graph when you can.



Use uniform units, formatting, numerical expressions throughout the product line.

Messy formatting makes a lot of extra work for the reader, even for those who can navigate through the fog of mixed units and expressions. For the less experienced, messy formatting is a minefield. Don't mix expressions like 5,000 Hz and 5 kHz; don't say millivolts here and mV there: be consistent.

What should good specifications look like?

The characteristics that are deemed important differ across classes of devices. Power is important for amplifiers; low noise is essential for microphone preamplifiers, and intelligibility is key for communications devices.

In this section we will look at two device classes, power amplifiers and microphones, with a few real-world examples in each class. We'll see which specifications are important and how the specifications and their conditions should be formatted and expressed. In each area we'll choose three actual manufacturers' spec sheets and show how the spec is rendered in the real world. It's often not pretty. Names have been withheld to protect the innocent and the guilty.

Power Amplifiers

Remember, the four key specs are level, frequency response, distortion and noise, stated one way or another. Audio power amplifiers generally specify at least these characteristics:

- Power Output
- THD or THD+N
- Frequency Response or Power Bandwidth
- Noise, SNR or Dynamic Range

Note that not all amps are designed for high fidelity. Amplifiers for paging systems, communications systems or bullhorns have different requirements.

Power Output

This is certainly the most controversial rating in consumer audio, largely because it is the key specification that many consumers consider when buying a receiver: they want to know how much power it has.

In response to this, the marketing departments of audio manufacturers around the world and throughout the history of electronics have continually come up with new and more stimulating ways to describe their products' power output. Standards organizations and trade commissions have been trying to referee this melee for decades, and confusion still reigns. Refer to the Power Ratings section of the Glossary for more on this topic.

For amplifiers destined for home entertainment use in the US, the Federal Trade Commission has adopted what is known as the FTC Amplifier Rule (Title 16 Part 432), regulating power output claims in advertising.

So, what does the FTC Amplifier Rule tell us?

1. Power output is to be expressed as “average continuous power in watts.”
2. Load impedance shall be $8\ \Omega$ or cited if otherwise.
3. All associated channels must be driven at rated power.
4. Power bandwidth or power frequency response must be cited.
5. Maximum THD from $\frac{1}{4}$ W to rated power must be cited.
6. The amplifier must be preconditioned at $\frac{1}{8}$ rated power for 1 hour.

It’s not a bad starting place. Home entertainment amplifiers are required to follow the rule for U.S. advertising, and pro audio and commercial amplifier manufacturers should start there and go beyond.

Important conditions that should be listed:

Load impedance, maximum THD or THD+N, number of channels driven, measurement bandwidth or power bandwidth.

Correct form:

100 W average continuous power into $8\ \Omega$; at less than 1 % THD+N, all channels driven, 20 Hz to 20 kHz, FTC.

Real world specs:

- **Pro audio amplifier**
600 W per channel into $8\ \Omega$, at 0.1 % THD+N (1 kHz), both channels driven. **[pretty clear, but “average continuous power” seems to be language avoided by this manufacturer,]**
- **Home theater receiver**
110 W minimum continuous power per channel, $6\ \Omega$ loads, 2 channels driven at 1 kHz, with a maximum total harmonic distortion of 0.1% (FTC). **[FTC sums it up, but “dynamic power” “IEC power” and JEITA power are all mentioned on the same sheet. Since this is a 7.2 receiver and the FTC Rule requires that “all related channels” be driven, why are we driving only two?]**
- **Paging amplifier**
60 W RMS output into $8\ \Omega$, at less than 2 % THD. **[This is a mono amp, so we know all channels are driven.]**

THD / THD+N

THD is Total Harmonic Distortion. THD+N is Total Harmonic Distortion plus Noise. See the Harmonic Distortion Appendix for more about these measurements.

Here we enter another swamp that the standards don’t help to clarify: the FTC rule asks for THD, without qualification. EIA/CEA-490-A wants THD, but will accept THD+N for rating purposes if it is identified as such. IEC60268-3 specifies THD, but will accept the THD+N method if the noise isn’t too high. CEA-2006 will take either. See the Standards Appendix and THD and THD+N in the Glossary.

Important conditions that should be listed:

Stimulus frequency, level, bandwidth or weighting filter.

Correct form:

1.26 % THD+N, 1 kHz at rated power, 22 kHz BW.

Real world specs:

- **Pro audio amplifier:**
<0.01 % 1 kHz at rated power into $4\ \Omega$, both channels driven. **[What bandwidth?]**
- **Home theater receiver**
0.08 % THD. **[That’s all they say.]**
- **Paging amplifier**
Less than 2 % from 50 Hz to 15 kHz. **[Is that the bandwidth, or are they sweeping the stimulus?]**

Frequency Response or Power Bandwidth

Frequency response is the amplitude at a device’s output, while a range of frequencies at a constant amplitude is applied to the device input. It can be stated as range of amplitudes across a range of frequencies, or shown as a graph.

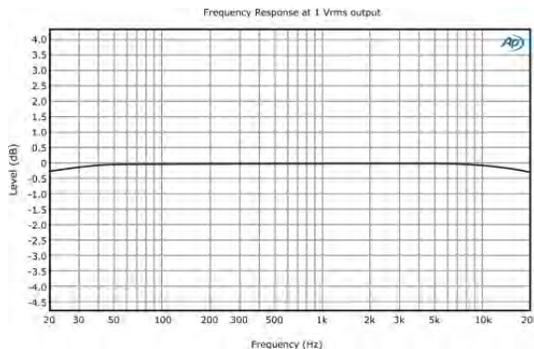
Important conditions that should be listed:

nominal measurement amplitude.

Correct form:

+0,-0.3 dB, 20 Hz to 20 kHz, at 2 dB below rated power.

or, a graph like this, with clearly labeled axes.



Power bandwidth is similar to frequency response, but includes the relationship to distortion and power as well. Specifically, power bandwidth is the frequency range for which half the rated power of an audio amplifier is available at rated distortion. In IEC60268 the term “power bandwidth” has been deprecated and is called “distortion-limited effective frequency range.”

Important conditions that should be listed:

Even though power bandwidth, as defined above, imposes its own conditions, you should state them here. Give the rated distortion and the power level.

Correct form:

24 Hz to 19 kHz, half-power at 0.5 % THD.

Real world specs:

- **Pro audio amplifier**
Power Bandwidth (rated power at 4 Ω, 1% THD+N) 20 Hz to 20 kHz, -0.84 dB/+0 dB
[Interesting, done at full power rather than half, and at 1% rather than .01% (the rated distortion).]
- **Home theater receiver**
0.03 % THD, 50 W, 8 Ω, 10 Hz to 50 kHz. **[50 W is ½ rated power.]**
- **Paging amplifier**
Not listed.

Noise, Signal-to-Noise Ratio, Dynamic Range

Noise in audio power amplifiers is stated a number of ways, as “Noise” or “Hum and Noise” or “Signal-to-Noise Ratio (SNR)” or “Dynamic Range.” If the conditions (signal

level, bandwidth and weighting filter) are correctly specified, these will all provide similar information.

The signal to noise ratio is exactly that: the ratio of an audio signal level to the noise level. The signal level is undefined, but can be the maximum output level, or the “nominal” operating level (usually 10 to 20 dB below the maximum output level). Signal level must be cited as a condition for this to be meaningful.

If signal level is the maximum output level, the result is the same as Dynamic Range.

Noise is typically measured using a bandpass limiting filter, usually set to 20 kHz or 22 kHz, or a weighting filter (A-weighting or ITU-IEC-468 / CCIR) is often used. These must be specified as conditions, because the results will vary with filtering.

Important conditions that should be listed:

Reference signal level, measurement bandwidth, weighting filters if any

Correct form:

SNR 95 dB referenced to nominal level, ITU-468 weighting

Real world specs:

- **Pro audio amplifier:**
Hum and Noise (A-weighted, full power, 4 Ω) – 105 dB. **[Not bad]**
- **Home theater receiver**
Signal to Noise Ratio 106 dB (LINE, IHF-A). **[Does LINE mean -10 dBV? We can only guess. IHF-A? Is that the standard, the filter network, A-weighted? Shouldn't we be using current standards?]**
- **Paging amplifier**
Hum and Noise: 85 dB below rated output.

Microphones

Microphones generally specify some or all of these characteristics:

- Frequency range
- Frequency response as an X-Y graph
- Sensitivity
- Noise
- SNR
- Max SPL
- Dynamic range
- Polar pattern

Note that not all mics are designed for the same applications. Studio mics are often very quiet and impart a characteristic “sound.” By using small elements, measurement mics often sacrifice low noise for very flat response. Communications microphones are primarily concerned with the 300 to 3 kHz voice intelligibility range, and may be more focused on acoustic noise cancellation than microphone self-noise or flat response.

Here are commonly specified characteristics and typical specs for three different classes of microphones.

Frequency range

A “frequency range” spec is not the same as a “frequency response” spec. Frequency range describes the extreme frequency limits of a device, often without stating the amplitude. This specification is often used for transducers such as microphones and loudspeakers that typically have poor response (compared to electronic devices) at the extremes of their range. When amplitudes are stated, they can represent cutoff points that can be down as far down as 6 dB, 12 dB or even more.

Important conditions that should be listed:

Amplitude variations within the range.

Correct form:

5 Hz to 20 kHz, +2, -8 dB

Real world specs:

- Classic studio mic, cardioid selection: 5 Hz–20 kHz **[How far down are the high and low frequency extremes?]**
- Measurement mic: 5 Hz–20 kHz **[Same question.]**
- Paging mic: 200 Hz–5 kHz **[And same question again.]**

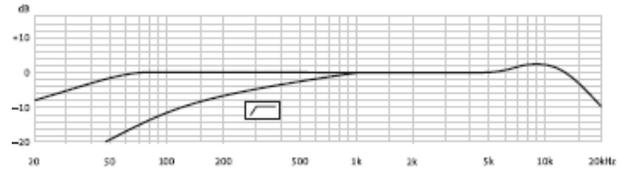
Frequency response graphs

Microphones typically include a response graph in addition to stating frequency range. Microphone responses are rarely ruler-flat, and a microphone’s tonal coloration can be an important consideration for the user.

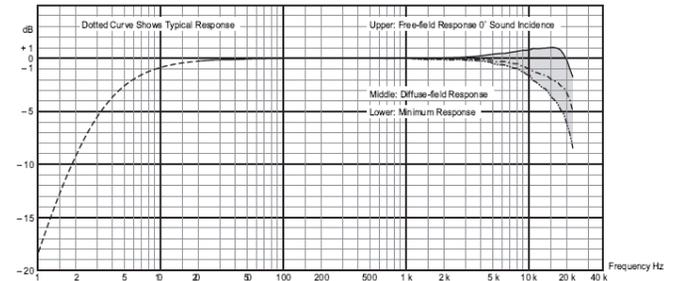
Important conditions that should be listed: pattern setting (if any), filter setting (if any). Identify axes clearly.

Real world graphs:

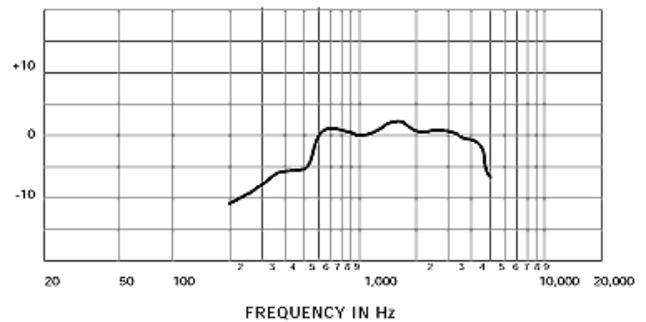
- Classic studio mic, cardioid selection:



- Measurement mic:



- Paging mic:



Sensitivity

Sensitivity is the ratio of electrical output in volts to acoustic input (sound pressure) in pascals. For microphones with integrated amplifiers, the gain of the amplifier is typically part of the calculation.

Correct form:

Correct form and conditions:
50 mV/Pa

Real world specs:

- Classic studio mic, cardioid selection: 28 mV/Pa **[Well stated.]**
- Measurement mic: 65 mV/Pa **[Well stated.]**
- Paging mic: 6 mV/Pa **[Well stated.]**

Noise

A microphone's self-noise is a combination of the thermal noise of the cartridge and (for mics that have an integrated amplifier) the amplifier's noise. Some manufacturers spec these separately.

Important conditions that should be listed:

Measurement bandwidth or weighting filter, if any. The accepted decibel reference for dB SPL is 0 dB = 20 μ Pa, and under this assumption the reference is rarely stated.

Correct form:

35 dB, BW, weighting (if any)

Real world specs:

- **Classic studio mic, cardioid selection:**
23 dB, CCIR; 12 dB, A-weighted **[Well stated.]**
- **Measurement mic:**
25 dB, Lin; 20 dB, A **[Can we assume "Lin" means unfiltered, and "A" means unweighted?]**
- **Paging mic:**
Not stated.

Signal-to-noise ratio.

The ratio of the nominal output level to the noise, usually weighted and stated in dB. If the ratio is to the maximum output level, this is the same as Dynamic Range.

Important conditions that should be listed:

Reference level of signal, measurement filters and weighting.

Correct form:

80 dB referenced to maximum output, ITU-468

Real world specs:

- **Classic studio mic, cardioid selection:**
71 dB, CCIR; 82 dB, A-weighted **[Well stated.]**
- **Measurement mic:**
See Dynamic Range **[An alternative to stating SNR.]**
- **Paging mic:**
Not stated.

Maximum SPL

The sound pressure level that produces the rated maximum distortion.

Important conditions that should be listed:

Distortion at max; once again, the accepted decibel reference for dB SPL is 0 dB = 20 μ Pa, and under this assumption the reference is rarely stated.

Correct form:

117 dB for THD=0.5 %

Real world specs:

- **Classic studio mic, cardioid selection:**
117 dB for THD=0.5 %; 127 dB with pad. **[Well stated.]**
- **Measurement mic:**
> 150 dB (peak) **["peak" is unclear.]**
- **Paging mic:**
Not stated.

Dynamic range.

This is an alternative to stating the noise level, the signal-to-noise ratio and the maximum SPL; it states the lowest and the highest sound pressure levels measurable below the rated distortion.

Important conditions that should be listed:

Signal level used as reference or distortion reading at reference level.

Correct form:

>100 dB (3% distortion limit)

Real world specs:

- **Classic studio mic, cardioid selection:**
105 dB, microphone amplifier only.
- **Measurement mic:**
> 130 dB SPL (Upper limit, 3 % distortion)
- **Paging mic:**
Not stated.

Polar pattern

This graph is often included to show the microphone's response for different frequencies at different angles of incidence.

Important conditions that should be listed:

Pattern setting, frequency legend.

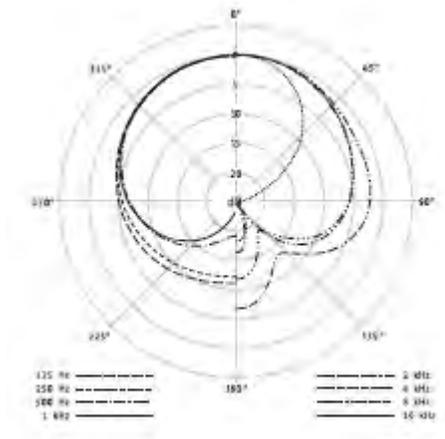
Correct form:

Microphone polar patterns are typically shown like

the classic studio mic, below. 0° angle of incidence is at the top, and the amplitude response of the microphone is graphed for 360°. Several different frequency plots are overlaid on the graph.

Real world graphs:

- **Classic studio mic, cardioid selection:**



- **Measurement mic:**
No polar graph, but instead these three specs:
Free-field response 0° incidence
 ± 2 dB 12 Hz to 20 kHz
Worst case response under any conditions
 ± 2 dB 12 Hz to 10 kHz
+2 to -8 dB, 5 Hz to 20 kHz
- **Paging mic:**
Identified merely as “omnidirectional.”

Conclusion

It's clear that there is a lot of variability in how specifications are written.

We encourage engineers and manufacturers to keep abreast of the standards changes, to write detailed specifications that always include the necessary conditions, to exercise care in choice of measurement units and to arrange and format their specifications sensibly.

Of course, marketeers will continue do what they must to tell a good story and sell a million widgets. The reader of brochures and data sheets should be wary of specifications without the proper conditions, of mixed or confusing units, and of any amplifier power claim that is not stated in terms of average continuous power output.

Appendix A: a brief history of audio standards

Over the years different organizations have issued recommendations to address these issues, describing methods for performing audio measurements and guidelines for stating the results clearly. For example, in the middle of the twentieth century the IHF (the now-defunct Institute of High Fidelity) published several revisions of an amplifier measurement standard, culminating in IHF-A-202 in 1978. This was superseded in 1981 by EIA-RS-490 (the EIA is the Electronic Industries Alliance), more lately succeeded by EIA/CEA-490-A, a strong influence in the US on the FTC Amplifier Rule.

Meanwhile, the Audio Engineering Society (AES) and the Deutsches Institut für Normung (DIN) and the International Electrotechnical Commission (IEC) were all merrily expanding the literature. Other standards have been written for transducers such as microphones and loudspeakers; for audio embedded in broadcast carriers; for audio embedded in digital bitstreams, etc.

As a result, most of the measurements cited in audio specifications have a standard method, and in some cases the defining standard is cited; for example, IMD is commonly measured using the recommendation of SMPTE, and is expressed as IMD (SMPTE); noise-shaping delta-sigma digital converter measurements require an analyzer equipped with a filter described in the AES17 standard; and, even today, a home theater manufacturer specs noise using the IHF recommendation may be expressed as “65 dB, IHF-A.” In the United States, consumer power amplifier output ratings must follow the FTC Amplifier Rule, and you will see expressions like “100 W (FTC).”

Be aware that even the standards can embed biases. The standards committees are made up of human beings who possess different opinions and varying degrees of entanglement with audio equipment manufacturers.

Additionally, various bodies regulate electrical safety and electromagnetic emission and other issues, and their recommendations are often included in published specifications.

IHF-A-200, IHFA-A-201, IHF-A-202 standards for audio amplifiers: superseded by EIA/CEA-490-A, a current North American standard. www.eia.org, www.ce.org

CEA-2006, a current North American standard for “mobile audio amplifiers” (car stereos). www.ce.org

DIN 45000 standards for audio amplifiers: withdrawn and replaced by

IEC60268, a current European standard. www.iec.ch

AES17, a current standard for digital audio measurements. www.aes.org

FTC Amplifier Rule, www.gpoaccess.gov/ecfr/, browse to Title 16 part 432.

Appendix B: harmonic distortion measurements

THD+N

A simple and time-honored method of measuring harmonic distortion is to stimulate the device with a very pure sine wave, then remove the stimulus frequency from the output using a very narrow notch filter. What's left is the distortion products and whatever noise the device has contributed. Not only is this simple and inexpensive, it also tells a great deal about the quality of a device in one number. For example, two real specs:

- Amplifier 1: THD+N <0.01%, 20 Hz to 20 kHz.

Not a bad amplifier, if power and response are up to your needs.

- Amplifier 2: THD+N <2%, 50 Hz to 5 kHz.

Hmm. Not for your home theater or studio, but might do fine as a paging amp in a warehouse.

Necessary conditions for THD+N include the frequency of the stimulus, the level of the sine wave at the output of the device, and the bandpass or weighting filtering used in measurement.

THD

It is also possible to measure only the distortion products, without the noise. This was quite time-consuming and expensive until the advent of computer-accelerated FFTs, so THD measurements were rarely done. Now it is relatively easy to make either measurement, with the right analyzer.

The problem is that the results are slightly different, and that the standards vary in whether to use THD or THD+N, and how to report it.

Our recommendation is to make a THD measurement for FTC Amplifier Rule ratings (which require it). For specifications not subject to the rule, choose your method, but clearly label your results with your choice (THD or THD+N).

Necessary conditions for THD include the frequency of the stimulus, the level of the sine wave at the output of the device, and how many harmonic products measured, five being the accepted number.

In more complete specifications, harmonic distortion is reported for more than one output level, or more than

one stimulus frequency, or even as a graph displaying distortion versus level or distortion versus frequency.

Sometime manufactures confuse us by expressing the distortion ratio in decibels rather than as a percent. Perfectly legitimate, but requires mental conversion. Don't mix percentage with decibels in the same document, please!

- 10 % = -20 dB
- 1 % = -40 dB
- .1% = -60 dB
- .01% = -80 dB.

Online calculators will convert other percentages for you. Visit www.sengpielaudio.com/Calculations03.htm

Glossary

This glossary is limited to terms and concepts brought up in this paper.

bandwidth filters

A bandwidth-limiting filter (often called a bandwidth filter) is used in measurement to exclude frequencies above or below the frequency range of interest, while maintaining a flat response in the range of interest, or “passband.” Bandwidth-limiting filters are typically used in noise or distortion measurements to reduce the amplitude of noise or other signals that are beyond the range of interest, usually 20 Hz to 20 kHz.

continuous power, continuous average power
see sine output power.

DIN power

Output power as defined by DIN 45000, which has been withdrawn and replaced by IEC60268. The output power measurement in IEC60268 is essentially continuous average power at rated distortion. Additionally, there is a “short-term maximum output” characteristic described that uses a burst signal and can produce higher power numbers. Some manufacturers spec this as “DIN peak” power, or just “DIN,” but the measurement is indifferent to distortion and overstates the power. Stick with continuous average power, and move up from the DIN spec to the current IEC spec.

dynamic range

Dynamic range is the difference, usually expressed in decibels, between the highest amplitude signal which a device can output at its rated distortion, and the noise level of the device.

dynamic power

Dynamic power replaced “music power” in IHF-A-201, once again as an attempt to take into account the typically low crest factor of music. A “transient-distortion” test is made, compared with the older “music power” curve on a graph, and the worse of the two is reported as the “dynamic power.” The term is still used in specifications to overstate amplifier power.

frequency range

Frequency range, when used as a specified characteristic, is a crude expression of frequency response, simply stating the range across which the device functions. Amplitudes within a frequency range expression may be 10 or more decibels below the amplitude at 1 kHz.

frequency response

Frequency response is typically expressed as a statement, but is often shown as an X-Y graph as well. It describes the amplitude variance (from a reference amplitude, usually at 1 kHz) across a frequency range, usually 20 Hz to 20 kHz.

IEC power

See DIN power. Some manufacturers spec the “short-term maximum output” characteristic is as “IEC peak” power, or just “IEC,” but the measurement is indifferent to distortion and overstates the power. Stick with continuous average power, which IEC60268 also defines.

IHF power

See IHF in the Standards Appendix. IHF power is a vague term, in that the first IHFM standard defined “music power”, which the second standard dropped as not particularly useful, introducing “dynamic power” and “continuous power.” So what does “IHF power” mean in a specification? Without more information, not much.

IMD

Intermodulation distortion. IMD results when two or more tones are combined in a nonlinear system. IMD products are sum and difference tones, not harmonically related to the stimulus tones. IMD is typically more insulting to the listener than a comparable level of THD.

IMD, SMPTE and MOD

The Society of Motion Picture and Television Engineers (SMPTE) standardized a measurement technique for IMD in SMPTE RP 120, using, in a 4:1 ratio, a 60 Hz tone modulated by a 2 kHz tone. The MOD IMD measurement is similar.

IMD, DFD

The Difference Frequency Distortion method uses two closely spaced high-frequency tones.

IMD, DIM (TIM)

Dynamic Intermodulation Distortion (DIM, also called Transient Intermodulation Distortion, TIM) is a technique for measuring IMD under rapidly-changing dynamic conditions, which typically stress audio power amplifiers. DIM uses a 3 kHz square wave modulated by a 14 kHz sine wave of lower amplitude. The DIM measurement is defined in IEC60268-3.

hum

Most electronic circuits have some mains power frequency components and harmonics, called hum.

music power

IHFMA-200 came up with this power definition to take into account the typically low crest factor of music, but within a few years dropped music power as neither sufficient nor meaningful. The term is still used in specifications to overstate amplifier power.

noise

All electronic circuits have some amount of broadband noise.

PMP, PMPO

Peak Music Power, Peak Music Power Output are vaguely defined schemes to report much higher power levels than continuous average power. Avoid these when writing specs and ignore when reading them. When PMP or PMPO are listed (as in some low-end computer speakers), divide by about 100 to get a guess at what the continuous average power might be.

power bandwidth

Power bandwidth is the frequency range that can be achieved sweeping an amplifier at ½ rated power, while maintaining less than rated distortion.

rated distortion

The rated distortion is the figure the manufacturer has chosen to claim as a minimum performance specification.

rated power

The rated power is the figure the manufacturer has chosen to claim as a minimum performance specification.

RMS power

RMS power is a misnomer, but one used in good faith. It means the same thing as “sine output power,” defined below. Although the output voltage is measured in rms volts, the result does not have the “rms” term in it. The result is simply “watts.”

sine output power

One of several common terms for the accepted means of measuring and reporting output power, used in EIA/CEA-490-A, IEC60268-3 and the FTC Amplifier Rule. Also called continuous power, continuous average power and (wrongly) rms power. The stimulus signal is a sine wave. The true rms voltage is measured across a load resistor and the power is calculated by the formula V^2/R . The amplifier should be capable of delivering this power continuously for at least 30 seconds (IEC) or five minutes (CEA-490). Visit the standards documents for detail.

SNR

Signal-to-noise ratio. Just what it says: the ratio, almost always in decibels, between the signal level and the noise level. The signal level should be specified; if not, a common level is the device’s maximum output level. Two measurements are taken: one to establish the signal level, and one to measure the noise in the absence of signal. Any filtering used for the noise measurement should be stated.

spurious signals

Spurious signals refer to any signal(s) in the output of an audio device that are not: the stimulus or program material, harmonic distortion, intermodulation distortion, crosstalk, hum or broadband noise.

SPL

Sound Pressure Level. Typically expressed in decibels, referenced to a sound pressure of 20 micropascals (20 μ Pa), the threshold of hearing. 94 dB SPL = 1 Pa.

THD

THD stands for Total Harmonic Distortion, a measure of all the harmonic distortion products in the DUT’s output, with the fundamental stimulus tone removed, and without consideration of noise. THD measurements are usually made with band-limiting or weighting filters.

THD+N

THD+N stands for Total Harmonic Distortion plus Noise, a measure of everything in the DUT’s output, with the fundamental stimulus tone removed. Noise and other interfering signal such as hum, buzz and aliased high-frequencies are reported in the result. THD+N measurements are usually made with band-limiting or weighting filters. THD+N measurements are regarded as a key benchmark of a system’s performance; the measurement is easy to perform and widely understood, and it shows at a glance not only distortion performance but also indicates a system’s immunity (or lack of it) to noise and other interfering signals.

weighting filters

A weighting filter has a specific response, with the effect of amplifying some frequencies and attenuating others. For audio amplifiers, one of several weighting filters is commonly used to produce a measured response that correlates with the human hearing experience. Weighting filters are typically used in noise measurements.