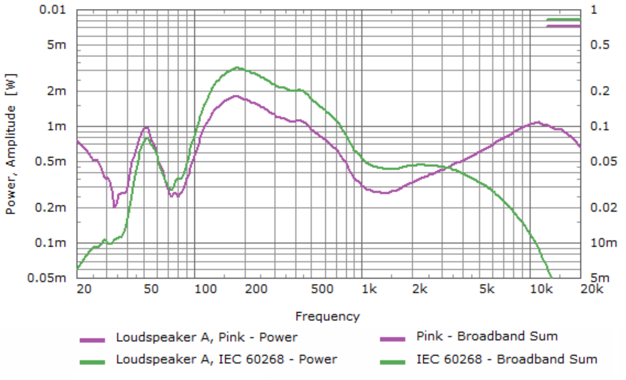
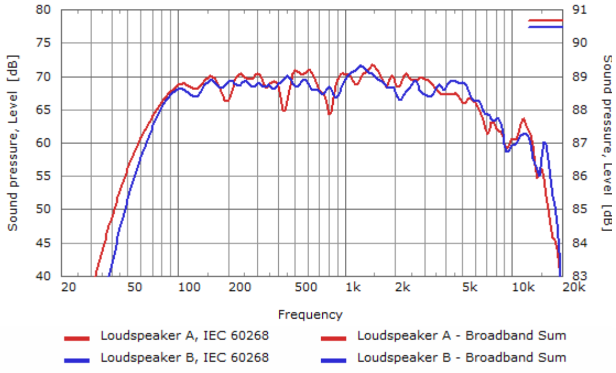
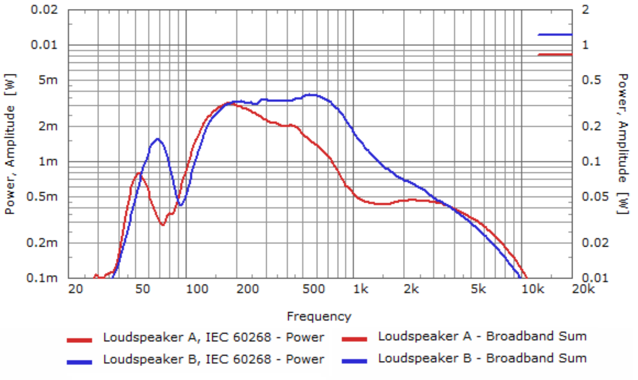
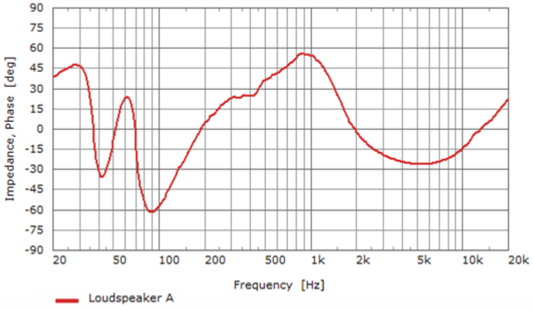
# Loudspeaker Power Ratings

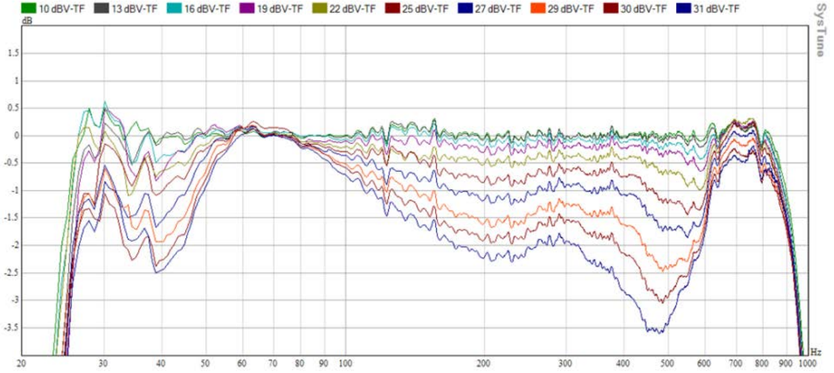


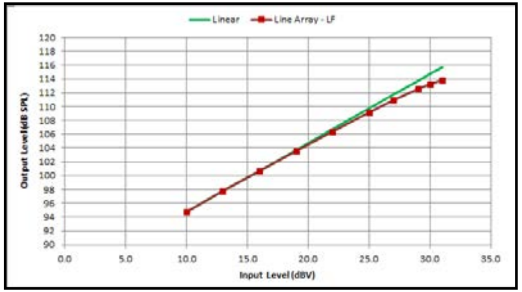




**Watts** **dBV** **Volts** **Amps**



# Topics

1) What Determines the SPL from a Loudspeaker
2) Calculating a Loudspeaker's Power Draw
3) Power Draw with Different Signals
4) Power Draw of Different Loudspeakers
5) Are Power Ratings Useful?
6) Other Loudspeaker Ratings that are Possibly More Useful
7) Alternate Units for Ratings

# What Determines the SPL from a Loudspeaker

**Loudspeaker sensitivity**

Input voltage of the signal

Spectral content of the signal

The higher the loudspeaker sensitivity, the louder the loudspeaker is with a given signal.

# What Determines the SPL from a Loudspeaker

Loudspeaker sensitivity

**Input voltage of the signal**

Spectral content of the signal

All other things being equal, increasing the voltage to a loudspeaker increases its output SPL.

For modern audio systems, voltage is what drives a loudspeaker and determines its SPL; not power.

The impedance of the loudspeaker will determine the current draw for the applied voltage. These two quantities determine the power.

# What Determines the SPL from a Loudspeaker

Loudspeaker sensitivity

Input voltage of the signal

**Spectral content of the signal**

Very few loudspeakers have a perfectly uniform (flat) sensitivity response as a function of frequency.

Triangle or Cymbals into Subwoofer = Little or No SPL

Bass or Kick Drum into Super-Tweeter = Little or No SPL

# Calculating a Loudspeaker's Power Draw

## Measuring Voltage

More often than not, power is not measured when performing tests for rating loudspeakers. It can be quite difficult.

Typically, voltage is measured. This is much easier.
Power is calculated based on the voltage and the loudspeaker's impedance.

This can lead to confusion if one does not know the impedance used for the calculation!

# Calculating a Loudspeaker's Power Draw

## Ohm's Law

$$Power = \frac{Voltage^2}{Resistance}$$

For an 8 ohm load ($Z_{rated}$)

$$\mathrm{Power} = \frac{28.3^2}{8.0} = 100 \text{ watts}$$

For a 6.4 ohm load ($Z_{min}$)

$$\mathrm{Power} = \frac{28.3^2}{6.4} = 125 \text{ watts}$$

# Calculating a Loudspeaker's Power Draw

## Ohm's Law

$$Power = Voltage * Current * \cos\theta$$

Measuring the complex voltage & the complex current, the actual power draw can be calculated (if it is really needed).

$$\text{Power} = 3.16 * 0.395 * \cos(0) = 1.25 \text{ watts}$$

For an 8 ohm resistive load

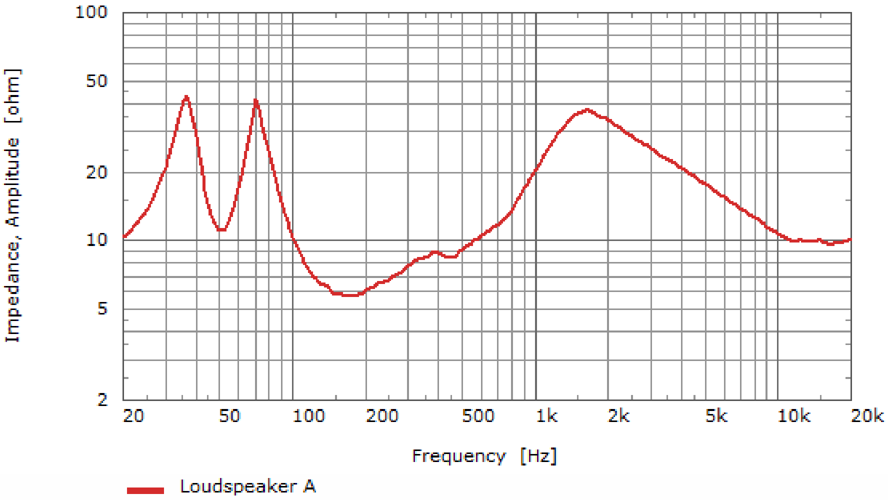
But loudspeakers are very rarely resistive loads.

$$\text{Power} = 3.16 * 0.395 * \cos(45) = 0.88 \text{ watts}$$

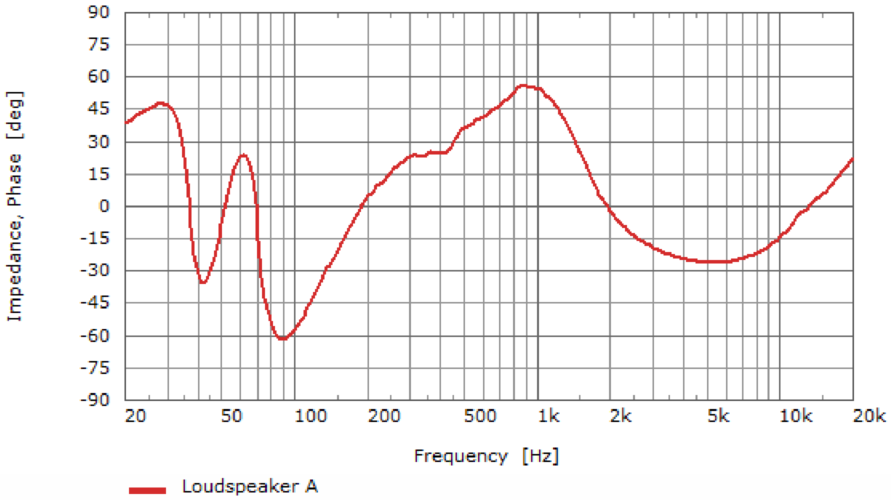
For an 8 ohm reactive load

# Calculating a Loudspeaker's Power Draw

## Loudspeaker Impedance




Magnitude



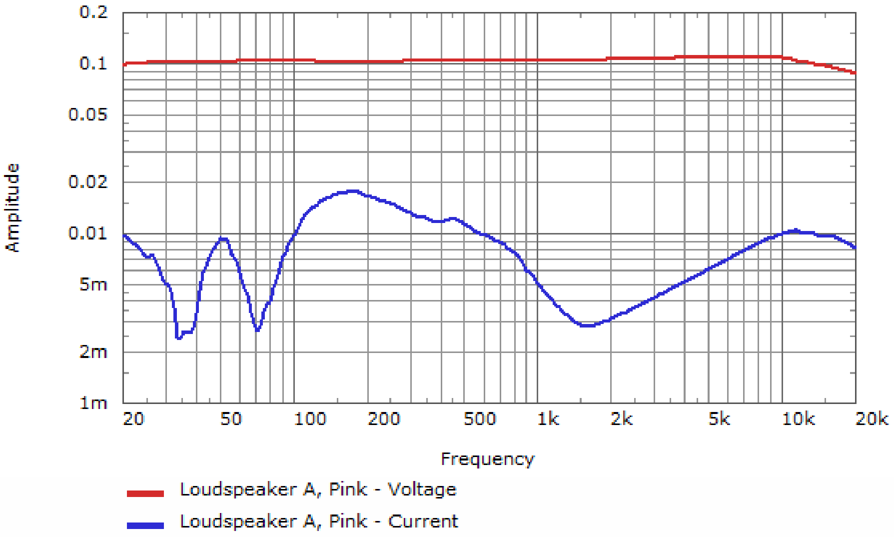

Phase

$Z_{rated}$ = 8 ohms

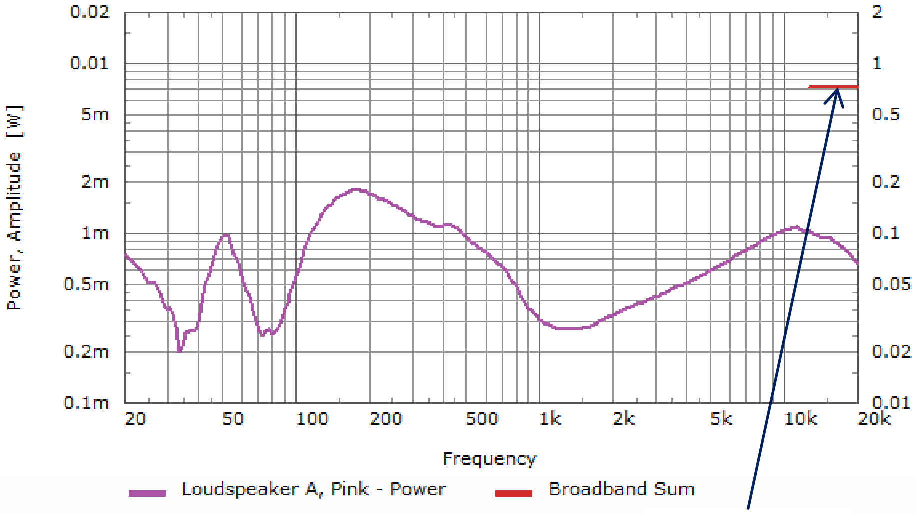
$Z_{min}$ = 5.7 ohms

# Calculating a Loudspeaker's Power Draw

## Pink Noise – frequency dependent current and power




Voltage & Current




0.72 W

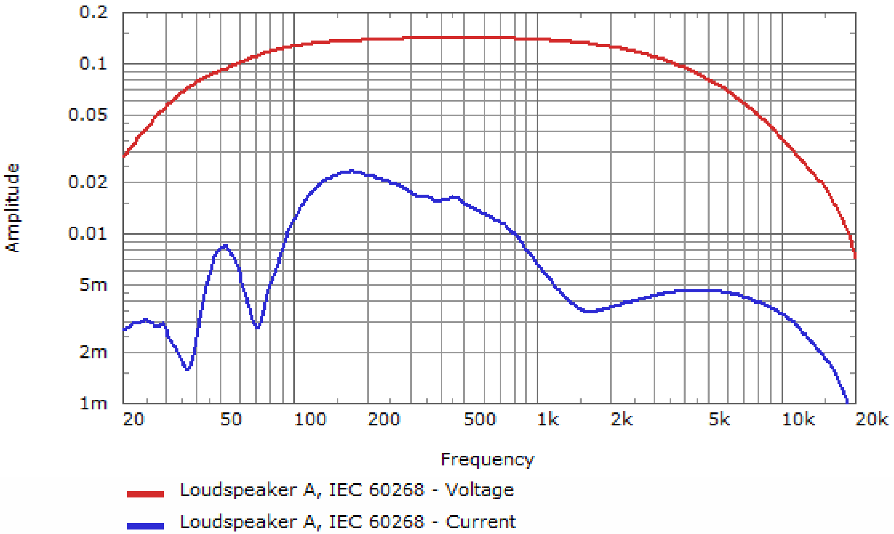
Power

$Z_{rated}$ => 1.25 W

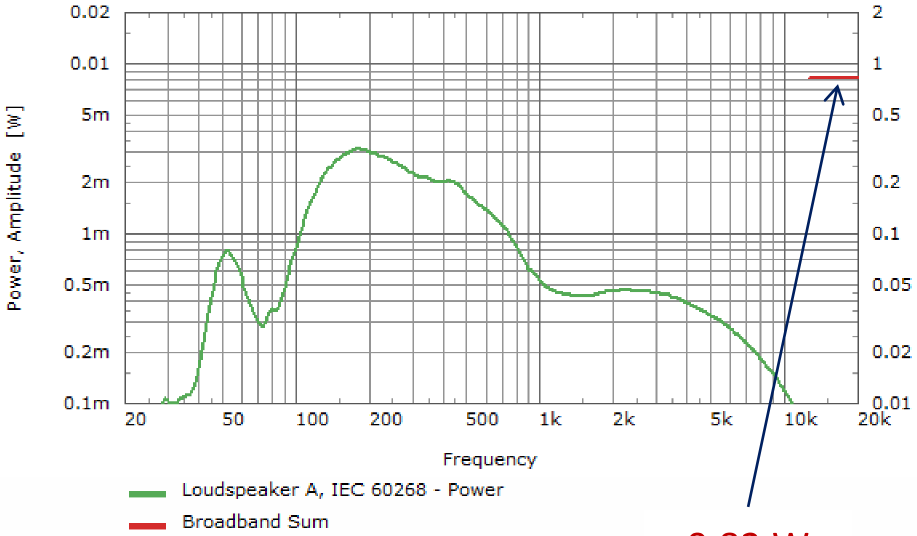
$Z_{min}$ => 1.75 W

# Power Draw with a Different Signal

## IEC 60268 Noise




Voltage & Current




0.82 W

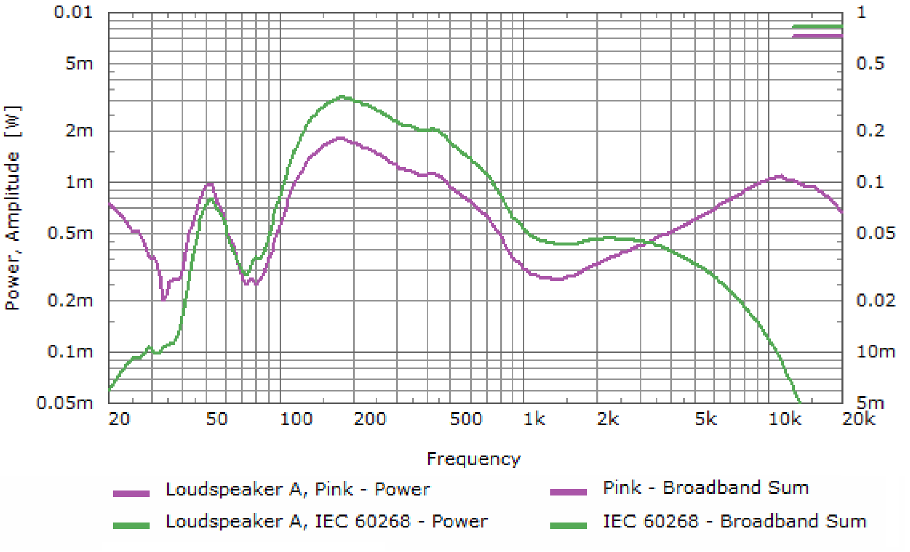
Power

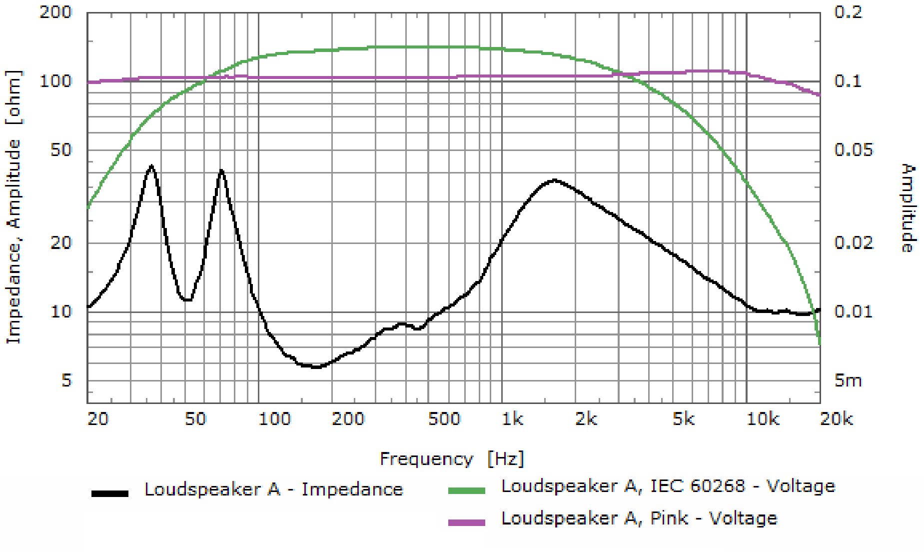
$Z_{rated}$ => 1.25 W

$Z_{min}$ => 1.75 W

# Power Draw with Different Signals

## Power Draw Comparison



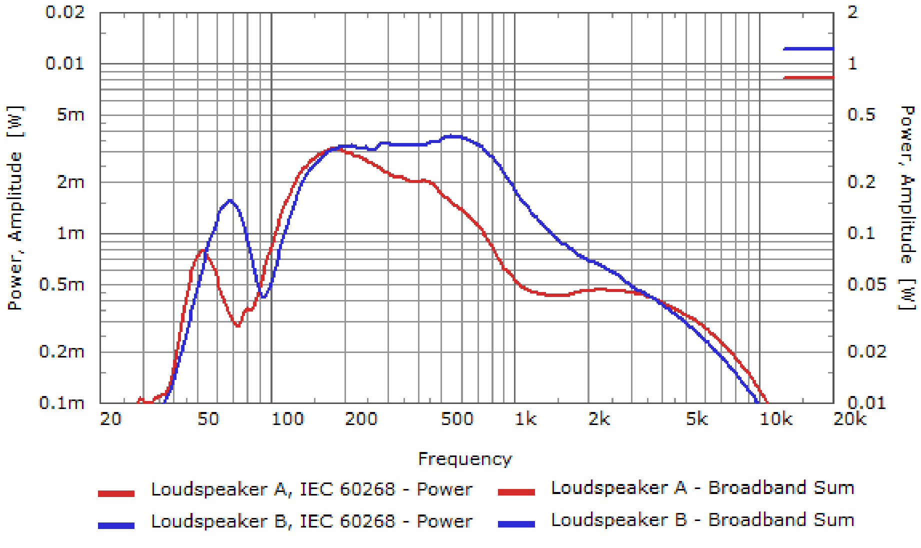



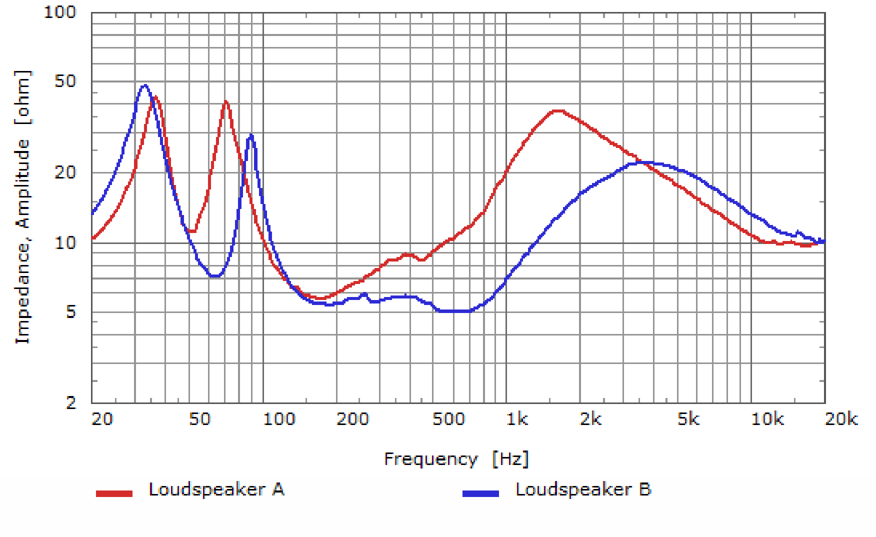

| IEC 60268 | Pink | IEC 60268 | Pink |
|---|---|---|---|
| 0.82 W | 0.72 W | 3.16 V | 3.16 V |

# Power Draw with Different Loudspeakers

## Power Draw Comparison

Both loudspeakers rated at 8 ohms




Loudspeaker A 0.82 W

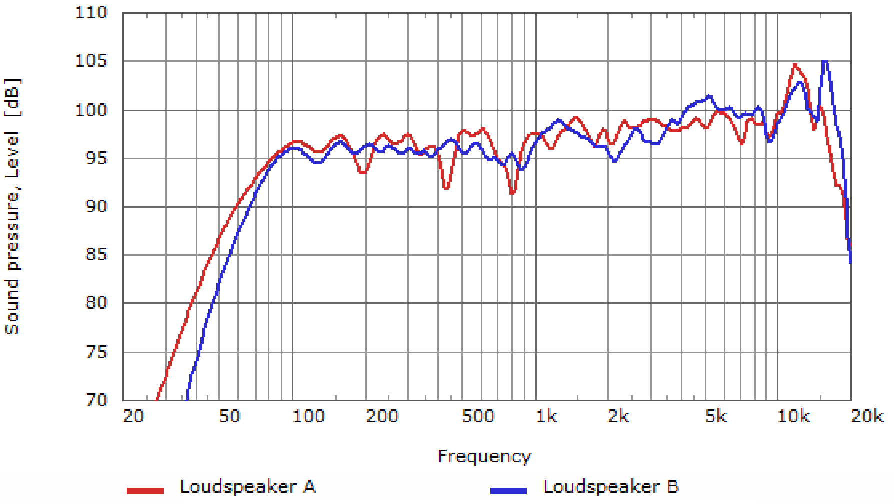
Loudspeaker B 1.21 W

Loudspeaker A 5.7 ohms

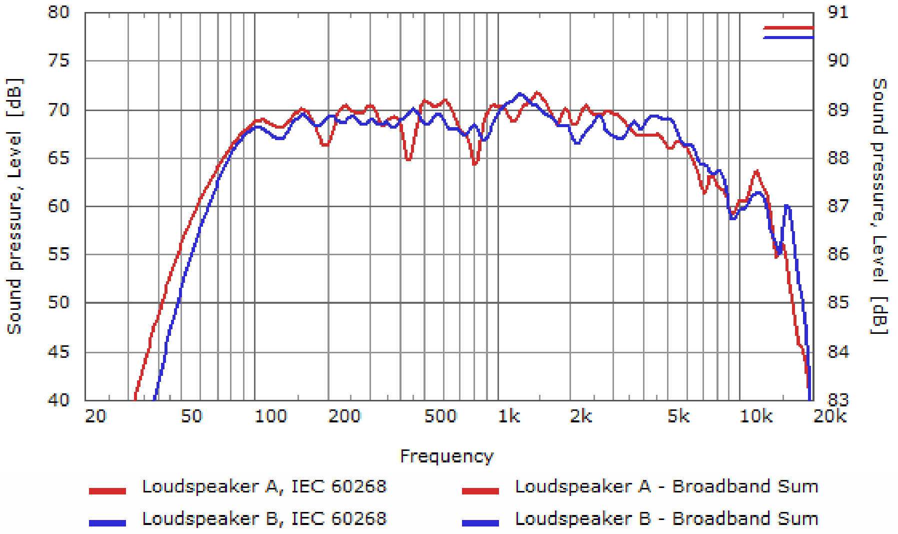
Loudspeaker B 5.0 ohms

# Are Power Ratings Useful?

For determining SPL, no.  SPL is a function of voltage, not power.




IEC 60268 Noise




Sensitivity (100 Hz to 10 kHz)

Loudspeaker A 97.0 dB

Loudspeaker B 96.9 dB

Loudspeaker A 90.7 dB

Loudspeaker B 90.5 dB

# Are Power Ratings Useful?

For determining the size of an amplifier, maybe.

However, voltage might still be better.

More often than not, power is not measured when performing tests for rating loudspeakers.

Typically, voltage is measured.  Power is calculated based on the voltage and the loudspeaker's impedance.

***Do you really know how much power your loudspeaker will draw?***

# Are Power Ratings Useful?

For determining the size of an amplifier, maybe not.

For sizing an amplifier we really need to know:

The continuous (rms) output ***voltage*** capability of the amplifier

The continuous (rms) output ***current*** capability of the amplifier

Once these have been combined into a ***power rating***, it is not always easy to get the needed info back.

If we know the output voltage capability of the amplifier and the input voltage limitations of the loudspeaker, things are much easier.

***SPL calculations & rms limiter settings also become much easier!***

# Possibly More Useful Ratings for Loudspeakers

## Maximum Continuous SPL Output

AES2-2012

The frequency response at progressively higher input voltages is compared to the frequency response at a fixed, lower input voltage.

The response at each input level is monitored for at least 1 minute, typically more, so the thermal change of the voice coil has stabilized.

When the frequency response has changed by 3 dB the test is concluded. The SPL is the maximum continuous usable SPL.

# Possibly More Useful Ratings for Loudspeakers

## Maximum Input Voltage (MIV)

AES2-2012

Also yields the maximum continuous (rms) input voltage for a loudspeaker.

The MIV can be used to help select an amplifier with the required continuous (rms) output capability to drive the loudspeaker.

The estimated SPL can more accurately calculated using the MIV.

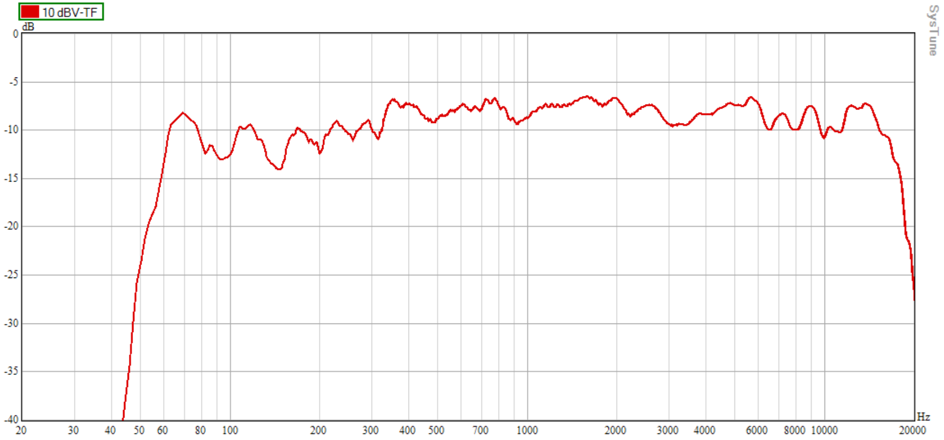
Limiter (rms) settings can be based directly on the MIV.

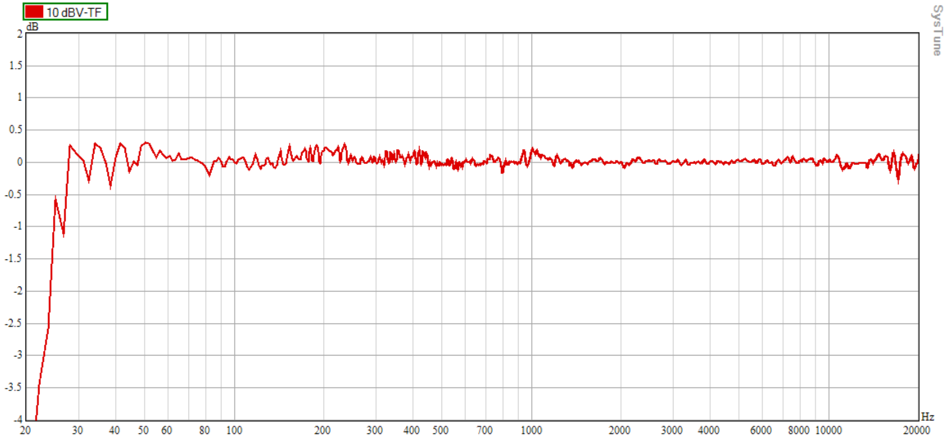
# Possibly More Useful Ratings for Loudspeakers

## AES2-2012

The initial measurement at a low input level (0 dBV or 10 dBV) is used to normalize all subsequent measurements.

This makes it much easier to determine when the frequency response has changed by 3 dB.



# Possibly More Useful Ratings for Loudspeakers

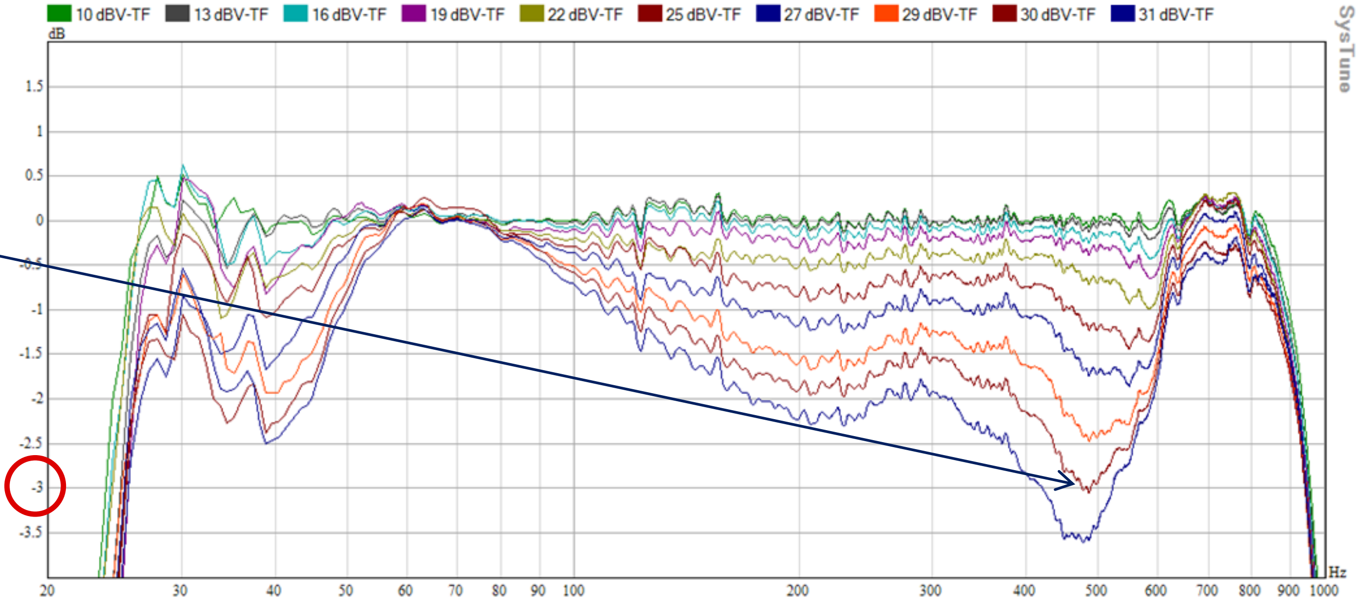
## AES2-2012

The LF section of line array loudspeaker, band pass filtered 30 Hz to 400 Hz

MIV determined by response change of 3.0 dB (500 Hz)

MIV
30 dBV
(31.6 V)

4 ohms => 250 W
3.1 ohms => 322 W



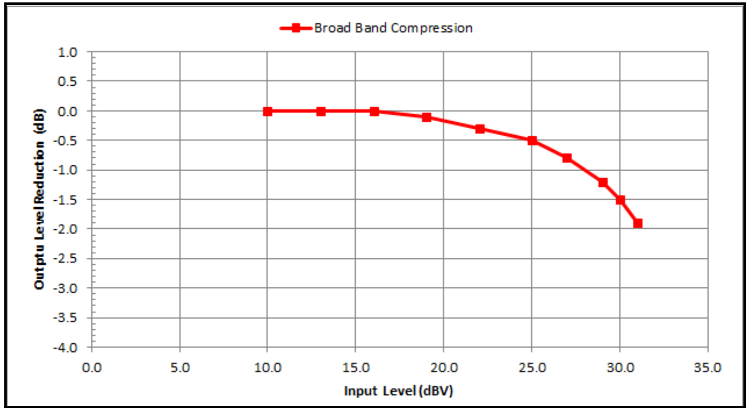
# Possibly More Useful Ratings for Loudspeakers

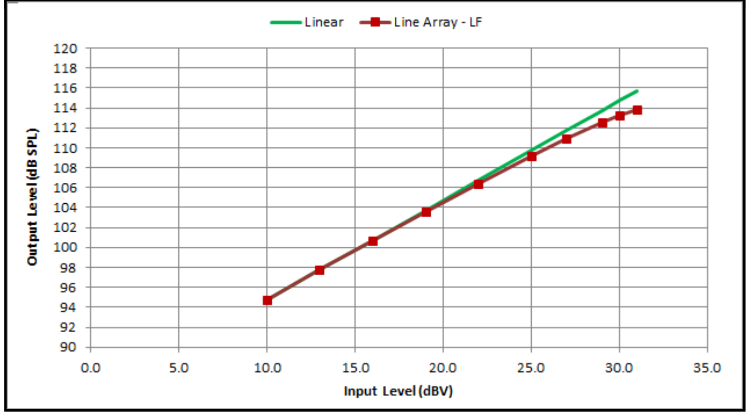
## Data Logged During AES2-2012 MIV Testing

Input voltage and output SPL

Line Array LF Section

| | | Distance (m) | Ground Plane | |
|---|---|---|---|---|
| | | 2.0 | -6.0 | |
| Input Level (dBV) | Voltage | dB SPL (2 m) | dB SPL (ref. 1 m) | Broad Band Compression |
| 10.0 | 3.16 | 94.7 | 94.7 | - |
| 13.0 | 4.47 | 97.7 | 97.7 | 0.0 |
| 16.0 | 6.31 | 100.7 | 100.7 | 0.0 |
| 19.0 | 8.91 | 103.6 | 103.6 | -0.1 |
| 22.0 | 12.59 | 106.4 | 106.4 | -0.3 |
| 25.0 | 17.78 | 109.2 | 109.2 | -0.5 |
| 27.0 | 22.39 | 110.9 | 110.9 | -0.8 |
| 29.0 | 28.18 | 112.5 | 112.5 | -1.2 |
| 30.0 | 31.62 | 113.2 | 113.2 | -1.5 |
| 31.0 | 35.48 | 113.8 | 113.8 | -1.9 |



# Possibly More Useful Ratings for Loudspeakers

## Maximum Current Draw

While performing AES2-2012 MIV testing it should not be too difficult to also measure the current drawn by the loudspeaker.

This could help to characterize the continuous (rms) current required from an amplifier driving a given loudspeaker with the specified signal.

Amplifier ratings that included the continuous (rms) output current capability could be very helpful for selecting the right amplifier to drive a particular loudspeaker.

# Possibly More Useful Ratings for Loudspeakers

## Peak Levels

AES2-2012 uses a signal with a 12 dB crest factor.  The peak voltage and current values at the DUT should be about 4 times greater than the rms values.

Additional tests to determine the peak input and output capability of loudspeakers using tone bursts can also be performed.
(Keele tone bursts, CTA-2010, CTA-2034)

Peak limiter settings can be based directly on either of these peak voltage values.

# Possibly More Useful Ratings for Loudspeakers

## Summary of Ratings

1) Maximum continuous (rms) voltage
2) Maximum continuous (rms) current
3) Maximum peak voltage
4) Maximum peak current
5) Impedance phase angle

# Alternate Units for Ratings

## Ratings in dB

Publishing loudspeaker and amplifier voltage ratings in dBV, rather than volts, might be more useful to both engineers and end users.

Knowing the sensitivity of a loudspeaker (dB SPL), subtracting 9 dB (2.83 V = 9 dBV) to get an equivalent level at 1 V (0 dBV), and adding the maximum continuous (rms) output voltage of an amplifier (dBV) immediately yields a good rough estimate of the maximum continuous SPL possible from a given loudspeaker with a given amplifier.