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Microphone sensitivity

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This article describes how to interpret microphone sensitivity ratings with respect to the analog mic input of a Biamp processor.

[+ Table of contents](#)

Basics

Microphones are transducers — they are devices that convert mechanical energy (the motion of the air caused by sound waves) into electrical energy (voltage).

An increase in sound pressure level causes more vigorous motion of the air, which causes a greater movement of the mic diaphragm, and the movement of the diaphragm element generates a proportional increase in voltage out of the microphone. There are a variety of diaphragm designs available, all of which vibrate in reaction to sound pressure waves of varying intensity.

Mics are rated by their sensitivity. This refers to the output voltage a microphone generates at a given sound pressure level (SPL). The standard "reference" SPL is a 1,000Hz tone at 94 dB-SPL at the mic capsule. Therefore, a microphone's sensitivity is expressed as the mic's output voltage when the mic capsule is presented with a 1,000Hz tone at 94 dB-SPL.

The *Gain In* setting on the Biamp DSP input block allows you to boost (or amplify) a low incoming voltage from a microphone (or other device) to a higher level that is appropriate for the DSP. Ideally, a microphone signal should be amplified until it registers an average level of 0dBu RMS while it is being spoken into at a normal volume and a normal distance.

All professional microphones come with a product data sheet that show the voltage the mic will generate for a known reference dB-SPL (sound pressure level). Here are some common terms you may encounter





- Sensitivity is expressed as the mic's output voltage in dBV (referenced to 1 Volt) or millivolts (mV), at either 1 Pascal (Pa) or 94 dB-SPL.
- The notation used may vary depending on country of origin for the microphone, and often will vary within the same product line.

Interpreting sensitivity values

How do I interpret these numbers?

Biamp DSP processors measure signal levels in dBu, which is a slightly different scale than dBV. dBu is always equal to dBV plus 2.21.

Let's say you have a mic with a rated sensitivity of 10mV/Pa. Using a decibel calculator, we can find that 10mV is equivalent to -40dBV. To hit 0dBu on the Biamp's input meters when a 94dB-SPL reference tone is applied at the microphone capsule (using a mic calibration tool) we would need to add about +40dB of gain at the input. (Again, Biamp DSP processors measure signal levels in dBu, which is a different scale than dBV, so technically you would only need about 37.8dB of gain. dBu is always equal to dBV plus 2.21.).

But, this assumes that the mic will be receiving a 94dB-SPL signal during normal operation, which is unlikely to be the case. If that mic is expected to function with an average 74dB-SPL input, then an additional 20dB of gain is needed. Now the signal should register near 0dB on the meters when the mic receives a 74dB-SPL signal. The *total* input gain would be about +57.8dB on the input block (the initial 37.8dB plus another 20dB).

From a practical point of view you will only be interested in the total gain applied but it is good to know how it is determined.



We commonly see *Gain In* levels of 48dB for ceiling mics in conference systems, of course, this will vary with the type of mic being used and the distance of the mic from the source.

When ceiling mics are used, it may be difficult or impossible to achieve 0dBu without also capturing unusable levels of ambient sound. In that case, a lower level may have to suffice, in conjunction with the use of noise reduction on the channel (if available). The gating automixer will also be of assistance.

More is better?

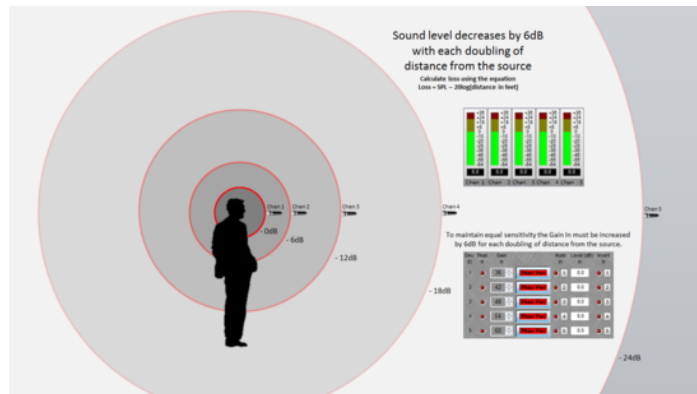
A microphone with higher sensitivity will "pick up" quieter sounds than a microphone with lower sensitivity - this is typically due to a lighter and more "sensitive" diaphragm which can react to smaller variations in air pressure.

Is higher sensitivity better? It all depends on what you are doing. For making a recording of bird songs in the Amazon, an ultra sensitive mic with very low "self-noise" may be just the thing, but that same mic would be overkill for a conference space. For a conference system, we want a blend of adequate sensitivity, low self-noise, and proper pattern design (as well as a reasonable price) for the application.




[Home](#) » [General](#) » [Audio](#)

much much more. Getting the sound you want (voices) requires careful and thoughtful positioning of the microphone as close as possible to the person speaking.



Microphone specifications

Here are a few examples from spec sheets of familiar microphones. They have different notation, but they are telling us the same things. This should help you learn to recognize the common properties of the notations.

Specs reference the power as an output voltage at 1 Pascal (mV/Pa). Remember that 1 Pascal = 94dB-SPL. Voltage doubles for every 6dB when increasing level, or is halved with every 6dB when decreasing level.

A microphone with a higher output level is said to be "more sensitive" than one with a lower output level. These numbers allow you to make broad comparisons before purchasing a microphone. They do not reflect audio quality or the "sound" of the microphone.


This mic produces -50dBV (50 dBV below 1 volt) when exposed to an SPL equivalent to 1 Pascal (equal to 94 dB-SPL).

It also restates that output level as 3.15mV when exposed to 94dB-SPL.

Type	Condenser
Frequency Response	50 to 18,000 Hz
Polar Pattern	Cardioid
Sensitivity (at 1,000 Hz)	Open Circuit Voltage: -50 dBV/Pa (3.15 mV) (1 Pa = 94 dB SPL)

This mic is rated at 37mV. The output can be converted from mV/Pa to dBV/Pa ---> 37 mV/Pa = -28.64 dBV/Pa.



 Home » General » Audio	
Frequency Response	20 Hz - 20 kHz
Polar Pattern	Cardioid
	Supercardioid
Output Impedance	150 ohms
Sensitivity	37 mV / Pa @ 1k
Signal/Noise Ratio (A-weighted)	72 dB
Equivalent Noise Level (A-weighted)	22 dB
Maximum SPL @ .5% THD	≥130 dB
Dynamic Range	108 dB
Power Requirements	18 - 52V phantom
Connector	3 pin mini-XLRm
Polarity	Positive pressure on diaphragm produces positive voltage on pin 2 relative to pin 3

Here the sensitivity is given as 114 mV/Pa (millivolts at 1 Pascal). We can assume the reference is at 1KHz but that should have been explicitly stated.

This can be converted from mV/Pa to dBV/Pa ---> 114 mV/Pa = -18.85 dBV/Pa.

Polar Pattern: Cardioid

Dynamic Range: 80 dB, 1 kHz @ max SPL

Signal/Noise Ratio: 60 dBA, 1kHz @ 1Pa

Frequency Response: 100 Hz - 12kHz

Sensitivity: 114 mV/Pa

Technical Specifications:

- Capsule type: 6 mm electret condenser
- Polar pattern: omnidirectional
- Frequency response: 18 Hz - 20 kHz
- Impedance: 200 ohms between pins 2 and 3
- Sensitivity at 1 KHz into 1K ohm: 10mV/Pa (-40dBV, re. 0dB = 1V/Pa)
- Max. SPL for 1% THD @ 1000Hz: 127dB
- S/N ratio: 70 dB A-weighted
- Connector: gold plated XLR
- Phantom power: +15 V to +48 V
- Weight: 144 grams

Some microphone specs are measured relative to 1 microbar (µbar). This is an older style of notation, microbar are a measure of pressure, similar to Pascal.

Adding +20dB will give the sensitivity relative to 1 Pascal. So for the example below, adding +20dB gives an equivalent rating of -45dB +/- 3dB at 1000Hz (0dB = 1 Pascal)

You can then convert from -45dB (assumed to be dBV) to mV and find the 94dB-SPL output is 5.62 mV.

Sensitivity

-65dB +/- 3dB at 1,000Hz (0dB = 1 microbar)



[Home](#) » [General](#) » [Audio](#)

This mic offers a differing output voltage depending on the capsule type you choose.

Be sure to make note of the correct sensitivity rating when comparing mics.

Open Circuit Sensitivity (at 1 kHz, ref. 1 V/Pascal*)

Cardioid: -35.0 dB (17.8 mV)
 Supercardioid: -33.5 dB (21.1 mV)
 Omnidirectional: -27.5 dB (42.2 mV)

All settings -12 dB at 0 gain

*1 Pascal = 94 dB SPL

Maximum SPL (1 kHz at 1% THD, 1 kΩ load)

Cardioid: 124.2 dB
 Supercardioid: 122.7 dB
 Omnidirectional: 116.7 dB

All settings +6 dB at 0 gain

Equivalent Output Noise (A-weighted)

Cardioid: 28.0 dB SPL
 Supercardioid: 26.5 dB SPL
 Omnidirectional: 20.5 dB SPL

Signal to Noise Ratio (referenced at 94 dB SPL)

Cardioid: 66.0 dB
 Supercardioid: 67.5 dB
 Omnidirectional: 73.5 dB

Converting mic output voltage

You can manually convert between values easily by remembering two things: that a 6dB change is always a halving or doubling of the previous voltage value, and the reference voltage you're working with. The reference will be 1v for dBV, or 0.775 for dBu.

Of course - it is much quicker to just use the proper formula! In Excel use the following
 "=20*LOG10(voltage/1)"

What if you want to determine the voltage output of a mic rated for -50 dBV/Pa?

- 1v = 0dBV
- 1v - 6dBV = 0.5v = -6dBV
- 0.5v - 6dBV = 0.25v = -12dBV
- 0.25v - 6dBV = 0.125v = -18dBV
- 0.125v - 6dBV = 0.0625v = -24dBV
- 0.0625v - 6dBV = 0.03125v = -30dBV
- 0.03125v - 6dBV = 0.015625v = -36dBV
- 0.015625v - 6dBV = 0.0078125v = -42dBV
- 0.0078125v - 6dBV = 0.00390625v = -48dBV
- 0.00390625v - 2dBV = 0.0031623v = -50dBV = 3.16mV/Pa

So we could restate the sensitivity to say that the mic produces 3.16mV when exposed to a 1kHz tone of 94dB-SPL at the capsule.

Volts, millivolts, microvolts





0.001v = 1.0mV = 1,000.0µV

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[Back to top](#) ▲

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This article explains how to calculate Potential Acoustical Gain (PAG), and Needed Acoustical Gain (NAG).



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This article describes functions and common usage techniques for the Automixer control block for Audia and Nexia products.



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