What Causes Audio Feedback?
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First off, everyone that has replied to my question: “Please list the major cause as well as the first thing you should do to eliminate feedback, using only one word”, thank you. That one word is “Distance”.

Most of the information I share with our community comes from the Audio Engineering Society, the European Broadcasting Union, (for our Members across the pond), and the manufactures of audio gear. So if you feel the need to disagree on this subject, disagree with them, not me.

Most of the information for this paper is taken from two sources. “*The Gain of a Sound System*”, by C.P. Boner and R.E. Boner and Rick Frank, who wrote the article titled “*Understanding Sound System Design and Feedback Using (Ugh!) Math*”, based his article based on the information taken from *The Gain of a Sound System*.

Feedback is caused by having the improper distance from the sound source to the microphone and can be mathematically calculated before you even turn on your sound system, using the formula below. While the results may not be absolute, they will get you very close.

Most if not all professional sound design companies will use this equation to determine what audio gear is needed to provide professional sound results. It all starts with the Inverse Square Law equation and it is used to calculate PAG/NAG. *Potential Acoustical Gain* (PAG), and *Needed Acoustical Gain* (NAG).

“New Level = Old Level + 20 X log of old distance - 20 X log of new distance, or in math shorthand it looks like this: $L' = L + 20 \log D - 20 \log D'$”.

The “*Needed Acoustical Gain*” (NAG) helps define a value in decibels the system will require to achieve, in order to provide the needed volume effectively. “*Potential Acoustical Gain*” (PAG) assists in determining the potential maximum amplification in decibels the system can apply before feedback occurs. A Feedback Stability Margin (FSM) of 6dB is often applied to the resulting value as a safety net.

The objective is to ensure that if we deduct the PAG from the NAG, written as “*PAG - NAG”*, we achieve a value of 0 **or** positive values. If this calculation results in negative numbers, we know that more then likely our sound system will suffer from feedback and people in the room won't be able to hear adequately. If the calculations above are applied with care, they can provide a fairly accurate estimation of the expected performance of a sound reinforcement system that can operate without causing feedback.

Definitions:

- ✧ D0 - The distance between the singer/talker and the farthest listener.
- ✧ D1 - The distance between the source microphone and the nearest loudspeaker.
- ✧ D2 - The distance between listener and his/hers nearest loudspeaker.
- ✧ D3 - The distance between the singer/talker and the nearest listener.
- ✧ D4 - The distance between the singer/talker and the microphone.
- ✧ NOM - Number of Open microphones.

At this point you may be thinking, "*this guy is out of his mind if he thinks I am going to whip out my smartphone, open my calculator and start punching in numbers*"! I don't blame you at all! That is just what I was thinking as I was being tested using this formula for one of the feedback courses I was taking last week!

Shure as well as BiAmp has a PAG/NAG calculator that takes the complexity out of the equation above. This mathematical equation is based on two things. Distance and open mics. Multiple open microphones create a greater risk of feedback in the system and degrade the quality of the sound due to comb filtering and increased reverberation, if set improperly due to improper distances. Again, this has to do with the distance between the mics, monitors, FOH speakers, as well as the distance from reflective surfaces.

For the Members of our community who wonder why I do things like this, it is because it is the way I have approached learning my entire life. Anyone can turn a knob or raise a fader, but if you truly want to know why you do the things you do when it comes to audio, then let it be from truly understanding the root issue, instead of, *because someone told me to*.

So now that we know that the true cause of feedback is distance, lets look at some of the myths that are associated with what causes feedback.

1. My gain is to high and when I reduce it, the feedback goes away.

That is the most common myth and is absolutely incorrect. If you have your gain set to high, it is due to improper distance from the input source to the mic. Your input gain should be set between a -18dbs and -15dbs at the loudest point of the input source when dealing with digital audio. This is the closest input level you can get to a "0" input using a analog mixer.

You often see this when someone is mic'ing a guitar cabinet with a SM57, that is 6 inches away from the speaker. If you move the SM57 to where it should be, 1/8 of a inch from the speaker, you can now reduce your input gain by close to 50% or more, depending on the output level of the guitar cabinet. Not only will you reduce your chances of feedback caused from improper distance from the mic, but you will also reduce the amount of mic bleed coming into the SM57 from stage background noise.

2. I have bad frequencies in the room so I need to EQ them out to stop my feedback.

That does not even make sense. Every room has its own unique characteristics and if you keep the “distance” doctrine in mind, you should understand how certain frequencies don’t cause feedback, but are a result of improper distances from reflective surfaces.

While some frequencies will act different from one room to another, that is due to the speed in which they travel, as well as the surfaces they are reflecting off of. But make no mistake about it, they do not cause feedback. Again, we can contribute this to distance. If you have your mic or your speakers to close to a reflective surface, it may be a certain frequency that is reflecting back due to the room acoustics into your mic, but it is not the cause of the feedback, it is because the mic or loudspeaker is to close to the reflective surface.

So why does EQ help when feedback occurs? Since some frequencies travel at different speeds, and react differently when reflected off of certain surfaces, we are led to believe that they are what caused the feedback to begin with. It’s simply not true. Room acoustics can boost/cut certain frequencies due to room resonance as much as +/- 12dB! If it is on the boost side, then you will need to use EQ to cut that frequency, but you should never have to reduce your input gain.

One of our Members, Steven Wriston, brought up a very valid point. “*Based on the many responses, **are we really preventing feedback or responding to feedback**? My goal is to prevent feedback by doing technical and behavioral activities prior to the event*”. Steven has the mindset of a professional. If you know what causes feedback, then you can stop it before it even starts or at the very least, take the proper steps to reduce the chances of getting feedback!

3. I have to many open mics and wedge monitors on a small stage and feedback can not be avoided.

This again is do to distance, not the fact of having open mics or a stage full of wedge monitors. Since we know that feedback occurs whenever the sound entering a microphone is reproduced by a loudspeaker, picked up by the microphone, and re-amplified again and again, then we need to do some measuring.

If we have the wedge monitors to close to the mic, then feedback occurs. It is not because the wedge is pointed at the mic, it is because the wedge is to close to the mic. If you understand that distance is the main reason for feedback, you can logically understand how to resolve the issue mentioned above, without reducing your input gain.

There are several things you can do in this situation. You can move the angle of the wedges that will change the distance from the wedge to the mic. You can lower the output volume of the wedge which in turn is simulating moving the wedge further from the mic.

You can try changing mics to reduce the pickup pattern, reduce the amount of wedges from the stag or better yet, use IEMs and remove the stage sound all together. In 2022 you can purchase the Behringer P2 for $39.00. I will be the first to admit that this product is no where close to the $4,000 wireless units, but they will be a hundred times better then your wedges! In recent years in-ear monitoring systems have begun to render stage monitors obsolete.

One of the questions I get asked repeatedly is "what microphone can I use that doesn't cause feedback?" The answer is quite simple, no such microphone exists. You don't have to take my word for it, just write Shure an email and ask them. While you are there, ask them if they have any feedback eliminator spray you can use for your mics or a can of squelch juice for your main speakers. ;-)

As mentioned above, virtually all sound systems need to be operated with a safety margin (called the feedback stability margin or FSM), usually 6dB, to avoid the annoying ringing sound associated with **pre-feedback** conditions. You can get a very good idea about running into any feedback issues, just by doing some calculations that all deal with distances, before you even power up your system.

So for all of our Members who gave their answers concerning "what causes feedback using one word", if you did not respond with "distance", then as Steven so brilliantly stated, the answers you gave did nothing to eliminate the cause of feedback, you are simply trying to reduce feedback, <u>***after it has already occurred***</u>!

If you have made it this far, then this is the prize at the bottom of the Cracker Jack Box. The following procedure for preventing/dealing with feedback is used by professionals worldwide, and with a little practice, you can use it as well.

1. To make a significant change in the gain of a sound system before it feeds back, distances need to be doubled or cut in half which is done using the Inverse Square Law formula. Or just use the PAG/NAG calculator to bypass the math.

2. To improve the potential acoustic gain of your audio system, make the loudspeaker to microphone distance as large as possible, while making the loudspeaker to listener distance, as small as possible. Simply put, get your mouth closer to your mic and consider maybe using some additional speakers halfway down your room so you can reduce your overall volume output, which in turn will reduce your risk of feedback due to lower output volume and reflective room conditions.

3. Limiting the number of open microphones will also improve the potential acoustic gain of the system. This is extremely important for large Churches. While you may need many mics on stage, you should be applying gates to keep them closed when not being used for picking up input signals.

It is impossible to list every room condition or stage setup and there may be times when you can do your best to prevent feedback, yet it still happens. I get it! The purpose of this paper is to give you as much knowledge as possible of how to prevent feedback before it starts, not what to do after it is happening. That's a entirely different subject.

If you're interested in studying these topics further, you can checkout the following books.

• Handbook of Sound System Design, John Eargle; ELAR Publishing Co., Inc.,

• Handbook for Sound Engineers, Ed. Glen Ballou

• Architectural Acoustics, M. David Egan

• The Gain of a Sound System, by C.P. Boner and R.E. Boner who wrote the original article on the topic.