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Mic Pre-amp Evaluation Methodology

by John Hardy

The following thoughts are directed at stand-alone mic pre-amp evaluation, but can generally be applied to any piece of equipment in the signal path.

Evaluating mic pre-amps can be simple, enjoyable, rewarding and accurate. Then again, it can be confusing, misleading, frustrating and impossible.

It seems so easy. Take the best microphones, power amps and speakers you can get, insert the mic pre-amp in the signal path, then listen. But there can be problems. (Lots of problems.) Whether you are looking for the most accurate mic pre-amp, or the mic pre-amp with just the right colorations for your application, you have much to think about. The following thoughts can generally be applied to any piece of equipment in the signal path.

Finding the weak link

You must intimately know the character and performance limits of every piece of equipment in the signal path. Otherwise you cannot be certain what to blame when things don't sound right. An unknown weakness or characteristic in one piece of equipment can mislead you about the performance of other equipment in the path.

Sooner or later it happens to all of us: You blame a problem on one piece of equipment, only to discover six months later that something else was causing the problem. Up to a certain point you can mentally compensate for a weakness or characteristic such as mild frequency response variations. Beyond that point you must upgrade the equipment if your evaluations are to be accurate.

Ideally you will be evaluating on the same equipment that you work with every day. That way, you will intimately know the limits of the equipment and will have eliminated any serious problems. If you are forced to evaluate an unfamiliar system, you must get to know the system before you can do anything meaningful. Otherwise, you are wasting your time.

You must also eliminate as much unnecessary equipment as possible from the signal path. That way, there will be fewer sources of error, degradation and mud to mislead you. The phrase “minimum signal path” is very appropriate. Ideally, you should go straight from the microphone to the mic pre-amp, and straight from the mic pre-amp to the monitor amp.

You should avoid the console completely, but if you must use a console, do the most direct patching possible to avoid as many op-amps, coupling capacitors, switches, connectors and miles of wire as you can. They all degrade the audio signal to some degree.

Avoid all outboard equipment. Even if the outboard gear is in “bypass” mode, it is often not a complete bypass. The signal is still sent through additional connectors, switches, op-amps, coupling capacitors and other parts, which are all sources of signal degradation.

The record/playback process, whether analog or digital, adds too much coloration to be part of the optimum signal path evaluation. Yes, sooner or later many of us have to record something to make a living, and you need to find out how the sound quality holds up after the record/playback process.

Ultimately, you need to hear how it holds up at the final destination, whether that destination is an expensive home system, a Walkman, a juke box, a PA system, my favorite 1958 General Electric Musaphonic AM radio, or whatever. But, for the most accurate evaluation of a mic pre-amp, the recording process should be avoided because it is a source of further error. It is a convenient way to do comparisons and has been used in many equipment reviews, but it is not accurate.

A popular analog tape machine sends the signal through a dozen op-amps just to get to the record head. Add the coupling capacitors, FET switches and EQ networks with their potential phase problems, and you will certainly have errors. And then there is the temperamental magnetic process involving the record head and tape. (Whew!)

Digital recording systems generally have their own problems with limited sampling rates, bits and anti-aliasing filters. Many consoles send the signal through a horde of op-amps, capacitors, FET switches and EQ networks too, just to get from a mic input to a bus output. Then it starts all over again when it's time to play the tape back. More errors. Avoid all of that circuitry whenever possible.

Whether you are working on your own system or an unfamiliar one, be suspicious of everything. Paranoia and skepticism are encouraged. Take detailed notes of the equipment being used, and the conditions under which it is being used. You might even want to consider the weather, and your personal health and mood. We all have days when nothing sounds good, and it's our own fault. A head cold, or head trip, can ruin everything. Start at the beginning and meticulously go all the way through the equipment until you are sure of what you are dealing with.

Microphones

What microphones are you using? What is their condition? Is this your first

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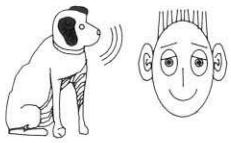

Figure 1. *Direct sound.*

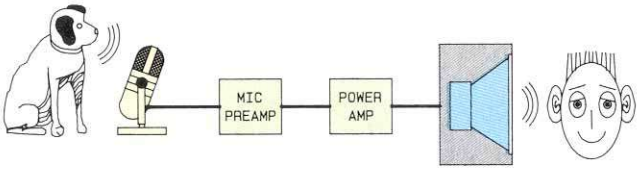

Figure 2. *Minimum signal path.*

experience with a particular model? If so, you can't be sure whether it is the mic pre-amp, or the microphone, or some combination of the two that creates the final sound. Pick-up patterns (on-axis and off-axis), capsule and electronics overload characteristics, noise, maximum input and output levels, and output impedance must be considered.

Mic cables

Use the shortest, best mic cables available. Go directly from the microphone to the mic pre-amp, avoiding the patch bay or any other connectors and cables. It does make a difference.

Mic pre-amps

One very important point: Many of today's console mic pre-amps leave much to be desired. They mask the full capabilities of your microphones. Some of them actually alter sound enough to force you to head for the EQ, hoping to re-create the sound as you heard it in the studio.

The problem may be inferior circuit design, poor execution of a design, or both. Perhaps there are budget limitations that cause unavoidable compromises in the choice of op-amps, transformers, capacitors and other components. Perhaps there is a lack of experience in basic mic pre-amp design. An expert in digital design may not be aware of the unique requirements of analog design. Improper grounding layout and circuit layout can seriously degrade the performance of even the best design. Whatever the reasons, the compromises are there.

This creates a serious problem: How can you make meaningful decisions about mic pre-amps when you've never properly heard your microphones? Do you really know what a U87 or SM57 is capable of? This is where your years of experience, talent, knowledge and intuition are really put to the test.

Regardless of what microphone you are using, you will eventually come upon a mic pre-amp that simply does a better job than the others, at least under certain conditions. If your goal is the highest accuracy, perhaps the better pre-amp will provide less distortion, or extended bandwidth, or a firmer low-end response, or a smoother mid or high end. Maybe it is more transparent. Cleaner. Warmer. Better focused. More detail. More air. Or maybe it's just incredible! No comparison! Descriptive terms can get pretty strange, but somehow, the meaning usually gets across. If your goal is a colored sound or special effect of some sort, you will recognize it when you hear it.

There are many variables to consider. Some pre-amps have transformer-coupled inputs, others have transformerless inputs. Some have transformer-coupled outputs, others have transformerless outputs. Some outputs are balanced, others are unbalanced or single-ended. Some mic pre-amps use monolithic op-amps, some use vacuum tubes, and some use combinations. There are many opinions on the advantages and disadvantages of these various constructions, and wide variations in quality within each type of construction. Decide for yourself.

Gain structure is very important. One engineer might be recording soft classical music from a distance, requiring a pre-amp with very high gain and low noise. Another might be recording a stack of screaming amplifiers at point-blank range, requiring a pre-amp with very low gain and the ability to handle extremely high input levels without distortion. With today's high-output condenser microphones, even routine vocal overdubs can drive some pre-amps into unavoidable distortion.

Some pre-amps sound better at certain gains than they do at other gains. Logically, you should be testing mic pre-amps under circumstances as close to yours as possible, but you must also consider the performance of the pre-amps under other circumstances. That classical engineer might suddenly find himself having to record a screaming amp one day. Good results for one set of conditions do not guarantee good results under others.

Find out the maximum gain available from the pre-amps. Also find out the maximum signal level the pre-amps can handle without causing distortion, and determine whether the distortion is caused by overloading the input or clipping at the output of the pre-amp. Also related to this is the minimum gain the pre-amps provide, and the maximum output level the pre-amps can produce.

For example, if you have a signal coming in at +4dBu, and the minimum pre- amp gain is 20dB, the output will be at +24dBu. That is fine if the pre-amp can handle a +4dBu input and provide a +24dBu output, but the signal will be hopelessly distorted if the pre-amp is only capable of a +18dBu output. Even then, you must also consider the load impedances the pre-amps will have to drive. All pre-amps should be able to drive a 10kΩ load, but what if you are driving several tape machines at once, resulting in a lkΩ or 2kΩ load? Play with the figures to see if the pre-amps can handle your requirements.

The method of gain adjustment is important. A multiposition gain switch might have the advantage of being resettable to exact gains, but what if the required gain falls in between two positions? Do you tell the singer to back up, or sing softer? Not likely. More engineers are going straight from the mic pre-amp to the tape machine these days, and there is no way to achieve an “in between” gain setting without going back through the console to use a fader. (And the whole idea was to avoid the console.) A continuously variable gain pot has an advantage in this case. It also allows you to ride gain. Everyone's situation is a little different, so you must decide what is best for you.

Contact plating is an area of great debate. Audio fanatics are sometimes called “golden ears”, yet some of them prefer silver-plated switches and connectors.

The phantom power supply is another concern. Some condenser microphones consume relatively high levels of current from the phantom supply. Some mic pre-amps can't provide sufficient current to operate those microphones. Some mic pre-amps don't have a phantom supply at all. Others have the supply, but you have to disassemble the pre-amp to turn the supply on and off. Check your requirements.

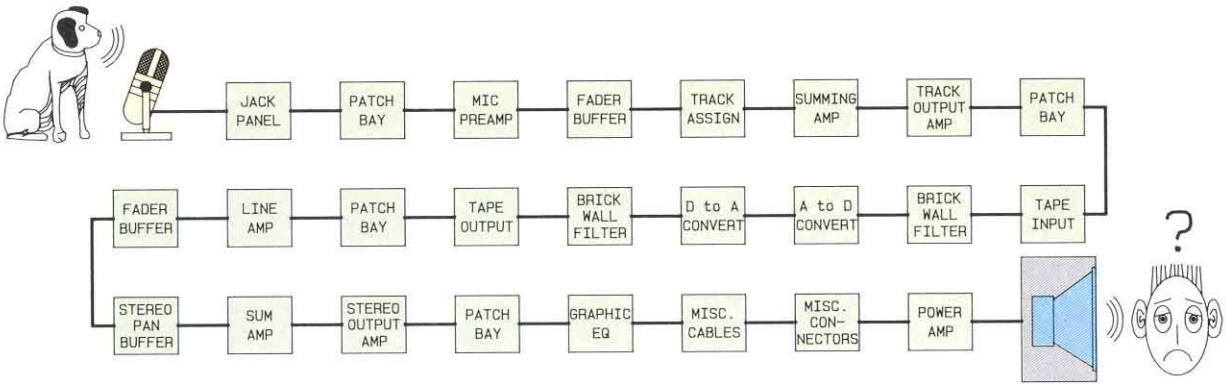

Figure 3. *A typical studio monitoring signal path.*

A microphone might sound better with some pre-amps than it does with others. Aside from the fact that some pre-amps are simply better than others, the differences in sound quality could also be caused in part by the matching of the microphone output impedance to the mic pre-amp input impedance. The output impedance of a "low impedance" microphone can vary substantially from one model to the next, and the impedance is not always linear. The input impedance of a mic pre-amp may also vary from one model to the next, and is not always linear. These impedances can interact like an equalizer to create subtle (and often not so subtle) alterations to the frequency and phase response of the audio signal. Distortion might also be increased. If the effect is desirable, great! If not, move along. You could conceivably end up with several pre-amps, each being best with a specific microphone.

Try to use the same listening levels when comparing equipment. This can be complicated by the fact that alterations in frequency and phase response, and differences in distortion may cause one pre-amp to sound louder than another, even when meters say the levels are the same. Polarity is another critical item. Some mic pre-amps invert the polarity, others don't. If you are comparing one pre-amp that is the proper polarity to another pre-amp that is inverted, your results will be faulty. Even two identical pre-amps will sound different if you reverse the polarity of one of them. This problem is compounded by the fact that not all microphones are wired with the same polarity either. Throw in a mic cable that (unknown to you) has pins 2 and 3 wired backward at one end, and you have a serious problem. You must verify polarity consistency in all of the equipment. A positive pressure on the microphone diaphragm should cause the monitor speaker cone to create a positive pressure by moving out. If there is a polarity inversion in the system, the speaker will move in when a positive pressure is applied to the microphone diaphragm.

Features and parameters such as polarity reverse, switching, metering, common mode rejection ratio, equivalent input noise (and others) must be considered. You should also look at factors such as ease of operation, quality of construction, quality of components, serviceability and long-term reliability.

Interconnect cables

The cable from the mic pre-amp to the power amp may not be quite as critical as the mic cable, but then again maybe it is as important. Use the best cable you can get.

Power amps

A wide range of amplifiers is being used in studios today, and substantial differences in their sound quality exist. High negative feedback, low negative feedback, no negative feedback, tubes, field-effect transistors, bipolar transistors, class-A, AB, C, D, and so on. You must know if the amps are causing any degradation.

Speaker wires

(Here we go again.) Not all wires are the same. Investigate.

Monitor speakers

What kind of monitors are being used? Big ones with response from DC to UV, or small near-field monitors with limited bandwidth? Do they sound good, or are they just popular? Do they have active or passive crossovers? Are they stock or modified? Who modified them? Did the modification make their performance better or worse? Lots of "great ideas" turn out to be not so great. Lots of great studios have their peculiarities.

Is a graphic equalizer being used? If so, check it out. It may be causing more problems than it is solving. Check the overall frequency response of the speakers. Different engineers have differing opinions on the ideal frequency response of a monitor system. Listen for phase problems at the crossover points. Your listening position relative to the monitor speakers is critical. Slight changes in listening position can cause major changes in frequency response and imaging. I have seen cases when a group of people gather around to listen, and you know they can't all be in the sweet spot. Take turns, do what you must, but find the optimum listening position. Anything less is probably a waste of time.

The room

Find out how the room affects the sound. Live ends, dead ends, standing waves, reflections and resonances can all affect what you hear. It is common practice for an engineer to bring a favorite master tape along to find out how an unfamiliar system sounds. You could also play a favorite record or CD through the system. It must be source material that you are extremely familiar with, material that you have heard on a wide variety of systems to avoid the problem of "tunnel vision", aurally speaking. The material must really challenge the unfamiliar audio system so you can find out where it is coming from. Discover the flavor and personality. Or discover a burned-out tweeter as I once did. You still face the potential errors of the tape machine, CD player, phono system or cassette deck, but you should get at least a rough idea of how the system sounds. You might even consider bringing your own cassette deck or CD player. Perhaps a better approach would be to bring a reference microphone and mic pre-amp to help you find out how the system sounds. Listen to something live, using the minimum signal path. This would eliminate the errors in the tape and CD methods.

Mic positioning and ear positioning

If you are not planning on sticking your ears exactly where the microphone is going to be placed, you will not hear the

same thing the microphone hears. You will not have an accurate reference point, and you should quit right there. Whether the sound source is jangling keys, a snare drum, a piano, an entire symphony orchestra, listen to it from the exact microphone position. If a stereo pair of microphones is going to be directly above a piano, you had better plan on listening from the same position. Otherwise, you won't know the tonal balance or the stereo image as perceived by the microphones. Move a few inches one way or another and the sound can change drastically, causing radically different perceptions of the same event.

If you have never listened from the actual mic position, you could end up saying "great sounding Steinway" only to find out it was a Yamaha, or a Bosendorfer, or a tack-hammer piano. Was that a German Steinway, or an American one?

I am stretching the point a little, but the principle is valid. If you listen from the microphone position, you have the legitimate right to ask two questions: "Which mic pre-amp is the most accurate?" and "Which mic pre-amp, although inaccurate, gives me the sound that I like the most?"

I have not discussed test equipment simply because the final and most important test equipment is your ears. Your ears can hear things that no meter can begin to measure. Some measurements such as common mode rejection ratio can be helpful in alerting you to potential problems that you might not experience in a routine evaluation. Frequency response, THD, maximum input levels, EIN and numerous other measurements can also be helpful, but most of them can be determined adequately by appropriate listening tests. Measurements must be made with the same care with which listening tests are made.

Then there is the matter of switching boxes. Many opinions have been expressed about switching boxes, most of them negative. If someone out there has the definitive switch box, let us know. If you use a switch box, you must switch the inputs, as well as the outputs, of the pre-amps. Do not connect a microphone to more than one pre-amp simultaneously! If a mic sees the load from two pre-amp inputs at the same time, it will probably sound different than it would if it saw only one load. If you have further suggestions, tips, variations, secrets, corrections, please send them in! We all can benefit. You must get to know the character and performance limits of every piece of equipment in the signal path. You must eliminate any unnecessary equipment, and be certain that the remaining equipment is not so limited that it compromises your evaluations. It takes just one tiny glitch to invalidate the results of your tests. If you are reading an equipment review, or an interview with an engineer, see if that person used these methods. If not, that person's opinions are suspect. It becomes much more than a mic pre-amp evaluation, it becomes a complete system evaluation. It also becomes a personal evaluation. It is a process of successive approximation: Do the best you can based on everything you know, learn from the experience, then do even better the next time with your increased knowledge. Find the weakest link and upgrade it. Then find the next weakest link, and the next, until you are satisfied. Once you have thoroughly and completely done all of this, evaluating mic pre-amps can be simple, enjoyable, rewarding and accurate. Have fun!

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