# Studio Site

## The Inside Story

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For the last few months we have been looking at various aspects of studio maintenance. We looked at how to set up a maintenance program and maintaining analog tape recorders, turntables, and compact disc players. This should cover most of the major parts of the studio audio chain except one - the electronics (consoles, preamps, and other amplifiers).

"Wait a minute!" you say, "Amplifiers just keep on working until some day when they fail. You might get a dirty switch or pot in the console, but these things don't need maintenance like a tape recorder or cart machine." I'm sorry to disillusion you, but amplifiers do some mighty strange things on the way to total failure.

In the "Good Old Days" of vacuum tubes (you might remember them, they were educated light bulbs) you had to frequently check bias and tube emission to make sure everything was working properly. Today, with solid state electronics, the failure modes are different and a bit more infrequent, but they still happen. The FCC recognized that performance would deteriorate over time and used to require annual Proof-of-Performance measurements.

A few years ago, in the early days of deregulation, they did away with the requirement for this annual exercise, but they did not remove the requirements for minimal performance. Many stations have not checked the audio performance of their system since then. However, performance may have degraded to the point where your equipment does not even meet the broad requirements of the FCC.

Accurately measuring the performance of amplifiers and consoles requires test equipment that is much more precise than that needed for most other parts of the audio system. For instance, it is not uncommon for a modern console to achieve total harmonic distortion (THD) numbers below .006% at output levels up to +27 dBv and signal-to-noise ratios of better than 125 dB. If you are unfamiliar with the dBv designation, it means dB referenced to .775 volts, which is the voltage equivalent of dBm. Many older signal generators and analyzers are unable to generate or resolve these specifications accurately. If your generator will only do .25% THD, it will not be much good for close inspection of your audio electronics.

Under normal operating conditions, consoles may develop any number of minor problems. Most of these are related to dirt, such as noisy or intermittent switches and dirty faders. In the case of many switches, the use of a good contact cleaner may solve the problem. However, some switches which are not used often may actually acquire a "memory" and will refuse to work at a certain point. No amount of cleaning will help these -- you will simply have to replace them. When replacing switches that carry audio, try to find an equivalent switch with gold contacts that is sealed or at least has a dust cover.

While this switch may cost a bit more than the original, it will save you a lot of trouble in the future, since the gold contacts will not oxidize as quickly as brass or tin plated contacts. If you cannot get gold contacts or sealed switches, be sure to treat your new switch with a good contact preserver and lubricant, such as Cramolin Blue. (Cramolin products are available from Caig Laboratories, 1175-O Industrial Ave., Escondido, CA, 92025-0051, telephone (619) 743-7143, or their distributors.)

Noisy faders may be a bit more trouble to fix than a dirty switch, since using a cleaner on some types of faders will destroy the resistive element. Before attempting to clean a noisy fader, check with the manufacturer of the console or the fader as to the suitability of your cleaner for that product. Even after cleaning, some faders may still be noisy or may jump in level. If so, they will need to be replaced or repaired. Some faders are built in such a way that they must be replaced if they have a problem. Others, such as some from Penney and Giles, can have their element and slider replaced, saving a good bit of the cost of a total replacement. Also, some faders require lubrication after repair or cleaning. Proper lubrication will extend the life of the fader and make operation much smoother. Again, check with the console or fader manufacturer for details.

One other area of concern in some consoles may be internal contacts, such as for plug-in circuit boards. Intermittent problems here can usually be dealt with by cleaning with a good cleaner such as Cramolin Red and application of a contact preserver, such as Cramolin Blue. When removing and inserting circuit boards into their sockets, be sure power is off if possible. Depending on the design of the equipment, the power surge may damage the circuitry or the edge connector.

While you are cleaning your faders and switches, try a good surface cleaning of your equipment. While this will not make a bit of difference in the operation or reliability of the equipment, keeping it clean will give everyone the impression that you are doing a good job. Keeping the surface of the equipment clean may also help keep the dirt from working its way into the switches and faders, and may eventually extend the life of the equipment.

After you deal with the obvious problems of bad switches and faders, you may have to dig a bit to find other problems. Just because you can't hear any problems doesn't mean that there aren't any. A regular check-out of the electrical performance of any piece of equipment may help detect problems before they become audible. Knowing what to look for and how to look for it is the key to doing this effectively.

A piece of equipment with a number of outputs and inputs, such as a console, may take quite a bit of time to check out. Planning your test procedure before you move in any test equipment will help reduce this time. Make up the necessary cables to connect the device under test (DUT) to

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your test equipment. Adapters are not a good idea here, since they can introduce any number of possibilities for bad contacts and incorrect connections. If you have a variety of connector types and input/output configurations, you should make different cables for each one and be sure you mark them appropriately.

If your test equipment is unbalanced and your DUT is balanced, an interface of some sort may be necessary. This interface may consist of a good audio transformer or some electronics. Remember that this interface has to have excellent audio characteristics, since it becomes a part of your test system. You may also want to add some other features to it to make your life easier. I have built many over the years, each one being better than the one before and having more features. Time and space do not permit more details of this here. If there is sufficient interest, this may be the topic of a future column in this same space.

While you are planning your test procedure, you should decide what the appropriate things are to test and how to test them. In other words, what are you looking for and how do you find it. Make sure your test equipment is ready to go and is working properly. If you can put everything on a cart and wheel it into the place where you are performing the tests, this may also save some time and hassle.

Each parameter you are testing requires different test signals and measurements. The chart shown below will help give you some idea what to do with this. Of course, check the specifications on the piece of equipment you are testing or your previous measurements for normal performance.

Each of the above tests may reveal a problem with either the adjustment of the equipment or a component within the equipment not working properly. Each input and output of a piece of equipment should be tested

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| Parmeter | Test Signal | Measurement | Look For | Comments |
|---|---|---|---|---|
| Output level | 1 kHz normal input level sine wave | dBv or voltage at output load | Specified output with specified load | All controls set for normal operation |
| Meter Calibration | 1 kHz normal input level sine wave | dBv or voltage at output | Zero level on meter | Adjust meter calibration for proper indication |
| Signal Clipping | 1 kHz maximum input level sine wave | Scope connected to output | Flattening of top or bottom of sine wave | If clipping is ecountered, try to isolate stage in which it occurs |
| Frequency Response | Normal input level sine wave varied across frequency range of DUT | dBv or voltage at output | Excessive variation in level with freqency | Make sure all equlaization circuits are defeated for measurement |
| Signal to Noise Ratio | No input signal. Terminate input with proper load | dBv or voltage at output | Signal greater than specified residual level | If possible look for repeating pattern on scope, especially at power line freq. or multiple thereof |
| Total Harmonic Distortion (THD) | Normal input level sine wave varied across freqency range of DUT | THD at output | Excessive THD, especially at low frequencies | This measurment is somewhat level sensitive, make sure you are measuring at the proper level. If S/N is to high, it will affect this measurement. |

***- Audio Parameter Test Chart -***

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for proper operation. Not only is this necessary to assure that everything is working properly, but will also help to isolate any problems that you may encounter.

Checking the output level of the equipment with a normal input signal will show that everything is adjusted properly. If the output is too high or too low, with the specified input signal, a gain control may be misadjusted which may cause other problems as well. This could also indicate a defective component in the system. If the problem is consistent with all inputs, you could have a bad resistor, integrated circuit, or transistor in the output stage.

If the level is 6 dB lower than it should be, and you have a balanced transformerless output stage, check your connections to your test equipment. You may be looking at only one side of the line. If your connections are correct, one side of the output amplifier may be dead. Further investigation may be necessary to determine the exact cause of the problem.

Proper meter calibration is necessary for the equipment to relate to the operator in a meaningful way. In normal operation, the meters on the equipment are the only way the operator has of knowing that his adjustments are correct. If the meters are faulty he may be feeding too much or too little signal to the next device. This is especially important when feeding any type of tape recorder (including DAT) or any processing gear. Improper levels can cause all kinds of problems with this other equipment. It is important that you measure the same output that the meter is monitoring or you may have some very confusing results.

Also, remember that some outputs of some consoles may have a different reference level than others, so be sure to check the book. Some audio equipment has no means of adjusting the meter calibration. In this equipment there is seldom anything that can cause an improper reading other than a defective meter. If the meter has a buffer amp between it and the signal line it is measuring, the buffer may be at fault. If you cannot bring the meter into proper calibration using the adjustment pot, you could also have a defective meter or driver.

Signal clipping is a problem that may be present in your system, but you may never really know it is there unless you look for it. Your audio may sound a bit harsh on the louder peaks, but this can also be masked by other problems such as marginal speakers. The level at which your system clips is the absolute maximum level that it can handle.

Depending on a lot of variables from system to system, the clipping level should be anywhere from 12 dB on up, relative to your nominal output level, in a piece of electronics. Remember that this is just for the electronics, not a system such as a tape recorder.

This difference from normal level to clipping is sometimes called headroom. If you do not have enough headroom in your system, peaks will be clipped. This may or may not be audible under normal circumstances, depending on the amount of headroom and the type of audio you are using. Any change in the headroom from the normal amount for your equipment can indicate improper adjustment of levels, a bad transistor or integrated circuit (usually in the output stage) or a faulty power supply. If you suspect the power supply, check all DC voltage rails powering your amplifier.

Most equipment using integrated circuits have bi-polar power rails. You should check for DC voltage with a voltmeter, but also check the rails with a scope for excessive ripple and variation with signal. A filter capacitor or regulator in the early stages of failure may work fine until you change the load quickly, such as when an audio peak goes through the system. Only the scope can find this sort of problem.

While checking the frequency response on most solid-state electronics may seem like a waste of time, it really is not. Most consoles and amplifiers use capacitors in the circuitry for interstage coupling and feedback control. Electrolytic capacitors are commonly used, and some equipment may use tantalum capacitors. As these capacitors age, they frequently lose capacity before they fail completely. Variations in the frequency response

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from normal, especially at low frequencies, may indicate a bad capacitor. Again, further investigation will be necessary to find the defective component, but it may avert a more serious problem, especially if the capacitor decides to short out when it fails.

The signal-to-noise ratio of a piece of equipment may be one of the most revealing measurements you can make. Transistors, integrated circuits, resistors, and capacitors may all contribute to excessive noise in an amplifier. However, this may all go unnoticed because noise is easily masked by the signal that is normally going through the equipment.

When making your measurements, be sure you use the same reference level that was used in creating the original specification. Some equipment is specified using the nominal "zero level" as the reference. Other equipment may use the clipping point or something close to it as the reference. The specifications should specify this reference level. Also, noise measurements are seldom made over an unrestricted bandwidth. Many audio voltmeters are flat up to a few hundred kHz.

While this is fine for measuring frequency response, it can be a problem when trying to measure noise. Noise is usually measured over a bandwidth to about 20 or 25 kHz, depending on the equipment. In some cases, it is measured using a weighting filter. The most common for electronics is the "A" weighting filter. This filter has a frequency response that has been standardized to approximate how the human ear responds to noise in electronics. If you try to measure noise with the wrong filter or over too wide a bandwidth, you will get readings that will never agree with the specification.

When measuring noise, it is good to look at the signal with a scope. If you can look at an output from your meter's electronics it can be even more revealing. If the noise is random, which is fairly typical, you will see a fuzzy line or grass across the screen. You will not be able to make the scope give you any more detail since the noise is random. Excessive random noise is usually caused by a bad semiconductor device or resistor.

If you see a very high frequency sine wave along with the grass, something is oscillating. This could be a bad bypass capacitor or even something as simple as an input wire too close to an output. This may even come and go as you adjust the gain of the circuit. It may even be caused by using an "improved equivalent" IC in place of the original. Don't fool yourself by thinking that the high frequency of the oscillation will not be heard. While it may not be heard directly, it may cause noise in switches and faders that you cannot get rid of and a general "grunginess" in the quality of your sound.

If you see a low frequency component on the scope that is synchronous with the power line (usually 60 or 120 Hz) look for a power supply problem, usually a filter capacitor that is not doing its job. This may also indicate an improper connection between your equipment and the test gear, so that is another vote for cables made specifically for that purpose.

Total harmonic distortion (THD) is a common measurement that can yield more information than many people think. Remember, though, that you will not get an accurate THD measurement until you get your noise where it belongs, since most equipment that measures THD is actually measuring THD plus noise. Since you are really measuring the signal with the noise, you will generally see lower THD readings as you increase the level until you reach the clipping point. Then you will see a sharp increase in the amount of THD with a very small increase in level.

By the same reasoning, the THD readings will increase as you decrease the level. Measuring THD used to be a very time-consuming process, since you had to manually adjust a number of controls until you got a minimum reading. I remember one THD analyzer that had eight controls on it to get a proper reading. Now there are some analyzers that adjust the level and null automatically and give you a reading. These are generally much more accurate than manually nulled analyzers, and as a result can show you a lot more about your equipment.

THD should be checked at a number of frequencies, since different components can cause problems at different frequencies. High THD figures in the mid-band may indicate a bad IC or transistor, or improper bias somewhere in the system. Normally the THD will increase as you lower the frequency in a system with audio transformers due to core saturation. Excessive amounts of low frequency distortion could indicate a problem with the transformer, or the presence of excessive DC through the transformer.

Excessive amounts of high frequency THD may indicate a decoupling problem or a slew rate limitation with a solid state device. Slew rate is the rate of change of the output voltage of the device (usually measured in volts per microsecond). This was a common problem with some early solid state designs, but can also result from improper substitution of an IC or transistor. Again, looking at the output of your analyzer on a scope can be helpful in determining the exact nature of the problem.

There are a number of other measurements that can be made on your signal electronics. While they all have a certain amount of value and can give you useful information, the procedures are generally more difficult or the equipment more expensive than is needed for the measurements above.

The first time you do any of this it may seem like a lot of trouble for nothing. However, like many other things, the more you do it the easier it will become. With some practice, you will be able to do all of this in only a few minutes, unless you find a problem. Of course, when you find a problem before it becomes a disaster, the whole exercise has shown its worth.

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