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HUM AND NOISE PREVENTION IN CINEMA SOUND SYSTEMS, A CLOSER LOOK

BY

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One of the more satisfying things about writing this column for the past 25 years has been observing the large number of past articles that are downloaded every month from my web site. For several years the number of downloaded articles has typically exceeded 100 per day. In the past few months, an article I did 11 years ago about hum and noise has seen a significant increase in demand. This is such an important topic that I reviewed the original article and have decided to update it here as well as include new illustrations.

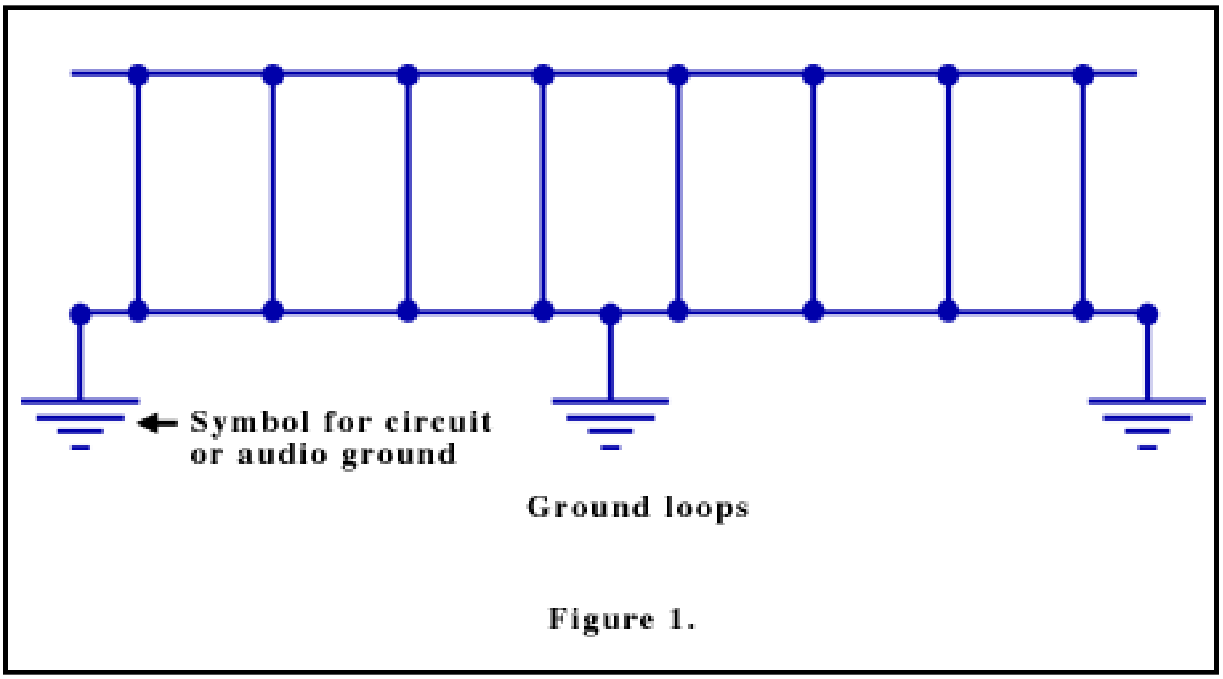


Figure 1.

Let's be clear about one thing, audible hum and noise in sound systems should not exist. It can be at least irritating and at most frustrating. Its causes can be both simple and complex. It is quite possible that one can wire and install a sound system while ignoring

common hum prevention techniques and escape without major problems. However, this is usually not the case. When hum occurs, it may take hours to track down all its causes. One can even correct a major contributor and not know it due to an oversight somewhere else. Believing the problem has not been helped, one might even put things back the way they were and remain in a vicious circle for a long time.

In the course of my travels, I have encountered all too many cinema sound systems that have been degraded by audible hum. True, the hum is usually masked when a film is playing, but it still doesn't belong there and may very well be audible during quiet scenes or before the show as the audience enters the theatre. The good news is that it's easy to prevent. Following some simple practices can virtually guarantee an absence of hum.

GROUND LOOPS

The greatest sources of hum in sound components or systems are poor grounding techniques. When one designs an amplifier, there will be only one point inside the chassis where all the audio circuit grounds are tied together and connected to the chassis ground. This is done to eliminate any possibility that current could flow between two or more grounding points and cause hum. A single grounding point prevents this.

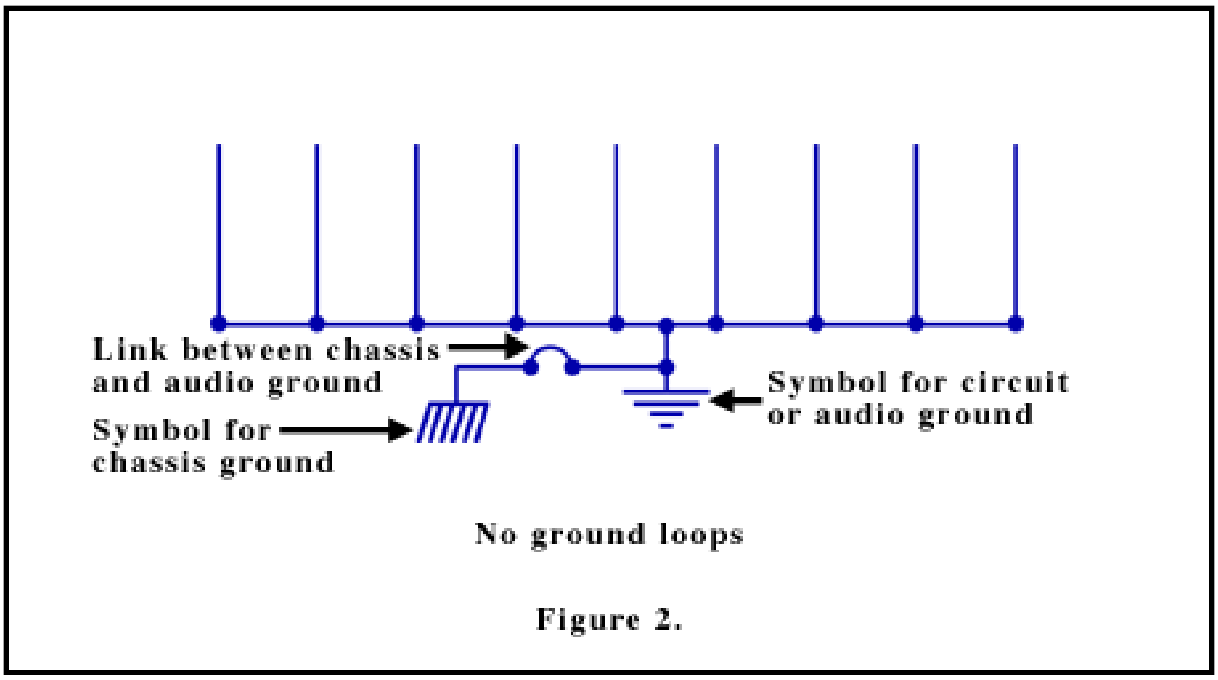
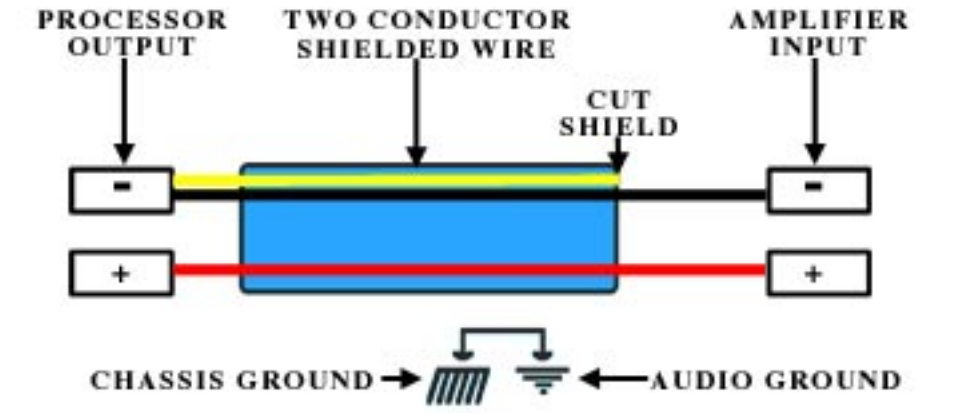


Figure 2.

Figure 1 shows what not to do. If one connects an imaginary wire anywhere on the grid, one quickly sees that there are multiple paths to the symbol marking the ground, or in this case multiple grounds. Figure 2 shows only one path to ground from anywhere in the circuit. When designing and wiring a sound system, one needs to keep this approach in

mind. However, this concept applies not just to the amplifiers and other components, but to the entire building as well. From the ground in the main breaker panel to any ground in any sound system in any theatre, there should be only one path.



This wiring is correct. There are no ground loops.
The amplifier chassis ground is disconnected from the audio ground.

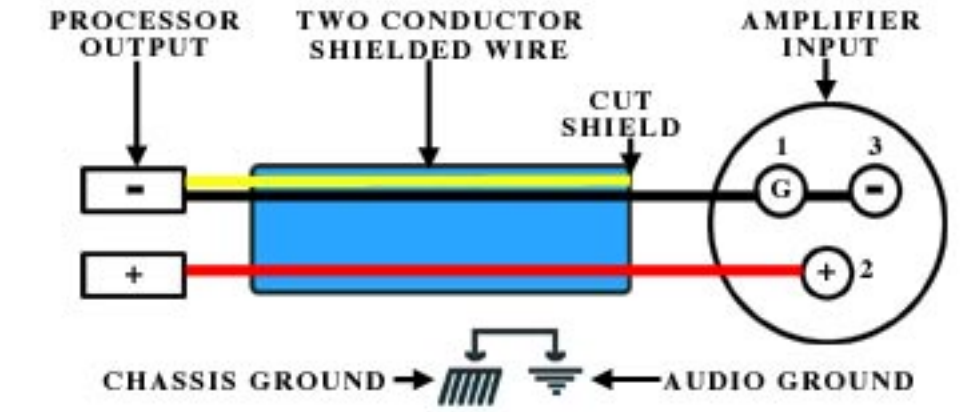
Figure 3. UNBALANCED PROCESSOR OUTPUT TO AN UNBALANCED AMPLIFIER INPUT

The sound systems in a theatre complex, whether there be one or 100, must be constructed in the same way. There must be only one point in the entire system where the various branches of the audio grounds are connected to the chassis ground. In cinema systems, this connection is typically made somewhere on the back-plane on the processor. This is as it should be as we want such a point to be as close to the signal source as possible.

Obviously when six, eight or ten audio channels require that multiple feeds be sent to multiple amplifiers, multiple ground wires are also connected. If the audio and chassis grounds are also connected in all the amplifiers, ground loop circuits are created back through the equipment rack and the AC power ground. Unless there is a means of disconnecting or lifting the audio-to-chassis ground in all these amplifiers, ground loop created hum will occur at various levels.

Professional power amplifiers provide a ground lift switch (or link) on the back panel to prevent this. Some economy amplifiers sold in the professional market leave this feature out, though I can't imagine why. Theatre sound systems using these amplifiers will experience hum at varying degrees. The more efficient the loudspeakers, the louder the

hum will be.



This wiring is correct. There are no ground loops.
The amplifier chassis ground is disconnected from the audio ground.

Figure 4. UNBALANCED PROCESSOR OUTPUT TO BALANCED AMPLIFIER INPUT

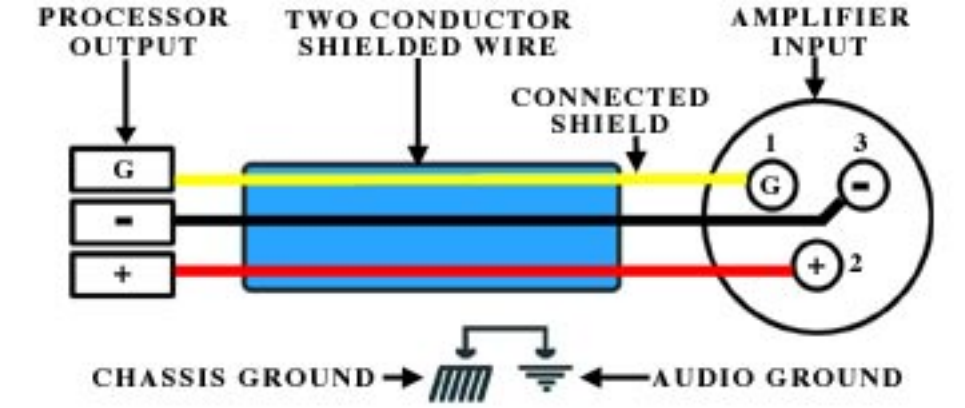
AMPLIFIER INPUT WIRING

Processor output to amplifier input wiring must be done correctly in order to avoid a major source of ground loops and hum. The choice of connectors is important, but mostly for reliability. XLR or Cannon type connectors are an excellent choice. Spade lugs connected to barrier strips (if available) also provide a good connection but are not as easy to disconnect. What should never be used are 1/4 inch phone plugs or "RCA" type consumer connectors as these will almost always become intermittent later on - sometimes as early as the first week.

When connecting a processor to an amplifier, it is best to use a two wire (usually red and black) shielded cable. A foil shield with an uninsulated shield or drain wire is preferred to a braided shield. The drain wire is usually only connected at one end of the cable. While many installers connect the shield at the amplifier or receiving end, it is probably best to connect the shield only at the processor, or sending end, as this is the point with a lower impedance.

In the past, cinema processors generally had unbalanced (two wire) outputs. This provides a signal wire, or plus (+), and a ground (-). Referring to Figures 3 and 4, when using amplifiers with unbalanced inputs, the red wire is connected between the "+"

terminals of both the processor and the amplifier. The black and shield wires are connected together at the "-" or ground terminal of the processor. The shield wire is cut at the amplifier end. Only the black wire is connected to the "-" or ground terminal at the amplifier's input.



This wiring is correct. There are no ground loops.
The amplifier chassis ground is disconnected from the audio ground.

Figure 5. BALANCED PROCESSOR OUTPUT TO BALANCED INPUT OF AN AMPLIFIER WITH GROUND LIFT SWITCH

Cutting the shield at the amplifier end, prevents a ground loop from being created with two wires (perhaps of different gauges) being connected between two points.

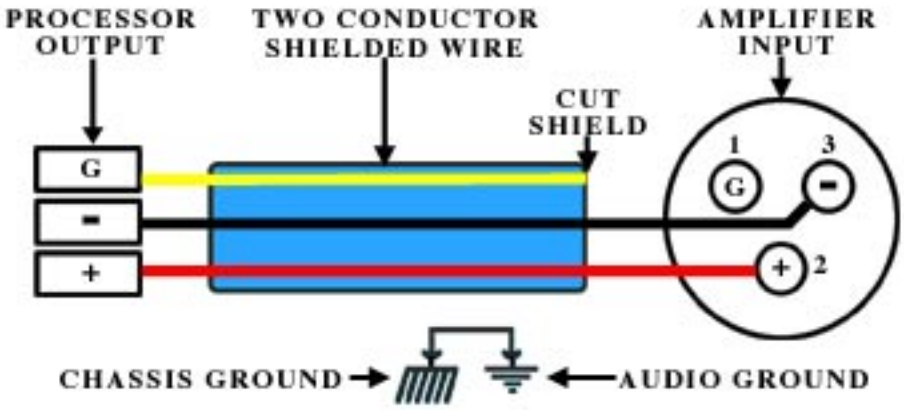
If an amplifier uses a balanced (three wire) input, follow the above procedure, but connect the "-" or "low" wire to pins one and three together in an XLR connector. See Figure 4.

When using a cinema processor with balanced outputs, one should always use amplifiers with balanced inputs. Balanced circuits are best for preventing hum so it's always best to take advantage of them. If a two wire shielded cable is used, connect the wiring according to Figures 5 and 6.

When connecting balanced processor outputs to balanced amplifier inputs, there is one exception to connecting the grounds between the processor and the amplifiers. If one is using amplifiers that do not provide a ground lift switch, do not connect the shield at the amplifier end. This prevents ground loops. The use of balanced wiring between the

processor and the amplifiers will provide the full audio signals without connecting the grounds. This can be a significant advantage. See Figure 6.

In the past few years more and more cinema sound systems have been wired using the FaastLink™ concept. This reduces rack wiring by connecting the processor, the booth monitor and the amplifiers, all with commonly available serial cables. Using this approach does not easily allow one to select the ground wires that will or will not be connected. Because of this, it is best that FaastLink be used with amplifiers providing ground link switches. If the amplifiers do not provide these switches or links, simply use conventional wiring as outlined above.



This wiring is correct. There are no ground loops. The amplifier chassis ground cannot be disconnected from the audio ground.

Figure 6. BALANCED PROCESSOR OUTPUT TO BALANCED INPUT OF AN AMPLIFIER WITHOUT GROUND LIFT SWITCH

These ground loop avoiding connection techniques are also applicable between devices in bi-amplified and tri-amplified sound systems.

AC POWER

As mentioned earlier, AC power wiring is also a very important factor in cinema sound systems when it comes to preventing hum. In motion picture theatres I recommend a single circuit outlet for each amplifier plus one additional circuit for the rest of the sound system.

It is best to place all of an individual theatre's sound components on the same phase.

Doing so eliminates the possibility of third harmonic current generation between the neutrals of different phases that can cause hum in sound systems when powered by all three phases of three phase power systems.

Each theatre ideally should have its own power sub-panel. I like to use isolated ground outlets for all the components in the sound system. These outlets provide a separate wire to ground that is not connected to the neutral or the conduit anywhere except at the main service entry of the building. All the sub-panels should be equipped with separate ground and neutral buses. The link between the neutral and ground busses in all the sub panels should be removed. This link should be connected only at the main breaker panel.

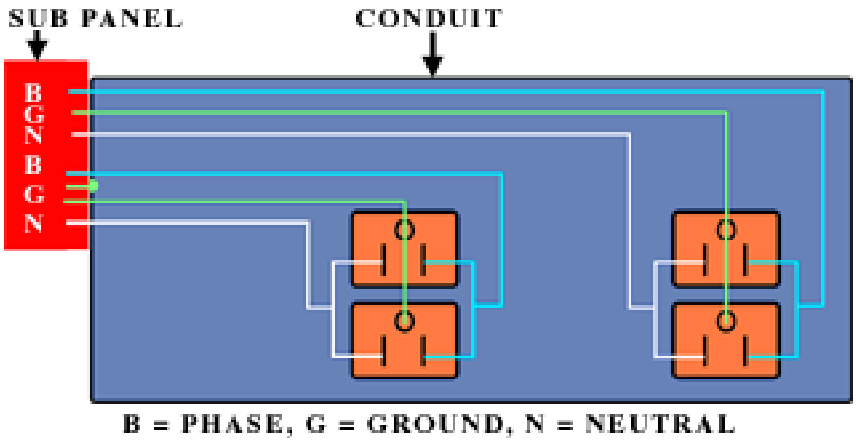


Figure 7. RECOMMENDED ELECTRICAL OUTLET WIRING

LynTec, Incorporated, of Lenexa, Kansas, (www.lyntec.com, 800-724-4047) builds cost effective breaker panels that not only are wired in accordance with good audio practices in mind, but they also provide one button power sequencing. This can be very useful in theatres for obvious reasons. Ground loops are prevented. Plus anyone who can push a button can power up an entire booth with everything coming on in proper order. Pressing the turn off button reverses the process and can even keep the ventilation fan(s) on for and extended period of time without having to wait around.

When wiring the electrical outlets themselves, each outlet should have its own dedicated neutral and ground wires from the breaker panel. No neutral or ground wires should be

shared between circuits. Finally, under no circumstances should metal conduit systems be considered appropriate for adequate grounding in sound systems. See Figure 7.

From the ground in the main breaker panel to any ground in any sound system in any theatre, there should be only one path

Summing up, the recommended practices for eliminating hum include amplifiers with ground lifts, single circuit isolated ground outlets for each amplifier, one additional circuit for all other sound components in the system and using the same phase for all the sound system circuits.

GAIN STRUCTURE

A good gain structure is important for maintaining ideal signal to noise ratios throughout the sound system. This can directly effect hum and noise levels in cinema sound systems. The stronger the signal, the quieter the hum and noise. With a poor signal to noise ratio, one may still hear hum and noise coming through the loudspeakers even if there are no ground loops. Because of this a proper gain structure is as important as wiring in preventing hum and noise.

It is well known that in many movie theatres the preferred position of an amplifier's input level controls is at maximum. This allows us to know that there can only be one certain place where these controls should be. Should the knob be moved either by accident, tampering or a normal service procedure, it can always be returned to maximum and be in the correct position.

I have always understood this approach. I used to do it myself. The disadvantage is that when the amplifiers are run wide open, the signal output voltage of the cinema processor is set quite low. The more efficient the speakers or the greater the gain of the amplifiers, the lower the processor's output becomes. In many situations the signal output of the processor can get as low as 50 to 100 millivolts, which is too close to the hum and noise floor of the cinema processor itself. The ratio of signal to noise is now so low that the hum and noise we hear is coming from the processor rather than a grounding error.

There are several ways around this. They all assume that the processor is operating with an output level of around 300 to 500 millivolts when its pink noise generator is on.

Considering a Dolby processor for example, the output voltage is set using their CAT-85 pink noise generator or its own internal generator. With the fader set at "7", the output levels are adjusted for 300 to 500 millivolts, as measured at the output terminals. The

subwoofer channel should be measured with the processor in the digital mode. (I recommend that the digital subwoofer output level be set at 160 millivolts.)

What happens next depends on where the amplifier's input level controls are located. If they are on the rear of the amplifiers, simply use these controls to set the proper sound levels in the theatre. Set the digital subwoofer level with the amplifier control, then use the optical subwoofer level control in the processor to adjust the optical subwoofer level. The amplifier input controls must now be locked into position. A small 3/8 inch ball of plumber's epoxy will do a great job of locking the knobs to the rear panels. This stuff turns into virtual concrete in minutes. The knob will never move. Should it be required, the epoxy can be knocked off and replaced in the future.

For amplifiers with front mounted input level controls, using epoxy could create an unsightly mess. It's best to use small amounts of epoxy placed under the knobs to make them less noticeable. Some amplifiers now come with handy covers to hide the input controls. These should be installed whenever they are available.

Any discussion of wiring must, of course, take into account local electrical codes and requirements. While the techniques outlined here are effective as they are described, one or more of them may not apply in some areas. Whenever there is any doubt it is always wise to consult with an electrical engineer.

John F. Allen is the founder and president of High Performance Stereo in Newton, Mass. In addition, he serves as the sound director of the Boston Ballet. He is also the inventor of the HPS-4000® motion picture sound system and in 1984 was the first to bring digital sound to the cinema. John Allen can be reached by E-mail at johnfallen@hps4000.com. Mr. Allen's 25 year series of articles written for BOXOFFICE are available for download at http://www.hps4000.com.