

PREVENTING HUM AND RFI

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You patch in a piece of audio equipment, and there it is: HUM! This annoying sound is a common occurrence in sound systems. Hum is an unwanted 60 Hz tone -- 50 Hz in Europe -- maybe with harmonics. If the harmonics are especially strong, the hum becomes an edgy buzz.

Your sound system also might be plagued by RFI (Radio Frequency Interference). It's heard as buzzing, clicks, radio programs, or %ash+in the audio signal. RFI is caused by CB transmitters, computers, lightning, radar, radio and TV transmitters, industrial machines, cell phones, auto ignitions, stage lighting, and other sources.

This article looks at some causes and cures of hum and RFI. By following these suggestions, you can keep your audio clean.

HUM AND CABLES

One cause of hum is audio cables picking up magnetic and electrostatic hum fields radiated by power wiring in the walls of a room. Magnetic hum fields can couple by magnetic induction to audio cables, and electrostatic hum fields can couple capacitively to audio cables. Magnetic hum fields are directional and electrostatic hum fields are not.

Most audio cables are made of one or two insulated conductors (wires) surrounded by a fine-wire mesh shield that reduces electrostatically induced hum. The shield drains induced hum signals to ground when the cable is plugged in. Outside the shield is a plastic or rubber insulating jacket.

Cables are either balanced or unbalanced. A balanced line is a cable that uses two conductors to carry the signal, surrounded by a shield (Figure 1). On each end of the cable is an XLR (3-pin pro audio) connector or TRS (tip-ring-sleeve) phone plug.

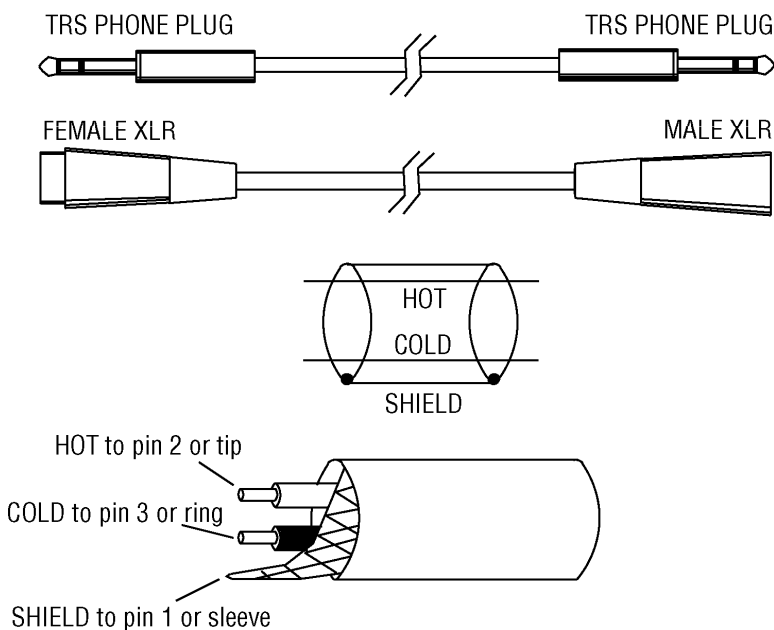


Figure 1. A 2-conductor shielded, balanced line.

Each conductor has equal impedance to ground, and they are twisted together so they occupy about the same position in space on the average. Hum fields from power wiring radiate into each conductor equally, generating equal hum signals on the two conductors (more so if they are a twisted pair). Those two hum signals cancel out at the input of your mixer, because it senses the difference in voltage between those two conductors -- which is zero volts if the two hum signals are equal. That's why balanced cables tend to pick up little or no hum.

An unbalanced line has a single conductor surrounded by a shield (Figure 2). At each end of the cable is a phone plug or RCA (phono) plug. The central conductor and the shield both carry the signal. They are at different impedances to ground, so they pick up different amounts of hum from nearby power wiring. There's a relatively big hum signal between hot and ground that results in more hum than you get with a balanced line of the same length.

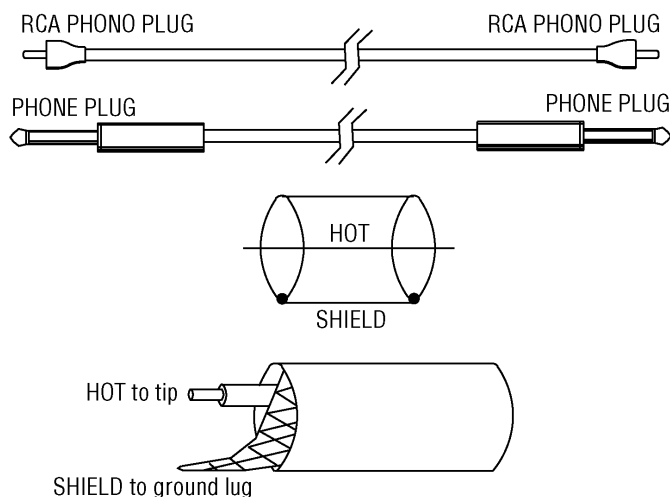


Figure 2. A 1-conductor shielded, unbalanced line.

Some hanging mics have long unbalanced cables, and some cables used between pieces of equipment are unbalanced. An unbalanced line less than 10 feet long usually does not pick up enough hum to be a problem.

Wherever you can, use balanced cables going into balanced equipment. Keep unbalanced cables as short as possible (but long enough so that you can service them). Check inside cable connectors to make sure that the shield and conductors are soldered to the connector terminals.

Route mic cables and patch cords away from power cords; separate them vertically where they cross. This prevents the power cords from inducing hum into the mic cables. Also keep audio equipment and cables away from computer monitors, power amplifiers, lighting dimmers and power transformers. Keep mic cables and mic electronics well separated from lighting equipment in the grids. Better yet, don't use hanging mics. A few stage-floor mics and wireless mics will suffice.

GROUND LOOPS

Another major cause of hum is a ground loop: a circuit made of ground wires. It can occur when two pieces of equipment are connected to the building's safety ground through their power cords, and also are connected to each other through a cable shield (Figure 3). The ground voltage may

be slightly different at each piece of equipment, so a 50- or 60-Hz hum signal flows between the components along the cable shield. It becomes audible as hum. Also, the cable shield/safety ground loops acts like a big antenna, picking up radiated hum fields from power wiring.

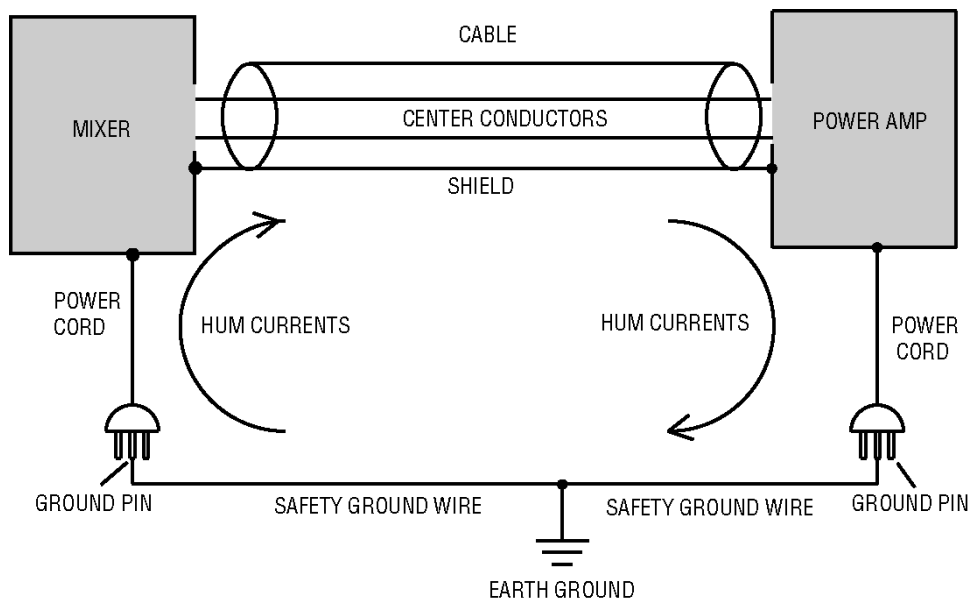


Figure 3. A ground loop.

For example, suppose your mixer's power cord is plugged into a nearby AC outlet. The system power amps are plugged into outlets on stage. So the mixer and amps are probably fed by two different circuit breakers at two different ground voltages. When you connect an audio cable between the mixer and power amps, you create a ground loop and hear hum.

To prevent ground loops, plug all audio equipment into outlet strips powered by the same breaker. (Make sure the breaker can handle the current requirements). Run a thick AC extension cord from the stage outlets to the mixer, and plug the mixer's power cord into that extension cord. That way, the separated equipment chassis will tend to be at the same ground voltage -- there will be very little voltage difference between chassis to generate a hum signal in the shield.

Caution: Some people try to prevent ground loops by putting a 3-to-2 safety ground lifter on the AC power cords. NEVER DO THAT. It creates a serious safety hazard. If the chassis of a component becomes accidentally shorted to a hot conductor in its power cord, and someone touches that chassis, the AC current will flow through that person rather than to the safety ground. Lift the shield in the receiving end of the signal cable instead, and plug all equipment into 3-pin grounded AC outlets.

Let's explain the signal ground lift in more detail. The hum current in a ground loop flows in the audio cable shield, and can induce a hum signal in the signal conductors. You can cut the audio cable shield at one end to stop the flow of hum current. The shield is still grounded at the other end of the cable, and the signal still flows through the two audio leads inside the cable.

So, to break up a ground loop, disconnect the cable shield from pin 1 in line-level balanced cables at the male XLR end (Figure 4). You can either cut the shield, or plug in an inline audio cable ground-lift adapter.

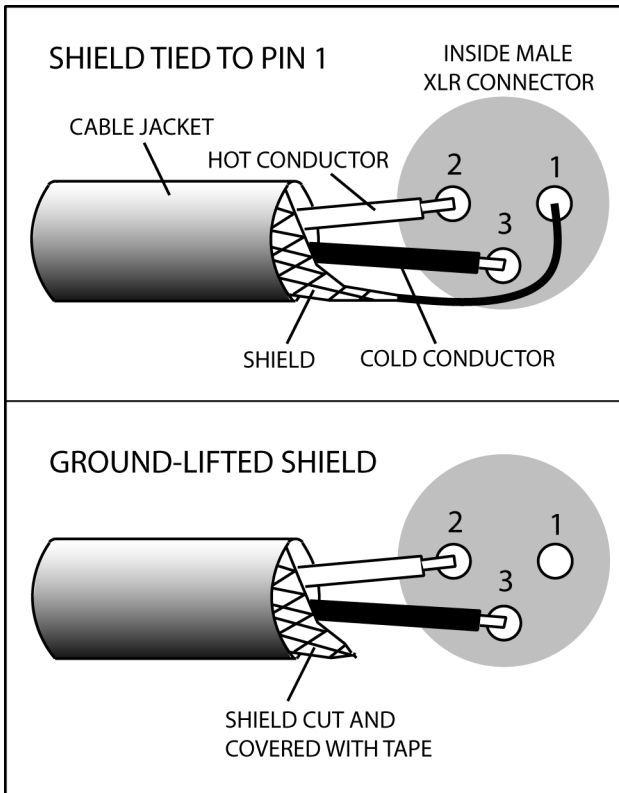


Figure 4. Lifting the shield from the pin-1 ground in a male XLR connector.

Removing the shield connection at one end of the audio cable makes the connection sensitive to radio-frequency interference (RFI). So solder a 100 pF capacitor between the shield and XLR pin 1 (Figure 5). This effectively shorts RFI to ground, but is an open circuit for hum frequencies.

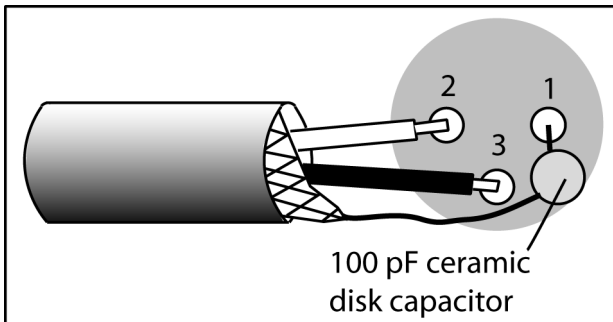


Figure 5. Supplementing the lifted shield with a capacitor prevents RFI.

Some engineers create a partial ground lift by placing a 100 ohm resistor between the cable shield and male XLR pin 1 (Figure 6). This limits the current passing through the cable shield but still provides a good ground connection.

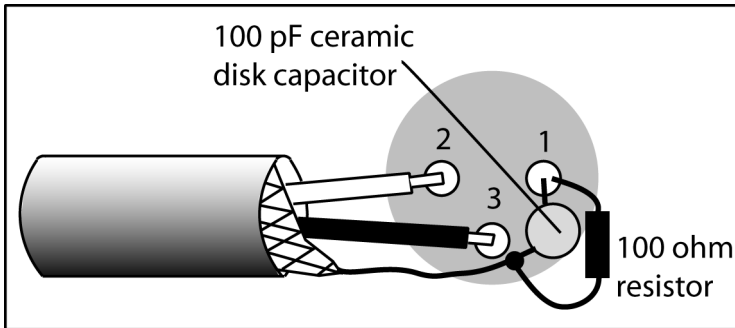


Figure 6. A ground lift using a 100 ohm resistor and a 100 pF capacitor.

Label the XLR connector "GND LIFT" so you don't use the cable where it's not needed. For example, mic cables must have the shield tied to pin 1 on both ends of the cable. The ground lift is only for line-level cables.

Here's another way to prevent a ground loop when connecting two balanced or unbalanced devices. Connect between them a 1:1 isolation transformer or hum eliminator (such as Jensen or Ebtech, shown below).



Jensen Iso-Max CI-2RR



Ebtech Hum Eliminators

OTHER TIPS

Even if your system is wired properly, hum or RFI may appear when you make a connection. Follow these tips to stop the problem:

- Unplug all equipment from each other. Start by listening just to the powered PA speakers. Connect a component to the system one at a time, and see when the hum starts.

- Remove audio cables from your devices and listen to each device by itself. It may be defective.
- Partly turn down the volume on your power amp, and feed it a higher-level signal from your mixer (0 VU maximum).
- If you are using a mic snake, be sure that its stage box is not touching metal.
- Do not wire XLR pin 1 to the connector-shell lug because the shell can cause a ground loop if it touches grounded metal. If you are sure that the shell won't touch metal, wire XLR pin 1 to the shell lug to prevent RFI.
- Try another mic. Some dynamic mics have hum-bucking windings.
- If you hear hum or buzz from an electric guitar, have the player move to a different location or aim in a different direction. Magnetic hum fields are directional, and moving or rotating the guitar pickup can reduce the coupling to those fields.
- If the hum is coming from a direct box, flip its ground-lift switch.
- Turn down the high-frequency EQ on a buzzing bass guitar signal.
- If you think that a speaker cable, mic cable or patch cord is picking up RFI, wrap the cable several times around an RFI choke (available at Radio Shack or other electronics supply houses). Put the choke near the device that is receiving audio.
- Install high-quality RFI filters in the AC power outlets. The cheap types available from local electronics shops are generally ineffective.
- Connect cable shields directly to the equipment chassis instead of to XLR pin 1, or in addition to pin 1. Some equipment is designed this way to prevent the "pin 1 problem". The cable shield should be grounded directly to the chassis -- not connected instead to a ground terminal on a circuit board inside the chassis.
- Periodically clean connector contacts with Caig Labs DeoxIT, or at least unplug and plug them in several times. See www.caig.com.

By following all these tips, you can greatly reduce the likelihood of hum and RFI in your audio system. Good luck!

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AES and Syn Aud Con member Bruce Bartlett is the author of *Practical Recording Techniques 5th Edition* and *Recording Music On Location* published by Focal Press.