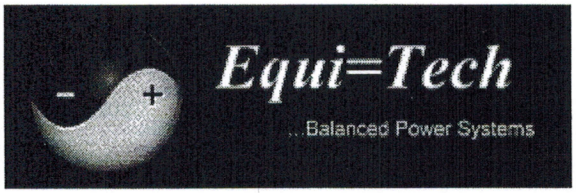


AUDIO WIRING AND GROUNDING

TWO BASIC TECHNIQUES OF AUDIO WIRING AND GROUNDING will be discussed -- standard methods used in facilities with conventional AC power and new methods used in facilities with balanced AC power. There are some grounding techniques that apply to both types of ac systems but there are a few important differences.

Most every system utilizing standard methods of wiring and grounding will see a significant improvement in the system's background noise level when balanced power is applied. Usually, noise can be attenuated still further when some additional grounding methods are applied.

Under a globally applied balanced power grid, these grounding methods may be used which were otherwise impossible under normal circumstances without increasing background noise. This is due primarily to a unity potential (zero crossing ac ground reference) that is now equally present in every equipment chassis in a facility. Removing most AC ground lift adapters and reconnecting the majority of shields that were previously telescoped or lifted at one end are some of the grounding techniques possible in a balanced-power oriented system.

A general rule which applies to audio wiring with balanced power is: ground everything, lift nothing and connect all shields (at both ends.) There are a few exceptions which will be described later in detail. If audio interconnections are unbalanced, balance them. If audio is already balanced keep it balanced.

Audio Ground References

Standard Methods:

All audio interconnections utilize a ground reference. In unbalanced audio interconnections, there is a direct mode signal between one signal conductor and the audio ground. In a balanced audio circuit, there is a common mode signal between two conductors that are inversely phased to audio ground. In both cases the audio ground is part of the audio signal reference and it is usually connected to the chassis of the equipment, which itself is often referenced to earth ground.

When connecting the audio ground between two pieces of audio equipment, a grounding path is created. If there is an increased potential in any chassis, reactive current (noise) will be introduced into the signal reference of which the audio ground is also a part. This is often called a "ground loop" -- but this is a misnomer. A "ground loop" is not really a loop but an indication of current flow into signal circuits resulting from objectionable voltage potentials transversing the grounding reference. Many techniques have been developed over the years in an attempt to deal with this problem. Some of these methods include using short audio cables, audio isolation transformers, single-point grounding, linear signal reference grids, star grounding, lifting audio

grounds from chassis and lifting or telescoping shields. Another common practice involves the use of AC ground lift adapters on gear with 3 prong AC power cords -- indeed a very dangerous technique. If any component were to short to chassis ground, touching that chassis could place one's body in the grounding path, a typical scenario for electrocution. (For example: holding a balanced microphone standing on a wet stage.)

New Methods Used with Balanced Power:

The "ground loop" phenomenon has not been clearly defined until the advent of balanced AC power. The technology provides a new reference point and a new understanding of grounding.

When chassis and audio grounds are connected to the center tap of a balanced AC isolation transformer, they are referenced to the mean AC voltage differential which is equivalent to the zero crossing point of the AC sine wave. There is no current or voltage on the center tap -- here is a clean single point ground reference for audio. Virtually all chassis, audio grounds and shields can be referenced back to this single point. The center tap of the transformer is then grounded to earth for safety and to shunt any electromagnetic and radio frequency interference away from shields and chassis.

In almost every case, AC ground lift adapters can be removed from gear with 3-prong AC power cords and the chassis of gear with a 2-prong AC power cords can now be grounded without introducing hum and noise into system as may be the case with unbalanced AC power. Most shields that were telescoped or lifted at one end can now be connected and grounded at both ends because there is no longer any difference in potential between the audio chassis. The audio grounds can be connected to a single point at the AC system. Generally as more gear is grounded and shields are reconnected, the system gets quieter.

Occasionally there will be a piece of equipment that has a "dirty" or noisy chassis because of a substandard power supply, internal grounding problems or for other reasons. In many cases this equipment is semi-professional unbalanced audio gear with a two prong AC power cord. The best way to deal with this equipment is to leave the two prong cord on it, isolate that chassis from any rack rails or other chassis, balance the audio with a direct box or audio isolation transformer and connect it to the console or other device's balanced connections. Then lift the audio ground/shield of the balanced line at the inputs so you do not contaminate your "clean" audio ground with this "dirty" chassis ground.

Unbalanced Audio Connections

Standard methods:

In a standard unbalanced interconnection there is a one signal conductor and a shield. The shield is commonly an integral part of the signal reference. One thing that has been done to alter this standard unbalanced wiring configuration is to use balanced audio cable with 2 conductors and a shield. Use the one conductor for the signal and the other for the ground and lift the shield at one end of the cable, usually at the input. Often upgrading from unbalanced cables to balanced cables with a good quality shield will yield positive results.

Another approach has been to insert various types of filters into the cable, including putting capacitors in place of a part of the ground wire, in an attempt to remove unwanted hum and noise from the system. This has worked to varying degrees, depending on the nature of the application. However, filters in the audio chain can alter

or colorize the signal and capacitors in the ground path are dangerous and could result in a shock hazard.

New methods used with balanced power:

In most cases when using balanced power, unbalanced audio can be interconnected in a standard way. Using balanced cable with a good quality shield is still a sound practice, just connect the shield at both ends. The only exception is when there is a "dirty" chassis (see section above.)

Balancing unbalanced audio at the source with a direct box or audio isolation transformer and running it balanced will lower the overall system noise floor. An example would be using a direct box at the output of a keyboard to balance the signal and sending it into a balanced pre-amp at the console. Balanced audio is highly compatible with balanced power -- perhaps more than unbalanced audio. General rule: if it's unbalanced, balance it if possible and keep it that way. Remember balanced power and balanced audio both reject common mode noise better than their unbalanced versions.

Balanced Audio Connections

Standard methods:

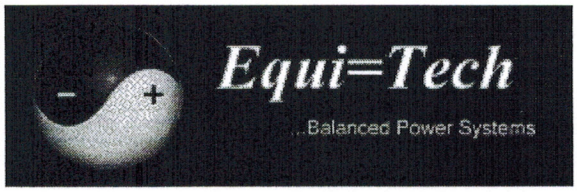
In a standard balanced interconnection there are two signal conductors and a shield. The shield is normally referenced to ground at one or both ends. Many times the shield is disconnected or lifted at one end, usually at the input to eliminate "ground loops" or noise. The problem with this approach is that while it may reduce hum, the shields act as radio antennas and pickup radio frequency interference from the environment. This can be a serious problem in an environment that has computers, MIDI gear and other digital systems.

Top engineers, as of late 1994, still have not agreed on which end of the shield to connect on balanced interconnections. Though most will tell you if it must be lifted, do it at the input, that way the shield (which now has an impedance across it like a radio antenna) is connected to the audio ground of the output device where EMI/RFI is less likely to be picked up by the input.

The degree to which a cable is balanced from each conductor to ground, as well as it's overall impedance and capacitance, seem to be critical factors in a cable's overall performance. Some manufacturers have even built balanced cables with filters in them to filter out unwanted noise and to deal with the cable as a component in the audio system.

New methods used with balanced power:

In virtually every case, with balanced power, balanced audio can be interconnected in a standard way with the shield hooked up at both ends. The only exception is when a piece of gear has a "dirty" chassis, which requires isolation away from the rest of the grounding system. This can usually be accomplished by lifting the audio ground at the input and isolating the offending chassis from other chassis with insulators. A "dirty" chassis condition is rare in professional audio equipment and it often is the result of a substandard power supply or the audio ground not being connected to the chassis. These problems can often be fixed with some effort. In general, wiring and grounding techniques are far simpler with balanced power and it is easier to identify and deal with any offending piece of equipment.



INSTALLING A TECHNICAL GROUNDING SYSTEM FOR BALANCED POWER

In most cases plugging an ***Equi=Tech*** Rack System into a standard grounded outlet will provide an adequate ground. An isolated ground is recommended for optimal performance. The following procedure will explain how to install an isolated ground for balanced power.

1.) Drive two copper-clad 8-foot x 5/8" min. ground rods, 6 feet apart or more. As an option, a ring ground, plate ground or other low impedance-grounding electrode may be used. Consult with a qualified electrical installer if you choose one of the alternates. Using an alternate grounding electrode for a technical ground is normally unnecessary with balanced power unless poor soil conductivity or very high RF levels are a problem.

2.) Run a #6 copper wire between the two ground rods passing through an acorn clamp on one of the rods and terminating the run at the main grounding electrode of the building's AC system. It is essential to bond together all of the grounding electrodes in a building for safety.

3.) NEVER use a separate grounding electrode system for the technical ground without bonding it to the building's main grounding electrode. Connecting them together insures that there will be no difference in the potential between the technical ground and the building ground. If the technical ground and building ground are not bonded together, it is possible that someone may be shocked if a fault condition occurs. Though it is common practice to use a separate technical ground for equipment, with balanced power this is not necessary.

4.) From the isolated AC ground buss in the studio power panel, run a #6 copper wire to one of the new ground rods and connect it with an acorn clamp. You can use a separate isolated ground buss if one is not available in the tech-power panel. The isolated ground buss is where all technical power circuit grounds will be bonded. The configuration of this technical grounding system is often referred to as a "single-point ground". All equipment grounds are referenced to the isolated ground buss, which is also referenced to earth ground and the center tap of the ***Equi=Tech*** isolation transformer.

5.) From the isolated ground buss, run a ground wire with the circuit wires to each receptacle outlet. If you are using metal conduit or metal clad (MC) cable and metal boxes, isolated ground receptacles must be used. If you are using metal conduit or metal clad cable make sure that you use an insulated green wire for your ground. Use the bare wire if romex is used. Multiple receptacles may be ganged together on a single ground wire. Radial or star grounding is unnecessary with balanced AC.

6.) Once the technical power circuits have been installed and all receptacle grounds have been connected to the isolated ground buss, you can now plug the ***Equi=Tech*** unit into the outlet. Equipment with a 3-prong plug is grounded via the AC cord. Equipment with a two prong cord may be grounded with a supplemental ground wire. This is done by connecting the bare metal of the equipment chassis to the technical ground with a #12 green copper wire. Use the grounding terminal on the back of the ***Equi=Tech*** rack system to ground equipment chassis.

7.) NEVER use an AC ground lift adapter on equipment that has a grounded 3-prong AC cord. This is very dangerous. When using unbalanced power, chassis and/or signal grounds are often lifted from the AC ground to reduce noise. When balanced power is used, all chassis and audio/video signal grounds can be referenced to the AC ground without adding interference. The only exception to this is when a piece of equipment has a rare "dirty chassis condition." (See ***Equi=Tech*** Technical Paper: "Audio Wiring and Grounding" for more information.)