ALTAIRA GROUNDING SYSTEM

CONCEPTS GUIDE

The subject of grounding can be confusing. There are many terminologies: earth ground, chassis ground, safety ground, circuit ground, signal ground, mains panel ground, ground rods, neutral ground, power supply ground, ground loops and more. It is not our intention to define or describe all of the technicalities associated with grounds — rather we will take a general and simplified approach so that the non-technical reader may understand the basics of grounding. These concepts and techniques are essential to optimizing and improving the performance of your home entertainment system.

HISTORICAL GROUNDING PRACTICES

Many of the best practices used in audio have come from the early days of the telecommunications industry. It was common practice to mount equipment in a metal rack. The equipment in the rack would be connected to a common grounding lug or terminal using braided ground conductors. Every electronic device had a dedicated grounding lug for this ground connection. This practice continues today in both the telecommunication and networking industries. Components of the era were commonly equipped with single-ended RCA jacks that are quite susceptible to ground currents which could result in audible hum and buzz. Connecting all equipment to a central ground point ensured electrical safety and eliminated voltage differences between component chassis that caused the ground loop problems.

With the advent of modern day, mass-market consumer audio products and plastic chassis, many components no longer include a ground terminal. The most common exceptions are turntables and phono-preamplifiers where ground terminals are required to prevent hum. Of course, turntables and phono-preamps are *legacy components* that have survived from an earlier generation of audio systems.

Although many components are no longer equipped with a dedicated chassis ground terminal, it is still advantageous to ground all of your equipment to a common grounding system. This reduces ground loop currents and the associated hum and noise problems. An external grounding system improves overall audio and video performance even if there are no obvious ground loops or hum.

There are two broad categories of grounding systems. While they are related and often interconnected, there are significant differences that are important in understanding how and why grounding errors can cause significant performance problems.

EARTH-GROUND SYSTEM

Earth-Ground System

The first category can be called the *earth-ground system*. It begins at the ground rod and includes the electrical panel grounds, in-wall AC ground wiring, socket or outlet ground pins, power cord ground wires and finally the metal chassis of each of the appliances or electronic device plugged into the AC power circuits.

Electrical Safety Ground

There are three conductors in modern household AC circuits: the line, the neutral and the *safety ground*. The safety ground wire provides an unbroken pathway from the appliance or electronic device through the in-wall wiring to the electrical panel's ground buss. Safety grounds serve only one purpose: to prevent electrocution and electrical fire.

Chassis Grounds

The term *chassis ground* refers to the metal enclosure of an electronic component or appliance. The component has an internal wire that connects directly from the AC power cord or inlet (ground pin) to the metal chassis itself. In essence, the component's chassis is an extension of the safety ground. The NEC electrical code *requires* this connection and it is critical in preventing electrocution or a potential fire hazard in the event of an electrical fault.

For example, if a live wire were to come loose within an appliance and touch the metal case it could potentially electrocute someone that touches the appliance. The *safety ground* ensures that the current is diverted (shorted) back to the electrical panel causing the circuit breaker to open.

You should NEVER disconnect the ground wires within an outlet, or disable the ground wire in a power cord, or use a cheater adapter to disable the ground connection.

SIGNAL-GROUND SYSTEM

The second major grounding system is the *signal grounding system*. Unlike the earth-ground system, there are many *signal grounds* in a system. Each electronic component that amplifies or transmits a signal will have one or more signal grounds.

The signal ground begins within the component's power supplies. The signal grounds include the ground wires from the power supply, the PCB ground traces, and the ground wires that interconnect the PCBs and electronic components. Finally, it includes the input and output connectors and interconnecting wires that carry electrical signals.

The purpose of the power supply is to rectify the power, which means it converts incoming AC voltage to DC voltage. The rectification circuit creates a specific DC voltage and it establishes a *zero reference point* the purpose of which is to provide a return-current pathway. This zero reference point is what is often referred to as DC ground or signal ground. This means that the current that flows through the DC power wires to the circuitry must have a return current pathway back to the power supply. Basically, current flows in both the signal paths and in the return ground pathways. As such, the ground pathways are part of the signal path and can profoundly affect sonic performance.

For example, a preamplifier is designed to amplify a signal from a source component and send that signal to an amplifier. Internally, the preamplifier has a power supply that converts the AC voltage to DC voltage. The amplification circuits in the preamplifier modulate the DC voltage with the input signal and send the amplified signal to the output connectors. A simple amplification circuit consists of a signal conductor and a signal return conductor which is commonly called the signal ground. So a signal ground is local to a specific circuit and the associated power supply that supplies voltage and current to it. It is usually directly connected to ground reference of the DC power supply. Engineers commonly refer to this as the *zero voltage level* when taking measurements with meters and oscilloscopes.

In most (but not all) components, the signal grounds are directly connected to the component's chassis ground. This is where the confusion between chassis grounds and signal grounds begins because measurements will show that they are electrically connected. However, there are some components that are designed in such a way that the signal grounds are NOT connected to the chassis grounds. Sometimes it is said that the signal grounds are *floating*. For this reason, the signal grounds *may not* be at the same voltage level when referenced to the chassis ground. Therefore it is important to treat signal grounds differently and more carefully than chassis grounds.

This illustrates the important fundamental difference between chassis grounds and signal grounds.
To summarize simply: Earth-grounds and chassis grounds DO NOT carry current during normal operation.
By contrast, signal grounds by their very nature must carry the return currents and are therefore very much part of the signal path.

This is the foundational reason that earth-ground systems and signal ground systems MUST be treated separately and differently depending upon the specific context and type of electronic components involved.

DOES CHASSIS GROUNDING REALLY MATTER?

The amount of noise that exists on the safety grounds and on the component chassis' can significantly impair the performance of even the most expensive systems. The long runs of wire in the wall, the power cords and the chassis' themselves can all act as antennas, picking up radio frequency signals and electrical interference in the environment. Although most people assume that ground implies ZERO, all power supply grounds and all chassis grounds in fact have some residual, measurable levels of noise. Using a power analyzer or oscilloscope will quickly reveal significant amounts of radio, television, microwave, Wi-Fi and cell phone interference pervading the grounding system.

Why Signal Grounding is Important

The electronic components themselves actually generate noise within the power supply and the electronic circuits. This noise is intentionally channeled or bypassed to the power supply ground in an effort to reduce signal noise. This practice often modulates the ground-plane of the power supply with random noise and harmonic distortion — the consequence being higher levels of distortion and noise at the signal output.

To compound the issue, multiple components may be interconnected with RCA, XLR, USB, Ethernet, and other connections; all of which can transmit noise from one component to another via the signal grounds. This type of noise is not always as obvious as in the case of audible hum, hiss or buzzing. This interference increases the noise level and decreases resolution and clarity of the source signal by raising the baseline noise level and smearing signal transients. A properly designed and implemented grounding system significantly improves overall system performance by reducing perceived noise, refining dynamics, and improving resolution.

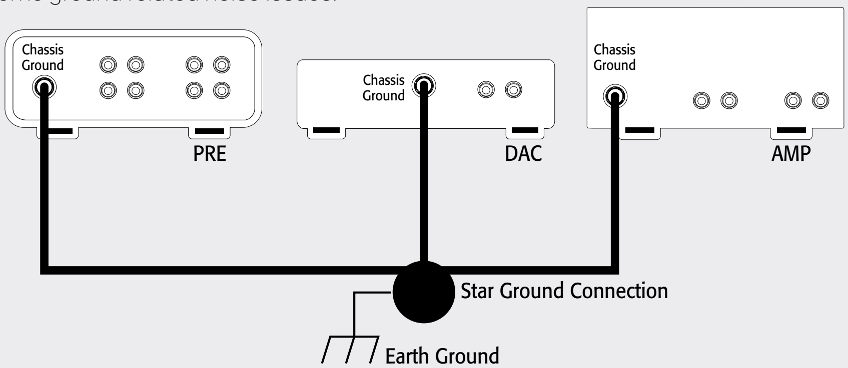
GROUND SYSTEM ARCHITECTURES

There are several different grounding architectures including a star ground system, a hub-based system, and ground network architectures. An understanding of these architectures is helpful when designing and configuring a high-performance grounding system.

Star Ground Systems

The most basic type of grounding architecture is a simple star grounded system. Star grounding reduces slight voltage differences between components' chassis and may eliminate or reduce ground loop issues. The measured voltage differentials can be as little as several milli-volts to several tens of volts between any two components' chassis.

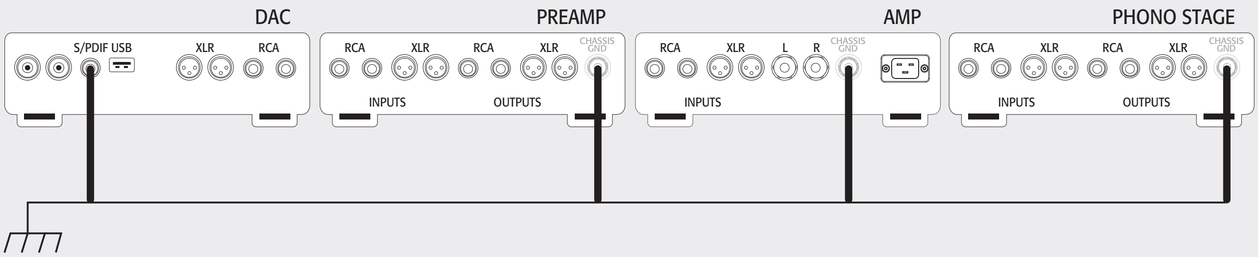
In a star grounding system each component has a separate ground wire that connects to its chassis. All of the individual grounding wires are connected to a single *earth-ground* conductive element such as a large safety ground wire, conductive bolt or conductive water pipe. In some installations, a highly conductive ground braid is used as the center of the star. A simple star grounding system for an audio system is relatively easy to create and can be very effective at eliminating ground loops and some ground related noise issues.



GROUND SYSTEM ARCHITECTURES

Buss Grounding Architecture

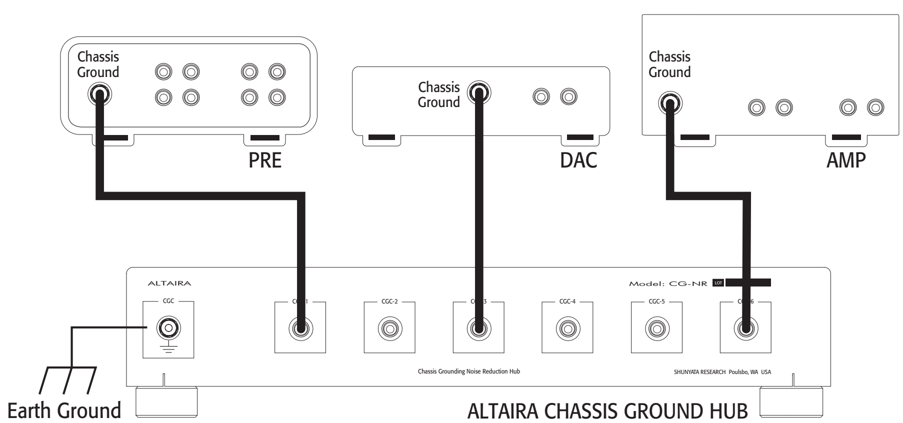
A buss type grounding system is different than a star grounding system in that it consists of a long wire or braid. The components are connected with short taps along the length of buss cable.



Hub Based Ground System

A hub-based grounding architecture is very similar to the star-ground system except the single connection point is replaced with a multiple terminal ground hub. The hub grounding system may improve on the star system by providing some form of noise reduction technology or provide ground-noise *component-to-component isolation*.

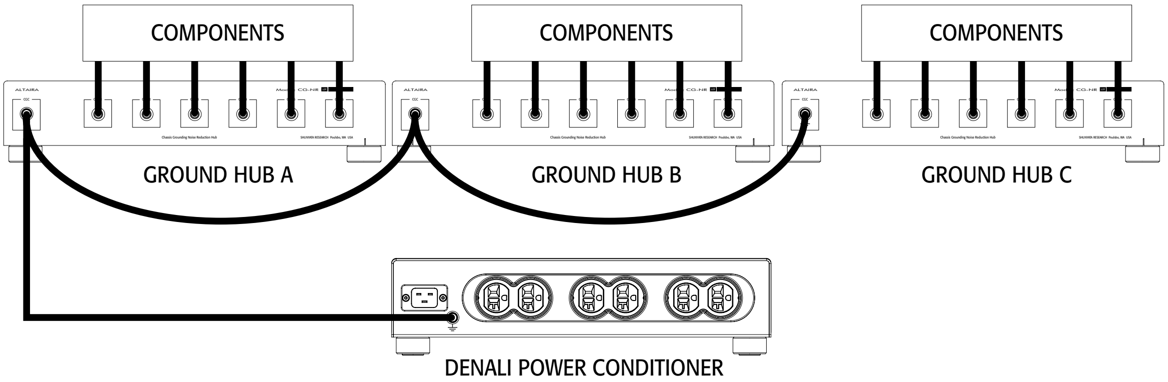
A grounding hub may also provide a means to interconnect multiple hubs together while providing a simple method to connection to a power distributor's earth-ground system.



GROUND SYSTEM ARCHITECTURES

Network Grounding System

The *network grounding architecture* is the most complex grounding system but has the ability to provide the highest levels of performance. Multiple ground hubs may be used to expand the grounding system to include many components. The hubs may be interconnected in network-like architectures and the grounding hubs may be configured in a variety of ways including; a star type configuration, a buss type or a hybrid array of both.



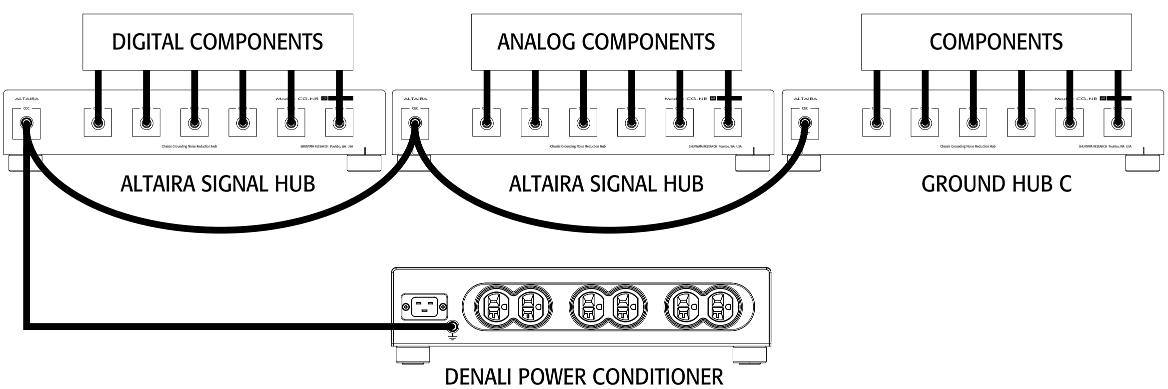
ADVANCED GROUNDING ARCHITECTURES

Segmented Ground Hubs

A *Segmented Grounding System* uses multiple grounding hubs to segregate specific component types into logical domains. Different components with different types of power supplies or circuit types produce different types and qualities of noise. Using a ground hub that has noise reduction technology can be an effective way to reduce the noise artifacts that are specific to certain types of components.

Segregating specific types of components and isolating them into a single ground domain may significantly improve performance. Digital components are notorious for producing prodigious amounts of ground noise that can interfere with other components. Phono-preamplifiers are particularly susceptible to low levels of ground-plane noise. Therefore, separating digital components from analog components may improve performance by protecting the analog component ground-plane from noise artifacts generated by the digital components.

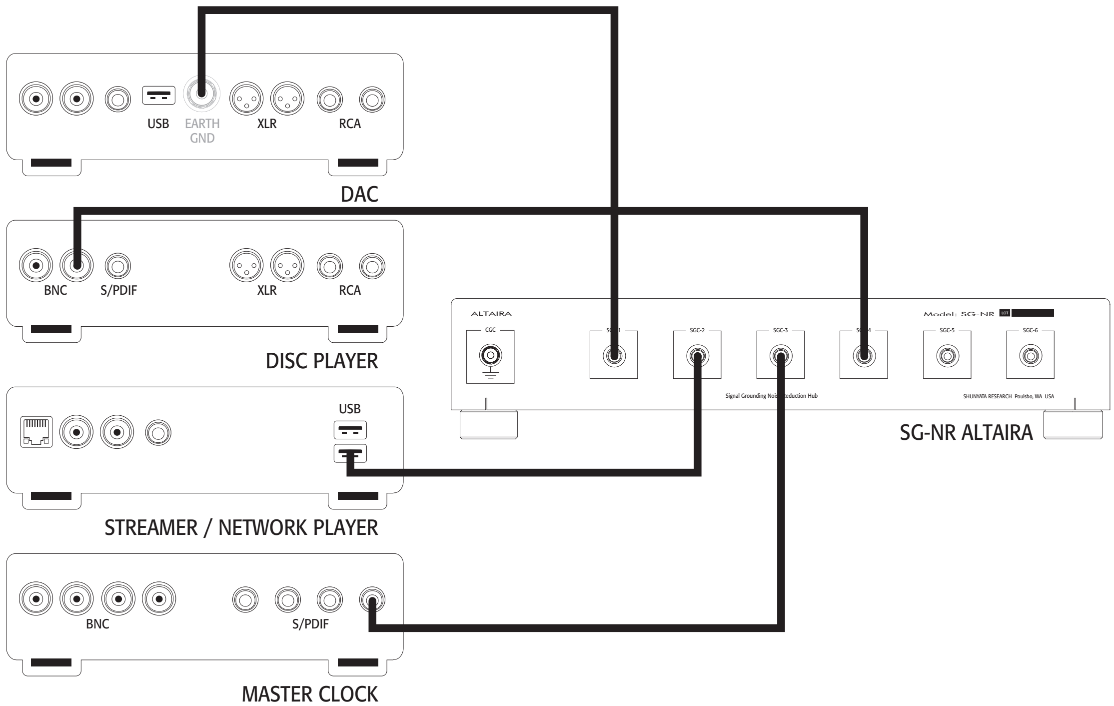
Grouping digital components, computer components, video components, and analog components onto individually segmented hubs reduces noise across the individual ground domains and improves overall system performance. Using a *ground-plane noise reduction type hub* can be an effective way to segregate the noise artifacts from each of the grounding domains.



ADVANCED GROUNDING ARCHITECTURES

Digital Component Stacks

Very advanced digital stacks that are composed of multiple components such as those from dCS, Esoteric and MSB benefit greatly from dedicating a single ALTAIRA Signal Ground Hub to the digital stack.



Dual-Mono Grounding Strategy

Many audio components have dual-mono circuitry that is intended to reduce cross-channel modulation and crosstalk between left and right channels. Dual-mono means that the left and right channels are completely separated within the component's chassis and may even have separate power supplies and power transformers for each channel. Some manufacturers actually provide separate chassis for each channel and separate power supply chassis.

If the audio system has separate components, from the same manufacturer, such as a phono-preamplifier, preamplifier and mono-block amplifiers, and all of those components are dual-mono; channel separation can be maintained through all the component amplification stages.

What is not well known is that a common internal ground-plane that is shared between the signal channels can seriously degrade the cross-channel noise isolation that was intended by the designer.

Introducing an external grounding system can completely upend this dual-mono separation. If a simple external grounding system is connected to any of these components, that separation will be effectively circumvented. This is because noise can travel from one channel, through the external ground system and then enter the other channel's ground-plane, degrading its performance. It is for this reason that *Shunyata Research has developed a grounding system strategy that provides the benefits of system grounding while at the same preserving the ground-plane channel separation intended by the component manufacturer.*

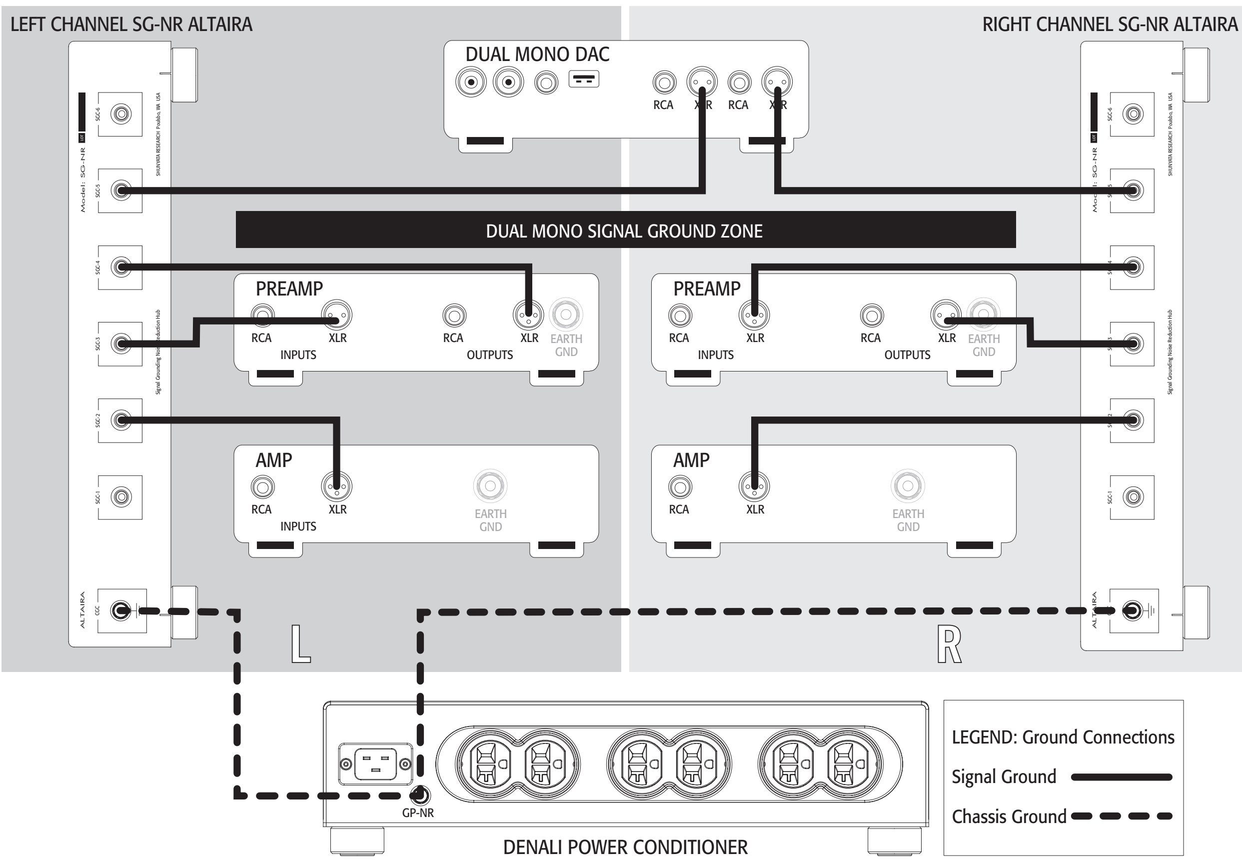
ADVANCED GROUNDING ARCHITECTURES

How to implement a dual-mono grounding system

Dual-mono system grounding requires two separate ALTAIRA signal hubs, one for each signal channel. One hub is dedicated to the left channel and a different hub is dedicated to the right channel. The right channel hub will have a ground cable connected to the right channel of the phono-preamp and a ground cable connected to the right channel of the preamplifier and a ground cable connected to the right channel mono-block amplifier. The left channel hub will have a ground cable connected to the left channel of the phono-preamp and a ground cable connected to the left channel of the preamplifier and a ground cable connected to the left channel mono-block amplifier.

This method provides a completely separate external grounding system for each of the channels, preserving signal channel isolation even through the ground-planes.

NOTE: The ground cables are connected to an unused signal connector's ground pin (XLR) or barrel (RCA). Some electronics brands actually have a "signal ground" terminal on the back of their equipment which makes this method easy to implement. (CH Precision is an example)



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