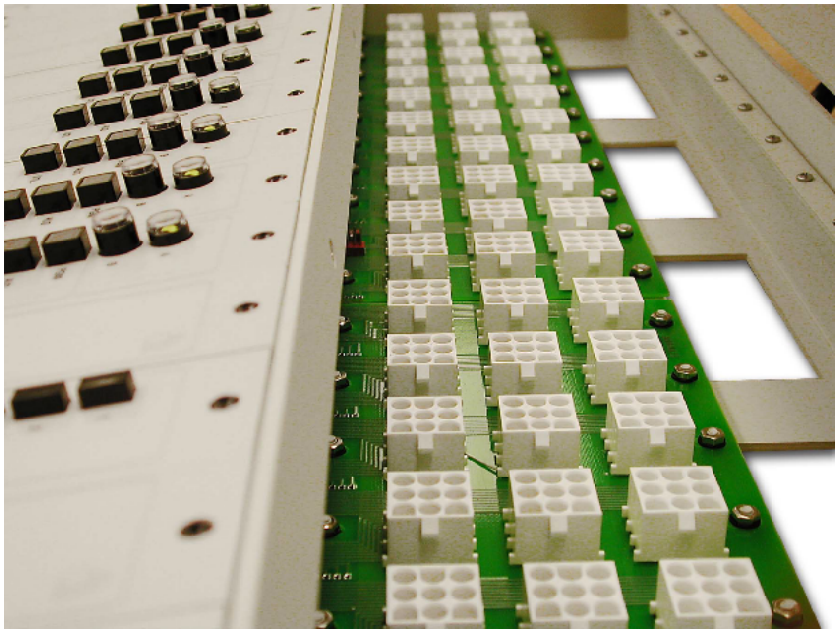
Audio Equipment & Cables

Arrakis Systems inc.

application note



Purpose of this Ap Note

This application note is designed as a practical aid for designing, installing, and debugging low noise, high performance audio broadcast studios and facilities. It is intended for use by novice and experienced “technical” people alike, including managers.

The application note focuses on the basic principles of audio “systems” design. Simple mathematical models are used only as they illustrate a principle. We find that it is the proper understanding and application of basic principles that results in a professional audio installation. It is often only through an application of basic principles that a problematic installation can be corrected.

In preparation for writing this application note, we have performed an extensive review of available technical literature and product manuals on these subjects. The review underlined the complexity of modern audio systems design and that this is a field under constant change. Combining audio products from the broadcast, consumer, music, commercial sound, and now personal computer industries into a single facility is a challenge. These different industries have different product design goals that have resulted in an inability to simply “plug and play.” It would be thought that it would be possible to simply purchase equipment and off the shelf interconnection cables to assemble an audio facility. However, variations in audio levels, impedance, connector designs, AC and audio ground systems, and other factors make this difficult. The purpose of this application note is to help to provide enough of an understanding of the underlying principles to be able to overcome these obstacles.

Arrakis Systems has been building professional radio consoles since the late 1970‘s and digital audio source equipment since the early 1990’s. We are a leading manufacturer and innovator in the professional broadcast audio industry. We have accumulated experience with thousands of studios in diverse conditions around the world.

I- Important Information

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Important Disclaimer

Use of the information in this document is entirely at the reader's risk. Although precaution has been taken in the preparation of this document, Arrakis Systems inc. assumes no responsibility for errors or omissions. Neither is any liability assumed for damages resulting from the use of the information contained herein.

Danger- Shock & other hazards

Electronic products may contain potentially lethal voltages and currents and should be serviced by trained and experienced personnel only. Any installation, test, or calibration procedures in this document that require access to the interior of the equipment should be performed by qualified personnel only.

How to Contact Arrakis

Arrakis Systems inc. is located at		Arrakis Systems inc 6604 Powell Street Loveland, Colorado 80538
Business Hours:		8:00am - 4:30pm mountain time
Contact:	Voice:	970-461-0730
	Fax:	970-663-1010
	email:	support@arrakis-systems.com
	web:	www.arrakis-systems.com

Having difficulty contacting Arrakis? Refer to the website (www.arrakis-systems.com) for current contact information

TYPES OF AUDIO EQUIPMENT

6.0 Unbalanced (Consumer type) Audio Equipment

a) The primary defining characteristic of consumer audio equipment is that it has an unbalanced audio signal path. This means (as shown below) that the audio signal is defined as the voltage difference between “Signal” and “Ground”. If there is any noise added to either the Signal wire or Ground, then that noise will appear at the output of the device.

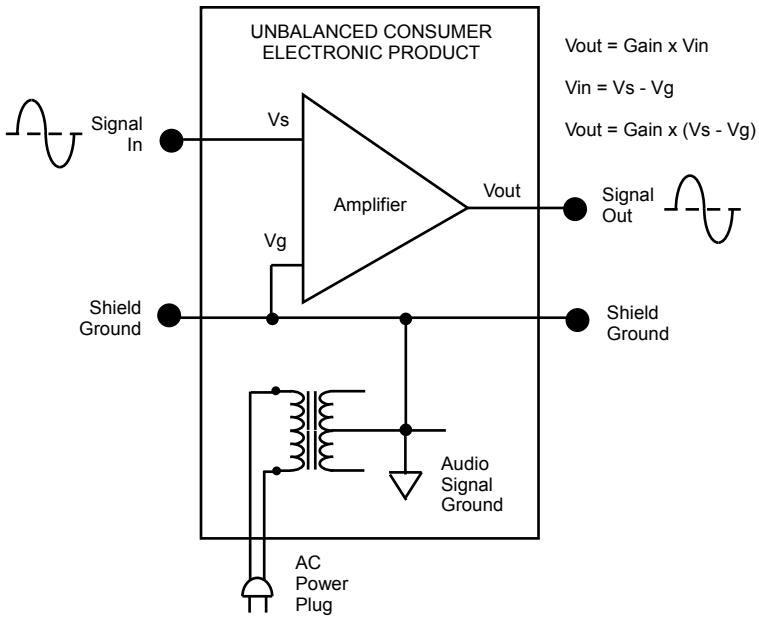
b) SIGNAL LEVEL- (-10dBu, 316 millivolts RMS)
Unbalanced consumer products use a lower average signal level than balanced audio (professional) products. The use of a lower average signal further increases the susceptability of consumer products to noise.

c) OUTPUT DRIVE
Most consumer products have a relatively high output impedance (> 500 ohms). This limits their ability to drive audio cables that are more than 25 feet long.

d) AUDIO PERFORMANCE
Unbalanced consumer products typically perform as well as (or outperform) similarly featured balanced professional products. The larger market size of the consumer market has driven a marked improvement in performance and reliability for consumer products.

e) RELIABILITY
Most consumer audio products have evolved to be as electronically reliable as professional products. Products designed for professional applications are usually more rugged, have panel controls designed for 24 hour operation, and are of a more easily serviced modular design. Conversely, consumer grade audio products are so inexpensive that it is often more cost effective to replace them than to repair them.

f) SYSTEM INTEGRATION
Care must be taken when installing consumer audio equipment. Because of noise susceptability, care must be taken in grounding, AC power, and interfacing to other audio equipment that is located more than a few feet away.



TYPES OF AUDIO EQUIPMENT

6.1 Balanced (Professional type) Audio Equipment

a) The primary defining characteristic of professional audio equipment is that it has a balanced audio signal path. This means (as shown below) that the audio signal is defined as the voltage difference between “Signal In (+)” and “Signal In (-)”. The input amplifier is a “differential” amplifier that will only pass audio signals of opposing polarity. In a perfectly balanced circuit, if the same signal is applied to both inputs of the amplifier (as in Figure B), then there will be NO audio output. A balanced amplifier will therefore naturally reject any noise coming in on the input cable. That includes 60 cycle AC hum, RF interference, etc.

b) SIGNAL LEVEL- (+4dBu, 1228 millivolts RMS)
Balanced professional audio products use a higher average signal level than unbalanced consumer type audio products. This further improves the immunity of professional products to system noise

c) OUTPUT DRIVE
Most professional products have a relatively low output impedance (< 100 ohms). This allows typical products to drive twisted pair audio cables for ~300 feet before low impedance cable or better drivers are required.

d) AUDIO PERFORMANCE
Professional products are designed with different design goals then consumer audio products. Audio performance will be high but greater effort is placed in the design to facilitate use in large distributed audio systems. Focus is often on CMRR, high output drive capability, RF immunity, etc.

e) RELIABILITY
Products designed for professional applications are usually more rugged than consumer products, have panel controls designed for 24 hour operation, and are of a more easily serviced modular design.

FIGURE A.

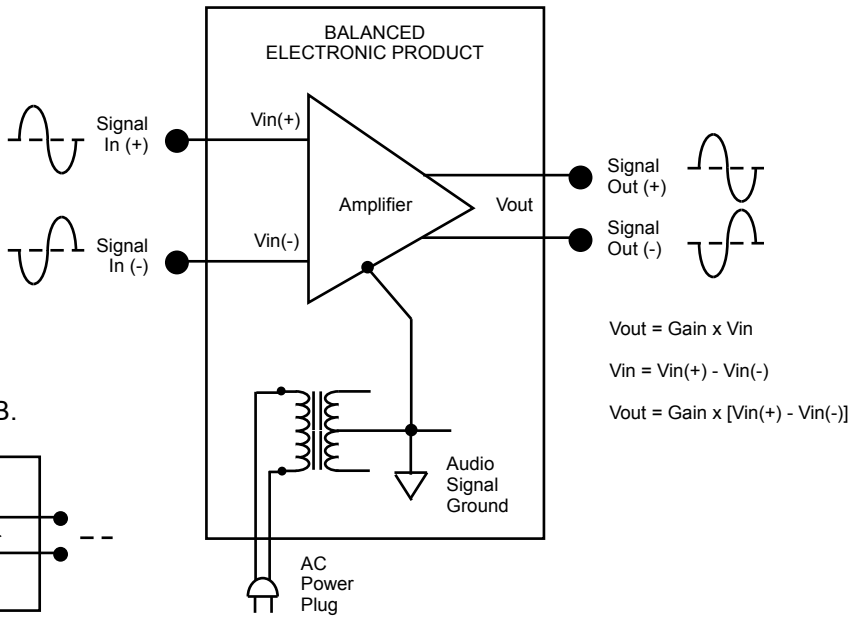
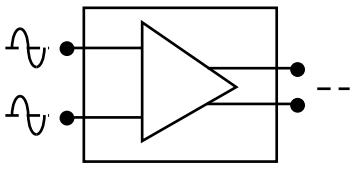


FIGURE B.



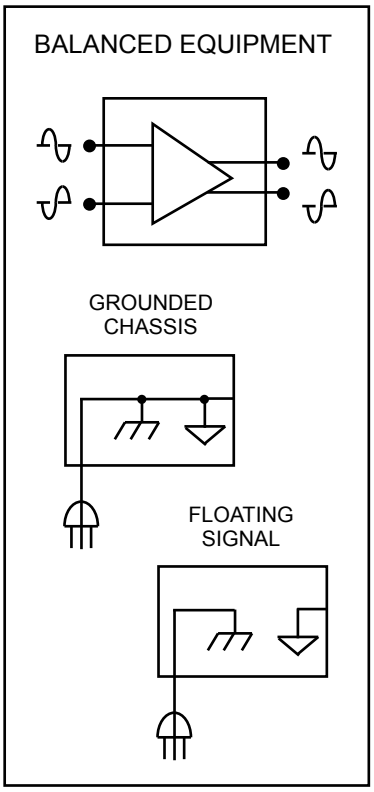
TYPES OF AUDIO EQUIPMENT

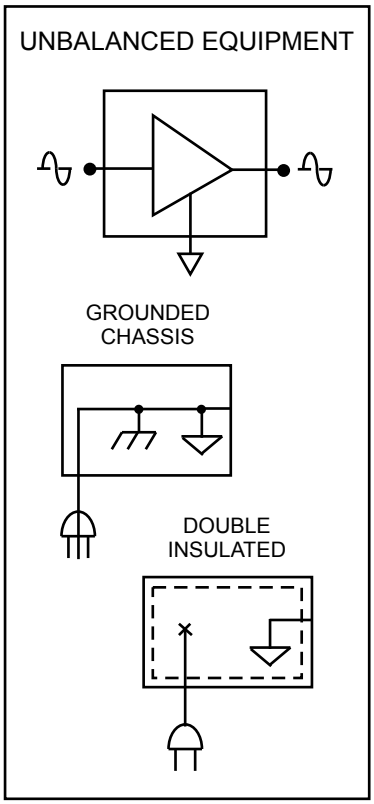
6.2 3RD WIRE SAFETY GROUND

a) One of the most important and yet not obvious specifications for any piece of audio equipment is how it is grounded: audio signal ground, chassis ground, 3rd wire safety ground.

b) BALANCED (PROFESSIONAL) AUDIO EQUIPMENT
Most of this type of equipment has a 3rd prong AC safety ground plug and the metal chassis is grounded to safety ground. Most of this type of equipment will also have the audio signal ground connected to the chassis and the 3rd wire safety ground. In some equipment, the audio signal ground connection is made on a terminal strip on the exterior of the cabinet so that the connection may be easily removed to eliminate a ground loop. This is highly desirable. In some equipment, the connection can be removed internally. In most equipment, it can not be removed and the probable ground loop must be eliminated by connecting the shield ground at only one end. This is adequate for balanced audio equipment. If the device is connected to an unbalanced audio device, the ground loop may be completed with the signal ground to the unbalanced device.

c) UNBALANCED (CONSUMER) AUDIO EQUIPMENT
Most of this type of equipment is currently double insulated. This means that there is no 3rd prong safety ground. This is highly desirable. A problem can occur if the chassis of the device (which will probably be audio signal ground) touches the chassis of another device which has a 3rd prong safety ground connection. This can occur by accident or in an equipment rack. The physical ground connection can complete a ground loop.





AUDIO CABLES

7.0 Shielded, Twisted Pair Cables

a) WHY USE SHIELDED CABLES

Shielded cable can guard the sensitive audio signal wires from RF energy. It can not guard the audio wires from EM (electromagnetic) interference such as power transformers. The shielding surrounds the audio signal wires and the RF (radio frequency) energy can not penetrate the shield. Examples of RF interference are mobile radios, cell phones, AC power transients, etc. Wherever possible, shielded audio cable should be used.

b) GROUNDING THE SHIELD

Simply shielding the audio cable is not enough to stop RF interference. The shield must be held at a constant potential or it acts as a long wire antenna. This is accomplished by grounding the shield at one or both ends of the cable.

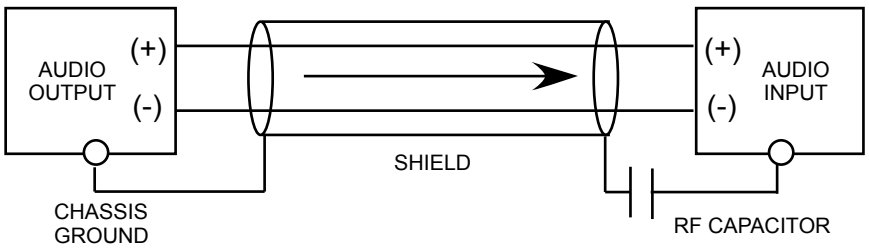
c) GROUND THE SHIELD AT ONE END ONLY TO STOP GROUND LOOPS

If the shield is grounded at both ends of an audio cable, then it is highly possible for the shield to form the second audio path between two pieces of audio equipment to form a ground loop and cause 60 cycle hum. Most often, the other path is through the safety ground on the 3rd wire of the AC outlet.

Theoretically, the shield wire should be grounded at the source equipment end (lowest impedance) for maximum performance. In practise, the shield can be grounded at either end without any noticeable difference in performance.

d) GROUND SHIELD AT ONE END WITH CAP AT OTHER END FOR RF INTERFERENCE

If the shield is grounded at one end only, the shield becomes an antenna. Grounding at both ends can cause a Ground loop. In some cases, the answer to this is to ground one end of the shield and install a small capacitor (0.1 microfarad, 100pF) to ground on the other end. The capacitor has a high impedance at 60 cycles to stop a ground loop but a low impedance at RF frequencies to ground the second end of the shield. Two capacitors in parallel may be required to have a low impedance at all RF frequencies.



d) TELESCOPING SHIELDS (Double shielded Cable) SOLVES EVERYTHING

A double shielded cable can have one shield grounded at one end of the cable and the other shield grounded at the other end of the cable. This eliminates ground loops and grounds both ends for maximum RF immunity without the need for a capacitor.

7.0 Shielded, Twisted Pair Cables (continued)

e) CONSOLE SHIELD GROUNDS

The RF energy from the shield grounds should not be taken to audio signal ground or through audio signal ground to studio ground. Unfortunately, many consoles ground the shield through a section of the internal audio signal ground before reaching the main ground for the product. This increases susceptability to RF interference.

As an example, a console will usually have an RF screw lug somewhere on its metal chassis. This screw lug is grounded to the main studio ground. The screw lug is where the console audio ground is also terminated. For ease of installation, it is easiest to have the audio signals and shield terminate into a single audio connector for each console input. The shield ground on this connector is usually audio signal ground on the motherboard. The signal ground on the motherboard is connected by a wire to the chassis ground. Therefore, RF energy on the shield passes through the motherboard audio signal ground before reaching the main equipment ground. This increases susceptability to RF interference.

f) PATCH PANELS

Jack fields create a unique ground issue since they dynamically change the ground system. It is possible to switch the ground through the jack field but this not commonly done in practice.

Because the jack field is a convenient single place, it is common to use it as the central star ground for the studio (or even facility) and to then take that point to main station ground.

AUDIO CABLES

7.1 Routing Audio Cables through the Facility

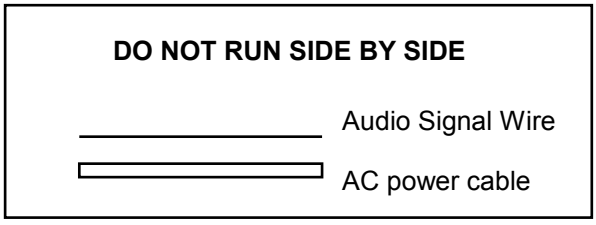
a) ELECTROSTATIC SHIELDING DOES NOT REDUCE ELECTROMAGNETIC INTERFERENCE
The shielding in audio signal cables does NOT reduce electromagnetic interference. For this reason, the magnetic fields from AC power cables can induce noise into an audio cable. Also, power transformers or any other device generating a magnetic field can magnetically couple noise into an audio signal cable.

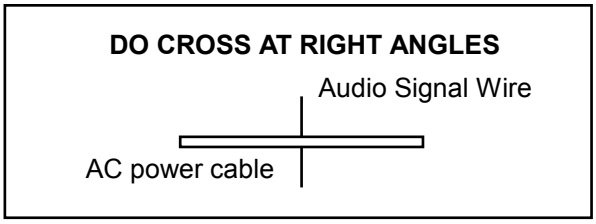
b) THE SIZE OF A GROUND WIRE DOESN'T REDUCE ELECTROMAGNETIC INTERFERENCE
Reducing a ground resistance by using a larger ground cable will NOT reduce electromagnetic interference.

c) FERROUS METALS (THE STEEL IN CONDUIT) SHIELD FROM MAGNETIC FIELDS
The ferrous metal in steel conduit reduces the magnetic field radiated by an AC power line. AC power lines should therefore be run in steel conduit.

d) DO NOT RUN AUDIO SIGNAL CABLES PARALLEL TO AC POWER CABLES
Keep audio signal wires away from AC power wires. In particular, do not run them together in the same conduit.

e) AUDIO SIGNAL CABLES SHOULD CROSS AC POWER CABLES AT RIGHT ANGLES
When an audio signal cable must pass an AC power cable, cross them at 90 degree angles so that there is a minimal common path.





A SUMMARY

8.0 A Summary of Basic Principles

a) A Radio Studio is part of a large distributed audio system.

b) There are 4 ground systems: AC power, AC safety ground, Shield ground, Audio Signal ground.

c) Audio Signal Ground must remain clean from all other ground systems and noises.

d) There must be only one ground connection between 2 pieces of equipment (or there will be a Ground Loop and 60 cycle hum!).

e) The 3rd wire AC safety ground must never be lifted. Ground loops can be broken in other ways.

f) All audio equipment in a studio should be on the same AC circuit and same phase.

g) No non-audio equipment such as lights should be on the same AC circuit as audio equipment.

h) Unbalanced consumer equipment can be used, but care must be taken with the grounding.

i) Shielded, twisted pair audio cable should always be used.

j) Audio wires should be kept away from AC power wires (cross at 90 degree angles).