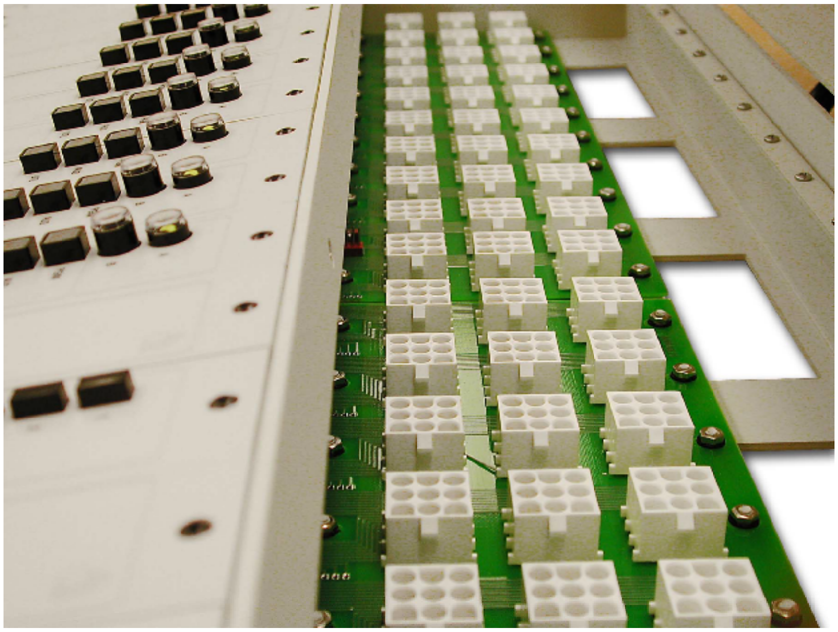
Analog & Digital wiring

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

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

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.

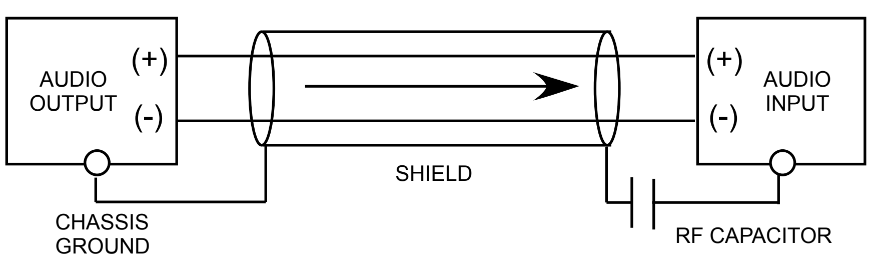
c) GROUND THE SHIELD AT ONE END ONLY TO STOP GROUND LOOPS

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.

AUDIO CABLES

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.

Section 7

AUDIO CABLES

7.1 Routing Audio Cables through the Facility

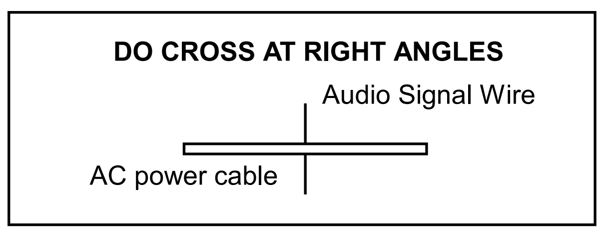
a) ELECTROSTATIC SHIELDING DOES NOT REDUCE ELECTROMAGNETIC INTERFERENCE
The shielding in audio signal cables does NOT reduce electromagnetic interference. For this reason, the magnetic fields from AC power cables can induce noise into an audio cable. Also, power transformers or any other device generating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

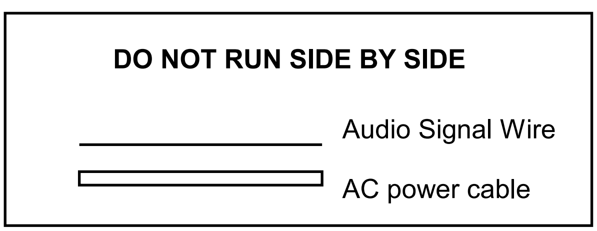
b) THE SIZE OF A GROUND WIRE DOESN'T REDUCE ELECTROMAGNETIC INTERFERENCE
Reducing a ground resistance by using a larger ground cable will NOT reduce electromagnetic interference.

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.





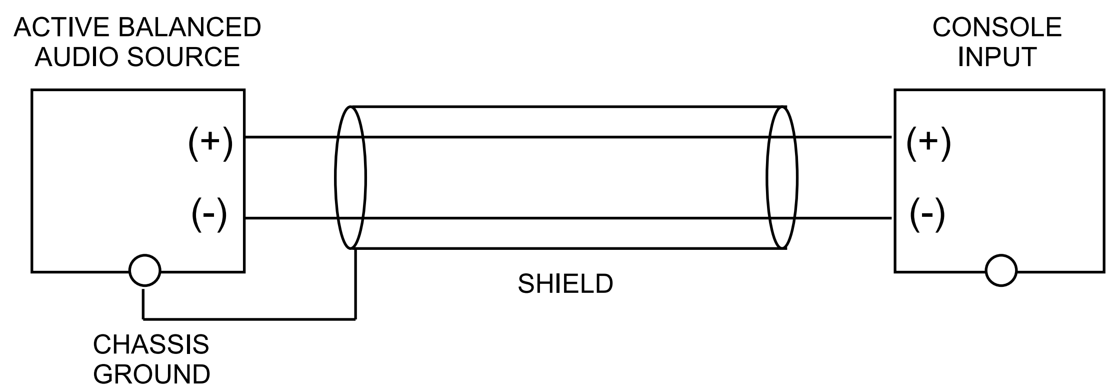
ANALOG AUDIO WIRING

13.0 Analog Audio Wiring

The following sections assume twisted pair, shielded audio cable for all analog wiring. The illustrations demonstrate how to wire balanced and unbalanced analog devices in various configurations.

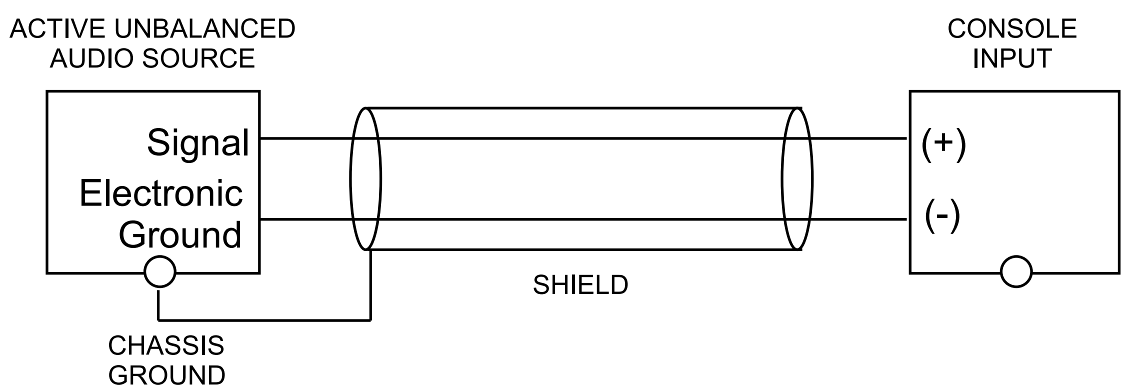
13.1 Balanced Source Output to Balanced Console Input

Balanced inputs and outputs are the best method to reject hum



13.2 Unbalanced Source Output to Balanced Console Input

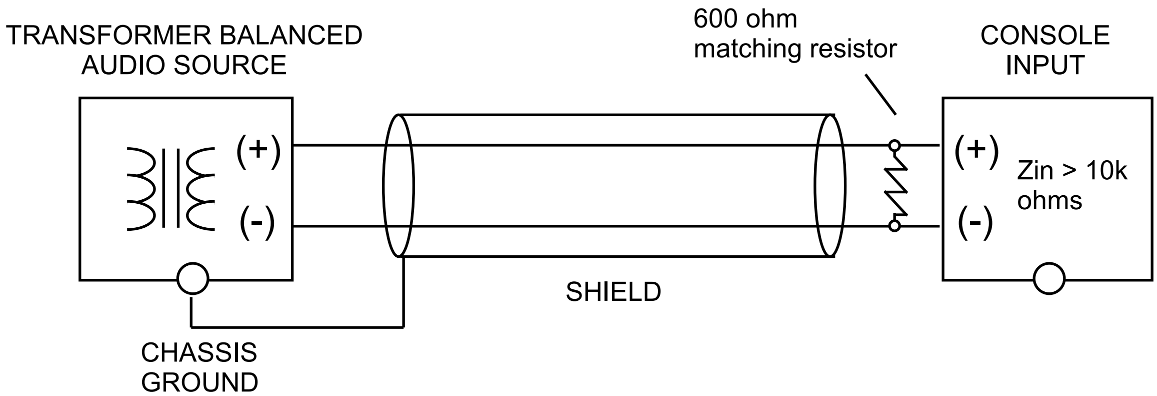
Use this wiring method for low noise connection of an unbalanced audio source to a balanced input on a console.



ANALOG AUDIO WIRING

13.3 Transformer Balanced Output to Balanced Console Input

Transformer sources require a fixed impedance for proper performance. The console input impedance is high compared to the impedance of most transformers and will require a resistor to match the transformer.

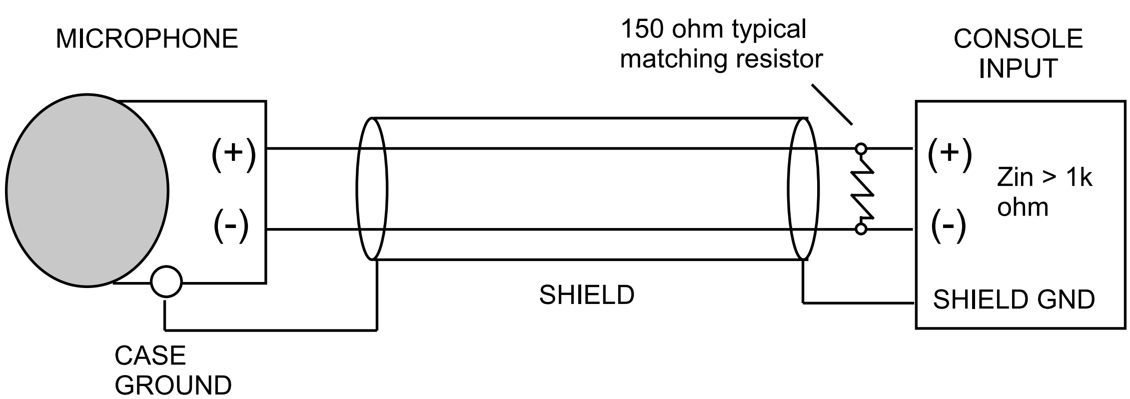


13.4 Microphone to Balanced Console Input

The input impedance of microphone preamps is high compared to the characteristic impedance of many microphones. Most microphones do not require impedance matching. Refer to the microphone spec sheet to determine if impedance matching is recommended. If required, the resistor should be added as illustrated below.

Stereo microphones will require an outboard stereo mic preamp and then be brought in to the console on a stereo line input channel.

IMPORTANT- High voltage static discharges to the mic case can ruin a mic preamp's input stage. Room carpets and surfaces should be chosen for low static or treated to reduce static.



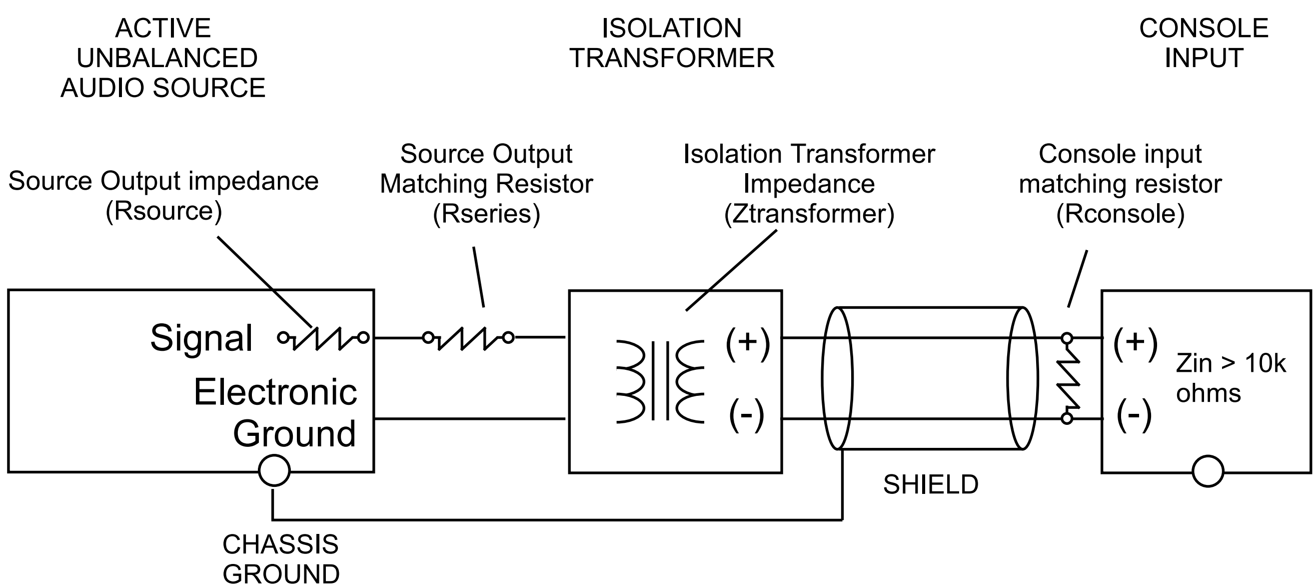
13.5 Use of an Isolation Transformer to convert an Unbalanced Source into a Balanced Source

In some situations, an isolation transformer is required for RF or ground loop isolation where the source output is unbalanced. The isolation transformer must be impedance matched to BOTH the source and the console.

To perform the matching, you must refer to the data sheet for the source device and find the output impedance. That will be Rseries as shown in the diagram. Select an audio isolation transformer with a specified impedance. The transformer impedance will be (Ztransformer)

Rseries = Ztransformer - Rsource

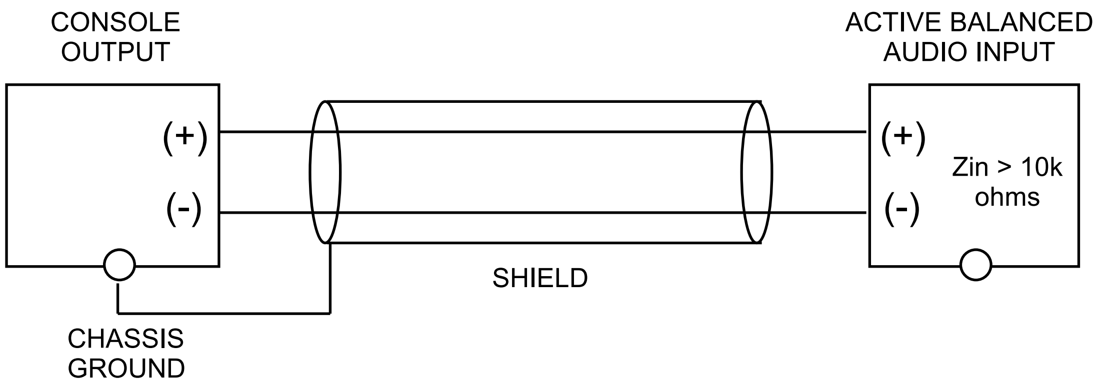
Rconsole = Ztransformer



ANALOG AUDIO WIRING

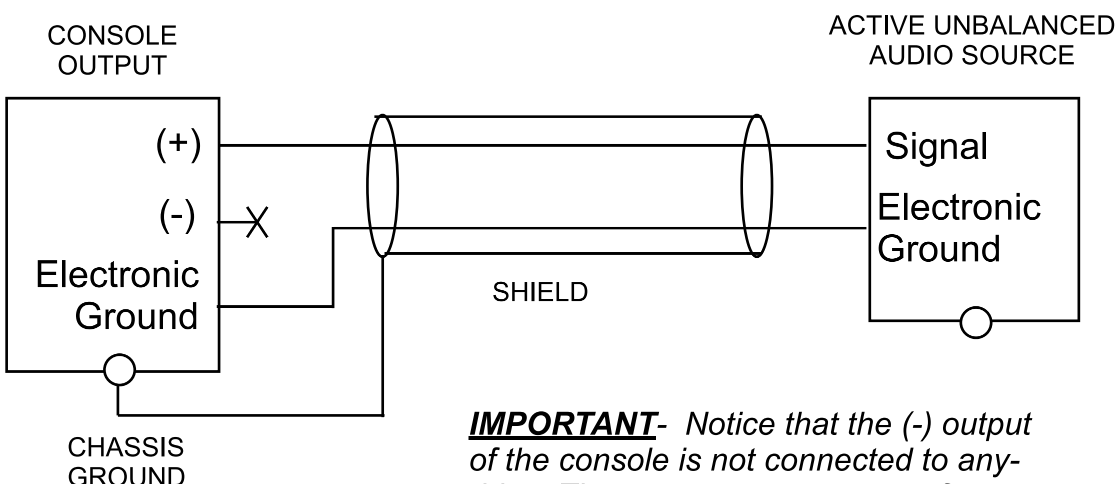
13.6 Console Balanced Output to Balanced Input

Balanced inputs and outputs are the best method to reject hum



13.7 Console Balanced Output to Unbalanced Input

Use this wiring method for low noise connection of an unbalanced audio source to a balanced output on a console.

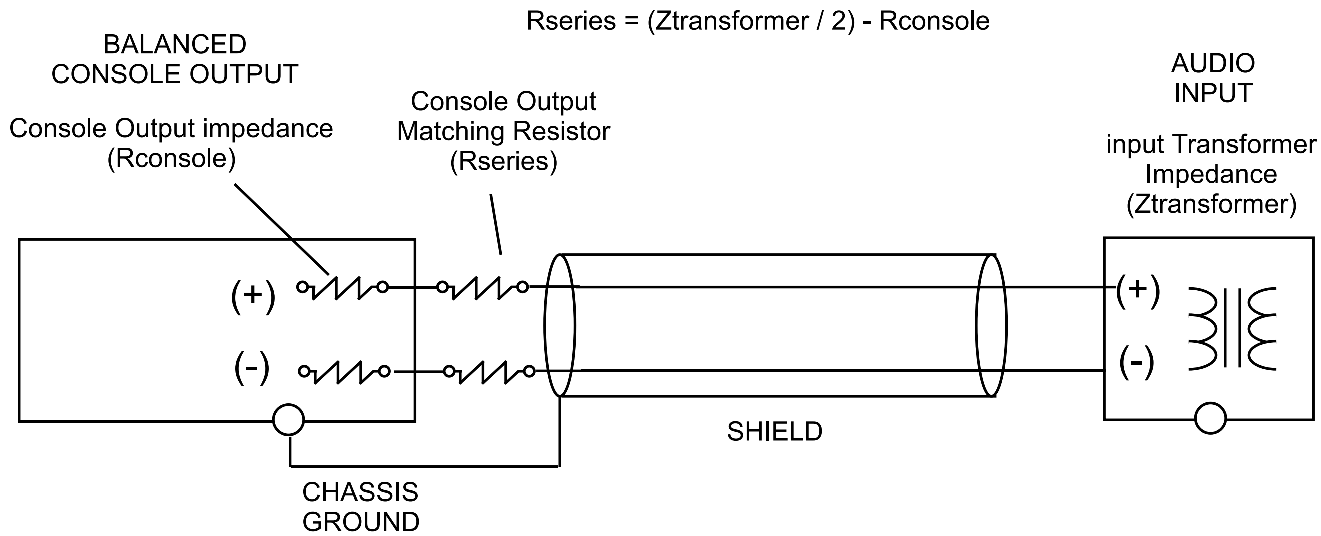


IMPORTANT- *Notice that the (-) output of the console is not connected to anything. The most common reason for output IC failure and for crosstalk is grounding unused balanced output drivers.*

ANALOG AUDIO WIRING

13.8 Console Balanced Output to Transformer Input

Transformer sources require a fixed impedance for proper performance. The console output impedance is low compared to the impedance of most transformers and will require a resistor to match the transformer.

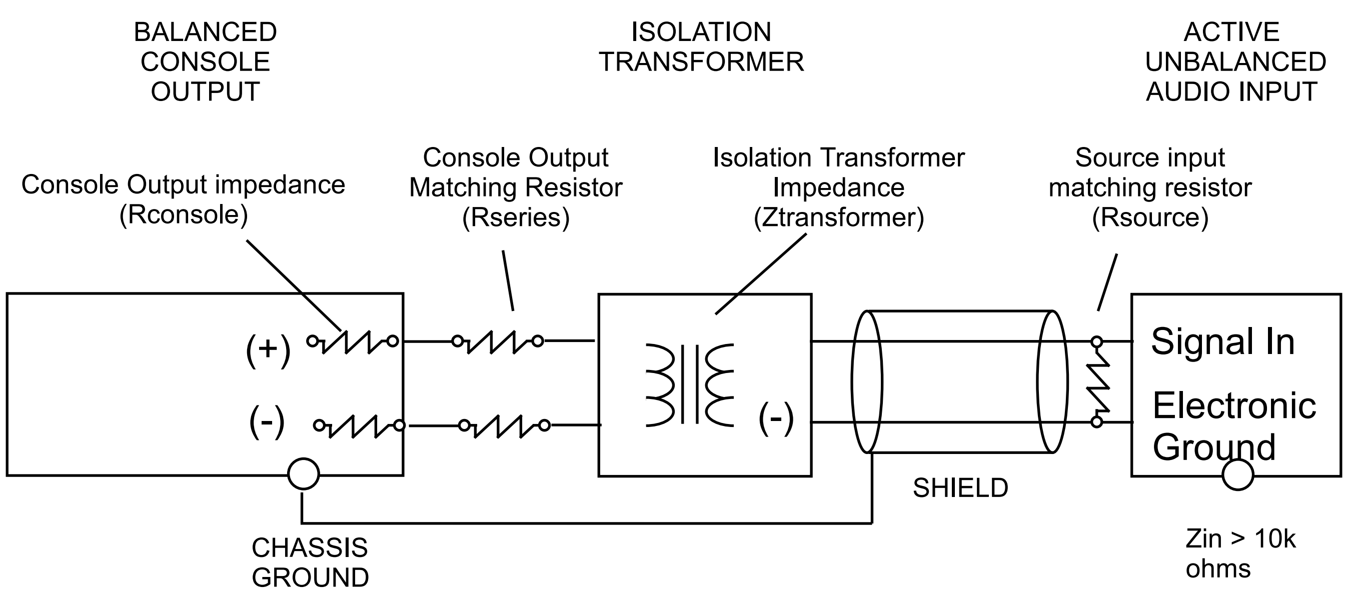


13.9 Console Balanced Output to Isolation Transformer Unbalanced Input

Transformer sources require a fixed impedance for proper performance. Matching resistors are required as illustrated below.

Rseries = (Ztransformer / 2) - Rconsole

Rsource = Ztransformer



DIGITAL AUDIO WIRING

14.0 Digital Audio Wiring

a) Two types of digital audio serial interfaces are in wide use today (1) AES3 (formerly AES/EBU) and (2) S/PDIF. The AES3 format has two varieties (AES3 & AES3id) designed for different cables and maximum cable lengths. The S/PDIF format is designed for short cable lengths and inexpensive cables. The differences between the standards is outlined in the chart.

	AES3	AES3id	S/PDIF
Interface	Balanced	Unbal	Unbal
Connector	XLR-3	BNC	RCA
Impedance	110 ohm	75 ohm	75 ohm
Output Level	2-7 Vpp	1.0 Vpp	0.5 Vpp
Max Output	7 Vpp	1.2 Vpp	0.6 Vpp
Max Current	64 mA	1.6 mA	8 mA
Min Input	0.2 V	0.32 V	0.2 V
Cable	twisted pair	Coax	Coax
Max Distance	100 m	1000 m	10 m

b) DATA PROTOCOLS

AES3 and S/PDIF are not the same. The data formats themselves are the same but the data in the packets are different between the two formats. An identifier bit tells the decoder whether the stream is AES3 or S/PDIF.

c) CONVERTING BETWEEN AES3 & S/PDIF

In older digital audio equipment, both AES3 and S/PDIF streams would not be accepted. In newer equipment, data receivers often support both protocols. It is therefore only necessary to convert the electrical interfaces (voltage, impedance, etc.) to convert from AES3 to S/PDIF and back again.

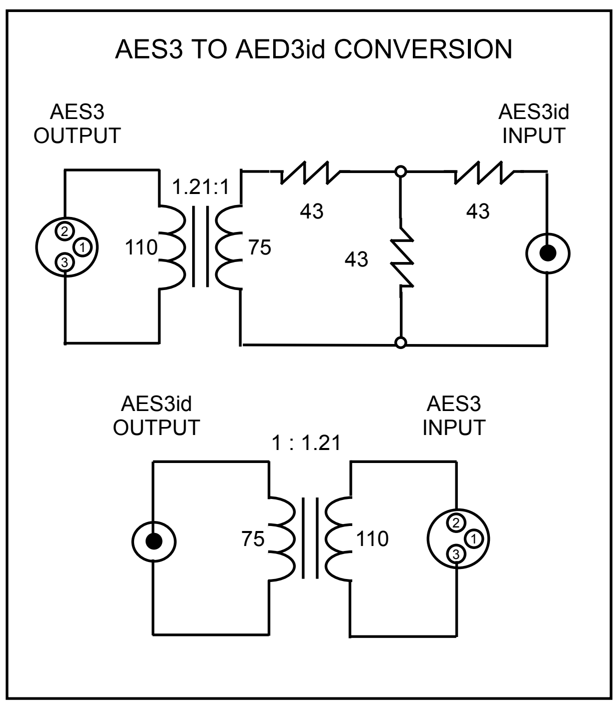
d) AES3 to AES3id CONVERSION

1) AES3 OUTPUT TO AESid INPUT

The AES3 output level is higher than the AES3id input can accept. The transformer matches the impedance and the resistor pad drops the level from the AES3 output to the lower level required by the AES3id input

2) AES3id OUTPUT TO AES3 INPUT

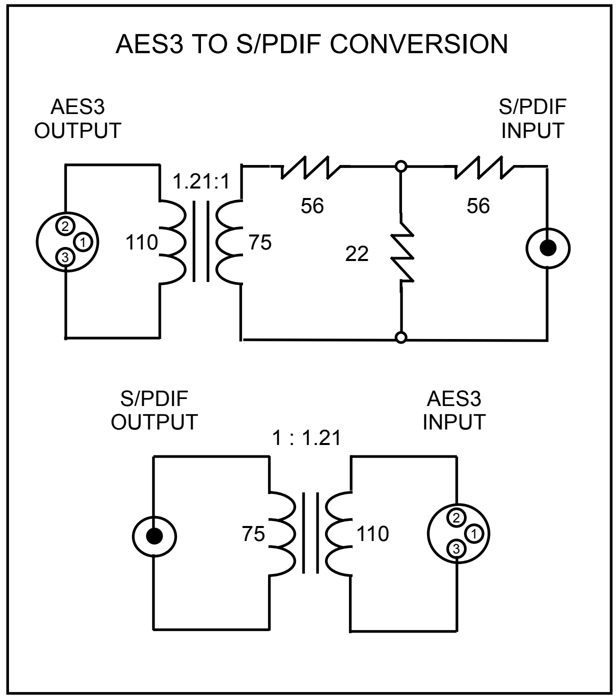
The AES3id output signal is lower than the AES3 output signal but is sufficient for the AES3 input. The transformer is used to match impedance between the 75 ohm AES3id output and 110 ohm AES3 input.



DIGITAL AUDIO WIRING

14.1 Digital Audio Wiring

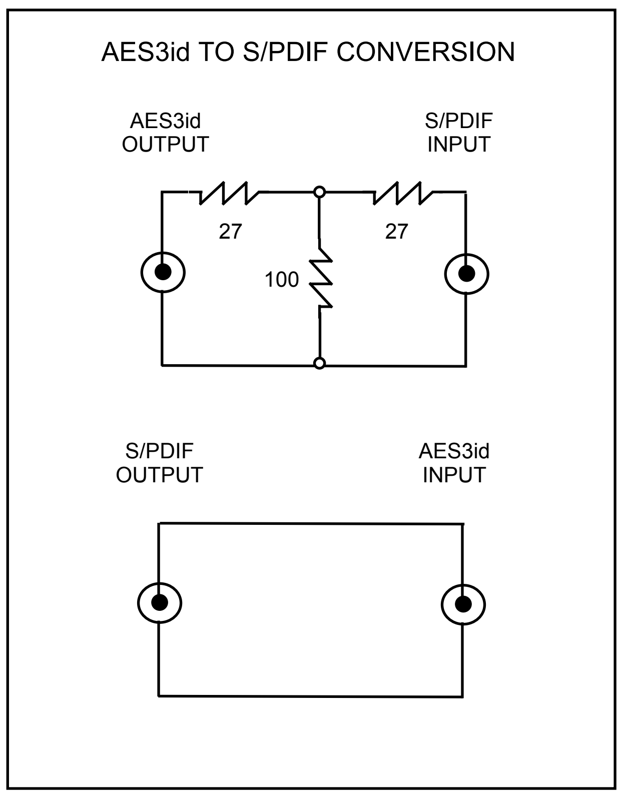
a) AES3 to S/PDIF CONVERSION



1) AES3 OUTPUT TO S/PDIF INPUT
The AES3 output level is higher than the S/PDIF input can accept. The transformer matches the impedance and the resistor pad drops the level from the AES3 output to the lower level required by the S/PDIF input

2) S/PDIF OUTPUT TO AES3 INPUT
The S/PDIF output signal is lower than the AES3 output signal but is sufficient for the AES3 input. The transformer is used to match impedance between the 75 ohm S/PDIF output and 110 ohm AES3 input.

b) AES3id to S/PDIF CONVERSION



1) AES3id OUTPUT TO S/PDIF INPUT
The AES3id output level is higher than the S/PDIF input can accept. The resistor pad drops the level from the AES3id output to the lower level required by the S/PDIF input. No impedance matching is required.

2) S/PDIF OUTPUT TO AES3id INPUT
The S/PDIF output signal is lower than the AES3id output signal but is sufficient for the AES3id input. No impedance matching or level shifting is required.