1. Installation Summary

This section summarizes some ofthe most important concepts to help you get started installing your Project Patch system. Please read this page before attempting an installation. For more detail, read the sections following.

Dealing with balanced and unbalanced equipment

Best quality is obtained by connecting equipment with balanced outputs to equipment with balanced inputs. In reality, you will encounter much unbalanced gear in your studio. The following chart shows what you can expect from hybrid connections (connections between unbalanced and balanced equipment). Keep in mind that unless all of your gear is fully balanced, you are making hybrid connection when you patch even if the normal path is fully balanced.

SOUND QUALITY	**Source Equipment**	**-to-**	**Destination Equipment**
Best	**BALANCED**	**—>**	**BALANCED**
Good	**UNBALANCED**	**—>**	**BALANCED**
Variable*	**BALANCED**	**—>**	**UNBALANCED**
Poor	**UNBALANCED**	**—>**	**UNBALANCED**

* The balanced to unbalanced connection is highly dependent on the circuit topology of the balanced driver. With transformer or cross coupled outputs, the results can be good, but with simple "differential" outputs signal current can flow to ground, causing crosstalk or distortion.

If you encounter problems with unbalanced equipment, first look at the AC grounding (see Understanding problems). Ideally, all unbalanced eqiupment should be balanced via balancing boxes, such as our Synth Driver, or transformers before wiring to a patch bay for ultimate performance and consistency. Please note that one-room studios with short cable lengths are much more forgiving than multi-room facilities with tie lines from room to room.

Grounding

Standard Project Patch cables are supplied with shield disconnected at the ptach bay end to avoid ground loops in the audio wiring which could be translated into audio noise by certain equipment. Keep in mind that Project Patch cables do not provide a ground to your equipment! You MUST provide a ground to all of your equipment. Usually the 3rd wire AC ground will suffice but in the case of equipment without a 3 conductor power cable, it may be necessary for you to attach an additional ground wire to the equipment.

If you have followed this rule and you still have hum or buzz in your setup, read "Troubleshooting" (section 5), and "Making it Work" (section 4).

Tips

- Be sure to get the modular Project Patch connector aligned properly with the pins before plugging in. If you have strange problems with signal continuity, look here.
- Be sure to tie down your Project Patch cables to the rear cable tray on each patch bay. The connector cannot provide any mechanical strain relief by itself.
- Remember to ground the patch bay.

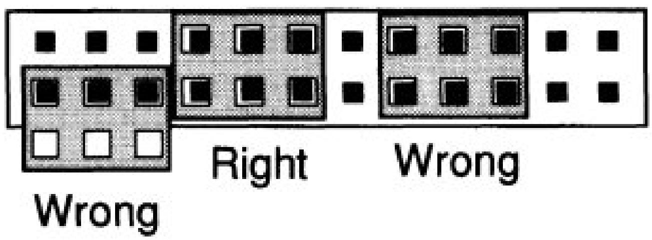
2. Installing your Project Patch™ bays and cables

Mounting the bays in the rack

You will notice that each bay has 8 mounting holes instead of the usual 4. This is because of the "1 1/2 rack" height of the Project Patch Bay. This height is a good compromise between maximum patching density, reasonable wiring access, and labeling space. If you have an odd number of bays, and wish to close the gap between the Bay and the next item of equipment in the rack, you may purchase our 1/2 rack unit blank panel.

Plugging in the cables

Because each connector is modular and stackable, it is quite possible to plug them in wrong! There are two important factors to watch for when you are plugging in the cables: Orientation and Alignment. Orientation is simply that each connector must be facing the right direction. This is accomplished by orienting the connector so that the channel printing is UP. Alignment refers to the horizontal and vertical position of the connector. Be sure to check the connector alignment with the pins of the Project Patch backplane before pushing them on. Avoid offsetting the connector either vertically (missing one whole row of pins) or horizontally (creating pinout confusion).



Unplugging cables

No special tools are required to unplug Project Patch connectors from the rear of the patch bay. Slowly and firmly pull one cable at a time directly out of patch bay. There is no mechanical latch other than the high force contact. The connectors are not intended to be mated and unmated every day, but should last a lifetime under normal use.

Grounding the patch bay

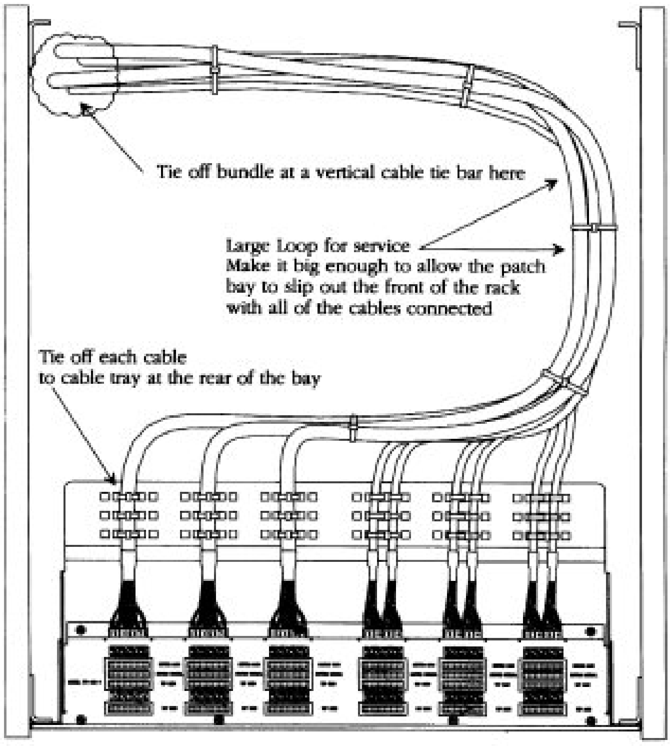
Inside the patch bay, the sleeves of all of the jacks are bussed together and connected to the banana jack on the rear of the bay. This jack is NOT connected to chassis! You must provide a ground to this jack in order to ground the shields of the patch cords, and also for signal cable shield ground in case you have elected to build shield-connected cables. The best place to take this ground is to your "technical earth" reference point if you have one - typically the isolated ground bus in the technical power panel. If you don't have one, you can connect this to the rack ground, power strip chassis, or - even better - the ground lug on the back of your mixing console.

Strain relief and cable management

The Project Patch connector will give years of service and many connect/disconnect cycles, however it offers no resistance against inadvertent pull-out. Therefore it is important that each cable must be tied off to the cable tray at the rear of the bay, using standard nylon tie-wraps.

Cable management for front access and service

The Project Patch system is designed to be serviced and changed from the front of the rack to facilitate ease of access in racks with multiple bays. This is why the silk screen on the top of the chassis and the channel numbers on the connectors read correctly from the front. The best installations are where the cables are dressed across to one side, then back and over to the opposite side of the rack where they are tied off to a vertical bar. This creates a natural service loop so that the entire bay can be slipped out the front of the rack and tilted down where you can look directly at the rear of the bay.



Top view of installed bay

If you have more than one patch bay in a rack, do not combine bundles from each bay until the cables are back to the vertical tie bar. This will aid in slipping each bay out individually.

When installing cables it is a good idea to plan your installation and lay in cables to one patch bay at a time, starting from the bottom and working up to the top. Get all of the cables into each bay and tied off back to the vertical tie bar before moving on to the next one.

Order of procedure for new installations

Following this procedure makes new installations go smoothly and quickly.

1. Open all packages and identify all parts.
2. Start with the bottom patch bay. Place the bay on the floor in front of the rack.
3. Pass the cables for the first bay through the rack.
4. Plug in the bottom row of cables (49-96) to the patch bay one at a time, labeling the far end of each for equipment / function as you go.
5. This is the most convenient time to plug in the normal jumpers.
6. Plug in the top row of cables (1-48) and label the far end as you go.
7. Tie off all cables to the tray and bundle the group to one side and back at least 18".
8. Tie the bundle down to a vertical tie bar in the rear of the rack. Screw in the patch bay.
9. Dress the equipment end of the cables and plug in to the equipment.
10. Repeat the entire procedure with the next bay up.
11. Ground all bays.

Order of procedure for changes

1. Pull patch bay out the front of the rack and let it hang.
2. Cut the ties holding the bundle.
3. Make any changes.
4. Re-bundle and return the bay to the rack.

3. Making your own cables

Signal Transport makes a full line of cables compatible with the Project Patch bay. We also have an extensive custom manufacturing facility and we are happy to quote on custom requirements, whatever they are. Please contact your dealer for more information on cables.

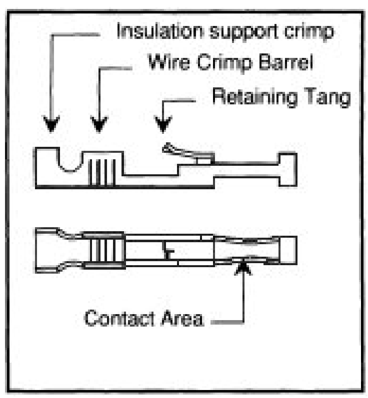
There are many reasons to make your own cables. Perhaps you need a special length or special connector which is not offered in the standard Project Patch cable line. Or you may be wiring your studio in the great "do it yourself" tradition. To make your project go easier, we offer compatible connectors, tools, and cable. Keep in mind that we also offer "stubs" if you would like to avoid the crimping part. These are 10' or 25' cables with the Project Patch connector at one end and nothing at the other.

If you decide to build your own, here's what you need to know to connect the cable to the Project Patch. (A comprehensive tutorial on wiring - including the myriad of other connectors in common use is a subject for another book. Please refer to the bibliography of this manual for suggested reading on the subject.)

Crimping pins

A proper crimp joint is formed by the combination of three elements: contact crimp size, wire gauge, and tool. Project Patch contacts are rated for wire gauge between 20 and 24 AWG stranded. For wire out of this range you must order special contacts. The object of the crimp process is to close the crimp contact around the wire and fully compact the strands inside the cavity, eliminating air and creating a low resistance, "gas tight" joint which resists corrosion and heating. To accomplish this correctly requires the exact amount of pressure, applied within a controlled area. The tool must be specifically designed for the contact and gauge of the wire, and must have a "controlled cycle" feature which prevents handle release until the contact has been crimped to the specified force. A proper crimp joint is superior to a soldered joint.

Crimp contacts have two separate crimp zones; one for the wire crimp and another for the insulation. The insulation crimp surrounds the insulated portion of the wire and provides support so that the wire will bend at a distance from the wire crimp. This avoids breakage at the weaker transition point where the stranded wire goes into the crimp. The insulation crimp should be snug but not tight enough to deform the insulation. The PP crimp tool we sell is preset for proper crimp tightness.



Be sure to avoid getting any insulation into the wire crimp! The presence of plastic in the wire crimp can cause wire breakage and lead to a discontinuous or intermittent joint which looks fine, but fails!

Specify proper contact size

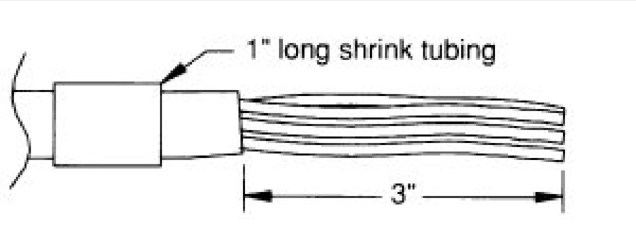
We offer two contact sizes: for 20-22 AWG wire and for 24-26 AWG. Be sure to specify your wire gauge before ordering contacts.

Re-pinning connectors

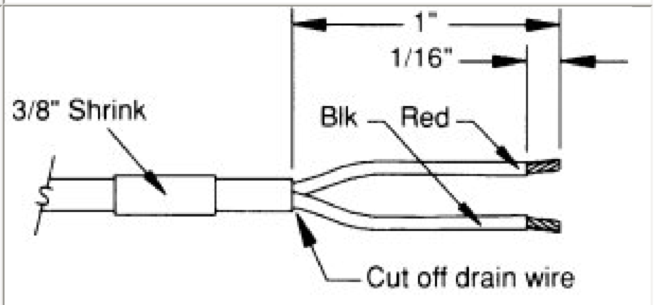
It is possible to re-pin a connector which has been inserted wrong by pressing down on the retaining tang and pulling the pin out. We do not recommend this practice as the tang has a tendency to damage the edge of the hole in the connector body, reducing the hold of the replacement pin. If you must re-pin we suggest starting over with a new connector body.

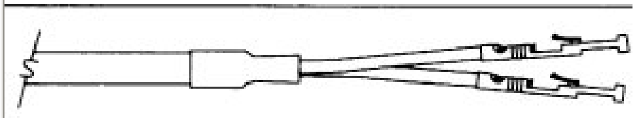
Cable preparation for Project Patch™ connectors

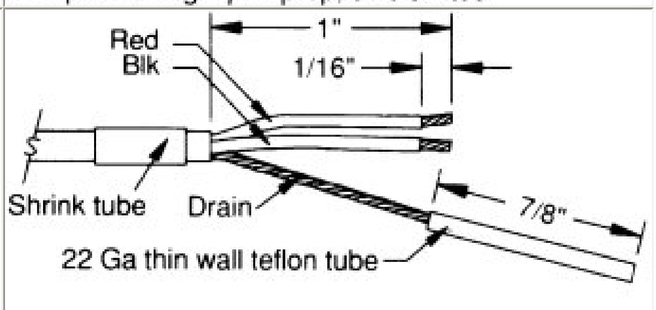
<table>
<tr>
<td>JACKET STRIP AND SHRINK

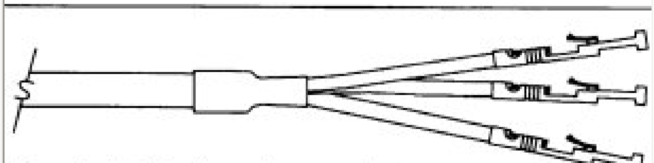
Start by stripping back the outer jacket 3". This length gives you lots of room to work with and also provides a nice flexible end so that the cable doesn't put strain on the connector. Put a 1" piece of 1/2" shrink over the end for neatness.</td>
<td>
</td>
</tr>
<tr>
<td>STANDARD PREP (SHIELD LIFTED)

Next, strip each pair 1". Cut off the drain wire and put a piece of shrink tube over the pair at the strip point. Strip back the red and black conductor 1/16" taking care not to nick the conductors.

Crimp on pins.</td>
<td>

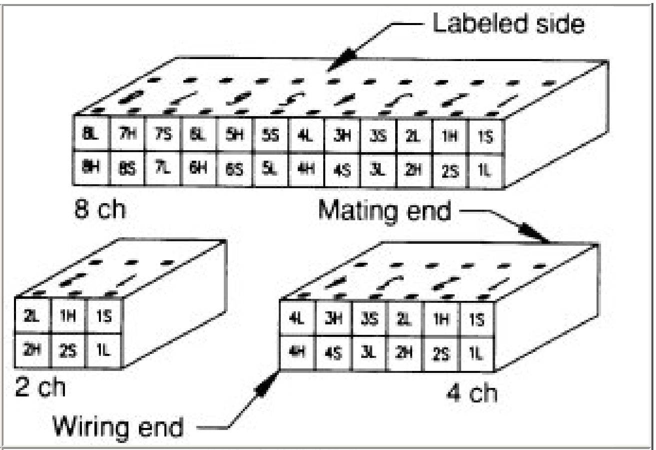

Completed single pair prep, shield lifted</td>
</tr>
<tr>
<td>ALTERNATE PREP (SHIELD CONNECTED)

Remember that the shield is lifted at the patch bay in the standard grounding setup. If you want to ground the shield, you should slip a 15/16" piece of 22 ga thin wall teflon sleeving over the drain wire and crimp a pin on it as well.</td>
<td>


Completed single pair prep, drain connected</td>
</tr>
</table>

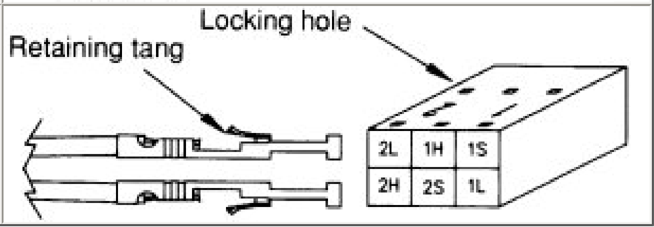
PIN INSERTION

Now insert the contacts into the blocks according to the pinout below. Connectors are available in 2, 4, and 8 channel sizes. Use the size that matches your cable. The orientation is provided by the channel indentification printed on the top of the connector. Be sure to orient the connector properly before inserting contacts.



PIN ALIGNMENT

Insert pins so that the retaining tang is facing the outside of the connector and latches into the connector block locking hole.



4. Understanding problems

When interfacing equipment in the real world, problems arise. This is because of the lack of industry standardization for audio interfaces. When installing Project Patch you should follow the instructions for grounding and shielding in this manual. Doing this will help ensure a trouble-free system. However, noise or other problems may still arise and you must be armed with good understanding of the underlying reasons. Simply installing Project Patch does not guarantee a noise free system - that is dependent upon your equipment and many other factors. This section provides some technical background to help you build your system right the first time.

Noise

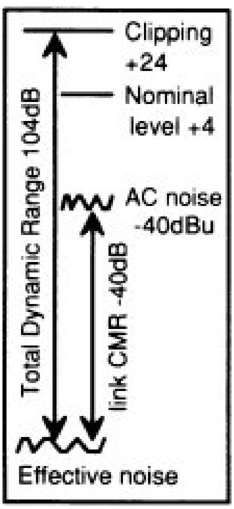
Noise developed in interconnection is "acceptable" only if it is low enough to be indiscernible beneath the equipment's internal noise level. It typically consists primarily of the 60 Hz power line frequency and it's harmonics, along with SCR dimmer noise, florescent ballast noise, and other non-musical signals which abound on the power and AC ground system.

The noise exists in our environment as radiated magnetic fields, resulting in voltage potentials between equipment. It is the object of good system design practice both to:

- Reduce the amount of noise present between equipment grounds.
- Increase the ability of the audio system to reject that noise so that it doesn't become audible.

Quantifying noise

"Dynamic Range" is the total range from audio clipping ("Headroom") to the noise floor. Most professional audio systems provide at least +22 dBu at clipping, therefore to achieve "16 bit resolution" (96 dB dynamic range) you need -74 dBu or better noise floor. For 20 bits of resolution you need to lower the noise floor to -98 dBu. This is extremely difficult.



Depending on the quality and attention to detail in the power and ground system, it is common to see AC ground noise in the range of 10-100 millivolts (0.010-0.1 V). This translates to an audio level of approximately -20 to -40 dBu. With reasonable quality balancing we can expect common mode rejection of 50 dB or better. This gives us a noise floor of at least -70 to -90 dBu, a very reasonable number. However you can see that if the CMR is inadequate or the AC ground noise level is too high, noise floor is compromised.

The problems are aggravated when we add a mixer. Hum and buzz are generally in phase across all of the inputs. When in-phase inputs are summed the level rises by 6 dB for every doubling of the number of inputs. For example, say you have a ground noise of -40 dBu between the mixer and the tape machine. If you fade one channel up you have -40 dBu on the output. Mix together 2 channels at unity gain and you have -34 dBu on the output. Four channels and you have -28. Eight channels and you have -22. Sixteen gives you -16 and thirty-two leaves you only -10! So the noise floor has been eroded by a full 30 dB by mixing 32 channels. In this example, if you want your buss noise to be down at -70 where it belongs, then you need common mode rejection of better than 60 dB between the console and tape machine.

From this example, you can see that -40 dBu (10mV) is a reasonable maximum limit for AC noise voltage. However, the lower the better.

Measuring noise

Another problem arises when we want to measure the noise present at the AC grounds. It would be awfully convenient to be able to say to our electircal contractor: "provide a ground voltage less than 1mV from any ground in the control room to any other." However, wires (test probes) must be run for the test. The wires themselves will pickup hum fields from stray electromagnetic fields. The routing of these wires will affect the measurement greatly - making it seem impossible to get an accurate and consistent reading.

Installed audio cables also pick up these fields, sometimes adding to the problem and sometimes subtracting. What we really care about is that there is a low noise voltage as measured through the audio wiring itself, which takes into account the physical path the audio follows. Unfortunately, this means that the ground noise tests cannot be made before all of the audio equipment and wiring is in place.

The only meaningful measurement is to disconnect equipment cables where they come into the console, and measure the voltage from the shield of the cable to the console ground. This is the voltage that your console / equipment I/O circuity must reject.

Ground

The first and foremost function of the ground conductor is safety. Ground conductors serve as a path for the "fault current" to follow in the case of a short. This fault current trips the circuit interrupter (breaker), preventing electrocution and fire.

Here's how it works. According to the electrical code, the incoming power neutral conductor is connected to ground at the service entrance. All of the mechanical devices such as breaker box chassis, conduit, and "U-grounds" are also grounded to this point. If for any reason the HOT conductor comes into contact with a box or length of conduit, a short circuit is formed and fault current flows. If the conduit wasn't connected to ground, nothing would happen except you could receive a shock if you touched the conduit.

If you disconnect the third wire ground from an item of equipment in your studio, you have defeated this safety mechanism. The only connection the unit has to ground may be through a signal wire, or there may not be any connection at all - as in a guitar amp. If the connection is through signal wire, then the entire fault current will pass through that wire. Since the conductor size in the typical signal wire is much smaller than power wiring, it may not be low enough resistance to trip the circuit breaker. It could pull enough current to heat up the wire to the point it bursts into flames! <u>The bottom line is: A buzzing system could make you crazy, but an ungrounded system could make you dead. Don't use power line ground lifters!</u>

For audio purposes, "ground" has a completely different role. It provides the zero voltage reference for all audio signals. A "good ground" is one which keeps all audio equipment at the same electrical potential; i.e. minimum voltage between all chassis.

How grounds become noisy

Noise voltages (Potential difference between the chassis of two or more devices) are developed by induction and conduction.

Induction

AC currents traveling in conductors generate magnetic fields which will induce noise currents in any conductor they cross. AC ground conductors, due to the fact that they must run in close proximity to the current carrying conductors, pick up a great deal of this noise. This is unfortunate as it is these same ground conductors which we must rely upon to provide our audio reference.

Conduction

Under ideal circumstances there should be no current flowing in the AC ground conductor. Reality is often different. Ground current is created by leakage in equipment power supplies, often from input noise filters. Wires have a certain amount of resistance, and the current passing through them is reflected as noies potential at the chassis as I x R (Current times Resistance).

It is standard commercial practice to use the metallic conduit as the safety ground conductor. However, the conduit is often inadvertently connected at several points along the path to building steel members, water pipes, framing, etc. These often have voltages present on them due to induction from large current consumers such as elevators, air conditioners, etc. When that voltage is shorted out against a branch circuit, noise current flows in the conduit.

Keeping the ground quiet

For those installations where it is possible to install new electrical wiring, there are several recommendations which can be made to improve the ground noise. This is only a summary of techniques. There are many other considerations which cannot be addressed in this space. Electrical work should be undertaken only by a qualified electrical contractor.

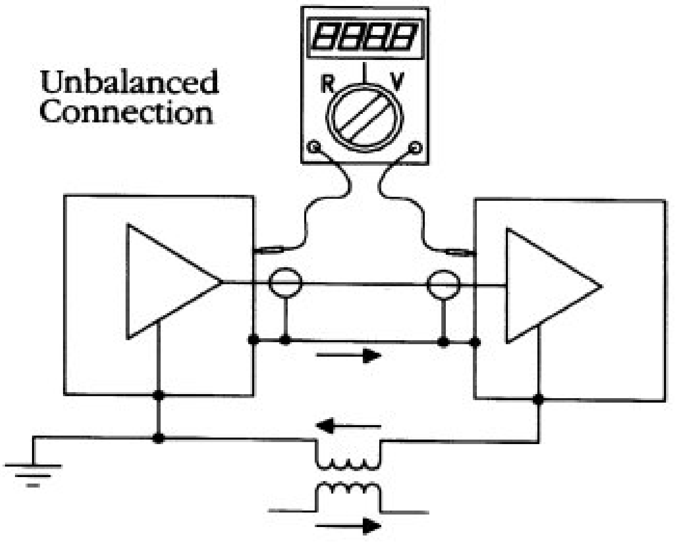
- Use a seperate "Technical power" system with "isolated ground" wiring and receptacles to avoid conducted noise currents.
- Use larger ground wire (size up one gauge) to reduce voltage resulting from noise currents.
- Twist hot and neutral conductors together in conduit to reduce induction.
- Keep the branch circuit lengths short. Locate technical distribution panel near control room.

Audio system noise sensitivity and rejection

Now that we have seen how and why noies exists, we can discuss how audio systems pick it up and how they can be rendered insensitive to it.

Unbalanced circuits

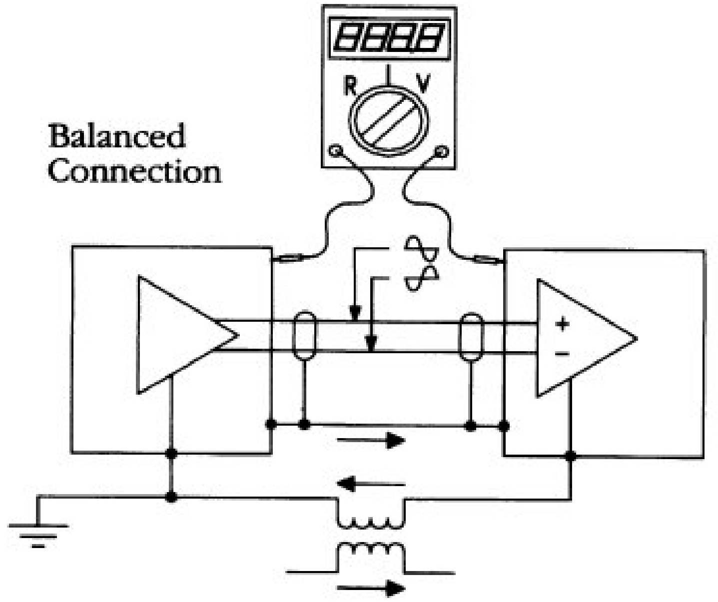
In the example shown, two devices are connected in an unbalanced configuration: the signal is impressed on a single conductor referred to ground. The meter in the drawing would be metering the voltage induced by the transformer between the two chassis. The transformer represents the inductive coupling of power line noise into the ground conductor between the two units.



The signal at the output of the second device would equal the signal at the output of the first device plus the noise voltage as shown on the meter; they would sum arithmetically. The unbalanced connection provides no rejection of noise.

Balanced circuits

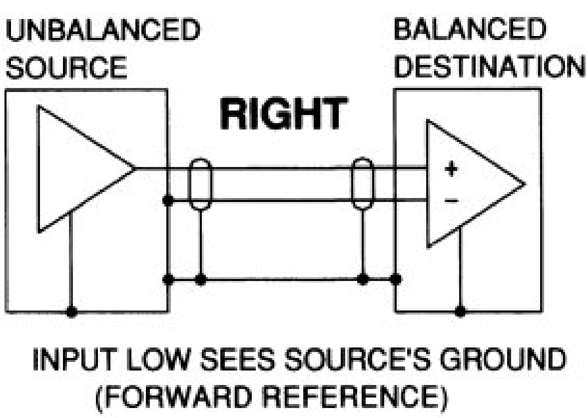
The only way to reject noise is to use a balanced connection. This is where the source is fitted with a balanced driver and the destination is fitted with a balanced receiver. The balanced driver impresses the audio on two conductors (the "High and the Low", or the "Hot and Cold") in equal and opposite (out-of-phase) amounts. The balanced receiver is sensitive only to this differential signal and ignores, or "rejects" the noise, which is impressed equally and in phase (common-mode). This is the Common Mode Rejection. With well balanced send and receive amplifiers, noise rejection of better than 60 dB is routinely achieved.

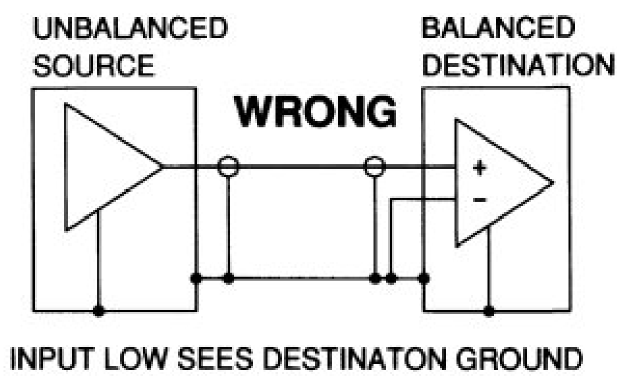


Hybrid connections

Because of the cornucopia of equipment we are faced with every day in the studio, hybrid connections are common: unbalanced outputs feeding balanced inputs, balanced outputs feeding unbalanced inputs. Unless every item of equipment in your studio has balanced I/O, chances are you will throw a patch one day which will cause a hybrid connection.

If wired properly, a hybrid connection becomes what is know as a "foward reference" connection. That means that the balanced low side references to the ground of the unbalanced device. This gives a degree of rejection of the common mode voltage between the units. Since the source is not balanced, there is no rejection of electromagnetically induced voltages in the wiring. Under the best circumstances you can expect 20-30 dB of common mode voltage rejection from this configuration - but only if the wiring is done properly. (This is how Project Patch cables are made)





Unbalanced to Balanced

This configuration is usually quite reliable and will offer 20-30 dB of noise rejection if wired as forward reference.

Balanced to Unbalanced

Depending on the type and quality of the balanced output circuit, a hybrid connection to an unbalanced input can work almost as well as an unbalanced. However, balanced outputs are not all the same. Most modern equipment has a "cross-coupled" output balancing amp which senses current flow in both sides and works to keep them equal. If you unbalanced such a device by plugging it into an unbalanced input, it's "hot" side rises by 6dB in compensation the "low" side (the one shorted out) is effectively off, or a reference.

Some equipment creates a balanced output simply by using an inverter with no cross coupling or sensing. When you short out the low side of these circuits they may misbehave. For example, they can oscillate and overheat.

This oscillation may not be audible but it often results in audible distortion in the hot side. Also, the low side can drive excessive amounts of signal current into the ground of the next device. This can cause crosstalk due to the "pin 1 problem."

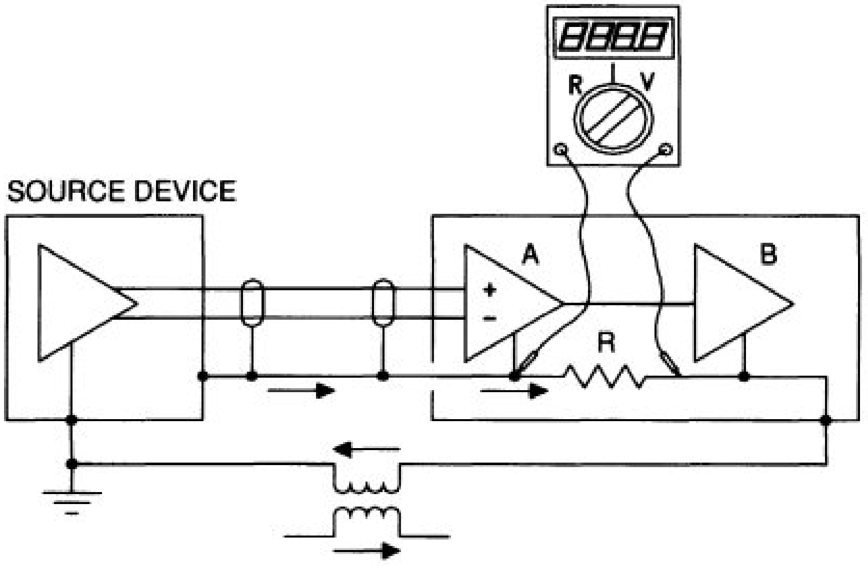
The Pin 1 Problem

The "pin 1 problem" is an extremely common but misleading anomaly. Basically it is this: some equipment is sensitive to currents being injected into the signal ground terminal at the inputs or outputs (pin 1 on an XLR). If a noise current is injected into the shield terminal on such equipment, that noise appears as an audio voltage at the signal outputs.

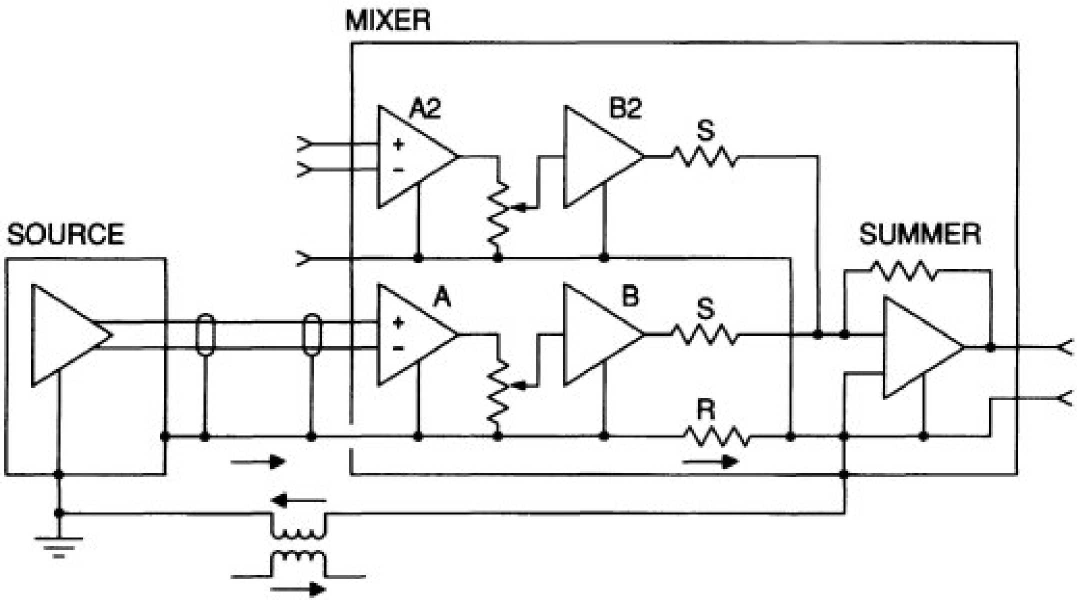
Understanding the Pin 1 Problem

The reason this happens is the internal geometry of the circuitry. Modern electronic production techniques make use of printed circuit board mounting of all components, including the input and output jacks. Sometimes the shield terminal (pin 1) is connected via circuit board traces, following the circuit common path through the board, inter-board interconnects, motherboard, etc. before it is connected to chassis ground. The problem happens when a noise current is introduced into this wiring. All wiring has resistance, including thin circuit board traces.

Referring to the illustration, the resistor R represents the resistance of these PC traces. Noise current flowing into the input shield is passing through resistor R, causing a voltage which may be measured by the meter. Since the resistor is the ground reference of stage A, the output of stage A is elevated by the IR voltage across R. The input to stage A is clean, but the signal is corrupted afterwards.



The pin 1 problem can be even more confusing than this. In the next example, the internal detection occurs in the summing stage of a mixer. Currents injected into an input shield are detected by trace resistance R. Even if the input fader is down the buss noise is elevated. This can be extremely confusing if you think that you have isolated an input by turning down it's fader!



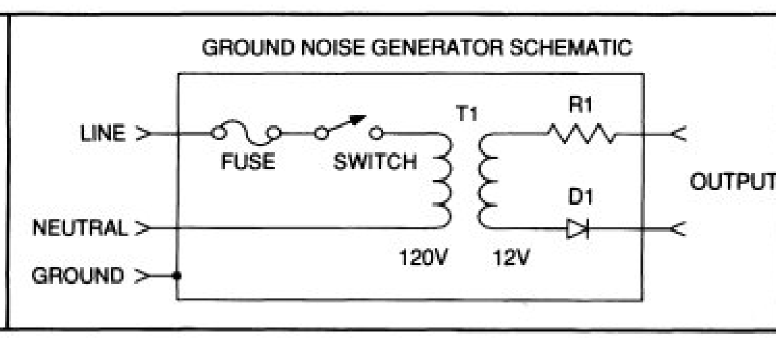
There is also a "reverse" pin 1 problem which has been documented in certain equipment. Due to proximity of ground traces or wiring to the power transformer inside the box the equipment itself is capable of inducing noise voltages between input and output jacks.

Testing for the Pin 1 Problem

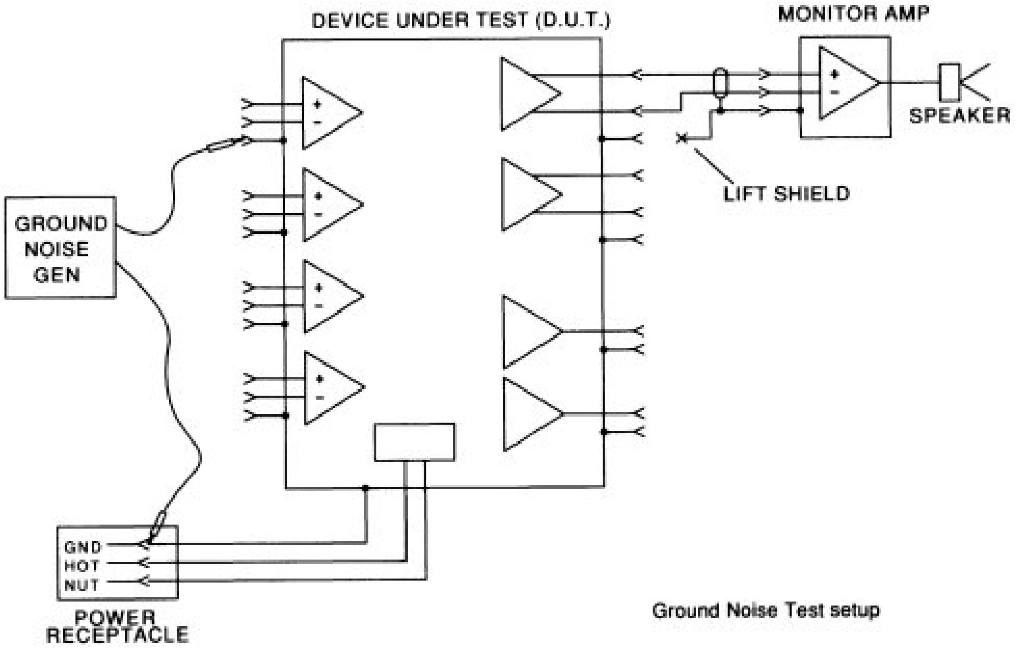
The pin 1 problem can be identified by a qualified technician using a simple test, requiring only a device to inject current into a ground pin, as shown below. A low voltage transformer is coupled with a current limiting resistor to drive approximately 100 mA into a short circuit. A diode is added to chop the waveform in half, giving it plenty of upper harmonics for audibility.

NOTE: Constructing and using this circuit requires knowledge and experience in working with live AC circuits. Refer to a qualified technician. Do not attempt on your own!

T1: 12VAC 1A 50-60hz
R1: 120Ω 2W
D1: 1N4001
Fuse: 1/8A
Values are approximate and not critical. Output current should be around 1/10 amp.



To use the tester, you need to isolate each device you want to test by disconnecting it from the rest of the system everywhere except the monitor output. Take care to wire the monitor output so that there is no ground loop there. Monitor the output with headphones or loudspeakers. Start at a low listening volume and then raise it to listen carefully to each test. Hook up one of the probes to the AC ground the device under test is plugged into. Move the other probe to the input and output connectors, probing the ground pins (Pin 1 on an XLR, sleeve on a 1/4"jack). You should hear no additional noise when you probe. You should be able to turn the monitor volume up high enough to hear the self noise of the device and still not hear the injected current. If a buzz appears when you probe any terminal, the gear has the pin 1 problem.



Ground Noise Test setup

If you find a piece of equipment with a pin 1 problem, you might consider modifying it by re-routing the shield terminals directly to the chassis internally. Take care though - you may be voiding a warranty by doing this!

Avoiding the Pin 1 Problem

The pin 1 problem is very common and for this reason we make all of our stock Project Patch cables with shield disconnected at one end to break the ground loop and eliminate circulating currents ("ground loops") into pin 1.

The one caveat to this system is that since we do not connect shield, it is necessary to have a ground to the equipment. Much consumer equipment is "double insulated" and falls under a different classification from commercial sound equipment, therefore it can be manufactured without grounded power cords. If this type of equipment is in your facility you will need to provide a ground to the equipment. This can be a clip-on ground or a lug under a chassis screw. Be aware, however, that some equipment has seperate audio and chassis grounds. You may find a difference between grounding the chassis and grounding the shell of the output connector.

5. Troubleshooting

Crosstalk

Crosstalk in audio systems is usually caused by one of two phenomena: capacitive coupling into high impedance circuits, or signal current circulating in the ground.

Capacitive coupling is dependent on the impedance of the line you are coupling into. In modern systems, the source impedance governs the line impedance and is usually below 100 ohms. If an input is unterminated, it will exhibit a high impedance and will probably pickup low levels of noise and signal crosstalk. For example, if you put a patch cord into a line input and leave it hanging, that line input is not being sourced by a low impedance. Turn up the gain on that channel and you will probably hear high frequency components from adjacent channels. This is normal and there is nothing you can do for it except to **not do it**: Turn off all unused inputs!

The pin 1 problem can also be a confusing source of signal crosstalk.

No Signal

If you have no signal or it is low, channels reversed, etc., check the orientation and alignment of the connectors at the rear of the project patch bay. The white channel numbers on the connectors need to be facing up, and the connectors must be properly aligned on the pins. See section Plugging in the cables of the Installing Project Patch section.

Hum and Buzz

There is no weapon against system noise better than an understanding of the problem. Have faith that there is a reason for your problems. There is no magic, no smoke and mirrors, no mystery to "grounding". Audio systems can be consistently quiet. But it is easy to get confused and follow a wrong path of reasoning that, once accepted as fact, causes the truth to be overlooked.

First, follow the universal rule of troubleshooting: ISOLATE THE PROBLEM. Turn down all of the input faders on the console. Make sure that all echo returns are down also. Turn up the monitor fader and listen. This is the buss noise of your console. If it has a hum and buzz component, this could be a problem of the console. If there is, try one more thing. Unplug all lines to and from the console. If the buzz goes away... you still have a console problem! Most likely it is the "pin one" problem relating to an unbalanced input or output... one of the cables you removed was injecting current into the console ground. Now you can plug in the cables one by one until you locate the problem.

If you have isolated a buzz to a particular interconnection, take a look at what you have. Is the interconnect Balanced to Balanced? Unbalanced to Unbalanced? If it is anything but Balanced to Balanced you will have to make efforts to reduce the noise voltages between the units. Take a look at the path the ground is taking. Perhaps you can reduce the relative voltage by changing the source of the power. Or you could try swamping out the voltage by adding an additional grounding connection between the units. If all else fails you should add balancing amplifiers or transformers. Under no circumstances should you defeat the safety grounding devices in a quest for low noise.

When you find a problem, isolate it and cure it before going on to more interconnects. Try to avoid the comedy of errors. As the system gets more complicated, understanding the mechanism by which the system is picking up noise becomes progressively more difficult.

Common misconceptions

"The shield dumps noise to ground"

"Ground" is not a sump where current goes never to be seen again. Ground is merely another one of the electrical conductors in the system and works to return current to its source. Remember that there can be no current flow without a closed circuit. Try to understand noise current flows throughout your system including capacitive paths. Also remember that all wire exhibits resistance; there is no "perfect ground."

"I need a Seperate Audio Ground"

No you don't! The most important function of an audio ground is to keep all equipment at the same potential. Installing a seperate ground (stake) invariably causes new currents to flow, defeating this purpose. What you need is a single ground, not multiples. Remember, it is the relative voltage between equipment that counts, not the absolute voltage from earth.

"My studio buzzes - I need better wire"

The wire is almost never the problem - unless you are using zip cord to wire the microphones. Most buzz comes from poor AC power grounding, unbalanced signal paths, and the "pin 1 problem."

What to Do

We have outlined the many ways in which audio can get noisy. The bottom line is that you want your studio to be quiet, and you don't want to have to get an engineering degree to get it that way. Here are a few simplified rules:

- Choose equipment with balanced I/O.
- Wire the entire studio with balanced wiring even if some gear is unbalanced.
- Put in a technical power system with isolated ground outlets and TEST the system before energizing.
- Use balancing boxes ("+4/-10" boxes) in line with consumer tape machines.
- Use cheap transformers in line with unbalanced Time Code I/O.
- Use Signal Transport's Synth Driver on your Midi gear.
- Put some undedicated audio transformers at patch so that when you encounter a buzzy patch you can patch in a transformer and quiet it down.
- The larger the facility, the worse the problem. Many small studios work just fine until they grow a machine room - then everything falls apart. Don't expect your old configuration to work the same as you grow.

6. Bibliography

Due to the nature of this manual, the depth of information is quite limited. If you desire further background on studio wiring and installation techniques, theory, and practice, we recommend the following reading.

- Giddings, Philip, Audio Systems Design & Installation, Carmel, IN: SAMS, a Division of Macmillan Computer Publishing, 1990.
  An up-to-date manual including information on all aspects of studio wiring, interface, and AC power systems.
- Glen Ballou, ed., Handbook for Sound Engineers, The New Audio Cyclopedia Second Edition, Carmel, IN: SAMS, a Division of Macmillan Computer Publishing, 1991.
  A basic primer on balancing and power can be found in section 31. This book is perhaps the most comprehensive reference on Audio Systems and should be the foundation of any audio bookshelf.
- Don and Carolyn Davis, Sound System Engineering Second Edition, Carmel, IN:SAMS, a Division of Macmillan Computer Publishing, 1987.
  A good overall text on the theory of audio systems. Primarily focused on sound reinforcement systems but the general information on audio and interface is useful.
- Sound and Video Contractor September 1995, periodical, Overland Park, KS: Intertec Publishing Corporation.
  This issue is devoted to grounding and shielding. Philip Giddings does an excellent summary of his book and brings it up to date. Several other excellent articles also focus on audio interface.