Theoretically with good common-mode rejection a fully balanced system needs no screen or shield - after all most telecommunications systems function without one for considerable sections of their cabling systems and most computer networks use UTP (unshielded twisted pair) cabling. The secret is that the balanced links do not directly reference to ground and so any induced noise is ignored by the balanced input stage.

In unbalanced systems the ground becomes the return path for the signal current. This system works fine in the protected environment inside the casing of your electronic thingy (mostly) but far less so in the hostile RF and hum-field saturated world outside. By using screened or shielded cable you are effectively extending the metal casing around the signal path and going some way to protecting your signal integrity. However as cable lengths increase and external noise rises so does the ability of this noise to get into your signal cable and also into the shield itself. Either of these adds noise to your signal. The solution is to only used balanced systems and if you have unbalanced inputs or outputs - balance them! This can be achieved either with electronic line drivers or simple line-balancing transformers.

So why do we still have a screen or shield? Well, the screen achieves two things:

- It protects the signal from picking up noise from outside
- It stops your signal from radiating out of the cable and becoming noise to somebody else.

In fact good twisted pair cable and line balancing achieves both of these too, so the screen is just there to help. On the second point, the frequencies encountered in audio signals are so low (compared to RF signals) that their wavelength makes even the longest practical audio cable very inefficient transmission aerials, however noise induced by much higher frequency processor clocks etc. in digital audio equipment can cause radiation problems on much shorter cable runs. So screens are provided which should be nothing more than the continuation of the metal casing around the equipment. i.e. the screen should be wired to the casing and stay as far away from the signal path as possible.

So why does some of my balanced equipment still buzz then? The plain fact is that very few pieces of even high quality audio equipment follow this rule. Firstly unless you use a transformer balanced input or output stage (and they are expensive for the really good ones) you will always have a ground reference present, secondly we live in world where compatibility with unbalanced systems (where signal ground and signal return are the same) is expected. And thirdly it is so much cheaper to take all the terminations to the PCB and deal with them from there than use labour intensive discrete wiring to chassis earth points. The result is that noise induced into the screen finds its way onto the signal ground inside your electronic thingy and modulates the ground itself; if the ground changes with respect to the signal (whether it is the signal or the ground which changes) you'll hear it.

But if the screen is connected to true ground doesn't the noise just get grounded or dumped to earth rather than upsetting the internal circuitry? You'd think so, and if the screen was truly connected to ground it would but even at modest frequencies a few centimeters of PCB track has enough impedance to isolate it sufficiently from true ground

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for the combined amplifier stages in most audio systems to make a big noise out of it.

So the solution is often to limit the number of ground points in a system. **The does not mean removing any mains supply grounds, however!** Sometimes removing the pin 1 link into a piece of equipment removes a current path through which an induced noise current can modulate the ground within a certain piece of equipment however a floating screen can act as an RF receiving aerial and curing one problem creates another. Other solutions include using transformers to remove any direct connection between equipment and thus removing any unwanted current paths. A useful addition to anybody's tool kit is a selection of balancing transformer boxes (600Ohm for line transmission and 10kOhm for line reception) with switches to offer either linked through earth or isolated.

What about my unbalanced dooberry - it doesn't usually buzz when I connect it to my balanced whatsit without any transformers or special cables? Like all hum and noise problems they often depend on the environment you are in at the time. This environment includes the exact configuration of balanced to unbalanced wiring, the quality of the input and output stages, how much noise there is around, how long the interconnections are and the gain structure of the system. Hopefully you have short enough cables and high enough quality equipment rather than just luck!

But what about mains - I've heard that you can just have bad mains? This is highly unlikely. There can be situations when the mains supply voltage falls so low that the power supplies inside equipment can't deliver the voltage required and that will cause all sorts of problems - noise being one of them. Earth faults on power distribution or cables can also be a cause but these should be regularly checked for safety reasons as the potential to kill somebody is rather more serious than a buzz on a sound system! The chopped waveforms thrown out by dimmers and motor controllers can cause noise problems but these are much more likely to EMI be (electromagnetic interference) radiated from dimmers, invertors, cables, motors and lamps and picked up by your cabling than carried into your equipment by the mains feed. Any all of the above problems will show up this sort of noise if its floating around. If you suspect there is a mains problem, get a reading of the mains voltage at load end of the cable under load. If it is within 8% then most likely that isn't your problem. Some equipment even gives tolerances as wide as 20% or more.

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troubleshooting - what to do when its all of a buzz

The first thing to do when tracking down a buzz or any sort of fault is to be methodical.

Narrow down the source of the buzz as far as possible before you do any thing else:

If just one or two speakers or other outputs are buzzing then look for a common factor

- are they fed from the same equaliser, amplifier or any other common piece of equipment?
- are the fed via a sub multi-core - and are the connectors pushed tight together and aligned properly?

- are they fed from the same mains cable that could have an earth fault?

If this is the case you can usually narrow it down to a cable fault, or a piece of equipment that can be patched around or replaced. If time allows you might be able to see if that piece of equipment performs badly elsewhere.

Pins in multipin connector sometimes get bent or pushed back and any one of those could be your problem. Most can be carefully repaired with a pair of pliers or another line used instead. Check all the multipin connectors are seated properly.

The same goes for inputs

Look for common factors:

- lower signal such as microphone signal are much more likely to show up EMI problems such as dimmer or motor noise as they are boosted much more, so check for the proximity of high power cables to your fragile signal multi-core try to leave as big a gap as possible.
- look for a group of microphones close to a source of noise such as motors or large lanterns
- the same checks apply here for multicores as above - check for correctly seated contact housings and bent pins.

If your whole system is buzzing then you either have a big problem or a very obvious fault

For more information, try the Rane publications grounding and shielding audio Devices or grounding & shielding computer controlled audio devices. Alternatively for the definitive text see the AES paper AES48-2005.

See also interfacing balanced and unbalanced connections.

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