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## Dealing with legacy pin 1 problems

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pin1.doc

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Bruno Putzeys

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### 1 The question

This document is a reply to various questions and statements along the following lines:

- **“Your amp module connects the audio ground to the chassis. This will cause hum when connecting. Can you please insulate the heatsink”**
- **“I can’t connect XLR pin 1 to chassis because the chassis is connected to mains earth and this causes ground loop currents.”**

Much to my delight, we don’t get these questions very often these days. Education does seem to work. But it should be an interesting read anyway. Plus, I’ll answer the perennial question how to connect an RCA source with an XLR input. Boy does *that* question recur often.

### 2 The short reply

In a balanced connection, there is no such thing as an “audio ground”. **There are just two wires.** The voltage between these two wires is the signal. The input is floating and does **not require a connection between the “audio grounds”** of the source and the receiver. That’s the whole point of balanced connections. You don’t want to rely on the two circuits being at the same potential because that’s often unachievable.

The third connection, pin 1, is only used to connect the cable shield. If making this connection causes hum, this indicates a misguided attempt to use pin 1 to connect the “audio grounds”. There is never a reason to connect pin 1 to directly to your circuit. If the a piece of kit has a such pin 1 problem, simply disconnect pin 1 on the cable end.

Lifting (floating) the internal ground is an illogical solution which doesn’t work and which is proof positive of a lack of understanding of the fundamental problem.

### 3 Is there a problem at all?

Pin 1 is not an audio connection. Pin 1 is for shielding. In principle you can connect balanced equipment using unshielded twisted pairs using only pins 2 and 3 of the connector. The only reason why this is not common practice is because it’s impractical to design input circuits that are wholly unaffected by radio interference. Otherwise, pin 1 would not be necessary.

Correct shielding practice requires that pin 1 connects to chassis and nowhere else. Current flowing through the shield should not be allowed into the audio circuit. After all, ground loops are a fact of life. The trick is to keep them out of your audio, not to try and get rid of them because that is usually not possible.

In the past, confused designers believed that pin 1 was an audio connection. So they wired it to the circuit board. This caused lots of problems. Fortunately, manufacturers have largely cleaned up their act in the past 20 years. Thanks to the hard work of the AES48 working group and outspoken manufacturers like Rane, pin 1 problems have been eliminated.

So to anyone saying “I must float pin 1” or “I must float the circuit” the first question is: have you kept up to date with current practice? Are you certain the problem still exists at all? Or is your perception still guided by scare stories caused by badly designed equipment in the past?

## 4 The long reply

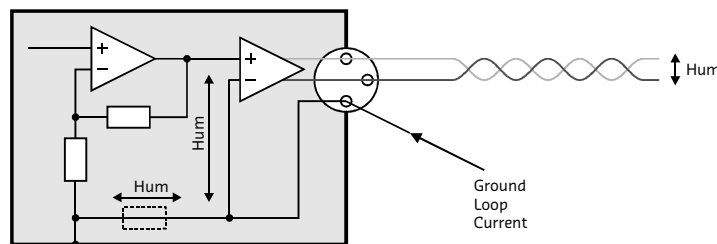
### 4.1 Cause

Ground loops never cause hum in **balanced interfaces**. Balanced interfaces have two wires, none of which is “ground”. The signal is the voltage between those two wires. Where those wires are with respect to “ground” is not relevant.

Ground loops do sometimes cause hum in **XLR connections** though. The reason is because XLR connectors have 3 pins and until a few decades ago people believed that the third pin was supposed to be connected to “my special ground”. Bingo! On top of the two signal wires they have just created a special input to usher circulating currents into their audio circuit! Looking back this is just incredibly daft.

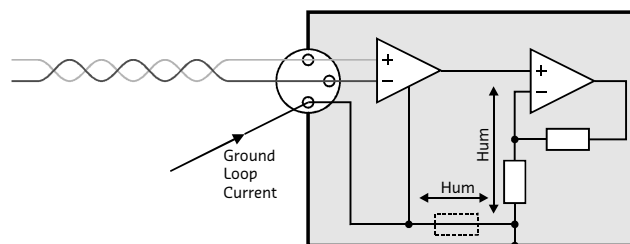
Pin-1 problems have nothing to do with balanced connections but with XLR connectors and how they’re wired.

Hum is often presented as something that only affects inputs. That’s a flawed assumption. Here’s a drawing showing an *output* which picks up hum injected through pin 1.



The loop current flows through the internal reference node (“audio ground”) and causes a voltage to develop in the wiring resistance of this node. Hum is introduced everywhere in the circuit.

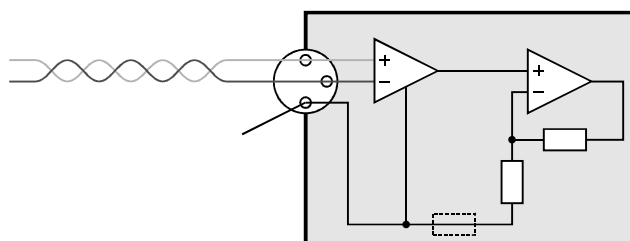
For completeness, here’s the same drawing for an input.



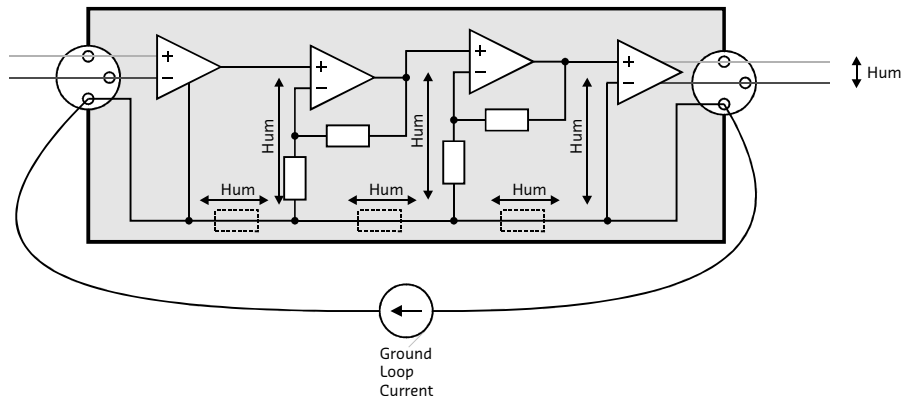
The root cause is the fact that an unthinkingly connected pin 1 functions as an unplanned input that gives direct access to an internal wire that nobody has any business with. This is completely unnecessary and counterproductive.

### 4.2 The bad solution: ground lifting

One can think of many places to cut the current flow. For reasons the author doesn’t understand, everyone at some point seemed to think the connection between the audio circuit and the chassis was the most logical one. That’s remarkable. A psychologist should look at it.

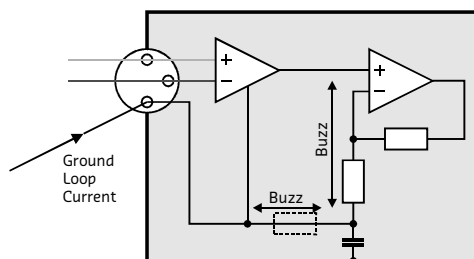


There are several reasons why this is flawed. First the *glaringly* obvious one: the chassis isn't always part of the loop, and disconnecting it will have no effect. As soon as you connect a second XLR, you're once again running your ground loop current all the way through your audio circuit.



Didn't help, did it? All that time invested trying to convince suppliers to make special parts with insulated screw holes and it just doesn't bloody work. **Lifting the ground is no solution.** It only helps to some degree when you have *exactly* one audio connector (an input or an output). But how many products can we think of with only one output and no input or vice versa? As soon as a second XLR turns up, that's the end of it. There is not a single documented case of an EQ or a compressor in which a ground lift switch has ever solved a hum problem. Didn't stop anyone from adding ground lift switches though and feeling smug about it.

The second reason is that for various EMC related reasons the circuit still ends up capacitively coupled with the chassis. Depending on the case, the capacitances range from nanofarads to microfarads.



Now, a 500nF capacitor may be a high impedance at 50Hz, at 4kHz it's not. Hum with the fundamental and lower harmonics removed is called "buzz". It's hardly an improvement.

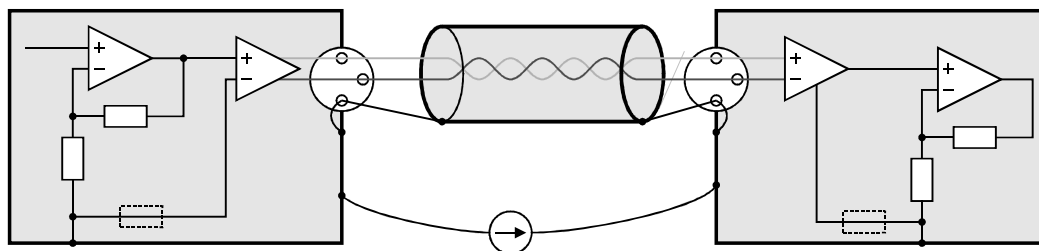
### 4.3 The good solution: AES48.

I'm told that in the mid 90's Rane corp had several staff manning phones to help people sort out hum problems. Then they took the courageous decision to cut the connection between the audio circuit and pin 1. Instead, pin 1 was connected to chassis. The audio circuit was also tied to the chassis, but crucially, *elsewhere*. A year later, support calls about hum problems had largely stopped coming.

What had been overlooked until then is that:

- Pin 1 has no actual function when it comes to transmitting audio. Two wires is all you need.
- Ground loop currents only cause hum when they are actually allowed into audio circuitry through pin 1.

Ground loops are a fact of life. There are many situations in which they can't be eliminated. So pin 1 should be recruited to safely conduct loop currents *around* the audio circuit instead of *through* it.



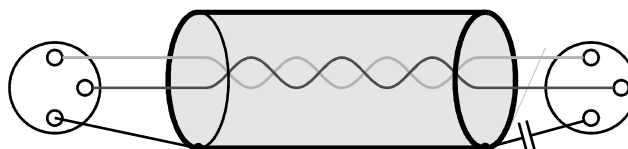
This astoundingly simple solution has been widely publicised and is enshrined in a standard called AES48. It has been wildly successful. It has been almost universally adopted and pin 1 problems are largely over.

### 4.4 What if the other box has a pin 1 problem?

This section is for users, not for manufacturers. By now it is a settled fact that AES48 practice is the correct way of doing things. It would be exceedingly short-sighted to deviate from AES48 simply because one day, one of your products might get connected to a box with a pin 1 problem.

So what to do if you're a user and you have a box with a pin 1 problem wired to an AES48 compliant product? The best solution of course would be to open the faulty box, disconnect pin 1 from the circuit board and connect it to the chassis with the shortest possible wire. That fixes the problem at its root.

OK so what if you're ham-fisted and you really can't be trusted with a screwdriver? **Don't cheat the mains ground. It's there for your safety.** Instead, cheat the ground connection in the audio cable. Make a cable with the shield disconnected on the receiving end. For RFI reasons it might be a good idea to add a small coupling cap (10n or so):

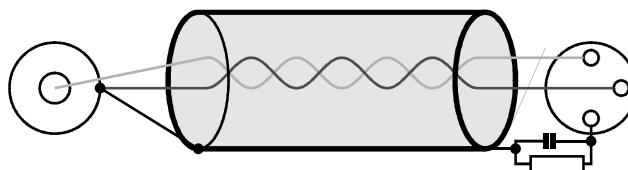


This serves to illustrate once again that the pin 1 problem is entirely self-inflicted. *There simply is no reason why, in a balanced connection, the two "audio grounds" should be connected by the audio cable.* So long as the two circuits are within volts from each other the whole set-up will work wonderfully.

I should stress that it is not a good idea to modify all your cables in this manner. The CMRR performance of the balanced connection is greatly improved when the shield is properly connected. Only use a cheater cable like the above when nothing else helps.

### 4.5 What to do with unbalanced (consumer) sources?

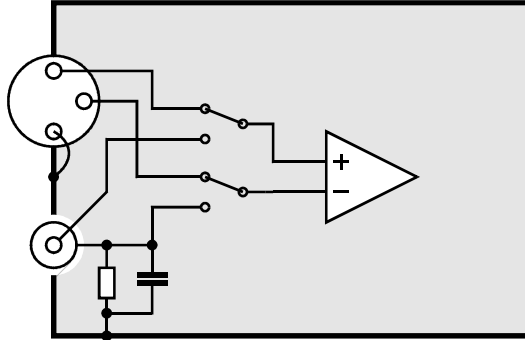
Although this is strictly outside the scope of this text, it's worth mentioning how to connect RCA to XLR. For starters, adapter plugs are a no-no. Instead, make this simple adapter cable:



The RC network (100nF, 100 ohms) can usually be shorted since consumer kit is always ground lifted. After all, it's the only thing that will have at least *some* effect when you only have 1 wire for the signal and the reference is sort of democratically negotiated among the boxes in the rig. This of course is why some pro designers were primed to think along those lines instead of just letting go of the whole "audio ground think" entirely.

The advantage of this connection is that the balanced input is used to sense the reference potential at the source instead of at the end of a conductor that also carries circulating currents.

When you're a manufacturer of semi-professional gear and you need to fit an RCA input on a grounded product, you do the same thing:



Essentially a differential input is a floating input. Nothing more, nothing less. The only reason why one should consider including an RC combination is to keep the signal within the common mode range of the input circuit (remember that the source may be floating) and to keep RFI that's been picked up by the RCA cable out of the box.

## 5 To read more

By the same author: "The G Word, or How to Get Your Audio Off The Ground", Linear Audio, vol 5 ([www.linearaudio.net](http://www.linearaudio.net)).

AES48-2005 (r2010): AES standard on interconnections - Grounding and EMC practices - Shields of connectors in audio equipment containing active circuitry.

Rane's famous app note: <http://www.rane.com/note110.html>

Also check out <http://rane.com/pdf/whitlock.pdf> for the tech support story.

Various good papers on the Jensen site, if with a slight pro-transformer slant:

[http://www.jensentransformers.com/apps\\_wp.html](http://www.jensentransformers.com/apps_wp.html)