Episode Book

EPISODE #5722

What Balanced Audio Actually Does in a DAC

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SYNOPSIS

Daniel has an editing workstation, monitor speakers, and a pile of outputs that don't line up. His question — what's the real path to a balanced signal out of a DAC, and when is it actually necessary? — turns into a tour of what's happening electrically inside the cable. We cover the difference between unbalanced and truly balanced wiring, why a shield that doubles as a ground is a hum delivery system, the three practical paths to a balanced rig (audio interface, optical isolation, pseudo-balanced wiring), and why mic-level signals need balanced far more than your desktop does. Plus: the DAC price ladder, where XLR stopped being exotic, and what to do when you're stuck unbalanced.

TRANSCRIPT



Corn

What's actually happening inside the cable when two pieces of gear refuse to get along?



Herman

That's the question that started this whole thing, isn't it.



Corn

It is, and it came from Daniel. He's got an editing workstation, a couple of monitor speakers, and a pile of outputs that don't line up cleanly. RCA works and it's reliable, but it's unbalanced. Toslink shows up sometimes, except the speakers don't always take it. And XLR on the output side of a DAC, he says, isn't as common as you'd expect. So he's asking four things. What are the most common paths to keeping a balanced signal on the output side of a DAC. When is balanced actually necessary. What interfaces show up as you climb the DAC price ladder for people who want it as a spec requirement. And whether power and audio running close together always injects noise, or whether that's a failure pattern you only see in specific setups. Plus, if you're stuck going unbalanced, what else keeps the noise out.



Herman

Four questions, one cable. That's a Daniel prompt.



Corn

He also said something I want to keep in the frame the whole episode, which is that this is a spec sheet term he's been confused about for a while. And he's not wrong to be confused, because the way it gets sold doesn't match what's happening electrically.



Herman

So let's start with what balanced actually means, because the connector doesn't tell the whole story. An unbalanced connection, sometimes called single-ended, uses one signal conductor plus a shield. And here's the part people miss. That shield isn't just a shield. It's the ground, and it's the current return path. The signal goes out on the center conductor and comes back through the shield.



Corn

Which is fine, until it isn't.



Herman

Right. Because now that shield is doing two jobs. It's carrying your audio back, and it's also the electrical connection between the grounds of two pieces of equipment. If any current is flowing along that path for reasons that have nothing to do with your audio, the voltage it drops across the shield's resistance adds straight into your signal. That's hum. That's buzz.



Corn

And the return current has no way to know it's supposed to be quiet.



Herman

Bill Whitlock, who wrote the Jensen application notes, put it more precisely. He said the inherent weakness of unbalanced interconnections is that the shield, which is also a signal conductor, is a path for power line related currents that always flow between equipment grounds.



Corn

Always. Not sometimes.



Herman

Always. They're always flowing. The question is whether they get into your signal.



Corn

So then balanced, on the other side.



Herman

Balanced uses two signal conductors plus a shield, and the two conductors have equal impedances to ground. That's the definition. Not the connector. Impedance symmetry. Typically it's XLR or a quarter-inch TRS jack, but the plug is downstream of the actual property. You can have a TRS jack that isn't balanced. You can have an XLR wired in a way that isn't balanced.



Corn

And the reason that symmetry matters is the transmission.



Herman

It's differential. You send two copies of the signal. The hot one at zero degrees, the cold one inverted, one hundred eighty degrees out of phase, down a twisted pair. Any interference that couples into the cable couples into both conductors roughly equally, because they're twisted together and sitting in the same electromagnetic field. At the receiving end, a differential amplifier subtracts one from the other. What's common to both gets cancelled. What's different survives.



Corn

The noise is common. The signal is differential. So you throw away the noise.



Herman

And how well you throw it away has a number. Common-mode rejection ratio. CMRR. That's the figure of merit. A simple adapter cable, the kind people buy to go from an unbalanced output to a balanced input, gets you about thirty decibels of rejection at sixty hertz. An input transformer gets you a hundred. A good four-to-one step-down input transformer gets you a hundred and twenty.



Corn

Thirty versus a hundred and twenty. That's the difference between a fix and a fudge.



Herman

That's exactly the difference. A thirty dB adapter handles some of it. It does not handle a real ground loop.



Corn

So that's the theory. Now Daniel's actual workstation, because this is where it gets practical. What's the realistic path to balanced out of a DAC feeding monitor speakers?



Herman

The honest answer for a desktop rig is usually that you stop looking at consumer hi-fi DACs and look at an audio interface instead. Interfaces are built for this. They've got balanced quarter-inch or XLR outputs as the default, because the whole pro and prosumer world assumes you're running to powered monitors.



Corn

There's a commenter on Hacker News who described exactly this setup. Mackie monitors that accept XLR, TRS balanced, and RCA unbalanced. And he built a custom TRS-to-XLR cable to go from his interface to the monitors.



Herman

That's the move. The monitors usually give you all three, so you meet them with whatever your source does best. And the source, in that case, was an interface. He also noted that Schiit gear at the time only offered RCA, which he described as sadly not balanced at all.



Corn

That's a real constraint. Schiit made good converters and they just didn't do balanced on the output.



Herman

Not on those models. And that's the thing about this whole category. It isn't a quality signal. It's a feature decision. Plenty of excellent-sounding gear is unbalanced on the output, because the designer decided the market for it didn't need XLR.



Corn

So interface is path one. What's path two?



Herman

Toslink. And this is the one I want to spend time on, because it's the most misunderstood tool in the box and it's arguably the highest leverage for Daniel's exact situation.



Corn

Because it's not an analog output at all.



Herman

It's not. It's a digital input. Optical. So people look at the back of a DAC, see a Toslink port, and assume they can run it to the speakers. You can't, unless the speakers have an optical in, which most monitors don't.



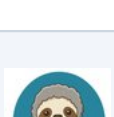
Corn

Right, and Daniel said that. Toslink shows up sometimes as an output but the speakers often don't support it.



Herman

Here's why it matters anyway. An optical cable carries light. There is no electrical connection between the two ends. The Toshiba datasheet for the TOSLINK parts describes it as complete galvanic isolation, not susceptible to electromagnetic interference, and it doesn't radiate electromagnetic noise either. It's light in a plastic fiber.



Corn

So the ground loop has nowhere to travel.



Herman

The ground loop is broken at that point in the chain. And that's the trick. You go optical from your computer into the DAC. The computer's ground and the DAC's ground are now electrically separate, because the only thing between them is a light pipe. Then you go balanced analog out of the DAC to the speakers.



Corn

So you break the loop on the digital side where it's easy, and you get the noise rejection on the analog side where it matters.



Herman

That two-step is cheaper and more effective than any boutique analog cable you can buy. It solves the actual problem. And for a PC-based editing rig, the PC is usually the worst offender in the chain, because a computer's ground is a noisy place. Switching supplies, fans, drives, display cable ground. You don't want that tied to your DAC's analog reference.



Corn

Daniel edits audio clips on this machine, so the PC isn't optional. It's sitting right there.



Herman

Then isolate it. That's the clean answer.



Corn

Path three?



Herman

Pseudo-balanced, or what Rane calls floating unbalanced. Some quarter-inch outputs are wired so that the tip and ring present equal impedance even though the circuit itself isn't truly differential. That lets them drive a balanced input without an adapter, and the noise rejection is partial but real. RaneNote 110 covers it. Jensen goes further and notes that a simple modification can convert an unbalanced output into a true balanced one, just by



Herman (continued)

adding an impedance-matched network to ground for the cold leg.



Corn

Which is a soldering iron answer.



Herman

It's a soldering iron answer, yes. But it exists, and it tells you something important. Balanced-ness is a property of the circuit and the wiring, and you can sometimes get there without changing boxes.



Corn

So we've got three paths. Interface, optical isolation, pseudo-balanced or modified. Now the question Daniel actually wants answered, which is when any of this is necessary.



Herman

SoundGuys put it plainly. Balanced is absolutely essential for microphone-level signals. And why? Because a microphone puts out millivolts. You then apply enormous gain to get it up to line level, and gain amplifies everything, including the noise. So at mic level, balanced isn't a luxury. It's basic hygiene.



Corn

Line level is a different world.



Herman

Completely different. Line level is around a volt. There's almost no gain needed downstream, so there's almost nothing to amplify the noise. SoundGuys again, for line-level home audio with short runs, using a balanced connection is unlikely to provide much benefit, beyond the more reliable connectors.



Corn

Which is a strange thing to hear from an audio site.



Herman

It's an honest thing to hear. Balanced becomes necessary when the run gets long, or when it's likely to encounter interference, or when you've got a ground loop in the system. Rane's rule of thumb is a hard line. Any unbalanced cable must be kept under ten feet. Past that, you're amplifying every nasty side effect of the ground loops that unbalanced wiring invites.



Corn

Ten feet. That's a small room.



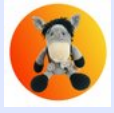
Herman

It's a small room, which is why most home setups are fine unbalanced. Your DAC is on the desk, your speakers are on the desk, the cable is three feet long, there's no loop, and it works.



Corn

And Rane's other point is that mixing balanced and unbalanced is where trouble starts. They're not compatible. You can't just adapt one to the other and expect the noise rejection to survive.



Herman

You lose the rejection the moment you leave the balanced pair. The common-mode noise has to be able to travel on both conductors together. The second you tie one of them to a shield that goes somewhere else, you've broken it.



Corn

So for Daniel, sitting at a desk with speakers two feet away, is balanced necessary?



Herman

Honestly? Probably not, if the speakers and the DAC share a clean ground and the cable is short. But he's asking a different question, and it's the right one, which is what do you do when it isn't clean. And the answer to that is worth knowing before you have a problem.



Corn

Now let's climb the DAC price ladder, because Daniel specifically asked what interfaces show up as you move up and people actually want balanced as a spec.



Herman

This is where the premise is a little outdated, in a way that helps him. XLR outputs are no longer exotic. They show up on budget desktop DACs now. Fosi Audio's ZD3 runs an ES9039Q2M converter, gives you both XLR and RCA out, and claims a signal-to-noise ratio of at least one hundred twenty-six decibels with distortion under point zero zero zero zero eight percent.



Corn

On a desktop DAC.



Herman

Kaamos W-DAC v3 is in the same zone. XLR at four volts RMS, RCA at two volts RMS, a hundred and sixteen dB SINAD. Ferrum ERCO gives you balanced XLR and unbalanced RCA line outs plus headphone outs. Emotiva's XDA-3 and DRD-1 are built around what they call a Differential Reference design, a fully balanced signal path end to end. Eversolo's DAC-Z10 gives you XLR and RCA, plus I squared S over HDMI, AES/EBU, dual coax, dual optical, HDMI ARC and eARC.



Corn

That's a lot of ports.



Herman

It's a Swiss army knife. And notice what's happening. At the top end, balanced is no longer a single feature. It's a whole architecture. Cantico's J-DAC uses custom output transformers for what they describe as complete galvanic isolation, with identical performance on the balanced XLR and unbalanced RCA outputs, and a physical selector that activates only one output at a time.



Corn

Only one at a time.



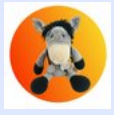
Herman

Because the transformer is shared. They don't want both loads attached. It's a deliberate constraint, not a bug.



Corn

And the digital side at that level?



Herman

That's where AES/EBU shows up, which is a balanced digital connection over XLR. So when a high-end DAC says balanced, it often means two different things. XLR analog out, and AES/EBU digital in. That's the rarer interface. The analog XLR has become common. The digital balanced has not.



Corn

Now the hidden gotcha, because you mentioned four volts versus two.



Herman

The level mismatch. Consumer gear runs at minus ten dBV, which is about three hundred sixteen millivolts RMS. Pro gear runs at plus four dBu, about one point two three volts RMS. That's a twelve decibel gap. And it matters when you go from an unbalanced output to a balanced input, or the reverse, because the levels don't line up. You may need gain to make up the difference. And Jensen makes a point that trips people up. A transformer can't supply gain reach. It can isolate, it can reject, it will not lift your level.



Corn

So you solve the hum and introduce a level problem.



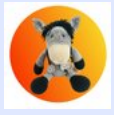
Herman

You can, if you're not paying attention. That's why the interfaces matter more than the adapters. If both ends speak the same level convention, you're fine. If they don't, an adapter won't fix it.



Corn

Now Daniel's fourth question, and I think this is the one where most people have the wrong mental model. Does running power and audio close together almost always introduce noise, or is that a specific failure pattern?



Herman

That's the reframe of the episode. Power near audio doesn't inject noise. Proximity is a red herring. What injects noise is sharing a ground path that carries current through your signal reference.



Corn

Say that again, slower.



Herman

Your audio signal is measured against a reference. If that reference is moving because current is flowing through it, your signal moves with it. That's the mechanism. It has nothing to do with how close the power cable is. It has everything to do with whether the two pieces of gear are sharing a conductor that's carrying current.



Corn

So the power cable lying across the audio cable is not the problem.



Herman

In a well-designed system with good common-mode rejection, it's not. Rane says almost all cases of noise can be traced directly to ground loops, grounding, or lack thereof. And they add that the mere presence of ground-loop current is no cause for alarm if your system uses properly implemented and completely balanced interconnects.



Corn

So the loop can be there and you don't hear it.



Herman

That's the point people miss. A ground1 white paper says low-current ground loops are entirely normal and may or may not create problems. Normal. Every building has them. Unbalanced interfaces will always be susceptible to them. Balanced interfaces only fail when the wiring is improper or the common-mode rejection is poor.



Corn

And the voltage difference between outlets is just a fact of AC wiring.



Herman

It's a fact. A properly code-compliant system will develop small, safe voltage differences between the safety grounds at different outlets. Millivolts between outlets on the same branch. Up to several volts between distant ones. That's not a fault. That's physics of a



Herman (continued)

shared electrical system.



Corn

Several volts is not nothing.



Herman

Several volts, into a signal that's a volt, is a lot. Which is why the interface matters and the proximity doesn't. Jensen has a concrete case in one of their notes. A ground voltage difference drove just under two hundred milliamps through the cable shields and produced about six decibels of hum. Six decibels is audible. That's a real, measured failure. And the cause was a specific multi-device ground loop, not two cables lying next to each other.



Corn

So the picture is, the loop is always there, the voltage difference is always there, and whether you hear it is a function of your interfaces and your wiring.



Herman

If you have unbalanced connections and a shared ground path, you may hear it. If you have balanced connections, the differential receiver throws it away. And if you've got a badly wired balanced connection, you can still hear it, because a balanced connector on both ends doesn't guarantee a balanced circuit.



Corn

Which lines up with where we started.



Herman

It does. The connector is not the property.



Corn

So Daniel's last question. If you have to go unbalanced, what keeps the noise out?



Herman

Transformer isolation is the first answer. Rane calls it the quickest, quietest, and most foolproof method to connect balanced and unbalanced equipment. You put a transformer in the path, and the transformer couples the signal magnetically. There's no galvanic connection between the two sides. So the ground loop current has nowhere to go.



Corn

And Jensen says the transformer preserves the noise cancelling characteristics of the balanced output.



Herman

It does. It's not a compromise, it's a translation. The signal goes in on one side and comes out on the other with the same differential rejection intact.



Corn

There's a Hacker News comment from this year on this exact topic. Transformers are imperfect, but if it works and you don't hear a problem with it, then there is no problem.



Herman

I love that line. Because it's true. A ground-loop isolator, one of those cheap one-to-one transformer boxes you find in the car audio aisle, is the practical DIY fix for computer-to-speaker hum. It's not elegant. It doesn't measure like a Jensen transformer. But for a hundred-dollar problem in a home studio, it's the right answer. If you can't hear it, it's not a problem.



Corn

Second option.



Herman

Optical, which we already covered, but it belongs on this list too. If you're stuck going unbalanced from the DAC to the speakers, you can still break the loop upstream with Toslink into the DAC. That doesn't fix the analog run, but it removes the computer's ground from the equation, which is usually the worst of it.



Corn

Third.



Herman

Shield termination. AES48 says tie the shield to the chassis at both ends. That's the standard, and it's usually right. But when it hums, you disconnect the shield at the receiving end. Rane notes that off-the-shelf cables with one end lifted aren't sold, so this is a custom cable job. You're building it yourself.



Corn

That's a specific, fiddly answer for a specific problem.



Herman

It's the kind of thing you only do if you've already diagnosed it. Pull the shield at the receiving end, and the loop breaks at that point. If it still hums, the problem is elsewhere. Or you use what's called a hybrid termination, a small capacitor, about zero point one microfarads, from the shield to the chassis, which gives you a path for radio frequencies but not for the hum frequency.



Corn

And the ground lift switch.



Herman

Rane calls it a band-aid. It rarely helps, and it reduces the unit's ability to be properly grounded. The switch exists because people asked for it. That doesn't make it a solution.



Corn

Anything else?



Herman

Keep the unbalanced run short. Under ten feet, per Rane. And use shielded twisted pair, even though it's unbalanced. The twist doesn't do much in an unbalanced connection, but the shielding is still doing something. Every foot you add is another chance for the ground current to drop voltage in your reference.



Herman

I want to come back to something, actually, because I think I skipped past a distinction I should have made.



Corn

Go on.



Herman

There's a trap in the spec sheet that I should have named earlier. Balanced headphone outputs. SoundGuys is blunt about this. They ask whether balanced headphone outputs are just another case of specsmanship and audiophile-targeted marketing, and their answer is, you betcha. That's not an audio site trashing a feature it doesn't understand. That's the mainstream position, and it's correct.



Corn

So the same word is doing two jobs.



Herman

That's the trap in the spec sheet. On a headphone output, balanced usually means a slightly higher voltage swing and a separate ground return per channel, which sometimes helps with high-impedance cans on a marginal amp. On a line-level interconnect, balanced is the one thing Rane says can guarantee hum-free results. Same word. Completely different engineering claim.



Corn

So a listener reading a DAC spec sheet sees balanced and doesn't know which one they're getting.



Herman

They don't, unless they read carefully. If it's under the analog output section, it's the real thing. If it's under the headphone section, it's more sloganeering than specification.



Hilbert

They're both correct.



Corn

Hm.



Hilbert

The wiring inside the cable can be the lie. I found that out the expensive way.



Herman

How so?



Hilbert

A quarter-inch TRS to XLR male. Sold as balanced. I bought it to go from a keyboard to a mixer. It hummed. Just there, under everything.



Corn

And the connectors were right.



Hilbert

Both ends looked correct. I opened it up at the TRS end. The ring and the sleeve were shorted together. One wire, jumped across. So the signal at the TRS had the cold leg tied straight to ground. That's not balanced. That's an unbalanced cable wearing balanced fittings.



Herman

That's a pseudo-balanced cable at best. On a lot of gear it works fine. On the gear I'm guessing you had, it wouldn't.



Hilbert

It didn't. I cut the short, ran a proper wire to the ring, and the hum went. That was the whole fix. One wire.



Corn

And this is the piece the theory doesn't teach you. The cable is a component. It can be wrong.



Hilbert

It cost me the price of a cable and an afternoon. I don't regret it. I learned more from the cable I opened than from the ones I bought that worked.



Corn

I want to sit with that for a second, because it changes how I'd look at Daniel's problem. If you buy a balanced cable, you don't necessarily have a balanced cable. You have a cable with balanced plugs on it.



Herman

You can't tell from the outside. You can test it. If you have a multimeter, you check continuity between the ring and the sleeve at one end. If they're connected, it's not balanced. That's the test.



Corn

One wire. That's the whole thing.



Herman

One wire, and the spec sheet can't tell you about it.



Corn

There's a line from Naiant Studio I want to read, because it lands the whole episode. It's humorous to see audiophiles spending hundreds of dollars on fancy RCA cables, when just about any reasonable quality XLR cable in a balanced interconnection would be a huge upgrade.



Herman

That's the whole lesson. You're paying for the wrong end of the chain. The cable with balanced wiring, even a cheap one, beats the boutique RCA every time, if the problem is noise rejection.



Corn

The piece of cable specificity that Hilbert just added. If the cheap XLR is miswired, you're paying for a label.



Herman

You are.



Corn

Let's land this. What's the takeaway for someone staring at a DAC spec sheet right now?



Herman

The first thing I'd say is that the question changes as budget gear catches up. Fosi and Kaamos and Emotiva are all shipping XLR out at prices that used to get you RCA only. So the question isn't can I get balanced anymore. It's do I need it.



Corn

The answer depends on the run length, whether there's a ground loop, and whether you're in a home studio or a rack full of gear.



Herman

That's it. A desktop rig with a two-foot cable and one grounded outlet is fine unbalanced. A rack with a dozen devices sharing grounds is not. The spec sheet can't tell you which one you have.



Corn

The other thing, and I keep coming back to this, is the real fix is often digital. Toslink into the DAC to break the loop, then balanced analog out. Cheaper than a boutique analog cable and it actually solves the problem instead of dressing it up.



Herman

If you have to go unbalanced, transformer isolation, short runs, and remember that the cable itself can be miswired.



Corn

On the cutting room floor. The thing I wanted to fit in and couldn't. Jensen measured rejection ratios on all the common ways of adapting between balanced and unbalanced. The best-performing cheap option wasn't a transformer or an adapter box. It was a four-to-one step-down input transformer, hitting a hundred and twenty decibels of common-mode rejection at sixty hertz. That's better than most flagship gear by a wide margin, and you can find them for a few dollars in surplus.



Herman

The switch in the cable?



Corn

No switch. Just a transformer, a shield, and a decision about which wire goes where.



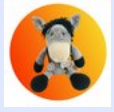
Herman

That's where the whole episode lives, honestly. The connector is not the property. The wiring and the isolation are.



Corn

Daniel asked whether power near audio causes noise. The answer is no. Ground loops do. And the fix is almost always upstream of the cable you'd blame.



Herman

Which is a good place to leave it.



Corn

This has been My Weird Prompts. Hilbert Flumingtop is our producer. If you enjoyed the episode, a review wherever you listen helps a lot.



Herman

You can find us at my weird prompts dot com, or email us at show at my weird prompts dot com. And if you've got a workstation with a grounding problem and a cable you don't trust, we want to hear about it.



Corn

We'll be back soon. Take care.