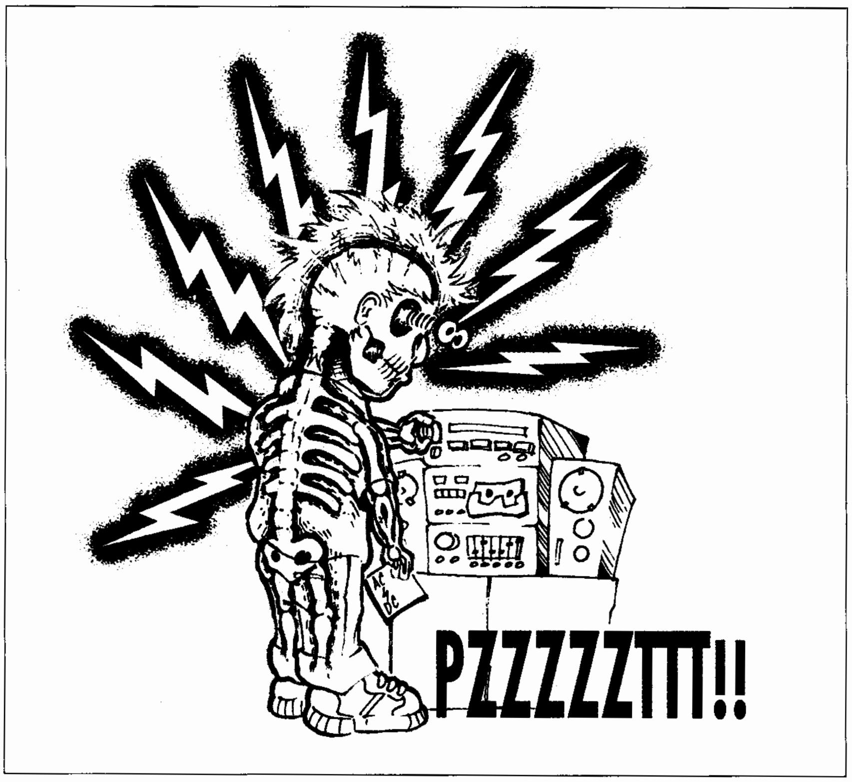
A Question of Balance

Finding problems in balanced interfaces

By Bill Whitlock

Previously (*Live Sound June 2006*), we explored the theoretical aspects of balanced interfaces and de-bunked the widespread myth that equal and opposite signal swings are somehow responsible for its noise-rejection properties. In this column, we will explain how to find most problems that degrade performance in real-world systems. The problems fall into two broad categories. The first is design errors in the equipment itself, most often the 'Pin 1 problem' that couples shield current noise into the audio. The second is problems caused by the type and/or routing of the audio cables themselves.



Hummmm... Now which Pin is that?

Since cable shields are tied to Pin 1 in XLR connections, this equipment design error was dubbed the Pin 1 problem by Neil Muncy in his famous 1995 AES Journal paper. This form of common-impedance coupling has been inadvertently designed into a surprising number of well-known products with balanced interfaces. As Neil says, *"Balancing is thus acquiring a tarnished reputation, which it does not deserve. This is indeed a curious situation. Balanced line-level interconnections are supposed to ensure noise-free system performance, but often they do not." [1]*

The Pin 1 problem makes the cable shield contact act as a very low-impedance signal input! Shield current, consisting mainly of power-line noise, is allowed to flow in internal wiring or circuit board traces shared by amplifier circuitry. Because these wires or traces have electrical resistance, tiny voltage drops are created and amplified to appear at the equipment output. When this problem exists in systems, it can interact with other noise coupling mechanisms to make noise problems seem illogical and confounding. This problem can afflict video and other unbalanced interfaces, too.

Fortunately, a simple test will reveal the Pin 1 problem. The 'hummer' (**Figure 1**) is based on an idea suggested by John Windt. *[2]* This simple device, whose schematic is shown here, forces an AC current of about 50 mA to flow through the potentially troublesome shield connections in the equipment under test. In *properly* designed gear, this causes no additional noise at the equipment output. The 12 volt transformer should be rated for about 50 mA. The optional LED (and 1N4001 diode) are used simply to confirm that current is indeed flowing.

Using the hummer, step by step:

1. Except for the output being monitored, disconnect <u>all</u> other cables and any other chassis connections, such as rack mounting, from the equipment under test.
2. Power up the equipment.
3. Meter (and listen, if possible) t o its output. The only noise should be white noise or 'hiss'. Try various settings of operator controls to familiarize yourself with the noise characteristics of the device under test *without* the hummer connected.
4. Connect one hummer lead to the device chassis and touch the other lead to the shield contact of each input or output connector. If the device is properly designed, there will be no output hum or change in the noise floor.
5. Test other potentially troublesome paths, such as from an input shield contact to an output shield contact or from the safety ground Pin of the power cord to the chassis or shield contacts. No such path should result in noise.

Rarely, shield contacts are not tied directly to chassis or safety ground and the hummer's LED will not glow. This is cause for concern, especially on an output — *output*

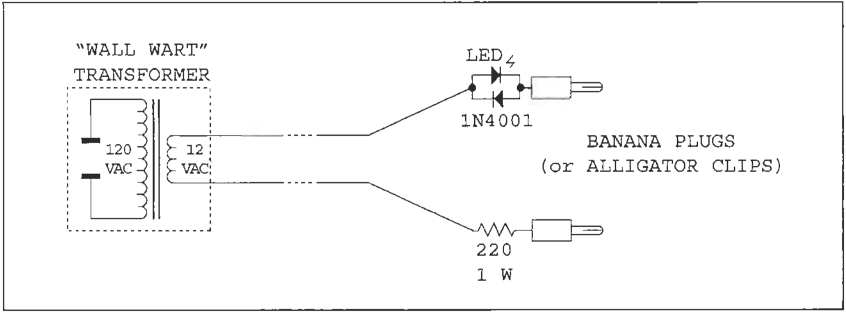


Figure 1 – The 'hummer'.

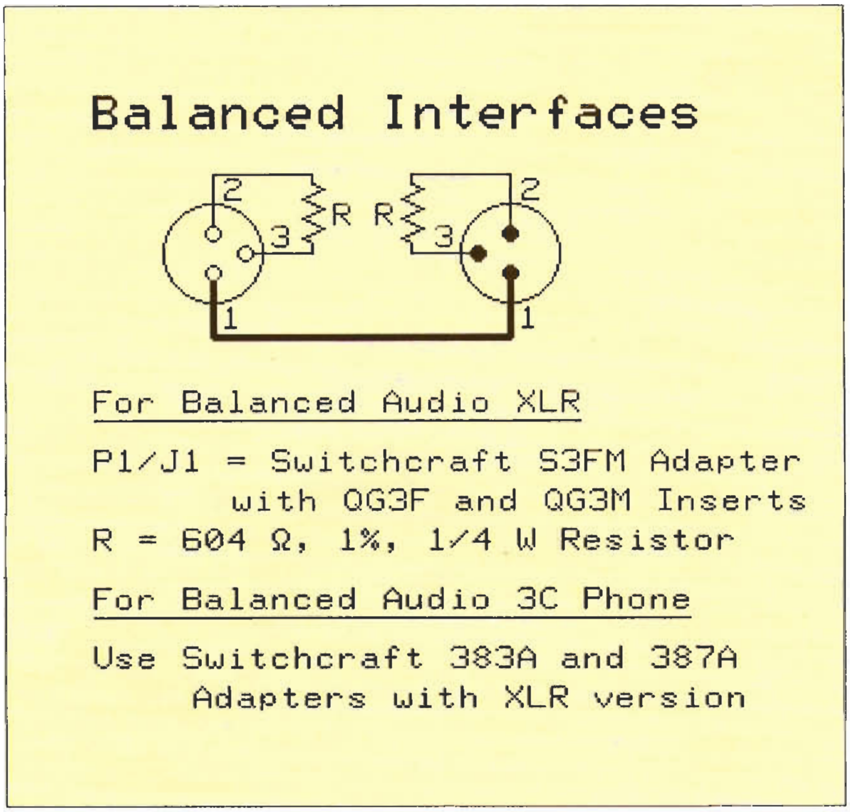
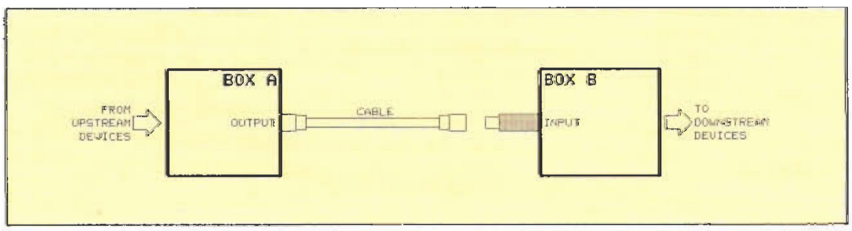
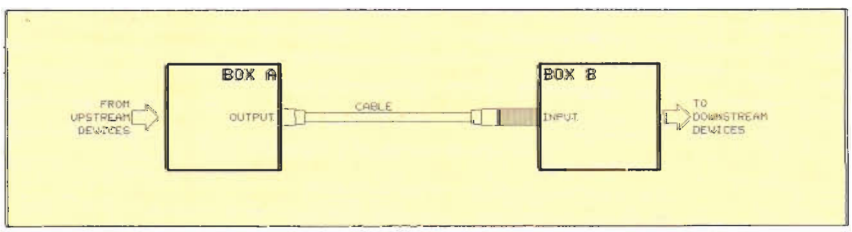


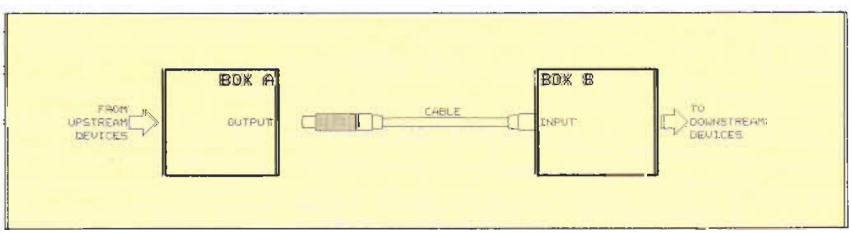
Figure 2 – Correct wiring for test adaptors (dummies).



Step 1



Step 2



Step 3

shields must *always* be grounded. *[3]* In any case, try to find out where the manufacturer has actually tied the shield connection.

FINDING CABLE-RELATED PROBLEMS

Easily constructed test adapters or 'dummies' allow the system to test itself and pinpoint the exact entry point of noise or interference. By temporarily placing the dummies at strategic locations in the interface, precise information about the nature of the problem is also revealed.
The tests can specifically identify:

- Shield-current-induced coupling in cables,
- Magnetic or electrostatic pickup by cables of nearby fields, or
- Common-impedance coupling *inside* defective equipment.

The dummies are made from standard connectors wired as shown in **Figure 2** – do not connect the metal shell to Pin 1. Remember that ***they do not pass signal***. Each signal interface is tested using the following four-step procedure:

STEP 1

Unplug the existing cable from the input of Box B and plug in only the dummy. Output quiet?

No — The problem is either in Box B or further downstream.
Yes — Go to next step.

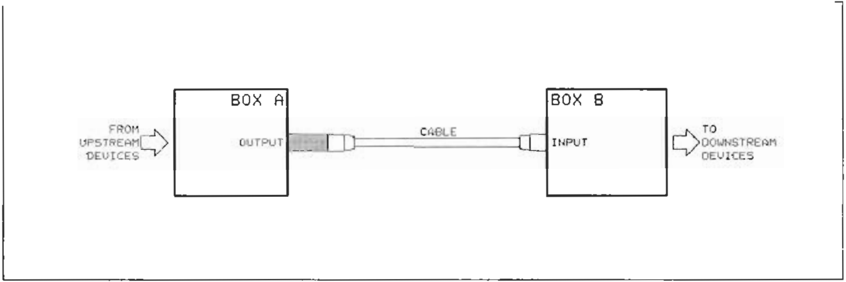
STEP 2

Leaving the dummy in place at the input of Box B, plug the existing cable into the dummy. Output quiet?

No — Box B has an internal "Pin 1 problem." The hummer test can confirm this.
Yes — Go to next step.

STEP 3

Remove the dummy and plug the existing cable into the input of Box B. Unplug the other end of the cable from Box A and plug it into the dummy. Be sure the *dummy doesn't touch anything conductive*. Output quiet?


BOX A
BOX B
FROM
UPSTREAM
DEVICES
OUTPUT
CABLE
INPUT
TO
DOWNSTREAM
DEVICES

Step 4

No — Noise is being induced in the cable by an external magnetic or electric field. Check cable shield connections at both ends and/or re-route the cable to avoid interfering fields.
Yes — Go to next step.

Leaving the dummy in place on the existing cable, plug the dummy into the output of Box A. Output quiet?

No — The problem is shield-current-induced noise or SCIN. Replace the cable with a different type or take steps to reduce current flow in the shield [4].
Yes — The noise must be coming from the output of Box A. Perform this 4-step test sequence at the next upstream interface.

In our next column, we'll discuss how to solve the problems revealed by this troubleshooting.

[1] Muncy, N., *Noise Susceptibility in Analog and Digital Signal Processing Systems*, Journal of the Audio Engineering Society, June 1995, pp. 435-453.

[2] Windt, J., *An Easily Implemented Procedure for Identifying Potential Electromagnetic Compatibility Problems in New Equipment and Existing Systems: The Hummer Test*, Journal of the Audio Engineering Society, June 1995, pp. 484-487.

[3] Whitlock, B., *Balanced Lines in Audio Systems: Fact, Fiction, and Transformers*, Journal of the Audio Engineering Society, June 1995, pp. 460-462.

[4] Brown, J. and Whitlock, B., *Common-Mode to Differential-Mode Conversion in Shielded Twisted-Pair Cables (Shield-Current-Induced Noise)*, Preprint 5747, Audio Engineering Society 114th Convention, March 2003, Amsterdam.

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