

# Pin 1

*Revisited...*

## Part 2

In the last newsletter (Vol 31, #2), I showed how very short lengths of wire connecting input shields to an equipment chassis could have enough inductance to couple significant radio frequency interference into audio equipment, and showed how one manufacturer had solved the problem. This time we'll look at other effective solutions.

The European EMC directive, implemented in the late 1990's, places limits on noise emissions from electronic equipment sold in most European countries. It caused a lot of manufacturers to get EMC religion, and gave new life to RF engineers working in labs dedicated to verifying compliance. The engineers, working in these labs and those specializing in designing for good EMC performance think in terms of RF immunity and computer/digital systems. Few have much practical experience with analog audio systems, and some of the design solutions they advance can cause us considerable grief - especially the treatment of cable shields.

From an RF point of view, the shell of an XL con-

ductor looks like it should work as the extension of the cable shield. For broadband RF immunity, it can be helpful to ground shields at every opportunity and carefully bond all grounded objects together at multiple points. Such a philosophy is the basis of the so-called "mesh" ground topology, and it can work well in installations where there's little difference in potential between grounds at opposite ends of the audio paths. But power system leakage currents cause enough power-related shield current to flow in most real world installations to couple noise into the sound system if both ends of a cable shield are grounded.

Since the 1930's, engineers have known that audio frequency noise coupling will be minimized with single point (star) grounding, while radio frequency noise coupling is minimized with multi-point (mesh) grounding. The solution is simple -- the shield of a balanced audio cable is connected to the shielding enclosure at the driving source, and to the shielding enclosure at the receiving end through a capacitor. It was easy to do this in the 40's, when RF signals higher than 30 MHz were rarely encountered. It's much tougher now, when the interference sources are strong RF signals from UHF cell phones and high power TV transmitters. Again, it's series inductance that makes life difficult, this time the inductance of the capacitor's wire leads.

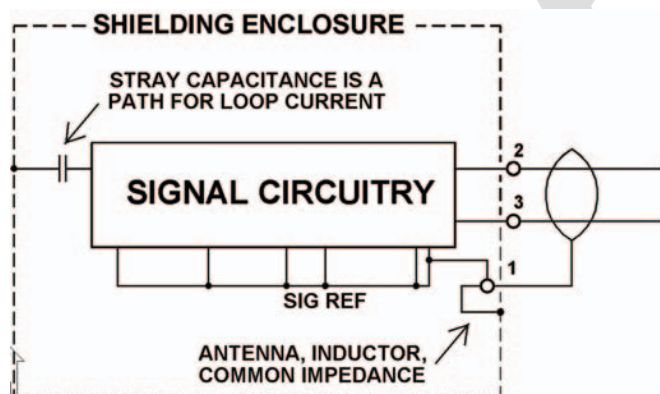


Fig 1 – This is the classic RF pin 1 problem in a mic. The cable shield goes to the enclosure, but through a wire long enough to have significant inductive reactance at VHF. The drop across the inductance is coupled to the signal zero reference, where it is added to the signal.

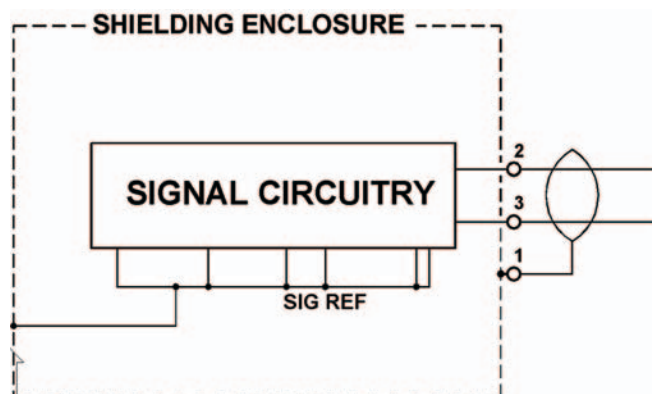


Fig 2 – A circuit configuration that avoids a pin 1 problem. The shield goes directly to the shielding enclosure. Signal reference common also goes to the shielding enclosure, but there is no common impedance.

Feed-through capacitors have been a solution to this problem since the 1930's. They mount in a circular hole in an enclosure. One "plate" of the capacitor is a wire going through the enclosure, while the other "plate" is a cylinder surrounding the wire and connected to the enclosure, with a dielectric (insulation) between the plates. This circular construction minimizes the inductance through the capacitor to the chassis enclosure, while the wire coming into the chassis enclosure still has inductance. The resulting electrical circuit is an effective RF filter while it also prevents a hole in the shielding.

To provide the most effective shielding, both cable shields and the shells of connectors within equipment should be bonded to the chassis. (Retired Bell Labs engineer and EMC authority Henry Ott observes that if this connection is to the outside of the enclosure, skin effect will keep RF currents outside the enclosure as well.) But what about cable-mount connectors? To make the EMC engineering community happy, mic cables should tie the cable shield to the connector shell, but to make audio folks happy the shield should go only to pin 1. A few years ago, I proposed the concept of making a cylindrical connection to the shield in cable-mounted connectors much like that in a BNC connector, with that cylinder surrounded by a cylindrical dielectric that was

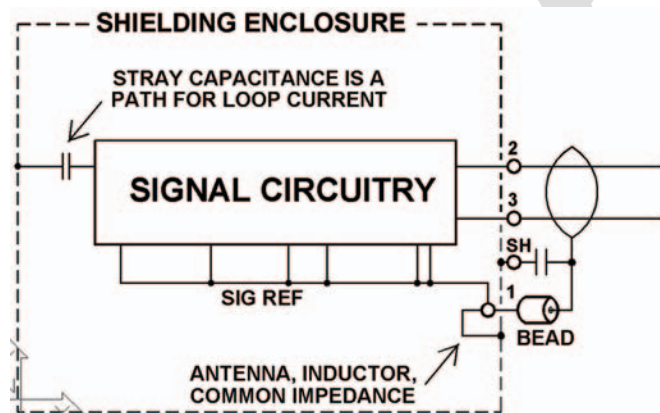


Fig 3 – The new EMC connector as it would be used at both ends of a mic cable. The shield has a DC connection to pin 1 with a ferrite bead around it. The concentric capacitor also connects it to the shell. The ferrite bead increases in series impedance through pin 1 at RF, while the capacitor makes a very low impedance connection of the shield to the equipment (or mic) enclosure.

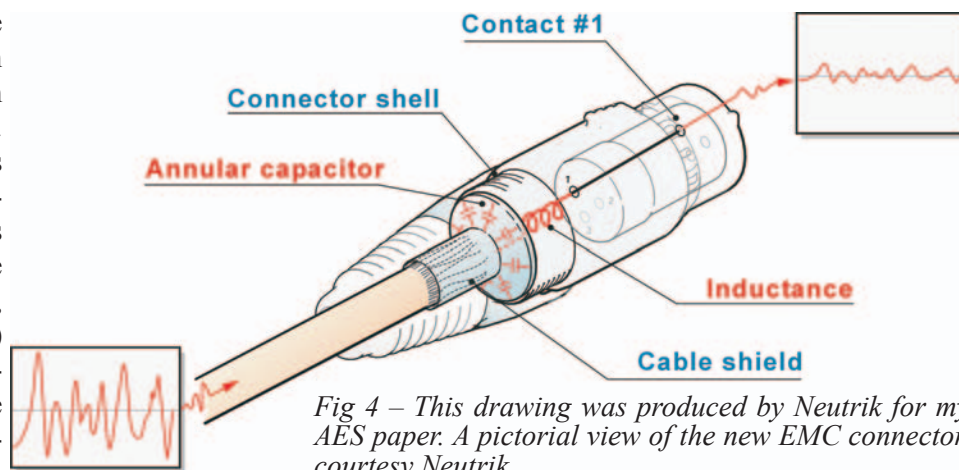


Fig 4 – This drawing was produced by Neutrik for my AES paper. A pictorial view of the new EMC connector, courtesy Neutrik.

itself surrounded by a cylindrical plate connected to the connector shell. Such construction would form a capacitor having very low series inductance, turning the XL connector into a two-circuit feed-through capacitor. It would connect the shield to the shell at RF, while isolating it from the shell at audio frequencies and DC. When used on mic cable, the shield is also soldered to pin 1. When used at line level inputs in a rack, an installer could decide not to connect the shield to pin 1, but it would still be connected to the shell at RF through the capacitor.

Engineer Joanne Dow observed that if such a connector were to be used with a connection to pin 1, the capacitor and the series inductance to the chassis through pin 1 would form a parallel resonance, and suggested a ferrite bead surrounding pin 1 in the cable connector to lower the Q of the resonance.

It took a while for these ideas to germinate, but before long, engineers at Neutrik had begun work on a practical implementation, and by early 2002 had developed engineering prototypes. British consultant John Woodgate tested them in his lab, and I tested them both in my lab and in the field. The results met my expectations, and yielded an unexpected bonus – they solved RF pin 1 problems, even when pin 1 was connected at both ends!

A simple circuit study shows why. Figure 3 shows a cable using the new connectors used with the mic shown in Fig 1 in from the last newsletter issue. The concentric capacitor ties the shield to the mic shell with an induc-

*Ferrite beads are very useful components that magnify the inductance of a wire passed through them because they offer a much better path for the magnetic flux surrounding the wire. At higher radio frequencies, the ferrite material provides more loss than inductance. Beads are made using a variety of materials to optimize their effect in different frequency ranges.*

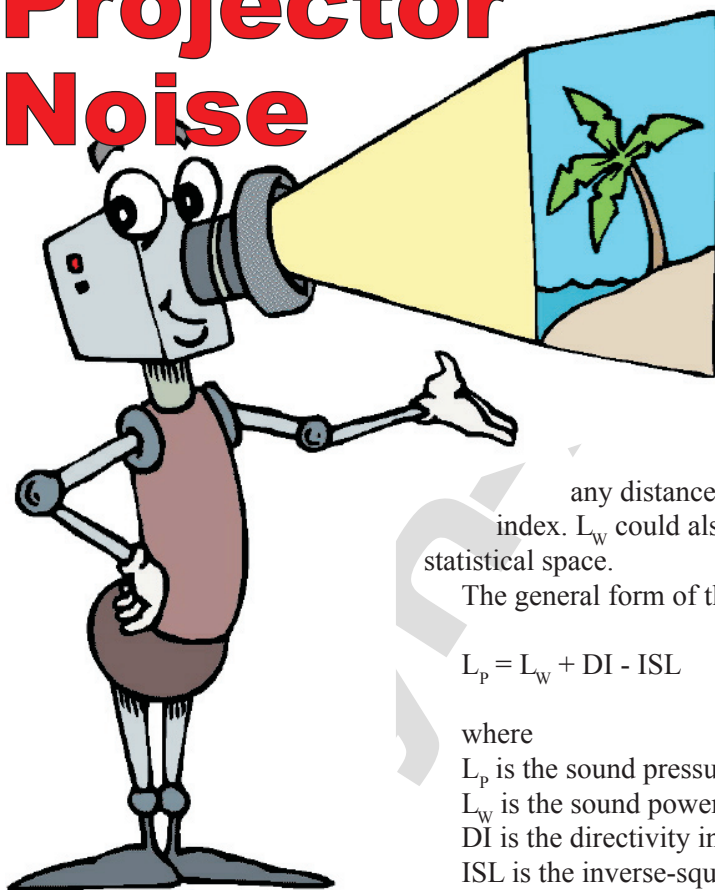
tance that is much lower than the wire inside the mic. Not only that, but the ferrite bead around pin 1 inside the new connector adds series impedance to the path through pin 1, effectively disconnecting the shield from the pin 1 problem. Shield current thus divides, most of it taking the low impedance path through the capacitance to the shell, with very little flowing through pin 1. In effect, the new connector bypasses the problem!

But even this well engineered solution cannot be effective if mating connector shells don't make good contact, or if the equipment connector shell is not bonded to the enclosure. I own a portable DAT machine that has a massive pin 1 problem, so much so that when it's used with its own preamp with a dynamic mic in downtown Chicago the detected FM and TV stations are nearly as loud as an interviewer a foot from the mic. The new EMC connector completely eliminates the detected RF – IF I carefully push against the side of the connec-

tor to force the connector shells to make contact. But without that pressure, the shells can lose contact and the RF interference returns! And the new connector doesn't help a popular mixer with a serious RF pin 1 problem, because the equipment connector shell is not connected to the enclosure!

Now that I've been alerted to them, these connector shell mating problems are turning out to be more prevalent than any of us would have suspected. It appears NOT to be limited to the use of off-brand or pirated connectors – it shows up on connectors that have been verified to have come from the same manufacturer! I've also seen it in connectors built into very good quality preamps and mics from a variety of manufacturers. So far, the list includes Audio-Technica, Mackie, Neumann, Sound Devices, and Tascam. *jb*

# Projector Noise



Projector fan noise has been an ongoing and nagging problem for our seminar setup. When researching noise specifications for new projectors, some serious omissions in the noise data were apparent. Noise levels were typically quoted as “X dB” or “X dBA” with no additional information. The magnitude of the number would seem to indicate that these were sound pressure levels, but no distance reference was stated. It does not help to know that the  $L_p$  is 37 dBA if one doesn't know the distance from the source where this is true. The only acoustic level that is not distance-dependent is  $L_w$  - the sound power level. This would represent the most useful form of noise specification, since it could be extrapolated to

any distance from the source with the knowledge of the directivity index.  $L_w$  could also be used to determine the reverberant field level in a statistical space.

The general form of the calculation would be:

$$L_p = L_w + DI - ISL$$

where

$L_p$  is the sound pressure level

$L_w$  is the sound power level

DI is the directivity index

ISL is the inverse-square law level change from the  $L_w$  reference distance.

Here is an example:

$$L_{P(1M)} = 41 + 3 + 20 \log \frac{0.282}{1}$$

$$L_p = 33dBA$$

It's unlikely that we will ever get  $L_w$  data from projector manufacturers since it is not currently supplied by loudspeaker manufacturers. *pb*