

Chapter 2: Transformers–Insurance Against Show-Stopping Problems

A White Paper from Lundahl Transformers
www.lundahl.se

Presented by ProSoundWeb
By Ken DeLoria

LUNDAHL
– TRANSFORMERS –

Introduction

Modern sound systems are subject to ever-increasing signal routing demands. For decades it was just front of house and monitor world that shared the signals from the stage. But today's sophisticated productions often call for a lot more. Potentially, there's a broadcast mix and a recording rig to worry about, and sometimes as many monitor consoles as there are musicians. Add to that some on-stage signal sharing that feeds several iterations of an artist's personal recording gear, feeds to press rooms, CCTV in the facility, Internet streaming, and so on.

The task seems straightforward enough: signals need to be shared, sometimes a large number of them, yet remain as clean and clear as the original source with no risk of harmful interaction among the various circuit branches. While it's easy to describe what's needed, it's not always so easy to accomplish it. Let's look at the obstacles, the various reasons why it's not best practice to simply hardwire paralleled connections from one source to feed multiple devices (which from this point on we'll refer to as "loads").

Ground loops are at the top of the list, as they're the most obvious offenders. Ground loops cause hum and buzz, and are time consuming to troubleshoot in a complex system without starting from scratch and adding only one load at a time. But even if you go through the system methodically, load #4 might be causing hum when loads #2 and #7 are connected, but not loads #1, #3 and #5. It can be very difficult to know which device is reacting with which, and the sheer number of isolation tests needed in a large system can be daunting, even if time is not of the essence. Now add in a time factor – and there always is one – and the potential for trouble is quite high.

Another common offender is sub-optimal loading from too many paralleled loads. The problems can range from merely a decrease in signal level that affects the S/N ratio, to a lot more. Not every input stage of every commercial device is a perfect study in "worst-case" design practices. When you switch "IN" an input pad on your console, the input impedance may drop to a problematically low value. This is not necessarily an issue if the console is used by itself, but potentially a big problem if two or three consoles are paralleled together. When the load impedance becomes too low, the result is a loss of low frequency response if the input stages are capacitively coupled (which they should be to prevent DC offset), as well as a potential for an increase in distortion as the source tries to drive a combined load impedance that is below its design capability.

Whenever loads are combined in parallel, the net impedance will always be lower than that of each individual load. An easily remembered formula is "the product over the sum" notated like this: $(Z1 \times Z2) / (Z1 + Z2) = Zt$. In this simple equation, Z1 is the impedance of load #1, Z2 is the impedance of load #2, and Zt is the value of the impedance when the two loads are paralleled together. For example, two 600-ohm loads in parallel will present a 300-ohm load to the source, which is well below the lowest impedance that most sources are designed to drive. This formula is useful in calculating any number of paralleled loads by breaking down the loads into pairs.

Going further, what happens when an input is fed by a paralleled signal and that device is not powered up? Instead of "seeing" a reasonable load impedance, the signal instead is feeding a network of resistors and capacitors followed by an op-amp or transistor input stage. The problem is that when powered down, op-amps and transistors behave like diodes, clipping the signal. The use of diodes in the signal path is how the early guitar fuzz-tones were made.

Isolate, Isolate, Isolate

Like the old real estate catch-phrase "location, location, location," the best insurance against the problem of feeding multiple loads from a single source is to "isolate, isolate, isolate" – each of the circuit branches, that is. This can be

accomplished actively by means of buffer amps, or it can be done passively by the use of transformers – or – it can be done by combining both approaches.

Passive transformer isolation is well-known as the workhorse of professional audio. Transformer equipped “splitter boxes” have been around for a long time and are still the go-to choice for the majority of needs. When a splitter box is built using precision transformer components, it provides the all-important galvanic isolation that interrupts and eliminates ground loops. As noted in Chapter 1 of this series, transformers have no galvanic connection between their primary and secondary windings; instead they are electro-magnetically coupled, thus isolating the ground connections and avoiding problems that occur due to differing ground potentials among the circuit branches.

The alternative to transformers is active splitting, usually based on op-amp circuitry. Active isolation without transformers has significant value in its own right, but typically serves to isolate only the signal, not the ground reference. On the plus side, an active splitter will avoid the too-low impedance problem discussed above, while also isolating interaction among the branch circuits. However, paths to ground still exist with the potential for ground loops, whereas transformers isolate the signal *and* the ground path. So transformers are the clear winner. Or are they?

A passive transformer solution for splitting signals cannot provide make-up gain, or a way to visually monitor signal levels without designing active circuitry into the passive splitter. This makes a pretty good case for combining the two technologies: a transformer based splitter with an active gain stage. There are certain advantages to this. An active input stage can be scaled to accept a wide range of levels from low-output ribbon microphones to high level line sources. LED monitoring, and/or remote control of gain can also be designed into an active splitter, both of which may be important in certain situations, and gain can readily be added as needed.

Disadvantages are significant though. A power interruption, or other failure mode within the active splitter, could cause a total loss of the signals passing through it. This is known as the “all of your eggs in one basket” syndrome. Additionally, the inclusion of isolation transformers at the input and the output of each channel of an active splitter will carry a significant cost premium. Precision transformers are expensive; putting two of them in every channel, along with active circuitry, would be a pricey proposition.

Thus, an ideal application for an active transformer splitter is when a common signal must be distributed to many loads without loss of gain, such as in a press pool – a device intended to provide many audio feeds for use by members of the press who cover award shows, political rallies, sports and other newsworthy events. A typical press pool has only one input transformer, but many output transformers.

Splitter Transformers with Multiple Secondaries

A long proven solution for trouble free signal distribution, one that’s used in a great number of applications, is the multiple-secondary transformer splitter. Transformer designers are well aware of the needs of professional users and have responded by developing transformers with more than one set of secondary windings for splitting the signal to more than one load. The source signal is connected to the primary of the transformer, and then multiple secondary windings feed the various loads, one winding for each load (Figure 1).

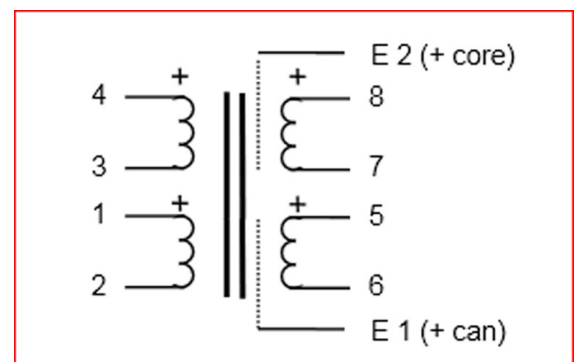


Figure 1: The schematic shows a pair of primaries (normally connected together in parallel) and two secondaries for driving two separate loads. Note the individual Faraday shields on each of the secondary windings (E 1 and E 2).

Such an arrangement isolates each of the branch circuits, thereby avoiding ground loops. This is very important, especially when one console might be in an OB truck with a very different ground reference than the consoles located inside the venue. Another advantage is that bandwidth is preserved, which can be an issue when long lines come into play. A passive splitter requires no batteries or power supply, and phantom power (+48 VDC) from one console cannot cause damage to another console, as transformers do not pass DC.

True professional grade splitter transformers are precision devices, available from only a small number of suppliers such as Lundahl Transformers, which offers a variety of models for splitters as well as transformers for many other purposes. The company's passive splitter transformers have internal Faraday shields individually surrounding each of the secondary windings, thus avoiding interference from electrostatic noise sources (Figures 1 and 2).

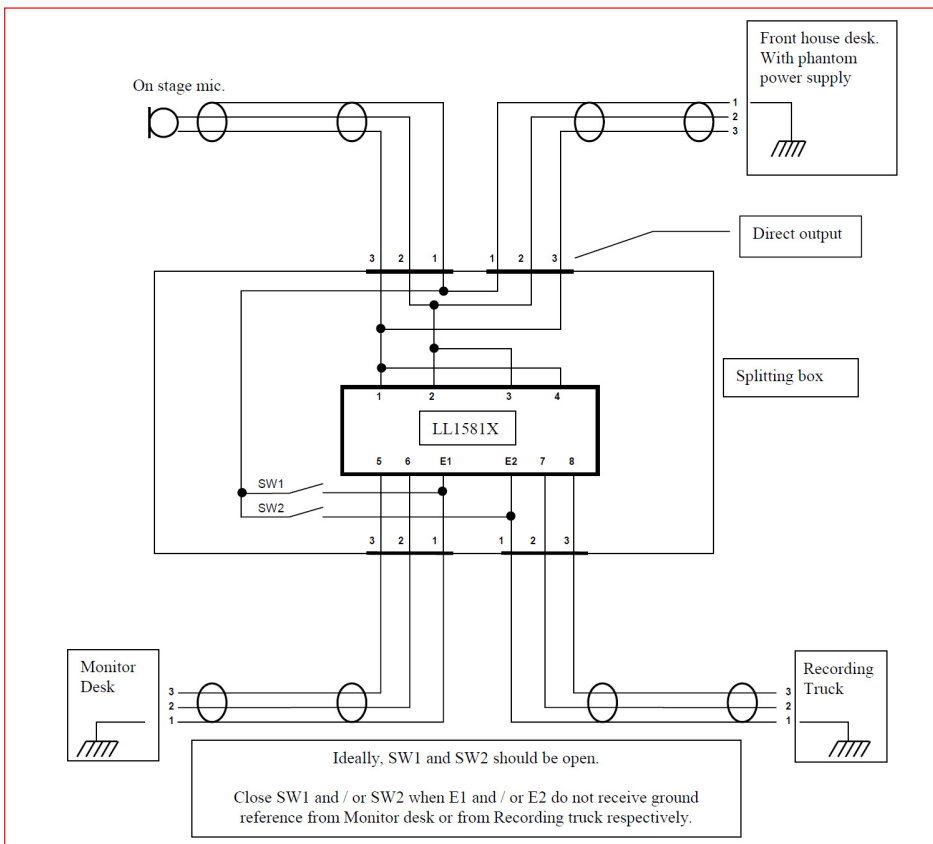


Figure 2:
A circuit showing dual secondaries of a Lundahl LL1581XL splitting transformer.

Efficient Faraday shields and high immunity to noise are particularly valuable when signal levels are low, such as from most microphones. Lundahl also manufactures transformers for active splitting with up to four secondary windings, but as signal levels are normally at line level in an active splitter, those models do not require internal Faraday shields.

Mid-Side Mic Technique with Splitting Transformers

An interesting and useful approach to stereo recording and broadcast is mid-side (MS) miking. The technique involves the use of two microphones, one with a figure-8 pattern and the other with a cardioid pattern, though an omni can replace the cardioid for a more spacious effect (Figure 3).



Figure 3: Two popular microphones placed in a mid-side (MS) configuration.

With MS miking, the width of the stereo field can be varied by changing the gain of the mics in relation to one another. Additionally, the two mics will always sum perfectly to mono, making the technique especially useful when the content may need to be distributed both stereophonically and monaurally.

MS miking requires a matrix network to provide the sum and the difference of the two microphones. The use of two 1 x 2 splitter transformers makes it an easy task to construct such a network (Figure 4).

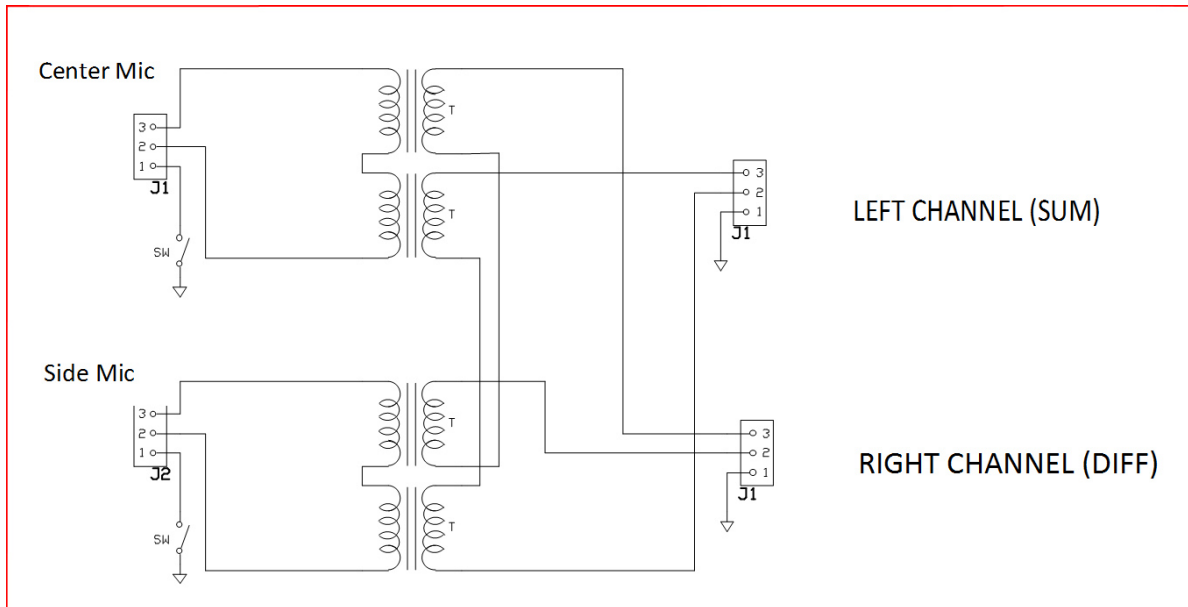


Figure 4: This schematic shows how the dual secondaries are wired to provide the sum and the difference of the two M-S microphones.

Conclusion

In sound reinforcement, live recording and live broadcast, there's never a chance to go back and re-do a show. The judicious use of transformer-based splitters – both active and passive – has proven to be the best possible insurance against unfavorable outcomes.

About The Author

Ken DeLoria is senior technical editor for ProSoundWeb and Live Sound International magazine, and has had a diverse career in pro audio over more than 30 years, including being the founder and owner of Apogee Sound.