

To Match Or Not To Match?

Paying attention to impedance

By Pat Brown

A common task in “audioland” is the need to feed a number of inputs from a single signal source. This may include driving a rack of amplifiers, providing feeds to the press, or distributing a signal around a building or campus.

The methods used to accomplish this range from the profoundly simple to quite complex, and the appropriate method can only be determined after sizing up the situation.

Impedance matching means that an output is terminated with a “mirror” input impedance. This configuration

yields maximum power transfer, and more importantly, reduces reflections from a load back to the source.

In multimedia systems, the matched interface is used for very high frequency signals. These include video, antenna and digital interfaces. One drawback of the matched interface is that active or passive splitters must be used if the source must drive multiple inputs. Otherwise the impedance match is violated and problems result.

One of the most common mistakes in audio is to attempt to apply this interfacing method to the basic analog

interfaces that dominate today’s sound reinforcement systems.

In a constant voltage interface, an electronic signal source with a low source impedance (i.e. an output) is used to develop a signal voltage across a high load impedance. The minimum ratio between the source Z and load Z is one order of magnitude (1:10).

This scheme is used universally in the audio industry for passing signals from component to component. One utility of this interface is that it provides the possibility of driving multiple parallel loads from a single source without additional hardware. The stipulations are as follows:

- The parallel combination of all loads cannot violate the 1:10 minimum impedance ratio.
- The path length (interconnecting cable) must be short when compared to the wavelength of the highest frequency component of the signal.

Because the speed of propagation of electricity approaches the speed of light, and audio cables are typically less than a few hundred feet, the second condition is easily met in the bulk of audio applications.

Radio frequency, digital, and video signal wavelengths are much shorter, and the impedance-matched interface must be used in lieu of the constant voltage interface to prevent signal degradation. (Figure 1)

“Y” TO THE RESCUE

Figure 2 shows an equivalent circuit of a single source driving multiple loads. Note that even though the load impedances are not the same, this is a parallel circuit so all of the inputs have the same voltage impressed across them.

Signal distribution requires a simple

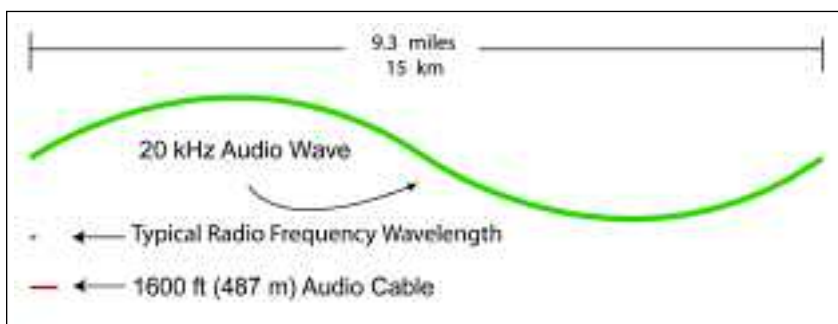


Figure 1: The relative lengths of an audio waveform, a VHF waveform, and an audio cable.

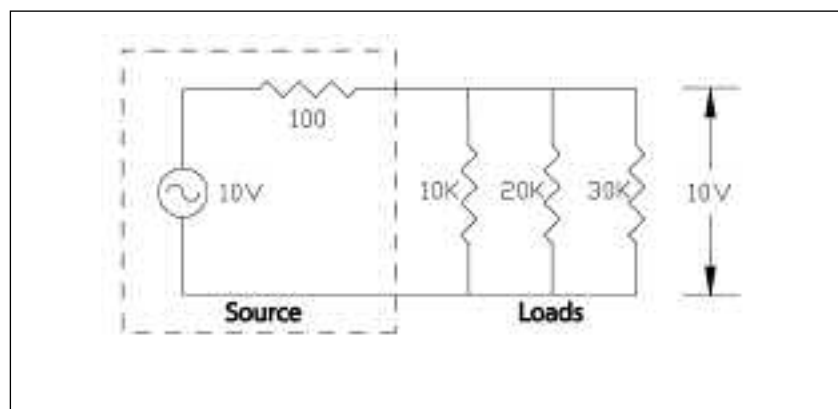


Figure 2: An equivalent circuit of a single source driving multiple loads.

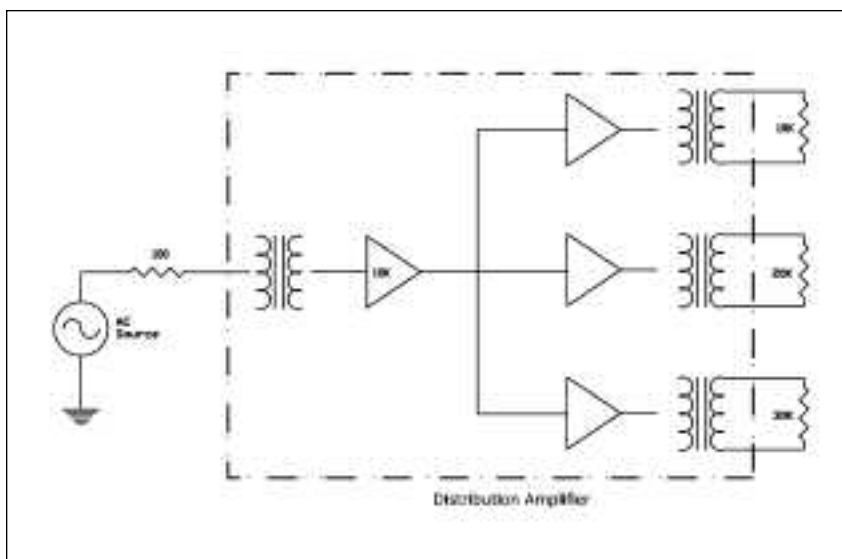


Figure 3: Isolation between source and loads.

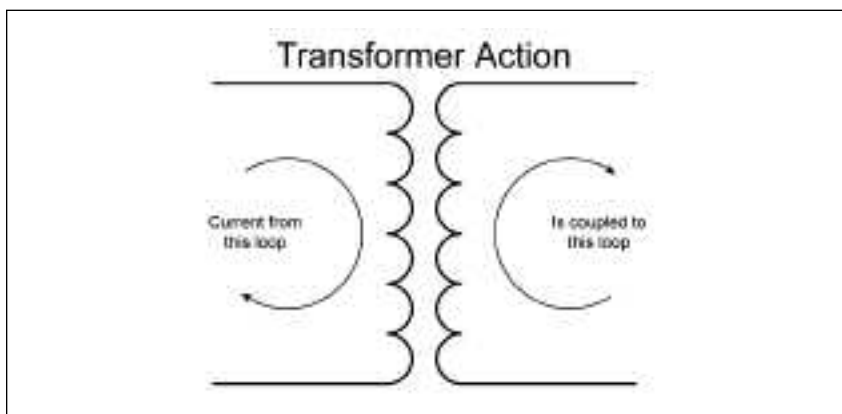


Figure 4: An isolation transformer.

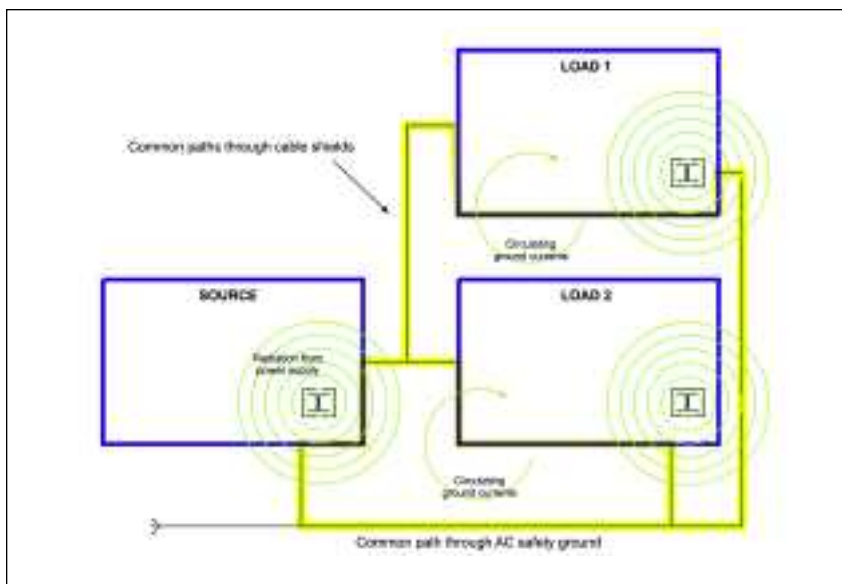


Figure 5: Ground loops and power supply radiation form an unwanted transformer in a sound system.

“Y” cable connected from the source to the multiple loads. This is a perfectly acceptable method of distributing the signal from a source to multiple loads. There is no need for impedance matching if the components involved are typical analog audio products or even digital products if they are being fed an analog signal.

A drawback to Y-cable signal distribution is the lack of isolation between the individual loads and the source. For instance, a short circuit across any of the inputs will kill the signal to all of the inputs.

For this reason (and others), this method is not recommended for driving loads that lie outside of the equipment rack that houses the source. In these cases, load isolation can be achieved by using a distribution amplifier (DA).

The DA provides a single high impedance input for the signal from the source, but provides buffered low impedance outputs that can be used to drive the remotely located loads. The load buffering is achieved by using an active stage for each of the DA’s outputs.

A short across any one output is buffered from the other outputs by the active stage (Figure 3). Note that this is not impedance matching since the output-to-input impedance ratio is still at least 1:10.

It must be strongly emphasized that while the Y-cable makes an excellent signal splitter it should NEVER be used as a mixer. Doing so places the source device under a load, resulting in an increase in output current that can lead to distortion under high signal conditions. When a mixer is needed – get a mixer.

IN THE WOODS

While the DA solves the isolation issue, we’re not out of the woods yet. Another problem that plagues distribution systems results from multiple ground connections between the various components. These “shared” ground paths include the AC safety ground, the cable shields, and possibly connections to the building ground through equipment racks, etc.

Noise currents will circulate through these “ground loops” (Mother

Nature does this without our permission) and possibly infect the audio signal if this parasitic ground current finds its way onto a circuit board. Isolation devices can allow the audio signal to be coupled from an output to an input with no physical wire joining the two circuits, eliminating at least one of the ground loops.

Transformer isolation allows the signal to be coupled via induction (Figure 4, previous page). Optical isolation uses pulsed light to couple the signal, but usually requires that the signal be converted to a digital format. The transformer has an advantage in that the signal can remain in analog form.

The irony is that the same mechanism that allows a signal to be coupled between two circuits inductively

also allows power supply fields to be coupled into ground loops (Figure 5, previous page). We're faced with the common engineering task of maximizing the effect when it helps us and minimizing it when it is working against us.

Signal distribution requires a simple "Y" cable connected from the source to the multiple loads

Putting all of these mechanisms to work, an active distribution amplifier with transformer balanced inputs and outputs may be the optimum way of distributing an audio signal to multiple components.

The active stages buffer the inputs from short circuits, and the transformers allow ground loops to be interrupted while allowing the signal to pass, while at the same time providing excellent common-mode rejection. Many DAs also include level controls for each output, allowing the signal level to be optimized for mic or line level devices.

When distributing an audio signal to multiple inputs, don't overlook the simplicity of simply using a properly wired Y-cable to accomplish the task. If the signal needs to extend beyond the rack, a good DA will easily justify the investment. ■

Pat and Brenda Brown own and operate Syn-Aud-Con, conducting training seminars around the world. For more info go to www.synaudcon.com.

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