APPLICATION NOTE

APN-3240-101

Ground Loops Associated with the NCS-3240 Multi-Switcher

What are ground loops?

When two or more pieces of electronic equipment are connected together electrically, there exist the possibility of unwanted currents flowing in the ground circuit. First, it must be stated that there is no such thing as a "perfect" ground. This leads to the possibility of different connected pieces of equipment being at different ground potentials, although connected to the "same" ground. The different ground potentials cause unwanted currents to flow in the ground paths causing a ground loop to exist. In audio equipment these undesired ground currents can cause hum, distortion, or erratic behavior of the equipment.

Station Grounding Techniques

One of the first steps to minimize the possibility of ground loops existing is to ensure that you have a good station ground. Often station grounds consist of a ground wire or braid daisy chained between the various pieces of equipment and then attached to a wire terminating in an earth ground outside of the house. This is illustrated in Figure 1 below.

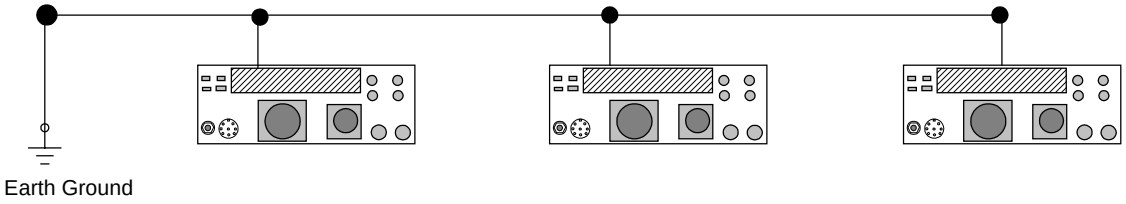


Figure 1 – The Daisy Chain Ground System

This type ground configuration enhances the possibility of ground loops existing among two or more pieces of station equipment since the connecting ground conductor(s) do not have zero resistance at all frequencies.

The correct method of grounding station equipment is the "single point" ground. This ground configuration minimizes potential differences between individual equipment grounds thus minimizing or eliminating the condition for ground loops to exist. The single point ground is illustrated in the following diagram.

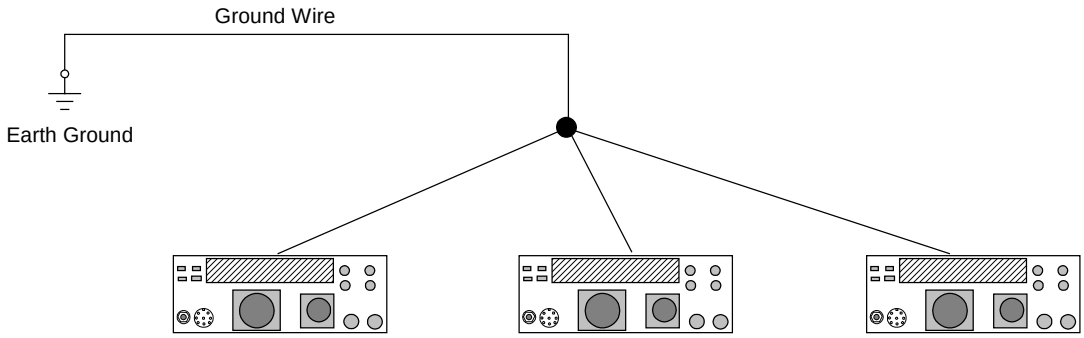


Figure 2 – Single Point Ground System

A good ground system must present a low impedance to DC as well as AC and RF currents. *Make no mistake, this is not easily achieved*. Even when the ground system is perceived to be excellent, it may not offer a low impedance to ground at all frequencies.

Ground Loops and the NCS-3240 Multi-Switcher

"*I didn't have an RF problem with my audio until I interfaced the NCS-3240 to my radios, and with the Multi-Switcher out of the circuit the problem goes away!*" While this is a relatively rare occurrence, when it does happen, the immediate conclusion is that the Multi-Switcher is defective. This is most likely not the case. All station configurations are different and there are many factors that enter into the equation when it comes to ground loops. No individual piece of equipment is at fault, it is simply the result of connecting multiple pieces of equipment together in the presence of a less than perfect ground system.

Figure 3 shows an example of how a ground loop is formed when the Multi-Switcher is connected to multiple radios. With only a microphone connected to each radio there is no ground path to form a ground loop. However, when the Multi-Switcher is connected to multiple radios an unwanted ground path can exist. When there is a potential difference between the grounds of the different radios and a ground path exists, a ground loop is formed.

The Multi-Switcher uses a 600-Ohm, 1:1 isolation transformer in the mic audio output to minimize this possibility. This isolation transformer in the Multi-Switcher is electronically switched to the selected radio using solid-state analog switches. Unfortunately, the isolation of the solid-state switches used to switch the transformer do not have *infinite* isolation. This *finite* isolation associated with these solid-state switches in rare cases can offer a path for unwanted ground

currents. Although these currents are quite small, they are significant enough to introduce hum or distortion on the transmitted audio.

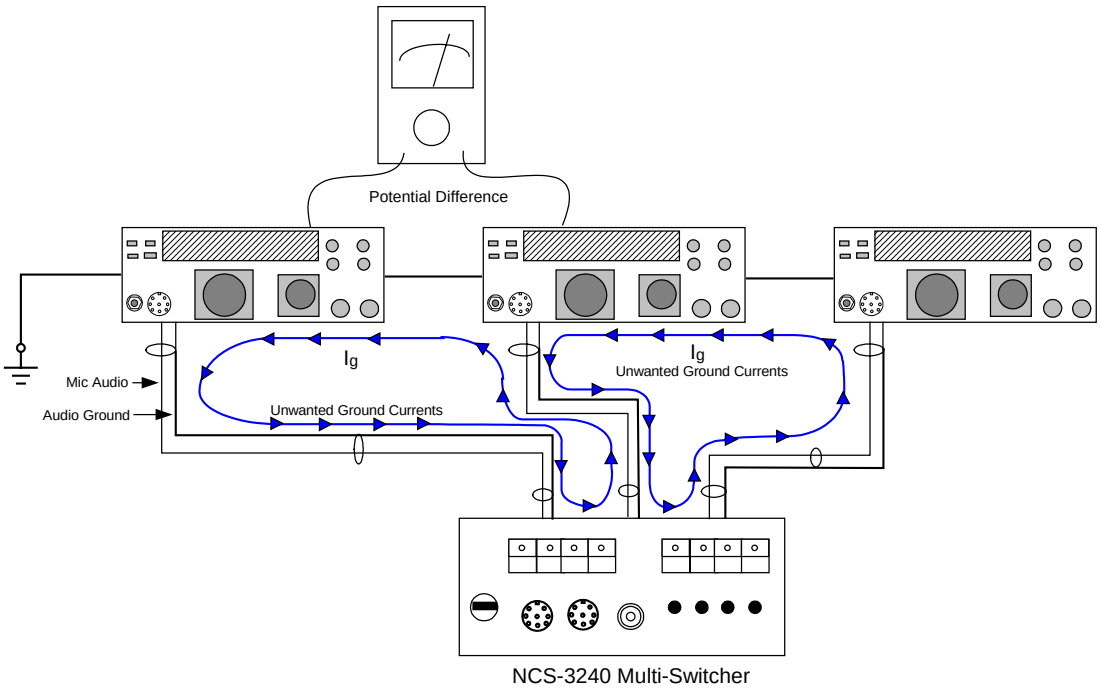


Figure 3 – Example of Ground Loop Formation

How Do I Determine If I have a Ground Loop Problem with the Multi-Switcher?

If you experience hum or audio distortion after connecting the Multi-Switcher to your radios, the easiest way to determine if it's a ground loop and not radiated RFI or some other problem is to disconnect all radios and cables (don't forget to disconnect the receive audio cables) except for a single radio. Additionally, power the Multi-Switcher from a separate power supply than that used to power your radios. A common power supply can also offer an unwanted ground path for ground loops to form.

Now, with only a single radio connected, you should not experience any hum or distortion on your transmit audio since you have removed all ground loop paths between radios and the Multi-Switcher. Often times you may have only one or two radios that are causing the ground loop. To determine which are the *offending* radios, connect one radio at a time until the hum or distortion returns.

Once identified, it may only be necessary to apply solutions to the *offending* radios.

The Ground Loop Solution

The solution to any ground loop problem is to break the ground path that is forming the ground loop condition. In the case of the Multi-Switcher the easiest method is to insert a 600-Ohm, 1:1 isolation transformer in the mic audio lines between the Multi-Switcher and the radio. As mentioned above, you may only have one or two offending radios and this solution need only be used with the radios supporting the ground loop condition. Figure 4 shows the insertion of an isolation transformer in each of the audio lines of the Radio Interface Cable. This breaks the audio ground loop path and eliminates any hum and distortion. In reality you may only need to place the isolation transformer in the cable connected to the *offending* radio.

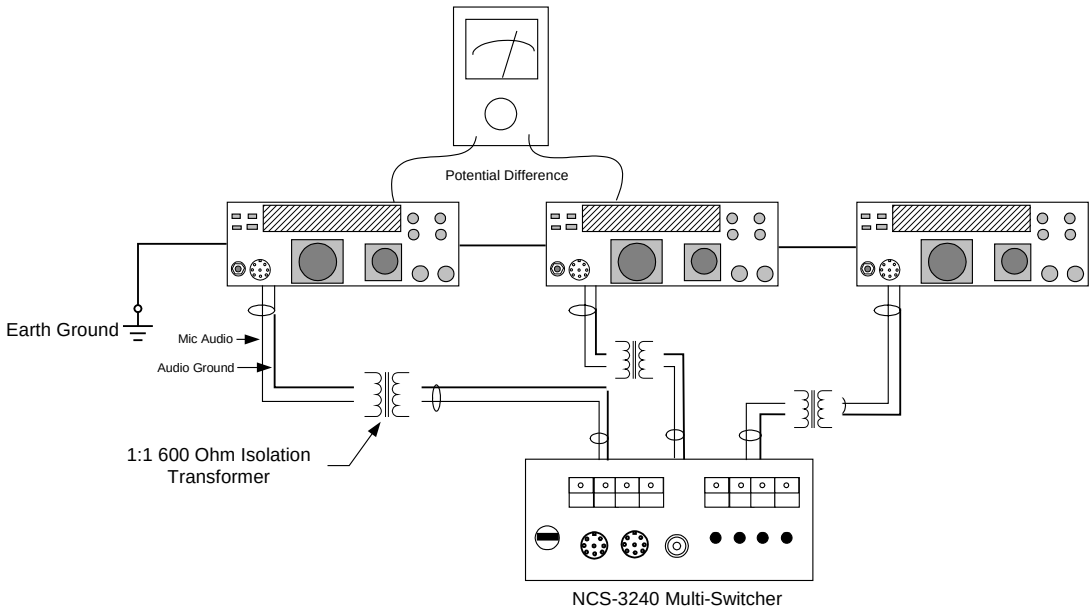


Figure 4 – Isolation Transformer Solution

Implementing the solution

Figure 5 shows the schematic diagram of the isolation transformer solution. The *green* and *white* refer to wire colors in the NCS Radio Interface Cable. While most any 600-Ohm, 1:1 audio isolation transformer will work, we recommend the use of the Stancor TTPC8 or the Radio Shack RS-27-1374. The Stancor transformer has excellent low frequency response, where as the Radio Shack transformer's low frequency response rolls off at approximately 300 Hz (See Figure 6).

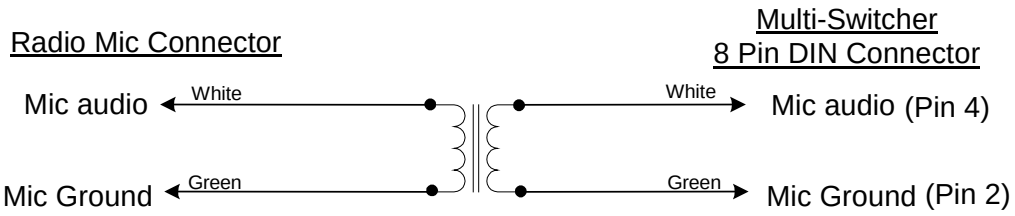
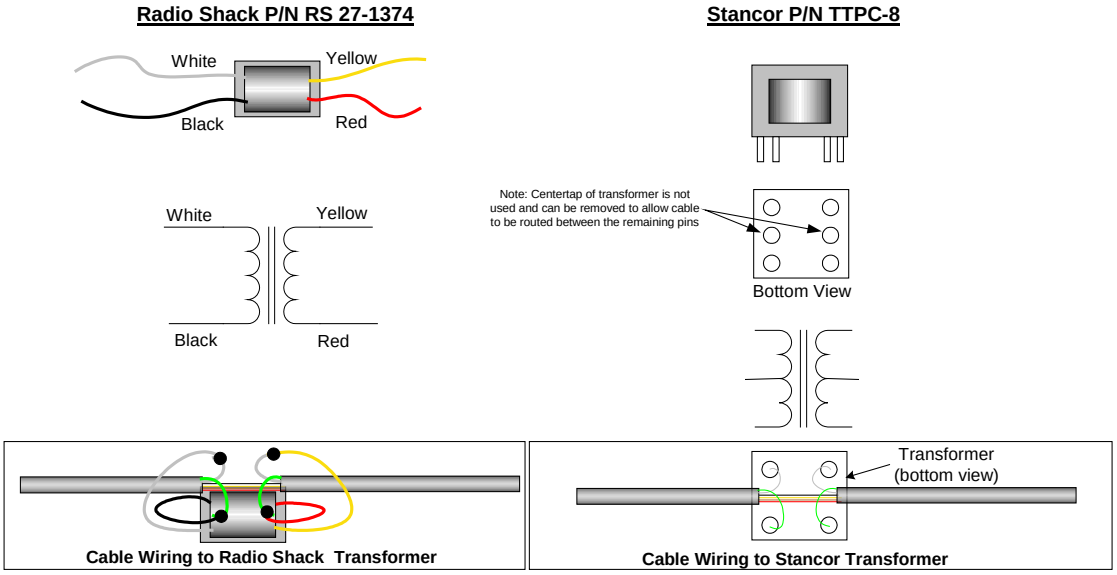


Figure 5 – Schematic Diagram

Recommended Audio Isolation Transformers



Note: Most any 600 ohm (1:1) audio isolation transformer will work for this application. The Radio Shack transformer has a frequency response of 300 - 3000 Hertz which is adequate for good communications quality audio. However, the Stancor transformer has a much broader frequency response from about 30 - >10,000 Hz. The Stancor transformer, because of its broad frequency response, will not modify your microphone's frequency response. For communications quality audio either will work.

Figure 6 – Recommended Isolation Transformers

Actual assembly steps for installing the transformer in the NCS Radio Interface Cable is detailed in Figure 7. ***Radio Interface Cables with isolation transformers installed are available from NCS (no assembly required).***

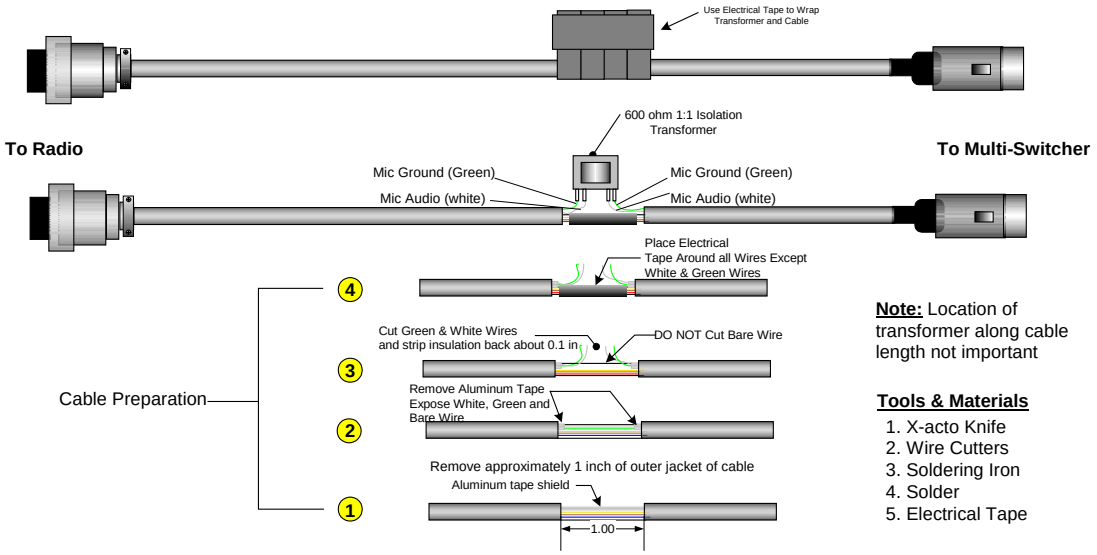


Figure 7 – Transformer Installation in Radio Interface Cable

When Not to Use an Isolation Transformer

The isolation transformer is not an effective solution for radios that use a common audio and PTT ground (generally older radios), since isolating the ground would disable the PTT function. However, if other radios in the "mix" have separate audio and PTT grounds, using an isolation transformer on these radios will be effective in preventing a ground loop path between the radio with a common ground and those with separate audio and PTT grounds.

Conclusions

In the vast majority of the cases, where audio distortion or hum on the transmit audio is present after installing the Multi-Switcher, the problem can be traced to a ground loop problem. These are relatively rare cases, occurring in only about 2% - 3% of Multi-Switcher installations.

The most effective way of dealing with a ground loop problem associated with the NCS-3240 Multi-Switcher is the use of the audio isolation transformer in the mic and mic ground lines between the Multi-Switcher and each radio. This has proved to be effective in 99% of reported ground loop problems.

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