How to Avoid Ground Loops and Hum when using vintage microphones with your StationPro

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Until about 1975, most amateur microphones such as the venerable Astatic D104 used a two-conductor shielded cable – one conductor for the microphone audio, and one for the push-to-talk line. For such microphones, the grounded shield was connected directly to the transmitter chassis, and both the microphone audio and PTT return currents flowed through the shield.

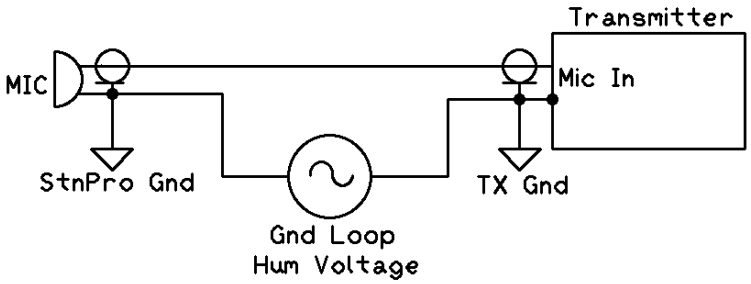
This arrangement generally worked satisfactorily so long as the microphone was plugged directly into a transmitter or transceiver. However, if used with any kind of switching device, or with push-to-talk circuits that used an AC control voltage, these microphones were found to be susceptible to hum pickup.

This problem was solved with the introduction of microphones that use two conductors for the audio, typically called "mic+" and "mic-," and today virtually all amateur microphones use this configuration. By using a dedicated "mic-" wire for the return audio currents, the low-level microphone voltage is not affected by hum currents on the shield or chassis of connected equipment. (A move toward low impedance microphones – 200 ohms is common – also provided enhanced hum immunity and also allowed longer cable runs than is possible with high impedance microphones.

Understanding How Ground Loop Currents Cause Hum

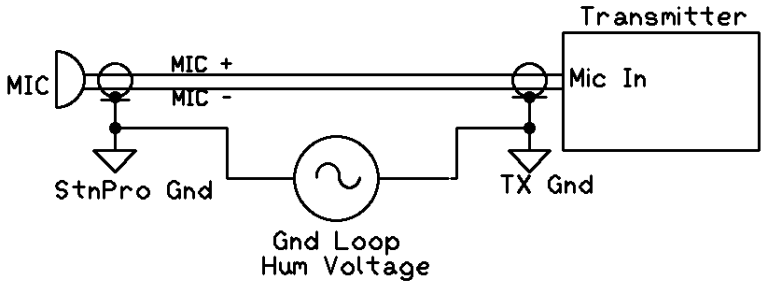
Numerous currents flow along the chassis of any transceiver or transmitter. In vintage vacuum tube transmitters, these might include several amperes of 50/60 Hz filament current, ripple currents from power supply filter capacitors, and 50/60 Hz AC currents from bypass capacitors on the AC line. When a chassis also carries the microphone audio return current, the voltages produced by these AC currents can be a significant fraction of the microphone audio voltage. This AC voltage adds directly to the microphone audio and appears as hum on the transmitted signal.

When a microphone attaches directly to the mic jack in vintage transmitters this hum voltage does not cause a problem, because there are typically only an inch or two between the transmitter's grounded microphone jack and the grid of the first audio amplifier stage. However, when a vintage microphone is routed to the transmitter through a piece of peripheral equipment, such as a VOX adaptor, audio speech processor, or a switching device such as the StationPro, then the AC hum voltage can be quite substantial. In these cases the hum voltage is caused by the AC currents that inevitably flow on the outer surface of the shielded cable that ties the peripheral equipment to the transceiver. The following diagram shows how these shield currents cause hum when the StationPro is used in connection with a vintage vacuum tube transmitter that uses its chassis for the microphone audio return.



In the diagram, a microphone is connected to the mic jack and chassis of the StationPro, which in turn is routed through a shielded interconnect cable to the mic jack and chassis of the selected transmitter. Although not shown in the diagram, the transmitter is assumed to be connected to a 120 VAC or 240 VAC line, and the StationPro is also connected, via the shields of its interconnect cables, to all the other station transmitters and linear amplifiers (each of which is also connected to the AC line, sometimes to multiple AC circuits). The inevitable ground current loops resulting from all these interconnected radios and amplifiers lead to a small (typically a few millivolts) AC voltage difference between the StationPro chassis and the chassis of the selected transmitter. In essence, the small AC current flowing on the interconnecting cable shield is a low-impedance hum voltage source. From the diagram we see that this hum voltage is *in series* with the microphone audio voltage, and while it may be only a few millivolts, that is still enough to be heard on a transmitted signal. Note that this hum voltage is not induced "pickup", e.g., from fluorescent light fixtures, or any indication of inadequate shielding. It rather is caused by AC currents that flow on the *outer* surface of the interconnecting cable shields.

The diagram below shows why modern microphones with dedicated "mic+" and "mic-" connections do not have this problem. In the diagram, there is still an AC voltage caused by ground current loops, but this voltage is no longer in series with the microphone audio and therefore causes no hum on the transmitted signal. The bottom line is that StationPro owners who want to use vintage microphones with simple shielded cables (and no separate "mic-" wire) must take careful steps to minimize audio hum in their AM or SSB transmissions.



How to Diagnose Ground Loop Problems

The easiest way to diagnose a potential ground loop problem with your StationPro is to jumper the microphone audio pin (mic+) to the ground pin or shield on one of the StationPro's mic connectors. Then key up your transmitter or transceiver and listen to your transmitted signal on a separate receiver. If you hear hum on your signal, even with the mic audio shorted to ground, then you have a ground loop. There is no need to worry

about this ground loop if you are using a modern microphone with a separate "mic-" wire, but if you wish to use a vintage microphone having a simple shielded cable, then you will definitely have to deal with it.

Basic Steps to Minimize Ground Loop Hum

1. Make sure all of your station transceivers or transmitter/receiver pairs are connected to the same AC circuit and not to separate circuits. (Of course, this will not be possible when using 120 VAC transceivers and 240 VAC amplifiers.)

2. If your transceivers operate off of a +12V power supply, then use that same power supply to power your StationPro. If your power supply has "floating" positive and negative output terminals, do *not* tie the negative terminal to the power supply chassis or to the AC ground terminal on the power supply.

3. Be careful if using a "wall wart" to power your StationPro, because these often have high AC ripple voltages on their +12V outputs. Obviously, to minimize hum, you need a clean +12V power source.

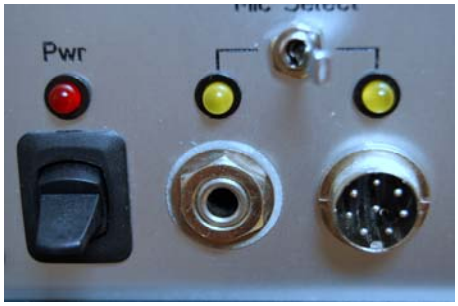
4. Bond the case of the StationPro to the cases of all of your transmitters, receivers, linear amplifiers, and power supplies with short braided ground straps. It is best not to "daisy chain" these ground straps from one rig to another, and it is important to use short lengths and as large a conductor as possible. (For a given ground loop current, a large diameter conductor will result in a lower hum voltage than a small conductor.) Listen to your transmitted signal (on a dummy load!) and pick the configuration of ground straps that minimizes hum. Because all station layouts are different, trial and error is the only practical way to find the optimal configuration.

Steps to Take If All Else Fails

If the above steps don't reduce hum to acceptable levels, and you still want to route a vintage microphone through your StationPro, then you will have to take additional measures to isolate the microphone audio from the hum voltage produced by ground loops. Here are suggestions for isolating the microphone audio. Some experimentation will undoubtedly be required to see which gives the best results.

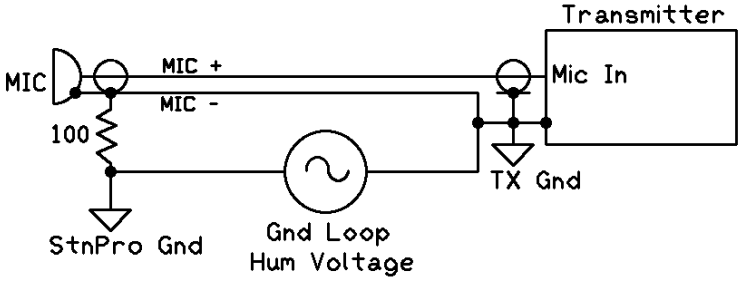
1. Rewire your microphone (and mic connector) so that the microphone element does not use the braided shield for its audio return. Unfortunately, this usually entails replacing the mic cable and connector.

2. If you want to use a "Collins" type two-circuit 3/16 in. mic plug, or a 1/4 in. "stereo" mic plug, then you can electrically insulate the mic jack body from the StationPro front panel by using fiber or nylon insulating washers. (Recall that that these jacks mount in a 3/8 in. hole, whereas the StationPro front panel has 5/8 in. holes for microphone jacks.)



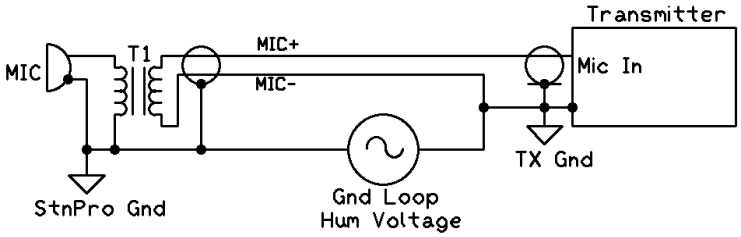
The Collins-type 3/16" mic jack is insulated from the front panel using homemade fiberglass washers on the front and back sides of the panel

As shown in the below diagram, you should jumper the shield terminal on the Collins-type mic jack to the StationPro "Mic-" header pad on the front panel circuit board, and then jumper the "Mic-" pad to the GND header pad on the circuit board with a 50Ω or 100Ω 1/4 Watt resistor. Using this configuration, the ground loop currents which would otherwise flow through the microphone element are short-circuited by the low resistance of the mic- wire in the StationPro's interconnecting transceiver cable, thus reducing the hum voltage to a negligible value. The purpose of the 100Ω resistor is to create a voltage divider, using the resistance of the mic- wire as the other resistor in the divider. If the mic- wire has a resistance of, say, 1Ω, then the hum voltage in series with the microphone element will only be about one percent of the hum voltage between chasses. Also, the shield of the microphone is still effectively grounded to the StationPro chassis through the 100Ω resistor – a low enough resistance to permit the PTT circuit (which also uses the shield in most vintage microphones) to function.



3. Two-conductor mic jacks that mount in a 5/8 in. hole, commonly used in vintage transmitters from the 1950s, pose a special problem because one can't insulate them from the StationPro's front panel, as in the previous step. For this situation, you can replace the 2-pin mic connector with a 4-pin mic connector (as used in some vintage Ten-Tec and Drake transceivers) and wire the connector as in the above diagram. Alternately, you can use a small audio interstage transformer to decouple the microphone from the ground loop currents,as shown in the diagram below. With this transformer, the ground loop AC voltage appears only as a common mode voltage on the transformer windings and does not result in any hum. A suitable subminiature transformer is the Model XT-1, sold by Heil Sound at http://www.heilsound.com/amateur/products/hc104/index.htm. This tiny transformer may be used to convert a modern low-Z mic to the high-Z output required by most vintage rigs. It may be mounted on the rear of the StationPro's front panel circuit

board with double-stick foam tape. Suitable 1:1 interstage audio transformers are available from other sources.



4. And finally, if you don’t want to bother with any of the above measures, then you can always bypass the StationPro’s microphone jacks and plug your vintage microphones directly into their mating transmitters. For vintage radio collectors, this might be the preferred (and certainly easiest!) solution anyway, since one can then pair a Collins microphone with a Collins KWM-2 transceiver, a Drake microphone with a Drake TR-4 transceiver, and so forth.