TECH TIME

Helpful tips for the Avionics Technician

BY AL INGLE

This month we continue our series on wire. Having previously discussed shielded wire in general and techniques to minimize capacitive and inductive coupling from unwanted sources, we will now expand our study to include shielded wires grounded at both ends. The reference for this series of articles is the FAA's Advisory Circular AC 43.13-1B *Acceptable Methods, Techniques and Practices for Aircraft Inspection and Repair.* The document is readily available at www.faa.gov/avr/afs/300/pdf/1a-cover.pdf.

A shielded wire may have its shield grounded at both ends in order to reduce interference. The shield in this case protects against voltage-induced interference and also acts as a conductor for the signal return. The high side of this signal now shares a common reference with the aircraft airframe. Figure 1 is an overview of this airframe ground.

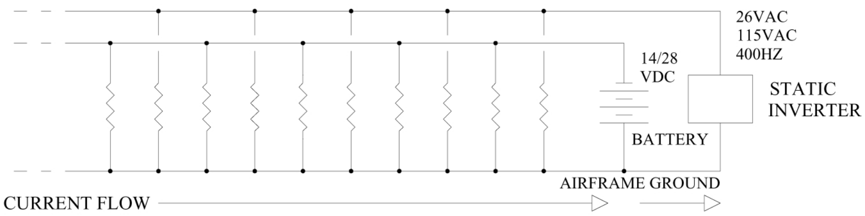

Figure 1 Dual source aircraft electrical system.

The airframe structure carries a pulsing current back to the battery and/or inverter common. Each power source has one true reference ground or lowest state. There is one for the battery and one for each of the 26 VAC and 115 VAC 400 Hz supplies. All other locations in an aircraft are at a higher potential and varying continuously.

Now let us look at an example of a typical circuit found in aircraft. Figure 2 is a phone jack making contact with the instrument panel.

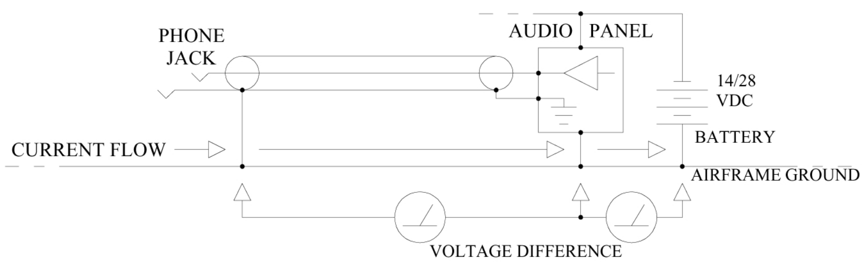

Figure 2 Typical (simplified) aircraft audio circuit.

Due to resistance in the aircraft structure a voltage is being produced as the current flows from various loads back to the battery. The audio panel is capable of producing zero output (with reference to its ground), but with the phone jack at a different potential, there is always a voltage difference due to a *ground loop*. A ground loop is nothing more than a difference in reference voltage due to current flow in the return path. Most, if not all aircraft have alternator whine. Have you ever noticed that it is greatest just after starting an engine, or that it increases when the landing lights, pitot heat, etc, are turned on? The increased current flowing through the airframe is causing the phone jack potential to increase with respect to the audio panel reference ground. The solution is to isolate the phone jack and carry the signal reference back to the audio panel. Now when the audio panel produces zero output, the phone jack and audio return are at the same reference and the pilot hears nothing. See Figure 3.

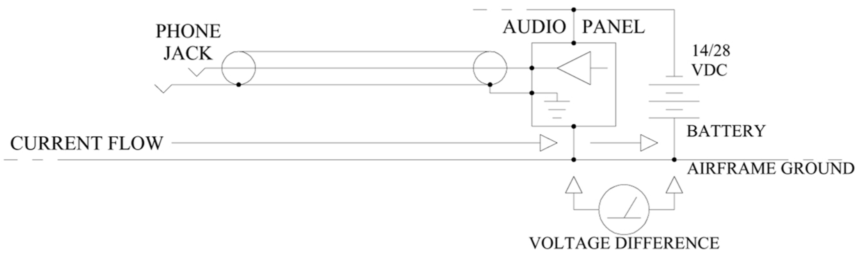

Figure 3 Isolated phone jack, with reference terminated at source.

It is important to remember in this scenario that the audio panel does not have to be at the same potential as the battery. What matters is that all of the audio circuits are referenced to the same potential. The circuit in Figure 3 is susceptible to capacitive coupling to the outer shield so we add another shield and use a twisted pair for the signal flow. See Figure 4.

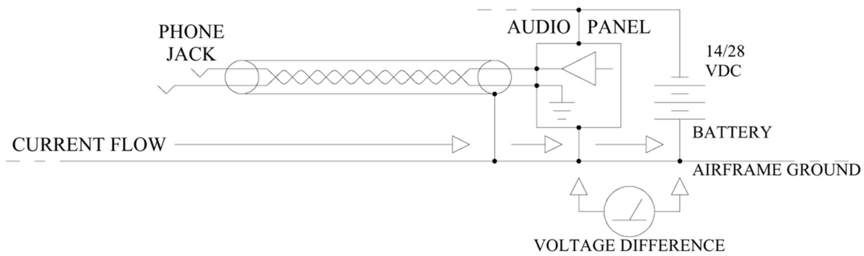

Figure 4 The use of twisted and shielded pair overcomes capacitive coupling.

Does this look familiar? It should, as this is how virtually every manufacturer recommends audio to be wired throughout an aircraft. It is the perfect and ultimate solution to our problem of interference, phantom noises and gremlins in our avionics systems, right?

Looking at the twisted shield pair from a capacitive coupling standpoint, the shield does its job of bleeding free electrons to ground, just as in single conductor shielded wire. Furthermore, a twisted pair has the added feature of coupling interference signals evenly on its conductors, creating a common mode condition. Reviewing Figure 3 again, the ground reference is still electrically noisy with current flowing but because all signals in the circuit are riding on this noise, it isn't detected. Ditto with the twisted pair. Any noise is coupled evenly on each conductor so there is no difference detected. Then why do we still hear, at reduced levels, electrical sources, strobes, etc., in our audio? Let us look again at figure 4. As discussed in last month's Tech Time, for all practical purposes you cannot shield a magnetic field. A twisted pair placed in such a field will have current induced into the conductors. This current will now flow to ground producing a voltage drop. But suppose that the conductors in the twisted pair have different terminating impedances. *The voltages induced into the wires are going to be different*. The phone jack body in Figure 4 goes straight to ground at the audio panel. This causes maximum interfering current to flow but with minimum voltage induced into the wire. The high side audio, being the source, presents a high impedance. Therefore, less current will be induced but with greater standing voltage. By analogy, think of a transformer primary inducing a current into two identical secondaries, each with a different terminating impedance (load). Floating references, use of twisted shielded pairs, etc., can help to minimize interference and unwanted signals, but where critical, pay special attention to magnetic fields and know the impedances.

In summary, to isolate and solve signal interference problems, you must first understand the impaired systems and their relationships to others.

Next Month: Coaxial cables (really)