Solder-it-Yourself Intercom

Reprinted from Private Pilot

Stop Shouting... Build This Neat Unit for Under 10 Bucks

by JIM WEIR

AIRPLANES ARE noisy. I mean REALLY noisy. In fact, the aeromedical types in Ok City tell us that significant hearing loss can occur in as short a time as 50 hours of flight time unless we are equipped with earplugs or other sound-deadening devices (like earphones). But, heck, flying with plugs or cans on our ears prevents us from talking to or hearing our passengers, students or crewmembers. Now, I contend that this is not all bad (and here you can insert your favorite mother-in-law joke), but for the most part, it is really quite convenient to have clear intercommunications capability within the aircraft during flight.

A number of manufacturers of airborne electronic devices (at last count, three) make a very serviceable ICS (InterCommunications System) that will fit any aircraft, is portable, voice actuated, and all the rest of that good stuff. However, the least expensive unit (pictured, the RST-441 from Radio Systems Technology) still sells for more than $75, and prices from other manufacturers spiral upwards past $200 for the super-deluxe, chrome-plated-with-droop-tips model. For flight instructors and renter-pilots (OPA-drivers), the store-bought ICS undoubtedly is the best way to go, as you really cannot spend the time to make a permanent installation in every aircraft you or your students decide to fly.

However, for those of you flying and fixing up your own aircraft, we ought to be able to come up with a pretty snazzy ICS that will give you some silver change back from a Hamilton bill.

(Speaking of Hamilton bills — next time you need some free avgas, bet one of the local airport bums $10 to a tankful of 80/87 that he can't name the Presidents on both the $10 and $100 bills. Answer: none — Hamilton and Franklin were never President.)

Anyway, let's get a little deeper into this ICS program. There is only one magic ingredient to inexpensive design, and that is to make one system or device do the work of two. In this attempt at a cheap intercom, I am going to make your present aircraft transceiver do double duty as both a transceiver *and* an intercommunications system.

All modern transceivers (say, from the MK-III on) have a very handy, seldom-used input called the "Auxiliary Audio Input." Some transceivers bring this terminal out to the transceiver power plug for connection (Genave A-100), some bring it out on a pigtail wire (Narco MK-12 blue-white wire), and some leave it internally connected within the transceiver chassas (RST-541), but no matter where it is connected, it is shown on the installation diagram as the "AUX AUDIO INPUT" or very similar words. Your first task on this intercom project, then, is to talk your friendly local radio shop into showing you the installation manual for your radio, so that you can make a later connection to the aux audio input (Figure 1).

This is the magic of this auxiliary audio input: if you provide an audio signal of about a volt to this input, the amplifier in the transceiver will provide an output signal to the speaker and headphones connected to the normal transceiver output. It will amplify and output this amplified signal at the same time it is outputting the normal transceiver radio signals. This means we can listen to the audio signal at the aux audio input at the same time we are listening to any signal which may come in on the normal transceiver radio. It's one of the very few places in this world where we get something for nothing!

Let's get a little more into the intended uses of the aux audio input, because it has a very specific function to perform in a complex avionics installation (Figure 2). You see, to design and build a good, low-distortion, high power 5- to 10-watt speaker and headphone amplifier is a rather heavy and expensive proposition. In that $1000, 10-pound transceiver you carry around in your radio rack, the audio power section is about five pounds and $300. The price be hanged, if your nav receivers, ADF and marker beacon receivers all had to have their own speaker amplifiers, you would be hauling about 30 pounds of pig iron around the skies. Now, I know you never land with less than half-tanks, but there are times I would have swapped my whole radio rack for another 30 pounds of gasoline.

As all good things go, there is a bit of detail yet to work out, but the foundation, the basics, have just been worked out. There are about four loose ends we have to work out, then we are home free. Well, not quite free, say, about $10.

First, we have to tell our microphone and PTT switch whether we are in the COM or ICS mode. Second, unless we have a fetish for slaughterhouse squeal, the speaker is going to have to be shut off in the ICS mode to prevent acoustic feedback. Third, some systems of isolating the pilot's microphone from the passenger microphones in the COM mode must be done to prevent unwanted (and sometimes humorous) passenger comments from going out on the air when the pilot pushes the PTT button. Last, and most difficult, is that the carbon mike

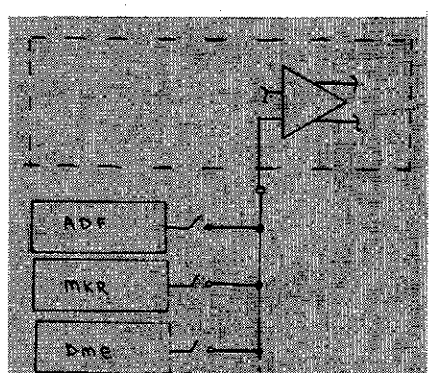


Figure 2 — Normal use of Aux Audio Input to connect ADF, DME and marker beacon.

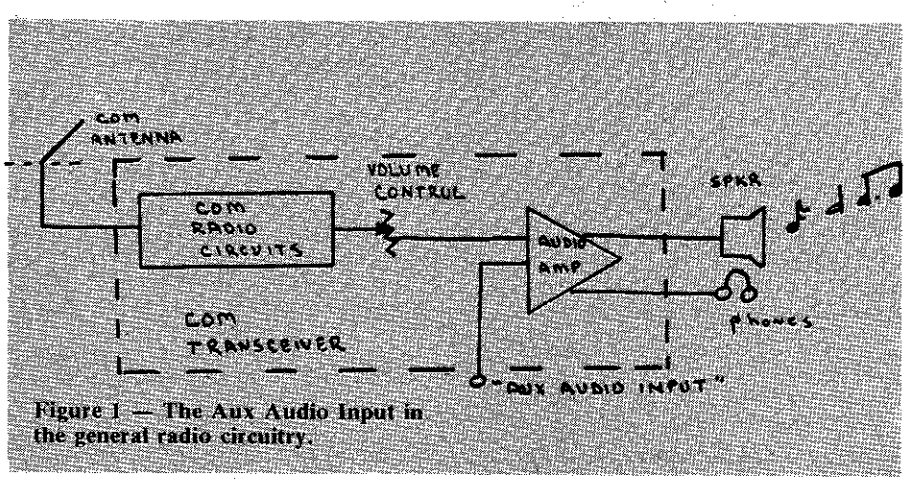


Figure 1 — The Aux Audio Input in the general radio circuitry.

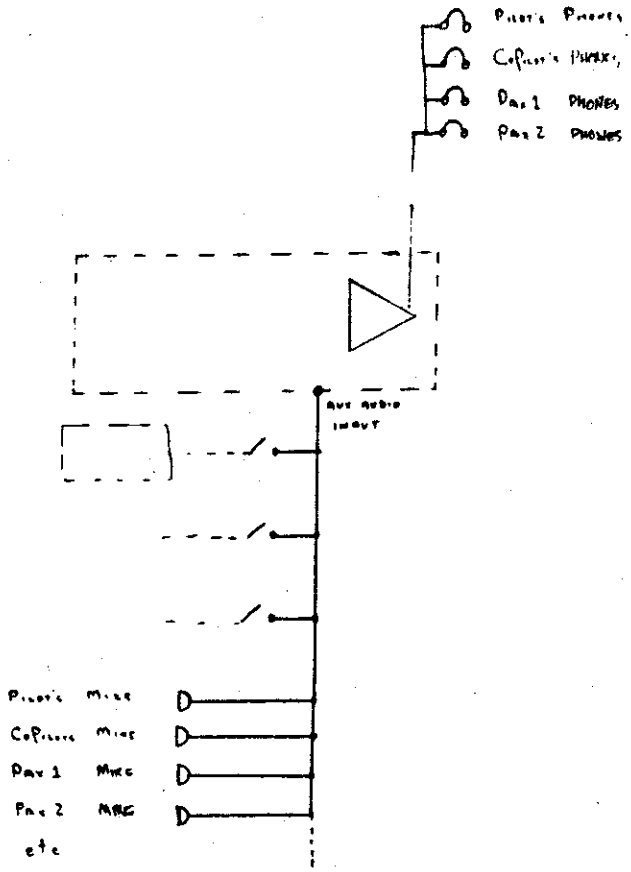


Figure 3 — Basic schematic of the cockpit intercom.

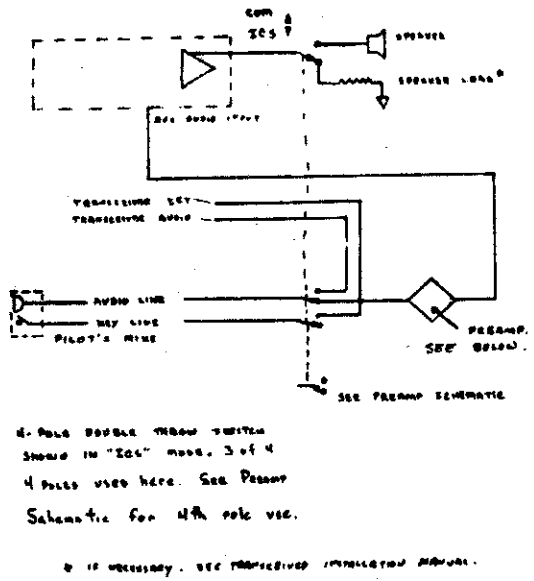


Figure 4 — Wiring diagram for the four-pole, double-throw switch.

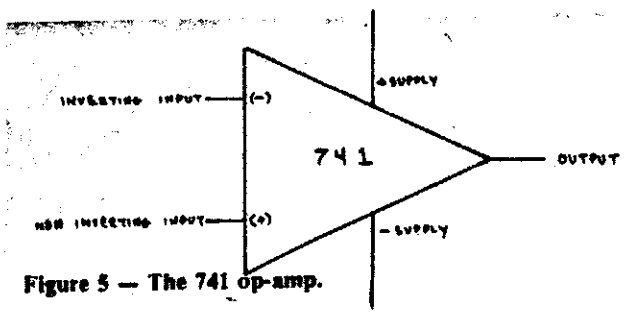


Figure 5 — The 741 op-amp.

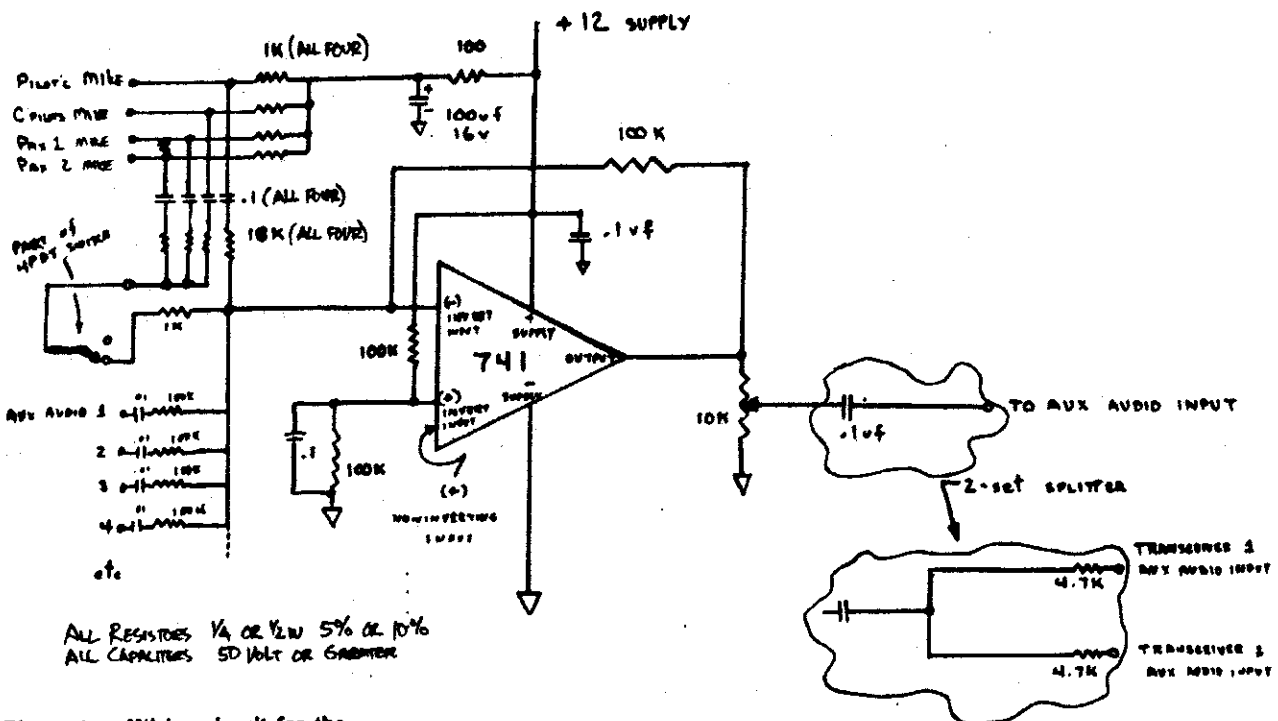


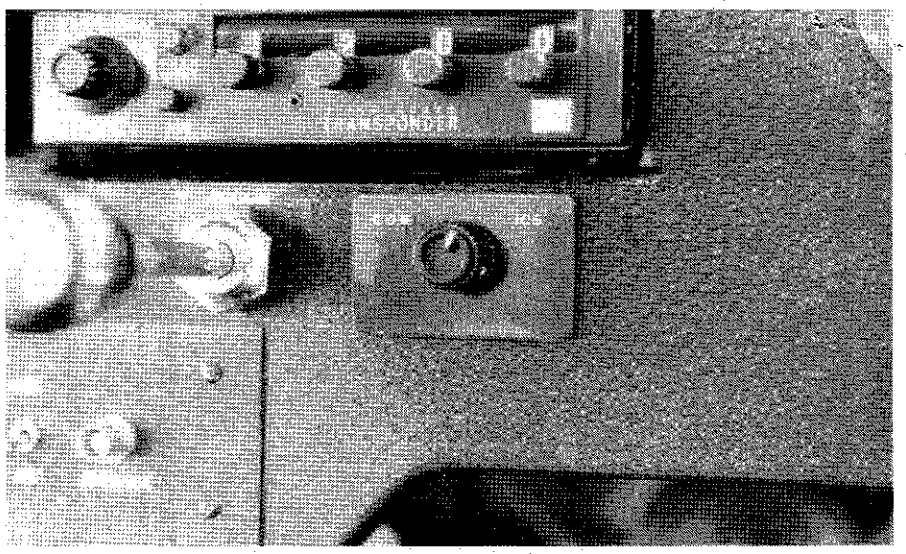
Figure 6 — Wiring circuit for the

does not quite put out enough voltage to drive the aux input directly. We will have to put in a bit of preamplification between microphone leads and aux audio input.

The first three of these problems can be taken care of quite simply — a four-pole double throw switch labeled "COM" on one throw and "ICS" on the second throw will solve the switching functions (Figure 4). A rotary 4PDT switch is available from most of the "hobby" electronic stores for about $1. If your tastes run to the toggle-style switch, you will have to find a pretty well equipped electronics distribution store (not your friendly local TV fixit shop) and be prepared to spend $5 or $6.

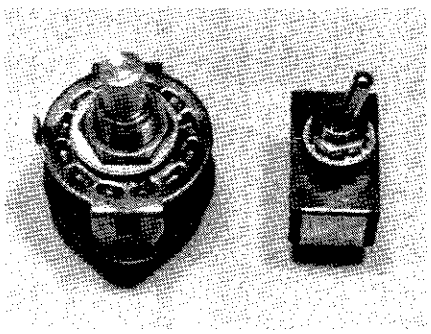
The last (preamplifier) problem will be solved for about $1 in electronic parts, plus about $3 in mechanical bits and pieces. In the experimental labs here at RST, we have developed a rather simple and pragmatic approach to the construction of circuits in onesy-twosey quantities. The construction technique involves the use of a small square of plumber's flashing copper or a small square of unused PC board material. This is then used as a small, solderable, sub-chassis substrate, which is then bolted directly to the (unsolderable) aluminum or plastic case (mini-box). The components of the circuit are then soldered directly to each other, or grounded (if the circuit so shows) to the solderable substrate. The circuit thus built may then be tested before bolting to the mini-box and installation into the aircraft.

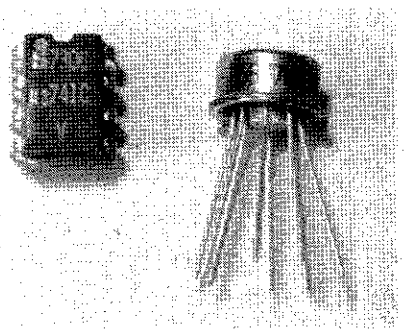
The heart of the preamp is a 741 integrated circuit (IC) operational amplifier (op-amp — Figure 3). These little gems are available at the local hobby electronics stores, two for a buck. We will be using these amplifiers to boost the microphone signal by a factor of about five, although the IC has the capability of amplifying by a factor of 1000 or more. It's rather like using a 300-hp Shakey Jake radial to power an aquarium pump, but, for 50¢ apiece, what the heck. The 741 has a total of five active inputs/outputs, but the package may have up to a total of 14 connections. Just follow the diagram (Figure 6) in this article and use the data sheet coming with the IC and you will be fine. The extra pins on the IC go exactly nowhere, so don't worry if there appear to be extra pins on the IC case. Note that on the schematic we have used a great deal of 2¢ resistors and dime capacitors to provide up to four microphones, plus up to four additional auxiliary inputs. The advantage of using the (—) inverting input of the op-amp as the input port for the aux radios instead of the normal aux audio input of the transceiver is that the tremendous gain reduction of the op-amp IC makes the (—) inverting input an isolation junction.



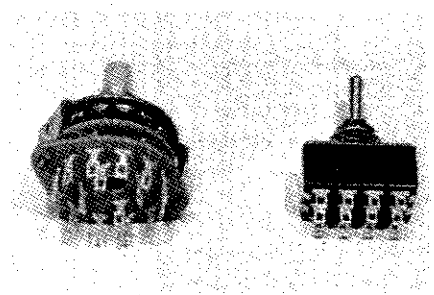
Photos: Jim Weir/RST

Intercom switch on neat subpanel installed just below the transponder (or anywhere there's room).

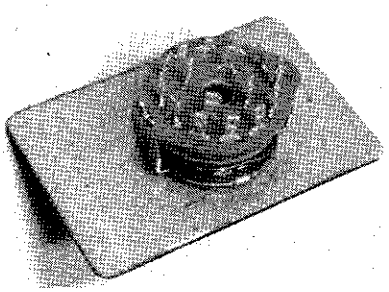




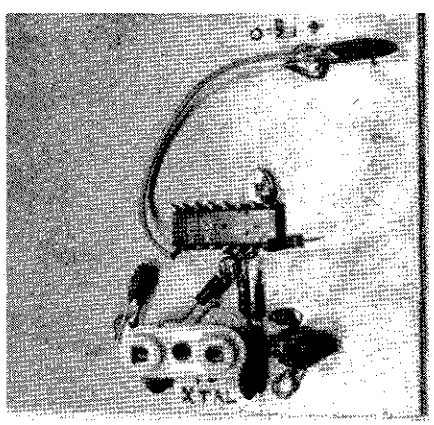
The uA-741 op-amp; it can come in either package shown.



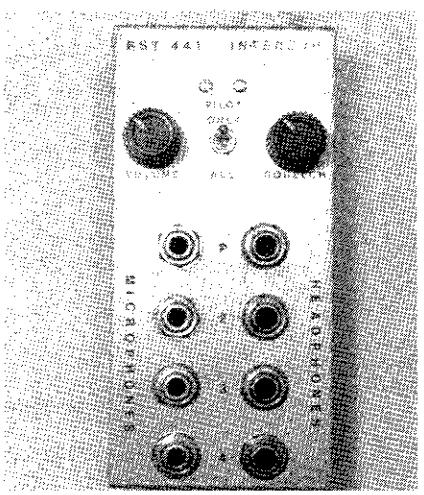
Front and back views of two different 4PDT switches; the one on the left is a rotary switch and less expensive than the toggle switch at night.



Back of subpanel with 4PDT rotary switch mounted, ready for wiring.



The IC circuit built on a scrap of PC material.



The RST-441 kit-built intercom, one of several commercially available.

Thus, in addition to providing microphone amplification, the op-amp also provides an isolation amplifier for the auxiliary radios. (Remember what I said about making things do double-duty?) The isolation amplifier is good, in that switching various combinations of radios and microphones on and off has no effect on the audio level of other inputs to the isolation amplifier.

Although the circuit as drawn is practically pilot-proof (one cut beyond foolproof), an easy check can be made using a 9-volt battery as the power source, a set of headphones connected directly to the op-amp output, and an aircraft microphone connected directly to any one of the four microphone inputs.

When installing this unit into the aircraft, adjust the output level control for a normal listening level with the circuit in the ICS mode while speaking in a normal voice into the microphone. In aircraft with dual com transceivers, you may wish to install the two-set splitter as shown so that the ICS circuit, as well as all the auxiliary radios will be audible no matter which com transceiver is turned on or in use.

So much for the $10 intercom. Things can really be made simple and cheap if you are willing to put out a little effort, can't they? On the other hand, I have had comments that some of my ideas and circuits are a little beyond the "average" pilot (meaning that the guy who wrote couldn't make heads or tails out of the schematic). And the heck of it is, I couldn't agree more! Quite honestly, I am writing for the above-average airplane driver — the guy who wants his airplane just a little neater, a little cleaner and a little more personal than the run-of-the-mill Spamcan. Yet, not everyone can be an electronic aficionado, and I can't run a school for the basics by letter or long-distance telephone. But each of you has access to a great untapped pool of expert electronics help within your own community. I refer specifically to the amateur radio (ham) licensee. Now, I didn't say CB, and I didn't say the TV repairman, I said *amateur ham*. The ham who can't answer your schematic questions doesn't exist. If you offer an hour or so in the air for an hour or so of intensive elektroniking help, you should have more aid than you can use. (Breathes there a ham with soul so dead that he could resist getting his antenna to 10 thou for an hour or so? Not a chance!)

In the last three issues, we have really beat this headphone-microphone-intercom field to death. Next issue will be spent discussing transmitter power, how the voice really gets from here to there, and maybe another $10 gadget that will light a big red panel lamp whenever a transmitter is keyed in the aircraft.

Until then, may all your anti-electrons move in step through the semiconductor crystalling lattice structure. —*Old Weird Jim*