TROUBLESHOOTING AC/DC RECEIVERS

By Curt Lutz

Back in the mid 1930s, radio manufacturers introduced the AC/DC receivers (employing series-string filaments and no power transformers). These radios could be built for about half the parts cost, due to the elimination of the power transformer -- the most expensive component.

The filament voltage of tubes used in series-string filament connections may be different, with various voltages, such as 6, 12, 25, 35, 45 or 50 Volt ratings. Adding all the filament voltages should add up to the AC line voltage; if not, a resistance must be wired in series with the string of filaments, to drop excess line voltage (and provide the correct current through and voltage drop across each filament in the string).

The current rating of all the tube filaments must be equal. Generally either 150 mA or 300 mA.

In may AC/DC radios, one side of the AC line is connected to the chassis, so we call this a "Hot Chassis". Most AC/DC sets had a non-polarized plug, so the chasis might be connected to the neutral or to the hot side of the AC line, depending on plug orientation. Also keep in mind that which ever side of the AC line is connected to the chassis when the radio is switched on -- will be reversed when the radio is switched off (due to the ON/OFF switch arrangement). This is a definite problem in normal use around the house, but, a much more serious problem when you want to work with the radio on your test bench. Most modern test equipment (signal generators, Signal Tracers and AC operated meters), may have a three wire grounding power cord, so trying to test or align an AC/DC receiver will require the use of an isolation transformer. I suggest that ou obtain a suitable Variac/Isolation Transformer, with appropriate voltage and current metering. Although it is not essential for work on AC-powered radios, amplifiers, phonographs, other equipment that has a power transformer, it is very important for technician safety and for preventing possible damages to equipment that may have internal shorts, high-leakage electrolytics and even shorted tubes.

GENERAL AC/DC TROUBLESHOOTING

1. CLEAN IT UP Compressed air is wonderful to blow out the greatest amount of dust, cobwebs and mouse defecation. On smaller radios, it works best if you take the chassis out of the cabinet first. On larger sets, I usually use the compressed air before and after disassembling it. If you do not have compressed air, you can use a vacuum cleaner with a crevice tool and a small bristle paint brush to suck up most of the dust and dirt.

2. VISUALLY INSPECT Lots of defects can be seen with the naked eye, so look for condition of the line cord and plug; most will probably need to be replaced. Look over the top of chassis, then turn it over and take time to thoroughly examine the underside. Look for any obvious damage, such as overheated or burned in two resistors, capacitors

with one end blown out or cracked plastic covers, unsoldered or poorly-soldered joints, broken wires or any bare component leads that are shorting to any other metal point.

3. OBTAIN SCHEMATIC If you elect to restore this AC/DC set, now is a good time to get a good legible copy of the correct schematic and technical data covering it. This information is available for almost any old radio, and having this makes it a lot easier to properly service your radio. Many radios have had components replaced by someone in the past, and, sometimes they put in parts of the wrong value or voltage ratings, worse yet, sometimes parts were installed incorrectly, either connect to wrong point or with reversed polarity.

4. TEST TUBES This is optional, but is particularly important when servicing AC/DC equipment -- since the filaments will all be in series, if any one of them is open, none of the tubes will light up. First test each tube for shorts and quality, then let it operate in the tube tester for about five minutes, then re-test for shorts and quality; it is especially important that tubes wired as series-string filaments do not have any shorts, which sometimes show up after the tube(s) are at full temperature. Tube testers vary in how they display internal tube shorts; most quality tube testers, such as Hickok and other Mutual Dynamic types, will indicate the "Normal" shorts that should be there when testing tubes with more than two connections to the filament (such as 35Z5 rectifiers). If you do not have access to a tube tester, it is possible to check some important things with your Ohm meter; use lowest Ohms range and check filament pins (tube manual is handy item, especially if your schematic does not show tube base pin numbering). Further checks can be made with your Ohm meter on highest range; connect one lead of Ohm meter to one filament connection, then check to all other pins with the other lead. If you find any leakage, check to see if it should be there (like another filament terminal). If the set has any Loctal tubes, it is a good idea to brush across all the pins with a small stainless steel or brass wire brush, to clean off surface oxidation; loctal tubes are notorious for having poor or intermittent contacts in their tube sockets. The same problem is common with the seven and nine pin miniature tubes/sockets.

5. MAKE RESISTANCE TESTS OK I like to make a few tests with an Ohm meter. Put one lead to one pin of the AC plug, the other lead to the other pin of the AC plug; if no continuity, turn on the radio power switch, and you should now have continuity (if not, something is open somewhere in the power cord, the filament string or the on/off switch). Next, check the speaker voice coil and both primary and secondary of the output transformer; to test the primary of the output transformer, connect Ohm meter between the plat of the AF output tube (usually has a blue wire from this plate to the output transformer), and the B+ point (usually a red wire from the output transformer to B+); this should read from 100 to possibly 300 or more Ohms). If the radio has push-pull output tubes, check from the primary center tap (usually red lead) to the plate of each output tube. In order to test the speaker voice coil and secondary of the output transformer, you should unsolder one lead of the output transformer from the lug on the speaker; now check across the two voice coil connections of the speaker, then check across the two output transformer secondary leads. Note that the speaker voice coil will probably read only 2 to 6 Ohms, and the transformer secondary will read even lower,

usually only 1 to 2 Ohms. Re-solder the lead you disconnected There are many other things that your Ohm meter can test, such as any resistor that appears discolored or overheated, leakage across the electrolytic capacitors, windings of coils and IF transformers. I must admit, that once in a while, I find so many problems with the Ohm meter tests, that I need to stop and make a decision whether it is worth restoring or not. At this point, if you decide to continue, do fix any known problem with the wiring, from the AC plug through the on/off switch and the entire filament string (including any ballast or resistance the set might have in series with the tube filaments). It is also a good idea to check the volume control resistance from each end to the arm, rotating the control to check for resistance change and the linear or logarithmic function.

6. POWER UP SLOWLY Plug the radio into the outlet of a VIT (Variac/Isolation Transformer), turn the variac control to zero, turn on the radio, then the VIT, then while watching the current meter, slowly increase the VIT output voltage; stay alert, as if there is some significant short the current will rise quickly and you will need to switch the VIT off (or quickly bring the variac back down fast). Note that, if three is an open in the load, anything from an open line cord or tube filament, filament dropping resistance or wiring, or, the on/off switch, there should be no current showing on the VIT, even when hyou have reached nominal AC line voltage out. If the radio powers up, you should hear something from the speaker after the tube heaters start emitting electrons, many times what you will hear is a loud hum, which can be sufficient to damage the speaker, so be prepared to shut it down when the hum gets louder. If hum level is fairly low, continue by slowly bringing up the volume control, while turning the set to see if you can receive any stations.

If the radio actually seems to operate, the next step would be to check operating voltages. Set your meter to DC Volts at least a 150 Volt scale to begin taking B+ voltages. Connect the negative meter conductor to the B- (find the negative lead of the filter capacitors, which may be independent of the chassis, then check B voltages at each of the positive ends of the filter capacitors; most AC/DC sets have two electrolytic filter capacitors in the B supply, usually in a single can or tubular unit with two or three caps inside. The third capacitor (if the multi-lead capacitor has a third cap), is usually 10 to 25uF rated at 20 to 50 Volts, and is used to bypass the cathode resistor of the output tube. Anther check, this time with your meter on an AC Voltage range of at least 100 Volts, is to check the AC voltage across the filament pins of each tube; what you should get are the 6.3, 12.6, 25, 35, 45, or 50 Volts, plus or minus about 5% based on the tube designations. If you find a voltage that is much more than the 5% high of low, try substituting another tube of the correct type, checking all filament voltages again. One more check I like to make is from B- to the grid of the Audio Output Tube; put meter back on DC, use a 15 or 50 Volt range and touch the positive probe to the control grid terminal of the final AF Amp. There should be little or no positive voltage at this grid (if over a one Volt positive, the coupling capacitor is leaky and needs to be replaced.

7. REPLACE CAPACITORS Now is the time for all good radio repairmen to recap the tube-type unit. Even if it looks like someone has already replaced some of the capacitors, if you want the radio to play well and be reliable, it is important to replace all the

electrolytic and paper-dielectric capacitors. Unless you find a defective (open, leaky or shorted) mica or ceramic capacitor in the equipment, do NOT replace these types, as they almost never fail. First, I suggest you replace the electrolytic filter capacitors, those in the B supply, plus any others such as might be a bypass for the output tube cathode resistor. In AC/DC sets that have a half-wave rectifier, the B supply filters should be rated at 150 or 160 Volts, and I replace multiple section electrolytics with single-section types -- under the chassis. If there is a top-of-chassis can with these filters in it, it is best to leave that can where it is, just unhook all the lead from each positive terminal and install a terminal strip so you can neatly connect the replacement capacitors in the available space under the chassis. It is OK to leave any B- connections to the old capacitor can, and you need to continue using this as the common point for the negative side of the new capacitors; conversely, do NOT leave any B positive connection to any of the old filter capacitors -- NEVER PARALLEL A REPLACEMENT CAPACITOR WITH AN OLD ONE.

Next step, watch carefully when you start cutting off leads of each of the paper-dielectric capacitors. If you think you will lose your way after removing any capacitor, it might be a good idea to make a sketch before cutting leads. I generally cut leads off one end of a capacitor (close to the capacitor), then attach one lead of the replacement to that point, then cut the other old capacitor lead close to the capacitor, then attach the other end of the replacement capacitor where it belongs. The on to the next one, etc., etc. Some sets will have only six or seven of the paper-dielectric capacitors, while others may have a many as ten or more. I like to replace the filters then try the set, then replace a couple of the paper-dielectric caps and try the set again; the point is, if you screw up and make an incorrect connection, it probably will affect the operation of the unit, so it is easier to find a mistake if you only have to go back and check on the last two you replaced. After all those capacitors have been replaced, turn the radio on and make a complete set of voltage measurements, based on the nominal voltages printed on the schematic (sometimes near the tube socket terminals, sometimes listed ion a chart somewhere on the technical data).

8. ALIGN THE RECEIVER Once you are satisfied that the radio is re-capped, has correct operating voltages and actually plays, the logical next step should be a careful alignment. First, if this is one of those early TRF (*Tuned Radio Frequency) Receivers, alignment can be a very difficult and frustrating project. I would suggest that, if the radio plays well, it might be best to forget alignment. Some of the TRF radios printed a detailed procedure for alignment, often with some unusual procedures; if you do not have that procedure available, it might be best to not attempt alignment, especially if the radio used any triode type tubes as RF Amplifiers. Fortunately, most AC/DC receivers will be superhetrodyne circuits, and these are relatively easy to align.

Superhet alignment begins by aligning the IF Amplifier tuned circuits. In most radios this will involve the tuning adjustments for two IF transformers, usually two adjustments on each of the transformers. The adjustments usually are small variable capacitors, although sometimes the tuned circuits used fixed capacitors with variable inductors. Most will have top-accessible screws for adjusting the capacitors, some will have a threaded screw protruding from the top and the second from the bottom for adjusting the inductances. Alignment tools should be non-metalic, or, have only a small metal tip at the ends. Some newer radios will have the mini IF transformers that have a couple ferrite slugs for tuning, some with a slot for a flat blade tool, others with a hex hole through the middle of the slug, requiring a correct size (non-metallic) hex tool to adjust; many of these with the inner hex opening can both be adjusted from either the top or from the bottom. It is a good idea to crank the receiver tuning capacitor to the fully-closed position (low end of the band), as this provides a much quieter receiver operation (lowernoise) during alignment. When you actually start aligning the radio, rock the tuning condenser to find a point near the low end where you get the least interference or noise.

You should have a minimum of three pieces of test equipment to begin alignment. First, use a Variac/Isolation Transformer (at the very least use an Isolation Transformer) to supply the AC power to the receiver, a quality signal generator and a meter to measure receiver gain during alignment. If your radio has AVC (Automatic Volume Control) there are two ways to measure receiver gain, by measuring -DC voltage between B- and the AVC bus; this usually will require use of a 5 Volt negative DC range of your VTVM. The preferred method is to use a sensitive AC volt meter connected across the speaker voice coil, which needs a meter that will read down to 0.3 or 0.1 Volts AC. Now connect the signal generator output cable shield to receiver ground (usually the chassis), then connect the coax center conductor through a small capacitor (about .001 or .002 uF), to the signal grid of the converter tube. Attenuate the signal generator output as far as possible and turn the radio volume control full up. Set the generator for modulated RF output and for the radio's Intermediate Frequency, then slowly bring up the generator output until you hear the tone in the speaker. During alignment, it is important to keep the signal generator output as low as possible while keeping the output (or AVC) metering on the lowest range possible -- without the receiver noise pegging the meter.

Now, adjust each of the IF alignment screws or slugs, one at a itme for peak output, reducing the generator output each time it gets close to pegging the meter. Then repeat those adjustments as there will be some interaction between primary and secondary peaks on each IF transformer, especially if they are slug-tuned.

Once the IF alignment is completed, the RF alignment in most 5-tube AC/DC receivers is really easy, usually consisting of only two trimmers to adjust. These trimmers are most often located on the main tuning condenser, one for the local oscillator and the other for the antenna tuned circuit. Before adjusting either of these trimmers, be sure the dial pointer is mechanically set correctly; this sometimes is a dot or line at the lower end of the dial scale, especially on sets that have a slide rule type dial. For sets with an airplane or speedometer type pointer, there may be a dot or line at the low end to set the pointer to with the tuning capacitor plates fully closed. On other sets that have a 180 degree pointer rotation, just set it so that it is balanced or leveled when at either end of the tuning range. Most schematics provide instructions for the RF alignment. Either way, set the signal generator for a frequ3ency around 1,4 kHz, feed the signal generator into the External Antenna terminal on teh chassis, or into the loop antenna through the same small capacitor, or just lay the generator output leads close to the loop antenna, turn the generator output up some till you find it on the radio dial, then move the generator signal up or down slightly if you are getting interference from any off air signals. Now, checking the generator frequency (let's say you wound up with the generator output at 1,350 kHz), so set the receiver dial at last step is to tune the antenna trimmer for maximum. I usually shut off the signal generator, tune in the weakest station I can find that is between 1,300 kHz and 1,500 kHz, then peak that antenna trimmer for maximum loudness. Some signal generators have such poor attenuation that it is difficult to get the generator signal low enough for this last adjustment.

9. WHAT ELSE CAN GO WRONG? OK, so you get to the middle of the aforementioned trouble shooting process and the radio still does not work. Just think about all those other components in even the simplest AC/DC receiver --things like the IF transformers, the Antenna, RF and local oscillator circuits, plus all those resistors, any one of which could have changed value or failed. This is one reason hat I suggested doing all those resistance measurements, before replacing components, plus checking operating voltages once the set is re-capped.

It is not unusual for the main tuning condenser to have shorts, in either the antenna or oscillator sections. You need a good light source and sometimes a magnifying glass (along with your Ohm Meter) to find such a short and hopefully, to correct it.

In about one of every six or eight of these AC/DC radios, I find a defective IF Transformer, usually with an open primary, less often with an open secondary coil. In some cases I have been able to remove the IF Transformer, locate a broken off lead wire and repair the thing. Testing the coils in an IF Transformer is easy with your Ohm Meter, however, be careful, as some of these IF Transformers had a resistor or two inside the can, so where you should get just 10 or 20 Ohms of resistance across each IF coil, you might 47,000 Ohms, due to an internal resistor -- check the schematic, which my show such items enclosed in the IF Transformer can. You may also buy a radio and when you take it home and look it over, find it is missing tubes, missing the speaker, or has a badly damaged speaker cone, even sets that have a missing back, which sometimes means the loop antenna is gone; keep in mind that those loop antennas actually are the inductance component of the receiver input tuned circuit, so replacing one of these requires one having the correct inductance, otherwise the input circuit will be seriously de-sensitized (won't tune or track with the tuning condenser).

Use a quality electronic cleaner to spray band switches, tone and volume controls. However, do NOT use WD-40 on switches or controls, as it leaves a resistive lubricant that causes leakage on the insulators of switches and the surface of carbon potentiometers. WD-40 does work OK on low-resistance wire wound potentiometers, but I just don' trust it anywhere there are high impedances or any high voltages.