

Making connections to a AA5 series heater radio

V1.2 Nov. 2025

This describes how to connect the FM converter to an AA5 (All American 5) series heater tube radio.

Starting in the 1930's, a radio architecture that typically uses 5 tubes with their heaters in series became very popular in North America. They became known as AC-DC sets or simply the All American Five (AA5). They can be identified by their ratings plate that will state that they are AC/DC.

The classical AA5 uses this octal tube line-up: 12SA7, 12SK7, 12SQ7, 35L6 or 50L6, 35Z5. Earlier octals could also include 12A8, 12K7, 12Q7.

The more modern version of the AA5 uses these miniature tubes: 12BE6, 12BA6, 12AV6 or 12AT6, 35C5 or 50C5 or 50B5, 35W4.

Other versions can use loktal tubes like 7A8 or 14B8, 7B7 or 14A7, 7C6 or 14B6, 50A5, 35Y4 or 35Z3. There were mixes of these tubes as well.

The above radios used tubes with 150mA heater current. There were earlier radios that used tubes with 300mA heater current.

In addition, some radios had additional tubes such as an RF amplifier or a push-pull output, or possibly only 4 tubes with the IF amplifier missing. All of these are candidates for FM conversion.



1. Preparing the FM converter board

See the other document that describes assembling the FM converter circuit board at <https://rabjohn.ca/gord/projects/fmconversion/> .

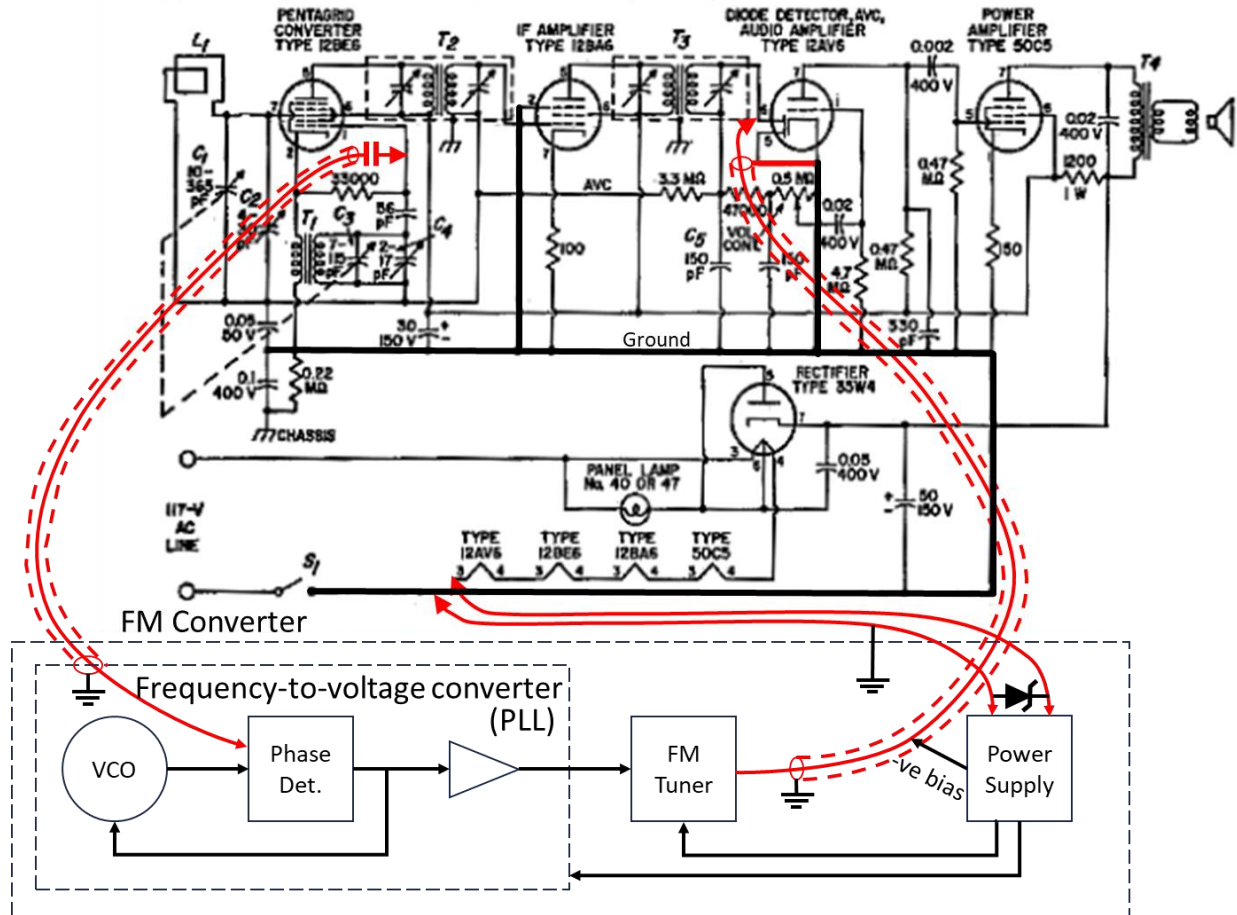
In assembling the board, note that diodes D41, a 1N5344 (an 8.2V Zener diode), is needed. This diode is in series with the heater string and allows the 150mA to flow, with a predictable voltage drop of 8.2V to supply the FM converter board. A voltage of 8.2V at 150mA (actually less current than that, because the converter takes some) is a power of about 0.65W (since this power is dissipated only half of the time; the other half, the diode is forward biased), so the 5W 1N5344 is conservatively rated. By the way, this leaves less voltage for the heaters, but since the heaters take about 18W, 0.65W is less than a 4% drop in heater power, quite tolerable.

The negative supply deserves some discussion. If a single D41 is used, the negative supply will not work because the waveform across the D41 cannot go more than about 0.7V negative. If it doesn't work, there is no need to populate it on the board (do not populate D43, R27, R40, R41, C46, C47) . So, do you need the negative supply? The negative supply disables the detector diodes and reduces the gain of the IF amplifiers in the host radio. Reverse biasing the detector diode prevents it from distorting the FM audio, and prevents it from detecting AM signals. Reducing the IF gain helps prevent AM signals from breaking through. If the detector diodes are disconnected at the socket adaptor, then they won't detect, and the negative bias should be unnecessary. Disconnecting the detector diodes is fairly easy on an octal socket adaptor, but is more challenging on adaptors made for loktal or miniature tubes. Shorting the AM antenna connection to ground on the host radio will also reduce break-through. If you find that you need the negative bias, there is another solution: D41 can be made with two Zener diodes in series back-to-back. This will allow a substantial negative swing, so the negative voltage supply will work.

2. Connections to the host radio

Three connections (local oscillator (LO) signal, audio output, power) plus ground must be made to the radio, generally made at the tube sockets. It is very easy to make these connections without any disassembly, modification, or soldering to the host radio by making the connections at the tube sockets with socket adaptors.

25-1 AC/DC SUPERHETERODYNE RADIO RECEIVER



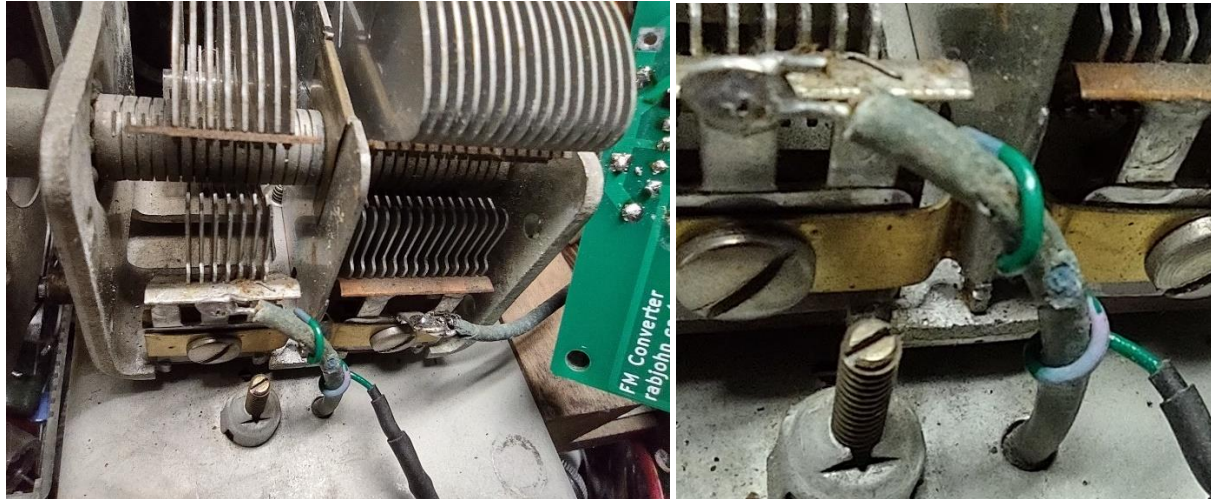
2.1 The local oscillator (LO)

There are 2 ways to get this signal: either use a capacitive link to the LO signal (usually at the tuning capacitor), or connect to a pin on the "Converter" tube (possibly with a socket adaptor). In either case, it is best to minimize the length of the shielded cable from the board to the connection in the radio. Since the cable is a significant part of a capacitive divider (formed by the gimmick capacitor or the series capacitor and the cable), if it is too long it will attenuate the signal excessively.

Capacitive link:

The FMC is very sensitive, so only a small LO signal is required, and this can be extracted with a capacitive link. An insulated wire wrapped around a wire (known as a gimmick capacitor) provides enough capacitance to extract the LO signal. The link can be made by wrapping insulated copper wire from the FMC LO port to the wire leading to the LO tuning capacitor in the host radio. Suitable radios have dual (or more) tuning capacitors, and you must pick the right one. If there is a pair and they are of unequal size, then the smaller one is the one you want to couple to. If they are equal size, try this: Turn on the radio and tune to a station at the upper end of the AM band. Touch each variable capacitor (stator) terminal, one at a time, with an insulated screwdriver. Touching the LO side will make it sound like the radio is being tuned away. Touching the other (antenna) side will have a less dramatic effect, may even increase volume.

Shielded wire (try to keep it short) should be used to get close to the tuning capacitor. A solid insulated copper wire should be soldered to the center conductor of the shielded cable to the board, and the outer shield left unterminated. Insulate well with heat-shrink tubing. The insulated copper wire is wrapped around (3 turns should be enough) the wire connecting to the LO variable capacitor that was identified above. No “DC” electrical connection is required.



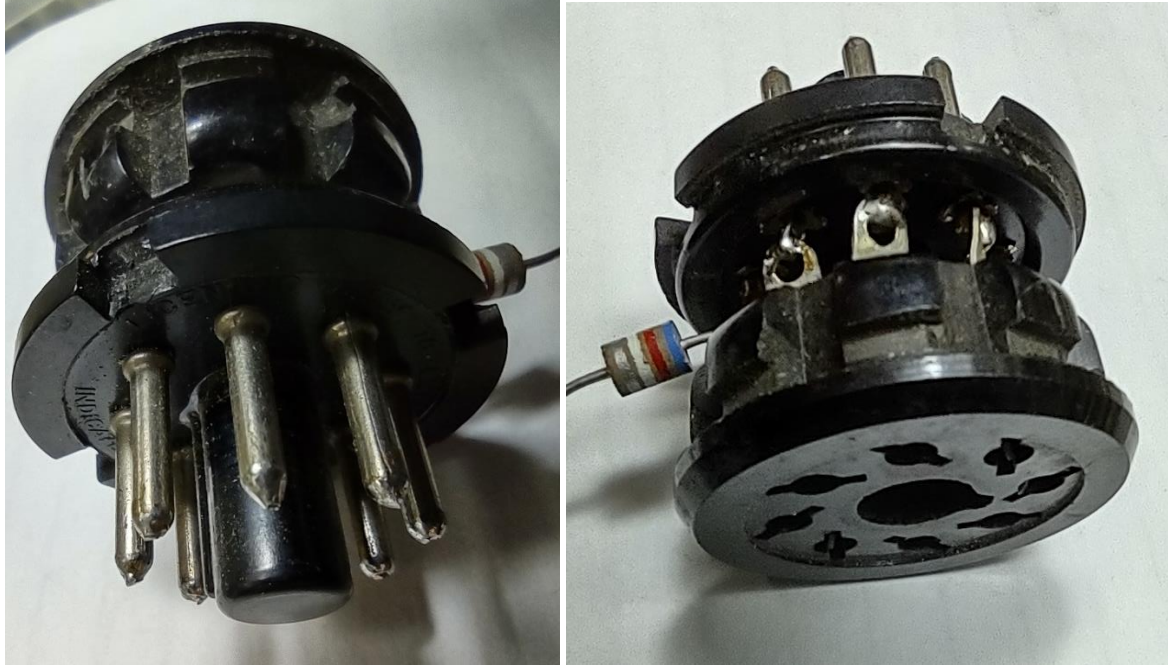
Coupling to the tuning capacitor.

Direct connection to Converter:

The LO signal may also be pulled from the “converter” tube. (This may be the easier technique if the tuning capacitor is difficult to access) In principle, you could pull the signal from either the grid or the plate of the oscillator, but I have found that the grid (which is usually connected to the oscillator coil and tuning capacitor) is more sinusoidal; the plate can have significant harmonics that can fool the phase locked loop. Typical tubes are:

Tube type	LO grid pin number
12SA7, 12A8	5 (octal)
12A7	5 (7-pin standard)
12BE6	1 (7-pin miniature)
7A8, 14B8, 14J7, 14Q7	4 (8 pin loktal)

Note that the tube list is not exhaustive; these are only the most popular converter tubes. The best way to make this connection is through a tiny capacitor (say 5pF, not critical) mounted very close to the pin. This way, minimal capacitance will be added to the radios LO circuit. The capacitor is connected to the circuit board LO port with shielded cable. A “socket adaptor” is recommended so no soldering is required on the host radio. For octal and “Standard” tubes, this is easily made with the male end taken from an old tube, and a matching tube socket on the female end. The pins are wired up 1 to 1. This gives you access to the nodes required. Miniature tube socket adaptors may take a little more creativity, but soldering rigid wires to a miniature socket works.

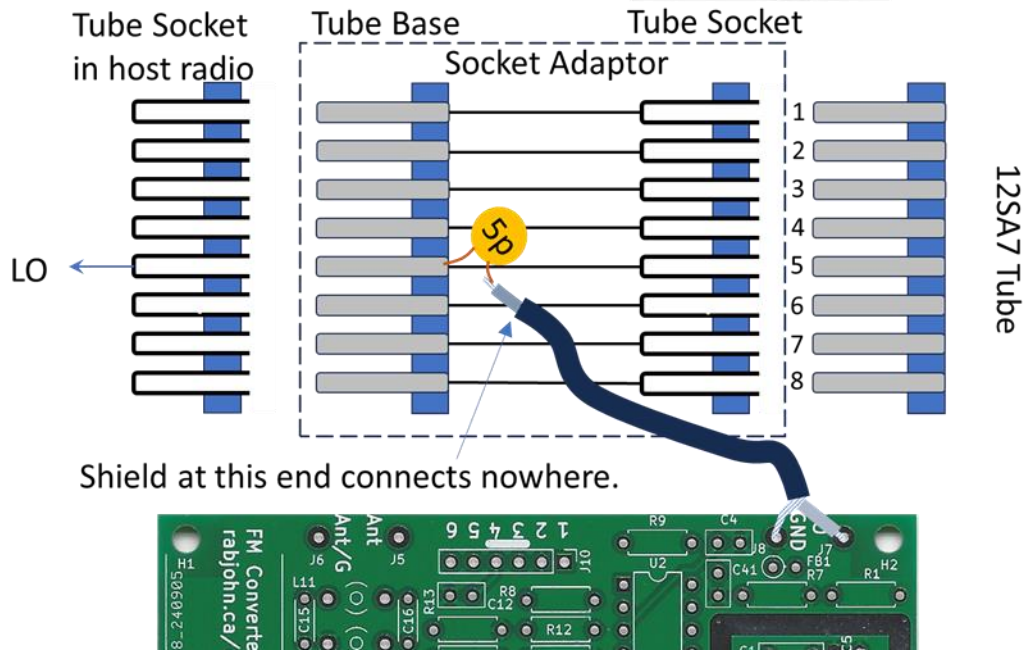


Above: a socket adaptor. It plugs into the radio, and the tube plugs into it.

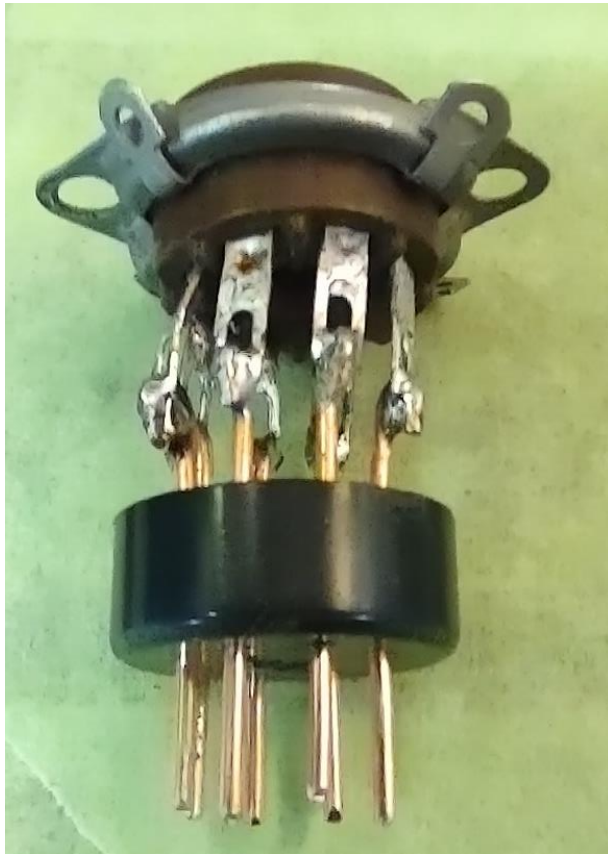
Another option is just to wrap a piece of solid wire around the tube pin:



Wrap wire around a tube pin. For the LO, the 5-10pF capacitor should be close to the tube (it is hidden under the heat shrink tubing).



Socket Adaptor for a 12SA7 tube



A socket adaptor for a 7-pin miniature tube. This is made with 18AWG wire soldered onto a 7-pin socket. The black plastic thing is a pin protector that is sometimes shipped with a tube, but it could be made by drilling 7 holes (perhaps using a tube socket as a template) into a plastic disc, perhaps a button.

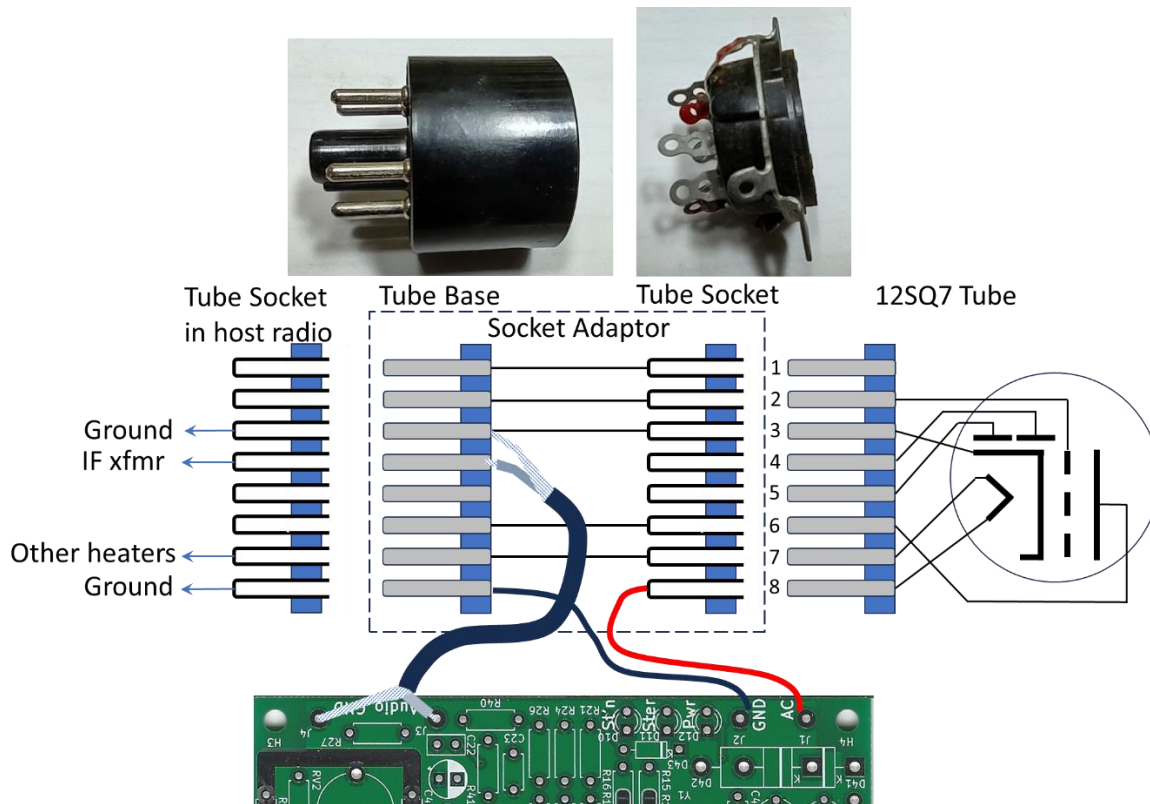
2.2 The Audio

The audio is injected at the detector. Detector diodes in tubes tend to come in pairs, and either or both diodes could be used as the detector, and the other diode could be open or shorted or used elsewhere. You will need to determine which diode to use, either by consulting the schematic, or looking under the chassis, or simple trial and error. The diode you want connects to the IF transformer. Typical detector tubes are:

Tube type	Pin #: Audio	Pin #: Cathode	Pin #: Power
12SQ7, 12SR7	3 or 4 (octal)	3	7 or 8
12Q7	4 or 5 (octal)	8	2 or 7
75, 85	3 or 4 (6-pin standard)	5	1 or 6
12AT6, 12AV6	5 or 6 (7-pin miniature)	2	3 or 4
7C6, 7E6, 14B6, 14E6	5 or 6 (8 pin loktal)	7	1 or 8

Note that the tube list is not complete; these are only the most popular tubes. This connection should be made with grounded shielded cable to avoid hum pick-up. The shield of the shielded cable should connect to ground at the socket as well. Be careful when selecting ground; the detector cathode is usually a good choice. Also, one of the heater pins should be at ground. Beware that “ground” in an AC-DC set is usually not the chassis.

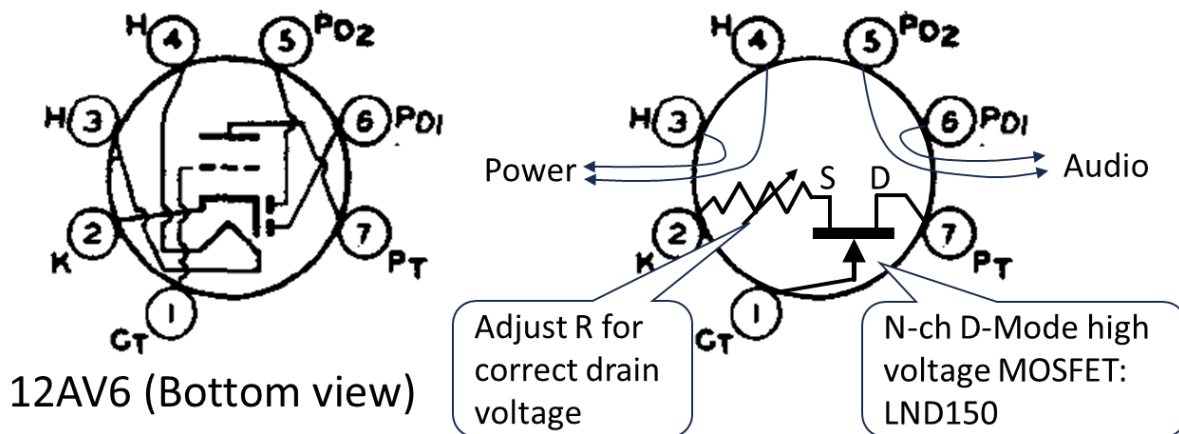
If you have room (height), a socket adaptor is the best way to make the connection. If you do not have enough head room for a tube adaptor, you can try connecting directly to the socket pins. The socket adaptor should preferably be wired so that the diodes in the tube are disconnected; the audio signal from the FM converter goes into the radio, not into the tube. Keeping the detector diodes connected will introduce a small amount of distortion unless the negative supply used; this will reverse bias the detector (eliminating distortion) and lower the gain of the IF amplifier (which may prevent noise and instability).



An example of the wiring of a socket adaptor for a 12SQ7. The diodes on the tube (pins 4 and 5) are disconnected, and audio is injected into the host radio at pin 4. Some radios may need this audio to be injected at pin 5 instead. Ground is shown at pin 8, but it could also be at pin 7 in some radios, making it

necessary to swap the red and black wires. Other tubes will require different socket pins to be connected. If it is not convenient to disconnect the diodes, the audio can still be injected, but make sure the negative bias supply is used.

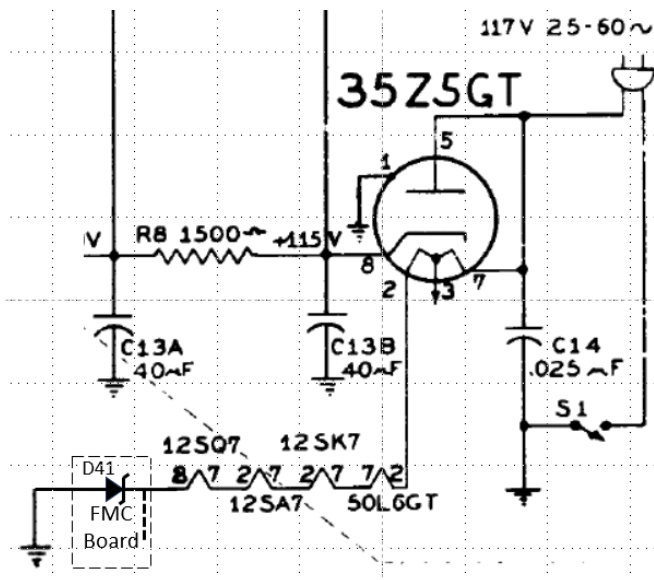
There is a third option: The detector is usually a dual-diode + triode tube. The diodes are not needed when used with the FM adaptor. The triode can be replaced with a FET, making the whole tube unneeded. I have used a LND150 D-mode high voltage MOSFET with a potentiometer (10k) in the source (to adjust the drain current) to replace the triode. The potentiometer is adjusted so that the drain runs at about half the B+ supply voltage for that stage. The power for the board is extracted in series with the heater string. This can be built on a socket recovered from a burnt-out tube, resulting in an assembly that is smaller and cooler than the original tube. Although I have not tried this with many tubes, it should work for the common low power audio triodes listed in the table.



2.3 Power

This version of the converter takes about 35mA (and, with half-wave rectification, this 70mA half the time). If this current is extracted by connecting it in parallel with a 150mA heater, then the heater is starved, and insufficient voltage is generated for the converter. So, for most AC-DC radios, the power must be extracted in series with the heaters. It is essential that the 8.2V, 5W Zener diode be populated at D41 on the board. (Failure to do this will destroy the board!)

You must locate the tube that is at the "ground end" of the heater string. This will almost always be the detector + first audio tube, the same tube used to inject the audio. One end of the heater will go to ground (generally not the chassis ground, rather it will be connected to the cathode of the triode). This ground-end of the heater is opened (with the socket adaptor), and connected to the power port of the board. On radios that use a 12SQ7, you would usually open the circuit at pin 8, but check, it could be pin 7. 12Q7 will usually be pin 2, but check, it could be pin 7. The illustration of the socket adaptor shows what might be done with a 12SQ7. It shows the series heater string being interrupted at pin 8 (because you discovered that pin 8 is the ground side of the heater). It also shows that detector diodes are disconnected at pin 4 and 5, and the audio is fed into pin 4, because you discovered that pin 4 connected to the IF transformer. The shield of the audio cable is connected to the ground on both ends.



←D41 in series with the heaters.

AC/DC radios all offer another challenge: safety. Even without the FMC, they can present a shock hazard because much of the radio circuitry is connected directly to the line cord. When connected properly, the FMC is tied to one side of the AC power line. To be safe, this board should be situated (possibly enclosed) within the radio so that it cannot be accidentally touched. Also, it is best to avoid placing the FMC near sources of heat, which can be a challenge with compact radios. Heat can induce drift.

Other AC/DC Radios

Some very old AC/DC sets use tubes with 300mA series connected heaters and line-cord dropping resistors. It is more difficult to describe how to connect to these radios as there was much less standardization. Some did not have diode detectors, in which case the audio would be injected into the triode or pentode detector. The order of the heaters in the series heater circuit can vary, and, the tube compliment was not standard. (often featured a 43 or 25A6 or 25L6 and 25Z5 or 25Z6, among other tubes) They were the earliest “cheap” radios, and often had poor performance. In addition, these can be some of the most frightening radios from a safety perspective, as there were fewer safety standards (the chassis was often “live”), and the line cord got hot! However, the FM converter can be used, if you dare.

I do not have direct experience with converting European radios, but they should pose no particular difficulty. Most AC/DC sets use the “U” series of 100mA heaters (UCH41, UCH42, UF41, UAF42, UBC41, UL41, UY41. UCH4, UF9, UBF2, UL1, UY1, UCH5, UF5, UBL3, UY3 etc) The “H” series are similar to North American AA5 tubes. European radios may have the detector diode in with the IF amplifier (...AF..BF... tubes) or with the audio output (...BL.. tubes.) The detector in with the IF amplifier makes for a very easy conversion since neither IF amplifier nor the detector are needed when using the FM converter. Rather than using pentagrid converters, they usually use triode-hexode types, with the local oscillator being the triode. Couple to either the grid or the plate (it seems that the LO tuned circuit can appear in either the grid or plate circuit), or just capacitive couple to the LO tuning capacitor.