

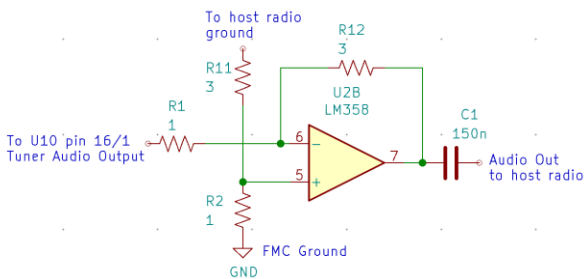
Making connections to a car radio

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This describes how to connect the FM converter to a tube car radio with negative ground. While it is possible to connect to a positive ground radio as well, it is much more challenging so will not be covered here.

There are three types of (negative ground) tube car radios covered here: 1) 12V “hybrid” radios (that do not use a vibrator) that operate with 12V plate voltage, and have a transistor output stage. These were popular from the mid 1950’s until the early 1960’s when fully transistorized radios took over. 2) 12V vibrator car radios, and 3) 6V vibrator car radios, typically made before about 1955. There are other older car radios that use dynamotors, or generators driven by the engine that can probably work with this converter, but need to be considered case by case.

The challenge with positive ground systems is in coupling the audio to the radio. On the FMC, the audio signal is referenced to the negative supply, which in a positive ground radio, becomes the battery supply which is noisy. The obvious answer is an audio transformer. Another possibility is using an op amp (there is an extra one on the board) to change the reference to the positive supply. You could try an op amp circuit like this:



I have not tried this. This circuit takes the FM tuner output voltage (about 0.75V) and flips it so that it is referenced to the positive supply (host radio ground). It has a gain of three, so the output is $3 \times 0.75 = 2.25V$ from the positive supply, about 3.75V in a 6V radio. Watch head room, you may want to connect the op amp pin 8 supply directly to 6V (rather than the 5V regulated voltage), or use a different op amp. The resistors labelled as 1 and 3 just need to be in the correct ratios, so use 33K and 100K for example. If you use the Si4836, R1 can be split into 2 resistors of 2 (or, say 68K) each (R2 would be two 68K resistors in parallel). Note that R1 may need to be reduced to compensate for the tuner’s output impedance to optimise noise rejection on the supply line.

Connecting to a car radio is not difficult; the challenge will have to do with space. Car radios tend to be quite compact, so there may not be enough space (height) for a socket adaptor, so there may not be enough room in the radio for the circuit board. The board can be mounted outside. OR, since car radios use parallel filaments, you can remove unneeded tubes (the RF amplifier, the IF amplifier, and possibly replace the first audio amplifier as described below) to create more room in the radio (and this also saves power and generates less heat).

The AM whip antenna may serve as an FM antenna for the converter antenna port.

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 and D42 are not needed. Since the radio is supplied by DC, the negative voltage power supply will not function, so do not populate D43, R40, R41, R27, C46, C47.

For 6V radios be sure to use a low dropout regulator (like the LP2950) for the 5V regulator, U40, and a Schottky diode (like 1N5817) for D40, or eliminate D40 (short it out) entirely.

2. Connections to the host radio

Three connections (local oscillator 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.

2.1 The local oscillator

There are 2 ways to do get this signal: either use a capacitive link to the “LO” signal, or connect to a pin on the “Converter” tube (possibly with a socket adaptor).

Capacitive link:

The FM converter LO input is very sensitive, so only a small LO signal is required, and this can be extracted with capacitive coupling. An insulated wire wrapped around a wire carrying LO 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. Car radios usually have variable inductors rather than variable capacitors, and it can be tricky to determine which wire you should couple to. Try this: Turn on the radio (with an antenna connected) and tune to a station at the upper end of the AM band. Touch each variable inductor terminal, one at a time, with an insulated screwdriver. Touching the LO inductor 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. You may find that two or more wires are candidates, in which case I suggest using trial-and-error. If you have a schematic, look for the terminal closest to the first grid in the converter tube.

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

Connect to the Converter tube:

The LO signal may also be pulled from a connection to the “converter” tube. 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 connected to the oscillator coil discussed above) is more sinusoidal; the plate can have significant harmonics that can fool the phase locked loop.

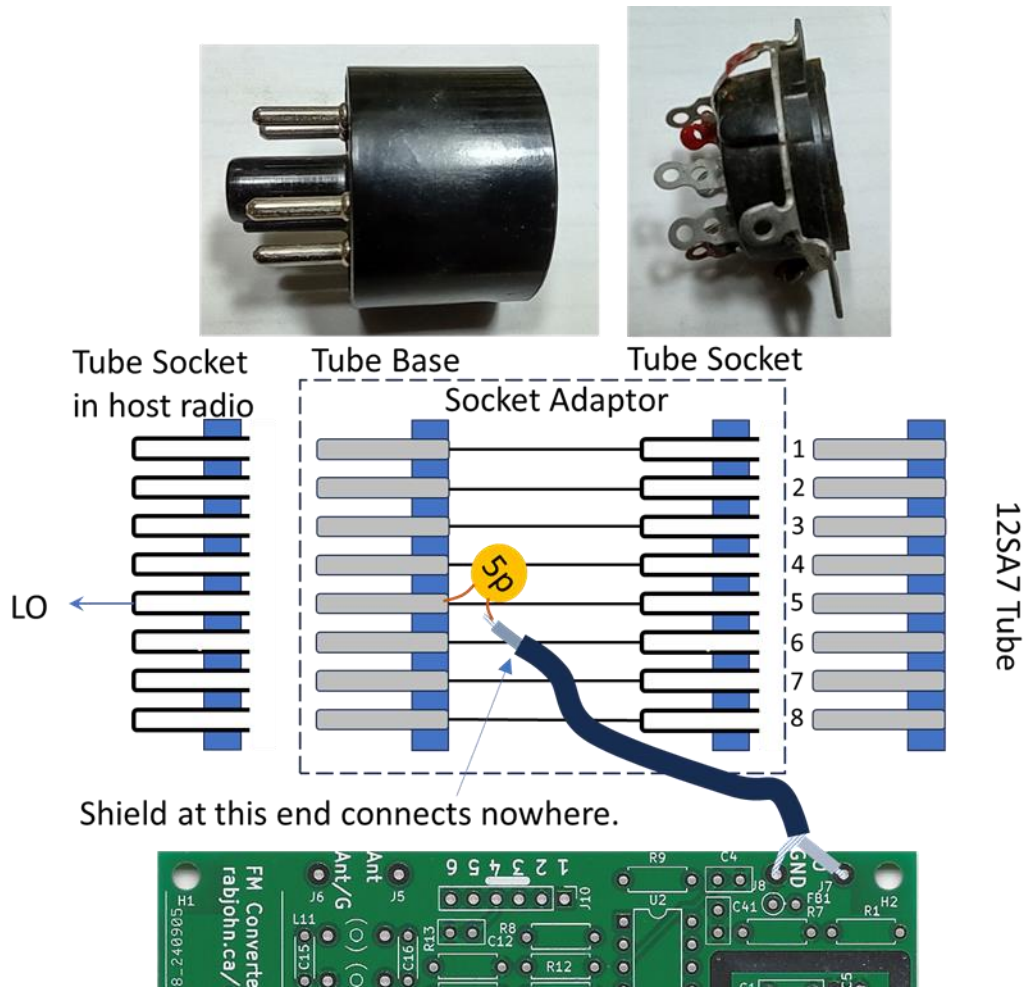
Tube type	LO grid pin number
6SA7, 6SB7, 12SA7	5 (octal)
6A8, 6J8, 6K8, 12A8	5 (octal)
2A7, 6A7	5 (7-pin standard)
6BE6, 12BE6	1 (7-pin miniature)
12AD6, 12GA6	1 (7-pin miniature)
12FX8	2 (9-pin)
7A8, 7B8, 7J7, 7Q7, 7S7, 14B8, 14J7, 14Q7	4 (8 pin loktal)

Note that the tube list is not complete; these are only the most popular 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 oscillator 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 may work.

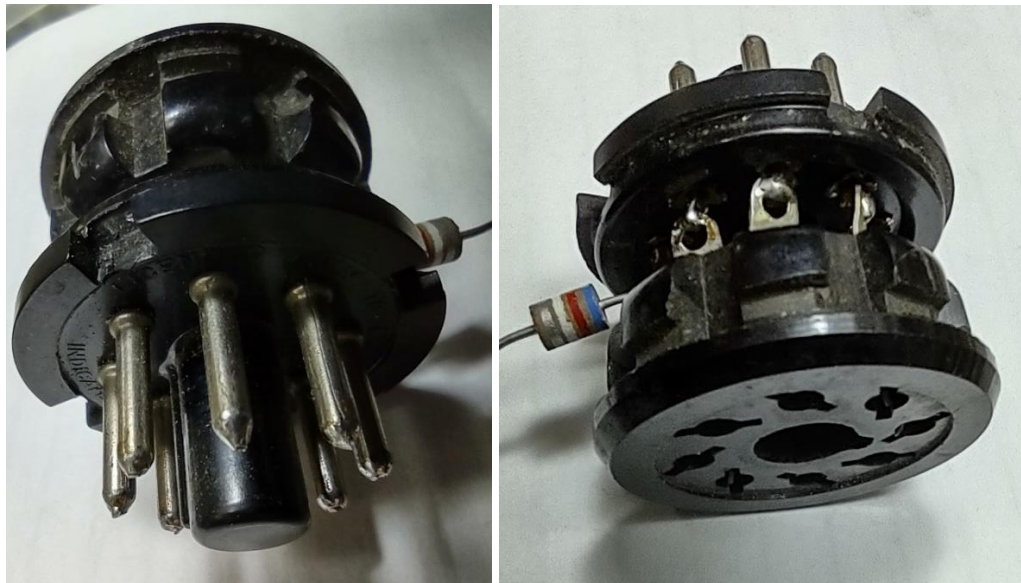
Being compact, car radios may not have enough “head room” above the tube to allow the use of a socket adaptor. Another option is just to wrap a piece of solid wire around the tube pin.



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



Above: Socket Adaptor Pictorial



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

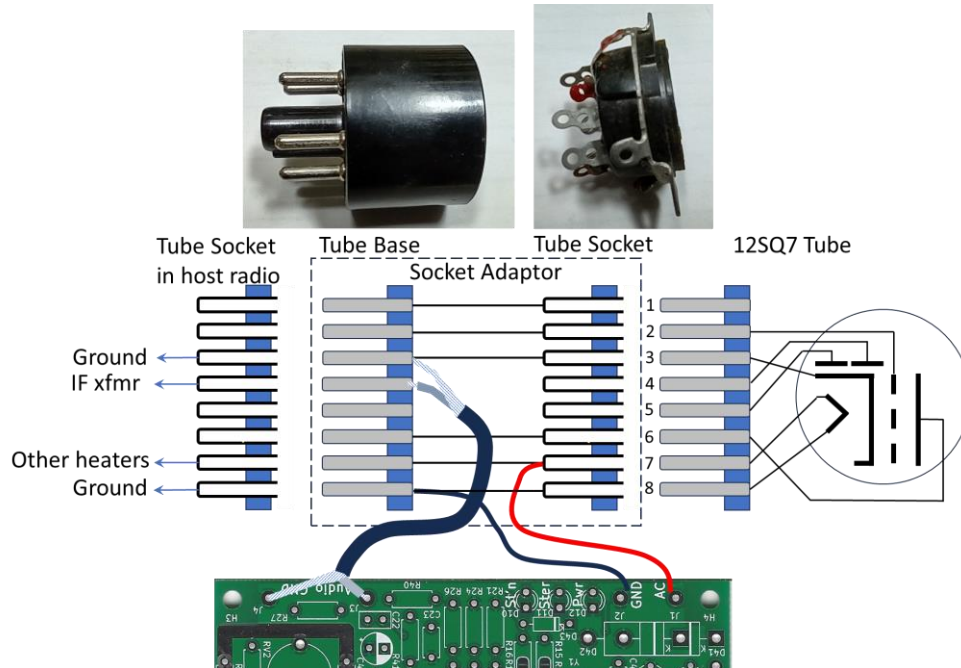
2.2 The Audio

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.

Tube type	Pin #: Audio	Pin #: Ground	Pin #: Power
6SR7, 6SQ7, 12SQ7, 12SR7	3 or 4 (octal)	3	7 or 8
6Q7, 12Q7	4 or 5 (octal)	8	2 or 7
75, 85, 2A6	3 or 4 (6-pin standard)	5	1 or 6
6AT6, 6AV6, 12AT6, 12AV6	5 or 6 (7-pin miniature)	2	3 or 4
6H6	3 or 5 (octal)	4 or 8 or 1 *	2 or 7
12AE6	5 or 6 (7-pin miniature)	2	3 or 4
12DL8, 12DS7, 12DV8	1 or 9 (9-pin)	8 or 4 or 5 *	4 or 5
12DU7	7 or 9 (9-pin)	2 or 4 or 5 *	4 or 5
12F8	1 or 6 (9-pin)	7 or 4 or 5 *	4 or 5
12FK6, 12FM6	5 or 6 (7-pin miniature)	2	3 or 4
12J8	8 or 9 (9-pin)	7 or 4 or 5	4 or 5
7B6, 7C6, 7E6, 14B6, 14E6	5 or 6 (8 pin loktal)	7	1 or 8

* Best to just use the chassis ground

This connection should be made with grounded shielded cable to avoid hum pick-up. The shield of the shielded cable can connect to ground at the socket as well. Be careful when selecting ground. The detector cathode might not be at ground. Find a true ground node, one of the filament pins will be at ground. The socket adaptor should 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.



An example of the wiring of a socket adaptor is shown above. 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. 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.

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. Keeping the detector diodes attached will introduce a small amount of distortion.

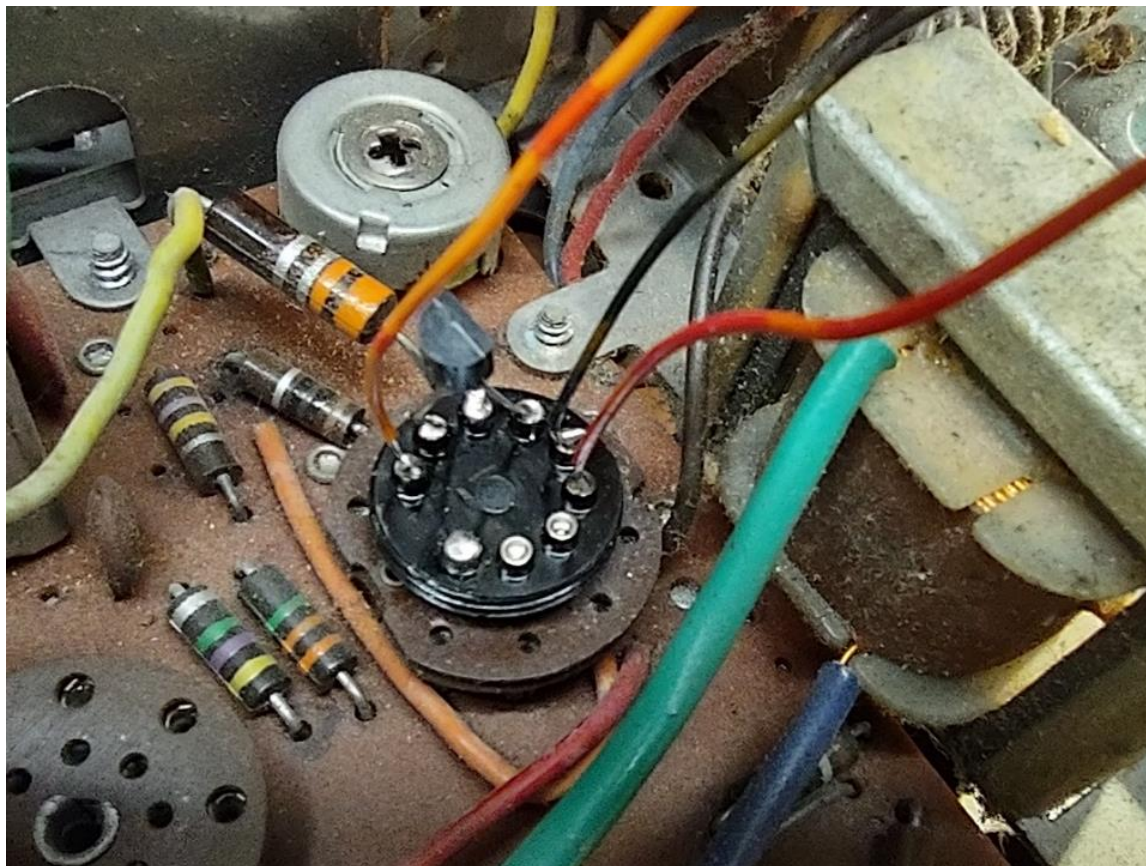
There is a third option: The detector is usually a dual-diode + triode (or space-charge tetrode) tube. The diodes are not needed when used with the FM adaptor. The triode/tetrode can be replaced with a FET. If the radio uses 12V on the plates, then it likely uses a space-charge tetrode which can be replaced directly with a common n-channel JFET like the MPF102. See

<http://rabjohn.ca/data/documents/HybridCarRadios.pdf>

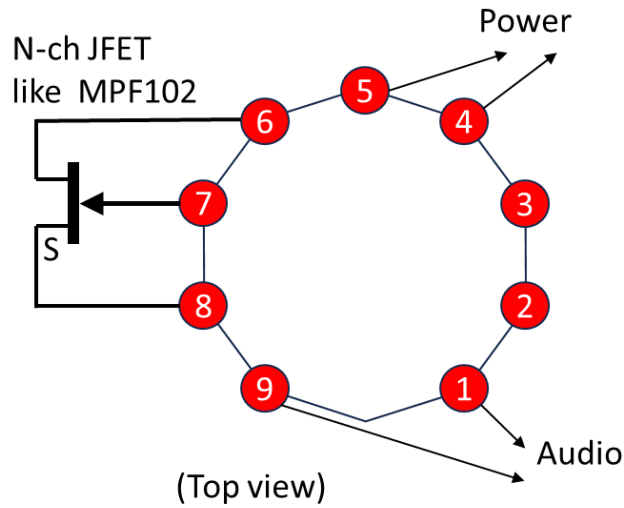
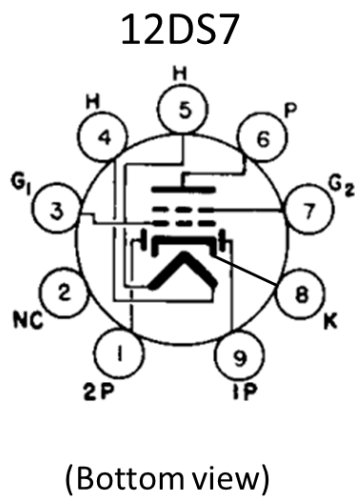
This is much smaller than the original tube, and eliminates the need for an additional socket adaptor.

For regular (high voltage) triodes like a 6SQ7, I have used a LND150 d-mode high voltage MOSFET with a potentiometer in the source (to adjust the drain current) to replace the triode. (see

http://rabjohn.ca/data/documents/FM_conversion_AA5.pdf for more details about doing this)



A MPF102 replacing the 12DS7 tetrode in a Delco (circa 1960) hybrid car radio. Black and red wires are power, orange wire is audio, out to the converter board.



A FET replacing a 12DS7 for a “Hybrid” car radio.

2.3 Power

The 6V or 12V can be extracted from any of the filament pins. Be careful with the ground, the cathode of the detector tubes may not be grounded, but one of the filament pins will be ground.

The IF amplifier and RF amplifier (if present) tubes can be removed. This will allow the set to run a little cooler, and may give more room to manoeuvre in compact sets.

Sets with a vibrator or cars with generators, noisy regulators, non-resistor spark plug wires can exhibit noise problems. An old car is a hostile environment for a radio, which is why they are always well shielded. Fortunately, if the radio works OK in AM, FM should work fine unless noise is getting directly to the FM converter board. These can be difficult to diagnose. It may be necessary to change the location of the circuit board (inside the radio is generally the best place), or add filtering. Shielding the LO and Audio wires is a necessary minimum.