A valve substitute

Unable to find a replacement 6V6 audio power valve for his radio, Dave Allen set about making a MOSFET substitute which, he says, works better than the valve it replaced. Here's how he did it...

After giving me many years of good service, my faithful Murphy wireless recently fell silent. This was due to a failed 6V6 audio output valve.

The valve's demise was caused by the coupling capacitor feeding its input grid on pin 5 going short circuit. This resulted in a positive voltage being applied to the valve's grid, which in turn caused excessive current between the anode and cathode.

Apart from the dead valve and capacitor, the rest of the radio was in good order. Replacing the 0.1μF/400V coupling capacitor was easy but finding a replacement valve was not. In view of this, I devised a direct plug-in replacement for the valve based on an IRFI830G high-voltage MOSFET – of which I had plenty.

In addition to the FET, all that was needed were a few peripheral components and the valve base from the dud valve.

Can this technique be applied to other valves?

It should be possible to build similar plug-in modules to valves other than the 6V6, like the 6P1 or KT61. This assumes that you can find information on the pin connections for the valve you want to replace, and that you have a suitable spare base to hand.

Such plug-in modules can directly replace a variety of octal-based output valves that are wired in a parallel heater chain without further modification to the original equipment.

Although I have not tried it yet, it should be possible to use similar MOSFET modules to replace output valves that are directly-heated – i. e. those with no separate cathode. Examples of these are the PX4 and PX25. Have you seen the price of these valves?

If a MOSFET valve substitute is to be used with a receiver that has a series connected AC/DC heater chain, fed via a mains dropping resistor, an additional resistor will have to be wired across the redundant heater pins on the valve holder. This ensures continuity of the

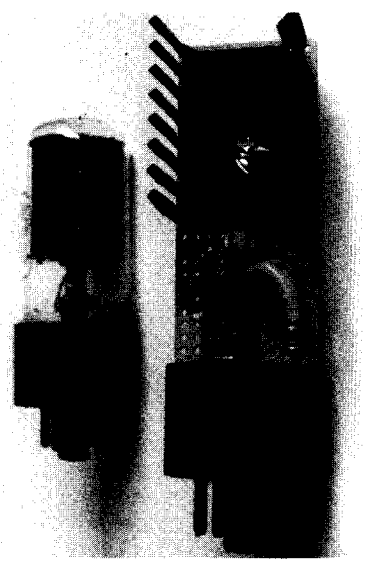

Table 1. Pin connections for the 6V6 tetrode.

Pin	Description
1	No connection. This pin may be connected to the suppressor grid, g_3, on certain pentode valves and can be ignored.
2	Heater
3	Anode
4	Screen grid (g2)
5	Input grid (g1)
6	No connection
7	Heater
8	Cathode

Substituting valves that are part of a series-connected heater chain

Removing a valve with a series-connected heater from a circuit disables all other valves in the same heater circuit. If you want to replace a valve with a series-connected heater using a MOSFET substitute, the missing heater will need to be substituded too using a resistor that simulates the heater.

A 20P3 valve is used here to illustrate how to determine the compensation resistor needed for the heater chain. This valve requires a heater voltage of 20V at a current of 200mA. Since $R=E/I$, the heater replacement resistor is 100Ω.

The power rating of the resistor is $E \times I$, hence 20×0.2, which is 4W. For this example, a resistor with a 5% tolerance rated at 100Ω and capable of handling 7W would be a good choice.

As this resistor is replacing a valve's heating element, it will get hot, so it is advisable to place it where it will have sufficient ventilation and electrical insulation from the metal chassis.

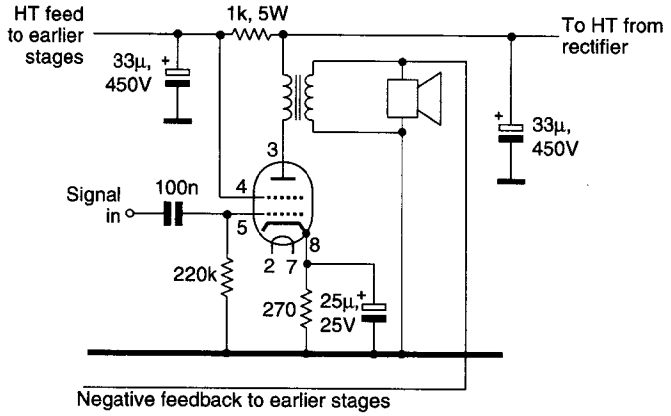

Fig. 1. Original valve audio power output stage.

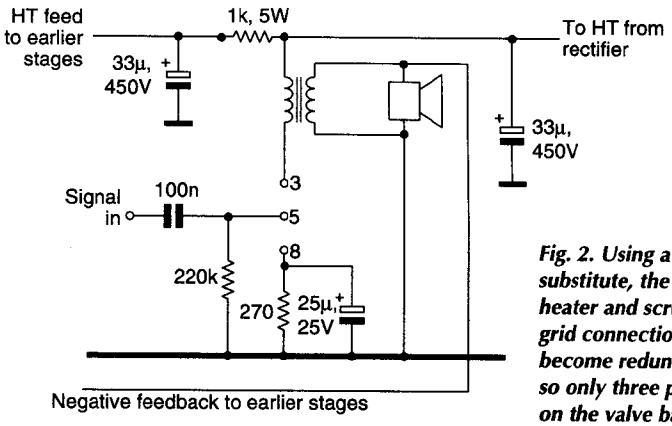

Fig. 2. Using a 6V6 substitute, the heater and screen grid connections become redundant, so only three pins on the valve base are used.

heater circuit, as the replacement module does not have a heater.

Simply shorting the heater pins of the redundant valve may overload the other valve heaters and/or the dropper. There's more on this in the panel covering valves in series heater chains on the previous page.

Details for the 6V6

Connections for the 6V6 valve are shown in **Table 1**. **Figure 1** shows a typical single-ended Class-A output stage using a 6V6 tetrode, or similar valve, incorporating cathode bias.

In **Fig. 2** is the output stage – minus valve – and the relevant connections shown for use with the plug-in module. **Figure 3** shows the circuit for the plug-in replacement module.

The circuit

The circuit is based on an IRFI830G MOSFET, wired as a triode. In this application, no screen grid connections to the valve base/holder are involved.

For the MOSFET to operate as an amplifier it has to be biased into conduction. This is achieved by applying a small positive bias to its gate.

Bias voltage for the FET is derived from a potential divider, fed from the HT rail. It consists of R_2, VR_1 and R_1. Resistor R_1 also serves as a current limit for the MOSFET and as a convenient test point for voltage monitoring when setting up the plug-in module.

Zener diode D_1 keeps the gate voltage stable, enabling the module to be used in a variety of receivers with differing HT voltages. Decoupling capacitor C_1, connected across VR_1, helps prevent any noise from the power supply entering the sensitive gate input of the MOSFET.

Capacitor C_2 provides input coupling for the module and is fed from an earlier audio stage in the receiver.

Implementing the valve substitute

A good starting point is the preparation of the valve base. Wearing safety goggles and gloves to protect you against cuts from broken glass is a good idea when reclaiming the valve base.

The best way to break the glass envelope is to place the dud valve in a thick plastic bag and tap the glass with a small hammer. Then carefully remove the shattered remains from the base.

Remnants of wire in the valve base pins can now be unsoldered.

A piece of 0.1in matrix stripboard with 11 strips by 32 holes is required for mounting the MOSFET, heat sink, and the few passive components.

After completion of the component board, three short flying leads can be connected to the board and taken to the relevant pins on the valve base and soldered. The board can then be held in place using epoxy resin adhesive.

Setting up

With the plug-in module completed, rotate the wiper of VR_1 so it is at the anode end of D_1. This will ensure there is no positive bias voltage on the gate of the FET when you first switch on your receiver.

Now insert the plug-in module into its socket and connect a meter switched to its 20V DC range across R_1. Switch on your receiver and let it warm up for about ten minutes.

Slowly rotate VR_1 until the MOSFET springs to life. This will happen quite suddenly. Finally adjust VR_1 for a drop of 2V across R_1. This corresponds to a current of 20mA flowing through the output stage, which works well with my particular receiver.

Power dissipation considerations

As the MOSFET in this case is biased in class-A, it is constantly dissipating power – or heat if you like – so a good heat sink will be required. The sink needs to be at least 9.9°C/W.

In my particular case, the voltage across the MOSFET was measured at 277V at a current of 20mA so the power being dissipated was 277×0.02, which is 5.54W.

In use

My original plug-in module has been in use for about two years now with no problems. As a bonus, the audio is much improved – especially at the high frequency end. ■

Main components

Resistors

R_1	100R, 0.6W
R_2	1M, 0.6W
VR_1	220k, horizontal mounting preset

Capacitors

$C_{1,2}$	100n, 63V metallised polyester film, 5mm spacing

Semiconductors

IRFI830G MOSFET (Farnell). This version of the MOSFET has an insulated tab so the heat sink will not be at HT potential.

Diode

D_1 is an 18V/400mW zener diode

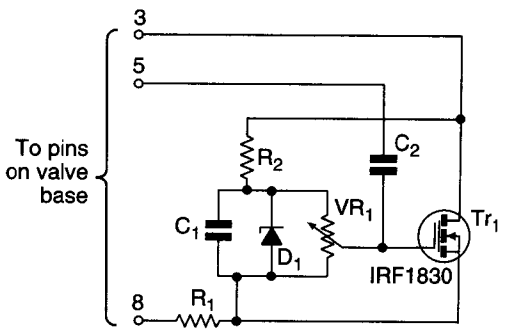

Fig. 3. MOSFET substitute for the 6V6 valve. Only three pins are needed on the valve base, to replace the valve's anode, cathode and grid.