Replacing Filament Resistors

Gord Rabjohn, January 2019

Many early AC-DC radios (made prior to the introduction of the "All American Five" tube line-up) and phonographs used high wattage filament resistors to drop the line voltage to a level appropriate for a series string of tube filaments. These resistors run very hot because they usually need to dissipate several watts of power. Sometimes, the resistance was formed using resistance wire hidden in the power cord. This caused the insulation to age quickly, caused a fire hazard, and was simply a waste of power. It is just as well that these line-cords are usually defective. This article describes a replacement for these resistors that results in a cooler and safer radio.

In some specific cases, the resistor can be replaced by a diode (see the article by Hurlbut in the Spring 1999 issue of the OVRC newsletter). A more general solution can be found by replacing the resistor with an appropriately sized capacitor. The capacitor dissipates no power, so runs cool. Modern film capacitors are available, are compact and reliable, and come in an appropriate range of values. (Electrolytic capacitors are not suitable for this application) Capacitors would not have been used in the original equipment because capacitor technology of the day made them huge and expensive. Also, the capacitor will work only with AC, so the so-called AC-DC sets would not work on DC, or any line frequency other than 60Hz.

It takes a little math to calculate the correct capacitor value. A capacitor is not a resistor, so you cannot simply replace the resistor with a capacitor of the same capacitive reactance as the original resistor. The easiest formula to use is probably:

$$C = \frac{I}{2\pi F \sqrt{V_{in}^2 - V_{out}^2}}$$

Where:

C is the required capacitor value in Farads
I is the filament current in Amps
F is the line frequency in Hz, generally 60Hz
Vin is the line voltage in Volts, generally 120V
Vout is the voltage supplied to the filaments, generally the sum of the individual filament voltages.

If we assume a 120V line and 60Hz line frequency and write the equation for microfarads, the equation becomes:

$$C\,(uF) = \frac{2653\,I}{\sqrt{14400 - V_{out}^2}}$$

Where:

C (uF) is the required capacitor value in microfarads
I is the filament current in Amps
Vout is the voltage supplied to the filaments, generally the sum of the individual filament voltages.

For ease of selection, a graph can be used to look-up the required value. The graph below shows the capacitor value required (on the left axis) for a given total filament voltage (on the bottom); select the curve for the filament current in your radio.

Filament Dropping Capacitor Chart
For 120V, 60Hz Line Voltage, four filament currents.
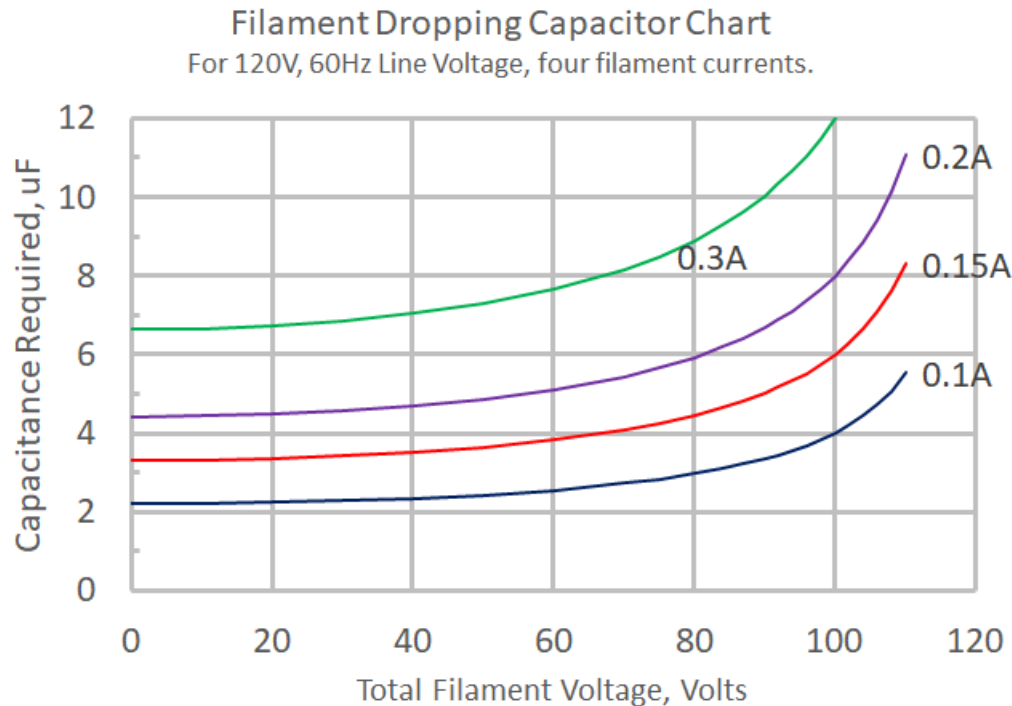
The capacitors required are generally in the range of 3-10 microfarad. I would recommend using a modern film capacitor designed for operation on the 120VAC line, not an old wax and paper capacitor from your junk box. Motor start capacitors or a ceiling fan capacitors have approximately the right value, and are available from the likes of Gervais Electronics, Sayal Electronics, or even electrical supply stores. They are also available as dual capacitors, which gives somewhat more flexibility in value selection. However, I recommend checking inside any discarded appliances that contain motors, as suitable capacitors are often used with induction motors. I have found suitable capacitors in bread makers, tape decks, dehumidifiers, and fans.
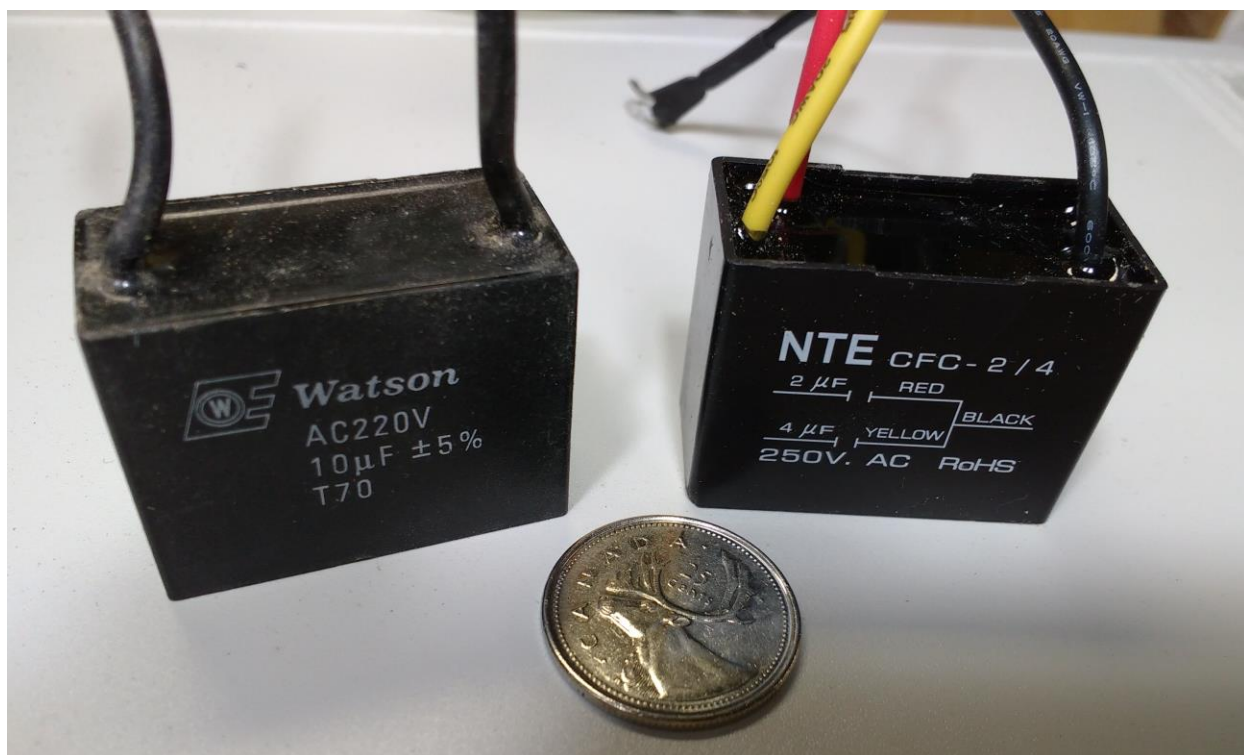
A capacitor could also be used to replace a ballast tube, but note that the ballast tube slows warm-up, which reduces the current surge thru the pilot lamp. Replacing the ballast tube with a capacitor (or a resistor for that matter), will increase the current surge in the pilot lamp at turn-on, and could cause the pilot lamp to fail. Two series back-to-back Zener diodes (8-9V for a 6V pilot lamp) in parallel with the pilot lamp will fix this.

As an example, my Spartan model 50 uses 25Z5, 43, 75, and two 78 tubes. 2 X 25V plus 3 X 6.3V adds to a total voltage of 69 volts. These are all 0.3amp tubes. Using the formula or the graph, I would need an 8.1uf capacitor that I might make with a pair of 4uf caps in parallel. (The Hurlbut solution would also work for this example)