Reforming electrolytic capacitors

Capacitors are the most troublesome parts in vintage radio receivers. This month, we look at the various capacitor types and describe an easy-to-build circuit that can be used to reform electrolytics.

In “VINTAGE RADIO” for October and November 2004, we looked at paper capacitors and described the problems that they can cause. Those articles also described how paper capacitors could be tested for leakage and described the circumstances under which they should be replaced.

In practice, the decision whether or not to replace a leaky capacitor often depends on where it is located in the circuit. In many cases, leaky capacitors in non-critical positions (eg, with low voltages across them) can be left in circuit, as they will have negligible effect on performance. By contrast, capacitors with high voltage across them or in certain critical positions (eg, AGC bypass capacitors and those in bias circuits) should be replaced if leaky.

In this article, we’ll look first at electrolytic capacitors and describe how they can be reformed (or re-polarised). We’ll then take a look at mica, polyester, styroseal (polystyrene), ceramic and air-dielectric capacitors.

Electrolytic capacitors

Electrolytic capacitors are usually used as power supply filters and as bypasses in valve receivers. They are also used as coupling capacitors in low-impedance sections of transistorised receivers.

Polarised electrolytics have positive and negative terminals and must be connected into circuit with the correct polarity. By contrast, bipolar or non-polarised electrolytic capacitors can be connected into circuit either way around, however they are seldom found in radio receivers.

Note that the capacitance values marked on electrolytic capacitors are only approximate. In practice, they can vary from about 10% low to as much as 50% high. So don’t get too upset if the measured value of a nominal 10μF capacitor turns out to be anywhere between say, 14μF and 24μF.

Main problems

Electrolytic capacitors suffer from two main problems: (1) loss of capacitance and (2) excessive leakage current. The first problem, that of reduced capacitance, occurs because the electrolyte inside the capacitor tends to dry out over the years. As a result, the capacitance of a nominal 10μF power supply filter capacitor may reduce to virtually zero. This will result in hum and/or “motorboating” in the audio output of the receiver and replacement is the only answer.

As for the second problem, electrolytic capacitors always have some leakage – usually be less than 1mA. However, an electrolytic capacitor stored for a long period of time can become depolarised. As a result, it will draw considerable current (greater than 40mA in some cases) until it is reformed (by applying a polarising voltage across it).

So how do you reform an electrolytic capacitor? There are three different methods and I’ll describe the pros and cons of each. Note that some capacitors will not respond to the reforming process and will need replacement.

Reforming method 1

Regrettably, some vintage radio col-
Polyester capacitors became available in the late 1960s, towards the end of the valve era, and are very reliable. Mica capacitors usually have relatively low values and are typically used as RF bypasses, in tuned circuits.

Rectors try the brute force method of reforming electrolytic capacitors—by giving the set a “smoke” test without first checking the power supply and for faults on the HT line. In many cases, this is exactly what does happen—smoke appears as soon as power is applied.

Often, a set will have been put aside because it has a fault and subsequently stored in less than ideal conditions which leads to further deterioration. This makes it extremely risky to turn any old set on before checking it thoroughly. There may be shorted capacitors or capacitors that are so leaky that they may explode after a short time. In the process, they may destroy the rectifier and perhaps even the power transformer.

A leaky paper audio-coupling capacitor could also cause the audio output valve to draw excessive current, destroying the valve in the process. In short, turning a set on without checking it can produce some rather expensive smoke.

Reforming method 2

Over the years, I have often used a method that some people consider risky when it comes to reforming electrolytic capacitors. First, I check that there are no short circuits on the HT line and that the minimum resistance from the HT line to chassis is at least 10kΩ (the actual value will depend on the circuit). In addition, if an initial physical check shows that any capacitors are bulging or leaking electrolyte, I replace them.

That done, I connect a multimeter via insulated short jumper clip leads across the first electrolytic capacitor and observe the rising voltage as the set is turned on for a brief period. This period is around 20 seconds for a set with an indirectly-heated rectifier and just a few seconds with a directly-heated rectifier.

In practice, I let the voltage rise to about a quarter of the expected HT voltage and then turn the set off. If the rectifier shows any sign of distress (red colour on the plates or sparks inside the works), I turn the set off immediately and recheck for shorts.

After about a minute, I then repeat the procedure, this time letting the voltage rise a little higher. If the electrolytic is reforming, the voltage across it will rise to the expected HT voltage after a few cycles of this procedure.

Note that it’s necessary to check the second filter capacitor as well. I’ve sometime found that one capacitor would reform but not the other. Note also that more modern electrolytics don’t seem to need much reforming. If an electrolytic capacitor shows any signs of overheating, it should be discarded as it obviously has far too much leakage.

What are the advantages of this method? It will successfully reform capacitors over a period of a few minutes of on-off switching. It has the advantage that no capacitor has to be removed from the set to do the reforming. If used with care in the manner described above it would be rare for any damage to occur in the receiver. What are the disadvantages? It is a bit harsh and if care is not taken the end result will be damage similar to that which occurs with the previous “smoke test” method.

(Editor’s note: we regard this method as decidedly risky. While initial resistance checks may indicate nothing amiss, when the voltage across a suspect capacitor rises to a critical value, the leakage current may suddenly increase or it may become short-circuit which can immediately damage the rectifier. If the capacitor then suddenly leaks all over the chassis, you then have a major clean-up job. And the smell is something you will remember for the rest of your life! Finally, an
exploding electrolytic capacitor poses an extreme risk to your eyes!)

Reforming method 3
Method number 3 is much more benign and involves using a special DC power supply. This supply should be voltage regulated (so that the applied voltage can not exceed the peak voltage rating of the capacitor) and should feature current limiting.

In operation, the capacitor is connected to the output and the current limiting set to 10mA. This current limit applies whether the voltage across the capacitor is 5V or 500V (or what ever the maximum working voltage happens to be).

When the capacitor has reformed, the voltage across it will be at the selected reforming voltage, while the current will have reduced to a fraction of a milliamp in most cases. However, if the current remains at about 10mA and the voltage doesn't risen to the selected reforming voltage, the capacitor is suspect and should be replaced.

You can get a good idea as to just how well a capacitor is holding a charge by disconnecting it from the supply and observing how quickly the voltage across it decreases with just a digital multimeter in place.

(100 SILICON CHIP)

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The high-voltage tester will usually reveal if a mica capacitor has noticeable leakage and if this leakage resistance fluctuates. Most mica capacitors were made as a “stack” interleaved with sheets of tin foil and mica clamped together and then encapsulated. Sometimes the contact between some metal foils and the clamps becomes intermittent and so the capacitance will vary.

If you don’t have a high voltage tester, the easiest way to test whether a mica capacitor is at fault is to replace it and see if this makes a difference.

Mica capacitors can really cause headaches because they can produce very obscure symptoms in a receiver. In fact, it’s not uncommon to find that the faulty component is nowhere near where you expected to find it but is in a different section altogether. Faulty local oscillator grid coupling capacitors have led me up the garden path more than once.

Polyester capacitors
Polyester capacitors are usually available in 160V, 400V and 630V DC ratings and take the place of paper capacitors. The most common style became available in the early sixties towards the end of the valve era.

I don’t think I have ever had to replace one of the yellow-coloured Philips units — they are just so reliable. In fact, it’s a pity they weren’t avail-
able many years earlier - valve radios would have been so much more reliable without paper capacitors.

“Greencaps” and MKT capacitors are also polyester types. However, their voltage ratings can differ from those quoted above.

**Styroseal capacitors**

Styroseal (polystyrene) capacitors became available around the same time as polyester capacitors and from my experience, are quite reliable. They have been used have been used in much the same way as polyester capacitors and also in tuned circuits to some extent.

**Ceramic capacitors**

Some early ceramic capacitors were not considered particularly reliable, whereas later types gave few problems. They generally come in two types. One type is used more as a bypass where the exact value is unimportant, whereas the other type is more precise in value and is often used in tuned circuits.

In addition, ceramic capacitors can be manufactured with negative, zero (NPO) or positive temperature coefficients, so that frequency drift in tuned circuits can be compensated for with changes in temperature.

Ceramic capacitors come in a range of voltage ratings from 50V up to several thousand volts. However, they are not usually used in valve receivers, with some exceptions. I now commonly use 47nF (0.047µF) 50V ceramic capacitors on AGC lines as replacements for leaky paper capacitors. They are small and can often be hidden which helps keep the set looking original.

**Air-dielectric capacitors**

The air-dielectric capacitors we see in vintage radios are the tuning and trimmer capacitors. And although these items do occasionally have problems, the faults are easily detected.

The problems to look out for are usually just mechanical. In tuning gangs, for example, the rotor (movable) plates may have been bent slightly so that they scrape against the stator (fixed) plates. This will show up as erratic tuning and crackles as the tuning gang is operated. It’s easy to track the problems down by removing all connections to the stators, connecting a multimeter (set to ohms) between the stator and the frame and then operating the tuning. As the unit is tuned, any shorts will soon become evident on the meter reading.

By placing a light behind the gang and looking along the plane of the plates, it should be obvious which plates are touching each other. The shorting plates can then usually be carefully bent back to where they should be to clear the shorts.

Sometimes, the meter may show that a short is present but no evidence of plates touching can be seen. In this case, there is probably a small sliver of metal that is shorting the gang. The best method to deal with this problem is to burn the short out.

First, check that the gang is still isolated from the circuit, then connect a 47kΩ 1W resistor from the receiver’s HT line to the stator. That done, turn the set on and rotate the tuning control from one end to the other and if there is a small sliver of metal causing the trouble, there will be some intermittent sparks between the capacitor plates. This should clear the problem but keep in mind that you are playing around here with a high voltage, so be careful. If you don’t understand exactly what you are doing, then don’t do it!

Another problem that commonly occurs is the rotor shaft not making good contact with the frame. This can cause jumps in frequency as the receiver is tuned. It can also cause crackles and the set may stop operating. Most, if not all, tuning capacitors have either a metal spring bearing onto the shaft to the gang frame or other spring-loaded contacts to ensure good contact is maintained between the frame and the tuning shaft. If any of these are missing, erratic tuning is almost a certainty.

There is one last problem and that is where the gang has virtually fallen to pieces. This occurs with very old gangs that have been made from poor quality metal and the only answer to this problem is replacement.

OK, now let’s take a look at the reformer circuit.
A Reformer For Electrolytic Capacitors

By RODNEY CHAMPNESS

Simple electrolytic capacitor reformer is easy to build and has six switchable output voltages ranging from 25V to 400V DC.

This simple circuit is based on an LR8N3 voltage regulator which has an input voltage rating of 450V DC and a maximum current output of 20mA – all in a TO92 package.

Fig.1 shows the circuit details. The input to the reformer is powered from up to 450V DC and this can be obtained from a suitable valve receiver. Diode D1 provides reverse polarity protection, while a neon indicator in series with a 560kΩ resistor across the supply line warns users that a high, potentially fatal, voltage is connected to the device.

The reforming voltage (ie, the voltage applied to the capacitor) is set by switch S2 which adjusts the resistive divider connected between the output and adjust terminals of the regulator (REG1). Switch S1 is selects between Reform, Off and Discharge.

The output current is monitored by measuring the voltage across a 1kΩ resistor. In operation, each milliamper through the resistor registers as 1V on the meter. The voltage across the capacitor itself can be measured using a digital multimeter.

When reforming is complete, S1 is switched to the Off position. This discharges the capacitor so that it is safe to handle.

Note that the discharge resistor is only rated at 1W even though the peak dissipation in the discharge mode is around 16W. However, this is for such a short time that no damage is sustained.

The high-tension (HT) DC input voltage can be obtained from a working receiver. This receiver MUST USE a mains transformer. Do not even think of connecting the reformer to a transformerless mains-operated set – not if you want to live, that is. The reformer should be connected to the receiver’s HT supply via high-voltage leads and an insulated terminal block.

(Editor’s note: if you want to build a self-contained unit, the 12AX7 Valve Preamp Power Supply described in November 2003 SILICON CHIP can be used to provide the HT. As described, this delivers a HT voltage of 260V but you can set this higher by reducing the 47kΩ resistor next to trimpot VR1. Alternatively, you could modify the Valve Preamp Power Supply to do the complete job by having switchable resistors in the feedback network, so that various output voltages could be selected.

Note that current limiting using a suitable resistor would be required and you would need to fit a discharge circuit, to discharge the capacitor after reforming).

The author’s prototype reformer was built on Veroboard and housed in a small plastic case. If you build the device, remember that it works at high voltages, so keep a liberal spacing between the various parts.

A plastic case is necessary because of the lethal voltages present in this device. For this reason, be sure to use Nylon screws to mount the board (no metal screws should protrude through the case). An external insulated terminal block was used for the metering points and I simply tighten down the screws to hold the probes in place.

Safety improvements

Editor’s note: instead of using a terminal block, we strongly recommend using recessed banana sockets for the metering points. These can be mounted on an internal bracket and suitably recessed inside the case to eliminate the risk of user contact with high voltages. It’s then just a matter of making up some high-voltage meter leads with matching banana plugs.
This electrolytic reformer circuit operates at lethal voltage. DO NOT build or use it unless you are experienced at working with high voltages and understand exactly what you are doing.

Note that the leads to the capacitor operate at high voltage and that a fully-charged capacitor can deliver a potentially fatal shock. Always discharge the capacitor before disconnecting it from the reformer and use your multimeter to confirm that it has indeed discharged before touching it.