Vintage Radio

By RODNEY CHAMPNESS, VK3UG

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 and 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 16μF capacitor turns out to be anywhere between say, 14μF and 24μF.

Electrolytic capacitors are commonly used in valve receivers for power supply line filtering and as bypasses.

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 16μF 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.

lectors 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

Styroseal capacitors became available around the same time as polyester capacitors and are quite reliable.

Early ceramic capacitors were not very reliable but later types gave few problems.

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).

Forming Electrolytic Capacitors

So what is this "forming" process? Basically it refers to re-forming the aluminium oxide layer on the aluminium foil electrode in the electrolytic capacitor. In essence, the aluminium foil is the positive electrode and the aluminium oxide layer is the dielectric of the capacitor. The conductive electrolytic in conjunction with another small aluminium foil and the aluminium can then forms the negative electrode of the capacitor.

In applying the "forming" current to the capacitor we are setting up a controlled chemical process between the conductive electrolyte and aluminium foil to re-anodise or oxidise the aluminium surface. This heals any breaks in the oxide layer (the dielectric) and thus reduces the leakage current.

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.

(Be careful though – a capacitor charged to a high voltage can deliver a fatal shock. Always make sure that a capacitor is fully discharged before touching it).

This method of reforming has a couple advantages. First, provided it's done properly, with the voltage increased in stages, no undue stresses are placed on either the capacitor or the test instrument. Second, it shows just how good a capacitor is and gives an indication as to whether it should be used or not.

What are the disadvantages? If the capacitor is "new old stock" and is out of circuit, there are no disadvantages. However, if it is in-circuit, it may need to have one lead disconnected.

A simple and very effective repolariser/reformer test instrument is described later in the article.

Mica capacitors

Mica capacitors usually have relatively low values and are typically used as RF bypasses, in tuned circuits and as vibrator buffer capacitors, etc. They are usually quite reliable but they can develop faults that give some strange effects in receivers. For example, local oscillators can drift or jump in frequency, while the audio output can have annoying crackles in it.

A 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 available 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.

Photo Gallery: Peter Pan GKL 4-Valve Radio

MANUFACTURED IN 1946 by Eclipse Radio, South Melbourne, the GKL was a compact 4-valve reflex superheterodyne receiver housed in a bakelite cabinet. These sets were produced in a number of colours, the pink example shown here being quite rare.
The valve line-up was as follows: 6A8-G frequency changer, 6B8-G reflexed IF amplifier/1st audio amplifier/detector/AVC rectifier, 6V6-GT audio output and 5Y3-GT rectifier. Photo: Historical Radio Society of Australia, Inc.

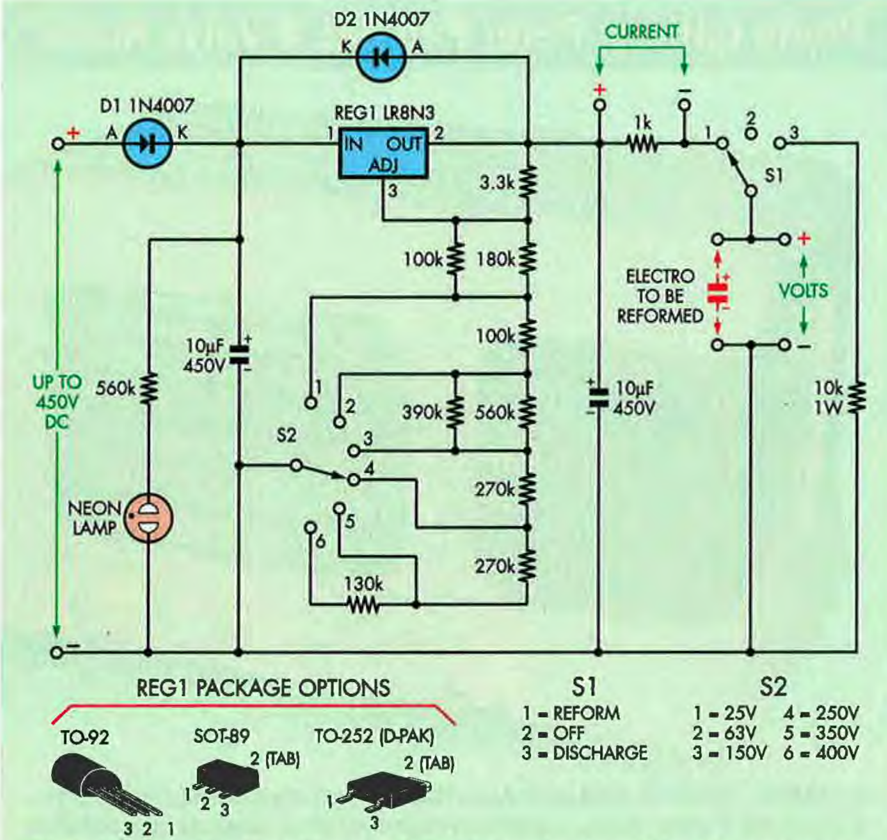


Fig.1: the circuit is based on an LR8N3 3-terminal regulator. Power comes from an external high-voltage DC source – eg, the high-tension (HT) line of a valve receiver or from the 12AX7 Valve Preamp Power Supply described in November 2003 SILICON CHIP.

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 milliamp 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 allows the operator to observe how quickly the capacitor discharges. The slower the voltage decreases, the less leakage there is in the capacitor.

Finally, S1 is switched to the discharge 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 transformer-less 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.

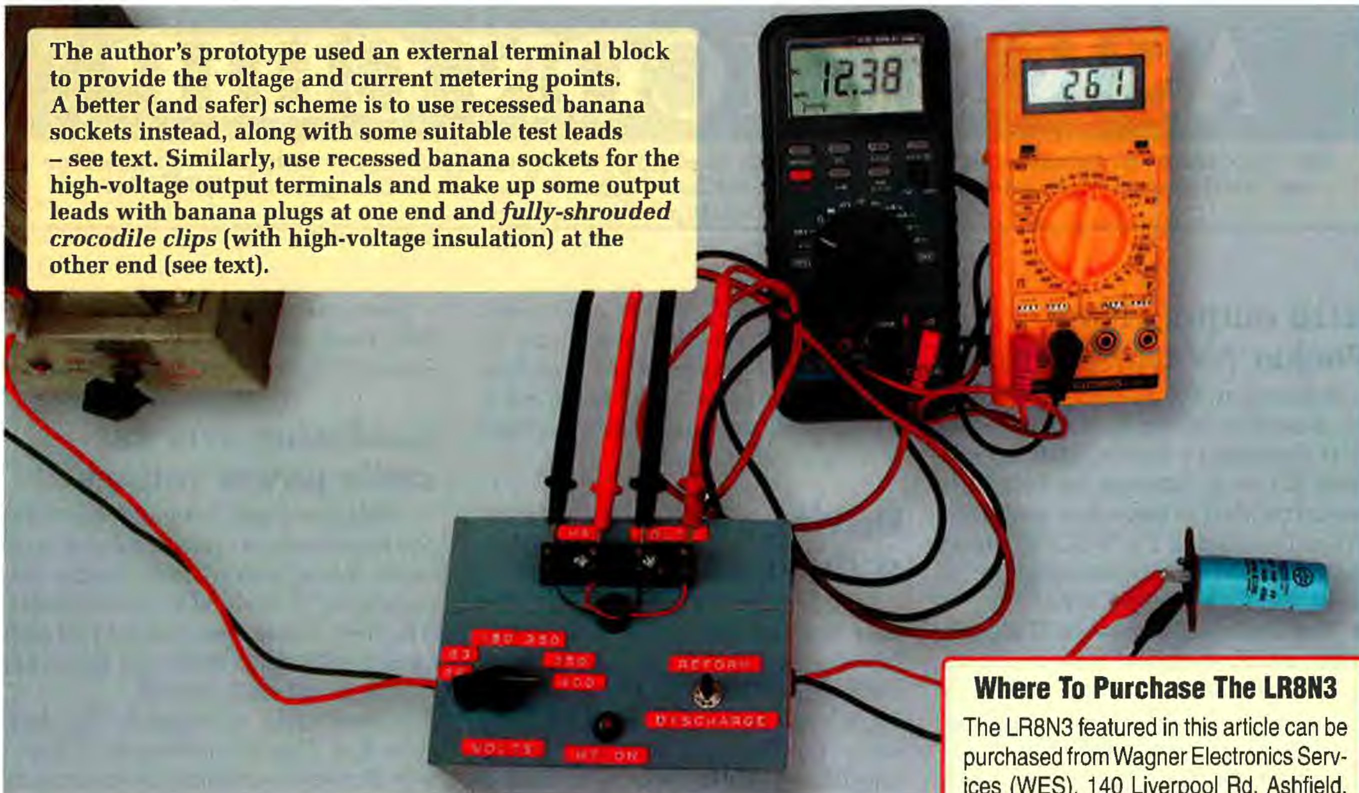
(Editor's note: if you want to build a self-contained unit, the 12AX7 Valve Preamp Power Supply described in November 2003 can be used to provide the HT. As described, this delivers a HT voltage of 260V but you can set this higher by reducing the 47kΩ resistor next to trimpot VR1. Alternatively, you 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.



The author's prototype used an external terminal block to provide the voltage and current metering points. A better (and safer) scheme is to use recessed banana sockets instead, along with some suitable test leads – see text. Similarly, use recessed banana sockets for the high-voltage output terminals and make up some output leads with banana plugs at one end and *fully-shrouded crocodile clips* (with high-voltage insulation) at the other end (see text).

Similarly, we strongly recommend that recessed banana sockets be used for the high-voltage output. A pair of high-voltage output leads (one red, one black) can then be made up, fitted with matching banana plugs. The other ends of these output leads should be fitted with fully insulated (fully shrouded) crocodile clips (also called "safety croc clips").

You can buy fully shrouded crocodile clips with high-voltage insulation from RS Components (www.rsaustralia.com). WES may also have them.

DO NOT use conventional crocodile clips with exposed ends (and minimal insulation), as shown in the photo. Remember – we are dealing with high voltages here.

Using the device

A HT filter capacitor in a receiver that's being restored can be reformed in the following way. First, remove all valves from the receiver and check that there are no shorts or bleeder resistors across the HT line. Alternatively, you can simply disconnect one lead of the capacitor from circuit.

That done, switch S1 to discharge, connect the reformer to the capacitor and select the appropriate reforming voltage (it must not exceed the voltage rating of the electrolytic that's being reformed – or any other capacitors connected to the set's HT line for that matter).

Now switch to the reform position and apply power to the reformer. Initially, the current will be about 12mA but will quickly drop as the LR8N3's thermal protection circuit kicks in. If the capacitor is reforming, the voltage across it will slowly climb until it reaches the reforming voltage.

Finally, when reforming is complete, turn off the power to the reformer and switch S1 to the Discharge position. This will discharge the capacitor and make it safe to remove the leads but you should always use a multimeter connected directly to the capacitor's terminals to confirm that it has indeed discharged before touching it.

Don't simply rely on the discharge circuit – if the discharge resistor goes open circuit, the capacitor will still be charged.

Where To Purchase The LR8N3

The LR8N3 featured in this article can be purchased from Wagner Electronics Services (WES), 140 Liverpool Rd, Ashfield, NSW 2131. Orders can be phoned through to (02) 9798 9233 or faxed to (02) 9798 0017. The part number is LR8N3-G and it is priced at $4.98 plus postage and packing. Payment may be made by cheque, money order or credit card.

The procedure for reforming an electrolytic capacitor out of circuit is virtually the same. **Make sure that the capacitor is securely located on an insulated surface, preferably inside a plastic container).** The whole process can take up to around three minutes, depending on how much reforming is required and the size of the capacitor.

One limitation of this unit has is that the reforming current isn't very high but if the capacitor can be reformed, it will get to the selected voltage in time. It also can not handle 525V and 600V electrolytics but can only reform them to about 400V (depending on the applied HT voltage). SC

WARNING!

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.