Shall I risk it?

Dave Porter G4OYX with Peter Chadwick G3RZP

In *Signal* Issue 31 Gerald Stancey G3MCK **[1]** asked about the criteria to be used and the risk assessments to be undertaken when employing vintage components and cabling in both prototype designs and rebuilds. This article aims to answer Gerald's questions and is illustrated with a selection of vintage and more modern resistors and capacitors showing the relative sizes of the components and, sometimes more importantly, the (long) lengths of the wire spills available for connections in point-to-point wiring as well as other fixing options.

Resistors

The answer to the question concerning the recommended (or safe) power dissipation for resistors of given rating depends on the temperature at which the components are rated and the maximum allowable temperature in use. The manufacturers probably state in their specification that the resistor is rated, say, 2 W at an ambient temperature of 20°C and de-rate the component so that, at 70°C, it dissipates, maybe 30% of its ambient temperature rating. For our purposes, when considering use in a receiver with a 100% duty-cycle, it is safe to assume the 70°C value; the component in question may be buried deep within an AR88, which itself is on a shelf with poor or marginal ventilation. For amateur transmitter use with a reduced duty cycle of say 50% when in QSO with another amateur, or 33% if in a group of three, then the specification can be relaxed. For broadcast transmitter use, the duty cycle is mostly considered as 100%.

Carbon composition resistors

Figure 1 (see rear cover) shows standard carbon composition components from the 1960s (left to right, 2 W: 17 mm x 8 mm; 1 W: 14 mm x 5.5 mm; 0.25/0.5 W: 10 mm x 3.5 mm; 0.125 W: 4 mm x 1.6 mm). The usual UK manufacturer of these resistors was Morganite in Tyne and Wear, for a time part of the Allan-Bradley conglomerate. Composition resistors are usually prone to upward variation of value over time, values above 100 kΩ being particularly susceptible. It was thought that moisture ingress was the cause but Peter G3RZP challenges this idea because, about five years ago, he opened the polythene bag within a polythene bag containing a NATO stock numbered single ¼ W, 5%, 4.7 kΩ resistor, packed in June 1964. Its measured resistance was 5.7 kΩ.

Figure 2 shows a pair of carbon composition resistors from the 1950s with visible end caps under the cement and were much used in domestic equipment including TV and radio. Those shown are, left to right, 1 W: 26 mm x 7.2 mm; 0.5 W: 17 mm x 3.8 mm. A 2 W version was also available. Overall, these resistors seem more stable over time than their younger smooth-sided moulded brothers.

Figure 3 shows three ceramic-bodied carbon composition resistors (left to right, 1 W: 17.5 mm x 5.8 mm; 2 x 0.5 W: 11.5 mm x 5.8 mm), manufactured in the 1950s and well into the 1960s; these were commercial units often with poor tolerances, typically ±20% even when new and usually ±10% at best. G3MCK asks whether it is possible to use these measured, upwardly mobile, resistors in circuits. They are still serviceable as long as the risks are appreciated. If attempting full restoration of a vintage piece to be placed in service, why risk its specification being changed as a result of poor-quality components? However, if it is to be a prototype chassis and experiments are to be carried out, then by all means use the component. Be aware that aged high value carbon composition resistors in the anode load of a triode or pentode audio amplifier can produce very high levels of noise with, oddly, the value of 220 kΩ being seemingly the worst in this regard.

Figure 4 shows a range of four carbon composition resistors (left to right, 2 W: 32 mm x 19 mm; 2 x 1 W: 20 mm x 6.2 mm; 0.5 W: 14 mm x 6.2 mm) that are superior in all respects over their commercial brothers. These resistors are characterised by a salmon-pink band after the usual red 2% tolerance band, though one illustrated has a gold 5% tolerance band. These were much used in professional equipment and show exceptional stability and low-noise in high resistance values. They were manufactured in the 1950s, 1960s and 1970s. If stocks of these are found at rallies then it is best to snap them up. Peter considers that these components "seem fine after over 60 years".

Cracked carbon (film) resistors

Cracked carbon film resistors made an appearance in the late 1950s, first as black and pink coloured types in various physical sizes manufactured by STC and Painton in Towcester, Northamptonshire. Peter comments that they do stay within tolerance. These were the original film resistors made by cracking a hydrocarbon in the absence of oxygen onto ceramic rods. They were the preferred choice for high ohmic value anode load resistors in hi-fi preamplifiers in the 1950s. Many have NATO Stock Numbers and sometimes come in unusual non-preferred values.

Carbon film resistors

Film resistors were a cheaper alternative to the cracked carbon type and first became available during the late-1960s. By the mid-1970s, RS Components had introduced a range of carbon film resistors from the Spanish firm, Piher. These are shown in **Figure 5** and are rated at (left to right) 2 W: 24 mm x 18 mm; 1 W: 16 mm x 6.2 mm; 0.5 W: 10 mm x 3.3 mm; 0.25 W: 6.3 mm x 2.5 mm. They are characterised by deep magenta coloured enamel paint finish and bright coloured rings. They were all ±5% tolerance in the E24 series.

Another brand of carbon film resistors commonly seen is that made in the 1970s by the then Yugoslavian company Iskra, wholesaled in the UK by Guest Electronics in Surrey and retailed by many including Electrovalue Ltd. These are shown in **Figure 6** in the five initial ratings, left to right, 2 W: 20 mm x 8.8 mm; 1 W: 15 mm x 6.2 mm; 0.5 W: 10 mm x 4.2 mm; 0.25 W: 8 mm x 2.8 mm; 0.125 W: 6.4 mm x 2.2 mm. It is interesting to note that their ratings were later upgraded to 2 W, 1 W, 0.75 W, 0.5 W and 0.33 W, respectively, for the identical components. The revised type numbers were very useful as a guide as they were UPM200, UPM100, UPM075, UPM050 and UPM033; add a zero to the end figure to give the rating in mW. In addition, the long lead length of 90 mm for the 2 W version could be most accommodating. In the author's opinion these were and still are a superb and favourite component, the UPM075 considered almost the universal resistor for low-power valve circuits and the UPM033 for solid state designs/printed circuit use. They were smooth-sided with no protruding end caps and had brightly coloured bands over the cream-coloured body. In general, for carbon film resistors, even after 30 years the values are stable in storage and in use. There is one important limitation for this type of component and that is their voltage rating. It is best to assume a maximum of 350 VDC for the larger-bodied component and 250 VDC for the smaller. Carbon composition types are better in this respect, 500 VDC being typical. Being helically cut, the resistance film medium could be seen as inductive at UHF but the author has seen 51 Ω 0.4 W Mullard types used as a sage-wire line load at CH68 on UHF TV with no ill effects. Composition types are preferred as RF loads but due regard must be taken of their tendency to drift high

Wirewound resistors

Wirewound (W/W) resistors are the power workhorses and a typical set of 1960s types is shown in **Figure 7**. These range from a stated 2 W dissipation by the smallest up to a quoted 15 W by the largest. However, it's important to realise that these are industrial worst-case ratings and, for amateur service, can generally be exceeded by up to 50%; again adequate ventilation is the key to reliability.

The author recalls a GPO/PO document that was made available to BBC Staff detailing the use of W/W resistors and citing failures that were attributable to corrosion of the resistance wire and spills owing to damp. This was due to them not being run at a sufficiently high temperature within the environment they were used. In effect, a high wattage component had been employed where one of a lower wattage should have been used. We are all probably guilty at some time of under-running a component to be on the safe side. Peter recalls that when he worked at Labgear, Colin Washtel G3CJY, Chief Engineer, told him that Labgear wound their own cement-coated 35 kΩ 50 W screen dropper resistors for the PA screen in the LG300. The cement coating did not really keep the moisture out, so the voltage differential along the resistor led to electrolysis of the wire which is why they all failed after a few years. Heat would not have helped too much in this case because they were not on all the time.

Capacitors

Electrolytics

G3MCK enquires about the reforming of electrolytic capacitors. Peter makes the point that electrolytics can (and should) be reformed. At Marconi, it was a requirement to reform at least high voltage capacitors in stores every two years. If they 'tick' or give an audible spark then they are bad and should go but, that said, Peter has some electrolytics in use which are almost as old as he is.

On BBC transmitter sites, the discipline was less regimented and mostly the capacitors stayed on the shelves from the time they were procured until the time they were required. The author does not recall any instruction to reform electrolytics on a regular basis. He is of the opinion that it is not possible to reform successfully every single leaky electrolytic but it is worth attempting to do so. It is difficult to measure the leakage current without a specialist reforming unit but a fair test whether the process has been successful is to check that the component does not run warm. Sometimes, in say a series string of capacitors across a DC HV supply with equalising resistors, a voltage comparison across each capacitor is a good diagnostic test because voltages should generally match to within 5%.

These days with many SMPS being produced, it is easier than ever to purchase quality electrolytics for HV use; for example, those manufactured by Nippon-Chemicon, Panasonic, Philips (now BC) and Rubycon. Thus, it may be prudent to ask whether it is worth the risk of reusing vintage HV electrolytics. It should be noted that electrolytics are usually date-coded YY/MM, *e.g*. 99/02 meaning 1999/February, which can be useful in determining those from a similar batch as well as age.

To answer Gerald's question concerning capacitor voltage ratings, it is recommended that the DC voltage across electrolytics in power supplies is 70–90% of that marked. This keeps the electrolyte well polarised. For other types of capacitor the recommendation would be 50% of the marked value, meaning that they are safe in DC circuits and head-room is provided or any AC signals on the DC, *e.g*. as for coupling capacitors in amplifiers.

Other capacitors

Peter suspects some of his moulded mica capacitors to have absorbed water when he found the capacitance to be 20% low and it could be brought up to value by squeezing the case. Some mica transmitting types go 'DC leaky'. Variable and fixed vacuum capacitors can lose their vacuum and the old waxed paper capacitors are, in general, good for little more than melting off the wax. Some of the metal-cased paper capacitors are fine, even after 50 years. The 'bathtub' types used in AR88s and similar wartime radios have a tendency to start leaking; the AC line filters in the Collins R390 are particularly prone to leaking. A fair number of the paper capacitors of the 1950s and 1960s in an epoxy or similar case can be found to leak badly, *e.g*. the red Hunts and brown Plessey types.

For comprehensive references to moulded and fixed ceramic capacitors and particularly their marking codes and temperature tolerances refer to Keith Snook's excellent web page **[2].**

Figure 8 shows a selection of tubular capacitors: the red one on the right is a West German component and of high quality. The grey unit is one from RS Components, made by Dubilier and is a polyester capacitor from the 1970s and, along with its yellow/black and blue/white clones, is generally as good as new now. A modern RS Components polyester type is shown in a yellow body with black writing. The other two components shown in **Figure 8** are definitely to be avoided; one is a sleeved Dubilier paper/foil unit and the other the infamous Hunts black-bodied 'horror'.

Figure 9 illustrates a further four capacitor types: uppermost is a Mullard polyester from the late 1960s and below another Mullard C280 polyester. Next, a yellow block Philips polyester from the 1980s and finally an Erie ceramic from the 1960s. Normally, these are all satisfactory. Ceramics, in general, are usually without problem but the reader is advised to discard any late 1970s red 'Wee-Con' ceramic capacitors. These were notorious for self-igniting on power, at best leaving the two lead out wires in the PCB and at worst setting fire to adjacent components. On the subject of self-destructing capacitors, Peter notes that the 'teardrop' tantalum capacitors (indeed any tantalum capacitors) should not be connected directly across a low impedance DC supply line, as they can explode with the initial surge current; they need 10–20 Ω in series.

It is worth checking Keith's pages **[2]** as he describes the older numbering system for tubular ceramic capacitors. For example, 470 has been used to mean 470 pF whereas on modern units it can mean 47 pF and for 470 pF the value of 471 would be annotated meaning 47 + a multiplier band, *i.e*. 47 and one zero.

Capacitor sizing and selection

Figure 10 shows a selection of ceramic capacitors all with values in the range 100–150 pF, the small yellow disk is 100 pF at 5 kV (1), the small ceramic block is 120 pF at 2 kV RF (2) and the long centre one is 150 pF at 7 kV (3), the 'door-knob' components are 110 pF at 5 kV (4) and 136 pF at 10 kV (5). For transmitter applications, these need to be selected carefully as it is not always the voltage rating that is of primary consideration; an appreciation of the RF currents involved is also required. For the padding out of the PA tune capacitor on a π-network components (3), (4) and (5) would be fine. Component (2) would be excellent for capacity to earth across a lower impedance part of a π-network as the RF currents flowing could be greater whereas (1) would be good for interstage coupling between a driver tube and the grid of a final amplifier.

Figure 11 shows five high power RF capacitors; there are three mica block types as referred to by Peter above, a German RF HV tubular ceramic component and a rod 120 pF capacitor rated 500 V. The latter capacitor is a high RF current type and not suitable for high voltage.

Cabling

G3MCK enquired of cabling considerations regarding current-carrying capacity and lengths. In general, a cable rated at 3 A and carrying 3.5 A would, over a short length in free air, probably be satisfactory. Concerns could be raised when the same piece of cable is enclosed in a cable form or is within a multicore cable due to the fact that the heat produced would dissipate itself in the rest of the form. Peter notes that it is generally recognized that acceptable current density for single PVC and polythene insulated wires can be 6 A/sq. mm, while for a number of wires, such as in a cableform, it is best to keep current density down to c. 3–4 A/sq. mm, but then there is the question of how many wires are carrying that amount of current. Usually, it is only the wires carrying filament or heater supplies that will really need consideration.

The author well recalls an FG Rayer design from Practical Wireless in December 1966 "The Beginners' 5-band TRF" where 18 SWG sleeved copper wire was suggested for the heater connections to a 6BR7 pentode. At 150 mA heater current, this recommendation was somewhat excessive It was not easy forming the wire round the McMurdo valveholder pins as it was too thick to pass through them.

To appreciate just how small the diameter of a cable needs to be to accommodate a current before fusing, consider the remarkably thin wire inside a 5 A quick-blow 1¼" (32 mm) cartridge fuse. Of course, for certain applications, particularly high-power MOSFET audio amplifiers, over-thick wire is recommended to ensure a low impedance AC and DC path connection between the PSU smoothing capacitors and the PCB. With regard to ribbon cable, it is the consideration of the current flowing in one of the conductors enclosed within the ribbon. For most examples of ribbon cable, a maximum of 1 A would seem reasonable, but voltage considerations should not be forgotten.

As regards insulation breakdown checks, the proposal made by G3MCK seems judicious in that if the wire is, indeed, clamped between two plates and a potential difference applied between the plates and inner of the cable, the breakdown voltage could be estimated. However that method could be dispensed with if the following 'rule of thumb' were applied: modern PVC-covered stranded cable, *e.g*. 16/0.2 mm is usually good up to 500 VDC, with the inner of RG58 satisfactory to at least 3 kV and the inner of RG8 to 6 kV, which covers most eventualities. In fact, Peter adds that even the old 75 Ω TV coax is good to well past 3 kV. It was used in the LG300 to connect the 1 kV 100% modulated supply between modulator/PSU and transmitter. The Marconi NT201 used it at 2.6 kV.

Conclusion

It is hoped that this trip down memory lane will assist members with their restoration and prototype projects and give them confidence to maybe risk it or, if not, at least believe they have made a reasoned and rational choice.

Peter warns that it is a case of *caveat emptor* when re-using old components. Having said that, he has a pair of Raytheon 6L6G for which his father paid the equivalent of four shillings (20p) each in G5NI's shop in Holloway Head in Birmingham in 1937. They are still going strong.

References

1. G Stancey G3MCK. Letters to the Editor. *Signal* 2014, 31 (May) 39.
2. http://www.keith-snook.info/component-colour-codes.html

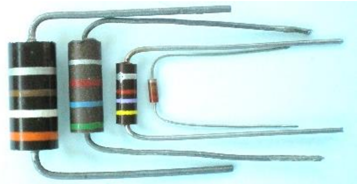

Figure 1

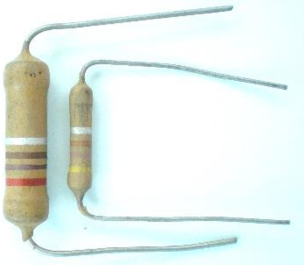

Figure 2

Figure 3

Figure 4

Figure 5

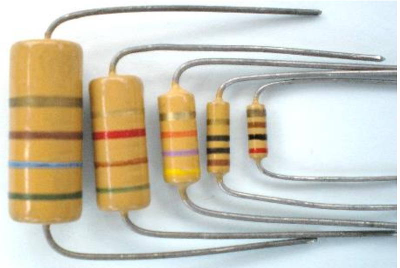

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10 **Figure 11**

Figures 1-4 show carbon composition resistors, Figures 5 and 6 show carbon film resistors and Figure 7 shows wirewound resistors. Figure 8 shows a selection of tubular capacitors, Figure 9 shows three polyester capacitors and a disc ceramic, Figure 10 shows a selection of high voltage ceramic capacitors (all in the range 100–150 pF) and Figure 11 shows a selection of high power RF capacitors. The individual components are identified in the text on pages 37–39