

Hot Iron

Issue 27

“Journal of the Constructors Club”

Spring 2000



Contents

- Audio output and walkman phones
- Identification of caps
- Miscellany
- Instability & chirp
- Dates for diary, website
- Practical tips

Editorial

Welcome to the new century. The sun is out and Spring is in the air and the orders are beginning to come in again! It's as though radio kit builders also go into hibernation during the winter! Many years ago when I first noticed this effect I thought it was just chance but now I recognise that actually not all that many people build in the depth of winter - maybe something to do with cold sheds at the bottom of the garden! How long till global warming is the salvation of the kit suppliers?

Watching the awful scenes on the box from Mozambique, where the flooding maybe connected with atmospheric warming etc., one is reminded of the help that amateur radio can provide in such circumstances. This is especially so in less developed countries where the nation's infrastructure is less capable than in Western Europe. However there is another difference, which is to the advantage of the less developed country. If such a disaster were to strike anywhere hereabouts, the devastation on the built environment would be many times worse. Consequently the time to recover would be a couple of decades, whereas in Mozambique it will be far shorter. This is not to

underestimate in any way the awful tragedy which they are suffering. The closer people are to their agricultural roots, the greater their ability to recover their earlier situation.

What's this got to do with building radios - not a lot! None of you have sent me any difficult or provocative questions and while pondering what to write this came to mind!

New Developments

Much of the winter months have been occupied with creating a website. My son offered to do it but I felt I had to do it so that I could easily keep it up to date. My on line catalogue is not an 'all singing and dancing' affair but is, I hope, sufficient. I shall as usual be especially pleased to have any suggestions as to how it could be improved. For those suitably equipped the address or URL is www.users.globalnet.co.uk/~walfor I am afraid that clicking on this page as you read it won't bring it up but you can send me an e mail via walfor@globalnet.co.uk Note the deliberate spelling mistake!

I have also started on a new major project - with much encouragement from a few dedicated members. I don't wish to reveal what it is yet, because I am only just starting to build the first prototype and it will be a little while before I can safely announce it fully. For anyone interested in a challenging HF transceiver project, this will be a full single 100 x 160 mm PCB. Various enhancements are planned! I shall be happy to discuss it with any keen builders. My mark 2 Antenna Matching Unit is now also available; all bands 10 to 160m for low or high impedance, balanced or unbalanced feeders, with an included resistive matching bridge. £39.

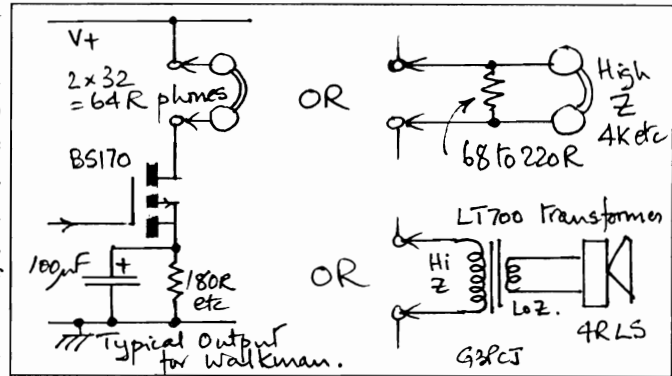
Tim Walford G3PCJ Editor

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 or e mail walfor@globalnet.co.uk The Walford Electronics website can be seen at www.users.globalnet.co.uk/~walfor The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

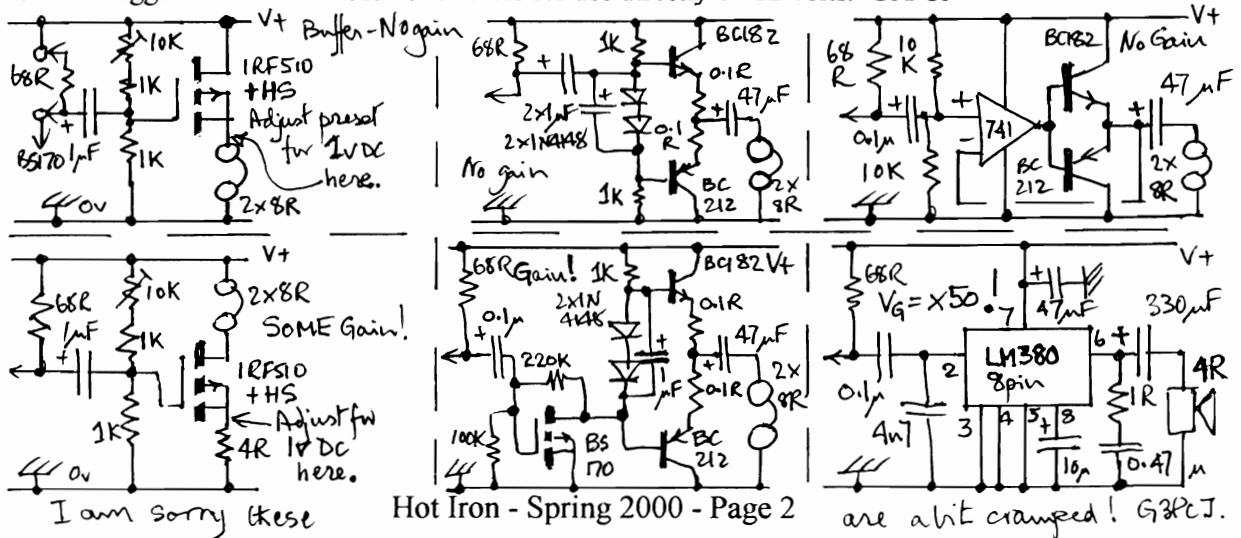
Audio Output stages and Walkman phones

It is attractive to use an output stage for walkman type stereo 32 Ohm phones in a low cost project because they are much easier to drive than 4 or 8 Ohm phones (or speakers). Some people do not like any form of phones, let alone the very low cost versions which are not much more than two shaped blobs on the ends of a forked wire! Their output can also seem low. There are several options for improvement. Firstly, try some alternative stereo 32 Ohm phones; their sensitivity and comfort are directly related to their wide range of price. I have a pair of padded 'full sized' ones that cost just over £10 a few years ago and would be cheaper now. In my rigs, which all have mono output, the ear pieces should be used in series for highest output, as gain is proportional to the output stage's load impedance. Wiring them in parallel for a 16R load will give only a quarter of the output compared to the 64R load when properly wired! (Remember that when properly connected, switching their switch to mono will short them out!) Its also worth checking that they are 32R each roughly and not 8R.

If this fails to effect an improvement, more electronics are required. The circuit alongside shows my typical walkman output stage so the first thing to do is make certain that its bias conditions are not upset when driving something else; this requires a replacement resistor of around 68R up to maybe 220R if more gain is needed. For those having the older type of high impedance phones, typically 4 KOhm, they can be used directly across the new 68R as shown in the right-hand circuit.



Transformers can be used but they may need another gain stage, are becoming scarce, and are not so easily incorporated physically! Otherwise, the extra stage for low Z loads has to provide much higher currents and maybe extra voltage gain, so unless at least two devices are added for Class AB or B operation, a single device has to be run in Class A with a high standing current drawn from the supply. This current needs to be a bit larger than the peak signal current into the load presented by the phones. The load will be 4R if both 8R ear pieces are driven in parallel implying a peak current of 250 mAmps for a 1 volt peak strongest signal giving just 1/8 W RMS output into the cans or a single 4R loudspeaker. Its better to drive the two ear pieces in series for 16R and 62 mAmps at 1 volt peak. I have sketched various possible circuits below and their characteristics. The single device circuits (left) have to be run in Class A with a large DC current in excess of the peak load current so will dissipate a few Watts continuously needing a heatsink. The two single device circuits have this DC current flowing through the phones so be rather careful about not burning them out! The multiple device Class AB approach avoids the high device dissipation but adds several components; it is the basis of practically all audio output chips. The two circuits, with 2 or 3 transistors (middle), are best for driving phones. Driving a LS, usually with higher output, needs more watty devices and heatsinks so you might just as well use a specialist chip. The first 'chip' circuit (right) using a 741 op amp can be OK for a simple rig but is a bit prone to crossover distortion which is why the previous two circuits have a pair of diodes to let a few mAmps flow through the output devices. For dedicated audio output chips, I prefer the LM380 in either 8 or 14 pin format, since it can take 8 to 22 supply volts. I am not keen on the often suggested LM386 - it is not suitable for use directly on 12 volts. G3PCJ



Identification of Capacitors

Capacitors, particularly small ones, are invariably the most troublesome two lead parts to identify and decide their value. Its quite easy to determine if they are capacitors, because their resistance between leads will be many megOhms. Small capacitors are usually quoted or labelled as pico-farads (pF) which is a million-millionth (10^{-12}) of a Farad. Middling sized capacitors are usually given in nano-farads (nF) which is a thousand-millionth (10^{-9}) of a Farad; large ones in micro-farads (μ F) which is a millionth (10^{-6}) of a Farad. Thus a capacity of 1000pF is the same as 1nF and 0.001 μ F. Giant electrolytics, or memory back-up capacitors, are sometimes found up to Farads but are uncommon in radio circuits. Makers often omit the F so that a 100 pF capacitors might have just 100p printed on it. It is also common to find the multiplier (p, n, or μ) at the start or in the middle of the numbers in the place where the decimal point would be for that unit of capacitance; for example, n15 is a 0.15 nF capacitor and 4p7 would be a 4.7 pF capacitor. When this is done there only two numbers for the first two digits of its value. If there are three numbers, usually without any other letters or symbols, the value is expressed in pF as the first two digits with the third acting as a decimal multiplier like resistors. For example, a capacitor marked 152 would be 15×10^2 which is $15 \times 100 = 1500$ pF, the common 10 nF disc is marked 103 meaning $10 \times 10^3 = 10,000$ pF. Some examples and equivalents:-

100pF	=101	=0.1nF	=n10	=0.0001 μ F
150pF	=151	=0.15nF	=n15	=0.00015 μ F
470pF	=471	=0.47nF	=n47	=0.00047 μ F
1000pF	=102	=1nF	=1n	=0.001 μ F
10,000pF	=103	=10nF	=10n	=0.01 μ F
100,000pF	=104	=100nF	=100n	=0.1 μ F
470,000pF	=474	=470nF	=470n	=0.47 μ F

It is rather harder to judge the type of insulating material in a capacitor but its shape is the best clue. Silver mica types are thin and rectangular with the leads projecting down the edges. Polystyrene are usually axial leaded cylinders in clear plastic or sometimes small metal cylinders, with close tolerance and maybe high working voltage. Polyester are usually either sharp cornered rectangular coloured plastic blocks with edge leads, or uninsulated blocks with leads projecting down the side metal contacts, or the same type dipped in an insulating material. Polycarbonate are also rectangular blocks with side leads but they are frequently somewhat bigger. Tantalum electrolytics are nearly always pear shaped blobs and ordinary electrolytics are cylindrical metal cans - with both of these sorts, the polarity of applied DC voltages must be correct or they may be damaged or explode. Disc ceramics, usually with a 'High K' dielectric giving high capacity for size but poor stability, are dipped circular thin blobs - not be confused with ceramic plate capacitors which are small rectangles with good temperature characteristics. Larger circular discs, about 3/8 in diameter, tend to be 1000v types - most others are 25 volt. If in doubt, always assume that they are high or medium K types and hence unsuitable for VFOs etc.. Ceramic ones are a little micro-phonic so should not be used in audio circuits but they are good in RF circuits. The rectangular Low K ceramic plate types, which are suitable for VFOs, have a single colour body (often light green) and a coloured tip. (Sometimes Low K ones are round and slightly bigger than high K types.) If the tip is black, it is a NP0 type with nominally zero temperature coefficient. The ceramic COG type also has zero tempco - my preferred COG ones have blue bodies, no black tip, and three digit (2 plus multiplier) pico-farad numbers! If the tip is orange it means a nominal coefficient of -150 parts per million per degree centigrade. The NPO/COG and N150 types are widely used in oscillators to counteract the normally positive tempco of the inductor. Violet tipped ones are no good for VFOs since their tempco is too high at -750 ppm/ $^{\circ}$ C. Silver mica and polystyrene types both have low negative or nominally zero tempco, so are widely used in VFOs; but in my experience they are much less consistent (and now harder to obtain). With both types there are can be marked variations in oscillator stability between different manufacturers and even between different batches from the same manufacturer.

Trying to match actual capacitors in a kit to the parts list can be difficult when the markings are faint; the best technique is to firstly compare numbers of the same size, then arrange them in ascending size which will correspond to ascending value. Best of all is to use the capacitance meter facility of many digital multi-meters! (I have complained many times to my suppliers but to no effect!) My thanks to the Editor of the Yeovil ARC Newsletter G3GC for permission to republish; he gave the subject its first airing many years ago.

G3PCJ

Mechanical Miscellany!

From Andy Howgate G7WHM - PCB protection I remove any PCB lacquer on the track side with wire wool, so that after soldering is complete, any flux residues can be scrubbed off and then re-lacquered with acrylic spray obtained from Halfords. Prior to use PCBs, can be prevented from going tarnished by wrapping in cling film.

Enclosures I like to have a rig enclosed for looks and to keep out unwanted visitors! Using a second PCB sheet for the rig's rear panel allows convenient mounting of supply and antenna connectors, occasionally used controls etc.. It needs to be the same size as the front one. Both end panels are drilled prior to fitting to the rig, sprayed with acrylic paint in your favourite colour and then labelled with lettraset etc.. I then fashion a plywood enclosure which is a rectangular 'tube' into which the rig is slid. This can have a smart front bezel all around the front 'tube' edge to stop the rig sliding right through. The rig is held inside by a suitable angle bracket affixed to the rear of the tube just behind the rear panel. The rectangular wooden enclosure is made from thin plywood with pinned & glued 90° beading inside the tube long joints. After sanding it can be covered in Fablon etc. and feet fitted. You can even have your own house style for several rigs! They can be any size and are always available so you don't suffer box manufacturers catalogue changes. (Full notes here if wanted. G3PCJ) *Craig Douglas G0HDJ* advocates a very similar technique to Andy's but using a three sided metal cover to just contain the rig. The rig sits on its normal feet on the bottom of the PCB. Either a single sheet can be bent into a large U or three flat sheets formed into a U with aluminium angle. It can even have front or rear top extensions, with sloping sides, for an eyebrow style! The metallic cover can be painted or finished with Fablon. It can be held in place with self tapping screws into the front and rear panel side braces. (Or bolts into brass nuts soldered inside to the PCB copper braces.) Ventilate well!

The smoke theory of electronics

The ingredient that allows all electronic components to operate is 'smoke'. Consider your own experiences. Remember when all the smoke was let out of your transmitter PA transistor. It immediately stopped working! When the new integrated circuit sprang a leak and all the smoke escaped, it also stopped working. When the big electrolytic capacitor gave off its smoke, it quit again! From these observations therefore it is logical to deduce that smoke is the ingredient that allows components to work and once it escapes nothing works anymore. (Thanks to QST via G0HDJ.)

Spin wheels

Eric Godfrey G3GC wants to know what I meant by a spin wheel when writing about control of a DDS chip. He understands what it does but not what it is. I meant the sort of control which is the main tuning control of modern commercial radios. Rotation one way or the other winds the frequency up or down. Usually the knob operates a shaft encoder which increments (or decrements) a digital counter controlling the frequency of the local oscillator; the counter maybe an actual digital circuit or realised in the software of a microprocessor. The LO can be based on a phase locked loop or DDS. These shaft encoders can be bought but cost many £s in small quantities. They have two sets of many markings around a disc which interrupt light shining onto a photo diode. The markings are slightly out of phase so that the timing of bright and dark signals from the two tracks indicate the direction of rotation. I had in mind to use a pot (on cost grounds) which would provide discrete up or down frequency increments in its midrange but would change to continuous up or down change at the ends.

Designing for EMC compliance

All commercial electronic equipment sold in the EU has to meet an Electro Magnetic Compatibility directive covering its susceptibility to unwanted signals and its emission of unwanted signals. Luckily for us, radio kits and individual experimenters designs have been exempted from the formal procedures BUT we still have a strong duty to be careful and not upset any other user of the radio spectrum either intentionally or not. Commercial organisations now have to spend much effort making certain that their gear is compliant. EMC aspects have now to be considered very early in the design stage, apart from exhaustive testing of prototypes and later modifications to rectify defects. Simulation can be used but sound electronic construction techniques such as have to be practised for radio equipment are often the most cost-effective. Recently there have been two excellent articles by MK Armstrong in the Institution of Electrical Engineers Journal (Sept and Oct) which advocate many of the ideas commonly used in radios. In particular, the used of a continuous copper ground plane for circuit boards comes high on his list of priorities! Next is supply distribution and decoupling!

There is now also a Low Voltage Directive covering the size of 50 Hz harmonics which can be injected back into the mains from PSU rectifiers. I think any PSU over about 10 Watts is covered. A transformer with rectifiers feeding massive electrolytics are out! Choke input smoothing is the scheme!

Instability and Chirp!

Recently, one of our members rang up about an 80m TX that he is building. The original question was about temperature compensating capacitors for the VFO but I have doctored the story slightly to make the point more general. It soon emerged that there was a far worse problem than just frequency drift. As soon as he increased the TX output stage drive level, aiming to achieve the potential 5 Watt output that should have been possible, things went wild and the whole rig was oscillating way off the desired frequency. Above about a Watt the frequency was almost uncontrollable! It soon emerged that the VFO was operating on the same frequency as the transmitter output stage - hence a single frequency amplifier chain starting from a high impedance low level buffer stage following the VFO, feeding two amp stages and output stage with tuned matching. This builder likes to make things small so the physical separation between VFO and TX output matching network was small. The likelihood of instability was high! The common factors contributing to the gross instability were all present - high impedances, lots of gain, close proximity of output and input in a single frequency amplifier chain. Although unlikely in this case, because he makes his own double sided PCBs with one side used as a ground plane, another common cause of trouble is relatively high shared impedances between different parts of the circuit operating on the same frequency. This can easily occur in the grounding (at RF) of different stages sharing a common track back to the main 'earthy' part of the circuit. An inch of shared thin track can be the culprit even on 80m! A copper sheet (on one side of the PCB) is the easiest way to minimise the unwanted shared impedances to ground but not even these are perfect solutions! Try measuring the RF voltage across opposite ends of a TX PCB ground plane when producing just 5 Watts; you will have a surprise - there might well be 250 mVolts! (Like many RF measurements, the figures can sometimes be a bit misleading unless done with care.)

Unfortunately, this part of the conversation alone left him with a major redesign task but I had to warn him of another problem! Unless the VFO has a very high Q resonant circuit, such as found with ceramic resonators or crystals, the likelihood is that some small amount of TX output current will find its way to the VFO resonator causing phase changes, and hence a frequency shift compared to the non transmitting frequency. This is the dreaded chirp where the receiving station can just hear the VFO altering frequency at the beginning and end of each morse character. (It can also sometimes be caused by other shared factors such as sagging supply voltages to the VFO or tuning diodes - these causes can be identified easily by intentionally altering supply voltage while transmitting.) I can admit to learning this lesson the hard way a few years ago with a compact single band VFO driven rig that was far too tender! There are two common ways to overcome this drawback, firstly to put the VFO in a separate rigid metal enclosure but even this must be separated from the TX output circuits. I once found that TX QRP currents were getting into a diecast VFO box casing and so coupling to the VFO coil inside which was about 15 mm from the box wall. This is why some CW rigs using a shared VFO have separate nearly empty cases for RX and TX. The second and safer solution is to change the VFO frequency, then mix it with another from a crystal oscillator, to obtain the wanted one. Because the VFO and TX output stage are no longer on the same frequency, the presence of unwanted TX RF does not affect the VFO. This approach also eases the gain distribution aspect by allowing some gain at the crystal and VFO frequencies and less at the output frequency. It adds a mixer, crystal and RF filter.

Crystals and ceramic resonators (on the TX frequency) don't suffer chirp because their high Q implies higher circulating currents so that any given level of unwanted TX output currents in the VFO are a lower proportion of the VFO resonator currents. The drawback is that the high Q also makes it much harder to pull their frequency intentionally for tuning purposes! Ceramic resonators are a reasonable compromise and can be pulled useful amounts but they have another drawback - their frequency is a bit prone to changes in temperature! They are quite adequate for a bench based 80m rig but take care with anything more adventurous. This is real reason why my latest CW rig, the Minehead, has a crystal mixing scheme allowing operation in principle on any chosen band up to 10m with the stability of a 4 MHz VFO. (For other reasons, the normal upper band limit is 20m.)

Website

For those of you suitably equipped, the Walford Electronics online catalogue is up and running. All the kits are there, with background explanations etc.. You can even see my electronics bench! I spent days arranging this photo but its not far off the usual state. As usual I am keen to have any feedback either by letter or e mail to walfor@globalnet.co.uk Note the funny spelling of Walford! www.users.globalnet.co.uk/~walfor

QRP Convention 2000

Mark April 16th in your diary if you can make a journey to Sherborne on the Somerset Dorset border. It is one of the few remaining genuine amateur radio events which have not been taken over by computers or the sellers of scrap telephones. Talks on a range of radio related topics, traders, displays, morse tests, etc.. The Construction Challenge is to build the most efficient 20m 1 Watt DC input transmitter. There will be a QRP Forum discussion session in the afternoon, with guest panel advisors covering all aspects of QRP. For those who like to make a weekend visit, there is a dinner the night before and Sherborne (with the surrounding area) is a most interesting place to visit for your partners. It is a thoroughly enjoyable event and is the only rally which I regularly attend - come and see the mystery project mentioned on the first page! Further details from G3CQR on 01935-813054.

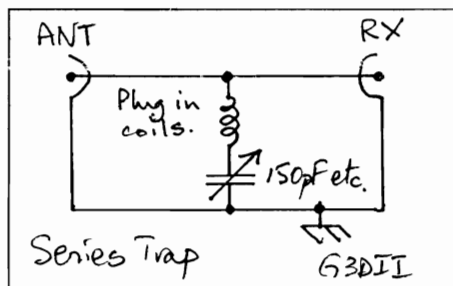
Somerset Homebrew Contest

There is still time to enter and maybe win a £50 voucher from that well known kit stable. Please see the Winter 99/00 Sprat for the full details. It is open to any single operator QRP station using homebrew RX or TX (or both). Any mode on 40 and or 80m near the QRP frequencies between 0900z and 1200z on Sunday March 26th in 2000. Exchange RST, Somerset Contest serial number starting from any random number over 100. Scoring is 5 points for a QRP contact both ways and 1 point for QRP/QRO contacts. Deduct 25 points if you did not build either the RX or TX yourself! Entries to G3XJS by April 30th with claimed score, details of equipment and antennas used etc..

Practical tips from Members

From Joseph G3DII - Makeshift Allen wrench Obtain a nail slightly larger than the key's hole and carefully file a point of 4 or 6 sides on the end; then cut off the tip so that it just avoids 'bottoming'. Bend the other end 90° for better leverage. If its badly stuck, use a rust loosening spray and maybe heating and/or a suitable blow to the makeshift key.

Interference trap The source can be any single, or close group of unwanted signals, coming down the antenna. The circuit shown alongside works by placing a low impedance short across the antenna input to the rig at the offending frequency, which is often near the wanted band. It might be BC stations just outside the wanted band, as on 40m, or possibly strong stations at the rig's IF or image frequency. (The image is twice the IF from the wanted frequency in a superhet.) Its desirable to be able to tune over a wide range to find the offending signal. A selection of coils with say 5, 8 and 15 turns wound on the bases of discarded octal valves can be plugged in to a valve socket on the top of a box containing a 150 or 300 pF variable capacitor with calibrated dial and input/output connectors. These three coils should cover approx. 3 to 25 MHz. Use only in a RX antenna feed. Once you have found the offending signal, you can fit smaller equivalent value parts within the RX case using a trimmer/fixed coil or fixed capacitor/slug tuned coil. Measure the resonant frequency, with a GDO, by shorting out either connector.



Handling MOSFETs If you are concerned about static electricity blowing these devices, and you should be if you have a hot dry shack with synthetic floor materials, then the following precautions should help. Do your electronic assembly on a metallic plate (or other conducting surface) connected to mains earth and make certain that your soldering iron body is properly earthed and connected to the plate. Then arrange to discharge static on your body by wrapping a bare wire twice around your wrist, the other end of which is connected **through a 1 MegOhm resistor to mains earth** or the conducting work surface. (Make certain this is mains earth and not RF earth.) Individual ICs can be protected with a 'bulldog' clip, obtained from a stationer. These are strongish clips for wedges of paper that have a pair of metallic sides or jaws with handles, pressed together by a curved spring. Before using the clip, make certain that it does not have any burrs on the jaws. Keep the device in its protective static conducting wrapper/bag/foam until ready for fitting. Discharge any volts between you and the device by gripping the conductive material (not the IC legs) and then gingerly place the clip on the device so that each jaw shorts the pins on the IC's side. If possible, do this before removing the legs from any packaging foam. To insert or remove the IC from a socket, grip the IC ends between forefinger and thumb so as not to disturb the clip. The clip can be left in place till the IC's legs have been soldered. The ground plane or 0 volt part of the circuit can also usefully be connected to mains earth.

From Michael G4BQA -Key for TOKO cores Toothpicks are seldom strong enough! Instead try filing down the end of the arm from the protective pocket cap of a cheap biro type pen. The cap part then becomes the handle when used as a screwdriver in the TOKO coil.