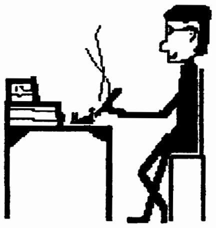
Hot Iron

Issue 9 *"Journal of the Constructors Club"* **Autumn 1995**



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Editorial

As this is the start of our third year for the Constructors Club I thought we ought to have a small facelift; I even managed to find and retrieve from the depths of the hard drive, the logo on the left that my son Charles drew some months ago after he complained about the original builder being rather po-faced! I am always pleased to have contributions and even those in pictorial form. We have a graphical progress report from GW3COI on his Yeovil and a frequent question to! Thank you John.

Kit developments

Some of you will know that I am a farmer, when not buried in my electronics bench! The splendid weather in August has allowed us to complete the harvest in record time and progress on new kits has been good. The high performance **Tuneable CW Filter** that I mentioned some while back is now out at £37. The low pass corner frequency, above which you will not hear interference, is tuneable by a pot or preset. It also provides all the functions to convert a phone only SSB transceiver into a CW rig; it can be used with most of the Somerset Range rigs or on its own with other makes. I have also decided to introduce a range of low cost simple instruments; the three items mentioned below are available now and I hope also to have a signal generator and simple counter in due course. The **Two Tone Audio Oscillator** has a separate section with diode detectors. As I hinted in the last Hot Iron, the detector part enables you to set up a rig using its two tone audio signals but WITHOUT a scope. Apart from this major advantage, the diode detector part incorporates a low power dummy load and acts as power meter with your DC voltmeter! The second item is a **Marker Generator**, which provides harmonic markers right up into the VHF region, with the spacing (or base frequency) being set by a PCB mounted rotary switch giving options of 10, 1 MHz, 100, 10, 1 KHz derived from a crystal. There are both wideband and rectangular 5 volt CMOS logic outputs with the facility for alternative outputs at 2 MHz, 200, 20, 2 KHz. The size is 50 x 80 mm with mounting by the switch bush or nuts and bolts. The third item is a 50 Ohm **Dummy Load,** rated at 30 Watts continuos. It is supplied as the two non-inductive resistors with a 1.6 °C/W heatsink. The cost of all three items is the same £16 for each or £45 for all three. Full details are available. Post and packing £1 please.

Win a kit!!!!!!!!!

To help me decide what to offer, all complete responses received by Dec 1st to the following questions will go into a **DRAW**. The prize is any one of the above three instrument kits, (indicate which you would like):-

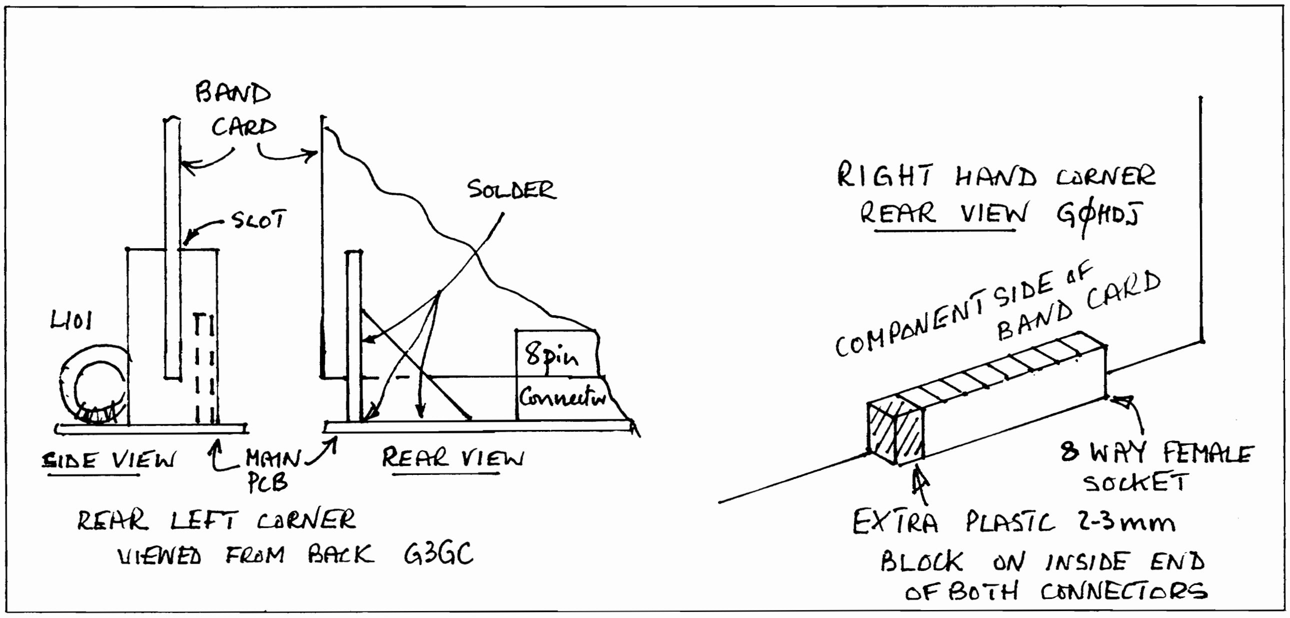
1. What bands and modes do your current homebrew rigs cover?
2. What other bands and modes would you like to see kits available for?
3. What would you consider a realistic price for such rigs?
4. What is the most sophisticated piece of test equipment that you own or have access to?
5. Do you consider it important for the kit to have a box as an optional extra?
6. Do you rate yourself as experienced, typical or beginner at electronic construction?

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 & Fax 01458 241224 Subscriptions are £5 per year for the UK (£7 overseas) from Sept 1st in each year. Sept 1st 1995.

Updates on the Taunton

Band Cards. A number of suggestions have come in from G0HDJ, G3GC and G3WUC. Firstly, it is advisable to apply insulating tape to the back of the heatsink as there is a risk that the band card can be bent forward with the risk of a +12 volt short onto the heatsink. Partly to prevent this and to avoid possible damage to the band card's edge connectors, it is suggested that two guides be made out of PCB material to keep the card vertical - two rectangular pieces about 10 x 25 mm are cut out (perhaps from the front panel PCB side cheeks if not required). Into each of these, a slot is cut wide enough to accept the thickness of the band card. They are then soldered vertically in a front to back direction onto the top of the main PCB near the outside rear edges so as to hold the band card vertical. Two more smaller triangular pieces of PCB material are then soldered at right angles so as to brace the new slotted guides. G3GC suggests "tac" soldering the extra PCB material into position with a band card fitted and then completing the soldering after removing the band card. The band card edge connectors can also benefit from a very small dab of Araldite under their body to secure it to the band card but do not allow it to get into the innards of the connector. Another suggestion is to glue two extra small blocks of rectangular plastic etc. to the band card just inside both edge connectors. G0HDJ no longer has a complete toothbrush as he found the handle of his to be just the right size! Another possibility is the shaft off-cut from a plastic pot shaft. These blocks should prevent the band card being inserted left or right of the correct alignment for the connector pins and thus avoiding potential damage to circuits. See the diagrams below.



Parts List. Derek Perrey G3WUE, has kindly notified me of some errors which I had not picked up. C127 appears twice - it is 68 pF N150 and not 10 nF. R110 is 1K not 180R. R111, not on the list, is 180R.

Circuit diagram. I think I have notified all builders about an error on L103 - it should be shown with the centre tap connected to pin 6 of the band card and the top high impedance end connected to C111. C304 should be a 10 µF Tantalum type - everyone building the TX should have had one from me, if not let me know. Pat King G4GFY also points out that the meter is 200 µAmp FSD not 20 µAmp.

Update on the Coker

Experience with some Cokers suggests that the regulator circuit is sometimes struggling to produce a nominal stabilised 10 volts from an actual 12 volt supply. The cure is to reduce the 10 to about 9.5 volts by adding a 15K in parallel with R7. This will affect the tuning calibration but little else. The general frequency stability and ease of setting the transmitter offset capacitor should be improved if the rig was sensitive to low supply voltages. It has not effected all Cokers. Gerrard PA3EKK had his on 160m from the Benelux QRP Club Family day field event with a 40m wire, it caused quite a pile-up! It took about 6 hours to build.

Update on the counter

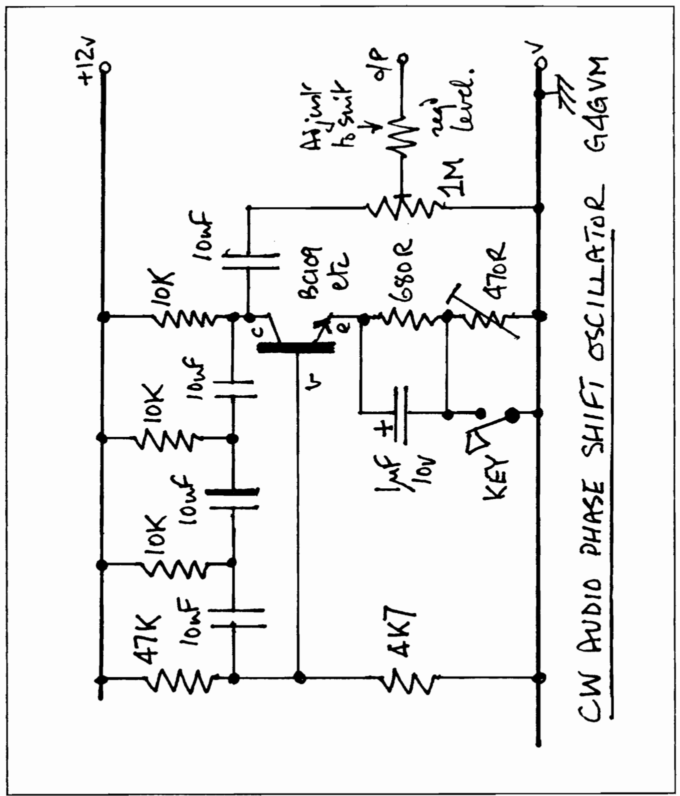
Fred Maddison, VK6GE, found that when he fitted a counter to his multiband phasing transceiver, the G3TDZ design in Radcom 1993, there were some specific sprogs with the sound of a motor boat due to the 5 Hz update rate of the displays. While not being able to replicate this effect directly, I suspect that the layout and physical arrangement of the control wiring is important. The two signals Cntl A and Cntl B are rather important and switch at the 5 Hz rate. They need to have as low a capacity as possible to maintain accuracy but from a radiation viewpoint they are best laid close on the ground plane. This recommendation is a general one and quite often can account for peculiar symptoms, instability etc. I don't think I have ever used screened wires for connections to front panels and around a PCB. I do however always lay wires tight against the ground plane or back of the front panel. Laying them in lines parallel to the edges of the PCB will also look neat. Most of the control signals in my designs are DC or low impedance audio, so the risk of cross-talk is small.

Sprogs and rig complexity!!

Simon Males, G0EVZ, reports finding very weak sprogs on his Yeovil at 14.29 MHz and the image of 3.71 MHz; those of you with Tauntons will also know that there one or two quite strong ones listed in the Manual. Sadly it is almost impossible to avoid them in simple rigs, particularly where there are multiple conversions. I don't have a ready explanation of the above sprogs but the usual source is a harmonic of the VFO, or some other oscillator, perhaps mixing with the harmonics of some other oscillator (either adding or subtracting) to produce the intended receive frequency or the IF. Getting rid of the harmonics is quite hard, particularly where the rig is multiband with an oscillator whose frequency changes with band. Sinusoidal oscillation is a jolly good starting point! The use of narrow band filtering wherever possible helps; this is why the Taunton has double tuned circuits at the oscillator mixer output. Narrow band front end tuning to reject signals outside the intended listening bands is a very good thing for many reasons; it helps with these unwanted harmonics, broadband noise, and unwanted very strong broadcast stations that can often cause overload. I find that double tuning in RF and mixer filters is usually the best compromise between complexity and cost. During 1994 and 1995, QST and Radcom have had some very interesting articles by Ulrich Rohde, KA2WEU, with further comments in Technical Topics, about the deficiencies of some black box front ends with diode switched octave filters etc. Achieving a simple and low cost multiband rig for kit builders almost certainly has to have oscillators dotted in among the wanted RF bands with the inevitable consequence of sprogs! Double conversion, high first IFs, Direct Digital Synthesizers with microprocessor for dual VFOs, multiple reed relay narrow band switching with super strong front ends, adjustable IF pass band and digital audio signal processing are not the stuff of low cost value for money kits, much as I would like to design them (and have the time to do so)!

A Phase Shift Oscillator - by Derek Alexander G4GVM

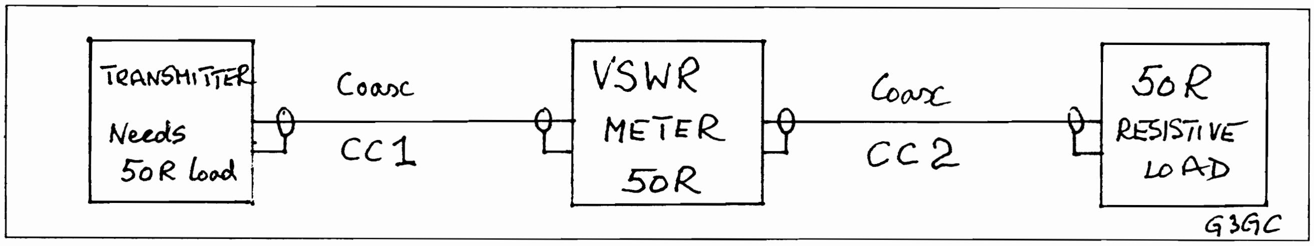
Here is a 800 Hz phase shift oscillator which could be used to add a CW capability to an SSB phone rig through the mike circuit, or as I had hoped, as a sidetone oscillator. The advantage of this type of oscillator is that it (usually! - Ed) produces a pure sinewave and therefore sounds good to the ear! I found the basic circuit in the QRP circuit handbook (page 58) when seeking a suitable sidetone oscillator but could not get it to work. However after some advice, I added the 1 µF capacitor in the emitter lead - this increased the gain and it burst into life! Further problems were encountered when I tried the suggested keying circuit. Putting a key in the emitter lead was no good as it was very slow starting due to the time taken for the DC levels to adjust to the running values. John, G4TRN, suggested that the key be paralleled by a small pot adjusted to just avoid oscillation which would maintain the DC conditions (nearly). This works well but I still have not satisfactorily sorted out how to key it, drive the TR control circuit, and key the transmitter! Interaction between these functions is the problem. Can anybody come up with a simple solution please? (Replies via the Editor please.)



Technical comment. Derek has suffered the classic problem of sidetone oscillators, that of stopping the oscillation without disturbing the DC conditions. The latter can cause the most obnoxious thumps, particularly when headphones are used. The frequency of oscillation with this arrangement is dependent on many actual component values. Not even an audio oscillator is simple! G3PCJ

Voltage Standing Wave Ratio Meters The first of two related notes by Eric Godfrey, G3GC

From my experience as the "Doctor" at the last Yeovil ARC's QRP Convention, it was obvious that there is widespread misunderstanding about Voltage Standing Wave Ratios, its measurement and meaning. (My apologies to those of you who are also members of YARC since you will be seeing this note twice - Ed.) I do not intend to go into the design or operation of VSWR meters here but only to say that they are always designed for a particular impedance, which for the amateur is 50 Ohms. As such it measures the VSWR with respect to that impedance and nothing else. The quality of the meter depends on the accuracy of its internal coaxial line and the ability of its coupler(s) to differentiate between forward and backward power.



The above figure shows a transmitter, designed to work into a resistive load of 50 Ohms, connected through a coaxial cable (CC1) to a VSWR meter designed for 50 Ohms which in turn is connected by another coaxial cable (CC2) to a pure resistance of 50 Ohms. What VSWR will the meter show? Well it all depends upon the impedance of CC2. If its impedance is 50 Ohms then the impedance at the input to CC2 where the VSWR meter is connected will also be 50 Ohms and the meter will read 1:1. However supposing that length of coax that you bought at some rally was not 50 Ohms as you thought but instead was actually video cable of 75 Ohms impedance, what effect would this have on the VSWR? This will depend on the length of the cable. If it is an electrical half wave long at the measuring frequency, then its input impedance will be the same as its terminating impedance, namely 50 Ohms and the meter will still read 1:1. On the other hand, if CC2 is a quarter wave long, then it will behave like a quarter wave impedance transformer, the input impedance being given by the formula $Z_{in} = Z_{tr}^2/Z_{out}$. Thus the 50 Ohm terminating impedance will be transformed into a 112.5 Ohm input impedance to CC2! The VSWR at this point is still referred to 50 Ohms by the 50 Ohm VSWR meter which will now indicate a VSWR of 2.25:1. Intermediate lengths will vary between a VSWR of 1:1 when the cable is a number of half waves long to 2.25:1 when it is an odd number of quarter waves long. At low frequencies cables are only likely to be a small portion of a wavelength long and the mismatch will be small and progressively less at the frequency is lowered. However at 28 MHz, the physical length of an electrical quarter wave in a solid polythene cable is only just over five feet and at 144 MHz even less at around fourteen inches, lengths which could well be used for interconnecting cables.

Now let us consider what happens if the cable CC2 is the correct impedance of 50 Ohms and the 75 Ohm rogue cable is used instead for CC1. The VSWR meter, since it is working into a 50 Ohm cable terminated in a 50 Ohm load, will read 1:1 indicating that the impedance at the meter is 50 Ohms. However since the cable CC1 is now 75 Ohms, then if it is an electrical quarter wave long it will again act as a quarter wave transformer and its input impedance will again be 112.5 Ohms which will be directly connected to the transmitter. Thus the transmitter will be working into a system whose VSWR is now 2.25:1 with respect to the 50 Ohm impedance it expects. It is most likely that the transmitter will not like it, and if it has protection circuits these will limit the power to a safe value, but without such circuits it is possible that the final transistor(s) may give up the ghost even though your VSWR meter shows 1:1. Of course the actual input impedance at the transmitter depends upon the effective electrical length of cable and again if it is a half wave long then its input impedance will be 50 Ohms and there will be no problem. Something that may intrigue you is that if CC1 and CC2 are both 75 Ohm cable each a quarter wave long, then the VSWR meter will read 2.25:1 but the transmitter will actually be working into a load with a VSWR of 1:1 with respect to its 50 Ohms. CC2 transforms the 50 Ohms resistive load up to 112.5 Ohms at the meter (hence the 2.25:1) and CC1 transforms it back down again to 50 Ohms at the transmitter. So all is well despite the meter showing 2.25:1! Summing up:-

1. A VSWR meter measures the VSWR with respect to its own internal impedance and nothing else.
2. If the meter reads 1:1 then all cables on the transmitter side of the meter must be of the correct impedance. Those on the terminating side maybe of any impedance provided that a VSWR of 1:1 is achieved. (See part 2.)
3. Keep all interconnecting cables as short as conveniently possible.

Note. You can check the impedance of a coaxial cable by measuring its capacity per unit length. For solid polythene cables it is 30 pF per foot for 50 Ohms and 20 pF per foot for 75 Ohms.

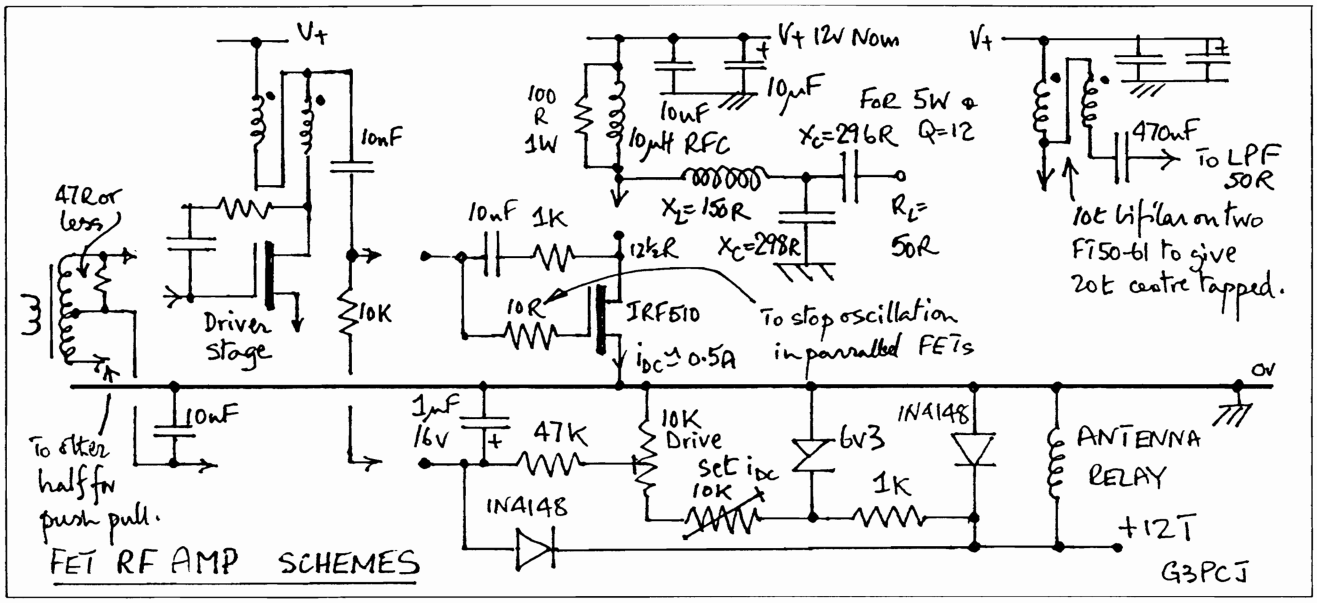
In the next part I will discuss impedance matching units, their uses and limitations.

FET RF Power Amplifiers

Over the last few months, I have been helping Joseph Bell, G3DII, with his experiments using power FETs as RF amplifiers. Although he has been using VN88AFDs, it has prompted this note which is rather more general although expressed in terms of my favourite device, the Siliconex IRF510. This N type device has a drain voltage rating of 100 volts allowing supplies up to potentially 50 volts but more importantly, its On resistance is 0.6 Ohms meaning that, at a typical peak operating current of 1 Amp, the On voltage is only 0.6 volts; this is a small proportion of a 12 volt supply and means it can be sensibly be used on this voltage or higher. (The VN88AFD has an On resisitance of 4.5 Ohms which means that 12 volt operation is very innefficient hence its usual use on 25 to 35 volts.) For any device, the maximum RF output power is given by the formula $P_{out} = V_{pk}^2/2R_L$ where V_{PK} is the maximum RF voltage that can be generated. A working figure for V_{pk} is the supply voltage less the On voltage at typical maximum current. A little mental arithmetic soon tells you that a typical QRP rig intended to run 5 Watts, needs a load on the device of 12.5 Ohms with a nominal 12 volt supply. The peak current will be 12 volts divided by the 12.5 Ohm load hence my Amp of current above and assertion that the 0.6 volts for On voltage can be almost ignored! Although the IRF510 is rated at 20 Watts dissipation, this is at a temperature of 25 °C which cannot usually be attained with practical heatsinks and a measure of derating is desirable for reliability and wide operating bandwidth. Use on a supply significantly below half the drain voltage rating will also markedly increase its ability to withstand unintentional abuse such as open or short circuit loads. The drain load of 12.5 Ohms for 5 Watts can be matched to the normal 50 Ohm feed line by two main techniques; firstly a broadband centre tapped toroidal transformer giving the desired 4:1 impedance ratio but this must be followed by suitable low pass filters to remove the unwanted harmonics that all output devices generate - particularly if it is working in class C conditions. The Yeovil employs this broadband basis, with a push-pull pair of IRF510s which has the advantage of reducing even harmonics and potentially higher output power. The other technique is to use some form of tuned matching network such as in Tiny Tim and the Taunton. This restricts the range of frequencies over which it can be used but has the advantage of getting rid of harmonics at their source and is often preferred by builders since the inductors are easier to wind! Such networks often work with a Q of about 10 to 12 meaning the rig output automatically falls off just outside most amateur bands. There are many available matching networks but the L network has the most practical component values for semiconductor amplifiers running on low voltage supplies. The capacitors can sometimes be made variable for tuning and obtaining the best match but RF voltages are high. Issue 4 of Hot Iron has some brief notes on these networks with formulas.

The input side of FETs is a little more distinctive! Their gates only require a DC bias of about 4 volts (down to 2 volts for small low power MOSFETs) to turn them on, and since they draw no DC current, it is very easy to arrange a suitable bias supply based on a Zener diode with extra capacitors and diodes to turn them on slowly and off quickly as the rig changes from receive to transmit and vice-versa. A convenient way is to power a Zener from the TR relay. These timing aspects are to ensure that the device is off whenever the load is not connected. It is customary to leave the main drain supply on the whole time and switch off the bias during receive so that their standing current (and dissipation) is reduced to zero. For class C service (CW and FM etc.) they can biased just below the point at which significant drain current begins to flow leaving the RF voltage to drive them into full conduction. For SSB phone, linear service (class A or AB) is necessary which implies at least some standing current. There is no magic figure but I find that about 0.5 Amp per device (for the IRF510) is a reasonable compromise between gain and low harmonic output. The gain can be reduced by lowering the standing current with a simple DC pot acting as a drive control. (The extremely high gate resistance means any unwanted charge on the gate does not leak away hence they are static sensitive devices.)

The AC aspects of the gate are much trickier! It looks like a capacitor, roughly 150 pF for an IRF510. This has to be charged up and down at the RF frequency which means an unusually low driving impedance. Impedances of around 47 Ohms are adequate for 80m use but to get up to 30 MHz requires nearer 10 Ohms. Some designs use a plain resistor of these values in the gate RF circuit but this is a lossy arrangement since the RF drive is wasted in these resistors. An alternative is to use a driving stage with a low output impedance and reduce it even further with a transformer between stages, as used in the Taunton. Inevitably the gain is lower with the low impedance drive but still useful. FETs of the IRF510 type are inherently very wideband devices (VHF) if you can get the gate to move that quickly but usually the drain output capacitance will become a problem at low VHF. I suspect that 30 MHz is a good practical upper limit for IRF510s. I also like to fit a little negative feedback from drain to gate, not really to have much effect on RF gain but I do find it helps to keep them alive under adverse conditions (no load)! If this feedback increases at low frequency it can reduce the LF gain and help even it across a wide operating band. I have sketched out some circuit ideas overleaf.



Snippets

PCB Production. Tony Measures G3WUC recently caused a certain amount of amusement by demanding instant trial samples of various ladies hairsprays; after careful evaluation he is now able to report that hardsetting Sunsilk Hairspray, at 99p from his local market, makes an excellent lacquer for sealing PCBs! He also draws our attention to a product called TEC 200 which is a form of iron-on etching resist that enables single copies of a track layout to be made by photocopying from magazine articles. He has not tried it yet.

Somerset Home Brew Contest. I am pleased to announce that WE is sponsoring a QRP contest on March 30th 1996 specifically for users of ***homebuilt*** gear. Details in next Hot Iron and SPRAT. The draw prize, for all entrants who complete a small questionnaire, is a tuneable CW filter; first prize is a Taunton RX.

And to end this issue, John Worthington's progress report. Happy building. Tim Walford G3PCJ