

HOT IRON

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Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Constructors Club**. Articles, suggested topics and questions are always welcome. Please send correspondence and membership inquiries to:-
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EDITORIAL

I am sure you will have noticed that Hot Iron has a new look - the intention is to make each issue more easily recognised by its appearance. The scene in the bottom left will change with the seasons - if anybody wishes to contribute a picture on 3.5 in floppy disc, I will be delighted to consider some alternatives. We also have several new contributors for which I am duly grateful. Three contributions are about modifications to the Yeovil. I have outlined some suggested improvements for Tiny Tim - all my own customers for Tiny Tim should already have received the details, but if there are others who you know who have built it from their own resources, they should be interested in the notes below.

I am also pleased to announce the availability of my long awaited new FET power amplifier kits. I have called them **QRP BOOSTERS** and they are suited to Tiny Tim, the Yeovil or any other QRP transmitter. Two versions are available, both capable of producing over **50 WPEP** from a maximum input of under 1 WPEP. The **MF 12 volt** Booster uses four IRF510 FETs for 160 and 80m. The **HF25 volt** Booster uses four VN88 FETs covering 160 to 10m. Both types are essentially broadband. On 25 volts the HF version produces about 35 WPEP but fitting extra capacitors related to the operating frequency enables 50 WPEP and up to 35 Volts for higher output. Both versions include relays for T/R switching & control inputs for direct control or rf sensing at the input. One control input has a delayed transmit hold facility that can also be used to provide semi break-in operation for separate TX and RX. In receive or with no power, the rf path is bi-directional. You will need low pass filters or a resonant antenna matching unit. The size is 100 x 160 x 35 mm over the heatsinks. Both prototypes produced about 70 WPEP on 80m but dont necessarily expect yours to do the same! The same PCB is used for both versions. Price is £45 - under £1 per WPEP. Send a SAE for the details.

Tim Walford

Editor

YEOVIL QRP CONVENTION

This year's convention is on May 8th at the Preston Centre, Yeovil, and has a very full programme of talks, demonstrations, QRP stations, trade stands and the like. We also have an annual construction challenge which should appeal to readers of this journal! This is the 10th convention so the theme is based on ten this year; briefly you have to design and build an 80m CW receiver using only 10 electronic components (no ICs) powered by a battery (less than 10 volts) giving an output between 10 Hz and 10KHz across a 10 KOhm load resistor. The results of your labours will be tested during lunchtime using a QRP transmitter equivalent to that used 40 years ago for the first long distance sky wave contact with a transistorised transmitter by the Yeovil ARC; the RX with the greatest output will be the winner. Contact Peter Burrige, G3CQR QTHR or phone 0935 813054, who will be pleased to send full details of the Challenge, the Convention and the CW Fun Run contest during the preceding week. Its a splendid day out, a chance to meet fellow constructors and QRPers, traders etc including Walford Electronics! Refreshments available all day. Bring the family - playing fields for kids, supermarkets and superstores within walking distance for the ladies.

Blue Tack!

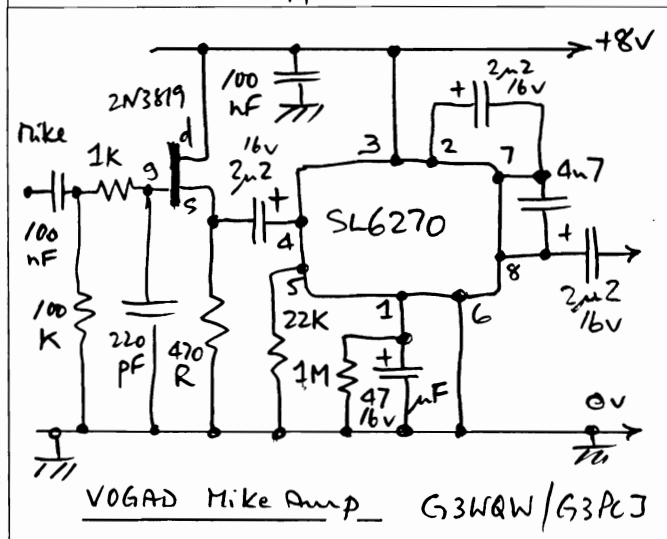
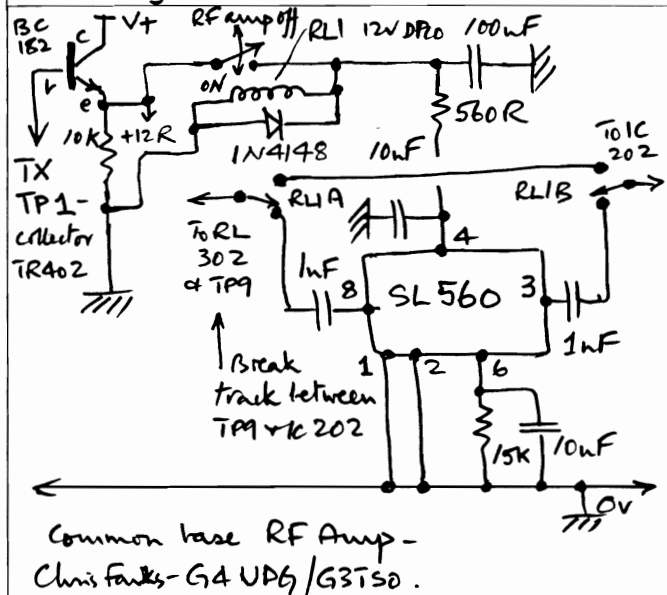
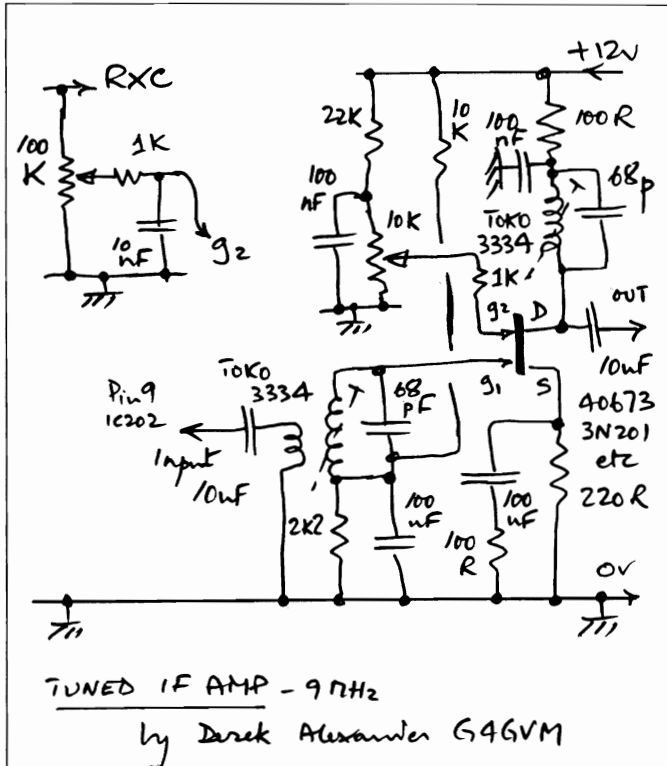
Stan Knight, G0BGI, offers a good use for a product which I regard as a decorators nuisance! "When soldering components of almost any shape or size into a PCB, if the item is held in the board with a small lump of Blue Tack, two hands are free to offer iron tip and solder to the job. Blue Tack is also a good heat sink. Removing items previously soldered this way is much easier since their leads do not have to be bent to stop the part falling out of the upturned PCB. A small tip but, I hope, a useful one."

Modifications to the Yeovil

The first two are aimed at improving the RX sensitivity. Derek Alexander, G4GVM, suggests an IF amplifier is a good solution to his need for more audio output since just advancing the audio gain control brings up the noise as well as signal. He writes " I have included the 9 MHz IF amp in the RX circuit just before the SSB filter (pin 9, IC202). The preferred position would be after the filter (pin 1, IC204) but I could not get rid of the howling which occurred! The fitting of the IF amp has not only produced a huge increase in RX sensitivity but the AF gain can be turned right down thus dramatically reducing the RX noise. The basis of the circuit is the IF amp from George Dobbs' MARLAND transmitter and is a fairly standard tuned RF amp, with a gain of about 40. I can see no reason why it shouldn't be used to improve the performance of most receivers. Ideally it should be inserted after the SSB filter, thereby amplifying only the filtered signals. Fitting to the Yeovil is easy; particularly for those who were foresighted enough to use IC holders! All that is needed is to lift pin 9, IC202, connect the amp input to the pin and connect the output to the socket and the supply to +12v; connect the RF gain control and the mounting will earth the board. I used 2 x 18 gauge wire posts between the board and the Yeovil ground plane. As will be seen, this involves the receive circuit only. (It has no effect on transmit - despite the amp's output remaining across the filter input.)" The circuit in the main part of the box is that used by Derek; I have added an alternative for the gate 2 input which will shut the amp gain down on transmit. G3PCJ

Chris Fawks, G4UDG, also tried an IF amp using a SL1612 but abandoned it in favour of an RF amp. "I built it on veroboard with a relay using a 12v supply switched off when on TX; the SL560 is about £3. The circuit is not my own but comes from the G3TSO TCVR which is also bi-directional! I have not noticed any overload problems but, just in case, I have switched it from the front panel with a toggle. Gain is about 15dB; sensitivity on 20m is greatly improved, on 80m not so profound but still useful. If you cant hear them, you cant work-em!" There is not normally a +12R supply in the Yeovil, so I have sketched in a suggested method-G3PCJ.

Stewart Sims, G3WQW, has installed a VOGAD amplifier IC on the mike input which enables him to regularly work VO1NP with only a modest antenna. This devices adjusts the audio gain so that the audio output level is reasonably constant. It enables him to adjust the mike gain to the limit so that there is no risk of splatter etc. while obtaining full output. Stewart has the distinction of building the first Yeovil outside the Yeovil club! He recommends the VOGAD kit available from Maplin using a SL6270; this kit includes a buffer amp to raise the input impedance so that it can be used with an electret mike. The circuit alongside can be used with most mikes including high impedance crystal ones. Clive Hardy, G4SLU, in his forthcoming review of the Yeovil in PW, has suggested adding a protection diode across the RIT relay coil RL303 to prevent latch-ups. Use a 1N4148 diode with its cathode end connected to V+ .



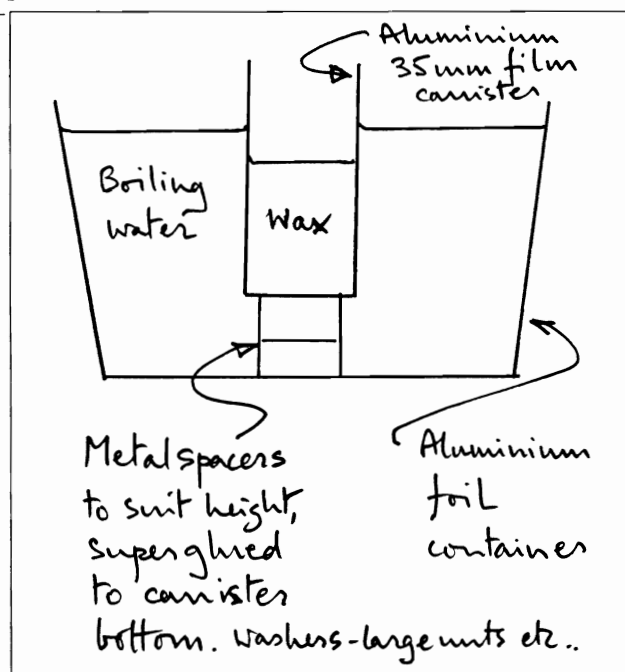
Tiny Tim and tuning voltages

Experience has shown that on some power supplies, the 8 volt regulator in Tiny Tim is not able to fully cope with the rf ripple present on the main 12 volt supply during transmission. This has the undesired effect of producing FM and very poor sounding SSB which also has a much narrower tuning frequency range over which the audio sounds reasonable. Luckily the cure is simple and cheap! Two extra 47 nF polyester capacitors should be added across the main 12 volt supply. The first should be placed directly across C33 (10uF) in the transmitter on the underside of the PCB and the second should be added from the main incoming supply pin the regulator IC5 (317T) to the nearest 0 volt point which is the earthy pin of R28 (10K). The addition of these capacitors should get the jump in VFO frequency when going to transmit with Tune on, down to around 10 Hz or less which is negligible. These two capacitors are also worth fitting to the top band version of Tiny Tim. It has also been found that some Tiny Tims are a little low on maximum rf output. If all the other possibilities have been exhausted you should increase C30 from 18 pF to 47 pF; after this change the RX rf input bandpass filters will need readjustment at the band centre.

Quite often, if a phone signal can only be read over a much narrower tuning range than normal, this is due to frequency modulation and it is unlikely to be due to rf feedback from the TX to the mike, it is usually from the TX to the oscillators invariably through the supplies. Feedback into the mike is more likely to produce a general roughness which is not resolved by tuning. I have explained this here since varactor tuned oscillators are obviously more prone to ripple on the tuning supply than those tuned by air spaced variable capacitors. In my rigs I use the 317 series of adjustable voltage regulators because their line and load regulation is appreciably better than the more common fixed regulators of the 7812/7805 type; furthermore despite needing two more resistors to set the output voltage they are not much more expensive. You can also set them to uncommon output voltages such as the +8 that I often use. This is a compromise between the highest voltage that can be obtained on a low 12 v input and the need for many chips to operate on about 6 volts. The 317 needs an input in the range 40 volts down to two volts above the desired output. The T version can source 1.5 Amps and dissipate up to 20W, but at this level it will need a large heatsink.

Boiling Wax

Craig Douglas, G0HDJ, offers the following technique for securing coils. "It works very nicely and anyone wanting to fix the coils of wire on a toroid or coil former, e.g. for an oscillator etc, will find it a good method. If you need to alter the turns, or reuse the former for something else, then you dont need to use nail varnish etc nor scrape the sealant off. Beeswax or paraffin wax can be used; there are other possible waxes but they invariably have higher melting points, are brittle and difficult to obtain without access to a chemical supplier! Beeswax congeals at 60 - 66 °C and Paraffin wax at 50 - 65 °C. The aluminium foil container can be a "take - away" type box - a largish volume will be needed to provide adequate heat. Water, which has just been boiled, will do but it may need topping up to keep the temperature up. Use a metal 35 mm film canister or similar metal pot just large enough to take the coil. Use washers etc. superglued to the bottom of the tin to keep it up and stop it floating. Using boiling water like this avoids getting the flammable waxes near naked flames and keeps the mess out of the kitchen! With toroids, a quick dunk will give a suitable coating, two dunks for a thicker coating on heavy gauge wires. Where it is important to keep the wax out of a former (e.g. for an adjusting slug), stuff a little cotton wool or newspaper into the end. If you need to remove the wax, a quick dunk into boiling water will remove it quickly and cleanly. Candle wax does not work by this method as it melts at over 100 °C. (Several years ago I had a problem with lead vibration & subsequent fracture in electronic gear on a tractor which I cured by dripping candle wax onto the wires - its still going - I think! It can be melted out by a lighted candle with care but it leaves a lot of soot - only for emergencies! G3PCJ)



Changes in AC mains supply voltage

During the next year or so, the electricity supply authorities are going to standardise on 230 volts 50 Hz as the normal domestic single phase supply voltage throughout the EEC and hopefully much of the rest of Europe in due course. Some Country's existing voltage will rise and others will fall, except for Northern Ireland which is already 230 volts so I am told. For most purposes the change will not be noticeable or have any negative effect. However it will directly affect unregulated power supply output voltages which vary in direct proportion to the mains input voltage. In principle an unregulated nominal 12 volt supply currently using 240 volts will go down to 11.5 volts. It may also be a problem with regulated supplies where the raw DC supply drops sufficiently for the regulator to run out of voltage headroom causing the regulator to partially shut down on each mains cycle leading to ripple on the output. Beware!

QRP Dummy Load Power Meter (and some notes on watts)

This instrument is a most useful thing to have in the shack for setting up low power rigs and for general development work. Apart from power supplies, this is the instrument that I use most frequently. It reads up to 5 watts RMS and presents a load resistance of 50 ohms enabling it to be used as an indicating dummy load. The meter is actually peak reading but the movement tends to average out the waveform over speech peaks etc. For convenience its calibrated in Watts RMS as I invariably use it on steady signals. Three ranges are provided using one scale with each range having a full scale deflection ten times the next lower range, thus each range adds 10 dB of power to give FSDs of +17, +27, and +37 dBm corresponding to powers of 50 mW, 0.5 W and 5 W RMS. Useful indications can be obtained down to 1 mW. It will work over all the HF band and, if the quality of construction is good, will also work in the VHF band. For calibration it has the great advantage that it can be set up with a DC voltmeter because it is a peak reading instrument. The intention is to indicate a general design concept so that readers may build one with the minimum of specially purchased parts and make good use of whatever is already available. Full construction detail is intentionally omitted because I don't know what you might have available for boxes, sockets, switches etc.!

The circuit shows the exact resistor values required for the input attenuator, they should be non-inductive - wire wound types are not suitable. R1 is best achieved with two 68 Ohm 2W resistors in parallel, R2 with 18 Ohms in parallel with 27 Ohms (both 0.5 W) and R3 can be two 10 Ohm 0.5 W resistors in parallel. Keep all leads as short as possible particularly around the input and R1,2,3, S1, D1, C1,2. Use a physically small switch for S1. While it is not essential to mount everything in a metal box, it adds style and keeps the RF where it should be! The ground connections should also be short. You can use any DC micro or milliammeter with suitable resistors R4 and 5 in series to read about 2 volts full scale and with a minimum resistance of about 2 Kohm; 1 mAmp or less will do. I happened to have a surplus 50 microAmp meter! The diode D1 should have low forward voltage drop which means it has to be either a Schottky type or germanium. A BAT85 Schottky diode will give better VHF (and HF) response than the germanium OA47 or OA90/91 which are best suited to HF.

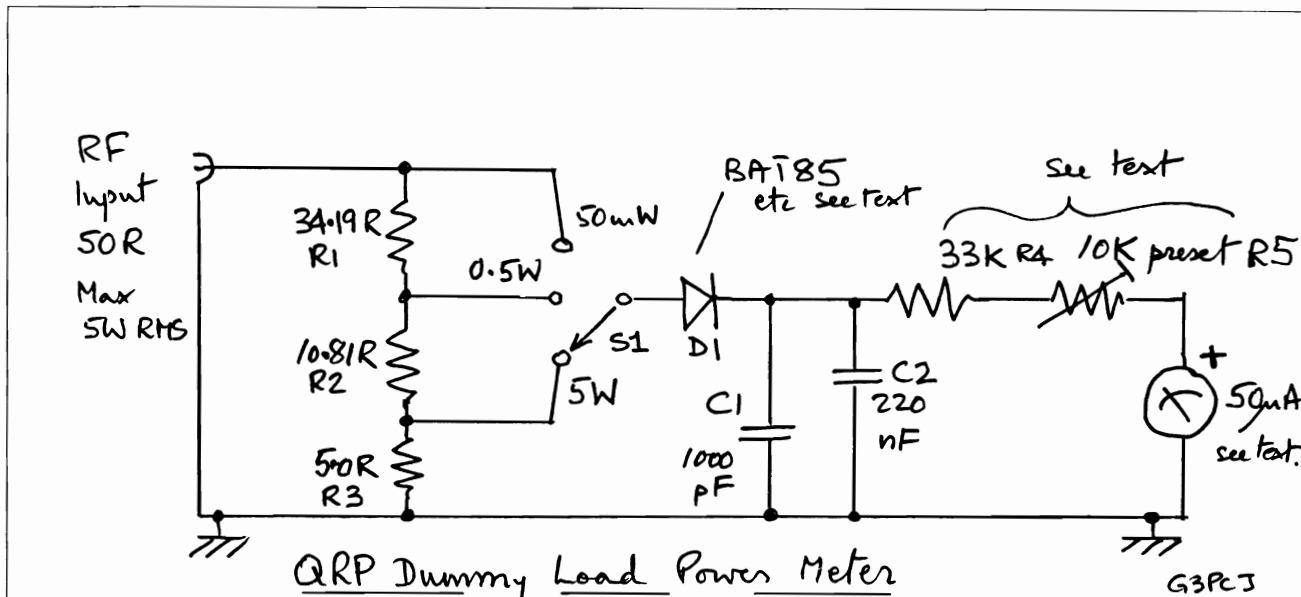
You should calibrate the instrument with a stable variable low voltage DC source capable of giving up to 50 mA into the 50 ohm load. (A 5 volt regulated PSU with a 100 ohm pot across it.) Read the applied DC voltage to the power meter as accurately as possible, preferably with a digital voltmeter. Adjust the supply/pot to give the voltages in the table and you can then mark the power meter scale, either in dB power relative to 1 mW into 50 ohm (more commonly known as 0 dBm) or in mW. You need only do it for the most sensitive range (S1 up in Fig 1). (The maths behind the table is $V_{dc} = \text{Square Root}(2RP)$ where $R = 50$ ohms and P equals RMS power.) Start by applying 2.240 volts on the 50 mW range and adjust your preset resistor R5 so that the meter reads full scale and label it +17.0 dBm (or 50 mW etc). Then work down through the table as the scale space permits. The meter should be used on steady RF levels; it is unreliable on SSB but will give a rough indication of signal level. Always leave the instrument on the 5 Watt range! I will leave discussion and some explanation of dBs for another occasion!

Note that I always state transmitter power output in Watts PEP because this is the correct figure to give for linear amplifiers being used for SSB (or DSB) phone transmission. When such amplifiers are used on steady tones, as for CW transmission, then the output figure in Watts RMS is half the Watts PEP figure. Power meters which are just marked "Watts" are usually calibrated in Watts RMS. This explains why many people think there is something wrong with my rigs when their power meters indicate an output of "5 Watts" instead of 10 - if they are using a steady tone the rig is producing 10 WPEP as it should. Consequently, if you were to use this meter with Tiny Tim, you might find it would produce a reading of full scale on the 5 Watt range corresponding to 10 WPEP output. You must always consider what the calibration on any power meter actually means. This power meter is calibrated in Watts RMS, despite being a peak reading device whose movement will "average out" variations in peak levels which occur more quickly than the mechanical movement can manage. Hence the importance of steady RF levels for meaningful readings. If you have a means of measuring the peak to peak RF voltage, such as an oscilloscope, then its easy to calculate the output power if you know the impedance, e.g. to check the calibration of this meter. The power in WPEP equals the peak to peak voltage times itself divided by four times the impedance. For example a steady 40 volts p-p across a 50 ohms dummy load is producing 8 WPEP or 4 WRMS. Watch out that I have used peak to peak voltages (because they are generally easier to measure than RMS voltages). There is a formula for RMS voltages but I wont give it to avoid any confusion!

Input DC volts	Power mW	dBm
2.240	50	17.0
2.000	40	16.0
1.730	30	14.8
1.410	20	13.0
1.000	10	10.0
0.837	7	8.5
0.707	5	7.0
0.548	3	4.8
0.447	2	3.0
0.316	1	0.0

$$W_{PEP} = \frac{V_{p-p} \times V_{p-p}}{4 \times R}$$

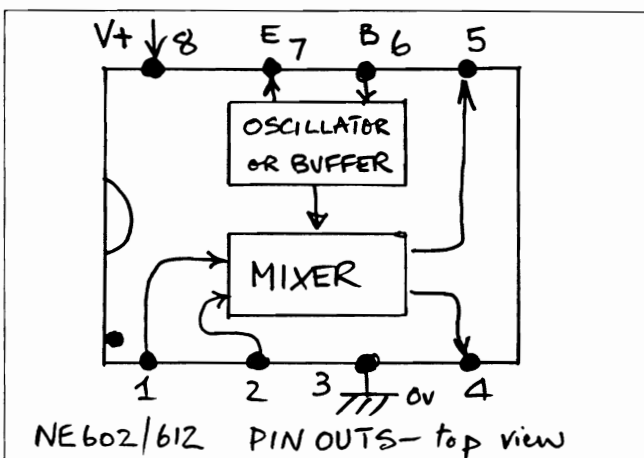
See the next page for the circuit diagram of the power meter.



The NE602/612 Mixer

These integrated circuits occur in many home built rigs because they are cheap, effective, versatile, low power and simple to use! They are used wherever the mixing function is required; for example to change frequency up or down, modulate, demodulate, or act as detector. Functionally the 602 and 612 are interchangeable - use whichever you can get hold of! They were originally intended for use in things like mobile phones but have now found their way into many types of RF equipment where the mixing function is required. The chip really contains two sections; a doubly balanced mixer and a separate section, which can be configured as an oscillator or buffer. This oscillator/buffer section

drives one of the mixer input ports. See alongside. The mixer output contains signals at both the sum and the difference frequency of the input signal and the oscillator input. Usually the output circuits will select either the sum or the difference and reject the unwanted one. The mixer section is doubly balanced meaning that the inputs and outputs are both "push-pull" in nature. This is actually achieved by a particular way of connecting several transistors in a form of tree; its known as a Gilbert cell. It also has the advantage of greatly reducing the unwanted feed through of signals from one port (input or output) to any other port. Achieving this requires a high degree of matching (or balance) between two halves of a circuit; in diode mixers, not only do the diodes have to be well matched but the transformers also require a great deal of



care which results frequently in the need to have some form of trimming adjustment to obtain the best balance. The Gilbert cell can be made with discrete components but it is necessary to have good matching between resistors and between the transistors in the "tree". With integrated circuits, the relative value or matching of both resistors and transistors can be very good and far more accurate than their absolute value; thus the process of making the integrated circuit deals with both aspects and will often mean that trimming is not required because the normal balance obtained in the integrated circuit is good enough. The Gilbert cell has other advantages; the input impedance is usually much higher - typically KOhms, the power that is required from the driving stages (and supplies) is appreciably lower, its cheap and they often have some voltage gain as opposed to the losses in diode mixers. The major drawback is their signal handling ability. There are so called "strong" Gilbert cell mixers which operate with higher currents, such as the SL6440, but there is always a trade-off between gain and signal handling performance. It is for this reason that most RF mixing circuits using IC mixers have a narrowband RF filter in front of the mixer to make certain that it receives only the low level wanted amateur radio transmissions and reject the very strong broadcast stations which can often be 100 times stronger and not many KHz away as on the 40 metre band. Mixer overload by such strong signals leads to all sorts of nasty effects where both wanted and unwanted signals can be tuned in on frequencies removed from the correct ones. Often a general buzz of broadcast station (or several station's) modulation can be heard all over a band irrespective of receiver tuning; this is the classic overload symptom. The cure nearly always is better preceding RF filtering, or in extreme cases a series tuned trap to remove some specific band - such as a 9 MHz trap at the antenna to prevent strong 9 MHz signals getting into the high gain part of the IF strip and then overloading the following product detector. The Gilbert cell mixer has been around for some time, but earlier designs such as the MC1496 tended to only have the mixer element, without the oscillator section or the biasing resistors present in the 602. These extras make the

602 a very easy chip to use. The supply voltage is nominally 6 volts but can range from 4.5 to 8 volts. A typical supply current is 2.4 mAmps. The mixer section has a 5 dB noise figure at 49 Mhz and will work to around 500 MHz. The conversion gain is typically 18 dB. The oscillator or buffer section should be limited to below 200 MHz.

Mixer inputs and outputs

The input impedance of each input is about 1.5 KOhms, so if a balanced circuit with both inputs is being used the load impedance on the driver (filter etc.) is 3 KOhms. The chip contains biasing circuits so signals should be AC coupled and definitely not connected by DC paths to 0 volts or the supply. It is only permissible to connect one input to the other in a DC sense, as through a coil. Either single ended inputs or balanced ones can be used, the latter will have twice the voltage gain but maybe less convenient for switching etc.. Matching to 1K5 (or 3K) can be done with capacitors whose size depends on operating frequency or by inductive coupling using taps or separate windings on the RF tuned circuit. As a very crude rule of thumb these taps should be 1/4 to 1/2 way up from the earthy end of the coil, or the separate winding should have 1/4 to 1/2 the number of turns on the main winding. If only a single input is being used, the other input must be decoupled to earth with a capacitor whose reactance is 10 Ohms or less at the operating frequency. See some examples alongside.

The output impedance of each output is also 1K5 and is actually a resistor from the transistor collectors to the supply. Like the inputs, the outputs are often capacitively coupled. However the outputs can be DC connected to the supply as through a coil. They can be used either singly or in balanced form. If possible, the output circuit is arranged to reject the unwanted frequency. If the application needs to be able to select either sum or difference output, it is quite in order to have two different tuned circuits, one on each output. The fact that both input and output impedances are the same is the key to bi-directional switching (e.g.. Tiny Tim, Yeovil) since the same tuned circuit can be connected to input or output.

Oscillator/buffer section

This part of the chip can be used as an oscillator or as a buffer; when used as an oscillator most of the common configurations can be used either for VFOs or with crystal control, it should be able to oscillate at up to 200 MHz. See examples alongside. When the mixer section is working at its maximum levels, there is a risk that the oscillator section may suffer frequency pulling so in these cases its best to use a separate oscillator transistor and use the 602s devices as a buffer to isolate the oscillator from the mixer. As with the mixer section, the inputs should be AC coupled. When used as a buffer, the input should be in the range 200 to 300 mVolts peak to peak; the input impedance is unspecified but is over 1 KOhms which makes it easy to drive from an external VFO etc.. (Its also high enough to not load a low impedance RF phase shift network such as might be used in a phasing receiver.) The buffer's emitter can also drive a cable to a counter so avoiding the cable loading the oscillator and causing pulling.

G3PCJ.

