Hot Iron

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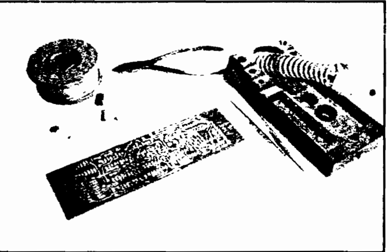

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Editorial

A new computer and digital camera - hence a vast number of hours finding out how to do simple things! Just too many knobs – rather like modern black box rigs! I just hope that the image on the left photocopies all right! I told my wife that I had to buy these gadgets so as to be able to send out sensible press releases etc. - that produced an instant demand that I photograph her topiary, which is one of her interests – far too difficult and needs good weather! It is extraordinary how we now take for granted all sorts of gadgets that seemed really quite revolutionary not all that many years ago.

The same applies to radio gear. I have been trying to simplify some of my designs, being conscious that some competitors seem to sell very much simpler kits successfully. I keep coming unstuck though because I reckon that most of us consider things like receiver sidetone in a CW transceiver as almost essential – I know years ago it would have been considered an unnecessary luxury! Having decided to incorporate it, then it has to be free of nasty clicks or thumps every time the key is open or closed, be of a good pure note, preferably with adjustable audio level also! Despite many tens of hours addressing this specific requirement, and all sorts of experimental circuits, I still don't feel entirely satisfied with my current design! It has also to use standard low cost components, preferably values that are used elsewhere within the kit so as to minimise the total number of different parts. My current circuit uses two small MOSFETs and about a dozen capacitors, resistors and a preset to set the level – it seems far too many! Clicks and clunks are particularly difficult to avoid - clicks often come from too sharp rise and fall times of a signal's envelope, whereas clunks often come from changes in DC levels in the audio path between key up and down. It is often quite tricky to find out the source of such clicks and clunks and other transients due to transmit/receive changeover!

Kit Developments

I have tested a new version of the 5 digit counter to replace the existing design which is showing its age! The original is my longest running kit ever – the text talks of rigs long since retired! The PCB size is unchanged but the new layout permits one end to be cut off if space is tight and you only wish to use three display digits. It will now also work with a supply down to 9 volts. Practically everything else is unchanged. The normal price remains £49 for 5 digits or £40 for 3 digits. Would anyone like to build one?

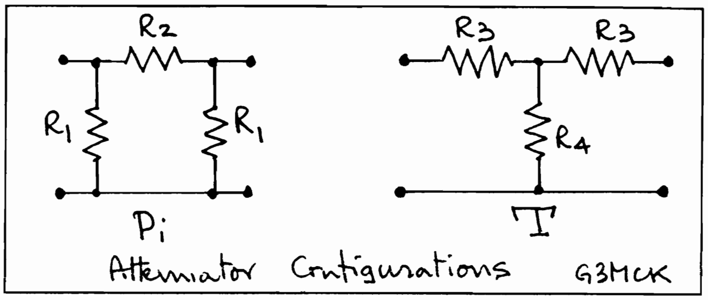
Somerset Homebrew Contest

Thanks to the good offices of the GQRP Club and Peter Barville G3XJS in particular, this contest will be held again this year with a first prize of a £50 voucher for anything from the Somerset Range. It takes place from 0900 to 1200z on Mar 24th on 40m. With the emphasis on homebuilt gear, you have to use either a homebuilt RX or TX or both. You do not have to have built them yourself. Full details in Sprat 109. Logs to G3XJS. Given the small number of entries, your chances of winning should be high! Tim Walford - Ed

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 always wanted. Please send any correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport Somerset TA10 9NJ. Tel 01458 241224 E mail walfor@globalnet.co.uk Subscriptions £6 per year for UK (£8 overseas) from Sept 1st

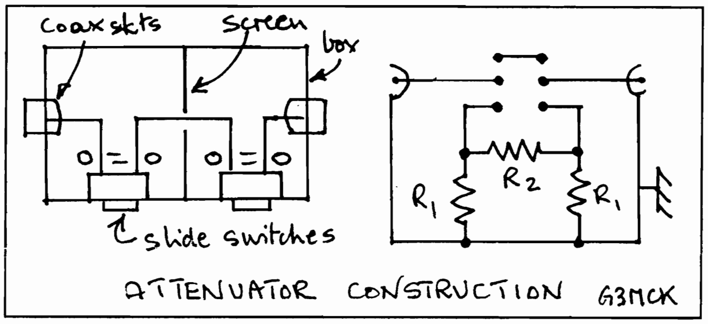
Attenuators by Gerald Stancey – G3MCK

These useful devices are used to introduce a known loss into a matched transmission line or as lossy matching devices. Let us look at the first use. Here two configurations are available; the Pi and the T forms – see right. In practice which one you use depends on what you have in the junk box! The values for R_1 and R_2 depend on the attenuation needed and the impedance of the line. Formulae for calculating them and tables of suitable values can be found in text-books but for use with 50R coax the table on the right give suitable resistor values in Ohms.



Attenuation	Pi form		T form	
	R_1	R_2	R_3	R_4
3 dB	*300*	18	*9.1*	150
6 dB	150	39	*16*	*62*
10 dB	*91*	68	27	*36*
20 dB	*62*	*240*	39	10

For attenuators that are used with a signal generator, 1/8th watt 5% resistors are suitable. The table covers most likely needs. If you need more attenuation, or other values, then connect two attenuators in series. Construction is easy – see right; simply mount two coax sockets on a piece of PCB or build it in a tobacco tin. They can be bypassed by a simple two pole slide switch. A set of attenuators can be built into a single box provided it is divided into separate compartments to prevent signal leakage from one section to the next. All leads should be kept as short as possible with the resistors being fitted direct to the switch tags. Where the table calls for non-standard resistor values (shown in italics) use either two in series or parallel to obtain the desired figure.

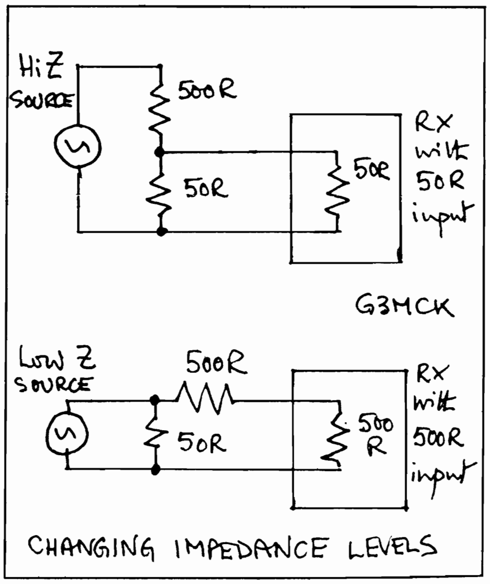


S Meter Calibration

This is straightforward if you have signal source of known strength and a set of attenuators. Set the signal generator to a suitable output level, switch in suitable attenuators and then note the S meter readings. Take S9 as 50 micro-volts PD across 50R and one S point as 6 dB. However if you only have the signal standard described in Hot Iron 33 don't despair! Proceed as follows. Make a 6 dB attenuator, preferably with a bypass switch. Feed a signal from the standard into your RX with maximum RF gain and note the S meter reading. This will be your standard against which all signals are measured. Insert 6 dB of attenuation and note the new reading S_A, remove the attenuation and decrease the RF gain until the meter reads S_A again. Insert 6 dB attenuation again and note the new reading S_B, remove the attenuation and decrease the RF gain till the meter reads S_B again. Repeat as often as you wish. You now have an S meter calibrated in S points against your standard and you can now give realistic relative signal strength reports. Its not a lab method but will give much better results than relying on typical S meter readings.

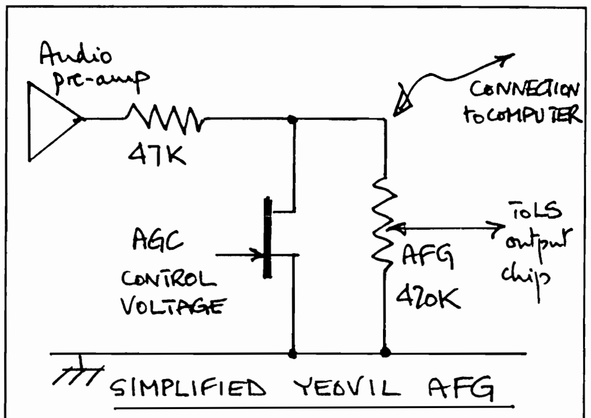
L Section attenuators

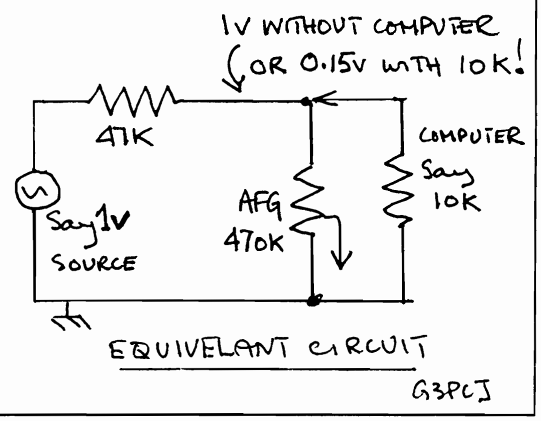
The box right shows a signal source that has a medium to high impedance output connected across an L type 13 dB attenuator – the 500R and 50R resistors. The Signal source will see a load of 525R and the RX will think that it is being fed from just under 50R. You can add 50R attenuators between the L network and the RX. This arrangement can be used to make a signal generator from a BC221; in practice 47R and 470R resistors are suitable. With my BC221, output is reasonably constant over 2 to 4 MHz and can be considered flat for small frequency changes (but do check yours). Using your signal standard and attenuators you can measure the BC221 output plus the L network in terms of your standard. The circuit can also be reversed as shown in the lower part for matching into a 500R load such as RXs like the HRO.



Output Impedance and Loading

Recently one of our members was trying to connect his Yeovil to the sound card input of his computer so that he could explore PSK31 etc. He found that, when he made the connection across the AF gain control (to avoid the level changing with AFG setting), the Yeovil's normal audio output was decimated! The explanation is fairly simple! It so happens that the circuit driving the Yeovil's AFG pot has a relatively high output impedance, roughly 47K to enable the rig's AGC to work on this point. This is why the AFG pot has an unusually high value (for modern rigs) of 470K. With no AGC action (full gain) the 470K pot does not attenuate the output through the 47K series resistor; however when reduced gain is required on strong signals, a FET is turned on across the AFG so that the 47K is now in series with a much lower effective value across the AFG. This forms a variable attenuator! (See previous article.) The computer input impedance is likely to be of the order of 10 to 50K, so even at the higher figure, it will halve the signal at the AFG due to the rig's series 47K resistor. If the computer's input impedance is even lower, the attenuation will be even more. The moral is that if you are to avoid unwanted attenuation, the load from any 'additional' device should be at least 10 times the source impedance at that point. This principle applies at any frequency and is equally applicable when connecting test gear to equipment being investigated. (At high frequencies extra stray capacitance becomes important and may make the above approach impossible so that low impedance matched connection to loads is necessary. In this situation, the open circuit voltage is often twice that registered when the load is connected - think of this situation as an attenuator.) Tim G3PCJ





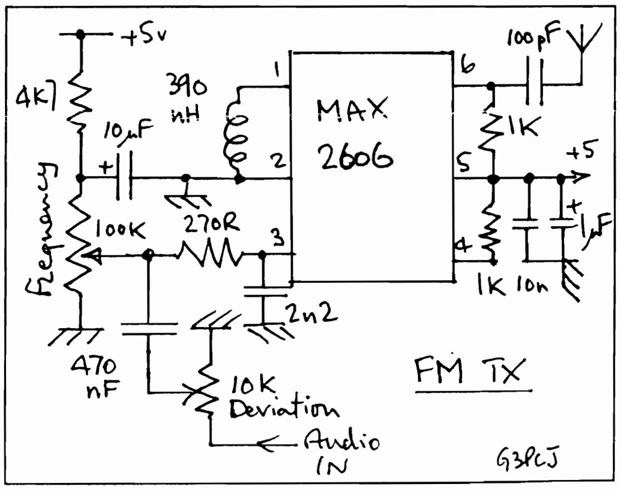
18th QRP Convention – Digby Hall, Sherborne April 21st 2002

Yet again a full programme of talks, displays, trader's stalls, morse tests on demand, QRP Forum, etc. etc. Make a note in your diary now! Steve Hartley, who writes the Newcomer's News in Radcom, will be amongst the speakers. There is a dinner the night before which is usually a very sociable affair! I am sure that you will all have already started on your entries ready for the Construction Challenge! The task is to build a stable 40m VXO with the widest useable frequency range. The 9 volt power supply and 7.03 MHz crystal will be provided by the adjudicator. There is also the Fun Run for CW contesters wanting to pass the time of day in a leisurely manner - between April 1st and 4th inclusive on 40 and 80m. Overnight accommodation can also be arranged. Full details of all these events from George Davis G3ICO QTHR.

Single chip FM transmitter

I spotted this design in some recent Maxim literature which suggests that most countries allow such low power unlicensed transmitters. They suggest you can listen to your favourite CDs at the bottom of the garden (with a portable domestic FM RX) by connecting your Hi-Fi audio output to drive this TX! The chip contains a voltage controlled oscillator using an internal varactor diode. Carrier output is –21 dBm into 50R on a 5 volt regulated supply. Use a 75 mm rod as an antenna. Tune it to a blank part of the 88 to 108 MHz band with RV1 and set the deviation for comfortable received audio level with RV2. (The audio input should not exceed 60 mV). G3PCJ

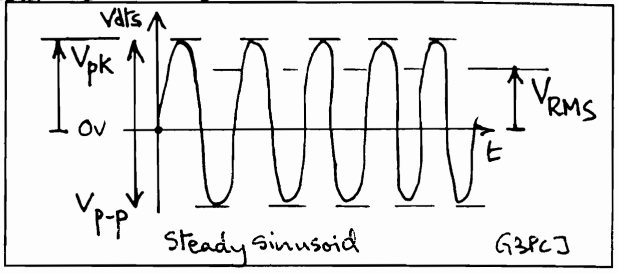
Check the rules before radiating!



Measuring RF Power

The DC power going into a resistive load is the product of the current through and voltage across the load. For an AC sinusoidal signal, the power is the product of RMS current and RMS voltage. Using Ohm's Law, it can be re-arranged into the more useful form as $(V_{RMS})^2/R_L$ where R_L is the load resistance.

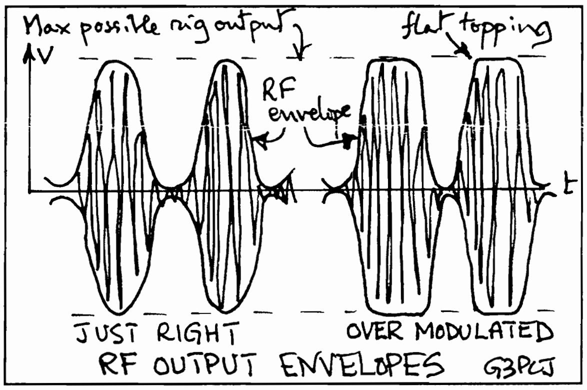
For these sinusoidal signals, such as that shown right, there is a simple relationship between RMS voltage and the more easily measured peak voltage. The peak voltage is √2 times the RMS voltage, so with a little juggling and squaring:-



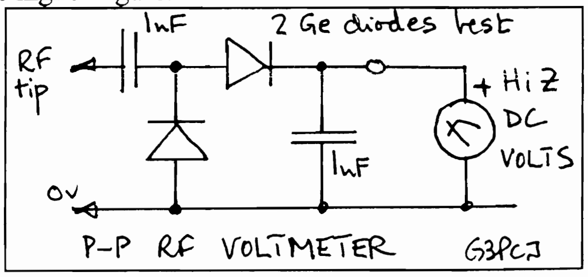
Power = $(V_{pk})^2/2R_L$ where V_{pk} = peak voltage.

For most transmitters, under no signal conditions, the output devices will have the rig's supply voltage on their collector or drain; when these devices are turned on by the input signal to give maximum output, they conduct fully, drawing the collector or drain to as near 0 volts as they can. Hence the instantaneous output signal starts at the supply volts, goes to 0 volts (or very nearly in a practical rig), and then because it is driving some sort of tuned load, the signal on the collector/drain will go on up to a maximum value which is twice the supply voltage and then back down again. This leads to the common expression for the maximum output of a transmitter being $(V_{supply})^2/2R_D$ – note that here R_D is the load on the device's collector/drain which may or may not be 50R. This tells us the maximum RF power that the rig can produce under any (sensible) conditions – either steadily for CW or momentarily for SSB. If the rig is producing CW, it will be what a commercial RF power meter would indicate. It can be easily measured with a scope or RF voltmeter since the RF envelope is nice and steady like that above. It will also be the maximum that it can produce on modulation peaks if it is an SSB (or AM) rig, and will be the peak envelope power or PEP figure. Note no doubling of figures here!

The best way to set up a SSB transmitter uses a 'two tone' audio signal to modulate the rig with the RF envelope then being observed on a scope. This makes it easy to see when it is being overdriven leading to the undesired flat topping of the modulation peaks which causes that horrible splatter either side of the nominal carrier frequency. The two tone audio signal is made up of two unrelated audio frequency signals with equal amplitude. The envelope of the resulting RF signal should be a nice sine wave at the difference of the two audio frequencies as shown right. Most mechanical RF power meters would not give the correct figure on this complex waveform because it is not a steady constant amplitude signal. The modulation peaks can be measured with the scope but historically, the easiest way was to turn off one tone leaving the other producing a nice steady signal which could be measured. Since the peak with both tones on is twice that of each tone alone, the PEP figure *is twice* the steady power out which *each tone would produce on its own whereas together they just cause limiting*. This is the origin of the myth that the CW output figure should be doubled for SSB! It should only be doubled when it is the CW power out of either single tone of the limiting two tone combination. The rig is however able to produce CW up to the higher figure.



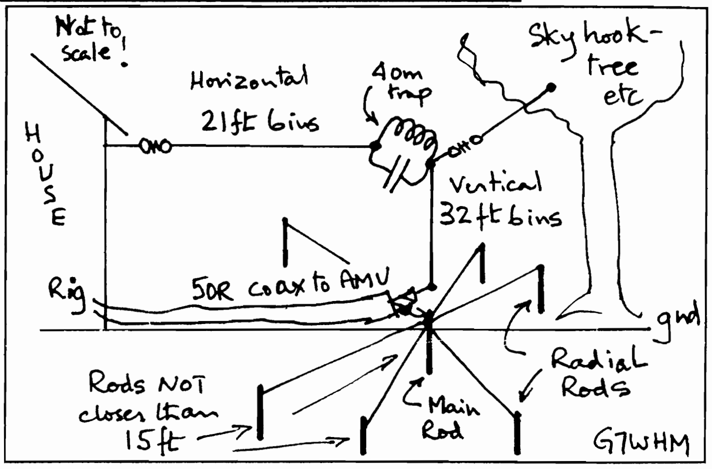
An easy way to measure the RF power of a steady CW signal uses a diode detector and high impedance DC voltmeter. The circuit shown right measures the *peak to peak* voltage of the RF so it is important to use it on steady sinusoidal RF signals. (It will give funny values on spiky and complex waveforms such as the two tone signal.) Since the peak to peak voltage is double the peak voltage the formula becomes Power = $(V_{p-p})^2/8R_L$



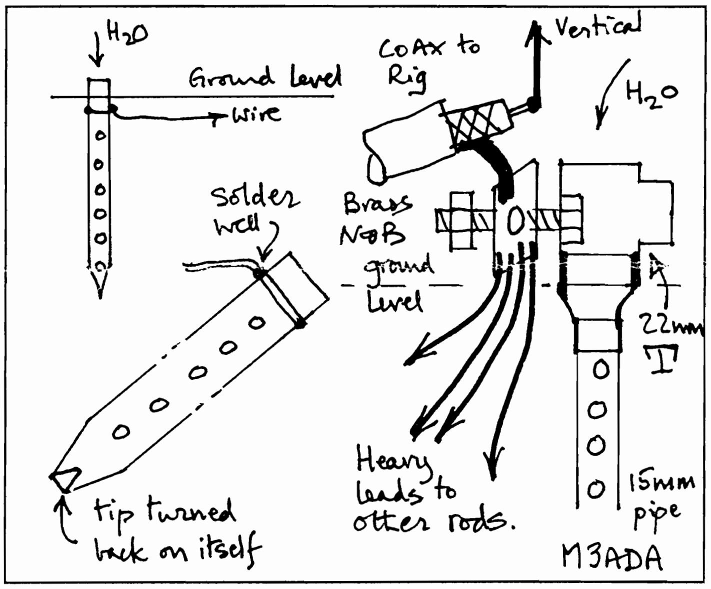
If you are measuring the power from either single tone alone of a limiting two tone signal you may then double it for the rig's SSB PEP figure! If it's the maximum steady CW output that it will sensibly produce, then it is also the PEP figure!

Tim G3PCJ

The Semi-vertical Trap antenna – Andy Howgate G7WHM and M3ADA



I found this design by G3RNL in a book called the HF Antenna Collection. My wish here is to particularly describe the 'earth' system; this is most effective but does NOT require the whole garden to be dug up and should be more acceptable to those members of the family less directly involved with radio! As can be seen right, the antenna has a vertical section over a good earth system, then a 40m trap and a further horizontal section. In essence it comprises a quarter wave radiator over a ground system for 40 and 80m. Consequently it should have a lowish impedance on these bands at the feed point and so present a fair match to the coaxial feeder. It will radiate on other bands but needs a good AMU and coax losses maybe high. I have laid mine out with the vertical section furthest from the house to get it away from house wiring and to make the 'earth' aspects easier. That also reduces the chance of you puncturing some vital buried service like gas, water, electricity and drainpipes to soakaways with earth rods near the house. Like most unbalanced antenna systems, it needs a good RF earth, which I achieved by a central ground 'rod' connected to several earth radials each terminated in a ground rod(s). For the radiating and earth wires, use the thickest plain copper wire that you can obtain (with or without insulation) or which the tree etc. will support! The trap is made of 23 turns of 18 gauge enamelled wire on a 1.25 inch diameter former resonated by 50 pF in parallel. It is adjusted to resonate at 7.1 MHz with a GDO by squeezing or expanding the turns along the former. Use a good quality high voltage capacitor and, after adjustment, fit inside a weather proof container. Use as many additional ground radials and rods as space or effort will permit – you can put two rods on a radial but allow at least 15 feet between any two rods. The original article suggested 3 ground radials but I fitted 6 and don't regret the extra work at all!



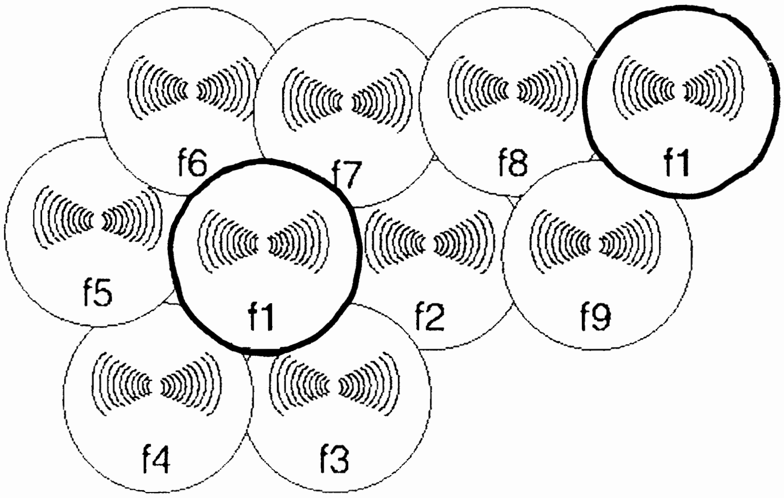
I decided against using the commonly available 'mains' type earth rods and made up specials using 15 mm copper water pipe. Make them as long as you think you can drive into the ground with the help of a pilot hole made by a very long slightly smaller old masonry drill or suitably pointed steel rod – not less than 3 ft! Don't attempt to make the pilot hole in one go, rather you should drive the rod down say 6 inches, rotate it and withdraw, then down another 6 inches etc.. Drill ¼ inch holes in the copper tube every 6 inches to let the water out that you will later pour down the tube to improve contact with the ground. The tip of the tube should be doubled back and formed into the shape of wedge. The earth wire should be generously soldered to the top of the tube and then the tube driven down with a rubber mallet till the top is just above ground level. The radial earth wires can be just buried within the lawn by making a small slit with a spade. The main or central earth rod requires a more elaborate connection scheme to join up the coax outer and the several earth radial wires. I used a 22 mm equal T pipe fitting soldered to the top of the 15 mm tube with a Yorkshire style 22 to 15 mm reducer. A hole for a large brass nut and bolt is drilled through the back of the T piece. This takes a copper (flattened off cut of 22 mm pipe) or brass plate to which the coax outer and radials are soldered. After tightening apply a generous covering of lithium grease. It took me 3 hours to make 7 rods, an evening for the above ground parts and a good day to install and bury some 90 ft of wire! I can always add more if necessary, I don't have blisters or back problems and the wife is happy because the garden looks the same! I wonder if she will mind if I ask her to water the earths as well as her plants (perhaps not). I would love to have some comments from other members on this scheme and how they think it could be improved etc.. (Get your pens out please! – G3PCJ)

The GSM Radio System – by Paul Tuton G0UBV

For a while now, I've been promising Tim a GSM overview. It's actually quite tricky. The GSM specification amounts to at least 6000 pages and almost every GSM fact has ifs, buts and maybes, all depending on… So in order to keep it to a sensible length and digestible, I've taken a few liberties with the details. As you get deeper into how GSM really works, the astonishing thing is that it works at all, so here are some of the key principles.

There are two frequency allocations for GSM, in the region of 900MHz and 1800MHz. I'll focus on 900MHz though principles are much the same in both bands. Base stations (the masts you see all over the place) transmit to the mobiles between 935MHz and 960MHz, and the mobiles transmit to the bases on corresponding frequencies that are 45MHz lower. So we have a 25MHz bandwidth that is shared between the network operators. Analogue speech is sampled and digitally coded into a 13Kbit/sec data stream. The carrier is frequency modulated with this data using a two-level digital modulation called Gaussian Minimum Shift Keying. GMSK was designed specifically for GSM, and it has a near-optimum combination of several desirable properties. These include small bandwidth and resistance to interference.

GSM carriers are spaced at 200KHz so there is capacity for 125 carriers, though one frequency is unused in order to provide a guard at the band edges. All traffic takes place on one of 124 paired carrier frequencies (for the mobile & the base station). A significant advantage that GSM provides over the earlier analogue systems is an increase in capacity. GSM achieves this by digitally 'dividing' each carrier into 8 time slots. When you make a call, the GSM system allocates a pair of carrier frequencies and a time slot within the carriers so the latter can be shared with 7 other users. Ignoring system control traffic, in principle a single base station could support 124x8 = 992 simultaneous users. To increase the number of actual users, we reduce the transmitter powers so that ranges are limited, and divide the required geographic coverage area into cells. Each cell has a base transmitter with a limited number of carrier frequencies. The same frequencies will be used in other cells, but a 'frequency reuse' plan ensures that the potentially interfering cells are far enough apart to avoid problems. The diagram illustrates the principle:



In rural areas, the cell radius might be anywhere between 5Km and 20 Km. In dense urban areas this can reduce to 500m or even down to 50m. Where users tend to congregate (railway stations, airports etc) more / smaller cells are required. A typical cell might be allocated 4 carrier frequencies. That means we have 32 timeslots of which 2 will be used for system traffic (SMS, 'ringing' a mobile etc) so it will support 30 simultaneous users.

Now comes the interesting part. What percentage of users will be active at any one time? This, of course, determines the service level and you will not find it easy to get 'actual' figures! Some of the figures that I have seen surprised me. 1 in 25 for example. No wonder you can never get through if you're in a traffic jam. Our 30-user cell can support 30 x 25 = 750 potential users. We just have to hope that only 1 in 25 of them wants to communicate at any given time.

The transmitters in the individual cells must be controlled, interconnected with each other and also to the public telephone network. The mobile network has a number of interconnected 'Mobile Switching Centres' (MSCs) which are rather like conventional exchanges. The 'main' MSC has a connection to the public telephone network. A central database contains details of all the subscribers to the network and each

MSC maintains its own database of mobiles that are presently active within its area of control. Each MSC controls several Base Station Controllers (BSC) which in turn control several Base Transceiver Stations (BTS) or individual cells. Each BSC manages the radio resources (mainly carrier frequency and time slots) for all the cells that it controls. So there is a hierarchy of MSC / BSC / BTS with interconnections at each level. The MSCs and BSCs are software-controlled switches and computers. They provide intelligence and control while the BTSs provide the radio connections. The MSC knows about subscribers and where they are, a BSC knows about the radio resources that its BTSs are using, and a BTS does what it is told by its controlling BSC. The whole agglomeration of MSCs, BSCs and BTSs forms a *"Public Land Mobile Network"* that is owned and managed by its operator.

When you switch on your mobile, it sniffs around and picks up broadcast channels from BTSs in the vicinity. After some discussion, the mobile and the system agree on the best BTS to use and the mobile associates with it (for the moment). The fact that the mobile is now 'on' is recorded by the MSC that controls the area. The MSC accesses the central mobile / subscriber database, locates the record for this mobile / subscriber and updates the 'location' entry to indicate that this MSC is where this particular mobile can be found. At the same time, the MSC reads (from the central database) subscriber details that are essential to authorise and control calls (e.g. details of subscribed services). The MSC stores these details in its own local database together with the present location of the newly-switched-on mobile.

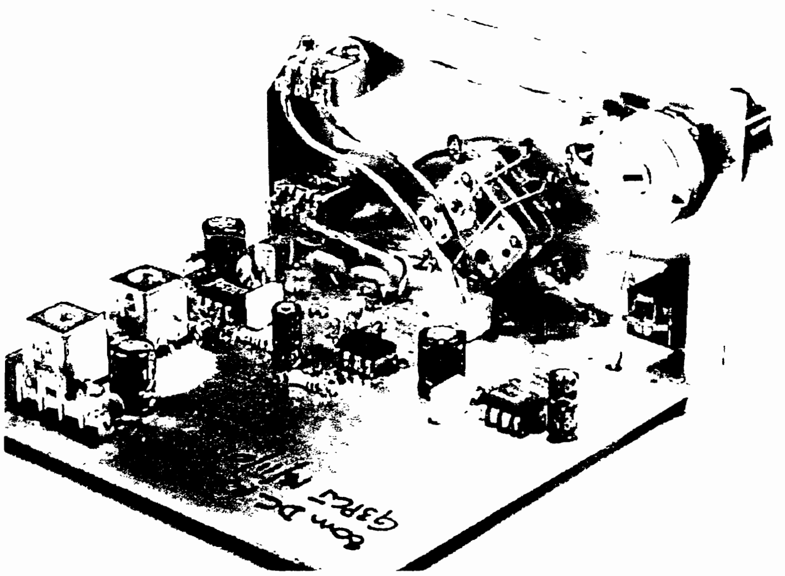
At one extreme, an MSC could record the finest detail of the actual cells for all mobiles in its area. This has the advantage that when an incoming call arrives at the MSC, it already knows exactly which specific cell it should page[1]. But this approach would generate an impractically large number of location updates as mobiles move from one cell to the next. At the other extreme, when a MSC receives a call for a mobile that could be anywhere within its area, it could page all its cells to find the specific cell containing the wanted mobile. Since an MSC might control an area the size of Wales this is also impractical! In reality the MSC records a mobile's position by "Location Area" - a cluster of adjacent cells. A location update is needed only when the mobile moves out of the cluster. In view of the extreme range of cell sizes, this is one of many factors that are adjustable in order to maintain an acceptable overall level of service.

Clearly the system depends on very complex computing systems and communications networks without which the actual line of sight radio equipment would be useless!

[1] Paging is a message that says 'are you able to take a call' and it is directed to a specific mobile. A mobile in the standby state has not yet been allocated a carrier / timeslot for the call, so the page takes place on one of the cell's 'common control channels'. These channels are monitored by all mobiles in the cell, at all times when they are in standby. When the mobile indicates a willingness to accept the call, carrier frequencies and timeslots are negotiated, the ringer sounds and so on.

New Rigs!

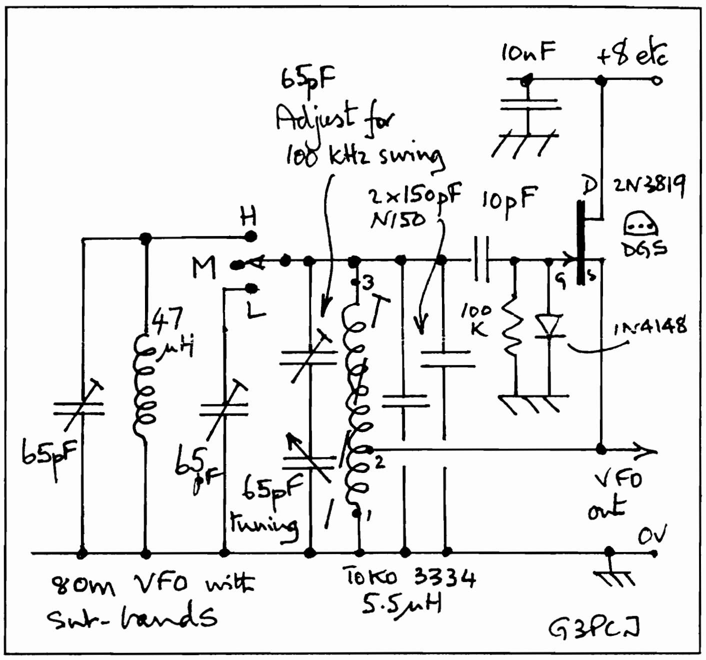
Since we have an extra page this time, I thought you might like to see a photo of the Compton.



Just to remind you, it is a serious 80m direct conversion receiver with audio filters for phone and CW. Able to drive a LS. No need for a counter to set the VFO since it uses two ceramic resonators selected by a switch giving coverage from about 3.52 to 3.7 MHz. Double tuned RF filters. Three integrated circuits only. Very easy to get going with the minimum of test equipment! It costs £39 for everything to build it as shown, plus £1 for P and P please. You can even add a Mixer kit working as a receiving converter to add 20 and 40m! The Dundon is the matching CW transmitter.

VFO with sub-bands

In an effort to improve frequency stability, it would be nice to avoid using varactor diodes. Their drawbacks are the need for a highly stable tuning supply voltage and an uncomfortable relationship between their temperature and capacitance. Varactor diodes suitable for HF VFOs are now also becoming like hen's teeth! Air variable capacitors are out since their cost is exorbitant! Instead, the style of variable capacitors known as Polyvaricons, are cheap and effective but they only have a 180° shaft rotation. Without using an expensive and difficult to mount reduction gearbox, the maximum frequency swing that is practical is about 50 to 100 KHz. For full coverage of a band like 80m, there is a need to have at least three sub-bands of about 100 KHz each. Adding some extra capacitance for one sub-band is easy with a toggle switch and a trimmer. The challenge is to get another sub-band using a centre off toggle switch, where the third sub-band has a higher frequency than the central off position. I have not actually tried the scheme shown above but I am confident it will work. By switching a further coil in parallel with the main one, the resonant frequency will increase; providing it always goes beyond the minimum increase required it can then be brought back down again with a trimmer. Although the actual frequency range on each sub-band will not be identical, they will be sufficiently close to allow a common incremental calibration – say 100 KHz segments for each sub-band. The values shown should be suit an 80m VFO for a DC RX. G3PCJ



Digital Potentiometers!

Equipment designers have long disliked mechanical devices like conventional pots as their cost is out of proportion to the rest of the electronic components. (Knobs are my pet example of excessive prices for what they are!) Chip designers have come to their rescue by integrating resistor chains on the same die as a series of electronic switches which connect the 'pot' output terminal to the desired tapping point. The same approach is now available for setting the gain of an op-amp under remote control by a micro-processor. There are many versions of such devices, often with very simple control methods such as simple up/down buttons to adjust the 'pot'. There are even versions which have a non-volatile memory of the output tap position! Needless to say they are all extremely small with surface mounting onto the PCB! They are excellent for tasks such as an AF gain control. I pondered if it might be possible to use such a digital 'pot' as tuning control for a varactor diode controlled VFO. Despite such 'pots' commonly having 256 tap positions, the resolution is nothing like small enough for tuning purposes. It emphasizes the challenge of making a VFO which has to be controlled within about 10 Hz over a range of 300,000 out of 3.5 million (for 80m) and not drift thereafter! G3PCJ