

Hot Iron

Issue 25

“Journal of the Constructors Club”

Autumn 1999



Contents

- 50Hz & RF earthing
- Joseph Bell's circuits
- Quote & Radstock note
- Direct Digital Synthesis
- Six metre Linear
- High speed logic
- Real components

Editorial

Welcome to the start of our seventh year of the Construction Club which will span the anniversary into the new Millennium. The last 100 years (roughly) since radio was 'invented' have seen increasingly rapid developments and the last 6 years in the world of amateur radio construction are no exception! There is no sign of things slowing down. As is happening in the commercial world, the technology of radio and computing are growing closer together. I wrote last time about the 'software radio' concept and nowadays digital techniques are widely used even in test gear for analogue equipment. A later article in this issue discusses the merits of Direct Digital Synthesizers (DDS) to replace conventional tuning oscillators - this is another example of digital techniques permitting significant improvements. Sooner or later we serious home constructors have to bite the bullet and tackle more complex digital matters and the other hurdle of surface mount technology. The latter has to occur because all the new interesting devices are now only made in surface mount package styles. Given the tremendous value of 'owning' a decent oscilloscope, I wonder if members would be interested in a test gear

project for a 'bandwidth extender' to use in front of a plain scope with limited bandwidth. It would take in high frequency signals, say up to 30 MHz, digitise them in an 8 bit analogue to digital converter for storage in a digital memory, and then spew the data out again at say 100th of the original sampling rate into a digital to analogue converter for display on a lower bandwidth scope. (A more complex version could feed into a PC but I am not up to the software!) An alternative project would be a DDS unit, perhaps as a signal generator or replacement VFO. I welcome your views please.

Kit Developments

Farming and work on barn conversions have got in the way so not quite so much to report! The **Pridy** (DC RX for 20,40 &80m) and **Minehead** (DC CW TCVR up to 20m) are now available. The **RT Chedzoy** is fully out with an article in the August issue of Radio Today magazine. It is aimed at first time constructors. Apart from medium wave, it can be tuned to either 80m or the broadcast stations near 4 MHz. It can copy AM, CW and SSB. I have been trying to improve my **Antenna Matching Unit** design with increased power, say to about 30 Watts, and to make its construction slightly less fiddlesome. Obtaining reasonably priced air spaced variable capacitors is the main hurdle; G3TUX kindly inquired about these when he was recently in the States and reports that kit suppliers there have the same problem. For this application, where smooth continuous variation in capacitance is not essential, I suspect the most cost effective solution is to use a range of increasing capacity high voltage fixed capacitors switched into circuit with toggle switches. Edge mounted tuning meters are also a bit expensive so I think that a change to an RF driven LED indicator can make an appreciable saving in cost. The technique will be to tune for least brightness. This approach suggests an updated design of my L match AMU can come **down** in price to between £30 and £35. Any early builders?

Having revamped most of the Somerset Range during the last 18 months, I am on the lookout for new ideas. What do you want to build that is not available in mine or other suppliers lists? Some have suggested valved projects but I am not keen for a variety of reasons; apart from the obvious ones, I would have to stock up with a completely different set of 'impossible' to obtain parts! Letters on any topic from members are always most welcome.

Tim Walford G3PCJ Editor

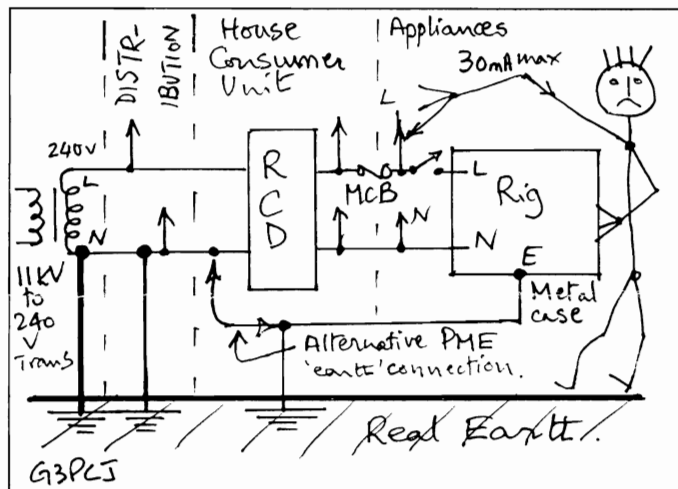
Earthing for 50 Hz & RF

David Proctor G0UTF asked for a note on the best way to connect up mains power supply, rigs, antenna matching units and antennas. None of our 'consultants' was willing to tackle this topic, so its down to me! Apologies for the length, but there are many aspects. Firstly the mains safety bit.

Mains earthing

Modern domestic wiring should be protected by a *residual current device* (RCD) which senses when the current in the 50 Hz main incoming phase (or live/line) wire and the neutral wire are not equal and then turns everything off. The currents are unequal when some of it 'escapes' somehow to earth and back eventually to the neutral connection of the electricity substation transformer so that less flows in the neutral wire through the RCD (see circuit). Usually this condition indicates a fault, either through poor insulation of some live part, or worse, due to a human standing on the 'earth' while in contact with a live part. Of course we don't have actual earth all over our houses, so the next best thing is to connect (or bond) all exposed metal work together through the mains earth wires with extra bonding to pipework etc., and to connect this lot to the best available earth. In ordinary houses this takes the form of an earth rod or spike driven into the ground. RCDs are available with a range of sensitivities but often a 30 mA device is used to protect sockets and normal domestic appliances. This current is (alleged to be) below the fatal levels for humans (do NOT put it to the test!) and can easily be passed by earth spikes without a significant rise in voltage of the mains earth metalwork above actual earth. So when you inadvertently connect yourself between something live and the 'earthed' metal work, the RCD senses that less current is flowing in the neutral wire and turns itself off before you can leap to the switch.

In high rise flats, you cannot have individual spikes driven into the actual earth, so an alternative system had to be devised; it uses a technique called *protective multiple earthing* (PME) where the supply neutral is frequently grounded (with buried wires) throughout the local distribution network in addition to the neutral connection on the distribution transformer. (This often done anyway.) By doing this, the neutral wire can be assumed to be as near earth potential as is reasonably possible in these difficult buildings and the electricity supply companies allow the exposed mains earth metalwork to be



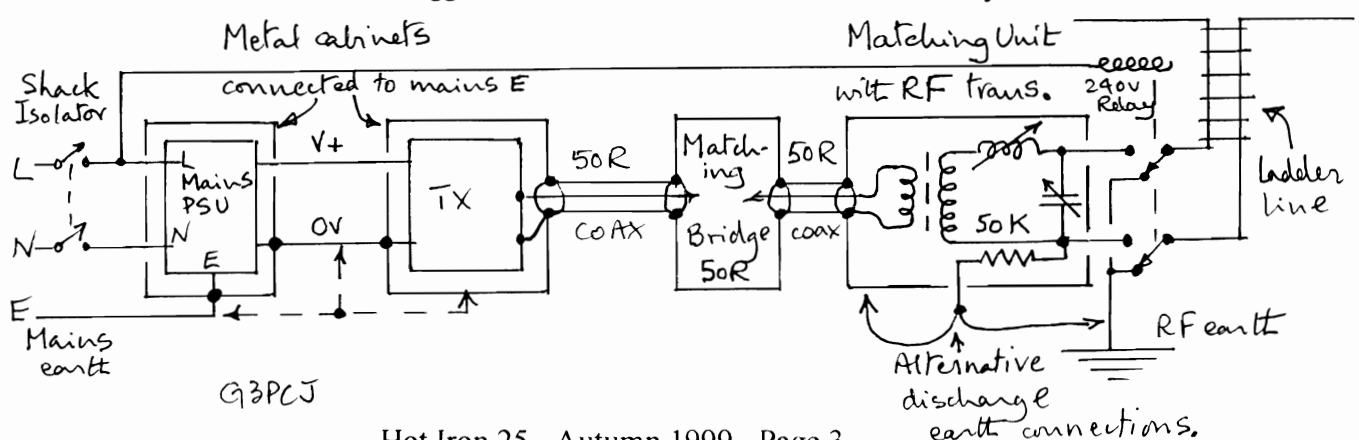
connected directly to the neutral. As before, if a leakage path exists between live and the mains earth metalwork, a lower current flows in the neutral conductor through the RCD and it turns off. This system is supposed to be safe even if the incoming mains neutral is broken because then everything is live including the 'earthed' metalwork, so with no voltage difference between live parts and 'earthed' metal work, you should not get a shock. The problems come if you can touch a live part and real earth, either something connected to a spike in the ground or an RF earth such as buried radials associated with an antenna. (Think also about outside water taps fed by metal pipework!) Now you would feel the full 240 volts so it is important to prevent contact between mains earth and real, or RF earth, if you use PME and the incoming neutral as the basis of mains earthing - a separation of 2m is suggested between different types of exposed earth metalwork to obviate contact by outstretched arms. Using an RCD is still sensible even with PME and it is a good idea to have your shack supplies protected by their own RCD even if the rest of the house is covered by another RCD. (The older style of voltage operated safety trips are no longer in favour and should be changed to RCDs.) Do not connect mains earth and RF earth together because if PME earthing is being used and the neutral does break, your RF earth wire might attempt to carry several hundreds of amps of 50 Hz - so see below regarding antenna matching units.

So the general advice is 1) always use an RCD, 2) have mains earth (and all exposed metalwork) connected by 16 mm² cable to a proper earth spike if possible, 3) avoid using the PME/incoming neutral earthing if there is an alternative, 4) prevent contact between mains earth and RF earth, 5) do not connect mains earth to RF earth. This short note does not fully cover the subject so please do take advice from a qualified Electrical Engineer if in any doubt and explain there is an RF aspect.

RF earthing

If the antenna system is balanced with equal length radiating arms (or a loop), then RF earthing is seldom a problem because there is return path for the 'outgoing' feeder current from the antenna matching unit (AMU) which enables it to return through the other feeder wire and back into the AMU. By implication the two AMU output terminals must not have any *internal* low impedance connection to RF earth and will often (but not always) be fed by a symmetrical circuit within the AMU. A balanced circuit is preferred for balanced feeders, e.g. ladder line, but can also be used for coax fed balanced radiators; here the radiation pattern maybe skewed by induced RF currents on the outside of the coax which do not have a proper return path through the AMU - hence the use of coiled up coax 'choke' baluns. For unbalanced radiators such as verticals or end fed long wires there is no copper wire return path and some sort of connection must be made to the actual physical earth to allow the driving current to return to the AMU. Because the need for this connection is often overlooked, it can lead to a 'hot' shack with 'RF everywhere'. Often the next best available earth is perceived to be mains earth, so people do join one side of the their AMU output to mains earth but as explained earlier, this is not a good thing for mains safety reasons. Furthermore, it seldom provides a good low impedance RF earth, risks RF currents through the PSU and may turn off the RCD trip. The ideal solution is to provide a good RF earth, connected by short thick low inductance cable from the AMU to a system of ground spikes or a mat of wires buried over a large area. This is not always possible, especially for the awkward high rise flat, so a counterpoise has to be used; this is a quarter wavelength long for the frequency in use and in crude terms, is providing the missing other half of the ideal balanced radiator. The main point is to provide a known path for all the currents, RF or 50 Hz fault currents, so that they are under control always! Hence the need for the RF output circuits of the AMU to be 50 Hz isolated from the transmitter's output and its chassis, which is likely to be the power units 0 volts and hence also connected to mains earth. This is why the AMU should have an RF transformer or link coupling circuits within it. It is a good thing to have a DC path between elevated radiator arms and earth (of any sort) to provide a static discharge path which will also help prevent lightning strikes. This should be fairly high impedance so as to not waste RF energy but it will not prevent serious damage if you do suffer a direct lightning strike. Another sensible scheme is to automatically ground the antenna when the power is off using a relay.

Finally a few points on AMU design. The internal output circuitry does not have to be fully symmetrical for feeding a balanced feeder and radiators; it is better but the complications often mean that an asymmetrical RF 'floating' arrangement can be accepted with the small penalty of skewing of the radiation pattern due to slightly unbalanced feeder currents. A separate RF output transformer can be used on the output of an asymmetrical matching circuit but it should have a ferrite core (not powdered iron to obtain sufficient leakage reactance), and it should work into a flat feeder line without standing waves due to a mismatch between radiating arms and the feeder - the reason is ferrites do not like reactive high power loads. This restriction means that such balanced AMU output transformers are less flexible than schemes where the output terminals connect direct to the matching network which thus allows them to absorb any reactive effects from random length line and mis-matched radiators. It is quite in order for the tuning inductor of a matching circuit to use a powdered iron core. The matching circuits should at least have a low pass characteristic to attenuate unwanted harmonics. It is also desirable to have a high pass characteristic to reject unwanted MF broadcast stations during reception hence the preferred option is a link coupled parallel (or series) tuned resonant circuit with a bandpass characteristic, and tapped for the anticipated load impedance. This can be complex for mutli-band operation so often the best compromise is an L match circuit fed by an RF transformer. This is the shown below with the suggested earth connections; this is the basis of my AMU kit. **Balanced ANT**



More circuits from Joseph Bell G3DII

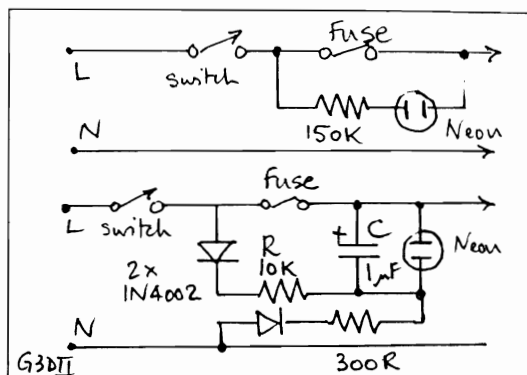
Blown fuse indicator

Wire a neon in series with 150K across a fuse and it will glow when the fuse is blown. Top circuit right.

Pilot light fuse indicator

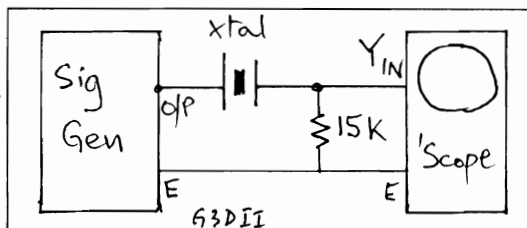
With the addition of two diodes, two capacitors and a resistor, the neon pilot light can also be made to blink when the fuse is blown. The R and C control the flash rate.

Take care with both these circuits due to the mains voltages!!



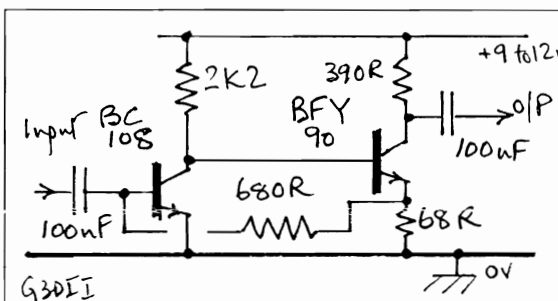
Crystal checker

This simple circuit can check the activity of a crystal and the calibration of your signal generator. As the signal generator output approaches the frequency of the crystal, at the exact point of series resonance, there will be a sharp increase in value of the Y amplitude on the scope. If the signal generator has sufficient output amplitude, the harmonic activity of the crystal can also be tested but the frequency will not be exactly 3 or 5 times the fundamental.



Broadband amplifier

Some of the circuits I mention need one of these circuits - if you haven't got one then you should have! This is an old but very effective circuit with a gain of 24 dB in a 50 Ohm system into the low VHF range. The actual input impedance is 10R and the output impedance 390R but ignore these since in most cases there will be an increase in signal level. You will find many uses including buffering inputs to counters, raising levels for an insensitive scope or low output oscillator, etc..



Sticking meter needles

Most hams have bought meters at junk sales only to find that the pointer sticks at some point on its traverse. However it is often possible to remove a foreign body stuck in the innards of the movement using adhesive tape, Sellotape etc.. Fold a small length of tape sticky side out and trim with scissors to make a narrow tapered 'probe' just longer than the size of the armature. Gingerly move the tape in the circular path of the pole pieces until the foreign particles have been picked up by the tape. With care there is a fair chance of success without damage to the meter.

Quote by William Thomson, Lord Kelvin, 1824 - 1907

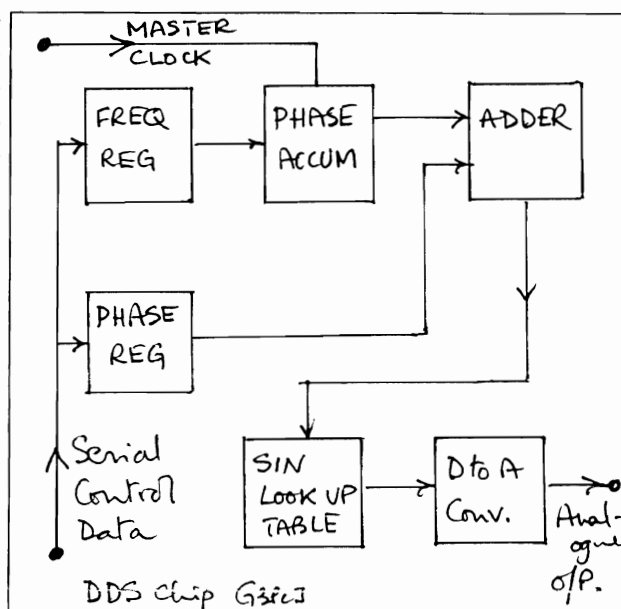
"When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: it maybe the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science."

Comments on the Radstock

After failing to find a vital part with the gadget in Hot Iron 17, David G0UTF, comments:-
"Driving someone else's car instead of your own is rather like using the Radstock after using your own simple DC RX. I found it strange at first with the very small audio bandwidth. Tuning through the bands to see what is there needs care as you are likely to miss those narrow bandwidths of signal. *But when you do get the hang of it, it is quite addictive.* When you tune in your signal, there is usually no other station! This is done by the 'phasing' method, which cancels the other sideband and emphasises the 750 Hz. This means the extra components make the PCB quite full. I took my time to build it - just two resistors crossed over and it worked well after the usual adjustments. After a few QSOs I fitted the board into a metal 280x85x190 mm case with a wide range of controls, LEDs and S meter. It has a nice solid feel. As an ex-Frome user, the Radstock is now my CW rig for 30/20m. After a week I have worked QRP stations from EA/OE/CT/IUU9/DL with my 'long wire' antenna."

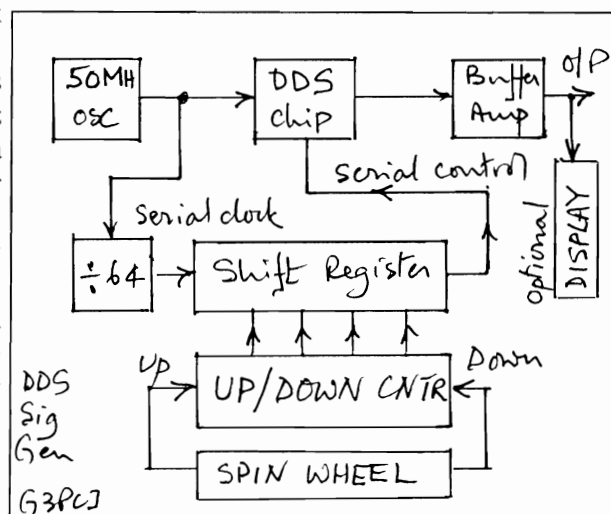
Direct Digital Synthesis

For signal generation up to around 50 MHz, the DDS technique has many advantages over conventional forms of frequency synthesis, particularly if any form of microprocessor is available to control what goes on. Its cost and complexity (in terms of the number of chips) is similar to a phase locked loop but its performance, in terms of frequency stability and agility/versatility, is very much better. I have recently been examining a DDS chip type AD9835 from Analogue Devices which can use a 50 MHz clock to generate a high purity sinusoidal output signal from nearly DC to 25 MHz maximum but realistically about 18 MHz if spectral purity is especially important - this is often the case for most oscillators. This particular product is in a 16 pin TSOP surface mount package with serial control signals for a micro controller. The device is pretty complex having provision for the instantaneous choice of two stored output frequencies either of which can have its phase instantly altered by up to four values - this is useful for novel forms of modulation. The figure below is a very much simplified block diagram of the chip. In essence a digital control word of 32 bits from the micro controller defines the duration of each step in phase of the output sinusoid by looking up the size of the output amplitude for each increment of phase angle. The output amplitude for each phase angle is stored digitally in a look up table; as time progresses these digital amplitudes are passed to the digital to analogue converter to create the smooth output sinusoid. The output frequency is the input master clock frequency (50 MHz here) times the binary (frequency) control word divided by 2^{32} . Do the sum and you will find the frequency has a resolution of 0.01164 Hz for any value up to the maximum of 25 MHz! The output frequency accuracy is directly related to that of the master clock which is usually a crystal based oscillator and hence very good.



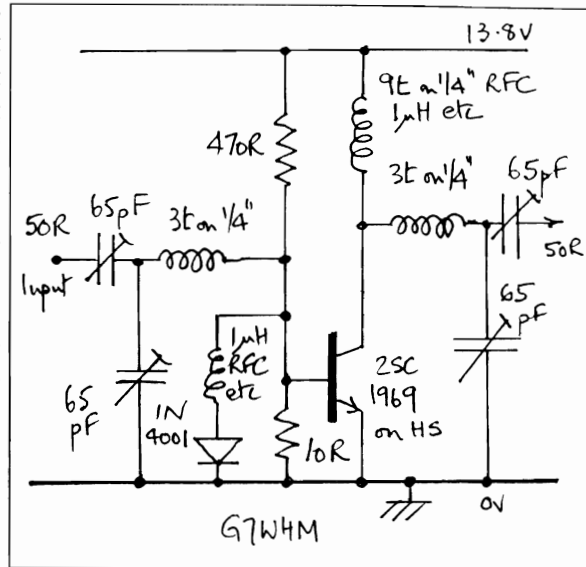
In commercial products, the DDS chip is controlled by a microprocessor which would also perform many of the house keeping functions such as displaying the output (or tuning frequency allowing for any IF offsets), choice of A or B 'VFO's, band changing, memorising channels, filter settings, etc.. As a potential kit project, where it is expected the builder would wish to have a good idea of what the controller is doing, a somewhat simpler dedicated logic controller would seem appropriate. Essentially this only needs to produce the serial 32 bit digital control word defining the output frequency. This could be generated from hexadecimal switches or an up/down counter under the control of a spin wheel or up/down buttons. The frequency could be displayed on a counter connected to the output if it was being used as a signal generator. If being used in place of a VFO for tuning a rig, then there might already be a digital readout. As a signal generator, the spin wheel might tune in (near) KHz steps whereas for a VFO steps of about 10 Hz would be appropriate. It should be relatively easy to devise a kit to do either task having a block diagram similar to that alongside. For example, if used to replace the Taunton's VFO, it would need to tune from 4.0 to 4.5 MHz with the 'spin-wheel'. I hazard a guess that a simple kit like this, to be either a signal generator or replacement VFO, would cost around £45. Obviously such a device could be designed fully into a new rig with savings by omitting the crystal oscillators in the LO chain but it would need a micro-controller etc.. I feel that these complications might be unwelcome for most builders. Interested?

Tell me what you think please!



Six meter power amplifiers

Andy Howgate has given me outline details of a PA that he has devised to run with his Street transceiver using the watty 2SC1969 transistor. It was salvaged from some commercial project complete with PCB and heatsinks. It is quite capable of producing 20 Watts using a 13.8 volt supply. Tuned input and output matching networks are used to provide the desired 50 Ohm input and output impedances. The LCC network shown here is best for VHF work because of its versatility for load unknowns. Biasing of this type of powerful bipolar transistor is tricky - often the bias circuits for bi-polar linears are quite complex, but in this simple scheme, the power diode controls the base bias so it must be in good thermal contact with the main device heatsink. Keep overs short until you are confident there are no thermal runaway problems.

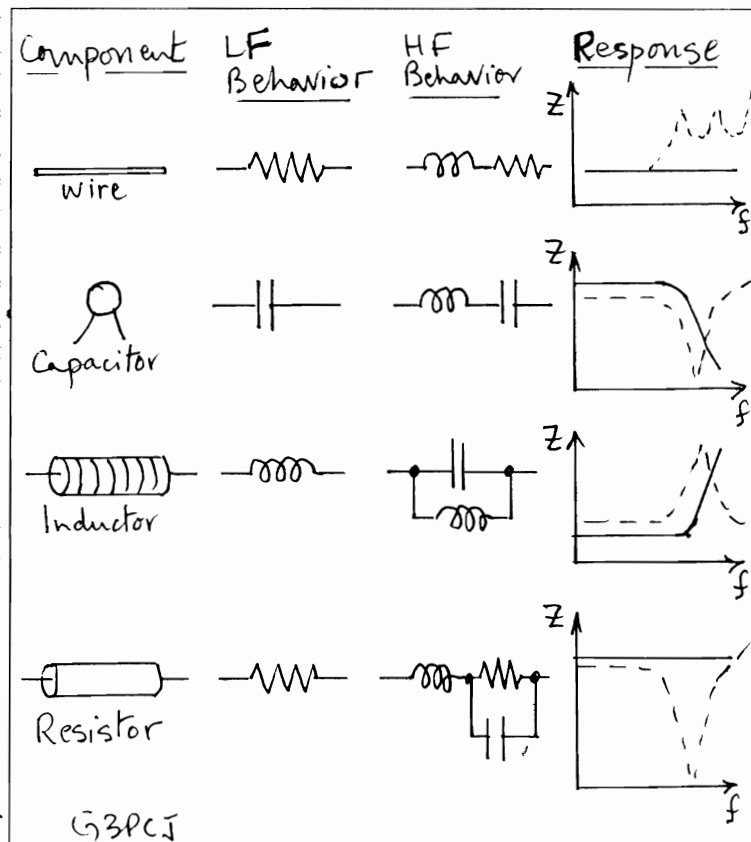


High Speed Logic

I see from a recent article that Motorola have announced a range of simple logic devices where the gate propagation delays are about 150 pico-seconds (150×10^{-12} secs). They are emitter coupled logic (ECL) devices with an upper toggle frequency in excess of 3 GHz! Rise and fall times of the digital signals are about the same 150 pS which means that any track over about 2 inches has to be terminated because it behaves as a transmission line for such high frequency signals. If the line is not terminated in its characteristic impedance, just like a radio transmission line, reflections are generated which degrade the digital signal waveform so negating the speed advantage. Generally, higher speed means increased dissipation because higher currents are required to charge and discharge the circuit capacity but they have managed to stay at around 30 mA per device for most '8 pin' functions by using lower voltage logic. Needless to say these devices are only available in surface mount format!

Real components!

Usually we draw circuits, and use parts, as though they behave in an ideal manner. But as frequency increases, this becomes a false assumption and it is worth remembering the degradation in ideal performance due to the parasitic effects, usually self capacitance and inductance. The figure right shows how parts behave beyond their 'normal' operating frequency range. Bear in mind that the actual frequency when a part ceases to have its theoretical performance may be quite low in real terms, this is especially so for large value fixed inductors. There is also a good rule of thumb, due to the same basic causes, that a low pass filter is unlikely to behave as expected theoretically when the frequency being considered is over 100 times the 3 dB down frequency. The converse is true for high pass filters where the low frequency response would not be as expected at 100 th of the 3 dB frequency.



N.B. Please write me some articles so that you don't have quite so much of my prose next time!