These goals are attained by using an RF oscillator with an AGC circuit. Q3 and Q4 provide broadband gain (coupled collector to base then emitter to emitter), and the frequency of oscillation is set by the variable 160pf tuning capacitor and inductors L1 – L5. Fine tuning is provided by back to back varicap diodes fabricated from the reversed biased collector base junctions of Q1 and Q2. The level of oscillation is set by the current flowing through Q3 and Q4, which in turn is set by the AGC circuitry Q5 and Q6. At switch-on when there is no oscillation, the 2K7 resistor in the collector of Q6 turns Q5 hard on causing maximum current through Q3 and Q4, and hence rapid build up of oscillation. As the oscillation increases, Q6 acts as an envelope detector and its collector potential falls, starving Q5 of base potential and hence limiting the current through Q3 and Q4. This process stabilizes the level of oscillation. AGC action is excellent because the AGC system has a very high gain, and the result is a very constant level of oscillation at the emitter of Q7 of around 600mV p-p.

This output is then buffered and amplified by a wideband power amplifier, comprised of Q8 through Q13. The amplifier provides a voltage gain of 5, and an output impedance of a few ohms to drive the test circuit with around 3 V p-p. The emitter follower Q8 provides a low impedance drive to a cascode voltage amplifier Q10 and Q11 (the cascode structure eliminates Miller effect and ensures a very wide bandwidth). These transistors in turn drive an emitter follower Q13 with active pull down Q12, ensuring equal current source and sink capabilities. The 70MHz bandwidth ensures the RF drive level to the test circuit remains flat to 30MHz.

Drive for the frequency counting function of the microprocessor is stolen from the emitter of Q10, and is amplified and buffered using a 74LS04. This is then divided by 1024 in the following 74LS93 and 4040 divider chips, and the resulting frequency is measured with the Picaxe to form a frequency display. Dual gating intervals are provided for frequency counting function of around 0.1 second and 1 second under the control of a logic level on pin 13 of the microprocessor. The shorter gating interval allows the user to "track" and easily set the generator frequency, while the longer gating interval allows the accurate frequency measurements which are necessary on very odd occasions. In practice, the 1 second gate which gives 5 digit frequency accuracy will almost never be used, as this accuracy is only really necessary for very narrow band HF antennas such as multi element wire yagis. Also note that in line with standard frequency counter practice, the display will "blink" as is updated with new information at the end of each gating interval. To save precious microprocessor memory, only one display routine is used, and in the four digit mode, the last digit of the 5 digit frequency display is permanently set to zero.

The 3 voltages discussed previously in the "Theory" section are derived from the test circuit using germanium diode envelope detectors. Note that only point contact germanium diodes can be used here (D4 – D9) as despite what the schools usually teach, germanium diodes have a zero turn on potential provided the load resistance they drive is high enough (in this circuit around 50 Megohms). This is not the case with silicon diodes (with turn on potentials around 500mV) or even with the best "zero bias" hot carrier diodes, which actually have turn on potentials of around 100mV. For SWRs of around 10 (a 5 ohm load on the test circuit) only about 150mV peak will be applied to D6. For accurate calculation, it is very important to have linear detection. Even with germanium diodes, the bottom end of the detector characteristic is very non-linear and must be linearised somehow. This is achieved by using the diode characteristic against itself in negative feedback loops around IC1A, B, and C. Each linearised output is then amplified by 4.3 (IC2A, B, and C) before being applied to the A/D converter inputs of the microprocessor. Much software muscle is then used to produce displays of resistance, reactance and SWR.

BUILDING THE ANALYSER

The first item to complete is the instrument case. The blank PCB can be used as a template to accurately mark and drill the box lid for all terminals, mounting pillars and switches. Once this is done, the central hole for the frequency selecting switch in the lid can be used to position the engraved front panel, which in turn is used to mark out the hole for the liquid crystal display. This hole is carefully formed, and the front panel is then attached to the box lid with contact adhesive, or double sided adhesive tape.

Next, using the component overlay provided, mount all components on the PCB starting with the lowest profile items and working upwards. The four links next to the two LM324 op amps go in first,