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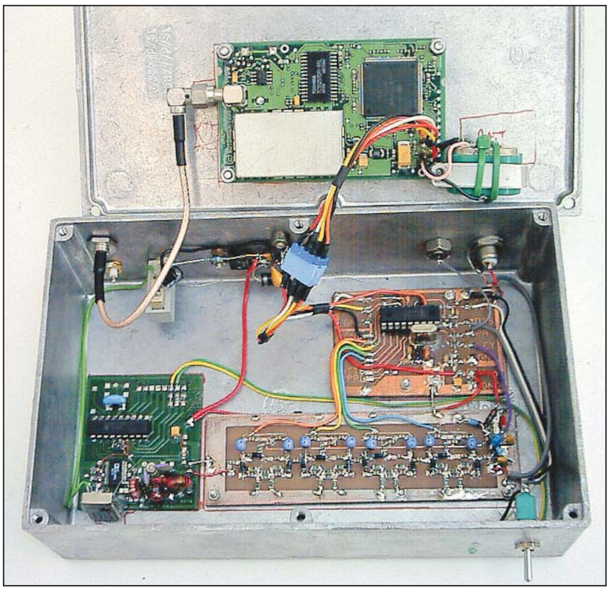
Design and construction of the 5MHz beacons GB3RAL, GB3WES and GB3ORK – part two

Andy concludes the description of the beacon project by considering the GPS module, the new power amplifier, and the final assemblies. He indicates the lessons that have been learned from the project, and shows how a complete multi-band propagation monitoring beacon becomes feasible, complementing those of the International Beacon Project, but on the higher bands.

All the PIC code for GB3RAL had been written for NMEA data supplied from a Garmin GPS25 module (which I had often used before, and was also what Mike Willis, G0MJW, had available), so the controller supplied to him worked straight away. For the later beacons, I intended using a surplus Motorola Oncore unit that was sitting on the shelf, then purchase another more modern version of this one for the third beacon. At first sight, the NMEA data appeared to be identical with that of the GPS25, so no software changes should be needed. On integrating the Oncore module with my existing PIC controller, however, there was no way the combination could be persuaded to work at all. It just dumbly sat there doing nothing! I could see the NMEA data by directly reading it on a PC, but the PIC software, which worked perfectly with the Garmin, just refused to take any notice whatsoever.

After much head-scratching and peering at long strings of letters and numbers, I noticed that, whereas the Garmin output its hours, minutes and seconds in the format …,HHMMSS,… the Motorola module was supplying …,HHMMSS.SSSS,… with decimals of seconds in the data string. Previously, the PIC software counted the commas as they arrived, then extracted the time by counting *backwards* from the second comma, having saved the last few items of previous data in memory. This was clearly now failing to give the correct time as the decimals of seconds and the dot were appearing where the hours and minutes ought to have been. The solution was to modify the software to detect the first comma, then store the *next* six characters to give the time.



The GB3WES driver assembly.

The new, more modern, Oncore M12 module needed a 3V supply rather than the 5V of the original, so a separate power regulator had to be provided, together with a separate chip to interface the 3V logic levels to the 5V required on the PIC. Once this interface was constructed, both GPS modules now communicated successfully with the PIC controller. The controller PCB, attenuator / keyer assembly built on another PCB, and the GPS module, were built into a single screened diecast box to give a stand-alone unit that was a complete beacon source - supplying a few milliwatts with the correct timing and power step sequence, albeit at only a few milliwatts. The photograph shows the completed driver hardware comprising the three modules.

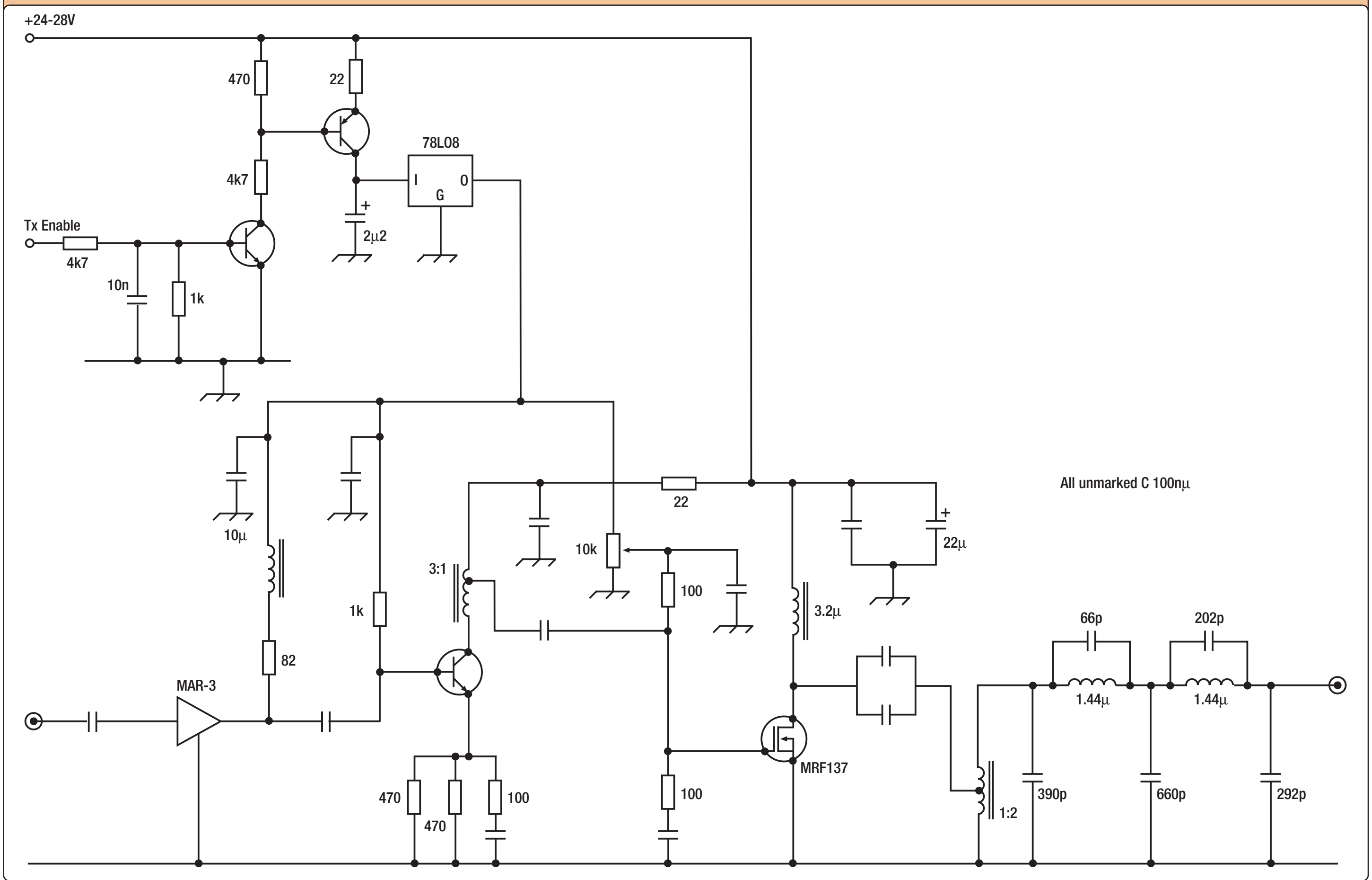
NEW POWER AMPLIFIER

Unfortunately, when it was tested, the second donated Yaesu power amplifier was found to be faulty – two driver transistors had failed. There were no more spare PA units available, the driver transistors were obsolete and difficult to obtain, so my spare PA module was pressed into service and integrated to make up the first complete beacon assembly. The whole lot was placed into a surplus 19in rack mount and put on to extended soak test, running on-air continuously as an attended beacon, signing G4JNT. The transmission sequence started immediately GB3RAL had completed its transmission. (Initially the beacon went on air signing G8IMR, my alternative callsign, until it was gently pointed out that G8IMR did not hold an NoV for 5MHz!)

There now remained the problem of what to do for a second power amplifier. A bodged repair job on the faulty one, using a different type of driver transistor, was just not the done-thing for high-reliability electronics targeted at 24-hours per day operation, the Yaesu amplifier was deemed to be beyond repair, so another solution was needed. I had several surplus TMOS power FETs of the MRF134/5/6/7 family, and previously had built a broadband 8W amplifier covering 20 to 80MHz for a non-amateur related project using a MRF136. This had been straightforward to get going, so the design was lifted, the inductors modified for the lower frequency and a bit more feedback included to tame the increased gain at low frequencies. The circuit is shown in **Fig 5**. A single MRF137 device will supply approaching 20W when used in this circuit, operating from a 24V supply. At the 10W output level, it was comfortably linear, running at less than 0.2dB of gain compression, so would amplify the power step sequence correctly.

The only snag was that now a 24V power supply was needed. The logic circuitry had its own internal regulator down to 5V (and 3V). Supplying the driver from the full 24V would lead to excessive dissipation in the driver unit, so an additional power resistor was added external to the driver to drop the voltage supplied to a more acceptable level to feed the regulators.

FIG 2 © RADCOM 000



THE FINAL ASSEMBLIES

The new PA was built into a second rack mount and integrated with its driver unit to form the final beacon hardware. It only required 24V at 2A which could be delivered from a surplus PSU found at a rally.

As there was going to be plenty of 12V power available at the site of GB3WES, the first beacon that had been built using the Yaesu PA became that one. This went on air in October 2004. GB3ORK was shipped up to the Orkneys along with the PSU, and came on air in December. Apart from a few teething and installation / shack decoration glitches and power cuts, both have operated continuously from then.

Some details of GB3WES can be found on the website of G3WGV [4].

A FEW LESSONS LEARNED

The switched attenuator and keyer turned out to be the most complicated part of this project but, fortunately, a large number of surplus PIN diodes that were ideally suited to this task just happened to be available. These devices, especially in the quantities needed here, would otherwise have been quite expensive – typically they cost £1 - £2 each. Discrete FET switches were tried, but failed to achieve the isolation needed for the higher stages of attenuation. An alternative would be to use packaged FET switches designed for RF routing – these are available from companies such as Minicircuits, and may have a slightly lower cost as many devices are included within one chip. However, isolation still couldn't be guaranteed and the final cost could begin to approach that of a ready-made attenuator module.

But, in retrospect, there was a much simpler solution – use a different DDS chip. The Analog Devices AD9852 device includes on-chip programmable control of the output amplitude to 12 bits of resolution, which allows the output power to be varied over a range of 70dB. Now, both power steps and keyer could be made by directly programming the DDS chip from the PIC controller, without any need for more RF hardware. The RF chain could now just simply be DDS chip and power amplifier / filter. This device will form the basis of any future beacon projects.

Much time was wasted getting the PIC software to read NMEA data from a different GPS module. Instead, the proprietary binary format should have been used and the old NMEA-compatible code jettisoned. It even appears that the Oncore binary format has become an 'unofficial' standard that other GPS receiver manufacturers have incorporated into their products. For example, the Jupiter-T GPS module defaults to this format at switch on. Furthermore, these are quite reasonably priced (I even had at least one spare!), and would have allowed simple frequency-locking circuitry with its 10kHz output.

THE FUTURE

As designed, the beacons can be used directly on 3.5 and 7MHz, just by changing the PIC code in the DDS controller. (In fact, new driver software in the DDS modules does now allow up to four pre-programmed frequencies to be selected in the range DC to 12MHz). The timing controller PIC could easily be programmed to change frequency bands as well as generate the power / keying sequence. By adopting the AD9852-based concept described above, a completely integrated, single board, multi-band beacon driver could be produced. With the addition of a broadband PA, a complete multi-band propagation monitoring beacon becomes feasible, complementing those of the International Beacon Project, but on the higher bands.

Furthermore, the AD9852 can directly generate frequencies up to 80MHz, making its use in VHF and UHF beacons feasible. The ability to change the frequency in steps of minute fractions of one hertz, together with the high resolution setting of amplitude and phase of the DDS output, means that a host of data modulation schemes could be incorporated into a new generation of modern beacon designs. At the other end of the spectrum, GB3SCX on 10GHz already uses an AD9851 DDS device to generate RTTY keying. ♦

Fig 5
The GB3ORK PA circuit diagram.

REFERENCES

[4] Details of GB3WES
http://g3wgv.com/gb3wes.htm