Harry Leeming's

in the shop

Harry puts on his magnifying specs and looks at a modern rig and discusses problems with low voltages and high current switching.

Recently I was asked to look at a Yaesu FT-767. This is a real bag of tricks, a high frequency (h.f.) transceiver with provision to fit modules for 50, 144 and 430MHz. There's so much packed into one case, that I find these rigs a bit of a nightmare to service and need my magnifying specs!.

The first problem on the FT-767 I was asked to look at, was that there was no transmitter output on h.f. Removing the transmitter output plug on the on the radio frequency (r.f.) board, and poking around with a diode probe, established that there was no drive at the output socket on the r.f. board.

The signal was coming to a full stop at the diode switch, see **Fig. 1**. Unusually this diode is switched into its conductive mode by a direct current (d.c.) voltage that arrives via the plug from the power amplifier (p.a.) unit, and at first this caused some confusion, as there could be no output with the plug removed!

Once I had sorted out as to how the circuit worked – and refitted the plug – the diode still didn't conduct and eventually the fault turned out to be a bad connection somewhere in the path to the diode. As is often the case when working with equipment like this, it was almost impossible to get to the underside of the board while the equipment was working. In the end I simply took pot luck and soldered every joint around this vicinity, fortunately all was then well and the rig worked perfectly on h.f.

No 144MHz!

The next problem was that the 144MHz unit was not transmitting, nor was it receiving any signals but yet it still sounded 'lively' on receive. This fault made me think back to the early 1950s when I started in the radio and TV trade at the tender age of 15. At first I was kept away from 'dangerous and complicated TV' sets but was given the odd radio to try and repair.

It was not long before I came across one that sounded 'lively' but would not pull in any stations. Puzzled, I asked for help and was enlightened as to the cause of the trouble. Although the intermediate frequency (i.f.) stage was active – thus producing the slight hiss' I could hear via the detector and audio stages – the 'frequency changer' valve, (the first oscillator and mixer to use modern terminology) was faulty, as it had an oscillator section that would no longer oscillate. A replacement valve cured the trouble.

Things might be a lot more complicated now but the principles of servicing still hold. In the case of the FT-767's 144MHz unit, of course, a simple valve oscillator did not generate the injection for the first mixer but a much more complicated phase lock loop arrangement.

No doubt some readers can glance at the circuit of these and immediately see exactly how they function. Unfortunately I'm not one of them! Usually however, it's not necessary to puzzle over exactly how the circuit works, and the following strategies enable most faults to be found in almost any synthesiser controlled rig that incorporates a phase locked loop (PLL)

A glance at the maker's alignment instruction for the PLL in any v.h.f. transceiver or add-on unit, will usually produce instructions similar to those in the FT-767's technical manual. "Tune to the high edge of the band and connect a high impedance d.c. voltmeter to TP2001. Adjust TC2001 for 8.2V on the meter. Retune to the low edge of the band and check that the voltage is between 1 and 2V".

The important point to check here is **not the exact voltage** but the fact that the voltage on the designated test point varies steadily as you tune across the band. If it does – and does not suddenly jump up or down at any point in the band – the PLL is in lock and you have a 99% chance that the first oscillator is on frequency and functioning correctly.

If the voltage does not change steadily – the PLL is out of lock then the first oscillator will be uncontrolled and probably miles off frequency. The 144MHz module in this case had around 1V at the test point and as this didn't vary with the tuning, it was

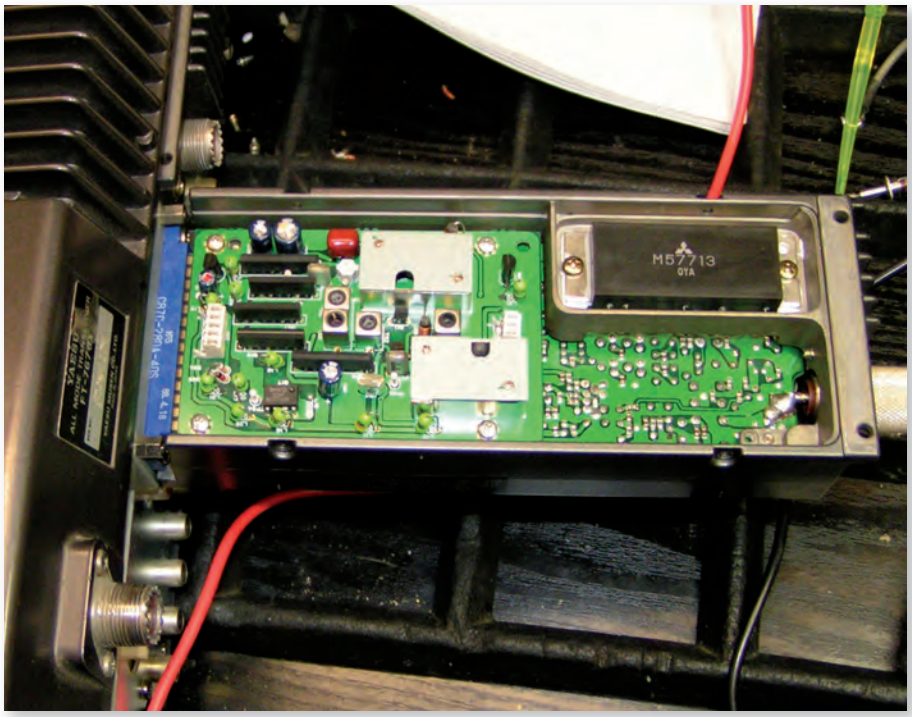

Fig. 1: The power amplifier module and diode switch assembly inside the Yaesu FT-767.

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Fig. 2: The FT-767 – taken with my old B&W camera!

certain that the first oscillator was out of lock. Theoretically there could be dozens of reasons as to why this was happening, but in practice it can usually be nailed down to one of two common faults.

No Reference Signal?

The first possibility was that there was no reference signal arriving at the PLL. With most v.h.f. rigs the simplest way to check this is to use a multimode wide range scanner and listen to see if all the crystal oscillators in the synthesiser unit are functioning. Just switch the scanner to single sideband (s.s.b.) and poke its antenna near to each crystal, when it should be possible to hear the oscillators loud and clear on the correct frequency.

I much prefer testing with a scanner rather than using probes and risking them slipping, shorting and causing damage, when an attempt is made to connect directly to the circuit. If one of the oscillators is not running, the most likely cause is a 'lazy' crystal. Hint: Touch a suspect crystal – very briefly – with a hot soldering iron so as to warm it up a little and quite often operation will then be temporally restored.

If it is the crystal fault the obvious cure is a new crystal – but with older equipment a replacement might not be that easy to obtain. Tip: A trimmer capacitor may be used to adjust crystals onto frequency and often – if this is tweaked – the crystal will operate more reliably.

Alternatively in some cases, there are fixed padding capacitors wired in parallel with the crystal. If these are removed – or capacitors of a smaller value fitted, the *Q* of the crystal will be increased and the stage will often then be found to operate reliably.

Doing this will throw the frequency out slightly but with many rigs it will be found that it's still possible to use other trimmers to get the frequency near enough, as especially with f.m. equipment, an error of a couple of kHz will usually go unnoticed. Incidentally, in the case of the FT-767 there's no reference oscillator in the 144MHz module as the rig's main reference oscillator is used and as the rig worked on 50MHz and h.f. this was presumed to be operating okay.

Next Common Problem

The next common trouble is that the free running frequency of the oscillator(controlled by the PLL) may be out of adjustment, resulting in the varicap diode having insufficient range to pull the oscillator back onto the correct frequency.

If the first oscillator is only a fraction off adjustment, quite frequently a rig will be found to either operate satisfactorily at one end of its tuning range, or to function at some particular temperature. In these cases a slight adjustment of the oscillator's trimmer will restore normal operation but in the case of the FT-767 there was no sign of lock. Never-the-less I decided to try adjusting the trimming capacitor and see what happened!

Then – while monitoring the voltage on the test point TP2001 – I gave a slight tweak to TC2001 and the voltage locked in at about 3V with the dial set at 145MHz. It then varied up and down from this value as I tuned around the band and the set came to life (the circuit had obviously drifted off with age). The next step was to set up the PLL as per Yaesu's alignment instructions. Or was it?

A quick check showed that the voltage varied by nothing like the amount stated in the FT-767 service instructions, when tuning from the h.f. to the low frequency (l.f.) end of the band. With the instructions – aimed at the Japanese or American service engineer – this was hardly surprising as their 144MHz band extends from 144 to 148MHz, and so the USA model has double the tuning range of the UK variant.

The important point when setting a PLL is not the exact voltage at the test point but – that whatever this voltage is set at – enables the oscillator to establish lock anywhere in the band. However, with older equipment this happy configuration often does not coincide with the service manual's recommendations!

Following my usual practice I set the tuning half way at 145MHz, with the rig in the s.s.b. mode receiving a harmonic of my workshop crystal calibrator. I then adjusted TC2001 and noted the highest and lowest voltage on the test point that gave lock and good reception

Problems

I like to hear about problems with older equipment, particularly pre-1990 Yaesu rigs. Please E-mail me, (add some radio related term in the subject heading, to differentiate against spam), or write and enclose a stamped addressed envelope. Remember that electricity is dangerous, if you are not familiar with safety precautions you must never work on your equipment whilst it is plugged into the mains. (Switching off at the wall socket does not necessarily make equipment safe)

I then set TC2001 so that the voltage measured was in the centre of this range. Next I left the rig overnight and made sure that when it was switched on from cold – that it would receive and transmit anywhere in the band – and that it also remained in lock after a few hours when it warmed up.

Beyond that, all I thought that could be done, was to put the rig back into use and hope that the fault that had caused it to lose lock is not intermittent. Those variable frequency oscillators (v.f.o.s) and voltage controlled oscillators (v.c.o.s) that drift or jump off frequency can be a real pain – but more about that some other time!

I come across quite a number of the older 144MHz rigs that are not functioning due to PLL troubles. I've no doubt one or two of my readers may have one and have decided that it's not worth the cost of getting someone to repair it. However, I encourage you to dig out the service instruction, or have a hunt on the Internet for them and it might be that a slight 'tweak' on the PLL trimmer, or attention to a lazy crystal is all that is needed.

Make Do and Mend

'**Bert**' arrived with an FT-902 that was intermittent on transmit. He told me that, "Sometimes I switch it on and it is fine, on other days there is no I/C reading (i.e. the p.a. valve's current meter) and it won't transmit!"

From my own experience I can say that intermittent faults are the nightmare of the service engineer! This is because it's possible to waste hours and the engineer just can't invoice 10 hours at £35 an hour to solder one joint! Fortunately, in this case I had an idea as to what the fault might be.

Like the FT-101 and the FT-901, the FT-902 has a heater switch on the front panel. The switch is rated at 250V at several amps but like most switches it's not that keen on switching low voltages with a high current over a long time. Valve filaments – in the same way as electric light bulbs – have a very low resistance when they are cold, resulting in a large switch-on surge.

If interested readers care to measure the resistance of the heater of a 6146 valve when it's cold, they'll find that it's less than an Ohm. And my rough calculations show that with two in series – plus the 12BY7A driver's heater in parallel – the surge for the first fraction of a second when the switch is closed must be in the region of 10 to 20 amps. After 15 or 20 years service the switch cries 'enough' and starts to be intermittent and this proved to be the case with Bert's rig.

Replacing the switch involves removing and refitting the entire front panel, the knobs and the nuts on many controls, together with quite a few connections. Rather a lot of work! The cost of this, plus a normal 'MOT' would amount to around two thirds of the value of the rig, hardly worth it. Personally, I could of course have just shorted out the switch but there's a better answer. More details next month! ●