Modifying The FRG-7

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Part 4

In this final part of the series on modifying the FRG-7 receiver we look at problems with b.f.0. drift and some of the points raised by readers.

BFO Drift

I menhoned in Part 1 of the series that one area of the receiver where performance was weak was the b.f.0. and its tendency to drift over fairly short periods of time. Sure enough it was the main point raised by those readers who wrote to me, in particular, Bob Marshall of Canterbury, Dr. Alan Bryce G4NCR and Bob Wilkinson G3VVT.

Everyone agreed that the close proximity (a mere 6mm) of the b.f.0. tuning coil to the heatsink of the audio amplifier i.c. was no doubt the main cause. Various suggestions were put forward but all involved fairly tricky modifications to the existing circuit. The philosophy of this series had been all modifications should be add-ons which could easily be removed and in fact by the time Part 1 was in print I was already working on a circuit that used ceramic resonators. I had chosen these in preference to quartz crystals which were expensive and bulky and not very easy to obtain.

Ceramic V Quartz

It has been known for years that oscillators could be made using standard ceramic filters as the resonating element and more recently manufacturers have been producing a range of ceramic devices intended specifically as inexpensive substitutes for quartz crystals. These ceramic resonators are not as accurately cut as good crystals and do not have the same temperature stability. Even so they are smaller than quartz equivalents at low frequencies and their stability is more than adequate for our purposes. Important as well from the point of view of this series, they cost pence and not pounds. Measurements made on the original b.f.0. showed that it was quite capable of drifting by as much as 200Hz over just 5 ininutes whereas with the circuit presented here the drift is limited to less than 20Hz in the same period.

Although details are given only for u.s.b. and 1.s.b. frequencies for the Toko MFL filter which has a centre frequency of 453-5kHz, it is possible to adapt the circuit for other i.f.s. A range of these devices is available from Cirkit and frequencies include 455, 460, 500, 560kHz and 1MHz.

Oscillator Design

Having decided on the method of curing **the** problem, the actual design proved a bit tricky. Several circuits for using ceramic resonators have been published and all in-' volved using a standard Colpitts oscillator. When these circuits were tried they were rich in harmonics which appeared as very strong signals within the receiver's normal tuning range. Even including a 455kHz transformer for coupling had little effect as the circuits were radiating

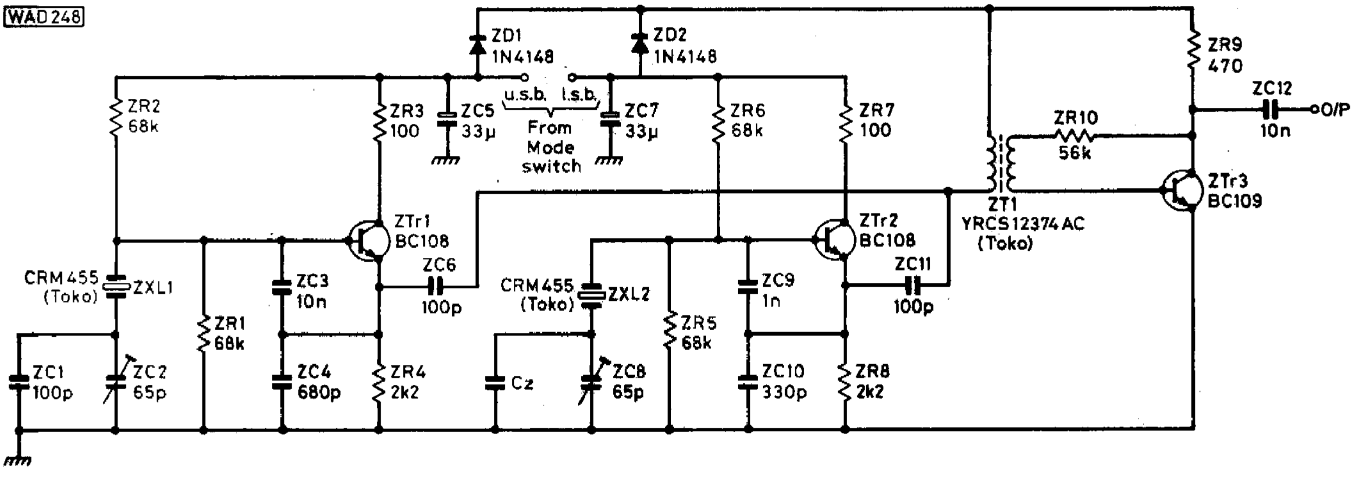

Fig. 4.1: Circuit diagram of the ceramic resonator b.f.o. for use with the Toko MFL 4535kHz i.f. filter. See text for alternative centre frequencies

strong signals. Other oscillator arrangements were tried but all seemed to suffer from the same problem to one degree or another and so it was back to the Colpitts circuit. Some 455kHz transformers were tried as part of the oscillator circuit but the old problem of thermal drift appeared again particularly when the resonator was pulled off its natural frequency. The only solution was to include an unusually high value capacitor between the base and emitter of the transistor. Despite the relatively small difference in frequency of the two oscillators the values of these capacitors vary quite widely and are fairly critical as are the emitter/ground capacitors if symmetrical waveform and reliable starting are to be maintained.

The Working Circuit

The final circuit shows component values for frequencies of 452kHz (ZTrl) and 455kHz (ZTr2) and these are the b.f.o. frequencies required for the MFL fdter. Notes are included at the end of this article for adapting the circuit for other frequencies. The two oscillators are switched into circuit by the FRG-7's **MODE** switch and diodes **ZD1** and 2 ensure that whichever circuit is on, current is still supplied to the buffer amplifier, ZTr3.

I found harmonics only appeared at low level at two points on the kilohertz tuning dial and were not a nuisance.

Construction and Fitting

Construction is fairly straightforward and the only word of caution concerns the capacitors in the tuned circuits. These should be good quality devices otherwise expect degraded stability. Use of the printed circuit board is advised as materials such as strip board may cause problems because of capacitance between tracks and non-compatibility with the pin-out of the transformer. The p.c.b. also has the advantage of having mounting holes that match existing positions on the FRG-7's chassis.

Once construction is complete the fitting process is fairly easy although the **MODE** switch will have to be unmounted and pulled out of its hole. Refer to Fig. 4.3 and note the position of the wire that bridges two contacts on the back wafer of the switch and then goes to a pad on the IF/AF board where it feeds to R442. This connection is the power supply feed to the original b.f.o. and the bridge on the wafer switch must be cut and the wire unsoldered from the pad. A second wire is soldered onto the now disconnected switch contact and both the wires now carry the appropriate oscillator supply to the new b.f.o. board.

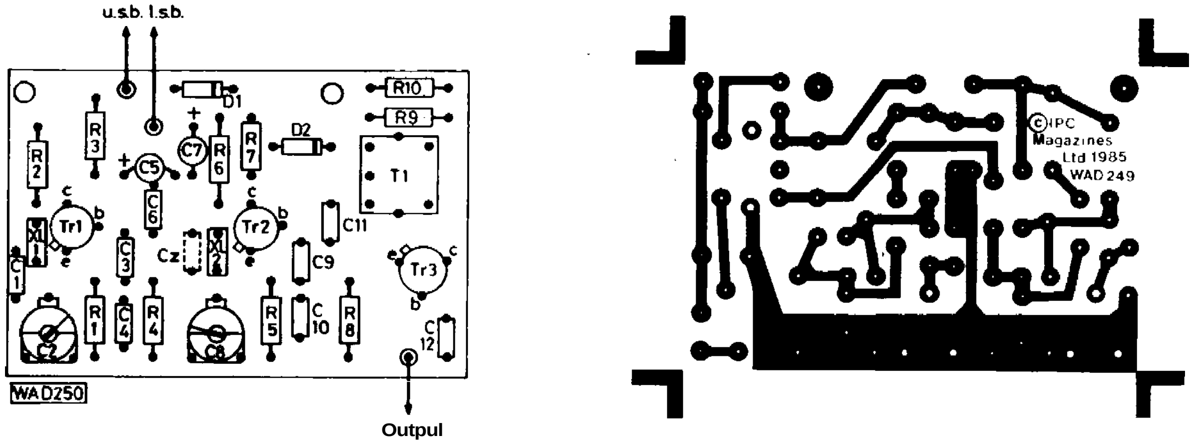

Fig. 4.2: Component placement and p.c.b. track pattern of the ceramic resonator b.f.o., shown full size. Capacitor C, is not required when using the MFL 453.5kHz filter. Note the prefix letter Z has been omitted for clarity

The circuit based around ZTrl is for the u.s.b. frequency, 452kHz and ZC1 provides the necessary high capacitance needed to pull the resonator, ZXC1, well off its natural frequency. The trimmer capacitor ZC2, is used to tune the circuit for the exact frequency and capacitor ZC6 couples the output to the transformer, ZT1. The oscillator based on ZTr2 is almost identical except for the values of ZC9 and ZClO (as already explained). Capacitor C, is not required when the circuit is used with the MFL filter but may be needed for other frequencies and so provision has been made for it on the p.c.b. layout.

The output from both oscillators goes to the coupling transformer ZT1 which was included to ensure that harmonics were not amplified to any appreciable degree. The transformer used was a second i.f. type salvaged from a portable radio but if a suitable component is not to hand a part number is included on Fig. 4.1.

Harmonics from this circuit are at roughly the same level as those from the set's existing b.f.o. and fitting the circuit board inside a screened case would obviously reduce them even further. Adding de-coupling capacitors back along the switched supply will also make a marginal difference. However, try the unit as it is as in my own case

It is important now that the coupling capacitor in the set's own b.f.o. is removed. It is clearly marked on the board as C439 and must be taken out of circuit otherwise the old b.f.o. will load the new circuit.

The output of the new b.f.o. is fed via a short wire link to the pillar of test point TP405 on the IF/AF board. The only other connection is chassis ground which can be taken to any convenient point.

Once these connections have been made, remove the two screws that hold the IF/AF board to the front right hand side of the chassis and replace them with screws from the underside of the chassis so that 25mm mounting pillars can be screwed onto them from the top. The p.c.b. is now mounted on these pillars and assuming there are no faults it only remains for the correct frequencies to be set up.

Alignment with Instruments

The use of a digital frequency meter and an oscilloscope will make alignment quick and easy but do not worry too much if you do not have access to such instruments. Absolute accuracy of frequency is not as important as stability and that latter quality is virtually guaranteed by the ceramic resonators. Assuming the instruments are available, allow half an hour for the set to warm up, disconnect the antenna and find any tuning point where there is no signal of any kind. Switch to u.s.b. and monitor the circuit output. Tune ZC2 for 452kHz: and adjust the core of the transformer for a good symmetrical waveform. Note that this adjustment may well affect the frequency of the oscillator slightly but don't worry about that at this stage. Now switch to l.s.b. and trim ZC8 for 455kHz. If the oscillator won't start, you will need to adjust the core of the transformer until it does. With the oscillators running at roughly the required frequencies it is now necessary to find a setting of the transformer's slug where the output level from each is roughly equal. Once this has been achieved, do not touch the transformer any further and now make final adjustments to obtain exact frequencies by using the trimming capacitors.

Trial and Error Alignment

If trial and error must be used then start by turning the core of ZTI until it is fully out and set ZC8 for maximum capacitance. Connect an antenna to the set, switch in the WIDE filter and find a good strong a.m. broadcast transmission. Tune it as accurately as possible using the S-meter and then switch to l.s.b. Now trim ZC8 until you hear the b.f.o. zero beat with the transmission (if this does not happen try screwing in ZT1's slug until it does). Once you have the zero beat, screw in the transformer slug and at some point the oscillator should switch off (if it does not, just leave the slug set at the mid-way position). Bring the slug back by a slight turn, switch to a.m. and then back to l.s.b. and the oscillator should start again. Zero beat will probably have been lost but bring it back by slight adjustment of ZC8. That completes the alignment for l.s.b. and the transformer setting.

Now find an amateur s.s.b. station on any of the bands above 10MHz, switch in the NARROW filter, tune for maximum S-meter deflection and trim ZC2 until the signal is resolved. If needs be keep repeating this procedure with different stations until you are happy with the results.

Performance Tests

Performance can now be checked on the various bands and if a d.f.m. has been used the b.f.o. frequencies can be monitored for drift. On the two prototypes built the worst case variation was on the u.s.b. oscillator and this is no doubt due to the relatively high value of capacitor ZC1. If variations greater than 20Hz are encountered then it may be a good idea to change ZC1 for a better quality device. If ZT1 has been salvaged from the junk box it is a good idea to check that it is not coupling an excessive amount of signal to the buffer amplifier. This can be done by monitoring the set's a.g.c. voltage and ensuring that under no-signal conditions it does not alter when either b.f.o. signal is switched in.

Other Sets and IF Frequencies

There is no reason why this circuit should not be used with other sets, particularly those with standard 455kHz i.f. stages. The b.f.o. frequencies for 455kHz will be at 453·5kHz and 456·5kHz. For the lower frequency, the component values around ZTr1 should work although ZC1 may need to be reduced. For the higher frequency, it is advisable to use a 460kHz resonator and pull it down in

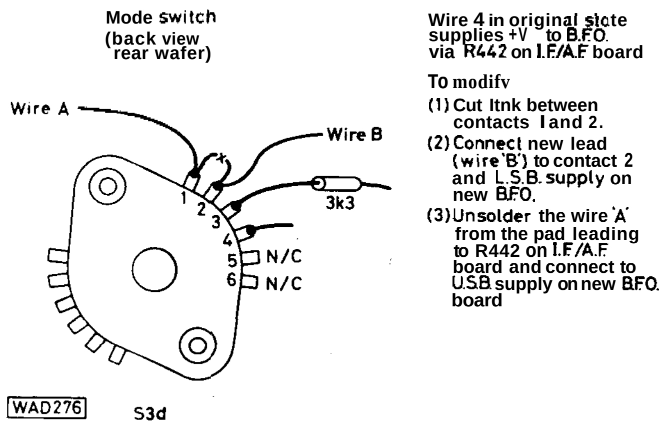

Fig. 4.3: Details of the modifications to the MODE switch wiring

frequency as pulling a 455kHz resonator up can lead to unreliable starting. Using the 460kHz version (CRM460) for ZXL2, C, will need to be included (try about 100pF) and the values of ZC9/10 will need to be juggled although start by trying different values for ZC10 only.

Back to Battery Packs

Apart from b.f.o.s the other main query raised by readers concerned the battery pack. My brain was obviously not fully engaged when I suggested in the first article that NiCads could be used, U2 versions of these cells are rated at 1·2 volts and multiplied by 8 that comes to only 9.6 volts which is 0.4 volts less than the output of the set's regulator. Reader John Hunt picked me up on this point and offered a solution. John is currently working in Iran and has great difficulty in obtaining U2 dry cells and so has opted for NiCads. He suggests fitting an L-shaped bracket to the back of the battery pack and mounting a dual (side-by-side) U2 holder on it. This unit is then merely wired in series with the existing holder to give 12 volts from the 10 cells. I have not actually fitted this modification to my own set but have measured the available space and confirmed that John is quite right, the extra cells are positioned in the space above the audio amplifier i.c.

This modification is worth considering even for normal dry cell use because as reader Bob Marshal1 pointed out even 12 volts is going to leave the regulator struggling the moment the battery voltage starts to sag. Using ten cells will give 15 volts and the set will happily cope with this.

Bob Marshall came up with one final simple trick that improves the audio quality of the set. The FRG-7 and many sets like it suffer from poor loudspeaker performance particularly when receiving broadcast stations. Bob tried sealing up all the ventilation holes and slots and found there was a noticeable improvement. He pointed out that as the set only consumes around 15 watts of power these slots are really quite unnecessary and it is quite easy to carry out this modification using sticky tape.

Finally, thank you to everyone who wrote in with ideas and I am pleased to say that from the correspondence it is clear that this series has provided solutions to these shortcomings that could be tackled at reasonable cost. I hope owners who fit circuits get as much enjoyment from their "new" FRG-7 as I do from mine. ●