How to Convert 'Unconvertible' CB Rigs to Work on the Ten-Metre Band

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IT all started in a pub. Four amateurs were bewailing the fact that the beloved Icom ICB1050 CB rig, which is so easy to convert to 10 metres FM, had become as rare on the dealers' shelves as the proverbial hens' teeth. As happens after one has had a skinful, an argument developed — this time as to why the 'dedicated chip' type of CB set cannot be converted. The reason is, of course, that the chip will only work if it has the right frequencies going into it.

On the point of falling over, one of the inebriated present asked the presumably fatuous question, "then why not *fool* the chip into thinking that it has the right frequency going in?" Well, why not indeed? A few beer mats got drawn on and it became obvious to those still standing upright that if a mixer were introduced between the VCO and the dedicated chip and a signal source injected into this mixer, the frequency of the injected signal has only got to equal the frequency by which you want to depart from the CB frequencies — and you're there. I was working out the differences between frequencies of the CB and amateur bands when suddenly I had one of those once-in-a-lifetime strokes of sheer genius. The funny thing about this idea was that next morning, when sober, it still made sense!

The Mathematics of the Problem

The dedicated chip found in most British CB sets is the LC7137. To minimise the shift of the VCO in the rig it runs at the required frequency minus the IF on receive, and at half the required frequency on transmit. Suppose, for some reason, you wished to transmit on channel 30 of the legal CB system, roughly 27.892 MHz; on transmit the VCO will be running at half this, *i.e.* 13.946 MHz. Should you wish to receive channel 30 the VCO will run at 27.892 minus the IF frequency of 10.695, *i.e.* 17.197 MHz.

Let us now consider what would happen if the chip would run on Ten. The action on FM is centred about 29.6 MHz. On transmit it would run at half this, *viz.* 14.8 MHz, and on receive 29.6 minus 10.695, equals 18.905 MHz.

If we consider the idea of injecting the difference into a separate mixer, to fool the chip, we would need to subtract the frequencies required for 10 metres from those required for CB. Thus on transmit we need 14.8 minus 13.946, equals 0.854 MHz, and on receive we need 18.905 minus 17.197, equals 1.708 MHz.

We now come to my once-in-a-lifetime stroke of sheer genius. Nearly all CB sets have a 10.240 MHz crystal in them. This is because not only can this frequency be digitally divided to give the required channel spacing (10 kHz) but is also used to convert 10.695 MHz IF to the 455 kHz IF. It just suddenly occurred to me that 10.240 divided by 6 is 1.7066, and divide this again by 2 is 0.8533. Almost exactly what we want! Now it so happens that 74LS92 IC's cost about 55 pence and are divide-by-two and divide-by-six all in the same package.

A Few Points About CB Sets

The difference in VCO frequency between transmit and receive, although minimised as outlined above, is still too far to pull by one varicap diode. Careful examination of the circuit will show that a fixed (or even pre-set) capacitor is switched in by a transistor on transmit. Since we will be moving the VCO frequency it will be necessary to locate this capacitor and fit a variable; I fitted a 10 to 50pF simply because it was to hand. You are also going to have to locate the capacitor connecting the VCO to the synthesizer chip, pin 19 of the LC7137, and remove it. The two lands vacated by the capacitor are those between which you are going to insert your new mixer.

You are also going to have to locate a rail that goes 12 volt positive on transmit, and the 10.240 MHz output from the chip, pin 11 of the LC7137.

A Warning

You really must understand what you are doing. If you don't understand *exactly* what you are doing, don't bother to read on. This article is *not* for beginners — you are entirely on your own and no one is going to help you out if you make a mess of it. No circuit layout is given because the components have to be assembled to fit inside the case of the particular CB set. Some sets contain plenty of fresh air, so modification is easy; some sets are so tiny that you have to shoe-horn in every component. This article is written as a guide for people who are competent enough to be able to adapt components to hand to suit. Also, if you haven't got a 30+ MHz 'scope, a counter and a decent multimeter then forget this modification.

Circuit Description

Many variants on the theme outlined above have been built by the author and incorporated into several types of CB set. The circuit diagram of the most comprehensive arrangement is shown in Fig. 1. Here C1 couples the 10.240 MHz from pin 11 of the LC7137 to input of the 74LS92. R1 acts as a hold down resistor, and its value is a bit of a compromise between excessive loading of the crystal and the correct functioning of the divide IC. Note that, due to the high-ish frequency involved, IC1 must be a Schottky device.

IC1 is a divide-by-six (in on pin 1, out on pin 8), and a divide-by-two (in on 14, out on 12) device, producing 1.7066 MHz and 0.8533 MHz, provided pin 6 is earthed! (Did *that* cause some trouble — but I digress!) IC2 acts as a switch, feeding the mixer with the correct frequency on transmit (0.8533 MHz) or receive (1.7066). Eagle-eyed readers may have noticed that there is a relay in the circuit that would do this job, and it is true. If the available space within the transceiver allows, then a double-pole relay may be used for RL1: the second set of contacts have the moving arm taken to C3, the normally closed contacts to pins 8 and 14 of IC1 and the normally open ones to pin 12. Since the only relay I happen to have to hand that will fit in the smallest CB sets is a single throw dual-in-line (DIL) type, I use the circuit shown when space is at a premium.

TR2 acts as a high level mixer. The LC7137 wishes to see a couple of volts in at pin 19, so mixing has to take place at this sort of level. The five volts of injection from our digital divider is presented to the mixer emitter, and the VCO signal comes in at the base. The required output of the mixer is selected by L1/C6 on receive; on transmit the required output is lower in frequency and TC1 is switched in to pad L1/C6. (I am prepared to admit that I spent a day trying to switch in TC1 electronically and would like to hear from any superior megabeings who manage to do this. The problem with electronically switching it in seems to be high RF level across the switch.)

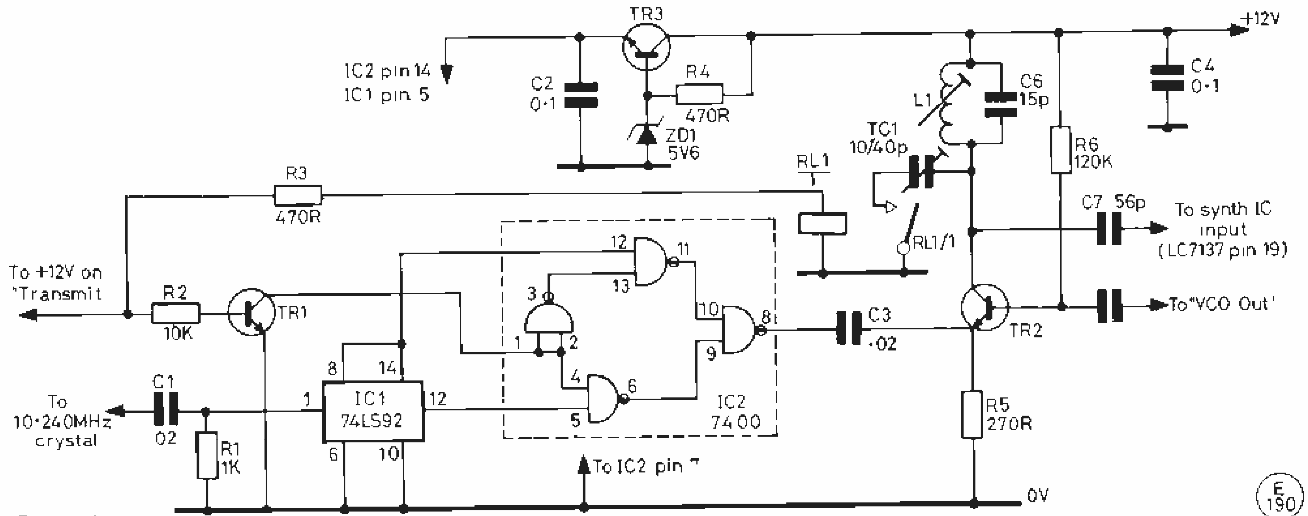

Figure 1

Table of Values
Fig. 1

R1 = 1K	TC1 = 10/40 pF
R2 = 10K	IC1 = 74LS92
R3, R4 = 470R	IC2 = 7400
R5 = 270R	TR1, TR3 = BFY50, 2N3053, etc
R6 = 120K	TR2 = BC107/8/9, 2N2369, etc.
C1, C3, C5 = 0.02 µF	ZD1 = 5.6V Zener, 400 mW
C2, C4 = 0.1 µF	RL1 = *see* text
C6 = 15 pF	L1 = *see* text
C7 = 56 pF	'Keyswitch' DIL = 5V (*see* text)

Note. all resistors are ¼-watt, all capacitors are disc ceramic

L1 has to pick out the frequencies that the chip wants to see, *viz* 17.197 MHz on receive, 13.946 MHz on transmit. It may conveniently consist of 23 turns on a 3/16" former, or a 10.7 MHz IF coil with its padding capacitor removed.

TR3 acts as a 5 volt regulator, and may be replaced with a chip type device if available. You may find a 5 volt source in the set, and if it is capable of supplying the increased current then by all means use that.

The Modification

Insert the additional, variable, padding capacitor into the rig and remove the VCO coupling capacitor from pin 19. Couple your counter into the VCO, and with channel 30 selected, adjust the VCO to 18.9 MHz on receive. Note that an easy way to couple in the counter is *via* a 10:1 'scope probe. Now switch to transmit and adjust the variable padding capacitor you fitted to the set until the counter reads 14.8 MHz. It should be remembered that the LC7137 has a built-in out of lock detector (pin 14 goes high when the chip is locked). This detector is only operative on transmit, so, with the loop now broken, the transmitter is inoperative.

The circuit of Fig. 1 can now be connected. On receive, tune the core of L1 for maximum output on 17 MHz, and the loop will be observed to have locked. Make sure that there is sufficient output from the mixer to re-lock the loop on its old frequency, so check with a counter.

On transmit, tune TC1 for maximum output from the mixer on 13.946 MHz. When this occurs, pin 14 will go high and the transmit strip may be tweaked for maximum output on 29.6 MHz.

On receive, inject a precise 29.6 MHz signal, modulated by a 1 kHz tone at 5 kHz deviation. Tune the pre-amp and mixer circuits for maximum sensitivity, and the discriminator for the least distorted audio output signal.

Results

The transmit output is actually 1.75 kHz low. No one has ever reported the signal low, however, so this is not noticeable. The receiver is about 3.5 kHz low and it was thought that this might cause problems. Luck has it, though, that the first IF is so wide it is a joke, so no problems here. If a narrow first IF filter has been fitted then the audio does tend to be garbled. There are plenty of filters available now quite cheaply, and one centred on 10.695 MHz with a 20 kHz bandwidth seems a good compromise if you are bothered

The second IF filter is fairly sharp, and in most sets is about 6dB's down 8 kHz off. It is thus just beginning to have an effect on received peak deviation, but in practice it is not noticeable in use.

Suggested Improvements

The name of the game was to produce a cheap ten-metre FM rig out of a CB set. Since the sets are available for £10 to £15 and the bits to modify it, as above, will only cost a couple of quid, then the objective has been met. The original rig, thus modified, has been extremely reliable and has given mobile-to-base results consistently over a twenty-mile path.

There, are however, some people who are never satisfied. One amateur realised that most CB sets have a spare crystal oscillator available in the FM demodulator chip. He thus *bought* (sin of sins) the crystal that would give him the correct injection frequencies. It is interesting to note that it appears better on test equipment but is indistinguishable when in use. Another amateur has used a divider chip with a programmable offset to achieve the same results. Unfortunately the chip costs a fiver, so that's out with me!

A Few Final Points

The original CB frequencies still exist in the rig, although they are not connected to the main receive mixer. This does cause problems when stuck in a queue of traffic next to a CB'er, as you can just hear them. If you think about it, the channel they are on will be the channel that they appear on in your rig, even though it's modified. This really is a very localised problem and will go away when they are a car or two in front of you.

The prototype rig was built to the author's usual standard, *i.e.* badly. The board carrying the modification circuitry had, it must be admitted, been used before. Due to the limited space available in the rig there was nowhere to mount the board so it was put in a plastic bag and secured in place with an elastic band. Although it ended up squashed against the transmit strip of the rig, no spurious outputs were noticed on a spectrum analyser. To quote the Editor, G3KFE, a proper installation!