The 'DIREX' - An Amateur Bands Direct Conversion Receiver

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In the April 1977 issue of Short Wave Magazine, the author described a "Simple Receive Adaptor" which used the principle of direct conversion to produce receive facilities from an existing VFO. The circuit was the basis for any direct conversion receiver, with the addition of a variable frequency oscillator and audio stages. This article takes the 'bones' provided by that circuit and adds a little 'flesh' to give a complete receiver.

A direct-conversion receiver mixes the incoming signal with a local oscillator in a similar manner to the superhet. However in this type of receiver, the difference between the two signals is the required audio frequency, so direct conversion from RF signal to audio signal occurs. The action is like that of a product detector in a single sideband receiver. The resulting beat note between the two signals makes the system only really suitable for CW or SSB signals, but these are the two most common amateur band modes.

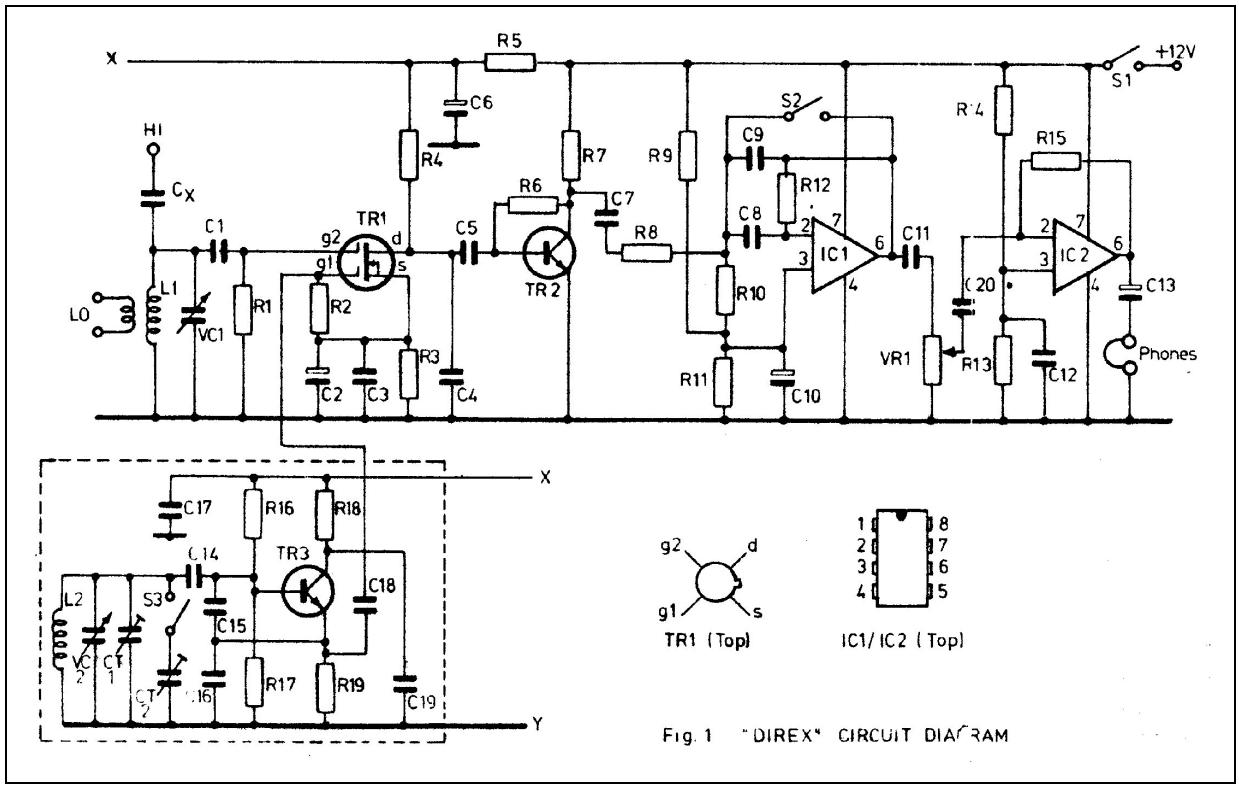


Fig. 1 "DIREX" CIRCUIT DIAGRAM

In a direct conversion receiver there are very few tuned circuits, which make the technique very suitable for amateur home construction; most of the gain and selectivity has to take place at the audio frequencies. It is usual to provide audio filtering for selectivity and high audio gain for sensitivity. The stability of the receiver depends upon the local oscillator, so a carefully constructed reliable VFO is required.

The circuit for the complete "Direx" receiver is shown in Fig. 1 - the circuitry around TR1 and TR2 is that of the article mentioned above; TR3 is a simple, but surprisingly stable VFO. A single stage of audio filtering is provided by the operational amplifier IC1. Another operational amplifier IC2 is used as a high gain headphone amplifier.

The prototype "Direx" was built to operate on the 7 MHz and 14 MHz amateur bands, though it is quite simple to use the circuit for any or all of the HF bands. L1 and L2 are identical coils and a pair of suitable coils would put the receiver on any required band. The circuitry from TR1 to IC2 could form the basis of a receiver with oscillator input taken to TR1 from a transmitter VFO - a very adaptable circuit.

TR1 is a dual-gate Mosfet mixer, and though Type 40673 is given in the table of values, the inexpensive substitute type sold by J. Birkett of Lincoln works well in the circuit; L1 and VC1 provide the front-end tuning for both bands. The 100pF value is enough to enable 7 and 14 MHz to be peaked for incoming signals, and this is coupled via CI into one of the gates of the dual-gate Mosfet.

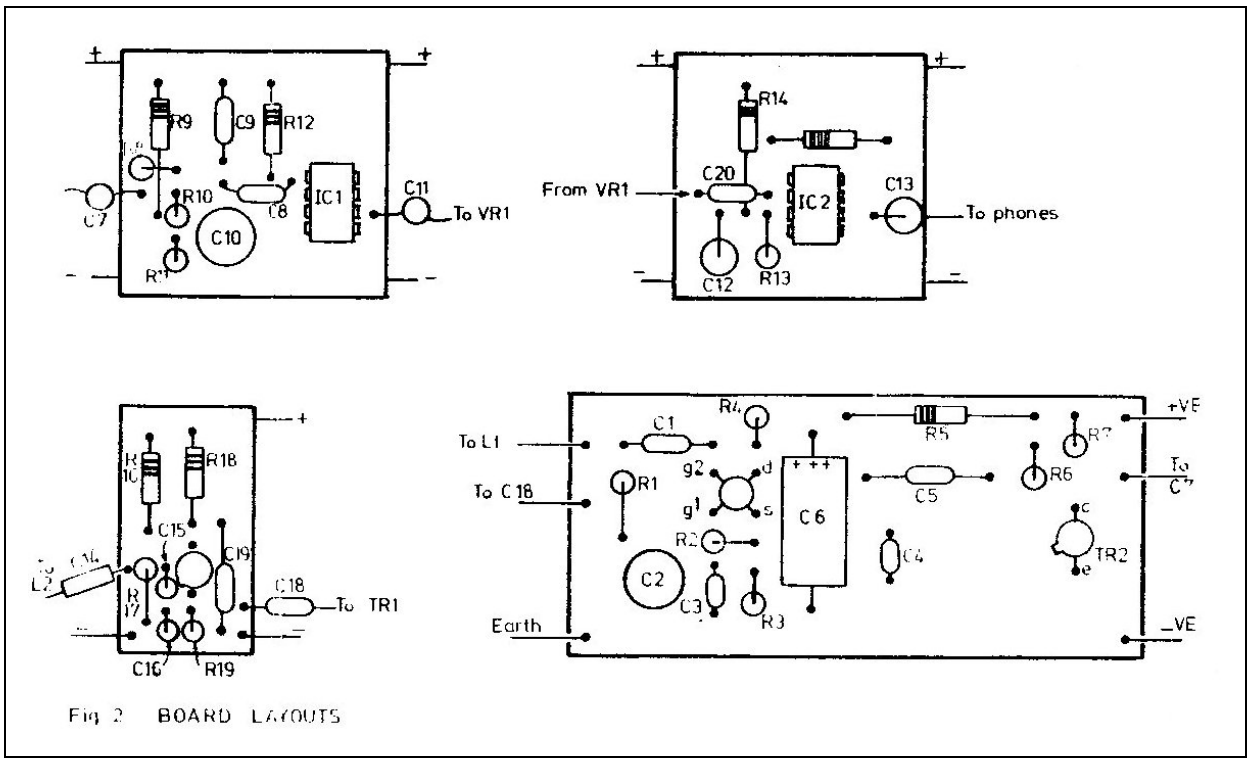


Fig 2 BOARD LAYOUTS

The oscillator is a simple single-stage Colpitts circuit: this was found to be sufficiently stable for two-band use (it would be possible for the constructor to use his own favourite HF oscillator circuit). L2 and VC2 allow a fair degree of bandspread tuning; for both bands by the switching-in of two trimmers CT1 and CT2; with S3 open the 14 MHz band is tuned and with S3 closed the 7 MHz band may be tuned. The oscillator output is taken from the emitter of TR3, via CIS, to the other gate of TRI.

LI and L2 are identically wound coils of 11 turns of 26 s.w.g. enameled wire on a 'in. (7mm.) 'Aladdin' former. LI has an additional winding to provide a suitable input for a low impedance aerial, marked LO on the circuit. A high impedance aerial, for example an unmatched length of wire, can be Coupled directly to the top of LI via Cx; Cx is an aerial coupling capacitor of sufficient value for RF transfer without undue damping of the tuned circuit. A value of some 100 to 200 pF will serve the purpose, or a trimmer with a maximum value of 250pF could be used. 7 MHz will be tuned with VCI vanes almost closed and 14 MHz will be tuned with the vanes almost open.

Arranging for TR3 to tune the two bands is a question of adjusting the trimmers and the dust core of L2; this can be done with a GDO with the components in circuit. However, an easier method is to get TR3 to oscillate and find the output on an existing receiver. The simplest procedure is to get VC2 to tune the whole 14 MHz band with CT1 by adjusting the trimmer CT1 and the dust core - attempt to obtain this with CTI unscrewed no more than about a third of its travel. If CT1 is unscrewed too far on the 14 MHz band, CT2 will not reach the 7 MHz band; when the 14 MHz band has been found, switch in CT2 and adjust only CT2 to the 7 MHz band. If CT2 will not enable the VFO to reach the low end of the 7 MHz, additional capacitance can be added in parallel.

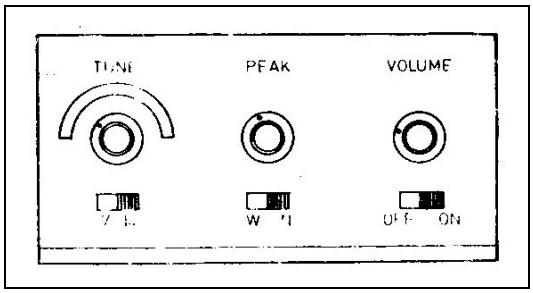
The output from the mixer, TR1, is RF decoupled by C4 and the audio is coupled via C5 into a single stage audio preamplifier TR2. This stage provides audio amplification to drive the audio filter. It would be possible to simplify the receiver by omitting this stage, but since most of the receiver gain is achieved at audio, it is advisable to retain TR2.

A simple single stage audio filter is provided by ICI: this is based upon the popular MFJ circuit. It provides a bandwidth of some 110 Hz with a centre frequency of about 800 Hz, and gives most of the receiver selectivity. The resistor network R9 and R11 enables a single rail power supply to be used with the op. amp; C8 and C9 should be close tolerance components. S2 shorts out this filter, and provides a wide/narrow bandwidth facility. C11 couples the audio signal to VR1, a simple audio volume control.

The final audio gain is provided by another 741 0p. amp. The feedback loop is controlled by R15 giving a high gain, but retaining stability. R14 and R13 allow for a single rail power supply for this amplifier. The output is coupled via C13 into a pair of high impedance headphones (this IC provides adequate headphone output).

The receiver was built in an aluminium box 5in. x 2.5in. x 3.5in., with the VFO built in a screened portion of it; the usual RF oscillator constructional practices should be followed. All the wiring should be direct and solid, and L1 mounted not too close to the side of the case to allow access to the dust core for tuning up.

The front panel layout (Fig. 3) allows a reasonable amount of space for construction. The VFO has a simple epicyclic 8:1 slow motion drive which is mounted onto the front of the box, and a pointer made from a length of stout copper wire is soldered to the reduced drive flange. This shows the frequency on a simple paper scale pasted on the front panel.



The circuits are built on Veroboard of the plain variety, without the copper strips; the interconnections are made beneath the board using the spare lead lengths of the components. There are four boards: VFO, Mixer/Preamp, Filter and Audio stages - the layout of components on these boards is shown in Fig. 2.

R1 = 47K	R18 = 470 ohms	C12 = 25 uF Elec.	PH - 2,000 ohms Impedance Headphones
R2 = 33K	R19 = 470 ohms	C13 = 50 uF Elec.	
R3 = 1K	VR1 = 10K Log. Pot.	C14 = 100 pF	
R4 = 4.7K	VCI = 100 pF variable	C15 = 470 pF poly.	S1 S2 & S3 = ingle-pole single - throw slide Switch
R5 = 220 ohms	VC2 = 10 pF variable	C16 = 250 pF poly	
R6 = 1.2M		C17 = 0.001 pF	
R7 = 4.7K	C1 = 100 pF	C18 = 1000 PF	
R8 = 33K	C2 = 25 uF Elec.	C19 = 0.01 uF	L1 - 11 turns 26 s.w.g. Enameled wire on 0.25in (7mm.) Aladdin former with dust core; 3-turn link winding over the main winding.
R9 = 27K	C3 = 0.02 uF	C20 = 0.1 uF	
R10 = 24K	C4 = 0-01 uF	CT1 = 3-30 Beehive Trimmer	
R11 = 27K	C5 = 0.22 uF	CT2 as CT1	
R12 = 1.8M	C6 = 100 pF Elec.		
R13 = 5.6K	C7 = 0.22 uF	TR1 = 40673 (see text)	
R14 = 5.6K	C8 = 0.001 uF 2%	TR2 = BC109	
R15 = 1M	C9 = 0.001 uF, 2%	TR3 = BC109	L2 as L1
R16 = I0K	C10 = 10uF Elec.	IC1 = 741	
R17 = 10K	C11 = 0.01 uF	IC1 = 741	

The VFO board is placed inside the screened compartment and the Mixer/Preamp board is mounted in the centre of the box close to the VC1 control. The Filter and Audio boards are placed behind the VRI control; these two are mounted in a vertical position to allow adequate spacing. The boards may be attached to the box by using blutack 'putty' which is ideal for holding small circuit boards in place.

This receiver could be built by a beginner without too much difficulty, and could also provide a portable or stand-by receiver for the more experienced amateur. It may also be seen as the basis for further experimentation, with its inherent lack of tuned circuit problems.