Project 756

As radioteletype (RTTY) is an increasingly popular transmission mode amongst radio amateurs, and as we've done a few RTTY projects in the past, we thought this project was a suitable addition to the series. Designed and developed by the R&D Department of Dick Smith Electronics, it is simply an add-on for their popular low-cost VZ200 home computer. Just attach your transceiver and type "CQ DX"!

**Neat and simple.** The project just plugs into the back of the VZ200. It must be the 'Mini Moke' of modems!

# A 'GLASS TELETYPE' USING THE VZ200

IF YOU'RE considering venturing into the world of radioteletype, an ancient and venerable form of digital communications (comparatively speaking), but would like to take the modern route — which means employing a computer — then this project is ideal. Or, if you've been playing with RTTY for some time, but have a combination of the older electromechanical technology and earlier electronic interfaces, and want to update, then this project represents a good 'stepping stone'.

If you're entirely new to radioteletype, then we recommend *"Radioteletype: It's finger-lickin' good"*, in the October '84 issue.

## The system

The Dick Smith VZ200 is a low-cost home computer but not lacking in features. One useful feature is a full expansion buss accessible via an edge connector on the main pc board, projecting through the rear of the case. Using this buss, one can attach a variety of peripherals and communicate in and out of the computer by decoding any of the Z80 CPU's ports suitable for the purpose. This project makes use of that facility.

One of the lesser-known features of the VZ200 is its internal RF radiation shielding. If you've ever had an HF receiver near a computer, you'll know just how much and how strong is the 'crud' they radiate from one end of the spectrum to the other!

The VZ200 tackles this computer quirk with the inclusion of extensive tinplate shielding over sections of the circuitry prone to radiation — particularly the memory circuitry. Hence the VZ200 can be sited near sensitive HF receiving equipment without the problems that plague many other computers. It's not entirely free from 'birdies' but, in general, they're out of harm's way. The VZ200 RTTY adaptor was developed by Ian Lindquist, VK2CA and Rex Callaghan, both of Dick Smith Electronics.

The project itself comprises two boards housed in a plastic peripheral box made by the VZ200 manufacturer. One board is the 'decoder' board, which contains the port decoding and RTTY terminal software in an EPROM, while the other board is the modulator/demodulator (or modem) board, containing the tone generator for driving the transmitter and the receiver converter for converting the incoming audio from the receiver and turning it into pulses for the computer to work on.

The idea is that the VZ200's keyboard becomes your erstwhile 'teletype' keyboard, and the video screen becomes your 'printout' — hence the term 'glass teletype'. A printer can be attached to the VZ200's printer port to give you 'hard copy' on paper, if you so desire.

The receiving converter features two cascaded active bandpass filters. These have a steeply rolling-off response to reduce noise and interference; their adjacent 'skirts' coincide, providing an essentially 'flat' bandpass response across the 2100 Hz to 2300 Hz band, neatly enclosing the 'amateur standard' 2125/2295 Hz tones (170 Hz shift) with a little leeway to cope with variations. An XR2211 phase-locked loop is used to generate 'mark' and 'space' pulses from the incoming tones. This chip conveniently provides a 'lock detect' output pin and this is used to drive a LED which lights when you have a signal correctly tuned.

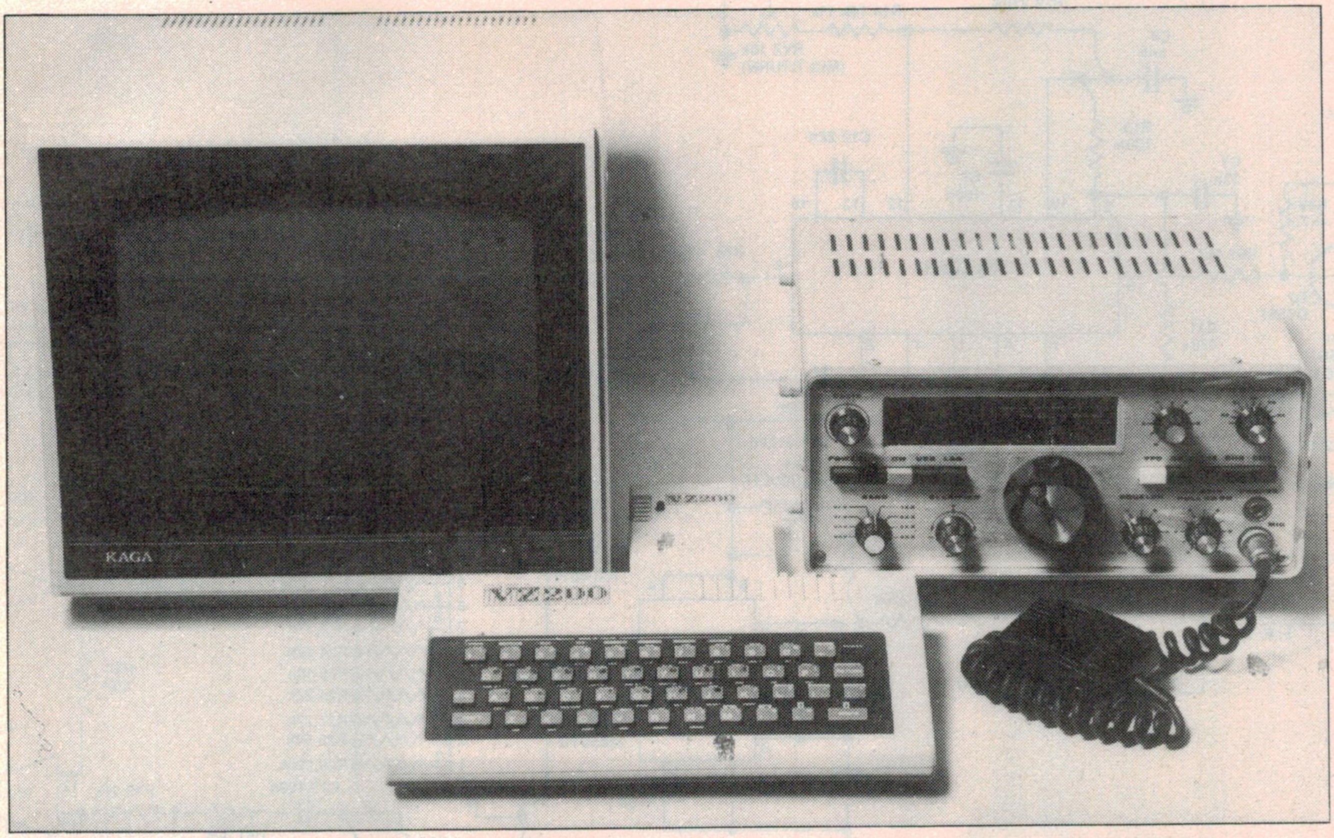
There is one special point worth noting about the PLL. The main VCO frequency determining component is C10, a 22n/400 V metallised polyester capacitor. This was chosen because it has a low temperature coefficient of capacitance around normal room temperatures (25° C). Substitutions may cause problems with excessive temperature drift and uncertain operation.

The transmitter section comprises a simple but reliable 'Walsh Function' pseudo-sinewave generator that generates, digitally, the two tones. This is followed by a filter, the output of which is fed to your transceiver's mic input.

Relay control of your transmitter is effected by a relay on the decoder board, the contacts of which go to the push-to-talk contacts (PTT) on your transceiver. This relay, and the transmitter section of the modem board, are each controlled by one of the decoded computer ports.

The project is powered from the VZ200 supply rail, via the expansion connector. The only interconnection required is to your transceiver's mic input, the PTT input and the audio output.

The software provides you with the two 'screens'. The upper screen is used to dis-




play the text you type, while the lower screen displays the received text. Each screen has independent scrolling. You can type and receive simultaneously. In other words, you can begin typing a reply while receiving text from another station.

You have a 'type ahead' buffer which can contain up to 1024 characters (1K). Apart from that, the software gives you a total of six transmit buffers, one of which is reserved as a 'who are you?' (or WRU) buffer. This versatile feature alerts you when another station calls you by your callsign or some other identification, and the unit will send a response. For example: say VK2ETI wishes to activate your WRU mode. He would send

VK2XYZ WRU VK2ETI

and your unit would respond with something like

STATION IDENTIFICATION
DE VK2XYZ (PETER)

and, if you had put a message in the WRU buffer, your unit could add

STAND BY
++ OPERATOR ALERTED ++

or whatever you had inserted. It is considered impolite to insert messages in the WRU buffer like

RACK OFF HAIRY LEGS!

There are various ways of using this feature, explained later.

There are seven pre-programmed messages stored in the unit's EPROM. Many are designed to insert your callsign automatically when called, saving you time and effort. You can send a string of CQs along with your callsign; a row of RYs (the accepted 'test' signal'; it contains the highest data density); the 'quick brown fox' message along with the numerals 0 to 9 (full alphanumeric series); the 'send — over' terminator; station identification; send your callsign; and send DE followed by your callsign.

There is a total of fourteen 'transmit' commands and nine 'immediate' commands, all called using the SHIFT key. The immediate commands control the overall operation of the 'glass teletype'. One toggles the current mode — i.e: from transmit to receive or from receive to transmit; one exits from the current operating mode to the menu; one controls the WRU mode; one gives you backspace; one changes the baud rate; one returns you to the 'callsign entry' — a sort of 'begin again' command, and two control the printer operation.

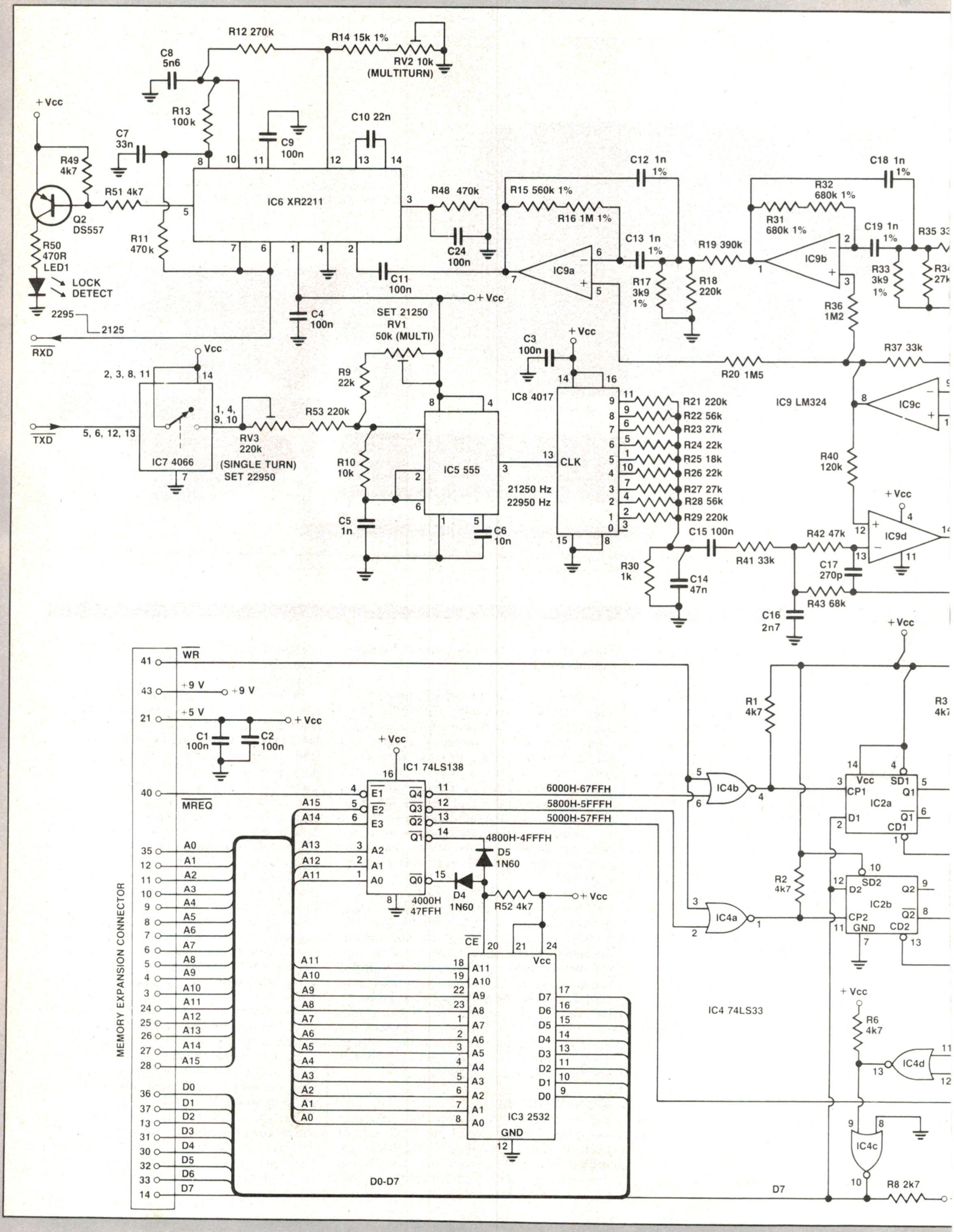
## Construction

Before commencing any of the electronic assembly, carefully check the track side of each pc board. See that all the holes are drilled and of the correct size. Check that there are no solder 'bridges' between closely-spaced tracks, particularly between IC pads. See that there are no obvious breaks in any tracks.

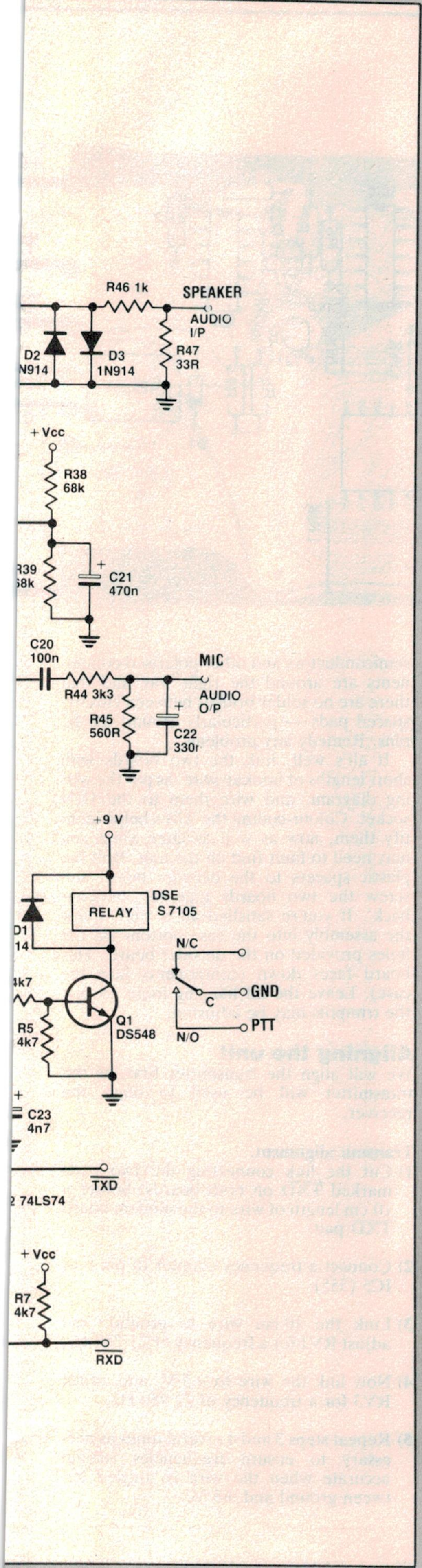
Probably the best place to start is with the case. It comes in two halves. Mark out positions for the DIN socket and the LOCK DETECT indicator LED on the case lid (the larger piece). See the accompanying photograph. Drill them to size and then insert the DIN socket and screw it in place. The LED mounts on the pc board on the ends of its leads and protrudes through the hole in the case lid. The length of its leads will permit some variation in the exact hole position in the case lid.

Once that's out of the way, you can tackle the board assembly. It's easiest to start with the decoder board. It's marked ETI-756a/ZA1694. There are eight links required on this board; install them first. Use 22g tinned copper wire. Next, install the resistors and capacitors. Make sure you get C23 the right way round. Solder ICs 1, 2 and 4 in place next, ensuring they are correctly oriented. Install a socket for IC3 next, but don't insert the EPROM yet. Now solder in the three diodes, followed by the relay. Check that the diodes are inserted the right way round. Now solder Q1 in place, then the 44-pin right-angle socket. Last of all, plug in the EPROM.

Put the decoder board aside and tackle the modem board next. As before, start by soldering in the links. There are only two (contrary to what you can see in the pictures — a prototype, later modified). One is ▶



R12 270k
R14 15k 1%
RV2 10k
(MULTITURN)
C8
5n6
+Vcc
R13
100k
C10 22n
C7
33n
C9
100n
R49
4k7
R51 4k7
IC6 XR2211
R48 470k
Q2
DS557
R11
470k
C24
100n
R50
470R
LED1
LOCK
DETECT
C11
100n
C4
100n
2295
2125
RXD
+Vcc
SET 21250
RV1
50k (MULTI)
R9
22k
C3
100n
IC8 4017
CLK
2, 3, 8, 11
1, 4,
9, 10
R53 220k
TXD
5, 6, 12, 13
RV3
220k
(SINGLE TURN)
SET 22950
IC7 4066
IC5 555
R10
10k
C5
1n
C6
10n
21250 Hz
22950 Hz
R21 220k
R22 56k
R23 27k
R24 22k
R25 18k
R26 22k
R27 27k
R28 56k
R29 220k
C12 1n
1%
R15 560k 1%
R16 1M 1%
C13 1n
1%
IC9a
R17
3k9
1%
R18
220k
R19 390k
C18 1n
1%
R32
680k 1%
R31
680k 1%
IC9b
C19 1n
1%
R35 33
R33
3k9
1%
R34
27k
R36
1M2
R37 33k
R20 1M5
IC9 LM324
IC9c
R40
120k
IC9d
C15 100n
R41 33k
R42 47k
R30
1k
C14
47n
C17
270p
R43 68k
C16
2n7
WR
+9 V
+5 V
C1
100n
C2
100n
+Vcc
MREQ
IC1 74LS138
A15
A14
A13
A12
A11
E1
E2
E3
A2
A1
A0
Q4
Q3
Q2
Q1
Q0
6000H-67FFH
5800H-5FFFH
5000H-57FFH
4800H-4FFFH
D5
1N60
D4
1N60
4000H
47FFH
R52 4k7
CE
IC3 2532
GND
Vcc
A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0
D7 D6 D5 D4 D3 D2 D1 D0
D0-D7
D7
MEMORY EXPANSION CONNECTOR
IC4b
IC4a
IC4 74LS33
R1
4k7
R2
4k7
R3
4k7
IC2a
Vcc
SD1
CP1
Q1
D1
CD1
IC2b
SD2
Q2
D2
CP2
GND
CD2
R6
4k7
IC4d
IC4c
R8 2k7




## HOW IT WORKS — ETI-756

There are two sections to the project, each contained on separate boards: the 'decoder' (or decoder/control) board and the 'modem' board. They are powered from the +9 V and +5 V supply rails of the VZ200. Let's take each section separately.

### DECODER BOARD

This decodes five ports and contains the software in EPROM plus the transmitter control relay. IC1 decodes address lines A11-A13, five of its Q outputs selecting the EPROM, transmit control and receive control circuitry as required. The outputs are 'enabled' when 1-1-0 appears on A14, A15 and the MREQ line.

Serial baudot data for transmit and receive goes in and out on bit seven of the VZ200's data buss (D7).

When you select transmit operation from the VZ200, the relay closes the push-to-talk (PTT) contacts, turning on your transmitter. When you send text, the data is sent via D7 and to the modulator board via the flip-flop IC2b and the $\overline{\text{TXD}}$ line.

When you select receive operation, the pulses from the demodulator on the modem board come in via the $\overline{\text{RXD}}$ line, and are gated onto D7 via IC4d and c. Note that, on selecting receive operation, Q1 gets turned off and the relay PTT contacts open, turning off your transmitter.

Diodes D4 and D5 make a simple OR gate, allowing the 'chip enable' pin of the EPROM to be activated when either the lower or upper 1K block of the EPROM is selected.

IC2 is a flip-flop that sets up the transmit control. Its outputs must be preset on power-up, hence the two 'clear' pins (CD1 and CD2) are initially clamped to 0 V on power-up because C23 is initially uncharged. It will charge via R3, by which time the Q outputs of IC2 will be correctly set.

### MODEM BOARD

The receiver portion comprises two op-amps from IC9 (a and b), and IC6, an XR2211 PLL chip.

The two op-amps are set up as bandpass filters, each with the centre frequency offset so that their adjacent skirts just overlap. The filter Qs were chosen to provide good skirt selectively so that noise and interference in the received channel do not adversely affect the demodulator's operation. The lower roll-off is at about 2070 Hz, the upper roll-off at about 2350 Hz, neatly encompassing the standard mark and space tones used in amateur RTTY of 2125 and 2295 Hz. Note that 1% components are used for the critical filter components.

The filter output, from pin 7 of IC9, couples to the PLL input via C11. The PLL centre frequency is determined by C10 (chosen for its low temperature coefficient — see main text) and R14/RV2. The latter sets the PLL on frequency.

The PLL's dc 'error' signal toggles from high to low as the incoming audio switches from 2295 Hz to 2125 Hz. This output is the $\overline{\text{RXD}}$ line, sending the baudot bit stream to the VZ200 via the decoder board.

The XR2211 provides a 'lock detect' pin and this is used to drive a LED indicator via a transistor buffer (Q2).

The audio input to the demodulator is taken from the receiver's speaker. The level is first attenuated and then clipped with back-to-back diodes, D2 and D3. The 500 mV pk-pk level here is further attenuated (via R34/R35) before being applied to the input of the filter stages.

The modulator comprises a 'Walsh Function' generator, which digitally generates a pseudo-sinewave, followed by a buffer filter. The Walsh Function generator consists of IC5, a 555 timer running at ten times the required output frequency, followed by a 4017 decade counter. The 555 is toggled between the two required frequencies (21 250 Hz and 22 950 Hz) by switching extra resistance across the 555's timing resistor, thus raising its frequency of oscillation. This is done using a 4066 CMOS switch to switch RV3-R53 in parallel with RV1-R9. The $\overline{\text{TXD}}$ line toggles the 4066.

The output of the 555 drives the clock input of the 4017. The decade counter's outputs are all 'chained' via resistors R21-R29 so that the voltage across R30 'steps' up and down, depending on the ratio of high-to-low outputs of the 4017. The CR network of C14-R30 provides some high frequency roll-off.

One op-amp from IC9 (d) provides a buffer/filter, 'rounding off' the digitally generated sinewave before it is passed to the transmitter's mic input. C15 provides ac coupling to the op-amp input. C17 prevents RF from creating havoc in the mic line.

The op-amps require a half-supply rail for their non-inverting inputs and this is provided by IC9c and the divider R38-R39. C21 bypasses the half-supply divider.

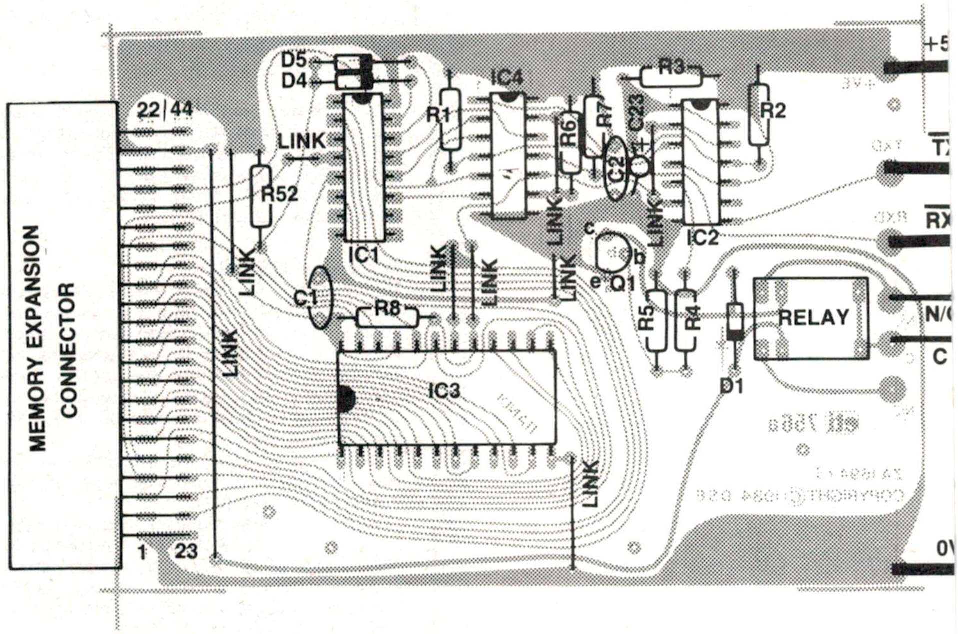
Trimpot RV1 sets the low tone, while RV3 sets the high tone of the modulator. Note that RV3 is only a single-turn trimpot, while RV1 is a multi-turn type.

located between R9 and R10, the other between R17 and R46. Use 22g tinned copper wire. Insert all the resistors next. Follow with the two diodes, Q2 and LED1 — making sure you get them all the right way round. Now solder all the ICs in place, seeing that you have them correctly oriented before soldering. With IC6, IC7 and IC8, solder the ground pins first, followed by the Vcc pin, and then all the remaining pins. This prevents any static or leakage current failure problems with the CMOS during construction.

The trimpots can be soldered in place next. Note that RV3 (SET 22 950) is a signal turn, vertical-mounting type, not a 10-turn trimpot like the others (and as seen in the pictures).

All the capacitors are soldered in place last. See that the two tantalums (C22 and C23) are correctly oriented.

Before proceeding further, *give each board a thorough check.* See that all the semiconductors and other polarised components are around the right way and that there are no solder bridges between closely-spaced pads — particularly around the IC pins. Remedy any problems.




**The following is a summary of the commands for this system:**

## TRANSMIT COMMANDS

When called, the following commands are inserted into the type — ahead buffer ready for transmission.

| | |
|---|---|
| • SHIFT Q | Transmit buffer #1. |
| • SHIFT W | Transmit buffer #2. |
| • SHIFT E | Transmit buffer #3. |
| • SHIFT R | Transmit buffer #4. |
| • SHIFT T | Transmit buffer #5. |
| • SHIFT 0 | Transmit buffer #0 (WRU buffer). |
| • SHIFT A | Transmit a row of RYs (32 characters). |
| • SHIFT I | Transmit "STATION IDENTIFICATION" along with your callsign. |
| • SHIFT P | Transmit "PLEASE KK KK KK" to terminate a call. |
| • SHIFT D | Transmit "DE" along with your callsign. |
| • SHIFT F | Transmit "THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789". |
| • SHIFT C | Transmit a row of CQs (32 characters) along with your callsign. |
| • SHIFT 0 | Transmit your callsign only. |
| • SHIFT 3 | Terminate the transmission at this point and exit to receive mode. (SHIFT 3 produces a #). |

## IMMEDIATE COMMANDS

These commands operate in both transmit and receive modes.

| | |
|---|---|
| • SHIFT Z | Toggle from the current mode to the alternative mode; i.e.: from TX to RX or from RX to TX. |
| • SHIFT | Exit from the current mode to the menu. |
| • SHIFT U | Enable/disable the WRU mode. The current status is displayed on the command line at the top of the screen. |
| • SHIFT H | Enable/disable the PRINTER mode. The current status is displayed on the command line at the top of the screen. |
| • SHIFT M | Backspace key. Deletes the last character typed. |
| • SHIFT S | Change the BAUD RATE. |
| • SHIFT B | Clears the internal printer buffer. |
| • SHIFT G | Exits the current mode and restarts at the callsign entry mode. |
| • SHIFT (RET) | Inserts a CR/LF into the internal printer buffer, forcing it to dump its contents to the printer. |

If all's well, link the two boards with short lengths of hookup wire, as per the wiring diagram, and wire them to the DIN socket. Colour-coding the wires helps identify them, now as well as later when you may need to fault-find on the unit. Bolt the plastic spacers to the decoder board and screw the two boards together 'back-to-back'. If you're satisfied all is well, screw the assembly into the case bottom via the holes provided on the decoder board. This board faces down (components face the case). Leave the lid hanging loose so that the trimpots may be adjusted.

## Aligning the unit

We will align the transmitter first, as the transmitter will be used to align the receiver.

**Transmit alignment.**

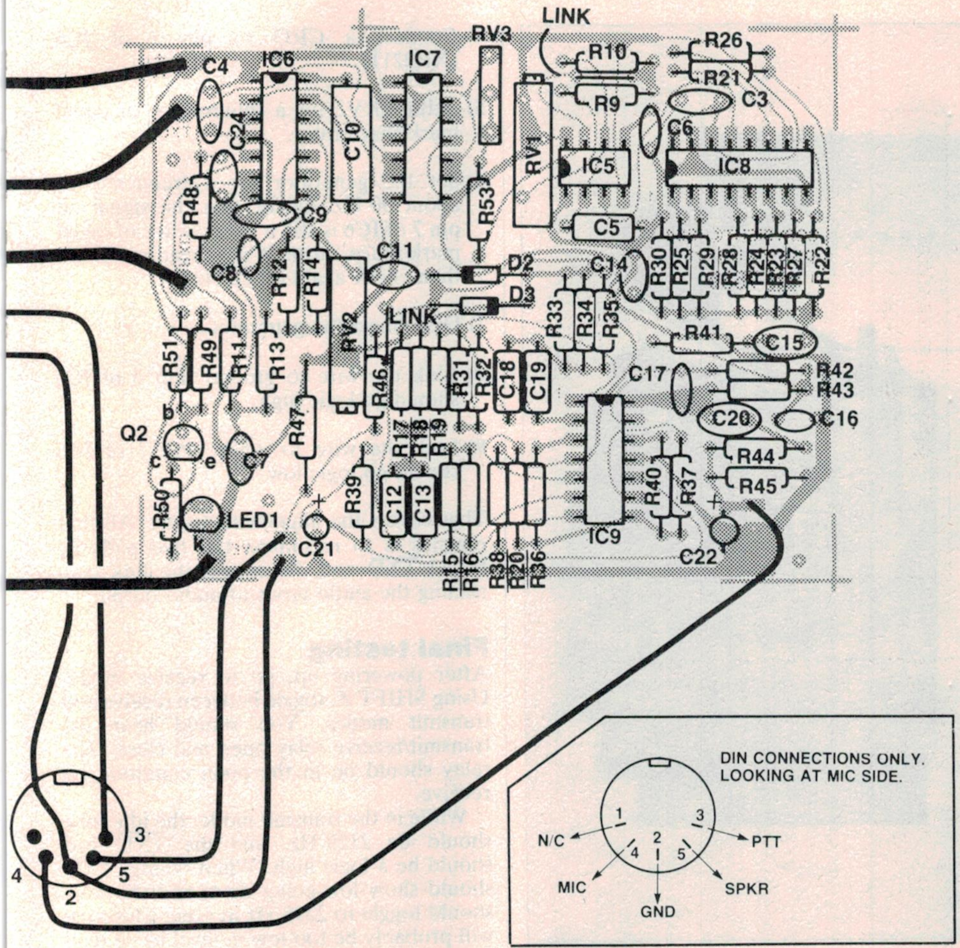
1) Cut the link connecting the two pads marked $\overline{TXD}$ on both boards. Solder a 10 cm length of wire to the modem board $\overline{TXD}$ pad.

2) Connect a frequency counter to pin 3 of IC5 (555).

3) Link the 10 cm wire to ground, and adjust RV1 for a frequency of 21 250 Hz.

4) Now link the wire to +5 V, and adjust RV3 for a frequency of 22 950 Hz.

5) Repeat steps 3 and 4 several times as necessary to ensure frequencies remain accurate when the wire is toggled between ground and +5 V.



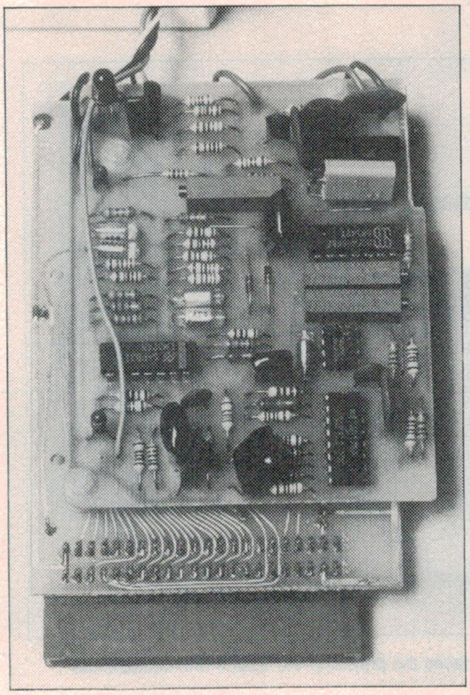

**PC BOARD**
The printed circuit artwork was done by Dick Smith Electronics and copyright is held by them. Hence, we have not reproduced the board pattern. Complete kits are available from Dick Smith stores.

**Receiver alignment.**

1) Wire a link connecting TX audio output to RX audio input.

2) Connect an audio generator to the wire used in the transmitter alignment.

3) Set the generator for a square wave, 0 dB attenuation, maximum amplitude, and a frequency of about 22 Hz. (This simulates a speed of approximately 45 baud).



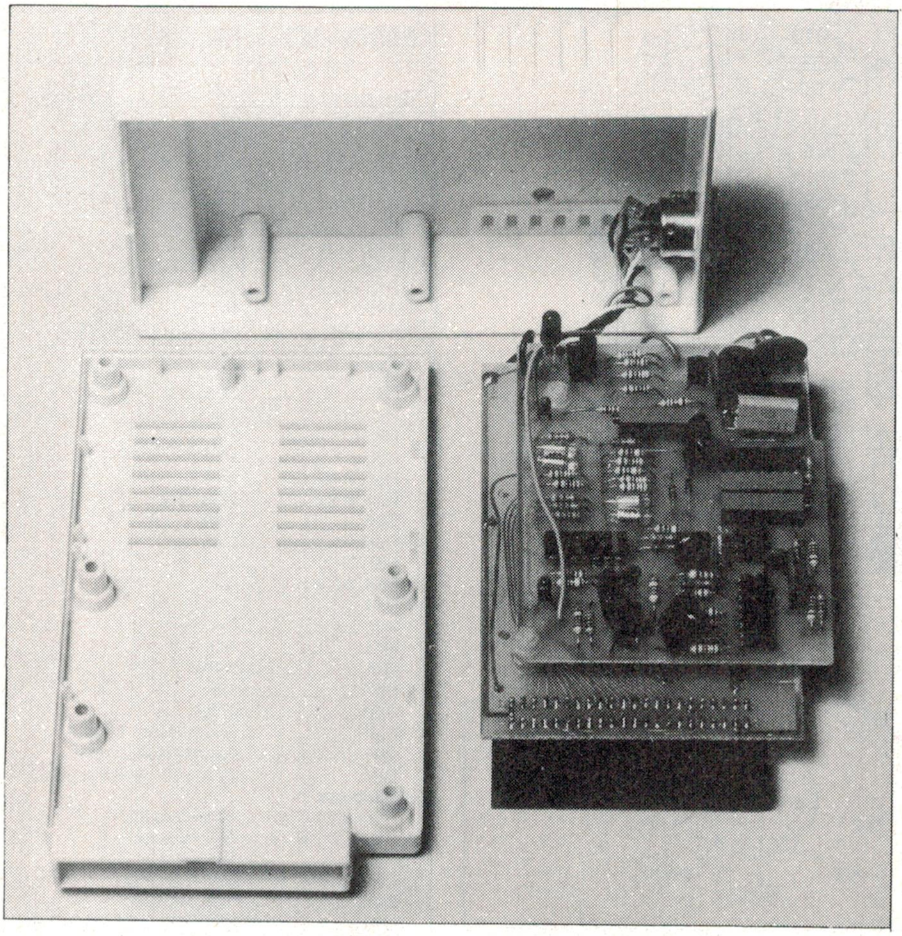
**Modem board.** The receiver demodulator and transmitter modulator are contained on this board, mounted on the rear of the decoder board. Note the indicator LED.

## PARTS LIST — ETI-756

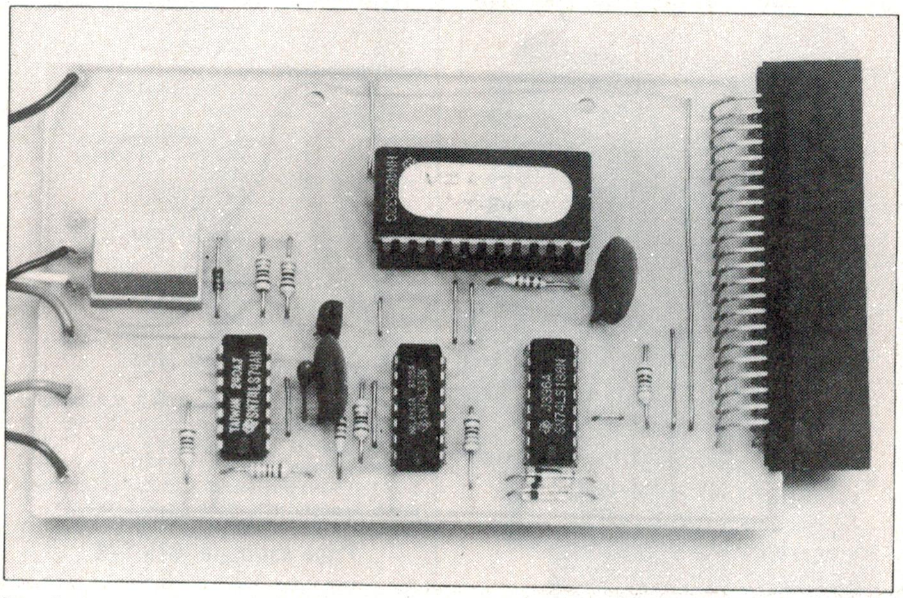
| | |
|---|---|
| **Resistors** | all ¼W, 5% unless noted |
| R1-6,49,51,52 | 4k7 |
| R7, R8 | 2k7 |
| R9,24,26 | 22k |
| R10 | 10k |
| R11, R48 | 470k |
| R12 | 270k |
| R13 | 100k |
| R14 | 15k, 1% |
| R15 | 560k, 1% |
| R16 | 1M, 1% |
| R17, R33 | 3k9, 1% |
| R18,21,29,53 | 220k |
| R19 | 390k |
| R20 | 1M5 |
| R22, R28 | 56k |
| R23,27,34 | 27k |
| R25 | 18k |
| R30, R46 | 1k |
| R31, R32 | 680k, 1% |
| R35 | 330k |
| R36 | 1M2 |
| R37, R41 | 33k |
| R38, 39, 43 | 68k |
| R40 | 120k |
| R42 | 47k |
| R44 | 3k3 |
| R45 | 560R |
| R47 | 33R |
| R50 | 470R |
| RV1 | 50k multiturn trimpot |
| RV2 | 10k multiturn trimpot |
| RV3 | 200k vert. mount trimpot |
| **Capacitors** | |
| C1-4,9,24 | 100n ceramic |
| C5,12,13,18,19 | 1n, 1% styro |
| C6 | 10n ceramic |
| C7 | 33n greencap |
| C8 | 5n6 greencap |
| C10 | 22n/400 V metallised poly cap. (mpc) |
| C11,15,20 | 100n greencap |
| C14 | 47n greencap |
| C16 | 2n7 greencap |
| C17 | 270p, 1% styro |
| C21 | 470n electro (pc mount) |
| C22 | 330n/10 V tant. |
| C23 | 470n/10 V tant. |
| **Semiconductors** | |
| D1,2,3 | 1N914, 1N4148 |
| D4, D5 | 1N60 |
| LED1 | 5 mm red LED |
| Q1 | DS548 |
| Q2 | DS557 |
| IC1 | 74LS138 |
| IC2 | 74LS74 |
| IC3 | 2532 EPROM, "VZRTTY" |
| IC4 | 74LS33 |
| IC5 | DS555 |
| IC6 | XR2211 |
| IC7 | 4066 |
| IC8 | 4017 |
| IC9 | LM324, µA324 |

**Miscellaneous**
ETI-756 a and b pc boards (D.S.E. ZA1694 and ZA1695); 44-way edge connector (D.S.E. ZA 4107); case — Vitec RAM PAK case (D.S.E. ZA4663); Relay — mini 12 V DPDT type (D.S.E. S 7112); 5-pin DIN socket (D.S.E. P1552); three plastic spacers; nuts, bolts, hookup wire, etc.

**Price estimate: $70-$75**



**Insides out.** The two boards mount inside a case from the VZ200's manufacturer. The bottom of the case is shown at left. The decoder board mounts to this, the modem board being mounted to the decoder board. Note the hole for the indicator in the case top.



**Decoder board.** There's not much to it. This unit interfaces the project to the VZ200 and contains the software in EPROM.

**4)** Connect a CRO to pin 7 of IC6 (XR2211).

**5)** Adjust RV2 for a squarewave of equal mark/space ratio.

**6)** Set the generator for a frequency of about 50 Hz. Check that the signal on pin 7 of IC6 is still a squarewave of equal mark/space ratio. If not, readjust RV2, then check again on 22 Hz.

**7)** Disconnect the generator.

**8)** Link the wire to ground. Pin 7 of IC6 should go logic high.

**9)** Link the wire to +5 V. Pin 7 of IC6 should go logic low.

That covers the alignment details. All that remains is to reconnect the two pads labelled $\overline{TXD}$ and disconnect the link connecting the audio input to audio output.

## Final testing

After powering up, go to receive mode. Using SHIFT Z, toggle between receive and transmit modes. You should hear the transmit/receive relay open and close. The relay should be in the open condition on receive.

While in the transmit mode, the idle tone should be 2125 Hz, and the $\overline{TXD}$ pad should be a logic high. When typing, $\overline{TXD}$ should show low-going data, and the tone should toggle to 2295 Hz in sync. This tone will probably be too low in level to be read by a counter at the audio output pin, but it can be read on pin 3 of IC5 (555). (NOTE: This reading is 10 times the final frequency, so don't be fooled.)

## Try out

Plug the project into the VZ200 expansion slot with the decoder board components facing *down*. Failure to observe this could result in the unit being damaged.

Once the module is fitted, turn your VZ200 on. If your VZ200 has Version 2.1 BASIC, you should hold down the CTRL key as you turn on, or else the display will contain inverse characters. If all is well, the VZ-200 should display

★ VZ-200 RTTY ★
★ TERMINAL PACK ★

followed by a copyright message. If not, power down immediately, and check the project for errors.

If all is well, you are ready to align the receive and transmit sections.

Before starting the alignment procedure, however, run through the general operation to ensure the software decoding is working fully.

**PART 2: In the next instalment, we cover the overall operation of the unit, plus a listing of the software and a guide to its workings.** ●