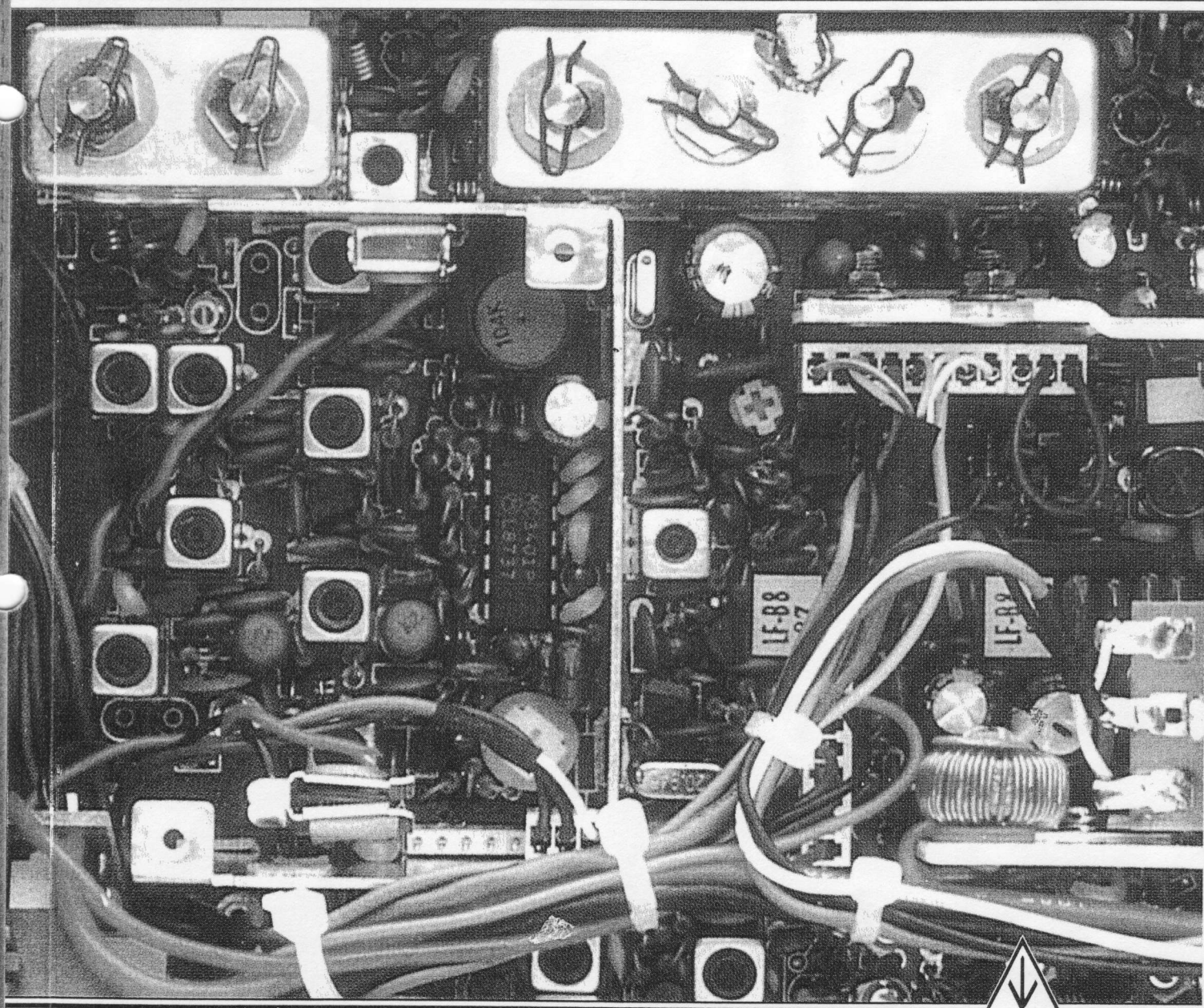


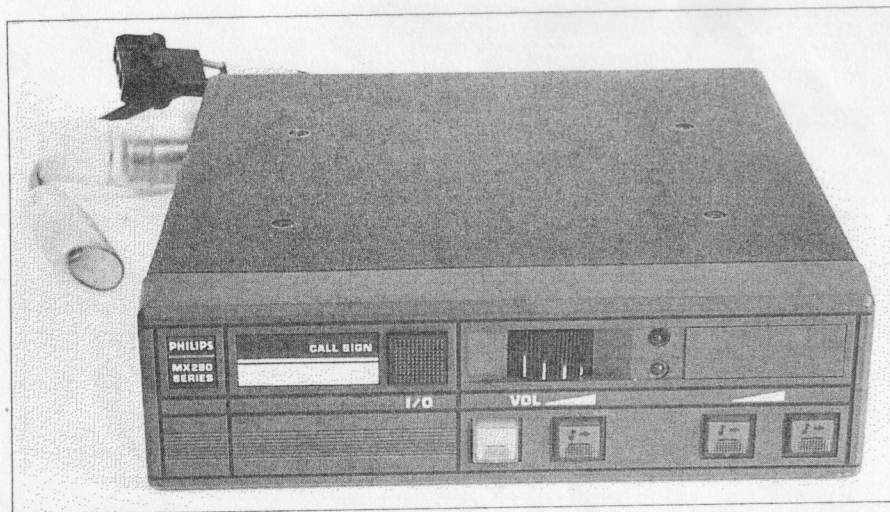
# PMR CONVERSION HANDBOOK



BY CHRIS LOREK, G4HCL







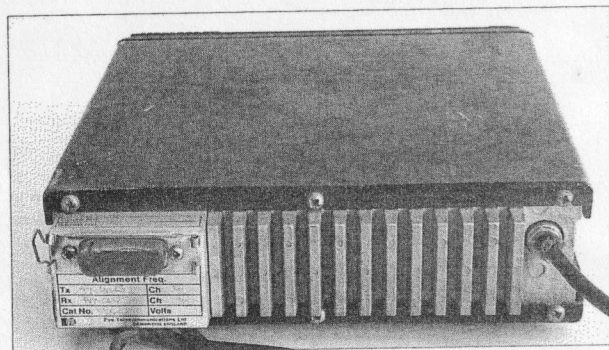
The MX290 series, fitted with a trunking controller in this case

control mounted on the set's front panel. Alternatively, you may wish to add a 'squelch open', ie 'busy', indicator. For this, connect an LED in series with a 1k $\Omega$  resistor between the set's positive supply and pin P2, which switches to 0V when the squelch lifts. P2 is often linked to pin M1, which in turn is connected to pin M on the main board.

### MX290 SERIES

The MX290 series of sets outwardly look physically similar to the M290 series at first glance. As they can share the same front-panel options, you could easily be excused for mistaking them! A closer look, however, shows that the set is built on a die-cast alloy frame, with top and bottom lids screwed on using two screws on either end of each lid. Also, rather than a 'smooth' rear panel, a small finned die-cast heatsink, which is part of the cast frame, is used, together with a smaller serial number panel. The sets come in four types:

- MX293: VHF AM
- MX294: VHF FM
- MX295: Band III (174–225MHz) FM
- MX296: UHF FM



The MX290 series can be identified by a finned rear-panel heatsink

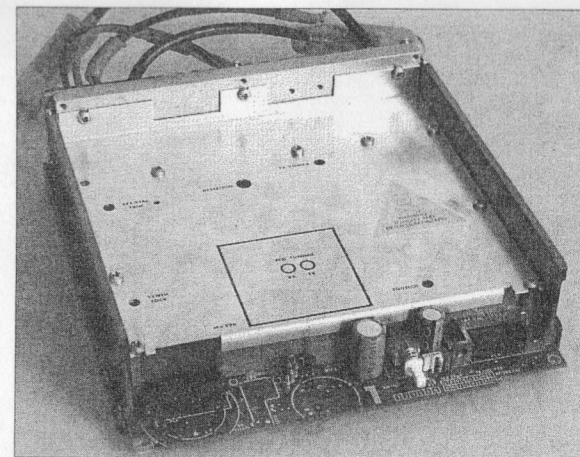
You'll often (but not always) find a trunking front panel on the MX295, although I've also seen other sets, particularly the MX296, also with trunking plug-ins for MPT1327 and other signalling formats.

The MX293, being AM, isn't detailed here, neither is the MX295 as this requires a substantial amount of RF circuitry changes to 'get it going' onto the amateur bands. The MX294 and MX296 are, however, often ideal for use on 4m, 2m, or 70cm. Although you'll need to expend a little effort in adding suitable frequency control, the end result is a high-performance, multi-channel set. I've used an E band (68–88MHz) and an A band (148–174MHz) MX294 continuously for several years at my local hilltop-sited packet radio node for 4m and 2m respectively – indeed, the 70cm port of this node uses an M296.

### Identification codes

The rear panel information label will give you the serial, code and catalogue numbers, together with the transmitter and receiver alignment frequencies. The typically found alphanumeric codes are in the order given in Table 4.5.

The MX294 and MX296 come in a variety of forms, the main difference being the front-panel channel control arrangement. You'll usually find this is a edge-wise mechanical 16-way channel switch, which appears virtually identical to the M294/M296 type apart from the greater number of switch positions. This switch is occasionally mechanically limited to the programmed number of channels – lift off the outer knob from the switch and remove the small metal ring from the switch itself. This ring will have a



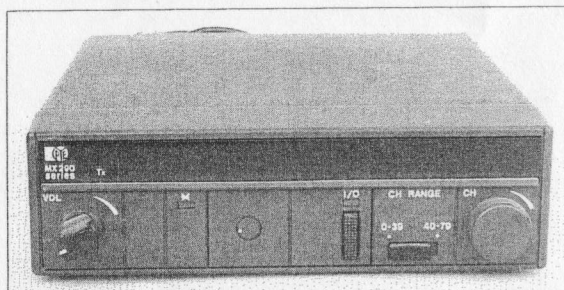
You'll usually find the RF circuitry is fitted with a large metal screen

Table 4.5. MX290 series identification codes

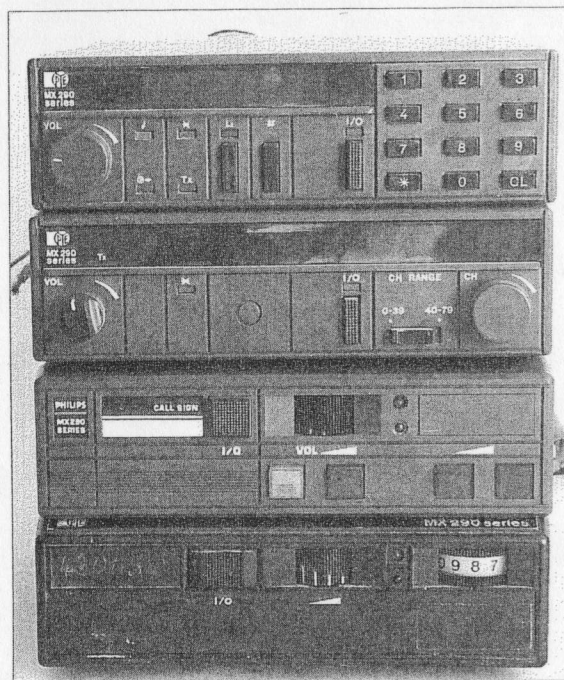
|                     |                                                                                                                                                                                                               |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Equipment type:     | MX294, MX296 etc                                                                                                                                                                                              |
| Market code:        | 01 (standard production)                                                                                                                                                                                      |
| Mobile type:        | 1 (standard), 2 (with fitted rear facility socket), 3 (for cassette mounting)                                                                                                                                 |
| Installation items: | A, 1–4 (speaker, mounting brackets etc)                                                                                                                                                                       |
| Number of channels: | 1–9, X (10), A–F (11–16), Q (up to 256 with special front panel)                                                                                                                                              |
| Brand label:        | 0–2 (front panel label)                                                                                                                                                                                       |
| Internal options:   | 0 (none), 1 (carrier level detector, eg for trunking sets)                                                                                                                                                    |
| Channel spacing:    | S (12.5kHz), V (25kHz), R (20kHz)                                                                                                                                                                             |
| TX/RX freq band:    | A0, E0 etc.                                                                                                                                                                                                   |
| Channel capacity:   | F (up to 16), G (all others)                                                                                                                                                                                  |
| Freq programming:   | T, 1–6 (various programmed options)                                                                                                                                                                           |
| Transmit power:     | 1 (25W), 2 (15W), 3 (10W), or 4 (6W)                                                                                                                                                                          |
| Primary options:    | 1A ('New' front panel), 1B (TEDX), 1C (TED3), 14 (TE1), 15 (TED1), 16 (TED6), 41 (40-chan), 45 (40-chan, TED1), 46 (40-chan, TED6), 81 (80-chan), 85 (80-chan, TED1), 86 (80-chan, TED6), S1 (CX290 trunking) |
| Secondary options:  | 00–30 (various mics), 90 (mic with internal TX timer).                                                                                                                                                        |



**Top:** The MX290 series is usually fitted with a 16-channel switch



**Middle:** If you find an MX294 or MX296 with a 40/80-channel front panel like this, you're in luck



**Bottom:** All these sets are from the MX290 series

detented 'stop' in it which fits into the appropriate channel position on the rotary switch to act as a mechanical stop. Alternatively, you might find an electronic channel control with a dual seven-segment LED readout giving either 40 channels or 80 channels. In the latter case, an edgewise plug is fitted to the front left of the set's main board to interface with the front panel's channel control. The latter form of front panel of course is ideal for amateur radio use, although you can if you wish add your own BCD switches to give channel control.

Don't be misled if you see an LCD readout on the front panel along with the 16-way switch – this is a TEDX micro-processor controlled selective calling unit, which has nothing to do with the RF channel control of the set.

You may sometimes find a trunking front panel is used, with a LED readout and keypad but no click-step channel knob. In this case, you'll need to replace this with an added channel switch of your own.

### Synthesiser

This uses an NJ8813 synthesiser divider IC and a HEF4750 reference divider IC, the latter in the case of the MX294 plugging into a socket on the main

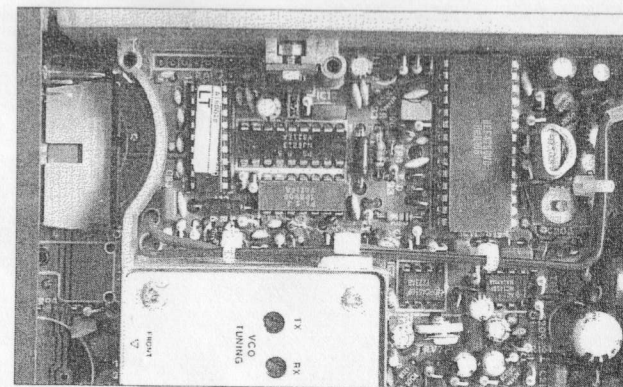
board. Note that this isn't an EPROM, even if it looks like one. The frequency control information is stored in a fusible-link TTL PROM. Now, most amateurs don't have programming facilities for these, although EPROM programming facilities for the commonly available 27 series EPROMs are usually readily available. As common 5V logic levels are used for both, with suitable pin-swapping a suitably programmed EPROM can be used as an effective replacement. I've helped supply over 200 such programmed EPROMs to amateurs in the UK for this very purpose.

You'll find that, for 16 channels, a 16-pin 82S129 PROM is used. For 40/80 or more channels, an 18-pin 82S185 PROM is used. The PROM plugs into an IC socket on the MX294 PCB, and this has facilities for either 16-pin or 18-pin IC sockets. Even if a 16-pin socket is used, the 'holes' are there in the PCB for 18 pins – pins 9 and 10 aren't used. To prevent confusion, the pin numbers I've given here always refer to those for an 18-pin socket – for a 16-pin socket simply subtract 2 from pin numbers 11–18 inclusive.

### Channel switch

The 16-way channel switch used is a reverse-logic type, which pulls the output lines to 0V rather than connects positive voltage as needed to the PROM address lines. A thin-film resistor array of eight 4.7kΩ resistors is used to 'pull up' to 5V the address lines to the PROM. You'll see a 7805 regulator next to the latter – this is used to supply the stabilised 5V line. You may also see a plug-in link LK1 next to the regulator. This is the 5V line link and should be left connected. You may also see link LK2 next to the PROM. This is used to pull the A7 binary address line (PROM pin 17) down to 0V. This is because the 82S129 has a capacity to store 32 channels, and this facility is used to provide an alignment channel for the set, which is the frequency marked on its serial number plate. By using the LK2 facility, either with a suitably programmed PROM or a replacement EPROM and the A7 line connected appropriately, with the 16-channel switch you can get access to 32 channels, ie all 2m FM 'S' and 'R' channels plus reverse repeater channels. To do this, use the 16-channel switch and add a toggle switch on the front panel, wired to the two pins on LK2 or to short PROM address line A7 (pin 17) to 0V if LK2 isn't present.

You must make the appropriate pin 'crossovers' when using a substitution EPROM. For this you can simply use several wires



The MX294 synthesiser section – the TTL PROM has a white label attached



Table 4.6. EPROM Substitution for 82S129 PROM

| EPROM function | EPROM pin number (18-pin) conn |      |      |       |       | MX294 PROM socket |
|----------------|--------------------------------|------|------|-------|-------|-------------------|
|                | 2716                           | 2732 | 2764 | 27128 | 27256 |                   |
| A0             | 8                              | 8    | 10   | 10    | 10    | Pin 5             |
| A1             | 7                              | 7    | 9    | 9     | 9     | Pin 6             |
| A2             | 6                              | 6    | 8    | 8     | 8     | Pin 7             |
| A3             | 5                              | 5    | 7    | 7     | 7     | Pin 4             |
| A4             | 4                              | 4    | 6    | 6     | 6     | Pin 3             |
| A5             | 3                              | 3    | 5    | 5     | 5     | Pin 2             |
| A6             | 2                              | 2    | 4    | 4     | 4     | Pin 1             |
| A7             | 1                              | 1    | 3    | 3     | 3     | Pin 17            |
| A8             | 23                             | 23   | 25   | 25    | 25    | 0V                |
| A9             | 22                             | 22   | 24   | 24    | 24    | 0V                |
| A10            | 19                             | 19   | 21   | 21    | 21    | 0V                |
| A11            | —                              | 21   | 23   | 23    | 23    | 0V                |
| A12            | —                              | —    | 2    | 2     | 2     | 0V                |
| A13            | —                              | —    | —    | 26    | 26    | 0V                |
| A14            | —                              | —    | —    | —     | 27    | 0V                |
| O0             | 9                              | 9    | 11   | 11    | 11    | Pin 14            |
| O1             | 10                             | 10   | 12   | 12    | 12    | Pin 13            |
| O2             | 11                             | 11   | 13   | 13    | 13    | Pin 12            |
| O3             | 13                             | 13   | 15   | 15    | 15    | Pin 11            |
| O4             | 14                             | 14   | 16   | 16    | 16    | o/c               |
| O5             | 15                             | 15   | 17   | 17    | 17    | o/c               |
| O6             | 16                             | 16   | 18   | 18    | 18    | o/c               |
| O7             | 17                             | 17   | 19   | 19    | 19    | o/c               |
| Gnd            | 12                             | 12   | 14   | 14    | 14    | 0V                |
| Vpp            | 21                             | 20   | 1    | 1     | 1     | Pin 18 (+5V)      |
| OE             | 20                             | 20   | 22   | 22    | 22    | 0V                |
| CE             | 18                             | 18   | 20   | 20    | 20    | 0V                |
| Vcc            | 24                             | 24   | 28   | 28    | 28    | Pin 18 (+5V)      |
| PGM            | —                              | —    | 27   | 27    | —     | Pin 18 (+5V)      |

appropriately soldered between the main PCB (with the PROM socket removed) and an EPROM socket mounted on a piece of Veroboard or similar.

### Programming codes

The MX290 series synthesiser requires four sequential binary 'words', of 4 bits each, for each TX or RX frequency (Fig 4.8). On the TTL PROM, it sequentially addresses in binary the A0 (pin 5) and A1 (pin 6) lines to obtain these, and the A2 line (pin 7) is used to switch between RX (binary 0) and TX (binary 1). The address lines, A3 (pin 1), A4 (pin 2), A5 (pin 3) and A6 (pin 4) are the 16-channel binary address from the channel switch, and A7 is the 'LK2' address for 'moving up' 16 channels. The first four hexadecimal 'words' programmed in your PROM/EPROM contain the channel 1 receive division code, the next four contain the channel 1 transmit code, the next four channel 2 receive code, the next four channel 2 transmit code etc. For transmit, this is the division code for the transmit VCO frequency, on receive it's the code for the local oscillator injection frequency, which for both 2m and 4m is 10.7MHz above the required receiver frequency, and for 70cm is 21.4MHz away from the receive frequency.

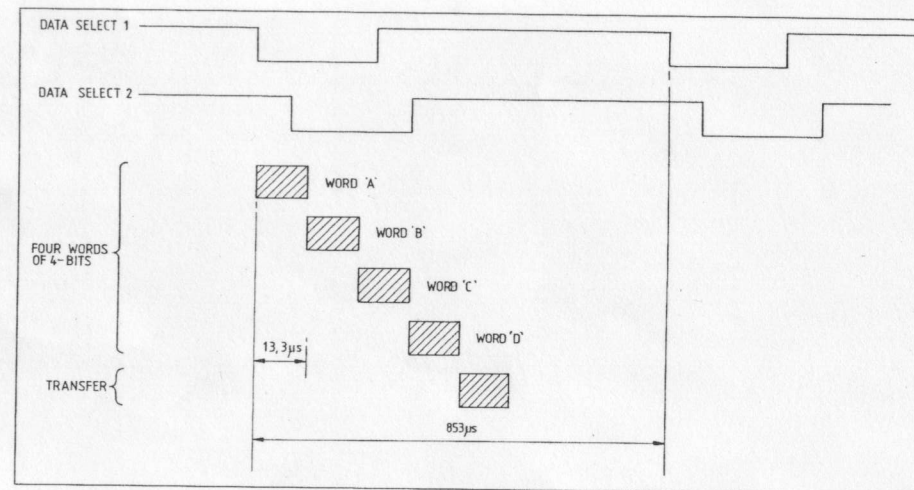


Fig 4.8. MX290 series PROM addressing

If your set is a (rare) 'AW' band (148–174MHz wide-band) or EW band (68–88MHz wide-band) set, identified by a 21.4MHz crystal filter (marked '21xxxx' on the top), then use an injection frequency of 21.4MHz removed from the receive frequency.

The MX296 uses a synthesiser reference frequency of 12.5kHz, and the MX294 uses either a 5kHz or 6.25kHz synthesiser reference. To check on the latter, look at the colour of the thin PCB between the large HEF4750 IC and its socket. If it's blue or red, the synthesiser reference frequency (ie the minimum channel step) is 6.25kHz, as found on virtually all sets in the UK. If it's green (rare in the UK), it's 5kHz. This is important when you work out the codes – a 5kHz reference means you won't be able to program 12.5kHz channel steps, only multiples of 5kHz. The reference frequency is present as a square wave on pin 25 of the HEF4750 if you're in doubt. All codes given in the tables in this section for the MX294 are for the commonly found 10.7MHz receiver IF and reference frequency of 6.25kHz – those for the MX296 are for a 12.5kHz reference and positive-side receiver injection.

### Code calculation

To calculate the division code for any required frequency (remember, this is the VCO injection frequency in receive mode), first divide your TX or RX injection frequency by the reference frequency, making sure you keep to the same frequency exponential, ie hertz, kilohertz or megahertz. For example, divide the final VCO frequency in megahertz by 0.00625 (6.25kHz – substitute 0.005 if yours is a 5kHz reference set, or 0.0125 if it's an MX296). Then, subtract 3840 from this number – this is a fixed synthesiser divider offset. Convert the number you now have into a four-digit hexadecimal word, DCBA, with D as the MSD (most significant bit) and A as the LSB (least significant bit). Now change this hexadecimal combination

20 kHz  
detti possib  
sur/mx296



Table 4.7. Suggested 2m channels

| Chan | LK1 in | LK1 out |
|------|--------|---------|
| 16   | R0     | Rev R0  |
| 1    | R1     | Rev R1  |
| 2    | R2     | Rev R2  |
| 3    | R3     | Rev R3  |
| 4    | R4     | Rev R4  |
| 5    | R5     | Rev R5  |
| 6    | R6     | Rev R6  |
| 7    | R7     | Rev R7  |
| 8    | S8     | S16     |
| 9    | S9     | S17     |
| 10   | S10    | S18     |
| 11   | S11    | S19     |
| 12   | S12    | S20     |
| 13   | S13    | S21     |
| 14   | S14    | S22     |
| 15   | S15    | S23     |

Table 4.8. 2m PROM codes

| Frequency (MHz) | RX BCAD | TX BCAD | Frequency (MHz) | RX BCAD | TX BCAD |
|-----------------|---------|---------|-----------------|---------|---------|
| 144.500         | 0205    | 5B04    | 145.275         | 72C5    | CBC4    |
| 144.525         | 0245    | 5B44    | 145.300         | 8205    | DB04    |
| 144.550         | 0285    | 5B84    | 145.325         | 8245    | DB44    |
| 144.575         | 02C5    | 5BC4    | 145.350         | 8285    | DB84    |
| 144.600         | 1205    | 6B04    | 145.375         | 82C5    | DBC4    |
| 144.625         | 1245    | 6B44    | 145.400         | 9205    | EB04    |
| 144.650         | 1285    | 6B84    | 145.425         | 9245    | EB44    |
| 144.675         | 12C5    | 6BC4    | 145.450         | 9285    | EB84    |
| 144.700         | 2205    | 7B04    | 145.475         | 92C5    | EBC4    |
| 144.725         | 2245    | 7B44    | 145.500         | A205    | FB04    |
| 144.750         | 2285    | 7B84    | 145.525         | A245    | FB44    |
| 144.775         | 22C5    | 7BC4    | 145.550         | A285    | FB84    |
| 144.800         | 3205    | 8B04    | 145.575         | A2C5    | FBC4    |
| 144.825         | 3245    | 8B44    | 145.600         | B205    | OC04    |
| 144.850         | 3285    | 8B84    | 145.625         | B245    | OC44    |
| 144.875         | 32C5    | 8BC4    | 145.650         | B285    | OC84    |
| 144.900         | 4205    | 9B04    | 145.675         | B2C5    | OCC4    |
| 144.925         | 4245    | 9B44    | 145.700         | C205    | 1C04    |
| 144.950         | 4285    | 9B84    | 145.725         | C245    | 1C44    |
| 144.975         | 42C5    | 9BC4    | 145.750         | C285    | 1C84    |
| 145.000         | 5205    | AB04    | 145.775         | C2C5    | 1CC4    |
| 145.025         | 5245    | AB44    | 145.800         | D205    | 2C04    |
| 145.050         | 5285    | AB84    | 145.825         | D245    | 2C44    |
| 145.075         | 52C5    | ABC4    | 145.850         | D285    | 2C84    |
| 145.100         | 6205    | BB04    | 145.875         | D2C5    | 2CC4    |
| 145.125         | 6245    | BB44    | 145.900         | E205    | 3C04    |
| 145.150         | 6285    | BB84    | 145.925         | E245    | 3C44    |
| 145.175         | 62C5    | BBC4    | 145.950         | E285    | 3C84    |
| 145.200         | 7205    | CB04    | 145.975         | E2C5    | 3CC4    |
| 145.225         | 7245    | CB44    | 146.000         | F205    | 4C04    |
| 145.250         | 7285    | CB84    |                 |         |         |

Table 4.9. 4m PROM codes

| Frequency (MHz) | RX BCAD | TX BCAD | Frequency (MHz) | RX BCAD | TX BCAD |
|-----------------|---------|---------|-----------------|---------|---------|
| 70.2500         | 9382    | EC81    | 70.3875         | A3E2    | FCE1    |
| 70.2625         | 93A2    | ECA1    | 70.4000         | B302    | OD01    |
| 70.2750         | 93C2    | ECC1    | 70.4125         | B322    | OD21    |
| 70.2875         | 93E2    | ECE1    | 70.4250         | B342    | OD41    |
| 70.3000         | A302    | FC01    | 70.4375         | B362    | OD61    |
| 70.3125         | A322    | FC21    | 70.4500         | B382    | OD81    |
| 70.3250         | A342    | FC41    | 70.4625         | B3A2    | ODA1    |
| 70.3375         | A362    | FC61    | 70.4750         | B3C2    | ODC1    |
| 70.3500         | A382    | FC81    | 70.4875         | B3E2    | ODE1    |
| 70.3625         | A3A2    | FCA1    | 70.5000         | C302    | 1D01    |
| 70.3750         | A3C2    | FCC1    |                 |         |         |

from DCBA to BCAD, because this is the order in which the synthesiser reads the information, B first, then C, then A, then D, and this is the order you need to program each frequency into your EPROM or PROM.

I've given typical codes in Tables 4.8, 4.9 and 4.10 for popular amateur FM channels.

### Substitution diode matrix

For single-channel use, maybe for packet, you can substitute a low-cost CMOS IC together with a few diodes and resistors for the PROM. I developed the circuit shown here for my 4m MX294 to be used on a hilltop packet node site. See Fig 4.9 and Table 4.11. To program this, fit the diodes needed to give you the correct binary 'words' for each address, in the same BCAD order. A diode present in any position provides a logic '1' while the absence of a diode in any position provides a logic '0'. You may wish to produce a PCB, although for the sake of simplicity a stripboard layout is preferred for 'one-off' boards.

### Links

If your set was fitted with a selective calling module, than at the front right of the set you'll see a set of links. For 'normal' operation (ie without any front-panel selective calling limitations of TX and/or

Table 4.10. Typical 70cm EPROM codes

| Frequency (MHz) | RX BCAD | TX BCAD | Frequency (MHz) | RX BCAD | TX BCAD |
|-----------------|---------|---------|-----------------|---------|---------|
| 433.000         | 5807    | 0F07    | 433.300         | 6887    | 1F87    |
| 433.025         | 5827    | 0F27    | 433.325         | 68A7    | 1FA7    |
| 433.050         | 5847    | 0F47    | 433.350         | 68C7    | 1FC7    |
| 433.075         | 5867    | 0F67    | 433.375         | 68E7    | 1FE7    |
| 433.100         | 5887    | 0F87    | 433.400         | 7807    | 2F07    |
| 433.125         | 58A7    | 0FA7    | 433.425         | 7827    | 2F27    |
| 433.150         | 58C7    | 0FC7    | 433.450         | 7847    | 2F47    |
| 433.175         | 58E7    | 0FE7    | 433.475         | 7867    | 2F67    |
| 433.200         | 6807    | 1F07    | 433.500         | 7887    | 2F87    |
| 433.225         | 6827    | 1F27    | 433.525         | 78A7    | 2FA7    |
| 433.250         | 6847    | 1F47    | 433.550         | 78C7    | 2FC7    |
| 433.275         | 6867    | 1F67    | 433.575         | 78E7    | 2FE7    |

Fig 4.9. MX290 series diode matrix PROM replacement

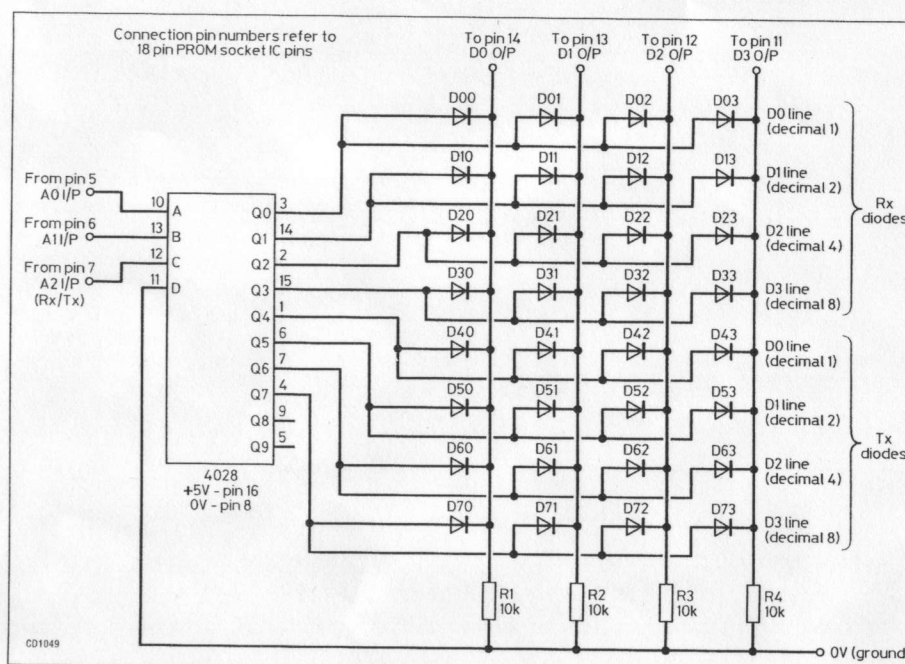


Table 4.11. Binary/hexadecimal codes

| Hex | Binary     |     |     |            |
|-----|------------|-----|-----|------------|
|     | MSB<br>D3x | D2x | D1x | LSB<br>D0x |
| 0   | 0          | 0   | 0   | 0          |
| 1   | 0          | 0   | 0   | 1          |
| 2   | 0          | 0   | 1   | 0          |
| 3   | 0          | 0   | 1   | 1          |
| 4   | 0          | 1   | 0   | 0          |
| 5   | 0          | 1   | 0   | 1          |
| 6   | 0          | 1   | 1   | 0          |
| 7   | 0          | 1   | 1   | 1          |
| 8   | 1          | 0   | 0   | 0          |
| 9   | 1          | 0   | 0   | 1          |
| A   | 1          | 0   | 1   | 0          |
| B   | 1          | 0   | 1   | 1          |
| C   | 1          | 1   | 0   | 0          |
| D   | 1          | 1   | 0   | 1          |
| E   | 1          | 1   | 1   | 0          |
| F   | 1          | 1   | 1   | 1          |

RX capability) you need to link F to S and K1 to L, and remove any other links. If your front panel does have some signalling electronics present, just remove the electronics of this, or at least the plug which mates with the radio itself next to these links, before refitting it after conversion.

### Preliminaries

The MX290 series uses the same microphone, speaker, and facility connections as the M290 series to provide interchangeability between plug-in modules. Thus, simply refer to the information I've given earlier in this chapter for these connections.

Opening the set up by removing the covers will usually reveal a large metal screen secured to the chassis with a multitude of screws. This is for screening purposes between the RF section and any added selective calling modules, and for amateur purposes without a Selcall unit fitted it can safely be left off if you need the room for an added EPROM board. Don't at this stage remove the lid above the square VCO unit. For tuning purposes I'd advise leaving the lid on which is next to the track side of the main PCB (this is either the top or the bottom lid, depending upon which front-panel control arrangement is used) to ensure the set doesn't short out on any stray metal on your bench. Before doing this, however, quickly make sure the four VCO unit screws on the track side of the main PCB are tight – you'll find if these are loose you'll get superimposed 'scratchy' noises on both transmit and receive due to vibration if you use the rig on the move.

Connect a 3–8Ω speaker to the rear blue/brown speaker lead, and for transmit alignment a microphone to the five-pin 270° DIN mic connector. Now connect your 13.8V DC supply. If you have a channel switch fitted then, with the controls towards you, check there's a red 'lock' LED glowing at the left of the set – this may occur on only a few channels as you rotate the channel knob. This shows the synthesiser is working OK. If it doesn't, then check whether the small black plug-in PROM is missing – it will usually have a white label on it identifying the stored information.

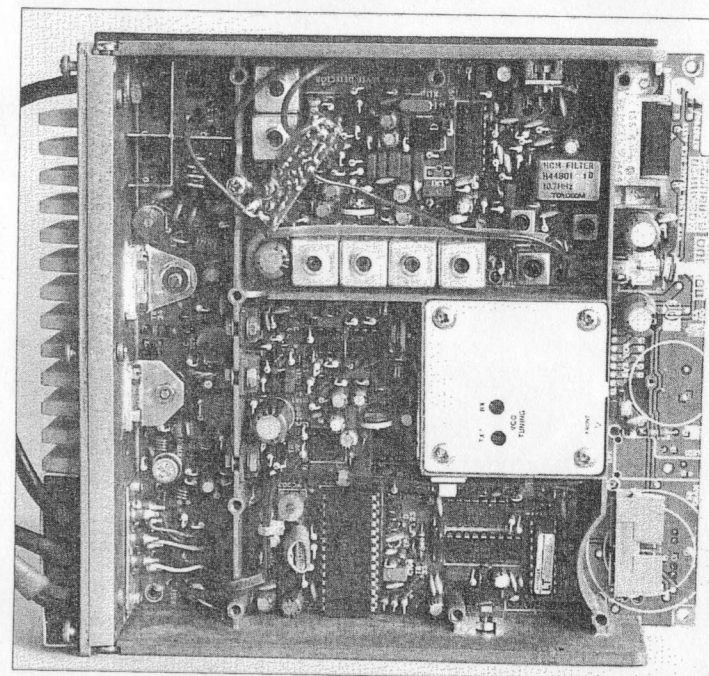
### MX294

Two slightly different versions of the MX294 receiver circuitry have been made – one is marked 'AT28790' on the main PCB and is fitted with a bipolar BFQ51 receiver front-end transistor, while the later model is marked 'AT28873' and is fitted with a BF981 which gives slightly better sensitivity. These transistors aren't interchangeable (don't try it!) but the receiver tuning details are identical between the models.

### Alignment

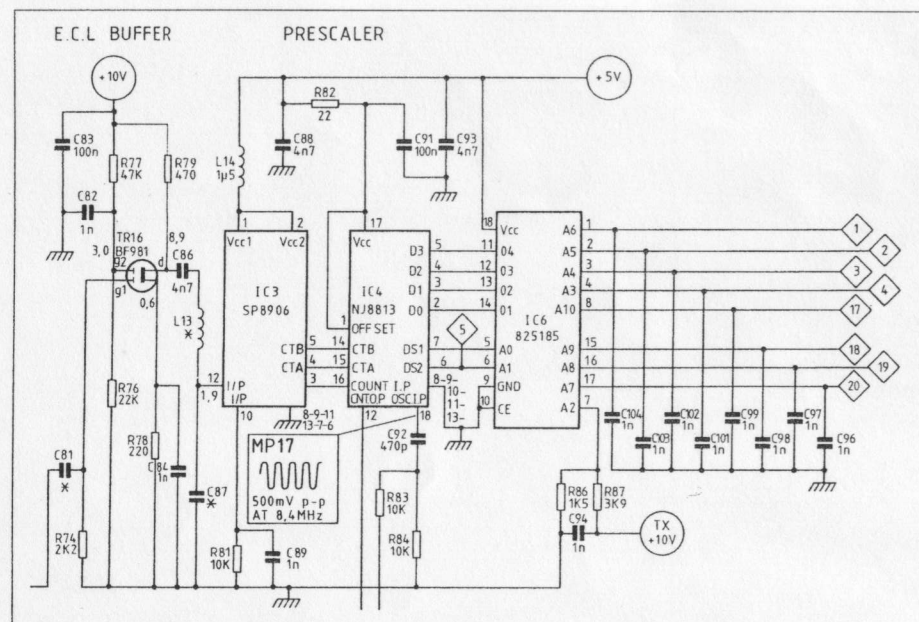
Details of the synthesiser layout and circuitry are given in Figs 4.10–4.14. Fit your programmed PROM or EPROM, and initially adjust the multi-turn RX VCO trimmer until the red 'lock' LED lights – then with the radio switched to the centre channel of your programmed frequency range, tune for a voltage of around 6.5V on TP3. You can also check with an oscilloscope or frequency counter that a pulse waveform is present on pin 1 of the HEF4750 reference divider IC – this is the divided VCO signal (a square-wave 6.25/5.0kHz reference derived from the crystal source is present on pin 25 for a comparison). As you adjust the VCO trimmer, the frequency of the waveform on pin 1 should vary in sympathy with the VCO frequency. Rotate RV1, the RX squelch control, until you hear noise from the speaker – if the VCO is out of lock you'll find the receive audio is muted. On receiving an off-air signal, adjust all six front-end coils L1–L7 for best signal, reducing the level of the signal as needed. Reset the squelch as needed.

For the transmitter alignment, key the PTT and adjust the TX VCO trimmer until the 'lock' LED lights, then with your set on the centre channel of your programmed frequency range, readjust for 6.5V on TP3. Set the transmit power control RV4 fully clockwise and adjust the three transmitter PA trimmer capacitors C126, C129 and C138 all for maximum transmit power (you'll usually find you can achieve 35–45W output). Readjust RV4 to the power output you wish, typically 25W for normal operation to prevent overheating of the PA



Inside the MX294 – this set has had a BF981 preamplifier added by the author

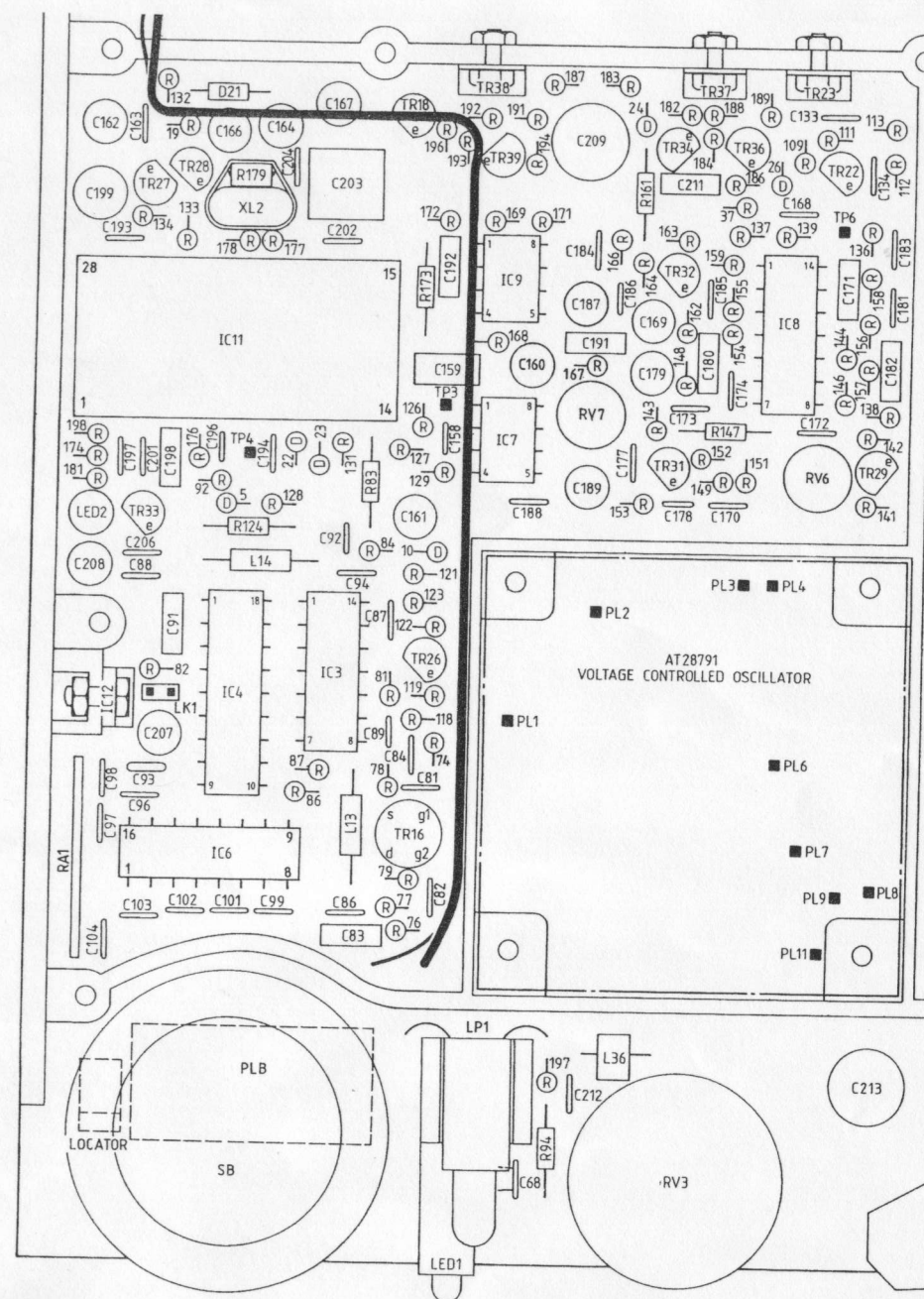
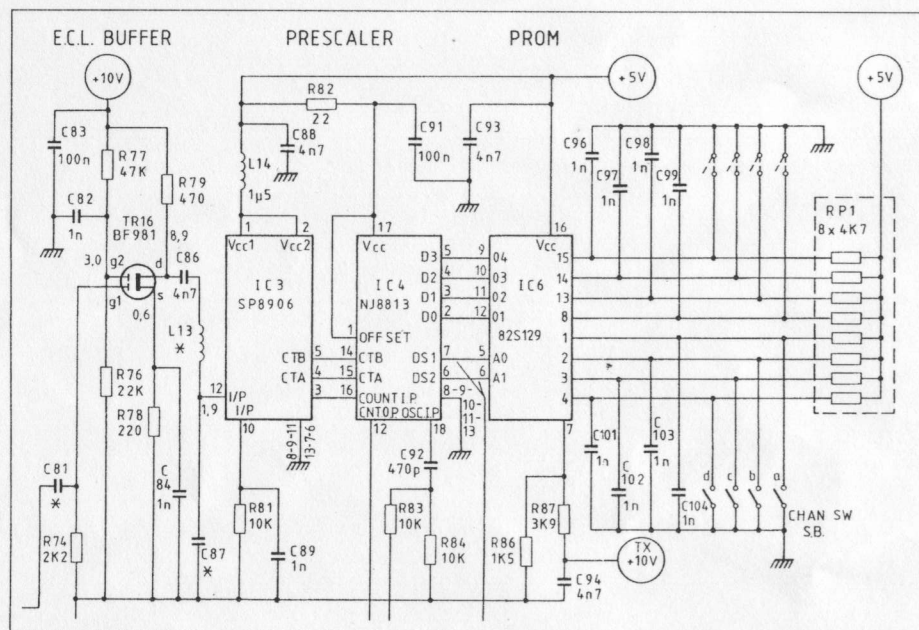




**Fig 4.10. MX294 remote channel control and synthesiser circuitry**

**Fig 4.11. MX294 16-channel PROM and synthesiser circuitry**

heatsink. RV6 sets the transmitter deviation but you'll first need to adjust RV7, which is the modulation balance control. Using either a high-impedance AC millivoltmeter or preferably an oscilloscope connected



to TP7, adjust RV7 for minimum reading (ie to 'null' the 'stepped' AC waveform to zero at this test point), at the same time as you're providing a modulation input at the microphone. You will normally

**Fig 4.12. Synthesiser component layout, MX294**

Fig 4.13. MX294 alignment diagram

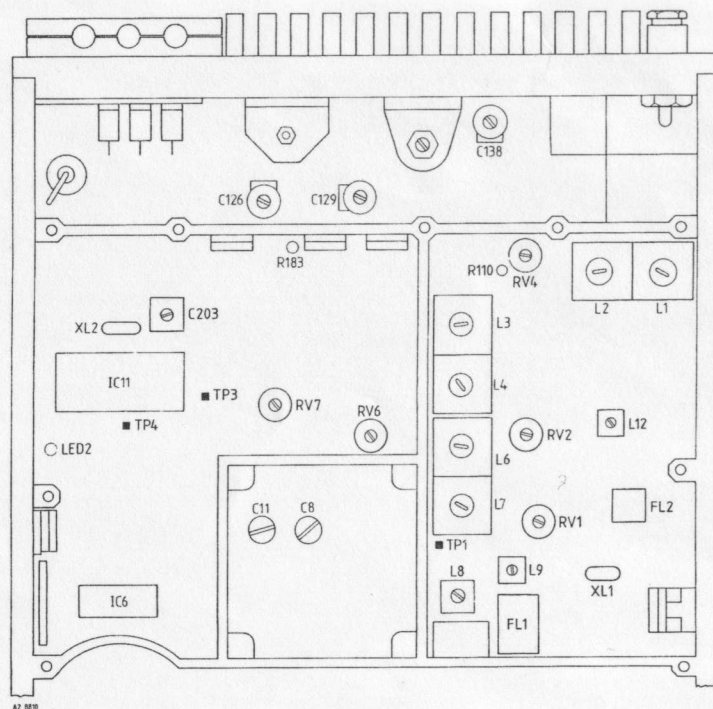
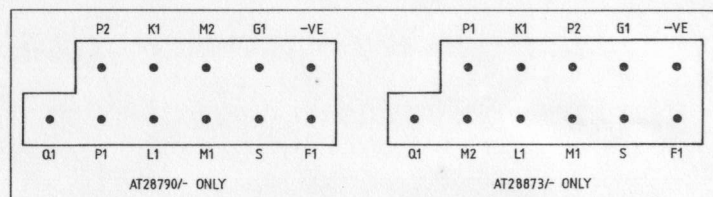


Fig 4.14. MX294 circuit links



not need to make any further adjustments but C203 is the reference frequency crystal trimmer, which sets the frequency of both transmit and receive on all channels.

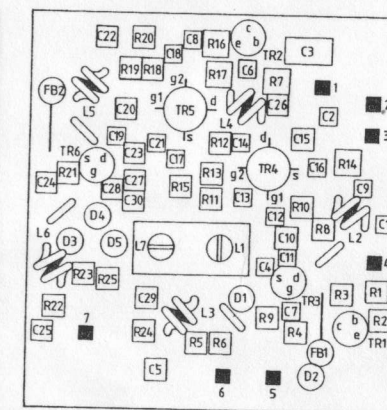
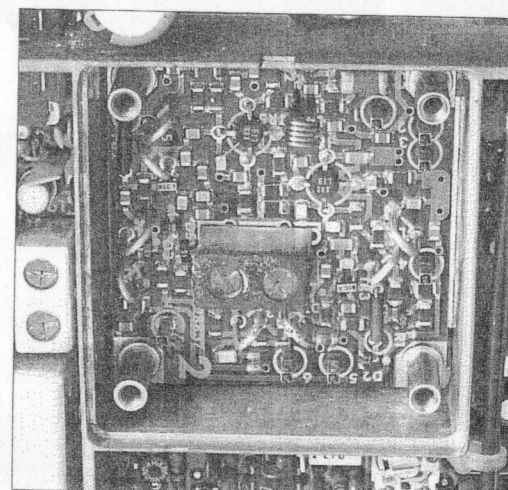
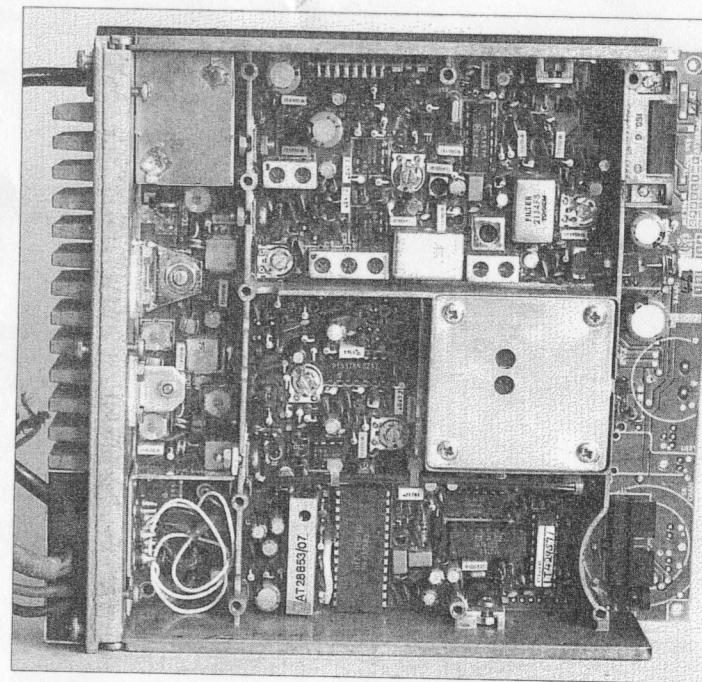
### MX296

The MX296 is outwardly physically similar to the MX294, and provides around 11W on transmit. After removing the lid and any selective calling module, make links to join pins S to F (RX audio), and pins K1 to L (TX PTT) on the small link header array at the front right hand side of the set's main board. Remove any other links.

### Alignment

Details of the MX296 layouts are given in Figs 4.15–4.18. After plugging in your suitably programmed PROM, or wiring in a replacement EPROM having thoroughly checked the connections, connect

Inside the MX296



your DC power supply and

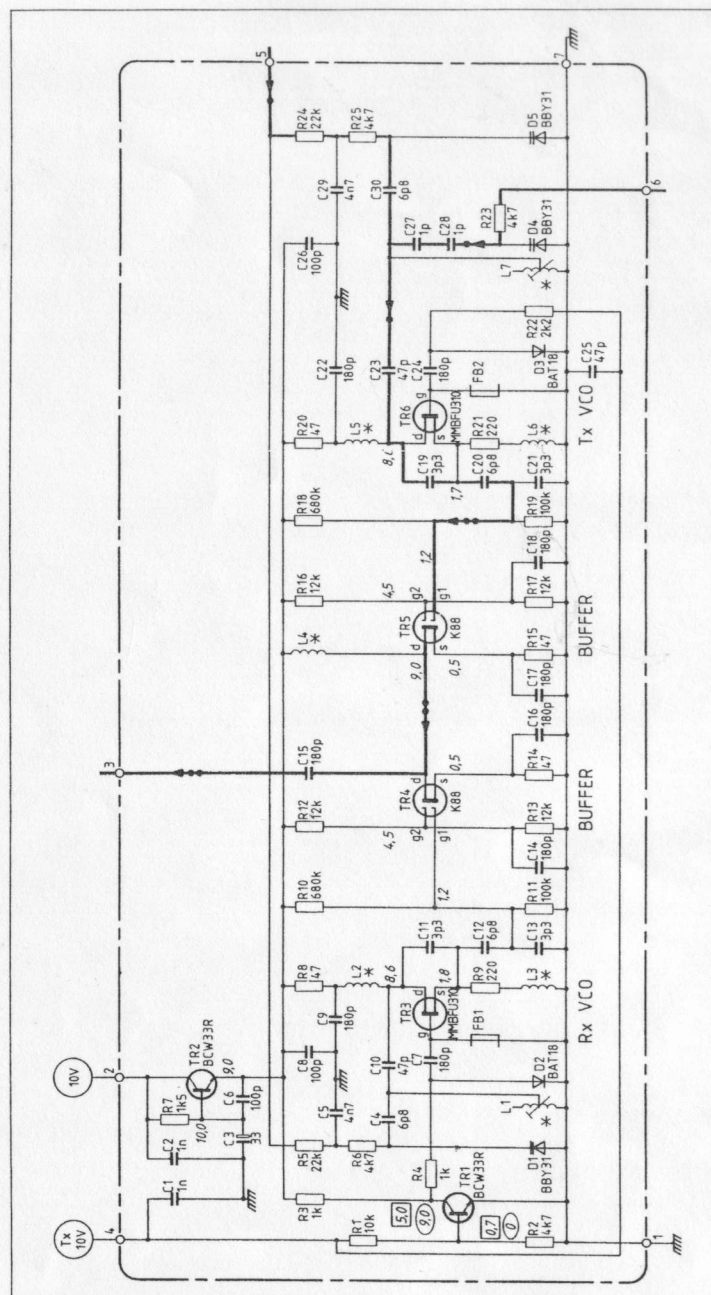
Left: The MX296 VCO unit

switch the set on. Carefully adjust L1 on the VCO board until the red 'lock' LED illuminates. This L1 adjuster may have some flexible rubbery sealant on it – just remove this if needed. If you find the LED doesn't light, then check your EPROM connections. You can also check with an oscilloscope or frequency counter that a pulse waveform is present on pin 1 of the HEF4750 reference divider IC – this is the divided VCO signal (a square-wave 12.5kHz reference

Above: Fig 4.15. The MX296 VCO component layout



**Fig 4.16. The MX296 VCO circuit**



derived from the crystal source is present on pin 25 for a comparison). As you adjust the VCO trimmer, the frequency of the waveform on pin 1 should vary in sympathy with the VCO frequency.

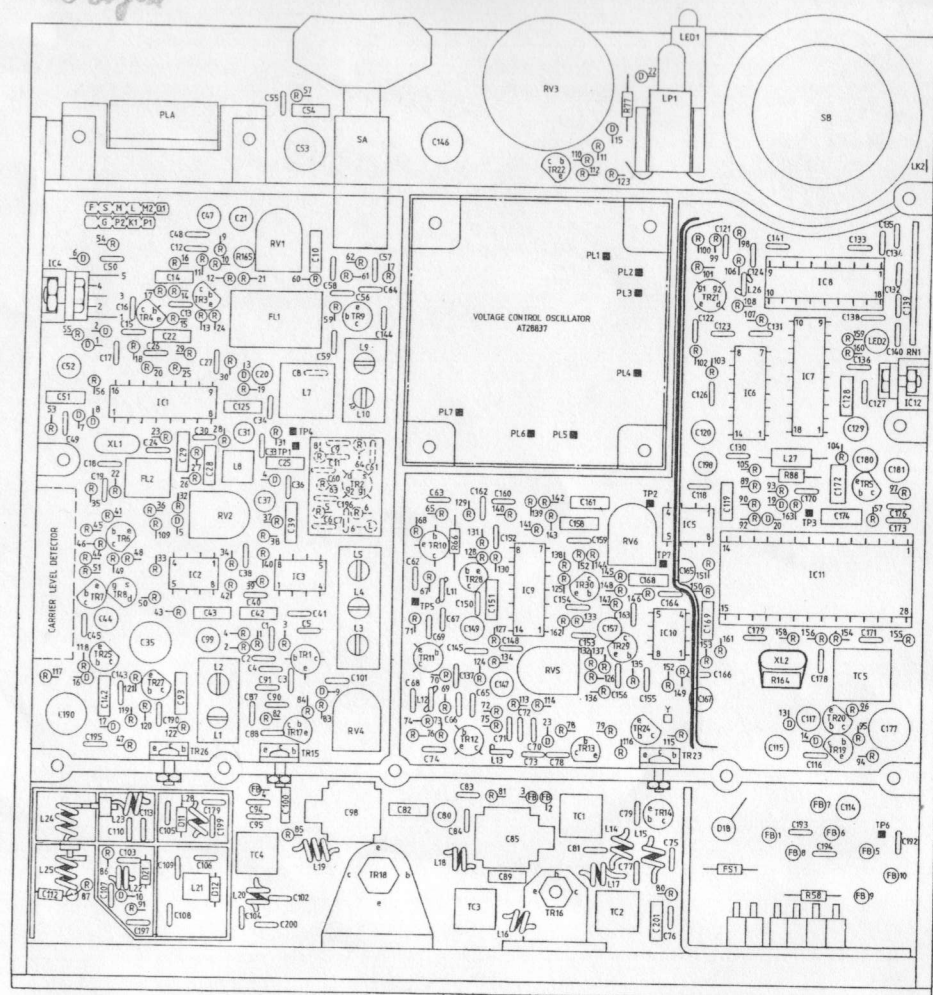
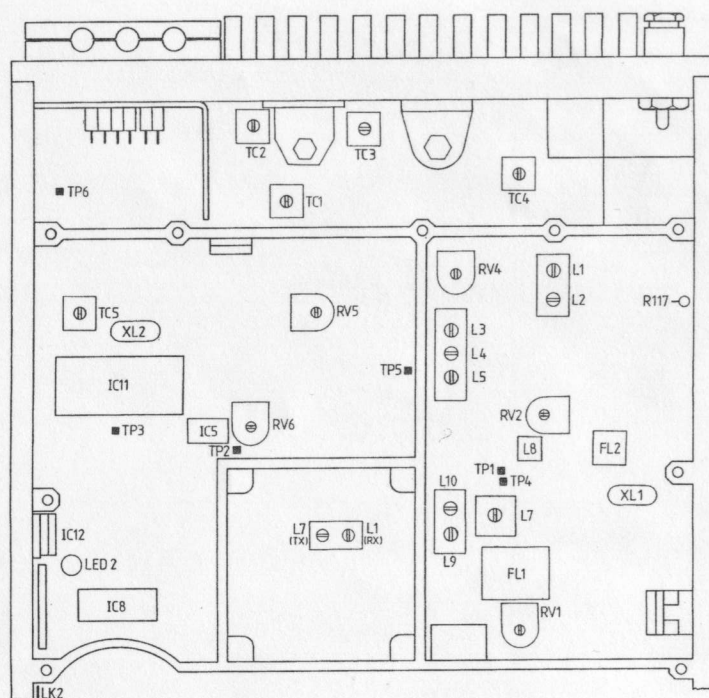


Fig 4.17. MX296 component layout

Assuming you obtain lock, adjust L1 until you get a reading of around 6.5V on test point TP2 – this voltage will vary in sympathy with your tuning when the synthesiser is in lock.

If you find that your VCO will not 'pull' enough for use on 70cm on receive, then you can slightly modify the hairpin coils, L2 and L3, on the receive section of the VCO. First remove the VCO board by removing the four screws securing the lid, followed by the four screws on the track side of the main PCB, and unplug the VCO board by carefully pulling the board-mounted pillars to lift the VCO board out. Unsolder L2 and L3, replacing these with slightly larger hairpin loops so that when the VCO is inserted the tops are just below the nearby metal can. Don't attempt to modify the turns on the coils inside the metal cans – you'll just end up with a mess of melted coil former!

**Fig 4.18. MX296 alignment diagram**



Now key the transmitter and adjust L7 on the VCO board again until the 'lock' LED lights, then again adjust this for around 6.5V on TP2. RV4 is the RF power preset control, which you should initially set to give maximum output power. Now adjust the transmitter driver and power amplifier trimmers TC1, TC2, TC3 and TC4 for maximum RF output power, repeating the sequence until absolute maximum output is obtained. If you don't get any RF initially, adjust these first for maximum current drawn by the rig from your power supply, then carry on adjusting for maximum RF power.

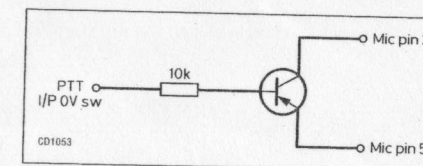
TC5, which sometimes forms part of a metal TCXO (temperature compensated xtal oscillator) block, is the reference frequency adjustment. If the unit came out of service, this should be accurately set, but may be adjusted if needed – it sets the frequency of all receive and transmit channels.

RV5 is the peak deviation control and, using an AC millivoltmeter or preferably an oscilloscope, adjust RV6 for minimum AC 'stepped' waveform voltage on TP3 while you're applying audio to the set's microphone.

Low-level receiver audio is present on pin 4 of the microphone connector – note that the front-panel volume control varies the level of this. You may wish to relink this to the top of the volume control for 1200 baud packet use.

Most packet terminal node controllers use a 'ground to transmit' line for PTT, so to interface with the set you'll need to add a suitable interface, like the one-transistor circuit of Fig 4.19. You'll find +10V on pin 5, and you'll need to switch +10V to pin 3 for transmit.

For 9600 baud packet, on receive you can take the receive discriminator audio out from pin 9 of the MC3357 IC in the receiver section on each set, using a series isolating capacitor. On the M294/6, the transmitter uses phase modulation rather than direct frequency modulation, but you can try injecting transmit audio to pin D of the facility connector. On the MX294 remove C187 (2.2 $\mu$ F, next to IC9) and inject your transmit audio to the pad previously connected to the positive lead of C187 via an isolating capacitor of at least 10 $\mu$ F (possibly using the capacitor you removed), with the positive lead to the MX294 connection. On the MX296, remove C165 (10 $\mu$ F, next to IC10, a 1458) and inject TX audio to the pad previously connected to the positive lead of C165, again with an isolating capacitor with the positive lead going to the MX296 connection.



**Fig 4.19. M/MX290 series TNC PTT interface**

**MOTOROLA MC80 ON 70cm**

Although Motorola mobiles have in the past been a rarity, there have been a large number of Motorola MC80 transceivers for UHF seen on the surplus market. My thanks go to Colin, G3PSM, for his help in providing me with valuable assistance including a copy of the technical service manual; to Steve, G1FIP, for modification information; to Steve, G3VMW, for his comprehensive information on packet on the MC80; and the notes by G4OAA on 9600 baud packet modifications and connections.

The MC80 is a two-channel set, with simple controls using two knobs for channel and volume adjustment on the left-hand side of the front panel, together with three push switches on the upper right of the front for signalling. The set may be fitted with 'Select 1' ('PL', or CTCSS to the rest of us), or 'Select 5' (five-tone sequential signalling), each of which use an internally fitted board which you'll probably remove for amateur use. The type number of the set is clearly visible below these. The UHF set comes in two band versions, 403–430MHz and 440–470MHz, either of which are suitable for retuning to 70cm. The sets commonly found are 25kHz channel spacing, and use a single IF of 10.7MHz with two crystal filters (Y31 and Y32 on the RX board). The transmitter uses PIN diode changeover (good for packet radio operation) and two transmit power versions are available, nominally 6W and 10W RF output – you'll typically get



# 82S126A 82S129A 1K-Bit TTL Bipolar PROM

## Product Specification

### Bipolar Memory Products

#### DESCRIPTION

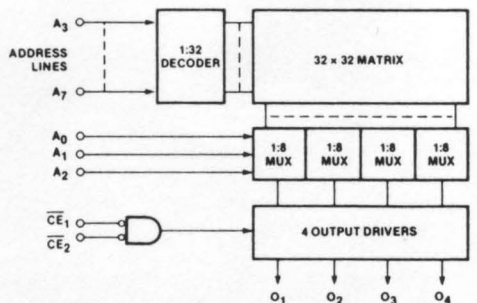
The 82S126A and 82S129A are field programmable, which means that custom patterns are immediately available by following the Signetics Generic I fusing procedure. The 82S126A and 82S129A devices are supplied with all outputs at logical Low. Outputs are programmed to a logic High level at any specified address by fusing the Ni-Cr link matrix.

These devices include on-chip decoding and 2 Chip Enable inputs for ease of memory expansion. They feature either Open Collector or 3-State outputs for optimization of word expansion in bused organizations.

Ordering information can be found on the following page.

The 82S126A and 82S129A devices are also processed to military requirements for operation over the military temperature range. For specifications and ordering information consult the Signetics Military Data Book.

#### BLOCK DIAGRAM



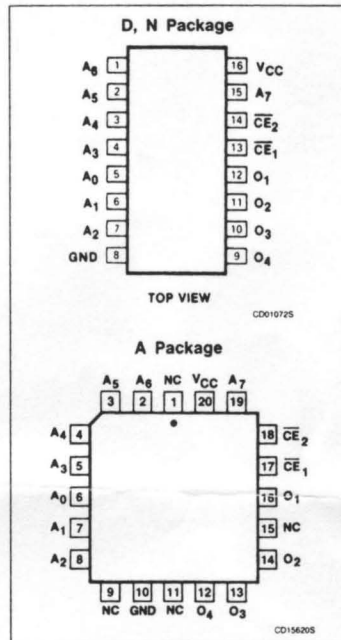
#### FEATURES

- Address access time:
  - N82S126A: 30ns max
  - N82S129A: 27ns max
- Power dissipation: 0.5mW/bit typ
- Input loading:  $-100\mu\text{A}$  max
- On-chip address decoding
- Two Chip Enable inputs
- Output options:
  - 82S126A: Open-Collector
  - 82S129A: 3-State
- No separate fusing pins
- Unprogrammed outputs are Low level
- Fully TTL compatible

#### APPLICATIONS

- Prototyping/volume production
- Sequential controllers
- Microprogramming
- Hardwired algorithms
- Control store
- Random logic
- Code conversion

#### PIN CONFIGURATIONS



## 1K-Bit TTL Bipolar PROM (256 × 4)

82S126A, 82S129A

## ORDERING INFORMATION

| DESCRIPTION                                         | ORDER CODE              |
|-----------------------------------------------------|-------------------------|
| 16-pin Plastic DIP<br>300mil-wide                   | N82S126A N • N82S129A N |
| 16-pin Plastic SO<br>300mil-wide                    | N82S126A D • N82S129A D |
| 20-pin Plastic Leaded Chip Carrier<br>350mil-square | N82S126A A • N82S129A A |

## ABSOLUTE MAXIMUM RATINGS

| SYMBOL            | PARAMETER                                             | RATING       | UNIT     |
|-------------------|-------------------------------------------------------|--------------|----------|
| $V_{CC}$          | Supply voltage                                        | +7           | $V_{DC}$ |
| $V_{IN}$          | Input voltage                                         | +5.5         | $V_{DC}$ |
| $V_{OH}$<br>$V_O$ | Output voltage<br>High (82S126)<br>Off-state (82S129) | +5.5<br>+5.5 | $V_{DC}$ |
| $T_A$             | Operating temperature range                           | 0 to +75     | °C       |
| $T_{STG}$         | Storage temperature range                             | -65 to +150  | °C       |

DC ELECTRICAL CHARACTERISTICS  $0^{\circ}\text{C} \leq T_A \leq +75^{\circ}\text{C}$ ,  $4.75\text{V} \leq V_{CC} \leq 5.25\text{V}$ 

| SYMBOL                                                | PARAMETER                                 | TEST CONDITIONS <sup>1,2</sup>                                                                                                                                                                                             | LIMITS |                  |                 | UNIT         |
|-------------------------------------------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------|-----------------|--------------|
|                                                       |                                           |                                                                                                                                                                                                                            | Min    | Typ <sup>5</sup> | Max             |              |
| Input voltage                                         |                                           |                                                                                                                                                                                                                            |        |                  |                 |              |
| V <sub>IL</sub><br>V <sub>IH</sub><br>V <sub>IC</sub> | Low<br>High<br>Clamp                      | V <sub>CC</sub> = 4.75V<br>V <sub>CC</sub> = 5.25V<br>V <sub>CC</sub> = 4.75V, I <sub>IN</sub> = -12mA                                                                                                                     | 2.0    |                  | 0.8<br><br>-1.2 | V<br>V<br>V  |
| Output voltage                                        |                                           |                                                                                                                                                                                                                            |        |                  |                 |              |
| V <sub>OL</sub><br>V <sub>OH</sub>                    | Low<br>High (82S129A)                     | $\overline{CE}_{1,2}$ = Low<br>I <sub>OUT</sub> = 16mA<br>I <sub>OUT</sub> = -2.0mA                                                                                                                                        | 2.4    |                  | 0.45            | V<br>V       |
| Input current                                         |                                           |                                                                                                                                                                                                                            |        |                  |                 |              |
| I <sub>IL</sub><br>I <sub>IH</sub>                    | Low<br>High                               | V <sub>IN</sub> = 0.45V<br>V <sub>IN</sub> = 5.5V                                                                                                                                                                          |        |                  | -100<br>40      | μA<br>μA     |
| Output current                                        |                                           |                                                                                                                                                                                                                            |        |                  |                 |              |
| I <sub>OLK</sub><br>I <sub>OZ</sub>                   | Leakage (82S126A)<br>Hi-Z State (82S129A) | $\overline{CE}_1$ or $\overline{CE}_2$ = High, V <sub>OUT</sub> = 5.5V<br>$\overline{CE}_1$ or $\overline{CE}_2$ = High, V <sub>OUT</sub> = 5.5V<br>$\overline{CE}_1$ or $\overline{CE}_2$ = High, V <sub>OUT</sub> = 0.5V |        |                  | 40<br>40<br>-40 | μA<br><br>mA |
| I <sub>OS</sub>                                       | Short circuit (82S129A) <sup>3</sup>      | $\overline{CE}_{1,2}$ = Low, V <sub>OUT</sub> = 0V, High stored                                                                                                                                                            | -15    |                  | -70             | mA           |
| Supply current <sup>7</sup>                           |                                           |                                                                                                                                                                                                                            |        |                  |                 |              |
| I <sub>CC</sub>                                       |                                           | V <sub>CC</sub> = 5.25V                                                                                                                                                                                                    |        |                  | 120             | mA           |
| Capacitance                                           |                                           |                                                                                                                                                                                                                            |        |                  |                 |              |
| C <sub>IN</sub><br>C <sub>OUT</sub>                   | Input<br>Output                           | $\overline{CE}_1$ or $\overline{CE}_2$ = High, V <sub>CC</sub> = 5.0V<br>V <sub>IN</sub> = 2.0V<br>V <sub>OUT</sub> = 2.0V                                                                                                 |        | 5<br>8           |                 | pF<br>pF     |

Notes on following page.



## 1K-Bit TTL Bipolar PROM (256 × 4)

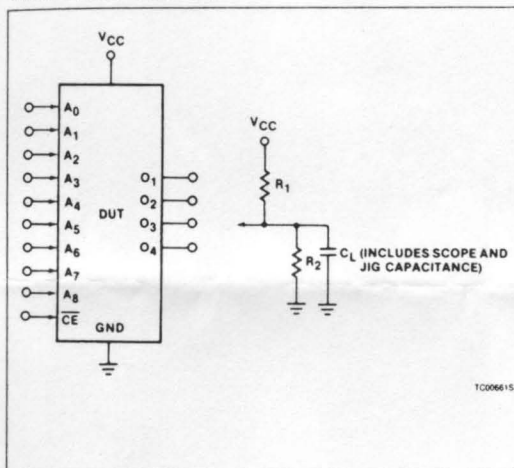
## 82S126A, 82S129A

**AC ELECTRICAL CHARACTERISTICS**  $R_1 = 270\Omega$ ,  $R_2 = 600\Omega$ ,  $C_L = 30\text{pF}$ ,  $0^\circ\text{C} \leq T_A \leq +75^\circ\text{C}$ ,  $4.75\text{V} \leq V_{CC} \leq 5.25\text{V}$

| SYMBOL                    | PARAMETER | TO     | FROM        | N82S129A |                  |     | N82S126A |                  |     | UNIT |
|---------------------------|-----------|--------|-------------|----------|------------------|-----|----------|------------------|-----|------|
|                           |           |        |             | Min      | Typ <sup>5</sup> | Max | Min      | Typ <sup>5</sup> | Max |      |
| Access time <sup>4</sup>  |           |        |             |          |                  |     |          |                  |     |      |
| t <sub>AA</sub>           |           | Output | Address     |          | 17               | 27  |          | 17               | 30  | ns   |
| t <sub>CE</sub>           |           | Output | Chip Enable |          | 10               | 20  |          | 10               | 20  | ns   |
| Disable time <sup>6</sup> |           |        |             |          |                  |     |          |                  |     |      |
| t <sub>CD</sub>           |           | Output | Chip Enable |          | 6                | 15  |          | 6                | 15  | ns   |

**NOTES:**

1. Positive current is defined as into the terminal referenced.
2. All voltages with respect to network ground.
3. Duration of short circuit should not exceed 1 second.
4. Tested at an address cycle time of  $1\mu\text{s}$ .
5. Typical values are at  $V_{CC} = 5\text{V}$ ,  $T_A = +25^\circ\text{C}$ .
6. Measured at a delta of 0.5V from Logic Level with  $R_1 = 750\Omega$ ,  $R_2 = 750\Omega$  and  $C_L = 5\text{pF}$ .
7. Measured with all inputs grounded and all outputs open.

**TEST LOAD CIRCUIT****VOLTAGE WAVEFORMS**