A Versatile EPROM

This EPROM Copier is easy to build and will cost less than $70. It can program 2716 and 2732 EPROMs and copy 2708, 2716 and 2732 devices.

There are many situations where one needs to copy the contents of one EPROM into another. For example, if you want to manufacture a small number of microprocessor-based products which use EPROMs, the copier can provide duplicates of a prototype master EPROM. Similarly, the copier is very handy for supplying preprogrammed EPROMs to customers at the point of sale. A master EPROM, such as our Car Computer EPROM from August 1982, can be kept by the supplier and copies provided on a "while you wait" basis.

As EPROM technology improves, it can also be advantageous to upgrade your EPROM storage to more modern devices. The classic 2708 EPROM holds 1K bytes of memory and requires three power supply voltages: +12V, −5V and +5V. The 2716, however, is a contemporary device which only requires a +5V supply. It holds 2K bytes of memory and is actually less expensive than its smaller and outdated counterpart, the 2708.

Much of the microprocessor-based equipment prior to 1979 utilised 2708 technology. With this copier, you can now reprogram into 2716 EPROMs or, alternatively, into the 4K byte 2732. This will enable you to do away with complex power supplies and, as an added bonus, you can upgrade your EPROM storage capacity.

For example, the contents of two 2708s can be programmed into a single 2716 device; or two 2716 EPROMs can be programmed into a single 2732 EPROM.

One word of caution: if you intend upgrading into a larger capacity EPROM for use in existing equipment, it may be necessary to alter the address decoding and pin connections to the EPROMs. Some equipment provides link options for various EPROM types and is thus readily suited for upgrading.

Of course, you can also direct copy between two 2716 or two 2732 EPROMs. Programming time for the 2716 is 80 seconds minimum while the 2732 takes twice this time. Note that Texas Instruments sells equivalent devices to the 2716 and 2732, and these are designated as the 2516 and 2532 respectively.

Main features

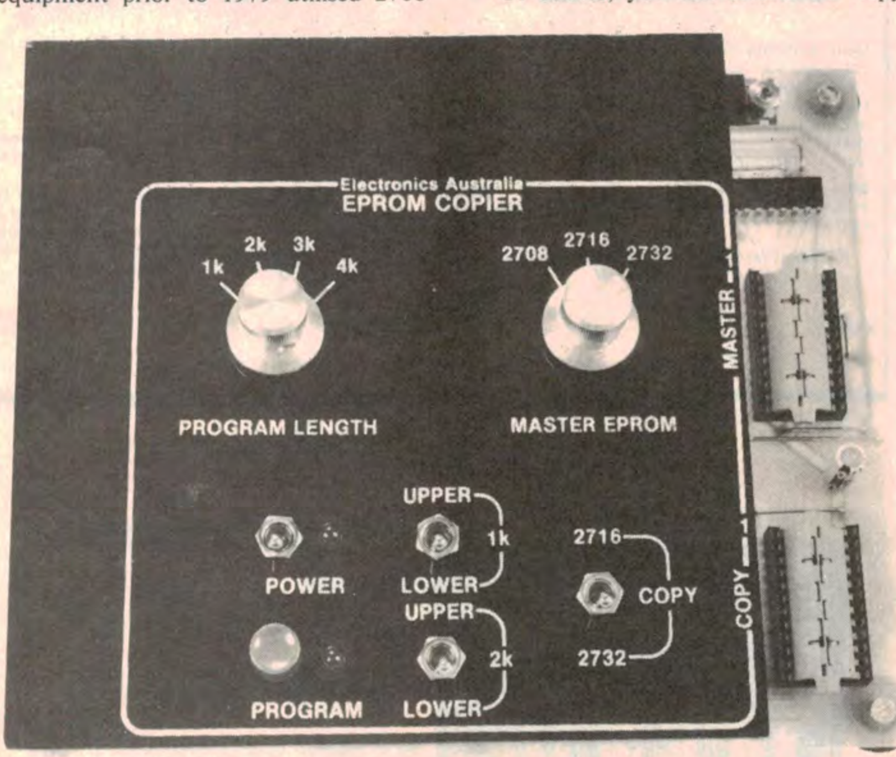
The EPROM Copier is a free-standing unit consisting of a single printed circuit board and a perspex front panel. This panel is supported by PCB-mounted switches while the PCB itself is supported on six rubber feet. The right hand side of the PCB is left uncovered to expose two zero insertion force sockets for the master and copy EPROMs. A 12VAC plugpack powers the unit.

The front panel controls are straightforward. A rotary switch at top right selects one of the three EPROM types for the master EPROM socket while the Copy toggle switch selects either a 2716 or 2732 copy EPROM. The momentary contact Program switch (bottom left) initiates programming and lights the programming LED.

The programming LED automatically extinguishes when programming is complete.

A further feature of the EPROM Copier is the Program Length control. This selects the address at which programming ceases and is selectable in 1K increments. Normally, this control is set to the memory capacity of the master EPROM.

If the master EPROM is not fully programmed, it may be possible to reduce programming time by using a lower setting on the Program Length



Above is a view of the prototype. The front panel is mounted directly on the switches while the PCB is supported by six rubber feet.

We estimate that the current cost of parts for this project is

$65-70

This includes sales tax but not the plugpack transformer.

COPIER COPIER

by JOHN CLARKE

control. The only proviso here is that the lower setting must encompass all the programmed locations in the master EPROM.

Copying between differing EPROMs requires a further control feature. This involves selecting the particular memory block of the copy EPROM. For example, when copying from a 2708 into a 2716, you can select whether the 2708 program goes into the upper or lower 1K block of the 2716. Similarly, when copying from a 2708 to a 2732, any one of the four 1K blocks can be selected.

The final possibility involves copying from a 2716 into a 2732. In this case you can select between either the upper or lower 2K memory block.

How it works

The basic concept behind the EPROM Copier is relatively straightforward: both EPROMs are connected in parallel so that the address and data lines are common. A binary counter also connects to the address lines and sequentially counts through all the EPROM addresses, starting from the zero address.

The master EPROM is connected in the read mode so that its data lines are outputs, while the copy EPROM is connected in the program mode so that the data lines are inputs. At each address, the data from the master EPROM is read by the copy EPROM during programming. Programming stops at the end of the master EPROM address range, as selected by the Program Length switch (S5).

Programming 2716 and 2732 EPROMs involves applying a TTL level 50ms pulse to the programming (PRGM) pin at each memory location. The 2716 requires a high TTL pulse while the 2732 requires a low going pulse to the PRGM pin. In addition, a 25V DC level must be present on the Vpp pin during the programming sequence.

Fig. 1 shows the pin connections and mode selections for each of the three EPROM types. Note that the connections are directly compatible with the exception of pins 18 to 21. These latter are the power supply and mode select pins for each EPROM.

The circuit

As previously mentioned, the address lines from A0 to A9 and the Data lines from D0 to D7 are connected in parallel between the master and copy EPROM sockets. IC1 is a binary counter used for the address counting and drives the address lines of the EPROMs. The remaining connections from pins 18 to 21 are connected to obtain the correct

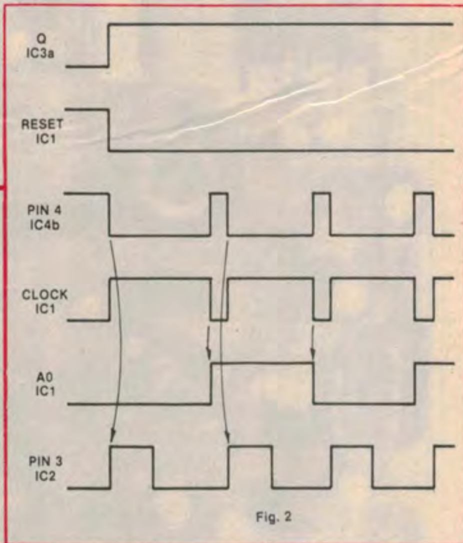


Fig. 1 (below) shows the EPROM data while Fig. 2 is the waveform timing digram.

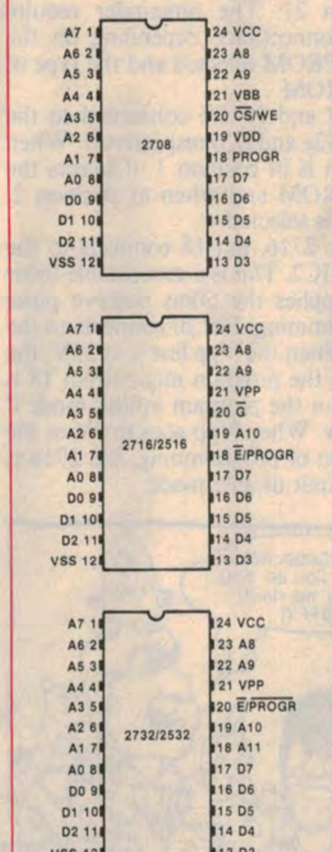


Fig. 1

MODE	PIN NUMBER						
	9-11, 13-17	12	18	19	20	21	24
* READ	D OUT	VSS	VSS	VDD	VIL	VBB	VCC
PROGRAM	D IN	VSS	PULSED VIHP	VDD	VIHW	VBB	VCC
DESELECT	HIGH Z	VSS	GND	VDD	VIH	VBB	VCC

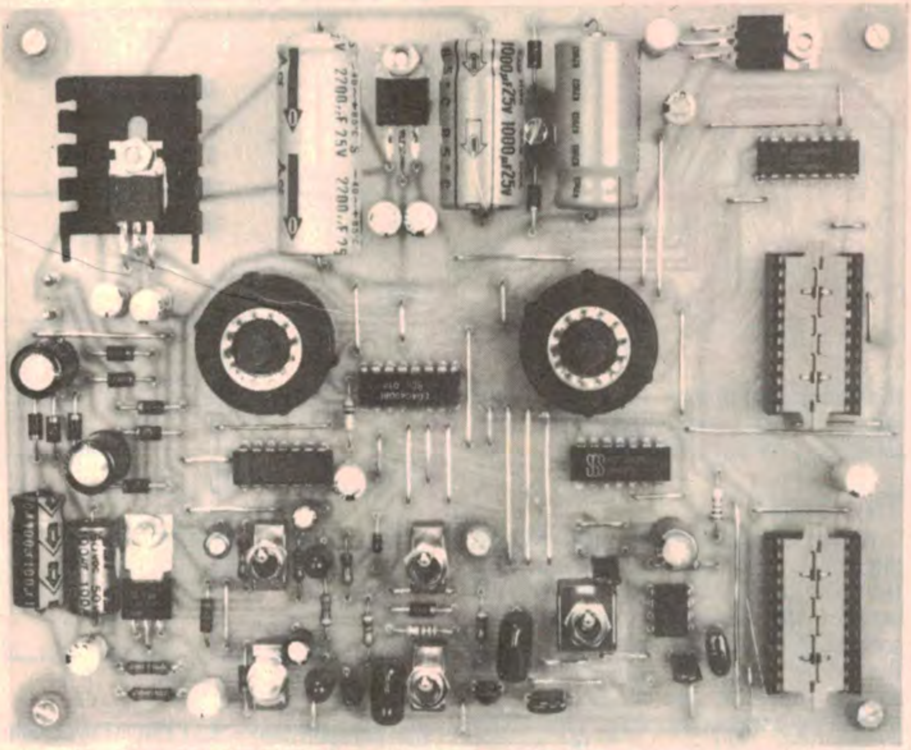
VBB = −5V
VDD = +12V
VSS = GND
VCC = +5V
VPPH = +25V

MODE	PIN NUMBER					
	9-11, 13-17	12	18	20	21	24
* READ	DATA OUT	VSS	VIL	VIL	VCC	VCC
* OUTPUT DISABLE	HIGH Z	VSS	DONT CARE	VIH	VCC	VCC
STANDBY	HIGH Z	VSS	VIH	DONT CARE	VCC	VCC
* PROGRAM	DATA IN	VSS	PULSED VIL TO VIH	VIH	VPPH	VCC
PROGRAM VERIFY	DATA OUT	VSS	VIL	VIL	VPPH	VCC
* PROGRAM INHIBIT	HIGH Z	VSS	VIL	VIH	VPPH	VCC

MODE	PIN NUMBER				
	9-11, 13-17	12	20	21	24
* READ	DATA OUT	VSS	VIL	5V	VCC
OUTPUT DISABLE	HIGH Z	VSS	VIH	5 TO 25V	VCC
* STANDBY	HIGH Z	VSS	VIH	5V	VCC
* PROGRAM	DATA IN	VSS	PULSED VIH TO VIL	VPPH	VCC
PROGRAM VERIFY	DATA OUT	VSS	VIL	5V	VCC
* PROGRAM INHIBIT	HIGH Z	VSS	VIH	VPPH	VCC

* MODES USED IN EPROM COPIER

Eprom Copier



This view shows the PCB assembly before the front panel is fitted.

mode of operation as described in Fig. 1.

Connections to the master EPROM are straightforward since it is always wired in the read mode. According to Fig. 1, pin 20 can be permanently tied to ground while, for the 2732, pin 18 can be tied to the A11 address line from IC1.

For the 2716 and 2708, pin 18 should be at Vss for the read mode. As it happens, A11 is at Vss for all memory locations up to 2K, which is within the address range of both EPROMs. Consequently, pin 18 can also be permanently tied to A11 for these devices. Should copying be allowed beyond the 2K limit, the high A11 will not damage either EPROM.

Switch S1 is a 4-pole 3-way rotary switch and selects for a 2708 in position 1, a 2716 in position 2 and a 2732 in position 3. The S1c and S1d poles are used for the master EPROM. S1c connects pin 19 to +12V for the 2708 and to the A10 address line for the remaining EPROMs. Pin 21 is connected to −5V via S1d for the 2708 position and to +5V for the 2716 and 2732 EPROMs. These connections satisfy the read mode requirements for all three EPROMs.

The copy EPROM requires more switching than the master EPROM to enable both the programming and output disable/standby modes. The only common pin between the 2716 and 2732 EPROMs in this application is the Vpp input, pin 21. The remainder require various connections, depending on the master EPROM selected and the type of copy EPROM.

Pins 18 and 20 are connected to the wiper of S2a and S2b respectively. When the switch is in position 1, it selects the 2716 EPROM and when at position 2, the 2732 is selected.

For the 2716, pin 18 connects to the output of IC2. This is a monostable timer which supplies the 50ms positive pulse for programming. Pin 20 connects to the 5V rail. When the Vpp line is at 25V, the 2716 is in the program mode if pin 18 is high and in the program inhibit mode if pin 18 low. When Vpp goes to 5V at the completion of programming, the 2716 is in the output disable mode.

When S2 selects the 2732 EPROM, pin 20 is connected to IC5d. This inverts the programming pulse from IC2 to provide a ground going 50ms pulse. Once again, Vpp is at 25V during programming. The 2732 is in the program mode when pin 20 is low and the program inhibit mode when pin 20 is high. With Vpp at 5V, the 2732 is in standby.

S2a connects pin 18 to the wiper of S1b for the 2732 EPROM. When S1 selects a 2708 or 2616 master EPROM, the A11 address line (pin 18) of the copy 2732 is connected to the wiper of switch S4. This selects the lower 2K of memory of the 2732 when switched low and the upper 2K when high. For a 2732 master EPROM, pin 18 connects to the A11 address output of IC1.

Pin 19 is the A10 address line for both 2716 and 2732 EPROMs. It is connected to the wiper of switch S2 (via S1a) when the master EPROM is a 2708. This allows selection of the upper 1K when the switch is in position 2 and the lower 1K when in position 1. When S1a selects a 2716 or 2732 master EPROM, the A10 address line is connected directly to the A10 output of IC1.

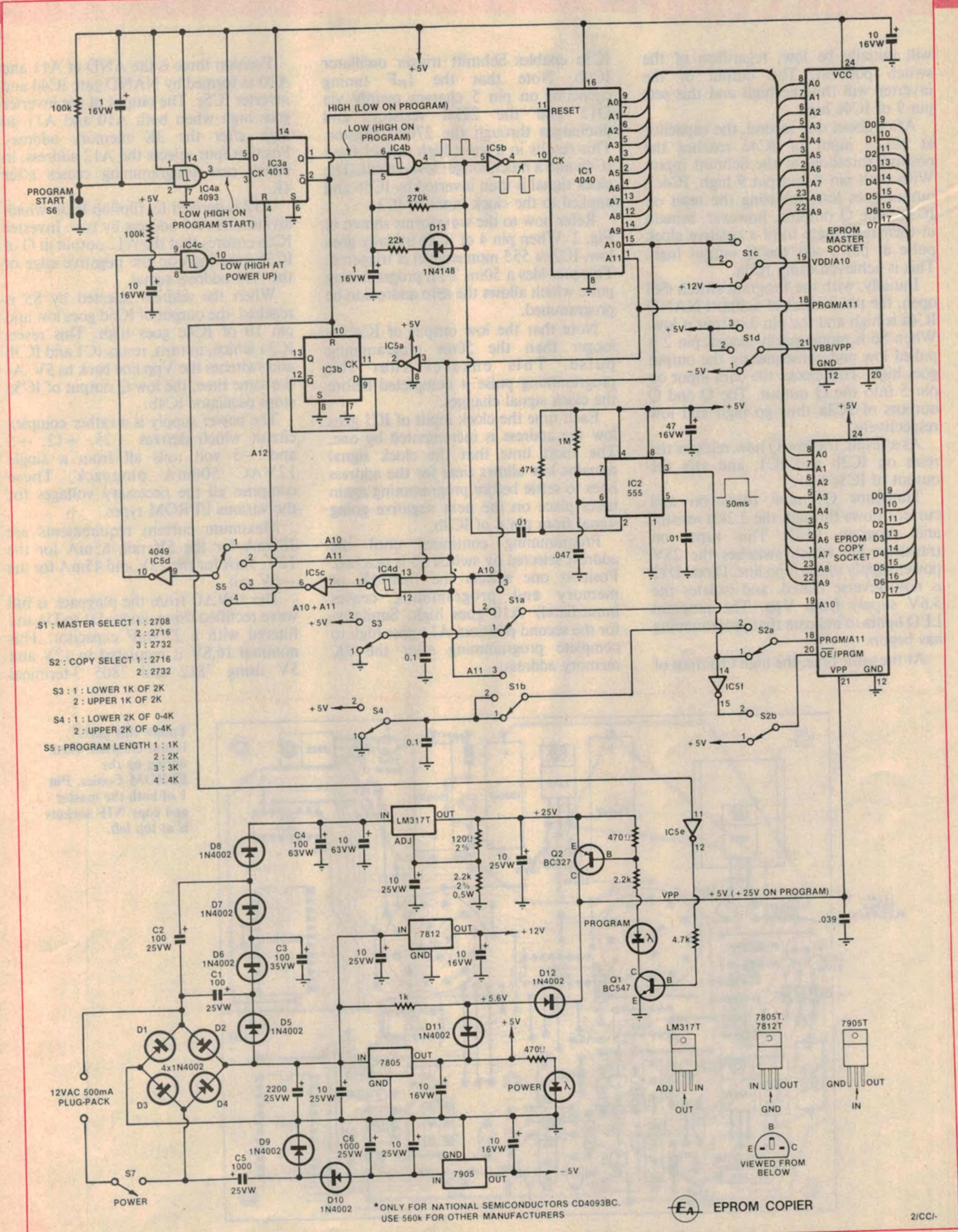
That describes the circuitry around the EPROM sockets. We shall describe the sequence of events that occurs when power is applied.

Initially, when power is first applied, the capacitor at the pin 8 input of Schmitt NAND gate IC4c is discharged. The output, pin 10, is high and this resets IC3a, a D flipflop, so that its Q output is low and the $\overline{Q}$ output is high.

The high signal on $\overline{Q}$ performs three functions. First, it resets IC3b, also a D flipflop, so that its Q output is set low; second, it resets IC1 to bring the address outputs low; and third, it is applied to the input of inverter IC5c.

IC5c is used to control the Vpp line which provides either 5V or the 25V programming level. When IC5c's output is low, transistor Q1 is off and so Q2 is also held off by virtue of the 470Ω resistor from base to emitter. Thus, the Vpp line is at 5V which is derived via diode D12. Note that the 0.6V drop across D12 is compensated for by providing 5.6V from the power supply.

Refer now to switch S5 which selects one of the address outputs from A10 to A12. Since the address outputs from IC1 and IC3b are reset, pin 9 of inverter IC5d



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will initially be low, regardless of the switch position. The output of the inverter will thus be high and this sets pin 9 of IC4c high.

After about one second, the capacitor at pin 8 input of IC4c reaches the positive threshold of the Schmitt input. With both pin 8 and pin 9 high, IC4c's output goes low, releasing the reset on IC3a. The Q outputs, however, remain in their reset state until a positive clock pulse at pin 3 sets the Q output high. This is achieved using IC4a.

Initially, with the Program switch (S6) open, the pin 2 input of Schmitt NAND IC4a is high and the pin 3 output is low. When S6 is momentarily closed, pin 2 is pulled low and consequently the output goes high. This clocks the data input on pin 5 into the Q output. The Q and $\overline{Q}$ outputs of IC3a thus go high and low respectively.

As a result, the low $\overline{Q}$ now releases the reset on IC3b and IC1, and sets the output of IC5c high.

Transistor Q1 now turns on and current flows through the 2.2kΩ resistor and program LED. This turns on transistor Q2 which switches the 25V power supply to the Vpp line. Diode D12 is now reverse biased, and isolates the 5.6V supply from Vpp. The program LED lights to indicate that programming has begun.

At the same time, the high Q output of IC3a enables Schmitt trigger oscillator IC4b. Note that the 1µF timing capacitor on pin 5 charges mainly via D13 and the 22kΩ resistor, and discharges through the 270kΩ resistor. This results in a short high output from IC4b and a much longer low output. The clock signal is then inverted by IC5b and applied to the clock input of IC1.

Refer now to the waveforms shown in Fig. 2. When pin 4 of IC4b initially goes low, IC2 (a 555 monostable) is triggered. This provides a 50ms TTL programming pulse which allows the zero address to be programmed.

Note that the low output of IC4b is longer than the 50ms programming pulse. This ensures that the programming pulse is completed before the clock signal changes.

Each time the clock input of IC1 goes low the address is incremented by one. The short time that the clock signal remains low allows time for the address lines to settle before programming again takes place on the next negative going signal from pin 4 of IC4b.

Programming continues until the address selected by switch S5 is reached. Position one selects the first 1K of memory and programming ceases immediately A10 goes high. Similarly, for the second position, A11 goes high to complete programming after the 2K memory address.

Position three is the AND of A11 and A10 as formed by NAND gate IC4d and inverter IC5c. The output of the inverter goes high when both A10 and A11 go high after the 3K memory address. Position four selects the A12 address, in which case programming ceases after 4K.

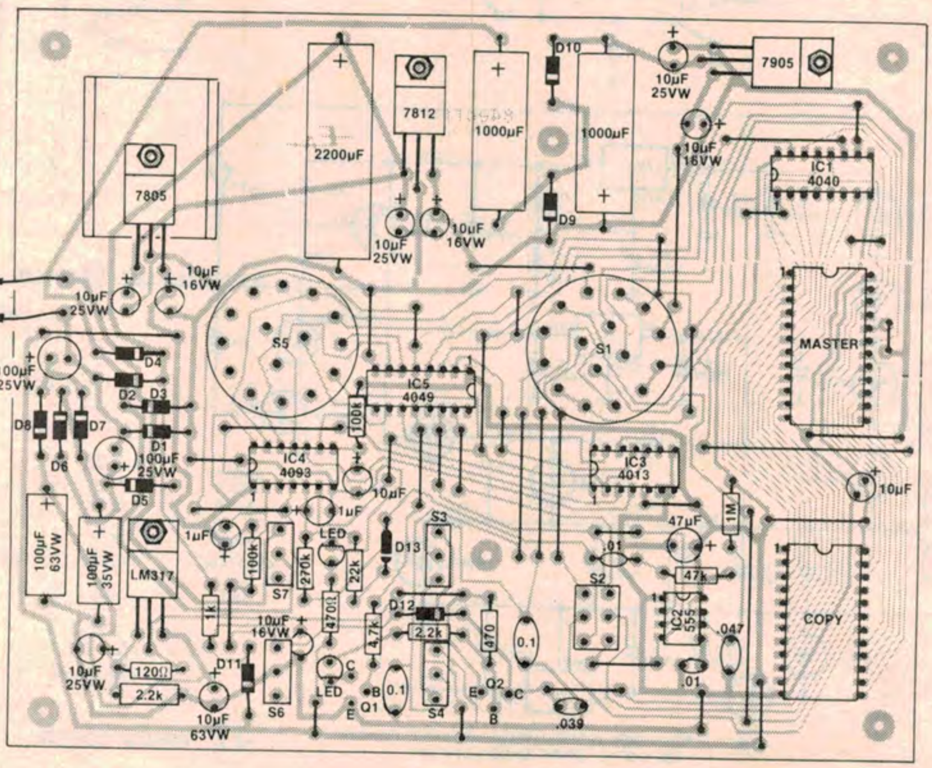
A12 is derived by flipflop IC3b which divides the A11 address by two. Inverter IC5a ensures that the A12 output at Q of IC3b goes high on the negative edge of the A11 address signal.

When the address selected by S5 is reached, the output of IC5d goes low and pin 10 of IC4c goes high. This resets IC3a which, in turn, resets IC1 and IC3b and switches the Vpp line back to 5V. At the same time, the low Q output of IC3a stops oscillator IC4b.

The power supply is a rather complex circuit which derives +25, +12, +5 and −5 volt rails all from a single 12VAC 500mA plugpack. These comprise all the necessary voltages for the various EPROM types.

Maximum current requirements are 300mA for the 5V rail, 65mA for the 12V, 5mA for the 25V and 45mA for the −5V rail.

The 12VAC from the plugpack is full wave rectified using diodes D1 to D4 and filtered with a 2200µF capacitor. This nominal 16.8V is regulated to 12V and 5V using 7812 and 7805 3-terminal



Follow this parts layout diagram when wiring up the EPROM Copier. Pin 1 of both the master and copy NIF sockets is at top left.

regulators. Note that D11 and a series 1kΩ resistor are connected across the input and output terminals of the 5V regulator. This provides a 5.6V reference at the anode of the diode.

The power indicator LED is driven from the 5V rail with current limiting provided by a 470Ω resistor.

The −5V rail is derived from a charge pump circuit comprising capacitors C5 and C6 and diodes D9 and D10. When the cathode of D3 goes positive, C5 charges via D9 to the peak of the waveform, or about 17V. On the negative excursion of the AC waveform, D3 conducts and brings the positive side of C5 to ground potential. The negative side of C5 thus goes to −17V and charges C6 via D10.

This voltage is then regulated to −5V using a 7905 3-terminal regulator.

The +25V rail is also derived using a diode charge pump circuit. Capacitors C1, C3 and diodes D5 and D6 function in a similar manner to the negative supply circuit just described. Note that because D5 is referenced to the positive output from the bridge rectifier the voltage across C3 is 34V with respect to ground.

C2 thus charges to +34V via D7 while its negative side is grounded via D1. On the next half cycle of the AC waveform, D1 is reverse biased and the negative side of C2 goes to +17V. The positive side of C2 now goes to +51V and this charges C4 via D8.

Thus, we have about 50V at the input of the LM317 which is set to provide a regulated +25V output.

Construction

Building the EPROM Copier is a heck of a lot easier than understanding how it works. All the parts are mounted on a single PC board coded 84ec11 and measuring 173 x 142mm. We used a perspex panel with screen-printed lettering for the prototype but most parts retailers will probably prefer to supply an aluminium panel and Scotchcal label.

Begin construction by installing the parts on the PC board, but do not mount the two LEDs at this stage. No special procedure need be followed although it's best to install the low profile components first. Make sure that all polarised parts are correctly oriented and note that diode D13 is a 1N4148 or 1N914 type. The remaining diodes are all 1N4002 types.

The 3-terminal regulators are bolted directly onto the PCB with their leads bent at right angles for soldering. Note that a heatsink is required for the 7805. We used a Thermalloy 6030 type

PARTS LIST

1 PCB, 173mm x 142mm, code 84ec11
1 Scotchcal label, 143mm x 142mm (see text)
1 perspex or aluminium panel, 143mm x 142mm (see text)
1 12VAC 500mA plugpack transformer
3 SPDT toggle switches (C&K 7101c)
1 snap action momentary contact pushbutton switch (C&K 8121c)
1 DPDT toggle switch (C&K 7201c)
1 4-pole 3-position rotary switch
1 3-pole 4-position rotary switch
2 knobs
2 24-pin NIF sockets (see text)
1 TO-220 heatsink, Thermalloy type 6030 or equivalent
6 rubber feet

Semiconductors

1 LM317 T 3-terminal adjustable regulator
1 7805T 3-terminal positive 5V regulator
1 7905T 3-terminal negative 5V regulator
1 7812T 3-terminal positive 12V regulator
12 1N4002 1A silicon diodes
1 1N4148, 1N914 silicon diode
1 BC327 PNP transistor
1 BC547 NPN transistor
2 red LEDs
1 4040 12-stage binary counter
1 4013 dual D flipflop
1 4093 quad Schmitt NAND gate
1 4049 hex inverter
1 555 timer

Capacitors

1 2200μF/25VW axial electrolytic
2 1000μF/25VW axial electrolytic
1 100μF/35VW axial electrolytic
1 100μF/63VW axial electrolytic
2 100/25VW PC electrolytic
1 47μF/25VW PC electrolytic
5 10μF/25VW PC electrolytic
1 10μF/63 VW PC electrolytic
4 10μF/16VW PC electrolytic
2 1μF/16VW PC electrolytic
2 0.1μF metallised polyester
1 .047μF metallised polyester
1 .039μF metallised polyester
2 .01μF metallised polyester

Resistors (¼W, 5% unless specified)
1 x 1MΩ, 1 x 560kΩ, 1 x 270kΩ, 2 x 100kΩ, 1 x 47kΩ, 1 x 22kΩ, 1 x 4.7kΩ, 1 x 2.2kΩ ½W, 1 x 2.2kΩ ½W 2%, 1 x 1kΩ, 2 x 470Ω, 1 x 120Ω 2%.

Miscellaneous
Screws, nuts, tinned copper wire, PC stakes, solder, etc.

Eprom Copier

although an equivalent heatsink made from scrap aluminium should also be satisfactory.

The Thermalloy 6030 measures 25mm x 30mm x 12mm (W x D x H). No mica washer is required but heatsink compound should be smeared on the regulator surface before assembly.

Some rotary switches supplied with kits may not be PCB-mounting types. If this is the case, you will have to cut the solder eyelets off using a pair of side cutters. Trim the switch shafts to length then mount the switches so that, when they are at mid-position, the flat of the shaft faces the bottom edge of the PC board.

Make sure that the switch bodies are mounted flat against the PC board before soldering.

The four toggle switches can be mounted either way round but pushbutton switch S6 must be oriented correctly. If you look closely at the switch body, you will see the following markings: C, NO and NC. Mount the switch so that the NC terminal is the one closest to the bottom of the PC board.

The EPROM sockets used in the prototype were low-cost NIF (no insertion force) types distributed in Australia by Mayer Krieg & Co (GPO Box 1803, Adelaide, SA 5001). These sockets are currently available from Jaycar, Geoff Wood Electronics and Radio Despatch Service, although other retailers should also have stocks by the time this article appears in print.

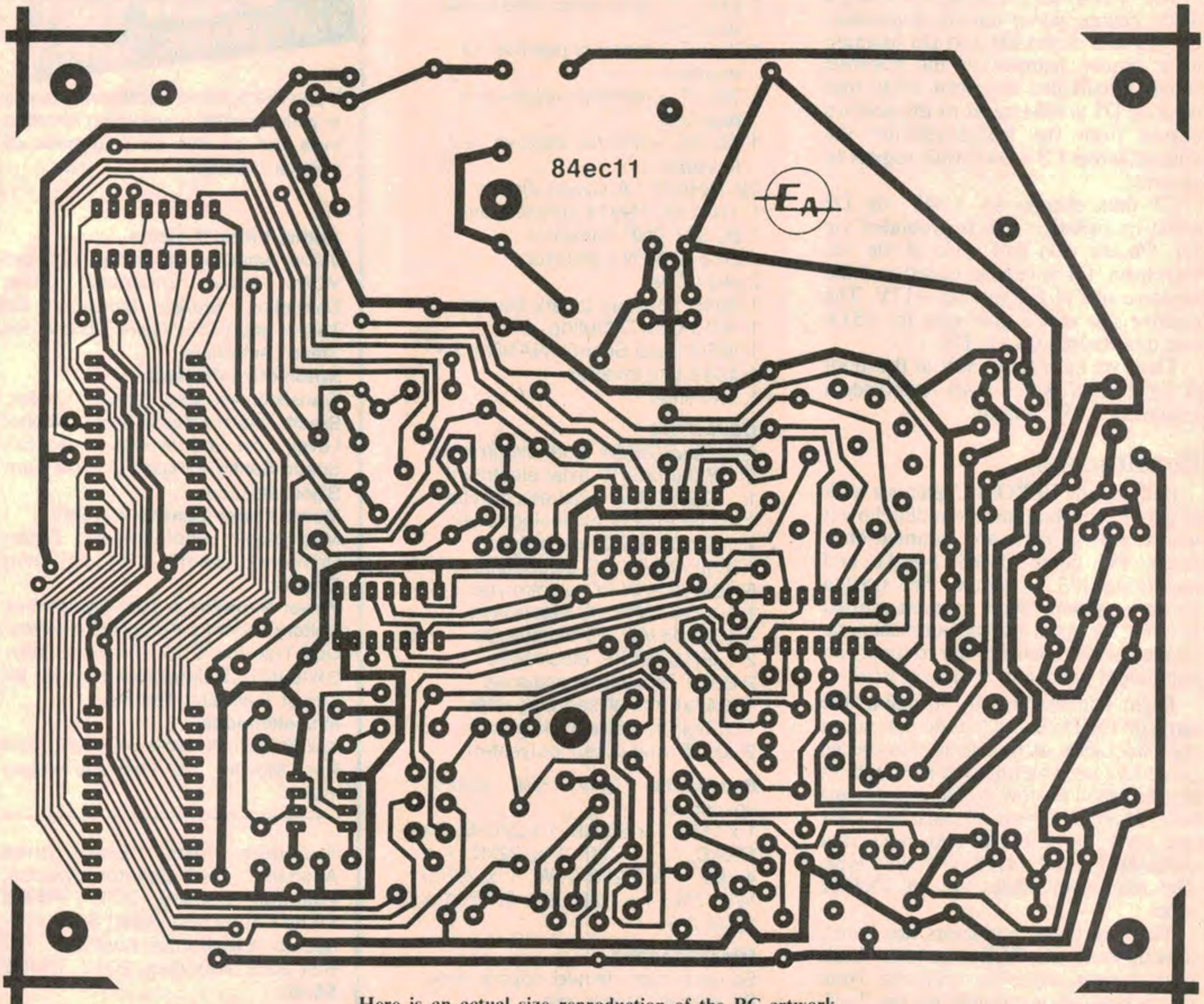
You can substitute lever-actuated ZIF (zero insertion force) sockets if you wish but note that these will cost more than the Mayer Krieg devices.

Once the PC board has been assembled, the six rubber feet can be fitted and attention turned to the front panel. Drill the necessary holes for the switches and LEDs, then mount the LEDs using bezels. The front panel can then be mounted on the switch bushings and the LED leads passed through their respective mounting holes on the PC board.

Pay particular attention to the orientation of the LEDs. The cathode of the Program LED goes towards the bottom of the board while the cathode of the Power LED goes towards the top.

Note that the front panel is stood off the rotary switch bodies by means of washers and secured from above using locknuts. For the toggle switches, it is necessary to use nuts on both sides of the panel. The Program switch bushing is slightly shorter than the toggle switch bushing and should be left unused.

Construction can now be completed by hooking up the AC plugpack supply. We used PC stakes to terminate the plugpack leads, but these are optional.



Here is an actual size reproduction of the PC artwork.

Eprom Copier

Testing

The test procedure is quite simple. First, apply power and check that +5V is present on pin 24 of both the master and copy EPROM sockets. This done, set the master EPROM switch to the 2708 position and check that pins 19 and 21 of the master socket are at +12V and −5V respectively.

Check also that all the address lines (A0-A9) are low and that +5V is present on pin 21 (Vpp) of the copy socket.

Now press the Program switch. The Program LED should light and the Vpp line should go to +25V. If you have an oscilloscope, you can check for the 50ms pulse train on pin 3 of IC3.

Readers with an oscilloscope can also adjust the IC4b clock to obtain maximum copying speed. The procedure simply involves reducing the 270kΩ timing resistor until the output low at pin 4 just exceeds the 50ms programming pulse at pin 3 of IC2. If no CRO is available, then use a 270kΩ resistor if IC4 is a National Semiconductor device and a 560kΩ resistor for devices from other manufacturers.

Operation

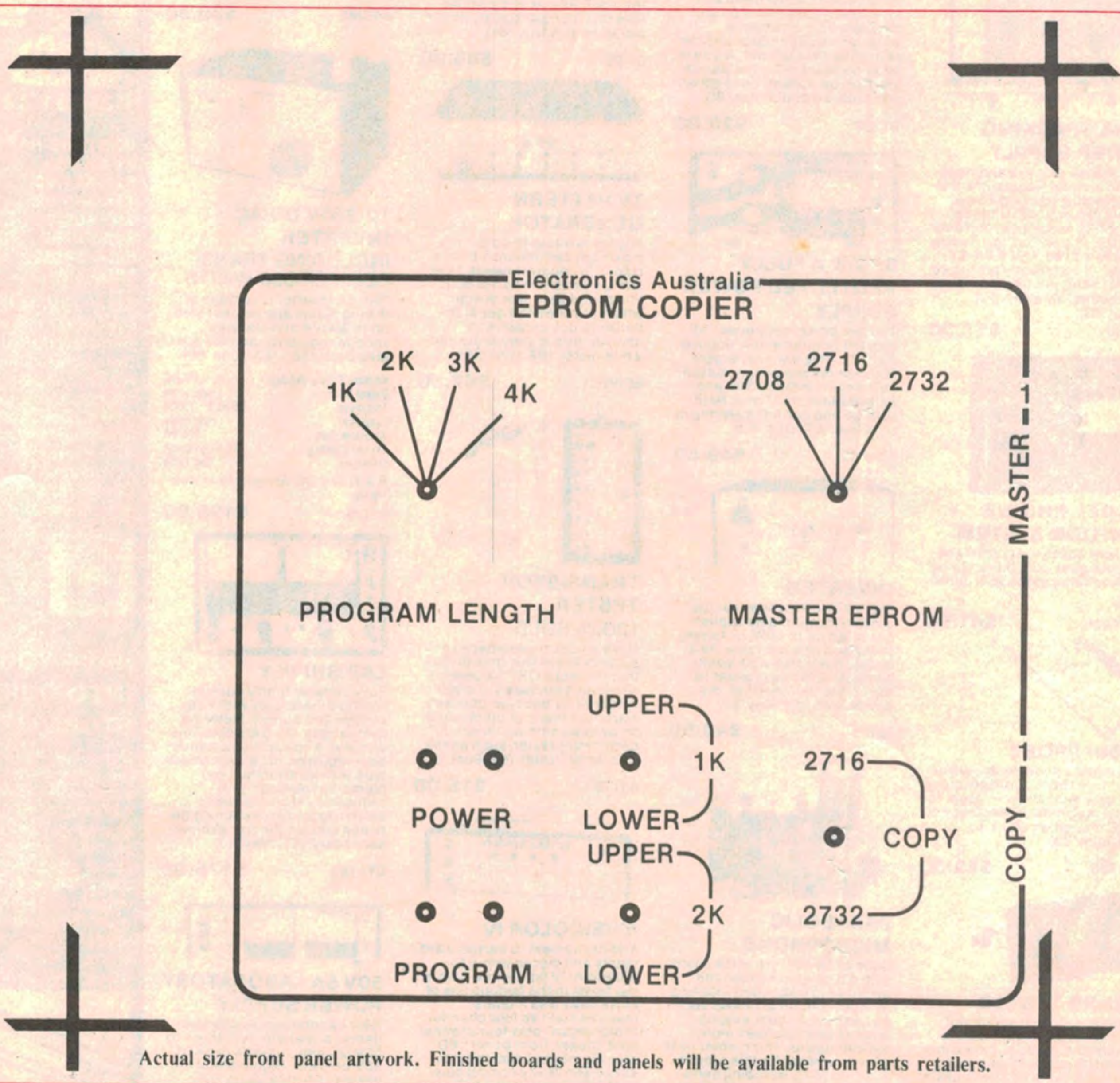
Before attempting to use the copier, it is important to ensure that the copy EPROM has been fully erased. A suitable EPROM eraser was described in our February 1979 issue and consists simply of a Philips TUV15W ultraviolet fluorescent lamp with a metal cover to prevent damage to the skin and eyes.

To use the copier, switch the power off and insert the master and copy EPROMs into their respective sockets with pin 1 at top left. If you are using two EPROMs of the same type, set the Program Length switch to 2K for 2716 devices and to 4K for 2732 devices. A lesser program length can be selected if the program falls within one of the available 1K blocks.

The Upper and Lower 1K and/or 2K switches are used only when the copy EPROM is different from the master. The 1K switch is used when copying from a 2708 into a 2716, the 2K switch is used when copying a 2716 device into a 2732 and both switches are used when copying a 1K block from either a 2708 or 2716 into a 2732, (ie, you can copy into any of the four 1K blocks in the 2732).

For all these cases, set the Program Length switch to the memory length of the master EPROM.

Once all the switches are correctly set, turn the power on and press the Program switch to initiate programming. When programming is complete, the program LED goes out and the copy EPROM can be removed.



Actual size front panel artwork. Finished boards and panels will be available from parts retailers.