

Program Those 2708s!

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Erasable programmable read-only memories (EPROMs) can be used to great advantage in many microcomputer applications. One of the stumbling blocks to more widespread hobbyist use of EPROMs has been the difficulty of programming them. Several companies offer programming services, but this can be time-consuming as well as expensive.

One of the first EPROMs to become available was the 1702

device, which is structured as 256 words by 8 bits. This EPROM is indeed difficult to program. All of its address and data lines must be switched at 50 V levels, requiring a multitude of level-shifting transistors, in addition to the timing logic. Although it is possible to construct a programmer for the 1702, it is certainly not simple.

Salvation for the hobbyist came with the Intel 2708 EPROM. This

device sports 1 K words by 8 bits of memory, four times the capacity of the 1702. It requires power supplies of +5 V, +12 V, and -5 V. For read operation, all that is required is to supply the address lines with the desired memory address, and select the individual EPROM device by grounding the chip-select input. The outputs appear on the data lines.

The greatest advantage of this 2708-type memory is its program-

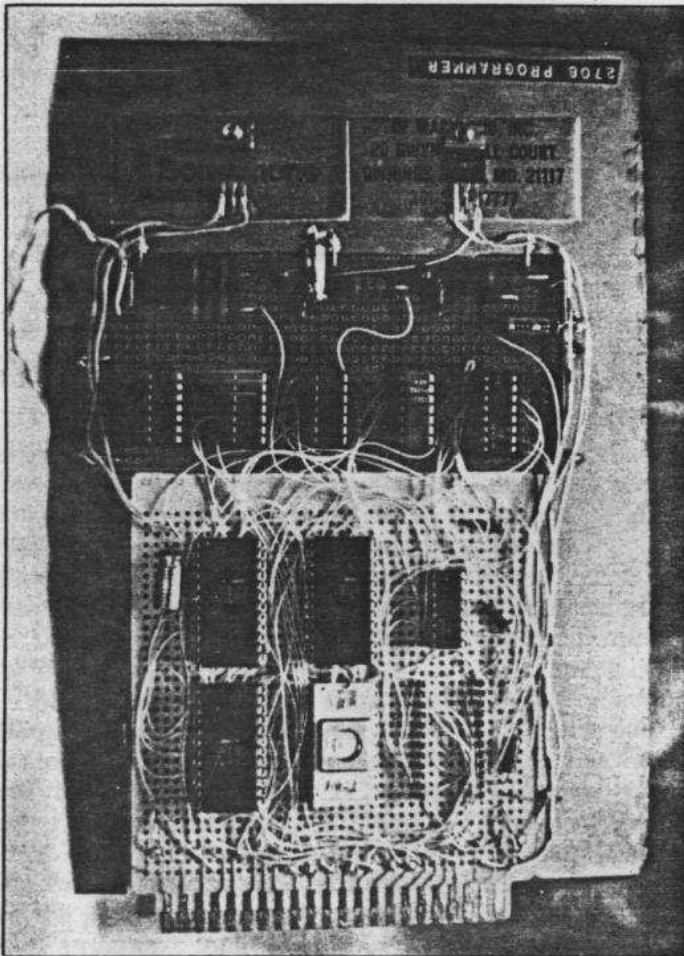


Photo 1: Front side of the EPROM programming circuit board. Components may be identified from diagram of figure 4. A Radio Shack 44-pin card forms the base of the board, which has had other sections added to it. TO-220 packages at top are voltage regulators.

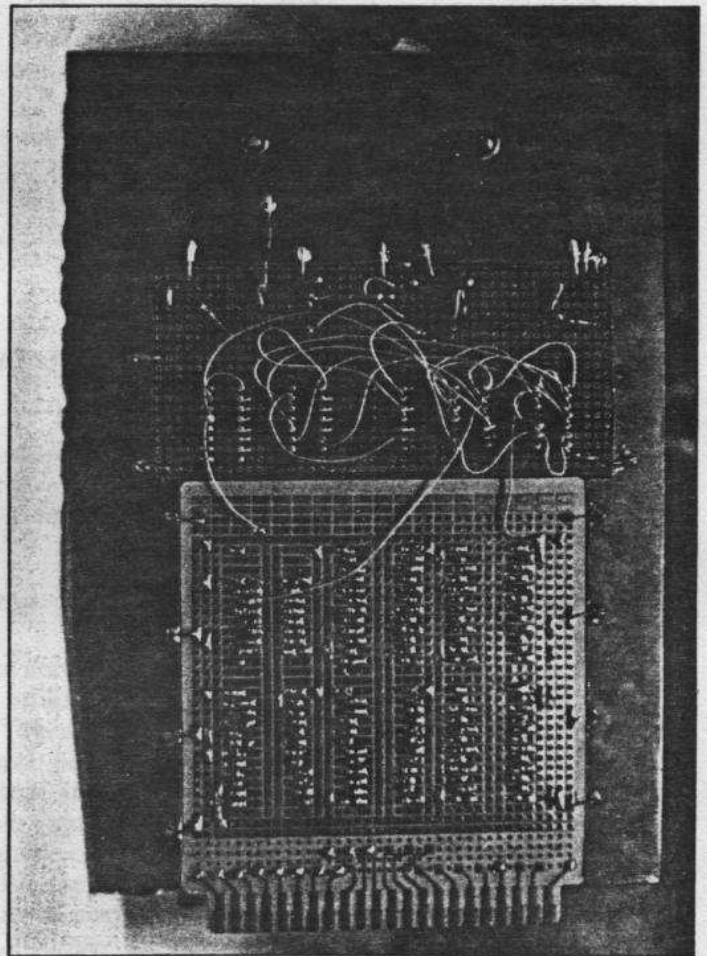


Photo 2: The back side of the EPROM programming circuit board. The author wishes to thank Marc Leavey MD, WA3AJR for performing the photography.

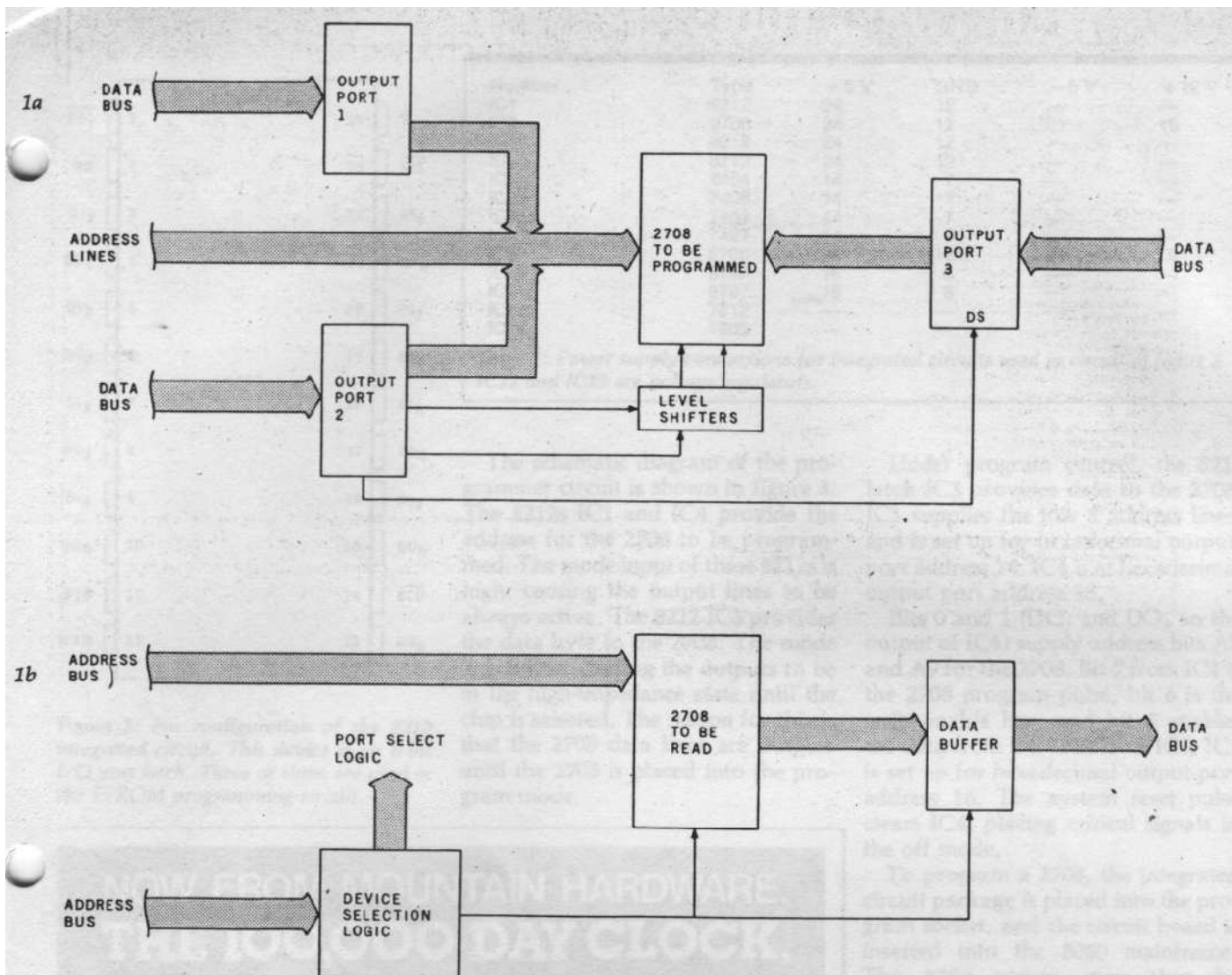


Figure 1: Block diagrams of the 2708 EPROM programming circuit (1a) and 2708 reading circuit (1b).

ming simplicity. All address and data lines need only be supplied with transistor-transistor logic (TTL) voltage levels. Two lines must be pulsed at non-TTL voltage levels. The write-enable line must be raised to +12 V, and the program pulse rises to +26 V.

After erasure with an ultraviolet lamp, all bits of the 2708 are in the logic 1 state. Programming consists of selectively changing the 1s to 0s. After the write-enable line is raised to +12 V, each byte is set up by applying the address and data information to the proper pins, and then pulsing the program input. The proper method is to sequence through all of the addresses many times. Each run through all addresses is called a *program loop*. The specifications of the 2708 device call for the number of

program loops, multiplied by the duration of the program pulse, to form a total pulse time of at least 100 ms.

Microcomputer 2708 Programming

A simple way to accomplish the programming is to utilize a microcomputer system. With a small program routine, several output ports and some level shifters, it is easy to program the EPROM. Figure 1 shows the block diagram of the circuit I use in my 8080 system for the programming operation. Output port 1 and part of output port 2 supply the address to the 2708 device to be programmed. Output port 3 feeds the desired data to the 2708. Part of output port 2 and some level shifters provide the programming pulses for the

device.

Each output port is an 8212 latch. The 8212 device is a general purpose I/O (input/output) port. The pin connections are shown in figure 2. The output of the latch is 3-state. If the mode input is high, the outputs are always enabled. When the device is selected by placing a low on $\overline{DS1}$ (active-low, device-select line) and a high on DS2 (active-high line), whatever data is present at the data input (DI) lines is latched and appears at the data output (DO) lines.

If the mode input is low, the outputs are in the high-impedance state until the device is selected. In this case, the data is latched by a signal on the strobe line. The 8212 places little loading on the data bus, and is quite suitable for the output ports used in this project.

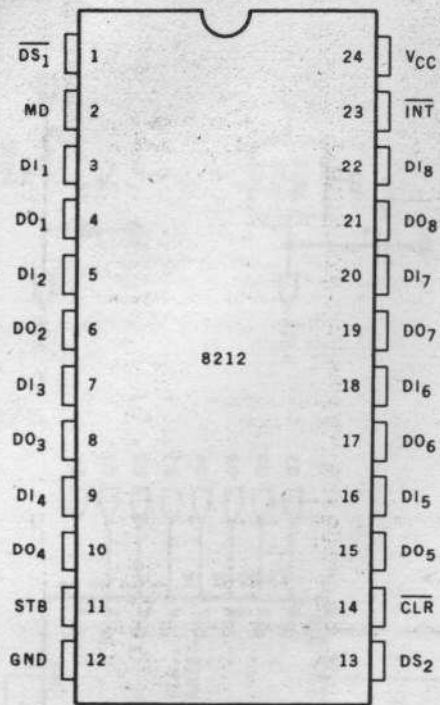


Figure 2: Pin configuration of the 8212 integrated circuit. This device is an 8-bit I/O port latch. Three of them are used in the EPROM programming circuit.

Number	Type	+5 V	GND	-5 V	+12 V
IC1	8212	24	12	—	—
IC2	2708	24	12	21	19
IC3	8212	24	12	—	—
IC4	8212	24	12	—	—
IC5	7404	14	7	—	—
IC6	7408	14	7	—	—
IC7	7404	14	7	—	—
IC8	7427	14	7	—	—
IC9	2708	24	12	21	19
IC10	8T97	16	8	—	—
IC11	8T97	16	8	—	—
IC12	7812	—	—	—	—
IC13	7805	—	—	—	—

Table 1: Power supply connections for integrated circuits used in circuit of figure 3. IC12 and IC13 are voltage regulators.

The schematic diagram of the programmer circuit is shown in figure 3. The 8212s IC1 and IC4 provide the address for the 2708 to be programmed. The mode input of these 8212s is high, causing the output lines to be always active. The 8212 IC3 provides the data byte to the 2708. The mode line is low, causing the outputs to be in the high-impedance state until the chip is selected. The reason for this is that the 2708 data lines are outputs until the 2708 is placed into the program mode.

Under program control, the 8212 latch IC3 provides data to the 2708. IC1, supplies the low 8 address lines, and is set up for hexadecimal output-port address 14. IC4 is at hexadecimal output port address 15.

Bits 0 and 1 (DO₁ and DO₂ on the output of IC4) supply address bits A8 and A9 for the 2708. Bit 7 from IC4 is the 2708 program pulse, bit 6 is the write-enable line, and bit 5 enables the data from the 8212 latch IC3. IC3 is set up for hexadecimal output-port address 16. The system reset pulse clears IC4, placing critical signals in the off mode.

To program a 2708, the integrated circuit package is placed into the program socket, and the circuit board is inserted into the 8080 mainframe. The 8080 system may then be powered up, and the program run. The 26 V power supply should be turned on just prior to supplying the address to the program.

It is important not to apply the high voltage before the system is powered up and reset. After programming, the sequence should be followed in reverse. The 26 V supply should be turned off, the computer turned off, the board unplugged, and the 2708 removed.

To read what has been written into EPROM, the device is plugged into the read socket. Hexadecimal address 0000 is used. If you already have an EPROM board which can read 2708s, then this portion of the circuit can be deleted. The inhibit line prevents the 2708 from being selected.

Construction

Construction will depend upon your particular system. My 8080-based system was built using 44-pin edge connectors. This permits the use

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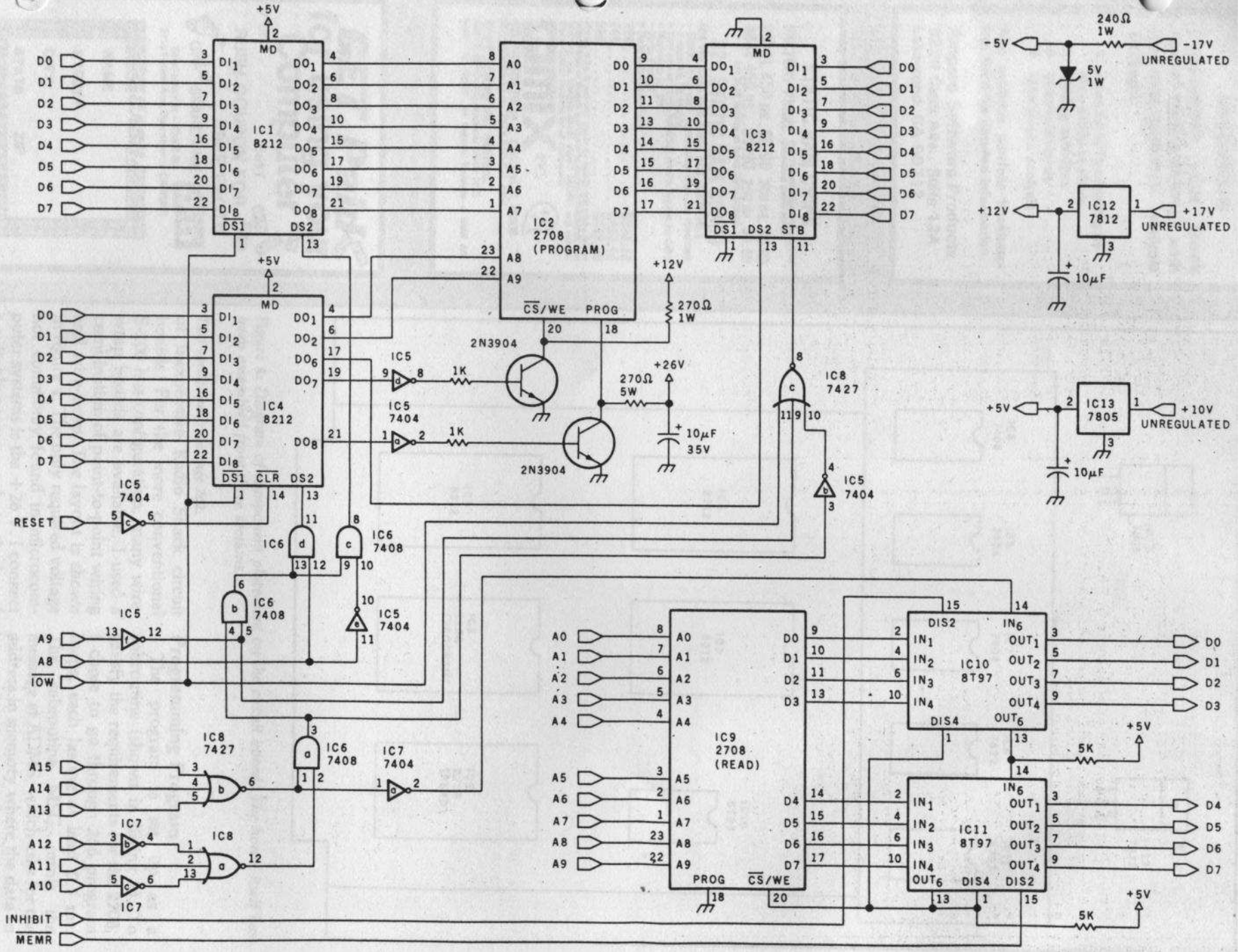
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Figure 3: Schematic diagram of the 2708 programming circuit. At right are shown voltage regulation schemes for power supplies.



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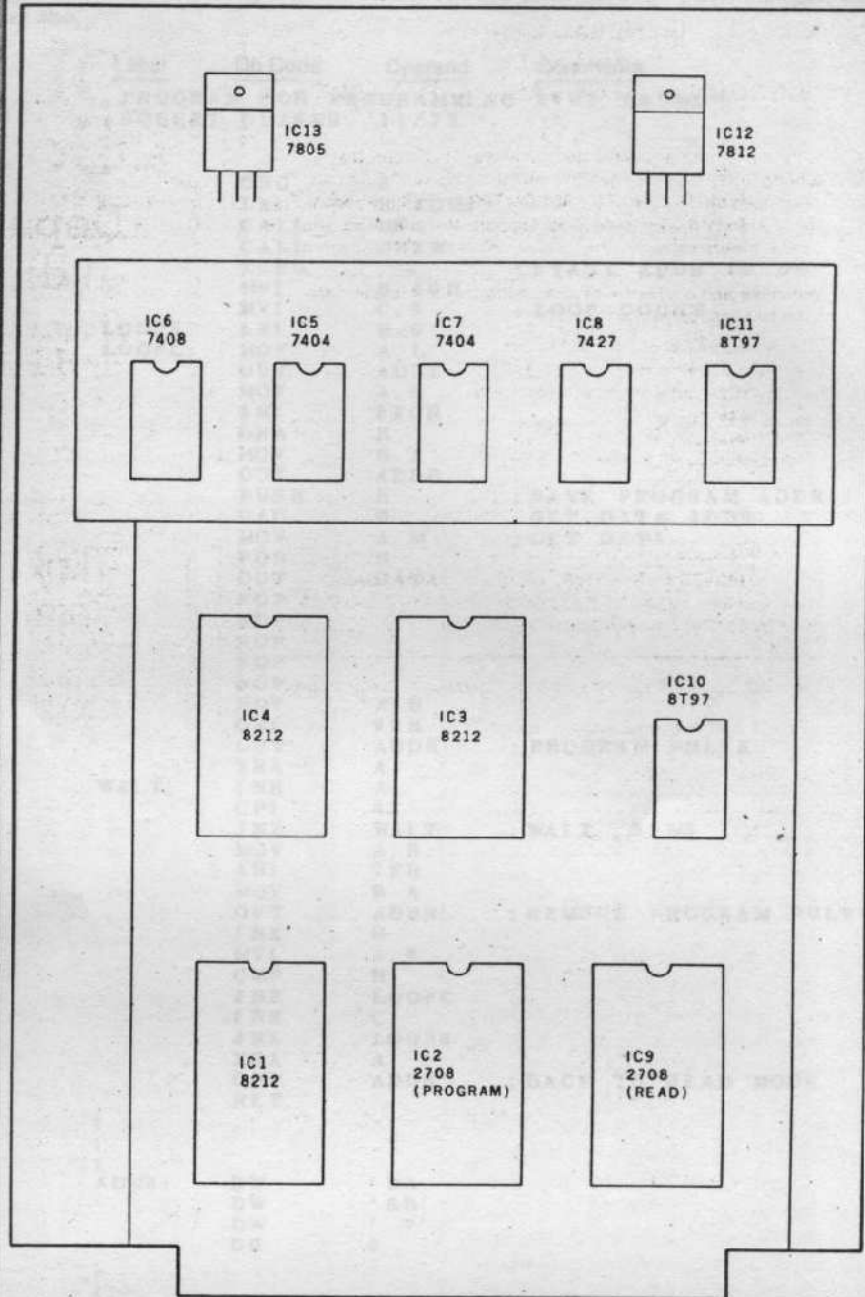


Figure 4: Diagram of component placement on the circuit board. The board itself has been assembled from three sections.

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of inexpensive Radio Shack circuit boards. For the more conventional S-100 bus configuration, many wire-wrap boards are available. I used a combination of point-to-point wiring and wire-wrap. The layout is shown in figure 4. The only required voltage not commonly found in microcomputer systems is the +26 V. I connect a suitable power supply to the board when it is needed.

Programming Program

The program is set up as a subroutine (shown in listing 1). To satisfy the requirements for the 2708, I chose to go through 256 program loops, each lasting at least 0.5 ms. The subroutine MSG prints the message at ADMS, which asks for the address in memory where the data to be programmed into the 2708 is to be found. It is assumed that 1 K bytes of

Listing 1: 8080 subroutine for programming the 2708 EPROM using the circuit described in this article. With minor changes, this routine can be used to program 2716 devices also.

Line	Address	Object Code	Label	Op Code	Operand	Comments
0001	0000					; PROGRAM FOR PROGRAMMING 2708 PROMS
0002	0000					; ROBERT GLASER, 11/77
0003	0000					;
0004	0000					;
0005	0000			ORG	0	
0006	0000	21 47 00		LXI	H, ADMS	
0007	0003	CD 79 ED		CALL	MSG	
0008	0006	CD 85 ED		CALL	GHXW	
0009	0009	EB		XCHG		; START ADDR TO DE
0010	000A	06 60		MVI	B, 60H	
0011	000C	0E 00		MVI	C, 0	; LOOP COUNT
0012	000E	21 00 00	LOOPS:	LXI	H, 0	
0013	0011	7D	LOOPC:	MOV	A, L	
0014	0012	D3 14		OUT	ADDL	
0015	0014	78		MOV	A, B	
0016	0015	E6 FC		ANI	0FCH	
0017	0017	B4		ORA	H	
0018	0018	47		MOV	B, A	
0019	0019	D3 15		OUT	ADDH	
0020	001B	E5		PUSH	H	; SAVE PROGRAM ADDR
0021	001C	19		DAD	D	; GET DATA ADDR
0022	001D	7E		MOV	A, M	; GET DATA
0023	001E	E1		POP	H	
0024	001F	D3 16		OUT	DATA	
0025	0021	00		NOP		
0026	0022	00		NOP		
0027	0023	00		NOP		
0028	0024	00		NOP		
0029	0025	00		NOP		
0030	0026	78		MOV	A, B	
0031	0027	F6 80		ORI	80H	
0032	0029	D3 15		OUT	ADDH	; PROGRAM PULSE
0033	002B	AF		XRA	A	
0034	002C	3C	WAIT:	INR	A	
0035	002D	FE 2A		CPI	42	
0036	002F	C2 2C 00		JNZ	WAIT	; WAIT .5 MS
0037	0032	78		MOV	A, B	
0038	0033	E6 7F		ANI	7FH	
0039	0035	47		MOV	B, A	
0040	0036	D3 15		OUT	ADDH	; REMOVE PROGRAM PULSE
0041	0038	23		INX	H	
0042	0039	3E 04		MVI	A, 4	
0043	003B	BC		CMP	H	
0044	003C	C2 11 00		JNZ	LOOPC	
0045	003F	0C		INR	C	
0046	0040	C2 0E 00		JNZ	LOOPS	
0047	0043	AF		XRA	A	
0048	0044	D3 15		OUT	ADDH	; BACK TO READ MODE
0049	0046	C9		RET		
0050	0047					
0051	0047					
0052	0047					
0053	0047	41 44	ADMS:	DW	' DA	
0054	0049	44 52		DW	' RD'	
0055	004B	3F 20		DW	' ?'	
0056	004D	00		DB	0	
0057	004E					
0058	004E					
0059	004E					
0060	004E		MSG:	EQU	0ED79H	
0061	004E		GHXW:	EQU	0ED85H	
0062	004E		ADDL:	EQU	14H	
0063	004E		ADDH:	EQU	15H	
0064	004E		DATA:	EQU	16H	

data are to be written into the EPROM from that starting point. If the 2708 is to be only partially written, the unused portion of source memory should be filled with the hexadecimal value FF.

Subroutine GHXW gets the 16-bit value which is input in hexadecimal, and places it in register pair HL. The

starting address is then moved to DE. Throughout the program this remains the same. Register pair HL contains the actual address applied to the 2708.

LOOPS (loop start) is the beginning of a program loop. At LOOPC (loop continue) the cycle begins. First the address is set up at ports ADDL

and ADDH. The data is then fetched and output at the DATA port. Several no-operation instructions are included to guarantee the timing specifications of the 2708.

The program pulse is then applied, and a timing loop of 0.5 ms is entered at WAIT. The program pulse is removed, and the current address is

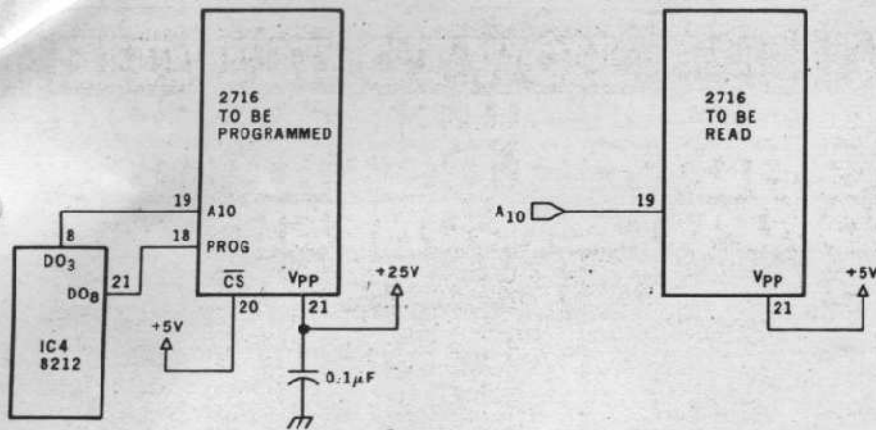


Figure 5: Modifications to the circuit of figure 3 that enable the programming of the 2716-type EPROM. Modifications to the software are also necessary.

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examined to see if a program loop is finished. If not, the control loops back to LOOPC. If the loop is finished, the loop count is checked to see if all 256 loops have been completed. If not, control goes back to LOOPS.

When the procedure is finished, the 2708 is returned to the read mode, and the routine returns to the calling program. To be on the safe side, timing values are longer than necessary. With the 8080 running at 2 MHz with one wait state, the routine takes 3 minutes and 6 seconds.

Variations

Other EPROMs could be programmed with this setup, as well as 2708s. By changing the value 4 to a 2 in line 42 of the program, 2704s can be programmed with no other modifications. To program 2716s, some other modifications need to be made. The 2716 is a 2 K word by 8 bit EPROM and has some advantages over the 2708. It requires only a +5 V supply for read operation. For programming, the program pulse need only be a TTL level voltage. The high voltage is not pulsed.

Figure 5 shows the necessary circuitry changes to accommodate the 2716. The high voltage applied to pin 21 is +25 V, not the +26 V used for the 2708. Pin 19 is the eleventh address line.

The 2716 needs only a single program loop, but the program pulse should be 50 ms or longer. The program should be modified. Delete lines 11, 45, and 46. The value 4 in line 42 should be changed to an 8, and the delay loop at WAIT should be surrounded by an external loop of 100 to change the 0.5 ms to 50 ms.

To use non8080 systems for programming the EPROM, all that need be done is to reconcile the buses. For 6800-type systems with no discrete output ports, the output ports would have to be addressed as memory.

I have programmed dozens of 2708s with this setup and have had no problems. My application has been with dedicated 8080 controllers. One such controller is used in the local amateur radio repeater to perform various functions. Many program versions were used in this application, since control and autopatch codes are all contained in the programmable read-only memory, which led to many program revisions. The 2708 programmer board was called upon many times. ■