CHAPTER 6
EPROM PROGRAMMING

6.1 INTRODUCTION

6.1.1 General

The M6805 HMOS/M146805 CMOS Family of MCUs uses either on-chip masked ROM or on-chip EPROMs for program storage. Erasable Programmable Read Only Memory (EPROM) devices allow programs to be written into memory and, if desired, later erased with ultraviolet light and revised. These features give the user an alterable, non-volatile memory. Each EPROM in this family includes a bootstrap routine in masked ROM, which makes programming relatively easy. Currently, four EPROM devices exist, three of which are implemented in the M6805 HMOS Family with the fourth being implemented in the M146805 CMOS Family.* These devices may be used to emulate various masked ROM versions of other members of the family. The EPROM devices have more capabilities than do the masked ROM versions, thus allowing some EPROM devices to emulate more than one masked ROM version.

Each EPROM includes a Mask Option Register (MOR) which is implemented in EPROM. The MOR is located at address $784 in the MC68705P3, $F38 in the MC68705R3, $F38 in the MC68705U3, and $1FF5 in the MC1468705G2. The M6805 HMOS Family MOR is used to determine which of the timer options are to be used and to select the clock oscillator circuit (crystal or RC); whereas, the M146805 CMOS Family MOR is used to select the clock oscillator circuit, divide ratio of the clock oscillator, and type of interrupt trigger input. The MOR, like all EPROM locations, contains all zeros after erasing. Table 6-1 gives a description of the function of each MOR bit used in the M6805 HMOS Family and Table 6-2 provides equivalent MOR information for the MC1468705G2.

6.1.2 M6805 HMOS Family Bootstrap

Each member of the M6805 HMOS Family of EPROM devices contains a bootstrap program which is implemented in on-chip masked ROM. The bootstrap program clocks an external counter which is used to generate an address. The address is then used to read a location in an external memory. The data from the external memory is presented to the EPROM via an I/O port. After data from that location is loaded into the EPROM, the

*At the initial printing of this manual, four different M6805 HMOS/M146805 CMOS Family EPROM types are available; however, others are scheduled to follow.

bootstrap routine clocks the counter to increment the address and read the next location. After the data from all locations are loaded into the EPROM, its contents are compared to those in external memory. The programming status is indicated by two LEDs (see Table 6-3 and Figure 6-1).

Table 6-1. M6805 HMOS Family Mask Option Register

b7	b6	b5	b4	b3	b2	b1	b0	Mask Option Register
CLK	TOPT	CLS			P2	P1	P0	

b7, CLK	Clock Oscillator Type 1 = RC 0 = Crystal **NOTE** V_{IHTP} on the TIMER/BOOT pin (8) forces the crystal mode.
b6, TOPT	Timer Option 1 = M6805 HMOS Family type timer/prescaler. All bits, except 3, 6, and 7, of the timer control register (TCR) are invisible to the user. Bits 5, 2, 1, and 0 of the mask option register determine the equivalent M6805 HMOS Family mask options. 0 = All TCR bits are implemented as a software programmable timer. The state of MOR bits 5, 4, 2, 1, and 0 sets the initial values of their respective TCR bits (TCR is then software controlled after initialization).
b5, CLS	Timer/Clock Source 1 = External TIMER pin 0 = Internal $\phi 2$
b4	Not used if MOR TOPT = 1. Sets initial value of TCR TIE if MOR TOPT = 0.
b3	Not used.
b2, P2 b1, P1 b0, P0	Prescaler Option – the logical levels of these bits, when decoded, select one of eight taps on the timer prescaler. The division resulting from decoding combinations of these three bits is shown here.

P2	P1	P0	Prescaler Division
0	0	0	1 (Bypass Prescaler)
0	0	1	2
0	1	0	4
0	1	1	8
1	0	0	16
1	0	1	32
1	1	0	64
1	1	1	128

Table 6-2. M1468705G2 Mask Option Register

b7	b6	b5	b4	b3	b2	b1	b0	Mask Option Register
CLK	DIV		INT					

b7, CLK	Clock Oscillator Type 1 = RC 0 = Crystal
b6, DIV	Determines Division of Clock Oscillator 1 = Divide-by-2 oscillator clock 0 = Divide-by-4 oscillator clock
b5,	Not used.
b4, INT	Determines type of Interrupt Trigger Input 1 = Both Edge-sensitive and level-sensitive triggered interrupt 0 = Edge-sensitive triggered interrupt only
b0, b1, b2, b3	Not used.

Table 6-3. M6805 HMOS EPROM LED Results

LED	Function
DS1 (PB1)	Turned on (when PB1 goes low) to indicate EPROM device is programmed.
DS2 (PB2)	Turned on (when PB2 goes low) to indicate EPROM contents are successfully verified (approximately two seconds after DS1 is turned on). Programming and verification are now complete.

Two examples for programming the M6805 HMOS Family MOR are discussed below.

Example 1 When emulating an MC6805P2 (using an MC68705P3) to verify your program with an RC oscillator and an event counter input for the timer with no prescaling, the MOR should be programmed to '11111000". To write the MOR, it is simply programmed as any other EPROM byte. (The same criteria is applicable when using the MC68705R3 to emulate the MC6805R2 or the MC68705U3 to emulate the MC6805U2.)

Example 2 Suppose you wish to use the EPROM programmable prescaler functions, and you wish the initial condition of the prescaler to be a divide-by-64, with the input disabled and an internal clock source. If the clock oscillator is to be in the crystal mode, the MOR would be programmed to "00001110".

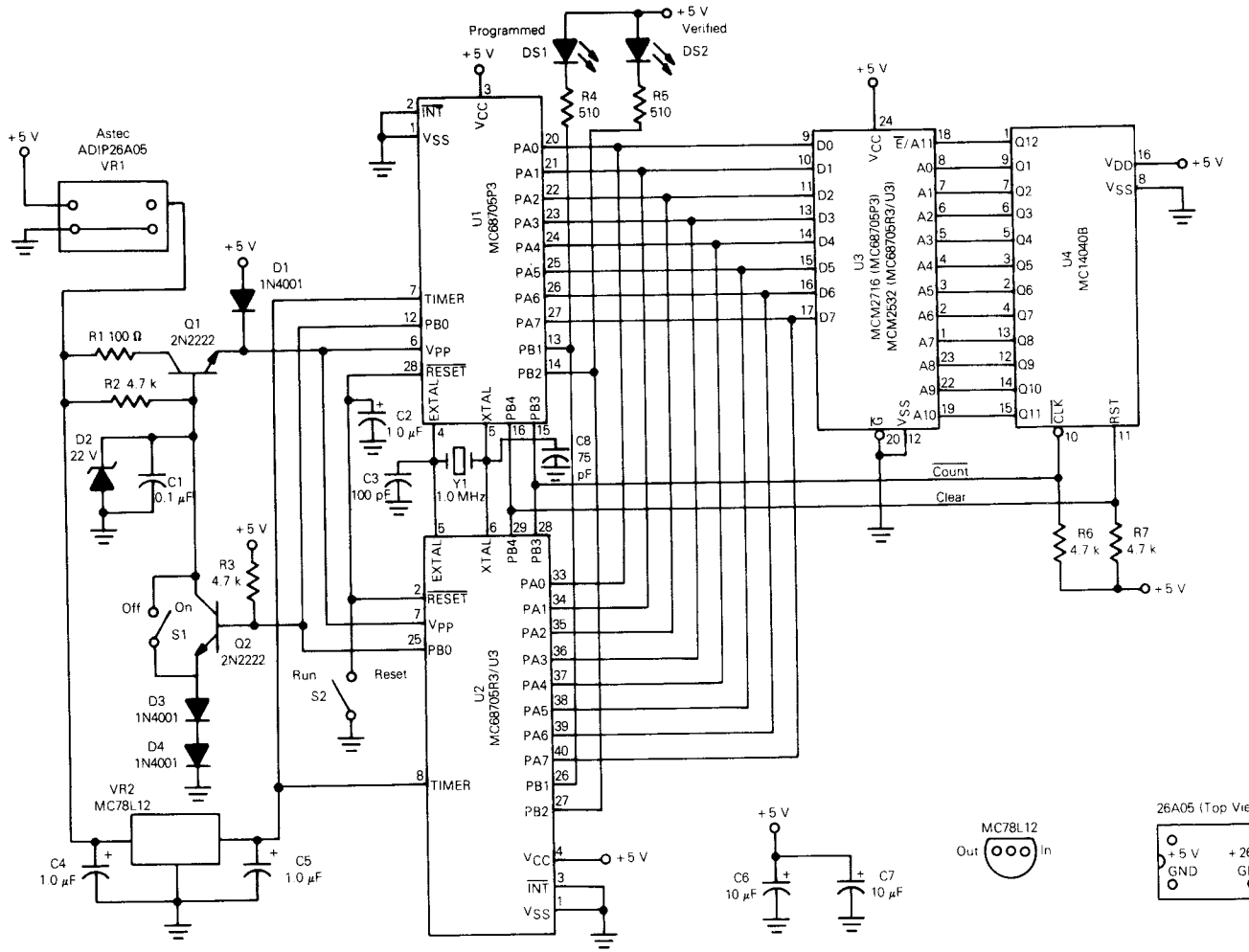


Figure 6-1. MC68705P3/R3/U3 Programming Module Schematic Diagram

6.1.3 M146805 CMOS Family Bootstrap

The MC1468705G2 MCU EPROM device also contains a bootstrap program which is implemented in on-chip masked ROM. However, in this program no external counter is required to generate the address. Instead, the address is generated internally and applied via port A and port D lines to read the location in external memory. As with the M6805 HMOS Family, the data from external memory is presented to an I/O port. After data from that location is loaded into the EPROM, the bootstrap routine increments the output address and reads the next location. Two LEDs provide an indication of the programming status (see Table 6-4 and Figure 6-2).

Table 6-4. MC1468705G2 EPROM LED Results

LED	Function
DS2 (PD6)	Turned on (when PD6 goes low) to indicate EPROM device is being programmed.
DS1 (PD5)	Turned on (when PD5 goes low) to indicate EPROM contents are successfully verified. Programming and verification are now complete.

An example for programming the MC1468705G2 EPROM MOR is as follows: when emulating an MC146805G2 (using an MC1468705G2) to verify your program with a crystal oscillator, a divide-by-4 oscillator clock, and both edge-sensitive and level-sensitive triggered inputs, the MOR should be programmed to "00010000".

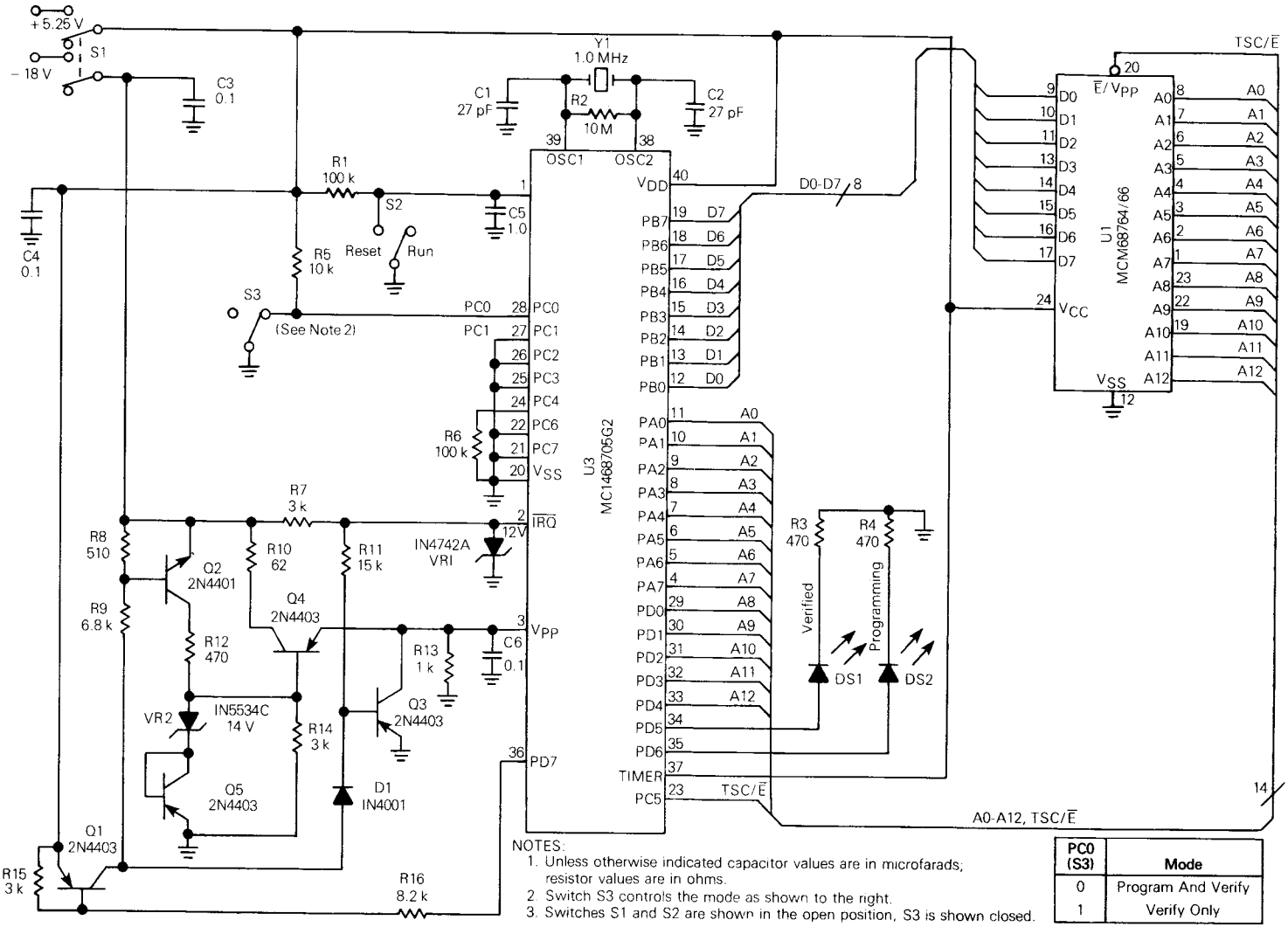
6.2 PROGRAMMING

6.2.1 M6805 HMOS Family

Figure 6-1 contains a schematic diagram of a circuit which can be used to program the MC68705P3, MC68705R3, and MC68705U3 EPROM Microcomputer Unit devices. Since the routine required to program the EPROM MCU is actually located within the device, only a small number of parts are required to build the circuit for programming the EPROM MCU. Figure 6-3 shows a parts layout of the printed circuit board and Table 6-5 provides a parts list.

Except for the socket used for mounting the EPROM MCU device the use of either a 2K (MCM2716) or 4K (MCM2532) EPROM for U2, programming either of the EPROM MCUs is basically the same. Because of this similarity, the procedure for programming the MC68705P3 is described first, followed by the MC68705R3/U3 procedure.

6.2.1.1 MC68705P3 Programming. Prior to programming the MC68705P3 EPROM, it should be erased by exposing it to a high-intensity ultraviolet (UV) light with a wavelength of 2537 angstroms. The recommended dose (UV intensity x exposure time) is 15 Ws/cm^2. The UV lamps should be used without shortwave filters and the MC68705P3 should be positioned about one inch from the UV tubes. Be sure the EPROM window is shielded from light except when erasing.


+5.25 V
S1
−18 V
C3
0.1
C4
0.1
Y1
1.0 MHz
C1
27 pF
R2
10 M
C2
27 pF
OSC1
OSC2
R1
100 k
S2
Reset
Run
C5
1.0
R5
10 k
S3
(See Note 2)
R6
100 k
R7
3 k
R8
510
R9
6.8 k
Q2
2N4401
R10
62
Q4
2N4403
R11
15 k
IN4742A
VRI
12V
R12
470
R13
1 k
C6
0.1
VR2
IN5534C
14 V
R14
3 k
Q3
2N4403
Q5
2N4403
D1
IN4001
Q1
2N4403
R15
3 k
R16
8.2 k
U3
MC1468705G2
VDD
VSS
IRQ
VPP
PD7
TIMER
PC5
TSC/E
D0-D7
8
R3
470
R4
470
Verified
Programming
DS1
DS2
U1
MCM68764/66
E/VPP
VCC
VSS
A0-A12, TSC/E
14
NOTES:
1. Unless otherwise indicated capacitor values are in microfarads; resistor values are in ohms.
2. Switch S3 controls the mode as shown to the right.
3. Switches S1 and S2 are shown in the open position, S3 is shown closed.
PC0 (S3)
Mode
0
Program And Verify
1
Verify Only
0 = Switch closed 1 = Switch open

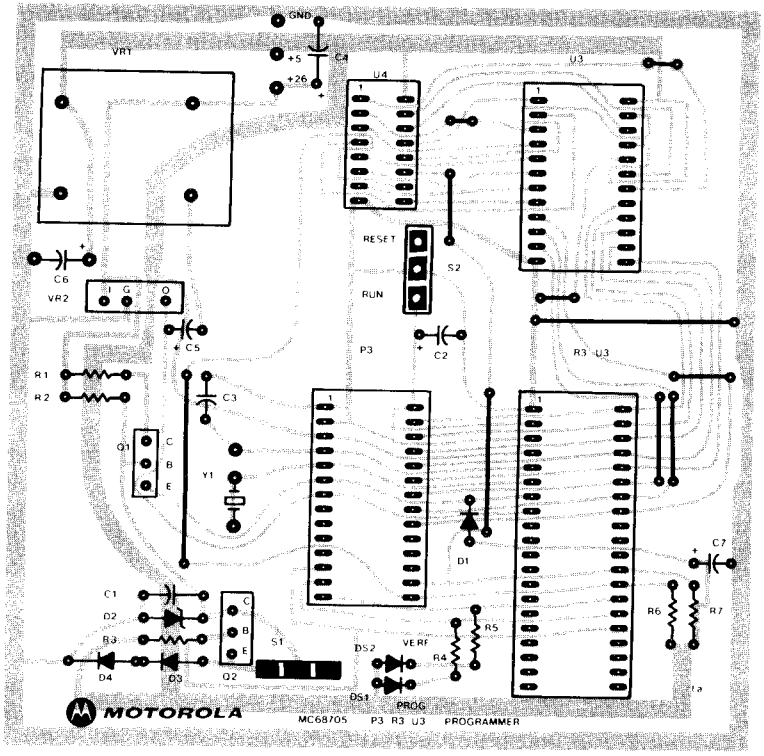


Figure 6-3. MC68705P3/R3/U3 Programming Module Parts Layout

Table 6-5. MC68705P3/R3/U3 Programming Module Parts List

R1	100 Ω
R2	4.7 kΩ
R3	4.7 kΩ
R4	510 Ω
R5	510 Ω
R6	4.7 kΩ
R7	4.7 kΩ
C1	0.1 μF
C2	1.0 μF
C3	100 pF
C4	1.0 μF
C5	1.0 μF
C6	10 μF
C7	10 μF
D1	1N4001
D2	22V Zener-1N4748A or Equiv.
D3	1N4001
D4	1N4001

Q1	2N2222 or Equiv.
Q2	2N2222 or Equiv.
Y1	1 MHz (AT-Cut Parallel Resonance, 100 Ω Max.)
U1	MC68705P3 } Only Use One
U2	MC68705R3/U3 } Only Use One
U3	MCM2716 or MCM2532
U4	MC14040B
VR1	ASTEC Voltage Converter 26A05
VR2	MC78L12
DS1	Red LED
DS2	Green LED
PCB1	Printed Circuit Board
Misc:	1 – 40 Pin Low Insertion Force Socket
	1 – 28 Pin Low Insertion Force Socket
	1 – 24 Pin Low Insertion Force Socket
	1 – 16 Pin Solder Tail Socket
	2 – SPDT Switches

The MCM2716 UV EPROM is used for U3 when programming the MC68705P3. Before the MC68705P3 can be programmed, the MCM2716 UV EPROM must first be programmed with an exact duplicate of the information that is to be transferred to the MC68705P3.

NOTE

The first 128 bytes of EPROM (MCM2716) are ignored; location $80 of the EPROM is placed in location $80 of the MC68705P3.

Step 1—Close switches S1 and S2 and be sure that voltage (+5 V in this case) is not applied to the circuit board.

Step 2—Insert the MCM2716 into the socket for U3 and insert the MC68705P3 into the U1 socket.

Step 3—Apply +5 V to the circuit board.

Step 4—Open switch S1 to apply V_{PP} to the MCU and then open switch S2 to remove reset.

NOTE

Once the MCU comes out of reset, the CLEAR output control line (PB4) goes high and then low, then the MC14040B counter is clocked by the PB3 output (COUNT). The counter selects the MCM2716 EPROM byte which is to load the equivalent MC68705P3 EPROM byte selected by the MCU bootstrap program. Once data is programmed, COUNT increments the counter to the next location. This continues until the MCU is completely programmed.

Step 5—Check that the programmed LED indicator is lit followed by lighting of the verified indicator LED. This signals that the EPROM MPU has been correctly programmed.

Step 6—Close switch S1 to remove V_{PP} and V_{IHTP}. Close switch S2 to reset the MCU.

Step 7—Disconnect (or turn off) the +5 V input to the circuit board and then remove the newly programmed EPROM MCU from its socket.

Step 8—Remove the U3 EPROM from its socket if no further programming is required.

6.2.1.2 MC68705R3/MC68705U3 Programming. Programming either of these MCU EPROMs is similar to that described above for the MC68705P3 with three minor exceptions. These three exceptions are:

1. The MCM2532 UV EPROM is used for U3 when programming either the MC68705R3 or MC68705U3 EPROM MCU. This UV EPROM must be programmed with an exact duplicate of the information being transferred to MC68705R3 or MC68705U3.

2. In step 2 the MCM2532 is inserted into the U3 socket and the MC68705R3 or MC68705U3 is inserted into the U2 socket.
3. In the note under step 4, operation of the MCM2532 and MC68705R3/U3 is identical to that described for the MCM2716 and MC68705P3.

6.2.1.3 Printed Circuit Board. The PCB is a double-sided board with plated through holes. However, a single-sided board requiring only 10 wire jumpers could be used. The wire jumpers would be in place of the wiring shown in the component section of Figure 6.4. Component tolerances are generally not critical. The 5-to-26 volt converter (VR1) is manufactured by ASTEC International under part number ADIP26A05; however, if this part is not available, + 26 Vdc may be applied to the soldering feed through which is adjacent to the C4 + soldering feed through (PCB ground must be connected for this supply).

Figure 6-3 is a parts layout detail as shown from the component side of the board. Figure 6-4 contains the circuit board art (both component side and circuit side) detail. These are actual sizes and can be used for developing a double-sided board.

6.2.2 MC1468705G2 Programming

Figure 6-2 contains a schematic diagram of a circuit which can be used to program the MC1468705G2 EPROM Microcomputer Unit, and Table 6-6 contains a parts list. Since the routine required to program the EPROM MCU plus the address to select the data is actually located in the device, only a small number of parts are required to build the circuit for programming the EPROM MCU. The procedure for programming the MC1468705G2 is described below.

Table 6-6. MC1468705G2 MCU EPROM Programming Circuit Parts List

R1	100 kΩ
R2	10 MΩ
R3	470 Ω
R4	470 Ω
R5	10 kΩ
R6	100 kΩ
R7	3 kΩ
R8	510 Ω
R9	6.8 kΩ
R10	62 Ω
R11	15 kΩ
R12	470 Ω
R13	1 kΩ
R14	3 kΩ
R15	3 kΩ
R16	8.2 kΩ
C1	27 pF
C2	27 pF
C3	0.1 μF
C4	0.1 μF
C5	1 μF
C6	0.1 μF

D1	1N4001
Q1	2N4403
Q2	2N4401
Q3	2N4403
Q4	2N4403
Q5	2N4403
Y1	1 MHz (AT-Cut Parallel Resonance, 100 ohms Max.)
U1	MCM68764 or MCM68766
U2	MC1468705G2
VR1	1N4742A
VR2	1N5534C
DS1	LED
DS2	LED
PB1	Printed Circuit Board
Misc.	1 – 40 Pin Low Insertion Force Socket 1 – 24 Pin Low Insertion Force Socket 2 – SPDT Switches 1 – DPDT Switch

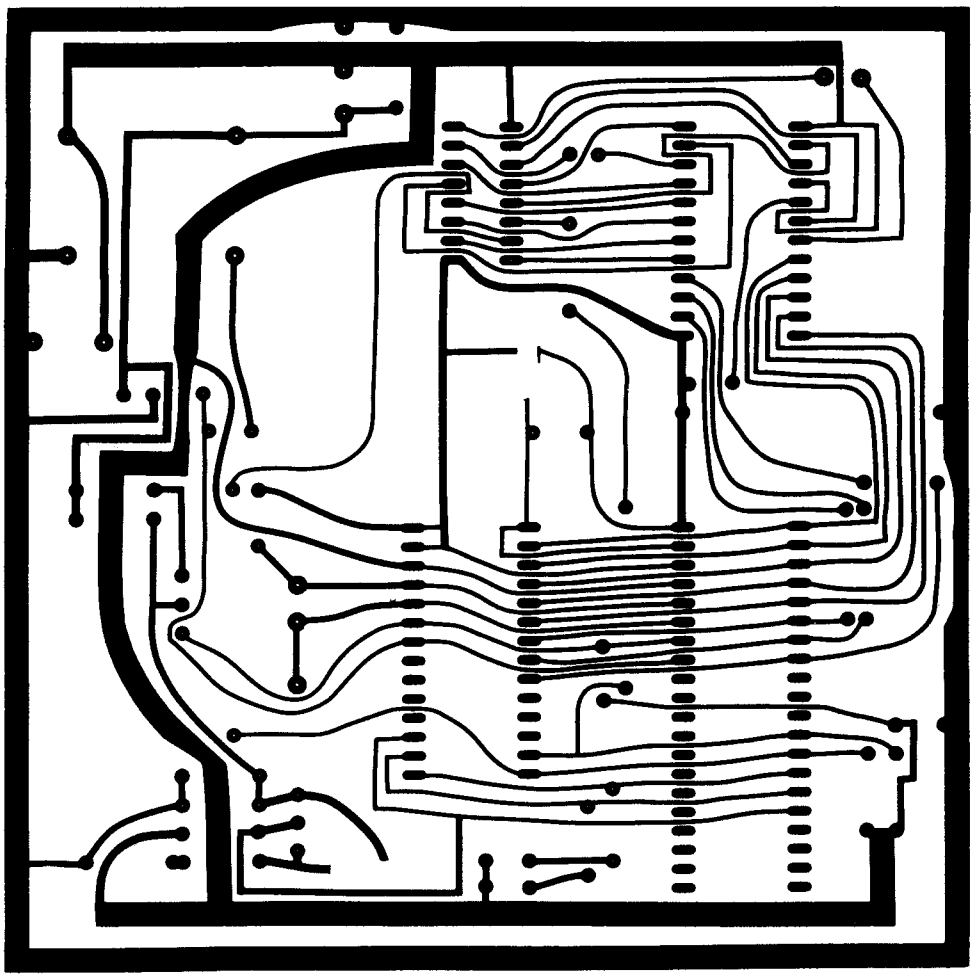


Figure 6-4a. MC68705P3/R3/U3 Programming Module Circuit Board Art

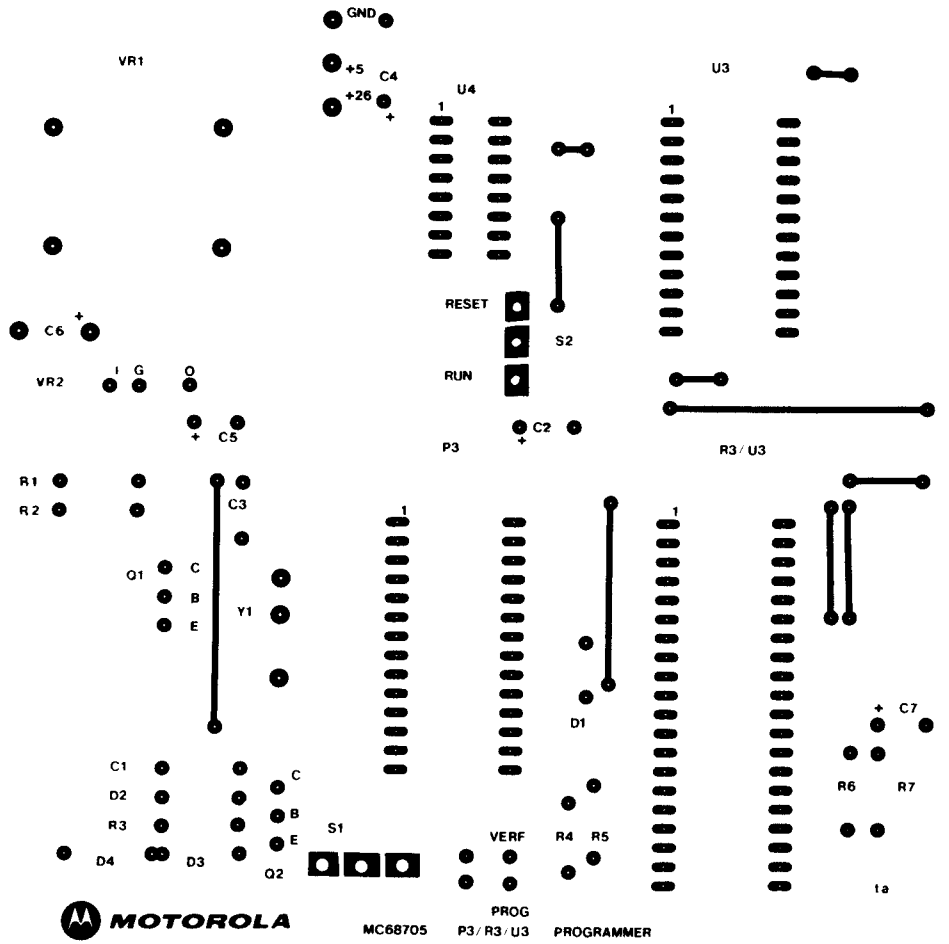


Figure 6-4b. MC6870P3/R3/U3 Programming Module Circuit Board Art (Continued)

The schematic diagram of Figure 6-2 provides connections for using an MCM68764 or an MCM68766 (8K X 8) EPROM. Since each of these EPROM devices are 24-pin devices, the 24-pin low insertion force socket connector for U1 can be used.

Since the actual EPROM memory used in the MC1468705G2 is 2106 bytes, the EPROM device(s) used in programming only needs 4K bytes of memory location. Figure 6-5 shows the MCM68764 or MCM68766 memory locations in which the MC1468705G2 program should be stored.

Prior to programming the MC1468705G2 EPROM, it should be erased by exposure to high-intensity ultraviolet (UV) light with a wavelength of 2537 angstroms. The recommended integrated dose (UV intensity × exposure time) is 40 Ws/cm2. The UV lamps should be used without shortwave filters and the MC14648705G2 should be positioned about one inch from the UV tubes. Be sure the EPROM window is shielded from light with an **OPAQUE** cover at all times except when erasing. This protects both the EPROM and light-sensitive nodes.

CAUTION

Be sure that S1 is open, and S2 is closed when inserting the MC1468705G2 and/or MCM68764 EPROM(s) into their respective sockets. This ensures that $\overline{\text{RESET}}$ is held low and power is not applied when inserting the device(s).

Note that the MCM68764 (or MCM68766) memory locations which correspond to RAM locations or unused EPROM or ROM locations in the MC1468705G2, may be programmed as either $00 or $FF (don't care).

To program the MC1468705G2 proceed as follows:

Step 1 — Open S3 to select the programming and verify mode. Close S1 (to apply the proper voltages for the V_{DD}, TIMER, and $\overline{\text{IRQ}}$ pins).

Step 2 — Open S2 to remove reset.

NOTE

Once the MCU comes out of reset, the V_{PP} control line (PD7) goes low and the V_{PP} voltage is applied to pin 3. With V_{PP}, applied, the EPROM is programmed one byte at a time with the corresponding data in the MCM68764 or MCM68766 EPROM. The MC1468705G2 bootstrap provides the address and enable TSC/$\overline{\text{E}}$ signals to permit complete self programming.

Step 3 — Check that the programming LED is turned on and remains on through the programming sequence. After completion of the programming sequence, this LED turns off.

NOTE

Transfer of the entire contents of MCM68764 or MCM68766 EPROM requires approximately 200 seconds. The internal timer is then cleared and the loop is repeated to verify that the programmed data is precisely the same as the incoming data from the EPROM; if so, the verified LED is turned on.

Step 4 — If the verified LED is not turned on, the exact program has not been loaded from the EPROM to the MC1468705G2, indicating a possible defect.

Step 5 — Close S2 (to reset the MC1468705G2) and open S1 prior to removing any device (MCU or EPROM) from its socket.

CAUTION

Once the MC1468705G2 is programmed and connected for normal operation, be sure that V_{PP} (pin 3) is connected directly to V_{SS}.

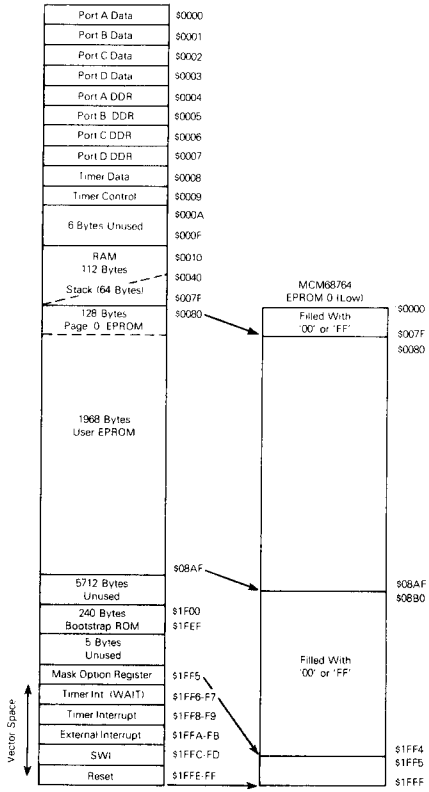


Figure 6-5. MC1468705G2 Program Memory Location In MCM68764