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PRINTED-CIRCUIT BOARDS
Which ones are best

ANTI-STATIC SPRAY
Keeps discs dust free

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What's up there to watch

PROM PROGRAMMER
You can build it

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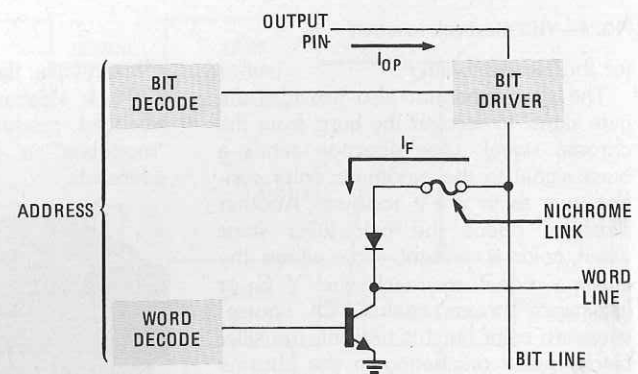
PROM PROGRAMMING

Programmable-read-only-memories can perform many logic functions and at the same time reduce circuit complexity. The key to using a PROM, however, is the ability to program it.

A read-only memory (ROM) is a random access memory in which data is mask-programmed during the manufacturing process. A programmable ROM, or PROM, is also a read-only memory; however, memory patterns are programmed into it by the user after manufacture. Read-only memories act as code converters that accept input codes and generate arbitrarily assigned output patterns. They are logically equivalent to truth tables in which the number of input variables equals the number of ROM address inputs and the number of output functions equals the number of ROM outputs. For example, an 8K PROM organized as 1024 x 8 bits implements the truth table for eight functions of ten variables.



I_{OP} PROGRAMMING PULSE CURRENT
I_F FUSING CURRENT

Fig. 1 Programming Current Path

Techniques for programming PROMs differ according to the technologies used to implement the devices. Certain types of MOS PROMS (EPROMs) can be erased and reprogrammed, but bipolar TTL PROMs can be programmed only once. In either case, the user can custom-program PROMs and, when necessary, make system changes without facing the substantial mask charges, manufacturing turn-around time, and need to maintain inventories of different patterns that are required by ROMs.

Bipolar TTL PROMs offer access times in the 25 ns to 50 ns range and ECL devices are available with access times in the 10 ns to 20 ns range, while MOS is slower than either type. Although MOS has historically been available in larger bit configurations than bipolar, advances in bipolar memory technology are narrowing the gap. Isoplanar Schottky PROMs, for example, offer densities between those of PMOS and silicon-gate NMOS. They are also cost- and performance-competitive not only with ROMs, but also with standard TTL on a per-function basis.

Isoplanar Schottky PROMs in various sizes and configurations are available from Fairchild, with high performance guaranteed across both commercial and military temperature ranges. These devices include the 93417/93427 256 x 4-bit, the 93436/93446 512 x 4-bit, the 93438/93448 512 x 8-bit, the 93452/93453 1024 x 4-bit, and the 93450/93451 1024 x 8-bit PROMs. They are completely TTL compatible, include fully decoded addressing, and are available with open-collector or 3-state outputs. A 256 x 4-bit Isoplanar ECL PROM with a typical access time of 11 ns is also available.

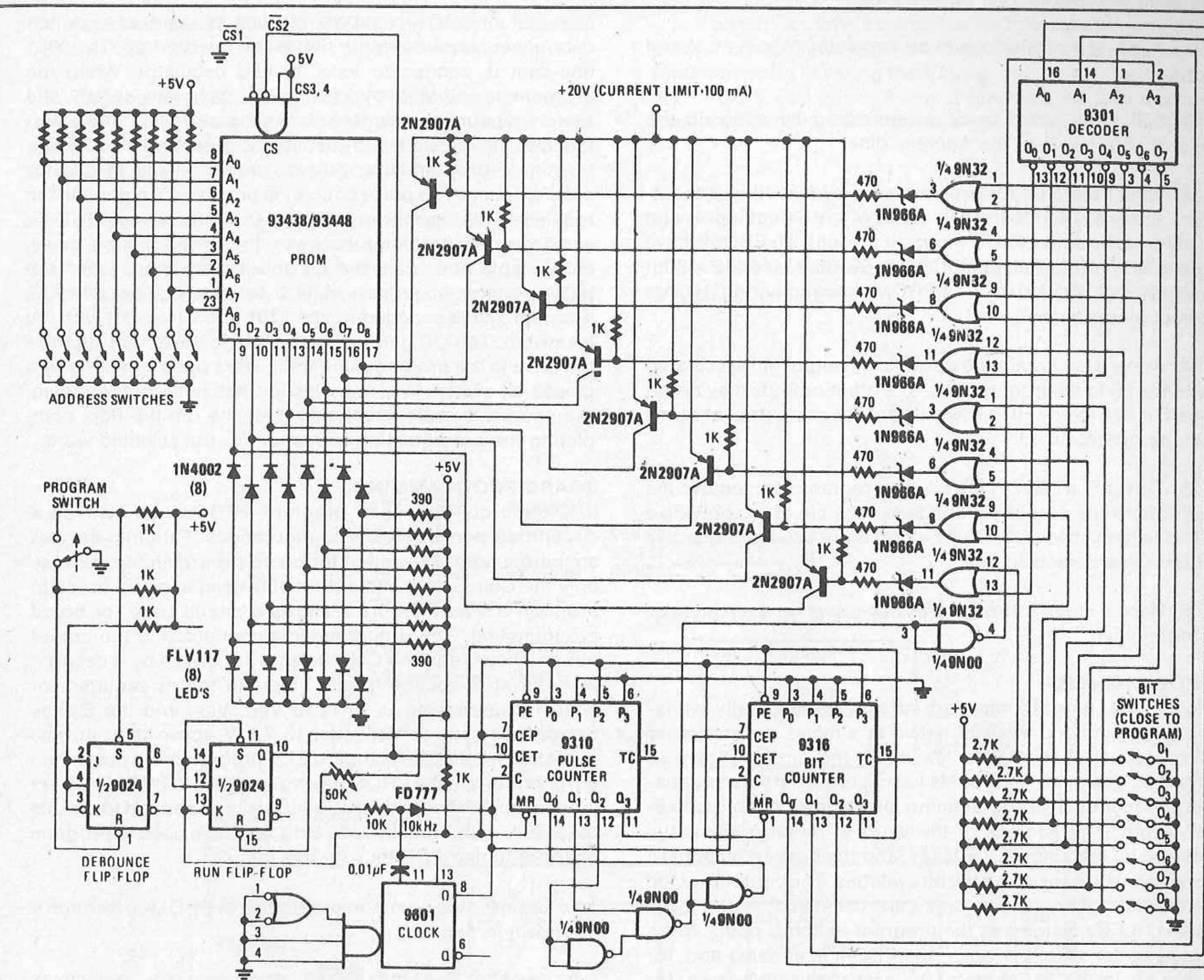


Fig. 2 PROM Programming Circuit

APPLICATIONS

Programmable ROMs are widely used today in microprogrammed computers ranging from the largest mainframe systems to microcomputers. They are also finding increased use as replacements for random logic in peripheral controllers, digital controllers, instruments, and terminals. Circuit applications include fixed data and instruction storage in computers, microprogrammed system control storage, look-up and decision tables, and address and priority mapping. Other applications include character/vector generation, encoding/decoding and sequential controllers. Many of these functions will, in time, be performed by field-programmable logic arrays (FPLAs); because of their large memory capabilities, however, PROMs will remain important elements in mass storage applications.

PROGRAMMING TECHNIQUE

The basic technique for programming a PROM having fusible links is to provide the amount of current necessary to permanently open the link associated with a selected bit, thereby programming the bit to a logic "0" or a logic "1", depending upon the circuit design.

Several materials are used to provide the programmable links within bipolar PROMs, including nichrome, tungsten, titanium, and doped polysilicon. The nichrome fuse link is the most popular because of extensive past experience with this material, high programming yield, and reliability. In Fairchild PROMs, the fuse is a thin-film nichrome link with a small, square notch that concentrates the fusing energy in a central neck during programming, ensuring a wide, clean gap.

Fairchild Isoplanar Schottky TTL PROMs are manufactured with all bits in the HIGH, or logic "1", state. When a programming current pulse (I_{OP}) is applied to an output pin, fusing current (I_F) is driven through the selected bit, as shown in *Figure 1*. Because of careful device design, almost all of the fusing energy is delivered to the nichrome link, opening the link and programming the bit to a LOW, or logic "0", state. Minimal losses to leakage paths and intermediate circuits permit the link to open rapidly with a low-energy pulse, which improves reliability. The nichrome links actually program on the rise time of the pulse; this permits the reduction of programming pulse width for high-speed, low-energy device programming. *Table 1* gives programming specifications for Fairchild PROMs.

PROGRAMMING PROCEDURE

The following steps, performed with reference to *Table 1*, can be used to program one bit at a time:

1. Apply the proper power by supplying V_{CC} = +5 V and ground.

2. Select the word to be programmed by applying the appropriate levels to the Address pins.

3. Select the chip for programming by disabling the outputs: apply a HIGH to the active LOW Chip Select inputs and a LOW to the active HIGH inputs, if present. All PROMs have active LOW Chip Select inputs; the 93438/93448 512 x 8-bit and 93450/93451 1024 x 8-bit PROMs have active HIGH Chip Select inputs as well.

4. Apply a programming pulse to the output pin associated with the bit to be programmed. The other outputs may be left open or tied to any HIGH. Note that only one output at a time can be programmed.

5. To verify a LOW in the bit just programmed, remove the pulse from the output pin and sense the pin after applying a LOW to the active LOW Chip Selects and a HIGH to the active HIGH Chip Selects, if any.

6. Repeat steps 2 through 5 as necessary for each bit to be programmed.

PROGRAMMERS

Most PROM programming is done with commercially available programmers. An alternative is simpler programmers with manual switches; for example, the circuit shown in *Figure 2*, designed for PROMs having eight outputs, is capable of sequentially programming all bits in words of up to 8-bit length. The address of the word to be programmed is entered by the address switches, and the desired bit pattern for that word is set up on the bit switches. The contents of the PROM at the selected address are displayed on the eight FLV117 LEDs as long as the program switch is open. When the program switch is open, the PROM is enabled and, for every bit in the HIGH state, the associated LED is on; for every bit in the LOW state, the associated LED is off. Closing the program switch disables the chip and all of the LEDs are simultaneously turned on by current supplied through the 390 Ω resistors. The 1N4002 diodes isolate the LEDs from the 21 V programming pulse.

One-half of a 9024 dual JK flip-flop is used as a switch debouncer, while the other half is the run flip-flop. The 9601 one-shot is connected as a 10 kHz oscillator. When the program is initiated by closing the program switch, the switch debouncer sets; this clocks the other half of the flip-flop into the run state and enables the pulse and bit counters to initiate programming pulses, preparing the PROM for programming. The pulse counter is preset to 5 to provide the requisite 20% duty factor, and the bit counter is preset to 8. To avoid overlap problems between the programming pulse, chip enable and scan, the bit counter advances when the pulse counter goes from state 3 to state 4. The bit to be programmed is decoded by the 9301 and wired-OR with the bit switch. The OR gate is a high-voltage driver that supplies the drive to the programming transistors upon selection by a closed bit switch. When the last bit has been programmed, the counter presets itself and resets the run flip-flop, completing the programming sequence for the selected word.

BOARD PROGRAMMING

It is often convenient to program PROMs mounted on a circuit board in wired-OR configurations. Fairchild devices are particularly convenient for board programming because only the Chip Select and output pins need to be accessed to program the part. *Figure 3* shows a circuit used for board programming. The programmer is connected to the output bus as shown and the Chip Selects are driven by a decoder with elevated voltage levels. Thus, all that is required for board programming is to raise V_{CC}, V_{EE}, and the Device Select inputs on the decoder to 7.6 V above their normal operating levels. The standard 21 V programming pulse then programs bits in the PROM having an active LOW Chip Select input of approximately 7.8 V, which is high enough to disable the PROM outputs. The following steps are used to program board-mounted PROMs with this circuit:

1. Connect the common output bus of PROMs 0 through n as shown in *Figure 3*.

2. On 93417, 93438, 93450, 93451, 93452, and 93453 PROMs, connect either $\overline{CS_1}$ or $\overline{CS_2}$ to 0 V. Connect the other active LOW Chip Select inputs to the active LOW outputs of the TTL decoder.

PARAMETER	SYMBOL	MIN	RECOMMENDED VALUE	MAX	UNITS	COMMENTS
Power Supply Voltage	V_{CC}	4.75	5.0	5.25	V	
Address Input	V_{IH}	2.4	5.0	5.0	V	Do not leave inputs open
	V_{IL}	0	0	0.4	V	
Chip Select	$\overline{CS_1}$, $\overline{CS_2}$	2.4	5.0	5.0	V	Either or both
	CS_3, CS_4	0	0	0.4	V	
Programming Pulse Voltage	V_{OP}	20	21	21	V	Applied to output to be programmed
Programming Pulse Current	I_{OP}			100	mA	If pulse generator is used, set current limit to this max value.
Programming Pulse Width	t_{pw}	0.05	0.18	50	ms	
Programming Pulse Duty Cycle			20	20	%	Maximum duty cycle to maintain $t_c < 85°C$
Programming Pulse Rise Time	t_r	0.5	1.0	3.0	μs	
Number of Required Pulses		1		4		
Case Temperature			25	85	°C	

Table 1. Programming Specifications

3. On 93436 and 93446 PROMs, connect the Chip Select inputs to the TTL decoder outputs.

4. On 93438, 93448, 93450 and 93451 PROMs, connect the CS_3 and CS_4 inputs to a HIGH or leave them unconnected.

5. To program a bit in one of the PROMs, simultaneously raise the TTL decoder supply voltages to V_{CC} = 12.6 V and V_{EE} = 7.6 V and select the desired PROM via the TTL decoder Address inputs (HIGH = 10.0 V, LOW = 7.6 V).

6. Close the bit switch associated with the bit to be programmed and raise the programming pulse voltage to 21 V. The selected PROM, the active LOW Chip Select input of which is at approximately 7.8 V, programs. The active LOW Chip Select inputs of all other PROMs are at approximately 10.6 V; these PROMs remain deselected, and do not program.

7. To verify a LOW in the bit just programmed, remove the programming pulse and sense the PROM output bus after simultaneously lowering the TTL decoder supply voltages to V_{CC} = 5.0 V and V_{EE} = 0 V and lowering the TTL decoder Address inputs to their normal levels (HIGH = 2.4 V, LOW = 0.4 V).

8. Repeat the procedure for other bits, following the normal programming sequence.

9. To select a different PROM on the board, change the TTL decoder address. R-E

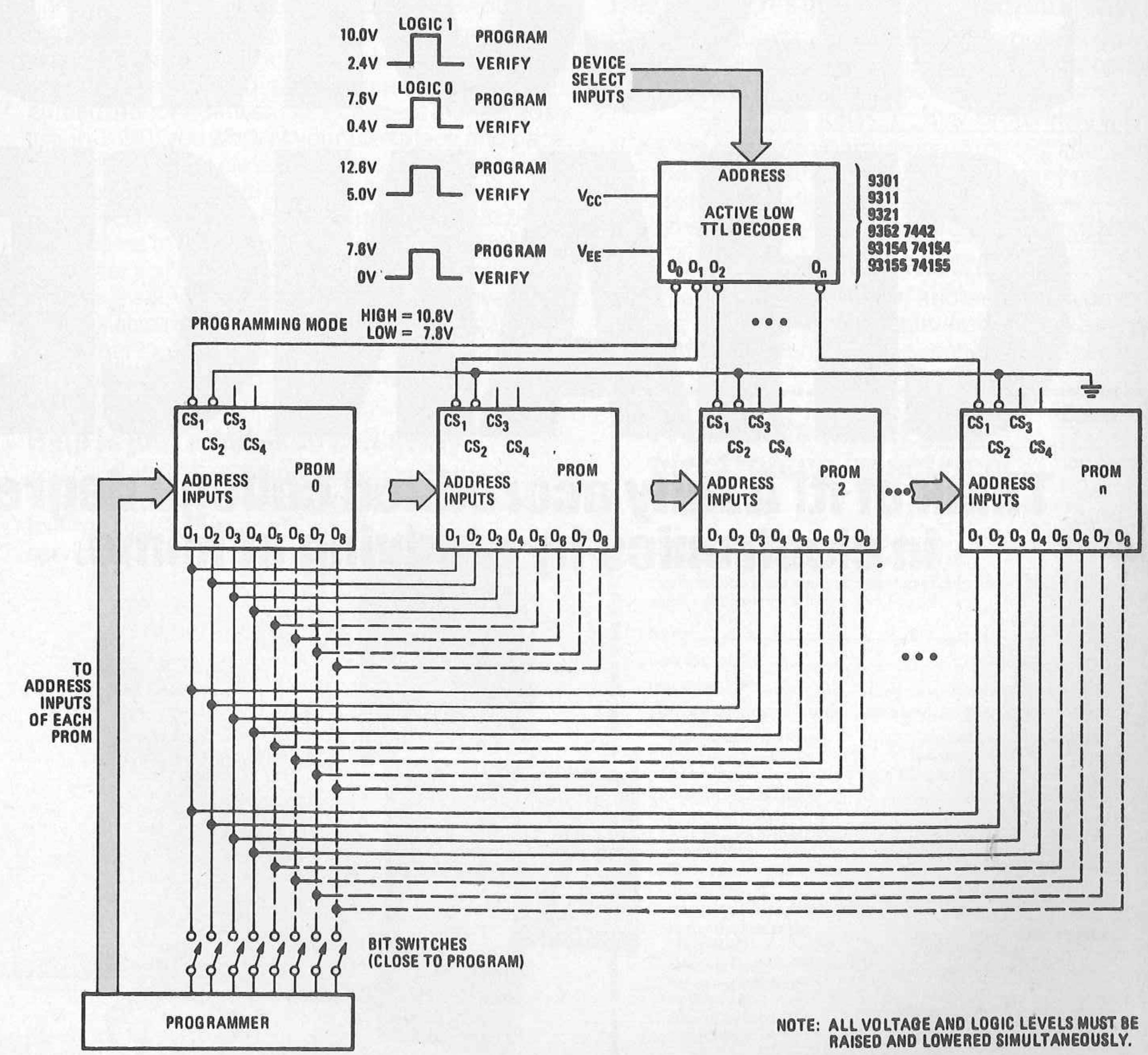


Fig. 3 Board Programming