Programming National UV EPROMs

National Semiconductor
Application Note 472
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INTRODUCTION

National Semiconductor is a broad-based supplier of low power CMOS EPROMs. CMOS EPROMs are programmed the same way NMOS EPROMs are programmed. CMOS and NMOS EPROMs are pin compatible in programming mode and in read mode. National EPROMs are superior to most competitive EPROMs on the market because the power drain is much lower with the CMOS process and also the access time is faster due to the clocked sense amp design. The parts are designed to interface with CMOS and TTL circuitry. Table I is a quick reference index for NSC CMOS EPROM programming algorithms.

TABLE I. CMOS EPROM Product Line

Density	Device Type	Programming Technique
16k	NMC27C16	25V Single Pulse—50 ms
16k	NMC27C16H	25V Single Pulse—10 ms
16k	NMC27C16B*	13V Interactive Programming 0.5 ms pulses
32k	NMC27C32	25V Single Pulse—50 ms
32k	NMC27C32H	25V Single Pulse—10 ms
32k	NMC27C32B*	13V Interactive Programming 0.5 ms pulses
64k	NMC27C64	13V Interactive Programming 0.5 ms pulses
128k	NMC27CP128	13V Interactive Programming 0.5 ms pulses
256k	NMC27C256	13V Interactive Programming 0.5 ms pulses
512k	NMC27C512*	13V Interactive Programming 0.5 ms pulses

*Future Product

EPROM PROGRAMMERS

The majority of the problems with EPROMs are programming related. The biggest cause of these problems is programmers not being equipped to program specific vendors' devices.

With National's older product lines, 27C16, 27C16H, 27C32, and 27C32H, customers have relatively few programming problems. This is because most 16k and 32k EPROMs on the market are programmed the same way, i.e., each byte in memory is programmed with a single 50 ms pulse, and the V_{PP} programming voltage is 25V. Thus a programmer manufacturer can use one programming routine for most vendor's parts. Furthermore these parts are quite mature and many programmer manufacturers have had time to develop the proper programming routines.

The EPROMs which have recently been introduced by National and other vendors do not have the same inter-company consistancy of the older parts. Different companies have different programming voltages and companies generally have their own unique interactive programming algorithms. Therefore, the EPROM manufacturers have to work directly with the programmer manufacturers to incorporate the proper hardware and programming routines for the specific EPROMs they are building.

The programmer manufacturers who are currently set up to program National EPROMs are listed in Table II. This list will expand significantly in the future as other programmer manufacturers develop the capability. The list does not include those which can program the older 16k and 32k devices because the majority of programmers in the field are capable of programming these parts.

National has evaluated the Data I/O, Stag, and EPRO programmers in-house and verified proper operation. Undoubtedly there are other programmers in the field which work as well.

A user who does not have a programmer which can program National parts can generally find a distributor in close proximity who has a Data I/O programmer. Distributors will usually provide programming service, particularly if the EPROMs were purchased from them.

NATIONAL INTERACTIVE PROGRAMMING ALGORITHM

All National EPROMs listed in Table I, with the exception of the 27C16, 27C16H, 27C32, and 27C32H are programmed with the National interactive programming algorithm, shown in *Figure 1.* A customer can also program with a single pulse of 10 ms. However, this is much slower and the National production testing is only done with the interactive algorithm. In either case the V_{PP} programming voltage must be 12.2V-13.3V. The programming efficiency is a strong function of V_{PP} programming voltage so 13.0V or more is recommended for fast programming.

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TABLE II. Programmer Manufacturers with National EPROM Programming Capability

Prgmr. Mnfr.	Model No.	Earliest Software Revision	Product
Data I/O	UniPak 2	V10	27C64, 27CP128, 27C256
	UniPak 2B	V10	27C64, 27CP128, 27C256
	120A/121A	V10	27C64, 27CP128, 27C256
	1000	V03	27C32B, 27C64, 27CP128, 27C256
	1000	V05	27C32B, 27C64, 27CP128, 27C256, 27C512
	201	V01	27C64, 27C256
	280	V01	27C64, 27C256
Epro	124	National	27C64, 27CP128, 27C256, 27C512
Stag	PP 39	10	27C64, 27C256, 27C512
	PP 40	3	27C64, 27C256, 27C512
	PP 41-42	1	27C64, 27C256, 27C512
	ZM2000	24	27C64, 27C256, 27C512

The interactive programming algorithm programs a byte with a 0.5 ms pulse, and then does a verify to determine if that byte was fully programmed. If it was not, the program pulse is repeated and again verified. This is done up to a maximum of 20 times, but most bytes will program with a single pulse. A marginally programmed memory cell will read as unprogrammed if the V_{CC} voltage is high. Thus the verify is done with V_{CC} at 6.0V which is a guardband of the 5.5V maximum operating voltage. This insures that the EPROM memory cells are fully charged. All parts are tested in the production screen and guaranteed to program with a maximum of 20 pulses.

It should be noted that the preliminary data sheets for the 27C64 and 27C256 parts show a programming algorithm with a maximum of 100 pulses and a single pulse program width of 50 ms. These values have been changed to 20 pulses and 10 ms respectively in the 1987 Data Book and the production screening reflects these changes.

MANUFACTURER'S IDENTIFICATION CODE

The 27C32B, 27C64, 27C512, and a later design revision of the 27C256 all have a manufacturer's identification code to aid in programming. The code, shown in Table III, is two bytes wide and it identifies the manufacturer and the device type. The first two digits, designate the manufacturer and the next two digits designate the device type. The first two digits, "8F", designate National Semiconductor as the manufacturer.

The code is accessed by applying 12V to address pin A9. Addresses A1–A8, A10 and above, $\overline{CE}$, and $\overline{OE}$ are held at V_{IL}. Address A0 is held at V_{IL} for the manufacturer code, and at V_{IH} for the device code. The code is read out on the 8 data pins. Proper code access is only guaranteed at 20 ± 5°C.

The primary purpose of the manufacturer's identification code is automatic programming control. When the device is inserted in an EPROM programmer socket, the programmer reads the code and then automatically calls up the specific programming algorithm for the part. This automatic programming control is only possible with programmers which have the capability of reading the code. The Data I/O and Stag programmers listed above can operate with or without the code control.

TABLE III. Manufacturer's Identification Code

Device Type	Code
27C32B	8F61
27C64	8FC2
27C256	8FC4
27C512	8F45

USING OTHER PROGRAMMERS

If a customer is using a programmer which National has verified to work properly, he should rarely have problems. If he is using another brand and is encountering difficulties he can try to determine the cause. Some of the common problems which have been experienced are discussed here.

V_{CC} and V_{PP} pins must have proper bypassing. High frequency capacitors, typically 0.1 μF, must be placed very close to each EPROM socket shunting V_{CC} and V_{PP} noise to ground. The noise is generated by the EPROM as well as by the system. In the quiescent mode the device draws power supply current in the micro-amp range. The current jumps to several milli-amps when an input transition occurs. This large current change will load down the power supply without proper bypassing. Noise can easily bring the power supply out of specification. The voltage levels should be checked with an oscilloscope so high frequency noise can be detected and also because the power supplies sometimes power down intermittently during programming.

Input voltage levels must also be within specification. (V_{IL} = 0.8V and V_{IH} = 2.0V). Inputs (including data pins) must not have noise transients which cause a polarity change or go beyond the power supply rails. A common problem on inputs is latch-up. If the input voltage level goes above V_{CC} or

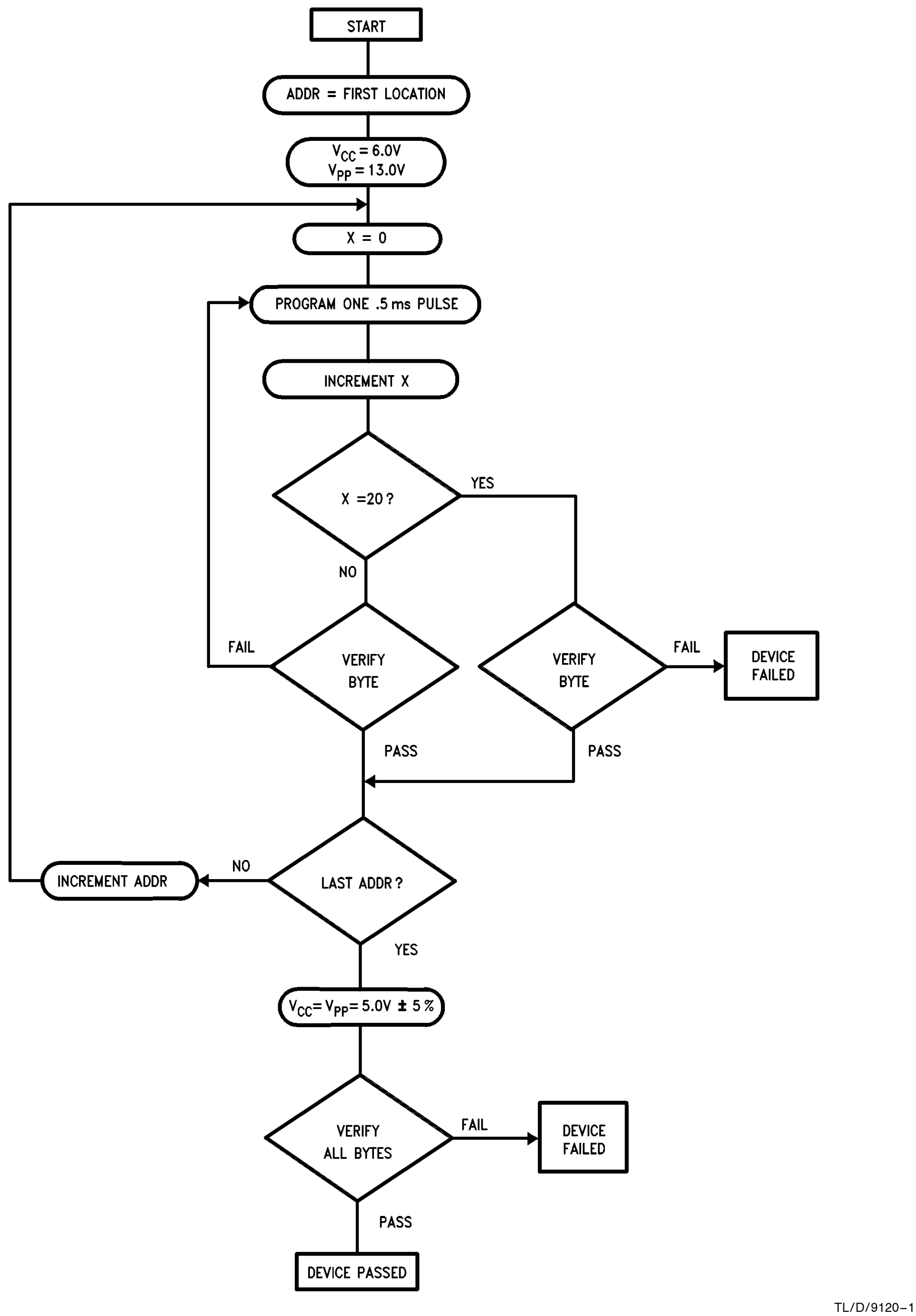


FIGURE 1. Interactive Programming Flow Chart

below ground an SCR latch-up can occur which will either cause the part to malfunction or to be permanently damaged. A small transient of a few ns can trigger latch-up, and the heavy latch-up current will destroy the part if the system does not have proper current limiting. If the problem occurs it will likely happen on the data pins (other inputs can withstand larger transients). Latch-up can be detected by adding high frequency diodes on the suspected pins which will forward bias when the pins go above V_{CC} or below ground. If the problem goes away with the diodes, latch-up is likely its cause.

The EPROM sense amps are clocked for fast access time. This means that V_{CC} must be maintained at operating voltage during verify. If V_{CC} temporarily drops below the specified voltage (but not to ground) an address transition must be performed after the drop to insure proper output data during verify. (If a V_{CC} drop occurs and an address transition is not added, the part can usually be made to verify properly by covering the quartz window.)

EPROM programmers have malfunctioned due to output signals cross-coupling back to input pins. A fast output level change will feed back to an input and cause it to change state, changing the output again, and thus causing oscillations. This problem can be corrected by isolating the outputs from the inputs, stabilizing the inputs, or slowing down the output transition.

Problems can occur if the socket has power applied during device insertion. However hot socket insertion is not as common with programmers now as it has been in the past.

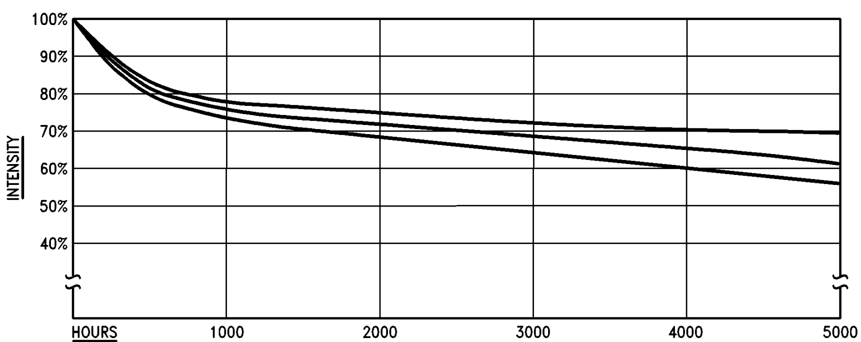
Electro-static discharge, (from the programmer or the operator), can damage parts. This normally happens on input pins and can easily be detected by checking input leakage current, which will be increased if the part has been damaged with a static charge. The production screen accurately tests and guarantees all parts to have less than 10 μa leakage on any input or output pin, and any part with more leakage current has probably seen a static charge.

Some erasure problems can look like a programming problem. If a part is partially erased it will usually be detected during the programmer's initial blank check, but sometimes it will not be detected until the verify after program, or until the part is being read in a system. A partially erased memory cell has some residual charge on the floating gate as opposed to being totally discharged. A low V_{CC} voltage is more sensitive to this residual charge than a high V_{CC} voltage. The initial blank check is typically done at 5.0V V_{CC}, the verify after program is 4.75V, and the part operates in the system down to 4.5V.

National performs a calibrated erase during production screening and guarantees parts will erase with a minimum ultraviolet light dosage of 15W-sec/cm^2 (2537 Angstrom wavelength). This means about 21 minutes in an eraser with a lamp intensity of 12,000 μw/cm^2. Most erasure problems are caused by degradation of light bulbs in the erasure system. Light bulbs lose their intensity with age, as shown in *Figure 2.* After the first 1000 hours of operation the bulbs typically degrade down to about 75% of their original intensity. If the customer does not compensate for this change with increased erasure time he will not give the parts a calibrated erase.

It does not harm an EPROM to over erase for a few hours. Thus, if uncertain about the lamp intensity the safe thing to do is erase two or three times the minimum erase time.

If further help is needed with programming, contact the factory.



TL/D/9120–2

FIGURE 2. Aging Characteristics of Erasure Bulbs

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