Using Existing Programmers to Program Low Voltage EPROMs

National Semiconductor
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INTRODUCTION

The range of EPROMs manufactured by National Semiconductor is one of the largest in the industry. National's new family of Low Voltage EPROMs, targeted for power supply voltages in the range of 3V–3.6V, constitute a recent addition to the growing family of EPROMs. These Low Voltage EPROMs are being introduced in densities of 512 kbit in byte-wide and 1 Mbit in byte and word-wide organizations. EPROM programmers currently available are designed to program the standard EPROMs which operate at 5V. With the introduction of Low Voltage EPROMs, most of the major manufacturers of EPROM programmers have begun the process of upgrading their hardware and software to accommodate the Low Voltage EPROMs. This issue of programmer updates is common to all manufacturers of Low Voltage EPROMs across the industry.

National's Low Voltage EPROMs use exactly the same programming algorithm as the standard 5V parts and are fully capable of programming on existing programmers, which program the standard 5V EPROMs, with no adverse effects whatsoever on their reliability and endurance. This note seeks to alleviate any concern the EPROM user may have on programming the Low Voltage EPROMs on programmers which program 5V parts and shows that these programmers are guaranteed to correctly program National's Low Voltage EPROMs. Beginning with a brief and simplified overview of the internal structure of EPROM, the note describes the process of programming and programming verify and shows that National's Low Voltage EPROMs program correctly on existing programmers.

EPROM OVERVIEW

The basic storage element in the EPROM is a MOS transistor which has an additional "floating" gate built in between the control gate and the channel. This element is usually referred to as the cell *(Figure 1)*.

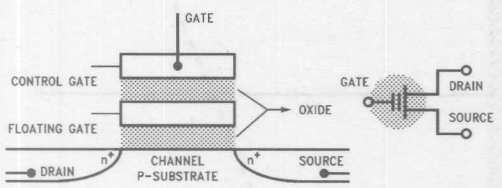

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FIGURE 1. EPROM Cell and Its Schematic

An important parameter of the cell is its threshold voltage—the control gate voltage at which the cell begins to conduct. The threshold voltage of an erased cell is well below the V_{CC} value. When the control gate is driven to V_{CC}, the erased cell conducts and this is a logic "1". Programming elevates the threshold of the cell by 5V–10V. This results in the programmed cell not conducting under normal operating voltages, and is permanently off. This is a logic "0". A fully erased EPROM reads all "1"s. Programming consists of applying elevated voltages to the gate and the drain of the cell. This causes electrons to penetrate the intervening oxide and deposit themselves on the floating gate *(Figure 2)*, thereby altering the threshold voltage of the cell. This process is called "hot electron injection." The shift in the threshold, as already indicated, is typically 5V–10V.

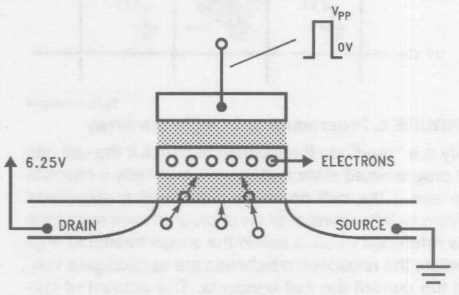

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FIGURE 2. Programming an EPROM Cell

Erasure consists of shining ultra violet light on the die through the quartz window provided. This light provides the electrons trapped on the gate with sufficient energy to return to the channel and on to the control gate, and thereby returns the cell to the unprogrammed state. This is illustrated in *Figure 3*.

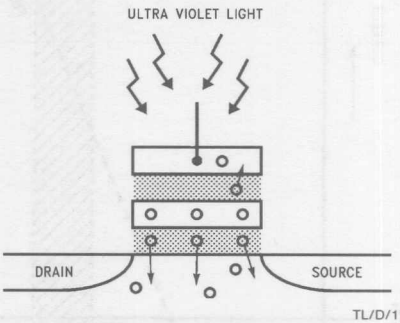

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FIGURE 3. UV Light Erasure of Cell

The number of electrons that get liberated depends on the intensity of the light and the duration of exposure. As already noted, then new Low Voltage EPROMs from National use exactly the same programming algorithm as the standard 5V parts.

PROGRAMMING

The programming algorithm specified by most manufacturers consists of programming data into the EPROM at the specified elevated voltage into all the locations that need to be programmed followed by a verify under normal read conditions. Programming the desired cell requires that an elevated voltage be applied to the bit line. The internal logic applies a high voltage pulse of 13V to the control gate in response to the external PGM pulse. This is illustrated in *Figure 4*.

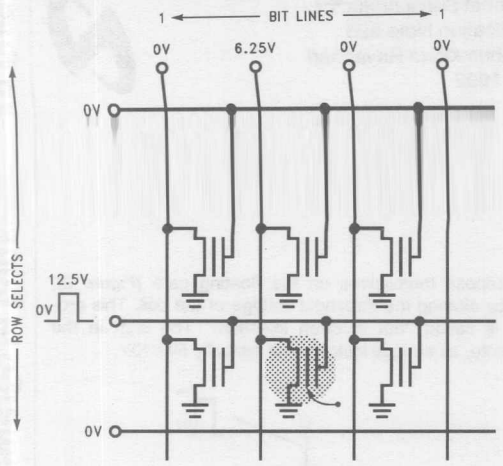

FIGURE 4. Programming a Cell in the Array

The verify is a "read" on the location to check if the cell has the right programmed state and margin. Internally a check is made to see if the cell conducts current of a magnitude greater than half the current of an unprogrammed reference cell. This reference value is called the sense threshold. *Figure 5* depicts the relationship between the applied gate voltage and the current the cell conducts. The amount of current a cell conducts depends on the threshold voltage of the cell and the magnitude of the voltages applied on the control gate and the drain.

PROGRAMMING VERIFY

An accurate verify must read the EPROMs at both V_{CC}(min) and V_{CC}(max). For the Low Voltage EPROMs the values are 3.0V and 3.6V respectively. Most of the current programmers perform verify at the voltage levels specified for a standard 5V part. As a result of incomplete erasure, the lowered cell threshold voltage which might be adequate for 5V levels may not be so for low voltage operation. What this actually means is that the higher level of voltages (5V as against 3.0V–3.6V) may cause the cell to conduct current in excess of the sense threshold. When the voltages are lowered to the correct values, the cell current might not exceed the sense threshold. This is illustrated in *Figure 5.* When the partially erased cell is verified at 5V levels, the current magnitude exceeds the internal sense threshold. However, it would not qualify when verified at voltage levels 3.0V–3.6V. Thus, a part which verifies correctly at 5V might not when operated at 3V. The inability to verify at V_{CC} levels 3.0V–3.6V is a limitation of current programmers and most programmer vendors are in the process of coming up with updates on their products which program and verify the low voltage parts correctly.

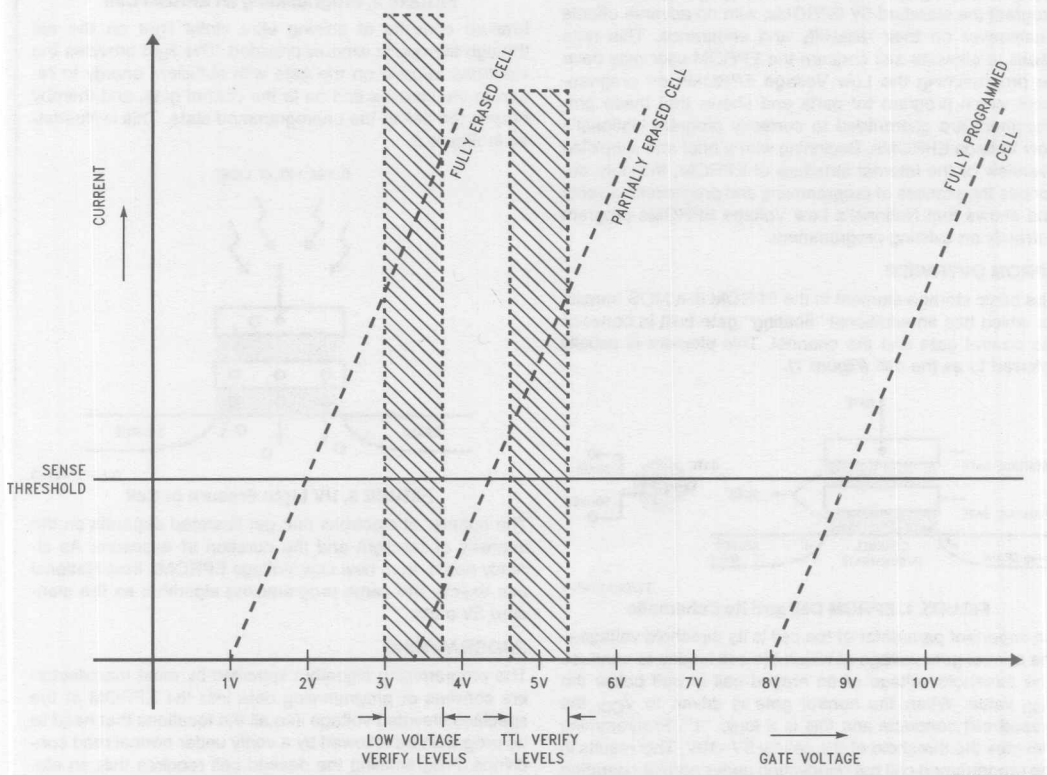

FIGURE 5. EPROM Cell Characteristics

PROGRAMMING LOW VOLTAGE EPROMs

National's Low Voltage EPROMs are also capable of functioning at the standard supply voltage (V_{CC}) of 5V. Furthermore, National's proprietary manufacturing process using the split-gate SVG technology guarantees that the threshold of factory shipped parts are well below the 3V level and hence may be directly programmed on existing programmers (which verify at 5V levels). The parts thus programmed are guaranteed to work at the 3V levels. National guarantees that the Low Voltage parts erased with an integrated UV light dosage of 15 W-sec/cm^2 will program (with verify at 5V levels) and work reliably at 3V levels. This dosage of UV light is obtained by exposing the part to a typical UV lamp (15 mW/cm^2) for 20 minutes. The part should be placed within 1 inch of the source, removing any filters that may be present. **This issue is of no concern to users of One Time Programmable (Windowless) EPROMs as National ensures complete erasure of parts prior to shipment thus guaranteeing requisite threshold levels.** National is working with manufacturers across the world to install the correct algorithm for low voltage parts. Table I lists the 5V programmers available from the major programmer manufacturers. These programmers use the correct algorithm for the 5V parts and may be used to program the low voltage EPROMs. These are the only programmers approved by NSC for programming NSC's memories.

TABLE I. EPROM Programmer Reference

Manufacturer	Programmer Model	NM27C512, NM27LV512	NM27C010, NM27LV010	NM27C210, NM27LV210
Data I/O (800) 255-2102	UniPak2 UniPak 2B 212 Mod EPROM S1000 Unisite 40 120/121A GangPak 2900 3900 280 201 288 60A Series 22	V13 V13 V1.1 V11 V2.2 V14.1 V1.7 V1.0 V02	 V15 V1.1 V11 V1.0 V1.0	 V20 V1.6 V1.0
Dataman 0-300-68066	S3			
Digilec (818) 887-3175	828			
Digital Media (714) 751-1373	IQ180/280			
Elan Digital Systems, Ltd. (0293)510448	3000 4000 5000 Universal	5.0	5.0	
Epro Corporation (800) 262-3776	124 2000	815-513-001 815-513-001	815-513-001 815-513-001	
G-Tek (601) 467-8048	7956			
IMS (408) 245-7180	IM3016			
Kontrol Electronics '08165770	EPP80/MPP-80S			
Logic Devices Inc. (800) 331-7766	GANGPR-8 PROMPRO-8X	8.07D 3.3		
MCT (612) 462-6486	AUTOPRO			
Microprossx 20 479 040	5100			
Minato '045 591-5611	1910	V2.02		

TABLE I. EPROM Programmer Reference (Continued)

Manufacturer	Programmer Model	NM27C512, NM27LV512	NM27C010, NM27LV010	NM27C210, NM27LV210
OAE (800) 828-0080	OMN164			
Southern Computer (404) 252-3340	512B			
Stack Ltd. 44-869-240404	C289			
Advantest	R4945 RA951 UP-UPROG	A02 D00	A02 D00	
HI-LO System	All-03	V3.0	V3.0	
BP Microsystems	ER-1140	V1.76	V1.76	
Stag Microsystems (408) 988-1118	39M101 40M100 40M101 40N101 41M100 41M101 42M100 42M101 ZM2000 ZM2500 ZM2800 ZM3000 PP40	4.0 7.0 3.0 5.0 04-01	4.0 3.0 5.0 04-01	

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