



# Non-Volatile Memory Programming Information

## Introduction

PROMs or Programmable Read Only Memories have existed since the early 1970s and continue to provide the highest-speed non-volatile form of semiconductor memory available. Until the introduction of CMOS PROMs from Cypress, all PROMs were produced in bipolar technology, because bipolar technology provided the highest possible performance at an acceptable cost level. All bipolar PROMs use a fuse for the programming element. The fuses are intact when the product is delivered to the user, and may be programmed or written once with a pattern and used or read infinitely. The fuses are literally blown using a high current supplied by a programming system. Since the fuses may only be blown or programmed once, they may not be programmed during test. In addition, since they may not be programmed until the user determines the pattern, they may not be completely tested prior to shipment from the supplier. The result of this inability to completely test is less than 100% yield during programming by the customer for two reasons. First, some percentage of the product fails to program. These devices fall out during the programming operation. Additional yield is lost because the device fails to perform even though it programs correctly. This failure is normally due to the device being too slow. This is a more subtle failure, and can only be found by 100% post program AC testing, or by trouble shooting an assembled board or system.

Cypress non-volatile memories use an EPROM programming mechanism. This technology has been in use in MOS technologies since the late 1970s. However, as with most MOS technologies the emphasis has been on density, not performance. CMOS at Cypress is faster than bipolar and, coupled with EPROM, becomes a viable alternative to bipolar PROMs from a performance point of view. In the arena of programming, EPROM has some significant advantages over fuse technology. EPROM cells are programmed by injecting charge on an isolated gate, which permanently turns off the transistor. This mechanism can be reversed by irradiating the device with ultraviolet light. The fact that programming can be erased totally changes the testing and programming situation and philosophy. All cells can be programmed during the manufacturing process and then erased prior to packaging and subsequent shipment. When these cells are programmed, the performance of each cell in the memory can be tested, ensuring that we ship devices that program every time and will perform as specified when programmed. In addition, when these devices are supplied in a windowed package they can be programmed and erased indefinitely providing the designer a reprogrammable PROM for development.

## Programmable Technology

### EPROM Process Technology

EPROM technology employs a floating or isolated gate between the normal control gate and the source/drain region of a transistor. This gate may be charged with electrons during the programming operation and when charged with electrons, the transistor is permanently turned off. When uncharged (the transistor is unprogrammed) the device may be turned on and

off normally with the control gate. The state of the floating gate, charged or uncharged, is permanent because the gate is isolated in an extremely pure oxide. The charge may be removed if the device is irradiated with ultraviolet energy in the form of light. This ultraviolet light allows the electrons on the gate to recombine and discharge the gate. This process is repeatable and therefore can be used during the processing of the device repeatedly if necessary to assure programming function and performance.

## Programming Algorithm

### Byte Addressing and Programming

All Cypress CMOS PROMs are addressed and programmed on a byte basis, unlike the bipolar products that they replace. The address lines used to access the memory in a read mode are the same for programming, and the address map is identical. The information to be programmed into each byte is presented on the data-out pins during the programming operation, and the data is read from these same pins for verification that the byte has been programmed.

### Blank Check for Differential Cells

Since a differential cell contains neither a 1 nor a 0 before it is programmed, the conventional blank check is not valid. For this reason, Cypress CMOS PROMs that use differential cells contain a special blank check mode of operation. Blank check is performed by separately examining the 0 and 1 sides of the differential memory cell to determine whether either side has been independently programmed. This is accomplished in two passes: one comparing the 0 side of the differential cell against a reference voltage applied to the opposite side of the sense amplifier, and then repeating this operation for the 1 side of the cell. The modes are called blank check ones and blank check zeros. These modes are entered by applying a supervoltage to the device.

### Blank Check for Single-Ended Cells

Single-ended cells blank check in a conventional manner. An erased device contains all 0s or all 1s depending on the device and a programmed cell will contain a 1 or a 0 again depending on the device. Cypress PROMs that use the single-ended approach provide a specific mode to perform the blank check, which also provides the verify function. This makes the need to switch high voltages unnecessary during the program verify operation. See specific datasheets for details. All CY7CXX (except CY7C271A), CY27C128 and CY27C256 blank check with all 0s. All CY27HXX, CY27CXX (except CY27C128 and CY27C256), and CY7C271A blank check with all 1s.

### Programming the Data Array

Programming is accomplished by applying a supervoltage to one pin of the device causing it to enter the programming mode of operation. This also provides the programming voltage for the cells to be programmed. In this mode of operation, the address lines of the device are used to address each location to be programmed, and the data is presented on the pins normally used for reading the contents of the device. Each



device has a read and write pin in the programming mode. These are active-LOW signals and cause the data on the output pins to be written into the addressed memory location in the case of the write signal or read out of the device in the case of the read signal. When both the read and write signals are HIGH, the outputs are disabled and in a high-impedance state. Programming therefore is accomplished by placing data on the output pins, and writing it into the addressed location with the write signal. Verification of data is accomplished by reading the information on the output pins while the read signal is active.

The timing for actual programming is supplied in the unique programming specifications for each device.

### Special Features

Depending on the specific CMOS PROM in question, additional features that require programming may be available to the designer. Two of these features are a Programmable Initial Byte and Programmable Synchronous/Asynchronous Enable available in some of the registered devices. Like programming the array, these features make use of EPROM cells and are programmed in a similar manner using supervoltages. The specific timing and programming requirements are specified in the data sheet of the device employing the feature. Several Cypress non-volatile memories feature an automatic device identification mode. This mode is accessed by placing the supervoltage on the A9 address pin. While A9 is HIGH, taking A0 LOW will cause the Cypress manufacturer ID (34H) to appear on the outputs. Taking A0 HIGH will cause the device identifier to appear on the outputs. See the specific datasheet for details.

### Programming Support

Programming support for Cypress CMOS PROMs is available on Cypress's QuickPro II and Impulse 3. Support is also available from a number of programmer manufacturers, some of which are listed below. In addition, Cypress offers factory programming for all of these devices. Parts are programmed and 100% speed tested to your code to ensure performance. Custom marking is available also on programmed plastic (OTP) devices. Minimum quantities apply. Contact a Cypress sales representative for more information.

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