3.0 Volt-only Flash Memory Technology

Technology Background

July 2003

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AMD and Fujitsu continue to support existing part numbers beginning with "Am" and "MBM". To order these products, please use only the Ordering Part Numbers listed in this document.

For More Information

Please contact your local AMD or Fujitsu sales office for additional information about Spansion memory solutions.

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Introduction

AMD's Am29LVxxx 3.0 volt-only Flash memory technology shares all the architectural features of AMD's industry-standard, 5.0 volt-only Am29Fxxx Flash memory technology. The 5.0 volt-only family offers single power-supply operation, sector architecture, Embedded Algorithms, and high performance. It has become the architecture of choice for system designers using single-power-supply Flash memory. AMD's Am29LVxxx 3.0 volt-only family is destined to become the Flash architecture of choice for designers of battery-powered applications, and offers the following:

- ❏ **3.0 volt-only, single-power-supply operation**
- ❏ **2.7 V to 3.6 V extended operating range**
- ❏ **Low power consumption**
- ❏ **High performance**
- ❏ **Industry standard architecture**

In addition, AMD's 0.35 µm and new 0.32 µm process technologies offer a minimum program/erase cycle endurance of one million cycles.

Single-Power-Supply Operation

The 3.0 volt-only design is based on the same process technology and many of the circuit design techniques as AMD's 5.0 volt-only Flash memory devices. The devices are fabricated using double metal layers, dual-layer polysilicon, and a triple-well CMOS process. AMD's process provides low-power, high-performance CMOS devices using the established NOR cell Flash architecture. AMD initially manufactured the 3.0 volt-only family on a 0.5 µm process, but introduced its 16 Mbit devices on a 0.35 µm process. Many of the 3.0 volt-only devices will migrate to a new 0.32 µm process technology by the end of 1998.

3.0 Volt-Only Design Techniques

AMD's 3.0 volt-only devices achieve single-power-supply operation by using a memory array constructed with core cells identical to those for AMD's 5.0 volt-only devices. The difference is that the 3.0 volt-only peripheral circuitry surrounding the memory core is specifically designed to interface with 2.7–3.6 volt levels only. The Am29LVxxx family circuitry contains charge pumps that enable a 2.7–3.6 volt external voltage to provide 5.0 volt-only performance for read, program, and erase operations.

The charge pumps in the 3.0 volt-only design raise the external power supply voltage to levels required for internal 5.0 volt operation. This approach is silicon efficient, as the 3.0 volt-only

charge pump design results in a negligible die size increase over the corresponding density, using the same design rules, in the 5.0 volt-only family.

The erase operation is accomplished through AMD's patented Negative Gate Erase technology (NGE), which incorporates Fowler-Nordheim tunneling (see Figure 1); the programming operation is accomplished with hot electron injection techniques (see Figure 2).

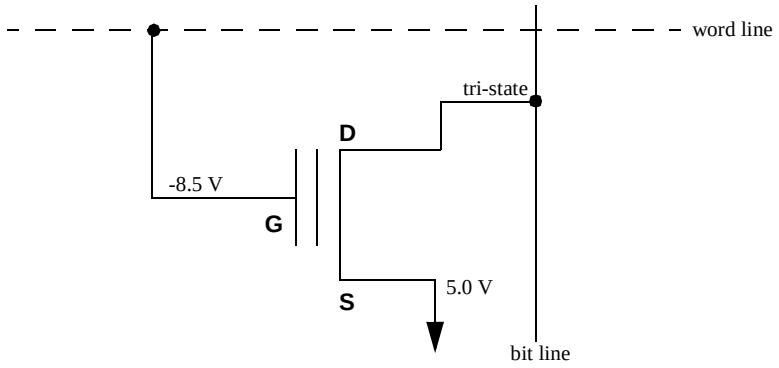

Figure 1. 3.0 Volt-only Negative Gate Erase Voltage Setup

Notes:

1. Gate terminal is pumped to -8.5 volts at less than 10 µA current.
2. 10 mA - 20 mA (peak) erase current is provided to the source terminal by the system's V_{CC} supply.
3. D = drain, G = Gate, S = Source

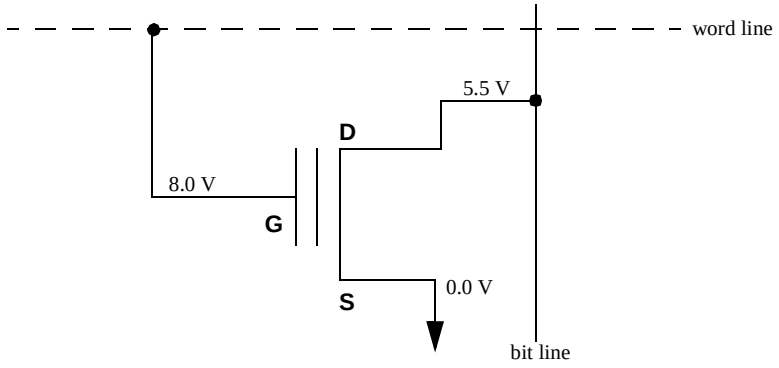

Figure 2. 3.0 Volt-only Programming Voltage Setup

Notes:

1. Gate terminal is pumped to 8.0 volts at less than 10 µA current.
2. Drain terminal is pumped to 5.5 volts from the 3.0 V supply at 0.5 mA.
3. D = drain, G = Gate, S = Source

AMD's 3.0 volt-only Flash devices read, program, and erase at a V_{CC} as low as 2.7 volts, using a single-power-supply pin, whereas so-called "3 volt" mixed-voltage, Flash devices read at 3.0 volts, but require either 5.0 V or 12.0 V to program and erase. Generating an additional voltage involves using another power supply or a DC/DC converter. With AMD's single-power-supply Flash devices, battery-powered applications require only a single power supply to accomplish in-system reprogrammability. Eliminating the need for the additional power supply or converter conserves power and provides system-level cost savings.

Optimized for Battery-Powered Applications

AMD's 3.0 volt-only design is optimized for battery-powered systems. To provide performance equivalent to 5.0 volt devices and lower power consumption, the 3.0 volt-only devices are designed to interface with 2.7–3.6 volt levels only. Although some systems designers may desire 3.0 volt-only devices that can interface with 5.0 volt levels, providing this capability requires additional circuitry, which adds cost and extracts a performance penalty.

Some systems have both 5.0 volt and 3.0 volt components that share the same data bus. System designers can still use AMD's 3.0 volt-only devices this type of design, but voltage translators must be used to buffer the devices from electrical over-stresses associated with 3.0 volt devices sharing the same data bus with 5.0 volt devices.

2.7-3.6 Volt Extended Operating Range

The operating range normally associated with "3 volt" Flash devices is 3.3 ± 0.3 V. AMD's 3.0 volt-only family of Flash devices have an operating range of 2.7 V to 3.6 V, which is ideal for battery-powered systems. This extended range allows portable systems to operate longer between battery replacement or recharging cycles.

AMD's devices also operate over an extended temperature range, which is important in many battery-powered portable applications.

Low Power Consumption

AMD's 3.0 volt-only devices operate with very low power consumption, while still providing performance equal to AMD's 5.0 volt-only Flash devices. AMD's 3.0 volt-only devices provide power savings in both the active as well as the inactive states.

In AMD's 3.0 volt-only device active modes (read, program, and erase operations), the reduction in power consumption versus a 5.0 volt device totals approximately 60 percent. The

reduced V_{CC} accounts for 40 percent, and design techniques that result in lower current consumption provide the remaining 20 percent. In addition, AMD's 3.0 volt-only family provides two inactive modes—a standby mode, and a new Automatic Sleep Mode—that provide further power savings. Table 1 lists the power consumption figures for these modes.

Table 1. 3.0 Volt-Only vs. 5.0 Volt-only Device Power Consumption

Mode	Typical Power Consumption(1)		Maximum Power Consumption(1)	
	3.0 Volt-only Device	5.0 Volt-only Device	3.0 Volt-only Device	5.0 Volt-only Device
Read	30 mW	100 mW	108/126 mW(2)	165/193 mW(2)
Program	60 mW	140 mW	126 mW	193 mW
Erase	60 mW	150 mW	126 mW	193 mW
Standby	3 µW	<15 mW	18 µW	28 µW
Automatic Sleep Mode	3 µW	n/a	18 µW	n/a

(1) Typical power values are the product of the typical current multiplied by 3.0 volts (for the 3.0 volt-only device) or 5.0 volts (for the 5.0 volt-only device). Maximum power values are the product of the maximum current multiplied by 3.6 volts (for the 3.0 volt-only device) or 5.5 volts (for the 5.0 volt-only device).

(2) Byte/Word Mode.

A design technique called Address Transition Detection (ATD), described under *High Performance*, provides power savings during read operations. A proprietary, intelligent programming algorithm provides power savings during program operations. This algorithm analyzes the programming task and then provides the optimal programming pulse (and thus the minimum power) required to complete the byte or word programming operation without sacrificing programming performance.

The 3.0 volt-only family optimizes power savings in the inactive state through the standby and Automatic Sleep Modes. The standby mode is user controlled (by holding the CE# pin high) and typically consumes only 3 µW of power when the device is deselected. During the Automatic Sleep Mode, the device typically consumes only 3 µW after the addresses have been stable for a minimum of t_{ACC} +30 ns, regardless of the logical state of the CE#, OE# and WE# pins. The device resumes active operation from either the standby or the Automatic Sleep Modes using the standard AC timing for t_{ACC}. There is no latency penalty associated with either the standby mode or the Automatic Sleep Mode; only the standard t_{ACC} or t_{OE} applies.

High Performance

AMD's 3.0 volt-only devices offer a choice of fast access times at an extended V_{CC} voltage range of 2.7 to 3.6 volts or faster access times at a regulated voltage range of 3.0 to 3.6 volts. For example, AMD's newly introduced Am29LV001B has a 45 ns speed option at the regulated voltage range and a 55 ns speed option at the extended voltage range. The speed and low voltage operation of the 3.0 volt-only family makes them ideal solutions for high-performance, battery-powered applications.

The following sequence of events within the device illustrates how AMD achieves high performance during a read operation:

1. A voltage transition that appears on the address pins initiates Address Transition Detection (ATD) circuitry to retrieve the next byte or word of data.
2. ATD initiates charge pump circuitry to boost the voltage on the word lines from 0.0 or 3.0 volts to 5.0 volts as the device decodes the address and loads the new data from the array into the data latches.
3. The word lines remain boosted at 5.0 volts internally only until the requested data is latched.
4. After the data is latched, ATD reduces the voltage on the word lines to 3.0 volts, and the data remains available from the data latches until the next read request from a different address.
5. If the address lines remain stable for t_{ACC} + 30 ns, the device enters the Automatic Sleep Mode, reducing the voltage on the word lines to 0.0 volts.

Boosting the word lines only as needed provides read access times equivalent to AMD's 5.0 volt-only Flash memories of similar density and organization. The Automatic Sleep Mode provides additional power savings without sacrificing performance.

In program and erase modes, the 3.0 volt-only design uses an efficient power supply charge pump design, which pumps gate voltage with low current, to reduce program and erase times. The 3.0 volt-only devices offer this performance without compromise at V_{CC} voltage levels as low as 2.7 volts.

Industry Standard Architecture

AMD's 3.0 volt-only family of products are based on the same process technology and industry standard architecture as AMD's 5.0 volt-only Flash devices. AMD's process provides low-power, high-performance CMOS devices using the NOR cell Flash architecture. The Am29LVxxx family offers the following features:

- ❏ JEDEC single-power-supply standard for pinout and software commands.
- ❏ A memory array that is segmented into smaller sectors for erase operation. This feature allows for modular code development, storage of boot code, parameters, and main code in different sectors, and the ability to write protect any or all sectors of the device.
- ❏ AMD's Embedded Program and Embedded Erase algorithms that simplify Flash operation by automating the programming and erase operations on the chip. This eliminates the need for dedicated CPU control of the device, and thus improves system-level performance. The embedded algorithms automatically detect and correct overerase, and eliminate program/erase software implementation errors associated with first-generation manual algorithm Flash devices.
- ❏ A guaranteed minimum endurance of 1 million program/erase cycles on the 0.35 µm and new 0.32 µm process technologies. This equates to higher reliability in systems that rewrite data even once to the Flash device.

Summary

AMD's 3.0 volt-only design offers all the advantages and performance of its 5.0 volt-only, industry standard architecture, while providing 3 volt operation optimized for battery-powered applications. Features of the industry standard architecture include single-power-supply operation, sector architecture, and Embedded Algorithms. In addition, AMD's 3.0 volt-only, Am29LVxxx family of Flash memories provides a 2.7 V to 3.6 V extended operating range and low power consumption without sacrificing performance.

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