Embedded Algorithms in Flash Memories

Application Note

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Despite their instant popularity, the first 12.0 Volt Flash memories introduced in the late 1980s had several drawbacks. One of the concerns most often voiced by system software designers was the need for cumbersome programming sequences to program and erase the devices. Embedded Algorithms were developed to eliminate these concerns.

THE DRAWBACKS OF PROGRAMMING WITH FIRST GENERATION ALGORITHMS

Figure 1 shows the flowchart for programming Flash devices using first generation algorithms. The steps needed to program a single byte of memory are illustrated in simplistic block diagram form. The programming code itself is obviously much more complex. The erase sequence is similar except Flash devices must first be programmed to all zeros prior to being erased.

A completed listing of code performing all of the program/erase functions for a Flash memory typically contains 100–200 lines. Although sample code can be obtained from the device manufacturer, designers usually need to generate their own code specific to the individuality of their application.

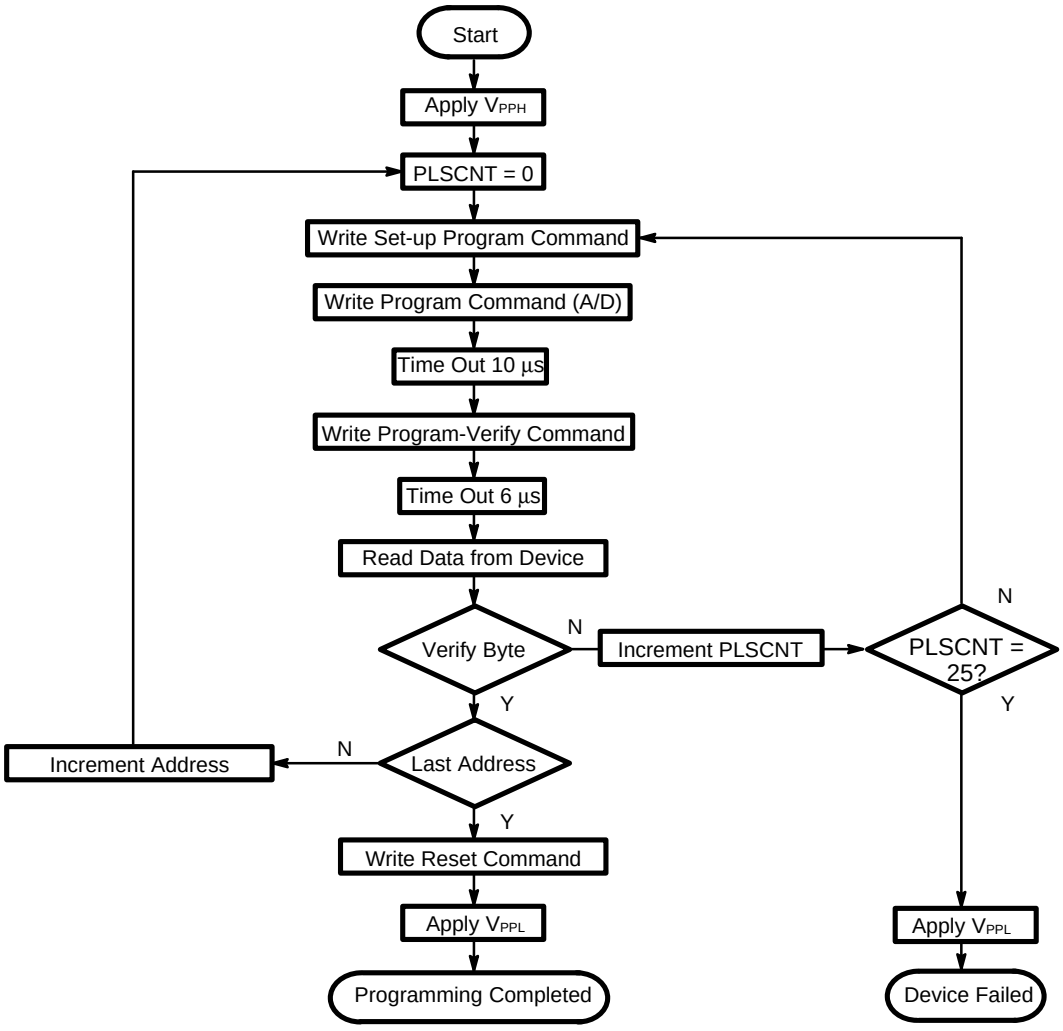

Figure 1. First Generation Programming Algorithm

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This extensive programming requirement has many disadvantages and can be quite costly. First, of course, is the amount of time required to generate and debug this code. Since prior designs utilizing EPROMs were programmed offline, most software engineers are not familiar with the programming of Flash memories. They find that the programming process is initially lengthy and error prone. The cost to the user includes not only the obvious cost of software development but also the lost opportunity costs resulting from time to market delays.

Another concern is the potential long term impact on system reliability caused by overstressing a Flash device. Since cycling endurance can be affected by improper writing or erasing, software bugs can cause latent field failures even in systems that appear error free in development. In fact, most customer returns at AMD have been traced to software errors generated during system development.

SIMPLIFYING FLASH PROGRAMMING

AMD was the first company to recognize the need to simplify programming of Flash memories and incorporated it in the design of its first 2 Mbit Flash memory. Figure 2 illustrates the Embedded Program Algorithm. The system processor simply issues the write set-up command followed by the write command and the internal state machine on the device takes over control of the write operation. The system processor simply does $\overline{\text{Data}}$ Polling until the device indicates that the write operation is complete. This simplicity is even more pronounced during an erase operation since each byte of the memory must be individually programmed prior to erase. The Embedded Erase Algorithm internally writes all zeros to each byte and then performs the erase. This entire sequence is controlled internally and is transparent to the host processor.

OTHER ADVANTAGES OF EMBEDDED ALGORITHMS

Besides simplifying the complex programming of Flash memories, Embedded Algorithms offer these other important advantages to the designer.

Reduced System Overhead

Since the Embedded Algorithms are completely automatic, the system processor is free to perform other functions, such as servicing interrupts, during the write or erase operations.

Improved Program/Erase Time

The Embedded Algorithms are designed to perform write/erase operations in the most efficient way possible. All system overhead is eliminated.

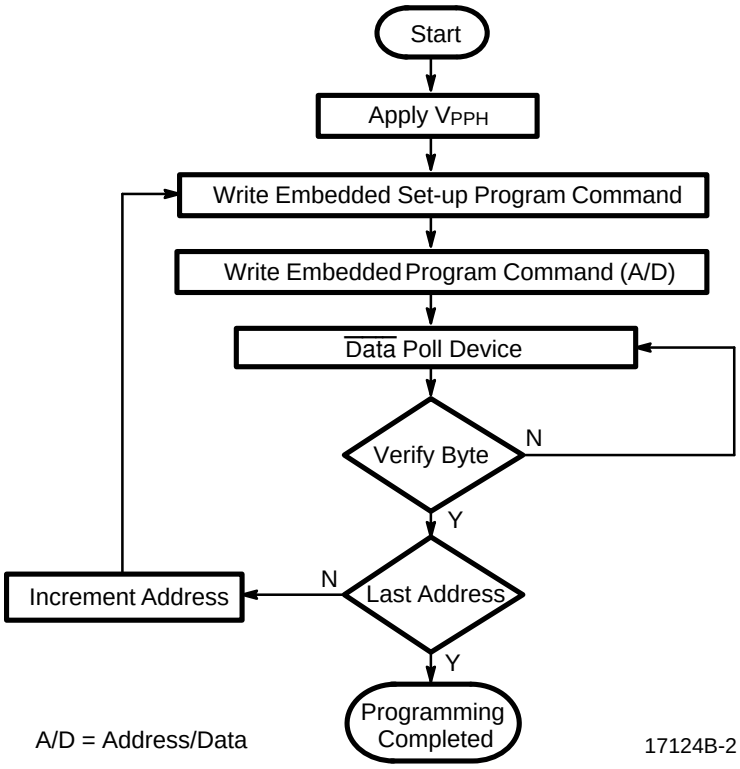

Figure 2. Embedded Programming Algorithm

Increased Cycling Endurance

By including a self correcting mechanism, Flash memories incorporating AMD's Embedded Algorithms will operate to a minimum of 100,000 endurance cycles; with 1,000,000 endurance cycles typical.

JEDEC standards for self programming of Flash devices are now being developed. The Embedded Algorithms incorporated in all of AMD's Flash devices conform to these standards.

SUMMARY

The benefits of Embedded Algorithms are available today from AMD on first generation 12.0 Volt devices (Am28F256A, Am28F512A, Am28F010A, Am28F020A) as well as the 5.0 Volt-only, fully sectored Am29Fxxx family. Employing these algorithms in existing designs will allow you to increase your system's endurance to over 100K cycles. In new designs, system development will be simplified and time to market reduced.