
System Design Considerations for Implementing a ROM Microcontroller

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INTRODUCTION

When developing a system that will ultimately utilize a ROM-based microcontroller (MCU), it is still typical to make use of an EPROM-based MCU during the final stages of the design. Initial development may also include the use of some type of emulator system, but prototype units normally make use of a windowed EPROM or OTP EPROM MCU, and the design is optimized/validated based upon the performance of the EPROM-based device without, in many cases, taking into consideration potential differences in the performance of the ROM-based device that will ultimately be used.

CAUSE OF OTP VS. ROM DIFFERENCES

While MCU manufacturers go to great lengths to ensure that the performance differences of EPROM vs. ROM devices are minimized, there are external factors that historically have prevented fully achieving this goal. There are a number of key factors that can contribute to differing performance between the two types of devices, which include:

- **Operating Voltage Range:**

ROM devices operate to a lower V_{DDMIN} due to the difference in physics between EPROM and ROM memory cells.

- **Parametrics:**

ROM and EPROM devices are not manufactured using the same fabrication process, leading to subtle differences in parametric performance.

- **Functional Operation:**

One device may have design changes implemented to improve performance or correct errata that exists on the other device.

Each of these issues is discussed in more detail in the appropriate sections that follow.

Designers who are developing systems using EPROM products that are targeted to move to ROM devices as production volumes increase, or who find themselves

needing to convert an existing EPROM-based design to ROM, should thoroughly review this application note to determine if the potential for problems exist. This document is not intended to be an all encompassing list of all possible issues, it is simply a reference resource for key items that have previously been identified as potentially causing problems.

OPERATING VOLTAGE RANGE

EPROM devices operate at V_{DD} levels above $\sim 2.3V$ limited by the device physics of an EPROM cell. The ROM devices do not have this limitation and, therefore, typically operate down below 2.0V. When designing a low voltage system and developing/validating the design using an EPROM device, it is necessary to use a higher V_{DD} level than that which will actually be used in the final design. The gain of the internal transistors are sensitive to the V_{DD} value and this can lead to functional performance differences in the oscillator start-up/stabilization time, the watchdog timer speed. V_{IH}/V_{IL} , and V_{OH}/V_{OL} levels. Each of these issues is discussed in greater detail under the 'Parametrics' section.

The system designer(s) should ensure adequate margin to the published specifications when using EPROM-based devices for development, and the use of ROM prototypes is highly recommended for low voltage application validation.

PARAMETRICS

The parametric performance of the ROM equivalent of an EPROM-based device may vary due to the processes used to fabricate the two different devices. There are a number of different scenarios that lead to the two devices being fabricated using different process technologies. First, ROM devices do not require several of the process steps required to make an EPROM device, so the processes are different by definition. Second, ROM devices are often manufactured using different starting wafer sizes and/or different process geometries. These options help maximize the cost savings that can be realized with ROM devices.

All of these may lead to some amount of variation in the parametric performance between the EPROM and ROM devices. The manufacturer ensures that both the ROM and EPROM devices meet the datasheet specifications so that drop in compatibility is maintained. However, it is sometimes the case that a design

becomes dependent upon the actual parametric performance of a device instead of being designed to operate under the worst case specifications. This can lead to problems when developing a ROM application using an EPROM, or if trying to port a EPROM product to ROM to realize a cost reduction.

OSCILLATOR PERFORMANCE

Oscillator performance is a key parameter that may vary relatively significantly between the EPROM and ROM devices. The operation of the oscillator is highly dependent upon the internal transistor gains, which are determined by the process technology used during fabrication.

The transistor gains of the oscillator circuit effect oscillator start-up time and the oscillator stability with a given set of external components (crystal/resonator, capacitors, resistors). It is absolutely critical that the system designer(s) make every effort to verify the performance of the ROM device with the intended crystal/resonator design. This is highly recommended for oscillator verification whenever possible.

Another potential issue is, if the VDD ramp rate is relatively slow, the oscillator start-up timer may start sooner, relative to the start of the VDD ramp.

WATCHDOG TIMER (WDT)

The watchdog timer (WDT) is another function which can be highly sensitive to the parametrics of the process used to fabricate the device. The WDT utilizes an internal free running RC oscillator. The values of the internal resistor and capacitor may vary relatively significantly between the EPROM and ROM devices. It is, therefore, necessary to either allow for this in the selection of the WDT time-out value, or verify the design using actual ROM devices, if possible.

CURRENT CONSUMPTION

The current consumption between EPROM and ROM devices may also vary as a result of parametric differences in the processes. This includes both IDD and IPD values. Again, the manufacturer ensures that both devices meet the datasheet specifications, but designs that are very power sensitive should be evaluated using actual ROM devices, if possible to verify that the final design meets the current and power targets.

VOLTAGE THRESHOLDS

Another area where process parametrics may cause subtle differences in device operation is related to the V_{IL}/V_{IH} and V_{OL}/V_{OH} values of the device. Because these levels are a dependent upon the internal transistor thresholds, which is a function of the process used to manufacture the device, careful consideration should be given to the input and output level specifications, and the system should be designed to work with the specified worst case values.

ELECTROSTATIC DISCHARGE (ESD) PERFORMANCE

In some cases, there may be a difference in the actual ESD performance of the ROM versus EPROM devices. This may lead to problems in some designs, where ESD events are likely or common. The system designer should check the ROM device datasheet to determine if there is a difference in the ESD specification and, for applications that are expected to be particularly susceptible to ESD, should perform system validation with ROM devices, if possible.

FUNCTIONAL OPERATION

Functional operation differences between EPROM and ROM devices that are meant to be equivalent occasionally do occur. These differences are typically due to the fact that one of the devices (usually the EPROM) is developed and released first and contains some errata concerning actual functional performance. The second device typically implements fixes for some or all the known errata and, therefore, does not function identically to the other.

In other cases, changes or improvements may have been implemented to enhance a device but the enhancements may not have been released to production on both devices, so there is some period where the devices do not function identically.

It should also be noted that it should not be assumed that any or all errata for the EPROM device has been, or will be, corrected in the ROM device, and it is also possible that new errata is introduced on the ROM device that did not exist on the EPROM device.

Functional differences are often related to the operation of one of the peripheral blocks including:

- USART
- SSP
- PWM
- Timers
- MCLR operation
- A/D Converter

In all cases, the system designer(s) should specifically request any errata that exists for each of the two devices, as well as any known device specific issues between the EPROM and ROM versions of the device being used. And finally, ROM prototypes should be used whenever possible for final system validation.

ROM PROTOTYPES

Microchip offers customers a ROM prototype service, which allows systems in the latest stages of design validations to be checked out using a ROM PIC rather than an EPROM-based micro. This should be used if there are any concerns about the functional or parameter differences between the EPROM micro and the intended ROM device.

SUMMARY

When developing a new ROM application using an EPROM-based MCU, or when attempting to move an established EPROM-based design to ROM to reduce costs, there are a number of key factors to be considered to minimize problems and ensure a reliable ROM design. The ideas presented in this application note are not intended to be all inclusive, but do represent key issues that have been identified in the past as presenting potential problems. It can not be stressed enough that actual ROM devices should be used for system/design validation whenever possible. This alone significantly reduces the risk of unanticipated application performance issues occurring in the future. It is also key that all hardware be designed so that acceptable operation at worst case device specifications is ensured.



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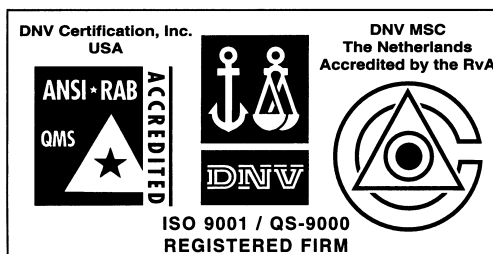
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