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## Serial EEPROM Solutions vs. Parallel Solutions

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In searching for solutions to their system non-volatile memory requirements, equipment, systems and product designers are faced with a plethora of design related issues and trade-offs. The non-volatile memory options available to them offer a variety of different device features including performance, ease of design, power consumption, operating voltage, programmability, density, and physical size. For the most part these non-volatile memory options can be grouped into two major categories: serial solutions and parallel solutions. This paper discusses the attributes of each, conducts a comparative analysis and in the process identifies the benefits and advantages of Serial EEPROMs.

### SERIAL EEPROMS

The main feature that makes a device a "Serial" and sets it apart from parallel devices is, as its name implies, the ability to communicate through a serial interface. This ability has numerous benefits. First, serial communication is accomplished with a minimum number of I/O's. Serial EEPROMs require only two to four lines (depending on the hardware and software protocol) for complete communication; memory addressing, data input and output, and device control. Thus, the hardware interface requirements for Serial EEPROMs are kept at a minimum. The most common Serial EEPROMs in use today are devices that utilize a 2-wire protocol.

Another benefit of serial communication is package size. Ranging from densities of 256 to 16K bits, most Serial EEPROMs today are available in space-saving 8 pin PDIP and 150mil wide SOIC packaging. This obviously is very beneficial for applications where product size and weight is a key design factor. The final benefit is low current consumption. Due to a limited number of I/O ports and therefore on-chip support requirements, operating currents for Serial EEPROMs are usually well below 3 milliamperes.

Other features of Serial EEPROMs include: 1) Byte programmability—The ability to erase and program one byte at a time without affecting the contents of the other memory locations in the array; 2) Clock rates of up to 6MHz—2-wire devices are rated at 100KHz and 400KHz per the standard I<sup>2</sup>C protocol, while 3-wire devices can be operated at 6M Hz rates; 3) Low voltage operation—Microchip has introduced a family of devices that operate, both read and write, down to 1.8V. This family complements other 2V and 2.5V low voltage Serial EEPROM families available.

### PARALLEL NON-VOLATILE MEMORIES

There are a number of memory devices that fall into this category. The major ones include Parallel EEPROMs, Flash memory products, EPROMs, and SRAMs with battery back-up.

The main common feature of all of these devices is that communication with the device is done through a parallel interface, which results in a high system clock rate. Each type of device has separate data, address and control lines. Thus pin counts are in the 24 to 40 pin range. This also results in relatively large and costly packages and large footprints, even with the most advanced surface mount packages like TSOP. SRAMs with on-board batteries require DIP package heights that are significantly higher than those of standard DIP packages, adding to its package size and cost disadvantage.

Parallel EEPROM and battery backed-up SRAMs are the only two of the four major types of parallel non-volatile memories that have the capability to erase and program one byte at a time. EPROM and Flash devices require the whole array or at least large sectors to be erased prior to reprogramming.

### SERIAL VERSUS PARALLEL

Serial EEPROMs have five major advantages over parallel non-volatile memories.

- 1) Lower Current Consumption - The maximum operating current (at 5 volts operating voltage) of a 16K serial EEPROM device is approximately an order of magnitude less than that of an equivalent density parallel EEPROM. Operating currents for 16K Serials are specified at 3mA, while 16K parallel devices are specified at 30mA and above. This relationship will continue as 64K serial devices are introduced. Since power consumption is directly proportional to current consumption, the lower the current the lower the power consumption.
- 2) Lower Voltage - Serial EEPROMs have been available in single supply low voltage options for some time. As mentioned above, Microchip has low voltage Serial EEPROMs that operate down to 1.8V, as well as other low voltage Serials that function down to 2.0V or 2.5V volts. 3V EPROMs

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and parallel EEPROMs and single voltage 5V flash devices are just being introduced to the market. (Most flash devices on the market today require 12V for programming in addition to the 5 volts required for normal operation). Low voltage operation also has a positive effect on power consumption. A reduction in the operating voltage from 5 volts to 1.8 volts will result in a power consumption reduction of almost 90% and almost a 65% reduction in power if the operating voltage is reduced from 3V to 1.8V.

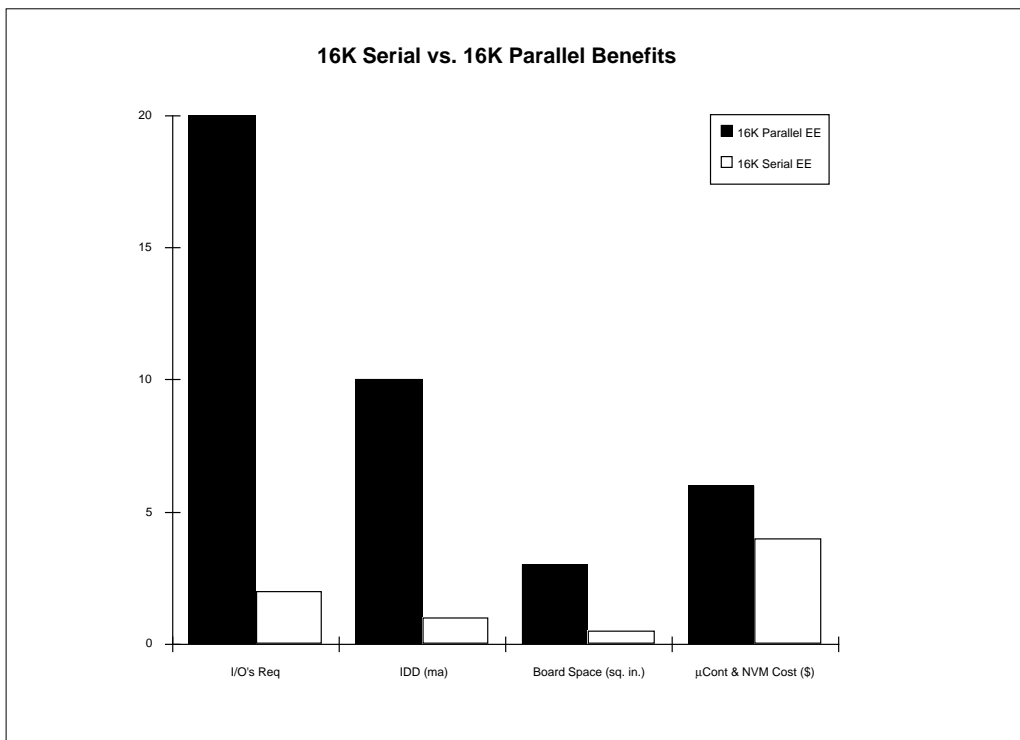
- 3) **Programmability** - Neither currently available Flash devices nor EEPROMs have the ability to program one byte at a time. Erasing is an array or sector function. Therefore, whenever one byte needs to be reprogrammed the entire array or sector must be reprogrammed. This procedure takes a relatively long amount of time to complete, time which may not be available, as is the case when storing critical parameters or data during inadvertent and unexpected system power loss. This procedure also requires software overhead to manage the retrieval and reprogramming operation.
- 4) **Physical Size** - Again, when comparing a 16K Serial EEPROM to a 16K parallel device the serial has a significant advantage. The area of the 150mil 8 pin SOIC footprint is less than 50K square mils. This

compares to an area of more than 250K square mils for a 24 pin SOIC and almost 800K square mils for a 24 pin 500mil DIP package footprint.

- 5) **I/O Requirements** - Serials only require 2 to 4 input or output lines for complete communications. Most parallel devices require at least 22 lines, depending on the memory density. This results in increased microcontroller/microprocessor overhead and additional real estate to accommodate the numerous hardware lines.

The advantages that parallel devices currently have over serial EEPROMs is memory density and AC performance. However, in most microcontroller based applications for which Serial EEPROMs are intended, high density and AC are not the most critical design issues or most needed product features.

The key benefits of Serial EEPROM solutions as a result of the advantages outlined above, are reduced system costs, enhanced feature sets, and improved system performance. System size and weight is reduced and power sourcing requirements are kept at a minimum. The following graph compares some of the main attributes of a 16K Serial EEPROM device to a 16K Parallel device.



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## USES AND APPLICATIONS OF SERIAL EEPROMS

### Uses of Serial EEPROMs

The days of simply being a DIP switch replacement for Serial EEPROMs is over. Here is a list of the functions that Serial EEPROMs perform in a variety of computer, industrial, telecommunication, automotive and consumer applications:

- 1) Memory storage of channel selectors or analog controls (volume, tone, etc.)
- 2) Power down storage and retrieval of events such as fault detection or error diagnostics
- 3) Electronic real time event or maintenance log such as page counting
- 4) Configuration storage
- 5) Last number redial and speed dial storage
- 6) User in-circuit look-up tables

### Serial EEPROM Applications

Serial EEPROMs have found homes in hundreds of embedded control applications in all major application markets. The following list demonstrates the number and variety of applications for serial EEPROMs.

### Market

CONSUMER

### Applications

TV tuners, VCRs, CD players, cameras, radios, and remote controls

COMPUTER/OA

Printers, copiers, PCs, palmtop and portable computers, disk drives and organizers

INDUSTRIAL

Bar code readers, point-of-sale terminals, smart cards, lock boxes, garage door openers, test measurement equipment and medical equipment

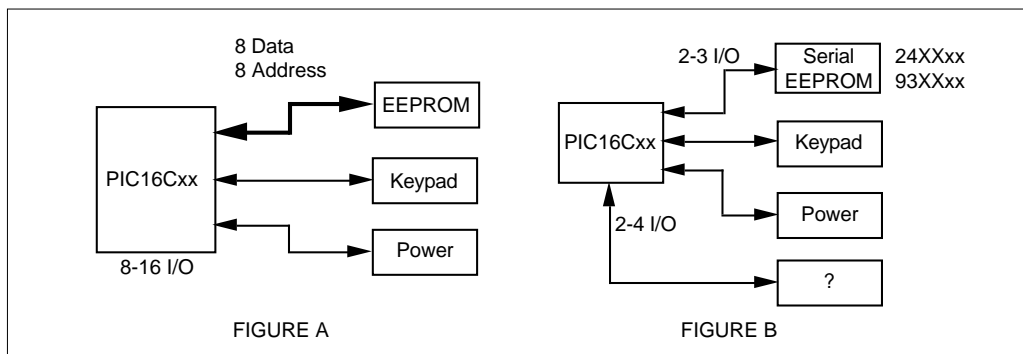
TELECOMM

Cellular, cordless and full feature phones, faxes, modems, pagers, and satellite receivers

AUTOMOTIVE

Air bags, anti-lock brakes, odometers, radios and keyless entry

Using Serial EEPROMs for critical data and configuration storage has only recently become a reality. The current offerings of 2- and 3-wire serial devices offers the systems designer interesting alternatives to the standard parallel EEPROM devices. The Serial EEPROM is basically a standard EEPROM array without the normal parallel data and address I/O. These functions are handled via serial I/O ports coupled with internal self-timed state machines. Not only will the serial device



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save power, board space, and cost, but they also offer the advantage of fewer I/O and consequently power in the embedded microcontroller because less I/O are needed to control the same functions. A typical embedded application is shown in Figure A, depicting a controller and several functions used in a personal communications device, such as a mobile or portable phone. The EEPROM stores speed dial and last number redial numbers, credit card numbers, ID numbers, and configuration parameters.

Figure B shows these same functions using a controller with fewer I/O and a Serial EEPROM. There is no loss of functionality but a significant savings in current, board space, I/O pads, and cost. The serial solution employs 8 to 16 less I/O on the microcontroller, freeing up much needed functionality, and possibly allowing for a much smaller device package and downsized circuit boards.

## SUMMARY

Serial EEPROMs are ideal cost effective solutions to all non-volatile memory embedded control applications that require: 1) A small footprint space saving format; 2) The ability and ease of programming one byte at a time; 3) Low current consumption and low operating voltage; 4) Low microcontroller overhead and support; and, 5) The best price performance non-volatile memory solution available.

Their size, ease of programmability, low power consumption, and low cost make Serial EEPROMs extremely suitable for all the fast growing handheld and portable battery powered computer, personal communications, medical and industrial markets.

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