Microchip Serial EEPROMs

Questions:

- Serial EEPROM advantages?
- Which EEPROM bus is “best?”
- Package options?
- Design tools?
- Pin limited?

 EEPROM Overview Slide 1

Hello, and welcome to this web seminar on Microchip’s serial EEPROM product line. My name is Barry Blixt, marketing manager for Microchip memory products.

Non-volatile serial EEPROMs are a key component of many embedded designs. This 20-minute seminar is an introduction to serial EEPROM technology, as well as an introduction to Microchip’s product line. Here are some questions that we will answer during this presentation.

Are you curious about the advantages of serial EEPROMs? We’ll talk about the features that make them so popular.

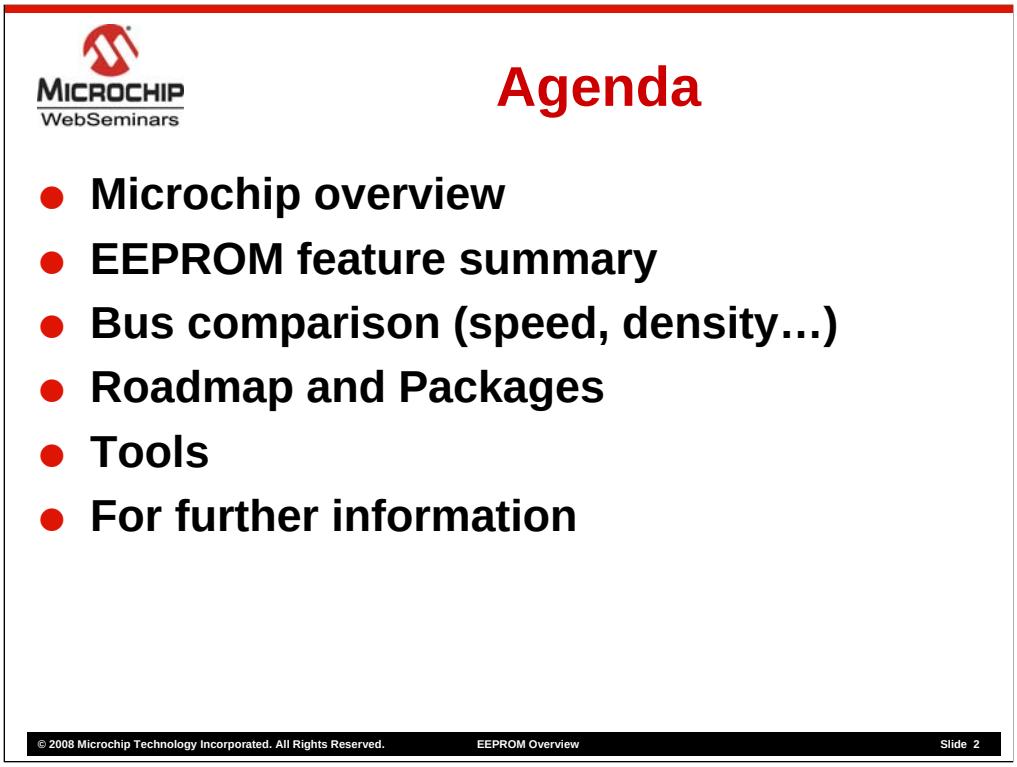
Do you ever have to decide which EEPROM bus is best for your application? We will compare the features of the major protocols.

Do you wonder about small or thin package options? One advantage of EEPROMs is their small packaging.

Do you wonder what design tools are available? We’ll talk about Microchip’s development tools and software development models.

Most serial EEPROMs use between 2 and 6 microcontroller pins. Are you pin-limited and looking for a way to save micro I/Os? We will talk about Microchip's new single-I/O EEPROMs.

Now, let’s look at our agenda.



We'll start off with a brief overview of Microchip's history of providing serial EEPROM products.

Then we'll take a look at some specific features common to all serial EEPROMs.

Then we'll compare and contrast 3 serial bus options: I^2C^{TM}, Microwire, and SPI. And I will introduce a 4th option, Microchip's new UNI/O™ family of single I/O EEPROMs.

After that, we'll check out our product roadmap and packaging options.

Finally, we'll look at a couple tools and close with some ways you can get more information.

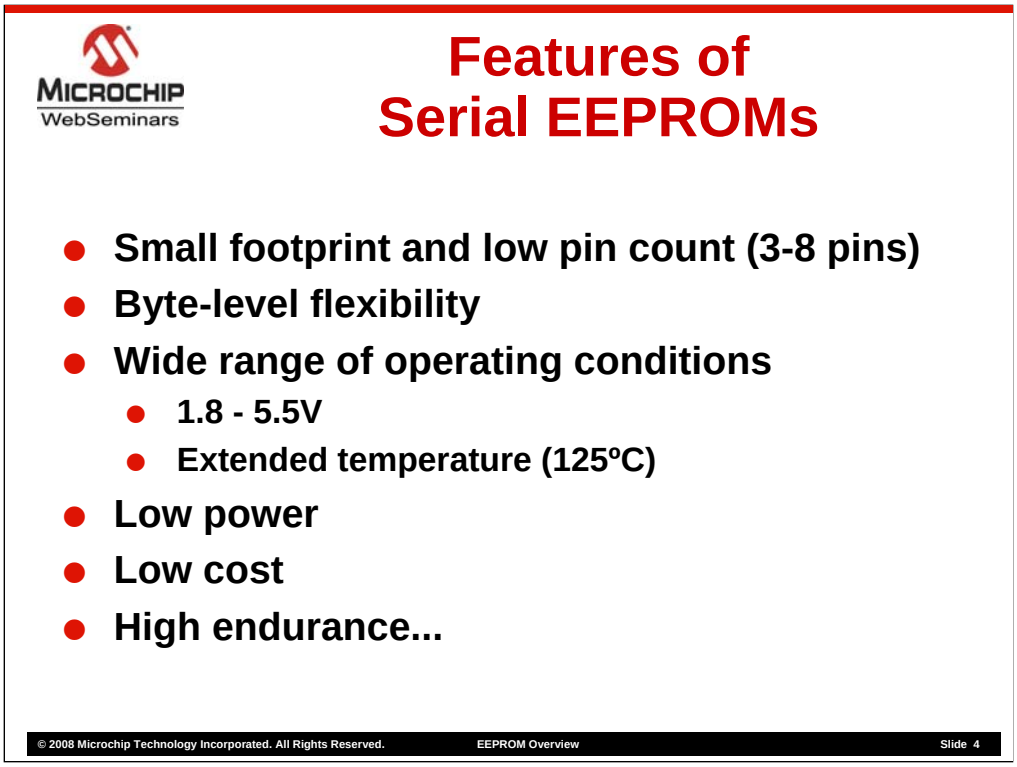
This overview seminar is a quick look at some major features of serial EEPROMs. If you have more specific questions, we have a series of more detailed web seminars on many of these topics. I'll go over the list of these other Webinars at the end of this one.

Even though Microchip is now primarily known as a microcontroller company, we have been manufacturing non-volatile memories for over 20 years. Today, we continue this tradition with a complete range of serial EEPROM products. Microchip is also known for having outstanding delivery performance, partly because of the company's world-class manufacturing capabilities.

Quality is a key component of Microchip's culture. Both of Microchip's fabs, as well as our assembly/test facility, meet the requirements of ISO/TS 16949. This is a strict quality system that covers both design and manufacturing. Most of our packaging is done at our own assembly site in Thailand, with the balance done at approved subcontractors. This control over our manufacturing helps us to achieve our excellent quality and delivery performance.

Endurance is a key part of Microchip's EEPROM products. We consider our industry-leading endurance to be a strong measure of our overall quality.

We also have a long history of innovation in our EEPROM product line. We've been the first to market with new features including low voltage operation, small packaging, faster speeds, and application-specific devices.



Before we get into the differences among the EEPROM buses, let's talk about some features and advantages that are common to all products – regardless of the bus.

First, serial EEPROMs have a low pin count – typically 8 pins – and are available in very small packages. There are also have 5- and 6-pin options. And, we have recently introduced 3-pin EEPROMs.

Second, EEPROMs can both write and read a byte at a time. This is in contrast to Flash technologies that are typically limited to sector operations.

EEPROMs are available in a wide temperature and voltage range. Most Microchip EEPROMs are available in 1.8V options, which is excellent for battery applications. They also work up to 5V and at automotive grade temperatures of 125ºC.

EEPROMs also have very low power requirements, with virtually all Microchip devices having a typical standby current of well under 0.1 uA.

EEPROMs are also very cost-effective since they are small devices in small packages

Finally, Microchip's EEPROM products are known for their extremely high endurance. We'll talk about that more on the next slide.

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Endurance

- Erase/write cycles before bit-level failure
- Data sheets = 1 million cycles at 25ºC, 5V
  - Total Endurance™ software model: specific conditions

- How we get endurance:
  1. Microchip's PEEC technology
  2. Triple Test Flow – every bit tested 3x

Endurance is defined as the number of times that one memory location, or bit, can be erased and re-written before that location fails, or no longer holds the correct information. This is a pretty tight definition; when 1 bit on a memory device fails, the entire device is defined to have failed.

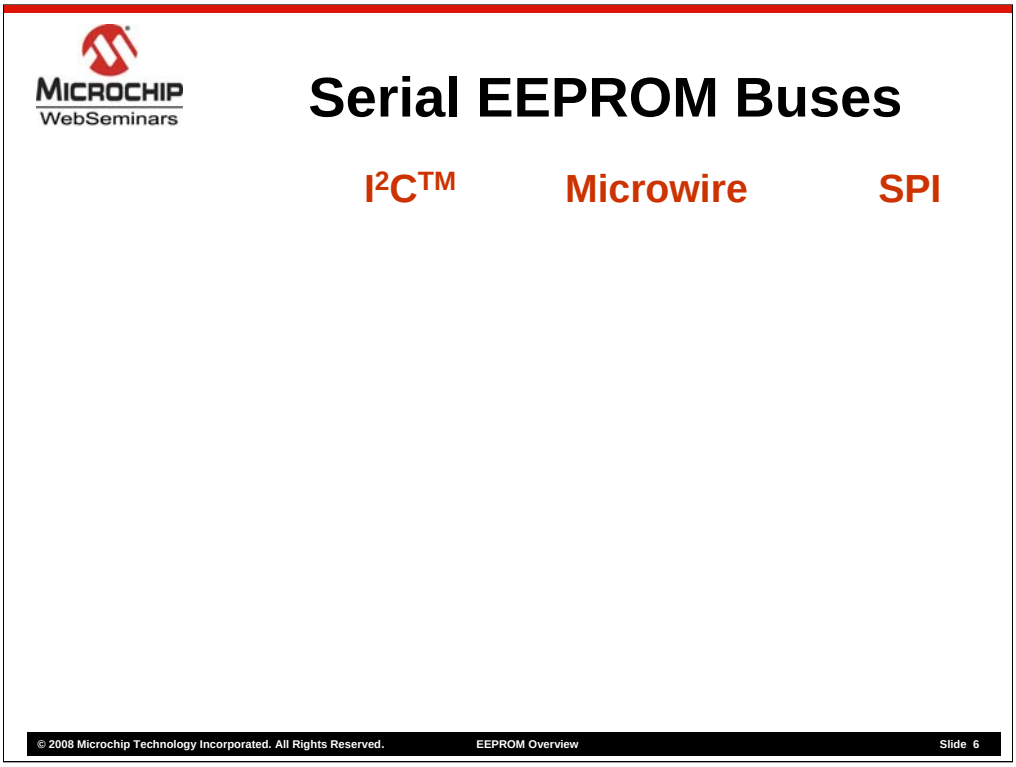
Serial EEPROMs are excellent for applications requiring many data changes. Most of our EEPROM products are specified to 1 million erase/write cycles, which is much more than most other non-volatile memory technologies.

This data sheet value of 1 million cycles is based on specific conditions of 25 degrees C and 5V. That's because endurance degrades with increasing temperature and, to a lesser extent, with increasing voltage. So to accurately predict endurance in an application, it's important to consider the actual operating conditions.

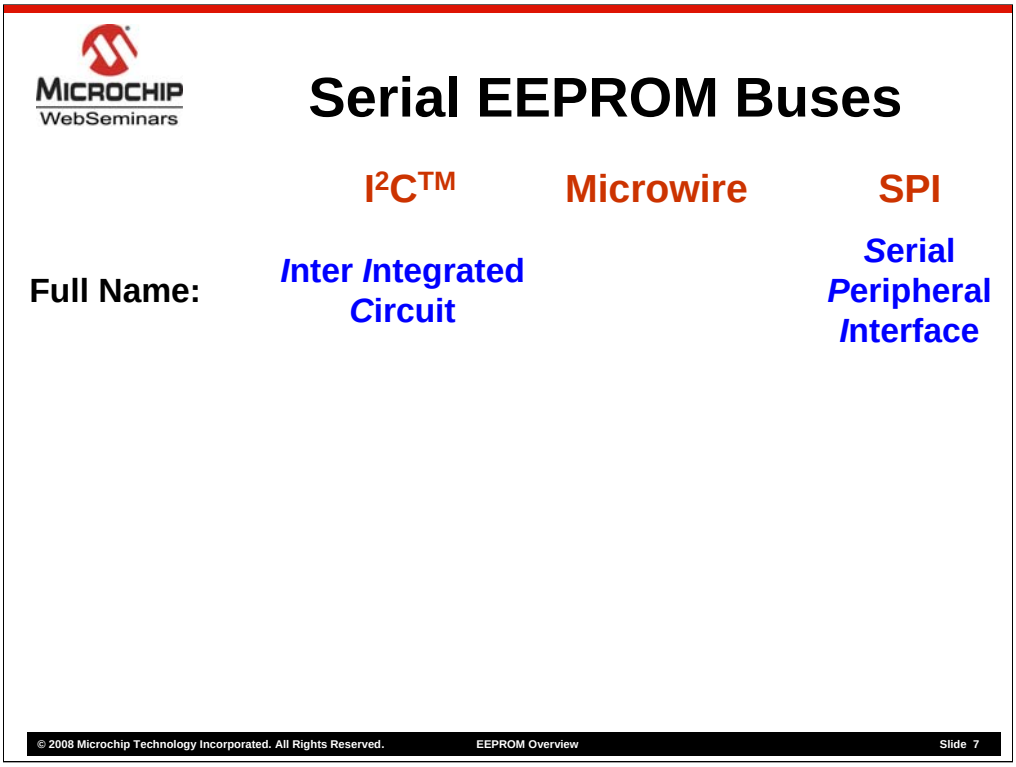
That's why we developed our Total Endurance™ software. This modeling tool allows the user to enter his operating conditions to create a model of the expected endurance in a specific application.

Two components give Microchip EEPROMs their excellent endurance. First, our products are built using Microchip's PEEC, or PMOS Electrically Erasable Cell, process technology. This cell was developed specifically to give our products high endurance and reliability. Second, every bit of every device is tested three times in our Triple Test Flow process. This combination of an excellent cell structure and outstanding testing gives Microchip its industry-leading endurance.

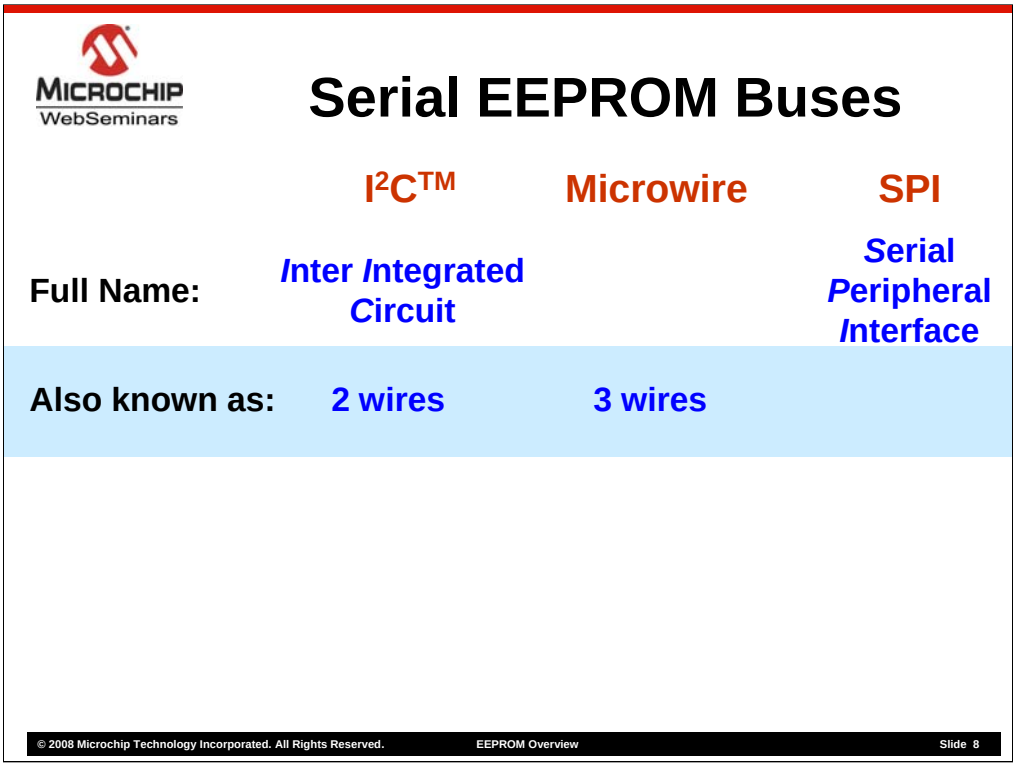
We've talked about the major features of all serial EEPROM products. Now, let's take a look at the 3 buses and some of the differences among them.



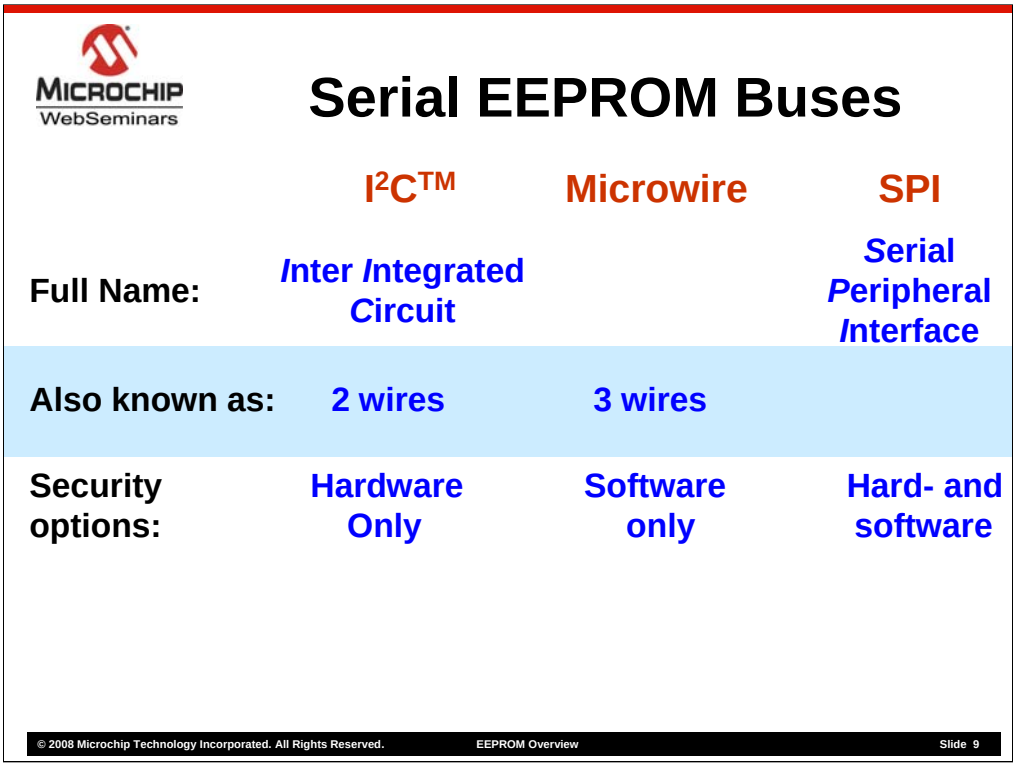
Serial EEPROMs have historically come in 3 bus types: I²C™, Microwire, and SPI. This table looks at some specific features of each bus.



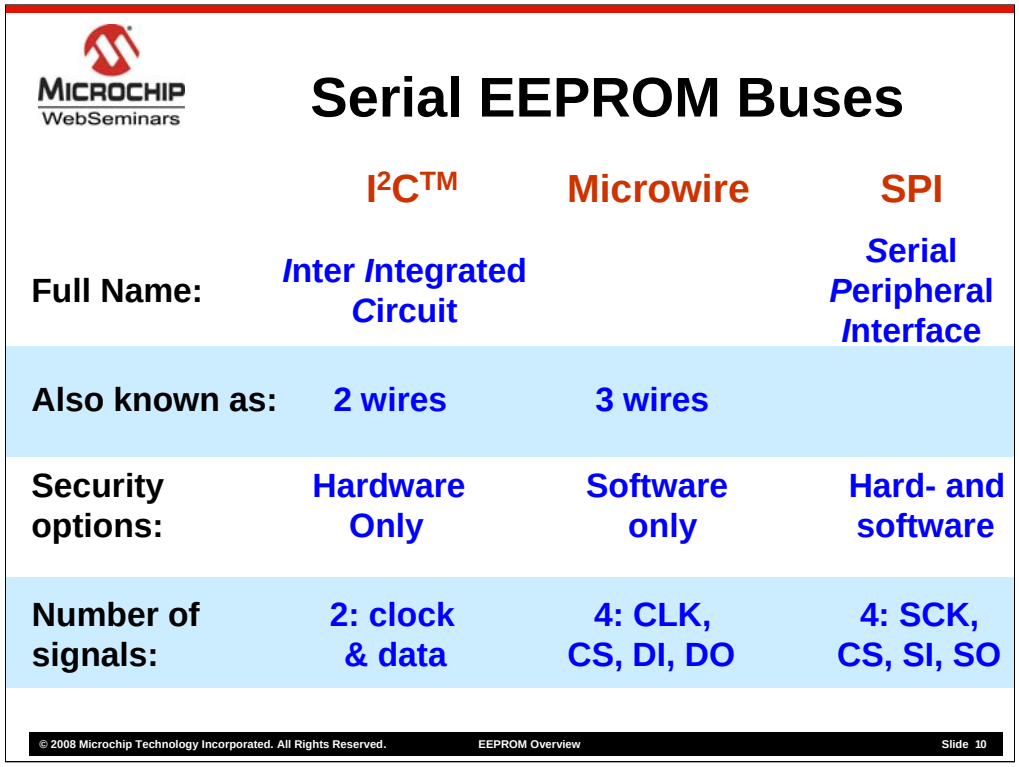
I^2C, developed by Philips, is an abbreviation for Inter-integrated circuit. Microwire was developed by National Semiconductor. SPI, an abbreviation for serial peripheral interface, was developed by Motorola.



You'll often hear I^{2}C devices referred to as "2 wires" since there are typically two signal connections between the microcontroller and the memory device. Similarly, Microwire devices are referred to as "3 wires."



Each bus has certain data security features. I^{2}C devices have a write protect pin that can prevent writes to the array. Microwire makes use of write enable and disable software commands. SPI also uses these software commands as well as a status register to protect the device. It also has hardware options that can protect portions of the array.



Let's pay special attention to the last parameter: the number of signal lines between the EEPROM and the microcontroller. I^2C devices only have 2 signal lines to the micro: a clock signal and one data signal that carries both incoming and outgoing data. Microwire and SPI devices both require 4 I/Os: independent data in and data out lines as well as a chip select and a clock. So, an advantage of I^2C is that it only uses two I/O ports on the microcontroller.

But, what if you would like to connect an external EEPROM to a micro using only 1 I/O pin? Microchip has developed its UNI/O™ protocol, which does just that. Let's talk more about the UNI/O bus and UNI/O EEPROMs on the next slide.

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UNI/O™ EEPROMs: Single I/O Serial Interface

- **Free up MCU pins**
  - **Add new features**
  - **Use smaller MCU**
- **Small packages**
  - **3-lead SOT 23**
- **Advanced features**

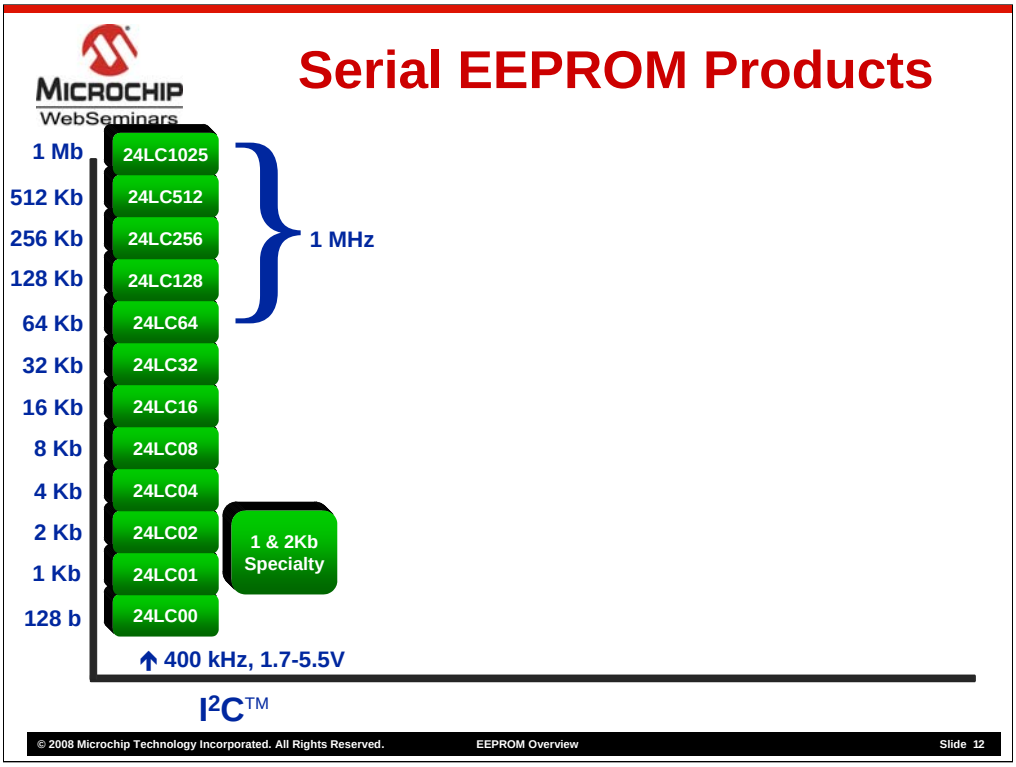
Microchip's recently developed UNI/O™ bus gives designers more flexibility when designing applications that require external memory. UNI/O EEPROMs only require one signal line to the microcontroller to carry both clock and data signals, thus creating a method to connect an EEPROM to a micro using only 1 I/O pin.

Microcontroller I/O pins are valuable resources. By only requiring one of these pins, UNI/O EEPROMs free up other I/O pins to be used for value-added features. This can increase system value using the same basic design. Or, it might be possible to lower the system cost by moving to a smaller microcontroller.

Another advantage of this bus is that these devices are available in very small 3-lead packages: one pin for clock and data and the other two pins for voltage and ground. This can mean a lower system cost and smaller designs.

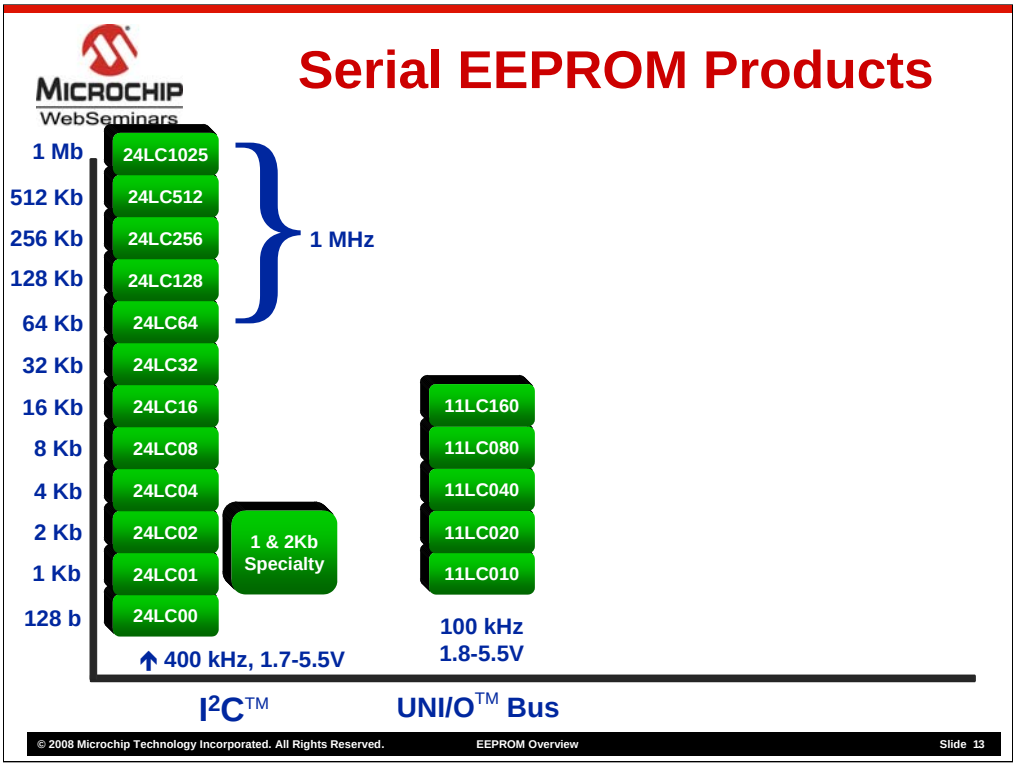
Finally, UNI/O serial EEPROMs have been designed with advanced features such as a STATUS register, advanced write protect options, and page writes. And, these devices have the standard EEPROM advantages that we talked about earlier: 1 million erase/write cycles, 1.8-5.5V operation, extended temperature options, and low power.

With that, let's take a look at Microchip's complete serial EEPROM product line.

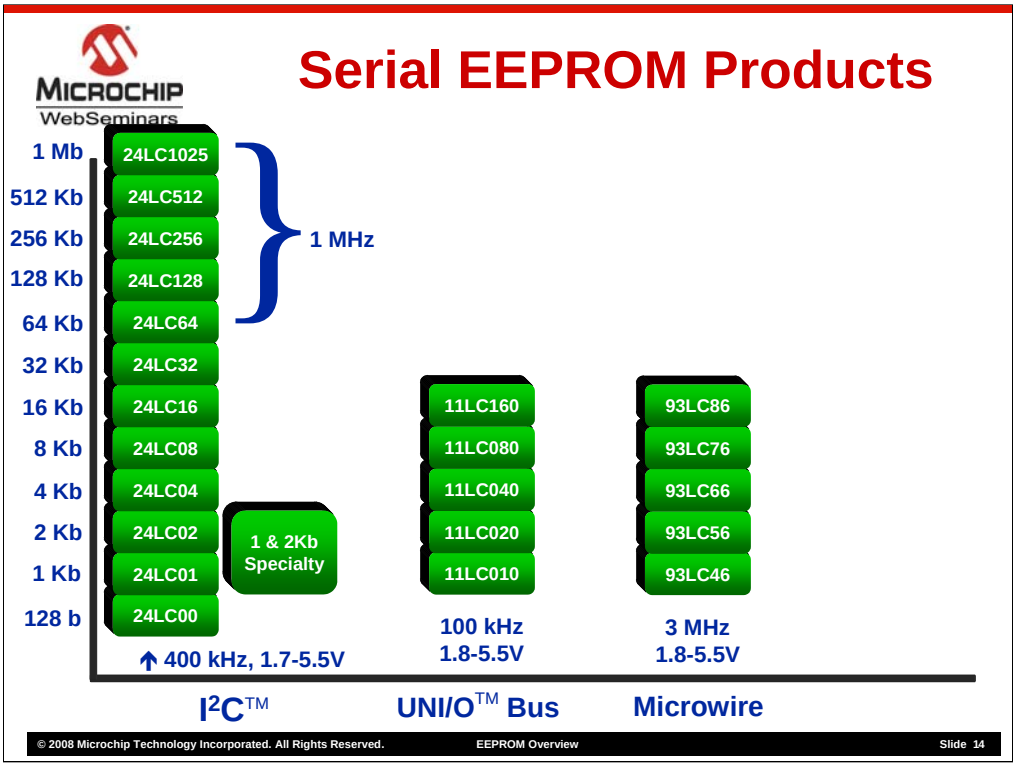


Here is our product roadmap. Let's first look at I²C™ products in the left-most column. Note that the available densities are listed along the vertical y-axis.

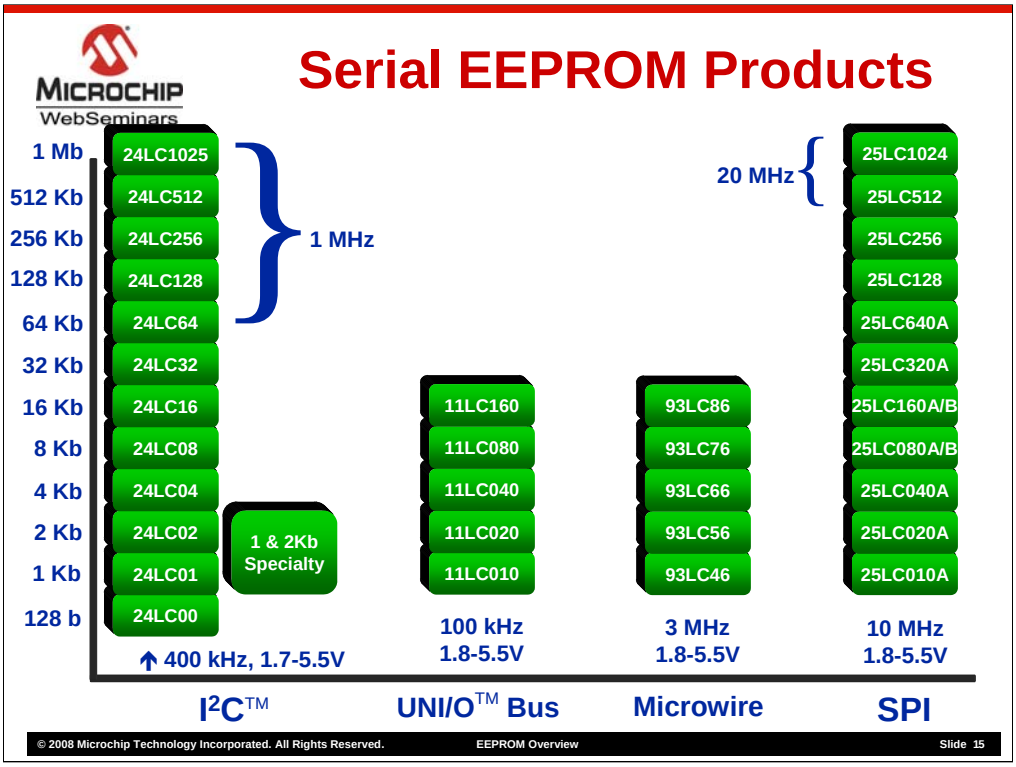
All products in this family start with a '24' prefix. It has a very wide density range – from 128 bits to 1 Mbit. The standard family has a maximum bus speed of 400 kHz, and our larger densities have 1 MHz versions. We also have several 1- and 2 Kbit specialty products used for applications like computer monitors and DIMM memory sticks.



Next is our UNI/O™ EEPROM family, which is available in 1 through 16 Kbit options. It has a voltage range of 1.8 to 5.5 volts and a maximum speed of 100 kHz. Remember that these new products require only 1 connection to the master.



Now, we'll look at the Microwire family. This family is also available in 1-16kb devices as limited by the Microwire protocol. The part numbering scheme starts with a 93 prefix and ends with 46 for 1 kb, 56 for 2 kb, and so forth. Although it has a narrower density range, Microwire is faster than I^2C and UNI/O parts at 3 MHz. And remember, this family has 4 signals, so it requires 4 micro I/Os as opposed to the 2-wire I^2C bus and the single wire UNI/O bus.



Lastly, here is the SPI product family, which also requires 4 I/O pins. Like the I^2C family, SPI has a very wide density range: from 1 Kb to 1 Mb. But, it also has much faster bus speeds – up to 10 MHz. Our 512 Kbit and 1 Mb devices have 20 MHz max bus speeds. But, SPI's speed and advanced data protection schemes do add to the die size, so SPI devices are a bit more expensive than similar devices in the other protocols.

Common Package Options

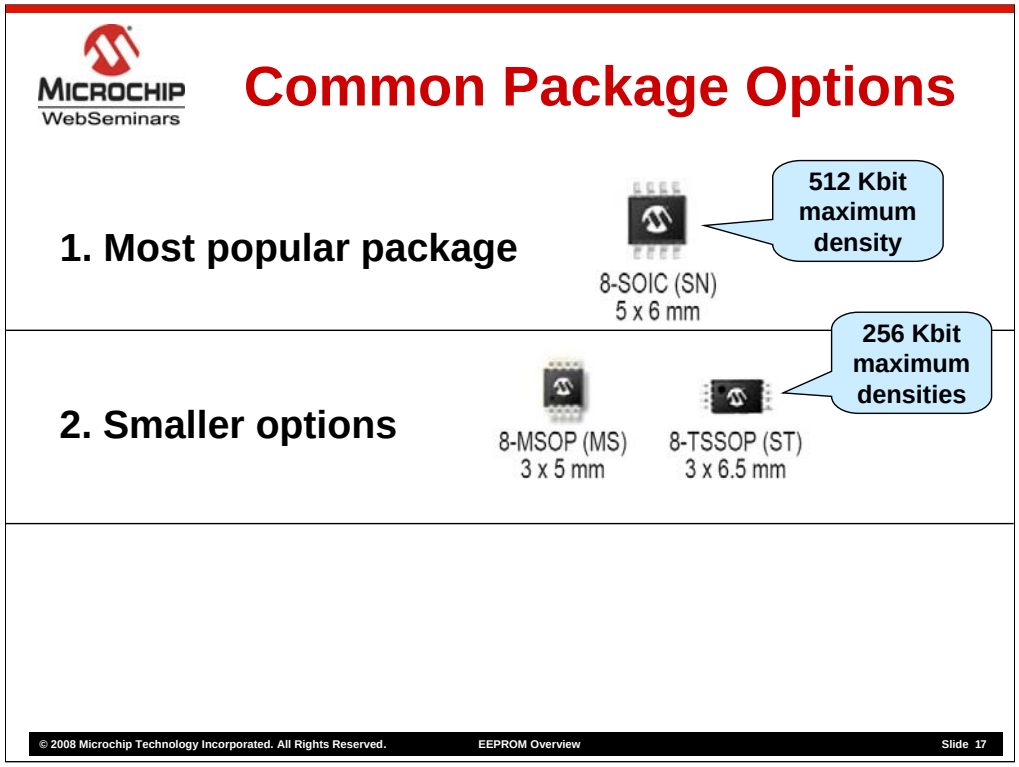
1. Most popular package

8-SOIC (SN)
5 x 6 mm

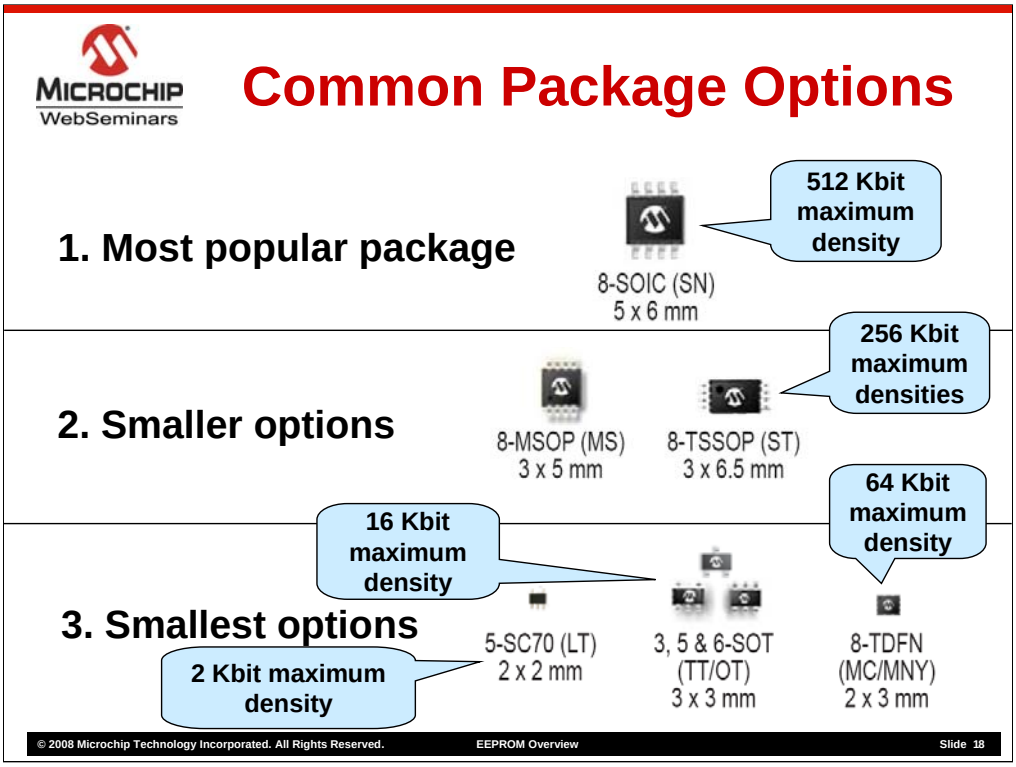
512 Kbit maximum density

This slide shows some of the more common EEPROM packages. All package photos are correctly scaled relative to each other. Under each package is its name and its footprint dimensions. I've also noted the maximum density that can fit into each package.

The most popular package is the 8-lead SOIC. It has a 5 x 6 mm footprint and can hold up to 512 Kbits.



The TSSOP and MSOP packages are also popular, and are smaller and thinner than the SOIC. Each can hold up to 256 Kbits.

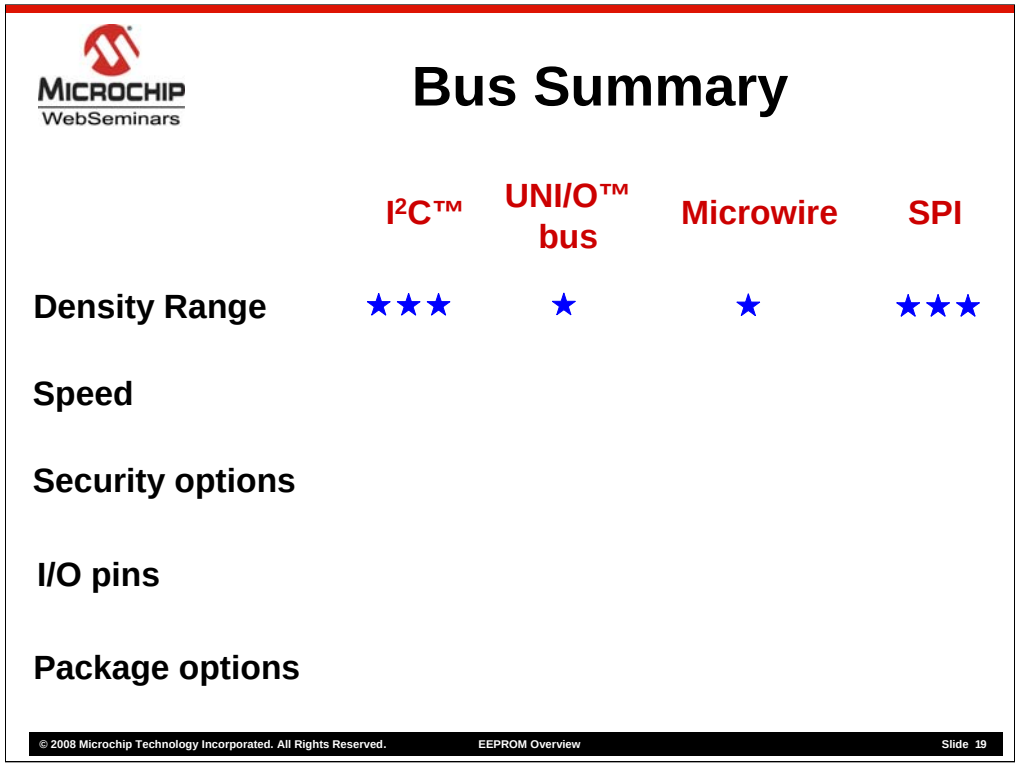


Our smallest packages are next: the 2x2 mm SC70 package is our smallest option, available in 1 and 2 Kbit devices.

The 3x3 mm SOT 23 package (in 3, 5 and 6 lead versions) can hold up to 16 Kbits.

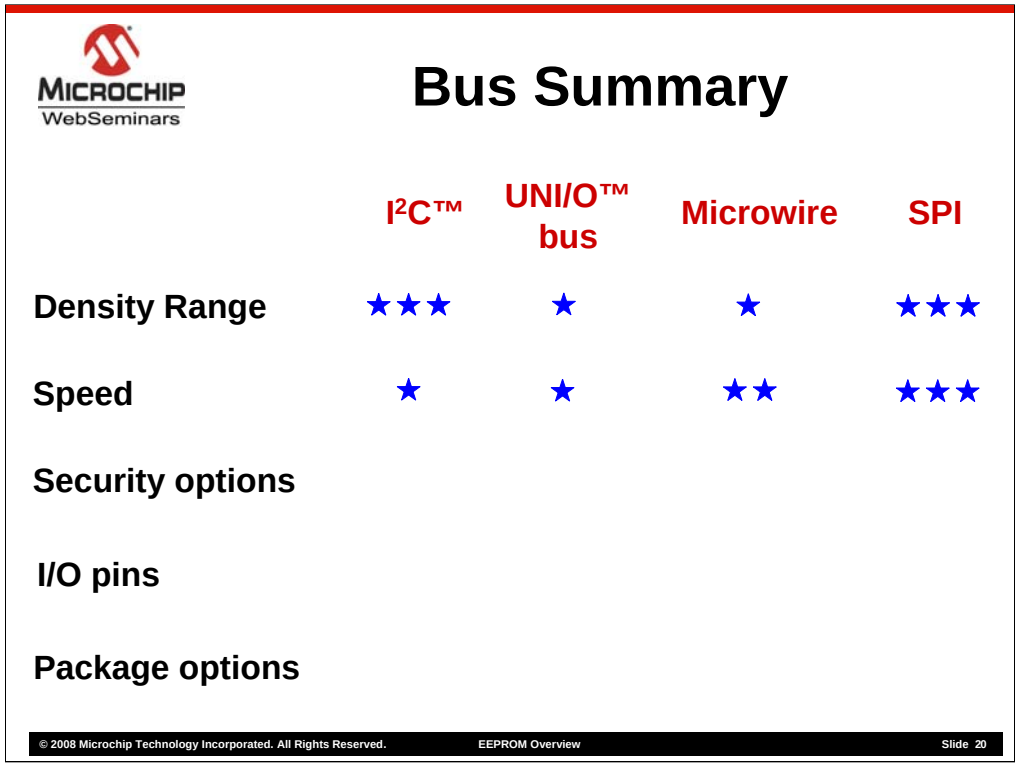
The 2x3 mm TDFN package is also very small and is less than 0.8 mm thick, making it an excellent choice for height-limited applications. It can hold up to 64Kbits.

Finally, just about all our products are available in die and wafer form.

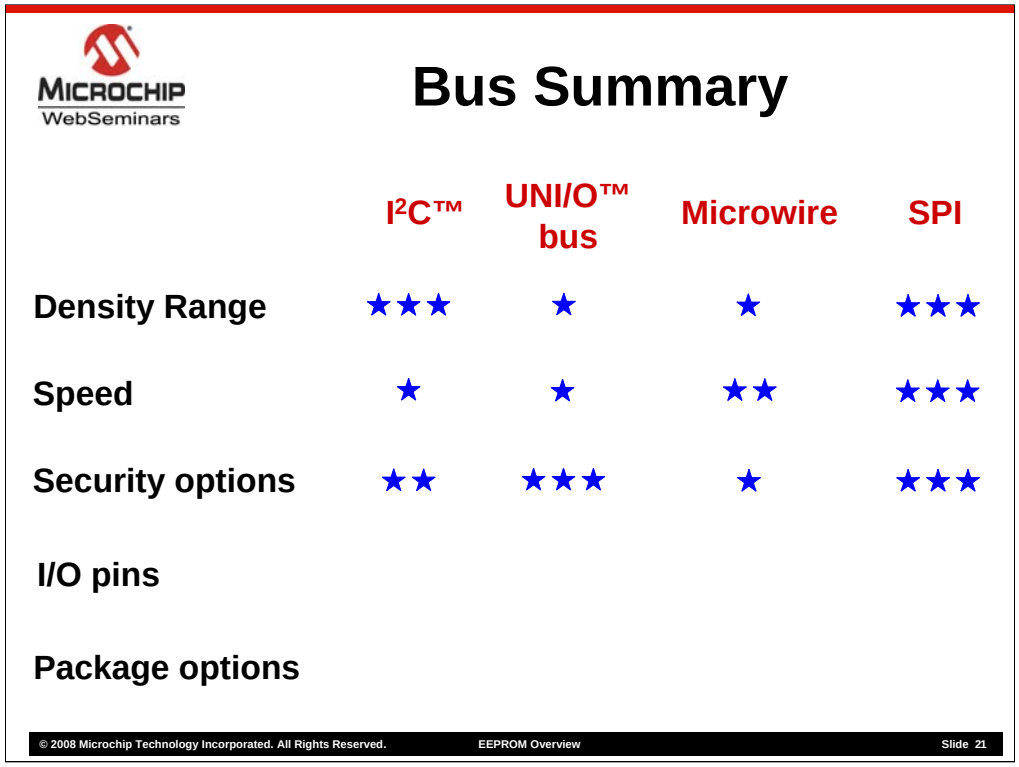


So, let's compare the 4 buses. Here's a chart that shows some key features of each protocol: density range, speed, security options, number of microcontroller I/O pins required, and package options. Under the heading for each bus, I've ranked that feature with 1 to 3 stars, with 3 stars being the best.

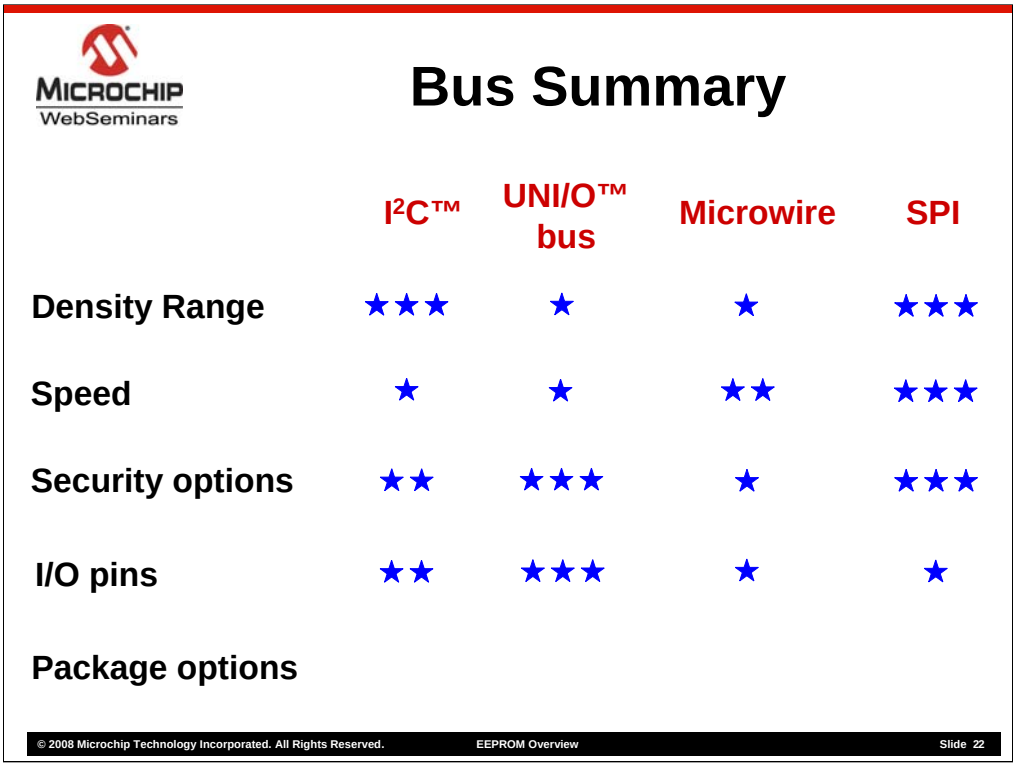
As we've discussed earlier I^2C^{TM} and SPI have the widest choices in density – all the way up to 1 Mb; so both these buses earn 3 stars in the density category. The Microwire and UNI/O™ buses have a comparatively limited density range of 1-16 Kb, so they only get 1 star.



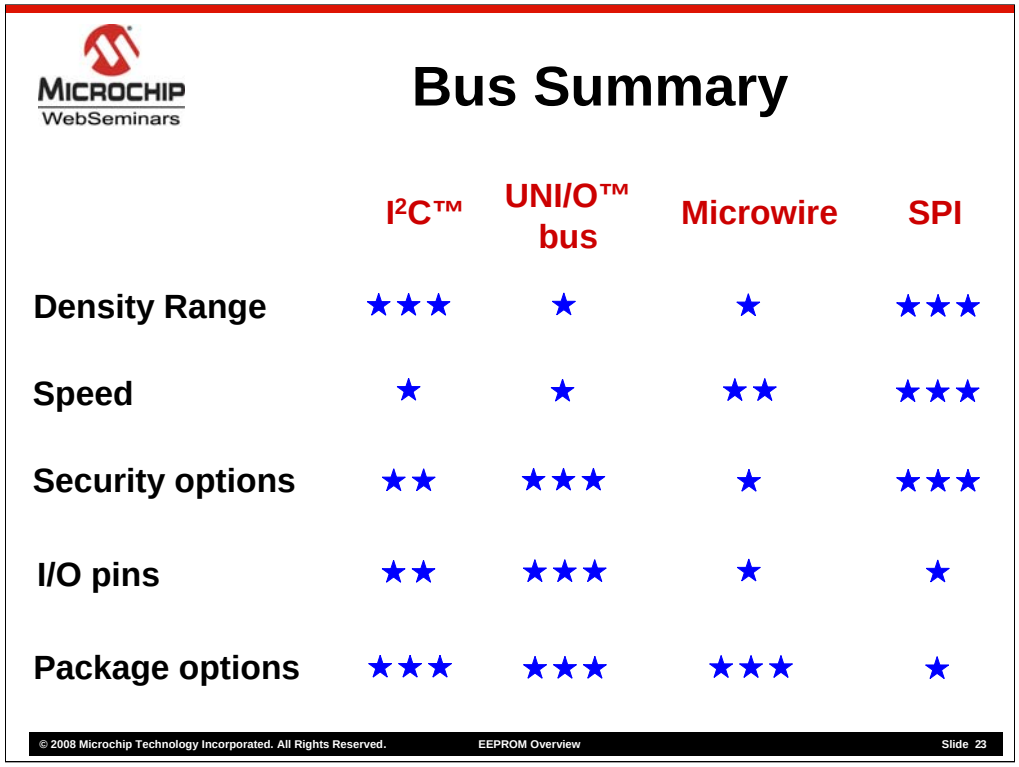
Next is speed: SPI has the fastest available bus speed, followed by Microwire. I^2C and the UNI/O bus are the slowest.



Now let's look at security: The SPI and UNI/O protocols have the widest range of security options, featuring both software and hardware data protection schemes. I^2C features only hardware write protect. And Microwire has the fewest data protection options.



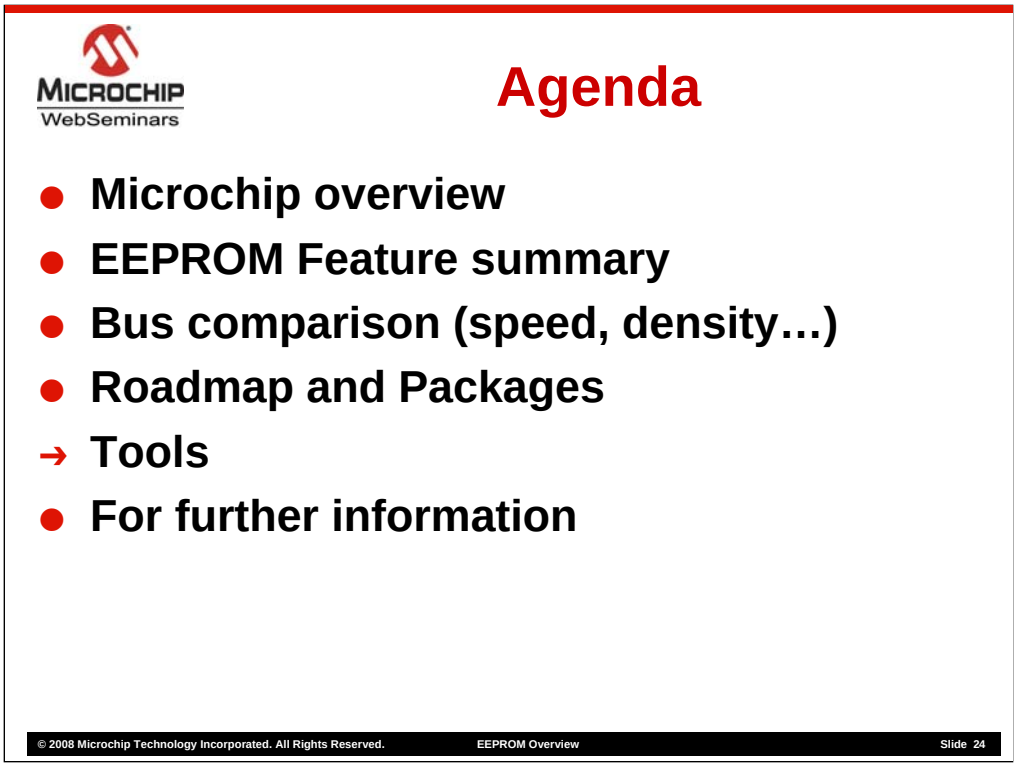
The UNI/O bus is clearly the best in terms of I/O pins used since it only requires one microcontroller pin. I^2C devices usually require 2 I/Os and Microwire and SPI parts require at least 4.



I^2C, Microwire and the UNI/O bus all score well in the small package category. SPI parts require slightly larger packages in most densities.

So, what's the best bus? That, of course, depends on the needs of the application. If speed is the most important factor, SPI or Microwire is the way to go. If speed at high density is most important, Microwire drops out and SPI is the clear choice. I^2C is the most popular bus, probably because of its wide density range, small packages, and modest I/O requirements. And, if you are pin-limited or space limited, a UNI/O device may be the best answer.

As you can see, there are a lot of choices. We offer the flexibility to optimize your design based on your application goals. Regardless of which protocol you choose, it is fairly simple to make the connection to a microcontroller. Many micros have specific ports for each of the buses, or general I/O ports can be used. We have a couple dozen application notes with code on our web site that explain how to connect devices of each bus type.



Let’s take a moment to recap our agenda.

First, we talked about Microchip’s long history of manufacturing non-volatile memory.

Then we talked about the general features of EEPROMs: small packages, low power, high endurance, byte-level flexibility, and operation under a wide range of temperature and voltage conditions.

Then we compared the features and advantages of each of the 4 major buses, including a look at our roadmap.

Now, let’s take a look at the tools we offer for our memory products.

MICROCHIP WebSeminars

EEPROM Design Tools

- **MPLAB® Starter Kit**
  - **Read, Write, or Erase any byte, block, or array**
  - **Supports all Microchip EEPROM devices**
- **Total Endurance™ Software**
- **Verilog models**

 EEPROM Overview Slide 25

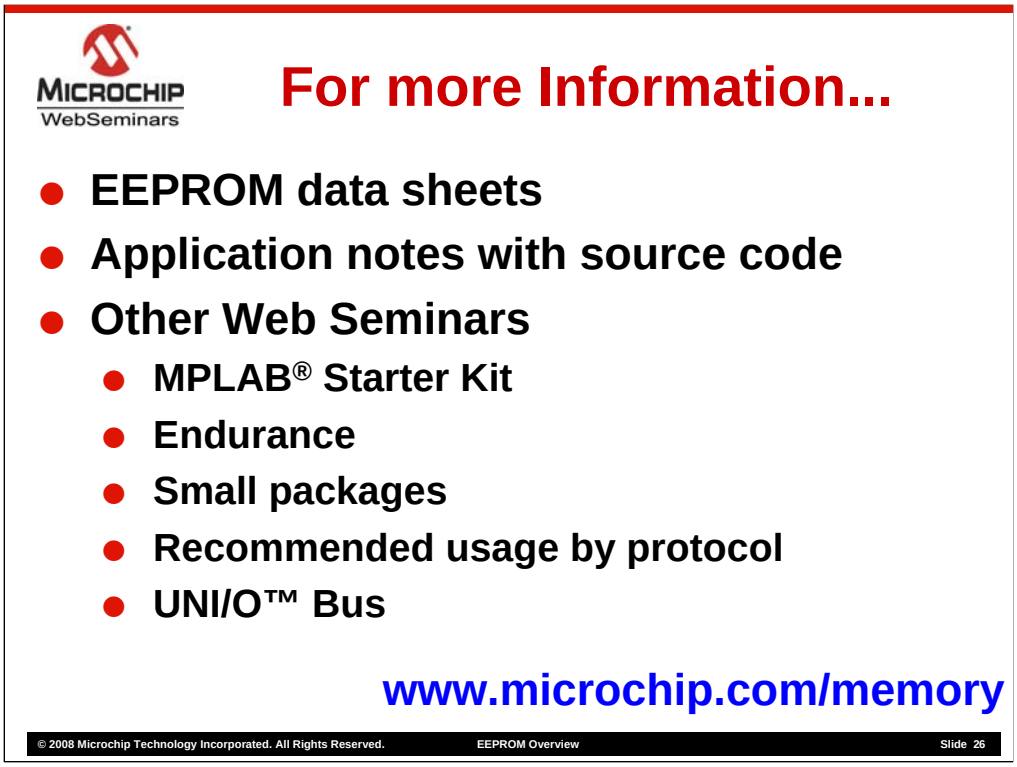
Our major EEPROM tool is the MPLAB® starter kit for serial EEPROM products. It is not just a memory programmer, but a debugging tool.

You can use the programming and read functions to write to or read from any Microchip serial EEPROM device. The tool features byte, block, and array functionality. And, you can transfer data to and from external files.

It's a very helpful, inexpensive debug tool. Our customers like its robustness, its user interface, and its simplicity.

I've already talked about our second major tool: The Total Endurance™ modeling software. Recall that understanding endurance can be crucial. In this free, downloadable software, you can enter application-specific data to model the expected endurance of that application.

Finally, we offer a large number of Verilog models on our website for download.



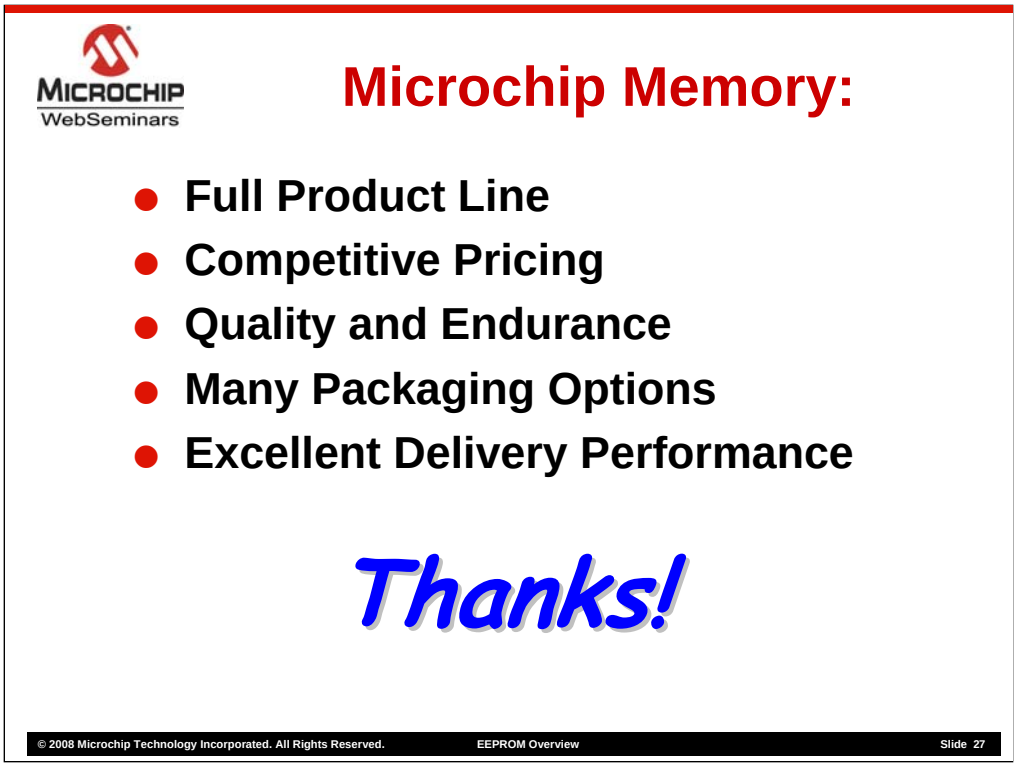
We're just about to the end of this seminar, and we've really just hit the highlights of this product line. There is a lot more information available on our web site.

For more information on the different bus protocols, check out our product data sheets. These have excellent functional descriptions including timing diagrams, command descriptions, and electrical specifications.

We also have many application notes that explain how to connect an EEPROM to a microcontroller using all 4 buses.

Finally, we have more EEPROM web seminars, including ones about our MPLAB® Starter Kit, endurance (with a tutorial on the Total Endurance™ software), small package options, usage recommendations for each bus, and details on the new UNI/O™ product line.

All these can be found on our memory home page at www.microchip.com/memory.



This wraps up today's seminar. In closing, I'd like to reiterate the following advantages of Microchip's EEPROM product line.

We offer a full line of serial EEPROM products in all 3 major bus types. And don't forget our UNI/O™ line of single-I/O EEPROM products.

We offer competitive pricing. We understand that cost is an important component of product selection.

All our EEPROM products have industry-leading quality and endurance.

We are also the industry leader in small packaging options including a broad range of products in SOT 23 and 2x3 DFN packages.

Finally, we understand how important delivery is to our customers. Because we own our own fabs and our own assembly/test facility, we have historically had excellent delivery performance, especially during up-cycles when memory product availability tends to become tight.

Thanks for your time.

Please take a look at some of the other excellent seminars we have prepared for you or take a look at some more memory information on our web site.