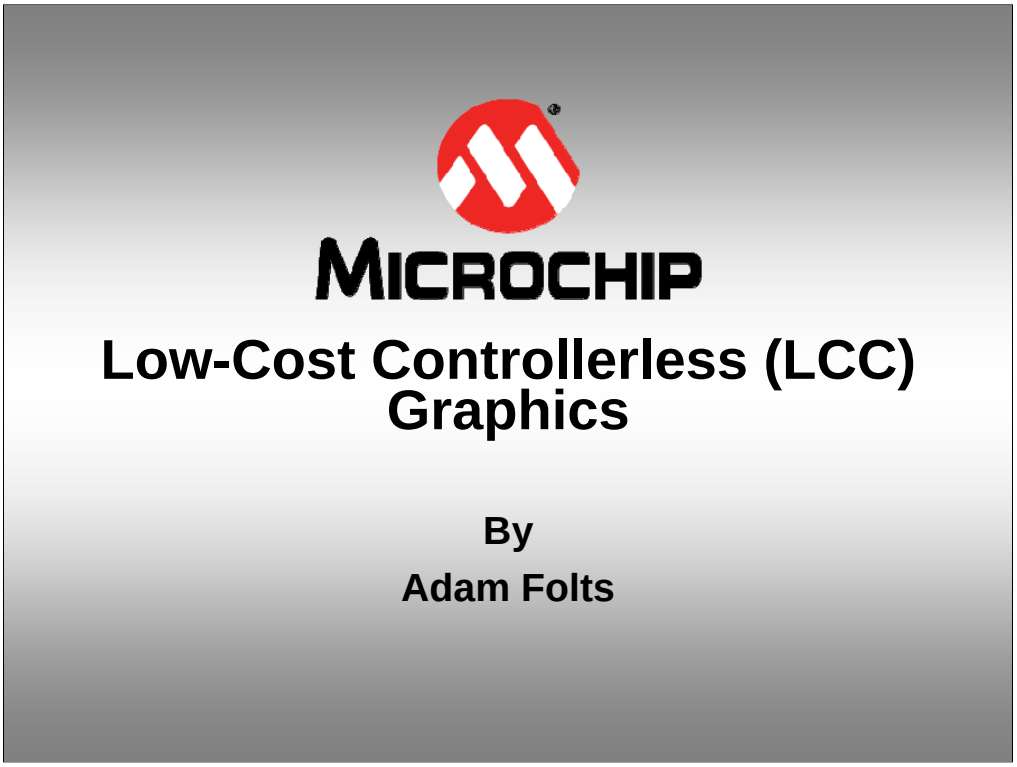
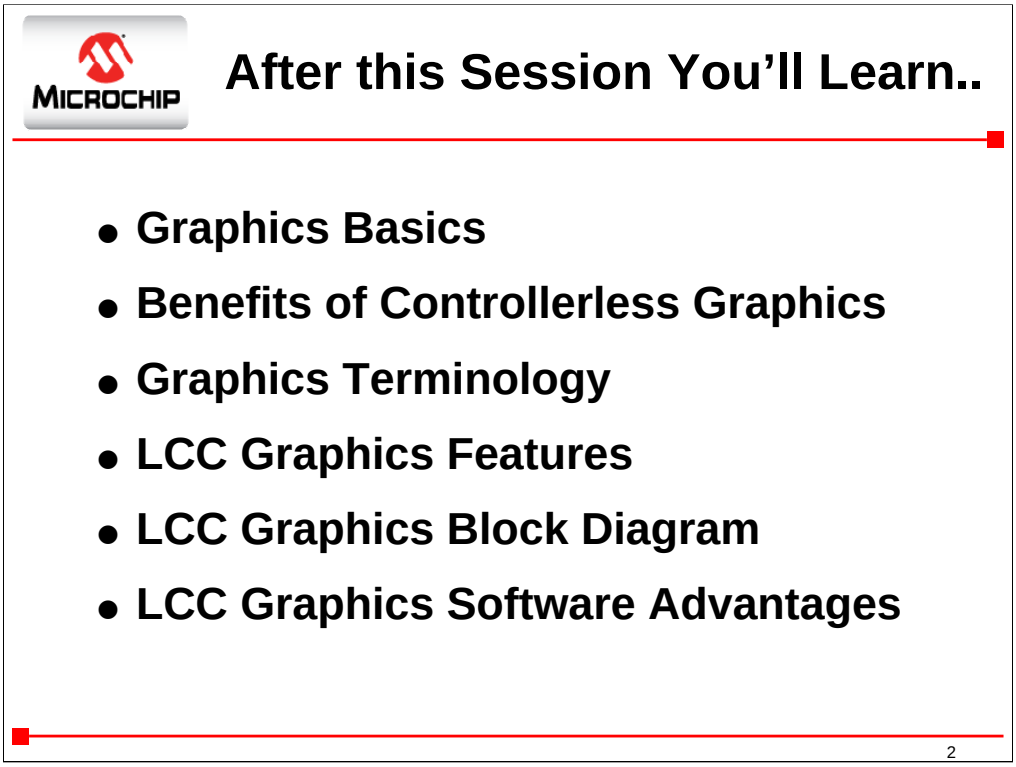


Hello, my name is Adam Folts. I am an Applications Engineer at Microchip. This webinar discusses the Low-Cost Controllerless Graphics PICtail Plus Daughter Board, and its features.



After this Session, You'll learn:

The basic graphic systems that are seen in the worldwide market.

The benefits of controllerless graphics over the other graphics systems.

Some basic graphics terminology to help aid in the discussion.

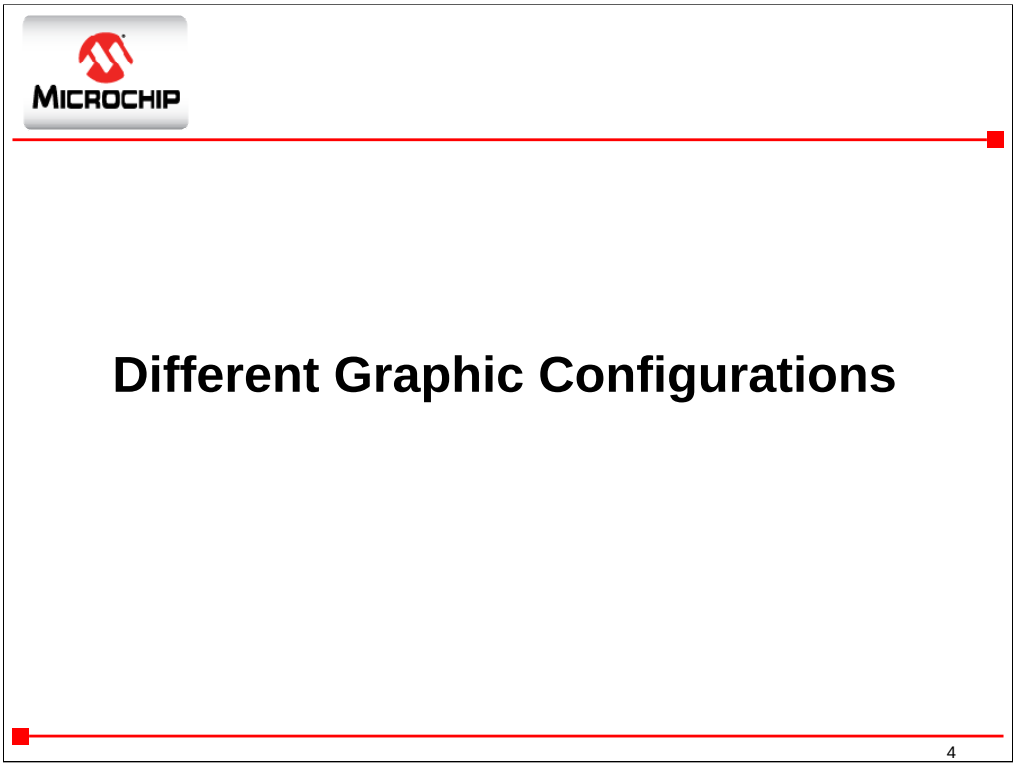
Specific information on the LCC graphics board including features, diagram, and software advantages.

Graphical User Interface Example Applications

- **Consumer**
  - Thermostats
  - Cordless Phones
  - Remote Controls
- **Home Appliance**
  - Coffee Makers
  - Washing Machines
  - Ovens
- **Industrial**
  - Digital Instrument Gauges
  - Storage Controls
  - Remote Terminals
- **Portable Medical**
  - Glucometers
  - Blood-Pressure Monitors
  - Portable ECGs

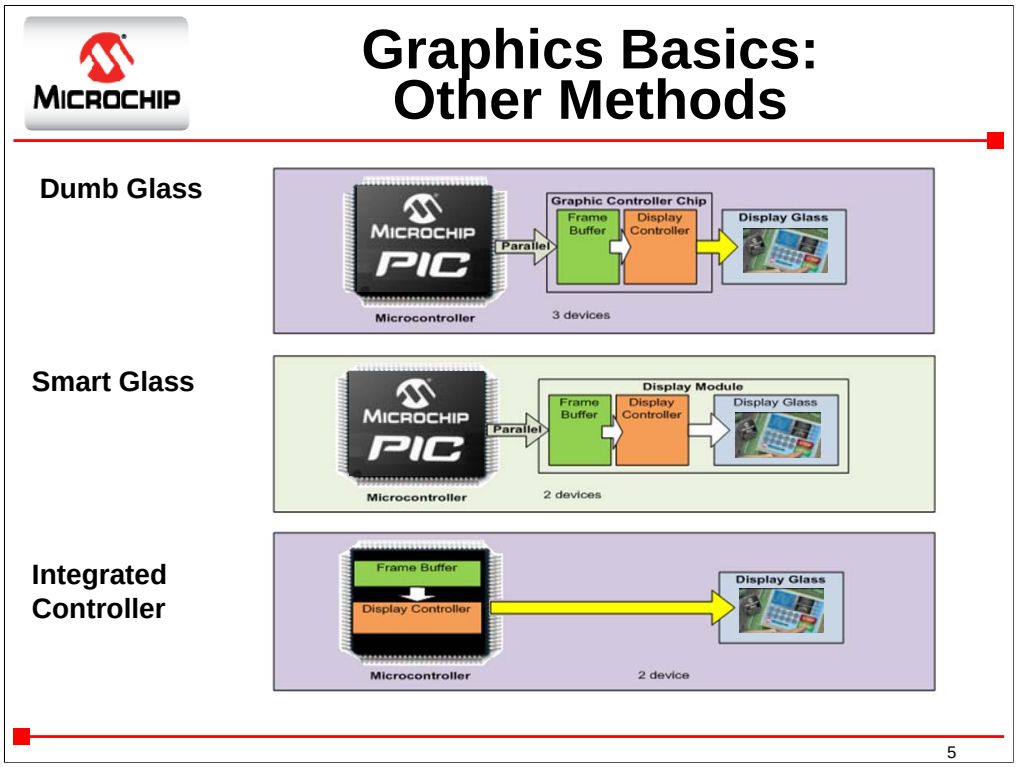
3

Graphical User Interfaces are being seen in more and more user applications such as thermostats, coffee makers, remote terminals, and other portable devices. They offer an easy way to control hardware while at the same time offering graphics for the front end. As these applications are becoming more and more common, the price of a typical LCD panel is dropping.



The first section is about the different graphics setups and will cover four types, which are:

1) External Graphics Controller (found in glass)
2) External Graphics Controller
3) Internal Graphics Controller
4) Controllerless Graphics

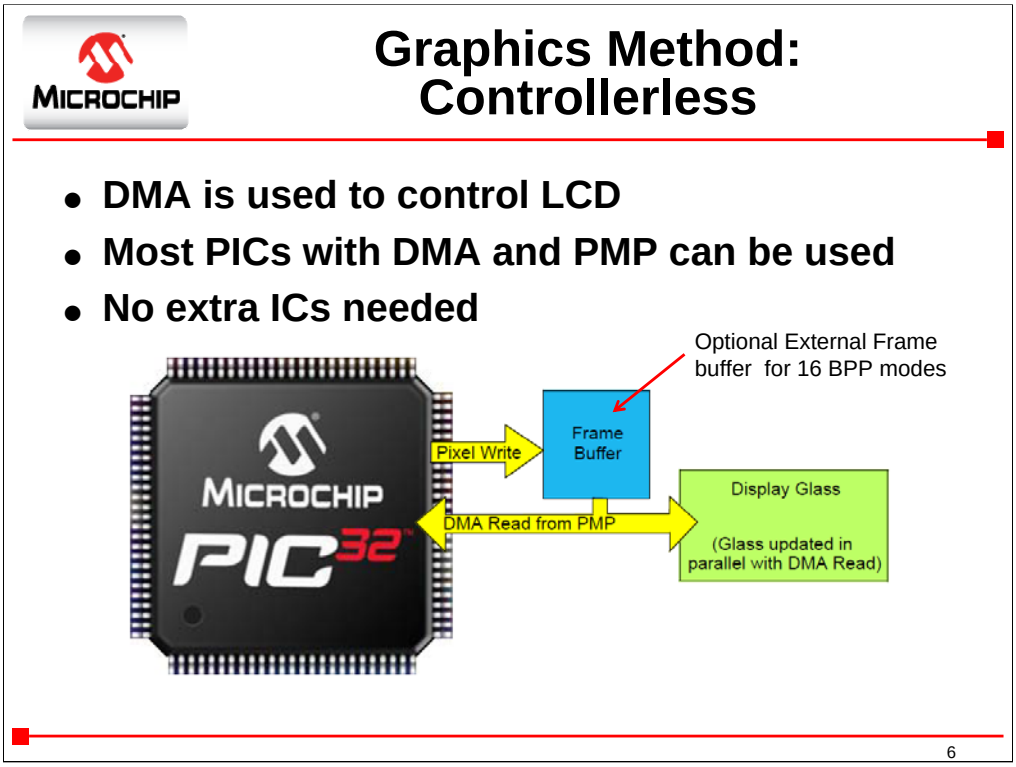


There are four types of graphics system methods discussed in this webinar.

The first type is using a dumb glass. The term “dumb” comes from the fact that the LCD panel itself does not contain an on-board graphics controller. This method involves the use of an extra controller, which adds cost.

With smart glass, the LCD panel itself offers an on-board graphics controller. These systems can be affordable at first; however, if the LCD panel is no longer produced, another solution would have to be developed, making it not a long lasting solution.

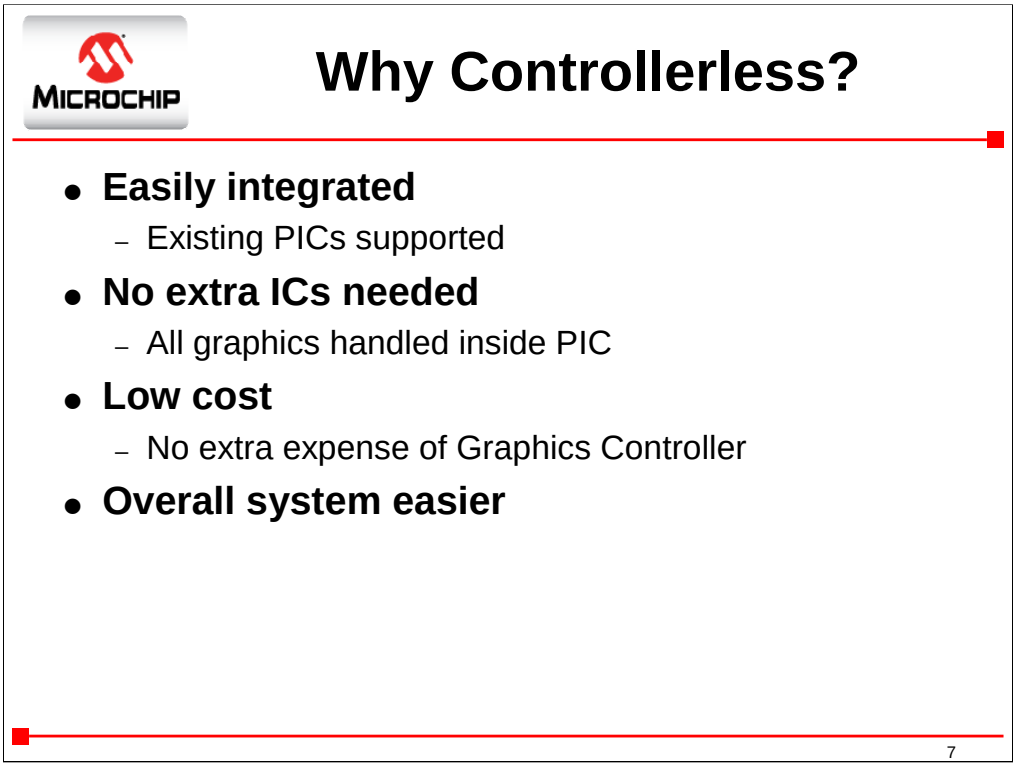
The third type is driving graphics with an integrated controller. In this method the microcontroller has a built-in graphics module to help drive graphical systems. This feature is nice, but is limited to specific processors, and therefore, is not versatile. Also, the processor may be missing important features or peripherals needed for your embedded applicatoin.



The last method discussed in this webinar is the controllerless method. This method creates a “virtual” graphics module inside a processor by using on-board peripherals. In the case of this process, it uses the DMA and PMP peripherals found on the PIC32.

A nice feature of the DMA is that once it is configured to write/read data, it does so without CPU intervention. This means the CPU is not loaded by driving the LCD panel.

This method is VERY low cost, and can be done on many PICs with DMA and PMP. It is easy to take an existing PIC32 system and upgrade it to one with graphics without having to learn a new product family.

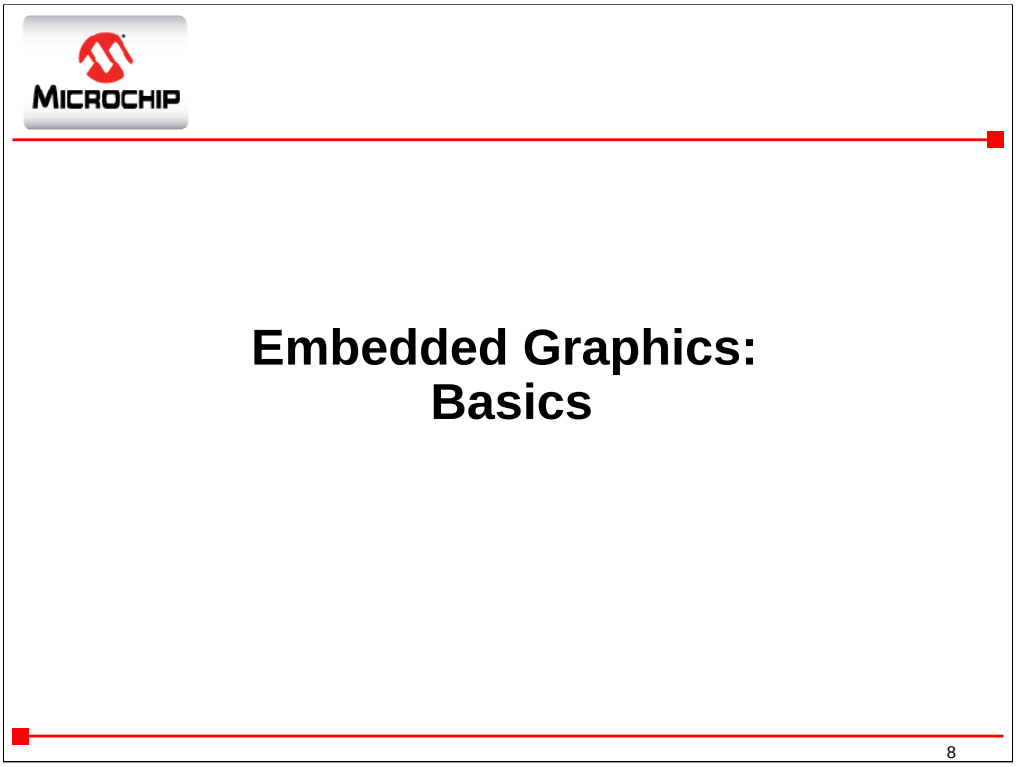


You may be asking youself, why controllerless?

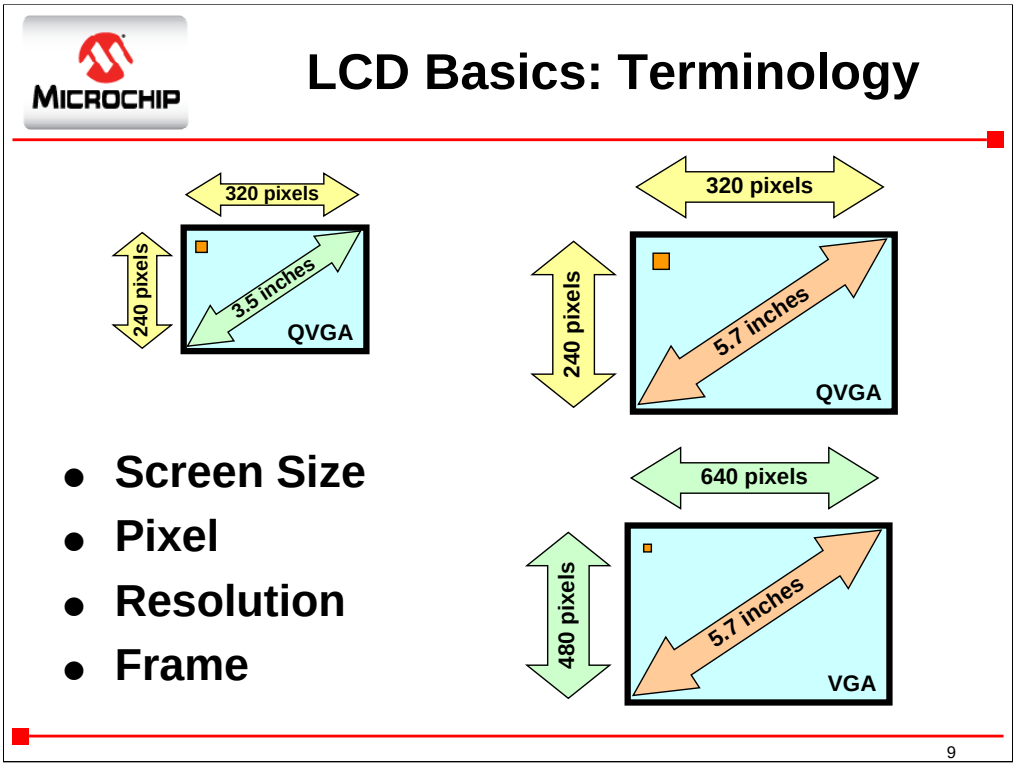
A controllerless method offers easy integration, since it works on many PICs with DMA and PMP.

This solution does not require the use of any extra ICs, which in the end is a cost reducer. There is no extra expense of the graphics controller, and in some cases external SRAM.

The system also becomes easier to produce, since there are fewer ICs and less communication taking place.



This section of the webinar covers some basics of graphics and graphics terminology to help assist in understanding this webinar.



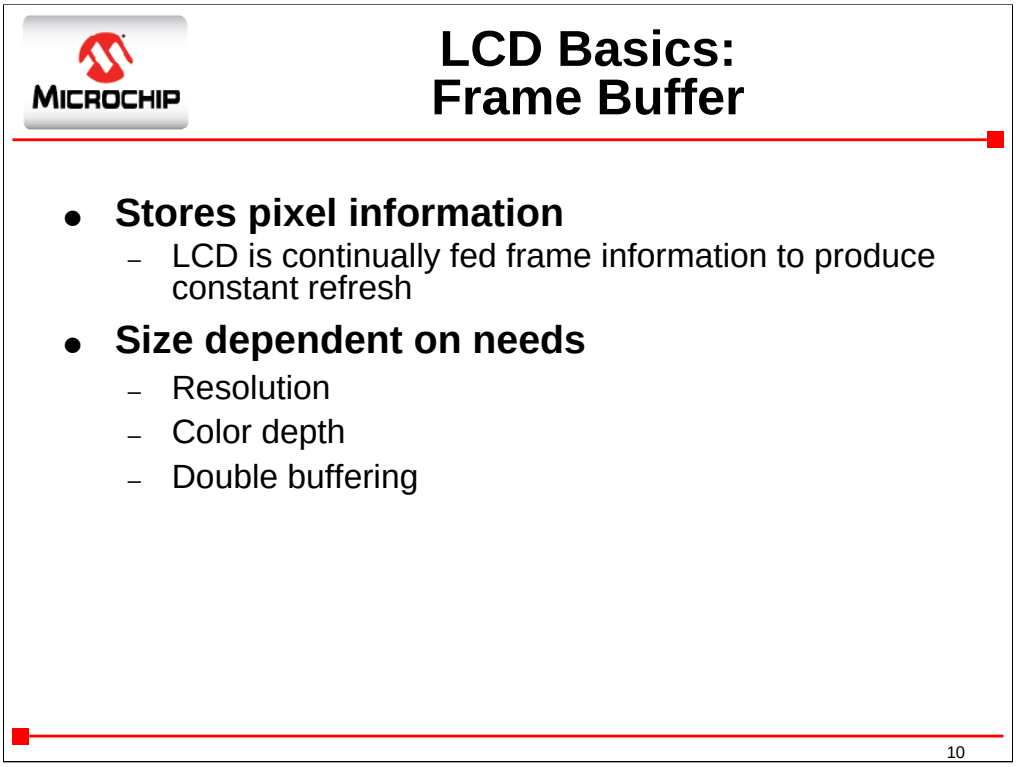
When choosing or discussing LCD panels, various words come up. These words include screen size, pixel, resolution, and frame.

Screen size refers to the diagonal size of the screen.

Pixel refers to one dot of color that appears on the screen.

Resolution refers to how many pixels a screen has. Some common ones are QVGA, VGA, and WQVGA. They are standards and are defined as such. Resolutions are not restricted to screen sizes.

A frame is the amount of bytes needed for all the pixels of a certain resolution. So a frame for QVGA, which is 320x240 pixels, and where each pixel is one byte, the frame would be 320x240 or 76,800 bytes.



A frame buffer is a place where the frame is stored. It is needed for LCD graphics systems so that the LCD panel can be continuously refreshed. The frame is then sent continuously to the LCD panel. This is how panels refresh at 60 Hz, or output the image frame buffer 60 times a second.

Frames for the Low Cost Controllerless PICtail Plus Daughter Board are handled by SRAM. Depending on the frame size, the buffer can be contained inside the PIC32. External SRAM is needed if the PIC32 does not provide enough SRAM.

Also, in some systems, customers may prefer multiple buffering. In this case, there must be sufficient amounts of memory to contain these multiple frames

Resolution and Buffer Size

Resolution	X Resolution	Y Resolution	Pixels	Color Depth (bpp)	Colors	Bytes Required
1/16 VGA	160	120	19,200	1	2	2,400
1/8 VGA	240	160	38,400	1	2	4,800
QVGA	320	240	76,800	1	2	9,600
1/16 VGA	160	120	19,200	8	256	19,200
1/8 VGA	240	160	38,400	8	256	38,400
QVGA	320	240	76,800	8	256	76,800
1/16 VGA	160	120	19,200	16	65,536	38,400
1/8 VGA	240	160	38,400	16	65,536	76,800
QVGA	320	240	76,800	16	65,536	153,600
1/16 VGA	160	120	19,200	18	262,144	43,200
1/8 VGA	240	160	38,400	18	262,144	86,400
QVGA	320	240	76,800	18	262,144	172,800

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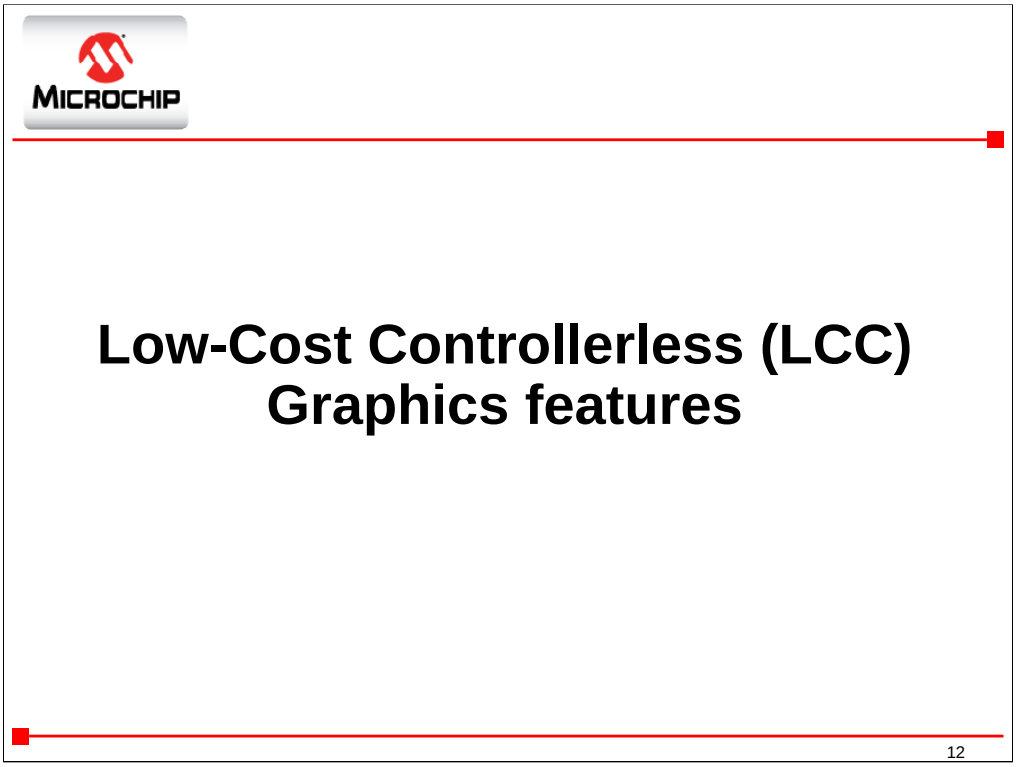
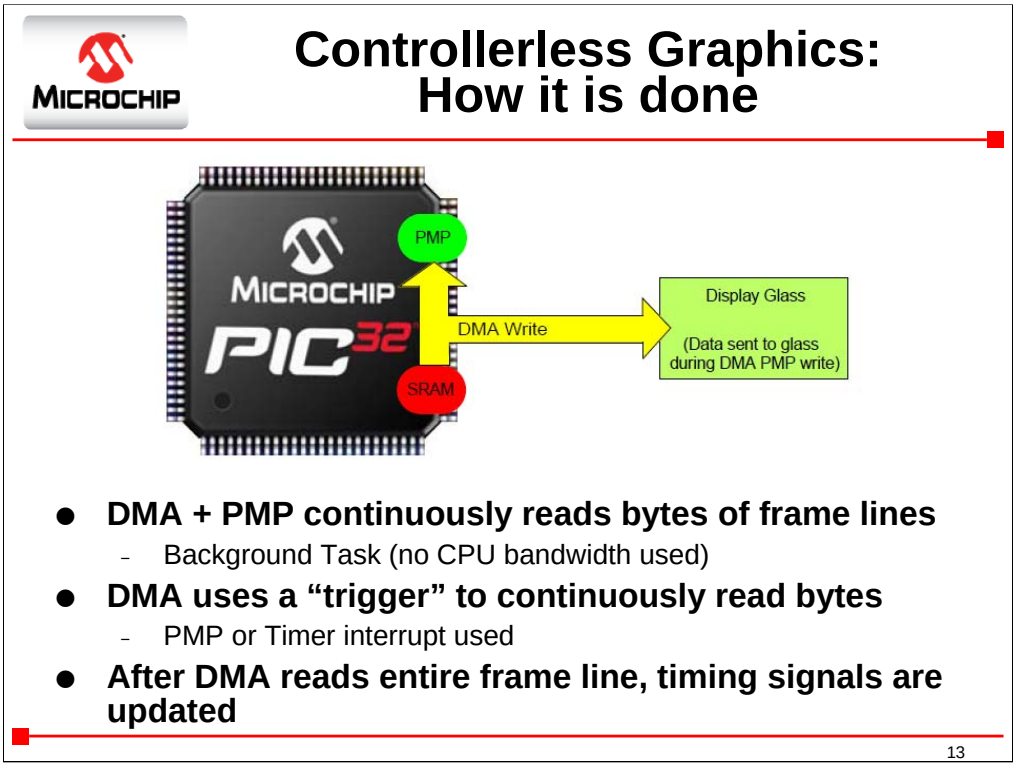
The LCD color depth and resolution defines the requirement for the image buffer to store data being displayed. This slide shows some typical configuration and memory requirements. The formula to calculate image RAM requirement is resolution multiplied by bytes per pixel.

In the case of QVGA 18-bit color, each pixel needs 18-bit data. We need 320 x 240 x 18 /8 bytes of RAM, which assumes digital logic can handle 18-bit. If standard peripherals are used, they either have a 16-bit interface or an 8-bit interface is used to get 24-bit data. The 24-bit data storage will waste some RAM. It is quite common to use 16-bit data and not use 2 Least Significant Bytes in color depth. This doesn't have any significant impact on picture quality. In case of 16-bit data, the common trend is to use 5 bits to represent Red, 5 for Blue, and 6 for green.

The LCC Graphics method allows for different fame sizes, but the daughter board is limited to 8 BPP and 16 BPP color modes.



The next section will cover the Low-Cost Controllerless PICtail Plus Daughter Board and its features.



The controllerless graphics method is done using two peripherals on the PIC32. They are the DMA and PMP.

Direct Memory Access, or DMA, is a peripheral that can access memory without interrupting CPU time. It is set up to send one line of frame data at a time to the LCD. At the end of each line read, proper timing signals are updated. These timing signals are HSYNC,VSYNC, DEN lines. These signals help the LCD panel know the proper frame position at all times.

The Parallel Master Port, or PMP, is used to clock the LCD panel. LCD panels are clocked with pixel data continuously. The read strobe of the PMP is used for this clock. The PMP can also keep the DMA transferring data by setting its interrupt flag. This helps "trigger" the next DMA transfer.

Depending on the controllerless method chosen, a minimum of around twelve I/O lines are needed. This keeps many I/O lines free for other uses and application support.

Controllerless Graphics: Software Advantages

- **Low MIPs usage**
- **Ample MIPs remain for other features:**
  - USB
  - Ethernet
  - Touch
  - Wi-Fi
  - more…

Digital Photo Frame using USB, Touch and Wi-Fi

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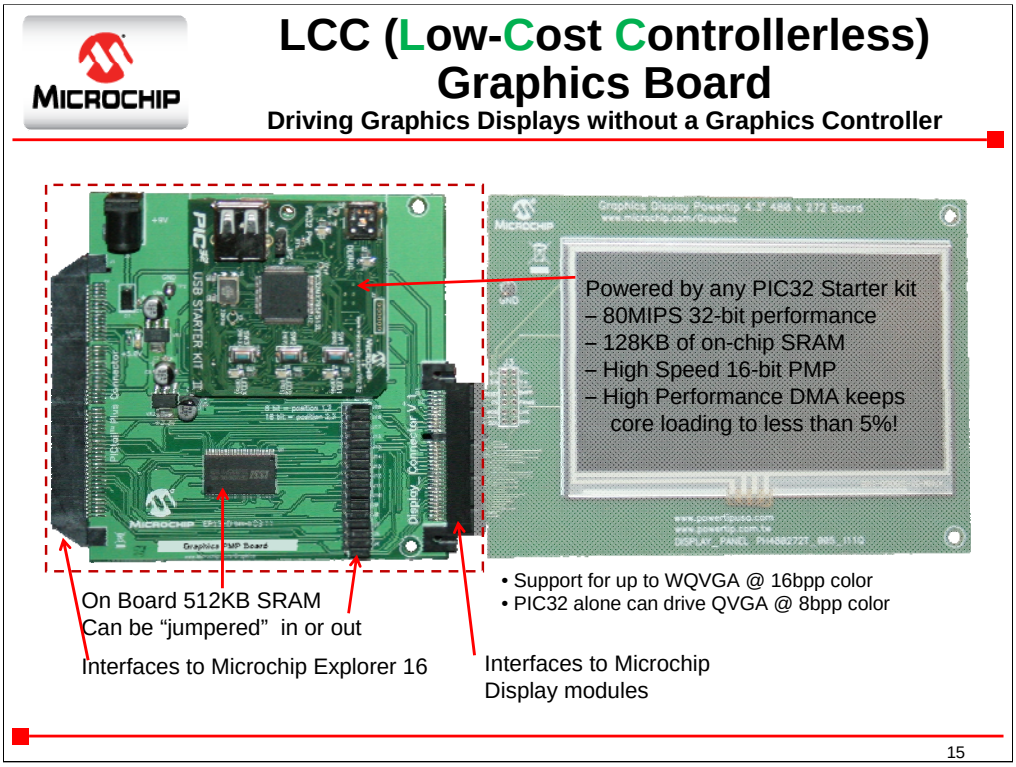
The controllerless graphics method does come at some CPU cost and does use up some MIPs of the PIC32. This is because at the end of each line transferred, the DMA is reconfigured and timing lines are updated.

This interrupt is run many times per second to maintain the refresh rate. The controllerless graphics method uses up to 5 MIPs to run depending on internal or external SRAM methods. This means there are still 75 MIPs remaining that are available for other applications.

Other applications could include USB, Ethernet, mTouch, or Wi-Fi, as the PIC32 offers software and hardware solutions for all of these applications.

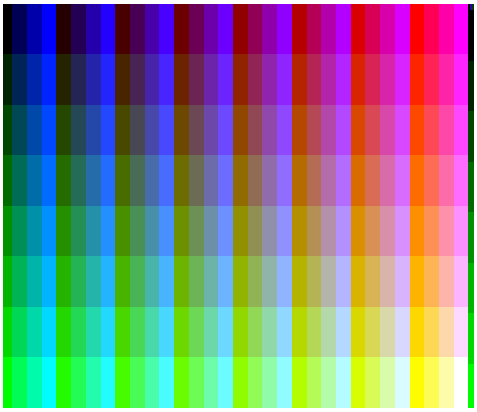
The DMA interrupt has to have priority over all other interrupts; otherwise, the LCD panel timing will be affected.



The Low-Cost Controllerless PICtail Plus Daughter Board showcases controllerless graphics support. It has two methods available for driving graphics using internal or external SRAM. The external on-board SRAM can support up to 512 k bytes of SRAM memory. The PIC32 has enough memory to drive a QVGA panel at 8 Bpp using only internal SRAM. The board can be used with an Explorer 16 Development Board, or with many starter kits, like the PIC32 Ethernet Starter Kit. Also, with the Display Connector V1 this board can be hooked up to many LCD display panels from Microchip including the Truly 3.2" QVGA board and the 4.3" WQVGA Powertip display panel.

LCC Graphics PICtail™: Internal Frame Buffer

- Supports 8bpp color on QVGA
- No external SRAM
- PIC32 SRAM used for frame buffer
- Color Look-up Table (CLUT)



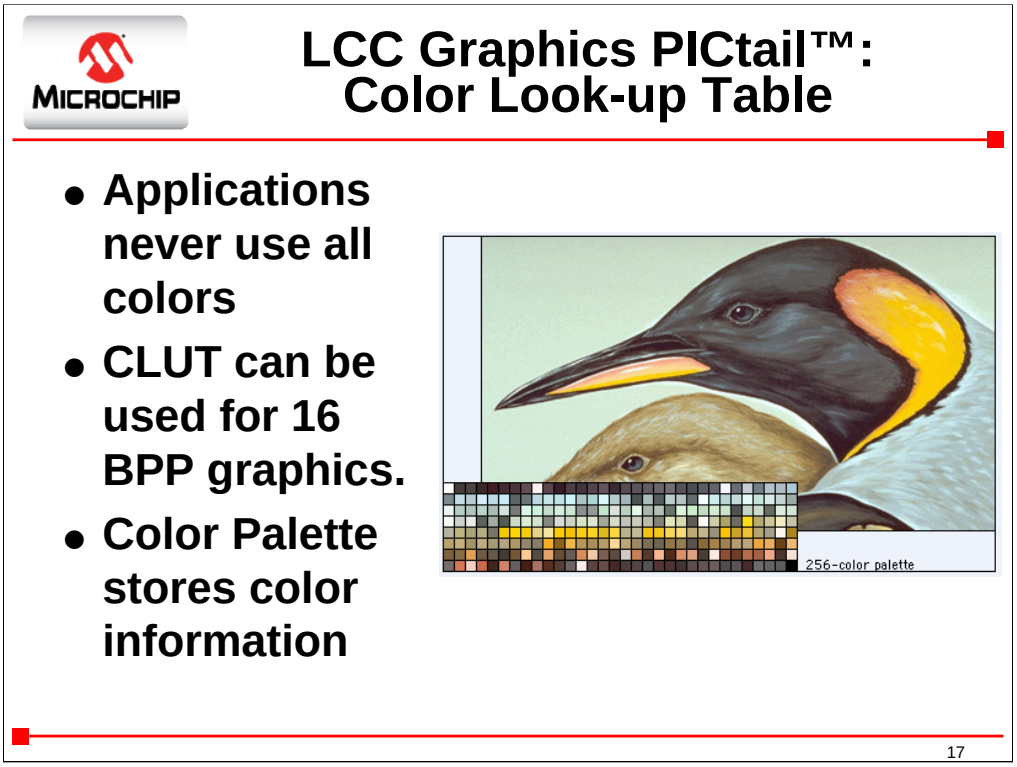
256 colors available with 8bpp

16

The internal SRAM method requires no external IC. The entire frame buffer is stored in PIC32 memory. As of now, microchip can handle 8 BPP color depth with QVGA resolution. This gives the application 256 color choices. A chart of the colors available is shown. With these colors, a meaningful graphical user interface can be created.

As SRAM sizes increase in PICs, then so will the color capabilities with this method. Pixels are updated by writing to SRAM memory locations inside the PIC. The DMA transfer works in conjunction with this pixel manipulation.

Another features available is a color look up table. With a color look up table an application can support 16 bit color by storing all the colors used in a system inside a color look up table.



Most applications call for nice color and images, yet although 1000s of colors are available, most end up with a certain scheme or pallette. This pallette be turned into a color look up table.

Another feature of the LCC Graphics PICTail is its ability to use a color look up table. This method is used with the internal frame buffer to help add more color depth to the demo without increasing frame buffer size. In most cases it reduces frame buffer size, since the frame buffer will store the CLUT index value instead of the actual color for a given pixel.

This feature has a high MIPS overhead of around 30 MIPS, but saves the need for an external volatile memory being added to the system just to achieve more colors in an application. Microchip's Graphics Library comes with an example demo of how to use and create a pallette effeciently.

LCC Graphics PICtail™ External Frame Buffer

- **Supports 16bpp color on QVGA**
- **External SRAM on LCC Graphics PICtail™ for frame buffer**
- **13MHz pixel clock achieved**

16bpp makes many colors available

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The external SRAM method requires the use of an external SRAM. The entire frame buffer is stored there. As of now, microchip can output a max pixel clock of 13 MHz to send the pixel frame to the LCD panel. With this clock frequency an LCD with WQVGA resolution can have a refresh rate of 60 Hz. Pixels are updated by writing to SRAM memory locations externally. The DMA transfer is halted while a pixel is being updated.

Graphical Tools Support

- **Microchip offers widgets and programs to implement embedded GUIs quickly**
  - Graphics Library
  - Graphic Display Designer
  - Graphic PICTails
  - Graphics Displays

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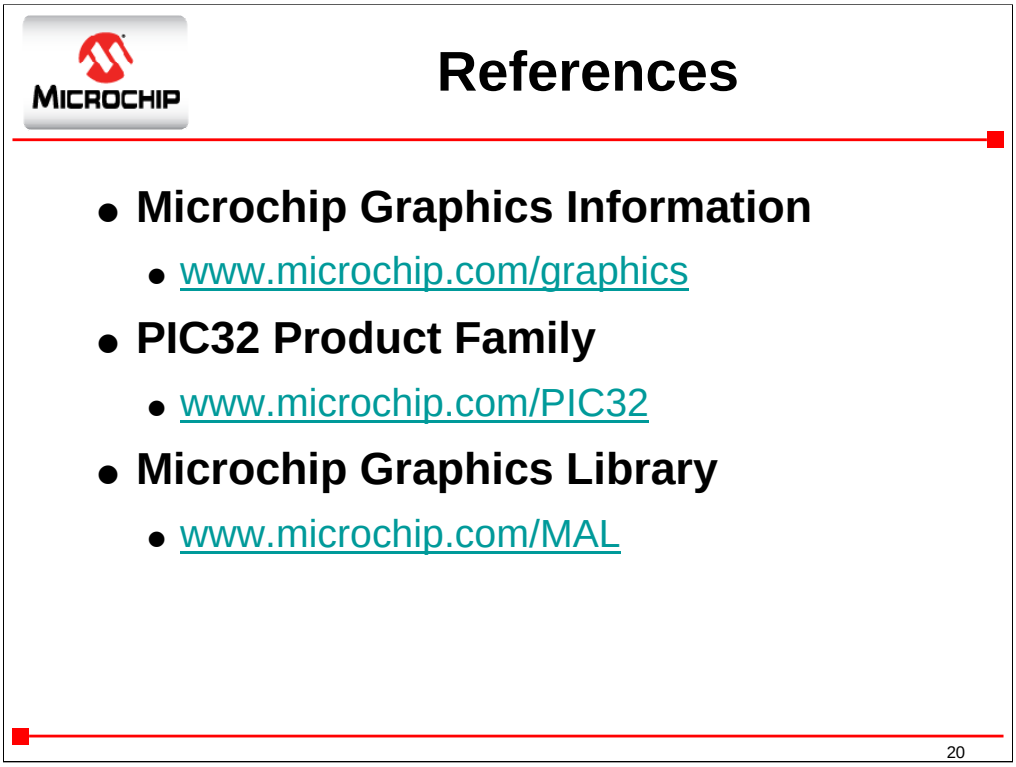
This board is supported by the Microchips Graphics Library, which is part of Microchips application library also known as MAL. This FREE library contains many widgets and features to make integrating graphics into a system easy. There is also a Graphics Display Designer utility to make creating the graphics user interfaces or GUIs easier as well. All these tools and libraries work with many different graphics hardware available from Microchip. For more information on this library please visit www.microchip.com/graphics.



For more information on anything discussed in this webinar, please visit the websites listed.

Thank you for watching the webinar. I hope the information provided has given you a better understanding of the low-cost controllerless solution offered by Microchip and has gotten you interested in applying this to your application.