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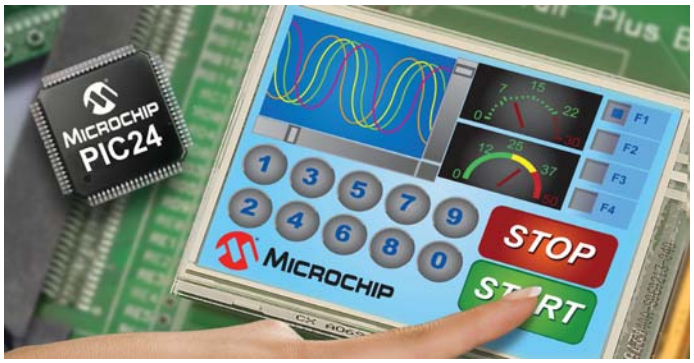
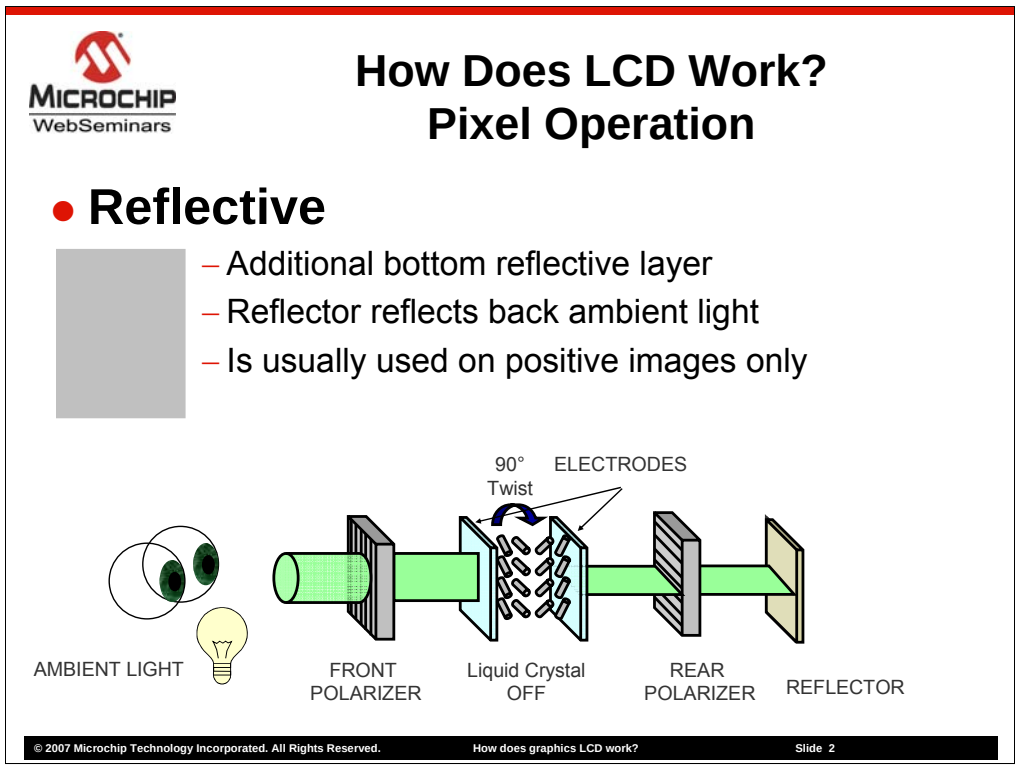


How does a graphics LCD work?

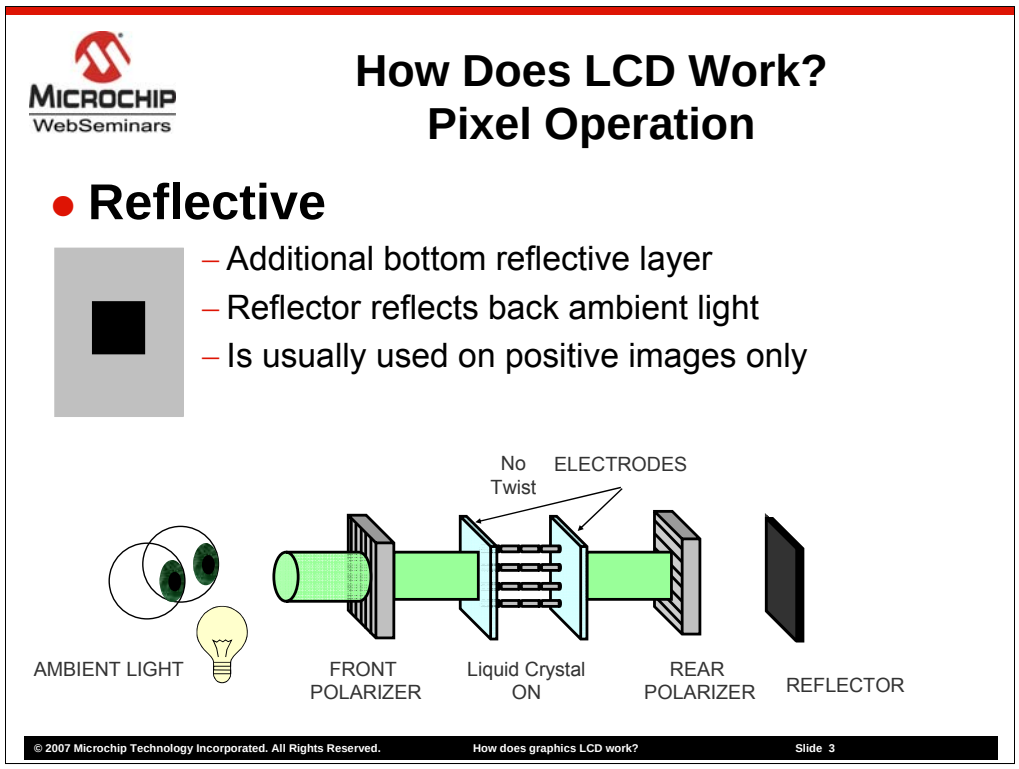
-Hello, my name is Gaurang Kavaiya and I am the PIC24F Applications Group Manager at Microchip.

-This session explains how a graphics LCD works and makes you familiar with some commonly used terminology

-It consists of 10 pages and it is estimated that it will take little less than 20 minutes.



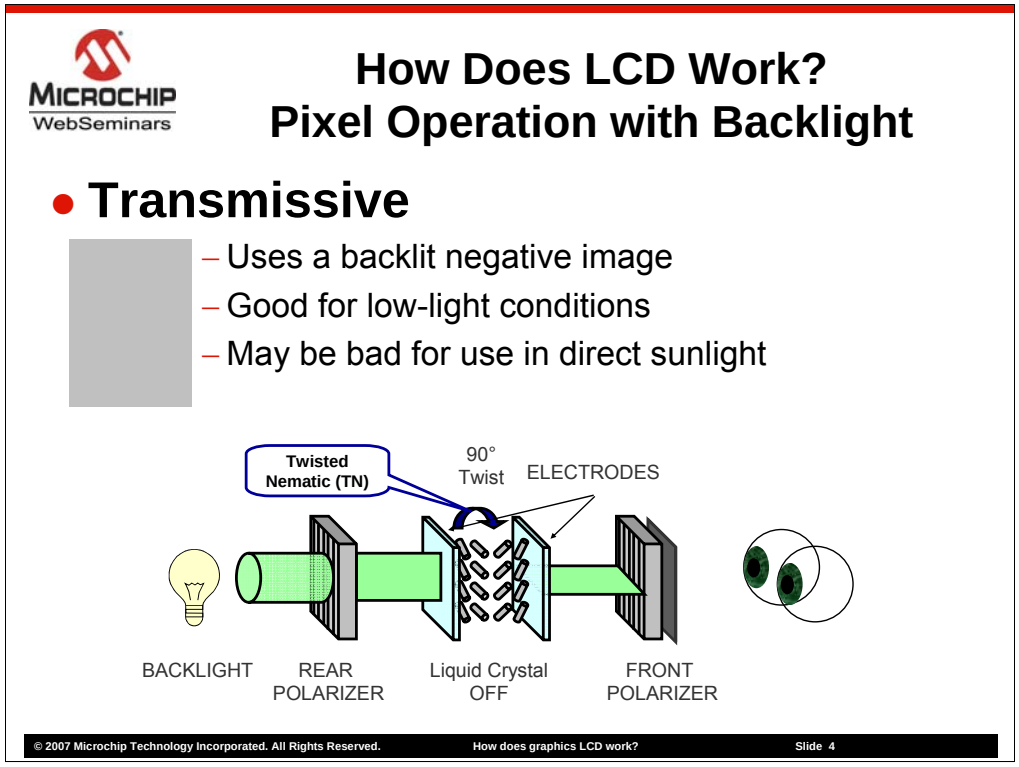
The graphics LCD is made of lots of pixels. For example very small graphics display of 1/16th VGA also known as QQVGA display has 160 pixels in one direction and 120 pixels in another director so total 19200 pixels. Before we look at the whole operation. Let's look at how each pixel works and then we'll look at how everything works together. The LCD as name suggests is made of liquid crystals. The liquid crystals are the heart of the display and the display operation depends on the manipulation of the light mainly its polarization. The ambient light passes through the front polarizer, the front polarizer removes all of the light rays except the one polarized vertically. The polarizer works in the exactly same way as in polarized sun glasses. Then light goes through the liquid crystals and it gets 90° turn. Then it goes through the rear polarizer gets reflected back and follows the same process and comes back in the front. If light gets out of the front then we will not see any image.



The liquid crystal orientation can be changed by changing charge applied on it. The charge is applied through some metal electrodes shaped like target image. For pixel in graphics LCD it will be square.

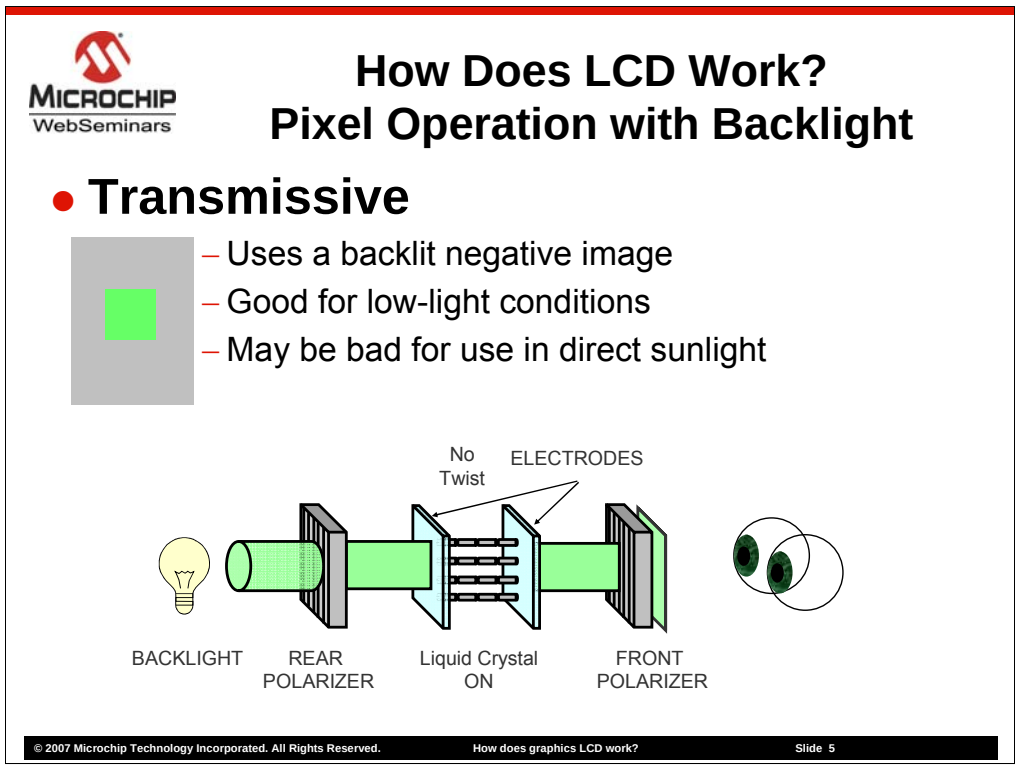
In this example the charge change results in no twist through liquid crystals. Because of that when the light reaches the rear polarizer it gets blocked due to vertical polarization on horizontal polarizer. As light does not get reflected back that particular pixel will be displayed as dark.

This type of LCD requires ambient light for the operation. The LCD will not work in a dark room. These operations is similar to what you see on many alpha-numeric displays. Many monochrome graphics LCDs also works this way.



The another type of LCD technology does not rely on ambient light its called transmissive type display. Instead it has a light built inside the display. Because it's on the back of the display, its called a backlight. The operation is same. If light gets the twist, it gets blocked by front polarizer and you do not see it in front. This display operation is opposite to ambient light based displays. Here if light is blocked you do not see image.

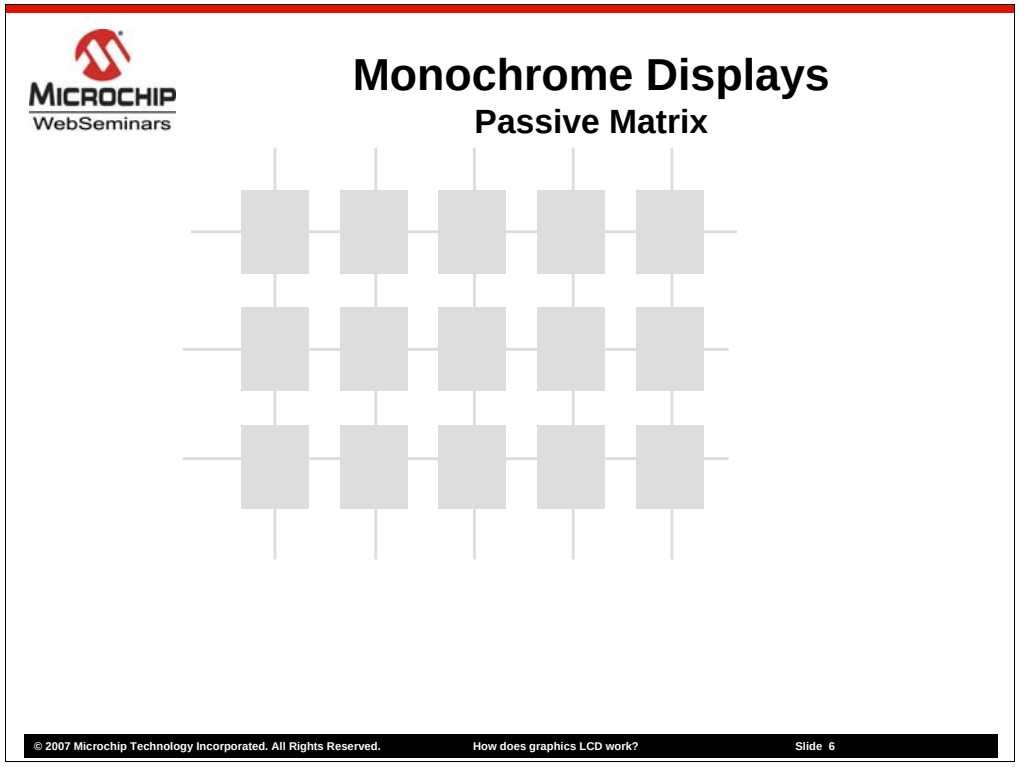
This also seems to be a right time to introduce one term. In this example liquid crystals are giving a 90° to twist to light. This property is called Twisted Nematic. Acronym for that is TN. If you hear TN in name of display (i.e. STN) it indicates the amount of twist given by liquid crystals. In case of STN (Acronym for Super Twisted Nematic), liquid crystals gives 270 degree twist to light. This higher twist helps to achieve display operation with lower voltage. which in effect provides faster switching speed.



As obvious if you change charge applied to liquid crystals to remove twist then light will pass through front polarizer and you will see light in front. Which in effect will seem like a pixel on.

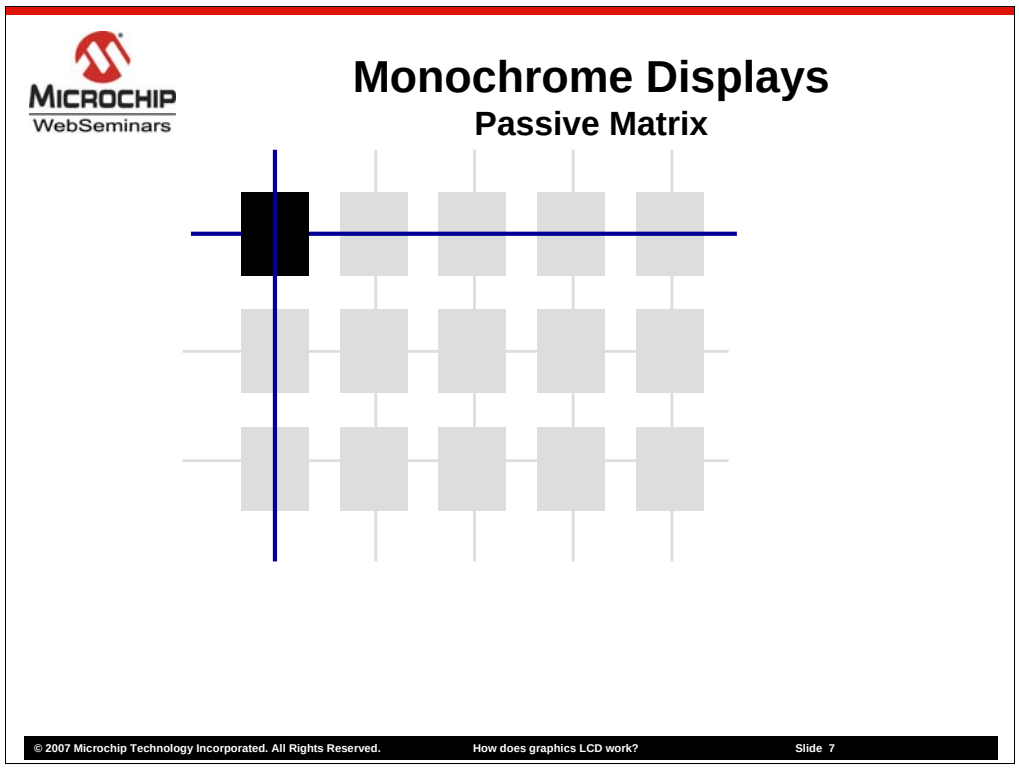
This type of display uses back light for operation so it can used in low-light condition or in dark room. This type of display may not work well in outdoor direct sunlight condition. The outdoor light is much brighter then internal backlight affecting performance of the display. One will need very good back light to support direct light based operation.

Almost all color displays utilize backlight based operation. In this case they need pure white light. If the light isn't white enough then it can affect color reproduction.

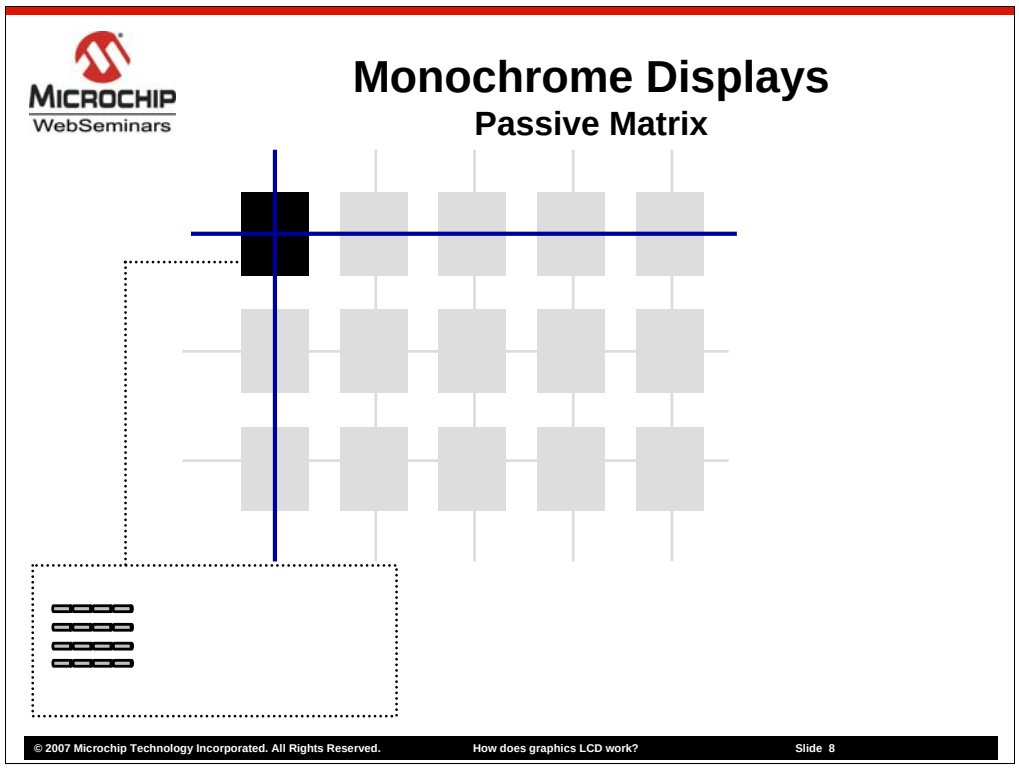


We looked at the operation of the single pixel. Now let’s look at how thousands of pixels are connected and controlled.

One obvious solution is to create a matrix and at each intersection of row and column put pixel.

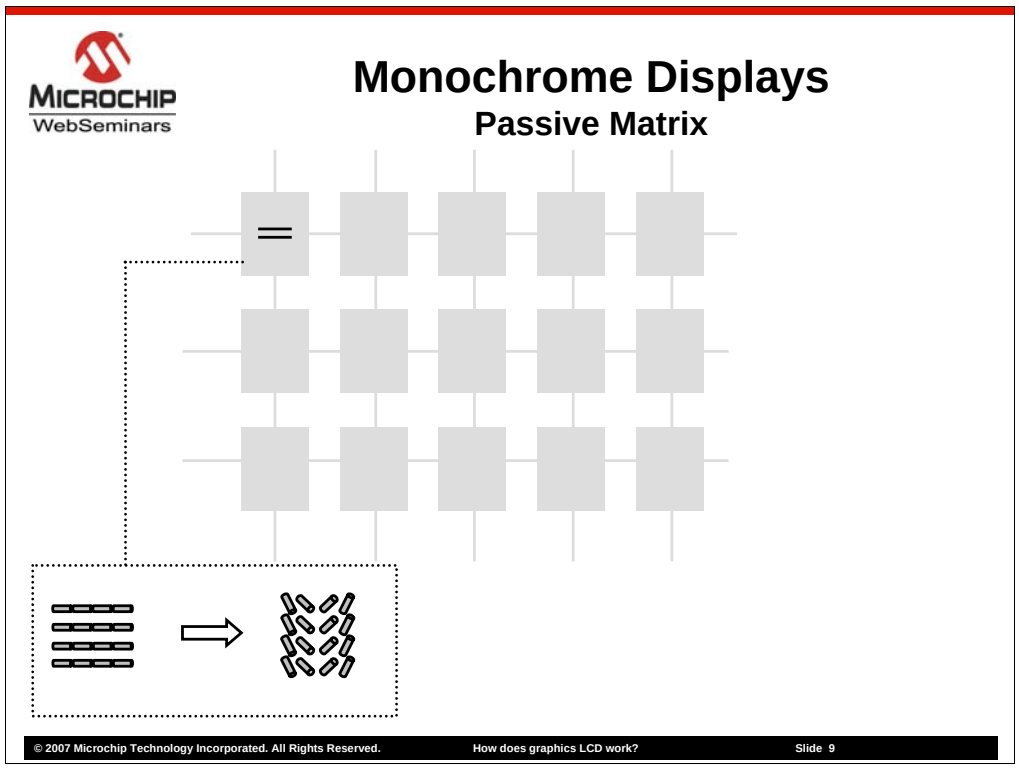


To enable a particular pixel, a particular row and column is enabled. When we enable particular pixel the mechanism is still same as explained earlier based on liquid crystal twist.

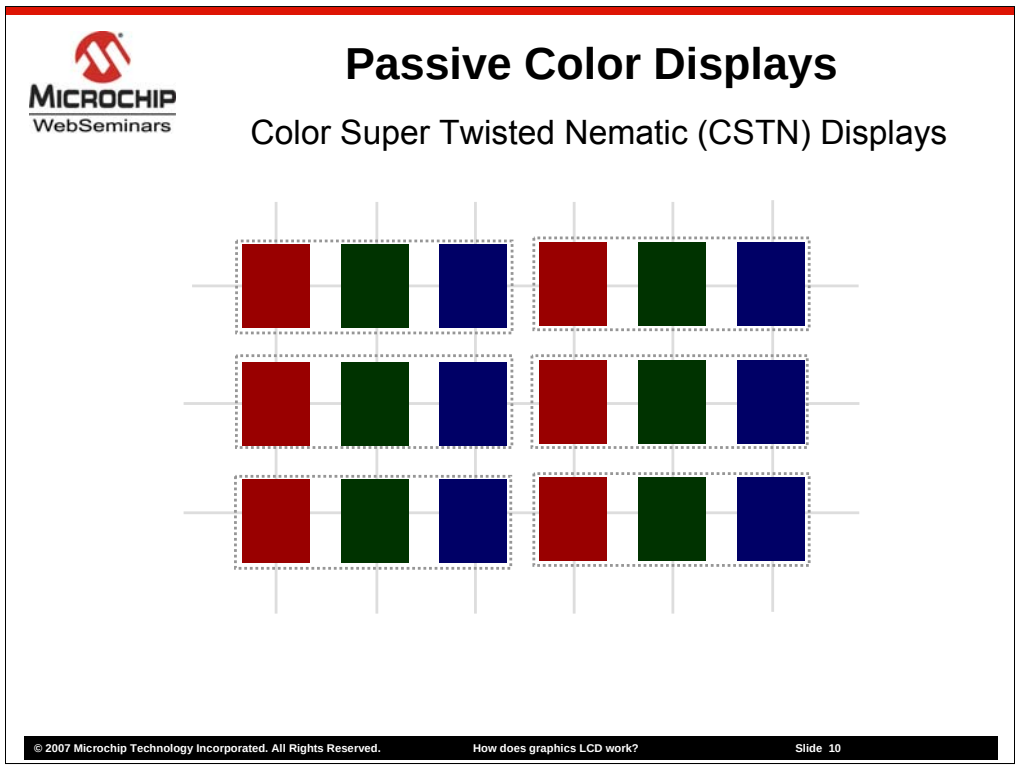


When we disable pixel, the liquid crystals cannot go from one state to another instantly. It requires some time to go to next state. Also electrically pixel is equivalent to capacitor where two metal electrodes are separated by die electric material made of liquid crystals. So when the charge is removed, it’s equivalent to capacitor being discharged. This determines the pixel turn off time.

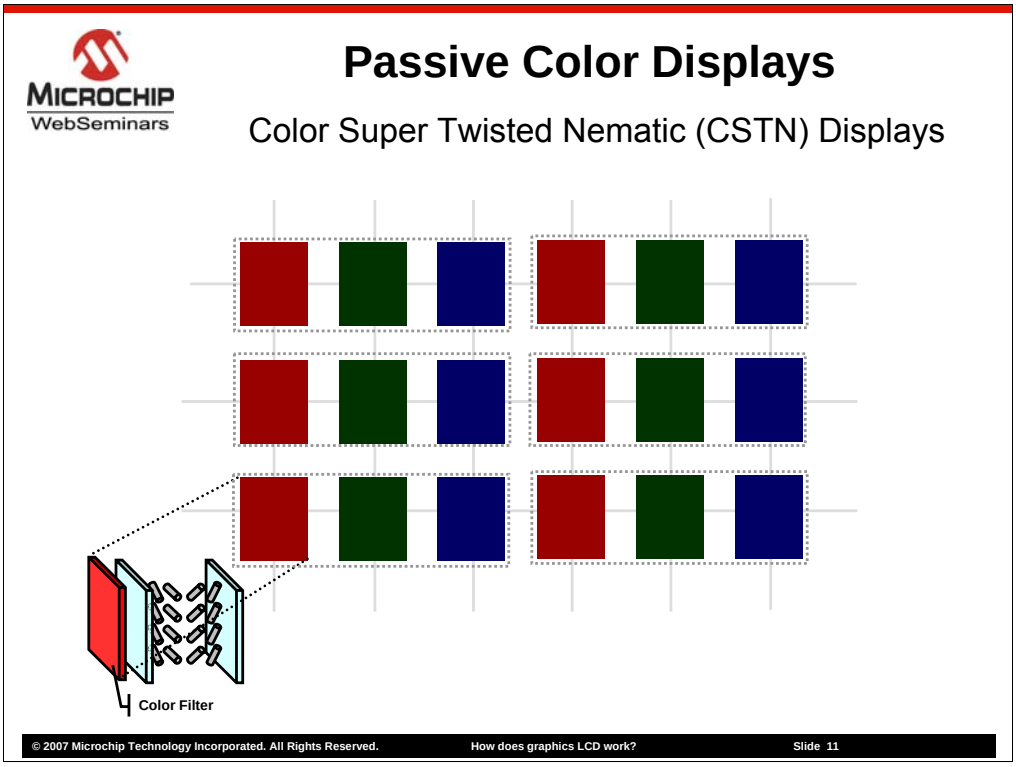
This kind of display is called passive matrix as all the pixels are connected through wires to form matrix.



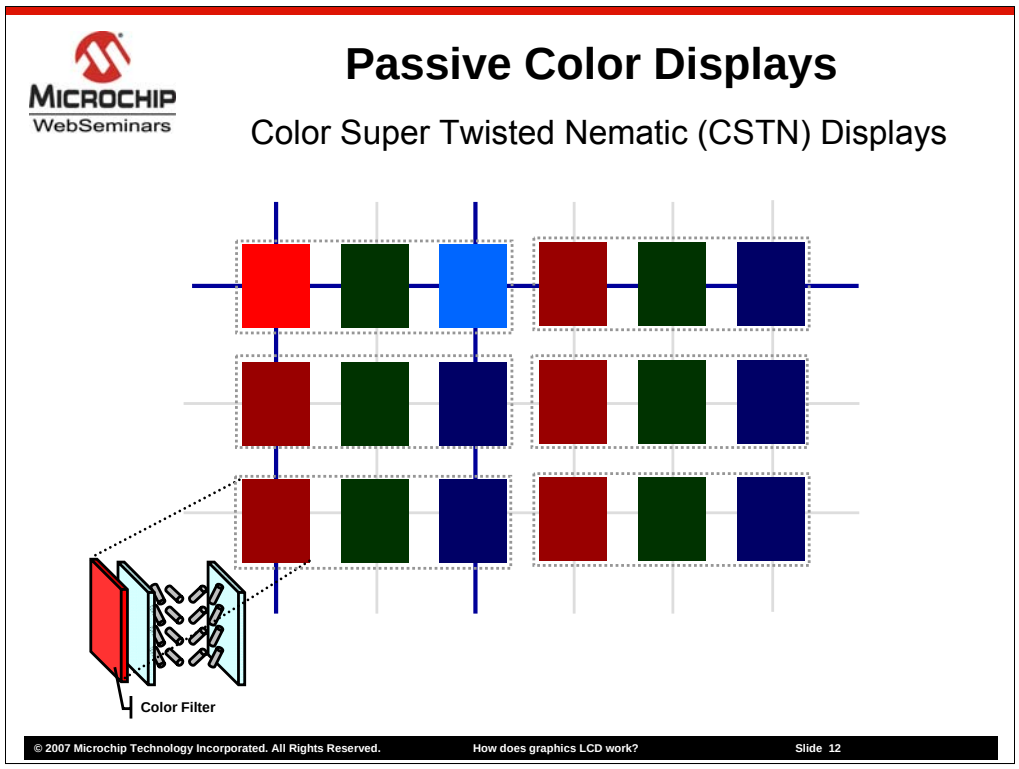
When you have thousands of pixels, if you try to do equivalent circuit of lots of capacitor connected together and stray capacitance due to wires then it can get complicated. In this configuration, it is highly likely that when you enable one pixel another pixel may see some charge due to capacitive coupling resulting in weak turn on of the pixel. This may result in less than optimum image quality.



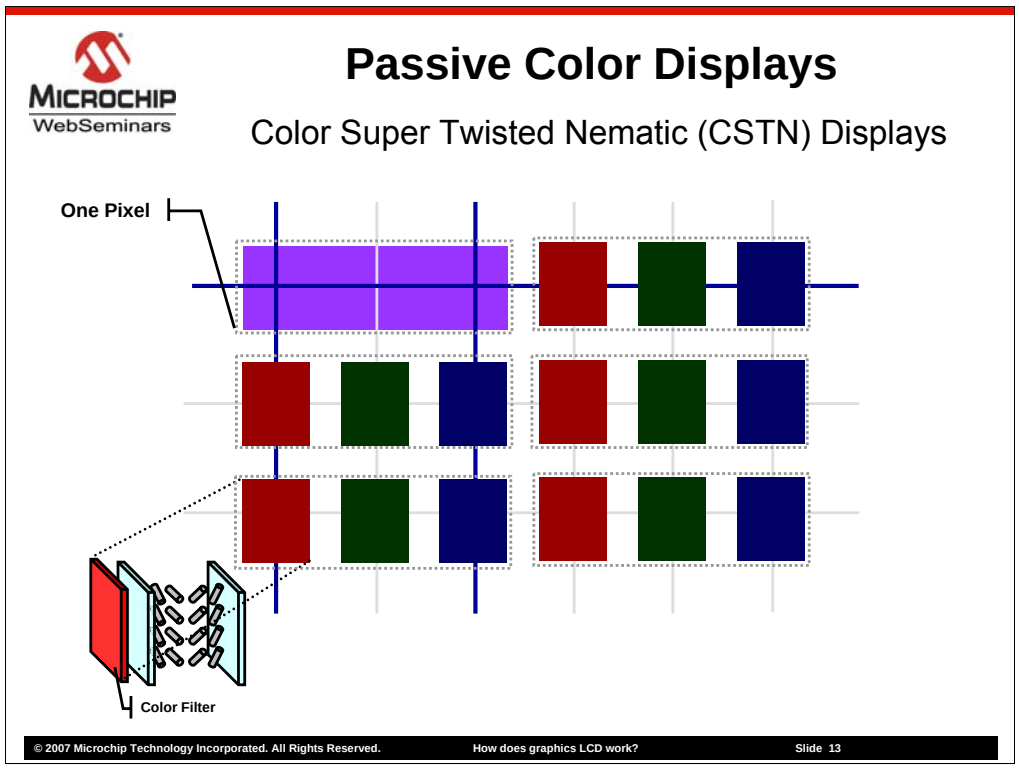
The next thing that comes to mind is how do we generate color picture. The liquid crystals do not have any color property, they only affect the polarization of the light.



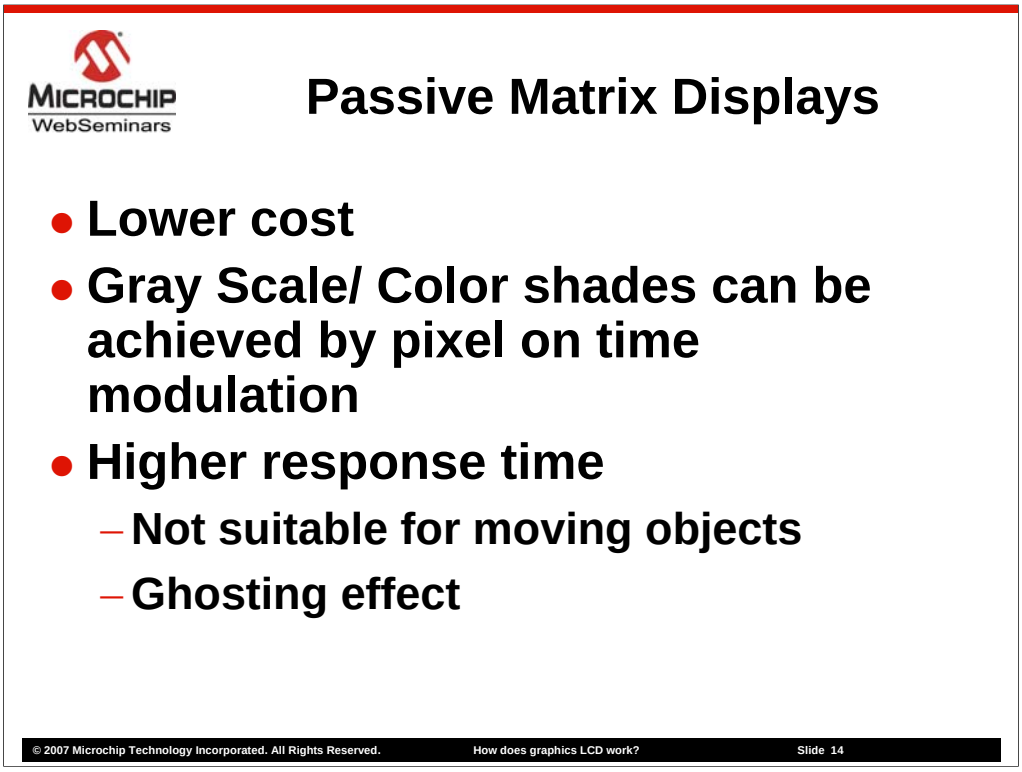
For color display white light source is used and then color filters are used to create three basic colors. The Red, Green and Blue pixels are placed very close to each other to create one color RGB pixel.



To display color other than basic color, more than one pixel is turned on at the same time. The process to turn on pixel is same as explained in the last slide for passive matrix. If R and B pixel is turned on you get resultant purple color.

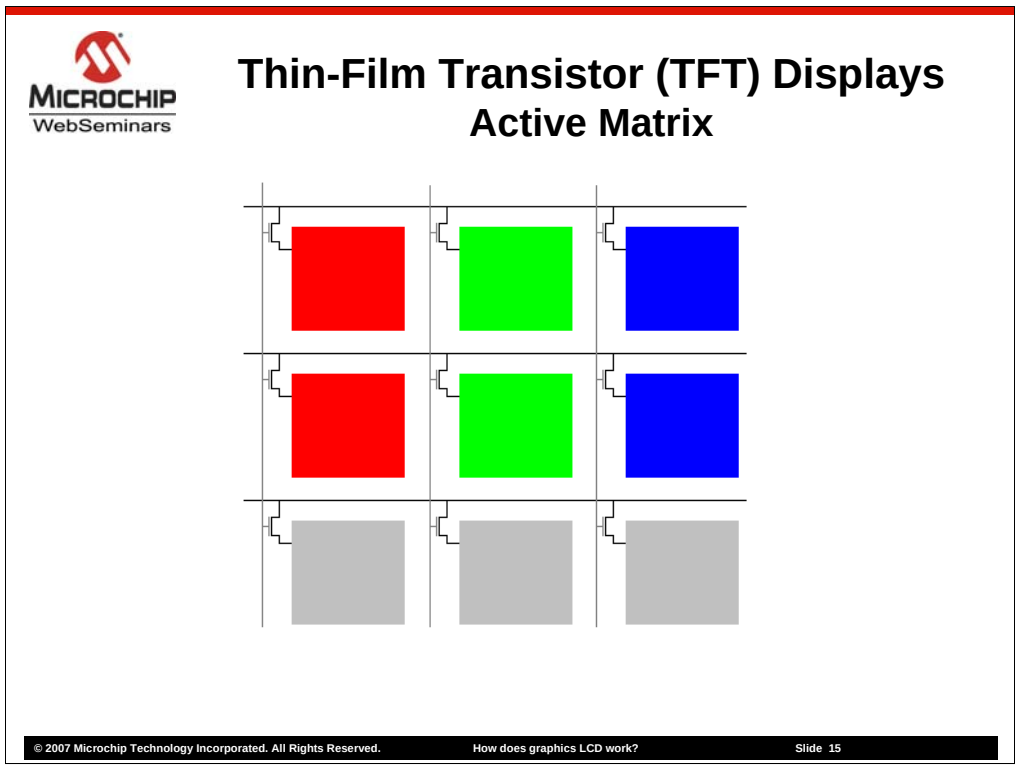


The Color Super Twisted Nematic displays (acronym CSTN) work in this way.



Previous slides explained operation of passive matrix displays. The advantage of this technology is lower cost. Many people who were used to manufacture segmented displays can manufacture it and is cheap to manufacture; mainly for monochrome and low color depth displays. They achieve gray scale or color shades by doing pixel on time modulation. This is equivalent to using PWM to get variable DC signal.

The main disadvantage of this technology is higher response time due to capacitor discharge effect explained earlier. Therefore, these displays are not suitable for moving objects as it may result in a ghosting effect. This technology is mainly popular for monochrome/ gray scale displays and low color depth displays.



The prime disadvantage of passive matrix technology is higher response time. The equivalent capacitor increases the response time. The active matrix display technology tries to solve this problem by using some electronic circuitry to quickly discharge the capacitor and also reduce the coupling between two pixels.

The obvious advantage of this technology is faster response time. The disadvantage of this technology is complex manufacturing process. It require mixture of semiconductor and display technology to manufacture this display. They etch transistors on LCD glass between pixels to create active matrix. Due to complex manufacturing technique very few vendor can manufacture their own glass. There are quite a few LCD module supplier who buys glass from few specific vendors and assemble them together to create module.

The most common example of this technology is Thin Film Transistor (acronym TFT) technology. The laptop LCD or desktop LCD screens, iPods many cell phones uses this type of display. This technology is becoming very popular so price is dropping quickly. For color displays many time it is cheaper than CSTN displays discussed earlier.

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Summary

- **We learnt**
  - **Pixel operation**
  - **Pixel matrix topologies and tradeoffs**
  - **Some commonly used terminologies**

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•This ends this webinar. To summarize this presentation, we learnt about two different techniques to turn on individual pixel in graphics LCD. One relies on ambient light while other uses in-built light source.

•We looked at the passive matrix and active matrix topology to control thousands of pixels in graphics displays and their trade offs

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•I'll like to thank you for viewing this webinar.