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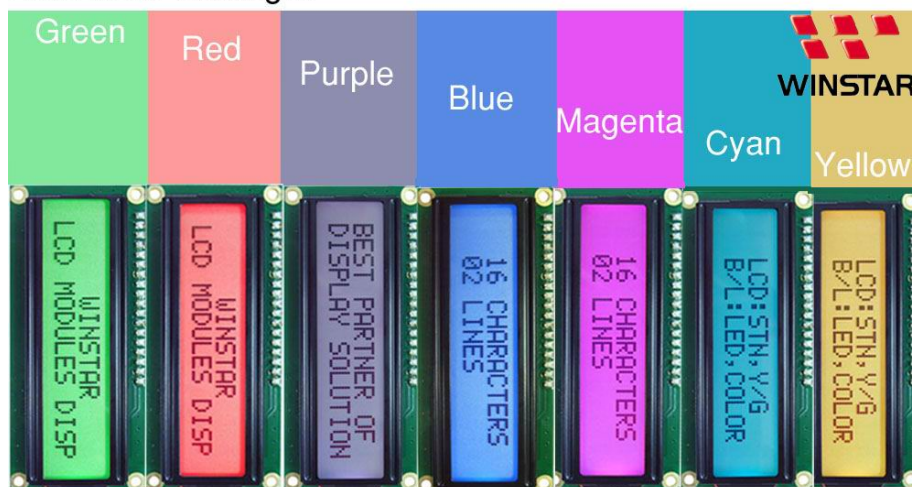
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## How to Use RGB LEDs Backlight on LCD Modules

LEDs have increased in brightness and lifetime significantly since their introduction, and now provide many alternatives to LCD display solutions. One can use single-color LEDs such as Yellow-Green, White, Blue, Red or Amber LEDs in monochrome displays, or white LEDs with color filter for color applications. A growing trend in recently for LCD displays is to use RGB LEDs as backlighting, especially in industry devices.

The displays with RGB backlight can show up to seven different colors which are Green, Red, Purple, Blue, Magenta, Cyan and Yellow. Using the latest surface mount RGB LED chips, these backlights use red, green and blue LEDs in various combinations which allows for a clear indication of the current state of equipment or process where, for example, Red may warn of a problem or issue, and Green denotes normal conditions. This style of visual indication can provide users with quick and unambiguous status information that is discernible when viewing from a distance. It is therefore ideally suited to applications typically in security, industrial automation, instrumentation and machine control.

### RGB Color Backlight





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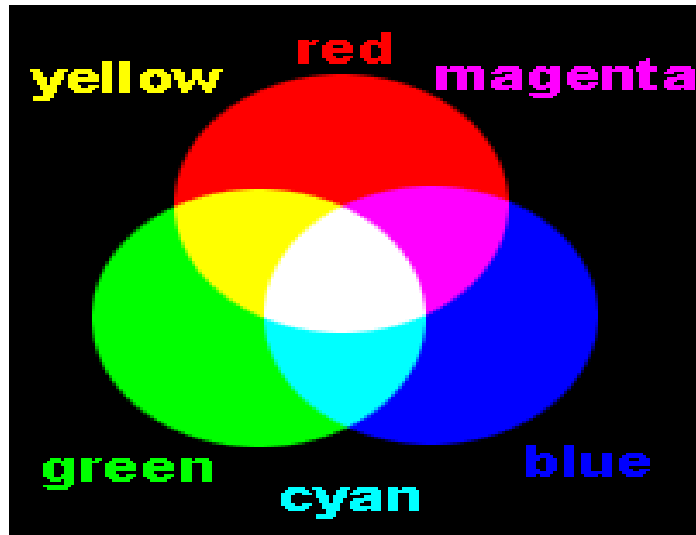
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### Color theory for RGB:

While discussing the RGB backlights, it should begin with the RGB color theory. The RGB color model is defined as primary color, and it's an additive color which the red, green, and blue light are added together in some ways to reproduce a broad array of colors. Human can see wide range colors because the primary color (RGB) is related to the physiology of the human eyes. Human retina is sensitive to the light of different wavelengths and that makes a large color triangle.

#### Additive Color



Zero intensity for each color gives the darkest color (no light source, which is black), and full intensity gives a [white](#); When one color has the strongest intensity, the color hue near this primary color (reddish, greenish, or bluish), and when two colors have the same strongest intensity, then the color hue is called secondary color ([cyan](#), [magenta](#) or [yellow](#)). For example, cyan is green+blue, magenta is red+blue, and yellow is red+green. Every secondary color is the complement of primary color; when a primary and its complementary secondary color are added together, the result is white: cyan complements red, magenta complements green, and yellow complements blue.

### RGB Display Driving Methods:

There are two driving methods for RGB LEDs backlight. One is to drive RGB LEDs by Parallel circuit; the other is by Serial circuit. If the designers use the parallel circuit to drive RGB LEDs, then the designers can choose to have RGB driver

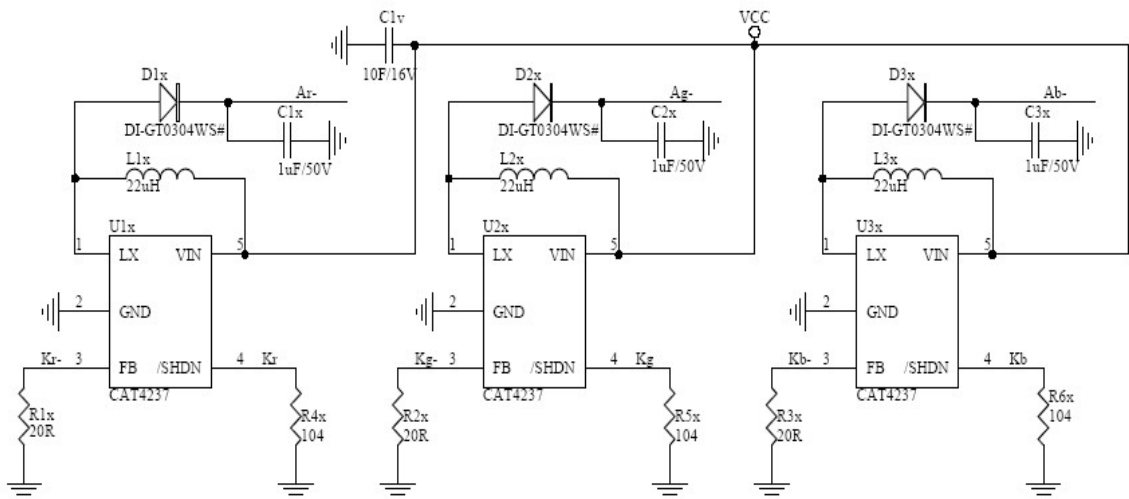


or not. The advantage of parallel drive is the circuit been easily to build and low production cost since without RGB LED driver. But the disadvantage is that might have the uneven luminance appears on LCD modules. To overcome this uneven luminance problem is to use the RGB LEDs with the same Forward Voltage (VF).

If the designers choose the latter option to use serial circuit, then a RGB driver is a must. There are two options for designing the circuit of the RGB LED drivers, one is built-in on PCB board of the LCD modules, and the other is to build the driver external the LCD displays. By using the serial circuit, the forward voltage is no need to be the same no matter the LED driver is built-in on board or external the display. The advantage of serial circuit is the luminance will be even on the display.

To built-in RGB LED drives on boards, the users can easily to light up the RGB LEDs, but the circuit is more complicated to build and the LCD modules cost will be higher. As to build the RGB LED driver external the LCD modules, the users are not easy to activate the program drive. But the circuit designed is simple, and then the LCD modules cost is lower than the previous one.

RGB LED Driving schematic drawing example:





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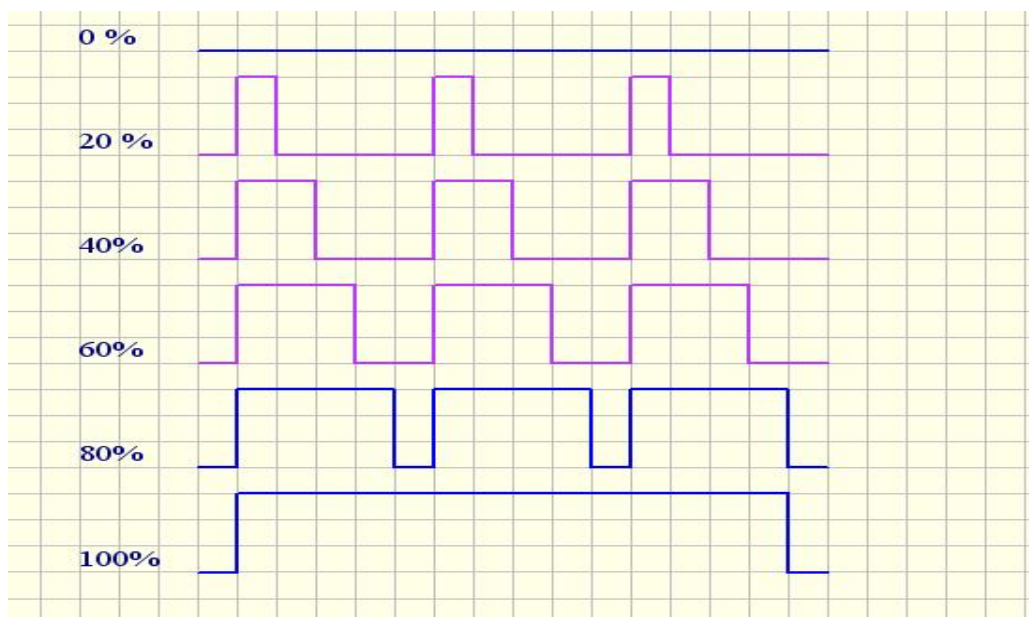
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It is popular to mix colors using the Pulse Width Modulation (PWM) method with red-green-blue LEDs. The color mixing control is available through hardware as well as software using the serial interface.

Since each of PWMs can be controlled individually, a range of colors can be generated by a combination of variations in the period and duty cycle of the PWMs. Using 3 PWMs for the red, green, and blue LEDs, different color combinations can be generated (0-255red, 0-255 green, and 0-255 blue).

The individual controls for each LED are provided as hardware control signals (PLUS and MINUS). A PLUS control signal increases the duty cycle while the MINUS control signal decreases the duty cycle of the corresponding LED. A serial interface is also provided to directly write the desired duty cycle value for each of the RGB LEDs. There are six duty cycle levels shown as below figure for options while using the PWM to design the RGB color mixed.



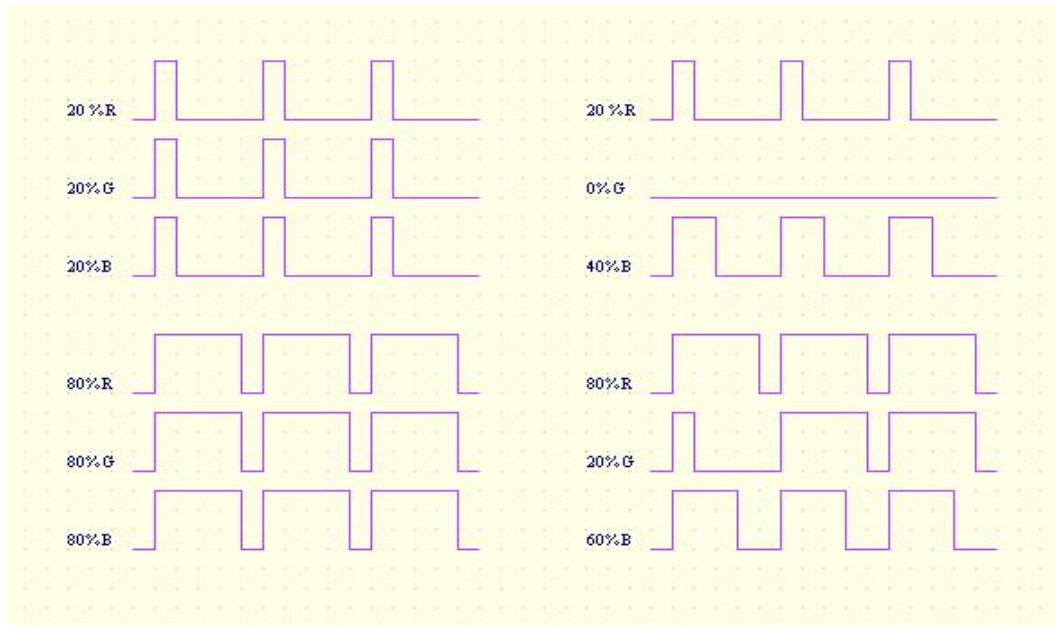
Below figure is the PWM program drive and Red-Green-Blue color mixed waveforms examples as reference. The PWM outputs vary according to the value of the duty cycle programmed.



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The designers can use the above RGB color mixed waveforms to design the devices. Also, to use the duty cycle of RGB-LEDs drivers to get different weights by using PWM modulation techniques. Below are the examples shown how to use the duty cycle and waveform to design color changing combinations.

- Example 1: 0% - 20% - 40% - 60% = 4 levels

4 levels Red \* 4 levels Green \* 4 levels Blue = 64 color gradation

- Example 2: 0% - 20% - 40% - 60% - 80% - 100% = 6 levels

6 levels Red \* 6 levels Green \* 6 levels Blue = 216 color gradation

- Example 3: 0% - 100% = 2 Levels

2 levels Red \* 2 levels Green \* 2 levels Blue = 7 colors + ALL dark = 8 color gradation



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Hopefully with this article, it would be a great help for the users to design RGB LED Backlight on LCD display.

If you need further information, please contact with us. Thank you.

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