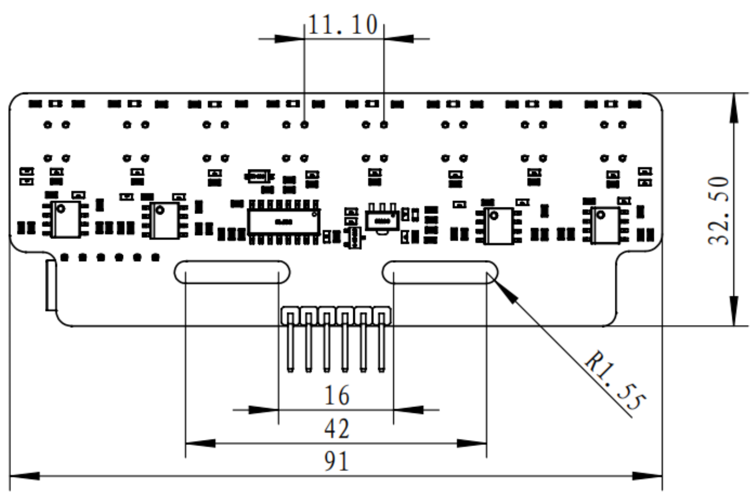
Introduction to the 8-Channel Grayscale Module

I. Product Parameters

1. Dimensions



2. Pin Functions

Indicator Light Names and Functions:

- Power Indicator: Indicates power supply, green.
- Function Indicator: Indicates recognition effect. On a white background, the indicator lights up when the corresponding color is recognized; on a black background, the indicator turns off when the corresponding color is recognized.

Port Names and Functions:

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- Positive and Negative Power Ports: For connecting to a 5V power supply.
- Output Port: For outputting digital signals, connected to the OUT pin of the CD4051.

Addresses 0, 1, and 2: Used to select the output channel. Please refer to the truth table below for details.

This table is compiled based on the CD4051 manual.

Input				**Channel**
EN	AD2	AD1	AD0	OUT
0	0	0	0	CH1
0	0	0	1	CH2
0	0	1	0	CH3
0	0	1	1	CH4
0	1	0	0	CH5
0	1	0	1	CH6
0	1	1	0	CH7
0	1	1	1	CH8

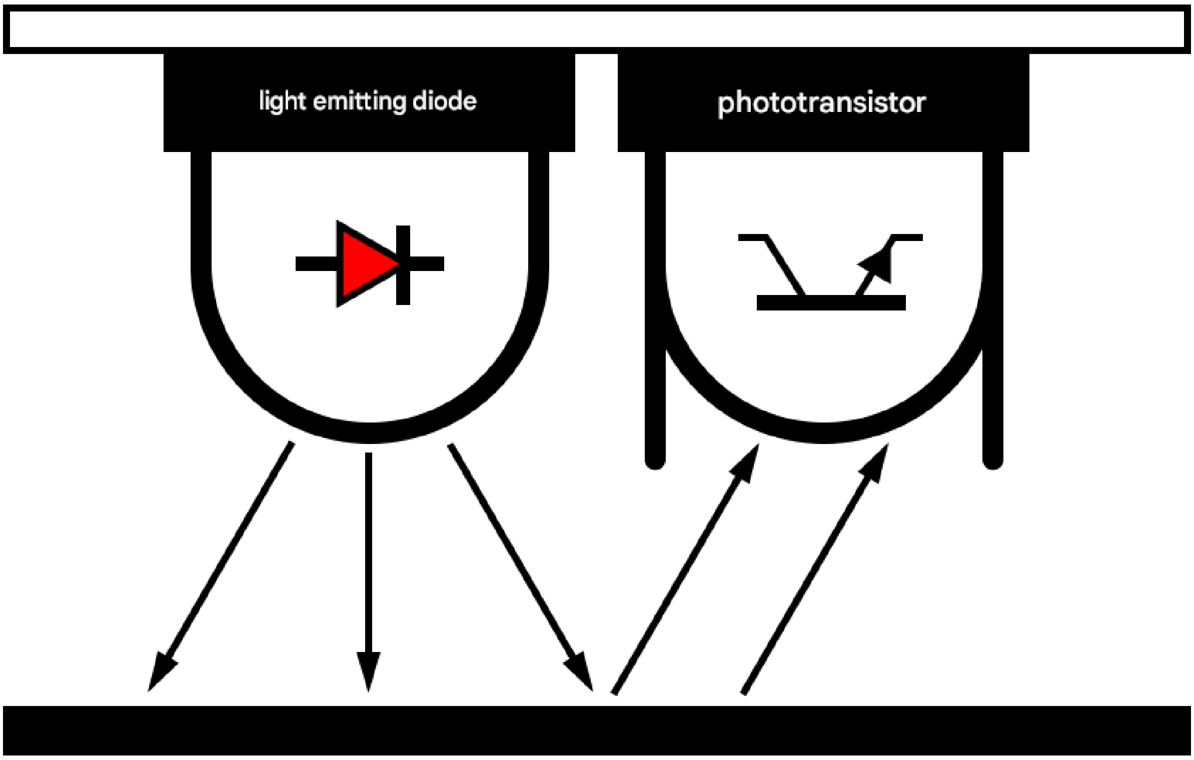
Note:

- The enable pin here has a default 10K pull-down resistor and is always in a low level state, requiring no processing.
- The output is a digital signal; the GPIO port outputs high and low levels. - If, under a sheet of white paper at the same distance, the data from 8 probes are found to be different, this is normal. This is due to the different factory sensitivities of each probe.

II. Grayscale Sensor Theory

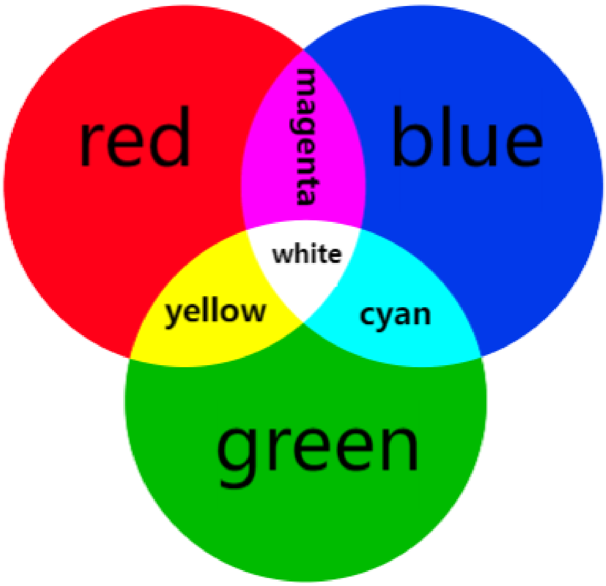
1. Principle

A grayscale sensor is a sensor used to detect the grayscale levels (brightness) of an object's surface. Its core function is to convert differences in light intensity into measurable electrical signals, thereby distinguishing the grayscale values of different objects (such as black, white, and gray gradients). This is a simplified schematic diagram of a sensor. An LED emits a beam of light, which is reflected by the detection surface and then shines into a phototransistor. The phototransistor is a light-sensitive device; the more light it receives, the greater the current flowing through it. When light shines on the detection surface, part of it is absorbed, and part is reflected into the phototransistor, thus generating a current value.



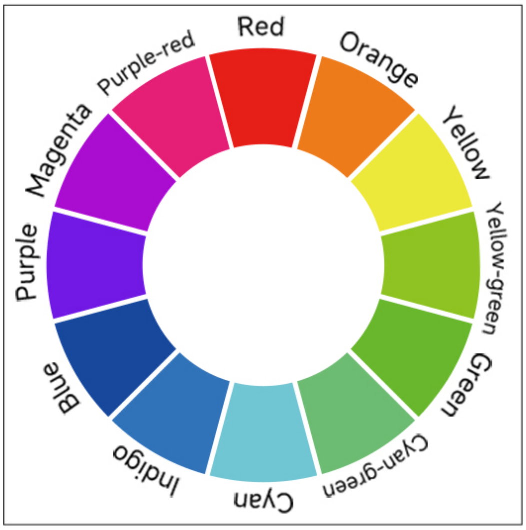
2. Color Theory

In the context of grayscale sensors, "gray" does not simply refer to a "fixed color between black and white" as we commonly understand it, but rather a broad concept of "brightness/darkness range"—essentially a quantitative description of the "difference in light intensity reflected from an object's surface," encompassing all transitional states from "dark gray close to black" to "light gray close to white." Its core is measuring an object's ability to reflect light through "grayscale values," rather than referring to a specific visual "gray tone." Here, we introduce the concept of a color wheel. The color wheel is based on three colors: red (100, 0, 0), green (0, 100, 0), and blue (0, 0, 100). These colors are called primary colors because they are the only colors that cannot be mixed from other colors. Mixing adjacent colors on the color wheel in equal amounts yields secondary colors. For example, red plus green equals yellow (100, 100, 0), blue plus red equals magenta (100, 0, 100), and blue plus green equals cyan (0, 100, 100).

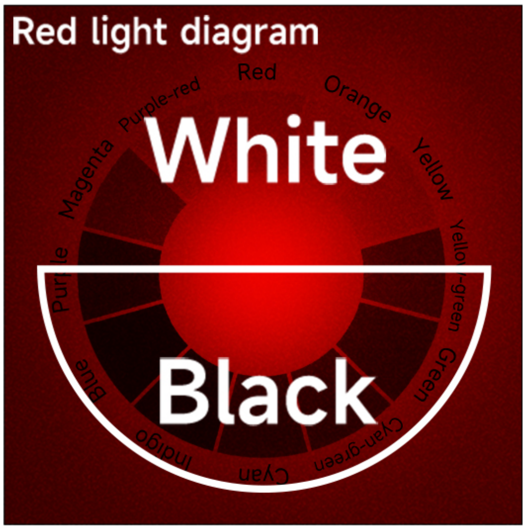


Furthermore, by combining the three primary colors with the three secondary colors, adjacent colors are combined to form secondary colors: orange (100, 50, 0), yellow-green (50, 100, 0), cyan-green (0, 100, 50), indigo (0, 50, 100), violet (50, 0, 100), and magenta (100, 0, 50). For example, red (100,0,0) and yellow (100,100,0) blend to form orange (100,50,0); cyan (0,100,100) and blue (0,0,100) blend to form indigo (0,50,100).

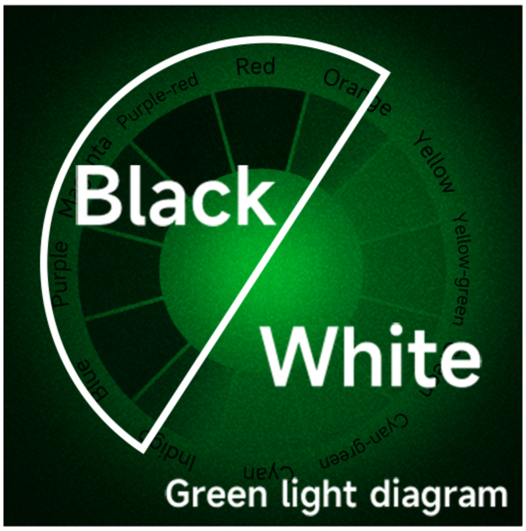
In the RGB color system, each color on the color wheel can be created by mixing the three primary colors, just like the screen you are looking at now, which is composed of countless red, green, and blue light-emitting units. When an LED emits red light, only red light is reflected by the detection surface. Therefore, the green or blue detection surfaces absorb the red light, resulting in black. Using this method, we can extract all the red channels, convert them into digital signals, and analyze them to obtain the grayscale of a single channel. We have also verified this conclusion in our experiments.



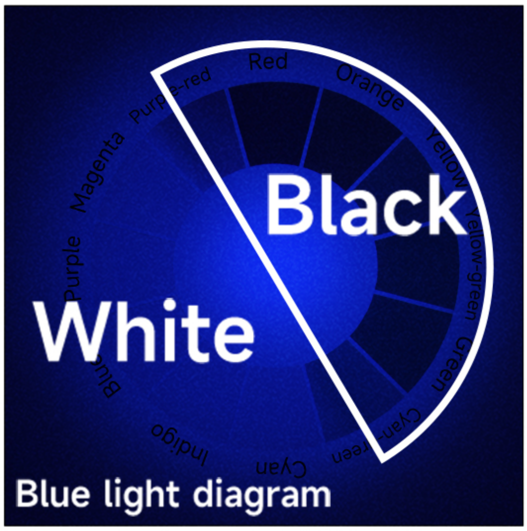
Hue Circle



Hue circle in red light



Hue circle in green light



Hue circle in blue light

As you can see, cyan and red, these complementary colors, are at a 180° angle in the image. In the color wheel theory, any two colors that are 180° apart in an image are complementary colors, meaning they have the strongest contrast. It's worth noting that if you encounter white and black, don't worry; grayscale sensors ultimately convert colors to black and white. You can consider white to be eternally white, reflecting the strongest brightness from any color LED, and the same applies to black. The following image is a table showing which lines to look for under four different lighting conditions, which can be used to quickly select the track and light color.

White background quick selection table					
base color	light color	red light version	green light version	blue light version	white light version
white	red	poor	excellent	excellent	poor
	orange	poor	medium	excellent	poor
	yellow	poor	poor	excellent	poor
	yellow-green	medium	poor	excellent	poor
	green	excellent	poor	excellent	poor
	Turquoise	excellent	poor	medium	poor
	cyan	excellent	poor	poor	poor
	indigo	excellent	medium	poor	poor
	blue	excellent	excellent	poor	poor
	purple	medium	excellent	poor	poor
	magenta	poor	excellent	poor	poor
	crimson	poor	excellent	medium	poor
	black	excellent	excellent	excellent	excellent
	white	/	/	/	/

Black background quick selection table					
background color	line Color	red light version	green light version	blue light version	white light version
black	red	excellent	poor	poor	poor
	orange	excellent	medium	poor	poor
	yellow	excellent	excellent	poor	poor
	yellow-green	medium	excellent	poor	poor
	green	poor	excellent	poor	poor
	cyan-green	poor	excellent	medium	poor
	cyan	poor	excellent	excellent	poor
	indigo	poor	medium	excellent	poor
	blue	poor	poor	excellent	poor
	purple	medium	poor	excellent	poor
	magenta	excellent	poor	excellent	poor
	purple-red	excellent	poor	medium	poor
	black	/	/	/	/
	white	excellent	excellent	excellent	excellent

III. Instructions for Use

1. The Influence of Height on the Probe

When a flashlight shines on a wall, the closer the distance, the more obvious the beam. The farther the distance, the more diffused the beam. The same applies to the transmitter of the eight-channel grayscale sensor; the closer the distance, the smaller and brighter the beam. Here, our transmitter uses a high-focusing LED, which is more focused than common LEDs. We use a yellow copper tube on the probe to isolate the influence of ambient light, receiving only the light reflected from the transmitter. Therefore, visually, we place the transmitter in front of the probe to reflect the received light source. During use, ensure the probe is on the line for line inspection.

Regarding height, we recommend using a probe height of 18mm from the ground as the optimal height. This ensures the most complete aperture coverage during testing, without interference between probes.

2. Usage Range

For these four models, the height range is listed, referring to the probe's height from the ground.

White Light	Blue Light	Green Light	Red Light
White Background	10-30mm	16-24mm	16-24mm
Black Background	10-30mm	12-20mm	12-20mm
Optimal Height	18mm	18mm	18mm

Note:

On a white background, the line color should ideally be matte for better absorption and better line tracking. For the green light version, due to poor blue absorption, a dark blue line is recommended for better absorption and identification. On a black background, check if the line shows through; if so, consider using two layers of line to cover the black background.