TCS3200-DB (#28302): *Color Sensor Module*

Product Overview

General Description

TCS3200-DB Color Sensor Daughterboard is a complete color detector, including a TAOS TCS3200 RGB sensor chip, white LEDs, collimator lens, and standoffs to set the optimum sensing distance. It plugs directly into the BASIC Stamp-2pe Motherboard (#28300), Propeller Backpack (#28327), MoBoProp (#28303, a future product) and will also interface to any BASIC Stamp module or Propeller board using the optional DB-Expander SIP Converter (#28325). The TCS3200-DB can detect and measure a nearly limitless range of visible colors.

The TCS3200 has an array of photodetectors, each with either a red, green, or blue filter, or no filter (clear). The filters of each color are distributed evenly throughout the array to eliminate location bias among the colors. Internal to the device is an oscillator which produces a square-wave output whose frequency is proportional to the intensity of the chosen color.

Features

- Sensor provides a readout of individual RGB color components as a digital frequency.
- Onboard white LEDs can be gated on and off for ambient light subtraction.
- The included 5.6mm lens provides a well-defined field of view.
- Module is plug-compatible with Parallax motherboards.
- Module can run from 3.3V or 5V logic supplies, plus 5V for the LED.

Applications

- Test strip reading.
- Sorting by color.
- Ambient light sensing and calibration.
- Color matching.

What's Included
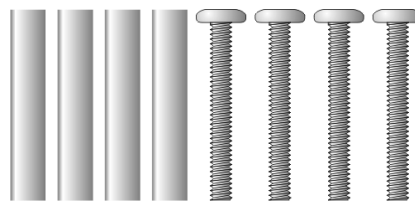
TSL3200-DB with lens, standoffs, and screws.

What You Need to Provide

- Parallax motherboard, or DB-Expander in conjunction with a BASIC Stamp or Propeller chip.

Out of the Box

The TCS3200-DB Color Sensor Daughterboard Kit consists of a TCS3200-DB daughterboard that includes the TAOS TCS3200 color sensor chip, a lens, and two current-regulated white LEDs. Also included are four one-inch aluminum standoffs and four 3/4" screws.

The daughterboard is compatible with all Parallax motherboards, including the MoBoStamp-pe, Propeller Backpack, and the upcoming MoBoProp. It can operate with Vdd set anywhere between 2.7V and 5.5V. However, a nominal 5V supply is needed for operation of the LEDs, which the motherboards automatically provide. For operation without a motherboard, such as with Parallax's Board of Education or Propeller Demo Board, an extension cable (p/n 800-28301) and a SIP adapter ("DB Expander", p/n 28325) are available separately to convert the TCS3200DB's two-row, 2mm header to a more convenient single-row, 0.1-inch spacing.

Getting Started

If you are using the TCS3200-DB with the MoBoStamp-pe, make sure that you have the GPIO3 firmware loaded into the AVR coprocessors. The MoboStamp-pe comes from the factory with the GPIO3 firmware installed. If you have installed other AVR firmware, reload the GPIO3 hex file using the LoadAVR.exe utility before proceeding.

The TCS3200-DB works best with the front surface of the printed circuit board located between 1" and 1 1/16" from the subject being sensed. For this reason, aluminum spacers are included, which can be affixed to form legs. If you are using your TCS3200-DB with a Parallax motherboard, remove all the screws from the brass spacers at both ends of the board, and replace them with the 3/4" screws included in this kit. The screws should be installed from the bottom of the motherboard and protrude through the brass spacers. At this point, you can install the TCS3200-DB on the "B" end of the motherboard and attach the spacers as shown below. The left-over short screws may also be screwed into the ends of the legs as a height adjustment.

If you are connecting the TCS3200-DB to the motherboard via the extension cable (p/n 800-28301), attach the spacers directly to the TCS3200-DB using the unused short screws provided with the motherboard.

If you are using the TCS3200-DB with the DB-Expander instead of a motherboard, you will need to obtain eight 4-40 x 1/4" panhead machines screws (Parallax p/n 700-00028) to attach the legs and to use as a height adjustment, since the 3/4" screws provided are too long.

Now, assuming you're using the MoBoStamp-pe, key the following BS2pe program into the BASIC Stamp Editor. (A similar program, along with programs for different BASIC Stamp versions is available for download at www.parallax.com on the TCS3200-DB product page.)

```
'{$STAMP BS2pe}

Out     CON 7
S3      CON 0
S2      CON 1
LED     CON 5

pRED    CON 15
pGREEN  CON 12
pBLUE   CON 9

RED     VAR Word
GREEN   VAR Word
BLUE    VAR Word

Start:
  HIGH  LED

MainLp:
  GOSUB  Color
  DEBUG  "R", DEC3 RED
  DEBUG  " G", DEC3 GREEN
  DEBUG  " B", DEC3 BLUE
  DEBUG  CR
  GOTO  MainLp

Color:
  LOW  S2
  LOW  S3
  COUNT  Out, pRED, RED
  HIGH  S3
  COUNT  Out, pBLUE, BLUE
  HIGH  S2
  COUNT  Out, pGREEN, GREEN
  RETURN
```

Next, connect the motherboard to your PC, and Run the program you've entered. Two things should now happen: 1) the white LEDs on the sensor module will come on, and 2) you will see output appear in the debug window that looks something like this:

R123 G065 B200
R120 G060 B187
        etc.

These numbers are relative values for the red, green, and blue components of the color the sensor is looking at. With the TCS3200-DB perched on its legs atop a piece of white paper, you will notice that the LEDs form a bright spot of light in front of the lens. You may need to adjust the LEDs or the height a bit to make sure that the spots from both LEDs merge into a single round spot.

Hardware Notes

No technical discussion of the TCS3200 sensor module set would be complete without the material contained in the TAOS TCS3200 datasheet. If you do not have this datasheet, you are encouraged to download it from the TAOS website, www.taosinc.com.

The TCS3200 has an array of photodetectors, each with either a red, green, or blue filter, or no filter (clear). The filters of each color are distributed evenly throughout the array to eliminate location bias among the colors. Internal to the device is an oscillator which produces a square-wave output whose frequency is proportional to the intensity of the chosen color. There is one output from this oscillator, and the color to be read is selected using two address lines: **S2** and **S3**. In addition, it is possible to program the divide rate of the oscillator using two additional lines, **S0** and **S1**. The settings for these control lines and their functions are summarized below:

S0	S1	Divide		S2	S3	Color
0	0	Pwr. Down		0	0	Red
0	1	1:50		0	1	Blue
1	0	1:5		1	0	Clear
1	1	1:1		1	1	Green

The TCS3200 chip's data and control lines are brought directly to the 2mm header, through which it interfaces to the motherboard or to another system. The only exception is the **/OE** output enable line, which is permanently asserted low. In addition, both **S0** and **S1** are pulled high through resistors to Vdd, which programs the TCS3200 for its maximum output frequency. Therefore, to use this setting, neither **S0** nor **S1** need to be connected. There are also jumper pads on the TCS3200-DB by which either **S0** or **S1**, or both, can be strapped low.

To program the data rate from a BASIC Stamp, it will be necessary to connect **S0** and **S1** to a programmable port. On the MoBoStamp-pe, this must be done through the AVR coprocessor via the **OWOUT** instruction, since these signals do not connect directly to the BASIC Stamp chip. To set **S0** and **S1** to the values (**0** or **1**) contained in variables of the same name, use the following PBASIC code:

```
OWOUT OWIO, 0, [$04 + S0, $14 + S1]
```

where the value for **OWIO** is given in the table below.

The following table maps the TCS3200-DB signals to ports on both the MoBoStamp-pe and MoBoProp boards for sockets A and B, the Propeller Backpack, as well as the DB-Expander board:

Signal	MoBoStamp-pe		MoBoProp A	MoBoProp B or Backpack	DB-Expander
	A	B			
S0	See code above.		A9	A1	B
S1	See code above.		A8	A0	A
S2	P9	P1	A12	A4	E
S3	P8	P0	A13	A5	F
OUT	P11	P7	A10	A2	C
LED	P12	P5	A11	A3	D
OWIO	P10	P6	—Not Applicable—		

When operating the TCS3200-DB using the SIP adapter (DB-Expander) instead of a Parallax motherboard, the correspondence between the signals and SIP pin markings will be that of the last column in the table above. When operated in this fashion, the **+5V** pin supplies power to the LEDs and must be at least 4.5V for good current regulation and never more than 7.5V. The **Vdd** pin supplies the rest of the board and can range anywhere from 2.7V to 5.5V. In any event, the **LED** enable input must be at least 2.0V to turn the LEDs on. Other signal level requirements can be obtained from the TCS3200 datasheet.

Optical Data

With the supplied 5.6mm lens and a subject distance of 1" (25mm) from the front surface of the circuit board, the sensor module will "see" a square area roughly 9/64" (3.5mm) on a side. This means that any color variation within an area that size will be averaged by the TCS3200.

The spectral response of any color sensor system is a function not only of the sensor's device response, but also of the system's optics and illumination. The combined response of this module to emissive sources, taking into account the lens' IR filter, is approximated by the curves below:
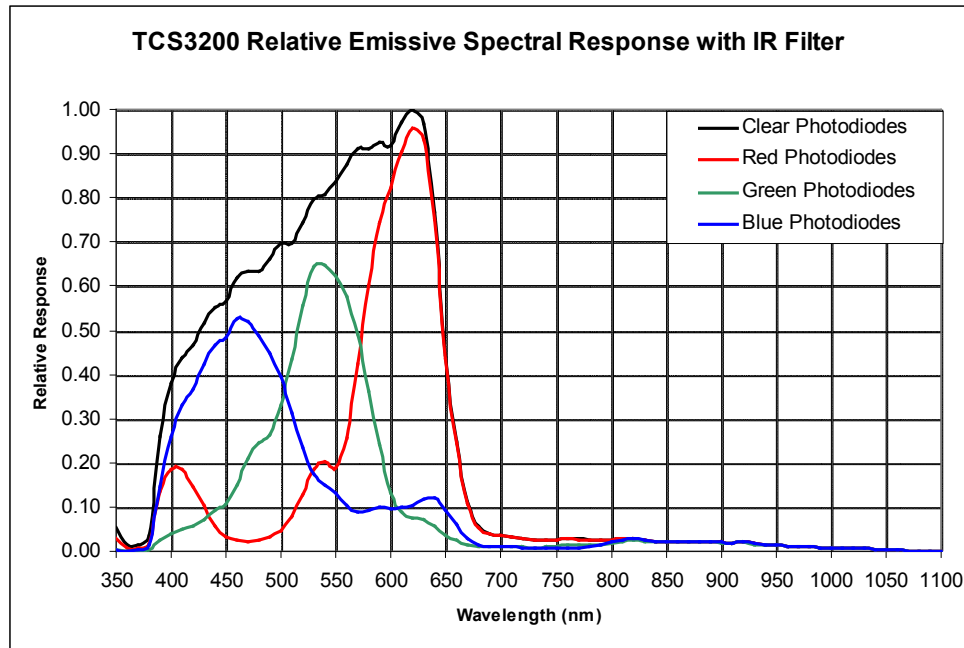
When the above is combined with the spectrum of the white LEDs for reflective subjects, the response curve looks more like this:

TCS3200-DB (January 21, 2010)
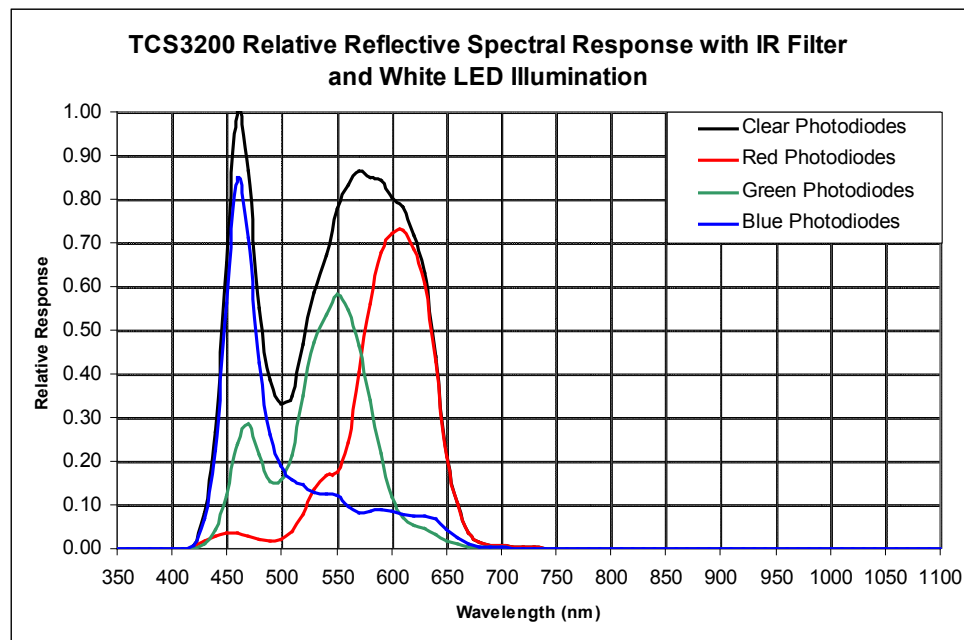
Software Notes

When used with a BASIC Stamp, the TCS3200's output frequency can be read using the Stamp's **COUNT** statement, as shown in the example code on the front side of this sheet. In this example, **S0** and **S1** were both pulled "high", enabling the TCS3200's fastest output rate. However, this rate can be as much as 600KHz or more at maximum light intensity, which is faster than the BS2 (limited to 120KHz) or the BS2pe (limited to166KHz) can count. So, **S0** and **S1** need to be set according to the maximum expected light intensity from the subjects being examined. On the MoBoStamp-pe, you can also measure the output frequency using the AVR coprocessor. This function is built in to the GPIO3 firmware, which can measure input frequencies up to 1MHz. See the GPIO3 documentation for the details. The TCS3200's **OUT** signal will appear on the GPIO3 firmware's port 2.

In order to save power — especially when battery-operated — you can power off the TCS3200 chip by setting **S0** and **S1** low. You can also operate the LEDs only when reading color. This works because the LEDs come on almost instantly, having no warm-up time as incandescent lamps do. This can be accomplished by strobing **LED** high only when you need to take a reading. This technique is also useful for canceling the effects of ambient light. Take one reading with the LEDs on and another with them off, then subtract the second reading from the first to get a more accurate color measure. This only works, of course, when the ambient light doesn't change between readings. Also, if the ambient light comes from a fluorescent light source, be sure that the measurement interval is a multiple of the mains period (1/60 sec. in the U.S.).
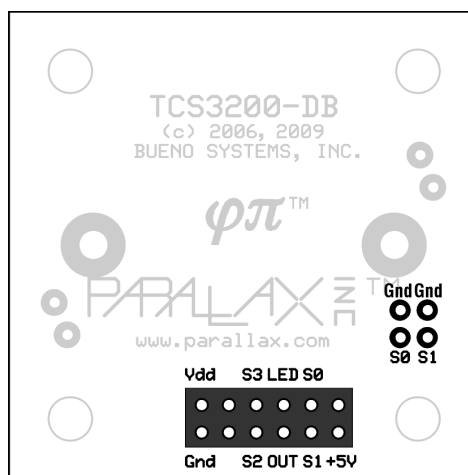
The **S2** signal line includes a 0.047µF capacitor to ground. This can be used to identify the presence of the TCS3200-DB or to determine which MoBoStamp-pe socket it's in, using the following PBASIC code:

```
LOW S2
PAUSE 20
RCTIME S2, 0, Id
```

If, after executing this code, the TCS3200-DB is present in the socket tested, the variable Id will have a value of around 35. An empty socket will yield a value of 1, and other TAOS light-to-frequency daughterboards will identify with different values.

Additional information, applications, and software examples can be found on both the TAOS and Parallax websites listed in the header on the first page.

Module Pinout

Rear View

Schematic