

# TCS230 COLOR SENSOR MODULE WITH APPMOD ADAPTER

## Out of the Box

The TCS230 Color Sensor Module set consists of two printed circuit boards and a short length of ribbon cable. These boards are packaged plugged into one another.



After unpacking the two boards, separate them. Do not power them up plugged into each other. To do so could irreparably damage both boards.

The AppMod adapter board (the one having the pass-thru connector) may be plugged directly into the Parallax AppMod connector, like the one provided on the Board of Education. It should be inserted so that the pin legends on the adapter board align and agree with those on the Board of Education.

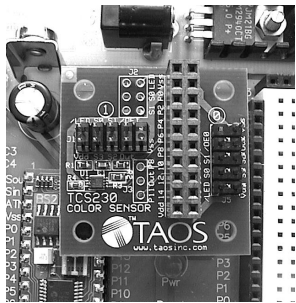


Figure 1. AppMod board correctly installed.



Make sure all 20 pins of the AppMod adapter are inserted into their respective socket holes. Offsetting the adapter (e.g. connecting just one row of pins or shifting it up or down) can cause irreparable damage.

The sensor module is connected to the AppMod adapter using the supplied 6" (150mm) ribbon cable. This cable is keyed with a blocked connector hole on each end. These correspond to the pins missing from the 2x5 headers on both boards. So long as all nine pins are connected, you cannot attach the cable incorrectly, and either end can be connected to either board.

The AppMod adapter has two headers to which the cable may be attached. They are addressable as 0 (J5) and 1 (J1), with the addresses screened onto the board. This is to accommodate two sensor modules at once, if desired, or to enable various mounting orientations when used with the BOE-Bot.

## Getting Started

Key the following BS2 program into the BASIC Stamp Editor (available for download from [www.parallax.com](http://www.parallax.com)):

```
'{$STAMP BS2}
EN      con      1
A0      con      2
S0      con      3
S1      con      4
S2      con      5
S3      con      6
nLED    con      7
OUT     con      8

pRED    con      12
pGREEN  con      6
pBLUE   con      5

RED     var      word
GREEN   var      word
BLUE    var      word

Start:   low      A0
         high     S0
         high     S1
         low      nLED
         high     EN

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

         end
```

With the sensor module *detached* and a serial cable connected from your PC to the Board of Education, power up the Board of Education, and *Run* the program you've entered. Power down, attach the sensor module to the AppMod adapter's J5 via the ribbon cable, and power up again. Two things should now happen: 1) The white LEDs on the sensor module will come on, and 2) You will see output appear on the debug terminal 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. Now, grasp the sensor module and aim it down at a light-colored piece of paper. Move the module up and

down as you watch the debug output. The numbers will increase, peaking at a maximum, then decrease again. Notice where the module is at the peak. The circuit board should be about one inch above the surface of the paper. Also notice that at this point the spots from the two LEDs converge into one. This is the position at which you will always want to read color.

You can easily construct a small stand for the sensor module using parts obtained from a hardware store:

4 ea. 4-40 x 1/4" (or M3 x 35mm) pan-head machine screws,  
8 ea. 4-40 (or M3) hex nuts.

Attach them to the sensor module as shown:

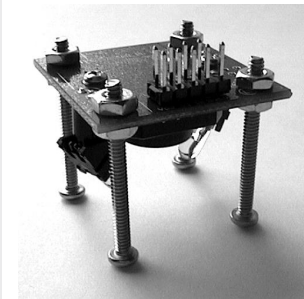


Figure 2. Adjustable stand made from machine screws.

The exact height can be set by loosening the nuts, advancing or retracting each screw, then retightening the nuts.

Alternatively, the **TCS230 Deluxe Mounting Kit** contains several fixtures, brackets and spacers for mounting the sensor module in a variety of orientations (both on and off the BOE-Bot).

## Hardware Notes

No technical discussion of the TCS230 sensor module set would be complete without the material contained in the TAOS TCS230 datasheet. If you do not have this datasheet, you are encouraged to download it from the TAOS website, [www.taosinc.com](http://www.taosinc.com).

The TCS230 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 tri-stable 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

Most of the TCS230 chip's data and control lines are accessed directly via BASIC Stamp port pins through the AppMod adapter board. The only exception is the **/OE** (active-low output enable) line, which is decoded for each cable header (J1 = **Unit 1**, and J5 = **Unit 0**) using **A0** and **EN** from the BASIC Stamp. In addition, each sensor module's **/OE** line further gates the LED enable, so that the board's LEDs cannot be on if the output is disabled. This additional logic accomplishes two things: 1) it prevents contention on the **OUT** line if two sensor modules are connected to the AppMod adapter, and 2) it prevents the excess current drain that would occur from two sets of LEDs being on concurrently. The BASIC Stamp port assignments are shown in the following chart:

Signal	Default	BS2 Pin	Option
EN		P1	
A0		P2	
S0		P3	N/C
S1		P4	N/C
S2		P5	
S3		P6	
/LED		P7	N/C
OUT		P8	P11

The "options" listed above are available at J2 and J3 on the AppMod board. By cutting the traces at J2 for **S0** and **S1**, these two signals will default "high", or they may be strapped to different levels at J1 on the sensor module. Cutting the **/LED** trace will default the LEDs "on" whenever the sensor module is selected. Cutting these traces will free up **P3**, **P4**, and

**P7** for other purposes. Additionally, if **P8** is used elsewhere, **OUT** may be switched to **P11** by cutting the trace on J3 and jumpering the center pin to the other outside pin.

The decoding logic is shown below:

A0	EN	/LED	/OE0	LED0	/OE1	LED1
0	0	0/1	disable	off	disable	off
0	1	0	enable	on	disable	off
0	1	1	enable	off	disable	off
1	0	0/1	disable	off	disable	off
1	1	0	disable	off	enable	on
1	1	1	disable	off	enable	off

The sensor module may also be operated without the AppMod adapter. In this case, the TCS230 signal **/OE** is controlled directly rather than through the address decoding logic shown above. LED "on" is still conditioned upon **/OE** being active low, however. Also, even though the TCS230 chip is capable of operation from 2.7 to 5.5V supplies, the module's **Vdd** must be a regulated +5.0VDC.

Additionally, the sensor module can operate using only the outside row of pins on J2 (**Vdd**, **S3**, **S2**, **Out**, **Vss**). When the inside row is left floating, **/OE** is asserted low, along with **/LED**. **S0** and **S1** float high but each can be strapped low individually at J2. This is to facilitate operation with the minimum required set of signals and to allow connection via a flat flex cable (e.g. DigiKey part number A9BBG-0506F-ND).

### Optical Data

With the supplied 5.3mm 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 5/32" (4mm) on a side. This means that any color variation within an area that size will be averaged by the TCS230.

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, taking into account the lens' IR filter and the LEDs' emission curve, is shown below:

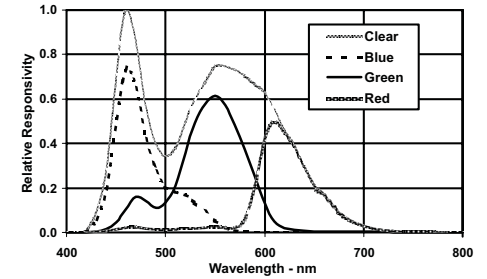


Figure 3. Sensor module color response.

### Software Notes

When used with the BASIC Stamp, the TCS230'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 set "high", enabling the TCS230'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 (being limited to 120KHz) can count. So **S0** and **S1** need to be set according to the maximum expected light intensity from the subjects being examined.

In order to save power — especially when battery-operated — you can 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 leaving **/LED** low and strobing **EN** high, or just by strobing **/LED** low when **EN** is high.

Additional information and software examples, as well as a PC host program can be found on both the TAOS and Parallax websites.

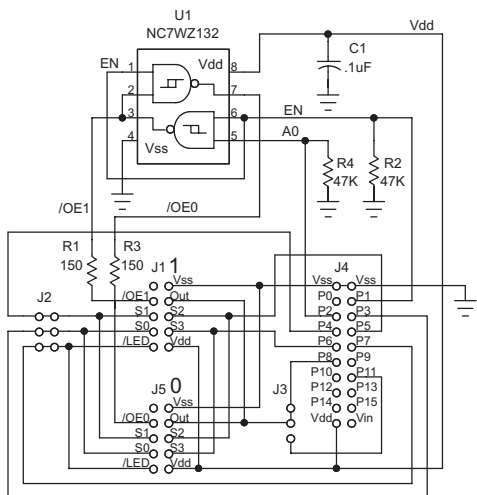


Figure 4. AppMod Adapter Schematic.

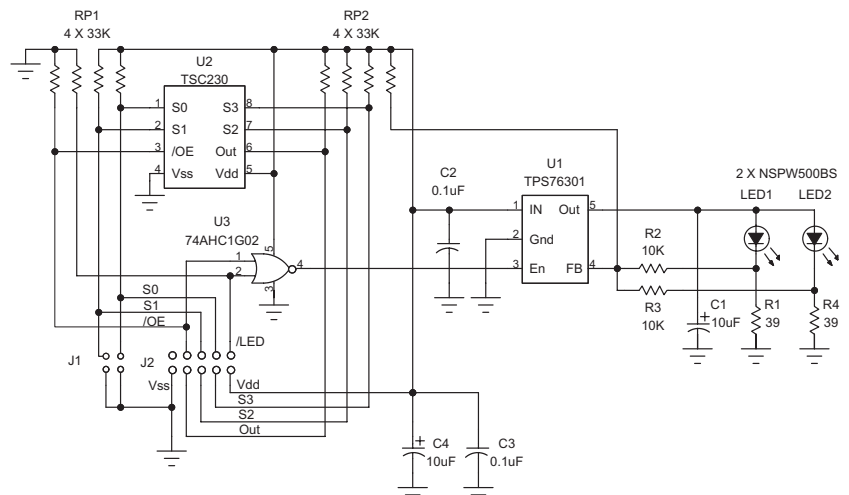


Figure 5. Sensor Module Schematic.