HDJD-JD07
Development Kit

User Guide

Contents

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Warning

DO NOT CONNECT OR DISCONNECT ANYTHING WHILE THE HDJD-JD07 DEVELOPMENT KIT OR THE PC IS SWITCHED ON!!! Doing so anyway may damage your PC and/or the HDJD-JD07 Development Kit permanently. Make sure power is off while interfacing with the Controller Board. DO NOT & never switch off power from controller board while program is running.

Credits

CIE xy chart – Prof. Geoff Hoffman
(http://www.fhoemden.de/~hoffmann/)

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Introduction

Avago Technologies has introduced a new smallest digital color sensor ADJD-S311-CR999, with a package size of 2.2x2.2x0.76[mm]. With a four-channel Red (R), Green (G), Blue (B) and Clear (C) color filters coated over the photo-diode array and integrated analog to digital converter (ADC), the sensor converts light to digital outputs. This device is designed to cater for wide dynamic range of illumination level and is ideal for applications like portable or mobile devices, which demand higher integration, smaller size and low power consumption. Sensitivity control is performed by the serial interface and can be optimized individually for the different color channel. The sensor can also be used in conjunction with a white LED for reflective color management.

The color sensor development kit, HDJD-JD07 is used as a guide to the application of ADJD-S311-CR999 besides demonstrating the principle of color sensing. The color sensor development kit can be used for both transmissive and reflective sensing.

Some of the HDJD-JD07 features include:

- Easily interface with PC via standard USB port which is compatible with most IBM PC.

- User-friendly software with displays of output digital readings, conversion to standard color format, data-log and CIE color chart features.

- Color sensor controller board consists of 2-wire serial interface to USB converter module, power supply module, LED constant current module and digital color sensor control module.

Avago's HDJD-JD07 serves as exemplary circuit application for composing other simple reflective and transmissive color detection system with ADJD-S311-CR999. This development kit will be the reference design for designers and users that needs to perform quick evaluation using the digital color sensor.

This user guide will discuss some features and advantages of ADJD-S311-CR999, the basics of reflective and transmissive sensing, the hardware construction of HDJD-JD07 development kit, how to setup and configure the kit and description of the GUI.

Startup

Included in delivery

Standard Avago HDJD-JD07 includes the following components:

• One sensor module

• One Controller Board (CB)

• One USB cable

• One CD with installation software

Figure 1. Sensor Module

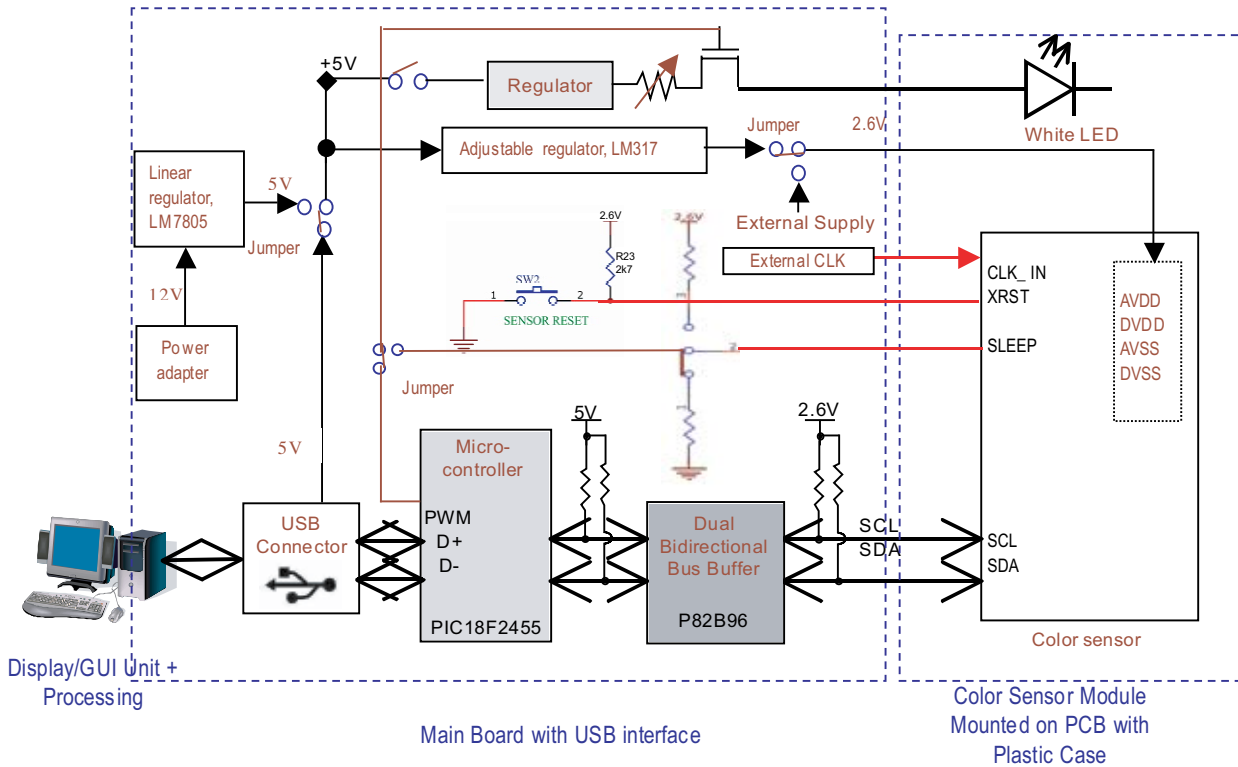

Figure 2. Digital Color Sensor Controller Board

Figure 3. USB cable

Figure 4. CD with installation software

Hardware Design

HDJD-JD07 Block Diagram

Display/GUI Unit + Processing

Main Board with USB interface

Color Sensor Module Mounted on PCB with Plastic Case

Hardware Features:

- The development kit consists of a main board and a sensor board which is interchangeable and is connected using pin connector and ribbon wire.

- The power supply for the color sensors can be selected from internal or external power supply. Using external supply will ease the measurement of power consumption of the color sensor using a power meter.

- The color sensors can have the option of using internal or external clock.

- The LED and the sensor can be controlled independently. There is a switch to turn on/off the LED and a trimmer to change the LED current. The LED can also be controlled by PWM or the sensor's SLEEP pin.

- The power supply could be chosen from the AC adaptor or the USB.

- There are switches at the main board to reset the color sensor and to control the sleep mode.

- Interface with PC via standard USB port.

Color Sensor Module

The color sensor module comprises an illuminant, digital color sensor and the mechanical block. The Avago white LED (HSMW-C191) is used as the illuminant/light source and digital color sensor (ADJD-S311-CR999) as the detector. The mechanical block which is made with delrin, will not only acts as the casing but also features an alignment gauge for maintaining an optimum gap between sensor and the targeted surface. The recommended distance of the sensor from the surface is 2.5 to 4mm for reflective sensing.

The ADJD-S311-CR999 is a cost effective, CMOS digital output RGB+C color sensor in miniature surface-mount package with a mere size of 2.2x2.2x0.76mm. The color sensor's basic architecture comprises integrated RGB+C filters built on a uniformly distributed photodiode array, a logic control core, and a gain selector with an ADC that supports digital communication. The uniform RGB filters and photodiode array minimize the effect of light-gradients caused by optical misalignment and irregularity of surfaces.

The output allows direct interface to micro-controller or other logic control for further signal processing without the need of any additional components. With its wide sensing range, the sensor can be used for many applications with different light levels, simply by adjusting the gain setting. Sensitivity control is performed by the serial interface and can be optimized individually for the different color channel. The integrated ADC helps to remove unwanted noise caused by analog signal preconditioning. Additional features include a selectable sleep mode to minimize current consumption when the sensor is not in use. For more details of ADJD-S311-CR999 specifications, please refer to the datasheet which can be download at www.avagotech.com.
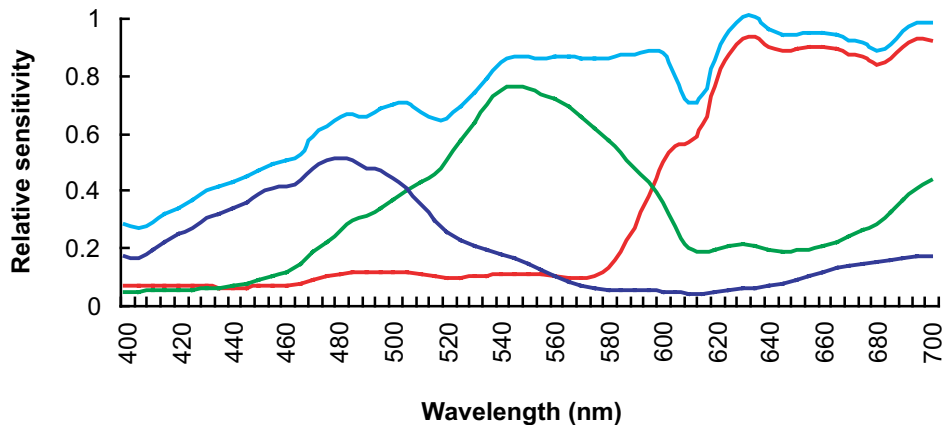

Figure 5. ADJD-S311 Spectral Response

Reflective Color Sensing Theory of Operation

By definition of reflective sensing, the color sensor detects light reflected from a surface or an object. The sensor module is designed in such a way that both the light source and the color sensor are placed closed to the target surface/object. Light coming from the LED is bounced off a surface/object and measured by the sensor. For a given light source, the color of light reflected off a surface/object is a function of the surface/object color. For example, white light incident onto a red surface is reflected as red. Since any color is uniquely represented by its **R**, **G** and **B** components, the sensor module effectively measures the color of a surface/object by converting the R, G and B components of the reflected light to digital value. In addition, given that the outputs increase linearly with the intensity of reflected light, the sensor also measures the reflectivity of a surface/ object where the clear channel could be use for this purpose.
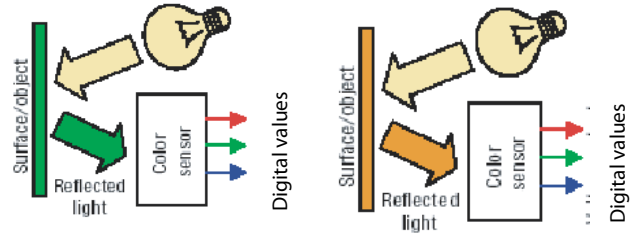

Figure 6. For a given light source, the color of reflected depends on surface/object color

Transmissive Color Sensing Theory of Operation

By transmissive, it means the application kit is placed facing the light source being measured. The filter-coated photodiode array of the color sensor converts the **R**, **G**, **B** components of light falling on it into photocurrent, which is then converted into digital values for each of the primary component. Given that any colored light is uniquely represented by the ratio of the primary colors, the color sensor provides a definite manner of measuring color. In addition, the sensor is also responsive to light intensity where its outputs increase linearly with increasing light intensity. To measure the brightness of the light source without the need to know the color, the clear channel can be used.
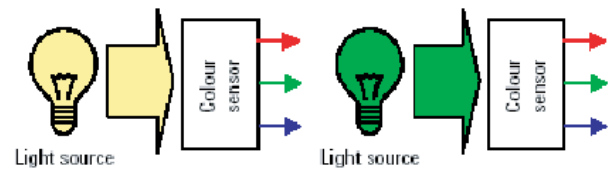
For a given light source, the application kit can also be used to determine the color of transparent medium through which the light is passed before reaching the sensor. For example, the medium could be glass, plastic or liquid. To use HDJD-JD07 in transmissive mode, simply turn off the white LED on the sensor module.
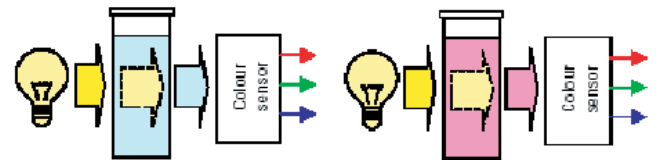

Figure 7. R, G, B outputs of the sensor is determined by color of light falling on the sensor

Figure 8. Apply color sensor on media such as color filter, gas or liquid

Digital Color Sensor Controller Board

The digital color sensor controller board consists of the following modules:

(i)   2-wire Serial Interface to USB Converter Module

(ii)   Power Supply Module

(iii)   LED Constant Current Module

(iv)   Digital Color Sensor Control Module

2-wire Serial Interface to USB Converter Module

This module converts the 2-wire serial interface from the digital color sensor to USB protocol that can be easily interface with the PC. The main components of this module are dual bidirectional bus buffer, P82B96 and USB microcontroller, PIC18F2455. The P82B96 interface the two different logic level from the microcontroller (5V) and digital color sensor (2.6V) while the microcontroller interface the 2 wire serial to USB.
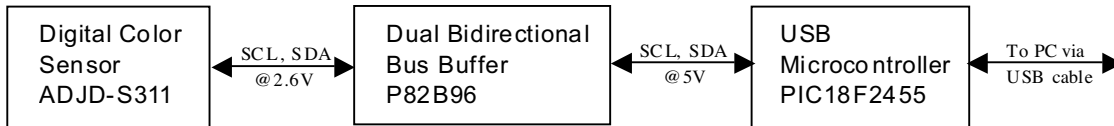

Figure 9. 2-wire serial interface to USB Converter Block Diagram

Power Supply Module

The power supply module taps power from the adapter and provides regulated voltage 5V for the microcontroller and 2.6V for the digital color sensor.
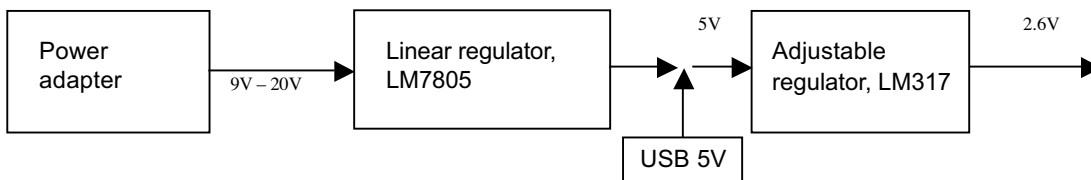

Figure 10. Power Module Block Diagram

LED Constant Current Module

This module provides constant current to the white LED using regulator LP38691-ADJ. The current can be adjusted from 2-30mA, however, typical current of 5mA is recommended. The LED current can be measured by measuring the voltage across R20 using test pin TP1/TP2. The current can then be calculated with $I = V/10$. (Note: The max DC current for the white LED is recommended at 10mA).
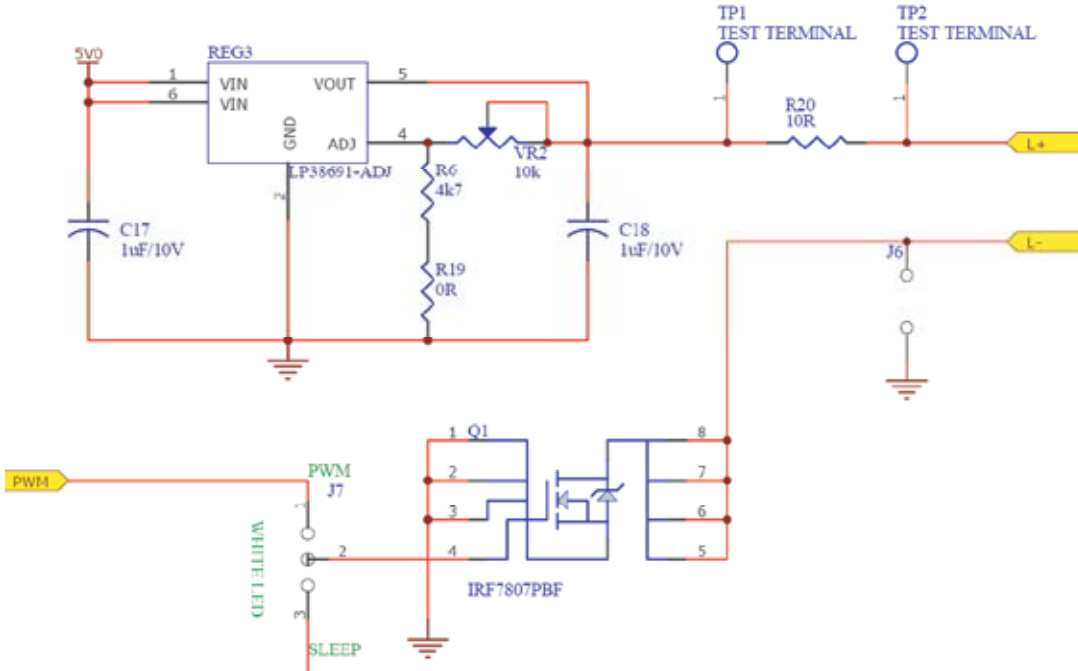
Figure 11. LED Constant Current Circuit

Digital Color Sensor Control Module

Consist of reset, external clock and sleep circuit for the digital color sensor. The clock signal from the signal generator or other oscillator can be connected to pin header J9.
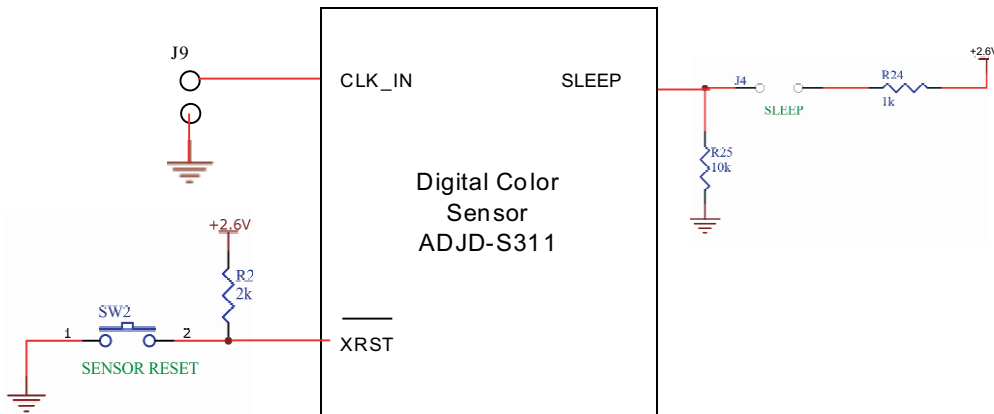
Figure 12. Digital Color Sensor Control Module Block Diagram

Hardware Setup and Configuration

Setup:

The HDJD-JD07 is designed with 2 different selections of power supply. User may select either the USB Port or Adapter Port as the +5VDC supply with respect to the changes of the Jumper J3.

1. Connect the USB cable from the computer to the evaluation board.

2. Select the jumper to the power source to use. If power from adapter is chosen, connect the adapter to the adapter socket.

Precaution: Please make sure that the adapter voltage is between 9V to 20V.

3. Connect the sensor module to pin header J8 on the evaluation board. Make sure the orientation is correct by checking the label on both the connector and board.
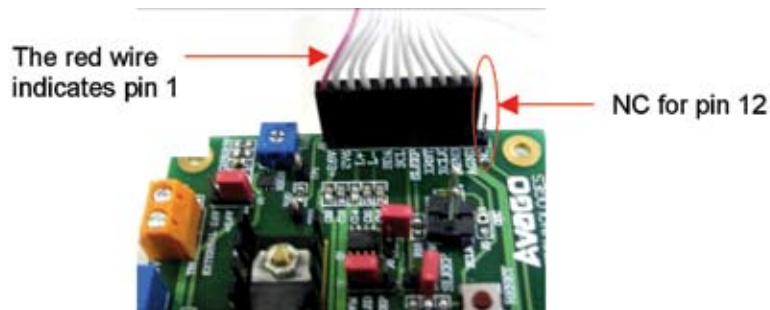
To power on:

1. Turn on the slider switch (SW1). The LED, L3 will light up to indicate there is power supply to the board.

2. The LED, L2 will light up if the USB cable is connected indicating there are communication between the controller board and the computer.

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Other functions:

1. Selecting internal or external power supply for the color sensor.

   Use J1 to select the source 2.6V for the color sensor. If external 2.6V is chosen, connect the supply to TB1. The external supply is to ease the measurement of sensor's power consumption.

2. Selecting White LED control

   The white LED can be turn on/off using 3 methods which is PWM from microcontroller, Sleep pin of color sensor during external clock mode and Jumper J6. Use jumper J7 to select either use PWM or Sleep pin, leaving the J6 disconnected. Connecting J6 will turn on the White LED using constant current bypassing the PWM and Sleep selection.

   The LED can be dim by changing the current by adjusting the variable resistor VR2. The LED current can be measured by measuring the voltage across R20 using test pin TP1/TP2. The current can then be calculated with I = V/10. (Note: The max current for the white LED is recommended at 10mA). Another way to change the brightness of the LED is by changing the PWM duty cycle from the software GUI although 100% duty cycle/constant current is recommended for sensor operation.

3. Sleep function

   Connect jumper J4 to put the sensor into sleep mode to minimize power consumption when sensor not in use.
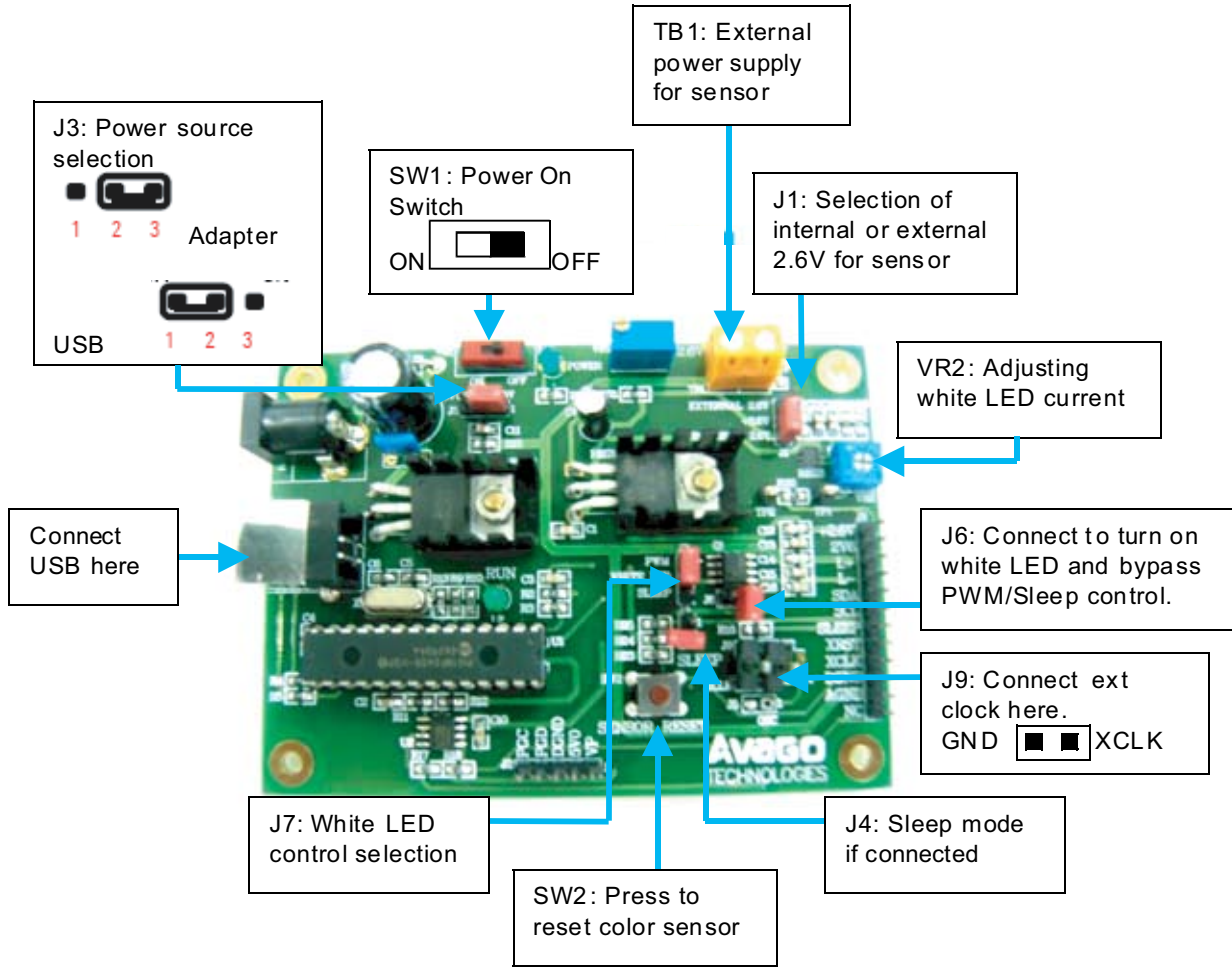
4. Color Sensor reset

   Push SW2 to reset the color sensor.

5. External clock

   The sensor is operating with internal clock at typical frequency of 26MHz. To use external clock connect the clock signal to pin 1 of J9 (the pin located closer to J8) while pin 2 of J9 is the reference ground.

Basic Description of Evaluation Board

J3: Power source selection

Adapter

USB

SW1: Power On Switch
ON ◻◼ OFF

TB1: External power supply for sensor

J1: Selection of internal or external 2.6V for sensor

VR2: Adjusting white LED current

J6: Connect to turn on white LED and bypass PWM/Sleep control.

J9: Connect ext clock here.
GND ◼ ◼ XCLK

Connect USB here

J7: White LED control selection

SW2: Press to reset color sensor

J4: Sleep mode if connected

PC Software Guide

Avago's HDJD-JD07 Digital Color Sensor Development Kit software is developed to be a tool for user to acquire knowledge on how to use ADJD-S311-CR999 and how color sensor can be applied. The interactive graphical user interface has made the software to be user friendly and easy to use. The same software can be used for both reflective and transmissive mode.

Software Installation

To install the software to the PC:

1. Insert the installation CD to the CD-ROM drive

2. Click Start, then click Run

3. Type D:\setup and press Enter.

IMPORTANT: Use the appropriate drive letter in the above command to install the software. CD-ROMs are commonly "D:".

The installation program will guide you through the software installation.

Note: If any text box appeared noting that the current system file has a newer version, just select 'Ignore' button.

Software GUI Guide
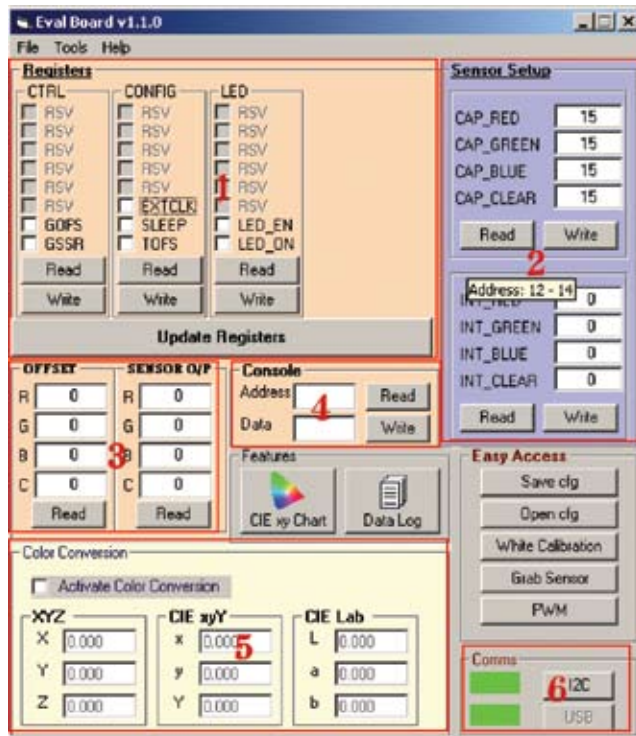
1. Configuration and control registers

   These are the internal registers that configure the color sensor and control its functions.

2. Sensor setup registers

   These boxes contain the sensor gain settings that adjust the sensitivity of the sensor. The user can key in data into these boxes to manually change the gain or can use the white calibration feature to generate the optimum gain value.

3. Sensor and offset registers

   The sensor registers store the digitized readings of the color sensor and the offset register store the offset value of the color sensor.

4. Console

   The console is a general-purpose method to write to and read from the sensor. The user enters just the register address to read. To write, enter both the address and data.

5. Color Conversion

   Display the sensor readings in XYZ tristimulus values, CIE Yxy color space and L*a*b* Color space. The XYZ, Yxy and Lab value will only be shown if the checkbox for "Activate Color Chart/Conversion" is checked after some settings are made.

6. Comms

   The user needs to check the communication between the software and the board before using the software by pressing the "test" button. Red means the communications test failed. Green means it passed.

Software Features:

• Compatible with Windows XP and 2000.

• Developed with Visual Basic.

• List of color sensor registers for user references.

• Display of R, G, B and C readings.

• Manual gain selection.

• White calibration (Auto-gain feature).

• Color Conversion to standard color space.

• Data-log features to save the R,G,B and C readings to text and excel files.

• CIE xy chart to display the color measured.

• PWM Window to turn on/off and control the brightness of white LED.

Writing and Reading Registers
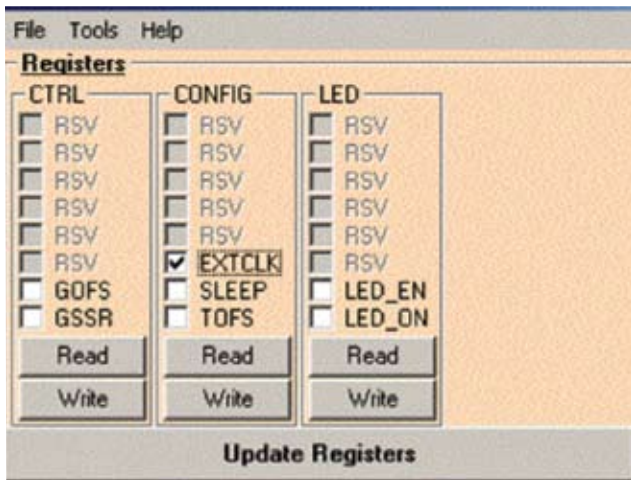
Check means put a tick next to the register bit and press the write button. A check means logic 1 written to the register bit. Nothing is written to the device until the write button is pressed. For example, to grab sensor readings, put a tick for GSSR and press the write button.

If the read button is pressed, the register for that read button is read. A logic 1 is represented by a tick next to the register but. E.g. in the picture, the read button for the CONFIG register was pressed and the EXTCLK bit has a tick to indicate that the device is using external clock.

To change the sensor capacitance or integration time, change the value in the textbox and press the write button.

The update registers button can be used to read all the registers at once, including sensor setup, offset and sensor output registers.

Brief description of the register bits. Refer to datasheet for details.

|	
GOFS	Check to grab offset reading.
GSSR	Check to grab sensor reading.
EXTCLK	Check to use external clock.
SLEEP	Check to put sensor in sleep mode when using external clock.
TOFS	If checked, the sensor output will automatically deduct the offset before stored in sensor output register.
LED_EN	Check to enable the LED control using Sleep pin when using external clock.
LED_ON	Check to turn on the LED.
CAP_RED	Enter 0 to 15 to choose number of red channel capacitor.
CAP_GREEN	Enter 0 to 15 to choose number of green channel capacitor.
CAP_BLUE	Enter 0 to 15 to choose number of blue channel capacitor.
CAP_CLEAR	Enter 0 to 15 to choose number of clear channel capacitor.
INT_RED	Enter 0 to 4095 to choose red channel integration time slot.
INT_GREEN	Enter 0 to 4095 to choose green channel integration time slot.
INT_BLUE	Enter 0 to 4095 to choose blue channel integration time slot.
INT_CLEAR	Enter 0 to 4095 to choose clear channel integration time slot.

File Menu

File>…

The user can save the current state of the GUI i.e. the check boxes and data in the text boxes into a configuration file. This file can be loaded in the next session and all previous user data will be re-loaded.

File>Open   Loads a configuration file

File>Save As…   Saves the current configuration as *.cfg

File>Exit   Exits the software
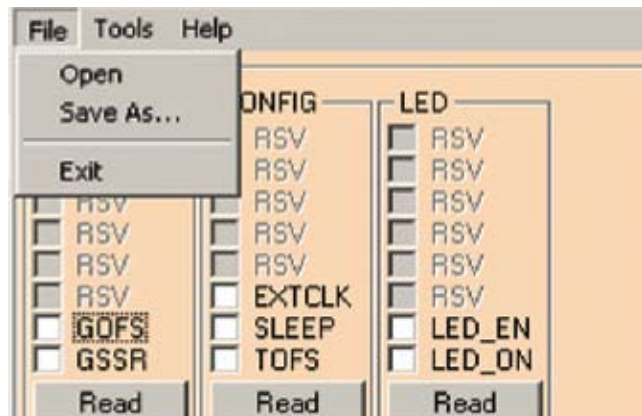
Tools>…

In Tools menu, there are several windows that can be accessed:

Tools>CIE xy chart   Opens CIE xy Chart window

Tools>White Calibration   Opens White Calibration window

Easy Access

Save the current setting to *.cfg file.

Load previous saved *.cfg file to the color sensor.

Open the White Calibration window, refer the window below for details.

Obtain the sensor output readings.

Open the PWM window to control white LED, refer PWM window for details.
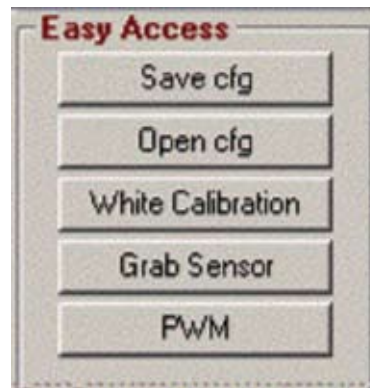
Press the Update button to write the PWM duty cycle stated at the textbox to the microcontroller. The duty cycle may be change although it is recommended to use 100% for reflective sensing applications.

To turn off the LED, press Off button.

Steps for white calibration:

1. Key in the target value of Red, Green, Blue and Clear channel.

2. Select the capacitance value from 0 to 15.

3. Select the maximum integration time the program will sweep to get target value (max 4095).

4. Click on the White Calibration button while pointing the sensor to the reference white surface (Gretag Macbeth Chart white patch).

5. The TINT (integration time) will changed and the sensor reading will be displayed. This is the integration time to get the target value and is updated to the sensor registers.
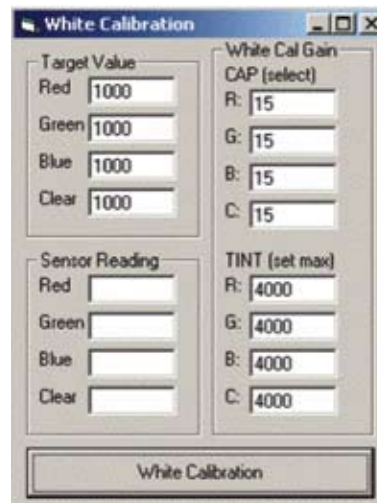
CIE xy chart

The CIE xy chart can be accessed in the following 2 ways:

1. Click on CIE xy Chart button at features section at the main GUI.

2. Click menu Tools -> CIE xy Chart.

To view the CIE xy chart real time, user had to activate the color conversion. Then a circle will appear showing the color measured by the color sensor at the CIE xy chart.

CIE xy coordinate

Circle (Color Space Indicator)
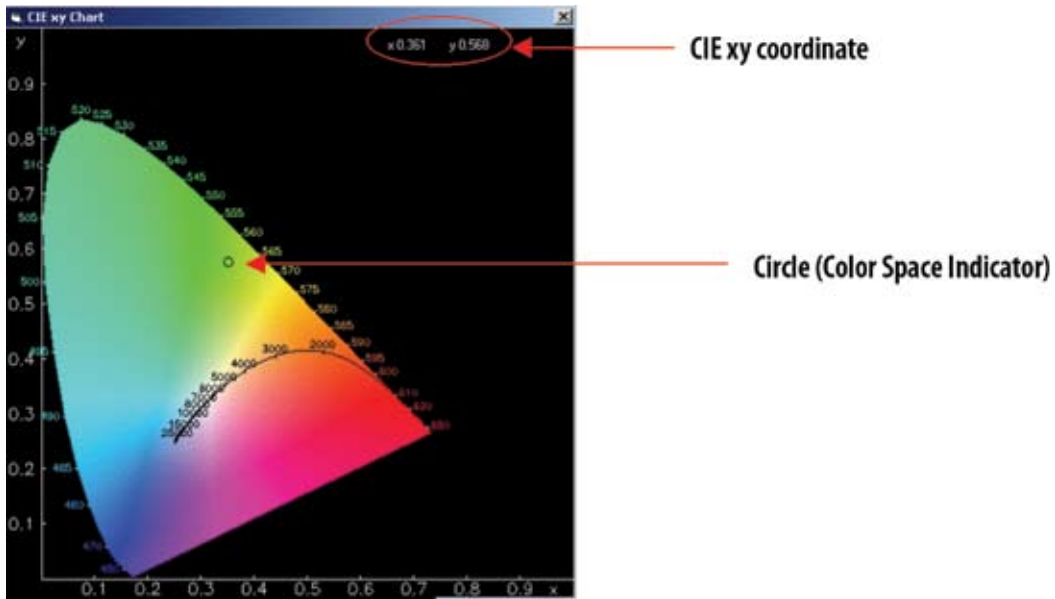
Numerical Data Log

With this numerical data log feature, the user can identify and keep track the consistency and repeatability of the color being scanned. The user can also save the data so that it can easily be retrieved later. The data log can be access by clicking on 'Data Log' button at features section at the main GUI.
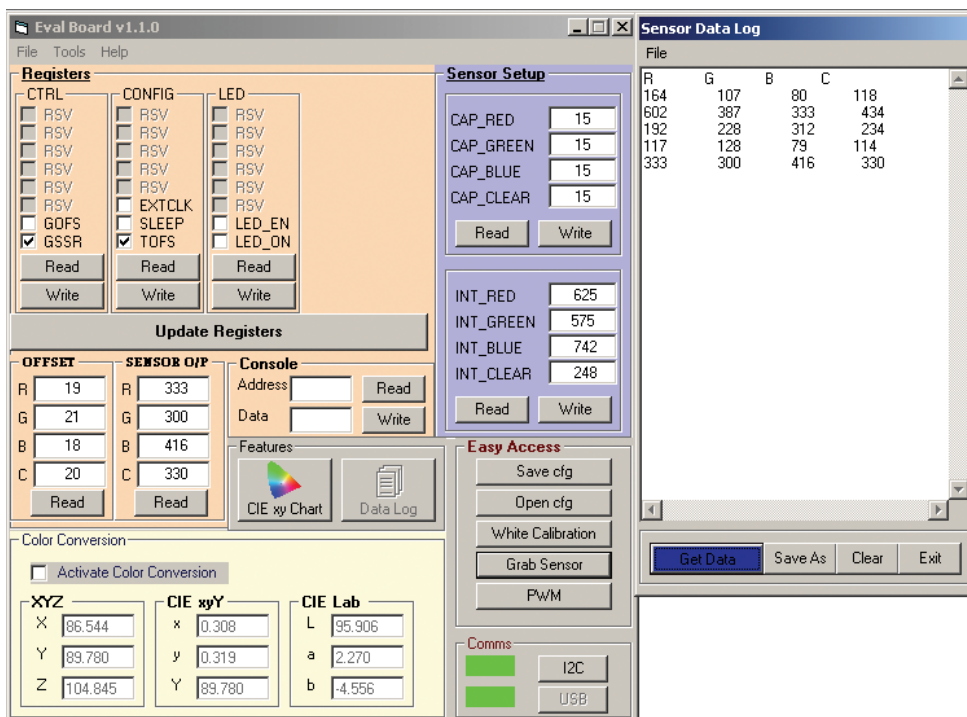
Buttons function at Data log windows:

Get data: Transfer the digital readings measured and displayed at the main GUI to the data log windows.

SaveAs :   Save file as several different types of format *(e.g. RTF, Text Files or Excel Files)*.
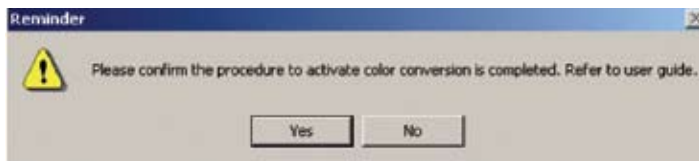
Clear: Clear the display screen of data log windows.

Exit: Close the data log window.

Activation of Color Conversion

The following is the step by step procedure to activate the color chart and color conversion. To make sure that the conversion is correct, the procedure should be strictly followed.

1. Perform white calibration with target value of 1000 for all channels using white patch of GretagMcbeth color chart.

2. After white calibration, check the Activate Color Conversion checkbox. A message box will appear, click Yes to confirm all procedure correctly done.

3. The color conversion and real time CIE xy chart is now activated. Click Grab Sensor button to measure color as usual but now the sensor reading will also be converted to other standard color space and displayed at the color conversion frame.

4. Once color conversion is activated, the gain setting (sensor setup) is disabled until the Color Conversion is unchecked.

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