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CLOUR SENSOR BASED MATERIAL SORTING ON CONVEYOR

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ABSTRACT

The Paper deals with an automated material handling system. It aims in splitting the coloured finished products, which are approaching on the conveyor by placing it in its separate allotted place. There by reducing the tedious work done by a human, accomplishing accuracy and rapidity in the work. The project includes a colour sensor (TCS3200) that senses the colour of the item and lead the signal to the controller. The microcontroller gives signal to servo motor that controls the guide rail to place the object it in the correct location. Depending upon the colour sensed the guide rail moves to the correct location to releases the object. The use of this system makes the work simple for the system operator, and no longer need to sort the materials based on the colours manually, this reduces the labours effort also increases the work efficiency and reduces the time and cost.

KEYWORDS: Colour sensor ; Conveyor; Automatic material handling system; Microcontroller.

1. INTRODUCTION

Automated materials handling System is an integrated system that involves the activities such as moving, handling, storing and controlling of materials. Many industries that are manufacturing products with different colours have different assembly/packing lines for different coloured products. This requires lot of space for each lines, more cost for initial setup, more labours and operators for each assembly lines are required. In this Project we are using a colour sensor (TCS3200) for sensing/identifying the colour of the finished products that are moving through the conveyor. The colour sensor is connected to Arduino UNO microcontroller. The sensor senses the color with the help of an 8x8 array of photodiodes. Then using a Current-to-Frequency Converter the readings obtained from the photodiodes are converted into a square wave with a frequency directly proportional to the light intensity. By using an Arduino Board we can read the square wave output and get the results for the color. Then based on the colour detected the guide rail moves to the location to where the detected object is to be placed. The setup also have an IR (infrared sensor) sensor and a PIR (passive infrared sensor) sensor. IR sensor is used to detect the objects moving on the conveyor, if there is no objects in the conveyor the system will turn off which can save the power. PIR is used to avoid injuries to the humans or animals that are approaching to the moving conveyor or the guide rails. IR and PIR sensors we are using here are standalone units.

1.1 Objectives

- To make the prototype of colour based sorting material.
- Many of the industries that are manufacturing different coloured product uses different packing lines for each coloured products, this requires lot of space, labor and money and also its a time consuming process.
- The implementation of this system makes the work simple for the operator, and sorting of materials will be easy, this reduce the efforts of the operators, labours and also increases the work efficiency.

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2. METHODOLDOGY

- Turning "ON" the power supply.
- IR object detection sensor checks if there any objects in the conveyor. If yes it will switch ON the supply to the PIR Relay "C" terminal, else IR relay Will Stay Off.
- Power Supply reaches to the PIR sensor relay "C" terminal. If PIR sensor detects humans near the working machines/Conveyor, the PIR relay turns ON and power supply through "NC" Terminal of the relay will break thus supply to microcontroller will stop. Else if there were no human presence the PIR relay will be "Off " and power will pass through "NC" Terminal to the microcontroller.
- The colour of the Moving object through the conveyor is being Sensed with the help of the colour sensor (TCS3200) and sends the signal to the micro controller.
- The micro controller identifies the colour of the object and sends signal to the servo motor connected to the guide rail.
- The guide rail then moves to the bin location, to where the identified objects need to place, then the conveyor moves and the identified object was moved to the guide rail

3. MATERIALS

There are different units in this setup, those units will work with the co-ordination of each other's in a particular time of intervals for the correct operation for the efficient process, and those are listed below.

Arduino Uno Microcontroller: This unit is the brain of the system. Based on the input received it will control all other systems connected to this. Arduino Uno is an open-source microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

Fig.1 Arduino Uno Pin Diagram

Specification

ι	Operating Voltage	5V
ι	Input Voltage (recommended)	7-12V
ι	Input Voltage (limits)	6-20V
ι	Digital I/O Pins	14 (of which 6 provide PWM output)

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ι Analog Input Pins	6
ι DC Current per I/O Pin	40 mA
ι DC Current for 3.3V Pin	50 mA
ι Flash Memory	32 KB (ATmega328) of which 0.5 KB used by boot loader
ι SRAM	2 KB (ATmega328)
ι EEPROM	1 KB (ATmega328)
ι Clock Speed	16 MHz

TCS3200 Color Sensor: The TCS230 colour sensor senses color light with the help of an 8x8 array of photodiodes. Then by using a Current-to-Frequency Converter the readings from the photodiodes are converted into a square wave with a frequency directly proportional to the light intensity. Finally, by using the Arduino Board we can read the square wave output and get the results for the color. The photodiodes have three different color filters, Sixteen of them have red filters, another 16 have green filters, another 16 have blue filters and the other 16 photodiodes are clear with no filters. The detection of color compared to the vision senor is much faster and cheaper. The Pin S2 and S3 are used to choose array of photodiodes (red, green, blue, clear). We can select the Scaling of frequency by using pins S0 and S1.

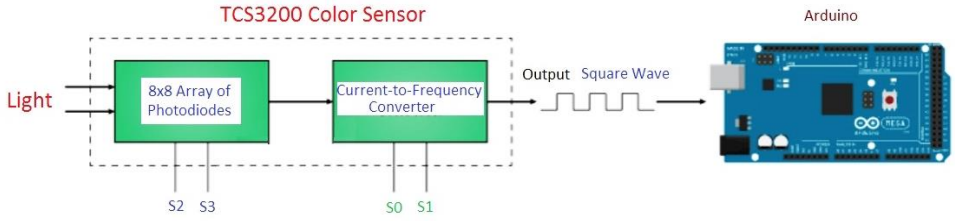

Fig.2 Functional Block of TCS3200 Color Sensor

Infrared sensor: IR sensor is used to detect the objects moving on the conveyor, if there is no objects in the conveyor the system will turn off which can save the power. Infrared object detection sensor has a pair of infrared transmitting and receiving LEDs. Infrared is emitted from the transmitter, when meet an obstacles (reflecting surface), reflected infrared is received. Distance can be adjusted using the potentiometer knob.

Specification

ι Effective Range:	2:30 cm (Adjustable by potentiometer)
ι Voltage Supply:	3.3 - 5V
ι Detection Angle:	35°
ι LED indicator	(red power on, Green detection)

PIR Sensor: PIR sensor detects a human being moving around within approximately about 10m from the sensor. PIR are fundamentally made of a pyro electric sensor, which can detect levels of infrared radiation A PIR sensor detects the infrared light radiated by a warm object. It consists of pyro electric sensors which introduce changes in their temperature (due to incident infrared radiation) into electric signal. When infrared light strikes a crystal, it generates an electrical charge. In this project is used to avoid injuries to the humans or animals that are approaching to the moving conveyor or the guide rails.

Specification

ι Operating voltage	DC 12V
ι Sensing distance	5 to 7m
ι Induction angle	About 120 degrees, 100 degrees up and down
ι Light control sensor	5LUX-500LUX (adjustable)

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Servo Motor MG995 MG 995 55g : The servo motor is a small and effective motor and it can be used in some serious applications like precise position control. The controlling of this motor can be done with a PWM (pulse width modulator) signal. The applications of these motors mainly include in industrial robotics. Here it is using to control the Guide Rail.

Specification

- Dimension 40mm x 19mm x 43mm
- Weight 55g
- Operating Speed 0.17sec / 60 degrees (4.8V no load)
- Operating Speed 0.13sec / 60 degrees (6.0V no load)
- Stall Torque 9 kg-cm (180.5 oz-in) at 4.8V
- Stall Torque 12 kg-cm (208.3 oz-in) at 6V
- Operation Voltage 4.8 - 7.2Volts
- Gear Type All Metal Gears
- Connector Wire Heavy Duty, 11.81" (300mm)

Conveyor unit: The main job of this unit is to move the object form other place in manufacturing units, the TCS3200 Sensor was placed over this conveyor.

Guide Rail: Guide Rail will move to the storage locations based on the output given by the microcontroller

4. DESIGN

All the components required for the project are connected together to work such a way that to give the required output.

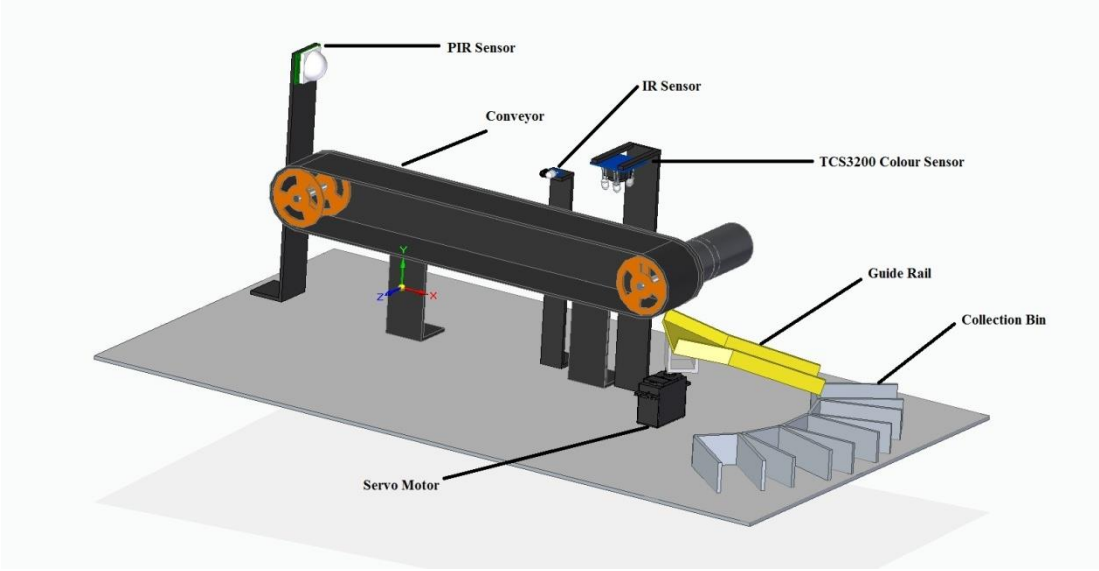

Fig.3 Project setup made by using solid edge ST9

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Circuit Diagram

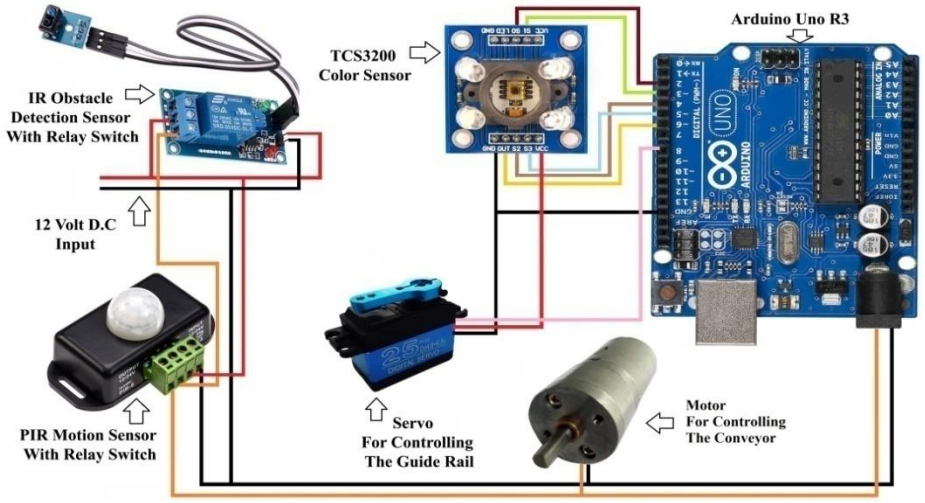

Fig.4 Circuit diagram for the Setup

5. WORKING PROCESS

Finished products after completing the production process will move through the conveyor to the final sorting or packing area there the color sensor TCS3200 is used to detect the colour based on the color of the material. After identification of the color of the material, the guide rail moves to the predetermined location of the colour identified. the number of storage locations and colours can be changed easily using a PC.

TCS3200 Colour Sensor working

The TCS230 colour sensor senses color light with the help of an 8x8 array of photodiodes. Then by using a Current-to-Frequency Converter the readings from the photodiodes are converted into a square wave with a frequency directly proportional to the light intensity. Finally, by using the Arduino Board we can read the square wave output and get the results for the color. The photodiodes have three different color filters, Sixteen of them have red filters, another 16 have green filters, another 16 have blue filters and the other 16 photodiodes are clear with no filters. The detection of color compared to the vision senor is much faster and cheaper. The Pin S2 and S3 are used to choose array of photodiodes (red, green, blue, clear). We can select the Scaling of frequency by using pins S0 and S1

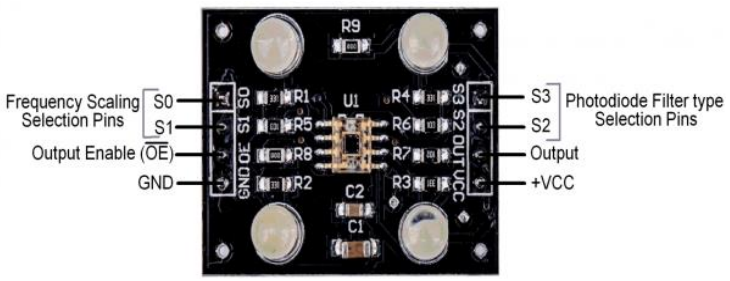

Fig.5 Color Sensor TCS3200 Pin Description

Pin 1 & 2 – S0 & S1: Output frequency scaling selection pins. These two pins are used to scale the frequency of current to frequency converter.

Pin 3 – OE (Active Low): Output Enable

0= Output pin is enabled.

1= Output pin is in High-Impedance state.

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Pin 4:5 – GND: VCC

GND= Power Supply Ground.

VCC= Supply Voltage to sensor.

Pin 6 – Output: This pin gives output in the form of train of pulses. The duty cycle of these pulses is fixed to 50% and the frequency of these pulses is varying according to the input light.

Pin 7 & 8 – S2 & S 3 – Photodiode filter type selection pins

The output of the sensor is a square wave (50% duty cycle) with frequency (f_0) directly proportional to light intensity:

$$f_0 = f_D + (Re)\ (Ee)$$

where f_0 is the output frequency; f_D is the output frequency for dark condition (when Ee = 0); Re is the device responsivity for a given wavelength of light in kHz/(mW/cm); Ee is the incident irradiance in mW/cm . f_D is an output frequency resulting from leakage of currents. As shown in the equation above, this frequency represents a light independent term in the total output frequency f_0 . At a very low light levels (dark colors), this dark frequency can be a significant portion of f_0. The dark frequency is also temperature dependent. As f_0 is directly proportional to frequency, it is possible to map between the frequency and RGB color value (0-255 for each of R, G and B) using linear interpolation.

Two points on the RGB line are well determined which are pure Black (RGB 0, 0, 0) and pure White (255, 255, 255). The values returned by the sensor can be read using easily obtainable color swatches.

The proportional relationship is expressed by the standard straight line equation y = mx + b. where,

- "y" is the reading obtained (in our case f_O)
- "x" is the normalized RGB value
- "b" is the value of y when x is 0 (in our case f_D)
- "m" is the slope, or proportionality constant, of the line (in our case $[f_W - f_D]/255$).

The resulting equation is

$$f_O = f_D + \frac{x \cdot (f_W - f_D)}{255}$$

or, rearranging to give us the desired RGB value

$$x = \frac{255 \cdot (f_O - f_D)}{(f_W - f_D)}$$

Table 1. Frequency Scaling Selection pins

S0	S1	**Output frequency scaling (f0)**	**Min o/p frequency**	**Max o/p frequency**
0	0	Power down mode.		
0	1	Output frequency is 2% of current to frequency converter's output.	10 KHz	12 KHz
1	0	Output frequency is 20% of current to frequency converter's output.	100 K	120 K
1	1	Output frequency is 100% of current to frequency converter's output.	500 K	600 K

Table 2. Photodiode type selection

S2	S3	**Photodiode type with their respective filter**
0	0	Red
0	1	Blue
1	0	Clear
1	1	Green

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Power down mode

- This mode is active when the Pins S0 and Pin S1 are in LOW states.
- The output pin is at High-Impedance state after this mode is enabled.
- The function of this mode is like OE (Active Low) pin.
- But, Power down mode saves more power compare to enabling OE (Active Low) pin.

Full Scale Frequency

Full scale frequency is the maximum frequency at which output is stable.

Operating Characteristics of Full Scale Frequency

- The Full-Scale Frequency is different for Red Pass Filter, Green Pass Filter and Blue Pass Filter.
- The wavelengths at which Red, Green and Blue colors are relatively responsive, are Highlighted.

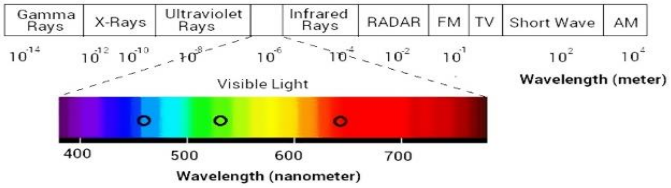

Fig.6 Frequency Spectrum

6. RESULTS AND DISCUSSION

The Automated material Handling system based on TCS3200 is fine working based on the instructions provided by the microcontroller Arduino UNO. The testing was done by placing five coloured (Red, Green, Blue, Orange, Yellow) objects over the conveyor. The sensor Identifies the colours correctly thus the guide rail moves to the predetermined location of the identified objects storage location.

7. CONCLUSION

The system can able to identify the specific color of the object and place it and place it in a required with the help of TCS3200 color sensor by sensing the color of the object. The three main tasks performed by the sensing section.

1. Recognition of color.
2. Detection of objects.
3. Detection of humans around the system.

This system is fully controlled by the Microcontroller and capable of transferring objects to its respective area. This cost effective and time saving device was designed by using simple concept to make the tasks simple and error free. This device can be used in industries that are manufacturing different coloured products.

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