Embedded based Color Recognition

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Abstract— With the advancement of technology things are becoming simple and easier for us. Color measurement is important for a very wide range of industrial applications including paint, paper, printing, photography, textiles, and plastics. A simple smart hardware embedded into a small lightweight device used for color recognition, which has limited area of equipment. The integrated photodiode with transimpedance amplifier converts the color into voltage. The photodiode output voltage is applied to Microcontroller using analog to digital converter, output is displayed on the liquid crystal display. The microcontroller program controls the ADC and LCD. A simple, precise and inexpensive Microcontroller P89C51RD2 based Instrument set up has been designed, developed to find the Color. Hardware and software are developed for color recognition.

Key words: Photodiode, Transimpedance Amplifier, ADC, Microcontroller P89C51RD2

I. INTRODUCTION

Color measurement is important for a very wide range of industrial applications including paint, paper, printing, photography, textiles, plastics [1, 2]. Let us consider an example. A manufacturer wants to produce goods with specific color appearance. He can design the appearance of the product and he can measure it. After the production process the appearance of the product might be changed or it can vary between manufacturing batches because of noise inherent in the process. Now a manufacturer would like to know if the actual color is sufficiently similar to the desired one or whether the color is so different that it is not economically advisable to sell the products because of fear of consumer complaints. From this point of view, it is very important to be able to handle measurements and calculations of small color differences [3]. Color measurements are of great importance in the production of a very wide range of manufactured goods in industry.

II. BLOCK DIAGRAM

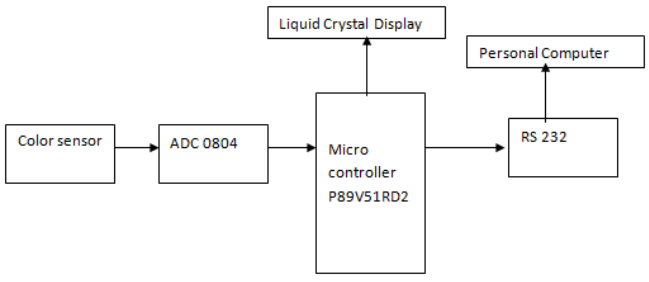

Fig 1: Block Diagram of Embedded based color recognation system

III. CIRCUIT DIAGRAM

Embedded system is a special purpose system in which the computer is completely encapsulated by or dedicated to the device or system it controls. Unlike a general purpose computer, such as a personal computer an embedded system performs one or a few predefined tasks, usually with very specific requirements. Since the system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded systems are often most produced benefiting from economics of scale.

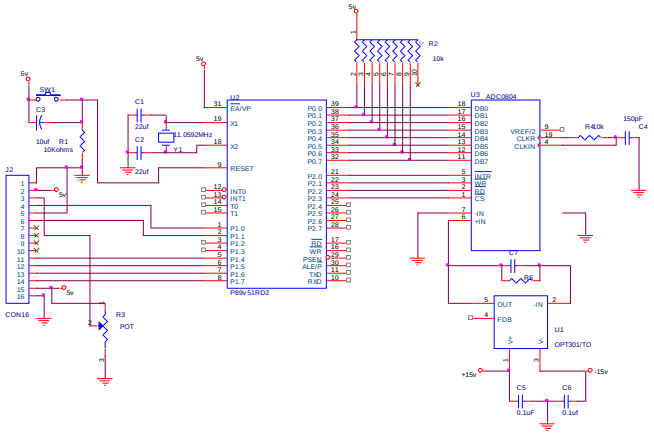

Fig 2: Circuit Diagram of Embedded based color recognition system

Personal Digital Assistants or Handheld computers are generally considered embedded devices because of the nature of their hardware design, even though they are more expandable in software terms. Embedded System range from portable device such as digital watches and MP3 players to large stationary installations like traffic lights, factory controllers or the systems controlling Nuclear Power Plants. In terms of complexity Embedded systems can range from very simple with a single microcontroller chip to very complex with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

IV. INSTRUMENTATION

The block diagram and circuit diagram of an Embedded Based Color Recognition System is shown in fig 1and fig 2. The system consists of a four blocks. The heart of the system is OPT301, which is an opto-electronic integrated circuit containing a photodiode and transimpedance amplifier on a single chip. Photodiode current, I_D, is proportional to the radiant power or flux (in watts) falling on the photodiode. At a wavelength of 650nm (visible red) the photodiode Responsivity, R_I, is approximately 0.45A/W. The OPT301's voltage output is the product of the photodiode current times the feedback resistor, (I_D X R_F). The internal feedback resistor is laser trimmed to 1MW ±2%. Using this feed resistor, the output voltage R, is approximately 0.45V/mW at 650nm wavelength. The output of the Photodiode is given to the ADC-0804 which converts the analog voltage into digital format.

The photo diode output voltage is applied to pin 6 $+V_{in}$ of ADC0804, Connect pin 7 $-V_{in}$ to ground. The ADC0804 includes an internal oscillator which requires an external capacitor and resistor to operate. The CS, WR, RD, INTR is connected to Port 2 of Microcontroller. ADC conversion will be start by making CS high ,WR signal low

the conversion start and wait for INTR pin to go low i.e., means conversion ends. Once the conversion in ADC is done, the data is available in the output latch of the ADC. Data of the new conversion is only available for reading after ADC0804 made INTR pin low. The Read the data from port where ADC is connected, make RD signal high, the result is available at pins 11 through 18 which read from Port 0. The microcontroller is interfaced with 16x2 LCD using Port1. The RS is connected to P1.0, En is connected to P1.1 and data lines DB4-DB7 are connected to P1.4-P1.7, the program loaded on the microcontroller control the ADC to read the color intensity of light and output is displayed on the LCD.

V. OPT301 INTEGRATED PHOTODIODE AND AMPLIFIER

A photodiode [4] is a type of photo detector capable of converting light into either current or voltage, depending upon the mode of operation.[4] The common, traditional solar cell used to generate electric solar power is a large area photodiode. Photodiodes are similar to regular semiconductor diodes except that they may be either exposed (to detect vacuum UV or X-rays) or packaged with a window or optical fiber connection to allow light to reach the sensitive part of the device. Many diodes designed for use specifically as a photodiode use a PIN junction rather than a p-n junction, to increase the speed of response. A photodiode is designed to operate in reverse bias [5].

Transimpedance amplifier is an amplifier that converts current to voltage. Its input ideally has zero impedance, and the input signal is a current. Its output may have low impedance and is measured as a voltage. Transimpedance amplifiers are commonly used in receivers for optical communications to convert the current generated by a photo detector into a voltage signal for further amplification.

The OPT301 [6] is an opto-electronic integrated circuit containing a photodiode and transimpedance amplifier on a single dielectrically isolated chip. The transimpedance amplifier consists of a precision FET input op amp and an on-chip metal film resistor. The 0.09 x 0.09 inch photodiode is operated at zero bias for excellent linearity and low dark current.

The integrated combination of photodiode and transimpedance amplifier on a single chip eliminates the problems commonly encountered in discrete designs such as leakage current errors, noise pick-up and gain peaking due to stray capacitance. The OPT301 operates over a wide supply range (±2.25 to ±18V) and supply current is only 400mA.

VI. ADC 0804 A/D CONVERTER

Analog to digital converters use as an intermediate device to convert the signals from analog to digital form. These digital signals are used for further processing by the digital processors. Various sensors like temperature, pressure, force, light etc. convert the physical characteristics into electrical signals that are analog in nature.

ADC0804 [7] is a very commonly used 8-bit analog to digital convertor. It is a single channel IC, *i.e.*, it can take only one analog signal as input. The digital outputs vary from 0 to a maximum of 255. The step size can be adjusted by setting the reference voltage at pin9. When this pin is not connected, the default reference voltage is the operating voltage, *i.e.*, Vcc. The step size at 5V is 19.53mV (5V/255), *i.e.*, for every 19.53mV rise in the analog input, the output varies by 1 unit. ADC0804 needs a clock to operate. The time taken to convert the analog value to digital value is dependent on this clock. An. ADC 0804 has an inbuilt clock which can be used. A suitable RC circuit is connected between the Clock IN and Clock R pins to use the internal clock. Connect the 150 pF capacitor from CLOCK IN to ground and the 10k ohm resistor from CLOCK IN to CLOCK R. ADC0804 has 8 bit Resolution and its conversion time is 100 μs

VII. MICROCONTROLLER P89V51RD2

The P89V51RD2 [8] is a low-power, high-performance CMOS 8-bit microcontroller. The device is manufactured using Philip's high density nonvolatile memory technology and is compatible with standard 80C51 instruction set and pin out. The on-chip Downloadable Flash allows the program memory to be reprogrammed in-system through serial interface. By combining a versatile 8-bit CPU with Downloadable Flash on a monolithic chip, the P89V51RD2 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded applications.

The P89V51RD2 provides 64k bytes of Downloadable Flash, 1024bytes of RAM, 32 I/O lines, programmable watchdog timer, Data Pointers, three 16-bit timer/counters, eight interrupt sources, a full duplex serial port, on-chip oscillator, and clock circuitry. The Downloadable Flash can be changed a single byte at a time and is accessible through the SPI serial interface. Holding RESET active forces the SPI bus into a serial programming interface and allows the program memory to be written. The microcontroller having advantages less power consumption, low cost, less space required and High speed execution.

Port 0 is an 8-bit open drain bidirectional I/O port. When 1s are written to port 0 pins, the pins can be used as high impedance inputs. Port 0 can also be configured to be the multiplexed low-order address/data bus during accesses to external program and data memory. In this mode, P0 has internal pull-ups. Port 0 also receives the code bytes during Flash programming and outputs the code bytes during program verification. External pull-ups are required during program verification. Port 1 is an 8-bit bidirectional I/O port with internal pull-ups. When 1s are written to Port 1 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current because of the internal pull-ups.

Port 2 is an 8-bit bidirectional I/O port with internal pull-ups. When 1s are written to Port 2 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current because of the internal pull-ups. Port2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that uses 16-bit addresses (MOVX @ DPTR). In this application, Port 2 uses strong internal pull-ups when emitting 1s. During accesses to external data memory that uses 8-bit addresses (MOVX @ RI), Port 2 emits the

contents of the P2 Special Function Register. Port 2 also receives the high order address bits and some control signals during Flash programming and verification. Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. When 1s are written to Port 3 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current because of the pull-ups.

Reset (RST) input, a high on this pin for two machine cycles while the oscillator is running resets the device. Address Latch Enable (ALE) is an output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming. In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing or clocking purposes. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode. Program Store Enable (PSEN) is the read strobe to external program memory. When the P89V51 RD2 is executing code from external program memory, PSEN is activated twice each machine cycle, except that two PSEN activations are skipped during each access to external data memory. External Access Enable (EA) must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed, EA will be internally latched on reset. EA should be strapped to VCC for internal program executions. This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming. Crystal (XTAL1) Input to the inverting oscillator amplifier and input to the internal clock operating circuit. Crystal (XTAL2) Output from the inverting oscillator amplifier.

VIII. LIQUID CRYSTAL DISPLAY

Liquid Crystal Display (LCD) is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. LCD's are preferred over seven segments and other multi segment LEDs because of low cost, easily programmable, have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

The LCD requires 3 control lines as well as either 4 or 8 I/O lines for the data bus. The user may select whether the LCD is to operate with a 4-bit data bus or an 8-bit data bus. The three control lines are referred to as EN, RS, and RW. The EN line is called "Enable." This control line is used to tell the LCD that you are sending it data. To send data to the LCD, program should make sure this line is low and then set the other two control lines and/or put data on the data bus. When the other lines are completely ready, bring EN high and wait for the sometime and set it low. The RS line is the "Register Select" line. When RS is low, the data is to be treated as a command or special instruction (such as clear screen, position cursor, etc.). When RS is high, the data being sent is text data which should be displayed on the screen. For example, to display the letter "T" on the screen you would set RS high. The RW line is the "Read/Write" control line. When RW is low, the information on the data bus is being written to the LCD. When RW is high, the program is reading data from LCD. The data bus consists of 8-bit data lines DB0, DB1, DB2, DB3, DB4, DB5, DB6, and DB7.

IX. POWER SUPPLY

Initial stage of every electronic circuit is power supply system which provides required power to drive the whole system. The specification of power supply depends on the power requirement and this requirement is determined by its rating.

The main source of power supply is a transformer. The maximum output power of power supply is dependent on maximum output power of transformer. If there is a transformer of 12V, 500mA then maximum power delivered by transformer is 6Watt. Every electronic circuit requires a dc power supply for rectification. Rectifier is a circuit which is used to convert ac to dc. We have used four diodes. After rectification we obtain dc supply from ac but it is not pure dc it may have some ac ripples. To reduce these ripples we use filters. It blocks dc and passes ripples to ground. Regulator is a device which provides constant output voltage with varying input voltage. The 7805 is used as voltage regulator for 5Vdc.

A. Flow Chart:

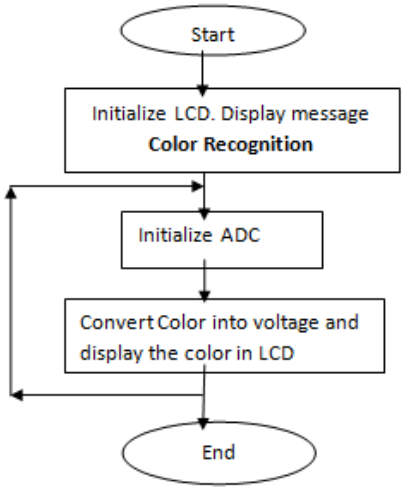

Fig. 1: Flowchart

X. RESULTS AND OBSERVATION

The paper has presented a color sensing system using photodiode. The hardware and software features of a microcontroller based system for the measurement of color are described. The performance of the embdedded based color recognition is designed, developed and tested. The necessary software is developed in C, using Keil IDE. The

system is quite successful for the measurement of color. A simple, precise and inexpensive Microcontroller P89C51RD2 based Instrument set up has been designed, developed to find the Color.

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