2.0 SYSTEM HARDWARE

2.1 Principle of Operation

Any light source emits energy over a certain range of frequency or wave lengths. Any electronic device which is affected by light is sensitive to a certain range of radiation frequencies. In photoconductive devices, the resistance of a material is changed when it is illuminated. The change of resistance in such type of devices like light dependent resistor (LDR) is proportional to the change of the light intensity.

The objects of different colours reflect different intensities of light. When 3 LDRs (Red, Green and Blue) are arranged such that the reflected light from different colours falls directly on them, their resistance changes proportional to the change of intensity, hence proportional to the change of colour. The reflected intensity is absorbed by three LDRs, by there producing different output resistance which is measured in terms of voltage. [1]
2.2 Description of the colour identification system

The block diagram of the AT89C51 based colour identification system is shown in figure 2.1. The system essentially consists of the following functional elements

Sensing Unit

8 bit 0809 Analog to Digital Converter (ADC)

AT 89C51 Microcontroller Unit

Audio Unit
2.3 Sensing unit

It unit consists of three sensors to identify the three primary colours, Red, Green, and Blue. Each sensor consists of an LDR covered with one of the filter and buffer and a buffer amplifier depending on the colour of the object. As the light reflected form it changes, therefore the corresponding sensor responds with higher voltages. The voltages from three sensors are processed to identify the appropriate colour. The functioning of the sensing unit is given in the figure 2.2

![Figure 2.2 Sensing Unit](image-url)
2.4 Analog to Digital Converter (ADC-0809)

The output of buffer amplifier is analog voltage which corresponds to the intensity of light. To process and identify the colour of the object this voltage is to be converted into digital form before it can be processed by the microcontroller. In the present work ADC 0809 is employed to convert the sensors output voltage into digital form. ADC0809 is a Successive approximation type Analog to Digital Converter with 8 input analog channels.

The ADC is having control signals. such as ALE (Address Latch Enable), SOC (Start Of Conversion), EOC (End Of Conversion) and it has 8 (CH0-CH7) channels, and three channel selections (ADA, ADB and ADC). The ADC control signals must be sent to the device. The 3 bit address of the desired input must be stable at least 50ns. The ALE input is sent with the help of AT89C51 microcontroller. The ALE is stable minimum 2.5μs time high. next the SOC start of the conversion input is sent high and then low with the help of AT89C51 microcontroller. After that ALE input brought low again. The ALE, SOC, EOC and two channel selections (ADA, ADB) are connected to one of the microcontroller Port0 pins p0.4, port0.0, p0.1, p0.2 and p0.3 of the microcontroller as shown in the figure 2.3. [2]
The first of these is a send channel selection 2bit address lines to the ADA and ADB inputs. Then the Start conversion signal it is indicates that to do a conversion of analog signal. After that EOC signal which is the A/D converter output to indicate that the conversion is complete and the output is valid. The conversion time is defined as the time it takes the ADC to convert the Analog to Digital (binary) number. The ADC CLK pin is connected to output of the 555 timer. The 555 timer is constructed to generate 100K Hz of square wave frequency, which is operated in astable (free running) mode as shown in the figure 2.3. The ADC Positive Voltage reference is connected to output of the 741 operational-amplifiers. which acts as a voltage follower. The Zenar diode (5.1V) using for to give a stable voltage to ADC [3, 4, 5].

The specifications of the ADC0809 used in the present study are

- **Resolution**: 8 Bits
- **Total unadjusted error**: ± (1/2 LSB) and ± (1 LSB)
- **Single supply**: 5V dc
- **Low power**: 15mW
- **Conversion time**: 100μs at 640 KHz.
- **Operating Temperature**: -40 to 85°C
Fig 2.3 circuit diagram of ADC 0809
Components

The components used for Interfacing ADC with Microcontroller are

- 8 bit ADC0809
- 555 timer
- 741 Operational Amplifier
- LDRs
- Resistors 5kΩ, 1kΩ, 6.8kΩ, 10kΩ, 6.8kΩ
- Capacitors 0.01μf (ceramic).
- Zener diode (5.1v)

2.5 AT89C51 Microcontroller

The Microcontroller 89C51 is the heart of the present work, as it controls the ADC control signals like SOC, ALE, EOC and channel selection ADA, ADB as shown in the figure 2.4. It receives three LDRs data from ADC, stores in Internal RAM memory and is compared with lookup table colours data. If any colour is matched, that colour voice is sent to the speakers with the help of EPROM and DAC. The Microcontroller controls all the interfacing devices with suitable assembly language program.
### Table 2.1 Description of AT89C51 port pins used in present work

<table>
<thead>
<tr>
<th>S. No</th>
<th>Port Name</th>
<th>Pin No</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Port 0</td>
<td>P0.0</td>
<td>Connected ADC for give start of conversion</td>
<td>Output</td>
</tr>
<tr>
<td>2</td>
<td>Port 0</td>
<td>P0.1</td>
<td>Connected to ADC for channel selection</td>
<td>Output</td>
</tr>
<tr>
<td>4</td>
<td>Port 0</td>
<td>P0.2</td>
<td>Connected to ADC for channel selection</td>
<td>Output</td>
</tr>
<tr>
<td>5</td>
<td>Port 0</td>
<td>P0.3</td>
<td>Connecting to ADC for End of conversion</td>
<td>Input</td>
</tr>
<tr>
<td>6</td>
<td>Port 0</td>
<td>P0.4</td>
<td>Connecting to ADC for Address Latch Enable</td>
<td>Output</td>
</tr>
<tr>
<td>7</td>
<td>Port1</td>
<td>P1.0 to P1.7</td>
<td>The 8 pins are connecting to ADC output D0-D7</td>
<td>Input</td>
</tr>
<tr>
<td>8</td>
<td>Port2</td>
<td>P2.0 to P2.7</td>
<td>The 8 pins are connecting to EPROM lower address lines A0-A7</td>
<td>Output</td>
</tr>
<tr>
<td>9</td>
<td>Port 3</td>
<td>P3.0 to P3.7</td>
<td>The 8 pins are connecting to EPROM higher address lines A8-A15</td>
<td>Output</td>
</tr>
</tbody>
</table>
Figure 2.4 Circuit diagram of interfacing EPROM and ADC with 89C51
The reasons for choosing Microchip’s micro controller are

- Information is easily stored in internal memories.
- It is available at low cost
- It is easy to program and the program can be executed before burning the chip using the Atmel programmer software
- The micro controller is used for performing the experiment in Microchip’s AT89C51. The AT89C51 features are discussed below

Chip Specifications

- 4K Bytes of Reprogrammable Flash memory- Endurance: 1,000 write/Erase Cycles.
- It is a 40-pin DIP package.
- It is an 8-bit CMOS micro controller.
- Programmable Memory lock bits
- Linear program memory addressing to 4K and linear data memory addressing to 128 Bytes.
- Maximum crystal frequency of 24 KHz.
- Priority level for interrupts
- Programmable Serial Channel
- Low power idle and Power-down Modes.
- Direct, indirect and relative addressing modes
- Power – on – reset (POR)
2.6 Audio Unit

This designed module identifies the colour of the object and announces the results in audible form. In the present work, 8 colours are identified and all announce the same clear, female voice in English version.

The audio unit takes care of generating the audio signal after identifying the colour of the object. This unit consists of EPROM 27C512, 8 bit DAC 0800, an amplifier and a speaker or headphones. [6]

2.6.1 Interfacing EPROM 27C512 with 89C51

In the present work, memory is divided into 8 banks, with each bank containing 8k bytes. The voice data of 8 colours are stored in 8 banks. To store voice data in 27C512 EPROM (Erasable Programmable Read Only Memory), first of all sound of each colour is recorded using windows multimedia sound recording facility and is properly edited and saved in PCM 8 bit mono format. Then the sound file is further processed with the help of MATLAB software to convert the samples into Hex code and stored into EPROM. The Hex file thus generated is dumped into EPROM using EPROM programmer.
EPROM chip contains 16 address lines A0-A15 and 8 data lines D0-D7. The 16 address lines are connected to 89C51 microcontroller and 8 data lines are connected to 8 bit 0800 DAC (Digital to Analog Converter). To read EPROM data the control lines are connected to ground OE /Vpp and CE.

For example: if the RED colour is identified, the Starting and Ending address of voice are calculated which is 0000h and 1FA0h in EPROM as shown in Table 2.2. Address lines are varied from starting (0000h) to ending (1FA0h) address with 8 kHz speed with the help of Microcontroller. Simultaneously voice data comes out through the EPROM data lines, which is converted into analog form and sent to Speaker or Microphone with the help of 8 bit 0800 DAC. [7, 8]

**Specification of EPROM 27C512**

- ✔ Software carrier capability
- ✔ 120 ns Access time
- ✔ Two-line control
- ✔ CMOS and TTL compatible
- ✔ Fast programming (programming time 8 seconds)
- ✔ Lower power (30 mA Max. Active and 100 μA Max. Standby)
Fig: 2.5 circuit diagram of Audio unit
Table 2.2 Specifications of EPROM memory

<table>
<thead>
<tr>
<th>Memory bank</th>
<th>Starting address</th>
<th>Ending address</th>
<th>Voice data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Hex</td>
<td>In Hex</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0000</td>
<td>1F40</td>
<td>Red</td>
</tr>
<tr>
<td>2</td>
<td>1F41</td>
<td>3E80</td>
<td>Green</td>
</tr>
<tr>
<td>3</td>
<td>3E81</td>
<td>5DC0</td>
<td>Blue</td>
</tr>
<tr>
<td>4</td>
<td>5DC1</td>
<td>7D00</td>
<td>Rouse</td>
</tr>
<tr>
<td>5</td>
<td>7D01</td>
<td>9C40</td>
<td>Yellow</td>
</tr>
<tr>
<td>6</td>
<td>9C41</td>
<td>BB80</td>
<td>Orange</td>
</tr>
<tr>
<td>7</td>
<td>BB81</td>
<td>DAC0</td>
<td>White</td>
</tr>
<tr>
<td>8</td>
<td>DAC1</td>
<td>FA00</td>
<td>Black</td>
</tr>
</tbody>
</table>
2.6.2 Digital to Analog Converter-0800

The reconstruction of the signal from digitally stored information in the EPROM needs a digital to analog converter. Hence an 8-bit digital to analog converter DAC0800 is employed in the present study. The specifications of DAC0800 are given as [3. 4]

- Resolution 8 bits
- Power consumption 500mW
- Settling time 100ns
- Full scale current 1.99mA
- Operating temperature -55 to +125°C

The EPROM output of the voice data is in form the binary and the 8 bit data is converted to Analog form using DAC. The current output of the DAC0800 is converted into voltage form with the help of an operational amplifier. The operational amplifier is operated in inverting configuration and output of the operational amplifier is given to the audio amplifier. Further the audio amplifier drives the speakers, thus voice is produced through Speakers. The circuit details are as shown in circuit diagram of figure 2.5.
Components

The components used in the present audio unit are

- EPROM 27C512
- 8 bit 0800 DAC
- 741 Operational Amplifiers
- Multimedia Speakers
- Resistors 5kΩ
- Capacitors 0.1μf (ceramic). 10μf Electrolyte.

2.7 Power supply unit

The colour identification system using AT89C51 Microcontroller requires the following D.C. supply voltages to operate the system.

+5V/500 mA

± 12V/500 mA

The transformers with secondary ratings 12 – 0 – 12V/1A are selected to meet the required specifications.

The circuit diagram of the power supply unit is shown in Figure 2.6. Three pin IC regulators 7805 is used to get the 5V power supply and 7812, 7912 for ±12V dual power supply.[9]
The diodes D1, D2, D3 and D4 used for rectification are BY127/1N4007 and the filter capacitors C1, C2 and C3, C4 are 1000μF/50V. The C5 is 100μF/50V which is used to suppress the ripple. It gives required voltages with in ± 0.01% line and load regulation. The complete schematic diagram of the power supply unit is shown in Fig. 2.6.
Photograph of the sensing unit
Photograph of the hardware circuit used in the present work
Photograph of the colour identification system
Photograph of the Source Code dumping PC to ATMEL programmer
References


