"INTERACTIVE DIRECT WRITING ELECTRONIC DISPLAY BOARD"

Project Report submitted in partial fulfillment of the requirement for the degree of Bachelor of Technology

In

Electronics and Communication Engineering

By

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Certificate

This is to certify that the project report entitled **"Interactive Direct Writing Electronic Display Board"**, submitted by **Anupam Chahar, Nitish Paliwal and Vigya Jindal** in partial fulfillment for the award of degree of Bachelor of Technology in Electronics and Communication Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

Signature

Date: 18 MAY, 2010

Mr. Tapan Jain
(Lecturer E.C.E)

It is certified that this work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

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Acknowledgement

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ABSTRACT

Through this project report, we propose the design a direct writing electronic display board with added features like retention of the last display by saving and loading the pattern, a single button clearing of the screen etc. The design discussed in this report is for building a prototype that is roughly of an A4 sized sheet. The electronic pen, or stylus, used in the design contains an IR LED to act as the input to the system. The technology used harnesses the attributes of an IR Photodiode that is used to sense the presence of the stylus and thus draw the patterns that the user intends to draw. The simultaneous usage of a large number of inputs and handling the outputs simultaneously necessitates the inclusion of digital logics and designs that are implemented using multiplexers, line decoders and latches. Further, the design consists of a microcontroller to handle the system and act as a root for managing the operations and an external EEPROM that is interfaced for the inclusion of design features. The implementation of the design is intended to be used as a replacement of the conventional white board that is used for didactic purposes in a typical classroom structure. The technology shall not only remove the environmental hazards that are emanated from the usage of marker inks, but also make teaching more interactive and convenient.

CHAPTER-1 INTRODUCTION

Consumer electronics include electronic equipment intended for everyday use. Consumer electronics are most often used in entertainment, communications and office productivity. One overriding characteristic of all consumer electronic products is the trend of ever-falling prices. This is driven by gains in manufacturing efficiency and automation, lower labor costs as manufacturing has moved to lower-wage countries, and improvements in semiconductor design. Semiconductor components benefit from Moore's Law, an observed principle which states that, for a given price, semiconductor functionality doubles every two years. The insatiable and an ever increasing demand of refinement in the field of consumer electronic relates to day to day problems and their associated solutions. Hence, the development of products those are to be made commercially available in due course, lay the foundation for easier lives. Most of the researches in the field of consumer electronics are directed towards improving the modus operandi of our quotidian lives.

An interactive whiteboard or IWB is a large interactive display that connects to a computer and projector or works independently. The board is typically mounted to a wall or on a floor stand. They are used in a variety of settings such as in classrooms at all levels of education, in corporate board rooms and work groups, in training rooms for professional sports coaching, broadcasting studios and more. The interactive-whiteboard industry is reached sales of $1 billion worldwide by 2008; one of every seven classrooms in the world will feature an interactive whiteboard by 2011 according to market research by Future source Consulting. In 2004, 26% of British primary classrooms had interactive whiteboards. Uses for interactive whiteboards include:

- Operating any software that is loaded onto the connected PC, including web browsers and proprietary software
- Using software to capture notes written on a whiteboard or whiteboard-like surface
- Controlling the PC (click and drag), markup (annotating a program or presentation) and translating cursive writing to text (not all whiteboards)
- In some instances the Interactive Whiteboard may be provided with an integrated Audience Response System so presenters can carry out polls and quizzes and capture the feedback on the Interactive Whiteboard.

To maximize the interaction opportunities, most IWBs are supplied with software that provides tools and features specifically designed to enhance the use of the IWB. These generally include the ability to create virtual versions of paper flipcharts with pen and highlighter options and in some cases virtual tools such as rulers and protractors and compasses to emulate traditional classroom teaching tools.

Interaction between the user and the content that is projected onto the Interactive Whiteboard primarily takes the form of a either a digital pen or stylus (Electromagnetic) or a finger or other form of token pen (Resistive). The vast majority of Interactive Whiteboards currently sold globally fall into one of these three categories.

Operation of a resistive, touch based Interactive Whiteboard:

In touch based systems a finger or other simple pointing device is used. In the most common resistive system, a membrane stretched over the surface deforms under pressure to make contact with a conducting back-plate. The touch point location can then be determined electronically and registered as a mouse event. For example when a finger is pressed on the surface it is registered as the equivalent of the left click of a mouse. Supporters of resistive IWBs claim the resistive system is easy and natural to use and can be used with different type of pointer, for example a stick and is not dependent on a special pen.

Operation of an electromagnetic pen based interactive whiteboard:

These interactive whiteboards feature an array of wires embedded behind the solid board surface that interacts with a coil in the stylus tip to determine the (X,Y) coordinate of the stylus. In the most common electromagnetic system, pens are passive and alter electrical signals produced by the board, but contain no batteries or other power source. As the pen is brought near the surface of the board, its presence is sensed to replicate its movements. Supporters of electromagnetic IWBs claim the system is more accurate at emulating a mouse (accuracy, mouse over and right click options), offers a natural pen action that will not malfunction if a user leans on the board while writing and has the in-built ability to offer multiple input using multiple pens.

Operation of a Wii Remote, IR pen based interactive whiteboard:

These interactive whiteboards feature greatly reduced cost over other models. They are based on sound electronic and optical principals. Several companies now offer, or are soon to offer complete packages for creating classroom or boardroom capable interactive drawing surfaces for usually just about one fifth the cost of resistive, touch based, or electromagnetic pen based white board systems. Another advantage of this system is that it is far more portable than the other systems.

Disadvantages are that the system cannot be used near direct sunlight and it does not come with a large library of educational software, the way some of the other systems do. This solution can also suffer from problems caused by 'line of sight', whereby an object (such as a hand or body) can occasionally block the light path between the pen and the camera, causing pen (writing) data to be lost.

A quintessential part of a teacher's didactic needs lies in the usage of a board that is used to teach. The necessity of various requirements include better visibility in terms of both range and surrounding light, accurate replication of handwriting, usage of different colored pens to highlight etc. Leading researchers and electronic designers around the globe have been putting up numerous efforts of replacing the conventional ink usage into an electronic interface to include ease and many other merits that mere ink and board cannot cater. One such design was patented by Osamu Majima et al of Sony Corporation, Japan, in the year 1990 [1]. Herein, the researchers devised a flexible electrostatic recording medium to be used in a display device, alternatively an electronic blackboard, in which a toner converts a latent electrostatic image formed on a substrate into a visible image. A flexible electrostatic recording medium used in conjunction with an electronic blackboard includes a base layer composed of a synthetic resin, a conductive layer formed on the base layer, and a dielectric layer formed on the conductive layer by a thin transparent film, preferably of polyvinylidene fluoride, and adhered to the conductive layer by means of an adhesive.

Later, there have been numerous developments to produce varied options that have been manufactured at industrial level. The technology providers have introduced various features like interactive whiteboards; front projection, rear projection and portable boards to cater to the needs of those who demand elegance and appreciate state of the art technology. The software supplied with the interactive whiteboard will usually allow the teacher to keep notes and annotations as an electronic file for later distribution either on paper or through a number of electronic formats.

The usage of such technologies, like others, has also been criticized for its usage. A report from London's Institute of Education on Interactive Whiteboards said:

- Although the newness of the technology was initially welcomed by pupils any boost in motivation seems short-lived. Statistical analysis showed no impact on pupil performance in the first year in which departments were fully equipped.

The report highlighted the following issues:

- Sometimes teachers focused more on the new technology than on what pupils should be learning.

- The focus on interactivity as a technical process can lead to some relatively mundane activities being over-valued. Such an emphasis on interactivity was particularly prevalent in classes with lower-ability students.

- In lower-ability groups it could actually slow the pace of whole class learning as individual pupils took turns at the board.

Only around 1 in 15 of the teachers studied had received any form of training or professional development in the use of the technology which is considered by commentators as a key factor in the deployment of anything intended to impact teaching and learning.

CHAPTER-2 BASIC PRINCIPLE AND DESIGNING

This project proposal is based on the Infrared Touch Sensing methodology to develop an interactive display board. The board is used as an electronic replacement of the conventional white boards that are ubiquitously employed in teaching purposes. The board is thus designed to simulate the handwritten texts and various other patterns as and in whatever way the stylus is moved on it. Further, the assembly is made to have various attributes of a modern IWB, like retention of last lectures, a one button erasing function, a compatible duster etc.

Figure 1 depicts the basic layout of the system, wherein there are numerous identical entities (called as cells henceforth) arranged in an array pattern. The figure aside is shown as a magnified cell to explain that each cell consists of a set of 8 monochromatic LEDs (shown as red squares) and an IR Photodiode (shown as a blue circle). The pattern as depicted in the figure typically exemplifies the usage of the board, wherein it is shown that any pattern of a handwritten scribbling can be simulated on the board. The board consists of a large number of cells arranged in concatenation in both horizontal and vertical direction. It is imperative to note that whenever a sensor of any cell catches the presence of stylus, it glows the corresponding LEDs of the cell thus leading to simulation of the user's handwriting.

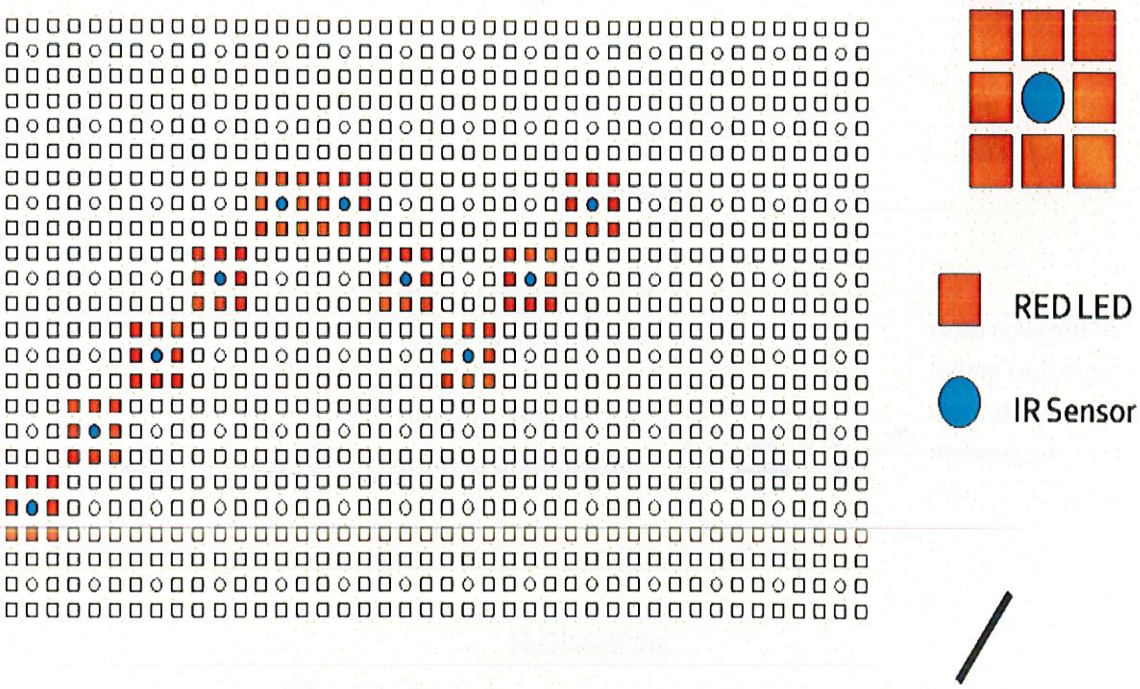


Figure1: Basic Layout

The project proposes the usage of a novel technology that uses Infrared radiation intensity as a parameter to sense touch. We intend to harness the attribute of Infrared sensor (i.e. Infrared photodiode in our design) wherein, current flowing through it is subjected to the amount of Infrared radiations falling upon it. Hence, the voltage drop across the sensor varies in accordance with the intensity of infrared radiations falling upon it.

The very variation of this voltage is further used to estimate the vicinity and/or presence of infrared radiations source. We use an Infrared LED as the source of IR radiations with an emission window of 20°. This LED is used in the making of a compatible electronic stylus used as a pen to scribble on the electronic board.

Since IR Led has an emission window of 20°, area covered by falling radiation on the PCB surface depends on distance between PCB and IR Led. Amount of radiation falling on particular point on surface is inversely proportional to area covered and distance between IR Led and point. For example, as it shown in figure2, the amount of radiation is greater when IR Led is at distance of 1 cm as compare to distance of 5 cm. Also, area covered by falling radiations at distance of 1 cm is lesser than the distance of 5cm.

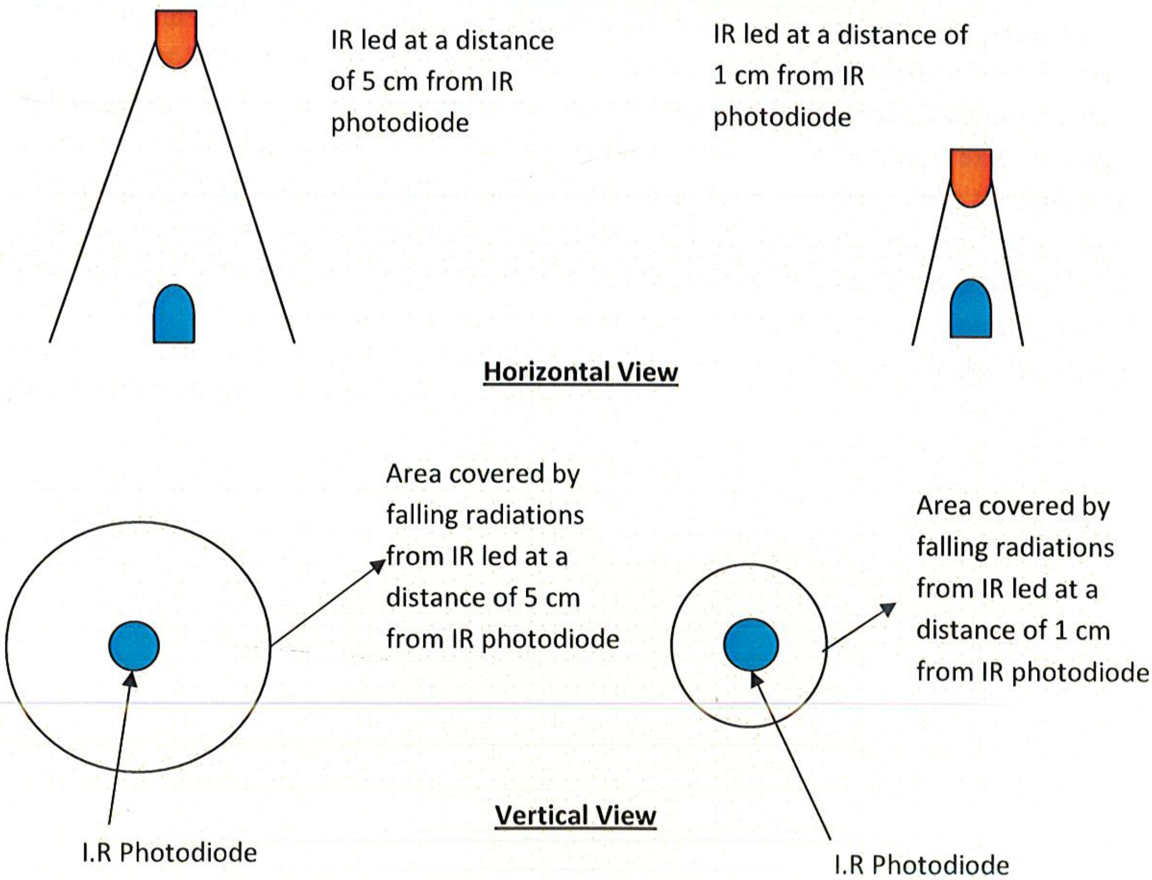


Figure2: Impact of Emission window

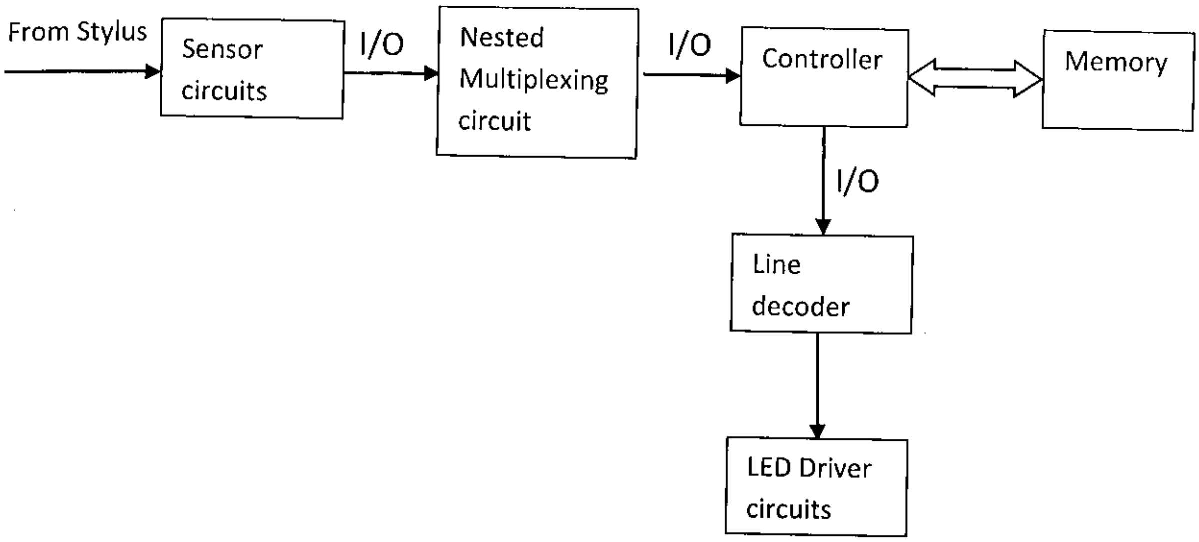


Figure3: Basic Block Diagram

Figure 3 depicts basic block diagram of proposal design of project. IR radiations falling from stylus containing IR Led is to be perceived by presence circuit. Basic function of sensor circuit is not only to sense the presence of IR radiations but also show output high when desired amount of radiation is present over IR photodiode. This output is feed into nested multiplexing circuit which is needed to handle large no. of inputs, so that minimum pins of microcontroller will be used. A controller take input from nested multiplexing circuit by selecting lines of each multiplexer. It keeps checking each sensor circuit at particular interval of time and drive cells through line decoder according to an algorithm embedded in it. Memory is interfaced with controller in order to save and retrieve data. Line decoder is used for managing large no. of cells. It is using binary to decimal decoders, which results in minimum no of controller pins being used for handling of cells. Each of these blocks has been discussed in detail in hardware assembly.

CHAPTER-3 HARDWARE ASSEMBLY

3.1 Making of a Stylus

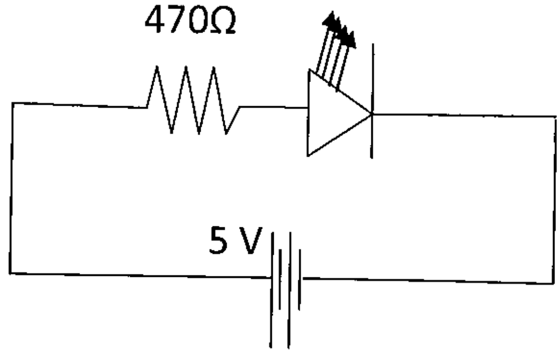


Figure4: Stylus circuitry

A stylus (or stylus pen) is a small pen-shaped instrument that is used to input commands to a computer screen, mobile device or graphics tablet. A stylus (plural: styli or styluses) is a writing utensil. The word is also used for a computer accessory (PDAs). It usually refers to a narrow elongated staff, similar to a modern ballpoint pen. Many styluses are heavily curved to be held more easily. The stylus is pointed at one end and is made to fit in the grip of a hand comfortably. With touch screen devices a user places a stylus on the surface of the screen to draw or make selections by tapping the stylus on the screen. Modern day devices such as touch screen phones can often be used with a stylus to accurately navigate through menus send messages etc. Today, the term stylus often refers to an input tool usually used with PDAs, graphics tablets, Tablet PCs, and UMPCs. In this method, the user operates a touch screen with a stylus, rather than using a finger, which avoids getting the natural oil from one's hands on the screen. It also improves the precision of the touch input, allowing use of smaller user interface elements. Styluses may be used for handwriting or drawing on the touch-sensitive surface.

The design of our electronic stylus comprises of an IR LED that is suitably biased to emit a particular amount of IR radiations. Figure[4] depicts the circuitry used in the making of the Stylus. In our design, we use a5V source voltage to forward bias the LED in concatenation with a 470 Ohms current limiting resistor. An IR light-emitting diode (LED) is a semiconductor diode that radiates infrared light when current passes through it in the forward direction. Electrons move though semiconductor medium and "fall into" other energy levels during their transit of the p-n junction. When these electrons make a transition to a lower energy level, they give off a photon of light which lies in the infrared region.

Conventional LEDs are made from a variety of inorganic semiconductor materials. For an Infrared LED, the wavelength of the source is greater than 760 nm working on $\Delta V < 1.9V$. The substrate used to manufacture IR LEDs is Gallium Arsenide (GaAs) Aluminum Gallium arsenide (AlGaAs). The current/voltage characteristic of an LED is similar to other diodes, in that the current is dependent exponentially on the voltage (see Shockley diode equation). This means that a small change in voltage can lead to a large change in current. If the maximum voltage rating is exceeded by a small amount the current rating may be exceeded by a large amount, potentially damaging or destroying the LED. The typical solution is therefore to use constant current power supplies, or driving the LED at a voltage much below the maximum rating. As with all diodes, current flows easily from p-type to n-type material. However, no current flows and no light is produced if a small voltage is applied in the reverse direction. If the reverse voltage becomes large enough to exceed the breakdown voltage, a large current flows and the LED may be damaged. If the reverse current is sufficiently limited to avoid damage, the reverse-conducting LED is a useful noise diode.

3.2 Sensor Assembly

Our design uses an IR photodiode as the primary sensor for sensing the presence of IR radiations. Photodiodes are essentially p-n junctions that are reverse biased to sense the IR radiations. Placing a p-type semiconductor in contact with an n-type semiconductor creates what's called a space charge region (SCR). Carriers generated (electron-hole pairs) in the SCR are separated by the field of the SCR. The particular choice of material determines the "band gap" of the material -- i.e. how much energy a given photon must possess in order to create an electron-hole pair. Photons with energy equal to or greater than the band-gap of the material will excite a valence electron to the conduction band, and the built-in field of the SCR will sweep those carriers out as a current. These detectors can, in principle, be very fast, depending on the design of the junction and choice of materials. It is necessary to collect the separated charge before the carriers can recombine. The photon of light must have high enough frequency (long enough wavelength) to excite an electron from the valence band to the conduction band of the given detector material. This junction creates the electric field which will separate the liberated carriers allowing for detection by observing the change in current or voltage of the device.

Another option for sensing the IR radiations is a Phototransistor which is essentially an assembly of 2 photodiodes. PIN photodiodes are best for fast IR signals which are used reverse bias them at several volts, and used to convert the photocurrent to an output voltage.

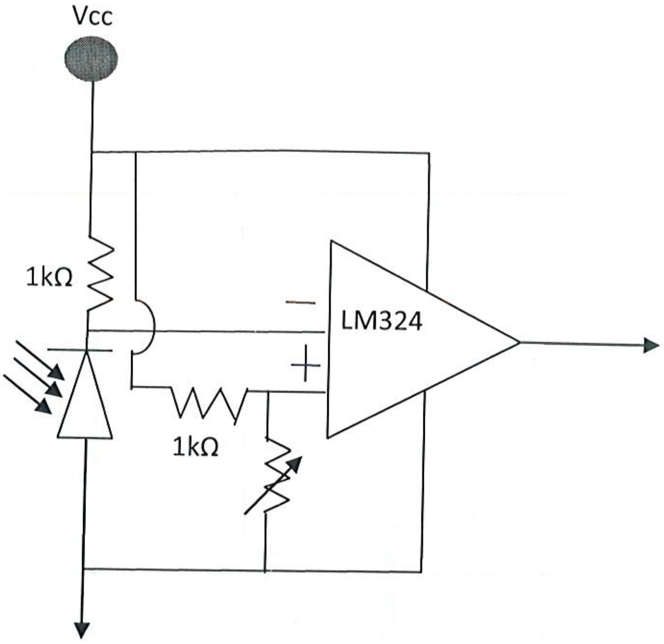


Figure5: Sensor Assembly

Phototransistors are slower to respond -- the photocurrent acts as base current into an NPN transistor. Thus, they are used to you connect a phototransistor up with a grounded base and a collector resistor to the + supply rail, further using the collector voltage as the output. The advantage of the phototransistor is that you get the gain of the transistor, so you get more output response for the same input IR level, as compared to the photodiode.

In our design, the voltage drop ΔV across the photodiode is subjected to the amount of IR radiations falling upon it, or essentially, is subjected to the vicinity between the photodiode and the IR LED source, the stylus. This voltage drop across the photodiode is used to sense the 'touch' perception when the stylus is brought in close vicinity to the photodiode. It is analyzed and found that as the stylus is kept father away from the photodiode, the voltage drop across the photodiode is greater than one when the stylus is brought nearer and nearer. This is because of the fact that lesser vicinity between the photodiode and IR source implies a greater amount of IR radiations being sensed, and thus greater conductivity across the photodiode leading to lesser voltage drop. This ΔV is then fed to an analogue voltage comparator LM324 that is used to produce an output as logic 1 whenever the stylus is present and logic 0 in the absence of the stylus.

LM 324 consists of four independent, high-gain operational amplifiers on a single monolithic substrate. An on-chip capacitor in each of the amplifiers provides frequency compensation for unity gain. These devices are designed specially to operate from either single or dual supplies, and the differential voltage range is equal to the power-supply voltage. Low power drain and an input common-mode voltage range from 0V to V± 1.5V (single-supply operation) which makes these devices suitable for battery operation.

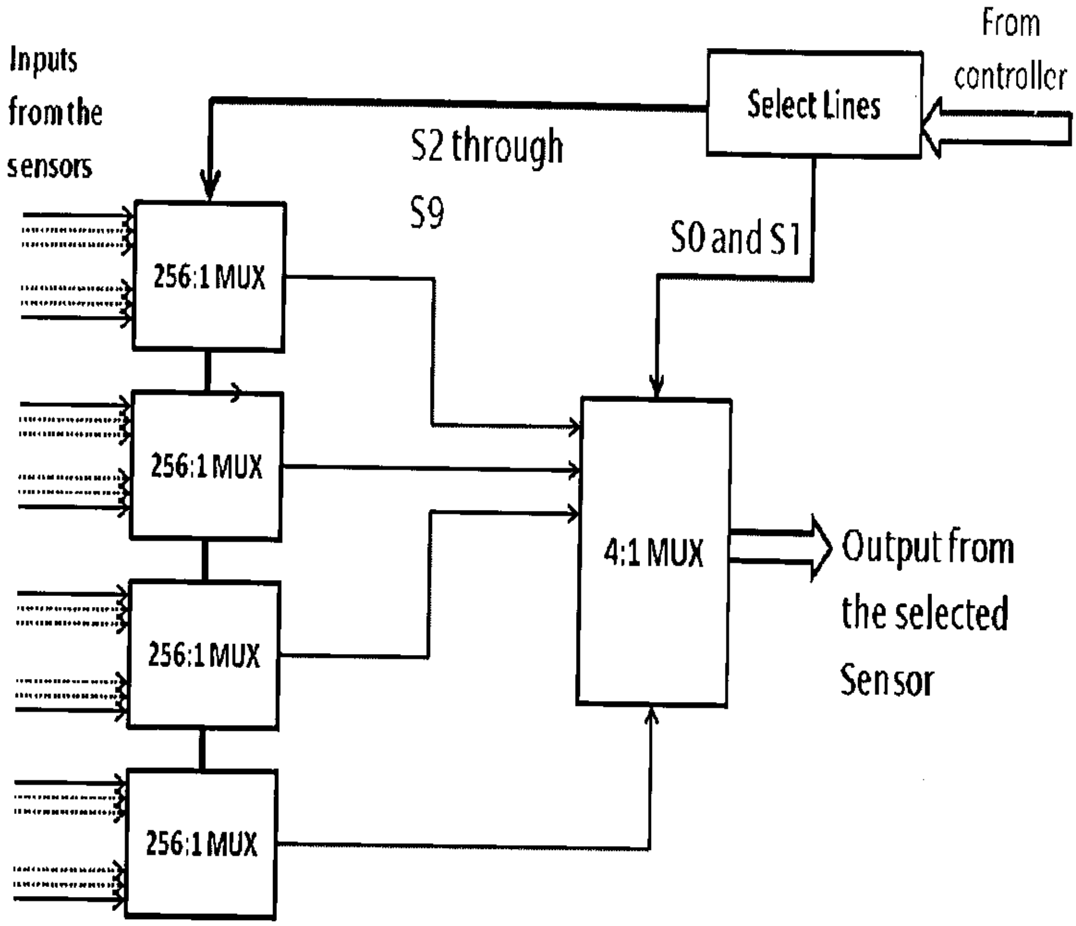


Figure6: Nested Multiplexing Circuitry

3.3 Nested Multiplexing

It quite often happens, in the design of large-scale digital systems, that a single line is required to carry two or more different digital signals. Of course, only one signal at a time can be placed on the one line. What is required is a device that will allow us to select, at different instants, the signal we wish to place on this common line. Such a circuit is referred to as a Multiplexer. A multiplexer performs the function of selecting the input on any one of 'n' input lines and feeding this input to one output line. Multiplexers are used as one method of reducing the number of integrated circuit packages required by a particular circuit design. This in turn reduces the cost of the system.

A multiplexer is a combinatorial circuit that is given a certain number (usually a power of two) data inputs, let us say 2n, and n address inputs used as a binary number to select one of the data inputs. The multiplexer has a single output, which has the same value as the selected data input. In other words, the multiplexer works like the input selector of a home music system.

Only one input is selected at a time, and the selected input is transmitted to the single output. While the selection of the input is made manually, the multiplexer chooses its input based on a binary number, the address input. The truth table for a multiplexer is huge for all but the smallest values of n. A digital multiplexer is a device for converting group input signals, which are asynchronous digital signals, on a plurality of channels to a higher-order group signal by the help of select lines. Digital multiplex systems are also known as subscriber loop multiplexers, remote subscriber multiplex terminals or remote line switches. Essentially, a multiplexer is a circuit that outputs one of several received data signals in response to received selection signals. Digital multiplexers used typically include a logic circuit with components such as gates and flip-flops. A high speed digital multiplexer accepts digital data from the lines of a plurality of buses. Each line in each bus provides digital data of an individual binary significance.

Our design consists of handling of 1024 cells totaling to a size of an A-4 sheet, approximately. Thus, it is imperative to handle 1024 sensor assembly outputs into the controller in order to judge the presence of the stylus over any point of the board. However, the constraint on the number of I/O pins in the controller emanates a new problem. The very obvious and direct solution to such a predicament leads to the usage of Multiplexing. Hence, our design includes the usage of nested multiplexing as shown in Figure [6]. The number of required select lines in order to handle outputs of 1024 sensors/cells is equal to 10 (as $2^{10} = 1024$).

In our design, we have used four 256:1 MUX and one 4:1 MUX in a nested format in order to handle the large number of sensors. Whenever the microcontroller sequentially accesses and polls the presence of stylus on the selected line, the output of that very sensor is read by a single bit input into the microcontroller. Thus, the microcontroller sequentially accesses the information and further process the information to decide whether which cell needs to be glowed. The first two MSBs S0 and S1 are fed to the 4:1 MUX to select one of the four other 256:1 MUX devices, while the lower 8 LSBs are kept common to the remaining 256:1 MUX.

For example, le the value of the 10 bit select line: **10** 00100011. Here, SO=1, S1=0, which implies that the 3rd MUX is selected; however, within the 3rd set of inputs 35th input is being polled. Now the microcontroller reads the input from the nested MUX and decided whether the stylus is present if the bit is set or otherwise if the bit is cleared. Thus, only 10 I/O microcontroller pins can handle a whole lot of

1024 cells. Hence, as an advantage of the process we cater to the need of a more reliable way to interconnect large number of inputs. Instead of adding more wiring and more connections that may pose a reliability issue and add cost to the system, ,we can take advantage of multiplexing technology and send multiple sensor signals over fewer wires.

3.4 Microcontroller

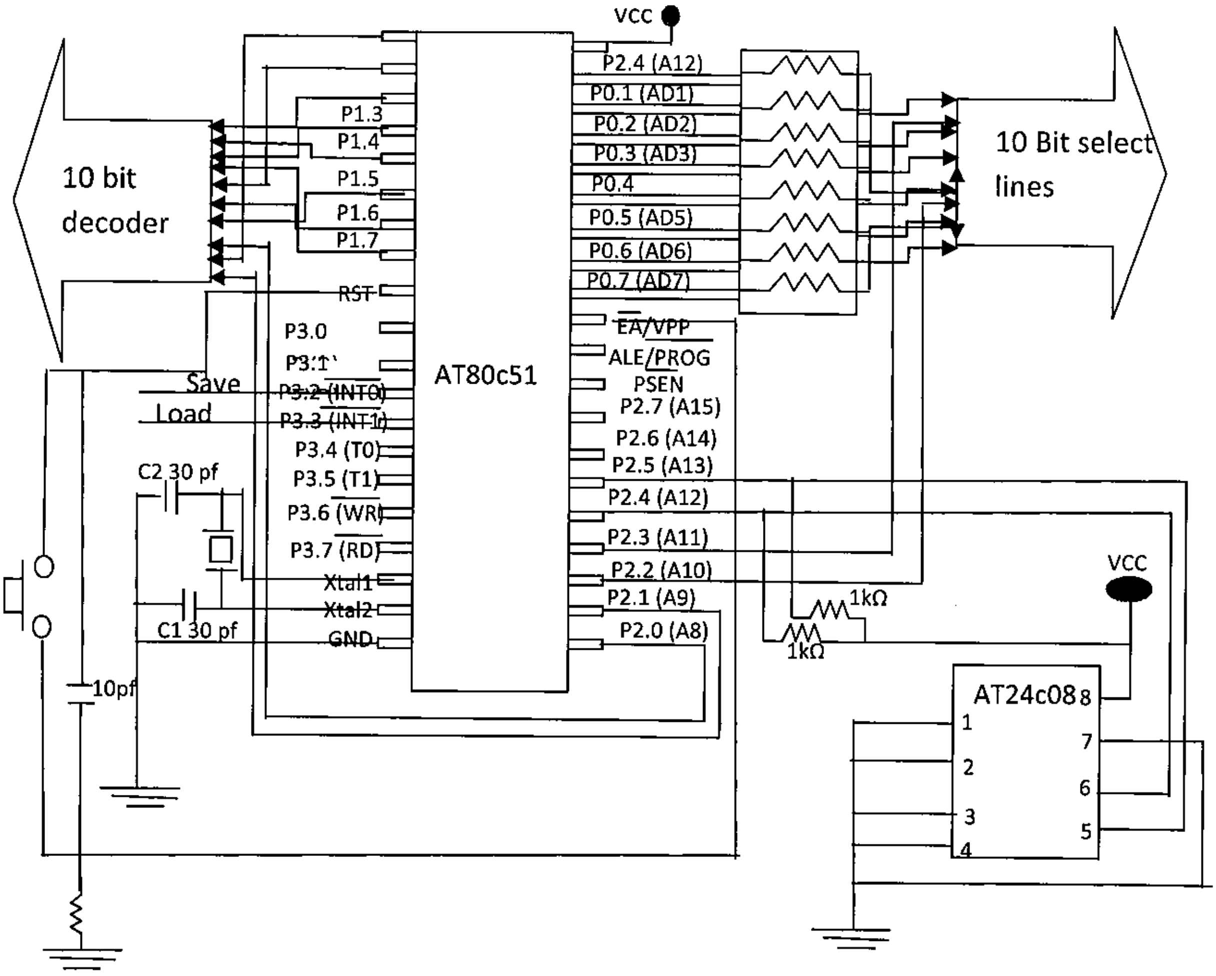


Figure7: Microcontroller circuitry

Our design employs the usage of AT89c51 microcontroller. The AT89C51 provides the following standard features: 4 Kbytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The Power down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset. The microcontroller has 4 8 bit I/O ports which are described below:

Port 0:

It is an 8-bit open drain bidirectional I/O port. As an output port each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high-impedance inputs. Port 0 may also be configured to be the multiplexed low order address/data bus during accesses to external program and data memory. In this mode 0 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.

Portl:

It is an 8-bit bidirectional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs. 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 (IIL) because of the internal pull-ups. Port 1 also receives the low-order address bytes during Flash programming and program verification.

Port 2:

It is an 8-bit bidirectional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs. 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 (IIL) because of the internal pull-ups. Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that uses 16-bit addresses. In this application it uses strong internal pull-ups when emitting 1s. During accesses to external data memory that uses 8-bit addresses 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:

It is an 8-bit bidirectional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs. 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 (IIL) because of the pull-ups.

Port 3 also serves the functions of various special features of the AT89C51 as listed below:

P3.0 RXD (serial input port)
P3.1 TXD (serial output port)
P3.2 INT0 (external interrupt 0)
P3.3 INT1 (external interrupt 1)
P3.4 T0 (timer 0 external input)
P3.5 T1 (timer 1 external input)
P3.6 WR (external data memory write strobe)
P3.7 RD (external data memory read strobe)

Clock Oscillator:

XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier which can be configured for use as an on-chip oscillator, as shown in Figure 7. Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 7. There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.

Interrupts:

Program flow is always sequential, being altered only by those instructions which expressly cause program flow to deviate in some way. However, interrupts give us a mechanism to "put on hold" the normal program flow, execute a subroutine, and then resume normal program flow as if we had never left it. This subroutine, called an interrupt handler, is only executed when a certain event (interrupt) occurs. The event may be one of the timers "overflowing," receiving a character via the serial port, transmitting a character via the serial port, or one of two "external events." The 8051 may be configured so that when any of these events occur the main program is temporarily suspended and control passed to a special section of code which presumably would execute some function related to the event that occurred. Once complete, control would be returned to the original program. The main program never even knows it was interrupted. The ability to interrupt normal program execution when certain events occur makes it much easier and much more efficient to handle certain conditions. If it were not for interrupts we would have to manually check in our main program whether the timers had overflow, whether we had received another character via the serial port, or if some external event had occurred. Besides making the main program ugly and hard to read, such a situation would make our program inefficient since wed be burning precious "instruction cycles" checking for events that usually don't happen.

We need to be able to distinguish between various interrupts and executing different code depending on what interrupt was triggered. This is accomplished by jumping to a fixed address when a given interrupt occurs.

Interrupt	**Flag**	**Interrupt Handler Address**
External 0	IE0	0003h
Timer 0	TF0	000Bh
External 1	IE1	0013h
Timer 1	TF1	001Bh
Serial	RI/TI	0023h

Table1: Interrupt Register

The 8051 offers two levels of interrupt priority: high and low. By using interrupt priorities you may assign higher priority to certain interrupt conditions.

For example, you may have enabled Timer 1 Interrupt which is automatically called every time Timer 1 overflows. Additionally, you may have enabled the Serial Interrupt which is called every time a character is received via the serial port. However, you may consider that receiving a character is much more important than the timer interrupt. In this case, if Timer 1 Interrupt is already executing you may wish that the serial interrupt itself interrupts the Timer 1 Interrupt. When the serial interrupt is complete, control passes back to Timer 1 Interrupt and finally back to the main program. You may accomplish this by assigning a high priority to the Serial Interrupt and a low priority to the Timer 1 Interrupt.

Interrupt priorities are controlled by the **IP** SFR (B8h). The IP SFR has the following format:

Bit	**Name**	**Bit Address**	**Explanation of Function**
7	-	-	Undefined
6	-	-	Undefined
5	-	-	Undefined
4	PS	BCh	Serial Interrupt Priority
3	PT1	BBh	Timer 1 Interrupt Priority
2	PX1	Bah	External 1 Interrupt Priority
1	PT0	B9h	Timer 0 Interrupt Priority
0	PX0	B8h	External 0 Interrupt Priority

Table2: IP register

When an interrupt is triggered, the following actions are taken automatically by the microcontroller:

a) The current Program Counter is saved on the stack, low-byte first.
b) Interrupts of the same and lower priority are blocked.
c) In the case of Timer and External interrupts, the corresponding interrupt flag is cleared.
d) Program execution transfers to the corresponding interrupt handler vector address.
e) The Interrupt Handler Routine executes.

An interrupt ends when the program executes the RETI (Return from Interrupt) instruction. When the RETI instruction is executed the following actions are taken by the microcontroller:

a) Two bytes are popped off the stack into the Program Counter to restore normal program execution.
b) Interrupt status is restored to its pre-interrupt status.

3.5 Electrically Erasable Programmable Read Only Memory (AT 24c08):

EEPROM (electrically erasable programmable read-only memory) is user-modifiable read-only memory (ROM) that can be erased and reprogrammed (written to) repeatedly through the application of higher than normal electrical voltage. Unlike EPROM chips, EEPROMs do not need to be removed from the computer to be modified. However, an EEPROM chip has to be erased and reprogrammed in its entirety, not selectively. It also has a limited life - that is, the number of times it can be reprogrammed is limited to tens or hundreds of thousands of times. In an EEPROM that is frequently reprogrammed while the computer is in use, the life of the EEPROM is an important design consideration.

The AT24C08 provides 1024/2048/4096/8192/16384 bits of serial electrically erasable and programmable read-only memory (EEPROM) organized as 128/256/512/1024/2048 words of 8 bits each. The device is optimized for use in many industrial and commercial applications where low-power and low-voltage operation are essential. AT24C08 which is an 8K serial EEPROM, is internally organized with 64 pages of 16 bytes each, the 8K requires a 10-bit data word address for random word addressing.

The device has the following standard operations:

CLOCK and DATA TRANSITIONS: The SDA pin is normally pulled high with an external device. Data on the SDA pin may change only during SCL low time periods (refer to Data Validity timing diagram). Data changes during SCL high periods will indicate a start or stop condition as defined below.

START CONDITION: A high-to-low transition of SDA with SCL high is a start condition which must precede any other command (refer to Start and Stop Definition timing diagram).

STOP CONDITION: A low-to-high transition of SDA with SCL high is a stop condition. After a read sequence, the stop command will place the EEPROM in a standby power mode (refer to Start and Stop Definition timing diagram).

ACKNOWLEDGE: All addresses and data words are serially transmitted to and from the EEPROM in 8-bit words. The EEPROM sends a zero to acknowledge that it has received each word. This happens during the ninth clock cycle.

STANDBY MODE: The AT24C01A/02/04/08/16 features a low-power standby mode which is enabled: (a) upon power-up and (b) after the receipt of the STOP bit and the completion of any internal operations.

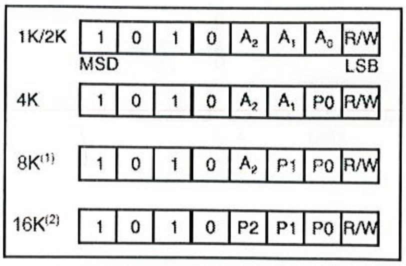
MEMORY RESET: After an interruption in protocol, power loss or system reset, any 2-wire part can be reset by following these steps:

1. Clock up to 9 cycles.
2. Look for SDA high in each cycle while SCL is high.
3. Create a start condition.

BYTE WRITE: A write operation requires an 8-bit data word address following the device address word and acknowledgment. Upon receipt of this address, the EEPROM will again respond with a zero and then clock in the first 8-bit data word. Following receipt of the 8-bit data word, the EEPROM will output a zero and the addressing device, such as a microcontroller, must terminate the write sequence with a stop condition. At this time the EEPROM enters an internally timed write cycle, t_{WR}, to the nonvolatile memory. All inputs are disabled during this write cycle and the EEPROM will not respond until the write is complete.

SEQUENTIAL READ: Sequential reads are initiated by either a current address read or a random address read. After the microcontroller receives a data word, it responds with an acknowledgement. As long as the EEPROM receives an acknowledgement, it will continue to increment the data word address and serially clock out sequential data words. When the memory address limit is reached, the data word address will "roll over" and the sequential read will continue. The sequential read operation is terminated when the microcontroller does not respond with a zero but does generate a following stop condition.

Figure 1. Device Address



Notes: 1. This device is not recommended for new designs. Please refer to AT24C08A.
2. This device is not recommended for new designs. Please refer to AT24C16A.

Figure 2. Byte Write

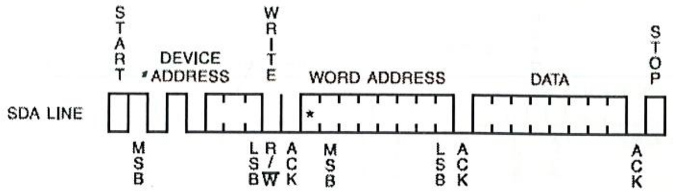
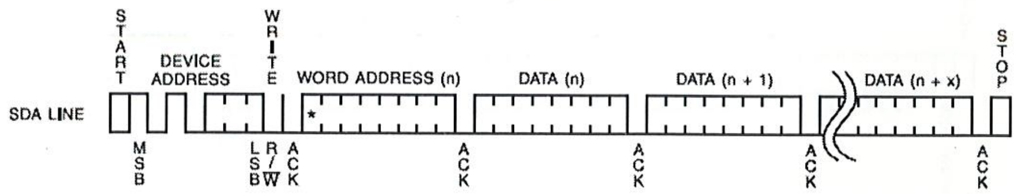


Figure 3. Page Write



(* = DON'T CARE bit for 1K)

Figure8: Write frames

Our design employs the usage of the memory in order to implement the 'Load' and 'Save' functions in the design. The design of our systems offers an option to save the handwritten patterns that are drawn on the board for future reference. Hence, the usage of an EEPROM is mandated for the inclusion of these features. The external interrupts on Pin 3.2 and Pin 3.3 are used for implementation of these functions. Whenever an external interrupt zero (IRQ0) is initiated, microcontroller executes an Interrupt Service Routine) catering to the interrupt. IRQ0 is used to recognize whether the user is willing to 'Save' the pattern that has been drawn on the board into the memory. Similarly, IRQ1 is used to load the last saved pattern on board and replicating the same again by illuminating the corresponding cells. More inputs on the exact usage of these functions are given in discussion on Software part of the system.

Figure 4. Current Address Read

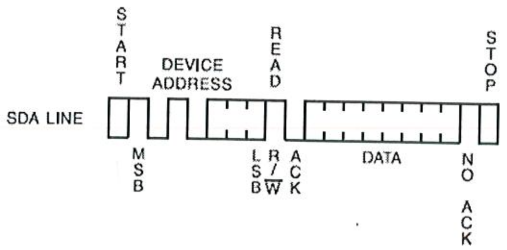
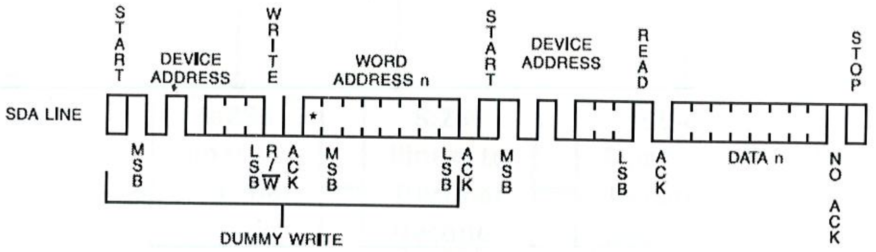


Figure 5. Random Read



(* = DON'T CARE bit for 1K)

Figure 6. Sequential Read

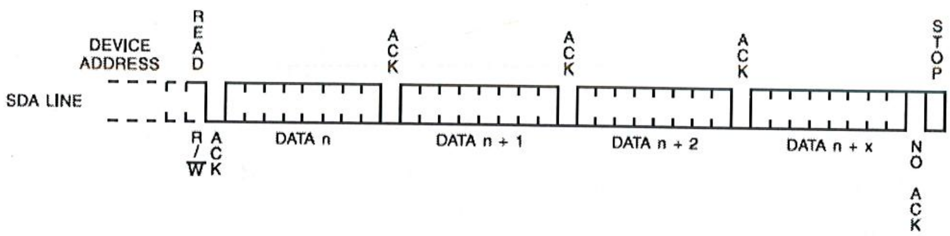


Figure9: Read frames

3.6 Binary to Decimal Line Decoders

In order to decode all possible combinations of n bits, 2^n decoding logic gates are required. This type of decoder is called the n-line-to-2^n-line decoder because they are n inputs and 2^n outputs. A decoder is a device which does the reverse of an encoder, undoing the encoding so that the original information can be retrieved. The same method used to encode is usually just reversed in order to decode. In digital electronics, a decoder can take the form of a multiple-input, multiple-output logic circuit that converts coded inputs into coded outputs, where the input and output codes are different. Enable inputs must be on for the decoder to function, otherwise its outputs assume a single "disabled" output code word.

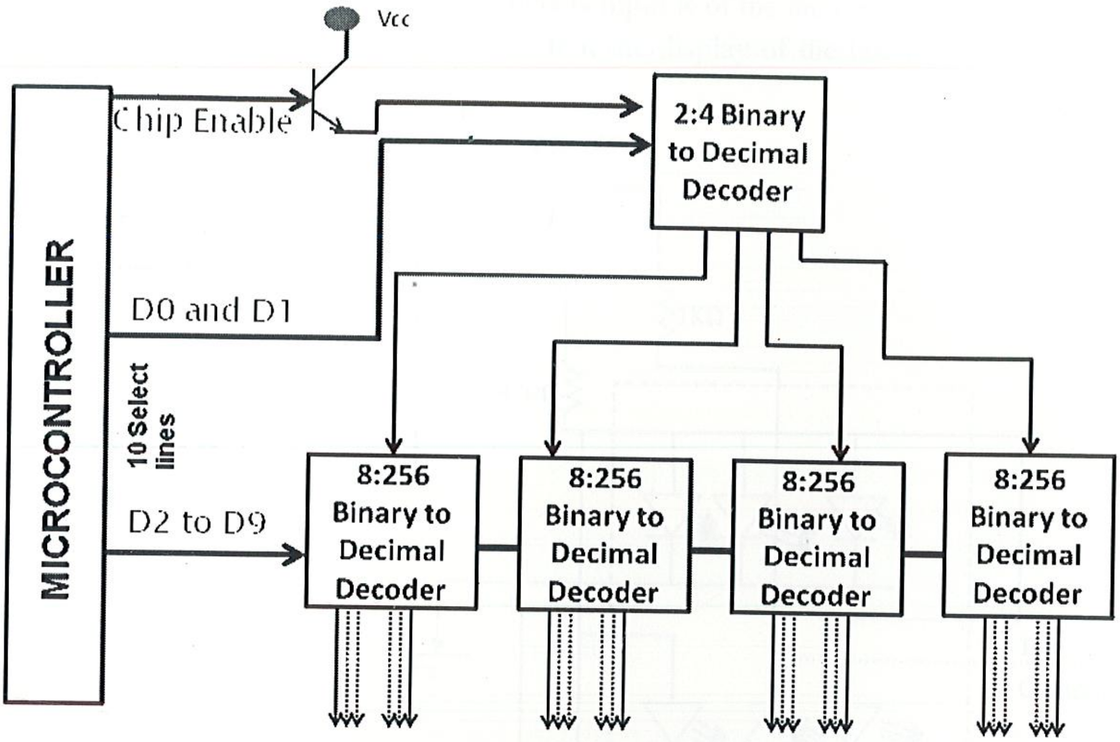


Figure10: Line Decoders

In a similar methodology like that of the inputs from the sensors, we need to access 1024 cells with the help of 10 select I/O pins only. Hence, we intend to use a nested line decoding as depicted in Fig [10]. The two MSBs D0 and D1 are used to select one of the 4 pools and the lower 8 bits are used to select the cell of 256 cells that is needed to be illuminated.

89c51 has 8 bit architecture and has 8 bit I/O bidirectional ports. However we need 10 bits to decode and reach the cell to be illuminated. Now, consider the following situation where the Cell no. 120 of pool 2 is needed to be illuminated. Therefore, the 10 bits needed to select the cell go as **01**11111000. Further, our design uses the enabling circuit for the 2:4 line decoder so that all 10 bits are made available to the decoding circuitry at the same time, thus obviating the possibility of a decoding error.

3.7 Cell Structure and Driving Circuitry

Every cell comprises of a decoding circuitry. Herein, we have used an SR Latch so that the cell keeps on glowing even after the values of Line Decoders change. Thus, the cell is devised to glow when S=1 in the latch. The input S of the latch is fed by the output of the Line Decoders, whereas input R of the latch is connected with the reset circuitry of the microcontroller so that the display of the board is cleared once the system is reset.

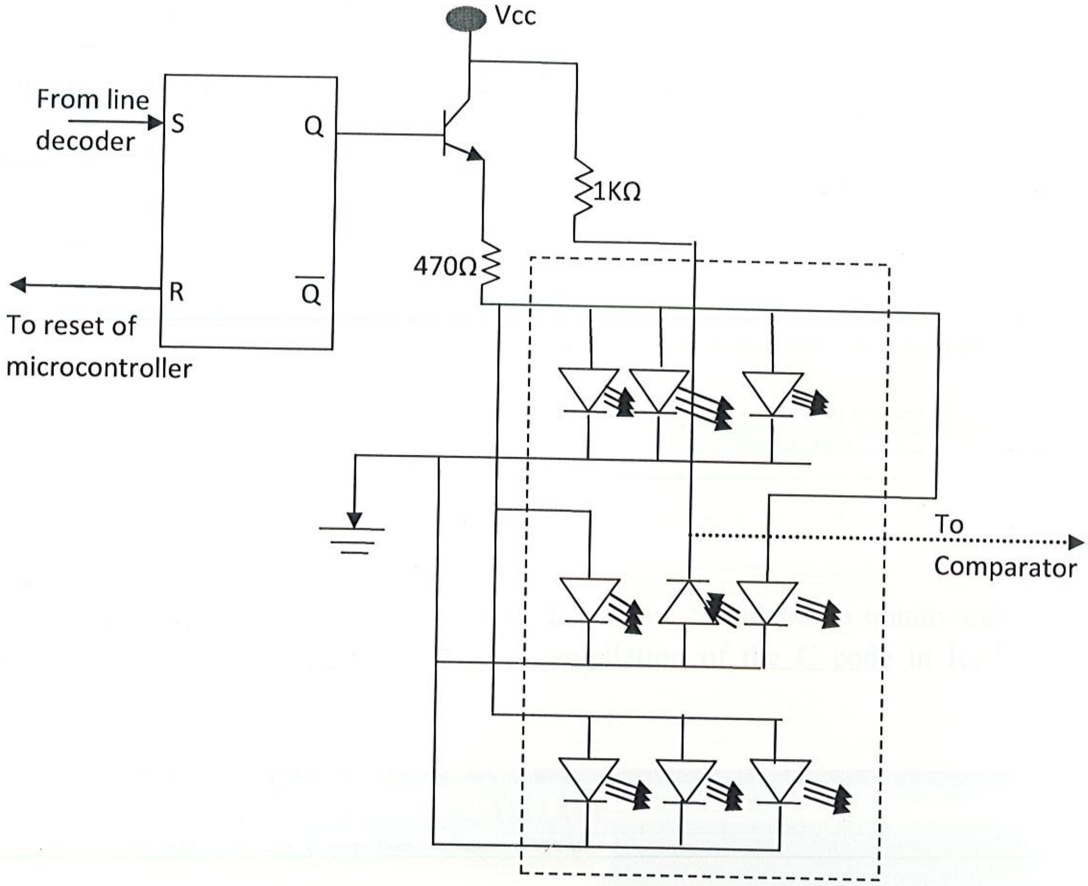
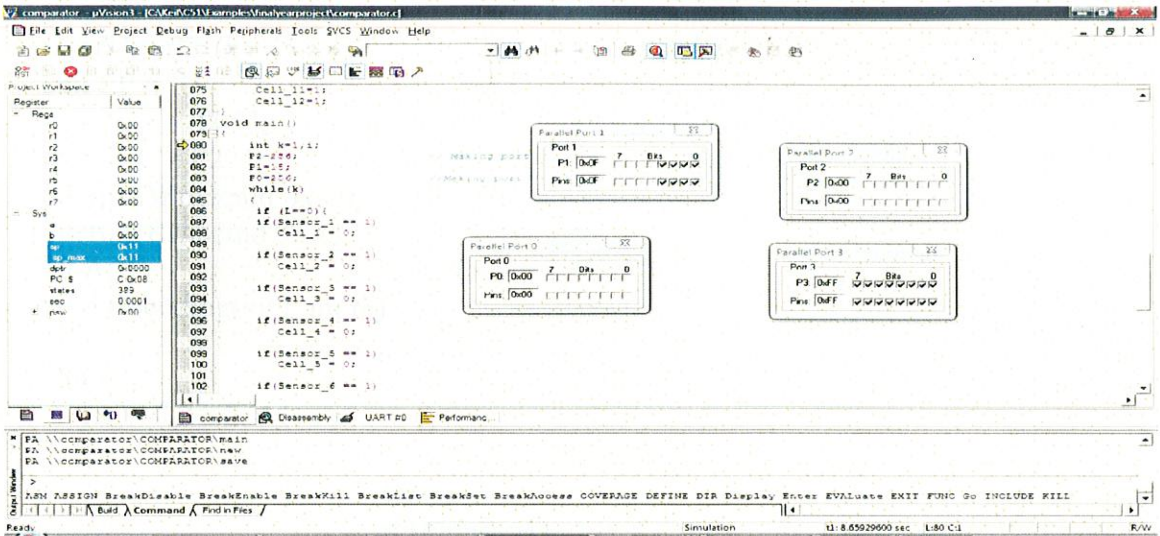


Figure11: Cell Structure

The cell also consists of 8 monochromatic red LEDs whose p substrate is common and is connected to the transistor that used for switching as per the output of the SR Latch. The n substrates of the LEDs are also kept common and are connected to the ground. Hence, whenever the latch outputs a value of 1 (alternately whenever S is put 1 through the line decoders) the respective cell is illuminated. As for the sensing part, the photodiode is kept reverse biased and the voltage drop across it is fed into the analog comparator which further forms the sensing circuitry.

CHAPTER-4 SOFTWARE

We used Keil Microvision Compiler (Version3) for writing the software of our project to be embedded in the microcontroller. The compiler is used to write codes in Embedded C Language and the port values can be altered as shown below.



Keil Compiler

We also used more interactive software, that is, Top-View Simulator to obtain and view the results of ASM files generated after compilation of the C code in Keil Compiler.

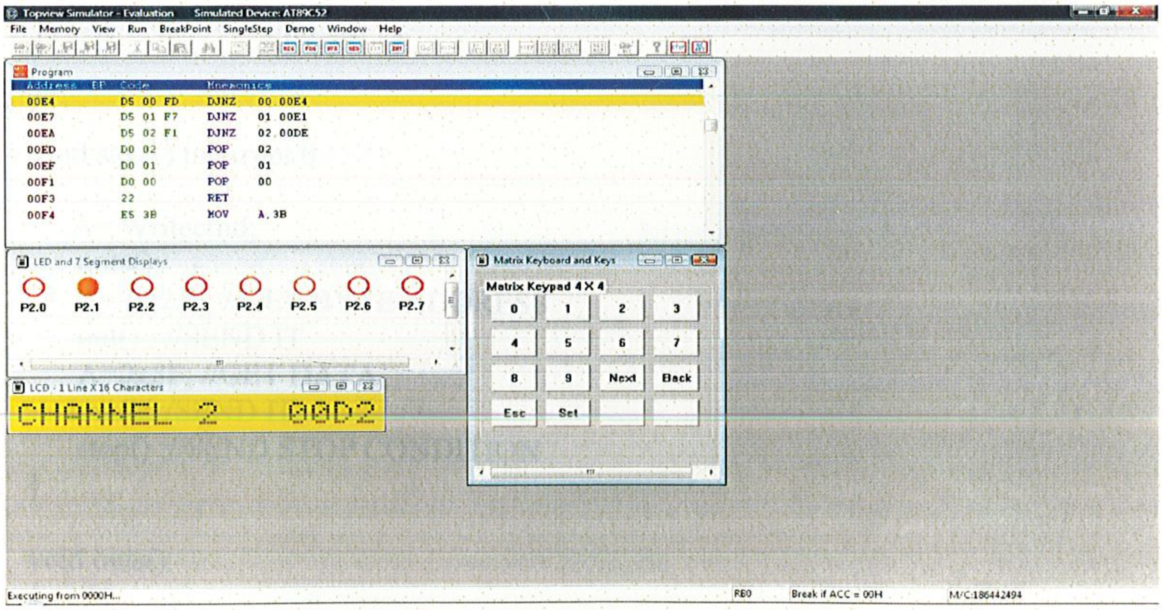


Figure Top View Simulator for Assembly

Embedded C code

```
#include<reg51.h>
sbit Input= P2^7 ;
sbit S0 = P2^2;
sbit S1 = P2^3;
sbit S2 = P2^1;
sbit S3 = P2^0;
sbit EP = P3^0;
sbit SDA = P2^5;
sbit SCL = P2^4;
#define Writecmd 0xA0;
#define Readcmd 0xA1;
int A;
void Decoding(int l, int m)
{
 int i;
   for(i=0;i<=255;i++)
   {
                  P0=i;
                  if (Input==1)
                  {
                    P1=i;
                  S2=l;
                  S3=m;
                    EP=1;
                    delay();
                    EP=0;
    }
  }
}


void save() interrupt 0
{
   A= Writecmd;
   outs();
   A= 0x2A ; //GET BYTE ADDRESS
   out() ; //SEND IT
   A=0x8F; //GET DATA
   out() ;//SEND IT
   stop() ;//SEND STOP CONDITION
}

void outs()
{
     SDA = 1;         //INSURE DATA IS HI
     SCL=1;           //INSURE CLOCK IS HI
```

```
delay();
SDA = 0;        //START CONDITION -- DATA = 0



delay();
                delay();
SCL = 0;        //CLOCK = 0
                for(r2=1;r2<=8;r2++)
{
                RLC    A          //SHIFT BIT
if(C==0)
{SDA=0;
                 SCL=1;
                }
                else
                   SDA=1;         //DATA = 1
SCL=1;          //CLOCK HI
                delay();
                delay();
                SCL=0;        //CLOCK LOW
}
                SDA=1;        //TURN PIN INTO INPUT
delay();        //NOTE 1

SCL = 1;        //CLOCK ACK
delay();
SCL = 0;
}

void out()
{
                int r2;
for(r2=1;r2<=8;r2++)
                {
                RLC    A          ;SHIFT BIT
if(C==0)JNC    BITL
{SDA=0;
                SCL=1;
                }
                else
                {
                SDA=1;        //DATA = 1
SCL=1;
                }       //CLOCK HI
delay();        //NOTE 1
delay();
                SCL=0;        //CLOCK LOW
```

```
    }
    SDA=1;        //TURN PIN INTO INPUT
    SCL=1;        ;CLOCK ACK
    delay();
    delay();
    SCL=0;
}




void stop()
{
                    SDA=0;        //STOP CONDITION SET DATA LOW
    delay();
                    delay();

    SCL=1;        //SET CLOCK HI
    delay();
                    delay();
    SDA=1;        //SET DATA HIGH
}

void load() interrupt 2
{
                    A= Writecmd      //LOAD WRITE COMMAND TO
SEND ADDRESS
     outs();      //SEND IT
     A=0x4D;         //GET LOW BYTE ADDRESS
     out();       //SEND IT
     cread();       //GET DATA BYTE
     A=r1;
     delay();

}
void in()
{
    SDA=1;          //SET DATA BIT HIGH FOR INPUT
    for(i=1;i<=8;i++)
    {
                    SCL=0;  //CLOCK LOW
     delay();
                    delay();
                    delay();

     SCL=1;     //CLOCK HIGH
    C=1;      //CLEAR CARRY
    if(SDA ==0)    //JUMP IF DATA = 0
```

```
        RLC A;
                                else
                                {
                                C=~C;           //SET CARRY IF DATA = 1
      RLC    A             //ROTATE DATA INTO ACCUMULATOR
        }
                                }
       SCL=0;
}
```

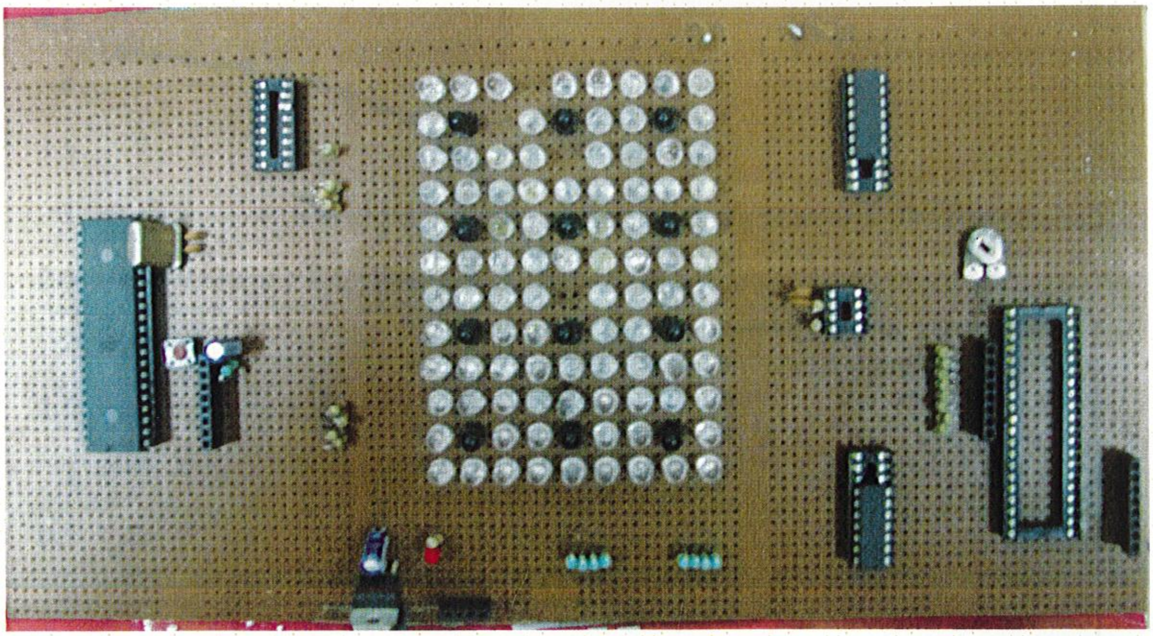
```
void cread()
{     A=Readcmd;      //LOAD READ COMMAND
      outs();         //SEND IT
      CALL    IN          //READ DATA
      r1=A;           //STORE DATA

     stop();          //SEND STOP CONDITION
}

void main()
{
  int i,j;
 IE=0x85;
 EP=0;
 while(1)
 {
 for(i=0;i<=1;i++)
  for(j=0;j<=1;j++)
                               {
                                S0=i;
                                S1=j;
                               Decoding(i,j);
                               EP=0;
                                 }

 }
 }
```

CHAPTER-5 PROTOTYPE



Hardware:

The prototype uses IC 7805 as a voltage regulator to obtain an uninterrupted power supply. Also, it uses decoupling capacitor to provide transient current to the circuit whenever the logic moves from LOW to HIGH. The circuitry also employs a variable resistor, a potentiometer, in order to set the sensitivity of the perception of touch.

The prototype built in order to substantiate the claim of designing consists of 12 cells that are directly interfaced with the microcontroller as shown in the figure above. Each cell consists of eight 8mm monochromatic red colored LEDs and a photodiode to sense the presence of stylus. There are three IC LM324 comparators used in order to arrange for the sensing assembly of each cell. Each LM324 contains 4 analog voltage comparators, whose output is directly fed into the microcontroller.

The sensing employs the usage of a reference voltage that is fed into the non-inverting input of the operational amplifier. We conducted an experiment to obtain the reference voltage below which the touch is sensed due to the presence of the stylus. It was realized that the voltage drop across the photodiode at the instance when the stylus was made available directly above the sensor was 1.6V. Hence, the potentiometer was set so as to provide a voltage of nearly $(1.6 + \Delta V)$ V at the non-inverting input of the voltage comparator. Thus, whenever a touch is perceived the inverting input reaches slightly below the reference voltage, the sensor outputs logic HIGH thus signifying the presence of stylus.

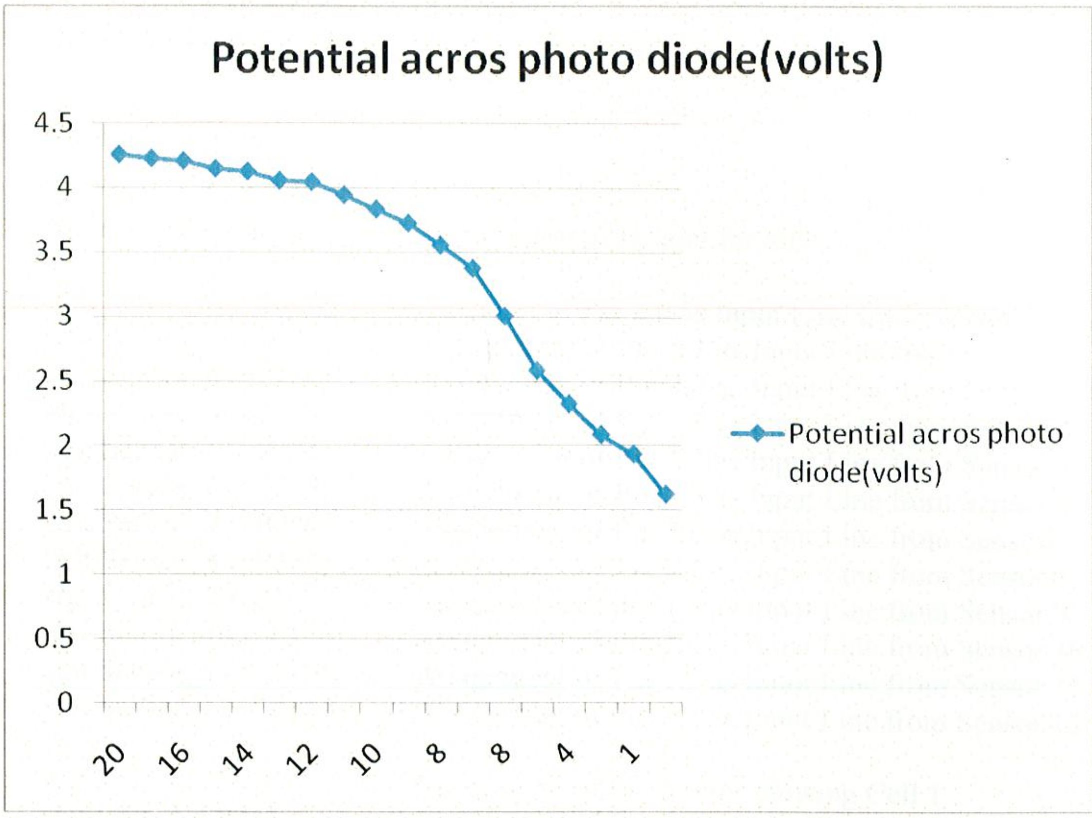


Figure12: Graph – Distance verses Potential across photodiode

Distance from stylus (Cm)	Potential across photo diode(Volts)
20	4.25
17	4.22
16	4.2
15	4.14
14	4.12
13	4.05
12	4.04
11	3.94
10	3.83
9	3.72
8	3.55
7	3.37
8	3
5	2.58
4	2.32
2	2.08
1	1.93
T ouch	1.62

Table3: Experimental analysis of results

Software

Embedded C code:

```
include<reg51.h>            // Inclusion of Header for 8051

sbit Sensor_1 = P2^0;   // Assignment of Pin 2.0 as Input Line from Sensor 1
sbit Sensor_2 = P2^1;     // Assignment of Pin 2.1 as Input Line from Sensor 2
sbit Sensor_3 = P2^2;     // Assignment of Pin 2.2 as Input Line from Sensor 3
sbit Sensor_4 = P2^3;     // Assignment of Pin 2.3 as Input Line from Sensor 4
sbit Sensor_5 = P2^4;     // Assignment of Pin 2.4 as Input Line from Sensor 5
sbit Sensor_6 = P2^5;     // Assignment of Pin 2.5 as Input Line from Sensor 6
sbit Sensor_7 = P2^6;     // Assignment of Pin 2.6 as Input Line from Sensor 7
sbit Sensor_8 = P2^7;     // Assignment of Pin 2.7 as Input Line from Sensor 8
sbit Sensor_9 = P1^7;     // Assignment of Pin 1.7 as Input Line from Sensor 9
sbit Sensor_10 = P1^6;    // Assignment of Pin 1.6 as Input Line from Sensor 10
sbit Sensor_11 = P1^5;    // Assignment of Pin 1.5 as Input Line from Sensor 11
sbit Sensor_12 = P1^4;    // Assignment of Pin 1.4 as Input Line from Sensor 12

sbit Cell_1 = P3^0;        // Assignment of Pin 3.0 for glowing Cell 1
sbit Cell_2 = P3^1;        // Assignment of Pin 3.1 for glowing Cell 2
sbit Cell_3 = P3^2;        // Assignment of Pin 3.2 for glowing Cell 3
sbit Cell_4 = P3^3;        // Assignment of Pin 3.3 for glowing Cell 4
sbit Cell_5 = P3^4;        // Assignment of Pin 3.4 for glowing Cell 5
sbit Cell_6 = P3^5;        // Assignment of Pin 3.5 for glowing Cell 6
sbit Cell_7 = P3^6;        // Assignment of Pin 3.6 for glowing Cell 7
sbit Cell_8 = P3^7;        // Assignment of Pin 3.7 for glowing Cell 8
sbit Cell_9 = P1^3;        // Assignment of Pin 1.3 for glowing Cell 9
sbit Cell_10 = P1^2;       // Assignment of Pin 1.2 for glowing Cell 10
sbit Cell_11 = P1^1;       // Assignment of Pin 1.1 for glowing Cell 11
sbit Cell_12 = P1^0;       // Assignment of Pin 1.0 for glowing Cell 12

sbit S = P0^0;                        // Assignment of Pin 0.0 for Save button
sbit L = P0^1;                        // Assignment of Pin 0.1 for Load button
sbit N = P0^2;                        // Assignment of Pin 0.2 for New button
int S0, S1, S2, S3, S4;         // Global variables for temporarily storing data

void delay ()                       // Function Definition for Delay
{
  TMOD = 0x01;             // Selecting Mode 1 for Timer 0
  TH0=0x00;                // Initializing Timer
  TL0=0x00;
  TR0=1;                              // To begin  timing
  while(!TF0);             // Monitoring TF Flag
  TR0=0;                   // For stopping Timer
  TF0=0;                   // Resetting Timer for future use
}
```

```
void save()                    // Save function for saving current data on screen
{
    S0=P3;
   S1=Cell_9;
   S2=Cell_10;
   S3=Cell_11;
   S4=Cell_12;
}

void load()                    // Load function for retrieving the saved data
{
   P3=S0;
   Cell_9=S1;
   Cell_10=S2;
   Cell_11=S3;
   Cell_12=S4;
}

void new()                     // New function for resetting the screen
{
    Cell_1=1;
   Cell_2=1;
   Cell_3=1;
   Cell_4=1;
   Cell_5=1;
   Cell_6=1;
   Cell_7=1;
   Cell_8=1;
   Cell_9=1;
   Cell_10=1;
   Cell_11=1;
   Cell_12=1;
}

void main()
{
   int k=1,i;
  P2=256;                      // Making port 2 as input port
  P1=15;
  P0=256;                      //Making port 0 as input port
  while(k)
  {
      if (L==0)
      {
                  if(Sensor_1 == 1)
                    Cell_1 = 0;
```

```
                    if(Sensor_2 == 1)
                        Cell_2 = 0;

if(Sensor_3 == 1)
                        Cell_3 = 0;

                    if(Sensor_4 == 1)
                        Cell_4 = 0;

                    if(Sensor_5 == 1)
                        Cell_5 = 0;

                    if(Sensor_6 == 1)
                        Cell_6 = 0;

                    if(Sensor_7 == 1)
                        Cell_7 = 0;

                    if(Sensor_8 == 1)
                        Cell_8 = 0;

                    if(Sensor_9 == 1)
                        Cell_9 = 0;

                    if(Sensor_10 == 1)
                        Cell_10 = 0;

                    if(Sensor_11 == 1)
                        Cell_11 = 0;

                    if(Sensor_12 == 1)
                        Cell_12 = 0;
}
if (S==1)
                    save();
if (L==1)
{
                    load();
                    while(~N);
}
if (N==1)
                    new();
for(i=1;i<=3;i++)
                    delay();
                    } }
```

CHAPTER-6 ANALYSIS AND PERFORMANCE

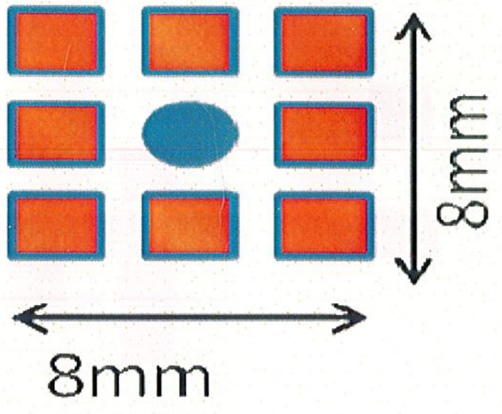


Figure13: Sizing of a cell

The design of the project is not complete without the analysis of the performance of the device. Hence, we conducted experiments and obtained results to judge the performance of the system. In our design, we propose to use SMD (Surface Mount Devices) LEDs which are essentially very small as compared to the standard 5mm or 8mm LEDs. The structure of a cell is arranged so as to have a 1mm gap between every adjacent LED. Hence, essentially the cell forms the shape of a square of 8mm sides. In order to develop a product that is roughly equal to an A4 sheet in size, we require 1024 cells to be used, which is well evident from the following calculations and approximations.

Size of an A4 sheet:	30 x 21 = 630 cm^2
Area of an Individual Cell:	0.8 x 0.8 = 0.64 cm^2
Number of Cells used:	1024 (approximately)

In order to calculate the average number of characters that the product could accommodate, we simulated the size and analyzed the number of cells each character used in MS Excel. Thus, we wrote the uppercase letters A through Z in the minimum space available keeping in mind that the character is discernable and easily identified. For instance, the Fig [14] depicts the drawing of the character 'M' on the board. As seen from the figure, a total of 11 numbers of cells are illuminated for drawing the discernible character 'M' in the minimal available space, depicted by red colored cells. On the contrary, it is imperative to understand that the cells lying absolutely adjacent to the glowing cells cannot be used for writing another character. If these cells were used, it would lead to an overlap of characters and may lead to a non identifiable pattern. Hence, effectively, a greater number of cells as compared to cells that are illuminated are occupied by a single character. In case of 'M', the total number of effectively used/occupied cells is 40.

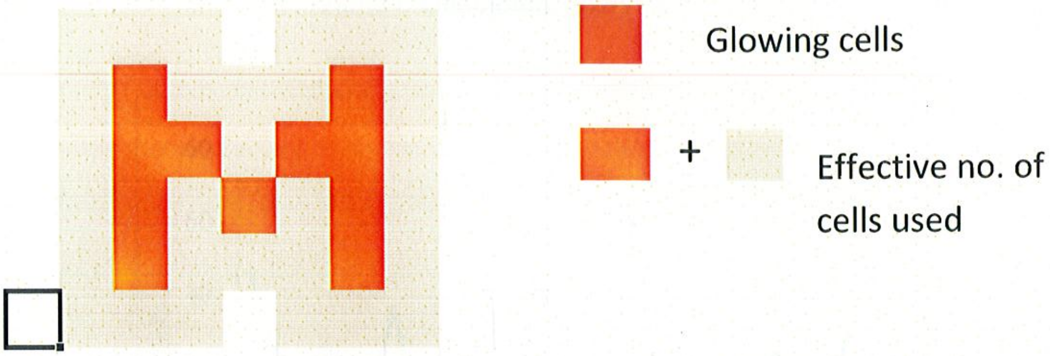


Figure14: Depiction of a character

Character	No. of Cells Used	Effective no. of cells used
A	12	43
B	10	33
C	6	28
D	10	33
E	8	28
F	6	23
G	10	38
H	7	25
I	3	15
J	5	24
K	10	41
L	4	18
M	11	40
N	10	36
O	8	32
P	7	27
Q	17	51
R	8	29
S	7	33
T	5	23
U	7	25
V	7	28

W	7	32
X	5	25
Y	4	21
Z	9	35

Table4: Characters analysis

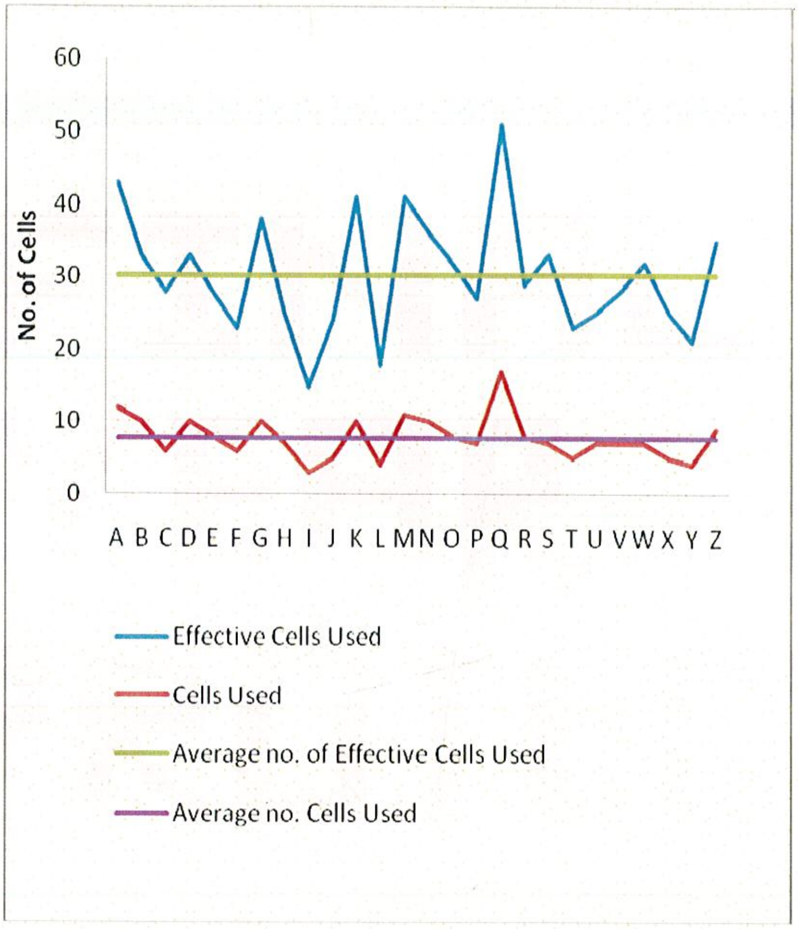


Figure15: Averaging over the alphabets

A similar analysis was done on all the uppercase alphabets and the results are tabulated as shown below. Interestingly, it was noted that the maximum number of cells illuminated (17) and used (51) were for letter 'Q', while the minimum number of cells illuminated and used was for the letter 'C', that is, 3 and 15, respectively.

The results were analyzed and it was found that the average number of cells illuminated per character comes out to be 7.8 whereas the average effective number of cells used is 30.26.

Average number of cells used per character: 30.26 Cells
Average space occupied per character: $30.26 \times 0.64 = 19.3664 \text{ cm}^2$

Area of an A4 sheet (approximately): 630cm^2
Number of Characters Accommodated: 32 Characters (approximately)

Thus, on an average, 32 characters can be accommodated on a device that is roughly of a size of an A4 sheet. However, there is no constraint on the shape and design of the patterns that are illuminated on the display board. The Figure [16] and [17] depict that any figure, pattern and any size of text can be illuminated on the board.

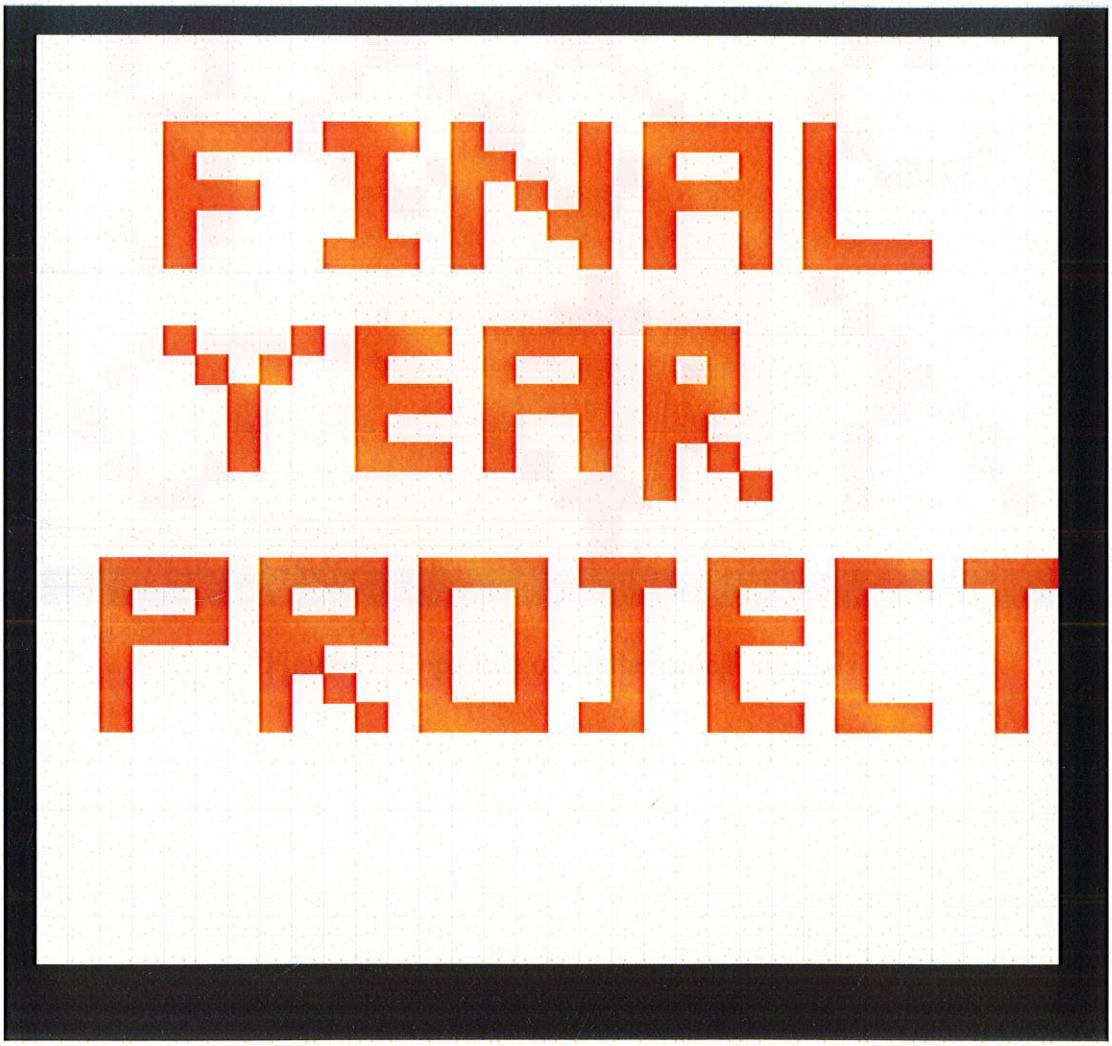


Figure16: Example of a handwritten text

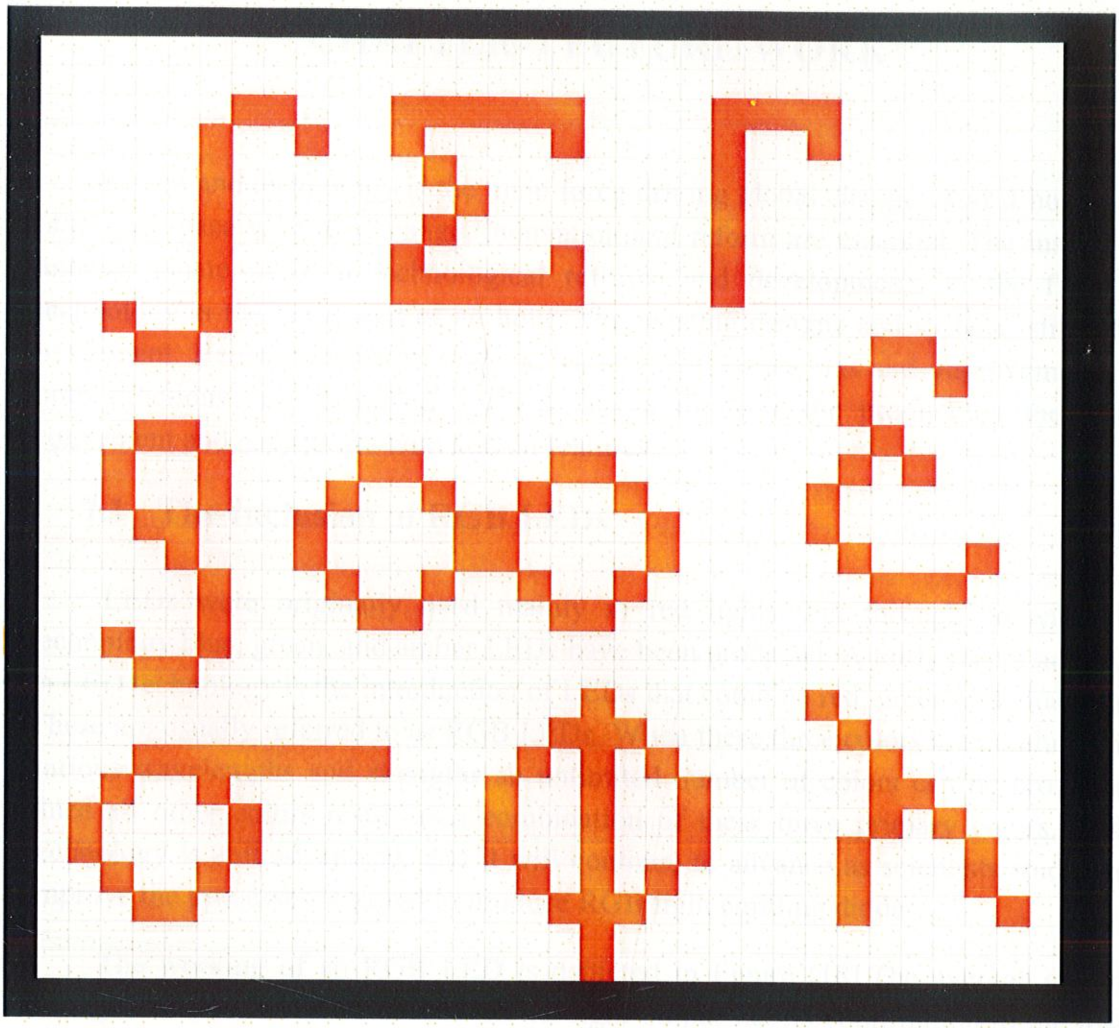


Figure17: Depiction of Mathematical symbols

CHAPTER-7 FUTURE WORK

Science and technology is the main force driving global change. And if humanity is to keep pace with this change, innovation and reform are essential. The insatiable and an innate need of technological reforms and developments in the field of technology is the very need of an hour. The existing designs and systems strive for betterment. Hence, we hereby propose some of the expansions and improvements in both functions and technology of our design to make the product all the more convenient and easy to use with add on features.

7.1 The Inclusion of RGB LEDs

LEDs were originally used mainly in red lights, but through advances in technology blue, green, and amber LEDs have been produced. A fairly recent advance in LED technology is the introduction of LEDs that combine red, green and blue light. These are usually referred to as RGB LEDs. When these three colors are combined in various wavelengths and strengths an unlimited number of colors can be produced, since all other colors result as a combination of these three primary colors. RGB technology is still advancing, and it will continue to advance as scientists study and improve the processes required to produce RGB light emitting diodes.

The working of an RGB LED is depicted in Figure [18].The average current through each of the LEDs determines its light output i.e. its contribution to the total output color. So by controlling the average current through each LED you can create almost any other color. By varying the current through each led you can create almost any other color but at close range you only see the individual colors of each LED. To see the 'merged' color, view it from a distance or put a diffuser over it. I used a small piece of baking paper - which is transparent enough to let the light through and opaque enough to diffuse the light from the three LEDs. In a proper design you would use a semi-transparent plastic. We have to use pulse width modulation to drive each of the LEDs in the RGB led.

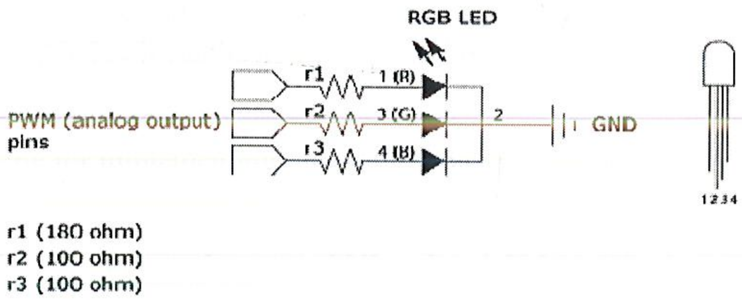


Figure18: Working of a RGB Led

By changing the duty cycle of each PWM signal you can control the average current flowing through each led creating any color you want. The limit is set by the resolution of the PWM (set at 256 steps per channel). The glow of LED relies on persistence of vision to make it appear that the led is continuously driven (the PWM signals must be repeated quickly enough so that you do not see any flicker) at a rate greater than 50Hz (approx). Too slow a rate can lead to the flickering of the LED.

The monochromatic LEDs can be very well replaced by the RGB LEDs with an inclusion of extraneous connecting circuitries and few changes in programming of the controller. This feature shall enable the display board to illuminate itself in different colors as per the choice of the user. However, it is also imperative to note that the inclusion of this feature mandates the usage of the extra I/O pins or a specific circuitry for driving these entities. It will also lead to an incremented complexity of the software wherein we shall be using a PWM generated by the software with varying duty cycles to produce a large number of colors.

7.2 Harnessing Bidirectional Property of LEDs

The properties of light emitting diodes (LEDs) can be exploited to render them useful for light detection as well as emission. This capability has been demonstrated and used in a variety of applications including ambient light detection and bidirectional communications. This implementation of LEDs is important because functionality can be added to designs with only minor modifications, usually at little or no cost. Several applications for this technology have been suggested and/or implemented, ranging from use as simple ambient light sensors to full bidirectional communications using a single LED. Most of these applications benefit from this technology because of the cost reduction or design simplicity gained by using the same component for multiple functions.

An LED is simply a diode that has been doped specifically for efficient light emission and has been packaged in a transparent case. Therefore, if inserted into a circuit in the same way as a photodiode, which is essentially the same thing, the LED will perform the same function. Additionally, the LED can be multiplexed in such a circuit, such that it can be used for both light emission and sensing at different times.

A scheme for implementing this multiplexing is presented:

An LED is connected to two bidirectional CMOS I/O pins on a microcontroller (or a microprocessor with an I/O bus).

To emit light, both of the I/O pins are set to output mode, and the LED is driven with current in the forward direction, resulting in current flow through the LED and emission of light.

- To detect ambient light, the I/O pins are set to output mode, and the diode is driven in the reverse-bias direction, such that the diode inhibits the flow of current and the LED's inherent capacitor is charged.

- The I/O pins are set to high-impedance CMOS input mode.

- The diode leaks current at a rate proportional to the incident light, as incident photons cause electrons to leap across the band gap.

- The time it takes for this leakage current to discharge the LED's inherent capacitor is measured and is inversely proportional to the incident light.

- In our design, the implementation of the above property of LEDs will obviate the need of IR photodiodes and thus removing the need of an IR stylus as well. Though, the inclusion of the bidirectional property leads to a much more complicated system wherein the I/O lines shall be used to forward and reverse bias the LEDs alternately with a high speed to enhance precision.

Manufacturing an Electronic Eraser

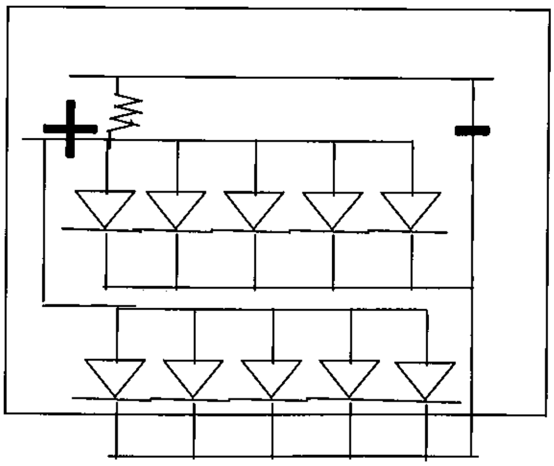


Figure19: Depiction of an electronic eraser

An electronic duster is a device that is used to wipe off the specific patterns and areas of the interactive board just like a normal white board. In order to include the features of still prevalent IWBs and conventional white boards, the electronic eraser is a feature that will extremely enhance the usage and convenience of the product. The electronic eraser shall consist of an array of IR LEDs so as to cover a given area of the board much similar to the present day dusters of the white boards. In this expansion of the work, we propose to include the feature of erasing the selected area wherever the IR radiations from the duster fall. The board shall contain a button to decide whether it is being used in 'erase' or 'write' mode. In the former mode, the microcontroller shall turn off the cells whose sensors depict the presence of IR radiations. While in the latter mode, the normal writing operation shall be carried out.

CHAPTER- 8 CONCLUSIONS

The electronic replacement of the conventional white boards will invite the drastic reduction in the usage of woods that I used to build such boards. In these difficult times where we are heading towards environmental crisis, this would lead to a drastic reduction in hazards that are being posed to our environment by continuous chopping off of the trees. Moreover, some markers contain cresol, xylene, and/or n-propanol (propyl alcohol), which are all respiratory irritants at high levels of exposure. Those who use industrial markers frequently in unventilated areas should consider the other hazards of common industrial marker ingredients. Xylene and cresol can have the following health effects in addition to respiratory irritation.

- Xylene: High levels can cause headaches, loss of muscle coordination, and dizziness.
- Cresol: High levels can cause abdominal pain and vomiting, heart damage, anemia, liver and kidney damage, facial paralysis, coma, and death.

Low to moderate levels of toluene, another chemical found in industrial markers, can cause fatigue, confusion, weakness, memory loss and nausea, loss of appetite, and hearing and color-vision loss. Some inks present health and environmental hazards because they may contain volatile organic compounds (VOCs) which contribute to air pollution and lead to the formation of smog, and because they may contain hazardous constituents such as heavy metals or toxic stabilizers. Product substitution and/or effective ink management can help reduce risk of exposure to these hazards, and can reduce waste.

Hence, an electronic replacement of the chemical ink shall bring in a healthier alternative of a potential hazard that we are generally unaware of.

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