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3D LED CUBE

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Abstract - *The 3D LED CUBE (8x8x8 voxels) exhibits different patterns and shapes in 3 dimensional space with help of a microcontroller. The cube exhibits shapes and figures on its surface according to the program or code stored/dumped in the microcontroller. The LED cube is similar to an LED screen but along with an extra dimension, i.e. a 3rd dimension, making it 3D. The project involves constructing a 3 dimensional LED array that would be displaying various graphics, patterns, shapes etcetera, as desired by the user. This cube is a work of science and technology.. The concept of Persistence of Vision, one of the abilities of human brain which enables us to think that an object is stationary at a particular place if it appears about 60 times a second (i.e. blink 60 times per second). The image can also be made to appear that it's moving by switching the LEDs on and off simultaneously at a rate of 60 time per second. C language is used to write the program using AVR studio dumped into the microcontroller. ARDUINO UNO is used as the required microcontroller in this project because of its ease to use and flexibility. The cube is powered by a power supply of 5V, 2A, provided externally. This cube can be used in educational and teaching, informant, entertainment sectors by displaying 3D structures thereby enabling users to view different perspectives of an object on a very high sense of flexibility and versatility.*

***Key Words*: 3D LED cube, voxels, Persistence of Vision, AVR Studio**

1. INTRODUCTION

A 3D LED cube consists of arrays of LEDs which are controlled using a microcontroller. The LEDs are switched on and off on user's discretion to meet the user's requirements. The LEDs are controlled using a microcontroller and the microcontroller monitors and controls the LEDs based on the code dumped in it. This cube is mainly used for display purposes. The microcontroller used will be capable of controlling all the LEDs in an 8x8x8 LED cube. Therefor the code is written by the user based on the image or structure that is to be displayed on the cube. The LED arrays are formed by soldering the LEDs into rows and columns. In this case as it is 8x8x8x cube, 8 LEDs in each row and column are soldered. This structure of LEDs can be housed in a acrylic covering for support purpose. Any other material such that visibility of the contents displayed is not disturbed from any direction. The cube will display any 3 dimensional structure, the dimensions of the structures are to be scaled down based on the dimensions of the display cube and the code shall be written according to it. It can display both stationary and moving 3 dimensional structures. The displaying of moving structures is more complex than displaying stationary objects, on just in terms of writing the code but also in the working of the cube. For instance, displaying a stationary image of a building involves switching on of only particular LEDs such that an image of the building is obtained on the cube, whereas picturizing "rain" on the cube involves more than just displaying, it involves demonstrating droplets falling down, thus multiple LEDs should be switched on and off according to the picturization such that the droplets are falling down. The LEDs used are RGBLEDs. RGBLEDs are specifically used to increase the range of color palette of the images that are being displayed on the cube. The human eye captures different colors which are either pure colors or combination of multiple colors. Combining red, green and blue colors at different combinations give out various colors. Thus the range of colors that can be displayed on the cube necessarily increases. Furthermore, the cube is powered using external source. The power source is required to provide power supply to the cube as well as the microcontroller. The 3D LED cube is a step further ahead of the traditional 2 dimensional display.

1.1 Objective of the Project

The main objective of the project is to construct a 3D LED cube which is controlled by a microcontroller, for exhibiting different images, structures, graphics, patterns etc. The cube shall be built using RGB LEDs. The main purpose of the cube is to be utilized in educational, entertainment, informant and various other sectors of the society to increase the sense of understanding of complex things.

1.2 Principle Involved

This project is a work of science and technology. The main principle involved in this project is the 'Persistence of Vision'. Persistence of Vision is the ability of the human brain believe that an object is stationary if it appears at a rate of 60 times in a second. The persistence of vision is a optical illusion. It is also known as "retinal persistence" or "persistence of impressions". This optical illusion is caused due to an afterimage in our eyes. An afterimage is an

image formed in our eye after significant exposure to light coming off an object, even after taking our eyes away from the object the object seems to appear for a fraction of second in our eye. The concept of "Flicker Fusion" among the different types of persistence of vision plays a more prominent role in this project. Flicker fusion means, when a light blinks at a very high frequency, the light stimulus appears to be stationary to a human eye. This concept is used at its full extent in the execution of this project. As the number of LEDs in the cube is very high(8x8x8 =512) it is very difficult to control all the LEDs all together, thus we control 64 LEDs at a time simultaneously at a rapidly fast rate thereby deceiving our brain into thinking that all the LEDs are working simultaneously. The concept of illusion based on Persistence of Vision fulfills this purpose allowing us to control 64 LEDs at a time instead of all the 512 LEDs and doing so also reduces the overall power consumption along with decreasing the complexity in execution of the project.

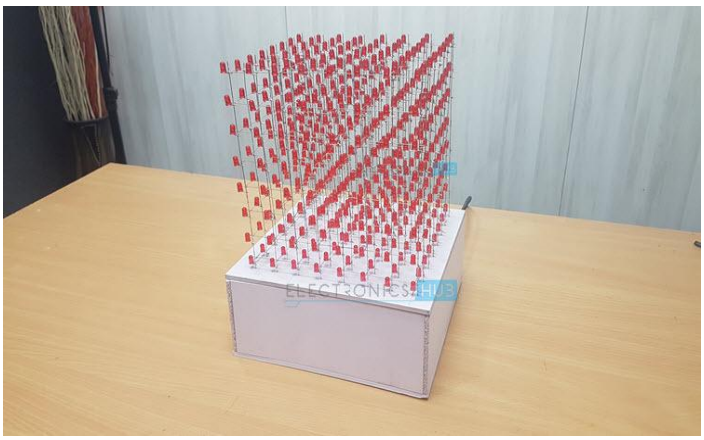

Fig -1: 3D LED Cube

2. PICTORIAL REPRESENTATION AND WORKING

2.1 Block Diagram and Schematic Diagram

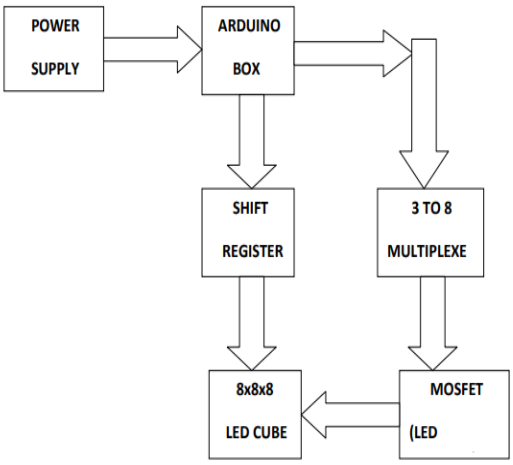

Fig -2: Block diagram of 3D LED cube working

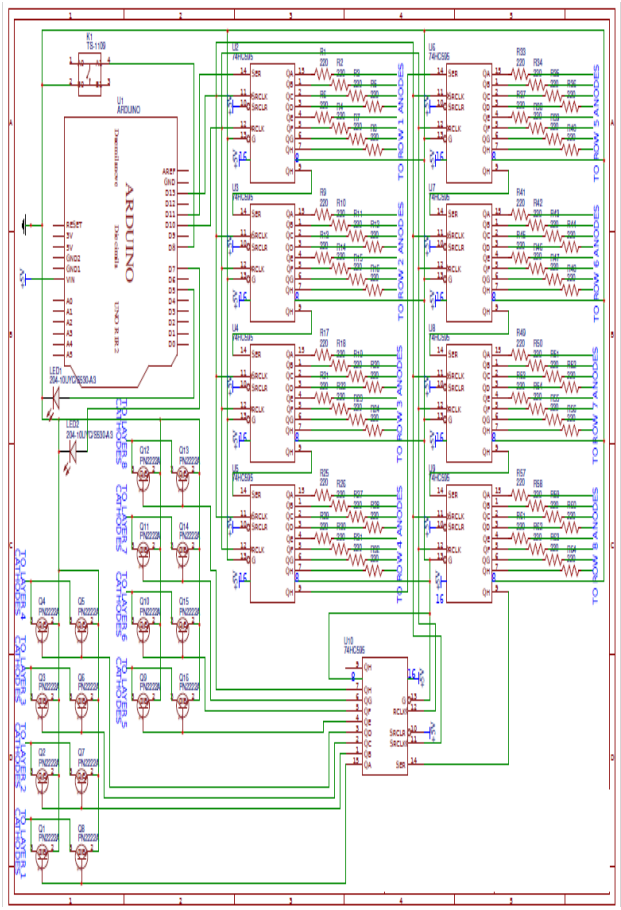

Fig -3: Schematic Diagram of 8x8x8 LED cube

2.2 Hardware and Software Involved (components and their description*)

LEDs: LED stands for Light Emitting Diode. An LED is a light source, it consists of semi conductor diode in forward biase. When it is exposed to flow of charge, the extra electrons in the n-type of the diode tend to recombine with the holes in p-type, thereby emitting energy in the form of photons and as a result, the LED emits light. The LEDs of three different colours are used in the project. RGBLEDs are used to increase the range of colors that are to be displayed, different colors can be obtained by combining red, green and blue color lights in different combinations.

ARDUINO UNO: Arduino UNO equips ATMEGA328P microchip and is developed by Arduino.cc. It consists many input/output ports for extension purposes. Arduino is an open source hardware and software microcontroller which serves its purpose in several projects involving electronics. It acts as a medium to form a conjunction between hardware and software in the project. The Arduino uses IDE(Integrated Development Environment) which can be run on a computer and is mainly used to

write code and dump it into the microcontroller, the microcontroller thereby executes the code and displays output accordingly. The code can be written in C++, a high-level general purpose language to achieve the desired purpose. The usage of C++ language reduces the burden on the user.

Integrated Circuits: An integrated circuit or IC in short, is a combination of set of circuits that are housed on a semiconductor chip. The semiconductor generally used is Silicon. The ICs have played a major role in revolutionizing the use of electronics in various fields. ICs can be seen in many electronic gadgets and appliances. The practical use of ICs was due to advancements in metal oxide semiconductor (MOS) fabrication. Large number of MOS transistors are fabricated on a small chip to form a IC. ICs are comparatively lower in cost and better in performance than compared to discrete circuits

Transistor: A electronic transistor could be a semiconductor unit accustomed amplify or switch electronic signals and wattage. It is composed of semiconductor material sometimes with a minimum of 3 terminals for association to associate in nursing external circuit. A voltage or current applied to 1 combine of the transistor's terminals controls the present through another combine of terminals. Transistors in this instance act as digital switch sanctioning the Arduino to manage numerous amount of LEDs.

Soldering Iron and Solder: A soldering iron is utilized for the purpose of soldering. It delivers heat energy to melt solder so as to, it could flow into the gap among two works. A soldering iron consists of a very hot metal tip at high temperature and a heat insulated handle. Heating is usually achieved with help of electicity, by passing current (supplied via an electrical chord or a battery cable) via a resistive heating element. Soldering irons are generally used for installment, repairs, and other small production purposes. A soldering stand may be used to keep the solder away from inflammable materials.

Battery Holder: A battery holder consists of compartments which are used for holding batteries. A battery holder is either a plastic case with the form of the housing moulded as a compartment or compartments that accepts A battery or batteries, or a separate plastic holder that's mounted with screws, eyelets, glue, double-sided tape

Printed Circuit Board: A Printed Circuit Board or a PCB gives mechanical support to electrical or electronic components while electrically connecting them. It does so through conducting tracks, pads and other features etched from layers of copper laminated onto a non conductive substrate. Components are soldered onto the PCB for good mechanical support and to establish electrical connection among them.

2.3 Working

The project consists of numerous circuit boards each fulfilling a particular purpose. The final project consists of 3 boards, one control board consisting of FPGA, CPU and other necessary components and two driver boards identical to each other. The driver boards consists of drivers and other necessary components which play crucial role in illuminating the cube(switching on the LEDs). Sheer number of components used is the reason why the project is split into multiple boards. The code is written in C++ such that the desired image or structure is displayed on the cube. The code written is dumped into the Arduino UNO thereby executing the code consequently. The code is dumped into the Arduino UNO with help of the Integrated Development Environment supported by Arduino. In the code each voxel is executed as a separate structured data type. Every 8 bit color panel of each voxel is executed as a solo 32 bit integer. First a single byte is assigned to the respective color channel followed by assigning all three color channels to different variables. Macros can be used to align all the functions used to be implemented as in line functions. The array is to be implemented as- one plane for slow scanning, one for fast scanning indices in the three dimensional space. Each voxel is corresponded to a unit coordinate along the positive planes in the cartesian coordinate system. A voxel should be held constant by passing a layer of voxels to which the axis belongs to. Another function to treat the voxel as 3 dimensional double ended queue thereby allowing a layer to be added through any face of the cube. All the voxels will be mapped to a nearby unit coordinate (like a reference coordinate) and consequently rotational and unmapped values will be assigned. When initialized all the voxels will have a color value of black(0x00). A voxel colour can be set directly by the user if intended to do so. The code is later dumped into the microcontroller after completing the assignment of the LEDs using C++ programming language.

2.4 CIRCUIT

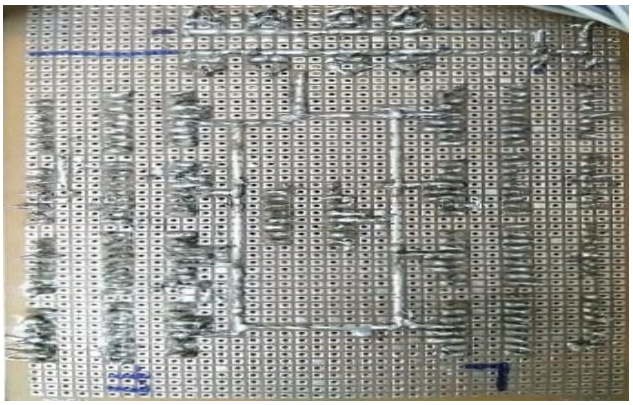

Fig -4: Soldering over the PCB

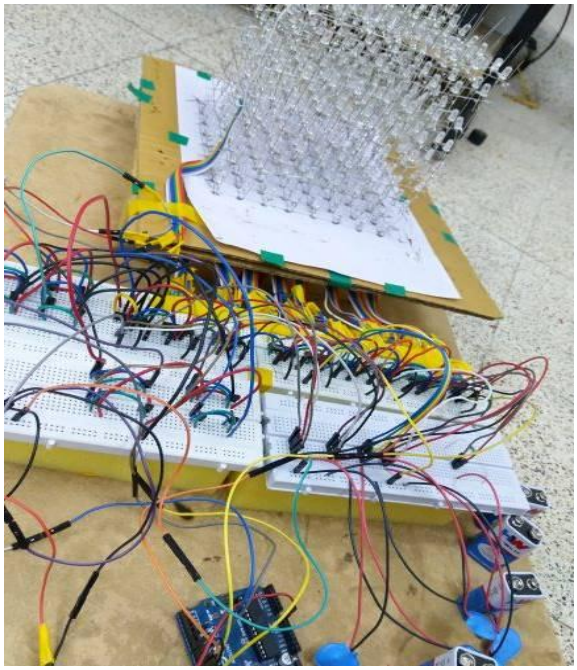

Fig -5: Circuit boards and connections

3. PROJECT PROTOTYPE TESTING

As part of prototype testing, initially a code was dumped to switch on all the LEDs to make sure all the arrays were soldered correctly and each and every LED was able to receive power supply. Once the initial steps were completed, a code to display a spiral pattern (form of a whirlpool) was dumped.

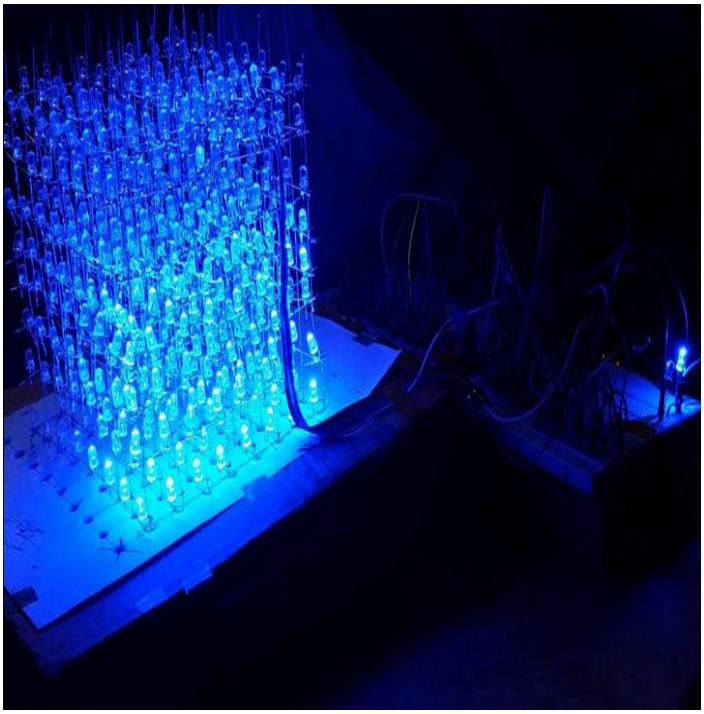

Fig -6: Prototype Testing of the LED cube

This is the picture was captured of the display of a spiral pattern being displayed on the cube.

4. CONCLUSION

A 3D LED cube can be used for displaying various patterns or structures in 3 dimensional plane with help of LED arrays and microcontrollers. The resolution of the image being displayed can be improved by increasing the voxels i.e the number of LEDs used are to be increased. A smaller cube also can be built using 4x4x4 configuration for simulation purposes.

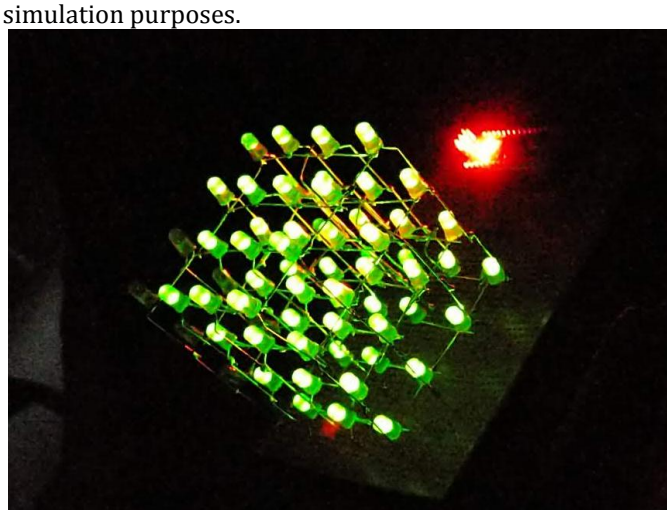

Fig -7: A 4x4x4 LED cube

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