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Free Space Laser Communication Using Modern Laser Diodes

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ABSTRACT:

Laser communication, is an optical wireless communication that is designed as the next generation of wireless communication technology due to its features such as increased bandwidth, high data rate, security, immunity to interference, unregulated spectrum, etc. Laser communication is a better alternative to traditional communication systems because of its potential features; terahertz power transfer, small size, weight and power components, which are critical factors in space mission design. Atmospheric factors, on the other hand, weaken the transmission beam of the laser, and strict field of view requirements lead to indication loss. Because of these factors, laser communication has been limited in its full implementation. Therefore, unlike RF communication, designing and testing a laser communication system is a complex task, as many environmental factors must be taken into account. During laser communication. These factors include stochastic atmospheric parameters, transmitter and receiver installation coordinates, and starting time of the transmitting metal. It requires modeling to perform virtual laser communication to analyze and optimize the system design. In this project we use a 4x4 digital keyboard as an input source in a transmitter, convert them to binary bits with a microcontroller and send with a laser. In the receiver, an LDR sensor is used as a detector and an Arduino (microcontroller) converts it into a corresponding electrical signal into binary bits and displays on a 16×2 LCD screen.

KEYWORD: Laser; Arduino; IDE;Program; LDR sensor.

1. INTRODUCTION

Laser communication, commonly known as laser communication, is a breakthrough in long-distance communication in the passive era due to its advantages such as faster transmission speed, faster data transmission, safety, anti-drag, uncontrollable movement and long distance. It is believed that there is potential focus makes laser contact a more advanced, stronger, improved advanced option compared to traditional contact circuits. Terahertz, power degradation, weight, and control component tradeoffs are critical factors in managing space missions. On the other hand, climatic factors affect the laser's transmission speed, and poor visibility leads to flag damage. These factors limit laser performance. Unlike RF communications, designing and testing laser communications systems can be a complex task involving many unique factors. Exposure to laser light. These components include descriptions of potential parameters, emitter and collector locations, and metal initiation protocols. Virtual laser communication requires modeling to map and analyze progress. This extension uses a 4x4 computer console as an input source for transmission, single-chip collimation, and laser transmission. Inside the complex, the LDR sensor is used as a flag, which the Arduino (microcontroller) turns into a 2-bit reference controller and displays on a 16 x 2 LCD.

Laser based communication system is an advancement in transmitting using radio signal optics. Information about open spaces. In contrast to traditional communication strategies, laser communication has special priorities. In other words, the higher the data rate, the higher the impedance and the lower the code of conduct. These controllable properties make laser communications ideal for routine tasks, especially space missions. In any case, the laser contact his frame application is affected by barometric factors such as air weight and random his parameters such as shielding effectiveness. Therefore, designing and testing test strategies has become a complex task requiring modeling for system analysis and optimization. Moreover, laser communication offers significant virtual performance advantages over traditional wireless communication. This effort could reduce the number of end-to-end communication stations and significantly increase data transmission capacity, which is of great value in star-to-satellite, space-to-terrestrial communications. You have a choice. As the amount of data from ground missions grows, you need a communication system that keeps you out of the shadows. Optical data transmission allows very high data transmission rates in bandwidth combined with limited areas. Although this field is primarily focused on NASA applications, advances in laser communications may find their way into commercial and Department of Defense applications in the future. Overall, laser communications are an untapped advance with great potential to transform space and communications to date [1-6]

Due to the increase in communication speed, it is called the era of modern long distance communication. , High data transmission rate, security, anti-interference effect, unregulated frequency, etc., Laser communication is much better. Much better; far; good; much better" Traditional patch racks have screws, so they are the most common choice. A thorough understanding of these variables is necessary to minimize lighting errors. Nothing is more important than wireless connectivity, planning, and device testing. Laser communication systems can be a complex task due to the many components involved in laser communication. These components include parameters such as air weight, grip insertion position, and metal exchange start time. This requires modeling to assess and improve the overall efficiency of virtual laser communication. In this case the 4x4 computer controller (keypad) acts as a transmitter and the input source is converted to parallel bits by the microcontroller and transmitted by the laser. The LDR sensor acts as a receiving detector and the Arduino (microcontroller) converts the reference electron particles into 2 bits and displays them on the 16x2 LCD screen [7-9].

2.LITERATURE REVIEW

Laser communication technology has become increasingly important in modern communication systems as traditional communication methods face limitations such as bandwidth allocation, power requirements, and dispersion parameters. As the number of users rapidly increases, laser communication offers a promising solution to these challenges. This project aims to design a communication system based on lasers that is simple to implement commercially, making it accessible and user-friendly for the general population. This technology reduces the complexity of communication in situations where optical fiber or wired communication is not feasible due to cost or logistical constraints.

The application of laser technology to communication, particularly in space communication, was first envisioned in the early days of laser development in the 1960s. For example, a method for secure communication between a satellite and a submarine was proposed by researchers in that era. Since then, government agencies, companies, universities, and individuals in many countries have made significant technical progress in optical-space communication, including inter-satellite optical-wireless communication. Today, the current satellite communication system uses microwave technology for space-to-ground and geosynchronous satellite-to-low-earth-orbit vehicles. However, in the future, satellite-to-satellite communication will be governed by optical-wireless links while satellite-to-ground links would remain in the microwave regime. The laser communication technology uses laser light of infrared wavelengths to transmit optical signals between two points via free space. This requires devices similar to those used for transmission through fiber-optic cable, except that the signal is transmitted through free space rather than via an optical cable. The technology is capable of transmitting data, voice, or video, and can be used to connect one satellite to another, whether the satellite is in the same orbit or in different orbits. Optical-wireless communication systems are capable of sending data at the speed of light with minimal attenuation since space is considered a vacuum [10].

Compared to radio frequency (RF) links, the use of optical links offers the ability to send high-speed data over long distances using small-size payloads. By reducing the size of the payload, the mass and cost of the satellite can be decreased. Additionally, the beam width that can be achieved using lasers is narrower than that of the RF system, resulting in lower loss compared to RF. However, using optical-wireless communication requires a highly accurate tracking system to ensure that the connecting satellites are aligned and have line-of-sight. The transmission of optical signals can be affected by environmental processes such as absorption, scattering, and shimmering, which can attenuate the transmitted energy, affecting reliability and bit error rates.Satellites revolve around the earth at their own orbit, and there are three commonly used orbits for satellites. Satellite orbits with orbital height of approximately 1000 km or fewer are known as Low Earth Orbit (LEO). LEOs tend to be generally circular in shape and take from 2 to 4 hours to rotate around the earth. This orbit is commonly used for multi-satellite constellations where several satellites are launched up to space to perform a single mission. Overall, laser communication technology offers numerous advantages over traditional communication methods, particularly in the context of space communication, making it a promising area of research and development for the future [11-13].

3.METHEDOLOGY

Components which are required for the project are

- 4x4 Keypad
- Arduino UNO
- Arduino NANO
- Laser
- LDR Sensor
- 16*2 Alphanumeric LCD
- 12C Interface module for LCD
- Breadboard

Transmitter section

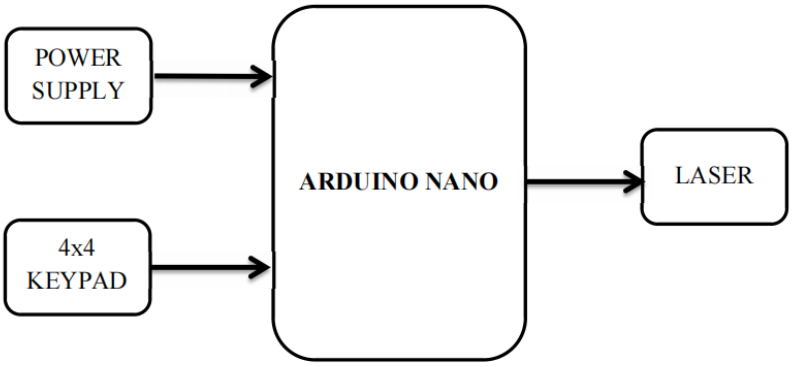

Figure 1. Transmitter section

Receiver section

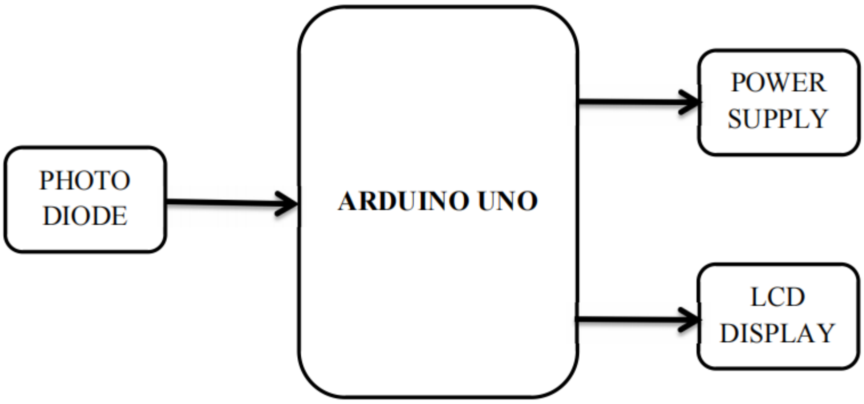

Figure 2. Receiver section

In summary, the data transmission is started by giving the input in the 4x4 keypad and then the data is converted into optical signal by the Arduino nano and then it is transmitted by the 5v laser.By this all the transmitting part is done. Then the laser travels in any medium and is then detected and captured by the photo-diode on the receiver side which is connected to the power supply and an Arduino uno which will convert the captured optical into electrical signal which when connected to any external devices the data can be retrieved.

4.TRANSMITTER SECTION

4x4 Keypad:

A 4x4 keypad is an input device consisting of 16 individual buttons arranged in a grid of four columns and four rows. The device is used to provide input to electronic systems and microcontrollers. Each button on the keypad represents a unique key or character, and when pressed, it generates an electrical signal that can be detected by a microcontroller or other electronic device. The 4x4 keypad is a popular choice for a variety of electronic projects and devices, including calculators, security systems, and access control systems. It is also used in consumer electronics products, such as mobile phones, remote controls, and gaming consoles. The keypad is designed in such a way that it is easy for users to locate and press the buttons. The keys are arranged in a square grid, with the numbers 1 through 9 in the top three rows, and the * (star) key, 0 (zero) key, and # (hash) key in the bottom row. Each button is typically labeled with a symbol or character that represents its function. For example, the numbers 1 through 9 are labeled with their corresponding digits, while the * and # keys may be labeled with symbols that represent their respective functions, such as the asterisk symbol for multiplication and the hash symbol for confirmation or input submission.

The 4x4 keypad Is connected to a microcontroller or other electronic device using a set of wires or a ribbon cable. When a user presses a button on the keypad, it generates an electrical signal that is sent to the microcontroller or device. The microcontroller then translates the signal into commands or data that can be processed and used by the system.In conclusion, the 4x4 keypad is a simple yet powerful input device that is widely used in a variety of electronic applications. Its compact design and easy-to-use layout make it a popular choice for many different types of projects and devices.

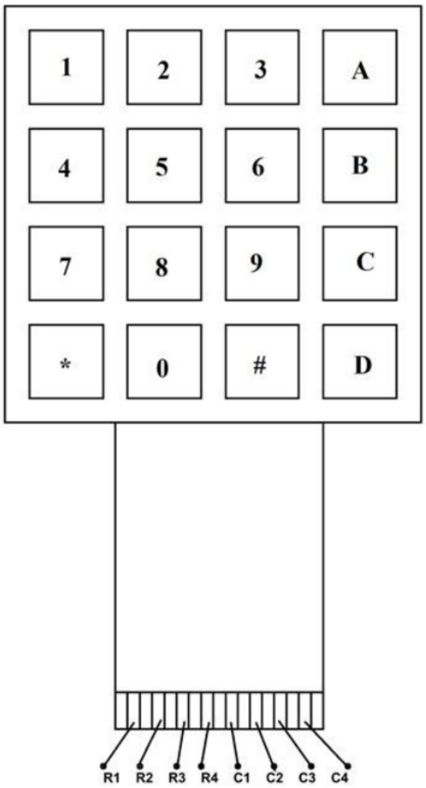

Figure 3. 4x4 Keypad circuit modul

The 4x4 keypad is a type of input device used to enter data or commands into electronic devices such as computers, calculators, or security systems. It consists of 16 keys arranged in a grid of four rows and four columns. Each key on the keypad is identified by a unique symbol or alphanumeric character. When a key is pressed, it completes an electrical circuit, which sends a signal to the device to which the keypad is connected. The keypad can be connected to a microcontroller or other control device, which interprets the signals from the keypad and takes appropriate actions. For example, a security system might use a 4x4 keypad to allow authorized users to enter a passcode to unlock a door or disarm an alarm. In addition to the standard numeric keys, a 4x4 keypad may also include special function keys such as "enter," "clear," or "cancel." Some keypads may also have backlighting or other visual indicators to provide feedback to the use

Arduino nano

The Arduino Nano is a small, powerful microcontroller board that provides easy access to the features of the popular Arduino platform in a compact form factor. The board is based on the Atmel ATmega328P microcontroller and has a USB interface that allows easy programming and communication with other devices. Arduino Nano boards are popular with enthusiasts, students, and professionals interested in embedded system development and electronic projects. The board is packed with features such as digital and analog I/O pins, PWM output, UART, SPI and I2C interfaces, 16MHz crystal oscillator and more. Additionally, the board features a 5V voltage regulator that can power external components. The Arduino Nano board is compatible with the Arduino Integrated Development Environment (IDE), which provides an easy-to-use interface for programming the board. The IDE contains a library of ready-made code that can be used to control various functions of the board, making it easy for anyone with little prior knowledge to get started programming.

One of the main advantages of the Arduino Nano board is its small size, making it ideal for projects with limited space. This board is relatively inexpensive, making it accessible to a wide range of users. Additionally, the board is open source. This means that the hardware and software designs are freely available and can be modified or extended by anyone. Overall, the Arduino Nano board is a powerful and versatile microcontroller board suitable for a variety of electronic projects and applications. Its small size, low cost, and compatibility with the Arduino IDE make it an ideal choice for hobbyists, students, and professionals.

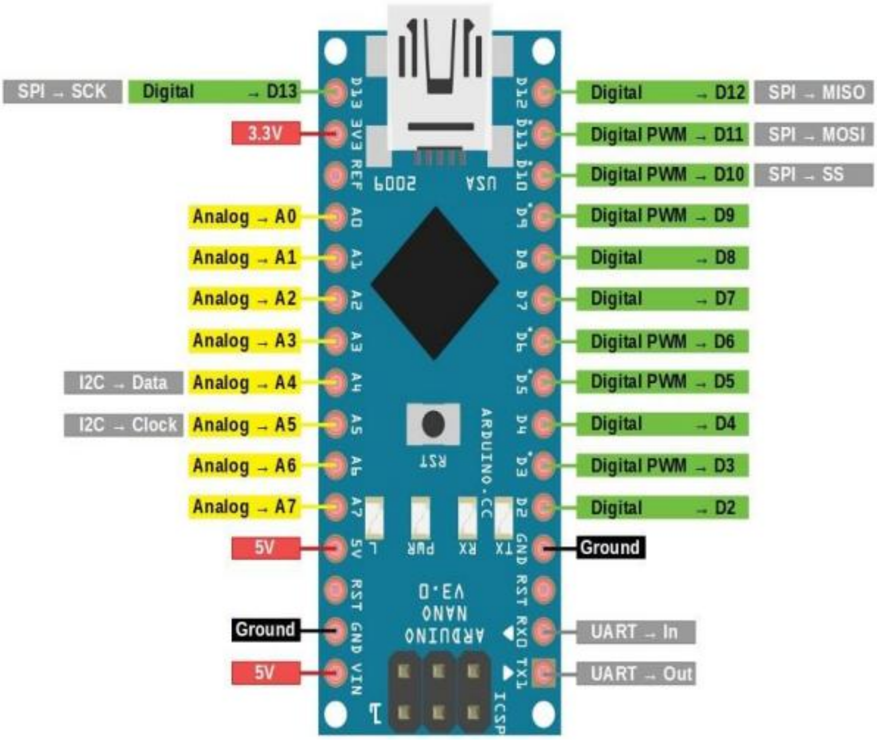

Figure 4. Arduino nano

5.RECEIVER SECTION

The optical signal which is transferred by the laser will be received in this section by the LDR sensor.Other than that the receiver section[5] consists of resistor,Arduino UNO,12*4 LCD display,12c LCD display interface.Which will convert the optical signal into electrical signal in order to display it.This is done by the arduinouno [6] in the receiver section.

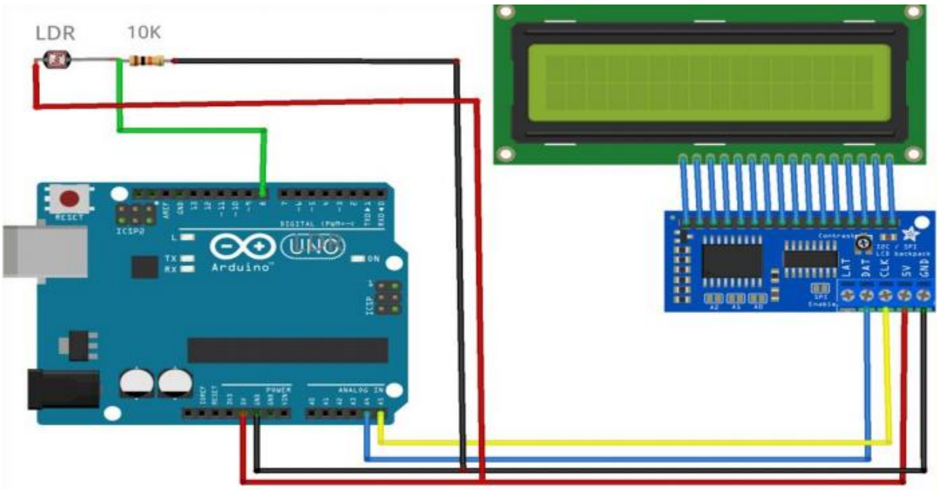

Figure 5. Receiver section

LDR sensor

An LDR (Light Dependent Resistance) sensor is an electronic component that detects the intensity of light and converts it into a corresponding electrical signal. Also known as photoresistors, they are widely used in various electronic circuits and devices. LDR sensors consist of a semiconductor material that changes electrical resistance depending on the amount of light striking it. When the sensor is exposed to light, the semiconductor material's resistance decreases, and when it gets dark, the resistance increases. This property makes LDRs useful for various applications such as light detection, automatic lighting control, and light-dependent alarms. LDR sensors measure the voltage across the sensor when light hits it. The voltage on the LDR changes with light intensity and can be used to control other electronic components or trigger alarms. Many circuits place a resistor in series with the LDR to create a voltage divider network that provides a stable output voltage that can be measured by other components.

LDR sensors come in a variety of shapes and sizes, with different resistance ranges and light sensitivities. The sensitivity of an LDR is determined by the wavelength of light to which it is exposed, which changes the resistance of the sensor accordingly. Some LDRs are more sensitive to visible light, while others are more sensitive to infrared and ultraviolet light. In summary, LDR sensors are widely used in various electronic circuits and devices to sense light intensity. Their ability to convert light energy into corresponding electrical signals makes them useful in many applications such as automatic lighting control, light-dependent alarms, and light detection. LDRs come in a variety of shapes and sizes and can be adjusted for light sensitivity based on application needs.

Arduino uno

Arduino Uno, a microcontroller board known for its reasonableness and ease of utilize, is based on the ATmega328P. It is prepared with computerized and analog input/output pins, shields and circuitry, permitting it to interface with a assortment of sensors and gadgets. It has 14 computerized and 6 analog input pins that can be utilized for input and yield capacities, as well as a USB connector, a control connector, and an in-ICSP connector for programming and investigating. To program the board, clients can utilize the Arduino Coordinates Improvement Environment (IDE), which is accessible both online and offline.

The board forms the light flag from the LDR sensor through Its coordinates circuit and changes over it into an electrical flag that can be translated by the microcontroller. These electrical signals can be utilized to control different gadgets or trigger particular activities based on board programming. By and large, the Arduino Uno may be a flexible and beginner-friendly board that can be utilized for a assortment of ventures and applications, counting those including LDR sensors.

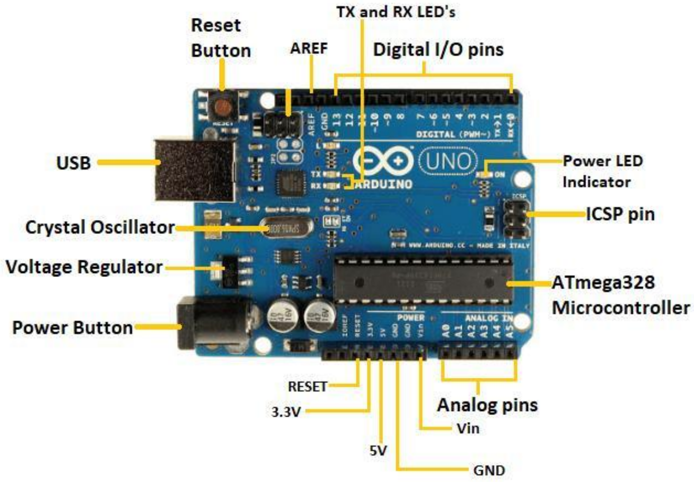

Figure 6.Arduinouno

6.Working and results

The process is initiated by giving input to transfer by the 4x4 keypad. In which numeric and special characters can be given to be transmitted by the laser. After pressing the buttons in the 4x4 keypad the keypad will create a electrical signal for the corresponding input. This input will go to the arduinonano which will convert the electrical signal into optical signal which will be transferred by the laser. For that arduinouno to convert the electrical signal into optical signal a code is necessary to do the work. Without the required code the arduinonano cannot transfer the electrical signal into optical signal and it also cannot be transferred by the laser. But if the code is valid then the electrical signal will be converted into optical signal without any error. After the conversion of electrical signal into optical signal that signal will be transferred by a 5v laser which is the main component of the transmitter section.The high the efficiency of the laser,the higher distance data can be transferred.

After the transmission from the transmitter side the optical signal will be received by the LDR sensor in the receiving end which will capture the optical signal without any loss of data. Then the captured optical signal needs to be converted into electrical signal to make it displayed in the 16*2 LCD display. For that arduinouno is used.The collected optical signal will pass through the arduinouno which will convert the optical signal into electrical signal. For that to happen a code is necessary for the arduinouno like the arduino Nano. Without the necessary code arduinouno cannot the optical signal into correct optical signal. Likewiseardunionano if there is an error in the code the system cannot convert the optical signal into electrical signal. So it is necessary to write a proper code into the arduinouno.Then after the conversion of optical signal into electrical signal, to display the output a display is needed. For that a 16*2 LCD display is used. It can be used to display the converted electrical signal.

After all this process the output will be displayed in the 16*2 display. If there are any problems in the circuit the output obtained will be corrupted or even may be not be obtained. This proposed system can be used to transfer data wireless and also without any radio frequency waves. The main advantage of this system is the speed of the data transfer, because of the usage of laser, the data transfer will be fast since laser travels in the speed of light which is 299.792.458km/so it the data transfer is faster than any of the existing system except the fiber optic communication which also uses light for data transmission. But unlike the optical fiber communication, this system does not need fiber optic cable as transfer medium. In this system the data can be sent in any medium. This cannot be done in the fiber optic communication. Also the data cannot be accessed by any third party sources, since to convert the optical signal into electrical signal a specific code is required. And any third party will not have the code,so they cannot retrieve the data which can be used to share secured data since it has high security.

Other than these advantages, this system also has its own disadvantages, the main disadvantage of this system is both the transmitter and the receiver should be stable to maintain a proper connection between them. Also many interference can block the path of the signal which will make the signal to not the reach the receiver. Such interference can be fog, any foreign objects,etc. Then another disadvantage is the distortion by the laser which will happen when the laser is pointed towards a very long distance. After reaching a certain range the laser will disperse in a small amount which will cause in a loss of data. The receiver should be within the range of the transmitter. But this disadvantage can be overcome by using a highly efficient laser.

In the present, this system may have these disadvantages but in future these disadvantages can be overcome, if that happens then this laser communication system will move on to the next level. Since it has a very high speed it can be used to transfer data from the Earth to the satellite and it can be also used to transfer data between the satellites within seconds because of the speed of the laser. It only needs to have a powerful laser. Since space does not contain many interference this can be happen very efficiently.

The working model of the proposed system Figure7 is shown below

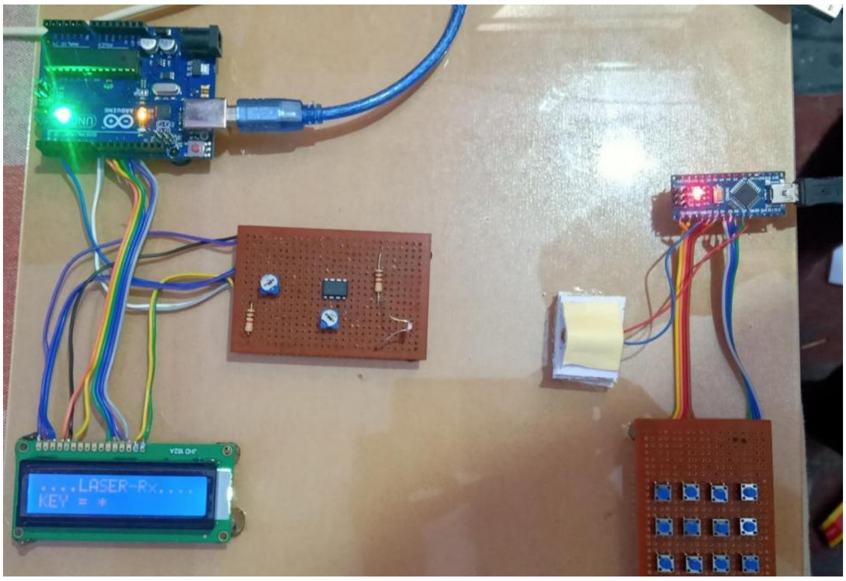

Figure 7. Proposed system working model

This is the working model of the proposed system which consists of the components mentioned which are 4x4 keypad, arduinonano, laser diode, LDR sensor, arduinouno and 16*2 LCD display.In this model numeric and data such as text can be transferred by using this system. In summary, the arduinonano is connected to the and the laser which acts as transmitter when the input is given by the 4x4 keypad and then the electrical signal generated by the 4x4 keypad will be converted into optical signal by the arduinonano which is connected with the keypad. Then the optical signal wil be transferred by the laser. After that the optical signal will be captured by the LDR sensor. Then that optical signal needs to be converted into electrical signal in order to be displayed. For that arduinouno is used which will convert the optical signal into electrical signal using a specific code. Then the converted electrical signal will be displayed by a 16*2 LCD display which is also connected with a LCD interface to make the LCD display work properly..

6.CONCLUSION

The main objective of this project is to explore the feasibility of using optical-based carriers for wireless data communication between two microcontroller-driven devices. In the process, the researchers aim to gain practical knowledge about microcontroller interfacing and software development, as well as learn about different wireless technologies. Although optical data communication has been in existence for over a decade, this project seeks to delve deeper into the underlying principles of optical wireless systems. The ultimate goal of this project is to create a comprehensive portfolio that can serve as a valuable resource for individuals interested in undertaking optical data communications projects utilizing laser technology.

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