DESIGN AND IMPLEMENTATION OF SURFACE DISINFECTION ROBOT USING UV LIGHT AND LIQUID SANITIZER

by

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CERTIFICATE OF APPROVAL

The project entitled as "**Design and Implementation of Surface Disinfenction Robot Using UV Light and Liquid Sanitizer**" submitted by **Fahim Bin Rahman**, bearing Matric ID: **ET 161053** and **Anik Das**, bearing Matric ID: **ET 161061** of session **Autumn 2020**, to the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Electrical and Electronics Engineering and approved for the examination held on **September 3, 2021.**

_____

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DECLARATION

It is hereby declared that this work has been done by us and no portion of the work contained in this thesis/project has been submitted elsewhere for the award of any degree or diploma.

_____
Fahim Bin Rahman

_____
Anik Das

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ABSTRACT

There is new general health emergencies compromising the world with the rise and outbreak of 2019 novel coronavirus (2019-nCov) or the serious intense respiratory condition coronavirus 2 (SARS-Cov-2). Because of the COVID-19 virus, human lives and livelihoods changed extensively and the only way to minimize the spread of the virus is to maintain social distancing and follow guidelines proposed by our respective government. Not to mention sanitization and sterilization have become an indistinguishable part of our daily life. Talking about sanitization and sterilization, there is a problem. We can't directly involve in the sterilization process because there is a chance of getting the deadly virus from the contaminated space, but what we can do to solve this problem is to build a powerful, efficient, and autonomous robot. The robot can sterilize a place very easily without exposing ourselves. Robots are in use for several applications where humans can be at risk of exposure. So, in this project we built a sanitization robot that will be able to kill the corona virus in the hospital and apartment building or elsewhere.

We have developed a arduino based robot where UV Light and Liquid Sanitizer is used for killing the corona virus. An ATMEGA328P Arduino microcontroller is used with Crystal 16 MHz which acts as the main interfacing device. The majority functions of the robot is controlled by NRF24L01 module. A gear motor,pump motor,wheel and L298 motor driver module is used for different functions of the robot. And two mobile phone is used as an IP Camera for monitoring the robot. Thus our robot can be used for the sanitization process where physical presence will not be required.

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CHAPTER 1

INRTODUCTION

1.1 : INRODUCTION

A new human coronavirus that is currently called SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2) and previously named CoV-19, was revealed in Wuhan, China, at the end of 2019 and is presently resulting in a pandemic. Covid-19 is the sickness brought about by the new kind of coronavirus named n-Cov19 [1-3]. This virus revealed on the underlying case at China and started to outbreak to the world [4]. Coronaviruses are wrapped positive sense RNA infections extending from 60 nm to 140 nm in diameter with what look like spike projections on its surface providing a crown appearance under electron microscope; henceforth the name coronavirus [5]. All ages are subjected to such infection. Disease is transmitted through droplets produced during sneezing and coughing by infected patients yet can likewise happen from asymptomatic individuals and before beginning of side effects [5]. Investigations have demonstrated larger viral loads in the nasal cavity when contrasted with the throat with no distinction in viral weight among symptomatic and asymptomatic individuals [5-6]. Patients can be infectious for whatever length of time that the symptoms keep going and even on clinical recuperation. The transmission of the infection was seen as spread through human-to-human that makes it effectively diffused. The transmissions origin from the infectee droplets when coughing or sneezing. Such droplets are able to survive on the inanimate surface even in air and transmitted the infection to human. In view of past studies on the perseverance of the infection on inanimate surface as well as air, the infection can stay until 3 hours in aerosol, one day on cardboard, 4 hours on copper, and as long as 3 days on the stainless steel and plastic [7-8]. The investigation proposes to evacuate the infection utilizing agents of biocidal, for example, hydrogen peroxide, sodium hypochlorite, alcohols, or benzalkonium chloride [9-10]. The absence of treatment, the high death rate and the transmission examples of COVID-19 included the setting of effective and facilitated methods for avoidance and stop the overall spread of this infection. To forestall this imperfection, an alternative innovation is required with less human co-operation to limit the likelihood of infection spreading.

In the amidst of this global pandemic called COVID-19, stepping in where humans should not, robots are being used for jobs such as sanitizing hospitals and delivering food and medicines, and have proved to be very much useful and handy.

Sanitization, which has become a very important aspect in these pandemic times and plays a very crucial role in preventing us from exposure of this deadly virus and thus helping in eradication of this global pandemic is very important. One of the high-risk zones of exposure to this deadly virus is in the area where people rush to for the cure, that are the hospitals and the medical wards. Sanitization in these areas is indeed challenging and requires very high measures to be taken. But in spite of all these high-end measures taken, there is always a risk associated with it.

The goal of this project is minimizing human interaction as much as possible and thus automating the tasks such as sanitization with the help of robots. In this case, the use of robots

can reduce human exposure to pathogens, which has become increasingly important as epidemics escalates. The project uses Arduino and NRF module for its design and development of the sanitization robot. Arduino integrated development and NRF24L01 module used for control and programming. The design of the robot has a nice feature that helps in spreading positivity amidst these times. The Robot uses powerful UV lights and sprays liquid sanitizer which can act against the COVID-19 virus.

1.2 : Can UV Light Kill the Coronavirus ?

1.2.1 : Familiarization with UV Lights

Ultraviolet (UV) light is a type of radiation. It has more energy than radio waves or visible light but less energy than X-rays or gamma rays. UV light can be exposed via natural sunlight or through human-made sources like tanning beds. UV light has been used as a means to kill germs like bacteria and viruses. It may have also heard of its use for killing SARS-CoV-2, the new coronavirus that causes COVID-19.

1.2.2 : How is UV Light Currently Used to Kill the Coronavirus

In the fight against the coronavirus disease 2019 (COVID-19) pandemic, an old weapon has re-emerged [11]. More than a century after Niels Finsen won the 1903 Nobel Prize for discovering that ultraviolet (UV) light could kill germs [12], UV light is surging in popularity as a method for disinfecting hospital rooms and other public spaces.

UV light is generally divided into three classes, based on the wavelength of the light. All of them are invisible to the human eye. The longest wavelengths are UVA (315–400 nm) and UVB (280–315 nm), which are found in ordinary sunlight. These are the rays that can cause sunburn if one stays outside too long without protection. UVA and UVB light rays have limited germ-killing ability because viruses and bacteria have had millions of years to adapt to them.

But UVC light (200–280 nm) is completely absorbed by our atmosphere and never reaches the surface of the earth [13]. Therefore, UVC light is just as novel to SARS-CoV-2 as the virus is to humans. According to the International Ultraviolet Association, it is generally accepted that a dose of 40 $mJ \cdot cm^{-2}$ of 254 nm light will kill at least 99.99% of "any pathogenic microorganism" [13],[14].

At present there are many different designs for UV disinfection systems. Some systems consist of just a bare lightbulb and a timer, while others are mobile robots that can reach hard-to-access

places[15]. Two of the major design choices are the wavelength of light and the method of delivery. By far the most common wavelength for germicidal light is 254 nm, produced by low-pressure mercury lamps. These lamps are easy and cheap to manufacture because they use essentially the same technology as a fluorescent light bulb. A fluorescent bulb actually produces UV light inside the bulb. But the phosphor deposited on the glass surface of the bulb absorbs that light and re-emits it at longer wavelengths that humans can see. To make a UV lamp, the glass is replaced with a material transparent to UV light, such as fused quartz.

However, 254 nm may not be the optimal wavelength for killing all viruses. Experts believe that different wavelengths disable viruses in different ways [16],[17]. The 254 nm light damages the viral deoxyribonucleic acid (DNA) or ribonucleic acid (RNA) so that the virus cannot reproduce. Shorter wavelengths, like 207–222 nm (sometimes called "far UVC") are believed to damage the proteins on the surface of the virus that it needs to attach to human cells. Thus, the curve that describes the viral killing ability of UVC light has a double-humped shape, with a peak at shorter wavelengths and another around 265 nm.

Disinfection with far-UVC lamps remains largely experimental but could have an intrinsic advantage. Initial evidence suggests that far-UVC light does not penetrate beyond the outer dead layer of skin cells or the liquid film on eyes in healthy people [18],[19]. Thus, it cannot cause skin cancer or cataracts, like UVA and UVB. It also seems not to cause temporary skin burns and eye damage ("welder's flash") like standard UVC. This presumably depends on the intensity of exposure; whether intense exposure to destroy pathogens on the hands, for example, would be safe is unknown.

UV light may also suffer from a quirk of history. In the 1940s and 1950s, antibiotics came into wide use, giving many doctors the impression that the war against microbes was won. UV light, therefore, was not only an orphan technology but also seemed obsolete. However, that complacency began to unravel in the 1980s, when drug-resistant bacteria emerged, particularly tuberculosis (TB). Nardell said that a partial solution to disrupt hospital transmission of TB, an airborne pathogen, used louvered UVC lamps to disinfect the air near the ceiling, which was then circulated to the rest of the room. But that strategy did not affect pathogens that depend on surface-based transmission. Hospital-acquired infections remain a major problem globally, affecting an estimated seven to ten of every 100 hospitalized patients. Many of the pathogens that cause these infections are multi-drug resistant and difficult or impossible to cure with drugs, so it makes sense to try to kill them before they can enter the body. Thus, before 2020, hospitals were the main customers for whole-room UV disinfection.

1.3 : MOTIVATION

In this pandemic situation people's life goes under a huge risk . People can easily be effected by this virus as it cannot be seen. When people get involved in the sanitization process directly, it becomes very risky for them and there is a chance to get affected.So to overcome the situation, we have developed a arduino project that can be used for the sanitization process. It can easily be controlled by anyone and can be used at mosques, hospital, offices,educational institutions and anywhere. Besides as the project is not very large, it can be kept anywhere and can easily be transported. Thus our project can be used for the sanitization process without involving ourselves directly.

1.4 : OBJECTIVES

The project objectives are described below

- To perform sanitization process without risk.
- Use UV light and liquid sanitizer for destroying Corona Virus.
- Wireless control and remote monitoring.

1.5 : LEARNING OUTCOME

By doing this project we have learnt about

- Interfacing with NRF24L01 wireless communication system.
- Different types of Motor Driver Module,Pump Motor,Gear Motor etc.
- Different types of functions and source codes.

1.6 : CHAPTER OUTLINE

During the planning and creation of this project six chapters has been covered.Chapters contents are as follows :

- Chapter 1 (Introduction) : The chapter presented the description,inspiration and goal of the projrct.
- Chapter 2 (Literature Review) : The chapter discussed previous work or research related to this projectand comparison with earlier work.
- Chapter 3 (Components) : The components that were used in this project have been discussed in depth in this chapter.
- Chapter 4 (System Design) : Interfaces between each module and Microcontroller are covered in this portion.
- Chapter 5 (Implementation and Result) : Is discussed about the implementation of the project and the results that we got from the project.
- Chapter 6 (Conclusion and Future work) : Finally this chapter addressed the description of this project in depth.The project's drawbacks and potential growth have been addressed.

CHAPTER 2
LITETERATURE REVIEW

2.1 : INTRODUCTION

The uses of Robot in the sanitization process has created a safer environment for people. The need for disinfection and cleaning in hospitals and other patient care facilities during the pandemic is obvious. However, as economies reopen, public gathering hotspots such as airports, event venues, and public transportation vehicles, and transit stations, schools, malls and workplaces also play a vital role in preventing virus spread, as frequently-touched surfaces such as doorknobs, handrails, elevator buttons, faucet handles, seats, and tables, etc., are most likely to be contaminated. Surface and air contamination must be similarly managed in large workspaces such warehouses, retail stores, and factories — all without loss of productivity. Most countries have protocols and procedures in place for cleaning open access spaces and industrial facilities. Under pandemic conditions, however, cleaning capacity quickly reaches its limit and frequent cleaning cannot be ensured.

The scope of the present study is to design a smart assistant robot by exploring various contactless wireless technologies. The robot should be compact for efficient handling and incorporate a quick learning real time environment recognition technology for its locomotion in a crowded place.

2.2 : REVIEW OF PREVIOUS WORK

In this global era research work are going on to fight against the deadly corona virus. Instead of manpower uses of robots are increasing day by day .With this view various updated approaches are available in the process of sanitization and many more are in the progress of study. Some of the previous works that were done based on satization process discussed below :

2.2.1 : SANITIZATION ROBOT

This project describes the evolving role of robotics in healthcare and allied areas with special concerns relating to the management and control of the spread of the novel coronavirus disease 2019 (COVID-19) [20]. The prime utilization of such robots is to minimize person-to-person contact and to ensure cleaning, sterilization and support in hospitals and similar facilities such as quarantine. This will result in minimizing the life threat to medical staffs and doctors taking an

active role in the management of the COVID-19 pandemic. The intention of the present research is to highlight the importance of medical robotics in general and then to connect its utilization with the perspective of COVID-19 management so that the hospital management can direct themselves to maximize the use of medical robots for various medical procedures. This is despite the popularity of telemedicine, which is also effective in similar situations. In essence, the recent achievement of the Korean and Chinese health sectors in obtaining active control of the COVID-19 pandemic was not possible without the use of state of the art medical technology . Diagram of the system block has been shown below in the fig 2.1 .

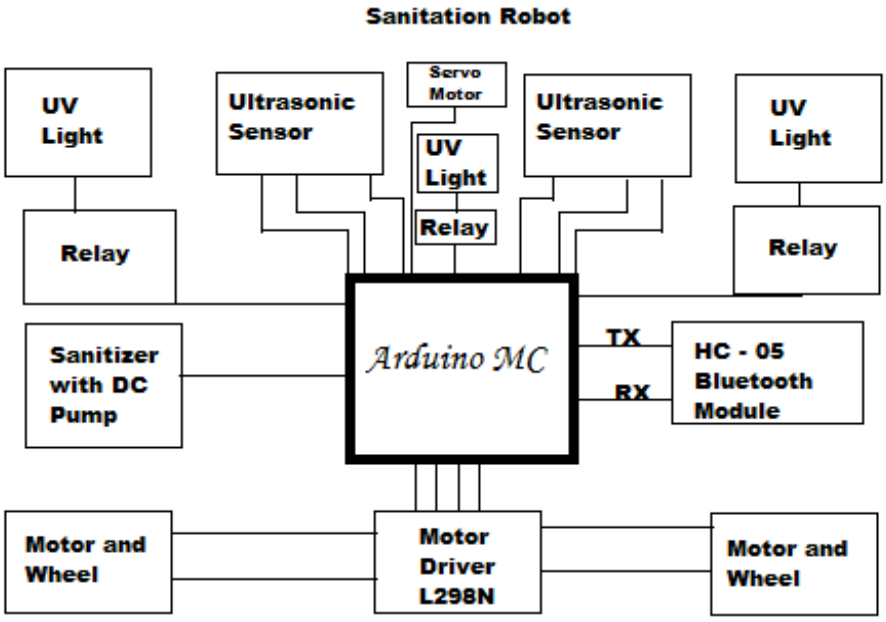

Fig 2.1 : System Block Diagram [20]

In this robot, DC powered pumps use direct current from motor, battery, or solar power to move fluid in a variety of ways. Motorized pumps typically operate on 6, 12, 24, or 32 volts of DC power. Solar-powered DC pumps use photovoltaic (PV) panels with solar cells that produce direct current when exposed to sunlight. Here, DC pump is used to pump out the sanitizer liquid and spray it through the nozzle in a controlled manner.

Relays are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuit. Here, Relay is used to switch the UV lights with separate power.

UV light connected to separate power supply via relay and switched on by electronic trigger generated from Arduino. Here UVC lights are being used as it is effective for the destroying pathogens and other bacterial, virus present in air and moisture. From relays UVC lights are connected and when trigger from Arduino is given, switch is closed in relay and UVC lights are on.

2.2.2 : Design and Development of Spray Disinfection System to Combat Coronavirus (Covid-19) Using IoT Based Robotics Technology

This robot based disinfection system is essentially made out of four components namely; auto-navigation vehicle, disinfectant spraying module, information monitoring module and smart controller [21]. The robot is carried by the auto-navigation vehicle to navigate and patrol livestock house based on the set up course. The unit of disinfectant spraying is utilized to atomize the chemical liquid, which involve air-based atomizing sprayer, disinfectant vessel, and stream valve. The data monitoring module feeds the online ecological data of domesticated livestock house. The robot would operate automatically the cleansing plan, as per the parameters set by the client. The recurrence of flow valve is consequently changed in accordance with control the disinfectant splashing stream, and the air velocity from the sprayer is automatically tuned to arrive at the disinfectant splashing distance, in order to understand the unmanned sanitization activity in the breeding condition.
Block diagram of the robot is given below in fig 2.2 .

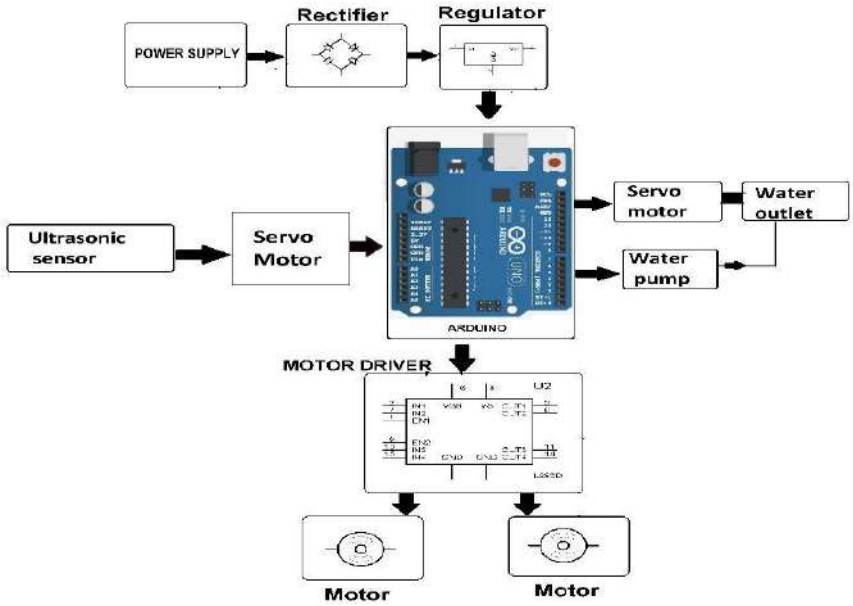

Fig 2.2: Block diagram of Spray Disinfection Robot [21]

The robotics unit is approved to be situated in a working environment in which the robot carry out the disinfection operation. Activities are resolved by means of the sensor unit and computer receives the feedback. The robotic unit manipulates all the movements while the robot incorporates the Arduino, sensor unit and PC programs. The sensor unit comprises of ultrasonic sensor that distinguish any obstacle at the work environment. The robotic is attached with two ultrasonic sensor finders which were situated on the top and at the bottom of the vehicle to distinguish any obstacle. A camera is joined at the front of the robot to register and show the atmospheres perspective on the workers screen show for powerful monitoring. Moreover, GPS

and GSM were joined with the robot so as to acquire data, message and images through data transfer.
The sprayer structure with gas-liquid extraneous mixture was built up to address the requirements of large flow and long-run splash. The nozzle that put a head of the robot aims to sanitize liquid sprinkler toward the target. The disinfecting liquid is pumped after being adjusted and controlled by the user. The ideal voltage of such water pump is 6V while the working voltage is around 4V to 12V with 0.8A corresponding current. Splashing bleach with low concentration and-water blends is utilized in this study which is utilizing one part of bleach with 99 parts of cold faucet water (dilution ratio1:100) for sterilization of surfaces. From the other hand, the user can monitor robot track by utilizing camera that connects with a cell phone. All the information from sensor is checked and controlled by Arduino.

2.2.3 : Automatic Surface Disinfection Robot Using Ultraviolate Lights

This project is completely automatic and it will detect obstacles and avoid those before a collision happen. There are many options to detect an obstacle, but for this project, there have chosen to do it with an ultrasonic sensor module because it has a lot more advantages over conventional IR based obstacle avoidance sensors**,** first is the range, it has a longer range compared to the range of an IR based proximity sensor. Second, like the IR sensor, sunlight doesn't interfere with the sensing capabilities of the sensor. In this robot, there is three ultrasonic sensors for detecting obstacles in the left, right, and front. When an obstacle comes in front of any sensor (at a certain distance) the robot will turn in to the opposite side and avoid that obstacle for example if an obstacle comes in front of the left sensor robot moves to the right. While the robot is powered ON, the UV LEDs will stay ON and the sterilization process will continue. It has a total of ten UV LEDs (Two on each side and two on the downside) so this gives a 360°+ downside sterilization. This robot is 100% safe to operate and it will detect items in the environment for its operation and the safety of operators (obstacle avoidance). The robot is fully autonomous when UV irradiation is being performed this robot has a full 360-degree movement.[22]

2.2.4 : Disinfactant Robots to Protect against COVID-19

This project is about a novel robot technology that can rapidly disinfect radiology treatment rooms using scientifically proven UV germicidal irradiation (UVGI) technology. One or more robots will be deployed in a radiology treatment room and programmed to follow a predefined trajectory, irradiating surfaces as it moves. Some degree of manual cleaning may still be required (estimate <5 minutes in total), and this can be undertaken while the robot is in the room (enabled by a range of proprietary in-built robot safety features). That may reduce the time to disinfect rooms by a factor of 4-6X. Their aim is to deploy UV disinfectant robots in Radiology departments in a regional Irish hospital, where it will be used alongside existing cleaning procedures to reduce dependency on human staff and improve workflow/equipment utilization. The project is conducted in two 4 week phases. In phase 1, it deploy beta versions of the UV disinfection robot in an Irish hospital. It will work closely with infection control and radiology

teams at the hospital to best integrate the robot within room disinfection practices. In phase 2, it deploy replace the beta version of the robot with an upgraded CE-marked version.[23]

2.2.5 UVD Robots

UVD Robots, a subsidiary of Blue Ocean Robotics, are able to disinfect patient rooms and operating theaters in hospitals. The robots consist of a mobile base equipped with multiple lidar sensors and an array of powerful short wave length Ultraviolet-C (UVC) light. .

The operators deploy the robot using a computer. The robot scans the environment using its lidars and creates a digital map. The operator can then annotate the map indicating all the rooms and points the robot should not disinfect. After that, the robot relies on simultaneous localization.

The robot then drives autonomously around hospitals while emitting 20 joules per square meter per second (at 1-meter distance) of 254-nanometer light to eliminate bacteria and other harmful microorganisms. As a result, hospitals can guarantee a 99.99 percent disinfection rate – reducing the risk for patients, staff and relatives of contracting dangerous infections.[24]

2.3 : COMPARISON WITH PREVIOUS WORK

In our project we have used NRF24LO1 module which enables to control the robot within a very long distance around 1 km from transmitter. By this module other functions of the robot such as switching of UV lights and spray liquid sanitizer both can also be controlled. We used two mobile phone as an IP camera to monitor the robot. This robotics based project bearing some effective features which make our robot more unique. The most unique features is wireless communication system by using NRF24L01 module. Again in this project we used mobile phone as IP camera to observe all the functions of robot. Beside them this robot is user friendly and bearing low cost.That's why it can be used widely. Also this is future upgradable.In future there can be used more unique features and technologies which will make this robot more unique and effective.

CHAPTER 3

COMPONENETS

3.1 : Introduction

Our project aims at designing and implementing of a surface disinfection robot.To get the desired output NRF and a microcontroller besed circuit is created to manage the whole system.As our Robot needs wireless communication system,we used NRF24L01 control module. Through this module the robot can be controlled within a very long diastance.To process the signal which is given by Nrf,a microcontroller named Atmega 328P is used. The microcontroller will interface the whole system for making the robot functionable.We used required UV light and liquid sanitizer for performing disinfection process.Finally after a complete setup by a remote control device the robot can be moveble from one place to another and the sanitization and disinfection process will go on.

3.2 : LIST OF COMPONENTS

In this project several types of components were used.The components are listed below :

- NRF 24L01
- Atmega328P Microcontroller
- L298 Motor Driver Module
- LM 1117
- Pump Motor
- Dc Gear Motor
- Relay
- UV Light
- Liquid Sanitizer
- Spike Tire Set

3.3 : NRF24L01 TRANSCEIVER

In wireless control system the NRF24L01 wireless transceiver module controlled with Arduino Microcontroller is more flexible, low cost and user friendly system . Using this system any electrical and electronics equipments can be controlled easily by attaching equipments and injecting the relevant control code into the Microcontroller unit.The NRF24L01 wireless transceiver module, and other equipments used in the controller are easy to implement in a circuitry. That is why it can be used for multiple systems to control without being changing the circuitry. Only have to change certain control codes in the transmitter and receiver unit.
The designed controller here will be used to control different functions of the Robot.In the controller the transmitter unit will send the instruction from controlling modules of transmitter via nRF24L01 through the processing unit. The receiver unit will receive the signal or

corresponding signal (if multiple signals are transmitted for multiple equipments attached with the receiver) and will execute the instruction. In fig 3.1 there is shown a NRF24L01 Transceiver Module and SMA Antenna.

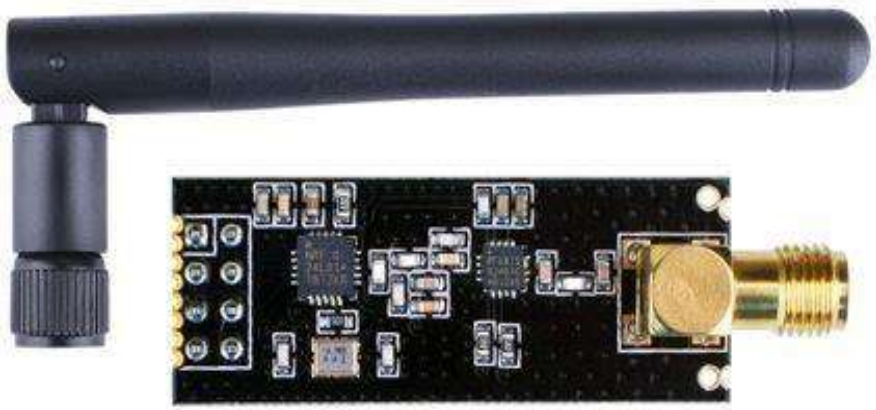

Figure 3.1: NRF24L01 Transceiver Module and SMA Antenna [25]

3.3.1 : Features of NRF24L01

1) 2.4GHz RF transceiver Module
2) Operating Voltage: 3.3V
3) Nominal current: 50mA
4) Range: 50 – 200 feet
5) Operating current: 250mA (maximum)
6) Communication Protocol: SPI
7) Baud Rate: 250 kbps - 2 Mbps.
8) Channel Range: 125
9) Maximum Pipelines/node: 6
10) Low cost wireless solution [25]

3.3.2 : SMA Antenna:

SMA antennas are a diverse group of radio frequency antennas that possess an SMA connector for attachment to a coaxial extension cable or other radio frequency hardware. An SMA connector serves as the primary channel through which radio frequency signals can flow between the antenna and the device it is attached to. These antennas are capable of intercepting electromagnetic energy and translating it into electrical current and vice versa. They are designed to connect by soldering or crimping to semi-rigid coaxial cable. This widely used and hard-wearing connector is the primary point of connection for the antenna and may even have to provide mechanical and structural support as part of an antenna's design. A single SMA connector may be installed on an antenna, or additional auxiliary SMA connectors may be

present, to support antenna diversity as we discuss further on. In this case, the type of class of antenna and its applications can vary widely but the consistent feature is the SMA connector used in the antenna.

3.4 : Atmega328P Microcontroller

The Atmel 8-b-based microcontroller as shown in figure 3.3 consolidates 32 KB ISP memory with read-While compose abilities, numerous guidelines performed in a solitary fixed cycle [26]. The most prevailing specifications incorporates: “High Performance, Low Power Design, 8-Bit Microcontroller Atmel AVR advanced RISC architecture,131 Instructions most of which are executed in a single clock cycle, Up to 20 MIPS throughput at 20 MHz, 32 x8 working registers, 2 cycle multiplier, Memory Includes32KB of programmable FLASH, 1KB of EEPROM, 2KB SRAM, 10,000 Write and Erase Cycles for Flash and 100,000 for EEPROM, Data retention for 20 years at 85°C and 100 years at 25°C, Optional boot loader with lock bits, In System Programming (ISP) by via boot loader, True Read-While-Write operation, Programming lock available for software security, 2 x 8-bit Timers/Counters each with independent pre-scalar and compare modes, A single 16-bit Timer/Counter with an independent pre-scalar, compare and capture modes, Real time counter with independent oscillator, 10 bit, 6 channel analog to digital Converter, 6 pulse width modulation channels, Internal temperature sensor, Serial USART (Programmable), Master/Slave SPI Serial Interface -(Philips I2C compatible), Programmable timer with independent internal oscillator, Internal analog comparator, Interrupt and wake up on pin change, Internal calibrated oscillator, Power on reset and programmable brown out detection, External and internal interrupts, 6 sleep modes including idle, ADC noise reduction, power save, power down, standby, and extended standby, 23 programmable I/O lines, 28 pin PDIP package, Operating voltage:1.8 -5.5V, Operating temperature range:40°C to 85°C, Speed Grades:0-20 MHz at 4.5-5.5V and finally Low power consumption mode at 1.8V, 1 MHz and 25°C:Active Mode: 0.3 mA.

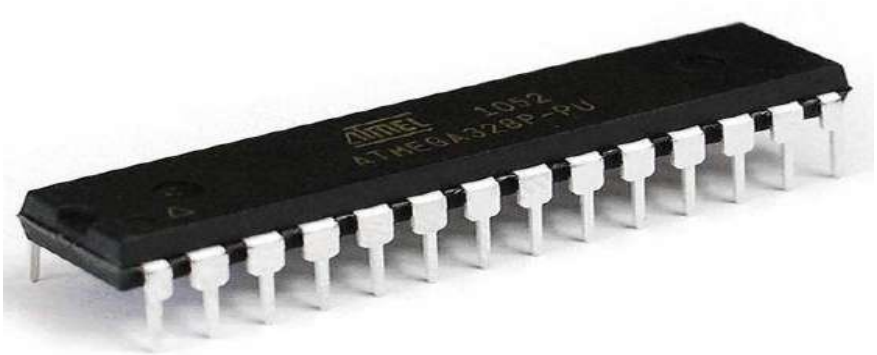

Figure 3.3 : ATMEGA 328P Microcontroller [26]

3.4.1: Technical Specifications

Technical Specifications of Atmega328P Microcontroller is given below in table 3.1.

Microcontroller	Atmega328P
Operating Voltage	5V
Input Voltage (Recommended)	7-12 V
Input Voltage (Limit)	6-20 V
Digital I/O Pins	14 (Of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current per 3.3V Pin	50 A
Flash Memory	32KB (Atmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (Atmega328P)
EPROM	1 KB (Atmega328P)
Clock Speed	16 MHz
LED Built in	13
Length	68.6 mm
Width	53.4 mm
Weight	25g

Table 3.1 : Technical Specifications of Atmega328P Microcontroller [26]

3.5 : L298N Motor Driver Module

L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control. 78M05 Voltage regulator will be enabled only when the jumper is placed. When the power supply is less than or equal to 12V, then the internal circuitry will be powered by the voltage regulator and the 5V pin can be used as an output pin to power the microcontroller. The jumper should not be placed when the power supply is greater than 12V and separate 5V should be given through 5V terminal to power the internal circuitry. The figure of this module shown below in fig 3.4.

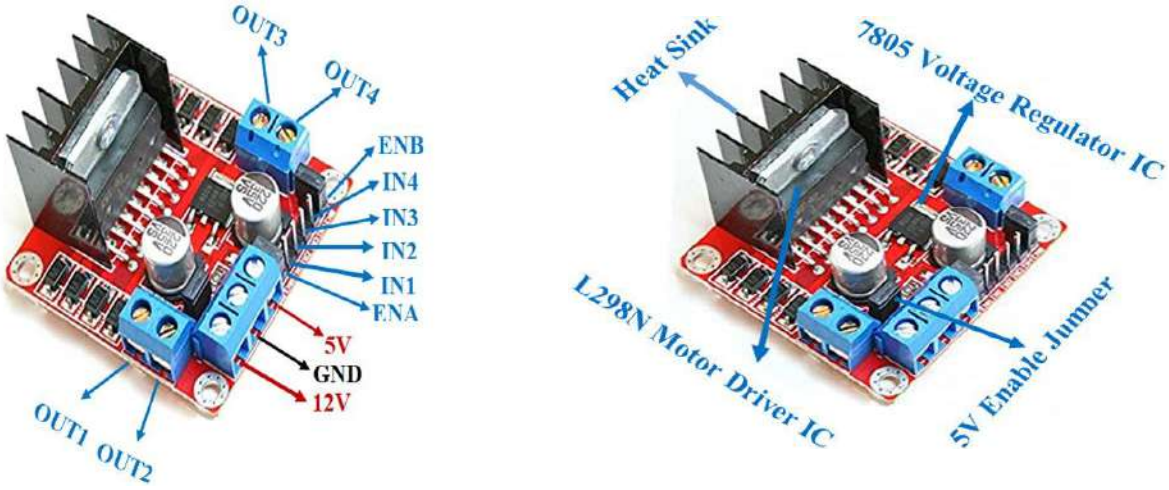

Fig 3.4 : L298N Motor Driver Module Pin Configuration [27]

3.5.1: L298N Module Pin Configuration

The pin configuration of L298N Module is given below in table 3.2.

Pin Name	Description
IN1 & IN2	Motor A input pins. Used to control the spinning direction of Motor A
IN3 & IN4	Motor B input pins. Used to control the spinning direction of Motor B
ENA	Enables PWM signal for Motor A
ENB	Enables PWM signal for Motor B
OUT1 & OUT2	Output pins of Motor A
OUT3 & OUT4	Output pins of Motor B
12V	12V input from DC power Source
5V	Supplies power for the switching logic security inside L298N IC
GND	Ground Pin

Table 3.2 : L298N Module Pin Configuration[27]

3.5.2: L298N Module Features & Specifications:

- Driver Model: L298N 2A
- Driver Chip: Double H Bridge L298N

- Motor Supply Voltage (Maximum): 46V
- Motor Supply Current (Maximum): 2A
- Logic Voltage: 5V
- Driver Voltage: 5-35V
- Driver Current:2A
- Logical Current:0-36mA
- Maximum Power (W): 25W
- Current Sense for each motor
- Heatsink for better performance
- Power-On LED indicator

3.6: LM1117

LM 1117 is the tiny Fixed Voltage Regulator that drops 5 Volt DC to fixed 3.3 V DC. It can output maximum 800 mA[28]. Like 78XX series Voltage regulators, LM1117 is also a three pin device with In, Out and Ground pins. Ideal Voltage regulator for Microcontroller and Arduino Projects that needs fixed 3.3V .[21]. The beow figure 3.5 shows a LM117 voltage regulator

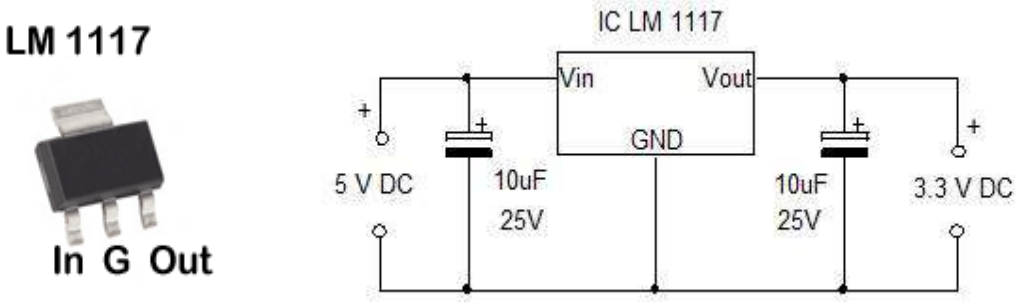

Fig 3.5: LM1117 Voltage Regulator and Circuit Diagram [28]

Only two capacitors are needed with LM 1117 to make a low voltage regulator power supply. Input can be 5 Volt DC up to 1 Amps which can be derived from the USB port also.

3.7: DC GEAR MOTOR

DC gear motor is ideal for robotic car or line-tracing robot.With plastic construction and coloured in bright yellow,the Dc gear motor measures approx.2.5 inch long,0.85 inch wide and 0.7 inch thick.The wheel can be mounted on either side and the gear motor works well between 4V to 7V(recommended 6Volts).At a ratio of 1:48 you can get some really good torque at 5 Volts [29]. In figure 3.6 there is shown a 12V DC gear motor.

Fig 3.6 : 12 V DC Gear Motor [29]

3.7.1: Specifications Of DC Gear Motor

- Voltage (Range) :12 Volt
- Current (Stall) : 100mA
- Speed : 120 RPM
- Torque : 0.8 kg.cm
- Gearmotor Style : Hobby
- Gear Material : Plastic
- Gearbox Ratio : 48:1
- Encoder : No

3.7.2: Extra Specifications

- Voltage :12V
- RPM : 3OOr /minute
- Current : 80-100 mA
- Reduction : 48:1
- Output Torque : 0.8kg.cm
- Brush-type : Brushless

3.7.3:Feachures

- Robotics Projects
- Battery-operated toys
- DIY Projects
- Machines Medical Equipment
- Automobiles Drive systems positioning

3.7.4: Dimensions

- 70 X 22 X 18 mm
- Shaft Size : 8mm X 5.4 mm diameter
- Weight : 17gr P

3.8: Pump Motor

Pump Motor Use basioc forces of nature to move a liquid.As the moving part (impeller,vane,piston diaphragm etc) begins to move,air is pushed out of the way .The movement of air creates a partial vacuum(low pressure)which cab be filled up by more air,or in the case of water pumps [30]. There is given the picture of pump motor in figure 3.7.

Fig 3.7: 12V Pump Motor [30]

3.8.1: Features :

- Model : Rs-360 micromotors small pump
- Operating Voltage : 12 Volt
- Current : 500 mA
- Motor Diameter : 27 mm
- Pump Length : 52 mm
- Out of the water hole diameter : 4 mm
- Weght : 70 g

3.9: Relay

Relay is frequently used in an automatic control circuit.To put it simply , it is an automatic switch to control a high-current circuit with a low-current signal.5V relay signal input voltage range,0-5V[31].VCC power to the system. The relay uses an electric circuit to open or close the contacts of a switch. In figure 3.8 there is shown a 5V relay.

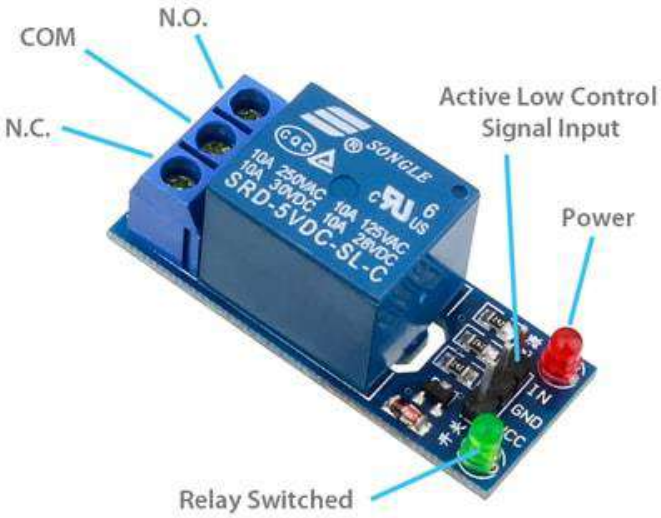

Fig 3.8 : 5V Relay [31]

3.9.1: Features of 5V Relay

- Trigger Voltage (Voltage across coil) : 5V DC
- Trigger Current (Nominal current) : 70mA
- Maximum AC load current: 10A @ 250/125V AC
- Maximum DC load current: 10A @ 30/28V DC
- Compact 5-pin configuration with plastic moulding
- Operating time: 10msec Release time: 5msec
- Maximum switching: 300 operating/minute (mechanically)

3.10: UV LED Light

Ultraviolet Round 5mm UV LED Light used in the project for disinfection.These LED's are very cost effective and takes low power consumption (around 5V) and by this power is saving. They contain wavelength of 275 nm.Total 15 UV led is used.Each of them have two pins and can be oprerate at normal temperature.

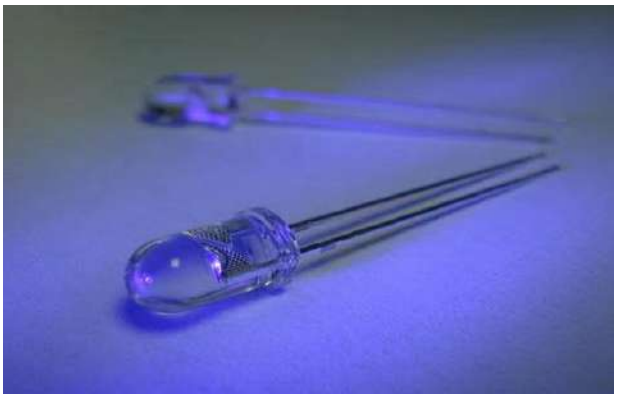

Fig 3.9 : UV Led Light

3.11: Liquid Sanitizer

According to WHO guidelines ,there are various types of disinfection solutions solution we may use for the sanitization process. In our project according to guideline we used Oxidized chemicals such as

*Sodium Peroxide

*Calcium peroxide (Not Powder only Liquid bleach)

*Savlon/Dettol (As required)

Iodine based solution such Viodine 0.5% or Povisep also recommended for this sanitization process also . [32]

3.12 : Spike Tire Set (2 Tires)

These two Tamiya spike tires come with two wheels, axles to be mounted on a 4 mm diameter shaft and axles compatible with a 3mm hexagonal shaft. Screws and mounting hardware are included [33]. In fig 3.10 there is shown spike tire set.

Fig 3.10 : Spike Tire Set [33]

CHAPTER 4

SYSTEM DESIGN

4.1 : INTRODUCTION

This Chapter contains a methodology to develop the prototype and described the system design of our project. Block diagram ,hardware interfacing ,circuit diagram and flowchart of the system described in this chapter. This chapter shows how the microcontroller and control module connected with each components and how data is collected from the system and run the project.

4.2: BLOCK DIAGRAM

The diagram depicts the components of a process with abstract,graphic symbols instead of realistic image.A model relies more on information interpretation and distribution than on functional operations.The diagram usually omits all information of this purpose that are not relevant to the data it attempts to convey and add unrealistic elements to support the understanding of the characteristics and relationships. The block diagram of the system has been shown below in the two fig 4.1 and 4.2.

4.3: BLOCK DIAGRAM FOR TRANSMITTER PORTION

The block diagram for transmitter portion is given below in fig 4.1.

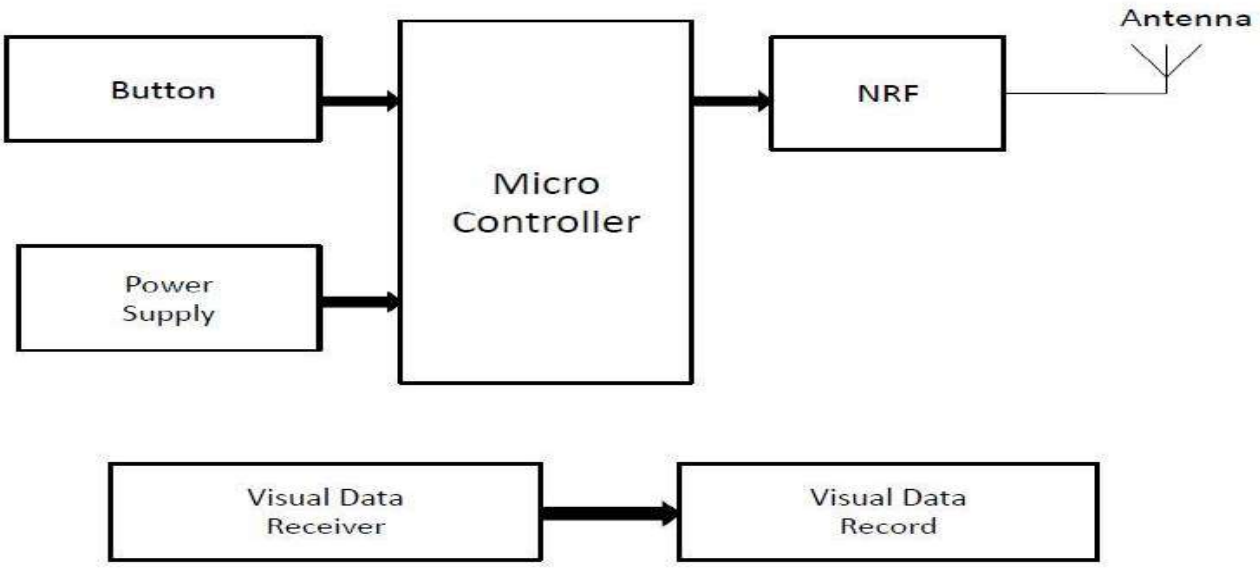

Fig 4.1: Block Diagram for Transmitter

4.4: BLOCK DIAGRAM for RECEIVER PORTION

The block diagram for receiver portion is given below in fig 4.2.

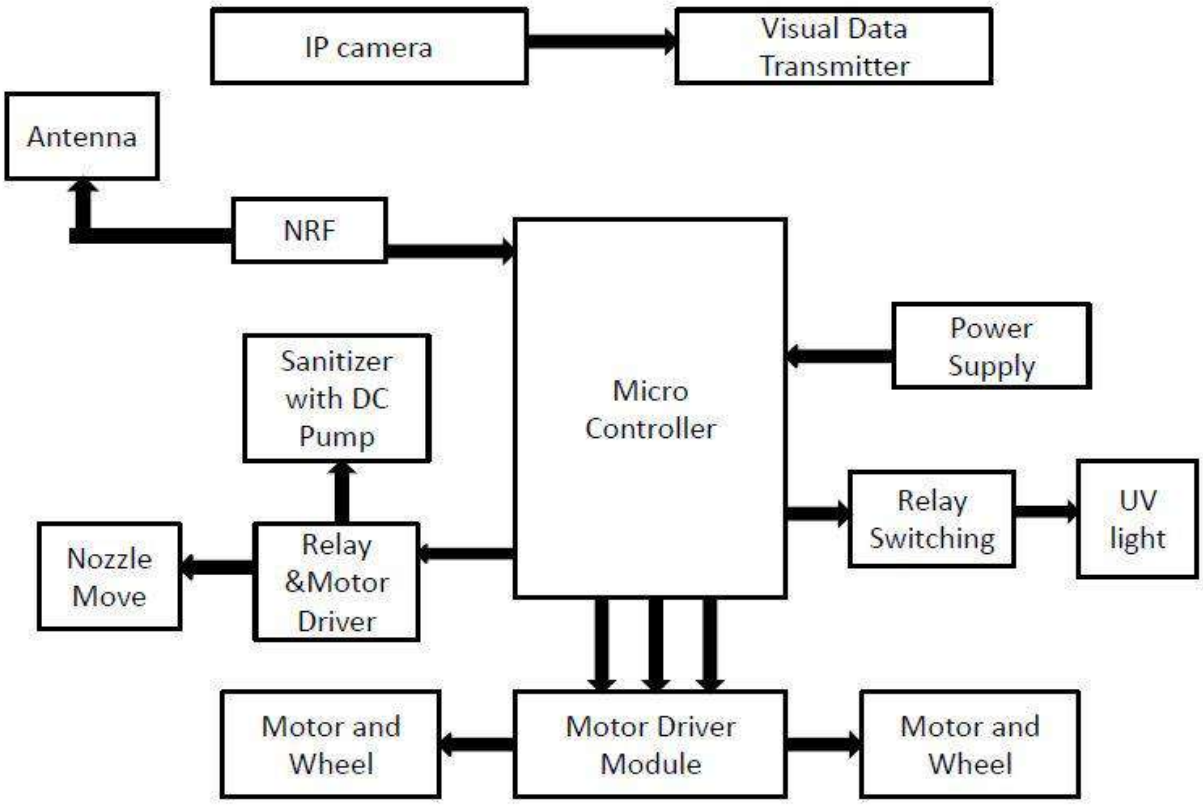

Fig 4.2 : Block Diagram for Receiver

4.5: OPRERATION OF BLOCK DIAGRAM

The operation of block diagram completed by two portion ; Transmitter and Receiver .

In Transmitter portion we used ATMEGA328P Micricontroller,NRF24L01(with Antenna). The main working principle of Transmitter is to control the robot.For controlling position of the robot transmitter is used. The robot can be mechanically moved to right/left/front/back when there is sent signal through module by pressing button.The activation and deactivation process of dc pump motor also performed by NRF remote control. The another important

part of the transmitter is IP camera. Every visual information of the robot can be got by the camera. Two mobile phone is used for this work. One phone is placed on the transmitter portion and another one is in the receiver.

In Receiver portion there is used ATMEGA328P Microcontroller, NRF24L01 module,L298 Moror Driver Module,Dc gear motor,pump motor,Relay, IP camera and UV light.Each of them performed different functions. The total system will be processed by microcontroller. When signal came to receiver from transmitter as when NRF received the signal through antenna, the microcontroller given command to motor driver module.After getting command the motor driver module can be understood in which side ;right/left/forward/reverse the robot need to move. Then in the specific space sanitization process will be continued. UV light and liquid sanitizer is used to kill the viruses. IP camera worked as a transmitter. The IP camera will served data to receiver,so thet we can get visual information of the robot and moving it to a particular place.

4.6: DEVELOPMENT OF THE SYSTEM

NRF24LO1 module is used to perform all the functions of transmitter and receiver. To cover a long distance NRF24L01 module is used. The Robot will be moved from one place to another by NRF24L01 module.By this module sanitization process will also be controlled. When the pump motor become active,the sanitization process will continue. After deactivation of pump motor sanitization process will stopped. NRF24L01,Atmega328p microcontroller,UV light etc are the main equipments of the system.

4.7: RECEIVING DATA FROM NRF REMOTE

We sent signal by NRF as a radio frequency from transmitter. There are available some buttons in the transmitter . By using the buttons we can move the robot to forward,reverse,left,right and so on. The whole sanitization process also running by the remote through activation or deactivation of pump motor.

4.8: INTERFACING MICROCONTROLLER WITH NRF24L01

We have used Nrf24l01 module which is inrerfaced with Atmega328p device which is used as a microcontroller.In this interfacing system,all data are transmitted through radio frequency as a wireless communication system.The connection between Atmega328p and Nrf24l01 has been shown in below fig 4.3.

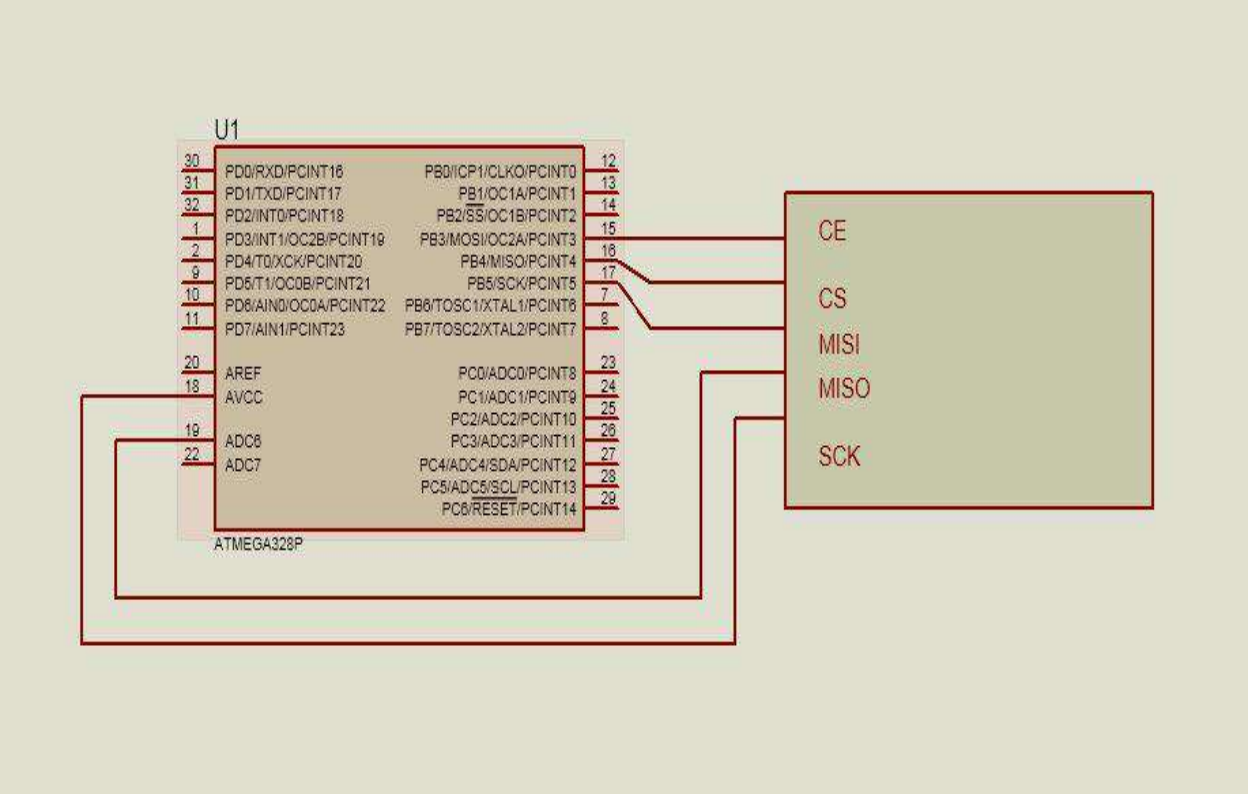

Fig 4.3 : Circuit Digram of Interfacing Atmega 328P with NRF

In this interfacing CE,CS,MISI and SCK are digital input pins.They are connected to pin no 15,16,17 and 18 of ATMEGA328P Microcontoller. Another pin MISO is functioned as a digital output pin which is connected to pin no 19 of ATMEGA328P Microcontroller.

4.9: INTERFACING ATMEGA328P WITH L298 MOTOR DRIVER MODULE

In this project Atmega328p is connected with L298 moror driver module .By this interfacing system the robot is controlled in clock-wise and anti clock-wise.Signal goes to L298 motor driver from Atmega328P where two motor are controlled after given 4 data pin. There are two number of H-bridge circuit in the L298 motor driver module. The connection between Atmega 328P and L298 Motor driver module has been shown in the below fig 4.4.

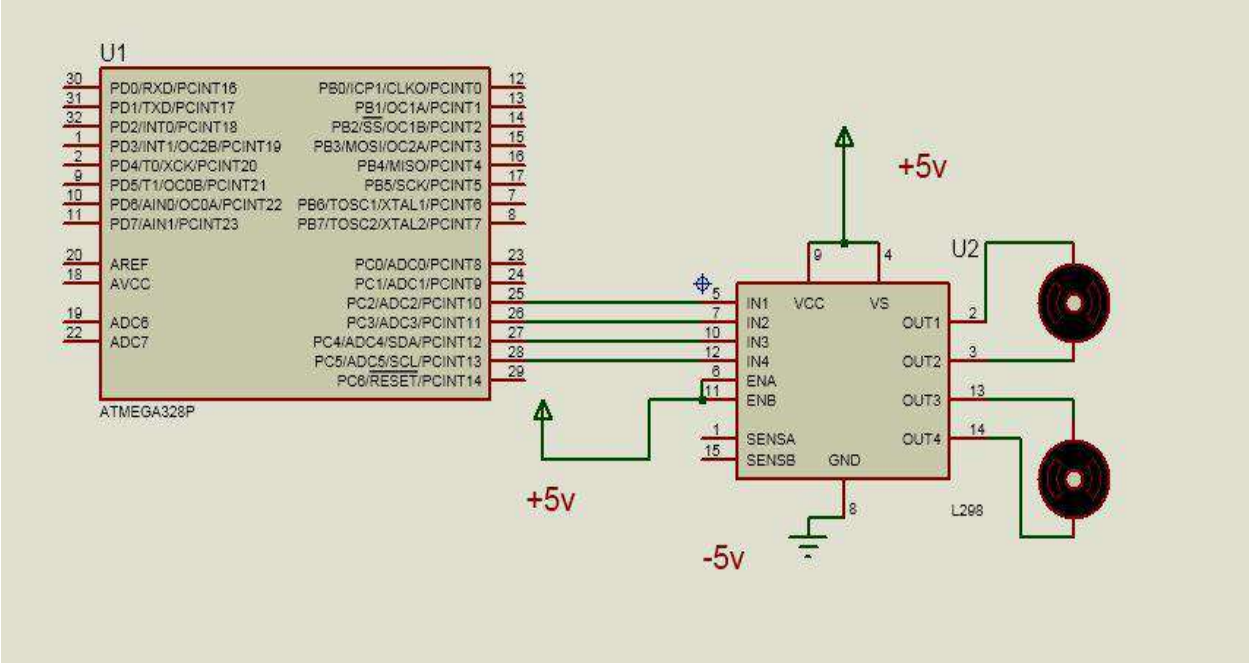

Fig 4.4 : Circuit Diagram of interfacing Atmega328P with Motor Driver

Here 25,26,27,28 no pin of microcontroller connected with IN1,IN2,IN3 and IN4 pin of motor driver. Due to connection of those 4 pins,2 motors will run.These 2 motor is connected with OUT1,OUT2,OUT3 and OUT4.The two supply voltage VCC and VS are coomon here.

4.10: INTERFACING ATMEGA328P WITH PUMP MOTOR

To control the pump motor there is connected a dc relay with Atmega328P.The pump motor which is used in the robot will be turn on and turn off by this relay. We have given electronic signal in the transmitter from Atmega 328P which operated the relay for switching. This relay has run as a single pole double through system. Connection between Atmega328P with dc pump motor has been shown in the below fig 4.5.

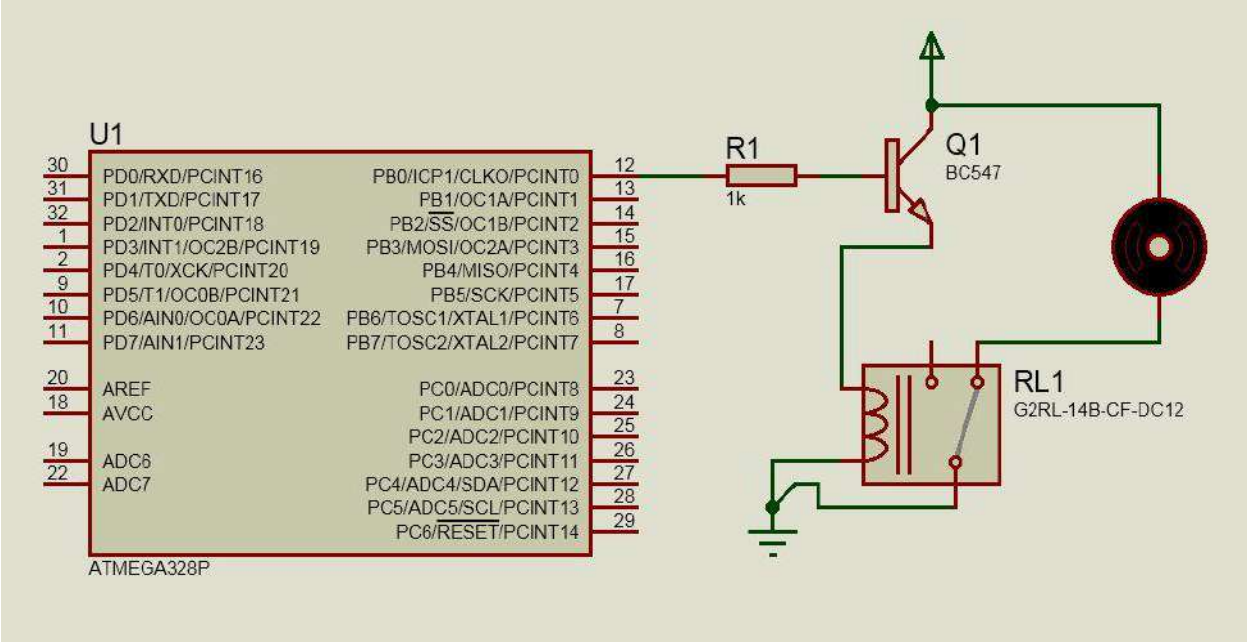

Fig 4.5 : Circuit Diagram of Interfacing Atmega328P with Pump Motor

In this interfacing 12 no pin of microcrocontroller is connected with the base of transistor through a resistor. By this transistor the relay will be swithching.The voltage passing through collector to emitter and the coil of relay received the voltage. After switching relay and transistor the pump motor will run.In this case the voltage passed through common and nc of the realy.

4.11: CIRCUIT DIAGRAM

The figure of the circuit diagram are shown in below fig 4.6 and 4.7 where it shows the complete connection and describe which pin connected with another and also shown here the components' pin configuaration.Both transmitter and receiver circuit diagram given here in fig 4.6 and 4.7.

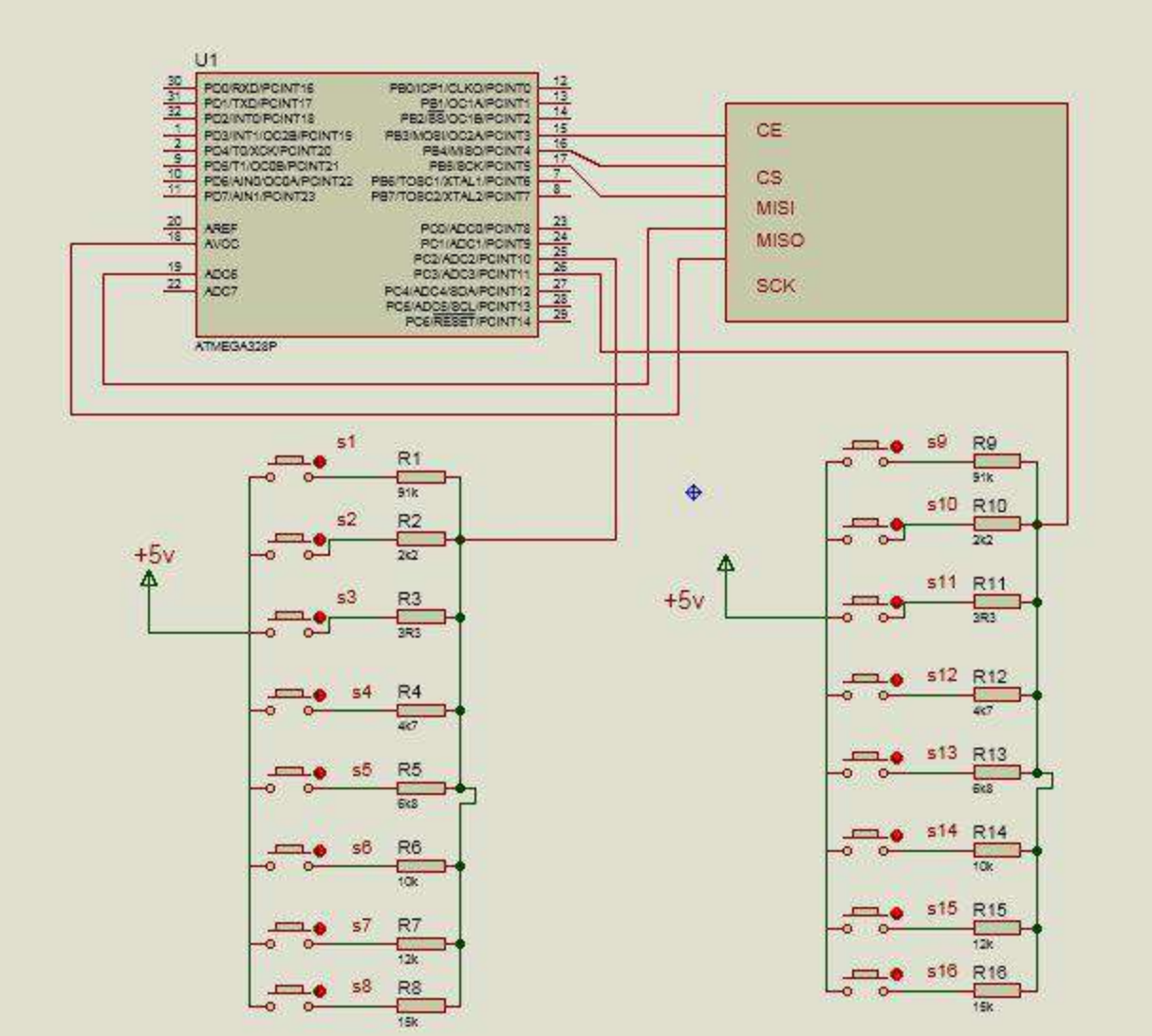

Fig 4.6 : Transmitter complete circuit

This circuit represents the full transmitter portion of the project.In this circuit it is shown how the NRF24L01 module and push button switches are connected with microcontroller.

Here all the button swiches are functioned by ADC (Analog to Digital) value. The ADC values are set by voltage divider circuit. Two resistors are used for one voltage divider circuit.Analog signal produced from the value of resistors and we make separate case with the analog signal.Those separated case are defined as a break. Break 1 is used as switch 1.break 2 is for switch 2,break 3 is for switch 3 and so on.Total 16 switches are placed there.Among them 12 swithces are used.

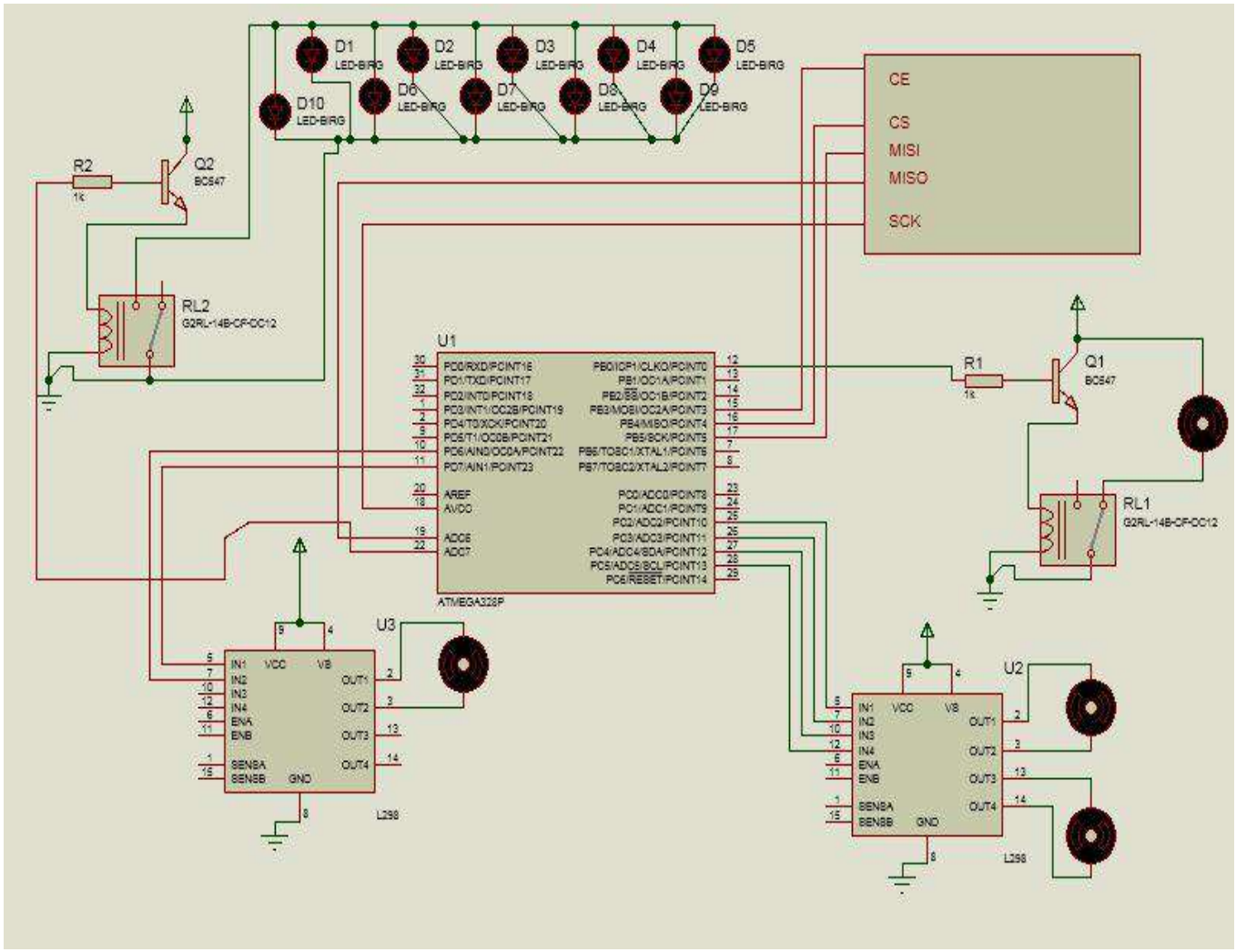

Fig 4.7: Receiver Complete Circuit

This given circuit represents the receiver portion of our project. Here is seen how all the equipments are connected schematically.NRF module ,two motor driver,two relay were connected for different functions.All of the equipments are interfaced with microcontroller.

CE,CS,MISI.MISO and SCK input and output pins from NRF module connected with pin no 15,16,17,18 and 19 of ATMEGA328P microcontroller.They are interfaced for wireless communication. The two relay connected with pin no 12 and 22 of microcontroller. One is used for controlling UV light and the other is for liquid sanitizer.By switching transistor they remain on and off. Then input pins IN1,IN2,IN3 and IN4 one motor driver module is connected with pin no 25,26,27 and 28 of microcontroller.The output 4 pins of this motor driver is connected with two wheels for controlling the movement of robot. The another motor driver module is used for controlling the movement of nozzle of liquid spray.Here 2 inputs is connected with pin no 10 and 11 of microcontroller and the output two pins are connected with the nozzle.

4.12: FLOWCHART OF THE SYSTEM

The flowchart represents the whole process of the project .By this chart it shows a clear view of the project work .The flowchart of the system given below in figure 4.8 .

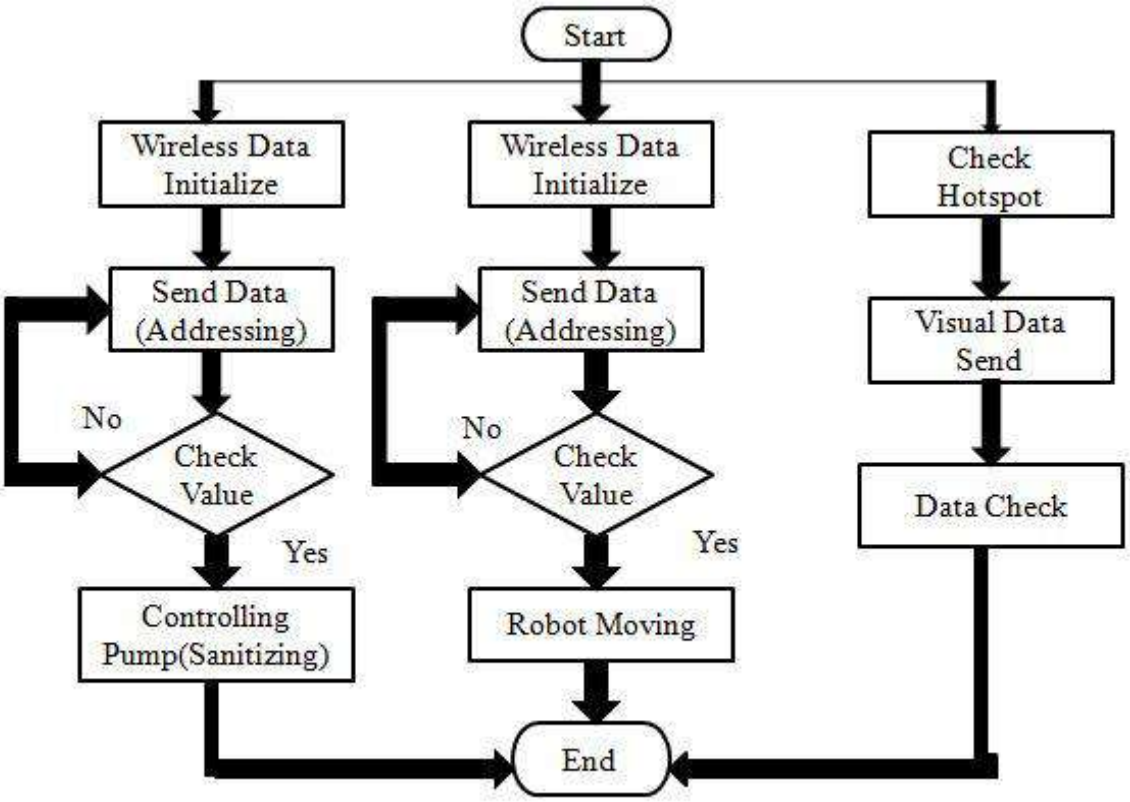

Fig 4.8: Flowchart of the system

In above fig ,we are showing the system flowchart of our system.The flowchart represent the overview of our project.It shows the process of moving of the robot,controlling pump for sanitization process.Visual information system also included here.In this flowchart a complete overview of the project is shown. After starting , wireless date is initialized and addressing them.If the value is addressed and sent properly then the sanitization process and movement of robot will be continued, otherwise not. The another portion in the flowchart is showing a overview of visual information.For getting visual information first of all there should be checking the hotspot and should connect virtually. Then the visual data can be able to send in the receiver.Lastly the process goes to end.

CHAPTER 5

IMPLEMENTATION AND RESULTS

5.1 : INTRODUCTION

This system is designed to perform sanitization process at any smooth surface. This robot will be applicable for mainly indoor places such as hospitals,educational institutions, offices and so on.This system maintain the sanitization process Using UV light and liquid sanitizer.Through a remote control device all the functions of robot will be performed. By push button switches the robot can move to the desired places for sanitizing.Push button switches also used for controlling the sanitization process by switching on-off of UV light and liquid sanitizer.

5.2 : IMPLEMENTATION

In the system in transmitter and receiver portion, NRF module and Microcontroller are placed on veroboard.Along them all other equipments are placed on the wooden board in the respective manner as prototype.The equipments was connected with each other through jumper wires. Since the equipments placed in such way,it can be easily either detached or mounted in case if they are to be replaced .

5.2.1 : Complete Overview

The complete overview of the system is given below in figures .Firstly there is given the transmitter portion in fig 5.1.

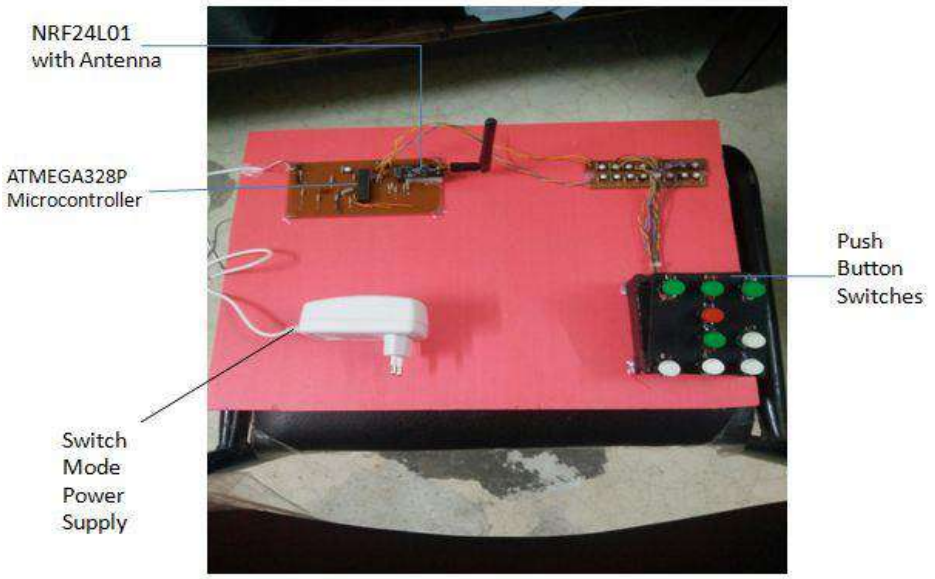

Fig 5.1: Transmitter and Controlling Portion of the System

In the above figure 5.1, Transmitter and Controlling portion is shown ATMEGA328P Microcontroller NRF module,push button swich are the controlling device.An SMPS(Switch Mode Power Supply) device is used for supplying voltage to transmitter.Push button switches will be applicable for controlling the movement of robot and also for controlling the sanitization process. NRF is used for processing the wireless signal.

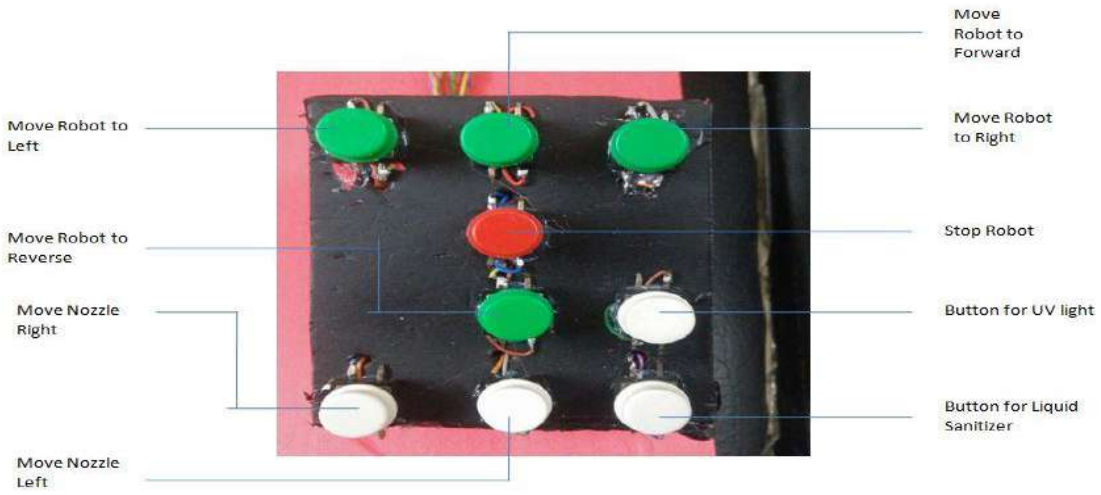

Fig 5.2: Indication of Push Button Switch

In this above figure 5.2, indication of all push button switches is given.Here we use different colours of switches as we can easily control the system.In this controlling sustem the green button switches are used for movement of the robot.Red button is for stop the robot.Lastly white buttons are for performing the sanitization process.

5.3 : Full Prototype Setup of The main Receiver Portion

In figure 5.3 there is shown the receiver portion of the robot.

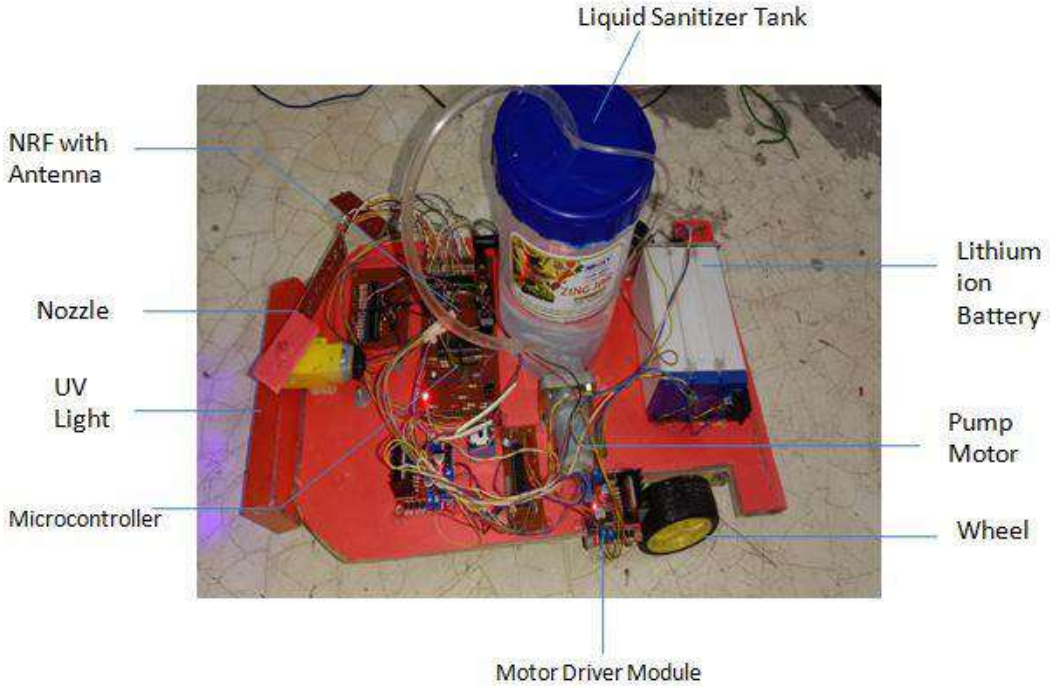

Fig 5.3: Receiver Portion and Prototype of the Robot

A complete prototype of the Robot is shown in the fig 5.3. UV light and Liquid sanitizer tank is placed here for completing sanitization process. Along with them all other necessary equipments are adjusted according to circuit diagram.

5.4 : Demonstration and Result of the Project

Here we have shown the result that we have obtained from our project in fig 5.4 and 5.5.

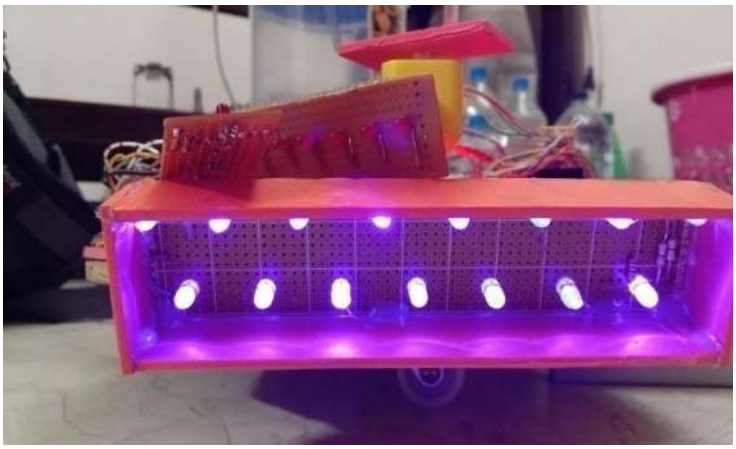

Fig 5.4: UV Lights On

The UV lights are placed at the front side of the robot. When a particular place need sanitization,we sent our robot there.Then after selecting a desired place we pressed the button for UV light.Thus UV light become active and the sanitization process will run.

The process of controlling liquid sanitizer can be accomplished in the same way . After pressing the button for liquid sanitizer this process will run.And after pressing off button the liquid will turn off. In Figure 5.5 we can see that the liquid sanitizer turned on.

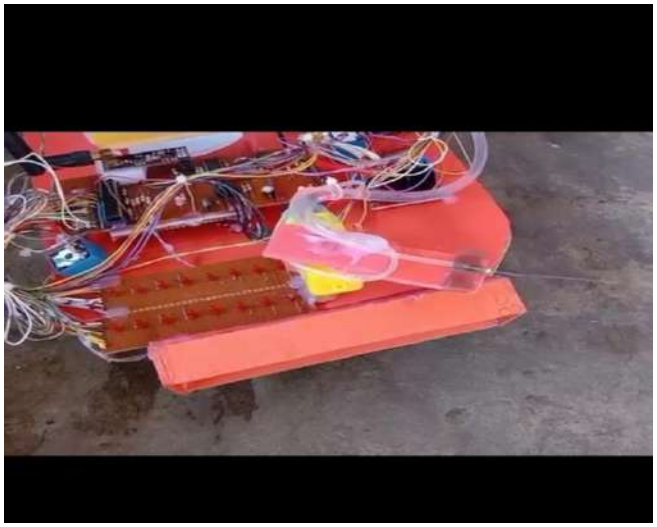

Fig 5.5 : Liquid Sanitizer On

5.5: Robot Controlling

This robot was built with arduino microcontroller device. The microcontroller is connected with DC Motor through Motor Driver module (pin25,pin26,pin27 and pin28) which provide power to actuators .Actuators are used to move robot in Forward,Backward,Left,Right and Stop directions.

Table 5.1 : Pin Description for Robot Movement

The brief description of input pins for movement of robot is given below in table 5.1.

Movement	Pin25	Pin26	Pin27	Pin28
Forward	1	0	1	0
Reverse	0	1	0	1
Left	1	0	0	0
Right	0	0	1	0
Stop	0	0	0	0

Table 5.1: Pin Description for Robot Movement

Table 5.2 : Pin Description for Sanitizing

In table 5.2 we try to show the pin description for sanitizing process.

Sanitization	Pin 12	Pin 22
UV Light	1 (On)	0 (Off)
Liquid Sanitizer	1 (On)	0 (Off)

Table 5.2: Pin Description for sanitizing

5.6 : Getting Visual Information

In the below figure 5.6, here is shown how we can get the visual information of the robot through a mobile phone. By this phone we can observe all the fuctions of the robot and this will help to control the robot smoothly.

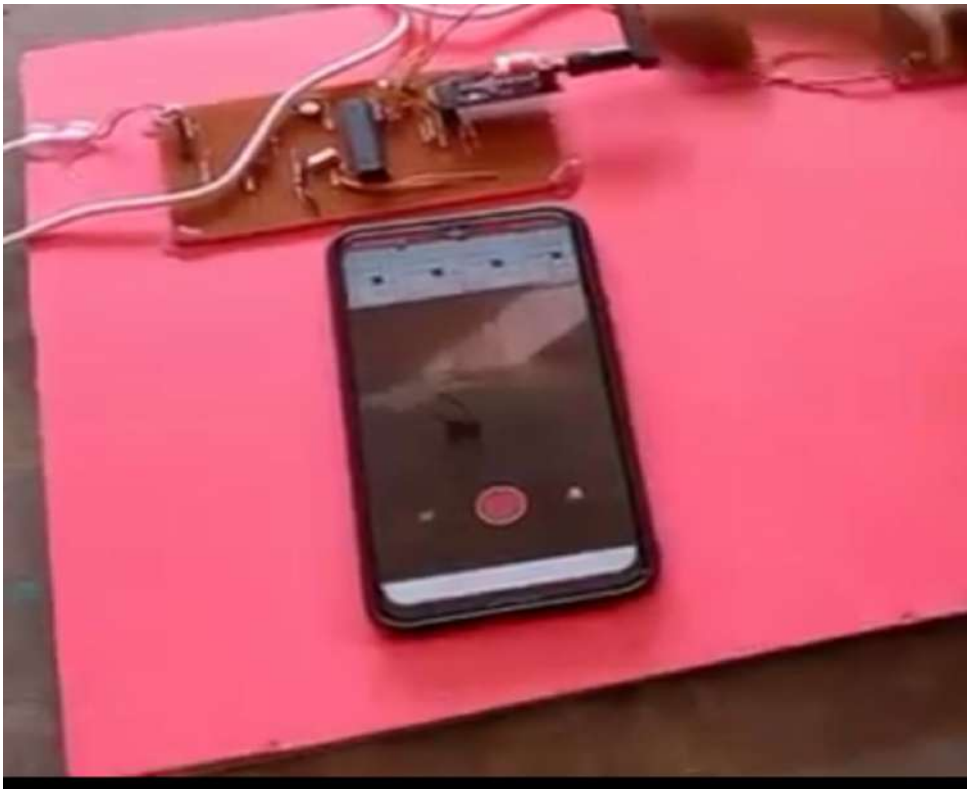

Fig 5.6: Placed a Mobile Phone for getting Vusual Information of the process

In this figure 5.6, we placed a mobile phone in the transmitter portion .The another mobile is placed in the movable receiver.Both phone are connected with each other virtually. Then through the phone placed in receiver we can get every visual information of the robot and the working process can be observed. The two phone used as IP camera here.

5.7 : APPROXIMATE COST OF THE PROJECT AND POWER ANALYSIS

This is very important to know about the total cost of project and how much power will consume by the project. So, total cost if our project and the power consumption are discussed in below section.

5.7.1 : TOTAL COST OF THE PROJECT

Our prototype project cost is around Tk 3200.If we want to produce for commercial purpose the cost will be reduced more by using only the components instead of Microcontroller and NRF module and the components can be designed on a PCB board. So,in this case the cost will come around Tk.3200 which will be effective as it has low cost.However, a detailed feasibility study is compulsory for the analysis.Table 5.3 shows the total cost of the hardware of this project.

Table 5.3 : Total cost of the project

No	Component Name	Price (BDT)
1	UV Lights	350
2	ATMEGA 328P	220
3	NRF24L01+ Antena	280
4	Battery (12V)	400
5	Pump Moror (12V)	250
6	L298 Motor Driver Module	160
7	Dc Gear Motor	800
8	Wheel	200
9	Relay (5V)	20
10	Others	500
	TOTAL	3200 /-

5.7.2 : TOTAL POWER CONSUMPTION ANALYSIS

We calculate the total power consumption considering our system during runtime.We take maximum ratings of all components.In real-time or for commercial purpose,this project's power consumption is more than the calculated values. A very deep feasibility study is necessary for the most accurate result.In this project,from the official data sheet of all components , taking maxium ratings of the consideration. Here our prototype project rating is Watt.To run the robot we use 12V dc supply which we have given through lithium-ion battery.Table 5.4 shows the approximate power consumption of the project.

Table 5.4 : Approximate Power Consumption of the project

No	Component Name	Required Voltage (V)	Operating Current (mA)	Power Consumption (Watt)
1	Atmega328p Microcontroller	4.98	16.43	0.081
2	NRF 24L01	3.3	100	0.33
3	Pump Motor	12	500	6
4	Gear Motor	12	500	6
5	Motor Driver Module	12	3000(Capacity)	36
6	UV Light	5	300	1.5
7	Battery	12	3000	36
			TOTAL	85.911

CHAPTER 6

CONCLUSION & FUTURE WORK

6.1 : CONCLUSION

Sanitization and disinfection process are too much needed in this covid pandemic situation. The virus that causes Covid-19 can land on surfaces.It's possible for people to become infected if they touch those surfaces and then touch their nose,mouth or eyes.When people involve in the sanitization process directly, there arrives a huge chance to be affected by the virus.In this situation surface disinfection robot is the best option.This must be help to prevent the virus from spreading. The aim of the project is to make the sanitization process risk free and save people from the virus. We aim to deploy the disinfection Robot in different places where it will be used alongside existing disinfection process to reduce dependency on human stuff and improve workflow.

6.2 : FUTURE IMPROVEMENT

In this project work we are using a small prototype of the system.This can be further improved in future. The obstacle detection system can be added.That time the robot can be moved independently without remote control. Our robot is usable only for smooth surface now. But when a belt system will be used for controlling robot chasis it can be applicable at any surface.Then internet of things(IoT) based networking system will be applicable as the robot can be controlled by a particular server.Thus many more functions can be added in future in this system.

6.3 : LIMITATIONS

Along advantages every system has some limitations also.Here some limitations of our system is listed :

- The UV light is not good for eye and skin.When the sanitization process going on it will be better to ensure that no one can enter the room.

- The range of NRF module is limited (Around 1 km from transmitter).The signal can be weak by obstacle.So there arrives a chance to lose the connection between transmitter and receiver

- We use a tank here for containing the liquid sanitizer.That's why the liquid resource is not enough.It need to be fulfilled after finished.The power source of the robot has also contained limited charge.

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APPENDIX
(SOURCE CODE)

Transmitter Portion

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
#define butt1 2
#define butt2 3
#define butt3 4
#define butt4 5
#define butt5 6
#define butt6 7
#define butt7 8
#define butt8 A5
RF24 radio(9, 10);
const byte addresses [][6] = {"TRANS", "RECIV"};
charcmd[2];
byteprevKey;
boolclearFlag;
void setup() {
Serial.begin(9600);
radio.begin();
radio.openWritingPipe(addresses[1]);
radio.openReadingPipe(1, addresses[0]);
radio.setPALevel(RF24_PA_MIN);
radio.stopListening();
pinMode(butt1, INPUT_PULLUP);
```

```
pinMode(butt2, INPUT_PULLUP);
pinMode(butt3, INPUT_PULLUP);
pinMode(butt4, INPUT_PULLUP);
pinMode(butt5, INPUT_PULLUP);
pinMode(butt6, INPUT_PULLUP);
pinMode(butt7, INPUT_PULLUP);
pinMode(butt8, INPUT_PULLUP);
}
void loop() {
byte b1 = getButton();
if (b1 != 0) {
if (b1 != prevKey&&clearFlag == 0) {
cmd[0] = (b1 / 10) + 48;
cmd[1] = (b1 % 10) + 48;
radio.write(cmd, 2);
delay(300);
prevKey = b1;
clearFlag = 1;
    }
  }
else {
if (clearFlag == 1) {
cmd[0] = (prevKey / 10) + 48;
cmd[1] = (prevKey % 10) + 48;
radio.write(cmd, 2);
delay(300);
clearFlag = 0;
prevKey = 0;
```

```
    }
  }
delay(300);
  }
bytegetButton() {
byte key = 0;
intadc = analogRead(A3);
switch (adc) {
case 220 ... 270:
key = 1; break;
case 390 ... 445:
key = 2; break;
case 500 ... 545:
key = 3; break;
case 590 ... 630:
key = 4; break;
case 680 ... 715:
key = 5; break;
case 720 ... 750:
key = 6; break;
case 790 ... 825:
key = 7; break;
case 830 ... 860:
key = 8; break;
  }

adc = analogRead(A2);
switch (adc) {
```

```
case 220 ... 270:
key = 9; break;
case 390 ... 445:
key = 10; break;
case 500 ... 545:
key = 11; break;
case 590 ... 630:
key = 12; break;
case 680 ... 715:
key = 13; break;
case 720 ... 750:
key = 14; break;
case 790 ... 825:
key = 15; break;
case 830 ... 860:
key = 16; break;
  }
return key;
}
```

Receiver Portion

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
#define LED A0
#define ds 6
#define sh 8
```

```
#define st 7
#define TOTAL_OUTPUT 32
RF24 radio(9, 10);
const byte addresses [][6] = {"TRANS", "RECIV"};
unsigned long led = 0;
void setup() {
Serial.begin(9600);
radio.begin();
radio.openWritingPipe(addresses[0]);
radio.openReadingPipe(1, addresses[1]);
radio.setPALevel(RF24_PA_MIN);
radio.startListening();
pinMode(LED, OUTPUT);
pinMode(ds, OUTPUT);
pinMode(sh, OUTPUT);
pinMode(st, OUTPUT);

output(led);
}
void loop() {
nRFCheck();
}
voidnRFCheck() {
if (radio.available()) {
digitalWrite(LED, 1);
while (radio.available()) {
bytetmp = ((b1[0] - 48) * 10) + (b1[1] - 48);
bitRead(led, tmp - 1) == 0 ? bitWrite(led, tmp - 1, 1) : bitWrite(led, tmp - 1, 0);
```

```
output(led);
digitalWrite(LED, 0);
}
void output(unsigned long val) {
for (int i = 0; i < TOTAL_OUTPUT; i++) {
digitalWrite(ds, bitRead(val, i));
digitalWrite(sh, 1);
digitalWrite(sh, 0);
  }
digitalWrite(st, 1);
digitalWrite(st, 0);
}
void output(int pin, bool state) {
static long val;
bitWrite(val, TOTAL_OUTPUT - (pin - 1), state);
for (int i = 0; i < TOTAL_OUTPUT; i++) {
digitalWrite(ds, bitRead(val, i));
digitalWrite(sh, 1);
digitalWrite(sh, 0);
  }
digitalWrite(st, 1);
digitalWrite(st, 0);
}
```