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Remote Control of Electrical Home Appliances Using RF Module based Remote

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Abstract

This study examines the use of an RF-based remote system to manage domestic electrical appliances. The wireless remote control based on an RF technology can toggle the status of equipment to ON or OFF from any site without necessitating a line of sight anywhere around house. The regulating circuit is developed around a 434 MHz operational frequency RF receiver and transmitter module, along with the HT12E encoder and HT12D decoder integrated circuits and a few other passive components. The four distinct channels at the encoder end are used as switches for input signal, and the four channels at the decoder end are used as outputs points, which is connected to the respective electrical devices that are to be controlled; if the appliances are of higher rating, the relays are used as an intermediary to connect the equipment to the receiving end of the circuit. The transmission method used in this instance is Amplitude Shift Keying (ASK), and the circuit is powered with a 9V DC battery source. The main objective of this task entails creating a closed circuit without any programming knowledge and making it functional without the need for line-of-sight utilizing the RF technology. Also, as proposed development to the current working model is stated with a brief description of its functioning, which aims to efficiently control more than four electrical units using the same remote-control technology with the aid of a matrix keypad as input for switching the states of the devices, a matrix encoder & decoder for respective encoding & decoding of signals, and a stable multivibrator for circuit operations.

Keywords: RF Module, RF Receiver, RF Transmitter, HT12E IC, HT12D IC, ASK, Wireless appliance control, IC CD4017, BC558, BC548.

Introduction

The goal of this project is to develop a home automation system that employs an RF-controlled remote. As technology progresses, electrical instruments are likewise getting smarter. Modern houses are undergoing a transition from traditional switches and toward a centralized control architecture leveraging RF operated switches. Currently, existing wall switches located throughout the home make it difficult for the user to operate them. Currently, existing wall switches located throughout the home make it difficult for the user to operate them. For the elderly or physically disabled, looking at so much becomes even more difficult. If all this manual effort is taken over by a simple remote control, even an elderly or disabled person can perform the task like an ordinary individual. Remote controlled home automation systems provide a simpler solution with RF technology. Bluetooth, GSM (Global System for Mobile), IR (Infra-Red), or RF (Radio Frequency) technology can be employed for the same purpose of regulating the appliances connected. Control of all loads at a time can be accomplished from one place (control area) without attaching any physical line between the loads and the control area. The RF modules used here are the transmitter and receiver units employing the ASK feature. Switches are provided at the transmitter side to manage the loads that are linked to the RF transmitter through the encoder. The encoder refers to

the position of the switches on a regular and repeated basis, providing information to the transmitter, and further transmitter transmits the information. On the receiving side, the receiver receives this data and provides it to the decoder IC. This decoder converts the single-bit data into 4-bit data and gives it to the controlling circuit.

A remote control is a component of a consumer electronic equipment designed to automatically manage the gadget wirelessly from a short range, such as a television set, air - conditioners, or other domestic appliances. Remote control is a user-friendly feature that allows users to operate devices and appliances that are out of reach for direct operation. Why not use most of the buttons on a remote control to control appliances and other electronics around the house? In this project, it will be demonstrated how to use a radio frequency (RF) signal to communicate between a switch and electrical devices that are placed at a certain distance from each other and then employ it to construct an outlet switch that can toggle the operational status of the electronics. This project is split into two segments: the transmitting component and the receiving component. The receiving part will be in a static position and coupled to any load, while the transmitter will work optimally. This circuit can be used to turn on or off any type of electrical device, which is entirely within the scope of the circuit's safety assessments.

Each method has advantages and disadvantages compared to the others; however, they all accomplish the same goal to minimise the manual effort of keying switches. The primary purpose of this project is to set up a system to control multiple devices by using RF technology. The potential of RF-based remote control to accurately operate devices within its set range without necessitating a line of sight is a significant advantage.

Circuit Diagram and Components

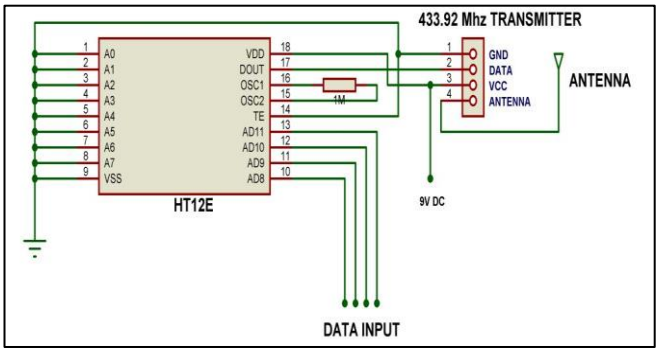


Figure 1: RF Transmitting circuit

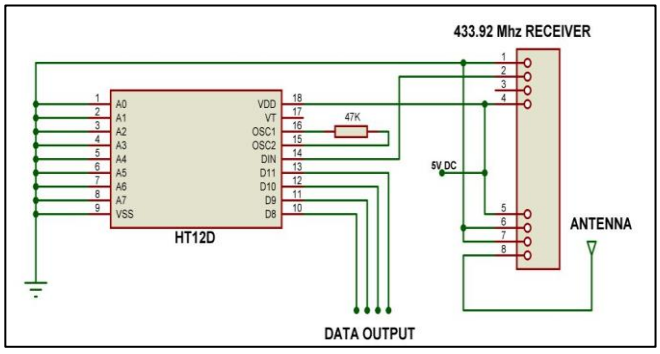


Figure 2: RF Receiving circuit

As per the circuit diagram following components are used for building the receiver and transmitter network.

1. **RF Module**: The RF module consists of two parts, namely the receiver and the transmitter. This module makes use of radio frequency. Radio frequencies range from 30 kHz to 300 GHz. RF modules in this system use ASK (Amplitude Shift Keying) modulation. Transmission through RF is a superior choice to IR transmission because; the radio frequency signal can travel longer distances as compared to the infrared. And IR mostly supports line-of-sight mode, whereas RF signals can travel even if there is an obstruction in the propagating path. So, RF transmission is more dependable and stronger as compared to IR. The frequency of the RF transmitter and receiver should be the same. The transmission speed of these modules

ranges from 1Kbps to 10Kbps.10Kbps.

a. Transmitter: A transmitter is a component of electrical equipment that creates radio waves using an antenna. The transmitter produces alternating current of radio frequency, which is ultimately applied to the antenna. After being energised by alternating current, the antenna transmits radio waves. The equipment that uses the transmitter uses radio waves for communication and radiolocation, such as radar. A power supply, an electronic oscillator, and a modulator comprise a radio transmitter.

b. Receiver: A receiver is an electrical device that absorbs radio waves as input and transforms the information conveyed by them into a usable format as the output of the equipment. A receiver is always used in conjunction with an antenna. The antenna translates electromagnetic waves into microcurrents which are subsequently applied to the receiver. The information is then extracted. Before retrieving the data through demodulation, the receiver isolates the electronic filters from the other necessary radio frequency signal.

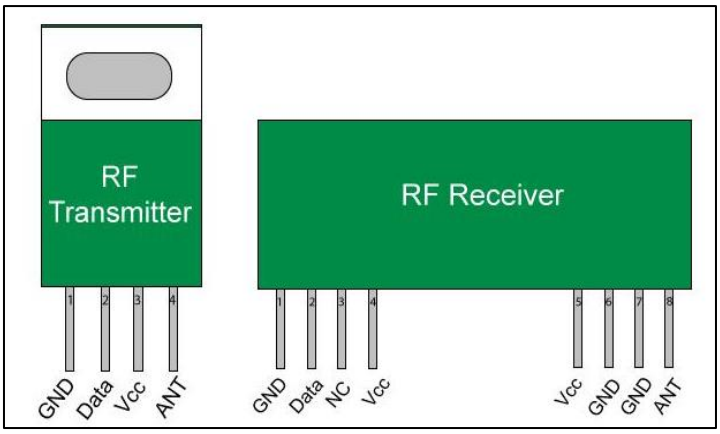


Figure 3: RF Transmitter and Receiver

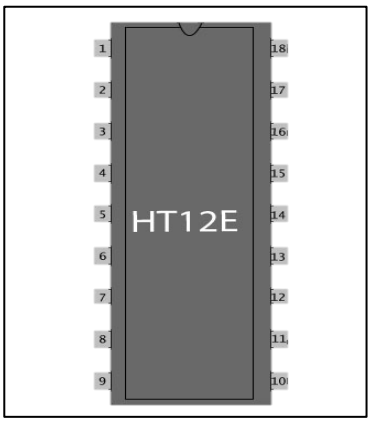


Figure 4: HT12E Encoder IC pin specifications

Pin No	Function	Name
1	Ground (0V)	Ground
2	Serial data input pin	Data
3	Supply voltage; 5V	Vcc
4	Antenna output pin	ANT

Table 1: RF Transmitter pin specifications

Pin No	Function	Name
1	Ground (0V)	Ground
2	Serial data output pin	Data
3	Linear output pin	NC
4	Supply voltage; 5V	Vcc
5	Supply voltage; 5V	Vcc
6	Ground (0V)	Ground
7	Ground (0V)	Ground
8	Antenna input pin	ANT

Table 2: RF Receiver pin specifications

2. **Encoder:** An encoder is an appliance that helps convert parallel signals to sequential ones. The H212E instrument customizes a set of signals to cypher. Effective data, together with address bits, form the input trace. The encoder protects the powerful kinetics characterized by an instrument. H212E has 2^n absorption lines and two transferring and producing lines. The HT12E encoder IC is part of the 2^{12} series of encoders. This IC is mainly used to interface RF and IR circuits. It can convert 12-bit parallel data to serial data. These 12 bits are divided into 4 data bits and 8 address bits. The IC has a transmitter enable pin. When a trigger signal is received on this pin, the address and data bits are transmitted together. When the enable signal is received, the HT12E begins a 4-word transmission cycle. The cycle is repeated until the transmitter enable is low. Figure 4 and Table 3 describe the pin details.

Pin No	Function	Name
1 - 8	8-bit Address pins for input	A0 – A7
9	Ground (0V)	Gnd
10 – 13	4-bit Data/Address pins for input	AD0 – AD3
14	Transmission enable. Active low	TE
15	Oscillator input	Osc2
16	Oscillator output	Osc1
17	Serial data output	Output
18	Supply voltage; 5V (2.4V-12V)	Vcc

Table 3: HT12E Encoder IC pin details

3. **Decoder:** A decoder is used to channelize a signal or data from n inputs to 2^n outputs. Moreover, it can influence the motion of a machine, i.e., direction, speed, position, etc. The decoder IC converts the serial signal into its parallel form. It generally finds use in RC cars, security systems, and alarms. The decoder IC converts serial input data to parallel data. A high VT (Valid Transmission) pin on the IC indicates valid transmission. HT12D is capable of decoding 12-bit data (8 address bits and 4 data bits). The output data remains unchanged until new data is received.

Pin No	Function	Name
1 - 8	8-bit Address pins for input	A0 – A7
9	Ground (0V)	Ground
10-13	4-bit Data/Address pins for output	D0 - D3
14	Serial data input	Input
15	Oscillator output	Osc2
16	Oscillator input	Osc1
17	Valid transmission	VT
18	Supply voltage (2.4V-12V)	Vcc

Table 4: HT12D Decoder IC pin specifications

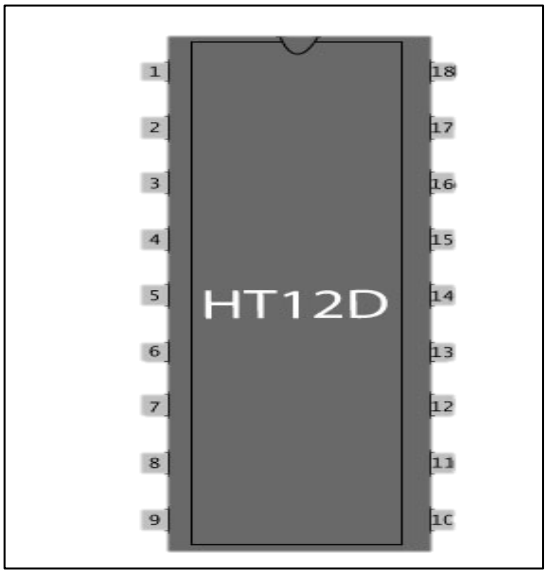


Figure 5: HT12D Decoder IC pin specifications

4. **Voltage Regulator**: Voltage regulator is an electrical circuit that regulates the voltage level closed to the prescribed range and keeps it constant to prevent the electrical appliances from getting damaged. It helps to convert a high variable voltage to steady output voltage. Voltage regulators are of two types:

a. Linear voltage regulator: This regulator minimises the input voltage to achieve the appropriate voltage.
b. Switching voltage regulator: This voltage regulator can minimize, maximize, and invert voltage with ease. Switching voltage regulator has a high efficiency.

Voltage regulators are used to maintain a constant and consistent output. Voltage regulator ICs are integrated circuits that are used for voltage regulation. The 7805IC is a member of the 78xx series of voltage regulator integrated circuits. It is a fixed-output linear voltage regulator. The xx in 78xx denotes the value of the IC's fixed output voltage. It is a +5V DC regulated power supply for the 7805 IC. This regulator IC also includes a heat sink arrangement, which aids in cooling. This voltage regulator allows up to 35 volts as input and outputs a stable 5 volts for any input value less than or equal to.

Pin No	Function	Name
1	Input voltage (5V-18V)	Input
2	Ground (0V)	Ground
3	Regulated output; 5V (4.8V-5.2V)	Output

Table 5: 7805 IC Voltage Regulator pin specifications

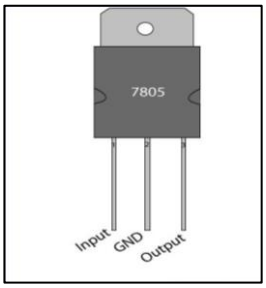


Figure 6: IC pin diagram

5. **Switch**: A group of manual electric switch packed together is defined as a DIP switch. DIP switches can be used in place of jumper blocks. Their merits of this type of switches are that they can be easily replaceable and there are no lose in it. DIP switches are sub-divide d into many types. Most common types are rotary, slide and rocker types.

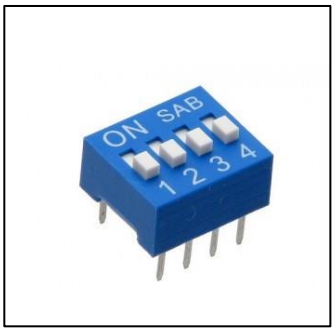


Figure 7: DIP Switch

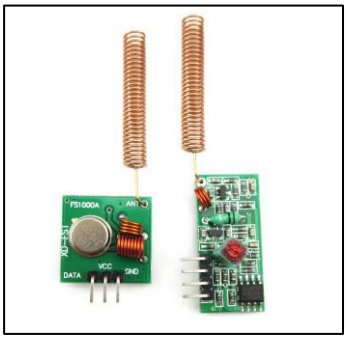


Figure 8: Antenna

6. **Antenna**: It is a connection between radio waves travelling over space and electric current flowing via a metal conductor. Typically used in conjunction with a transmitter and receiver system. An antenna is a specialised transducer that transforms radio frequency fields into alternating current and vice versa. It is classified into two types: receiving antennas that acquire RF energy and provide AC to electronic equipment & transmitting antennas which transmit AC to electronic equipment. The transmitting antenna, on the other hand, is the antenna that receives AC from electronic equipment and creates an RF field. An antenna typically catches and transmits electromagnetic waves.

7. **Driver IC**: ULN2003 driver IC is an array of seven NPN Darlington transistors with a rating of 500 mA and 50 V output. In a Darlington pair, it consists of an arrangement of two bipolar transistors. It details the common cathode flyback diodes for switching inductive loads. In the same family of ICs are the ULN2002A, ULN2004A, ULQ2003A, and ULQ2004A, designed for different logic input levels. It is available in a variety of packages, including DIP, SOIC, SOP, and TSSOP. The ULN2003 is recognized for its steep-current, steep-voltage capacity. The drivers can be used in a parallel connection for even higher current output. Further, mounting one chip on top of another, both electrically and physically, has been done to achieve a higher current output. Each output channel in the ULN2003IC is rated at 500 mA and can sustain a maximum current of 600 mA. In the IC, the input and output pins are opposite each other. In addition, each driver unit includes suppression diodes, which are intended to reduce voltage spikes while driving inductive loads. In general, it can be implemented for interfacing with a stepper motor or loads where the motor or loads demand high ratings which other interfacing devices cannot provide.

Pin No	Function	Name
1 - 7	Input for Channel 1-7	Input 1-7
8	Ground (0V)	Ground
9	Common freewheeling diodes	Common
10	Output for Channel 7-1	Output 7-1

Table 6: ULN2003 Driver IC pin specifications

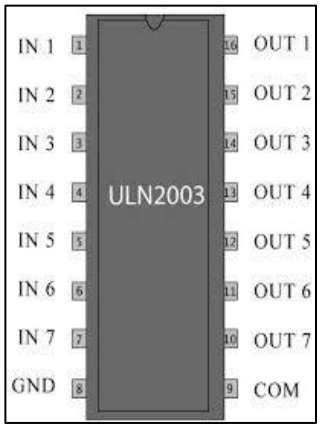


Figure 9: ULN2003 Driver IC

Block Diagram and Circuit Implementation

The block diagram of operation of RF communication for electrical appliance control for both, transmission and receiving end is shown for better understanding of the circuitry.

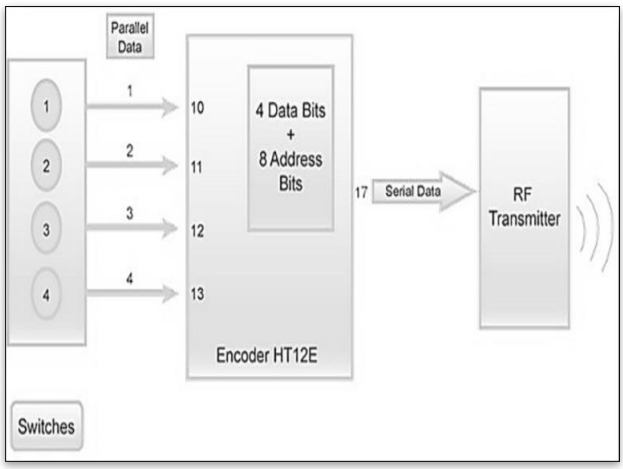


Figure 10: Schematic re-presentation of Transmitter End

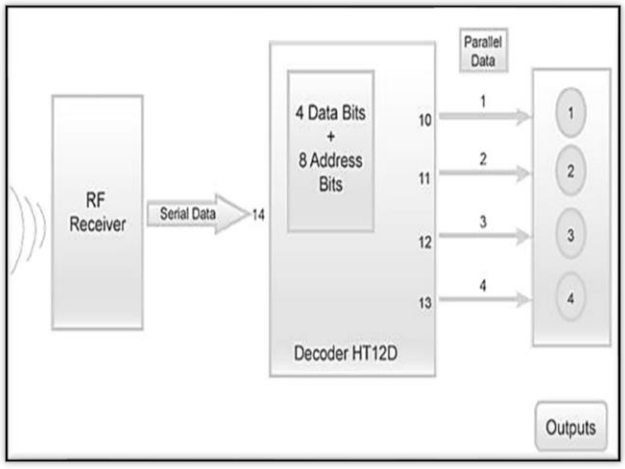


Figure 11: Schematic re-presentation of Receiver End

The circuit employs an RF receiver and transmitter (Tx/Rx) for a wireless remote, which is used to power an output from a remote location. To convey signals, the RF module employs radio frequency. These signals are sent at a certain frequency and baud rate. A receiver can only receive radio frequency transmissions if it is set to that operating frequency. In this system, a four-channel encoder-decoder pair was also employed. The input signals are routed through four switches on the transmitter side, while the outputs are monitored on a set of four loads matching to each input switch. The circuit can also be used to create a remote-control system for numerous appliances. The receiver's outputs can power appropriate loads or relays.

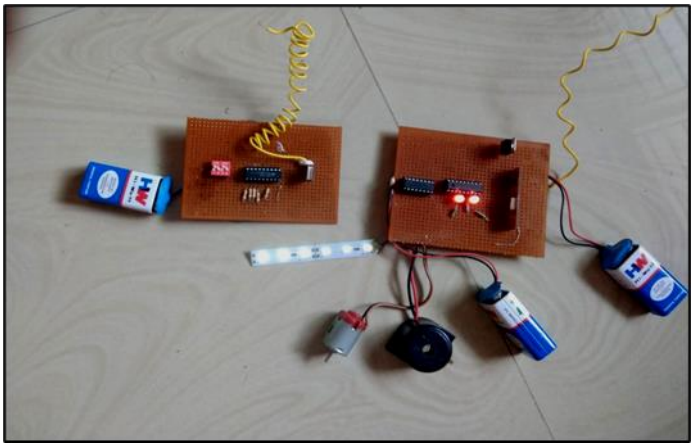
This RF transmission system employs the Amplitude Shift Keying (ASK) technique, with the module's transmitter and receiver pairs operating at 434 MHz the transmitter end accepts serial input and sends signals through RF. The signals are received by the receiver end, which is located apart from the source of transmission. This technology only allows for one-way communication between the two available nodes, which is transmission and reception. The RF module was combined with a set of four channel encoder/decoder ICs. HT12E and HT12D were utilized as encoder and decoder, respectively.

The encoder IC incorporates the 212 series of encoders. A transmitter activate pin is included on this integrated circuit. When a trigger signal is received on this pin, the address and data bits are provided at the same time. When the enable signal is received, the HT12E begins a 4-word transmission cycle. This broadcast cycle will continue until the transmitter enable is reduced to zero or low. The decoder IC transforms serial data into parallel data. This IC shows valid transmission by setting the Valid Transmission pin to high. The HT12D can decode 8 address bits and 4 data bits. Until fresh data is received, the output data remains unaltered.

This receiver and transmitter module is used in conjunction with a decoder and encoder, each of which has four dedicated ports set as input and output channels. The encoder turns the parallel data from the four input switches into serial data, which is then sent into the transmitter module's input pin-2 through 17. The signals are sent serially via the antenna of the RF transmitter. To enable transmission, Pin 14 is linked to the active low state. The receiver receives the set of sent data and feeds it serially to the decoder. The decoder converts serial data to parallel data. The output is sent through ports D0 to D3. Each switch regulates a certain electrical device.

When a switch at the transmitter end is turned on, the encoder transmits a signal to the transmitter. The appropriate encoded signal will be serially delivered from the transmitter to the receiver. The signal will be received by the receiver and sent to the decoder. The signal is decoded by the decoder, which turns serial data into parallel data. The decoded signal is sent to appropriate relays, which are used to switch on/off electrical equipment through ports D0 to D3.

When no signal is received at the decoder's input data pin, it enters standby mode and draws a very tiny current (about 1 A) from a 5 V supply. When the signal is received by the receiver, it is routed to pin 14 of the decoder. When a signal is received, the oscillator in the decoder is triggered. The decoder then decodes the serial data and validates the address bits three times. If these bits match the decoder's local address pins (pins 18), it places the data bits on its data pins (pins 1013) and raises the Valid Transmission button. A LED is linked to the decoder's valid transmission (VT) pin, Pin 17. This LED serves as a signal of proper transmission.



To summarise, each transmission sends 8 address bits and 4 data bits which makes up the 12 bits of data. At the receiver's terminal, the information is acknowledged and relayed to the decoder IC. If the address bits are equivalent, the decoder transforms them to simultaneous data and lowers the associated data bits, which are used to regulate the loads.

Scope of Development

With the present configuration of this gadget, only four devices or electrical appliances may be managed at the same time. Because the ICs used in the transmitter and reception portions transform BCD parallel data into serial data, the intended scope of development makes this device capable of managing up to 16 electrical appliances or devices. Because BCD input is possible, a total of $2^4 = 16$ different forms of input may be supplied and decoded at the receiver part. The IC 74C922 is used on the transmitter side to obtain the BCD output by pushing any button on the keypad matrix, and the IC 74LS154 is used on the reception side to decode each BCD code. The components required for the stable multi vibrator circuit are IC CD4017, BC558, BC548 transistor, 0.1uf capacitor, Resistor (220k, 470k), IN 4007 diode, Relays.

Sl.	Component name	Qty.
1	RF(ASK) receiver	1
2	HT12d IC	1
3	Resistor(51k)	1
4	Resistor(10k)	1
5	BC548 transistor	1
6	Resistor(470ohm)	1
7	LED	17
8	74LS154 IC	1
9	Resistor (330 ohm)	16

Table 7: Modified transmitter requirements

Sl.	Component name	Qty.
1	4*4 matrix keypad	1
2	74C922 IC	1
3	0.1uf capacitor	2
4	1uf capacitor	1
5	Led	1
6	Resistor(330ohm)	1
7	Ht12e ic	1
8	RF (ASK) transmitter	1
9	Resistor (1.1m)	1

Table 8: Modified receiver requirements

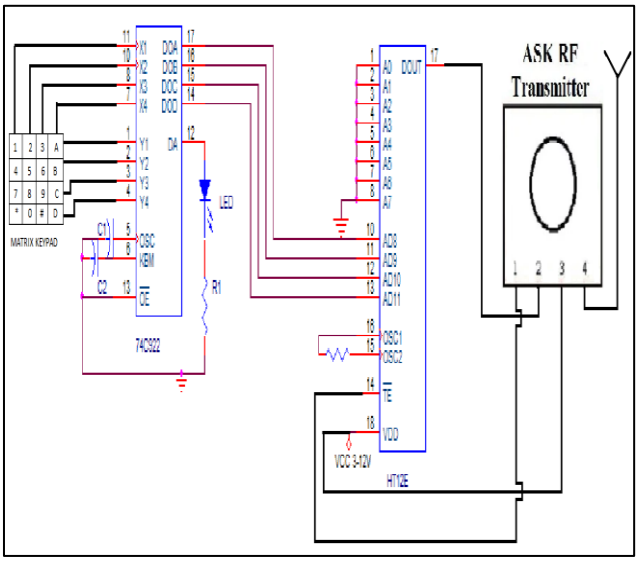


Figure 12: Modified transmitter end circuit

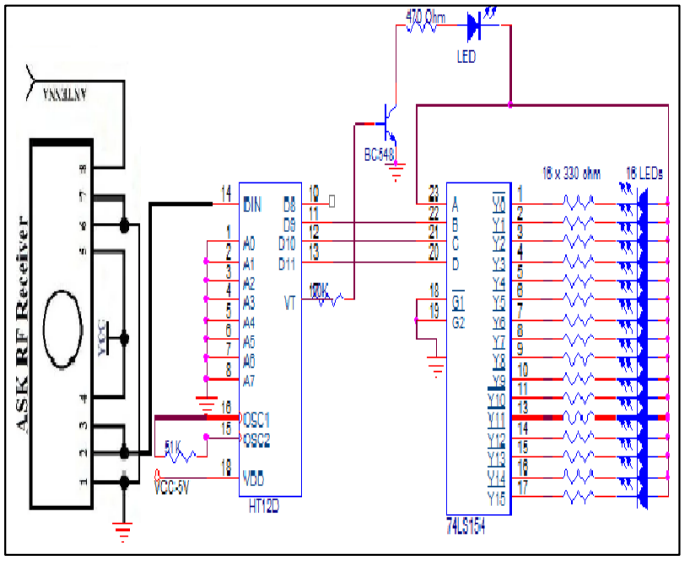


Figure 13: Modified receiver end circuit

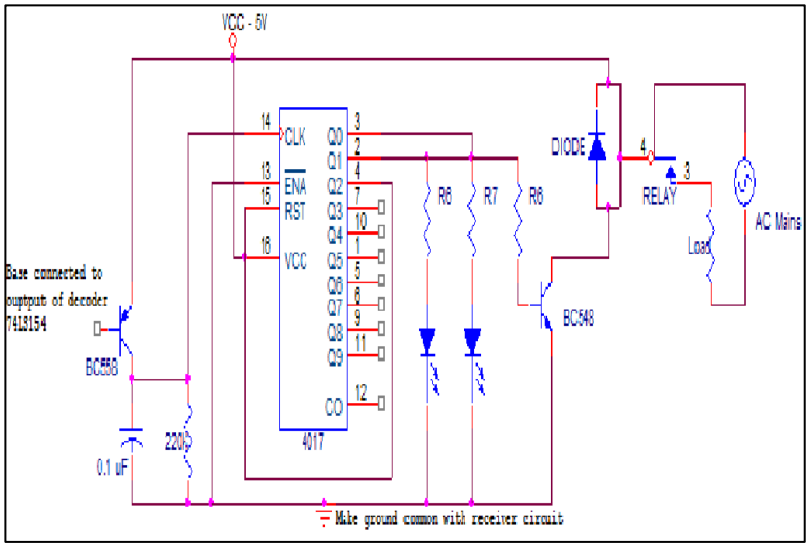


Figure 14: Stable multivibrator circuit

Results and Conclusion

For wirelessly running electrical appliances connected to the receiver system, the needed system has been successfully developed, constructed, and operated for transmitting and receiving signals at roughly with a range of 100 meters and a working frequency of 434 MHz. This project's major purpose is to allow a person to control any device wirelessly with minimal manual effort. This is extremely beneficial to both the elderly and individuals with physical impairments. The gift of technology to humanity is the ability to make life easier. This system envisions, presents, and implements a remote control for a variety of household appliances. The design is long-lasting, sturdy, and solid, and it is built using easily accessible tiny ICs and an RF module, with no microcontroller used. Any four or more appliances may be managed at will from anywhere in the home without the need for line of sight. In the case of high-rated electrical appliances, a relay is interfaced with the loads to be managed through radio frequency signals that communicate only when a switch is flipped. Utilizing a single remote, several devices may be controlled by using separate receivers with different addressing modes.

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