DESIGN AND CONSTRUCTION OF A REMOTE CONTROLLED POWER SUPPLY UNIT

BY

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2000/9815EE

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DEDICATION

This project is especially dedicated to God Almighty and to my beloved parents, Mr. and Mrs. Anthony Danbaki, my siblings Tagwai, Esther, Jerusha, Abigail and to my colleagues in the federal university of technology minna, too numerous to mention.

CERTIFICATION

This is to certify that this project design and construction of a remote controlled power supply unit was carried out by Danbaki Anthony Bulus (2000/9815EE) under the supervision of Eng'r. M.S. Ahmed for the award of bachelor of engineering (B.Eng) degree in electrical/computer engineering federal university of technology MINNA Niger State

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CHAPTER ONE

1.0 INTRODUCTION

With advancement in engineering technology over the years life has been made easier as engineering has and is always devising new ways (methods) of identifying and solving problems these problems could be mechanical, structural environmental chemical or electrical.

Electrical engineering can now be imperiously said to be the finding of electrical solutions various human needs and problems. This can be achieved using electrical components and circuits.

Engineering's greatest goal is to satisfy all of man's needs found within its fields and current capabilities, because man has always had needs and desires which are numerous.

Man's need may spread from easier ways of production and constructions to his protection and convenience. Protection from natural disasters, his fellow man etc. One major problem faced by man is protection against electrical disaster or faults in our homes offices etc. In spite of the various complex measures and means employed to combat this problem of protection against electrical faults, circuit breakers etc In our homes and officers, these problem continues to eat deep in most cases, like cases of over current or over voltage which to is a result of a phase to phase fault on the distribution cables. With the advancement in technology new electrical protective devices with various levels of complexity have been designed for this purpose. Even with this, different failures from these systems have been recorded. These system, also have a disadvantage when it comes to their cost of production and installation, taking into consideration the economical state of some part of the world these system are deemed unaffordable. This motivated the design and construction of a reliable cost effective protective device, "the remotely controlled power supply switching

CHAPTER TWO

LITERATURE REVIEW/THEORETICAL BACKGROUND

2.0 INTRODUCTION

The infrared remote control is made up of a transmitter and a receiver (Photo detector). The transmitter transmits light with a particular colour within the frequencies of 30 KHz and 60 KHz having a wave length of about 950nm. This is just below the red part of the visible light spectrum, and cannot be seen by the human eye.

The control works by pressing a button on the transmitter, which sends signals by a binary code, a series of logical zeros and ones having different combinations to tell the receiver what to do.

These codes hold information, like the address to the receiver i.e. the particular receiver the information was meant for and also to the appropriate location, with commands to be executed. The first thing the transmitter sends to the receiver is called the header. The header is a burst of highs that alerts all the infrared receivers in an area.

After the header comes the code which includes the address to the specific receiver that is to be operated. Then comes the command that tells the receiver what to do, this command will continue as long as a button on the transmitter is held or pressed down when the button is released a string of code as sent to the receiver telling it to stop. [9]

2.1 LITERATURE REVIEW

One of the earliest examples of a remote control development in 1893 by Nikola Tesla and described in his patent U.S patent 613809, named, method of and apparatus for controlling mechanisms of moving vehicle (s) .

It also would be difficult to find a sound that wouldn't accidentally be duplicated by either household noises or by the sound coming from TV programming.

Regardless of the specific system chosen, Zenith sales people were against using batteries in the remote control. In those days batteries were used primarily in flashlights. If the batteries went dead, the sales staff said, the customer might think something was wrong with the TV. If the remote control didn't emit light or show any other visible sign of functioning, people would think it was broken once the batteries died.

Zenith's Dr. Robert Adler suggested using "Ultrasonic", that is, high frequency. Sound, beyond the range of human hearing. He was assigned to lead a team of engineers to work on the first use of ultrasonic technology in the home, as a new approach for a remote control.

The transmitter used no batteries, it was built around aluminum rods that were light in weight and, when struck at one end, emitted distinctive high frequency sound. The first such remote control used four rods, each approximately 2 – ½ inches long. One for channel up, one for channel down, one for sound on and off, and one for on and off.

They were very carefully cut to lengths that would generate four slightly different frequencies they were excited by a trigger mechanism similar to the trigger of a gun that stretched a spring and they released it so that a small hammer would strike the end of the aluminum rod.

The device was developed quickly with the design phase beginning in 1955 called zenith space command the remote went into production in the fall of 1956, becoming the first practical wireless remote control device.

The original space command remote was expensive because an elaborate receiver in the TV set, using additional six vacuum tables was needed to pick up and process the signal though adding the remote control system increased the price of the TV set by about 30 percent it was a technical success and was adopted in later years by other manufacturers.

In the early 1960s solid state country (i.e. transistors) began to replace vacuum tables. Hand held battery powered control units could now be designed to generate the inaudible sound electronically.

By the early 1980s, the industry moved to infrared or IR, remote control technology. The IR remote works by using a low frequency light beam so low that the human eye cannot see it, but which can be detected by a receiver in the TV. Zenith's development of cable compatible tuning and Teletext technologies in the 1980s greatly enhanced the capabilities and uses for infrared remotes which replaced ultrasonic remote controls.

Today remote control is a standard feature on other consumer electronic products including VCRs, cable and satellite boxes, digital video disc players and home audio receivers. And the most sophisticated TV sets have remotes with as many as 50 buttons.

In year 2000, more than 99 percent of all TV sets and 100 percent of all VCRs and DVD players sold in the United States are equipped with remote control. The average individual these days probably picks up a remote control at least once or twice in an hour.

With most pieces of consumer electronics from camcorder to stereo equipment an infrared remote control is usually always included. [9].

2.2 THEORETICAL BACKGROUND

The remote controlled power supply switch has five (5) functional blocks namely.

A - The transmitter stage

B - The detector (phototransistor)

C - The NAND Schmitt trigger stage

D - The flip flop stage

E - The relay stage

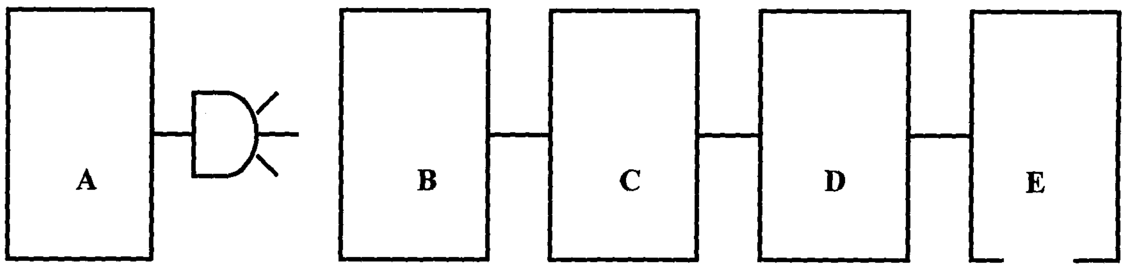


Figure 2.3.1 A block diagram of the design.

The circuit comprises of a transmitter which is designed to generate an average frequency from 30 KHz to 60 KHz. [7]. The frequency rate of the output pulse is determined by the values of two resistors "R1 and R2" and the timing capacitor "C of the 555 timer [8]. The signal generated by the timer is picked up by the IR detector unit which goes low on receiving the signal [1], [5] and [6]. The detector unit (photodiode) is set by different values of "R1" and "C1", the values for the resistor "R1" may to be as high as 10Kohms and the capacitor C1 40μF. This will prevent the photodiode unit from turning on under normal lighting conditions [7]. The output to the photodiode which is at low level is then inverted by the NAND Schmitt trigger, (the NAND gate is a NOT -AND, or an inverted AND function)[2]. The NAND gate I used for this project is the CB 4093 BCN, the output of the NAND gate (a high) is now fed to into the flip flop which is a D – type of flip flop and it stores the information it receives which is a high (i.e.1), until it receives a contrary command or information which may be a low (i.e.0) when the transmitter button is pressed again[3]. The flip flop receives data or information which is a single bit and stores it, the data may be a low or high depending on the input. The output of the flip flop now turns on or triggers the relay which supplies power to the AC supply line. The flip flop I used for this project is the TC 4013 BP. The relay acts as a switch and as an isolator in this project because it was used to isolate the main circuit from the AC supply line, and it switches the power supply of a given room ON or OFF as the case may be.

CHAPTER THREE

3.0 SYSEM DESIGN AND IMPLEMENTATION

The remote controlled power supply switching unit was designed using six (6) functional blocks, namely:

- Power/Regulator stage
- The transmitter stage
- The defector (phototransistor)
- The NAND submit trigger stage
- The flip – flop stage
- The relay stage

3.1 POWER / REGULATOR

The power supply used in this project is a linear power supply type which comprises of a step down transformer, filter capacitors, rectifier and voltage. The two regulators were used to give the various voltage levels used in this project. The power supply circuit diagram is shown below

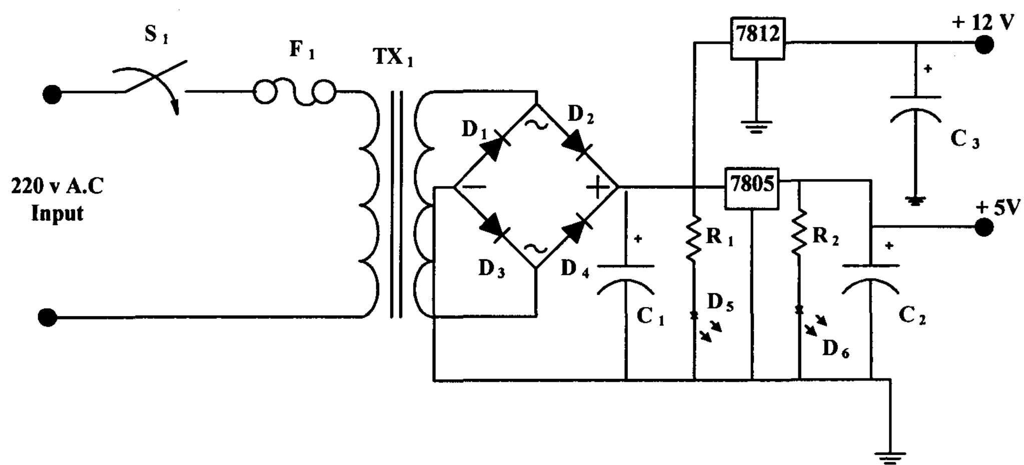


Figure 3.1 Power supply unit

3.1.1 THE TRANSFORMER

The turn's ratio of a transformer in a d.c power supply can be selected to either increase or decrease the 220V ac input. With most electronic equipment, a supply voltage of less than 220V is required, and therefore, a step down transformer is used. The secondary output voltage (Vs} from the transformer can be calculated with the formula below.

$$V_s = \frac{N_s \times V_p}{N_p}$$

Where	Vs	=	Secondary voltage of transformer
	Ns	=	Secondary windings of transformer
	Np	=	Primary windings of transformer
	Vp	=	Primary winding of transformer

Below is the simplest form of a single phase transformer which has two coils wound and a ferrous core. Usually, the coil is connected to the load is the secondary coil.

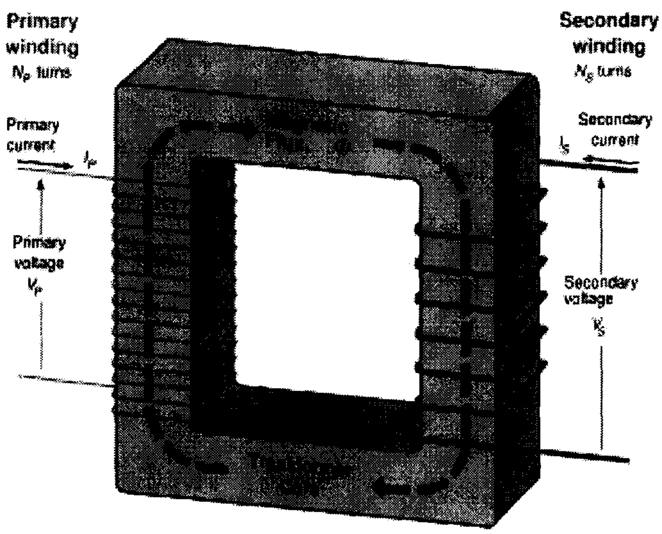


Figure 3.1.1 Schematic diagram of a transformer

The two electrical conductors called the primary and the secondary windings are mutually coupled. Energy is coupled between the windings by the time varying magnetic flux that passes through both the primary and the secondary windings. Thereby supplying a certain voltage at the output of the transformer. Below is the graph of the transformer output.

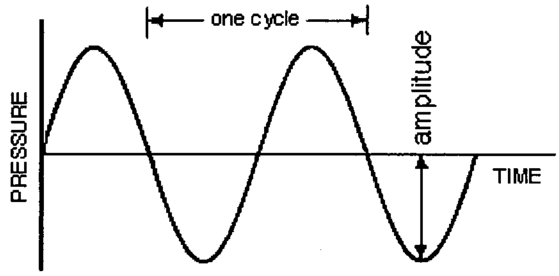


Figure 3.1.2 Graph of the transformer

3.1.2 THE RECTIFIER

The rectifying unit is used to change or convert the AC voltage from the transformer's output to d.c voltage used by the circuit. There are two types of rectification: the half wave rectification and the full wave rectification. The full Wave rectification was used for this project. The full wave rectifier consists of four diodes which only allow current flow in one direction. The full wave rectifier was chosen for this project because its output can easily be filtered to a smooth d.c. level as against the half wave rectifier unit. See bride rectifier below.

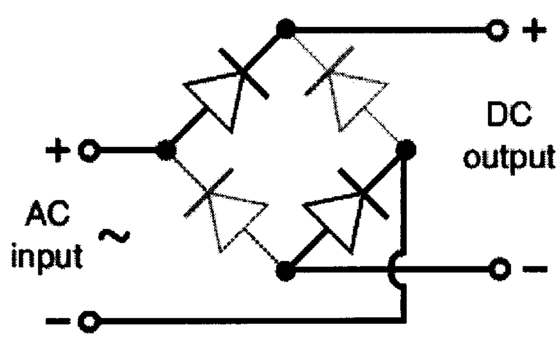


Figure 3.1.3 The Bridge Rectifier Circuit

Rectifiers are now available in IC forms for easy construction work, a typical rectifier IC like the one used for this project can be seen below.

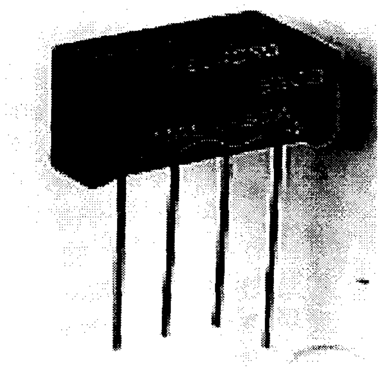


Figure 3.1.4 Rectifiers I.C.

The output of the transformer after rectification gives a waveform output which is the full wave rectification output waveform

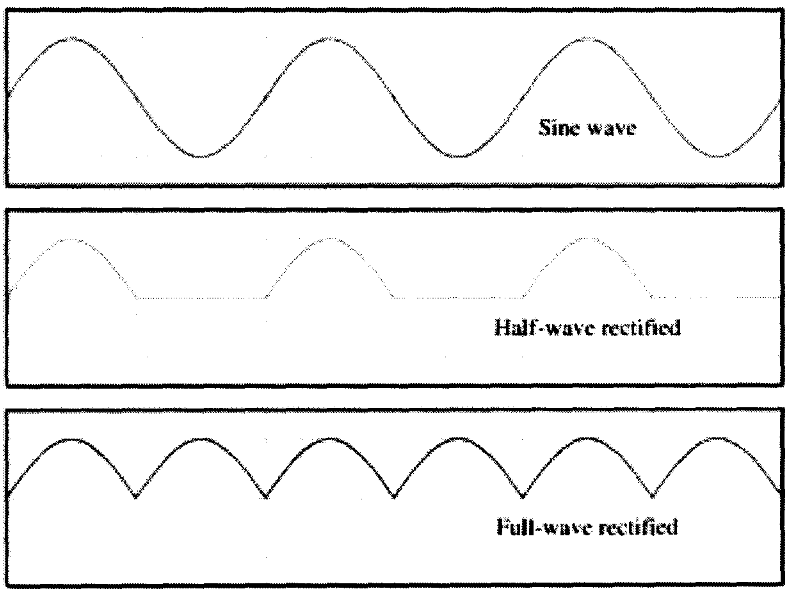


Figure 3.1.5 Transformer waveforms

3.1.3 CAPACITOR FILTERING

Filters in a dc power supply convert the pulsating d.c. output from the full wave rectifier into an unvarying d.c. voltage. When the a.c. input swings positive, the diode is turned ON and the capacitor charges, but the charge time constant will be small because no resistance exists in the charge path except for that of the resistance of the connecting wires. When the a.c. input begins to fall from it's positive peak (at 90^o) the diode is turned OFF by the large positive potential on the diode's cathode being supplied by the charge capacitors, and the decreasing positive potential on the diode's anode being supplied by the input. With the diode OFF, the capacitor begins to discharge. The discharge time is a lot longer than the charge time because of the load resistance. As the a.c. input and the rectifier's pulsating d.c. cycle repeat, the output (Vout) is an almost constant d.c. output with a slight variation or ripple above and below the average value.

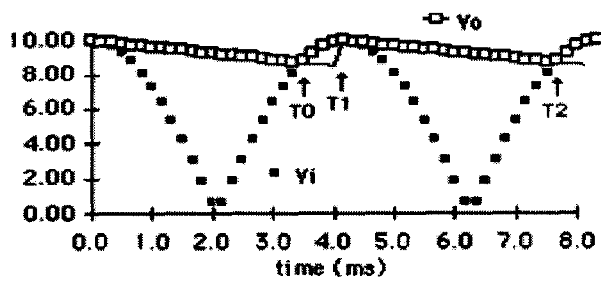


Figure 3.1.6 Output waveform of capacitor

3.1.4 REGULATORS

The voltage regulators in a d.c. power supply maintains the d.c. output voltage constant despite variations in the a.c. input voltage and the output load resistance. The regulators used for this project are:

The LM 7805

The LM 7812

The regulators were used to supply 5 and 12 volts respectively, used to supply voltages to main circuit.

3.2.0 TRANSMITTER

The transmitter usually is powered by a battery. It should consume as little power as possible and the IR signal should also be as strong as possible to achieve an acceptable control distance.

For this project, a 9 volts battery was used. A 555 timer was used to generate signal and the 555 timer was configured in Astable mode. The threshold input pin (6) six is connected to the trigger input pin (2) two. The external components R_1, R_2, and C_1 form the timing network that sets the frequency of oscillation.

When the switch S_1 is closed, power is turned on, and the capacitor "C_1" uncharged, thus the trigger voltage (pin 2) is at 0 volt. This causes the output of the comparator "B" to the HIGH and output of comparator "A" to be LOW, Forcing the output of the latch, and thus the base of Q_1 LOW and keeping the transistor off. Now, C_1 begins charging through R_1 and R_2 as seen in Fig. 3.2.2 when the capacitor voltage reaches $^1/3$ Vcc, comparator B switch to its LOW output state, and when the capacitor voltage reaches $^2/3$Vcc, comparator A switches to it's HIGH output state. This RESETS the latch, causing the base of Q_1 to HIGH, and turns on the transistor. This sequence creates a discharge path for the capacitor through R_2 and the transistor. The capacitor now begins to discharge, causing comparator A to go LOW. At the point where the capacitor discharges down to $^1/3$ Vcc, comparator B switches HIGH; this SETS the latch, which makes the base Q_1 LOW and turns off the transistor. Another charging cycle begins and the entire process repeats. The result is a rectangular wave output whose duty cycle depends on the values of R_1 and R_2. The transmitter circuit can be seen below.

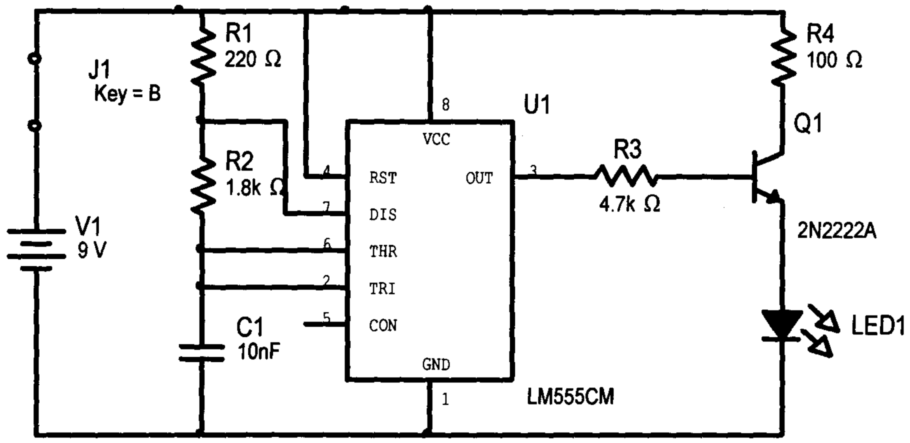


Figure 3.2.1 Transmitter circuit

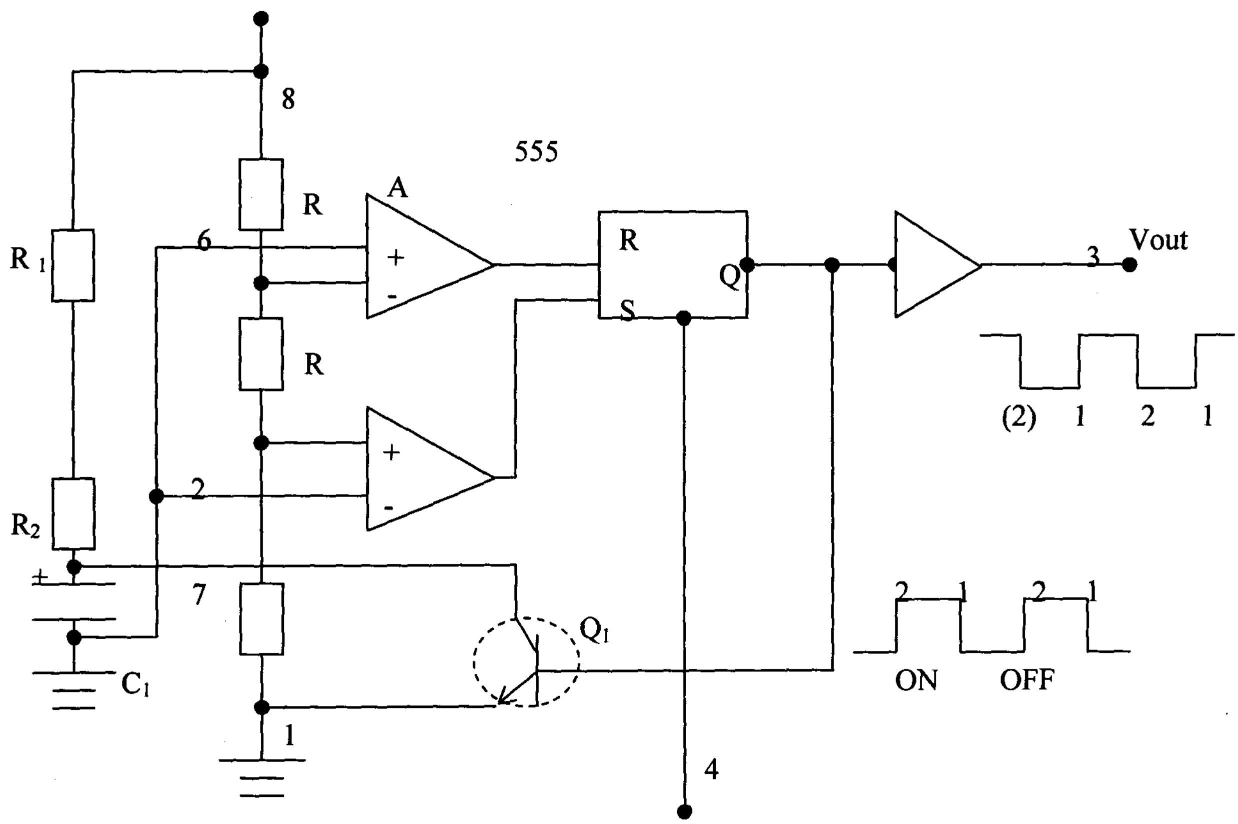


Figure 3.2.2 Operation of the 555 timer in the astable mode.

The resistor R2 was chosen to be one with very high resistance, because a duty cycle approaching a minimum of 50% can only be achieved if R2 >> R1 so that the charging and discharging times are approximately equal. Therefore, R2 was chosen to be 1.8kΩ and R1 to be 220Ω for this project design.

The capacitor alternately charges towards Vo and discharges towards zero according to the input voltage shown in fig. 3.2.3 below. Here, the frequency (and therefore period) of the input square wave voltage is exactly such that the capacitor is allowed to fully charge and discharge. The time constant "t," is equivalent to KRC.

t = KRC ------------------------------- 2

Assume a square wave voltage, like the one in the figure above, is applied across an RC circuit, if one were to continually monitor the voltage across the capacitor, the waveform would resemble that of figure 3.2.3 shown below.

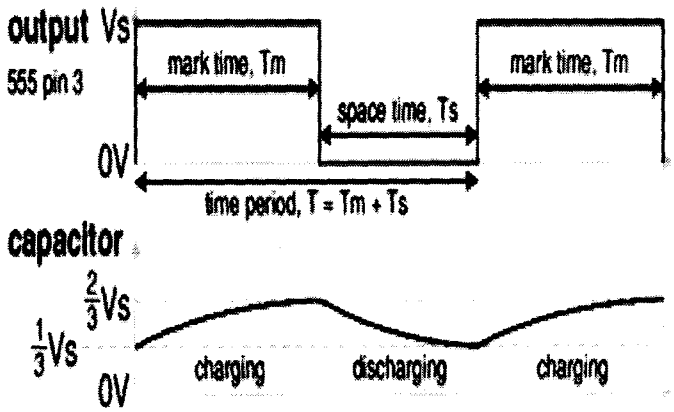


Figure 3.2.3 Waveform of an RC circuit

$F = 37,696,34H_z$

$F = 38$ KHz

$$\text{Duty cycle} = \frac{T_{Charge}}{Pulse\ period\ time} \times 100 \quad = \frac{14\mu}{27\mu} \quad = 0.5185 \times 100$$

Duty cycle is therefore 51%

3.2.2 OSCILLATION

The oscillator in this circuit is a free running non-sinusoidal oscillator. The oscillator can be defined as a circuit which generates ac output signals without requiring any external applied input signal. Or it can be defined as an electronic source of alternating current or voltage having sine, square or saw tooth, or pulse shapes.

A non sinusoidal oscillator may be defined as a circuit in which voltage or current changes abruptly from one value to another and continues to oscillate between these two values as long as dc power to supplied to it.

3.2.3 RC RELAXATION OSCILLATORS

A very simple kind of oscillator can be made for charging a capacitor through a resistor (or a current source), then discharging it rapidly when the voltage reaches a certain threshold, beginning the cycle anew. The Oscillator used for this project is based on the RC principles, which is called the RC relaxation oscillator.

Here, it should be noted that the product RC (Resistance x capacitance) is known as the time constant, "t" and has units of time. This time constant is the characteristic time of the charging and discharging behavior of an RC circuit and represents the time it tells the current to decrease to e^{-1} of its initial value, whether the capacitor is charging or discharging.

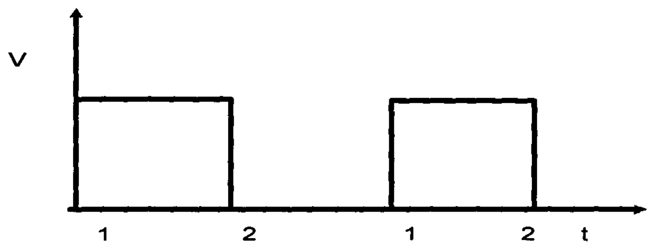


Figure 3.2.4 Square wave that drives the RC circuit

3.2.4 THE TRANSISTOR AS A SWITCH

The ON/OFF switching action of the transistor is controlled by the transistor's base-to-emitter (B-E) diode. If the B-E diode of the transistor is forward biased, the transistor will turn ON; if the B-E diode of the transistor is reverse biased, the transistor will turn OFF. See diagram below

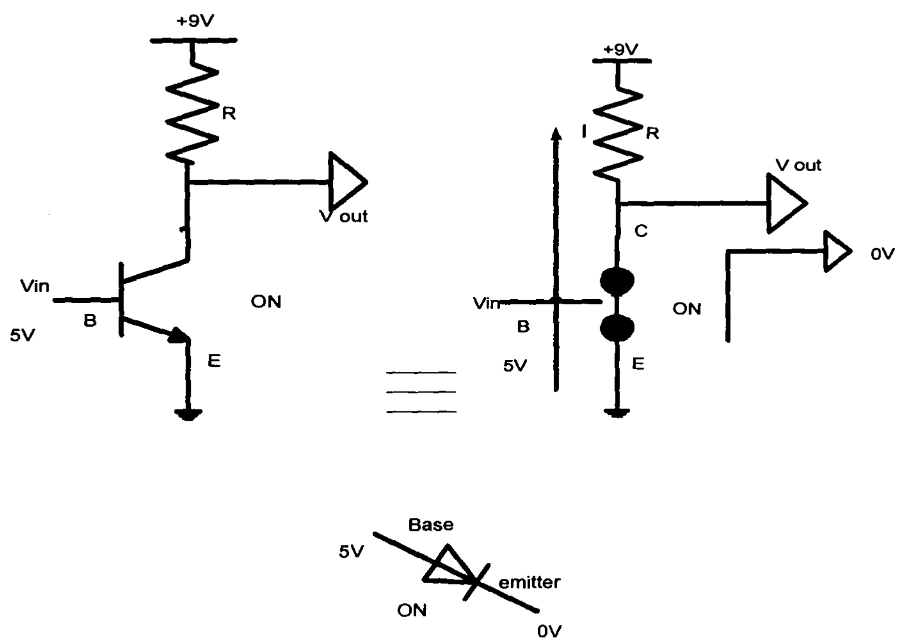


Figure 3.2.5 Bipolar transistor ON

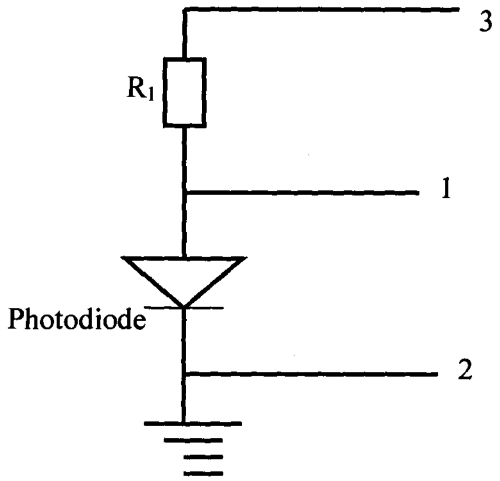


Figure 3.3.1 Receiver circuit

3.4.0 THE NAND GATE

The NAND gate is a popular logic element because it can be used as a universal gage; that is, NAND gates can be used in combination to perform the AND, OR, and inverter operates.

3.4.1 LOGICAL OPERATION OF THE NAND GATE

The nand gate produces a LOW output only when all the inputs are HIGH when any of the inputs is LOW, the output will be HIGH. For the specific case of a 2- input NAND gate (the one used for this project), with inputs labeled "A" and "B" and the output labeled "X", the operations can be stated thus:

The output "X" is LOW if input "A" and "B" are HIGH, "X" is HIGH if either "A" or "B" is LOW, or if both "A" and "B" are LOW.

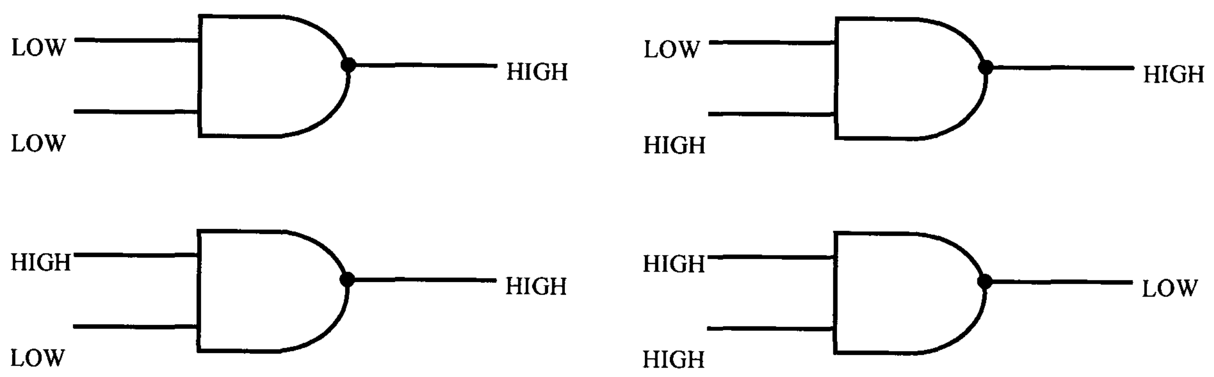


Figure 3.4.1 Logical operation of a 2- input Nand gate

Input		Output
A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

1 = HIGH, 0 = LOW

Table 1 Truth table of a two input nand gate

This operation is opposite that of the AND in terms of the output level. In a NAND gate, the LOW level (O) is the active output level, as indicated by the bubble on the output as seen above.

3.5.0 THE FLIP - FLOP

Flip – flops are synchronous bistable devices in this case the term synchronous means that the output changes state only at a specified point on a triggering input called the clock

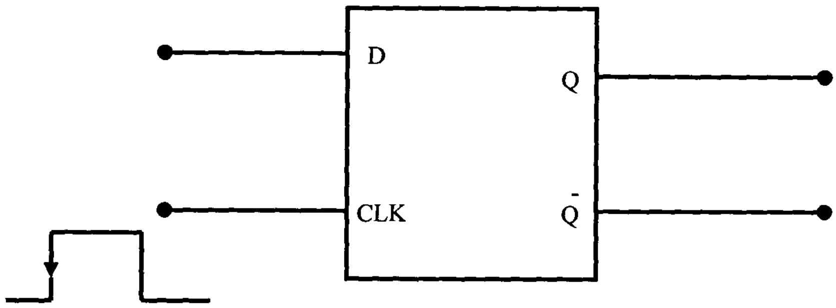


Figure 3.5.1 D flip- flop that triggers only on PGT

INPUT		OUTPUT		COMMENTS
D	CLK	Q	$\overline{Q}$	
1	↑	1	0	SET (stores a 1)
0	↑	0	1	RESET (stores a 0)

Table 2 Truth table for a positive edge – triggered D – flip

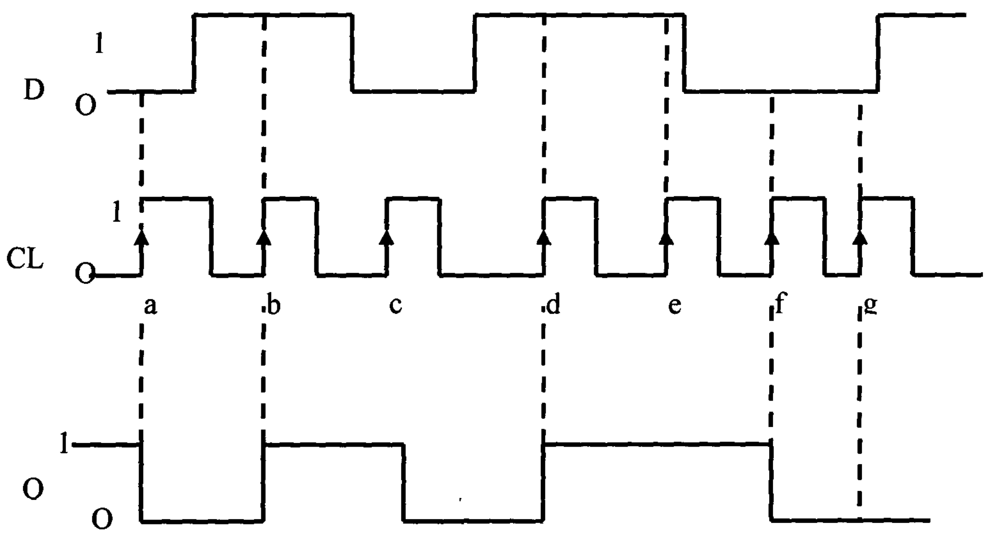


Figure 3.5.2 D flip-flop trigger pgt waveform

A small voltage applied to the input terminal e.g. 6v applied to the input terminals, which activates the electromagnet and close the contacts. These contacts can then switch on a larger amount of current and voltage safely.

It can be used to enable transistors or IC circuits to switch on higher voltage or current components. For example an automatic porch lamp.

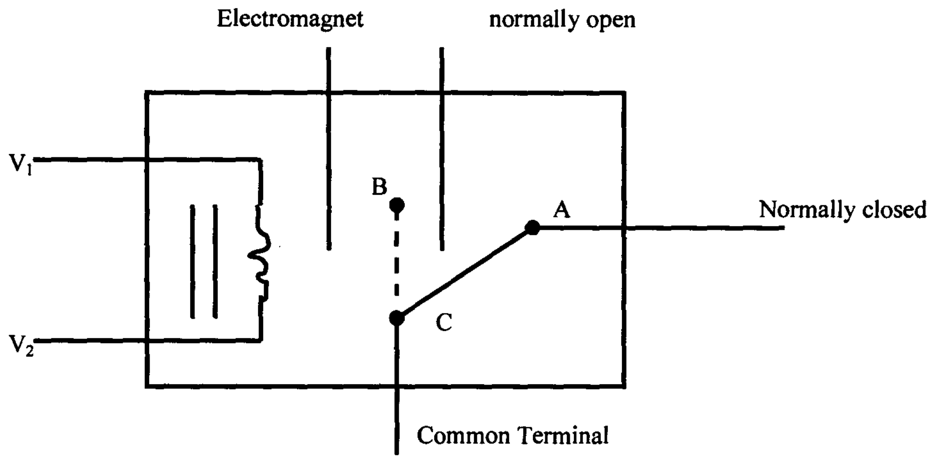


Figure 3.7.2 A single pole double throw relay

Another practical use of relays is for switching one circuit "ON" when another circuit is been switched "OFF" or broken.

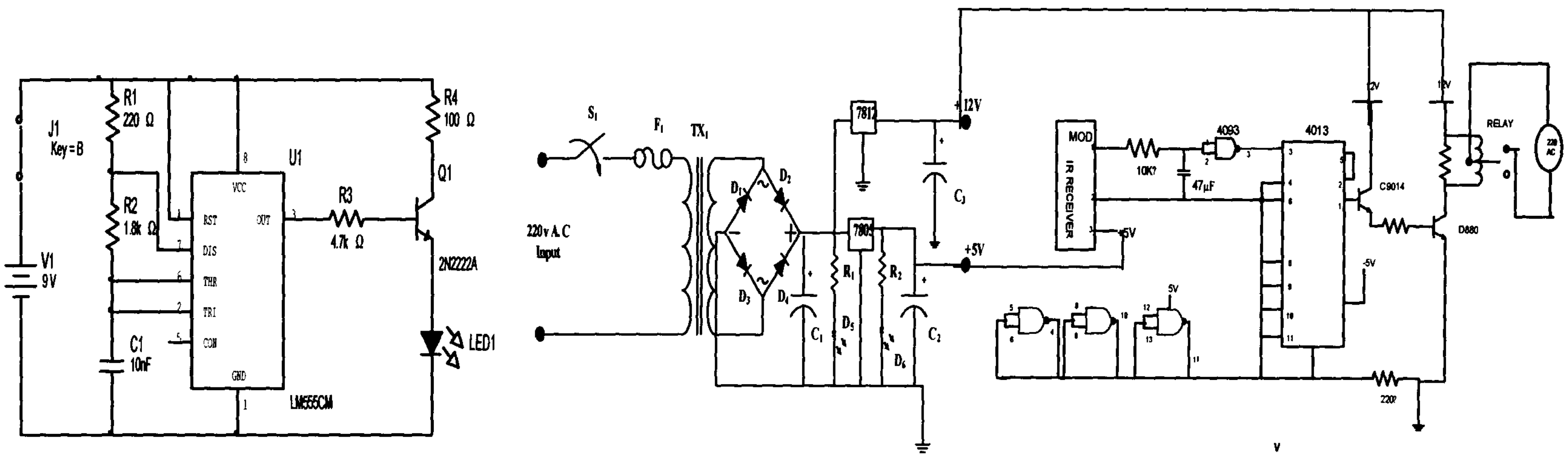
As is the case with many mechanical devices being replaced by their electronic equivalents, relays are being "phased out" by solid state relays (SSRs). Mechanical relays do have their disadvantages when compared to on SSR.

1- Switching is much slower

2- The contacts wear out

3- They make noise when they switch

4- Their magnetic field can cause problems for nearby components.



Transmitter stage

Power supply stage

Receiver stage

Complete Circuit diagram of an infrared remote control unit

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

The transmitter will transmit signals to the receiver from a distance of 5m and above when functioning at its best. It was observed that the transmitting intensity depends on the strength of the battery because it was observed that when the battery went low, the transmitter will have to be brought closer to the receiver before it (receiver) picks the signal, but reverse is the case with a stronger batteries. Another factor that determines the frequency of transmition was discovered to be the values of the resistor and capacitor used at the transmitter stage. The AC was connected to the relay output, and it performed its normal operation of switching either "on" or "off", once the transmitter button was pressed.

5.1 PROBLEMS ENCOUNTERED

Actually not many problems were encountered during the construction of this project, there was less expenses and no component was either destroyed or burn. The very challenge was inability to make used of the opto isolator in the initial design, because a good number of the IC (opto isolator) gotten from the market did not work. So the option of a relay came into play, but with modifications because cmos current could not trigger the relay, until a buffer circuit was used. At the end of these modification the desire results were obtained

5.2 CONCLUSION

The main objective of this project being the design and construction of a remote controlled power supply unit has been achieved, with both theoretical and practical knowledge in terms of exposure and experience were provided. And finally the transformation of the designed circuit diagram to reality (actual construction).

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