THE DESIGN AND CONSTRUCTION OF AN INJECTOR DE-ENERGIZER SYSTEM

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A THESIS REPORT SUBMITTED AS A PRE-REQUISITE FOR AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING IN THE SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

NIGER STATE

NOVEMBER 2004

DECLARATION

I hereby declare this project is my original work and has never to my knowledge been submitted elsewhere before.

....
OTARU MICHAEL O.

....
DATE

CERTIFICATION

This is to certify that I have supervised, read and approved this project report, which I have found adequate both in scope and quality for the partial fulfillment of the requirement for the Award of bachelor of Engineering in Electrical/ Computer Engineering.

PROJECT SUPERVISOR
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31/01/2005
DATE

EXTERNAL SUPERVISOR

DATE

DEDICATION

I will like to dedicate this to my entire family members, parents, brothers, sisters, cousins, in-laws and friends who have in their own effort encouraged me to work hard and supported me in all my Endeavors and also to myself, for my perseverance.

ACKNOWLEDGEMENT

Nothing they say is impossible to achieve, but at the same time nothing comes without hard work. I wish to therefore acknowledge the immense contribution of those who made my time in the University possible and bearable. During the course of my undergraduate studies.

I thank GOD ALMIGHTY for the grace of good health and life, and also for the provision of the needed finance.

My special thanks to my parents, Mr. & Mrs. G.O. Otaru , for being there for me at all times and also to my siblings, Ethel, Oghie, Afe, Omarari, Chafu, Blehle and Jojo, for also being behind me the whole time and for their moral support. Also acknowledged is the Lakoju family who also supported me during the time, May God bless and reward your family a thousand fold

In a special way my Project Supervisor Engr. Rumala for his immense contribution to the success of my project and also to the completion of my thesis.

Credit also to my friends and colleagues Uche, Val, Lekan, Ebere you guys are the bomb finally to my cousin Mikee, you are the man

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ABSTRACT

This is a concise write up on the Design and Construction of an infrared activated INJECTOR DE-ENERGIZER system, whose aim is to act as an antitheft car device. It remotely de-energizes the injector hence, cutting off the fuel supply which is a necessary factor for the working of an Automobile, thus preventing unauthorized movement of the car

The mode of activation of the system is from the infrared control pad which on depressing sends a signal to the receiver which is incorporated in the de-energizer circuit. As a safe guard for the life of the car owner, a timer circuit has been incorporated which allows the thief or car snatcher to travel for some preset time duration, after which the fuel supply is cut off. The action of the de-energizer can only be reversed on depressing the reset button on the infrared control module, which resets the car back to its normal working conditions.

CHAPTER ONE

1.1 INTRODUCTION

Technology has evolved over the course of time, more so in our present day generation, right from its humble beginnings to launching man into space. The Automobile industry also partook in the evolution process, advancing from coal powered cars which ran at a speed of 30km/hr. to turbo powered cars which can run at a maximum speed of about 400km/hr.

Unfortunately, as Technology got more advanced, the frequency of occurrence of automobile theft also increased and also the methods employed by the thieves also advanced. This has led to the upgrading of the available automobile anti-theft devices available which include, fuel-cut, auto-alarms, sirens, burglar- alarms, etc. Depending on the specification of the car owner, the device can either be remotely controlled or by a hidden button in the vehicle.

1.2 METHODOLOGY

The Methodology of the project is based on the ability of the de-energizer to cut the action of the fuel injector, hence cutting off the fuel supply to the combustion chamber of the car engine. The concept was picked, to help forestall false alarms.eg in a car protected by an alarm system, the alarm can be triggered on by anything which touches the car, be it the would be thieves, children playing or an animal scratching against the life of the owner.

1.3 PRINCIPLE OF OPERATION

Efforts have been made by the Electronic Manufacturing Companies to produce security systems that will be very efficient and they go as far as using sophisticated components to build the systems believing the failure or efficiency depends solely on the materials used.

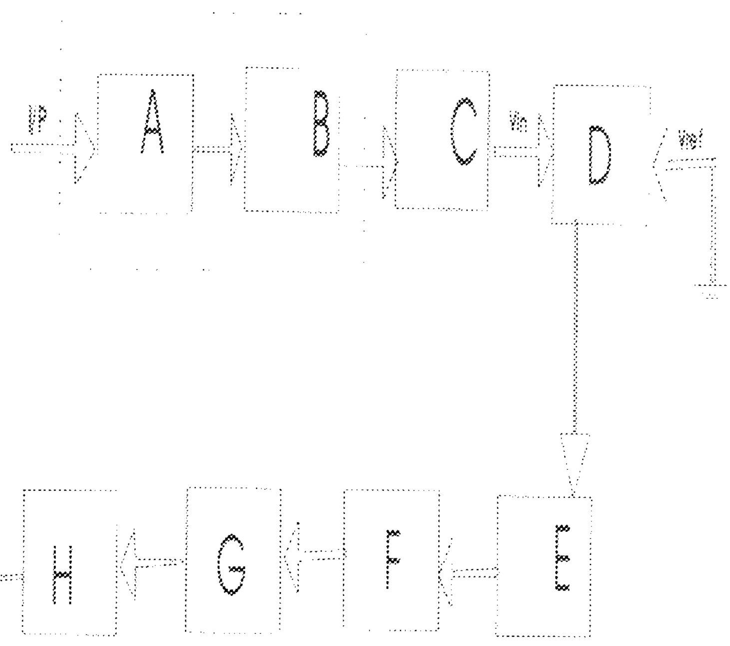


FIG 1.1 BLOCK DIAGRAM OF THE INJECTOR DE-ENERGIZER

The study objective therefore, involves the design and implementation of an INJECTOR DE-ENERGIZER system that can solve the problem of false alarms and at the same time safe guarding the life of the car owner. The Block diagram of the system is shown above and it comprises,

A – TRANSMITTING MODULE

B – RECEIVING MODULE

C – INVERTING MODULE

D – VOLTAGE COMPARATOR

E – TIME GENERATING MODULE

F – PULSE GENERATING MODULE

G – DELAY MODULE

H – SWITCHING MODULE

I – INJECTOR

The system is activated by sending infrared pulses from the transmitting module which is received by the receiving module. At the receiving module signals are sent to the photo transistor, through the inverter and to the voltage comparator whose output is sent to the sent through a time generating module comprising a signal diode, capacitor and two resistors. From there, the signal is inputted into a 555 Timer which is set in the MONOSTABLE mode, generating a single pulse which passes through a delay module (D Flip-Flop) where the signal is delayed for some preset time before being sent to the switching module which de-energizes the action of the Injector.

1.4 PROBLEMS ENCOUNTERED

During the construction process, a problem was encountered with the infrared transmitter whose transmitting distance was quite short, but we were able to overcome the problem by increasing the transmitting frequency, which then allowed transmission up to about 7 meters.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Security systems are devices which are designed with the aim of protecting human lives or property, or in some cases both lives and property.

The first documented case of car theft was around 1896, only a decade after the gas powered cars were first introduced [2]. From that early era to today, cars have been a natural target for thieves. They are valuable, reasonably easy to resell and they have a built in getaway system. Some studies claims that a car gets broken into every 8 seconds around the world [2].

In the light of this startling statistics, it is not surprising that millions of car owners around the world have invested in expensive security system. Today it seems that every other car is equipped with sophisucated electronic sensors, blowing sirens, remotely-activated systems etc, making most cars high security fortresses on wheels

There is a wide range of remarkable security systems, but it`s even more remarkable that car thieves still find a way to get passed the security systems, despite the advancement in their configurations.

2.2 TYPES OF CAR SECURITY SYSTEMS

There are a number of car security systems and these differ mainly in the sensors used and how the various devices are wired together.

2.2.1 DOOR SENSORS ALARM

This is set so when the front hood, trunk or any door on a fully protected car is being forced opened, the alarm system is triggered.

Most cars utilize the switching mechanism that is already built into the doors. In modern cars, opening the door on the trunk turns on the inside lights. The switch is similar to the one which controls the light in a refrigerator. The draw back to this system is that the intruder can gain entrance into the car through means other than the doors

2.2.2 SHOCK ALARMS

This is triggered depending on the intensity of the shock wave on the car, assuming somebody hits, jostles or moves the car. A substantial jolt causes the flexible contact to sway, this closing the circuit briefly. The alarm is sounded by the blowing horn and the headlights coming ON and OFF. The problem with the design is that all shockwaves on vibration closes the circuit in the same way, hence sending out false alarms.

2.2.3 TOUCH SENSITIVE ALARM

The touch sensors are installed at strategic points on the car and are triggered by touch. A signal is sent to the oscillator which generates a frequency which is sounded out from a speaker connected to it. The draw back of the design is the high probability of false alarms occurring.

2.2.4 DEMOBILIZERS

The demobilizer can either be activated by a hidden switch in the car or from an infrared remote control pad which when engaged sends a signal to the demobilizer circuit activating the circuit. The device operates by allowing the thief to travel for a preset time after which the car is demobilized by cutting of all electrical supply to the automobile. The car cannot start working again until the reset pin on the remote control is depressed to reset the car to its normal working state.

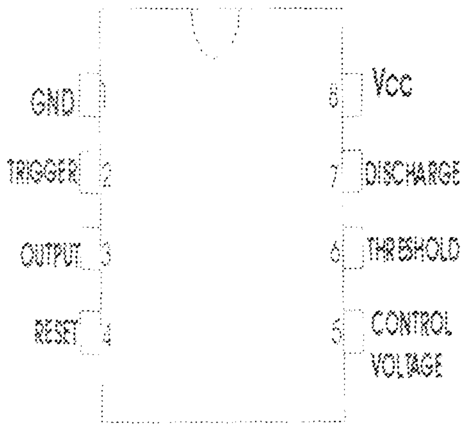
Generally speaking all the automobile anti-theft devices that have been mentioned totally fail when the car is being jacked, as the motorist does not have the chance of pressing any button or manually triggering out any circuit at that instant.

2.3 ELECTRONIC PRINCIPLES OF SOME DEVICES USED

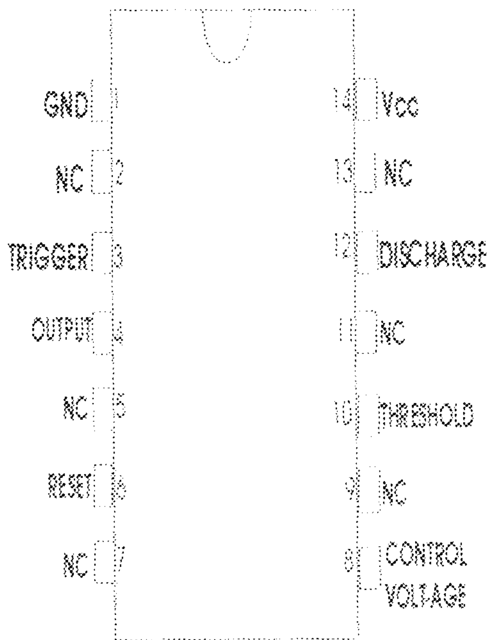
2.3.1 THE 555 TIMER IC

The 555 timer integrated circuit is a monolithic timing circuit. Its package exists either as an 8-pin mini DIP (dual-in-package) or as a 14-pin DIP, as shown in figure 2.2.1 (a) and 2.2.1 (b) respectively. It can be employed for pulse generation purposes and for producing a time delay or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. As an oscillator, the force running frequency and duty circles are both accurately controlled with two external resistors and one capacitor.

The figure 2.2.1 © below shows the internal circuitry of the timer, which can function in either the ASTABLE or MONOSTABLE modes.



2.3.1(a) 555 TIMER 8- PIN DUAL-IN- PACKAGE



2.3.1(b) 555 TIMER 14- PIN DUAL-IN-PACKAGE

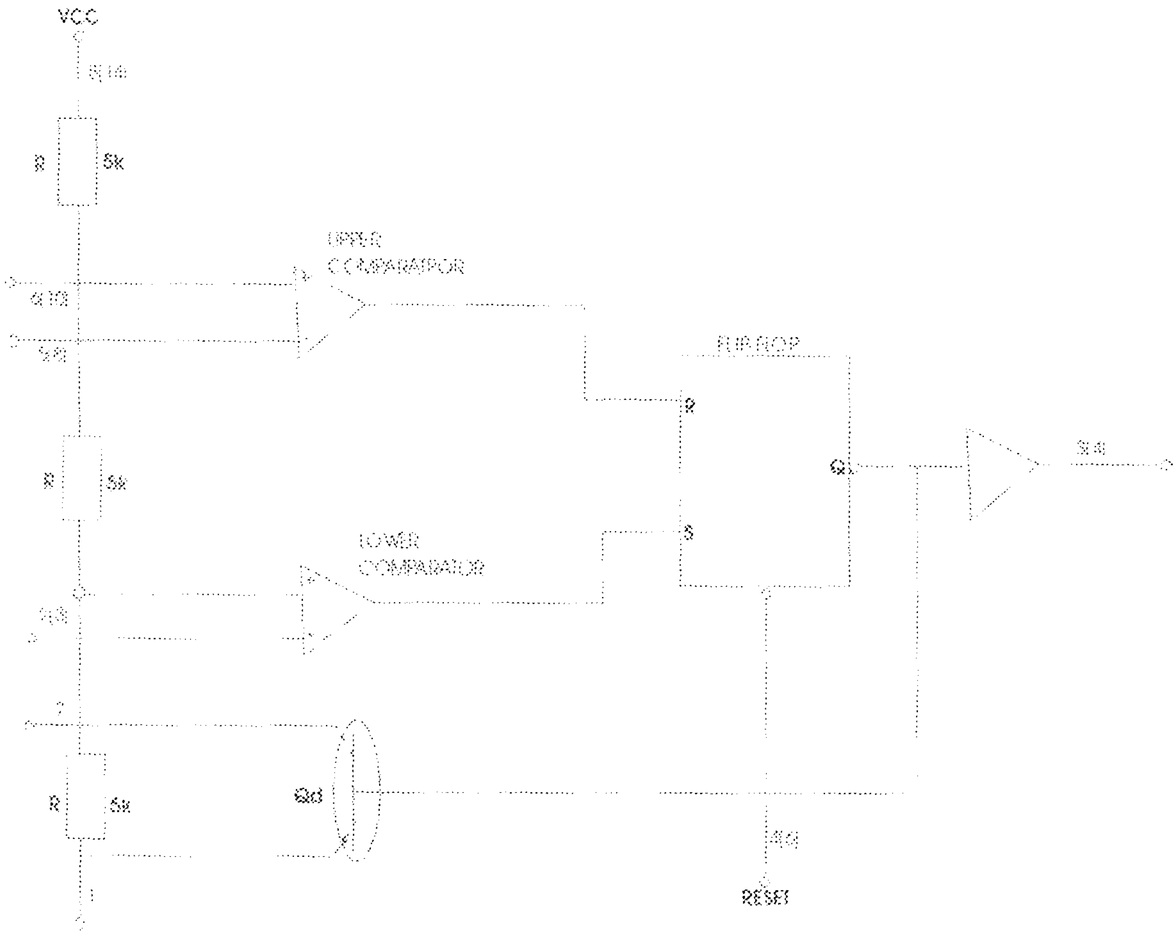


FIG 2.3.1© INTERNAL DIGRAM OF A 555 TIMER INTERGRATED CIRCUIT

The internal circuitry of the 555 timer comprises two comparators i.e. the upper and the lower comparators. It has two inputs viz. The threshold input (pin 6 (10) and the trigger input (pin 2(3)). The three precision series connected resistors of 5 kilo ohms are used to set the voltage comparator levels. The upper and lower comparators have reference of 2/3 V_{cc} and 1/3 V_{cc} respectively. The state of the flip flop is controlled by the output of the comparators

When not in use, the pin 4(6) which is the rest pin is connected to the supply voltage Vcc. The flip flop is set when the voltage between the trigger input {pin2(3)} and the ground (pin 1), falls below $1/3V_{cc}$ and the output (pin 3(4)) jumps to its high level, while the discharge (pin 7(12)) is disconnected from the ground. The connection to the external RC timing network is normally from the threshold input (pin 6(10)).

When the capacitor (external) voltage exceeds 2/3 V_{cc}, the upper comparator resets the flip flop, which in-turn switches the output of the timer pin 3(4) back to its low level. At low output, the discharge transistor is turned on (i.e. the discharge (pin 7(12)) is connected to the ground) and produces a path for rapid discharge of the external timing a one-shot or a time delay element

The suitable range of operation is between +5volts and +15volts on any D.C supply.

2.3.2 ASTABLE MODE OF THE 555 TIMER.

When connected in the ASTABLE mode, as shown in fig 2.2.2 the external components R_1, R_2 and C form the timing network that sets the frequency of oscillation. The 0.01 micro-farad capacitor connected to the control output (pin 5) is strictly for decoupling and has no effect on the operation.

At the initial stage, when power is applied C is unchanged and thus the trigger voltage (pin2) is at 0v, causing the output of the upper comparator to be low. This forces the output of the flip flop and hence the base of the Qd low keeping the transistor OFF. Now C begins changing though R_1 and R_2 as shown below. When the capacitor voltage reaches $1/3V_{cc}$, the lower comparator switches to its low output state and when the capacitor voltage reaches $2/3V_{cc}$, the upper comparator switches to its high output state. This resets the flip flop causing the base of Qd to go high, turning on the transistor. The capacitor now begins discharging causing the upper comparator to go low. At this point where the capacitor discharges down to $1/3V_{cc}$, the lower comparator switches high, setting the flip flop which makes the base of Qd low and turns of the resistor.

Another changing cycle begins and the entire process is repeated. The output is a rectangular wave whose duty cycle f depends on the values of R_1 and R_2.

The timer that the output is high depends on how long it takes C to change from $1/3V_{cc}$ to $2/3V_{cc}$ and it is expressed as

$t_h = 0.693(R_1 + R_2)C$

Where:

t_h = time on

The duration of the low output is how long it takes C to discharge from 2/3 V_{cc} to 1/3 V_{cc} expressed as:

$t_l = 0.693 R_2 C$

Where

t_l = time off

The period T of the wave form is the sum of t_h and t_l.

$T = t_h + t_l$

$= 0.693(R_1 + R_2) C + 0.693 R_2 C$

$= 0.693(R_1 + R_2 + R_2) C$

$= 0.693(R_1 + 2R_2) C.$

Frequency, F = 1/ Period (T)

Thus,

Frequency, F = 1/ 0.693($R_1 + 2R_2$) C

= 1.44/ ($R_1 + 2R_2$) C

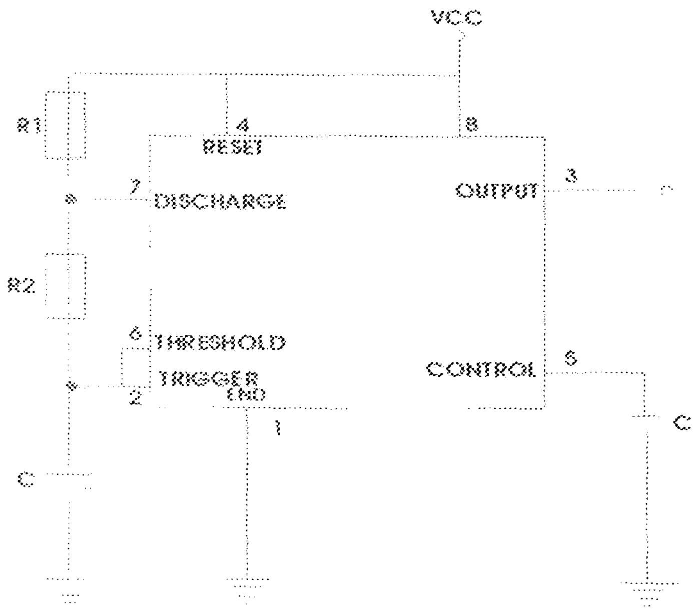


FIG 2.2.2(a) 555 TIMER IN ASTABLE CONFIGURATION

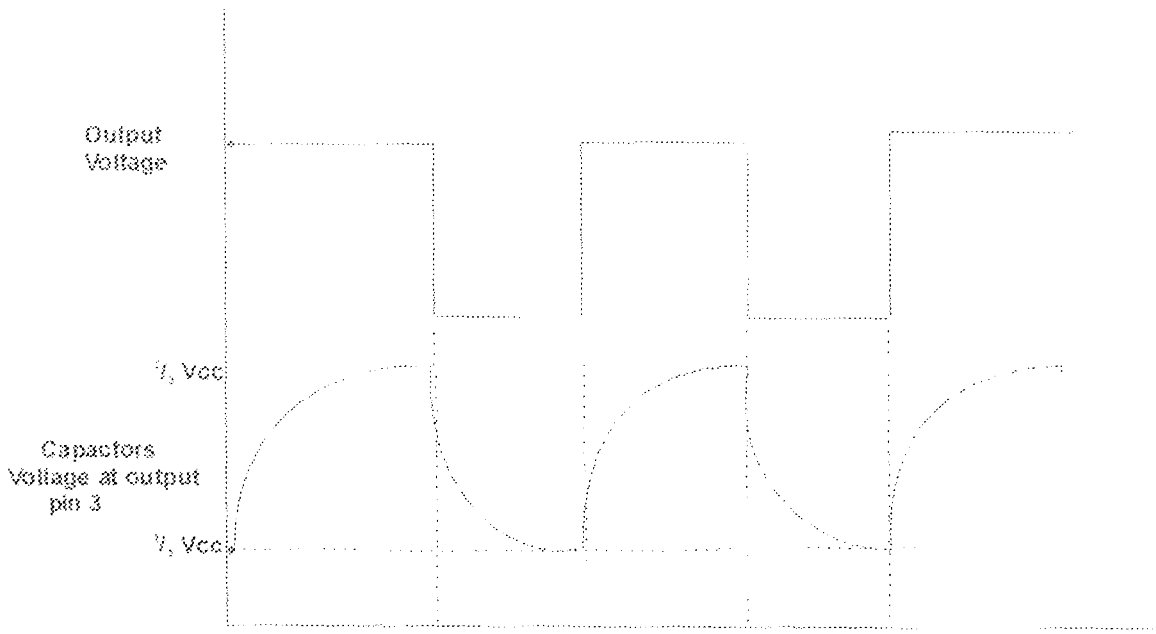


FIG 2.2.2(b) OUTPUT WAVEFORM AT PIN 3

2.3.3 MONOSTABLE OPERATION OF 555 TIMER IC

For MONOSTABLE mode, the 555 timer is connected as shown in figure 2.2.3 (a) below. In the stable state (i.e. off state), pin 2 is high, i.e. more positive than $1/3V_{cc}$, so that the output of the lower comparator is low and resets the flip flop which reaches the short circuit across the timing capacitor thus turning Qd off and the output goes HIGH.

With the timing capacitor now being un-damped, the voltage across it rises exponentially through R_1 towards V_{cc} with a time constant RC. After a time period, the capacitor voltage will equal $2/3V_{cc}$, the upper comparator resets the internal flip flop which in turn discharges the capacitor rapidly to ground potential when the transistor is ON. As a result the output returns to ground state since the external capacitor voltage changes exponentially from zero (0) to $2/3V_{cc}$

$2/3V_{cc} = V_{cc}(1 - e^{-t/RC})$

$2/3 = 1 - e^{-t/RC}$

$e^{-t/RC} = 1 - 2/3$

$e^{-t/RC} = 1/3$

Taking log of both sides

$-t/RC = Log_e 1/3$

$t = 0.693R_1C$

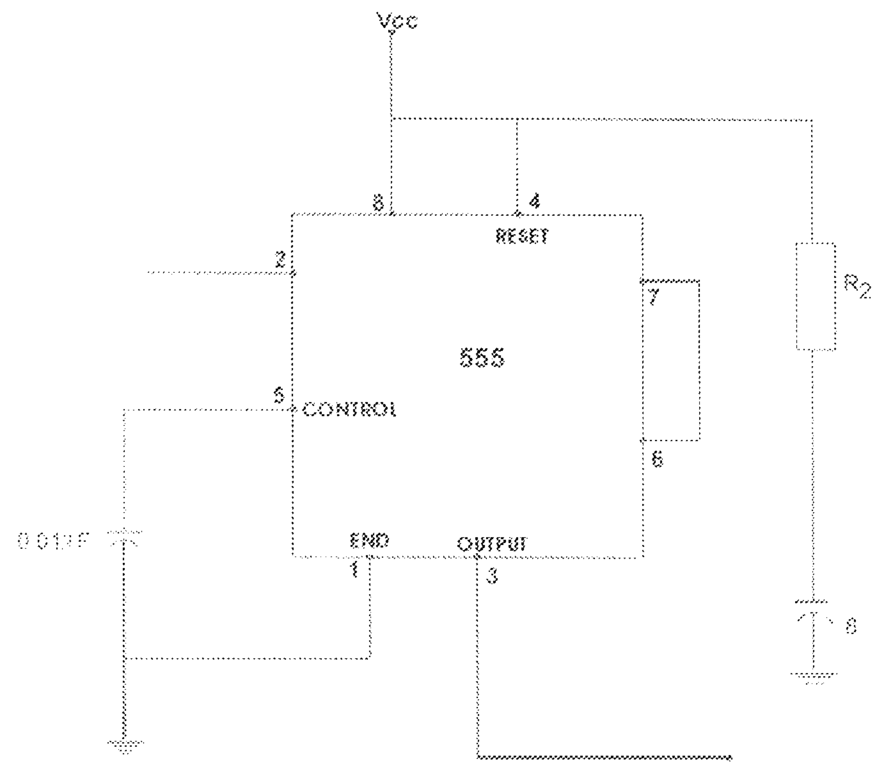


FIG 2.3.3(a) MONOSTABLE CONFIGURATION OF 555 TIMER INTERGRATED CIRCUIT

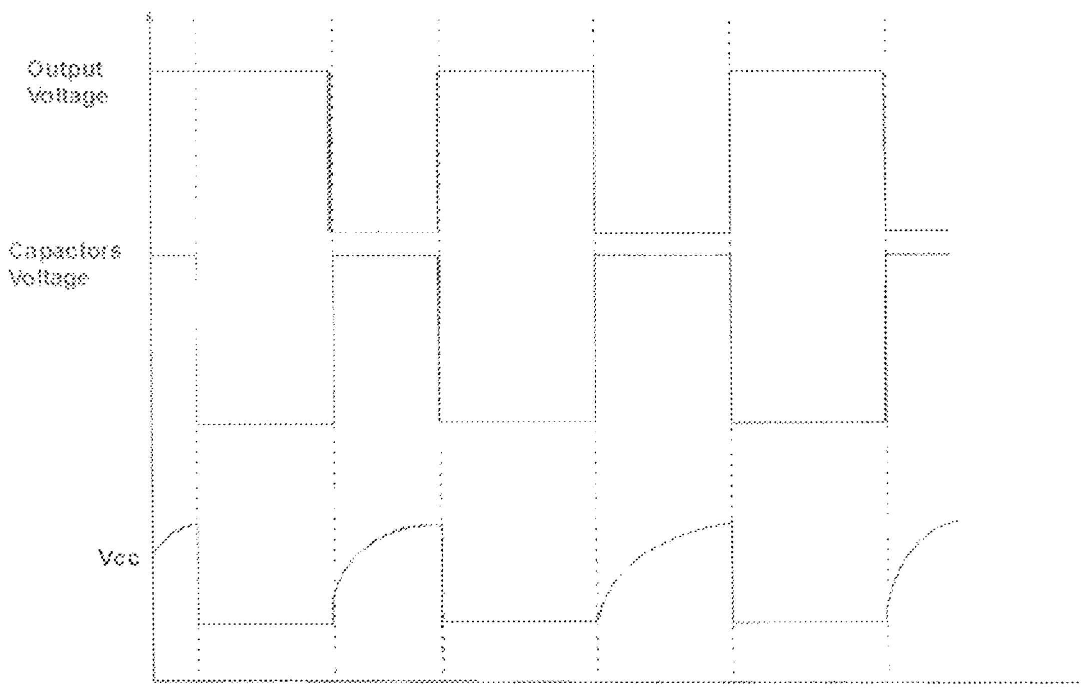
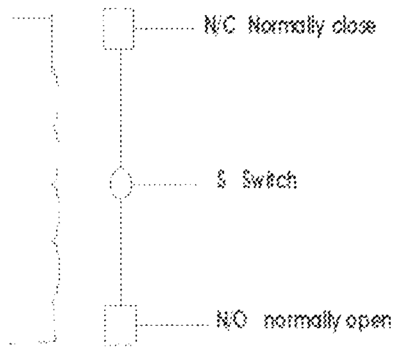


FIG 23.3(b) OUTPUT WAVEFORM AT PIN 3.

2.3.4 RELAY

A relay is an electromechanical switch which when current flows through its coil, a magnetic field is set up and this attracts a conductor in the process makes or breaks a contact. The feature of a relay is shown below.



A relay has the function of initializing actions, this actions may be positive (starting), negative (stopping) balancing or informative.

CHAPTER THREE

DESIGN ANALYSIS

3.1 INTRODUCTION

In modern times, the life of the car owner is taken into consideration when building the car security system and as the methods employed by criminals become more sophisticated, the design is upgraded to checkmate them.

This chapter gives a complete description of the various modules used in the design and construction of the INJECTOR DE- ENERGIZER. The theoretical background of each module is detailed and the block diagram shows the "INJECTOR DE- ENERGIZER" system (With reference to fig. 1.1)

The de-energizer system can be powered from the car battery (D.C source), but preferably by a separate 12v battery (smaller in size than the main car battery) which can be concealed to prevent easy de-activation of the system. The system comprises a small hand- held transmitter and a receiver which provides a one channel output. The system has a typical remote control range (from transmitter to receiver) of about 7metres.

Following the Block diagram, the system is activated by depressing the SPDT (Single Pole Double Throw) switch on the infrared remote control which generates continuous infrared pulses at a frequency of 75 kHz. The photo transistor at the receiving end produces electrical pulses which follows two routes. The first route is the LED (Light Emitting Diode) indicator through an inverter since the receiver works on an active low output. Through the second route, the electrical pulses produced are amplified by the high gain amplifier and fed to the 555 Timer which is connected in MONOSTABLE mode. At the 555 Timer, a single pulse is sent to the switching module via a delay module and on to the injector. Thus, the injector is de-energized after a preset number of seconds.

3.2 POWER SUPPLY MODULE

This module supplies the desired voltage (V_{dc}) 12v, to drive the electrical system of the car. The injector gets power from the car battery enabling constant fuel delivery to the combustion chamber of the car when the ignition system of the car is engaged.

3.3 TRANSMITTING MODULE

This module is meant to generate the infrared rays required to activate the Injector De-energizer system. It is made up of an oscillator, infrared transmitting LED (Light Emitting Diode), A SPDT (Single Pole Double Throw) switch as well as capacitors, resistors and a transistor for switching on the LED

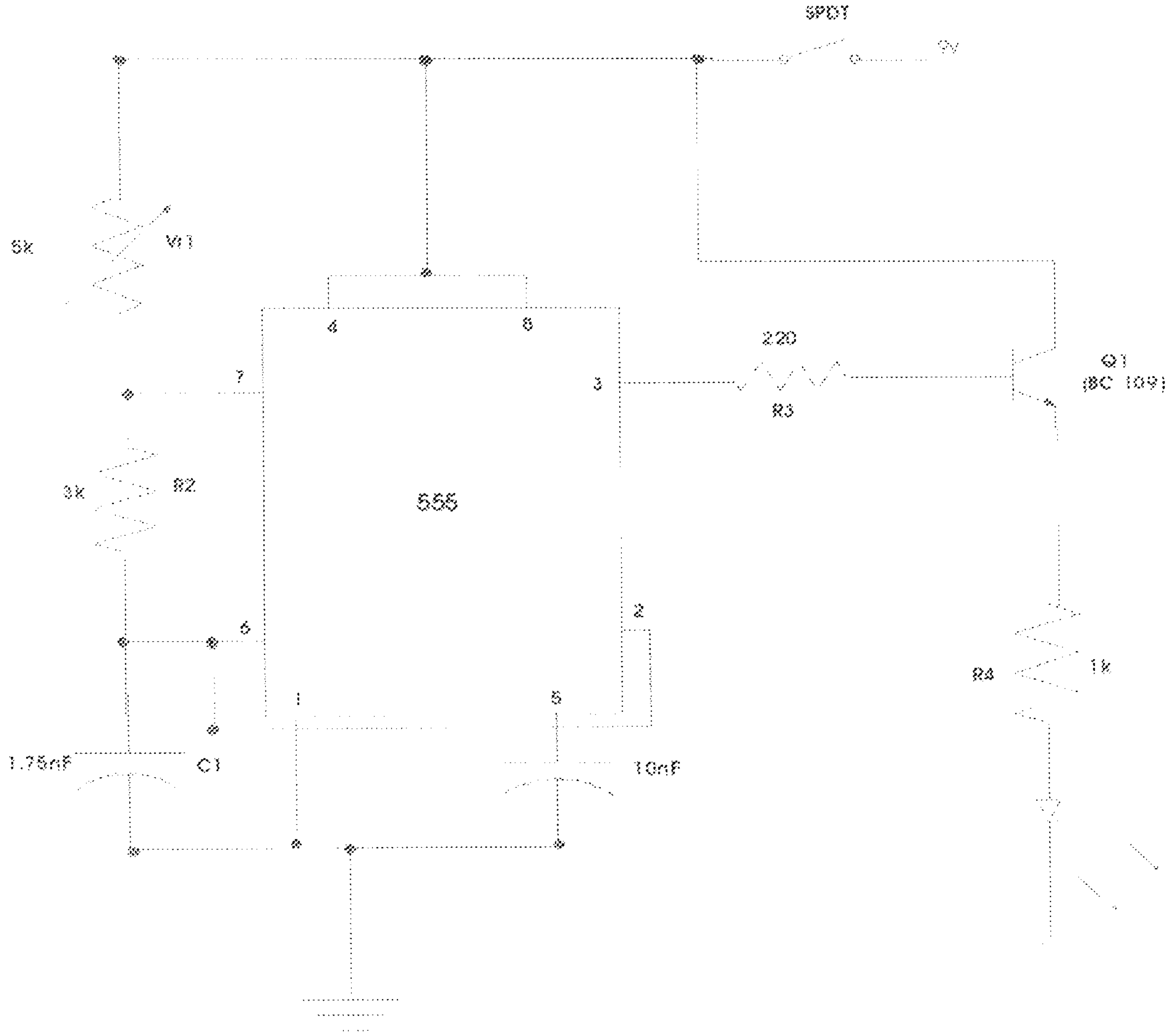


FIG 3.1 THE TRANSMITTING MODULE

3.3.1 DESIGN CALCULATIONS OF THE TRANSMITTER MODULE

From the charging equation of the capacitor,

$V = V_{max} (1 - e^{-t/RC})$

Where

V – Capacitor Instantaneous voltage

V_{max} – Maximum voltage V_{cc}

t – Time constant

e – Naparian logarithm constant (2.71828)

From $V = V_{cc} (1 - e^{-t_1/RC})$

Let $t = t_1$ when $V = 1/3\ V_{cc}$

$1/3\ V_{cc} = V_{cc} (1 - e^{-t_1/RC})$

$1/3 = 1 - e^{-t_1/Rc}$

$e^{-t_1/Rc} = 1 - 1/3$

$e^{-t_1/RC} = 2/3$

Taking log of both sides

$-t_1/Rc = \log_e 2/3$

$-t_1 = RC \log_e 2/3$

Let $t = t_2$ when $V = 2/3V_{cc}$

Similarly,

$t_2 = -RC \log_e 1/3$

$t_{on} = t_2 - t_1$

$t_{on} = -RC \log_e 1/3 + RC \log_e 2/3$

$t_{on} = RC\ \text{loge}\ 2/3 - RC\ \text{loge}\ 1/3$

Where loge = l_n

$t_{on} = RC\ l_n\ 2/3 - RC\ l_n\ 1/3$

$= RC\ (l_n\ 2/3 - l_n\ 1/3)$

$t_{on} = 0.693RC$

Since the capacitor charges through R_1 and R_2,

$R = R_1 + R_2$

$T_{on} = 0.693\ (R_1 + R_2)\ C$

From discharging equation for the capacitor,

$V = V_{max}\, e^{-t/RC}$

When $V = 2/3\, V_{cc}$, $t = t_2$

$2/3\, V_{cc} = V_{cc}\, e^{-t2/RC}$

$2/3 = e^{-t2/RC}$

Taking log of the both sides

$-t_2/RC = \log_e 2/3$

$-t_2 = RC \log_e 2/3$

When $V = 1/3\, V_{cc}$, $t = t_1$

$1/3\, V_{cc} = V_{cc}\, e^{-t1/RC}$

$1/3 = e^{-t1/RC}$

Taking log of both sides

$-t_1/RC \log_e 1/3$

$t_1 = -RC \log_e 1/3$

$t_{off} = t_1 - t_2$

$t_{off} = -RC \log_e 1/3 + RC \log_e 2/3$

$t_{off} = RC\,(l_e\, 2/3 - l_e\, 1/3)$

$= 0.693RC$

Since the capacitor discharges through R_2, therefore,

$t_{off} = 0.693R_2C$ PROVED

Frequency, F = 75kHz

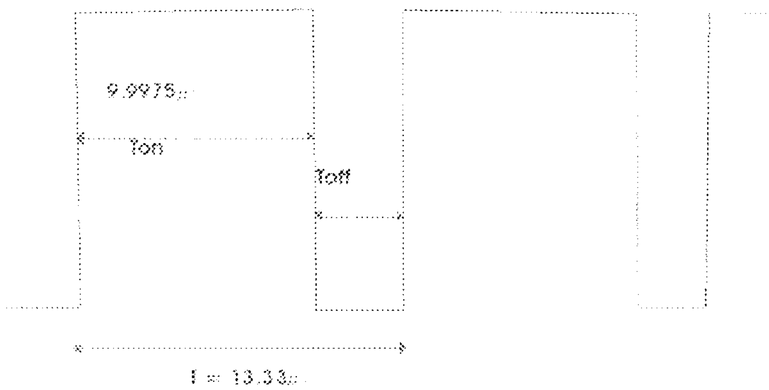
Period, $T = 1/F = 1 / (75 \times 10^3)$

$= 1.333 \times 10^{-5}$ s

$T = 13.33 \times 10^{-6}$ s

T = 13.33 μs

With a Duty cycle of 75%, mark to space ratio of 3: 1 as illustrated below



$T_{on} = 75\% \times T$

$= 0.75 \times 13.33\mu s$

$T_{on} = 9.9975\mu s$

Since $T = T_{on} + T_{off}$

$T_{off} = T - T_{on}$

$= 13.33 - 9.9975$

$T_{off} = 3.3325\mu s$

But,

$T_{on} = 0.693\ (R_1 + R_2)\ C$ ……………(1)

$T_{off} = 0.693\ R_2\ C$ ……… (2)

From equation (2)

With $T_{off} = 3.3325\mu s$

$3.3325\mu s = 0.693 \times 3 \times 10^3 \times C$

$3.325 \times 10^{-6} = 0.693 \times 3000 \times C$

Hence,

$C = (3.3325 \times 10^{-6}) / (0.693 \times 3000)$

$C = 1.693 \times 10^{-9}\ F$

$C = 1.75nf$ (npv)

(npv – nearest preferred value)

From equation (1)

$T_{on} = 0.693\ (R_1 + R_2)\ C$

Where $T_{on} = 9.9975\mu s$

$9.9975 \times 10^{-6} = 0.693\,(R_1 + 3000)\,1.75 \times 10^{-9}$

$(9.9975 \times 10^{-6}) / (0.693 \times 1.75 \times 10^{-9}) = R_1 + 3000$

$R_1 = ((9.9975 \times 10^{-6}) / (0.693 \times 1.75 \times 10^{-9})) - 3000$

$R_1 = 8243.66 - 3000$

$= 5243.66\Omega \approx 5.24k\Omega$

$R_1 \approx 5\ k\Omega$ (npv)

3.4 RECEIVER MODULE

This is made up of an infrared photo transistor detector (302). It receives and modulates infrared signal. It has a TTL (Transistor Transistor Logic) output that is active low.

3.5 INVERTER MODULE

This module inverts the output of the TTL receiver (infrared receiver) whose output is active low on receiving signal. Signal to the LED indicator is passed through the inverter, which inverts the low output to high and hence lights up the indicator LED.

INPUT		OUTPUT	
A		B	
VOLTAGES	BINARY	VOLTAGE	BINARY
LOW	0	HIGH	1
HIGH	1	LOW	0

TRUTHTABLE FOR INVERTER MODULE

3.6 COMPARATOR MODULE

The comparator as the name implies, is a circuit that compares the magnitude of two voltages (usually analogue signals) between the inverting and the non-inverting inputs producing a logic output. It is a high gain amplifier similar to a differential amplifier operating in an open loop mode.

However, due to the high gain, the output is normally saturated in either high or low state depending upon the relative amplitude of the two input voltages. Thus, a logic state output is gotten which is indicative of the amplitude relationship between the two analogue signals.

The Op-Amp was used in amplifying the low output signal from the infrared receiver, at the same time comparing it with a reference voltage at a particular threshold value with the aim of producing the desired output voltage. The figure of the comparator is shown below.

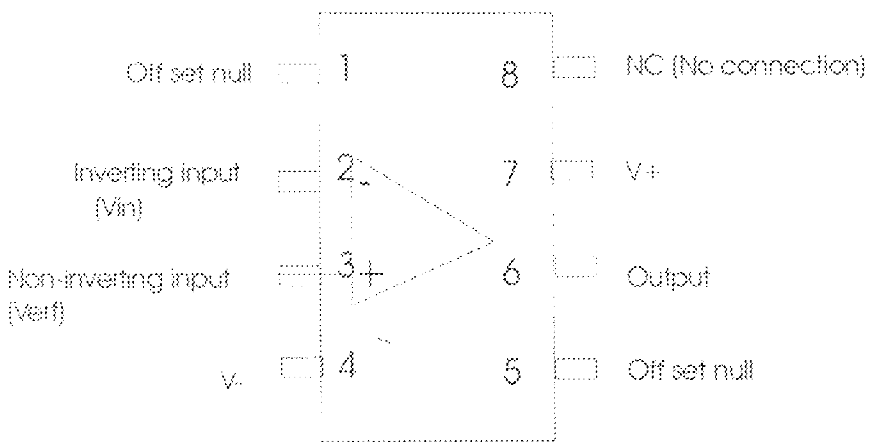


FIG 3.6 COMPARATOR MODULE

3.7 TIME GENERATING MODULE

The module comprises a capacitor, two resistors and a signal diode. The capacitor is charged by one of the resistors and discharged by the other resistor. The signal diode prevents the capacitor from discharging too quickly so as to ensure good pulse duration required to drive the pulse generator.

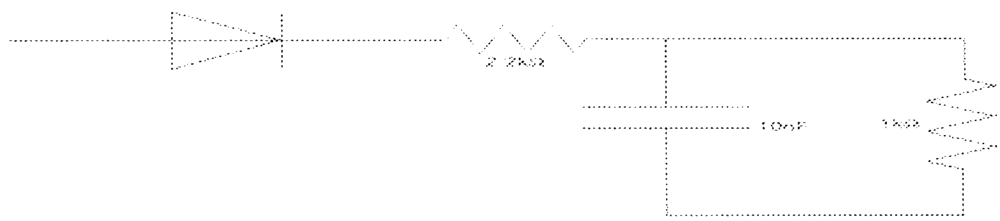
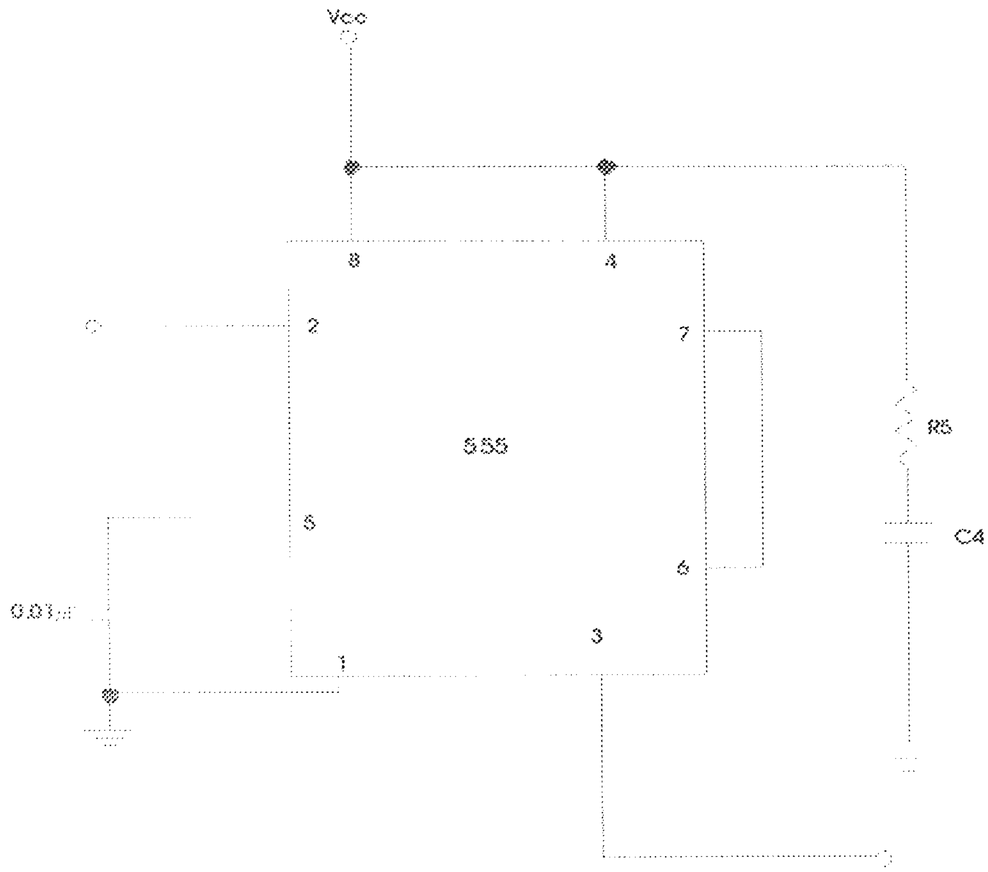


FIG 3.7 THE TIME GENERATING MODULE

3.8 PULSE GENERATING MODULE

The pulse generating module is made up of a 555 Timer wired in the MONOSTABLE mode. The device has six functional leads in addition to the pins for the biasing voltage (V_{cc}) and ground. The reset (pin 4), threshold (pin 6) discharge (pin 7) and control voltage (pin 5) are the control leads, with pin 2 and pin 3 as the trigger input lead and single output respectively. The trigger input is used to start the operation of the timing circuit and a square or pulse wave at the threshold lead decides when the output switches between 0 and 1 circuit. The RC combination is used to set the timing of the multivibrator waveform. The discharge lead provides a path for the discharge of the capacitor in the RC timing circuit. So the lead (pin 7) is involved in the recovery of the circuit for the next output pulse.



3.8 THE PULSE GENERATING MODULE

3.8.1 DESIGN CALCULATIONS OF THE PULSE GENERATING MODULE

$T_{on} = 1.1\ R_5\ C_4$

For a T_{on} of 24 seconds

Let $C_4 = 10\mu F = 10 \times 10^{-6}\ F$

$R_5 = ?$

$24 = 1.1 \times R_5 \times 10 \times 10^{-6}$

$R_5 = 24/ (1.1 \times 10 \times 10^{-6})$

$= 21818\ 182\Omega$

$\approx 2.181\ M\Omega$

$R_5 \approx 2.2M\Omega$

3.9 THE DELAY MODULE

The Delay module is made up of a D Flip flop (Delay Flip-flop). The inputted data (a 0 or 1) is delayed for a clock pulse from getting to the output Q. Hence, the pulse from the generating module is delayed for one clock pulse before directing it to the switching module via the parallel combination of resistors. This module ensures the accomplishment of the aim of the project.

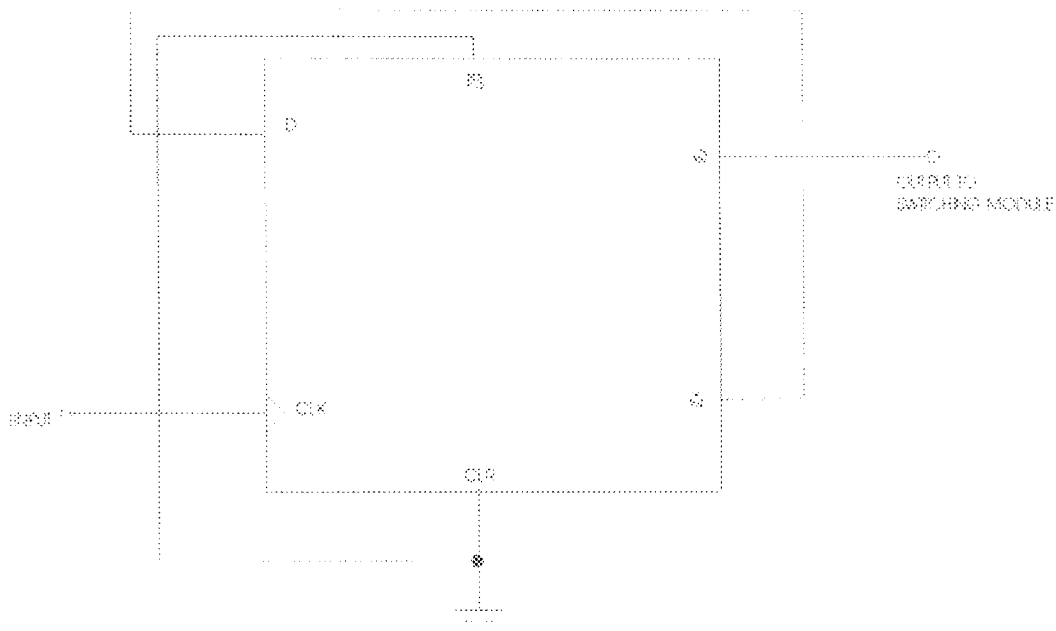


FIG 3.9 THE DELAY MODULE

MODE OF OPERATION	INPUTS				OUTPUTS	
	ASYNCHRONOUS		SYNCHRONOUS			
	PS	CLR	CLK	D	Q	$\bar{Q}$
ASYNCHRONOUS SET	0	1	X	X	1	0
ASYNCHRONOUS RESET	1	0	X	X	0	1
PROHIBITED	0	0	X	X	1	1
SET	1	1	↑	1	1	0
RESET	1	1	↑	0	0	1

0 = Low X = Irrelevant

1 = High ↑ = Low-to -high transition of clock pulse

D FLIP-FLOP TRUTH TABLE

3.10 SWITCHING MODULE

This module carries out the actual switching of the Injector, interfacing the entire system with the Injector. The module receives signal from the Delay module, switching it's transistor from it's cut-off region to it's saturation region and subsequently the relay via the coil. At this instance the normally close contact connected to the Injector becomes De-energized, turning off the Injector. Thus, the car comes to a stop.

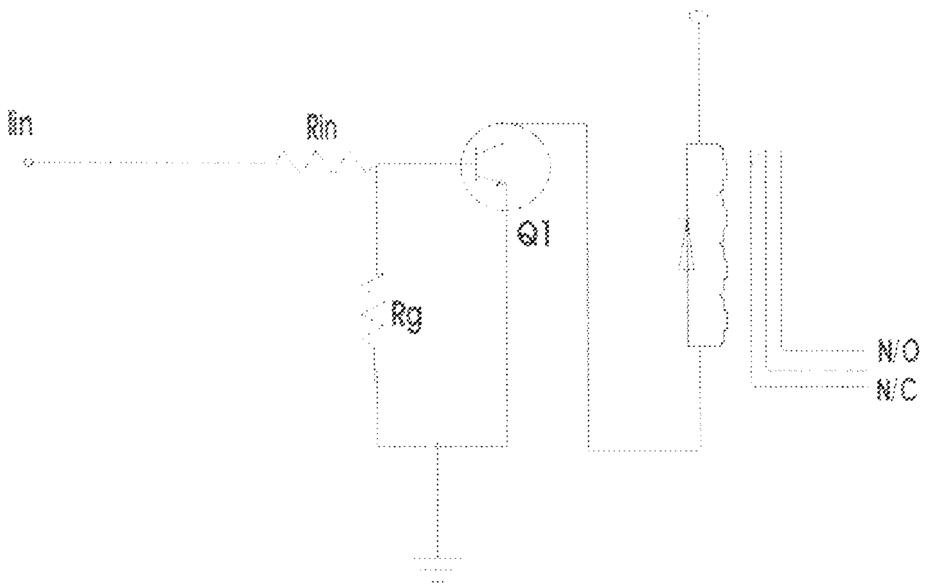


FIG 3.10 SWITCHING MODULE OF THE INJECTOR DE-ENERGIZER

Characteristic of Q_1 (2N2222A)

From the data sheet

$IC_{max} = 0.8A$ $V_{BE} = 0.8V$ $R_{in} = ?$ $\beta = 40$

$IB_{max} = 0.02A$ $V_{cc} = 12V$ $R_g = ?$ $V_{RB} = 2V$

From Ohm's Law

$I_C R_L = V_{cc}$

$V_{cc} / R_L = I_C$

Where R_L = load resistance i.e. relay coil resistance measured to be 410Ω using a digital Multimetre.

Thus,

$I_C = 12/410$

$= 0.029A$

Ignoring any leakage current I_{CBO}, we get

$I_{Bmin} = I_C / \beta$

$I_{Bmin} = 0.029/40 = 7.25 \times 10^{-4}$

$= 725 \times 10^{-6}$ A

$= 725\mu A$

The current through R_g necessary to ensure cut-off for an over driven switch (by the thumb rule) is equal to $2I_{\beta min}$ (i.e. to ensure saturation)

Thus, $I_g = 2\ (0.000725)$ A

$= 1.45 \times 10^{-3}$ A

$= 1.45mA$

Applying Kirchoff voltage Law

$I_g R_g = 2 - 0.8$

$= 1.2V$

$R_g = 1.2 / I_g$

$R_g = 1.2 / (1.45 \times 10^{-3})$

$= 827.586\ \Omega$

$R_g \approx 0.828\ k\Omega$

$R_g \approx 1k\Omega$ (npv)

Solving for R_{in}, applying Kirchoff voltage Law

$I_{in} = I_{\beta min}$

$I_{in} R_{in} = V_{in} - V_{BE}$

(where V_{in} is the comparator output voltage measured using a digital multimetre)

$V_{in} = 8V$

$I_{in} = I_{\beta min} = 725\ \mu A$

$725 \times 10^{-6} \times R_{in} = 8 - 0.8$

$725 \times 10^{-6} \times R_{in} = 7.2V$

$R_{in} = 7.2 / (725 \times 10^{-6})$

$= 9931.03\Omega$

$\approx 9.931\ k\Omega$

$R_{in} = 10k\Omega$ (npv)

The $10k\Omega$ // $1k\Omega$ voltage divider network is meant to protect the switching module against Thermal Runaway.

CHAPTER FOUR

CONSTRUCTION AND TESTING

4.1 INTRODUCTION

Construction is the process of putting together the various components of the circuit on a Vero board. In constructing the system, the construction of the various modules was carried out in sequential order.

All the stages involved in the project were initially tested on a breadboard before finally transferring to the Vero board for soldering. All the stages worked properly both on the breadboard and the Vero board as well. The individual components were carefully picked and their ratings carefully calculated before assembling them together.

4.2 CONSTURCTION TOOLS USED

Most of the hardware construction tools used is given below,

1. Soldering Iron and Lead
2. Digital Multimetre
3. Lead Sucker
4. Precision Screwdrivers
5. Breadboard and Insulated copper wires
6. Vero board

4.3 COMPONENT SELECTION

Components for Infrared Transmitter

Resistors	Ratings
R_1	5kΩ
R_2	3kΩ
R_3	220Ω
R_4	1kΩ

Capacitors	Ratings
C_1	1.75kF
C_2	0.01μF

Semiconductors	
IC_1	555
LED_1	Light Emitting Diode
T_1	BC 109

Components for receiver Section

Resistors	Ratings
R_1	5.6kΩ
R_2	1kΩ
R_3	470Ω
R_4	470Ω
R_6	2.2kΩ
R_7	1kΩ
R_8	3.3kΩ
R_9	10kΩ

Capacitors	Ratings
C_1	100nF
C_2	10nF
C_3	10μF

Semiconductors

Photo Transistor	302
IC_1	Operational Amplifier
LED	Light Emitting Diode
Zener Diode	6.2V
IC_2	555
IC_3	D Flip-flop

CHAPTER FIVE

MAINTENANCE, RECOMMENDATION AND CONCLUSION

5.1 MAINTENANCE

The system is very easy to maintain, hence with just a digital multimetre and visual inspection you can almost carryout all the required maintenance process on the system. There are three basic steps in locating faults in the system.

1. **Fault Detection:** This has to do with the observation of the system operation comparing with the expected correct operation, checking for any disparities.
2. **Fault Isolation:** Involves the performance of various tests and measurements in order to isolate the faulty component.
3. **Fault correction:** Process of replacing the faulty component(s), repairing faulty connections, removing short circuitry or bridging particles, etc.

In maintaining this system, a systematic approach should be carried out taking in to consideration the various modules that make up the system, therefore each stage must be checked in sequential order.

5.2 RECOMMENDATION

For the installation, due to the necessity of the system to be concealed and it's small size, it can be installed in the drivers door. For the power supply, it is recommended that a separate 12V battery be used. The separate battery should be properly hidden to hinder easy de-activation of the system. In the case of a commercial version of the design, the preset switching time can either be increased or decreased by applying the formula ($1.1\ R_5C_3$), incorporating suitable values of R and C.

5.3 CONCLUSION

After the construction and testing of the design, it worked properly despite initial problems encountered during the course of the construction. It can be observed from this project that the design and construction of an INJECTOR DE-ENERGIZER system requires careful planning and implementation.

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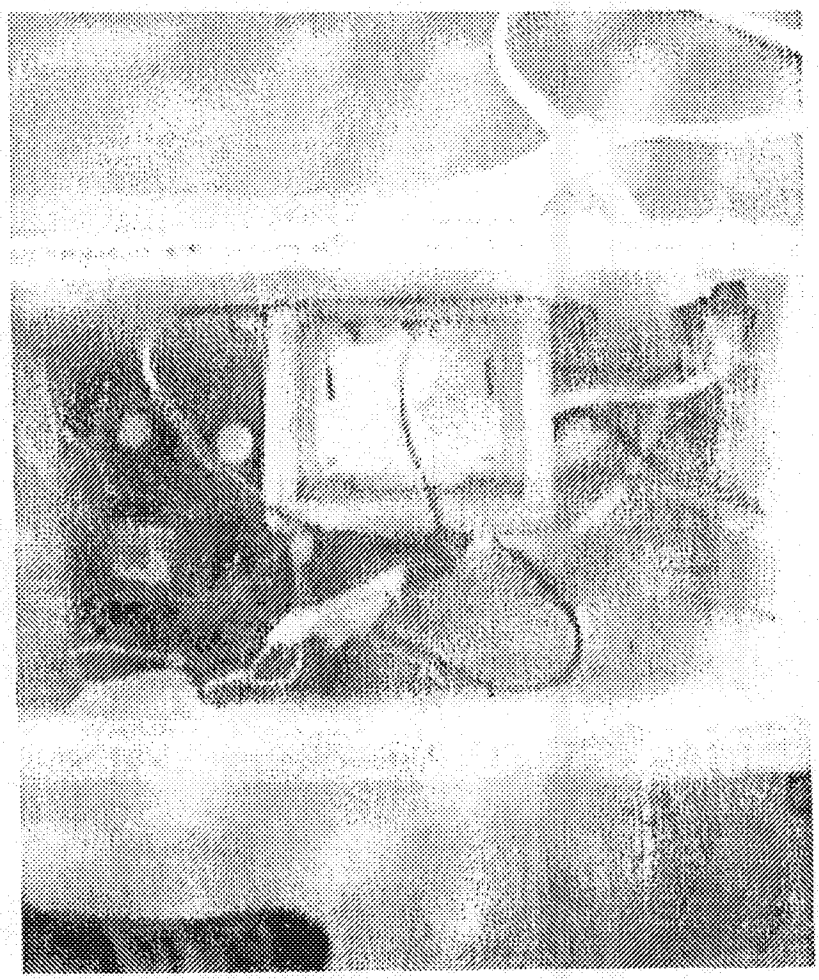
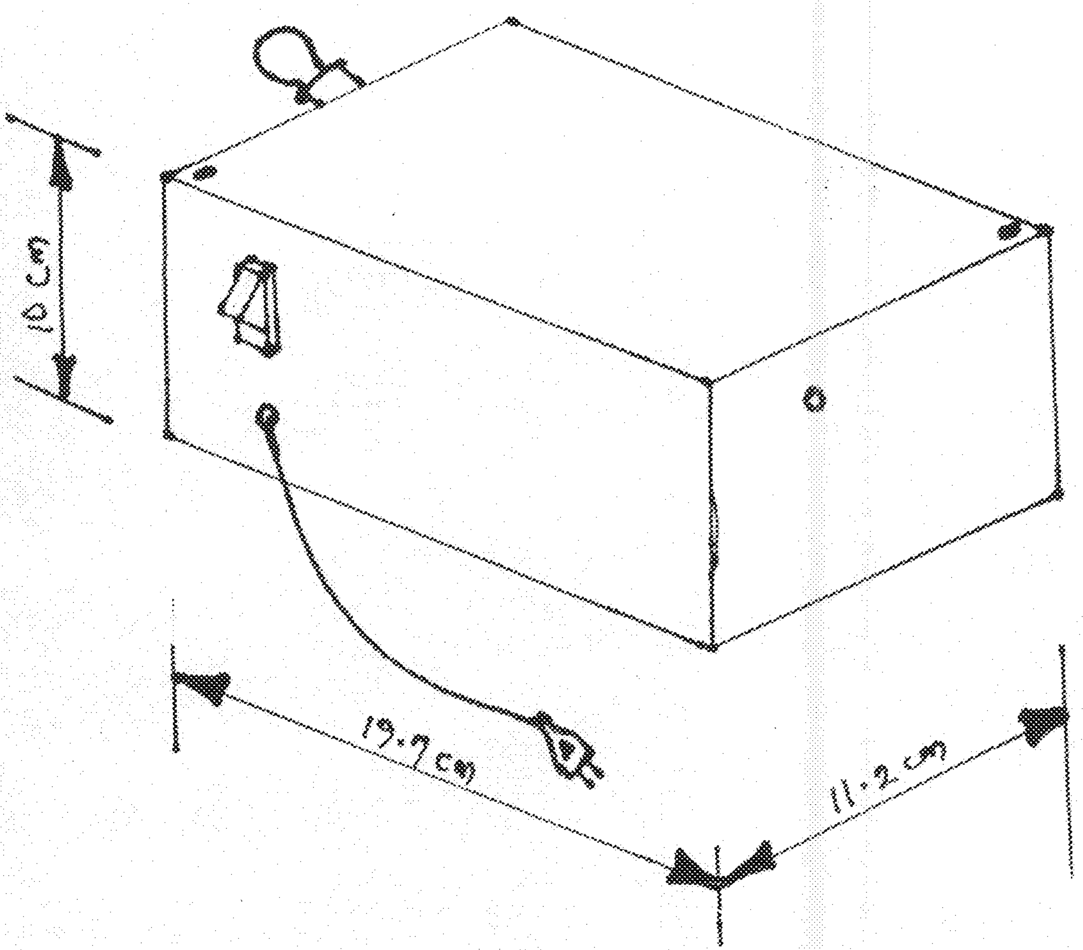
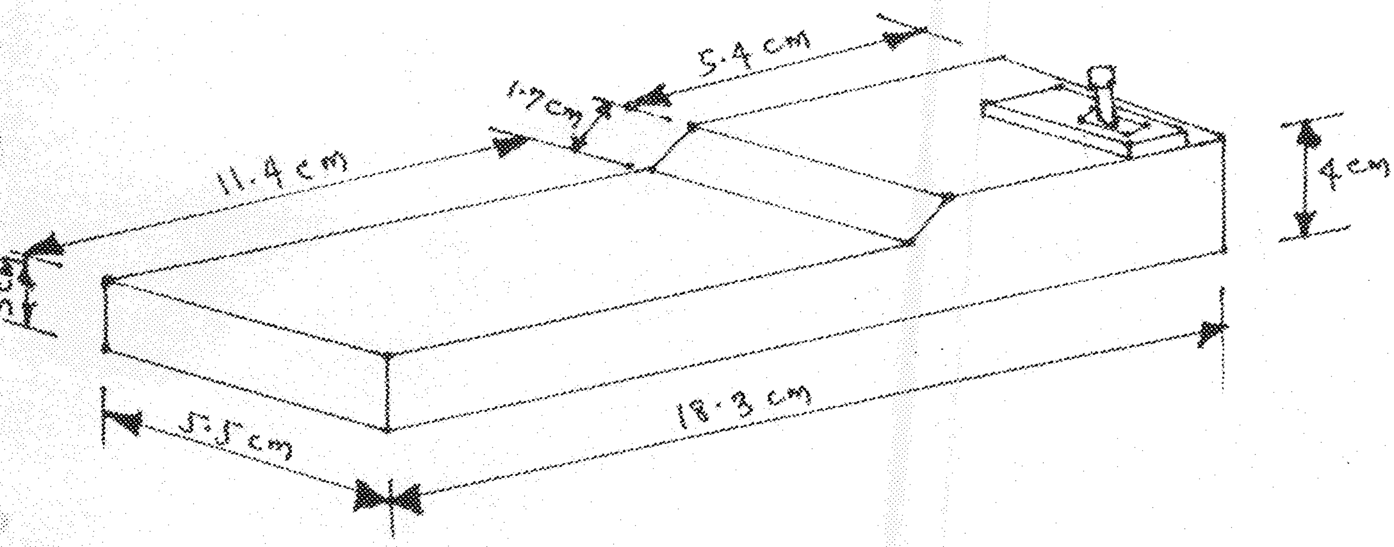


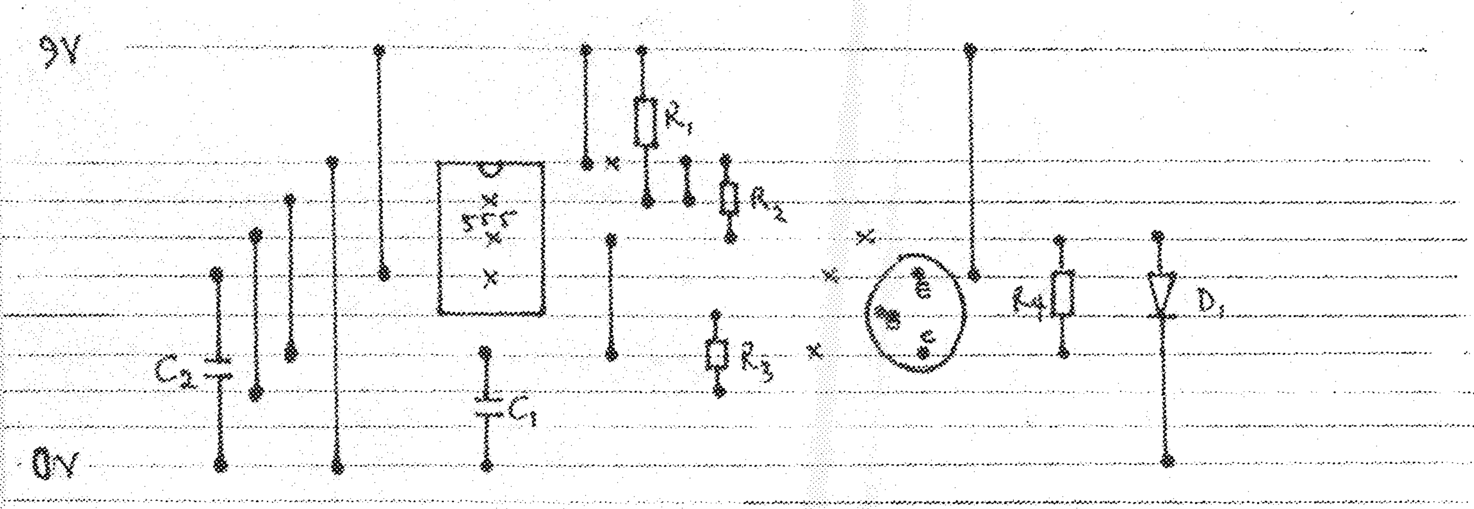
SCANNED PICTURE OF CONSTRUCTED PROJECT.



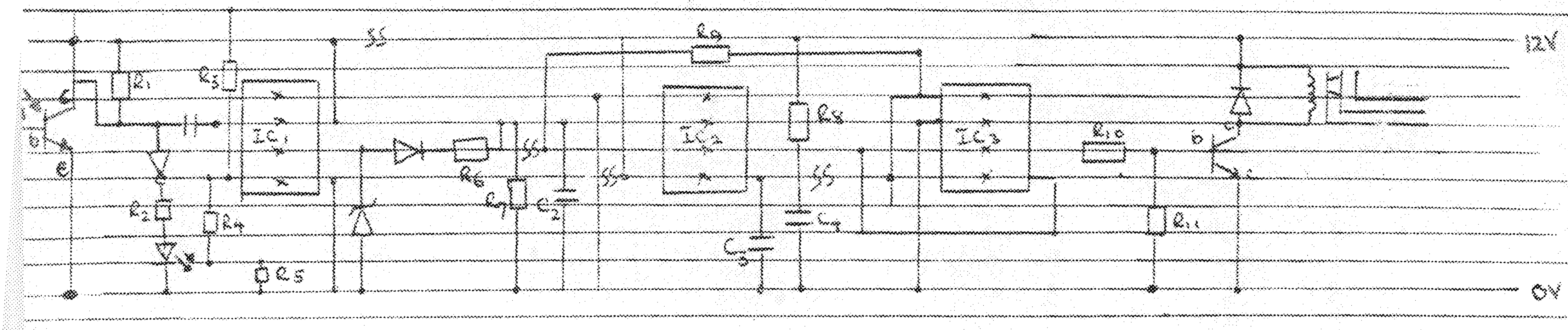
SKETCH SHOWING CONTROLS/INDICATORS ON CASING OF THE RECEIVING MODULE.



SKETCH SHOWING CONTROLS ON CASING OF THE TRANSMITTING MODULE.



CIRCUIT LAYOUT OF TRANSMITTER SECTION.



CIRCUIT LAYOUT OF RECEIVER SECTION.