DESIGN AND CONSTRUCTION OF

555 TIMER LABORATORY KIT

BY

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DEDICATION

I sincerely dedicate this work to the LORD of the Universe WHO HAS always driven one towards his/her destiny, and to my beloved and dear parents: Alhaji Sulaiman Dangana and Mallama Zainab Muhammad.

DECLARATION

I Dangana Muhammad declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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Student

Engr' M.S Ahmad

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Supervisor

30/10/2016

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Signature and Date

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External examiner

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ACKNOWLEDGEMENT

My undying gratitude and all praises to the LORD of the worlds (owner of the day of judgment) for sparing me to a successful completion of this project and my programme as a whole.

My profound gratitude to my dear father (on whose shoulder ALLAH HAS being building me) for all his love, support and advise. I also thank my Ummu (Zainab Muhammad) for her unforgettable advises, prayers and encouragements. My thanks to my beloved step mother (Buzrat Dangana) for her help and advises and to my brothers and sisters (Bintu, Hussaina, Hassana, Hadiza, Abdullahi, Umar and Isah) for their considerations. I love you all, you are all wonderful!

I sincerely appreciate the assistance rendered by my able supervisor, Engr. M. S. Ahmad, for out of his busy academic schedule, took time to monitor my project and whose adivse helped a great deal.

ABSTRACT

This project is an experiment kit design to illustrate the properties and uses of 555 Timer. The kit is design for easy and accessibility.

Various experiments involving the uses of 555 Timer in the circuits are described. The experiments can be performed independently of each other and gives the user the opportunity to do some individual circuit connections, to achieve desired results.

The theory of operation of this Integrated circuit is analysed after an introduction of the nature of the IC. Design and construction were done at minimal cost.

Further circuit examples or experiments were later suggested for practice. It is hoped that this thesis will assist in the efficient use of this device.

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CHAPTER ONE

1.0 General Introduction

1.1 Introduction

This project work, a laboratory kit working on 555 Timer, is basicallydesign to be an educative device in illustrating the various uses of 555 timers. This device is mostly regarded as the basic building block of most linear and non- linear circuits used in oscillators, voltage regulators, multivibrators etc.

The 555 Timer is one of the most remarkable integrated circuit ever developed. It usually comes in a single or dual package and even low power CMOS versions exist – ICLM755. Philips components and semiconductors Australia [1] described their 555 monolithic timing circuit as a " highly stable controller capable of providing accurate time delays, or oscillations.

The 555 Timer has some unique advantages and capabilities, such as: low – price, wild range of operating voltage (5 to 15V), the capacity to drive " high" currents, the ability of being reset by small currents and the design to be used as an astable or multivibrator.

1.2 PROJECT OBJECTIVES

The versatile use of 555 Timer in various applications in control systems and signal display systems necessitated the need for the design of an experimental kit to illustrate the basic properties and uses. This is a useful educative kit that is that is developed at moderate cost.

Due to inadequate understanding of students to courses like Analogue Electronics II, Digital Communication etc, this was design to provide learning aid to students, teaching aid to lecturers, designing engineers and scientists on various ways 555 Timer can be configured to achieve a desired output. Various configurations are described through the analysed experiments illustrated later in the text.

It is hoped that through a careful study of the theory, design and the performance of the described experiments in this text, the reader will be familiar with the properties of this device and it significance in the modern electronics.

In Nigeria, use of this device in institutions especially in universities and polytechnics are on the increase as more of design and construction of electronic systems are being carried out, thus the need for a solid foundation. This is hoped to be achieved through the use of this kit in its experimental illustrations.

1.4 PROJECT LAYOUT

The laboratory kit is an educative device in which students and lecturers will have the opportunity of designing their own experiments and performing the illustrated ones. This thesis outlines the theory, design, construction and testing of a laboratory kit operating on 555 timer.

Chapter one gives the general introduction, project objective and project layout. Chapter two discusses the theory of operation, various design step and power supply . Chapter three illustrate the construction procedures as related to the power supply and circuit relating to described experiments and testing of the whole kit. Chapter four is used to discuss the various results obtained from experiments carried out and describes further suggested experiments. Chapter five summarizes the contents of the thesis in a concluding form, stating constraints that limits the scope of the project and recommends future development possibilities.

CHAPTER TWO

2.0 LITERATURE REVIEW

Many laboratory kits projects have been carried out in the past to illustrate the basic properties and operations of some basic components or devices. These devices include: CMOS, TTL, Op – Amps etc. they are usually constructed (laboratory kit) to contain two or more of these devices. This has resulted into inadequate analysis of these devices which provide insufficient understanding of these devices and in turn do not solve the basic problem of providing solid foundation for the ever growing design and construction of electronic systems.

In contrary, this project work provides full analysis and illustration of the properties and functions of 555 Timer only. In other words, this project attempts to analyse mainly the 555 Timer as a basic electronic device in order to provide solid foundation for the design and construction of electronic systems.

The analysis and experimental illustrations on the usefulness of 555 timer can never be overemphasized due to the major role they play in analogue and digital circuit. The 555 timer IC was first introduced around 1971 by the Signetics Corporation as the SE555/NE555 and was called "**The IC Time Machine**" and was also the very first and only commercial timer IC available. It provided circuit designers with a relatively cheap, stable, and user-friendly integrated circuit for both monostable and astable applications. Since this device was first made commercially available, a myriad of novel and unique circuits have been developed and presented in several trade, professional, and hobby publications. The past ten years some manufacturers stopped making these timers

because of competition or other reasons. Yet other companies, like NITE (a subdivision of Philips) picked up where some left off.

Although these days the CMOS version of this IC, like the Motorola MC1455, is mostly used, the regular type is still available, however there have been many improvements and variations in the circuitry. But all types are pin-for-pin plug compatible.

This project have examined in detail along with its uses, either by itself or in combination with other solid state devices. This timer uses a maze of transistors, diodes and resistors and for this complex reason a more simplified (but accurate) block diagram is used to explain the internal organizations of the 555.

2.1 THEORITICAL BACKGROUND

2.1.1 INTRODUCTION

The 8-pin 555 timer must be one of the most useful chips ever made and it is used in many projects. With just a few external components it can be used to build many circuits, not all of them involve timing!

Although the 555 timer is an extremely versatile integrated circuit and can be used to build lots of different circuits, the structure and internal configuration of the 555 timer determine how appropriate they could be used in circuits.

The applications of 555 timer can not be overemphasized these include: precision timing, pulse generation, sequential timing, time delay generation and pulse width modulation (PWM).

2.2 STRUCTION OF A 555 TIMER

As earlier defined, timer are devices design to generate adjustable delays.

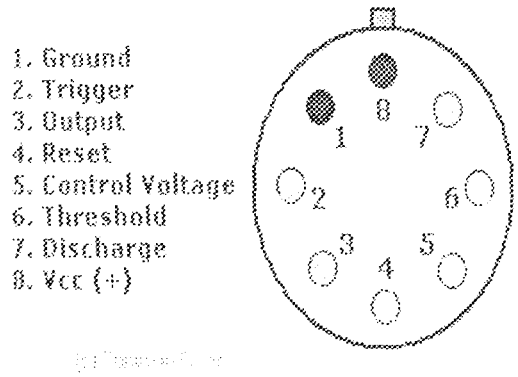

fig. 1. 8-pin T package

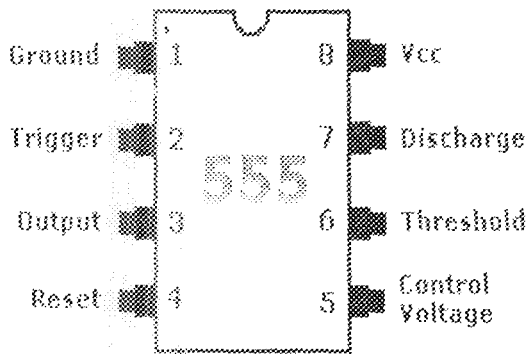

fig. 2. 8-pin V package

The 555, in fig. 1 and fig. 2 above, comes in two packages, either the round metal-can called the 'T' package or the more familiar 8-pin DIP 'V' package. About 20-years ago the metal-can type was pretty much the standard (SE/NE types). The 556 timer is a dual 555 version and comes in a 14-pin DIP package, the 558 is a quad version with four 555's also in a 14 pin DIP case.

Inside the timer as shown below, are the equivalent of over 20 transistors, 15 resistors and 2 diodes, depending on the manufacturers. The equivalent circuit in block diagram, providing the functions of control, triggering, level sensing or comparison, discharge and power output. Some of the more attractive features of the 555 timer are: Supply voltage between 4.5 and 18 volt, supply current of 3 to 6mA, and a Rise/Fall time of 10sec. It can also withstand quite a bit of abuse.

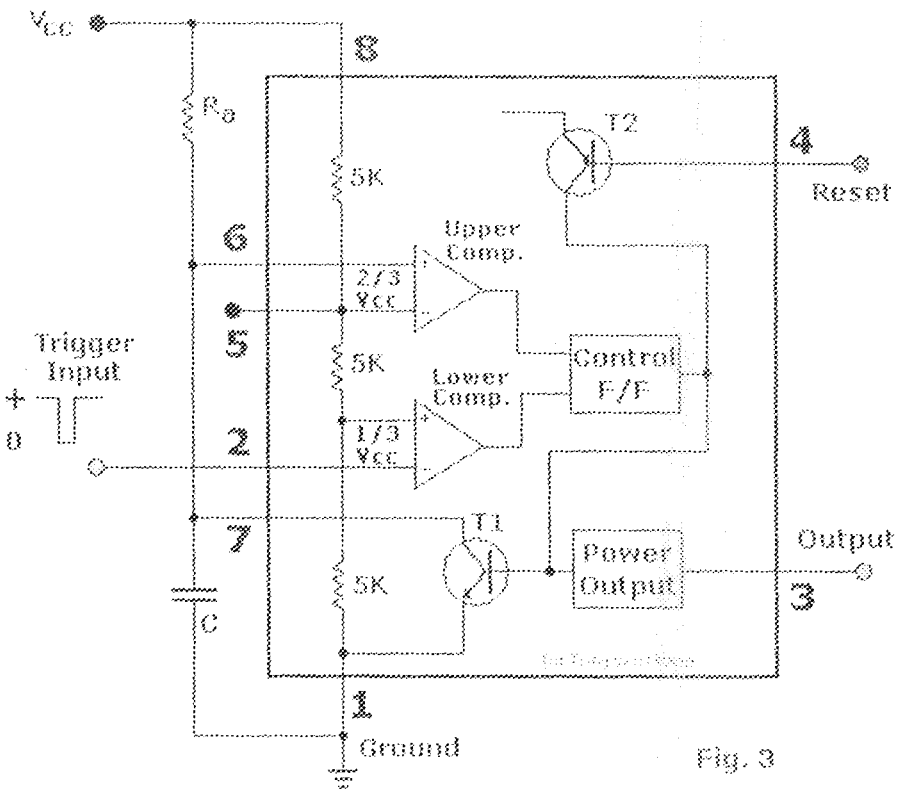

Fig. 3

Internal structure of a 555 Timer

The threshold current determine the maximum value of Ra and Rb. For 15V operation the maximum total resistance R (Ra + Rb) is 20M Ohms.

The supply current, when the output is 'high', is typically 1 milli-amp (mA) or less. The initial monostable timing accuracy is typically within 1% of its calculated value, and exhibits negligible (0.1%/V) drift with supply voltage. Thus long-term supply variations can be ignored, and the temperature variation is only 50ppm/°C (0.005%/°C).

All IC timers rely upon an external capacitor to determine the off-on time intervals of the output pulses. It takes a finite period of time for a capacitor (C) to charge

or discharge through a resistor (R). Those times are clearly defined and can be calculated given the values of resistance and capacitance.

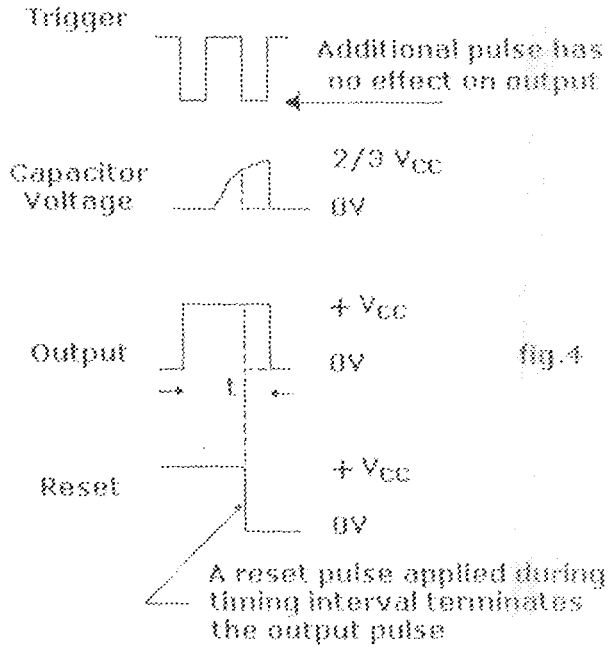

fig.4

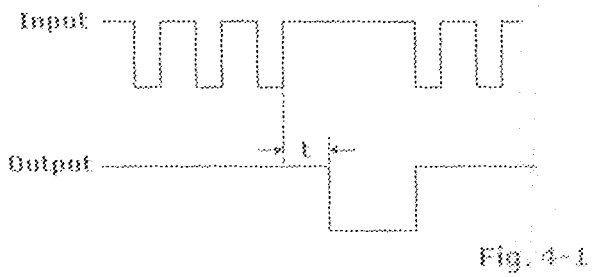

Fig. 4-1

555 Timer graphical representations

The basic RC charging circuit is shown in fig. 4. Assume that the capacitor is initially

discharged. When the switch is closed, the capacitor begins to charge through the resistor. The voltage across the capacitor rises from zero up to the value of the applied DC

voltage. The charge curve for the circuit is shown in fig. 6. The time that it takes for the capacitor to charge to 63.7% of the applied voltage is known as the time constant (t). That time can be calculated with the simple expression:

$$t = R \times C$$

Assume a resistor value of 1 MΩ and a capacitor value of 1uF. The time constant in that case is:

$$t = 1{,}000{,}000 \times 0.000001 = 1 \text{ second}$$

Assume further that the applied voltage is 6 volts. That means that it will take one time constant for the voltage across the capacitor to reach 63.2% of the applied voltage. Therefore, the capacitor charges to approximately 3.8 volts in one second.

In figure 2.5, change in the input pulse frequency allows completion of the timing cycle. As a general rule, the monostable "ON" time is set approximately one third longer than the expected time between triggering pulses. Such a circuit is also known as a "missing pulse detector".

2.3 DEFINATION OF PIN FUNCTION

Refering to the internal 555 schmatic of figure 2.3;

2.3.1 PIN ONE (GROUND).

The ground (or common) pin is the most-negative supply potential of the device, which is normally connected to circuit common (ground) when operated from positive supply voltages.

2.3.2 PIN TWO (TRIGGER).

This pin is the input to the lower comparator and is used to set the latch, which in turn causes the output to go high. This is the beginning of the timing sequence in monostable operation. Triggering is accomplished by taking the pin from above to below a voltage level of 1/3 V+ (or, in general, one-half the voltage appearing at pin 5). The action of the trigger input is level-sensitive, allowing slow rate-of-change waveforms, as well as pulses, to be used as trigger sources. The trigger pulse must be of shorter duration than the time interval determined by the external R and C. If this pin is held low longer than that, the output will remain high until the trigger input is driven high again. One precaution that should be observed with the trigger input signal is that it must not remain lower than 1/3 V+ for a period of time *longer* than the timing cycle. If this is allowed to happen, the timer will retrigger itself upon termination of the first output pulse. Thus, when the timer is driven in the monostable mode with input pulses longer

than the desired output pulse width, the input trigger should effectively be shortened by differentiation.

The minimum-allowable pulse width for triggering is somewhat dependent upon pulse level, but in general if it is greater than the 1uS (micro-Second), triggering will be reliable.

A second precaution with respect to the trigger input concerns storage time in the lower comparator. This portion of the circuit can exhibit normal turn-off delays of several microseconds after triggering; that is, the latch can still have a trigger input for this period of time *after* the trigger pulse. In practice, this means the minimum monostable output pulse width should be in the order of 10uS to prevent possible double triggering due to this effect.

2.3.3 PIN THREE (OUTPUT).

The output of the 555 comes from a high-current totem-pole stage made up of transistors Q20 - Q24. Transistors Q21 and Q22 provide drive for source-type loads, and their Darlington connection provides a high-state output voltage about 1.7 volts less than the V+ supply level used. Transistor Q24 provides current-sinking capability for low-state loads referred to V+ (such as typical TTL inputs). Transistor Q24 has a low saturation voltage, which allows it to interface directly, with good noise margin, when driving current-sinking logic. Exact output saturation levels vary markedly with supply voltage, however, for both high and low states. At a V+ of 5 volts, for instance, the low state Vce(sat) is typically 0.25 volts at 5 mA. Operating at 15 volts, however, it can sink

200mA if an output-low voltage level of 2 volts is allowable (power dissipation should be considered in such a case, of course). High-state level is typically 3.3 volts at V+ = 5 volts; 13.3 volts at V+ = 15 volts. Both the rise and fall times of the output waveform are quite fast, typical switching times being 100nS.

2.3.4 PIN FOUR (RESET).

This pin is also used to reset the latch and return the output to a low state. The reset voltage threshold level is 0.7 volt, and a sink current of 0.1mA from this pin is required to reset the device. These levels are relatively independent of operating V+ level; thus the reset input is TTL compatible for any supply voltage. The reset input is an overriding function; that is, it will force the output to a low state regardless of the state of either of the other inputs. It may thus be used to terminate an output pulse prematurely, to gate oscillations from "on" to "off", etc. Delay time from reset to output is typically on the order of 0.5 µS, and the minimum reset pulse width is 0.5 µS. Neither of these figures is guaranteed, however, and *may vary* from one manufacturer to another. In short, the reset pin is used to reset the flip-flop that controls the state of output pin 3. The pin is activated when a voltage level anywhere between 0 and 0.4 volt is applied to the pin. The reset pin will force the output to go low no matter what state the other inputs to the flip-flop are in. When not used, it is recommended that the reset input be tied to V+ to avoid any possibility of false resetting.

2.3.4 PIN FIVE (CONTROL VOLTAGE).

This pin allows direct access to the 2/3 V+ voltage-divider point, the reference level for the upper comparator. It also allows indirect access to the lower comparator, as there is a 2:1 divider (R8 - R9) from this point to the lower-comparator reference input, Q13. Use of this terminal is the option of the user, but it does allow extreme flexibility by permitting modification of the timing period, resetting of the comparator, etc. When the 555 timer is used in a voltage-controlled mode, its voltage-controlled operation ranges from about 1 volt less than V+ down to within 2 volts of ground (although this is not guaranteed). Voltages can be safely applied outside these limits, but they should be confined within the limits of V+ and ground for reliability.
By applying a voltage to this pin, it is possible to vary the timing of the device independently of the RC network. The control voltage may be varied from 45 to 90% of the Vcc in the monostable mode, making it possible to control the width of the output pulse independently of RC. When it is used in the astable mode, the control voltage can be varied from 1.7V to the full Vcc. Varying the voltage in the astable mode will produce a frequency modulated (FM) output.[6]
In the event the control-voltage pin is not used, it is recommended that it be bypassed, to ground, with a capacitor of about 0.01uF (10nF) for immunity to noise, since it is a comparator input. This fact is not obvious in many 555 circuits since I have seen many circuits with 'no-pin-5' connected to anything, but this is the proper procedure. The small ceramic cap may eliminate false triggering.

2.3.5 PIN SIX (THRESHOLD).

Pin 6 is one input to the upper comparator (the other being pin 5) and is used to reset the latch, which causes the output to go low. Resetting via this terminal is accomplished by taking the terminal from below to above a voltage level of 2/3 V+ (the nonnal voltage on pin 5). The action of the threshold pin is level sensitive, allowing slow rate-of-change waveforms. The voltage range that can safely be applied to the threshold pin is between V+ and ground. A dc current, termed the *threshold* current, must also flow into this terminal from the external circuit. This current is typically 0.1μA, and will define the upper limit of total resistance allowable from pin 6 to V+. For either timing configuration operating at V+ = 5 volts, this resistance is 16 MΩ For 15 volt operation, the maximum value of resistance is 20 M Ohms.

2.3.6 PIN SEVEN (DISCHARGE).

This pin is connected to the open collector of a NPN transistor (Q14), the emitter of which goes to ground, so that when the transistor is turned "on", pin 7 is effectively shorted to ground. Usually the timing capacitor is connected between pin 7 and ground and is discharged when the transistor turns "on". The conduction state of this transistor is identical in timing to that of the output stage. It is "on" (low resistance to ground) when the output is low and "off" (high resistance to ground) when the output is high. In both the monostable and astable time modes, this transistor switch is used to clamp the

appropriate nodes of the timing network to ground. Saturation voltage is typically below 100mV (milli-Volt) for currents of 5 mA or less, and off-state leakage is about 20nA (these parameters are not specified by all manufacturers, however). Maximum collector current is internally limited by design, thereby removing restrictions on capacitor size due to peak pulse-current discharge. In certain applications, this open collector output can be used as an auxiliary output terminal, with current-sinking capability similar to the output (pin 3).

2.3.7 PIN EIGHT (SUPPLY OR POWER).

The V+ pin (also referred to as Vcc) is the positive supply voltage terminal of the 555 timer IC. Supply-voltage operating range for the 555 is +4.5 volts (minimum) to +16 volts (maximum), and it is specified for operation between +5 volts and + 15 volts. The device will operate essentially the same over this range of voltages without change in timing period. Actually, the most significant operational difference is the output drive capability, which increases for both current and voltage range as the supply voltage is increased. Sensitivity of time interval to supply voltage change is low, typically 0.1% per volt. There are special and military devices available that operate at voltages as high as

V.

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2.4 OPERATING MODES.

The 555 timer has two basic operational modes: one shot and astable. In the one-shot mode, the 555 acts like a monostable multivibrator. A monostable is said to have a single stable state--that is the off state. Whenever it is triggered by an input pulse, the monostable switches to its temporary state. It remains in that state for a period of time determined by an RC network. It then returns to its stable state. In other words, the monostable circuit generates a single pulse of a fixed time duration each time it receives and input trigger pulse. Thus the name one-shot. One-shot multivibrators are used for turning some circuit or external component on or off for a specific length of time. It is also used to generate delays. When multiple one-shots are cascaded, a variety of sequential timing pulses can be generated. Those pulses will allow you to time and sequence a number of related operations.

The other basic operational mode of the 555 is as and astable multivibrator. An astable multivibrator is simply and oscillator. The astable multivibrator generates a continuous stream of rectangular off-on pulses that switch between two voltage levels. The frequency of the pulses and their duty cycle are dependent upon the RC network values.

2.4.0 MONOSTABLE MODE

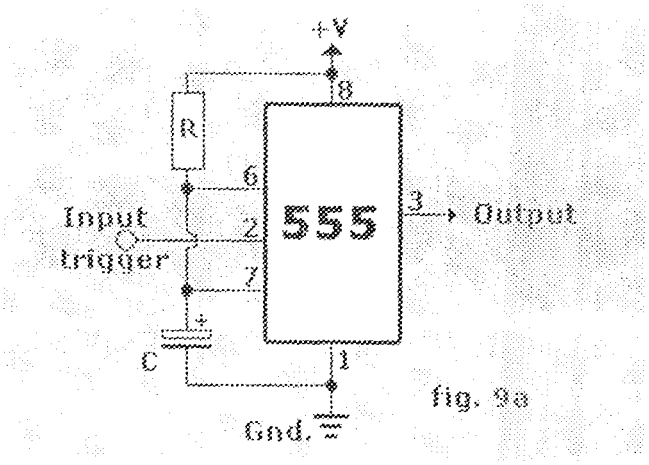


fig. 9a

Monostable mode

The 555 in the above figure is shown in it's utmost basic mode of operation; as a triggered monostable. One immediate observation is the extreme simplicity of this circuit. Only two components to make up a timer, a capacitor and a resistor. And for noise immunity maybe a capacitor on pin 5. Due to the internal latching mechanism of the 555, the timer will always time-out once triggered, regardless of any subsequent noise (such as bounce) on the input trigger (pin 2). This is a great asset in interfacing the 555 with noisy sources. Just in case you don't know what *'bounce'* is: bounce is a type of fast, short term noise caused by a switch, relay, etc. and then picked up by the input pin.

The trigger input is initially high (about 1/3 of +V). When a negative-going trigger pulse

is applied to the trigger input (see fig. 9a), the threshold on the lower comparator is exceeded. The lower comparator, therefore, sets the flip-flop. That causes T1 to cut off,

acting as an open circuit. The setting of the flip-flop also causes a positive-going output level which is the beginning of the output timing pulse.

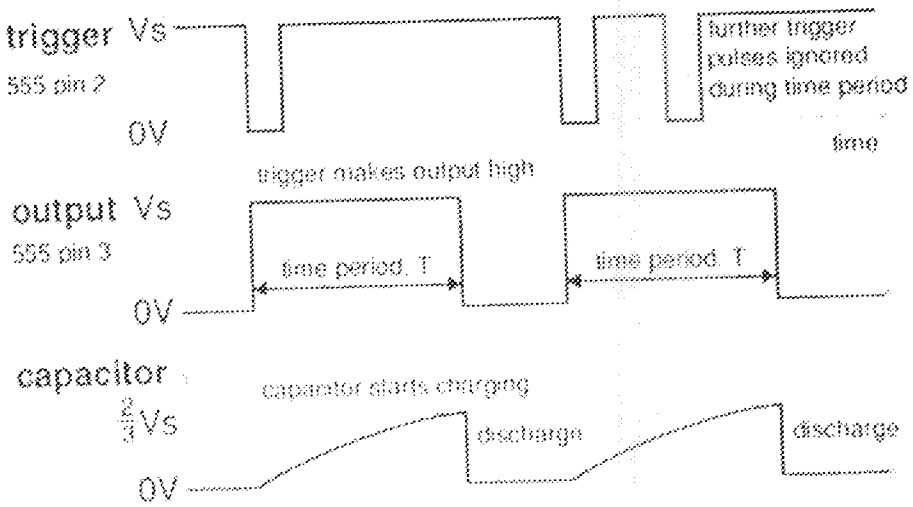
The capacitor now begins to charge through the external resistor. As soon as the charge on the capacitor equal 2/3 of the supply voltage, the upper comparator triggers and resets the control flip-flop. That terminates the output pulse which switches back to zero. At this time, T1 again conducts thereby discharging the capacitor. If a negative-going pulse is applied to the reset input while the output pulse is high, it will be terminated immediately as that pulse will reset the flip-flop. Whenever a trigger pulse is applied to the input, the 555 will generate its single-duration output pulse. Depending upon the values of external resistance and capacitance used, the output timing pulse may be adjusted from approximately one millisecond to as high as on hundred seconds. For time intervals less than approximately 1-millisecond, it is recommended that standard logic one-shots designed for narrow pulses be used instead of a 555 timer. IC timers are normally used where long output pulses are required. In this application, the duration of the output pulse in seconds is approximately equal to:

$$T = 1.1 \times R \times C \text{ (in seconds)}$$

The duration of this pulse width is called **TIME PERIOD.** The maximum reliable time period is about 10 minutes. The factor 1.1 is used because the capacitor charges to two – third = 67% so it a bit longer than the time constant (RC) which is the time taken to charge to 63%.Although the above formula defines the output pulse width, it has relatively few restrictions, timing components R(t) and C(t) can have a wide range

of values. There is actually no theoretical upper limit on T (output pulse width), only practical ones. The lower limit is 10uS. You may consider the range of T to be 10uS to infinity, bounded only by R and C limits. Special R(t) and C(t) techniques allow for timing periods of days, weeks, and even months if so desired.

2.4.1 MONOSTABLE OPERATION.



Graphical representations of monostable operation fig. 2.4.1

The timing period is triggered (started) when the **trigger** input (555 pin 2) is less than $^1/_3$ Vs, this makes the **output** high (+Vs) and the capacitor C1 starts to charge through resistor R1. Once the time period has started further trigger pulses are ignored.

The **threshold** input (555 pin 6) monitors the voltage across C1 and when this reaches $^2/_3$ Vs the time period is over and the **output** becomes low. At the same time **discharge** (555 pin 7) is connected to 0V, discharging the capacitor ready for the next trigger.

The reset input (555 pin 4) overrides all other inputs and the timing may be cancelled at any time by connecting reset to 0V, this instantly makes the output low and discharges the capacitor. If the reset function is not required the reset pin should be connected to +Vs.

2.4.2 POWER – ON RESET OR TRIGGER.

It may be useful to ensure that a monostable circuit is reset or triggered automatically when the power supply is connected or switched on. This is achieved by using a capacitor instead of (or in addition to) a push switch as shown in the diagram.

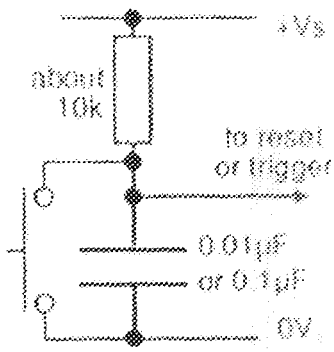


Fig 2.4.2 Power on- reset

The capacitor takes a short time to charge, briefly holding the input close to 0V when the circuit is switched on. A switch may be connected in parallel with the capacitor if manual operation is also required.

2.4.3 EDGE – TRIGGERING.

If the trigger input is still less than $^1/_3$ Vs at the end of the time period the output will remain high until the trigger is greater than $^1/_3$ Vs. This situation can occur if the input signal is from an on-off switch or sensor.

The monostable can be made **edge triggered**, responding only to **changes** of an input signal, by connecting the trigger signal through a capacitor to the trigger input. The capacitor passes sudden changes (AC) but blocks a constant (DC) signal. For further information please see the page on capacitance. The circuit is 'negative edge triggered' because it responds to a sudden fall in the input signal.

The resistor between the trigger (555 pin 2) and +Vs ensures that the trigger is normally high (+Vs).

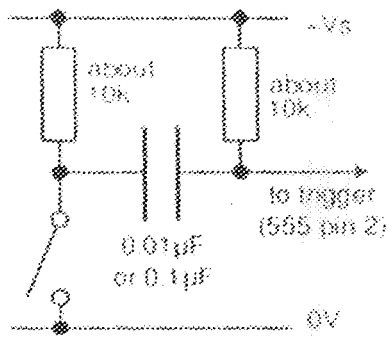


Fig 2.4.3 Edge triggering

2.5 SELECTION OF EXTERNAL COMPONENTS FOR MONOSTABLE OPERATION.

Although special R and C technique allows for timing periods of days, weeks and even months, however, a reasonable lower limit for R(t) is in the order of about 10Kilo ohm, mainly from the standpoint of power economy. (Although R(t) can be lower that 10K without harm, there is no need for this from the standpoint of achieving a short pulse width.) A practical minimum for C(t) is about 95pF; below this the stray effects of capacitance become noticeable, limiting accuracy and predictability. Since it is obvious that the product of these two minimums yields a T that is less the 10uS, there is much flexibility in the selection of R(t) and C(t). Usually C(t) is selected first to minimize size (and expense); then R(t) is chosen.

The upper limit for R(t) is in the order of about 15 MΩ but should be less than this if all the accuracy of which the 555 is capable is to be achieved. The absolute upper limit of R(t) is determined by the threshold current plus the discharge leakage when the operating voltage is +5 volt. For example, with a threshold plus leakage current of 120nA, this gives a maximum value of 14MΩ for R(t) (very optimistic value). Also, if the C(t) leakage current is such that the sum of the threshold current and the leakage current is in excess of 120 nA the circuit will never time-out because the upper threshold voltage will not be reached. Therefore, it is good practice to select a value for R(t) so that, with a voltage drop of 1/3 V+ across it, the value should be 100 times more, if practical.

So, it should be obvious that the real limit to be placed on C(t) is its leakage, not it's capacitance value, since larger-value capacitors have higher leakages as a fact of life. Low-leakage types, like tantalum or NPO, are available and preferred for long timing periods. Sometimes input trigger source conditions can exist that will necessitate some type of signal conditioning to ensure compatibility with the triggering requirements of the 555. This can be achieved by adding another capacitor, one or two resistors and a small signal diode to the input to form a pulse differentiator to shorten the input trigger pulse to a width less than 10uS (in general, less than T). Their values and criterion are not critical; the main one is that the width of the resulting differentiated pulse (after C) should be *less* than the desired output pulse for the period of time it is below the 1/3 V+ trigger level.

2.6 ASTABLE MODE

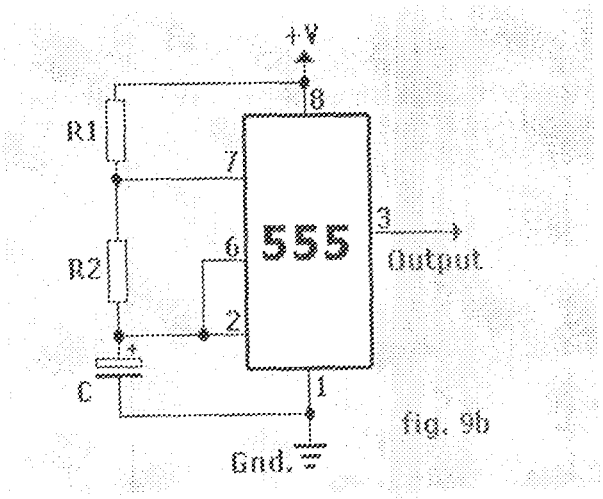


Fig 2.6.1 Astable mode

The above figure shows the 555 connected as an astable multivibrator. Both the trigger and threshold inputs (pins 2 and 6) to the two comparators are connected together and to the external capacitor. The capacitor charges toward the supply voltage through the two resistors, R1 and R2. The discharge pin (7) connected to the internal transistor is connected to the junction of those two resistors.

However, an astable circuit produces a 'square wave', this is a digital waveform with sharp transitions between low (0V) and high (+Vs). Note that the durations of the low and high states may be different. The circuit is called an astable because it is not stable in any state: the output is continually changing between 'low' and 'high'. The TIME PERIOD of the square wave is the time for one complete cycle, but it is usually better to consider frequency (*f*) which is the number of cycles per second.

The **frequency**, or **repetition rate**, of the output pulses is determined by the values of two resistors, *R1* and *R2* and by the timing capacitor, *C*.

The **design formula** for the frequency of the pulses is:

$$f = \frac{1.44}{(R1 + 2R2) \times C}$$

The HIGH and LOW times of each pulse can be calculated from:

$$\text{HIGH time} = 0.693(R1 + R2)C$$

$$\text{LOW time} = 0.693(R2)C$$

The **duty cycle** of the waveform, usually expressed as a percentage, is given by:

$$\text{duty cycle} = \frac{\text{HIGH time}}{\text{pulse period time}}$$

An alternative measurement of HIGH and LOW times is the **mark space ratio**:

$$\text{mark space ratio} = \frac{\text{HIGH time}}{\text{LOW time}}$$

Before calculating a frequency, you should know that it is usual to make $R1$=1 kΩ because this helps to give the output pulses a duty cycle close to 50%, that is, the HIGH and LOW times of the pulses are approximately equal.

2.6.1 ASTABLE OPERATION.

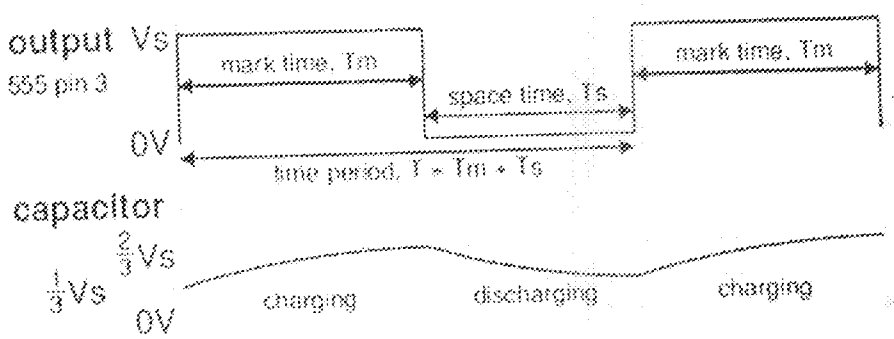


Fig 2.6.2 graphical representations of Astable operation

When power is first applied to the circuit, the capacitor will be uncharged, therefore, both the trigger and threshold inputs will be near zero volts (see Fig. 10). The lower comparator sets the control flip-flop causing the output to switch high. That also turns off transistor T1. That allows the capacitor to begin charging through R1 and R2. As soon as the charge on the capacitor reaches 2/3 of the supply voltage, the upper comparator will trigger causing the flip-flop to reset. That causes the output to switch low. Transistor T1 also conducts. The effect of T1 conducting causes resistor R2 to be connected across the external capacitor. Resistor R2 is effectively connected to ground through internal transistor T1. The result of that is that the capacitor now begins to discharge through R2.

As soon as the voltage across the capacitor reaches 1/3 of the supply voltage, the lower comparator is triggered. That again causes the control flip-flop to set and the output to go high. Transistor T1 cuts off and again the capacitor begins to charge. That cycle continues to repeat with the capacitor alternately charging and discharging, as the comparators cause the flip-flop to be repeatedly set and reset. The resulting output is a continuous stream of rectangular pulses.

Although the time intervals for the on and off portions of the output depend upon the values of R1 and R2. The ratio of the time duration when the output pulse is high to the total period is known as the duty-cycle as stated earlier. The duty-cycle can be calculated with the formula:

$$D = t1/t = (R1 + R2) / (R1 + 2R2)$$

The duty-cycle can be adjusted by varying the values of R1 and R2.

2.7 SELECTION OF EXTERNAL COMPONENTS FOR ASTABLE OPERATION.

R1 and R2 should be in the range 1kΩ to 1MΩ. It is best to choose C1 first because capacitors are available in just a few values. Capacitor C1 should be chosen to suit the frequency range you require. R2 should be chosen to give the frequency (f) you require. Assume that R1 is much smaller than R2. Then R2 =(0.7)/FC1.

R1 should also be chosen to be about a tenth of R2 (1kΩ min.) unless if the mark time Tm is wanted to be significantly longer than the space time Ts.

If you wish to use a **variable resistor** it is best to make it R2.

If variable resistor is used, then it should bemade equal to R2.

CHAPTER THREE

3.0 DESIGN OF LABORATORY KIT OPERATING IN 555 TIMER.

The design of this kit is based on the analyzed theoretical consideration of 555 timer and also their practical considerations. Since the kit will be used in the laboratory for practical illustrations, the choice of components are made flexible for good illustrations and provisions are made for easy replacement of faulty components. The power unit which is to supply a constant 12Vdc to the 555 timer is permanently connected to resist variations and short in supply.

3.1 DESIGN OF AN ASTABLE MULTIVIBRATOR.

In this design a careful selection of components were made to facilitate flexibility. As shown below.

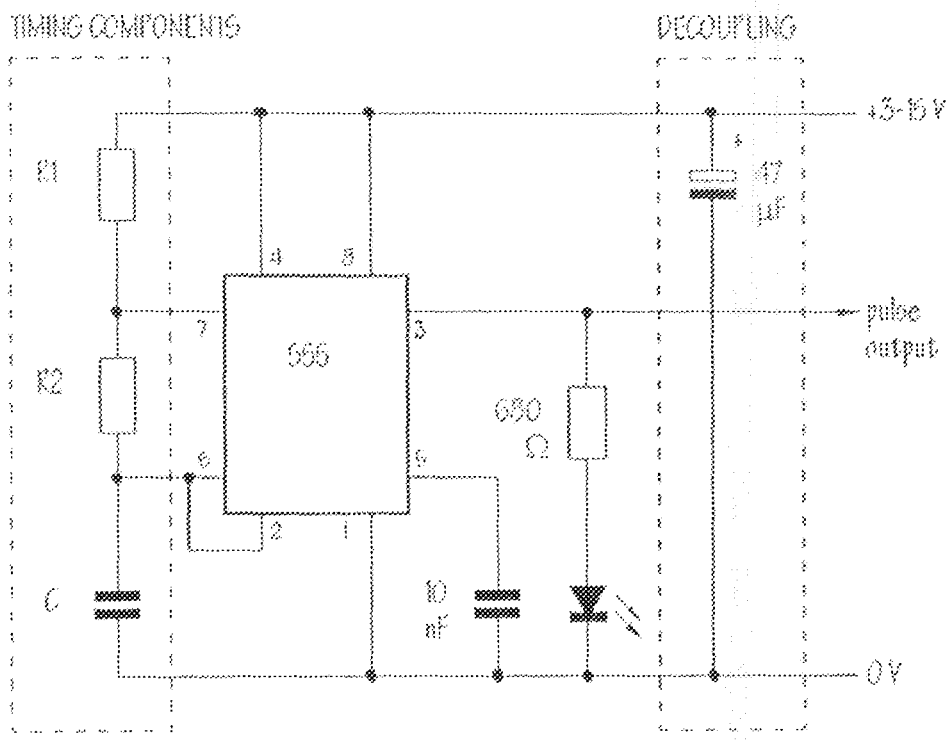


Fig 3.1.1 A Multivibrator

In the diagram above, resistor R1 and R2 and capacitor C form the timing circuit. When power is applied to the circuit via pin 8, the trigger and the threshold are below 1/3 Vcc and timing capacitor starts to charge up towards Vcc and the output will be high. At the end of this period, the voltage on the capacitor would have reached 2/3 of the supply and the upper comparator in the 555 timer will trigger the internal flip – flop which facilitates the discharge of the capacitor through R2 only. The discharge time T2 = 0.693 R2C.

This time will last until the capacitor voltage falls to 1/3 Vcc. The connection of the trigger pin 2 to threshold pin 6 automatically retriggers the timer and process starts again. Note that subsequent time to charge the capacitor will be less because the

charging starts from 1/3 Vcc and not zero. Thus the time taken for subsequent capacitor charging period T3 = 0.693 (R1 + 2R2)C.

Invariably the total time taken to complete one charging and discharging cycles T = T2 + T3. T = 0.693(R1 + 2R2).

The frequency of oscillation can be determine from the reciprocal of the period, T.

F = 1/T = 1.44 / (R1 + 2R2)C.

Since the capacitor discharges through R2, a resistor with large resistance value was chosen for R2 and a small value for R1. A variable resistor can also be used as R1. This is to vary the pulse duration as varying the value of R1 in turn vary the pulse duration.

Also, the duty cycle ("ON" time divided by the total cycle time) may be precisely set by the ratio of the resistors. As R1 decreases the duty cycle approaches (but never reach) 50%. Resistors 24K Ohms and 12K Ohms were chosen for R2 and R1 respectively. Capacitor of 100uF was used and this gave a period of 4.16 sec as calculated using the eafier stated formula. That is, the period was determined for the relationship T = 0.693 (R1 + 2R2)C

T = 0.693(100E-6 * 12E3 + 2 * 24E3)

T = 4.16 Sec.

Frequency of waveform generated = 1/T

F = 1/ 4.16

F = 240mHz.

The duty ratio was determine from the relationship

D = R2/ (R1 + 2R2)

D = 0.8

The output waveform will be high for a duration of :

Output High = 0.693 (R1 + 2R2) = 2.45 Sec.

While Output Low = 0.693 R2C = 1.71sec.

The purpose of the resistor 680 ohms is to limit the current through the LED in order to prevent it from being damaged by drawing too much current and overheating. A small capacitor of 10nF is used to suppress extraneous noises. And big electrolytic capacitor of 47uF is used to decouple the power supply as the current drawn change from 1m Amp. or less to 100m Amp or more. Other values of resistors are placed on board to facilitate a wide range of waveform with varying period s and frequency.

3.2 DESIGN OF MONOSTABLE MULTIVIBRATOR.

A monostable circuit produces a single output pulse when triggered . It is called a monostable because it is stable in just one state: ` Output Low'. The output high state is

temporary. Monostabble operation of multivibrators require an input trigger through a switch or a pulse .[4].

As earlier analyzed in the theory, the timing of the generated waveform are dependant on the values of R and C. These two components were chosen such that a period of 1.1 sec. will be achieved for the waveform generated. The relationship below defines the period of oscillation.

$T = 1.1\ RC$

For a capacitor of 100uF, the value of resistor R used was calculated from:

$R = T / 1.1\ C = 100$ K Ohms.

The next shows the configuration that give a period of 1.1 sec.

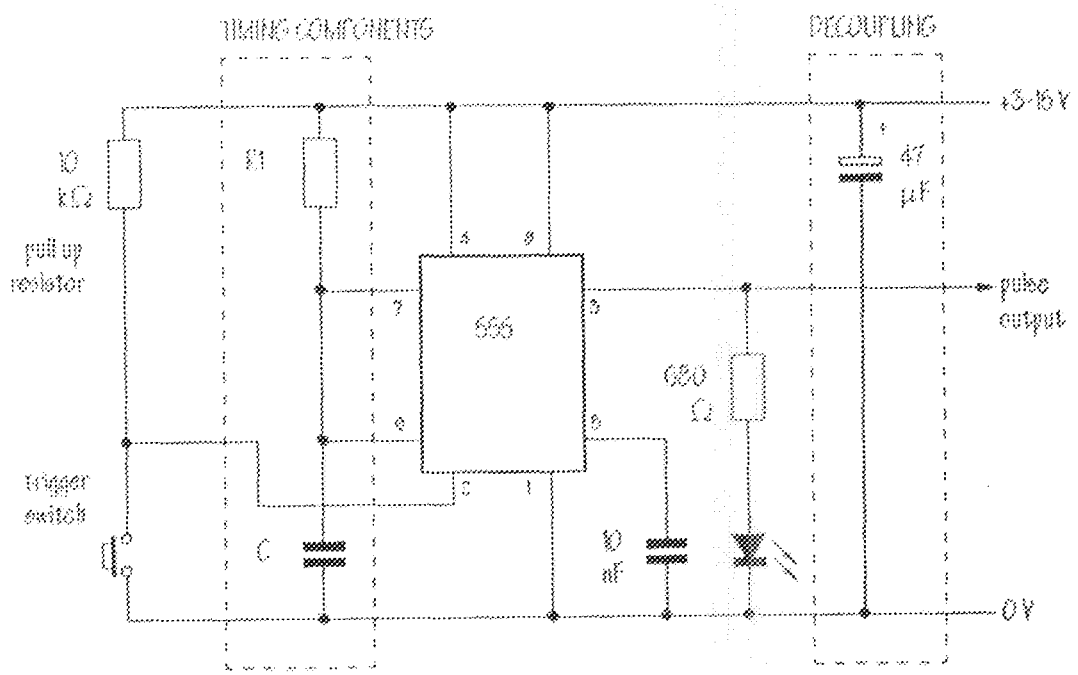


Fig 3.1.2 Astable Multivibrator

On switching the power supply on, the output is low and the LED is off. At this point the voltage across C is discharge through the internal transistor of the 555 timer. The monostable vibrator is triggered by momentarily pressing a push – to – make, relesed – to – open switch S. This action open the internal switch of the 555 timer and at the same time makes the output to go high. The LED lights and capacitor C begins to charge through resistor R1. The LED remains lit until the voltage across C reaches 2 /3 Vcc, which pin 3 senses. At this instance the internal switch of the 555 timer closes. C is instantly discharge through pin 7, the output goes low and the LED switches off, awaiting another trigger pulse. [5]

3.3 DESIGN OF POWER SUPPLY UNIT.

Most 555 timer are mostly biased with positive voltage. Manufacturers power specifications for 555 timer ranges from +4.5 (minimum) to 16V (maximum). The device will operate essentially the same over these range of voltages without change in timing period. Actually, the most significant operational difference in output drive capability, which increase for both current and voltage range as the supply voltage is increase. Sensitivity of time interval to supply voltage change is low, typically 0.1% per volt. There are special and military devices available that operate at voltages as high as 18V. With the diagram shown below (power supply designed for the kit), the unit is divided into three sections: the transformer section, the rectifier section, and the filtering section. Against a more efficient albeit, more complex design attractive found in the switching power supply, a linear power supply is used for making regulated dc available to components from utility supplied ac. The utility supply (PHCN) is fed straight to the primary of the transformer which steps the supply voltage down to 12Vac. A center tapped transformer is used to expedite the ease of realization of both negative and positive dc voltage levels.

The rectifying section convert the ac input into pulsating waveform with both ac and dc components. This is done from the arrangement of the four diodes D1, D2, D3 and D4 as shown in the figure. Two opposite diodes conduct at different half cycle of input sinusoid. This result in a pulsating waveform output.

The pulsating waveform goes into the filtering circuit where the ace components are filtered with the aid of well selected capacitors. The output from the filtering circuit, now – 12 Vdc into the 12V regulator which now regulate the voltage into steady 12 Volts.

The half wave rectifier was not due to it s considerable variations and is indeed zero for half the time. Such waveforms are more suitable for simple applications like battery charging as the variations will appear as noise at the output.

3.4 PLACEMENT OF COMPONENTS

It can be rightly said that the durability of this kit depends to a large extent on the method used in fixing components and devices on the board. Bearing in mind that this kit will be used by lecturers and students, a simple, cheap and effective method of holding components and devices are used. All components and devices are glued on the board via electrical connectors.

The first step used in the placement of components was to arrange all similar components and device at the same side. This resulted into fixed resistor section, capacitor section, variable resistor section, LED section , diodes section, transistor section, switch section, load speaker section, zener diode section and power supply unit. The device were fixed on board via IC sockets with protruding well soldered unbridged legs, which all leads into the connectors.

The power unit has its transformer firmly screwed on board to the bottom right hand side with the 12V terminal sideways to the 555 timers. All other networks were also carefully glued on board via connector which makes it easy to connect or disconnect experimental wires as desired by just unscrewing the other end of the connector and the component is linked to the circuit.

3.5 LEBELLING AND NOTATION

The lebelling method used in this design enables the user to do a bit of circuit component tracing and devices are not directly lebelled on board but rather, a detailed scaled diagram of the components layout was neatly lebelled and provided or made available in the kit. Also circuits which can be built using the 555 timer and the provided components are drawn and posted on the inside of the cover of the kit. All the user need to do is to look at the diagram and trace on the board to connect desired circuit.

CHAPTER FOUR

4.0 INTRODUCTION

The laboratory kit is constructed out of wood which measures 45 cm by 50 cm. The board was clearly marked and demarcated for placement of various components. These components can be connected in quite a number of ways to illustrate various experiments involving 555 timer. Considering the nature of experiments to be carried out using this kit, it has been designed to be reliable and efficient. It portable size makes it readily available foe use in laboratories, classroom and offices.

All the electronic components and devices supplied on the kit were the outcome of carefully selection after making a diligent survey and analysis of general uses, experimental circuits and application of 555 timer. It is important to note here that it is not practicable to build a single kit like this that will accommodate all experiment relating to 555 timer. The components on this kit were selected over a wide range of 555 Timer circuit and optimized. It is this inevitable limitation that led to the provision of spaces for components that may be needed but not mounted on board.

4.1 GENERAL CONSIDERATIONS WITH USING 555 TIMER.

Most devices will operate down to as low as 3V DC supply voltage. However, correct supply filtering and bypassing is critical, a capacitor between 0.01uF to 10nF (depending upon the application) should be placed as closed as possible to the 555 supply pin. Owning to internal design considerations the 555 can generate large current spikes on the supply line.

While 555 will operate up to about 1MHz , it is generally recommended it not be used beyond 500KHz owning to temperature stability considerations. Owning to low leakage capacitor consideration limits maximum timing periods to no more than 30 minutes.

While selecting external components care should be taken in selecting stable resistors and capacitors for timing components in the 555 Timer. Also the data sheet should be consulted to determine maximum and minimum component values which will affect accuracy. Capacitor must be low leakage types with very low dielectric absorption properties. Electrolytic and ceramics are not especially suited to precision timg applications.

4.2 RESULT AND DISCUSSION

After the design, construction and testing, results obtained were not properly observed for documentation. This was due to in availability of a good oscilloscope in the laboratory to test the generated pulses. Instead an analogue multi meter along side a digital multi meter were used to monitor the pulses generated. Although this result could be documented but reliability of the result is paramount.

For the power circuits the output from the regulators were measured and found to fall within the acceptable range. The values are tabulated below:

Table 4.2.1 Results obtained.

Regulator	**Output Obtained**	**Ideal Output**
7912	- 12.26V	+ 12V
7812	+ 11.98V	+ 12V
7802	+ 4.97V	+ 5V

4.3 TIMER APPLICATION.

While these circuits were built, the following points where bone in mind as earlier explained: for proper monostable operation with the 555 Timer, the negative – going trigger pulse width was kept short compared to the desired output pulse width.

Values for the external timing resistor and capacitor can either be determined from the previous formulae. However, one should stay within the ranges of resistances as discuss ealier to avoid the use of large value electrolytic capacitors, since they tend to be leaky. Otherwise, Tantalum or mylar types should be used. (For noise immunity on most timer circuits, a 0.01uF or 10nF capacitor between pin 5 and ground should be used also).

4.3.1 POWER ALARM.

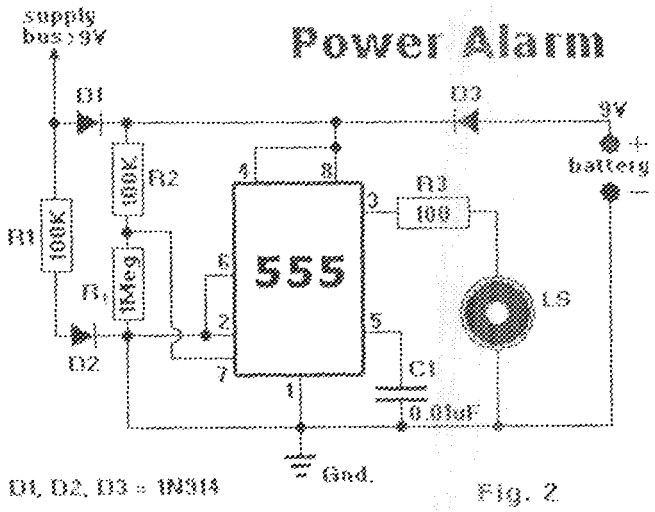


Fig. 2

Power Alarm.

This circuit can be used as a audible 'Power-out Alarm'. It uses the 555 timer as an oscillator biased off by the presence of line-based DC voltage. When the line voltage fails, the bias is removed, and the tone will be heard in the speaker. R1 and C1 provide the DC bias that charges capacitor Ct to over 2/3 voltage, thereby holding the timer output low (as you learned previously). Diode D1 provides DC bias to the timer-supply pin and, optionally, charges a rechargeable 9-volt battery across D2. And when the line power fails, DC is furnished to the timer through D2.

4.3.2 DARK DETECTOR

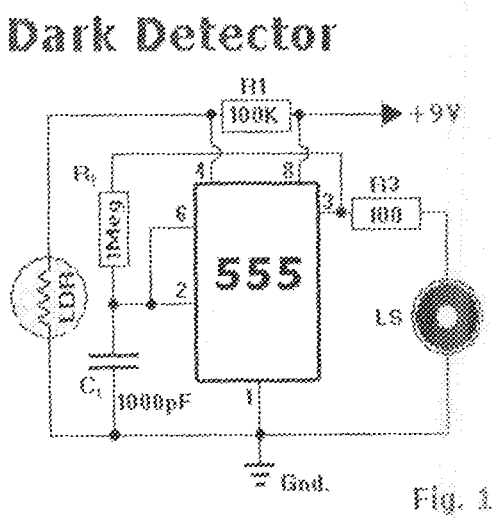


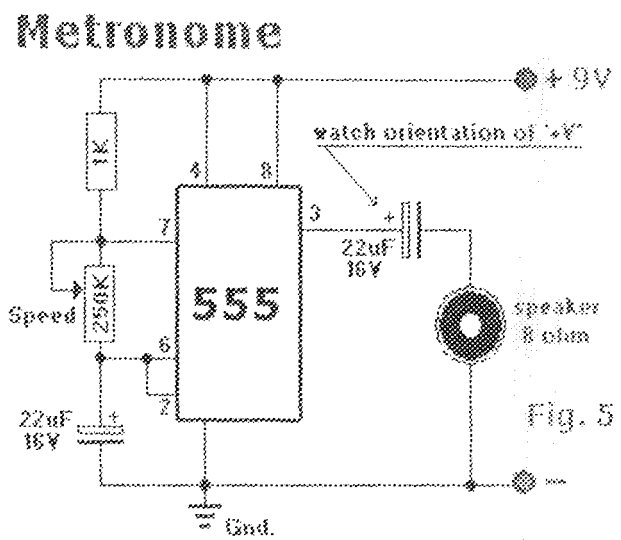
Fig. 1

Dark Detector

It will sound an alarm if it gets too dark all over sudden. For example, this circuit could be used to notify when a lamp (or bulb) burns out. The detector used is a regular

cadmium-sulphide Light Dependent Resistor or *LDR*, for short, to sense the absence of light and to operate a small speaker. The LDR enables the alarm when light falls below a certain level.

4.3.3 METRONOME



Metronome

A Metronome is a device used in the music industry. It indicates the rytme by a 'toc-toc' sound which speed can be adjusted with the 250K potentiometer. Very handy if you are learning to play music and need to keep the correct rhyme up.

This circuit is used to keep recording of telephone conversations legal. As you may know, doing otherwise without consent of the other party is illegal. The output of IC1 is fed to the 2nd 555's pin 3 and made audible via C2 and the speaker. Any 8-ohm speaker will do.

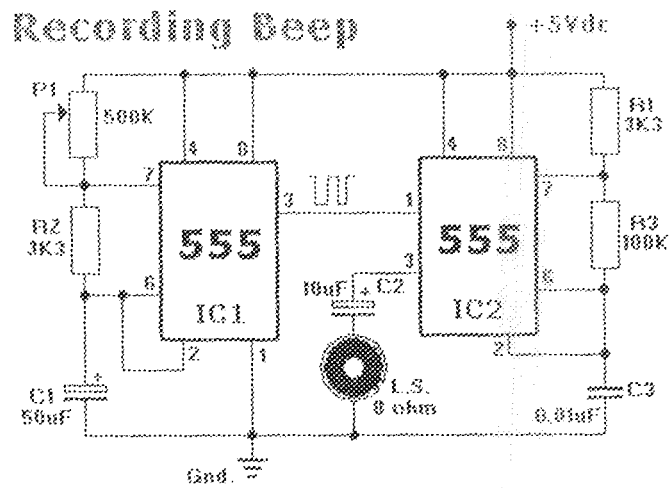


Fig. 12

Recording Beep

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION.

The importance of 555 Timer in electronic application cannot be overemphasized. The design and construction of this kit will greatly simplify the task of designing and experimenting in laboratory for students and engineers.

Although results are needed, some are obtained and recorded but the desired result from the 555 Timer under test cannot be recorded. This was due to the absence of a good oscilloscope to show the real waveform of the generated wave from the Timer.

However, it is evident from the fact that Integrated circuits such as 555 Timer have largely supplanted discrete – device circuits as they are capable of producing oscillating pulses e.t.c.

5.2

RECOMMENDATION

In view of the numerous facilities provided by this kit, especially to students, it is recommended that the department of Electrical and Computer Engineering embarks on construction of more kits. These kits should be equipped with more electronic components and devices to facilitate a wider range of design and experimental analysis.

Adequate and diligent use of this kit will go a long way in helping students and engineers in the design of more electronic circuits.

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