DESIGN, CONSTRUCTION AND

TESTING OF A DIGITAL STOP WATCH

BY

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DEDICATION

This project is dedicated to my Brother and his wife Dr/Mrs. Idongesite Okon Ibok and my entire family members.

DECLALATION

I ODUDU OKON IBOK hare by declare that this project report, design and construction, is the result of my handwork. It was conducted under the supervision of Dr. Tsado in the department of Electrical and Computer Engineering of Federal University of Technology, Minna, Niger State, Nigeria.

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ACKNOWLEDGEMENT

Praise be to Almighty God whom by his infinite mercy spared my life up to this moment and make this project a successful one. My special thanks and appreciate goes to my brother, Dr. Idongesite Okon Ibok and his wife for their moral and financial support rendered on me since the beginning of this programme.

My profound gratitude to my supervisor, Dr. Tsado for his contribution towards the success of the project and first degree programme.

My special thanks goes to my Pastor and other good wishers who in one way or the other have contributed immensely to my successful completion of this programme not forgetting all my friends who have also contributed in different ways during this programme.

ABSTRACT

This project design, construct and test a digital stop watch with range of 0–999 seconds. The design of the stop watch is centered on clock pulse generation, division and counting. It is an interconnection of integrated circuits and logic gates which operate with an A.C voltage of 9v or a 9v D.C battery produced from the output of its power unit. A 555 timer is used as the pulse generator for the frequency unit of the project circuit. The frequency generated was processed via the counter, BCD seven-segment decoder and displayed in the display unit.

The importance of timing to human existence and the need to realize the exact timing of an event has been the motivation for this project and the digital stop watch was made with this principle in mind.

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CHAPTER ONE

1.0. Introduction

With advances in technology, everyone knows that a day is divided into twenty-four (24) hours, each containing sixty (60) minutes of sixty (60) seconds. Until recent years the accurate measurement of time has not been easy. In fact, the entire system of time measurement has grown out of the observation of recurrent events in series to define the basic time interval such as:

- **Short time:** Measured by the use of the human heartbeat as the timing instrument.
- **The day:** depending on the Earth spin
- **The month:** based on the waxing and warring of the moon
- **The year:** based on the recurring season.

With technological advancement, internal mechanism of oscillators such as pendulum in a clock and spring-operated balance wheel in a watch were developed. Clock and watched often indicate the recurring time intervol by means of a set of rotating points driven by some mechanism controlled by an oscillatory device. This device can be regulated so that the time intervals are standardized to degree of precision depending on the type of oscillatory device used.

This report is based on the design, construction and testing of a digital stopwatch with range of 0 to 999 sec.

The stopwatch was operated from an A.C. supply with a small D.C 9v battery that powered a quartz crystal oscillator with square wave output. The D.C 9v battery is provided so that the device can still be useful in an area where there is no A.C. Supply or in event of power outage. This squire wave output is the frequency which is divided down to 1Hz. This was achieved with the use of an Astable Multi-vibrator (555 timer).

1.1. Mode of Operation

To Use: the reset button is pressed to clear the display. Press the start/stop button to start counting in seconds, and on releasing the button, the watch will automatically stop the counting process.

The stopwatch has a sound effect for every count. If the sound is not desired, the sound button is pressed to off the sound and on pressing the button, the sound comes up again if the need arises.

This report consist of five chapter viz:

- Chapter one: An introduction to the report topic
- Chapter two: Literature review
- Chapter three: Analysis of main work
- Chapter four: Material selection, testing and discussion of result
- Chapter five: Conclusion and recommendation for future work.

CHATPER TWO

2.0. Literature Review

Time is defined as the interval between two physical events. Any event which repeats itself in regular interval of time is called a periodic event. We can use periodic event to measure time. [3]

The first device used to record time of the day was stick or pillar driven into the ground, the length of the shadow cast gives an indication of the time of the day.

The time at night or when the sun was observed was recorded by water clocks This is simply by measuring the amount of water escaping from a vessel through a small hole into the other. This method was rendered inaccurate due to the difficulty in regulating the pressure of water outflow.

The Sand glass similar in principle to water clock was developed. The sand glass measured time by means of sand running from one glass vessel through a narrow passage to another marked half and one full hour. [1, 3]

Another clock in use was candle and lamp clocks. This consists of a glass bottle with numbers inscribed by the side containing oil and a small tube and burning. As the oil burnt, the level of the oil in the glass bottle reduced and the time in hour would be indicated with the aid of inscribed number on the side of the bottle.

Construction of mechanical clock, such as our modern ones, began in the 14th century, although there were some primitive versions as early as 200BC. The first mechanical clocks were sound clocks. They had no faces or hands to look at but a bell that rang a number of times each day. More advanced versions of bell clock were driven by a weight attached to a cord that was wrapped around a cylinder. The weight pulled down the cord to ring the bell, such clock were not very regular or efficient. [1, 3].

Pendulum clock: in 1656, Christian Huggen, a Dutch Scientist, built the first pendulum clock; while in 1675, he built another clock powered by a spring that regularly carried and uncoiled [1].

WATCHES: In 1500 AB, Peter Helein made the first watches in Germany. They were elaborate, expensive toys of the rich that kept time quit poorly [1]

2.1. Modern Artificial Clocks

The early clocks were affected by gravity, location, movement, wear and temperature, and they needed constant concentration. A pendulum clock would be of little use in a tossing ship at sea. The movement of such things as a shadow, sand, water, fir, sun and moon are not sufficient to measure the changes of atomic particles or the movement of bodies in outer space. For these purposes, scientist needed a steady and detailed standard that also was affected as little as possible by external influences. They eventually found the answer in atoms themselves. [4, 6]

Scientist determined that the regular, predicable vibration (also called waves, cycles, oscillations and resonations) of certain elements could function as a time standard.

The number of oscillations of the element "Cesium" in one second is 9,192,631,770. In 1967 this number of oscillation was adopted in the international system of unit (SI) as the definition of one second. Years are now officially measured in seconds, which at one time was based on astronomical observation.

The atomic clock is only inaccurate by the second in many thousands of years. This is quite good, but we have not seen the end of clocks. New ones are already being developed, clocks will change with new discoveries and needs. No one clock or watch can meet all the needs of everyone. There is no perfect clock or absolute time [3, 5].

Mover over, the increase in technology dated back to 1937, which led to the development of the digital computer from the work of a small group of practical thinkers like Howard Aiken of Harvard University on the design of a full Automatic Calculating machine in collaboration with International Business Machines Corporation (IBM) and a paper presented by E.J. Mc Dusky in 1973 at New York which he pointed out that between the year 1952 and 1964, the transistor developed at Bell laboratories and its incorporation into digital computing technology has being a great scientific break through. He further stressed that the period 1964 – 1971 witnessed the development of 'integrated circuit'. The development of integrated circuit culminating in the implementation of several logic functions on a single chip and introduction for LSI (large scale integrated) chip in 1970, which witnessed the fourth generation of computing technology ushered into the modern day "Digital watches or clocks" [1,5,6].

The mechanism of the modern watch and clocks varies in design but have certain feature in common viz: power source, regulating mechanism and the time display unit. In most watches and clocks, the time is shown by display of numerals.

Of all the devices used in indicating the time of the day and might, the digital stopwatch is the most accurate of them viz:

- Powered with small D.C battery which make it portable to be used anywhere in the absence of A.C source.
- Use in timing short duration of task such as laboratory experiment. With the use of reset and start/stop button you get the exact time duration as compared with other non-stop watches.

CHAPTER THREE

3.1.0. MAIN WORK DONE (CONSTRUCTION)

3.1. Introduction

The block diagram representation of a digital stop watch is as shown below:

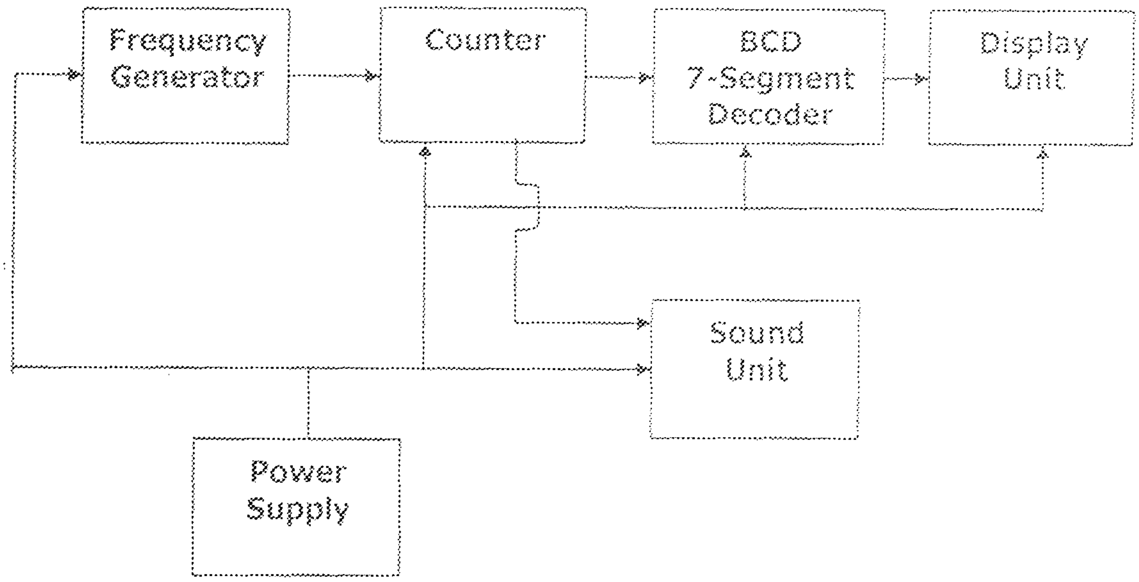


Fig 1: Block Diagram of a digital stop watch

Each block represented above represent a part in the whole circuit. There are six units all together that forms the digital stop watch. Viz:

- Power Supply Unit
- Frequency generator unit
- Counter unit
- BCD -7-segment driver unit
- Display unit
- Sound unit

3.1.1. Power Supply

The Power Supply is made up of:

(i) The main power supply (A.C. Source)

(ii) Alternative power supply (D.C. Source)

The main power supply is used when there is power from the national grid e.g. PHCN, and switches automatically to a 9v battery which is the alternative; this way the battery life is conserved when there is A.C. power supply

The D.C source also make it possible for the stop watch to be used anywhere in the absence of A.C. source.

The power supply is made up of a step down transformer, full wave bridge rectifier, a filtering capacitor, a voltage regulator and a relay for automation. A skeleton circuit is shown below;

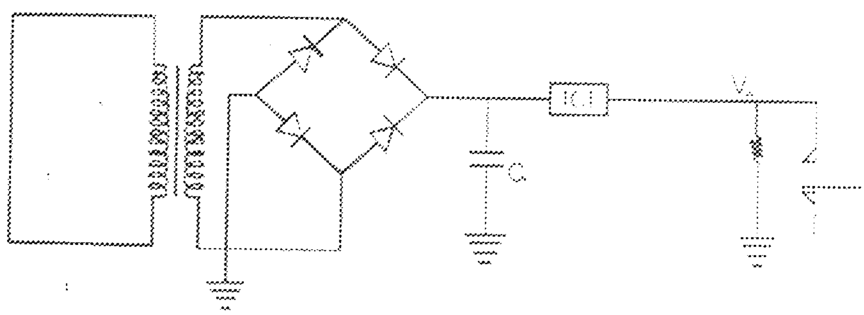


Fig 3.2: A skeleton circuit of the power unit

The supply voltage V+ for the circuit is 9v. Hence, we will require a 9v voltage regulator, which is a 7809 voltage regulator IC. Therefore, IC1 7809 was chosen.

The input voltage to the voltage regulator, 7809, is set at 15V, so that the IC would not get heated up and consequently get damaged.

The full wave bridge rectifier is made up of silicon rectifying diodes, which drops 0.6V. Hence the peak voltage of the transformer is 15V + 0.6V = 15.6V

Therefore $V_{rms} = \frac{V_{peak}}{\sqrt{2}} = \frac{15.6}{\sqrt{2}} = 11.143V.$

Hence, a preferred value of 12V is chosen since there is no transformer value of 11.143V.

Therefore the step down transformer should be a 220V/12V transformer.

For the filtering capacitor C_f, we have

$$I = \frac{Cdv}{dt}$$

$dv = \%\ ripple \times V_{peak} = 20\% \times 15.6 = 3.12v$

$dt = ½\ T = ½\ 1/f = 1/2x50 = 1/100 = 0.01s.$

Therefore $C_f = \frac{Idt}{dv} = 1 \times \frac{0.01}{3.12} = 3.21 \times 10^{-3}$

$= 3210\ \mu f$

Hence a preferred value of 3300uf is chosen

The battery is connected to the normally closed (NC) side of the relay, while the 9v supply is connected to the normally opened (NO) side. Thus when there is A.C. supply, the relay switched to the 9v regulated supply, and if there is not A.C. power supply, the relay switches back to the battery automatically.

The circuit diagram of the power supply is as shown below.

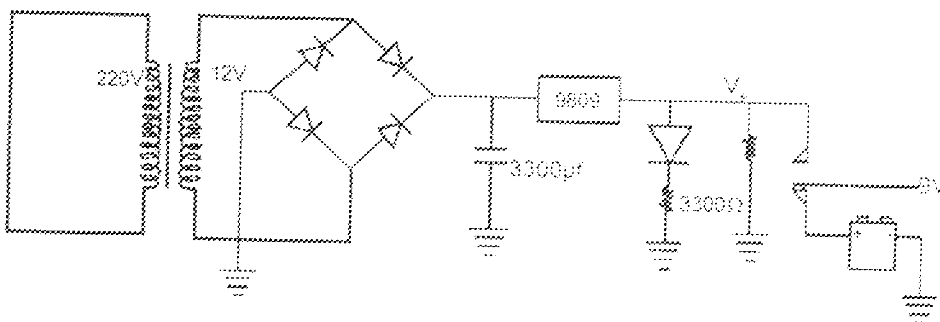


Fig 3.3: Power supply circuit with values

3.1.2. Frequency Generator Unit

The frequency is generated using a 555 timer. In the astable mode, the 555 timer astable configuration is as shown below:

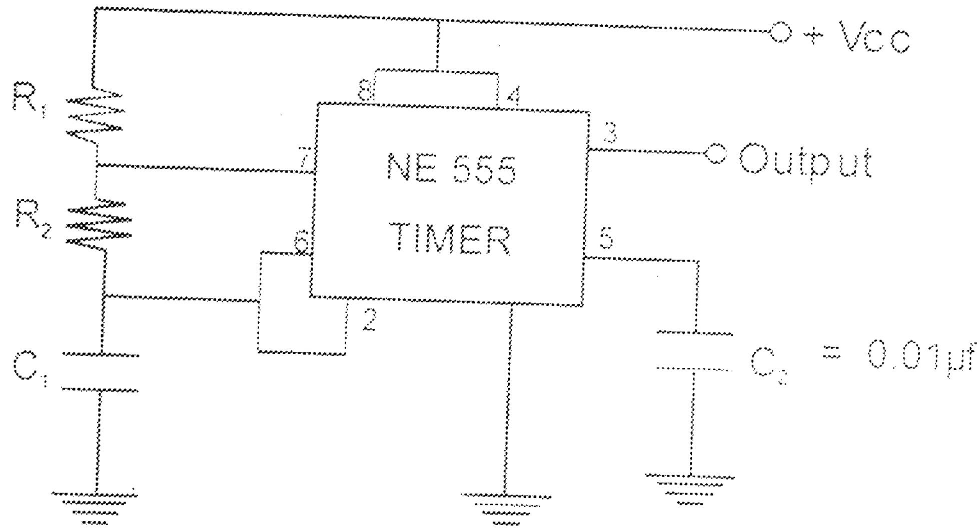


Fig 3.4: A 555 Timer Astable Configuration

Formular

$$F = \frac{1.44}{(R_1 + 2R_2)C}$$

We require a 1Hz frequency, so that the digits will change every 1s, given an accurate timing. From the formular, we assume

C = 1μF

R_1 = 1KΩ

F = 1Hz

$$\text{Therefore } 1 = \frac{1.44 \times 10^6}{(1k + 2R_2)}$$

$$1k + 2R_2 = 1.44 \times 10^6$$

$$R_2 = \frac{1.44 \times 106 - 1}{2} = 719.500k\Omega$$

Hence, a preferred resistor of 1mΩ resistor of 1mΩ is used to give a 1 Hz frequency.

The circuit diagram of the 555 time is as shown below:

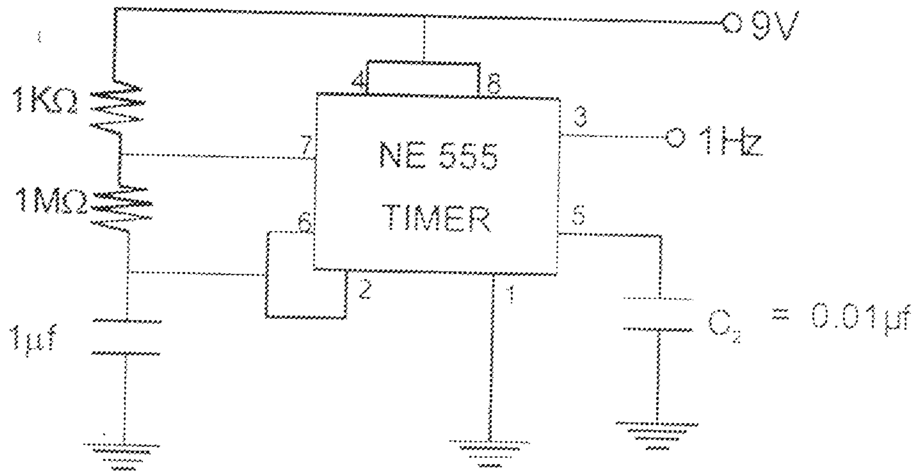
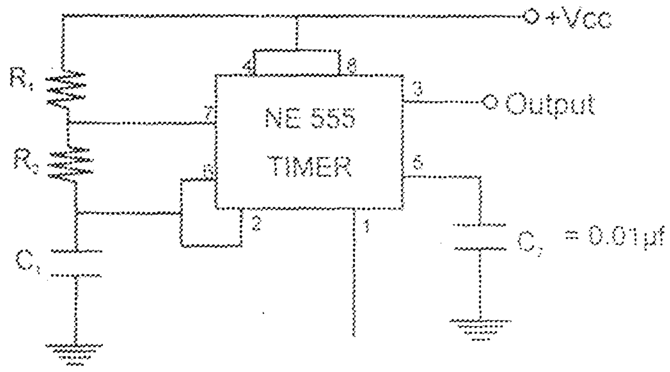
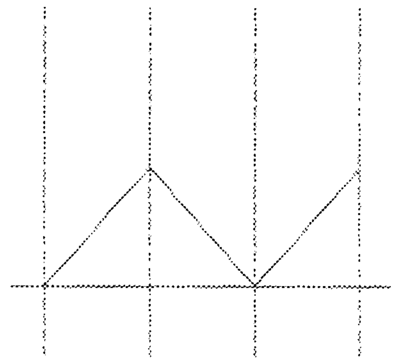


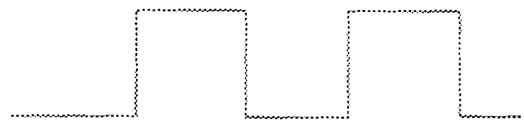
Fig 3.5: A 555 timer circuit

3.1.3. Operation of 555 Timer Connected as Astable Multi-vibrator

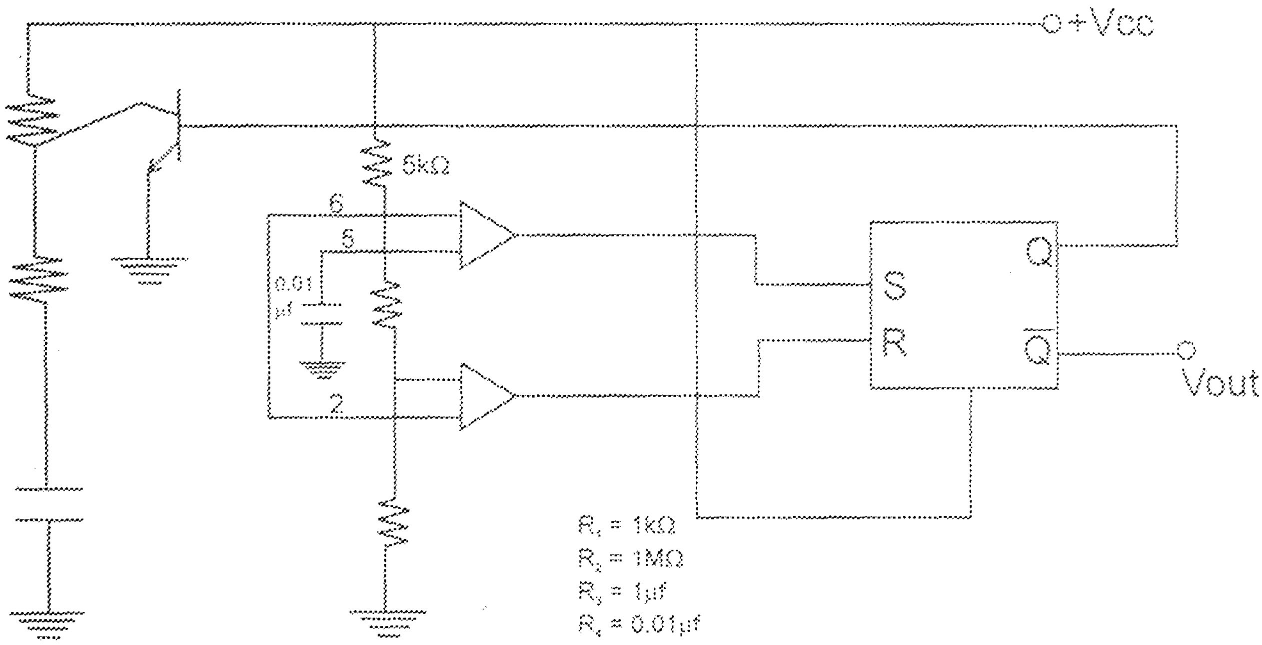




(ii) Voltae waveform of Capacitor C.



(ii) Wave form of charging and discharging of capacitor C



(IV) Internal Circuiting of a 555 timer

Fig 6: Operation of 555 timer connected as astable Multivibrator [2]

The figure shown above is a 555 timer connected as an astable multi-vibrator (free running multi-vibrator). The inverting input called the trigger (Pin 2) of lower comparator is connected to the threshold input (pin 6) and these two points are now connected across capacitor C. When the voltage at pin 2 is a little lower than one third of Vcc, the output of the lower comparator becomes high and this resists the flip-flop leaving Q at logic zero. This forces the discharge transistor to its cut-off region and as the collector of this transistor is connected across R_2 and capacitor C at pin 7, no current flows through the transistor and all the current from the supply flows through R_1 and R_2 to charge up capacitor C. As this capacitor charges up, the voltage across it rises first jo 1/3 Vcc. When this voltage rises slightly above this value, the voltage of the inverting input and the output of the comparator goes low. This has no effect on Q output. The voltage across C continues to increase until it is slightly above 2/3 Vcc. Then, the threshold voltage is slightly greater than the voltage at pin 5. This turns the output of the flip-flop high and sets the flip-flop which implies that Q = Vcc. This voltage drives the discharge transistor into a saturation and then short circuit pin 7 to the ground.

The voltage at pin 7 is grounded meaning that capacitor will now discharge through R_2 and via the discharge transistor to ground. The voltage across the capacitor begins to fall until it gets to 2/3 Vcc and slightly below this, the upper comparator output is switched low. But this does not affect the output Q. the voltage across C falls to 1/3 Vcc and slightly below it, the output of the lower comparator then switched high. The Rs latch is then reset and the process is repeated. The continuous charging and discharging of capacitor C results in the rectangular waveform at the output pin 3 as shown in (iii). The wave form of the voltage across capacitor C also decreases and increases exponentially as shown in (ii). The capacitor charges up to 2/3 Vcc and discharges up to 1/3 Vcc. The by-pass capacitor (0.01uf) connected to pin 5 is just to provide noise filtering for the control voltage. If the reset terminal (pin 4) is connected to the ground, it will not activate the whole circuit and hence it is always connected to the supply terminal as shown in the figure above.

3.1.3. Counter Unit

The counter employed is the 7490 asynchronous counter. this gives a binary count of 0 – 9. the 7490 advances count when the master reset and set pins are at logic level zero (0). i.e. when there is a clock pulse.

The circuit diagram of the counter is as shown below:

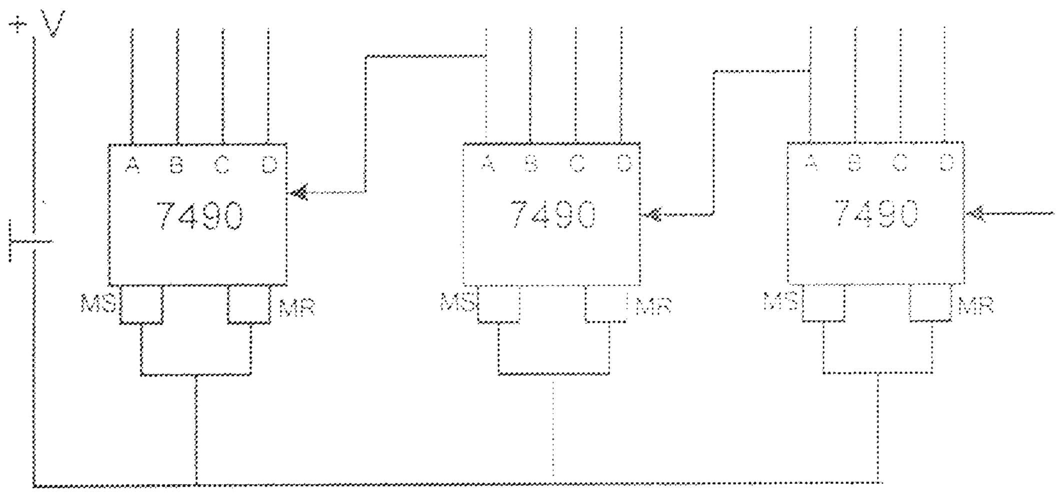


Fig 3.7: Circuit diagram of a counter (7490)

Sound Unit

The sound used here comprises of a buzzer that sounds every second. This makes the stop watch more interesting and will aid the concentration of the person using the stop watch. The buzzer is powered by a 1Hz 555 astable multi-vibrator.

The circuit diagram is as shown below:

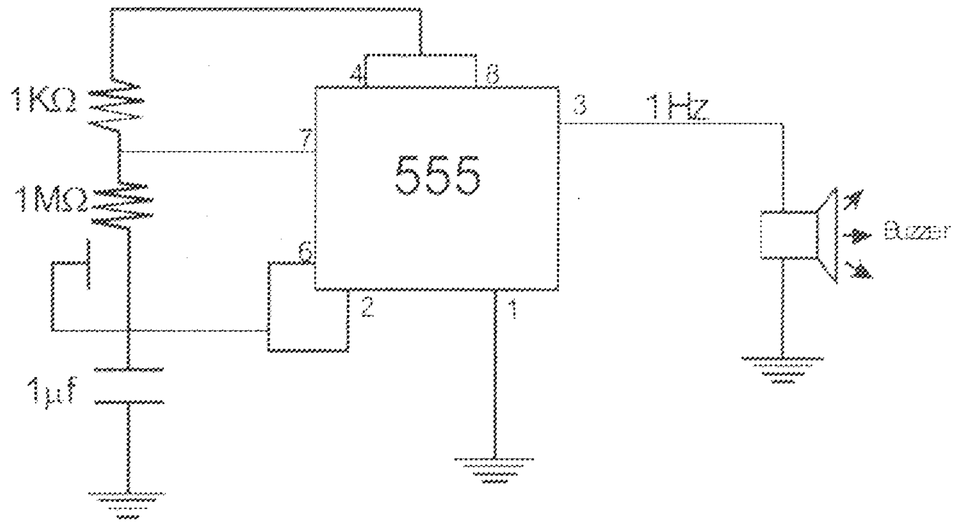


Fig 3.8: circuit diagram of a 555 timer with a sound (speaker) incorporated

3.1.5. The Decoder Section

In digital electronics, all operations are carried out in binary form. The information at the output of the counter are in binary form, therefore, it is necessary to find a way of converting this information in binary to a form suitable for a man to interpret and a circuit required for this purpose is known as a "DECODER".

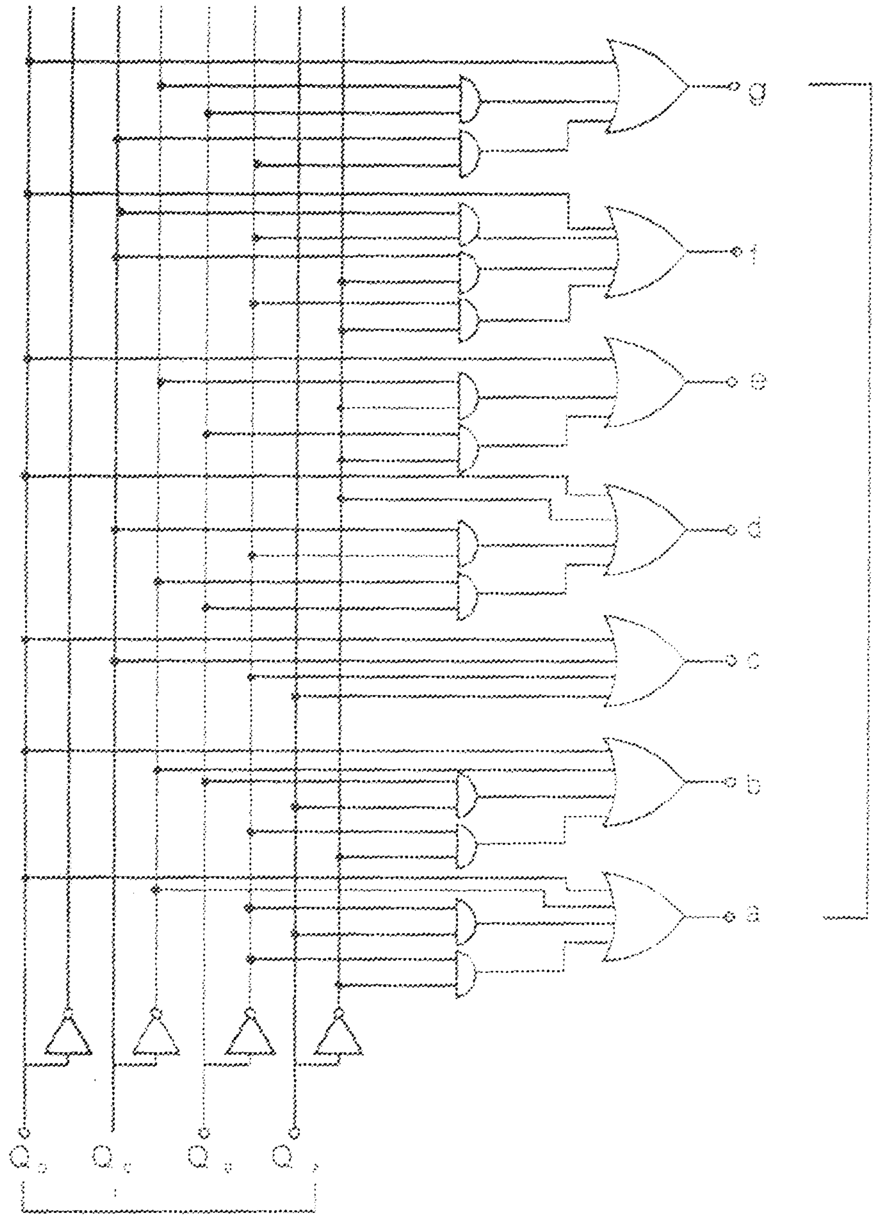
A decoder is a combinational logic circuit that converts binary information from n-input lines to a maximum of 2^n unique output lines. If the n-bit decoder information has unused combinations as is the case with the special decoder used for this project, the decoder output will have less than 2^n outputs. This decoders are referred to as n-to-m line decoders where m is less than or equal to 2^n.

A seven segment decoder is used for this project. It is a 4-to-7 lines decoder. It has four inputs and seven outputs. These outputs are used to drive a seven segment display.

3.1.6. Design of a Seven Segment Decoder

A truth table for the seven segment Decoder

DECIMAL DIGIT	INPUTS				SEGMENT (ON = 1)						
	Q_D	Q_C	Q_B	Q_A	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	1
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	1	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1



BCD INPUTS

Fig. 3.9: Combinational Logic Circuit of the Seven Segments Decoder/Driver

3.1.7. Choice of Decoder/Driver IC

As it can be seen in the figure above, if one is able to implement this circuit using single scale integrated circuit, the number of components required is enormous. If several of such circuit is to be implemented at the end of the day, the cost of production would be very high. Therefore, it would be wiser to go for circuit that is less costly and most effective and such circuit comes in a medium scale integrated circuit e.g. 74LS47 (7447) decoder. It is a decoder/driver used to drive a seven segment display in this project.

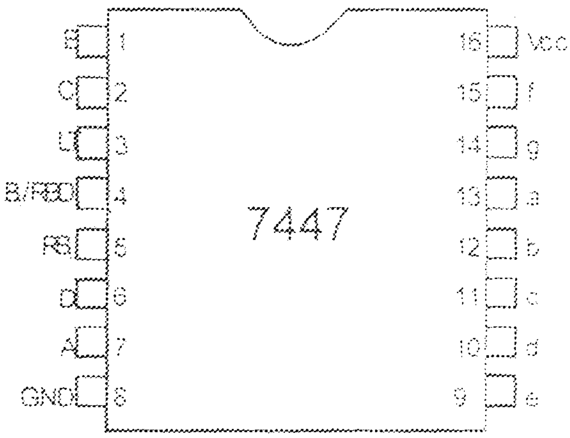


Fig 3.10: A seven segment Decoder (7447)IC.

The figure above is a 4-to-7 line decoder. It has four data inputs, A,B C and D and seven active low outputs a, b, c, d, e, f and g. These outputs, if a binary seven, A = 1, B = 1, C = 1 and D = 0 are present at the data inputs, the outputs a, b, c would be at an active low since the display used in this project is a common-anode, only the segment to which these outputs are connected (a, b, c) are turned ON, therefore a decimal seven is then displayed. Thus, the 7447 decoder/driver converts the binary output of the 7490 to the seven segment format. The circuit diagram is as shown below:

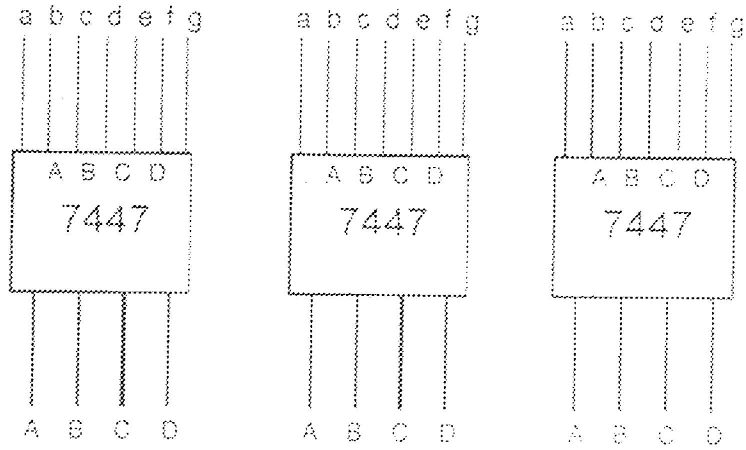


Fig 3.11: Block diagram of a 7-segment decoder (7447)IC

3.1.8. Display Unit

The display employed in this project is the seven segment display which is widely used as readout for modern digital equipment.

There are three types of seven-segment display. These are:

(i) Light emitting diode (LED)

(ii) Liquid Crystal display (LCD) and

(iii) Gas Discharge display (GDD)

However, the seven-segment indicators in this project are basically Red Light emitting diodes (LED), depicting the shape of decimal numbers from 0 – 9 depending on figure below. The LED was chosen because it is cheap and readily available in the market.

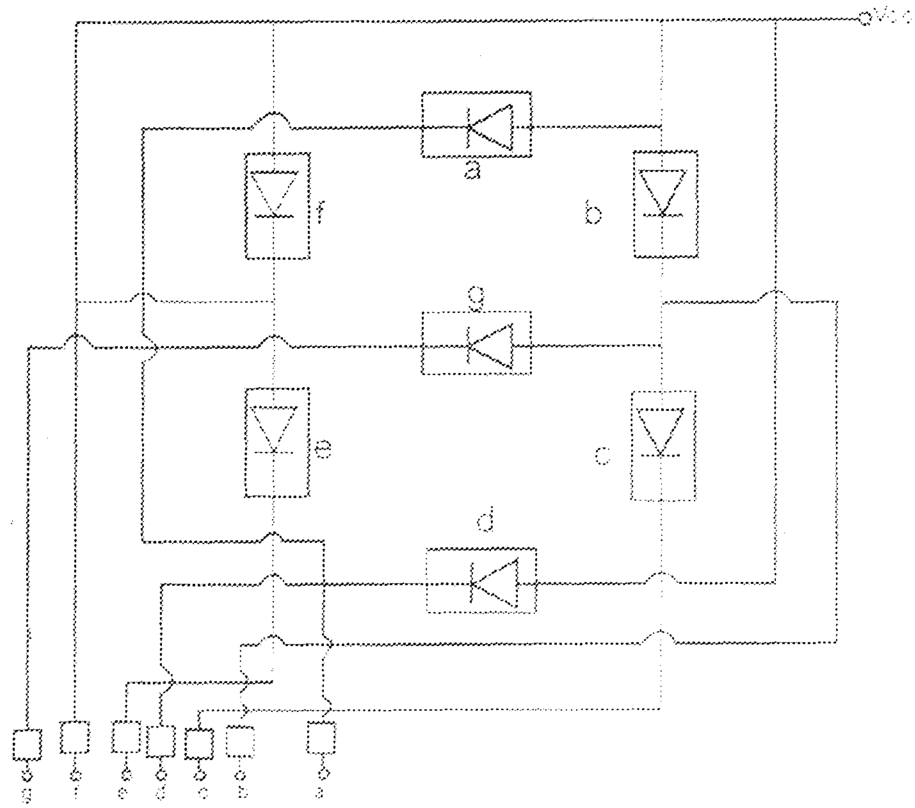


Fig 3.12: Red colour even segment display [6]

The LED seven-segment is a common-anode display in which all anodes are connected together while the cathodes are independent as shown in the figure above.

To operate the LED display, all anode terminals must be supplied with positive voltage. The current flowing through each diode must be limited to about 20mA which is the maximum amount of current that must pass through each for safety. Therefore, in order to prevent current passing through these diodes, a current limiting resistor must be introduced in series with each diode at their respective cathode.

Three seven-segment displays are used in this project to display the time count as decoded by the 7447 decoder. The circuit diagram is as shown below:

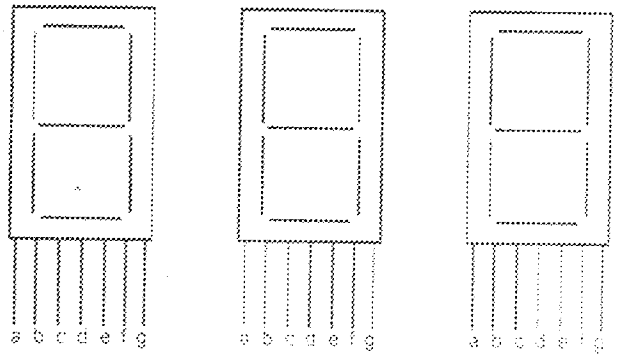


Fig 3.13: Diagram of the seven-segment Display

CHAPTER FOUR

4.0. TESTING AND DISCUSSION OF RESULT

4.1.0. Testing

Each unit of the project was first tested on a bread-board and each module under test was given enough time to response to test in order to ensure their reliability. The modules were then disconnected from the bread-board and transferred to the vero-board for permanent soldering using the soldering techniques. Hence, the entire circuit was tested sectionally in order to ensure that they are perfectly soldered and functioning as expected. After soldering, non-stop test for 999 seconds twice repeatedly.

4.1.1. Discussion

The design and construction of this project was aimed at obtaining accurate and less tedious measurement of time. This was enhanced along side some technical problems encountered during the project design and construction.

One of the problems encountered at the time of construction is that some components were burnt. This becomes difficult and consume money in the course of replacing them as well as posing delay in the process of construction.

However, the reading of the device after several testing and comparison with other commercial stop watches, was found to be accurate to some fraction of a second which satisfy the aim of this project.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

Having tested the finished (constructed) digital stop watch accuracy. It can be concluded that the objective of this design was achieved.

Though the resulting instrument in a little bigger than the available commercial digital stop watches due to the fact that commercial manufacturers used large scale integration (LSI) which are not readily available in the market for project designs.

In a further work on this project however, large scale integration should be searched for in the market for use in order to reduce the physical size of the project a little. The student should also try to increase the accuracy of this device to hours and minutes.

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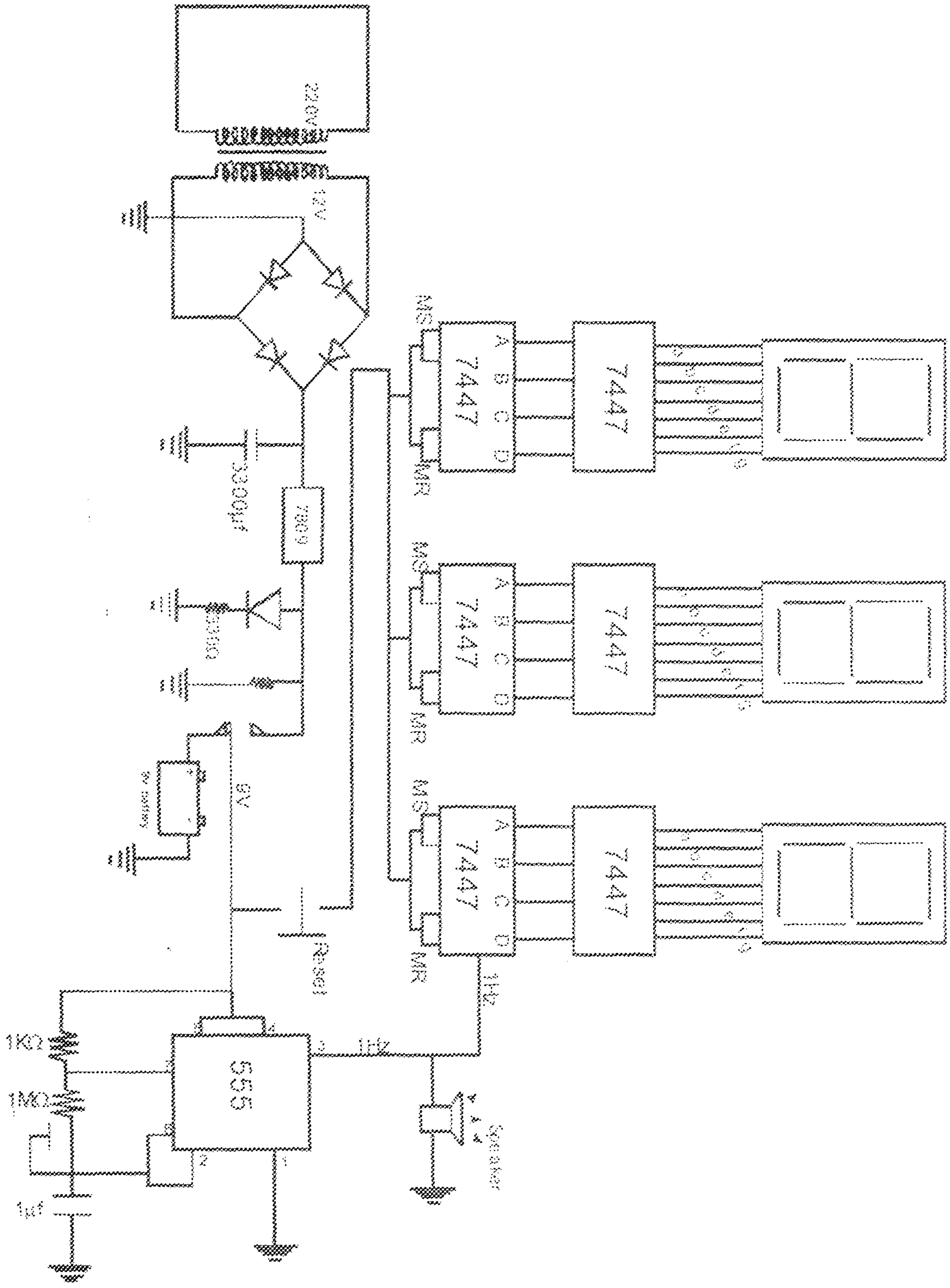

MAIN CIRCUIT DIAGRAM