DESIGN AND CONSTRUCTION OF A PROGRAMMABLE CONTROL TIMER

BY

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING IN PARTIAL FULFILLMENT FOR THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING (B.ENG) IN ELECTRICAL AND COMPUTER ENGINEERING OF THE FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

OCTOBER 2006

DEDICATION

To Almighty God who has made me find favour in His sight and from men.

DECLARATION

I, IFABIYI OLUWASEUN DAVE hereby declare that this project is presented in partial fulfillment of the requirement for the award of Bachelor of Engineering (B. Eng) degree. It has not been presented before either wholly or partially for any other degree elsewhere. Information hereby obtained from published or unpublished works of others are acknowledged accordingly.

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Casting a retrospective glance at the last few years, I am stunned by God's mercies. Even if all my hairs are tongues, it won't be enough to give Him thanks. I still remain speechless before the almighty (The Alpha and Omega) His grace saw me through despite all odds.

First and foremost my appreciation goes to my able supervisor Engr J.G Kolo, a man of monumental erudition and articulate attributes for the efforts expended in making this work a reality and for teaching me the ideals of hardwork and diligence. Your humility and simplicity never cease to amaze me. THANK YOU SIR!

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THANK YOU AND SEE YOU ALL AT THE TOP!

ABSTRACT

Any economy that want to advance must embrace time management and proper conservation of electrical power supply. This can be achieved through limiting wastage in the limited power supply from PHCN.

Since time is a limited commodity, a device that can help in achieving a lot within the available time will be inevitable. With the use of the programmable control timer, a user can put on or off any electrical appliance connected to it while the user attends to other things knowing fully well that an electronic assistance is available.

The programmable control timer was designed to put off or on electronic appliances connected to it. The user can preset the device to a certain value. This is possible with the use of set buttons on the device. A set button is pressed to enable the time input buttons to be pressed. After presetting a certain time value which is displayed on the digital display, a press on the count button makes the preset time to countdown to zero. After attaining a "000" value. The appliance connected to its sockets either goes on or off.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

A control timer is intended to provide controls for processing, manufacturing, and domestic appliances based on exact timing, where the measurement of time is critical to successful operation without intermittent human input. It is quite evident that for proper organization, events should be done in specific time. For case, there are specific machines designed to alter or perform some defined task at particular instances. A good example is a "Timer". It is tasked to trigger ON or OFF an event at a time. It is quite useful in everyday life. A simple example is in the case of clocks incorporating its application to alert people at a time by triggering on an alarm. Some advanced electronic timers are used for military purposes. Since World War II, the use of time bomb was seen as a great success. Away from Military into Civilian life, timer has proved to be of great importance in microwave ovens, computer systems, laboratory experiments, heater e.t.c. Besides, there are several industrial practices that would not go well without the presence of a timer.

1.2 AIMS AND OBJECTIVES

The design and construction of the programmable control timer is aimed at achieving the following goals

- To enhance effectiveness in results of productions or operations which are time dependent.

- The device would ensure conservation of energy due to its ability to switch of an electronic device connected to it when the preset time as been attained.
- To encourage proper organization and time management.

1.3 METHODOLOGY

This project involves the design and construction of a programmable control timer which is designed to count down a preset time to zero and trigger ON or OFF the output load. The programmable feature allows it to work with different time inputs that do not exceed 999 seconds (16.65 minutes).

This basic concept of design involves the use of a 4060B CMOS integrated circuit that takes the task running a 32768Hz crystal. The frequency input (32768Hz) is divided by internal dividers in the 4060B integrated circuit. The division results into 2Hz. An additional flip-flop is added to provide the needed 1Hz (or 1 second period pulse). This leading pulse passes through control logic before it is fed into a down counter unit. This unit consists of three BCD down counters which is assigned a particular preset number through the control logic. The control is made of latches or flip-flops. External switches are connected to the specific inputs of the flip-flops to provide specific controls. Furthermore, the counter unit is set to count down through the control unit. When a zero value is reached, a zero detector signals the state and feedbacks to the control unit. Thereby resulting into the output load being triggered ON or OFF. The timer alters the electric power supply to the output load through an external relay circuit. This provides better switching performance and higher load capacity.

1.4 SCOPE

The common cathode nature of the display shows that the involving integrated circuits are Complementary Metallic Oxide Semiconductor (CMOS). The choice for such logic extends over its merits. The logic (CMOS) is seen in modern electronic devices, especially in computers. Although the old 70`s type was attributed to a lot of failure. The most exposed demerits were statistics distribution and low speed. Recent CMOS provides extremely high and jet speed features[13].In addition, due to insufficient modern electronic exposure, experience and limited information resources, a number of student that carried out timer project, based there design on transistor-transistor-logic (TTL), 555 timer, fixed timing and excess component use. It is quite obvious that TTL is relatively fast but does that with extremely high power consumption. This feature makes it unfriendly to battery power applications. Moreover, any battery powered electronic device made of CMOS stands firm without power supply for months. TTL types wont dare try.

CMOS logic integrated circuits are extremely denser than any other logic technique. Therefore it makes design very compact. The use of CMOS technology is the driving force for driving electronic cost.

The other feature in the leading design is a crystal CMOS oscillator. A 555 timer can never work for precision. It is an RC oscillator which has a lot of factors that contribute to instability in its frequency output. Precision operation is very certain in crystal type oscillator. In the design, the oscillator works on 32768Hz crystal and through supported internal frequency dividers of the involved integrated circuit. A 1Hz frequency is achieved in clocking the counters. The timing technique reduces any effect of frequency instability.

The design is based on readily available electronic components which are in cheap series. Therefore the overall cost of construction is indeed economical.

Moreover, the design is attached to some demerits. The first obvious one is the choice of LED display. A LCD type provides lower power consumption and better performance. The limited available ones are defined with high cost. Another demerit is that the integrated circuit can be substituted with a single chip technology for further compatibility. This definitely proves too advance for student project. The design could have been better with sound effect and greater timing.

The project was carried out with sufficient information materials. There was access to every involved electronic component data sheets from the manufacturers. The purpose is to put the design to acceptable performance and standard.

CHAPTER 2

2.1 LITERATURE REVIEW/THEORETICAL BACKGROUND

Timer shares one and the same history as clocks or alarm clocks. A timer is merely a specialized type of clock. It is can be used to control the sequence of an event or process[17]. Timers have gone through several modifications overtime since its inception. There are various types of timers ranging from mechanical, electromechanical to digital timers.

2.2 HISTORY AND DEVELOPMENT OF TIMER

2.2.1 MECHANICAL TIMERS

The first mechanical clocks were made in the 14th century, and were large monumental clocks. They possessed little commercial importance. Household clocks were in use by 1620 and some of them had alarm mechanisms[8]. The alarm is simple in concept, typically having a cam that rotates every 12 hours. It has a notch into which a lever can fall, releasing a train of gears that drives a hammer, which repeatedly hits a bell until it runs down or is shut off (many alarms have no shutoff control). Moreover, one of the earliest alarm clock references to a German iron wall clock with a bronze bell, probably made in Nuremberg in the 15th century. This clock is 19 inches tall and of open framework construction. It needed to hang high on the wall to make room for the driving weight to fall[17].

Moreover, other alarm clocks from the 1500's are in existence. They are the Clock work Universe German Clocks and Automata 1550 – 1650. English clockmakers immigrated to the United States in the 18th century and no doubt carried the idea of the alarm clock with them. It has been said that Levi Hutchins of Concord, New Hampshire invented the first alarm clock in 1787 He may have made an early American alarm clock, but his clock was predated by the German and English ones mentioned above[17]. Seth Thomas Clock Company was granted a patent in 1876 for a small bedside alarm clock. This may have been the first clock of this type, or perhaps other makers were working on this idea at the same time. In the late 1870's, small alarm clocks became popular, and the major US clock companies started making them, followed by the German clock companies. The predecessor of Westclox was founded in 1885 with an improved method of small clock construction[21].

Westclox introduced the Chime Alarm in 1931. This clock was advertised with the slogan "First he whispers, then he shouts." The Westclox Moonbeam was introduced in 1949. This clock's alarm flashes a light on and off, and then a buzzer sounds. Westclox now sells an excellent reproduction of the Moonbeam[17].

Therefore, the early timers were purely mechanical in operation. They possessed similar typical clock work mechanism. The basic operational parts were escapement and spring to regulate their speed. Poorer designs worked on cheap mechanisms that use flat beater that spins against air resistance. Mechanical egg-timers are usually of this old design.

Recently, more accurate mechanisms resemble small alarm clocks. The chief advantage of these is that they require no battery, and can be stored for long periods of time. They were quite cheap and with little maintenance. The most widely-known application is to control explosives. They were used during World War I and II for time bomb applications.

2.2.2 ELECTROMECHANICAL TIMERS

Electromechanical timers were developed with the increased availability and efficiency of electricity. The early types were mere modification of the then mechanical timers. Electromechanical timers have two common types. A thermal type which has a metal finger made of two metals with different rates of thermal expansion (steel and bronze are common). An electric current flows through this finger, and heats it. One side expands less than the other and an electrical contact on the end of the finger moves away from an electrical switch contact, or makes a contact (both types exist). The most common use of this type is now in the "flasher" units that flash turn signals in automobiles, or sometimes in lights[17].Another type of electromechanical timer (a cam timer) uses a small synchronous AC motor turning a cam against a comb of switch contacts. The AC motor is turned at an accurate rate by the alternating current, which power companies carefully regulate. Gears slow this motor down to the desired rate, and turn the cam. The most common application of this timer now is in washers, driers and dishwashers. This type of timer often has a friction clutch between the gear train and the cam, so that the cam can be turned to reset the time[21].Electromechanical timers survive in these applications because they are known with cheap price. Even, their operation is really simple.

Many decades ago, these electromechanical timers were often combined with electrical relays to create electro-mechanical controllers. Electromechanical timers reached a high state of development in the 1950s and 1960s, in the height of cold war, because of their extensive use in aerospace and weapons systems. Programmable electromechanical timers controlled launch sequence events in early rockets and ballistic missiles of the United States of America (USA) and Russia. The application of such timer made the first moon landing and other unbelievable space explorations possible[8].

2.2.3 DIGITAL TIMERS

In the late 1950's, the first integrated circuits were invented by two scientists: Jack Kilby of Texas Instruments filed a patent for a "Solid Circuit" made of germanium on February 6, 1959. Kilby received patents US3138743, US3138747, US3261081, and US3434015. Robert Noyce of Fairchild Semiconductor was awarded a patent for a more Complex "unitary circuit" made of Silicon on April 25, 1961.The development of such complicated and compact circuits gave way to digital electronics[17]. Logic units constructed using Transistor-transistor logic (TTL) and Complementary metallic Oxide Semiconductor (CMOS) became available. Elements such as AND, OR and NOT gates are good digital design tools. Circuits such as flip-flop, counter, latch and shift register are derived from the units. They can be looped-up in group for advanced and specified tasks due to involving high flexibility.

Timers with digital operation are indeed modern. They are designed with digital visual numerical read-out. They involve programmable timing. They can also be used in safety device such as a Gas Timer. Digital timers can achieve higher precision than mechanical timers because they are quartz clocks with special electronics. Therefore, the timing is really stable or with minimum error. Integrated circuits have made digital logic so simple that an electronic digital timer is now less expensive and more effective than many mechanical and electromechanical timers. They are mainly designed with the application of down counter. However, most timers are now implemented in software[21].

Modern controllers use a programmable logic controller rather than a box full of electromechanical parts. The logic is usually designed as if it were relays, using a special computer language called ladder logic. In programmable logic controllers, timers are usually simulated by the software built into the controller. Each timer is just an entry in a table maintained by the software. Individual timers are implemented as a simple single-chip computer system, similar to a watch[17].

The programmable control timer's uniqueness to the earlier mentioned timers is found in its ability to switch on and off an electrical load connected to it after a preset time.

CHAPTER THREE

CIRCUIT DESIGN ANALYSIS

3.1 THE COMPONENT CHOICE AND DESCRIPTION

The circuit is designed using CMOS 4000 series. The group of logic integrated circuit provided numerous logic functions for digital designs. CMOS logic is attributed to low power consumption, high turn-out, high compatibility, wide power supply and a lot more merits. The TTL 74 series is not suitable for this particular design mainly because of its high power consumption and limited available logic function. Evidently, from practical point of view CMOS integrated circuit is more suitable than its TTL counterpart.

The main electronic components are given below:

(i.) 4060B (crystal oscillator/ divider)

(ii.) 4013B (latch or flip flop)

(iii.) 4029B (BCD down counter)

(iv.) 4511B (7-segment decoder)

(v.) 4081B (2-input AND gate)

(vi.) 7805 and 7812 (5V and 12V regulators)

(vii.) 2SC945 (switching NPN transistor)

3.1.1 4060B

A stable oscillator or pulse generator is required for the timer. No other type serves like a crystal oscillator. Definitely, 555 timer is not suitable for this particular project. It is designed for RC configuration. Therefore, the required precise 1-second timing from the timer can not be achievable. But, with a 4060B integrated circuit a crystal oscillator is possible. The device is attributed to reasonable frequency stability.

This same device is in-built with 14-stage counter/divider logic. The feature merely divides the main frequency down to lower outputs. Through this technique, the 4060B generates ten frequencies at once. All the outputs are buffered for heavy load driven ability. It's pin 12 so required low for the device to work. And, its crystal move is governed by pin 11 and 10.

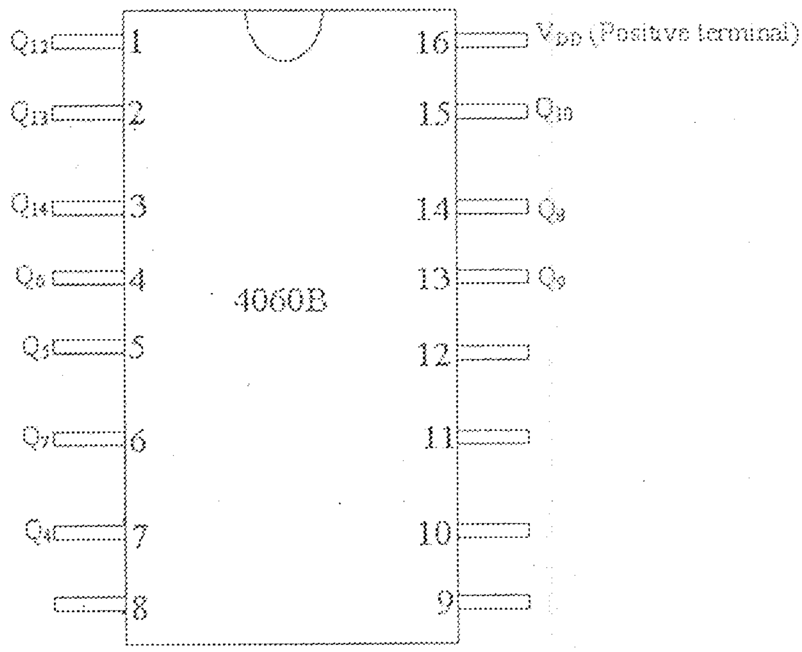


Fig. 3.1 Pin layout of the 4060B

Based on the device's data sheet, the frequency of the ten output is given by the following formula:

$$f_{ax} = \frac{f_{in}}{2^x}$$

x is the Q value of a particular output terminal.

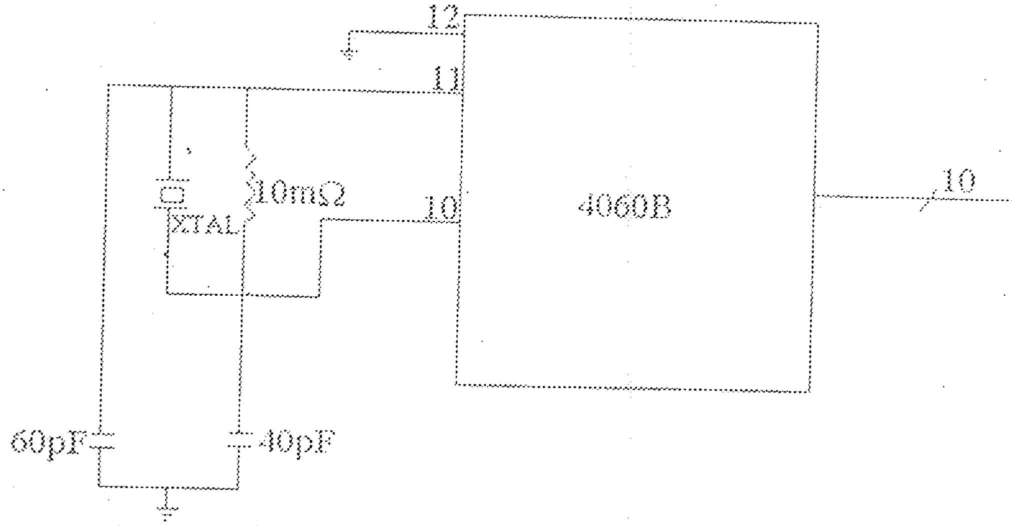


Fig. 3.2 Configuration of the 4060B as a crystal oscillator

In the case of this project, XTAL (crystal) is 32768Hz. Therefore, the frequency output at pin 3 is given by:

$$f_{Q14} = \frac{f_{in}}{2^{14}} = \frac{32768}{2^{14}} = 2\,\text{Hz}$$

Pin 3 is related to Q value of 14

For pin 1

$$f_{Q12} = \frac{f_{in}}{2^{12}} = \frac{32768}{2^{12}} = 8\,\text{Hz}$$

The two terminals are used for circuit design.

3.1.2 4013B

The 4013B is a dual D-type latch CMOS integrated circuit. This single device holds two independent latches. The device is mostly used in control applications. It functions in that manner in the project. All its input terminals are active high. A positive trigger at the clock input store the logic level at the D input into Q and Q is complementary.

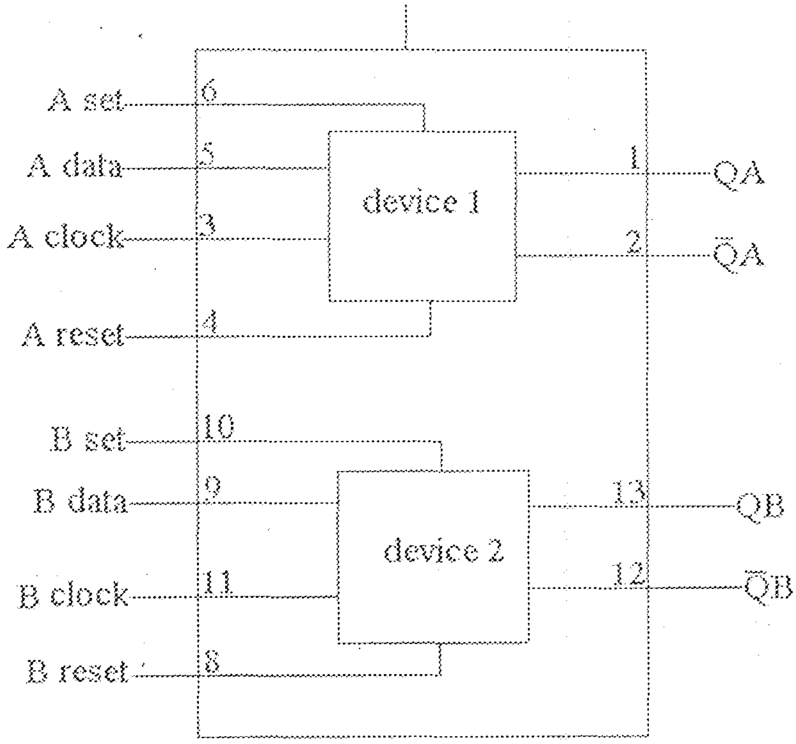


Fig. 3.3 Functional diagram of the 4013B

The device can be configured in either D-type or SR modes. The basic connections involve the grounding of unused terminals to remove error of logic indeterminately. The two modes are used in the circuit. No other suitable CMOS logic function provides such flexibility function for this circuit design. The other and close counterpart (4027B) is for toggling function which is not required in the design.

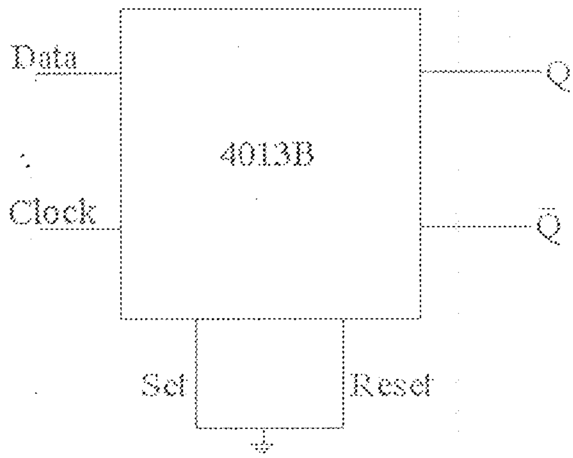


Fig. 3.4 A D-type latch configuration

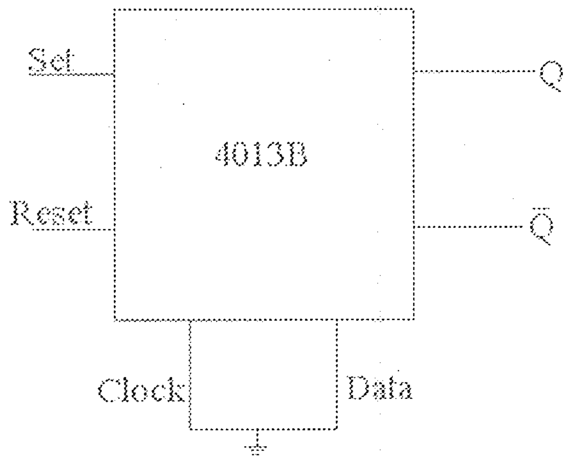


Fig. 3.5 A SR latch configuration

Set	Reset	Q	Q̄
0	1	0	1
1	0	1	0
1	1	1	1

Table 3.1. A simple truth table of the SR latch configuration.

Sometimes a particular pin grounded through the use of resistor value within 1-100 KΩ (from the device's data sheet). The reason is to allow external control through a soft touch switch or button.

3.1.3 4029B

The 4029B is quite a high-tech CMOS counter. It has a lot of features which is designed for wide range of digital applications such as both up/down counting and jamming ability. The device is merely a presetable up/down counter which counts in either binary or decade mode depending on the voltage level applied at its binary/decade input. If the binary/decade is at logical "1" the counter counts in binary, otherwise it counts in decade. Similarly, the counter counts up when the up/down input is at logical 1 and vice versa. The counter is set at decade and down modes for the purpose of this project.

A logical "1" preset enable signal allows information at the "jam" input to preset the counter to any logic state. This feature is not used for the design. All the jam inputs are grounded. The counter advances one count at the positive going edge of the clock if the carry in and preset enable inputs are at logical "0". Advancement is inhibited when either of there two inputs is at logical "1". The carry out signal is normally at logical "1" state and goes to logical "0" state when the counter reaches its maximum count in the "up" mode or the mininum count in the "down" mode provided the carry input is at logical "0" state.

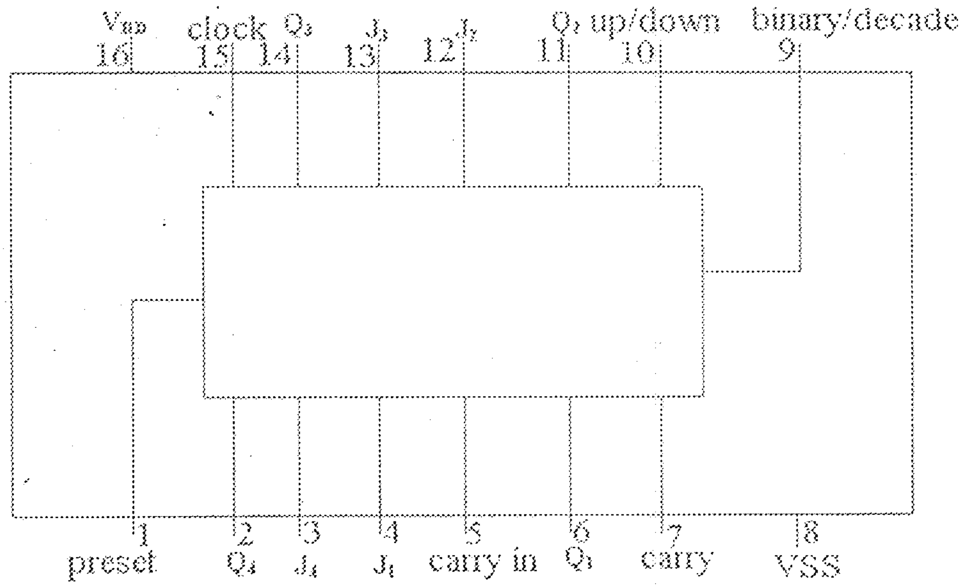


Fig. 3.6 Pin assignments of the 4029B

The 4029B is the main counter of the project. It is adjusted to down and BCD modes.

3.1.4 4511B

A display decoder is required for the 4029B counter. The 4511B is chosen to decode the BCD codes from the counters into visual information on the common cathode 7-segment display panel.

The 4511B is a popular and quite available 7-segment decoder for wide range of circuits. It consist of four data inputs and seven drivers or outputs. The outputs are associated with NPN bipolar configuration for high power driving ability. Therefore, the usage of the device is further than just LED displays but incandescent and low-voltage fluorescent display applications.

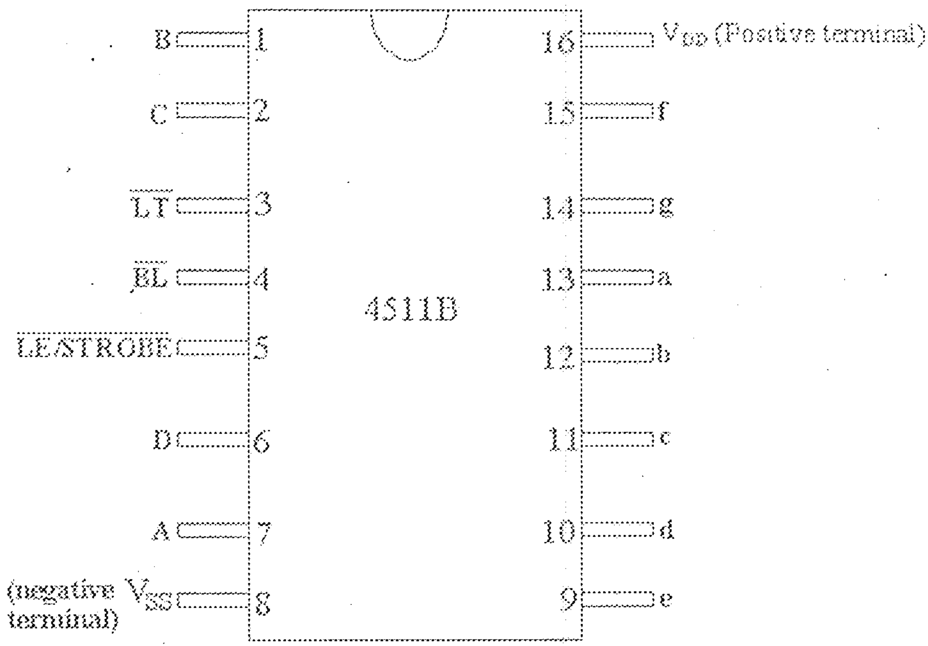


Fig. 3.7 The pin connections of the 4511B

	Code	Corresponding digit
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9

Table 3.2 The code-digit table of the 4511B

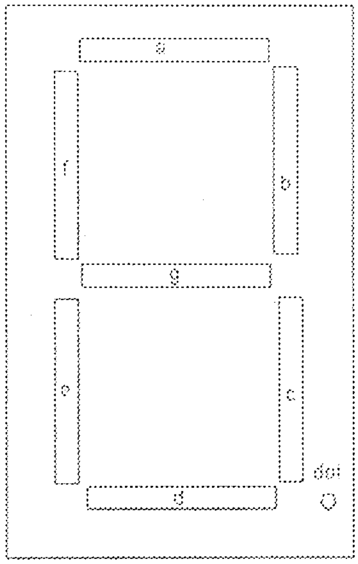


Fig. 3.8 The 7-segment display layout

The integrated circuit is designed for common cathode display.

3.1.5 4081B

The 4081B is CMOS quad 2-input AND gate integrated circuit. It is usually used for directing signal in a circuit.

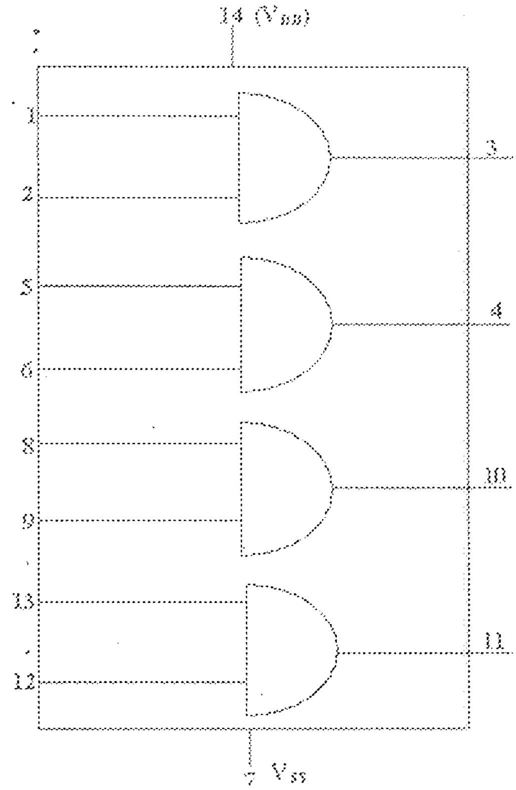


Fig. 3.9 The functional diagram of the 4081B

3.1.6 7805 and 7812

Power regulators are required for circuit stability. The 78XX positive regulator series include both 7805 and 7812 which provide 5V and 12V regulation respectively for the circuit. Both operate with maximum voltage and current rating of 35V and 1A respectively.

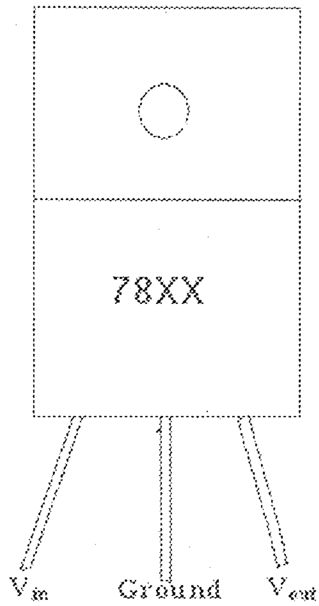


Fig.3.10. The pin layout of the 78XX regulator series

3.1.7 2SC945

The 2SC945 is a NPN bipolar transistor. It is often used for switching application. The device possesses a typical current gain of 100. It is used for the relay circuit`s switching.

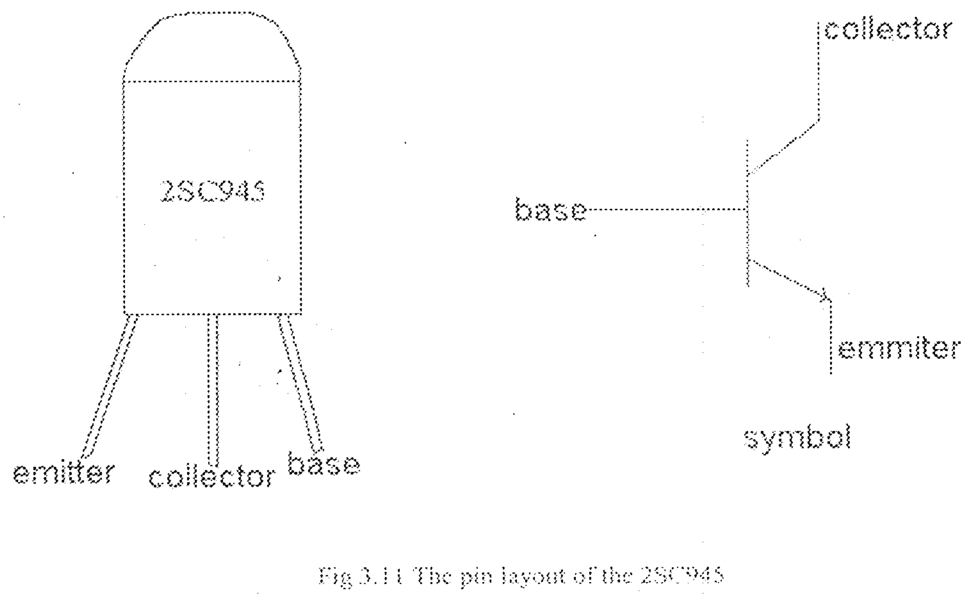


Fig 3.11 The pin layout of the 2SC945

3.2 THE CIRCUIT DESIGN ANALYSIS

The circuit is grouped into seven main units.

They include:

(i.) Crystal oscillator

(ii.) Logic control unit

(iii.) Counter unit

(iv.) Display unit

(v.) Zero detector

(vi.) Output unit

(vii.) Power supply unit

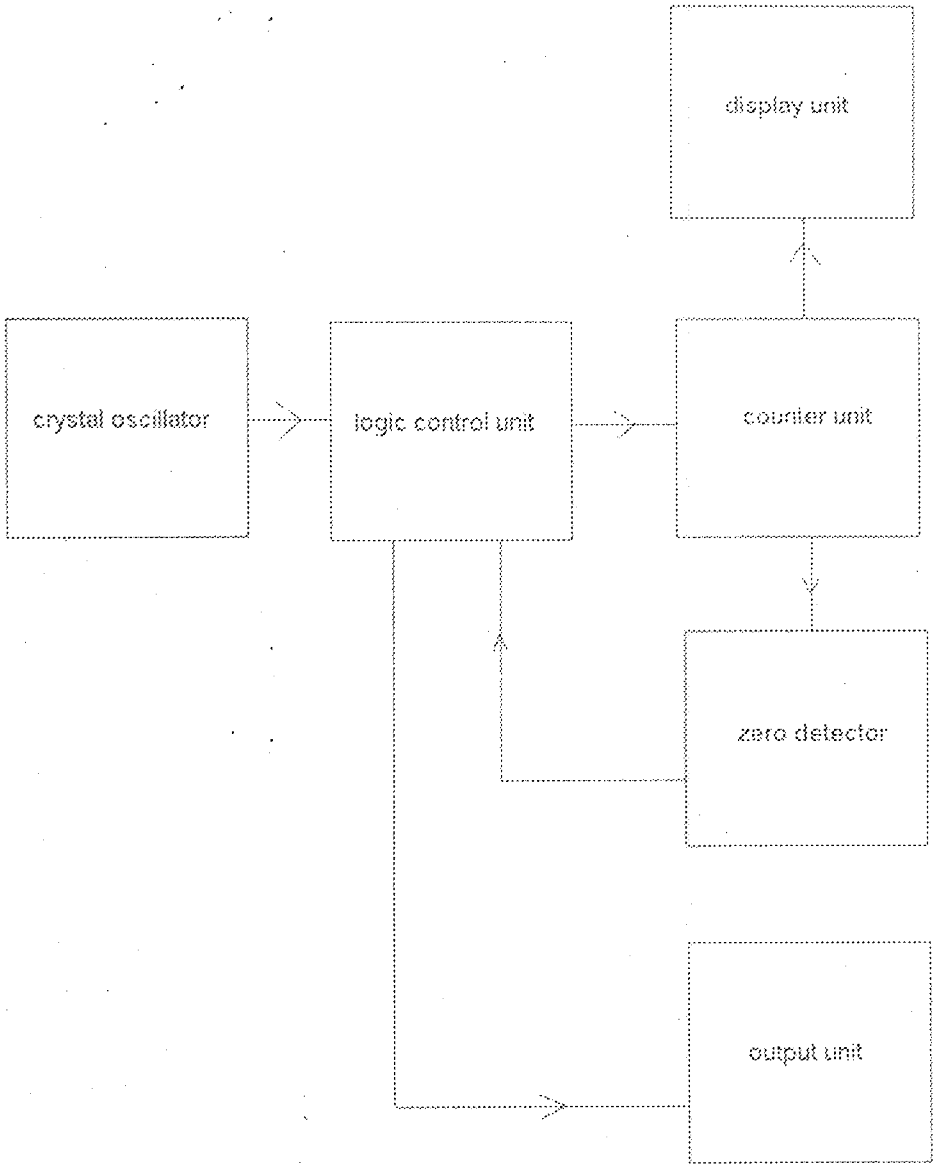


Fig. 3.12 The block diagram of the control timer

3.2.1 <u>Crystal oscillator</u>

The crystal oscillator is a 4060B integrated circuit with few external electronics components. The unit was earlier explained at the components` description. This unit simply generates precision frequencies of 2Hz and 8Hz.

3.2.2 Logic control unit

The logic control unit is the central part of the whole circuit. It is designed to further divide the frequency outputs from the crystal oscillator, controls the counters and also used to operate the output's load. This unit embodies latch logic functions.

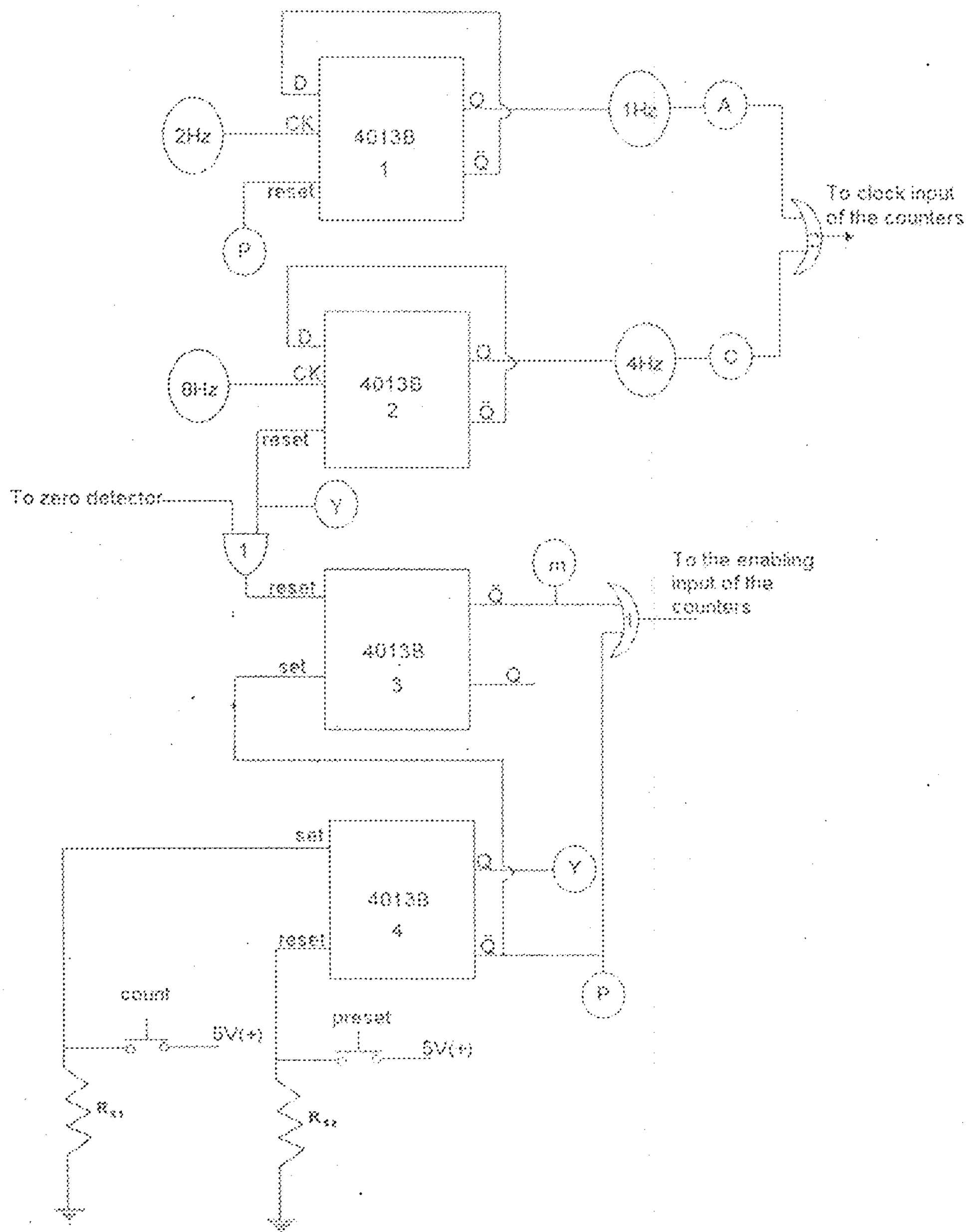


Fig. 3.13 The logic control unit

The logic control unit holds four latches. The 4013B 1 and 2 are divide by 2 configured latches. 4013B 1 divides the 2Hz pulse from the crystal oscillator to 1Hz. This resulting signal is aimed for counting purpose. Its period is evidently 1 second. This timing provides 1 second timing for the counter unit. 4013B 2 deals with the 8Hz signal from the crystal oscillator. The resulting pulse 4Hz is used for preset purpose of the counter. Interestingly, the two latches are used for control purpose. Their reset terminals are useful for such control. The control involves raising a particular reset input to high logical level. This results in disenabling the latch with high rest value.

4013B 3 and 4 are used for device control. 4013B 3 deals with the output control. It responds, the instant the counter is at the lowest state i.e "000". 4013B 4 is the main latch. It controls every logic unit in the circuit. The latch has external inputs involving two soft touch buttons. Whenever any of the buttons is pressed, a high logical level signal is sent to the corresponding input to the latch. A button is used for count control while the other for preset function. The buttons works in accordance with basic SR latch or flip-flop's truth table. One of the buttons must be pressed at a time.

When the preset button is pressed, 4013B 4 is reset. The result Q brings out high level logic, while Q is low. The terminal P output makes 4013B 1 disabled and 4013B 2 enabled. Therefore, OR gate 2 has 4Hz to clock the input of the counters. The 1Hz signal is cut-off. The OR gate 1 is low high due to terminal P.

AND gate 1 is disabled during the preset action. This prevents the accidental triggering of the output by the zero detector. When the count button is pressed, 4013B 4 is set. Its Q output changes from logic 0 to 1 and Q is low. In this case, the output of OR gate 1 is low. Now, 4013B 1 is enabled, while 4013B 2 is disabled. The output of the OR gate 2 is 1Hz. This is a 1 second period timing for counting down the counter unit.

The AND gate 1 output is logical 1 when terminal Y is high and a high signal is sent from the zero detector. Y is high when 4013B 4 is at the count mode i.e Q is high.

The preset mode is used for entering a particular digit or time into the counter unit at a relatively high speed (0.25 second period). Its count mode is a free-running operation of the counter. The count decrements every one second timing.

The feedings from the other parts of the circuit makes the operation of the logic control unit complete and reasonable.

3.2.3 Counter unit

The counter unit holds three 4029B BCD down counter. The counters are systematically and synchronously cascaded. The maximum count is 999 seconds or 16.65 minutes.

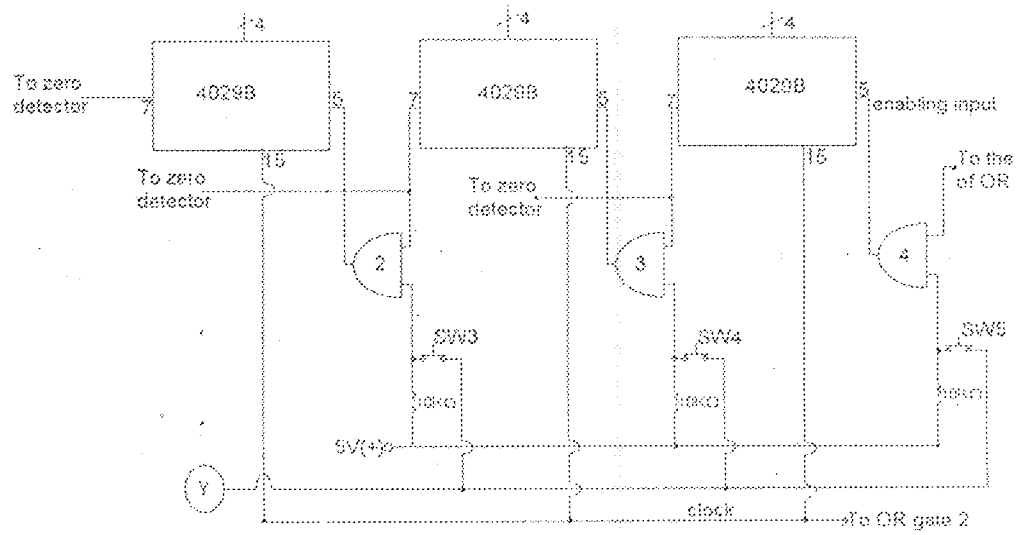


Fig. 3.14 The counter unit

The cascading of the counters is done in such a way that individual counter can be preset to a particular digit through buttons. Each counter has a preset button. The logic is achieved through AND gate 2, 3 and 4.

The configuration of the 4029B allows pin 7 (carry out) to go low whenever a particular counter is at the lowest digit i.e "0". The output is low logical level for the integrated circuit to be functional.

A 2 input AND gate is used to preset each counter. Three of such gate is used in the circuit, one for each counter. The AND gates are connected as shown in the above diagram. One of the input of the AND gate is connected to a particular pin 7 of a 4029B. The other input is connected to the positive (5V) through a 10KΩ resistor. The resistors put the inputs of the AND gates to high logical level. The result is normally carry in to carry out flow. The current status of the AND gate allows normal cascading of the counters.

When the 4013B 4 is at the preset mode, terminal Y is low. This allows the outer terminals of the switches to be low. Therefore, pressing any of the switches makes the corresponding AND gate's output logical 0. Therefore, the corresponding pin 5 (carry in or enabling input) is activated. Since the counter is synchronously cascaded with a particular common clock the corresponding counter to the active switch starts counting down with 4Hz speed. This is earlier explained at the control logic unit. This preset action is disabled when the count button is pressed. Y is now at high logical level. The necessary low logical signal at the respective AND gate is not possible. The output BCD code from the counter unit is fed to the display unit. The three carry out terminals from this unit goes to the zero detector unit.

3.2.4 Display unit

The display unit is made up of three 4511B integrated circuits. They are incorporated into the circuit to convert the BCD codes of the counters into corresponding 7-segment display. A 220Ω resistor is usually connected to each segment line to drop the voltage across corresponding LED segment.

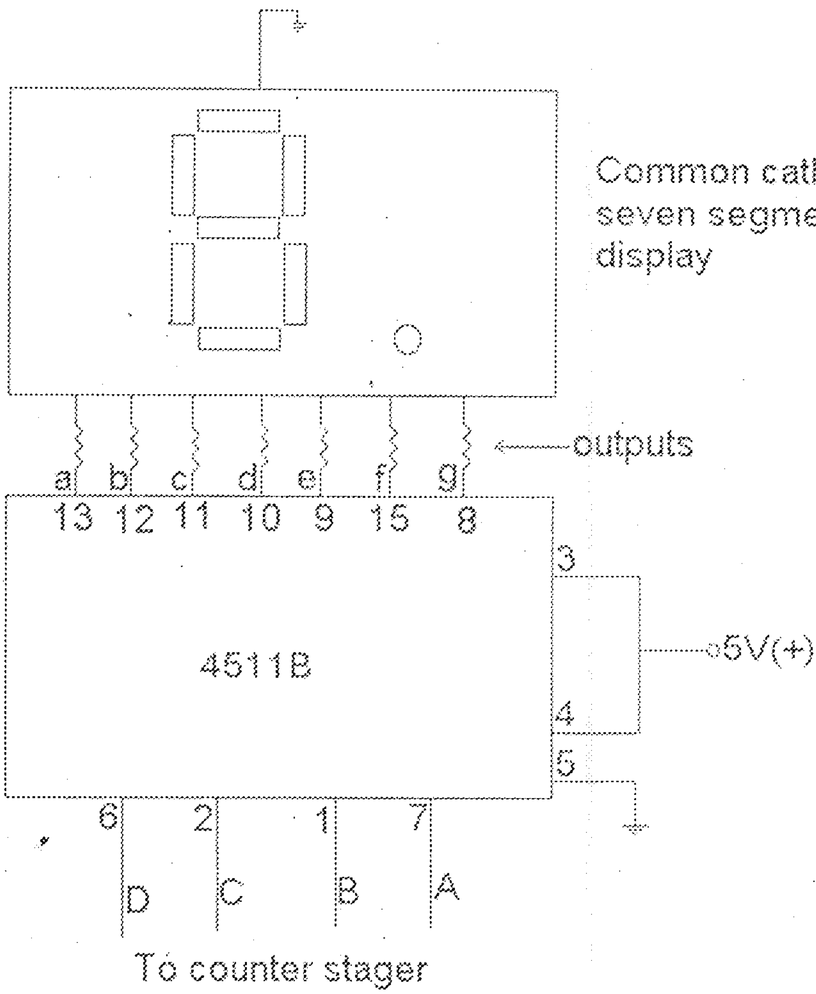


Fig. 3.15 The circuit of a 7-segment decoder/display unit

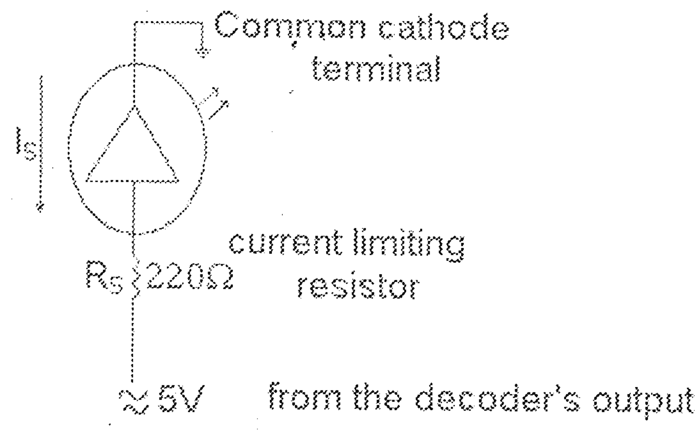


Fig. 3.1.6 The circuit of a single LED segment's circuit

For normal condition, the expected voltage at the segment or LED is 2.7V and current is 9.5mA.

Therefore, the voltage across the series resistor given by:

$$5 - 2.7 = 2.3\text{V}$$

$$R_s = \frac{2.3}{9.5\times10^{-3}} = 242.1\Omega$$

$$R_s = 242.1\Omega$$

The resistor value used is 220Ω. The value is of more practical importance. Pins 3 and 4 are made positive or at logical 1 while pin 5 is made low as specified by the datasheet of device.

3.2.5 Zero detector

The zero detector is designed to indicate the "000" condition or reading of the counters. It is made up of mere 3-input OR gate and inverter.

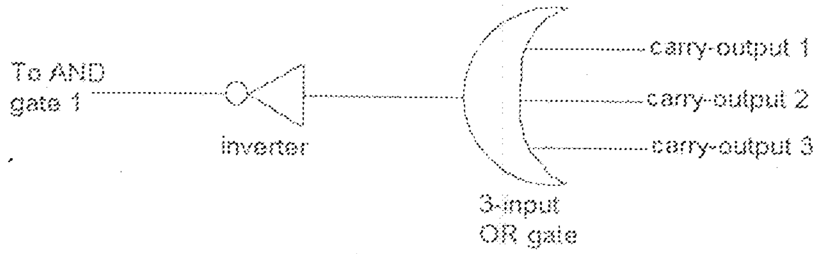


Fig. 3.17 The zero detector unit

The input of the OR gate is connected to the three carry-outputs from the three counters. The output of the gate is low when all carry-output is low. Therefore, the inverter changes the low level logic high.

The zero detector is used for triggering or operating the output through 4013B 3.

3.2.6 Output unit

The output unit involves a relay switching circuit. It responds to signals from the control logic unit through 4013B 3.

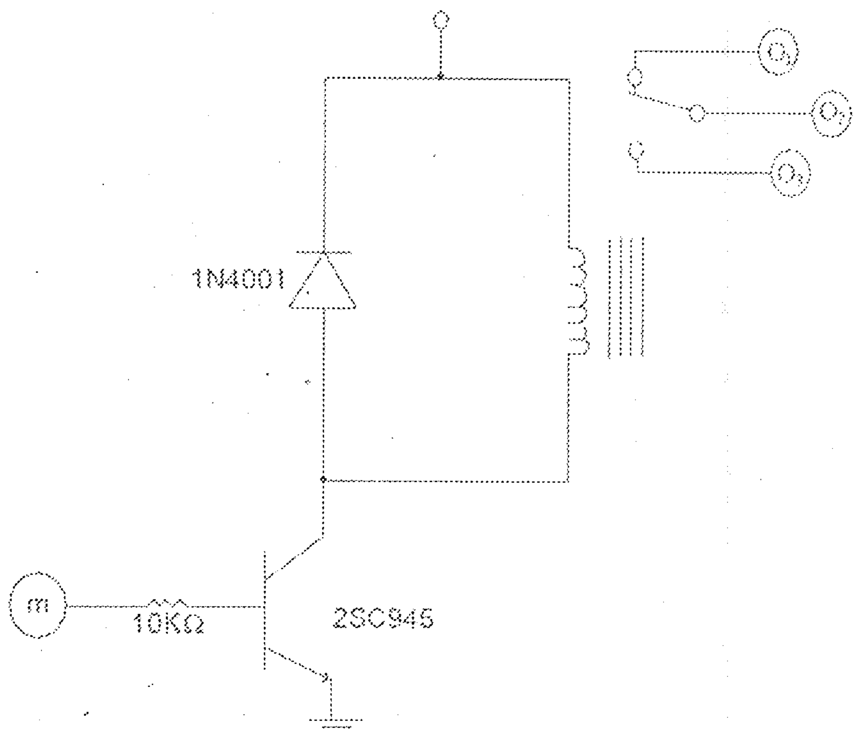


Fig. 3.18 The output unit

The output unit has a NPN switching transistor (2SC945), a diode, and a 12V relay. The base of the transistor is connected to point m of 4013 B 3. Whenever, terminal m is high, the transistor is energized and the relay is switched on. When the same terminal is low, the relay is disabled. The switching on occurs when contact O_2 is connected to O_1. The relay is off when O_2 is connected to O_3.

The relay is a load of 400Ω. The circuit is connected to 12V power supply. The transistor has a typical current gain of 100.

Therefore, the collector's current is roughly

$$I_c = \frac{12}{400} = 0.03A = 300mA$$

Therefore,

$$I_B = \frac{I_c}{100} = 0.3mA$$

Therefore, the base resistor is given by:

$$R_b = \frac{5-0.7}{0.3\times10^{-3}} = 14.333K\Omega$$
$$R_b = 14.3K\Omega$$

10KΩ is used for the circuit. The reverse biased diode at the relay is used to protect the transistor. It works against the Lenz's law of induction in which there is an opposing voltage to voltage change in the coil. The diode cancels out the induced back-e.m.f. The produced e.m.f. due to switching can destroy the transistor. The diode is therefore used to protect the transistor.

3.2.7 Power supply unit

The power supply unit involves a 24V step-down transformer with 7812 and 7805 regulators that produce 5V and 12V output respectively. The A.C. voltage from the transformer is converted to D.C. with the bridge rectifier circuit. The bridge rectifier has four rectifying diodes.

The output from the bridge rectifier is attributed to ripple. Therefore, a filtering capacitor is connected in parallel to remove or minimize the ripple. The 12V supply is connected to the relay circuit while the 5V supply is for the involved integrated circuit. The regulators are required mainly for stability.

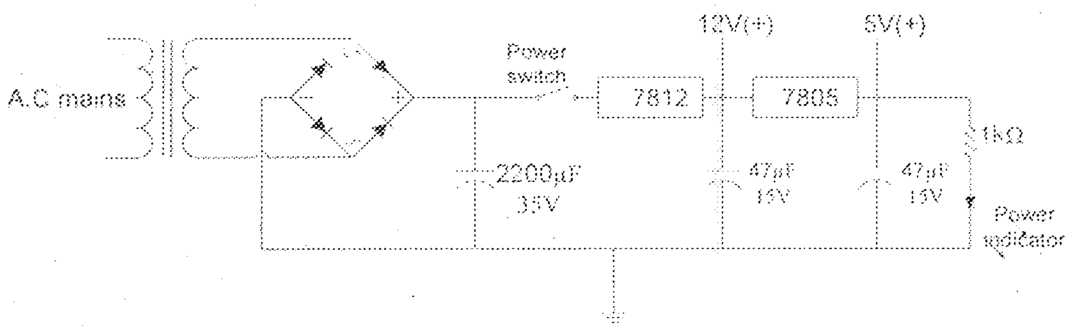
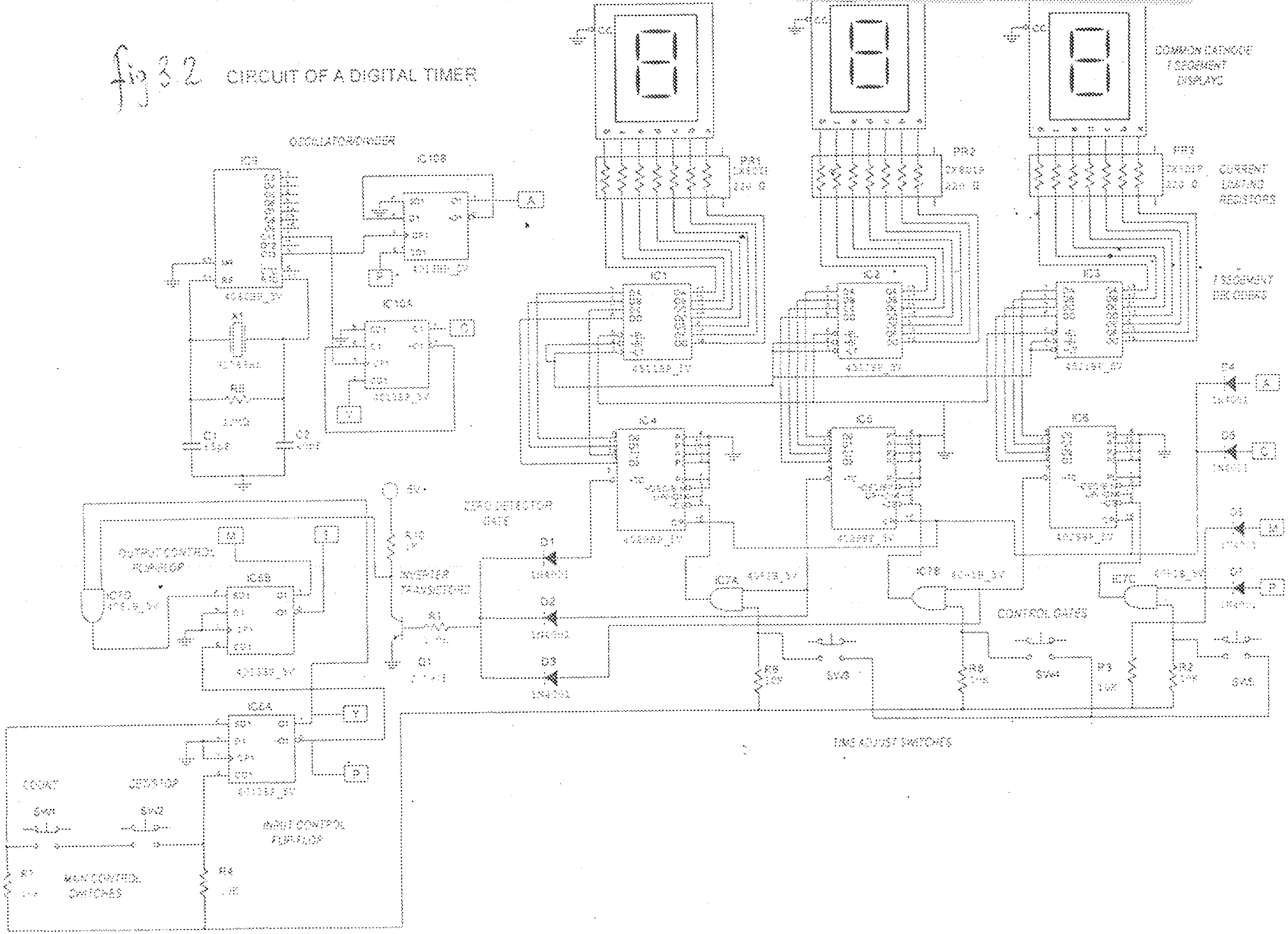


Fig 3.19 Power unit

fig 3.2 CIRCUIT OF A DIGITAL TIMER



CHAPTER 4

CONSTRUCTION, TESTING AND RESULT

4.1 CIRCUIT CONSTRUCTION

The circuit construction involved direct component connection on a suitable size vero-board. Bread board testing was ignored during construction due to the complexity and reliability of the circuit. Instead, a workbench software was used to simulate the circuit. The circuit diagram was carefully followed during the course of the construction.

The first step in the construction was to acquire the relevant components. They were new and apparently in good working conditions. Some of the components were tested with a digital meter.

The following list shows the working tools used for the construction.

i.) A 60 watts soldering iron.

ii.) Cutting Scissors

iii.) Razor blade.

iv.) Brush.

v.) Cutting plier

The components used were set on a suitable size vero-board one after the other. The complete circuit was divided into sections. Each section was executed one after the other. They were connected together to form a complete working circuit.

4.2 TESTING

The testing of the-circuit was performed after the completion of the circuit. This was done by connecting the device to different loads with different time inputs to test its ability to switch it ON or OFF.

The first step carried out was to plug the device to the A.C mains. After the power was on, the set mode button was pressed. A particular time was adjusted through the three preset buttons which was indicated on the display. The count-down button was then pressed to activate counting down of the preset time. After a value of "000" was obtained on the seven segment display the load connected to it was put off.

Different time values were set on the device during the test. The main aim of the test was to see the effect of zero-time mark on the output electric sockets. This was successfully achieved.

4.3 RESULTS

The results came out as expected. Two loads were plugged to the device. One to the normally on electric socket.and the other to the normally off side. At zero-time mark the two output electric sockets reversed their states. Thereby making the electronic device which was on to go off and the other which was off to come on.

5.) Connections on board were properly tested a digital meter before connecting the circuit to the electric supply.

5.3 RECOMMENDATIONS

1.) The available digit or timing can be expanded for longer time application.

2.) The numerous integrated circuits can be replaced with more compact and complex types for reduction in space.

3.) The involved LED display can be replaced with LCD type for reduction in overall power consumption.

4.) An auxiliary battery power supply can be incorporated into the design for better reliability incase of electric power failure.

5.) Remote control features like infra-red or radio can be incorporated.

6.) Sound effects can be added to show the decrement in timing.

7.) Application of more powerful switching relays can be used to achieve higher current switching of great industrial importance.

8.) Computer interfacing of the device will allow for better control features and flexibility.

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