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ABSTRACT

The enormous use of transistors in circuit design to accomplish new electronic fashion has made transistors an important device in electronic industries today.

With the design and construction of the NPN/PNP bipolar junction transistor tester device, transistor testing will be done in bulk and faster with less effort.

The basic operating principle of the device involves the application of a pulse to the base of the transistor under test and a corresponding output at the collector shows that the transistor is good. A bad transistor shows no amplification at the output.

The workability of the device was made possible by the use of 4060B (oscillator) IC and 4017 (sampler) IC. The output of the transistor under test is connected to the clock input (pin 14) of the 4017B, while the 4060B provides the pulse for testing and the test result is indicated via the seven segment display and an alarm sound from a speaker.

The NPN/PNP Bipolar transistor tester unit was designed, constructed and found out to be working perfectly well.

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CHAPTER 1

1.1 INTRODUCTION

The most commonly used solid-state semiconductor device is the "transistor". It is involved in almost every modern electronics. It usually features as an amplifier or a switch. It is the dominated unit in integrated circuits. A single silicon chip is capable of holding unbelievable high density of the leading component. Its advanced use merely involves digital circuits. A single microprocessor, microcontroller or reasonable space memory unit holds thousands of transistors working in accord.

By reason of the importance of transistor to electronic design; coupled with its intense production rate, the possession of a transistor testing device is really significant to electronic industries and laboratories. Such devices allow identification of "good" and "bad transistors. The project focuses on a NPN / PNP bipolar transistor test machine. It is designed to state the condition of the leading semiconductor device. It features both visual and audio outputs to level up with the test task.

The visual attachment holds a Light Emitting Diode (LED) display panel that digitally shows "good" for a right condition transistor under test. The word "bad" is read on the display whenever a bad transistor is tested. The message blinks on the display for attraction. The audio output involves a deep and high tone of frequency sound from a small speaker. The high frequency audio alarm comes on whenever the test is positive (or the transistor is in a good condition). The same speaker responses to a negative tone through a deep tone (or a test transistor is bad). Both known bipolar transistor (NPN and PNP types) can be tested with the machine.

1.2 AIMS AND OBJECTIVE OF THE PROJECT

The project is aimed at the design and construction of a NPN / PNP Bipolar transistor tester unit. The device is designed to display "good" with a high tone sound for good transistor and a "bad" display with a deep tone sound for bad transistors. It is digital in nature.

1.3 METHODOLOGY

The design is all about the application of high frequency signal to the base (or input) of the transistor under test. The test circuit is common emitter configuration, therefore, the input is the base and the collector serves as the output. It is quite evident that at a proper situation the signal fed into this input comes out amplified at the collector. Only good transistors allow such result. The leading output is connected to a digital sampler or detector unit. The unit logically defines the situation at the collector in response to the input through logic 1 or 0. The high logical level shows that the transistor under test is "good". But a low level result defines "bad" to the transistor under test. The machine is designated for PNP and NPN transistor testing.

In addition, the output of the early unit is used for controlling both visual and audio circuits as earlier explained. This output responds in two manners to the state of the inputs (test devices).

1.4 SCOPE OF THE PROJECT

The project is all about NPN and PNP Bipolar transistor testing. It involves both high tone sound and "good" display for good transistors and both deep tone sound and 'bad" display for bad transistors. The project involves complementary metallic oxide semiconductor (CMOS) integrated. The aim is low cost and reasonable performance.

1.5 LIMITATION OF THE PROJECT

The project is limited to PNP and NPN Bipolar transistors. The device cannot work with other transistors such as MOSFETS. It does not feature polarity testing or current gain computation. The project design is quite a challenge. But, through related information of the involved components and circuit the project is a success.

The involved circuit is attributed to significant improvement as compared to similar early designs. This is evident in the digital display section. The device provides a user's friendly feature thorough the visual information.

The design is achieved by the use of limited number of electronics components. Therefore, it is quite economical. Also, the overhaul electric current flow in the circuit is small due to the low power requirement of involved electronic components.

CHAPTER 2

2.1 LITERATURE REVIEW

The project is unique in operation. It is incorporated with both audio and visual features. No other project for testing bipolar transistor holds the leading attachments. Early works were attributed to mere Light Emitting Diode (LED) indicator for recognizing a working or bad semiconductor device. Some other related project involved the usage of analog meter for reading the diode (PN) Junction of the Emitter and Base, simply ignoring the collector's condition.

But in the case of this work, the three active terminals of a transistor are put into consideration. A signal is connected to the base of a transistor and amplification is expected through the flow of current through the collector and Emitter. The technique minimizes error to a good extent. The most interesting thing about the design is the friendly nature. The result of every test is acquired both through sound and visual manners.

Further improvement on the test device involves the type of logic integrated circuit used for its implementation. The Complementary Metallic Oxide Semiconductor (CMOS) is widely used for the altogether design. It is attributed to high flexibility, low power consumption, wide power supply, high number of logic functions, low cost and encouraging availability. Most of the other similar projects are related to Transistor-Transistor Logic (TTL). The TTL is not quite suitable for this kind of design. It is designed for high speed and power application. It's high speed is of no significant to this low speed design and it's high power consumption is definitely not economical.

2.2 THEORETICAL BACKGROUND OF TRANSISTORS

The first type of transistor is the bipolar junction transistors. It was invented in 1948 by J. Bardeen and W.H.Brattain of Bell Telephone Laboratories in the United States of America (USA) [1, 6]. The invention involved three semiconductor differently doped regions, the emitter region, the base region and the collector region are respectively p-type, n-type and p-type in a PNP, and n-type, p-type and n-type and a NPN transistor. Each semiconductor region was connected to a terminal, appropriately resistively material. The electric current at the base terminal merely influenced the electric current flowing through the emitter and collector regions. Such effect was used to amplify the current input at the base to the output collector. The transistor as made with Germanium Semiconductor. The design was lacking reasonable reliability or accuracy. Therefore, it was of no commercial interest. But more were developed for experimental use. Large scale commercial use did not come until mulch later owing to slow development.

Transistor used in most early entertainment equipment was the germanium types. When silicon electronic use was discovered and developed, silicon transistors took off dramatically to replace unsatisfactory performance of germanium technology with more acceptable importance. As early stated, the first advantages of the transistor were relatively low power consumption at low voltage levels which made large scale production of portable entertainment device feasible. A notable device is the transistor radio. It is quite smaller in size and low battery powered. In contrast, the thermionic tube radio devices were very expensive and not user friendly. The invention of transistor made electronic devices relatively economic as compared to the situation decades ago.

In 1960, Dawon Kahng and Martin Atalla at Bell laboratories, in the United State of America invented the metallic oxide semiconductor field effect transistor (MOSFET) [12], a more advanced transistor as compared to bipolar type. The MOSFET was structured by putting an insulating layer on the surface of a particular semiconductor and then placing a metallic gate electrode on it. It used crystalline silicon for the semiconductor and a thermally oxidized layer of silicon dioxide for the insulator. The bipolar transistor can be combined with MOSFET to create innovative circuits that take advantage of the best characteristics of both types. This is called BIMOS and is increasing its areas of application.

The idea of a compact transistor circuit was first conceived by a radar scientist Geoffery W. A. Dummer, working for Royal Radar Establishment of the British Ministry of Defence, and published in Washington DC on May 7, 1952 [7]. He unsuccessfully attempted to build such a circuit in 1956. Some years later, the first integrated circuits were manufactured independently by two scientists. Jack Kilby of Texas Instruments filed a patent for "solid circuit" made of Germanium on February 6, 1959. Robert Noyce of Fairchild semiconductors was awarded a patent for more complex "unitary circuit" made of silicon on April 25, 1961 [7].

The first integrated circuit contained only a few numbers of transistors. It is called small scale integration (SSI). Such technology was used in early space and military rockets. Medium-scale integration (MSI) and large-scale integration (LSI) were later introduced. The other integrations involve very-large-scale integration (VLSI) and ultra-large-scale integration (ULSI). The circuits hold thousands of transistors in an incredible small silicon space. These circuits are of great importance to computer and communication systems.

In addition, away from transistor integration, another great achievement in transistor technology is the development of Hetrojunction Bipolar Transistor (HBT). It is an improvement of Bipolar junction transistor (BJT) that can handle signals of very high frequencies to several hundreds Giga-hertz. It is common nowadays in ultra fast circuits, mostly radio frequency (RF) systems.

Different materials can be used for the substate, silicon and silicon-germanium alloy, aluminium gallium arsenide and gallium arsenide, or indium phosphate and indium gallium phosphate. Wide-band gap semiconductors are especially promising, e.g. gallium nitride and indium gallium nitride.

A pseudomorphic heterojunction bipolar transistor developed at the University of Illinois, was built from indium phosphate and indium arsenide and designed with compositionally graded collector, base and emitter was demonstrated to run at a speed of 604 gigahertz. Important Heterojunction Bipolar Transistor (HBT) applications are mixed signal circuit such as analog-to-digital and digital-to-analog converters. It holds great importance in modern GSM communication system.

2.2.1 BASICS OF TRANSISTOR OPERATION

The junction is simply a sandwich of one type of semiconductor material between two layers of other types. A layer of N-type material sandwich between two layers of P-type material is described as PNP transistor. An NPN transistor consist of a layer of P-type material sandwiched between two layers of N-type material.

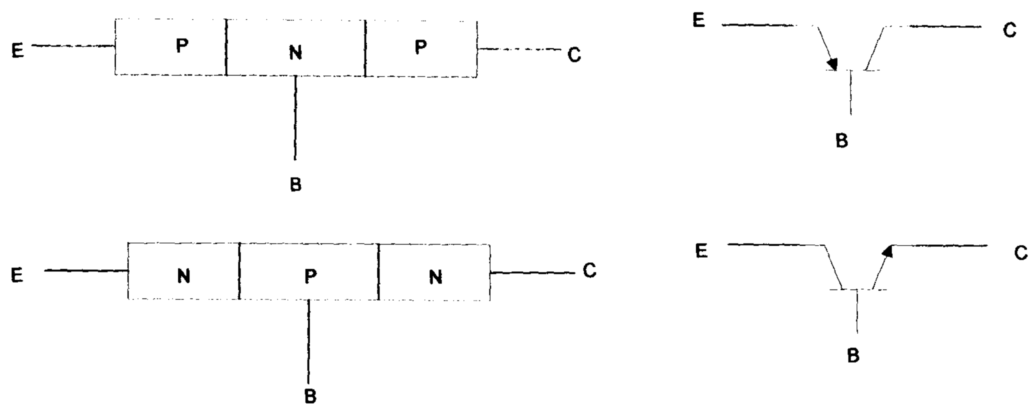

Fig. 1.1.NPN/ PNP sandwich between 2 layers of N-type and P –type material respectively

The symbols employed for PNP and NPN transistors are also shown in the figure above. The arrowhead is always at the emitter (not at the collector) and in each case, its direction indicates the conventional direction of current flow. For a PNP transistor, arrowhead points from emitter to base meaning the emitter is positive with respect to base (and also with respect to collector). For NPN transistor, it points from base to emitter meaning that base (and collector as well) is positive with respect to the emitter.

A transistor is a three terminal semiconductor device that can perform two functions that are fundamental to the design of electronic circuits: amplification and switching. The two junction of the must be given the right dc voltages, by an external source, so that appropriate dc currents flow in and out of the transistor. Thus, the base-emitter junction is forward biased which results in a low (input) resistance, and the base-collector junction is reverse biased given a high (output) resistance.

The most commonly used transistor is the NPN bipolar type. It can be considered as two diodes connected anode to anode. In an NPN-type transistor for example, electrons from the emitter diffuse into the base. These electrons found in the base are in the minority and there are plenty of holes which are to recombine. The base is always made very thin so that most of the electrons diffuse over to the collector before they recombine with holes. The proportion of electrons able to penetrate the base and reach collector is approximately constant in most conditions.

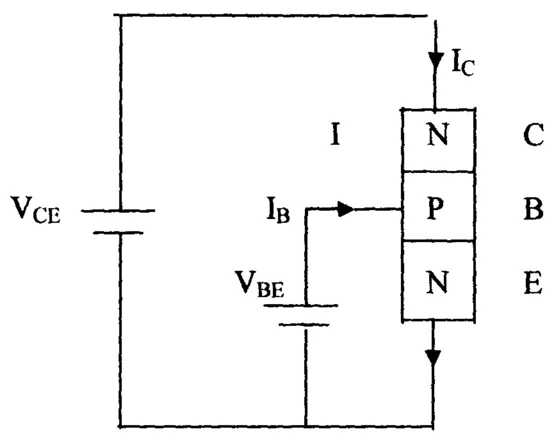

Fig.1.2 Structure and current-voltage flow of NPN transistor

The above diagram shows a schematic representation of an NPN transistor connected to two power supplies. To make the transistor active or conduct reasonable current (in the other of 1mA) flows from C to E, V_{BE} must be equal or slightly greater than the cut-in voltage. The cut-in voltage is frequently between 600mV and 700mV for silicon based Bipolar Junction Transistors. This applied voltage caused the lower P-N junction to "turn on" allowing a flow of electron from the emitter into the base. Due to the electric field existing between the base and collector (caused by V_{CE}), the majority of these electrons crosses the upper P-N junction into the collector to form the collector current, $I_{C.}$ The remainder of the electrons exists in the base connection to form the base current $I_{B.}$ As shown in the diagram, the emitter current, I_E, is the total transistor current which is the sum of the other terminal current that is:

$$I_E = I_B + I_{C.}$$

The ratio of collector current to the base current is called DC current gain.

The Bipolar junction transistor has three modes of operation; Cut-off, Active (or normal), and Saturation modes. In the cut-off region, both junctions are reverse biased. The transistor is off, because the base current is not large enough to turn it on.

In the active mode, the transistor acts as an amplifier and a linear relationship exists between collector and base currents. The collector-base junction (CBJ) is reverse biased while the base-emitter junction (BEJ) is forward biased.

In the saturation mode, both CBJ and BEJ are forward biased. The base current is relatively high and the collector-emitter voltage drop (V_{CE}) is low. When the transistor is used as a switch, it is constrained to operate between cut-off and saturation, (spending a little time in the active region as it moves from cut-off saturation or from saturation to cut-off).

2.3 DESCRIPTION OF VARIOUS BLOCKS IN THE BLOCK DIAGRAM

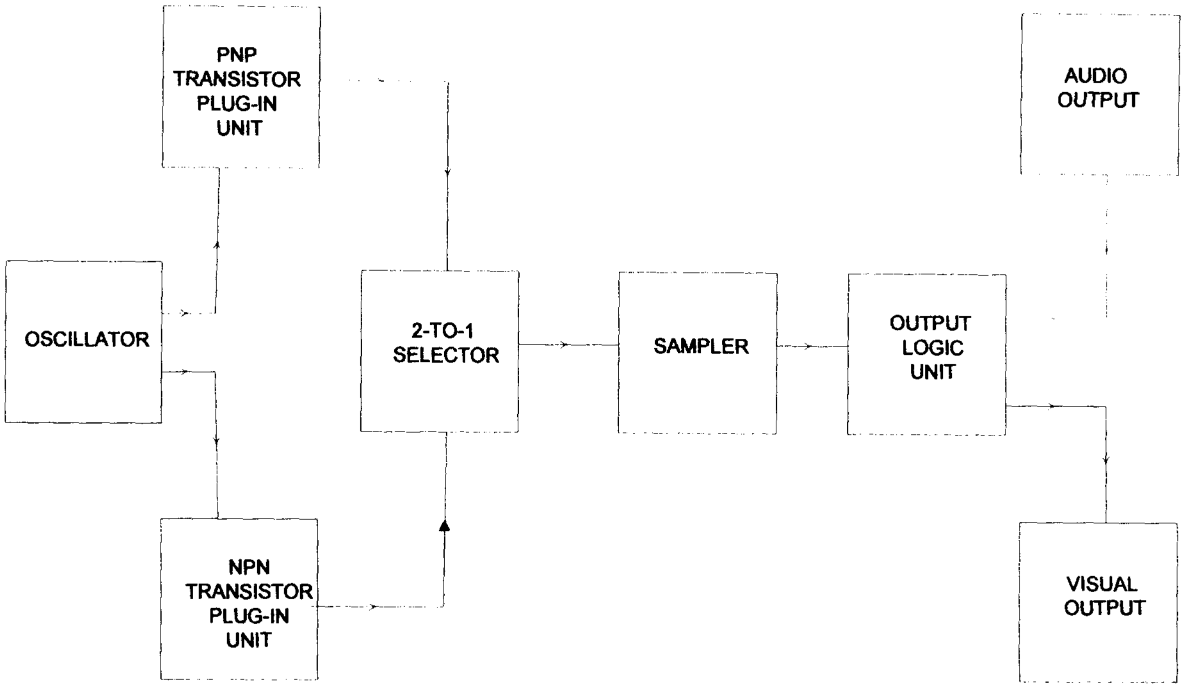

Fig. 2.3 Block diagram of the PNP/NPN bipolar transistor tester unit

2.3.1. THE OSCILLATOR

The oscillator is designed to generate three different frequencies. One of the frequencies is used for sampling operation. The other two are used for alarm effect. The oscillator is solely made up of the 4060B (IC) integrated circuit, and the oscillator is RC type. The most interesting feature of the oscillator is that it produces ten frequencies at once. But, only three are in use. Therefore, the integrated circuit is really compact. Also, the integrated circuit is controlled through a switch.

2.3.2. PNP/NPN TRANSISTOR PLUG - IN UNIT

The PNP/NPN transistor plug-in unit is designed for PNP/NPN transistor connection to the device. The unit provides a common emitter configuration for the test PNP/NPN transistor. That is, the base and collector of the transistor are input and output respectively. The input is connected to a high pulse from the oscillator. The output is connected through a selector to the sampler. Amplified output signal is expected at the collector side for a normal transistor.

2.3.3. 2 – TO - 1 SELECTOR

This unit is a mere 2 to 1 switch. The design involves testing of one of NPN and PNP transistor inputs. Therefore, the selector is used for selecting a particular output from the available two to the sampler.

2.3.4 SAMPLER

The sampler holds a single 4071B integrated circuit (IC). The sampler defines the output of a selected transistor's input or circuit. At normal condition, the selected transistor's circuit ought to posses an amplified signal of the input test pulse. The sampler merely shows whether the expected signal is there or not. It is done digitally when the expected signal is present. The sampler gives out logic 1 to define the situation. The output logic 0 is for bad transistors.

2.3.5 OUTPUT LOGIC UNIT

The output logic unit is designed to switch both audio and visual outputs. The switching is logically performed. The main aim of such operation is to better identify the condition of test samples. The output logic unit is made up of logic gates. Their connection with the input allows a high tone sound to be heard and "good" as display for functional transistor samples. And a deep tone sound and "bad" as display for non functional transistor samples. The output logic unit merely switches on a particular output in response to a particular test.

2.3.6. AUDIO OUTPUT

The audio output unit embodies an amplifier-speaker circuit. The unit gives out a deep sound for bad transistors a high tone sound for good transistor. The output is dependent on the result of sampling and control from the output logic unit.

2.3.7. VISUAL OUTPUT

The visual output unit is made up of common cathode seven segment displays. The main function of the unit is to display "good" or "bad" for results. The alpha-display is logically achieved because normal common cathode seven segment displays is designed for digital and not alphabet application.

2.4 COMPLETE CIRCUIT DIAGRAM

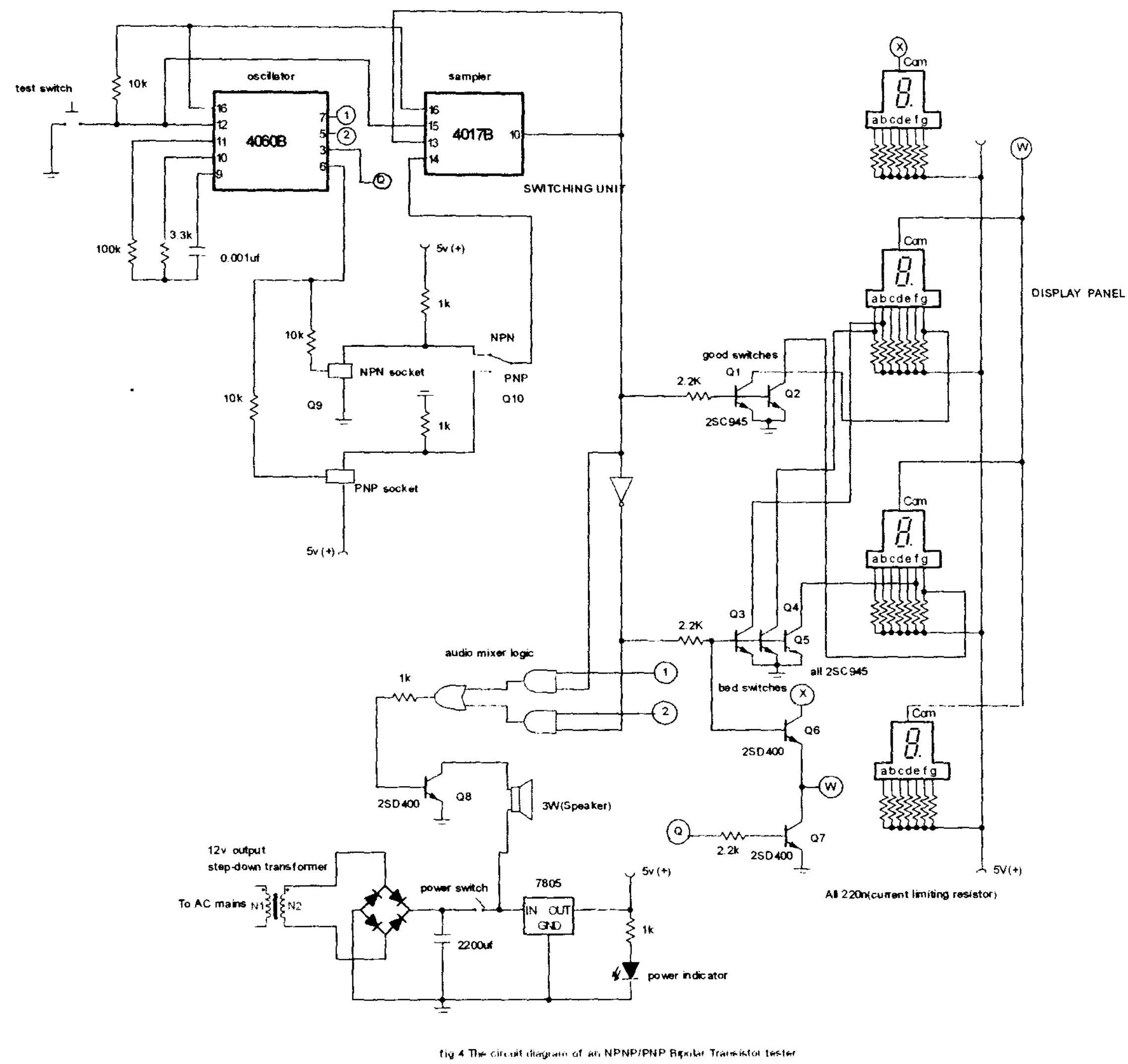

fig 4 The circuit diagram of an NPNP/PNP Bipolar Transistor tester

Fig. 2.4 The working circuit of NPN/PNP Bipolar junction transistor tester

2.4.1 OPERATING PRINCIPLE OF THE NPN / PNP BIPOLAR TRANSISTOR TESTER CIRCUIT

The circuit is used for testing both PNP and NPN transistor. The main design technique involves the connection of a high pulse or signal from the oscillator to the base of the transistor under test. The transistor under test is put at common emitter configuration so that the base and collector are input and output respectively. Normal or functional transistors are expected to produce amplified signal at the collector or output. Thus, a particular output is used for judging whether a transistor is "good" or "bad".

The oscillator produces high pulse for test. The same integrated circuit produces two other outputs for the alarm circuit. One of the frequencies is high tone and the other is attributed to low frequency sound. Whenever the test switch is pressed, the oscillator starts working.

The sampler examines the output from a selected transistor. The sampler counts a very small time of the expected signal from the leading output. The sampler is basically 4017B integrated circuit. It gives out logic level "1" for a working transistor and logic level "0" for non functional transistor. The sampler results are used for switching the other parts of the entire circuit.

Through an AND-OR logical selection circuit, two sound signals are fed to an audio amplifier circuit. As earlier stated, deep sound is heard for bad transistors and good transistors go for high tone sound output. The audio amplifier is a single NPN transistor circuit. The active device is 2SD400.

The same sampler is output switches on a particular word for the result of sampling or test. The proper switching of a particular display is achieved through connected switching NPN transistors. The transistors receive logical signal from the sampler for a specific display.

CHAPTER 3

3.1 COMPONENT CHOICE AND DESCRIPTION

The following are the major component of the project: -

1. 4060B
2. 4017B
3. 4081B
4. 2SC945
5. 2SD400
6. 7805
7. 1N4001
8. Common cathode 7-segment display.

3.1.1 4060B

The 4060B is a very useful oscillator whenever multiple frequencies are required in a circuit. It is among the CMOS 400D series logic functions. It mainly produces ten frequencies at a time. The frequencies are derived for multiple division of a main or central frequency. This frequency can be generated through both RC and crystal configuration of the IC. Every output of the IC is buffered for high current switching application. Four different frequencies are required for the design. Therefore four common 555 timers is somehow equivalent to the single 4060B application. The IC possesses a RESET terminal for control application. It is active low.

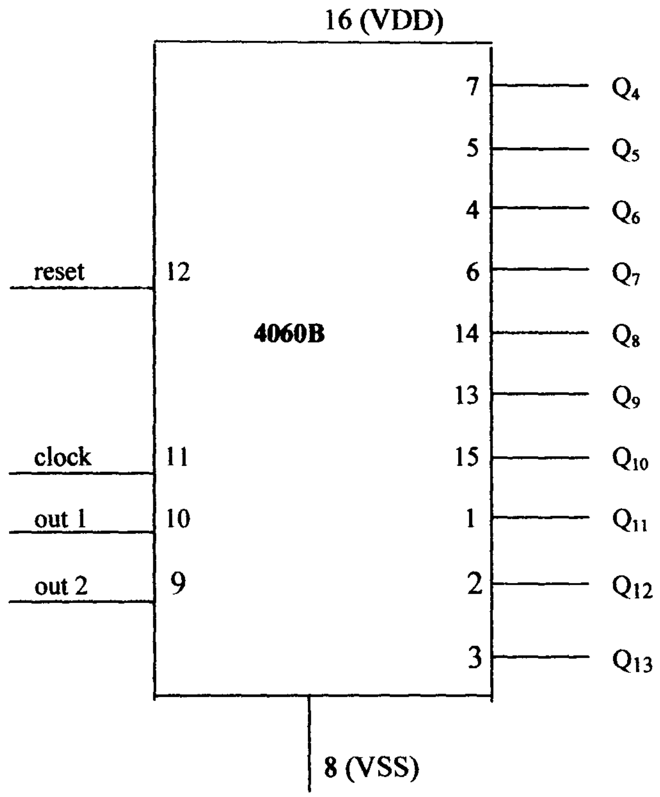

fig. 3.1a the functional diagram of 4060B

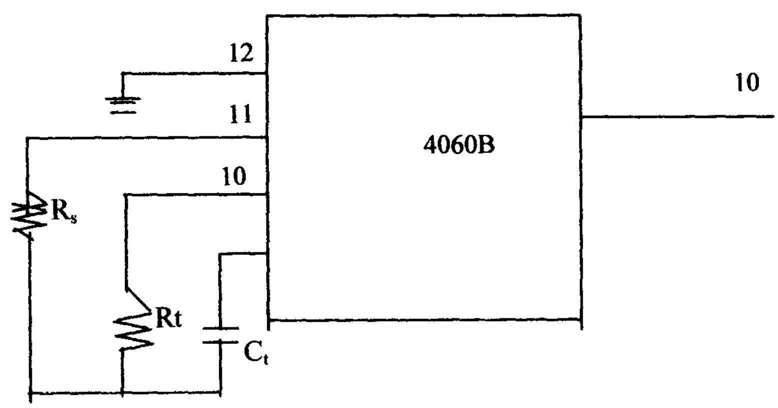

fig. 3.1b the common IC configuration

The main frequency of the configuration at 10V is given by:

$$F_m = \frac{1}{2.3R_tC_t}$$

The relationship between R_t and R_s is given by:

$$10R_t \geq R_s \geq 2R_t$$

The resistance must be below 1mΩ for the relationship to be applicable.

The RC configuration used for the design is popular, and the values of R_t and C_t are 33KΩ and 0.001μf respectively.

The frequency at a particular output terminal is given by;

$$F_{QX} = \frac{f_m}{2^x}$$

Where, x is the numerical attachment of a particular Q output.

3.1.2 4017B

The 4017B is normally called a logic stepper. This is because it has ten outputs in which logical 1 makes a single increment for every positive clock trigger input. The device is indeed a 5-stage Johnson counter. It is really unique in its position in the circuit. Only few integrated circuit do the work as much as the 4017B. It is really suitable in terms of economic.

The integrated circuit possesses ten frequency outputs. The outputs are controlled by a clock input (pin 14) which is active high. Pin 15 and 13 must be low for any positive device response.

DESIGN AND CONSTRUCTION OF PNP/NPN BIPOLAR TRANSISTOR TESTER UNIT

BY

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

OCTOBER, 2006

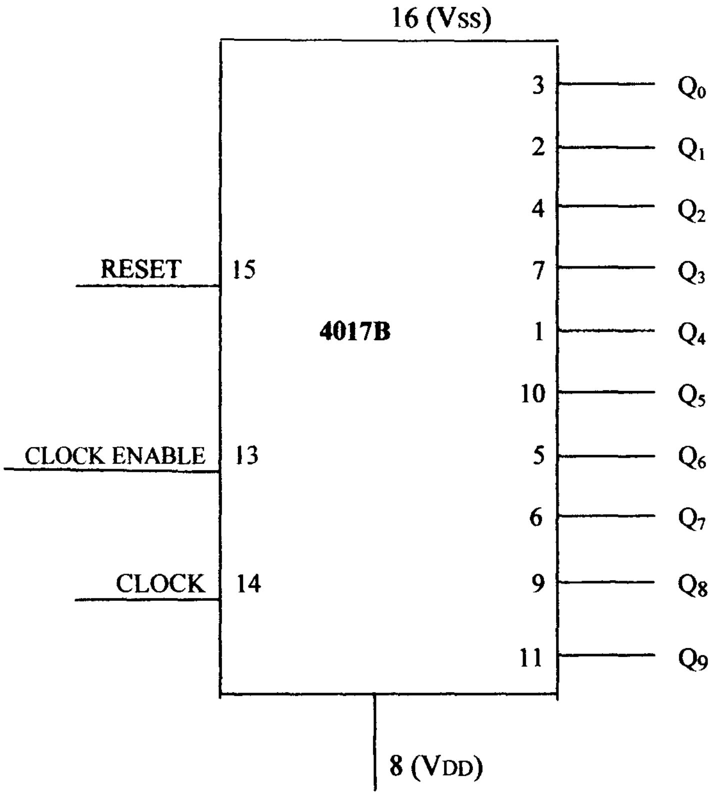


Fig. 3.2 the functional diagram of 4017B

3.1.3 4081B

The 4081B is a quad 2-input AND gate. That is, the IC has four 2-input AND gates. It is a common or conventional device for AND operation.

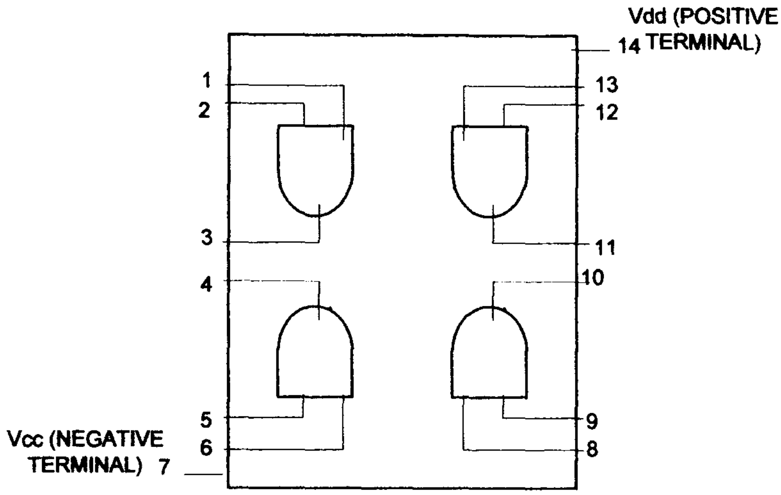


Fig.3.3 the functional diagram of 4081B

3.1.4 2SC945

The 2SC945 is a NPN bipolar transistor for both low power audio amplifier and low speed switching application. It has a typical current gain (hfe) of 100. It operates with maximum current and voltage ratings of 100mA and 50V respectively. It is a very common and cheap device.

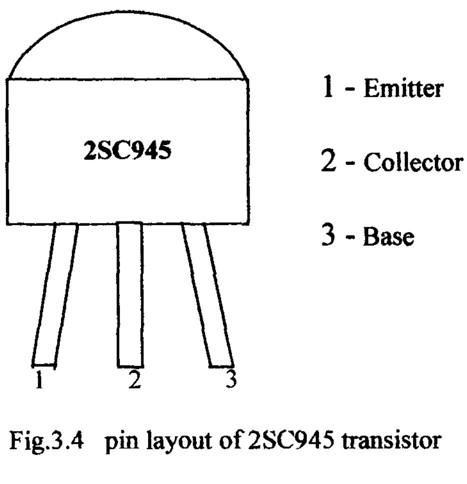
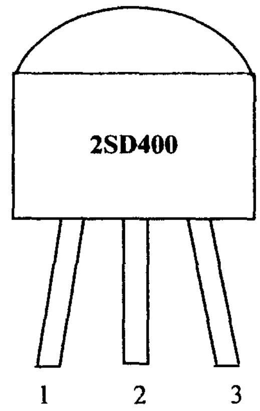


Fig.3.4 pin layout of 2SC945 transistor

3.1.5 2SD400

The 2SD400 is quite similar to the 2SC945. But, it is used for high current application. It can derive current as high as 900mA. It has a typical current gain (hfe) of about 80.



1 - Emitter

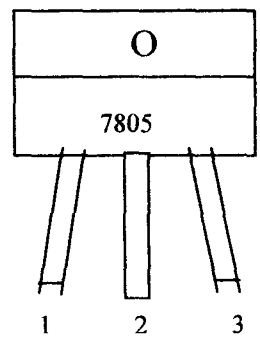
2 - Collector

3 - Base

Fig. 3.5 the pin layout of the 2SD400 transistor

3.1.6 7805

The 7805 is a positive voltage regulator that derives a maximum current of about 1000mA. It operates under 35V. It is often used for smoothening and stabilizing current flow through a current. It is used at the power unit to regulate the involved 12V to 5V.



1 – VOLTAGE IN

2 _ (GND) GROUND

3 – VOLTAGE OUT

Fig. 3.6 the pin layout of the 7805 voltage regulator

3.1.7 1N4001

1N4001 is a mere PN diode for A.C. voltage rectifying application. It operates with maximum current and voltage of 1000mA and 50V respectively. It is used for the bridge rectifier side of the power supply unit.

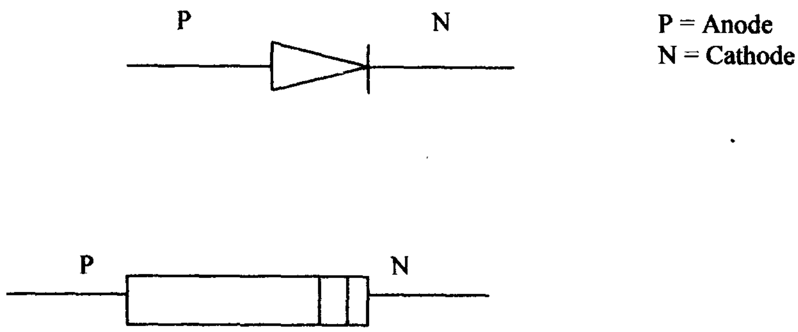


Fig. 3.7 the terminal layout of IN4001

3.1.8 COMMON CATHODE (SEVEN) 7-SEGMENT DISPLAY

The common cathode seven segment displays are specially designed for CMÓS application. The common-anode type is for TTL devices. It is designed for displaying digits, sometimes certain alphanumerical characters as used in the project.

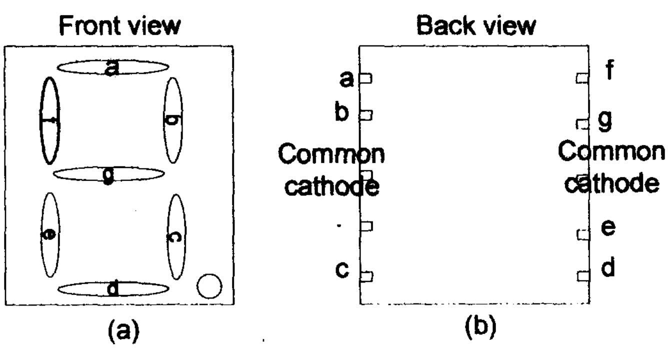


Fig. 3.8 (a) segment view of the common cathode 7-segment display

(b) pin layout of the common cathode 7-segment display

3.2 CIRCUIT DESIGN

The circuit is grouped into six major groups. They are as follow: -

(i) Power supply unit.

(ii) Control oscillator.

(iii) Device test input.

(iv) Sampler.

(v) Display unit.

(vi) Audio unit.

3.2.1 DESIGN OF POWER SUPPLY UNIT

The power supply unit is quite an invert ional bridge rectifier. The unit supplies both 12V and 5V for the circuit. The 12V is directly from the bridge rectifier and the 5V is from a connected 7805 (5V regulator) IC. The regulator produces a steady current in the circuit.

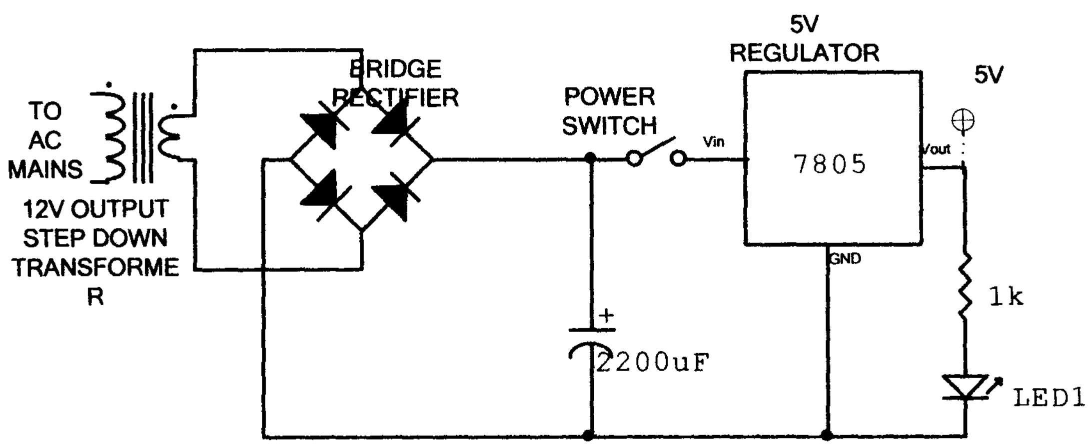


Fig. 3.9 the power circuit

A 500mA, 12V AC step down transformer supplies electric power to the circuit through the AC mains. A bridge rectifier consisting of four rectifying diodes converts the

AC voltage into corresponding DC. The bridge rectifier's operation is quite normal. Two diodes are forward biased at the same time while, the other two are reverse biased. A 220µf 35V capacitor is connected in parallel to the output from the rectifier to remove or minimizes remaining AC component in the rectified voltage. The capacitor ranges from 1000µf above. The device is normally called a filtration of the ripple from the expected DC voltage output.

A power switch is incorporated into the design to close and open the circuit. A 7805 (5V regulator) IC stabilizes a voltage supply of 5V to the circuit. The integrated circuit works within 6 – 35V range.

A power indicator circuit consisting of 1KΩ resistor and a Light Emitting Diode (LED) shows the presence of electric current in the circuit. The resistor is in series with the diode. It causes voltage drop across the Light Emitting Diode (LED). This is because the light device needs a maximum supply voltage of roughly 2.8V.

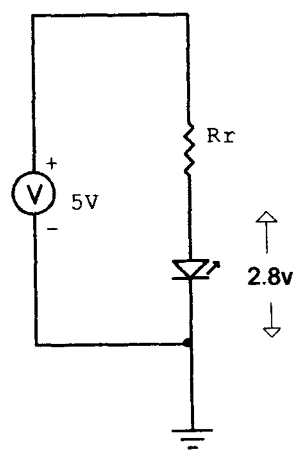


Fig. 3.10 Power indicator circuit

The value of the series resistor can be calculated by assuming a typical current of 3mA for such circuit. The voltage across the resistor is:

V=IR

For I=3mA

V=5-2.8=2.2V

And R=V/ I .... (1)

Therefore, $R_r = \frac{2.2}{3 X 10^{-3}} = 733.33\Omega$

1KΩ is used in the design because it provides more technical and practical performance.

3.2.2 DESIGN OF CONTROL OSCILLATOR

The heart of the control oscillator is the 4060B integrated circuit. It is designed to produce ten frequencies. But, only four are in use in the design. The control oscillator generates necessary timing for the circuit altogether. The oscillator is activated through the test switch.

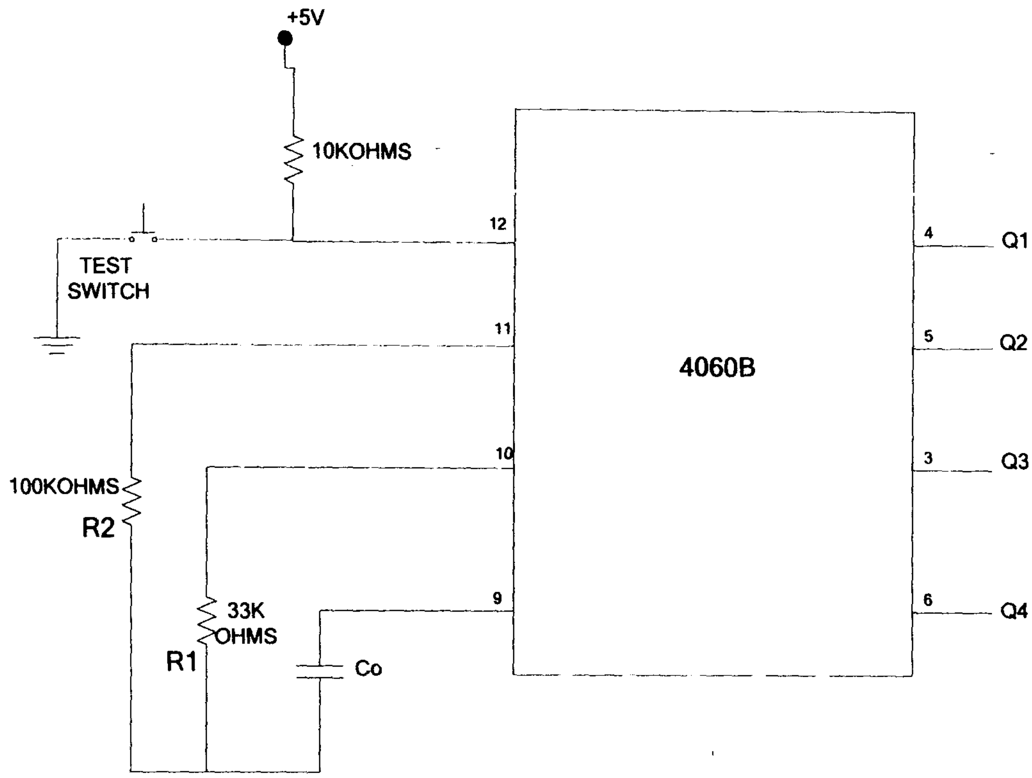


Fig. 3.11 RC configuration of 4060B IC

The oscillator is at RC configuration, its control input is pin 12. It is connected through a 10KΩ resistor to the positive terminal (5V). The resistance value can be in the range 1 – 100KΩ, as specified by the data sheet. The integrated circuit requires a low logical level at the pin 12 for functional mode. Therefore, by pressing the switch, negative signal is fed to the leading pin. The four frequencies at the output of the logic device are dependent on the resistor and capacitors at the oscillator's input pins. The frequencies are derived from the main one. The main frequency is calculated with the following formula: -

$$fm = \frac{1}{2.3R_1C_0} \qquad \text{..} (2)$$

R_2 must be twice greater that R_1, but it must not be more than ten times R_1.

$$fm = \frac{1}{2.3 \text{ X } 3.3 \text{ X } 10^3 \text{ X } 0.001 \text{ X } 10^{-6}} = 13.2\text{KHz}$$

The related frequency output are based on the following formula: -

$$f_{QX} = \frac{fm}{2^X} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

Where x is the digit concern with a specific Q.

Therefore, the frequency output at pin 33 (Q_{14}) is given below: -

$$f_{Q14} = \frac{13.2 \text{ X } 10^3}{2^{14}} = 0.81\text{Hz}$$

For pin 5 (Q_5)

$$f_{Q14} = \frac{13.2 \text{ X } 10^3}{2^5} = 412.5\text{Hz}$$

For pin 7 (Q_7)

$$f_{Q7} = \frac{13.2 \text{ X } 10^3}{2^4} = 825\text{Hz}$$

For pin 6 (Q_6)

$$f_{Q14} = \frac{13.2 \text{ X } 10^3}{2^7} = 103.125\text{Hz}$$

The frequency outputs from Pin 6, 5, 7 and 3 are used for sampling bad test input result, good test input result and alarm breaking effect.

3.2.3 DESIGN OF DEVICE TEST INPUT UNIT

The device test input unit is designed to accommodate the test transistors. It possess two inputs, both for the PNP and NPN transistor samples. The unit is all about placing the leading transistors at the common emitter configuration.

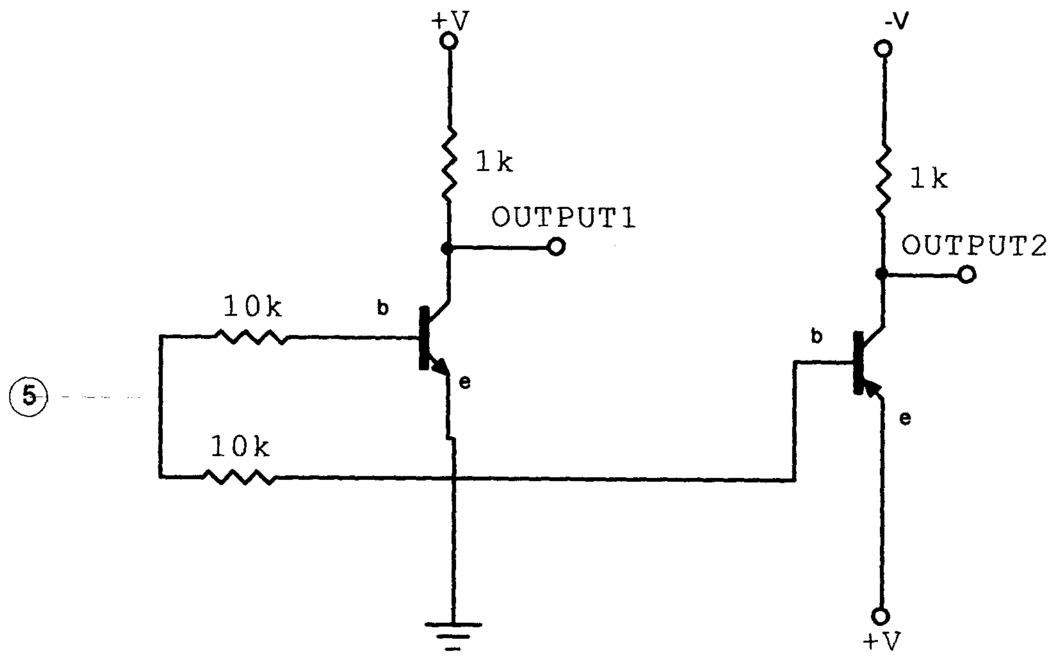


Fig. 3.12 The test device input unit

The figure above shows the connection of the leading test sample. The signal (103.125Hz) from pin 6 of the 4060B IC is connected to the base terminals of the connection through 10KΩ resistors. The resistors serve as for popular base bias. Each collector terminals are loaded with a 1KΩ resistor. The resistance values are typical of any normal transistor.

The basic principle of operation of the unit is that a pulse from pin 6 (103.125Hz) of the 4060B (control oscillator) is connected to the base of a test transistor, and an amplified signal is expected at the collector. This basic defines the transistor's test.

Although, the current gain (hfe) of the test transistor determines the output signal, the sampler (the next unit) responses to any reasonable output level from a selected collector.

3.2.4 DESIGN OF THE SAMPLER

The 4017B is made up of the sampler unit. It is designed to figure out an expected amplified signal for a particular collector's output. The device is functional whenever its pin 15 in made logical 0. The test switch is used to achieve this required state. Its pin 10 is high logical level whenever a signal is received from a particular output. The pin 10 remains low logical level at no signal condition.

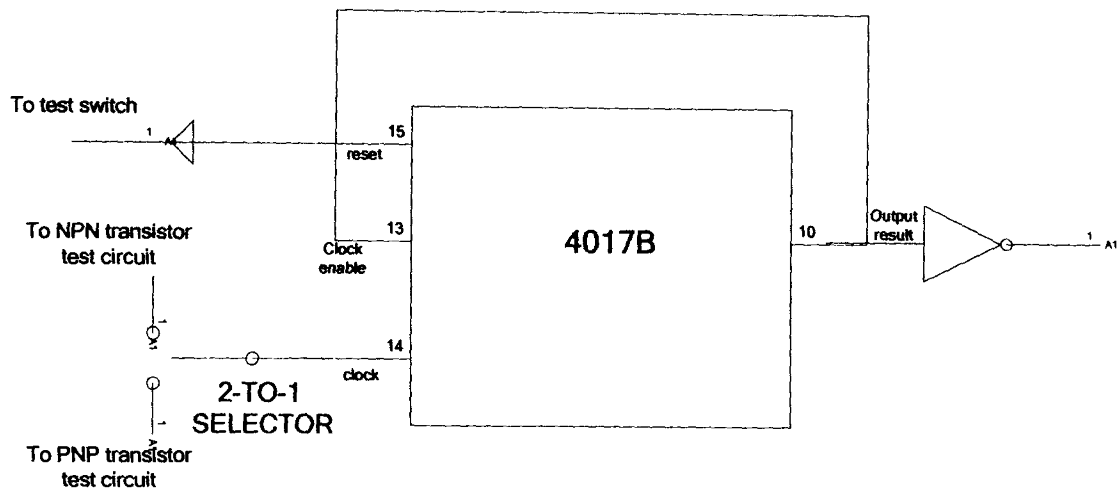


Fig. 3.13 The functional diagram of the sampler unit

The device's clock input is connected to a 2-to-1 selector/switch. The selector/switch allows a particular input from the NPN or PNP transistor test circuits. Therefore, only one transistor can be sampled at a specific time. The rest terminal is connected to the test switch. Whenever, a pulse is present at the clock input, the 4017B, owing to it's counting ability, begins to count the input pulse or signal through its ten decoded outputs. The counting operation enters the fourth state whenever its pin 10 becomes high.

This is basically the sampling operation. No input condition results into holding logic 0 on the pin 10. The pin is fed back to the clock enable input (pin 13) so as to stop further sampling or counting. Therefore, the high logic level at the pin 10 is held HIGH until the test switch is released, thereby resetting the device by making its pin 15 high logical level. The leading pin 10 is connected to an inverter.

3.2.5 DESIGN OF THE AUDIO UNIT

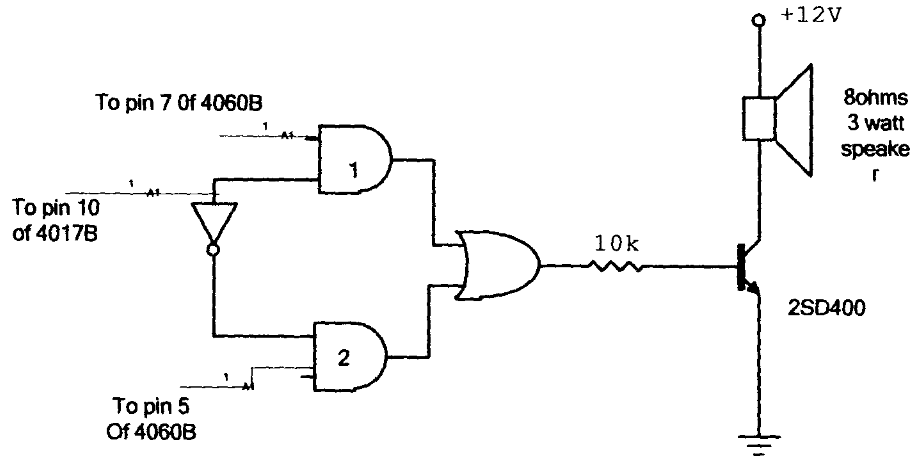


Fig. 3.14 The audio unit

The audio unit is designed to respond to the input or test. It produces two different sound outputs, both deep and high tone. The deep and high tone sound outputs are for recognizing "bad" and "good" transistors respectively.

The circuit embodies limited number of components. The more evident part is an AND – OR selector. The selector receives control logical levels from the sampler unit to produce or select a particular sound output. AND gate 1 and 2 are related to the 825Hz, 412.5Hz audio signal from the oscillator. The signals are fed into one of their two inputs. AND gate 1 and 2 other inputs are directly connected to the pin 10 of the 4017B IC and the output of the inverter connected to the pin 10 of the 4060B IC respectively.

Based on the common truth table of a 2-input AND gate, whenever the pin 10 of the 4017B IC (the sampler) is high, the 825Hz audio signal passes through AND gate 1, while the 412.5Hz frequency is disallowed to flow through AND gate 2. The situation is reversed whenever the pin 10 is logical 0.

The 2-input OR gate sums up the two output from the AND gates. The particular output from the OR gate is connected to the base of a single NPN transistor amplifier in common either configuration. The collector (output) of the transistor is connected to a speaker or the load of the amplifier.

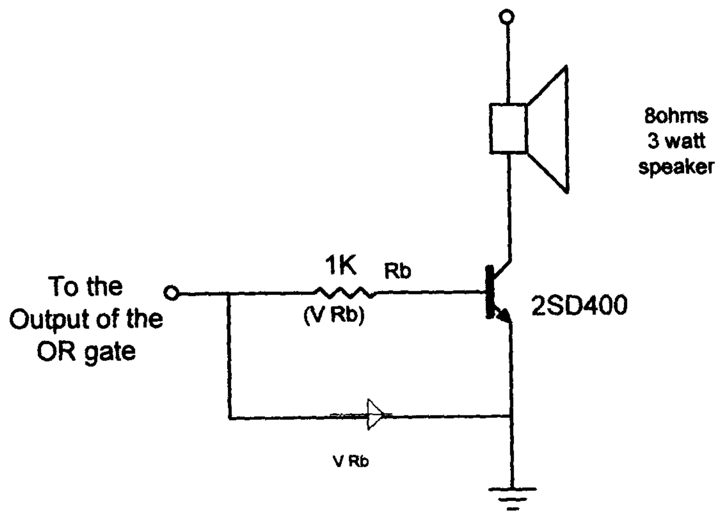


Fig. 3.15 The single transistor amplifier

The speaker is rated 8Ω 3watts

Therefore, Power = I^2r .... (4)

But, r = 8Ω

p = 3watts

Then $I = \sqrt{p/r} = \sqrt{3/8} = 0.61A$

A current of 0.61A is expected at the collector of transistor. The NPN transistor (2SD400) is rated 1A. It is suitable for this application.

e.g. 1A > 0.61A

The current gain (hfe) of the transistor is typically 100.

Therefore, $$I_B = \frac{I_C}{hfe} \qquad \text{.......................................} (5)$$

$$= \frac{0.61}{100} = 6.12mA$$

Therefore, a current of 6.12mA is expected at the base for a peak response. The base resistor is 1KΩ.

From fig. (16) V_{RB} is assumed 5V. This is because the voltage supply to all the integrated circuit together is 5V from the 5V regulator.

Therefore, $V_{RB} = 5 - 0.7 = 4.2V$

So that, $$R_b = \frac{4.2}{I_b} = \frac{4.2}{6.12 X 10^3} = 702.6\Omega$$

But, 1KΩ is replaced of 702.6Ω because 1KΩ is more practical.

3.2.6 DESIGN OF THE DISPLAY UNIT.

The display unit is designed to response to the input test by showing or displaying "good" for working transistor, and "bad" for non-functional ones. The major design concept involves the supply of positive signal to specific anodes of four common cathode 7-segment displays. The corresponding segments come on. And, five switching transistors are connected to pin 10 of the 4017B and the connecting inverter in a manner that certain parts of the 7-segment displays are switched off. This technique allows a particular digits or alphabets to be displayed in representing a word.

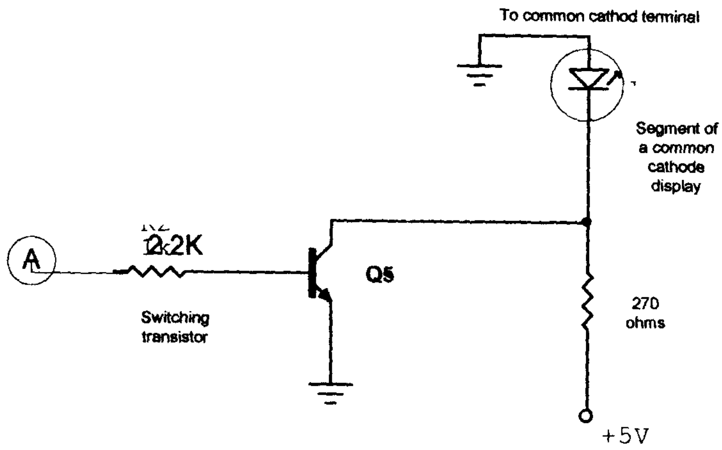


Fig. 3.16 the switching operation on a particular common cathode display's segment

Whenever terminal A is at low logic level, the transistor is cut-off owing to the fact that the base is far below 0.7V required for switching the LED comes on. Current I_{LED} flows from the positive terminal (+5V) to the negative terminal (ground) through the series resistor and LED. The resistor is of current limiting function. It allows a voltage of about 2.8V across the LED. A supply voltage of 5V is damaging to the light indictor.

Assuming a voltage of 2.8V is expected across the LED, therefore, the voltage across the resistor is 5 – 2.8 = 2.2V. And assuming a typical current of 11mA through the circuit,

$$R_S = \frac{2.2}{11X10^{-3}} = 200\Omega.$$

200Ω is more of practical importance than 200Ω. In fact, the higher the resistance, the lower the illumination from the LED.

In a situation whereby terminal A is high logical level, terminal C is low R_S serves as load to Q_S. The transistor experience saturation. And, current can not flow through the LED any more. It is switched OFF. The transistor is basically used for switching ON and OFF a particular segment. This operation is used for displaying either "good" or "bad".

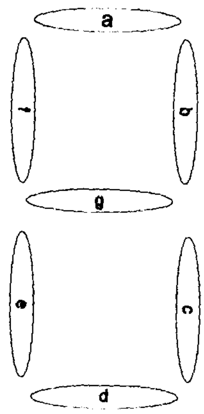


Fig. 3.17 The segment assignment of a 7-segmnt display

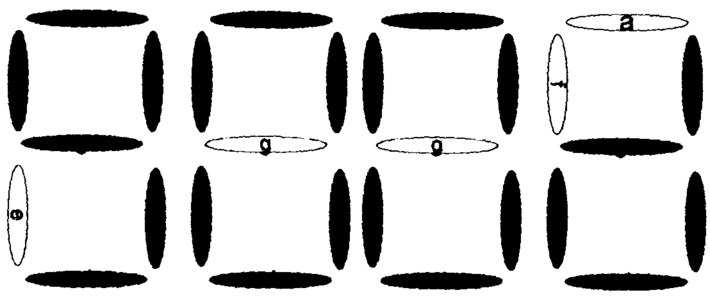


Fig. 3.18 The display showing "good"

Four common cathode displays are used for generating the required words. Display 1 and 4 are constant type, that is display 1 and 4 display "g" and "d" respectively. Display 1 is controlled by Q_6 transistor. The display is only switched ON whenever the sampler's pin 10 is logic 1. Whereas, display 2,3 and 4 are controlled by transistor Q_7. In fact, Q_7 switches Q_6.

Q_7 is the display main switching transistor. Its base is connected to 0.81Hz signal from the oscillator. Therefore, during test, when the test switch is pressed, Q_4 is forced into a switching or saturation cycle in accord with the 0.81Hz signal. Therefore, the altogether display comes ON and OFF. But, the output from the 4017B IC (sampler) defines what is indicated on the display.

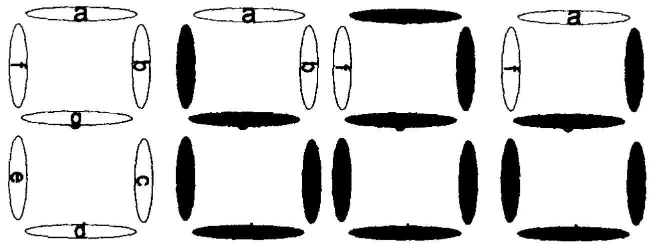


Fig. 3.19 The display showing "bad"

As earlier stated, whenever the output of the sampler is at HIGH logic level, the display is "good". Q_7 switched ON the whole 7-segment display involved.

Q_6 is switched ON by Q_7. Therefore, display 1 is switched on showing "g". Q_1 and Q_2 switches OFF both "g" of display 2 and display 3. The result is a blinking "good" display. It shows the transistor under test is good or functional.

Whenever the test transistor is bad, and pin10 of the sampler is low, Q_7 is switched ON while Q_6 is OFF. Digit 1 is switched off. Moreover Q_3, Q_4 and Q_5 headed to switch off digit 2 a, digit 2 b, and digit 3 F. Segments respectively. This results into blinking "bad" display. The four digits hold "d" because it is common for both "good" and "bad".

CHAPTER 4

CONSTRUCTION, TESTING AND RESULT.

4.1 CIRCUIT CONSTRUCTION.

The circuit was first constructed on the bread board to ensure that the circuit design is working. Thereafter, the circuit construction was made directly on the Vero board. The Vero board was cut to a suitable size that could hold the complete circuit design. The Vero board was cut into sections for the altogether units of the circuit design.

The back of the Vero board was scraped with razor blade for smoothness, because the working surface of the Vero board was required to be smooth for ease in soldering. Moreover, each part of the circuit was worked upon starting with the power unit.

. Integrated circuit socket were soldered at specific points for the involved integrated circuit. Other components were directly soldered on the board. But, the soldering operation was made as fast as possible to prevent heat damage to the components. The sockets allows for easy replacement of the integrated circuit in case the IC is bad or damaged.

The circuit diagram was properly forwarded in the construction. Suited components were mounted at particular terminals. Thereafter, jumper wires were used tin linking the terminals of the components together in accordance with the circuit diagram. Every soldering operation was carefully carried out by putting short circuiting into consideration.

After all sub-circuits were soldered to their various boards, they were linked together as a complete circuit.

4.2. CASING CONSTRUCTION.

The casing involves rubber and plastic materials. The rubber material was a readily made electric socket covering. Two of such materials were used in the construction. The plastic material was a plain 3mm sheet. It was cut into suitable sizes that would accommodate the complete circuit design.

Also, aluminium sheet was used in covering the bottom of the casing. The materials were put together for good finishing.

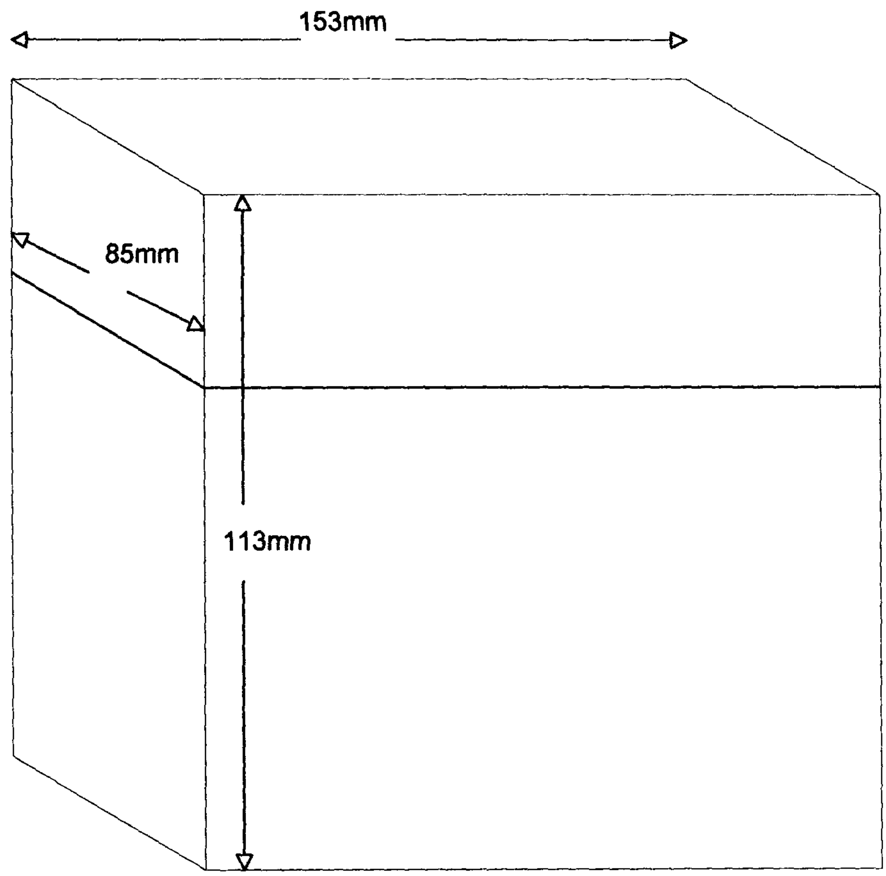


fig.4.1 Casing dimension

4.3. TESTING

The proper testing of the complete circuit design and construction was of great significant so as to compare its performance with the expected result. The testing was straight forward. It involves two set of transistors. One of the sets contains four new and intact transistors of both NPN and PNP types. The other set contains four transistors of both NPN and PNP which were intentionally destroyed with high voltage supply. The intact ones were marked "A" and the damaged ones marked "B" respectively.

The test unit was plugged to the Ac mains and the power switch was put on. The selector switch was positioned at PNP dot and the four PNP transistors were pinged into the PNP socket one after the other for testing. Each time a transistor is inserted into the test socket, the test button is pressed. The response on both sound alarm and the digital display output were constantly observed.

The same test procedures were observed while testing the other set of NPN transistors. But in this case, the selector switch was positioned at NPN dot and the transistors were inserted into the NPN test socket.

The same test was carried out using a multi-meter and the results obtained are shown in the tale below:

s/n	Transistor Types	Result From Circuit Design	Result From Multi-meter Test	Remark
	NPN			
1	Q2XC C945	GOOD	GOOD	100% EFFICENT

2	K030 C945	GOOD	GOOD	"
3	K952 C945	GOOD	GOOD	"
4	P3YC C945	BAD	BAD	"
	PNP			
1	8050 B 130	GOOD	GOOD	"
2	8550 B 039	GOOD	GOOD	"
3	8550 B 039	GOOD	GOOD	"
4	A733 K 23E	BAD	BAD	"

Table 4.2 The results from the test

4.4 DISCUSSION OF RESULT

The results of the early test were referenced with the aim of the project. The results showed the extent of the circuit accuracy and workability. Interestingly, the transistors marked "A" (both for PNP and NPN) corresponds to both high tone sound and displayed "good" on the display unit. The transistors marked "B" (both for PNP and NPN) gave both deep tone sound and displayed "bad" on the display unit.

In accordance with the results, the transistors that gave both high tones sound and displayed "good" on the display unit, signifies functional transistors. The ones that gave deep tone sound and displayed "bad" on the display unit define nonfunctional transistors.

The functional transistor demonstrates their ability of amplification while the nonfunctional ones do not meet such requirement.

4.5 BILL OF ENGINEERING MANAGEMENT AND EVALUATION

S/NO	NUMBER OF COMPONENT	COMPONENT NAME	DESCRIPTION USE OF COMPONENT	COST PER UNIT	TOTAL COST
1	1	4060B	Oscillator/ divider	=N=130	=N=130
2	1	4081B	Quad 2 input AND gate	=N=130	=N=130
3	1	4017B	Logic stepper	=N=130	=N=130
4	4	Soft touch button	Switching operation	=N=30	=N=30
5	4	4511B	Latch / 7 segment Decoder	=N=130	=N=520
6	1	8ohm 3watt Speaker	Alarm Output	=N=100	=N=100
7	1	7805	5V regulator	=N=50	=N=50
8	1	LED	indicator	=N=5	=N=5
9	4	Common cathode 7-segment display	Indicator	=N=100	=N=400
10	28	220Ω resistor	Current limiting device	=N=10	=N=280
11	1	12V A.C step-	Power supply	=N=150	=N=150

		down transformer			
12	4	1N 4001	Rectifying diodes	=N=5	=N=20
13	3	2SD400	NPN power switching transistor	=N=20	=N=60
14	1	Toggle switch	Switching operation	=N=50	=N=50
15	1	2200uf 35V electronic capacitor	Filteration	=N=50	=N=50
16	5	2SC945	NPN transistor switching	=N=10	=N=50
17	1	0.001uf capacitor	Oscillator external capacitor	=N=10	=N=10
18	3	100k and 33k resistor	Oscillator external resistor	=N=10	=N=30
19	3	1kΩ resistor	Power indicator	=N=10	=N=30
20	3	10k resistor		=N=10	=N=30
21	1	Casing			=N=300
TOTAL				**=N=2555.00**	

Table 4.3 the bill of engineering management and evaluation

CHAPTER 5

5.1 CONCLUSION

The project demonstrated the importance of logic devices in electronic design. The electronic components are good for various application, they posses reasonable flexibility. They provide the design with such an interesting visual and audio sound features.

The project shows the manner in which a bipolar transistors can be tested by considering it's three terminals. The output reading which involves both visual and audio sound is indeed unique.

5.2 RECOMMENDATION

It is quite obvious for any electronic device to be perfect. Therefore, certain improvements or modifications could be done to the design.

The recommendation includes;

1. The use of microcontroller circuit could improve the proper performance of the altogether design through computer inter-facing.
2. The design could be made fully digital and capable of measuring and comparing the current gain (h_{fe}) of the transistor.
3. The design could be modified to test other transistors such as MOSFETS.
4. The display could be modified to liquid crystal display (LCD) from the available light emitting diode (LED) to reduce power consumption.
5. An advanced modification to the design could yield voice tags for defining the results of the test.

6. The device could be made low power consumption through limited number of component for full battery powered application.

5.3 PROBLEMS ENCOUNTERED

1. The most evident problem is the design of the display section of the circuit. It is quite logical and it is achieved through careful analysis of the task.
2. Another associated difficulty with the project is the acquisitions of the involved integrated circuits were purchased in Lagos.
3. During the project construction some involved integrated circuits were bad and needed replacement.
4. Getting a suitable casing for the work was quite tasking due to the nature of the circuit.

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