DEVELOPMENT OF A COMPUTER AIDED BJT (BI - POLAR JUNCTION TRANSISTOR) **CURVE TRACER.**

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A PROJECT REPORT SUBMITED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE (B.ENG) IN THE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING,

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FEDERAL UNIVERSITY OF TECHNOLOGY MINNA.

NOVEMBER, 2004

DECLARATION

ere by declare that this project work is my original work and has never been submitted

se where before now.

CERTIFICATION

his is to certify that this project titled “Development Of Computer Aided BJT Curve racer” was carried by Imeh Nancy under the supervision Engr. P.O Attah and submitted Electrical And Computer Department, Federal University Of Technology Minna, in partial lfillment of the requirement for the award of Bachelor Of Engineering (B.Eng) Degree In lectrical And Computer Engineering.

ENGR P. ATTAH Project Supervisor	3rd Dec. 2004 DATE
ENGR N.D ABDULLAHI Head of department	31/01/2005 DATE
External examiner	DATE

DEDICATION

To **God the Almighty Father**, to **Jesus** and to My Dad

ACKNOWLEDGEMENT

Firstly, I must thank the Almighty God who spared my life till this day and above all r seeing through this study.

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My most appreciated gratitude goes to my Dad - Mr E. D.A Imeh for his love and upport morally and financially all through my education most especially during the course f this project work. Also to my sisters Esther, Vicky and Imoh, your help, encouragement and presence have been too invaluable. Thank you so much.

I thoroughly appreciate the assistance of Austin Chibuzo-my hardware programming supervisor-for his selfless help throughout this project design. To my personal people-Chinelo, Gloria and Chehor-I cannot forget your support and love; also to Chris, Obiekwe(JJ), Michael , Abel, Olabisi and Yinka :thanks for being there. I thank my special course mates and a host of others that God sent to bless me in one way or the other, for all their encouragement. I'll just say may God bless you all.

ABSTRACT

determine the functionality of transistors, their corresponding characteristic curves will ve to be seen. The use of a computer to generate varying voltage signals to the base d the collector of the transistor under test while measuring its collector current for each lue forms a table of values by which the output characteristic graph could be drawn. This is carried out with the aid of a designed circuit and a written software.

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CHAPTER 1

INTRODUCTION

1.0 BACKGROUND

Advances in microelectronic technology over the past few decades have brought about dramatic changes in the complexity and size of electronic circuits and components. These developments are continuing, and seem likely to do so for sometime yet and are making it increasingly difficult to adequately define tests procedures. At the same time, testing occupies an increasingly important place both in manufacture (where it is needed to guarantee the quality of the product) and in maintenance and field services, where it is needed to provide diagnostic capability.

Quick and reliable testing is an expensive process, but the consequences of inadequate testing within the manufacturing process can be even more expensive in the long run. The choice of a testing strategy is a matter of economic judgement based on the costs of tests equipment, the predicted failure rates, and the consequential costs of failing to find faults at any particular stage in production. This **computer aided transistor curve tracer (CABCT)** is an Automated test Equipment which has been made to aid testing of BJTs. A bipolar junction transistor, (BJT) is a very versatile component. It can be used in many ways, example as an amplifier, a switch or an oscillator and for many other uses. Research also has shown over the years that an individual watching an event understands it better than one who just hears about it. Also the one who participates in it, has an even better chance of both understanding and remembering it, than those who only saw or heard about it. In most of the developing countries the training of students in tertiary institutions in various fields are abstract. The students are often compelled to learn only the theoretical aspect of their course, due to unavailability of many experimental facilities. Developed countries have more resources than do developing countries to invest in basic and vocational education/ training programs. As a result, workers and managers in developed economies typically receive better education and training and so turn out better equipped in their professional fields. These facts emphasize the relevance of experiments in academic programs as it brings about highly competent graduates who have a real knowledge of their field of studies. This cost effective product **(CABCT)** would afford the student the opportunity to visualize what has been taught theoretically. Considering the current rapid spread in computer literacy all around the world, it was thought wise to make a provision for interfacing the curve tracer circuit with a computer that has a parallel port available on it. This would make it flexible and can be used anywhere there is a computer.

1.0.1 TRANSISTORS

The Transistor is a circuit component (usually with three leads) that can serve several functions- amplifier, switch, or oscillator, among others. It is a semiconductor device used in amplifiers, oscillators, and control circuits in which current flow is modulated by voltage or current applied to electrodes. The three leads of a transistor are the emitter, base, and collector, and in the most common mode of operation, a large current flow between the collector and emitter terminals is controlled by a small current applied to the third terminal, the base. The current can be turned on and off, causing the transistor to behave as a switch. Transistors are tiny electrical devices and can be found in everything from radios to robots. They have two key properties:

1) They can amplify an electrical signal and

2) they can switch on and off, letting current through or blocking it as necessary. Most transistors are based on the use of silicon.

1.0.2 TYPES OF TRANSISTORS

There are three main classifications of transistors each with its own symbols, characteristics, design parameters, and applications

- **Bipolar junction transistors** are considered current driven devices and have relatively low input impedance. They are available as NPN or PNP types. The designation describes the polarity of the semiconductor material used to fabricate the transistor.
- **Field Effect Transistors,** FET's, are referred to as voltage driven devices which have high input impedance. Field Effect Transistors are further subdivided into two classifications:

1) Junction Field Effect Transistors, or JFET's, and

2) Metal Oxide Semiconductor Field Effect Transistors or MOSFET's.

* **Insulated Gate Bipolar Transistors**, known as IGBT's, are the most recent transistor development. This hybrid device combines characteristics of both the Bipolar Transistor with the capacitive coupled, high impedance input, of the MOS device.

1.0.3 IMPORTANCE OF TRANSISTORS

In microchips today, which contain millions of transistors 'integrated' together in a particular pattern or 'design', the amplified output of one transistor drives other transistors that, in turn, drive others, and so on. Build the sequence one way and the chip can be made to amplify weak antenna signals into rich quadraphonic hi-fidelity sound. Build the chip differently, and the transistors interact to create timers to control watches or microwave oven, or sensors to monitor temperatures, detect intruders, or control car wheels from locking (ABS systems). Arrange the transistors in a different array and create arithmetic and logic processors that drive calculators to calculate, computers to compute, 'process' words, search complex data bases for information, networks to 'talk' to each other, or systems that transmit voice, data, graphics and video to make our communications networks. It may take a score of transistors, interconnected in teams called logic gates, to accomplish a task as simple as adding one and one. But put enough transistors together in appropriate patterns and transistors end up knock off big jobs by working fast-- switching on and off 100 million times per second or more--and by working in huge teams. As discrete components as in the old days, a thousand transistors would occupy dozens of printed circuit boards the size of postcards. But thanks to such techniques as photolithography and computer-aided design, millions of transistors and other electronic components, complete with wiring, can be compactly organized on an integrated circuit smaller than a cornflake.

1.0.4 TRANSISTOR CURVE TRACER

A **Transistor Curve tracer** is an instrument designed to physically measure transistor parameters such as current gain, breakdown voltages, and impedance etc and reproduce the result on a cathode ray oscilloscope. A transistor Curve Tracer measures the collector currents Ic and the collector emitter voltages (Vce) for varying values of base currents. This data is typically graphed with voltage on the X-axis and current on the Y-axis. The resulting graph is usually in the form of curves, hence the name, curve trace. These curves describe the relationship between voltage and current for a given load. This relationship is often called a characteristic because it remains constant under fixed conditions. If a transistor characteristic is different from that of a known good device to another, this would usually indicate some sort of malfunction (failure).

The curve tracer can generate and display a family of curves showing:

- ***Output characteristics*** – This illustrates the changes that occur in collector current with changes in collector/emitter voltage, for a constant value of base current. Alternatively, the collector current can be plotted against collector / emitter voltage for constant values of base / emitter voltage.
- ***Input characteristics*** – This shows the way in which the base current varies with change in the base /emitter voltage, the collector / emitter voltage remaining constant.
- ***Mutual characteristic*** – This shows the changes in collector current that occurs with changes in the base / emitter voltage, with the collector / emitter voltage held constant.
- ***Current Transfer characteristic***s – This show the way the collector current changes with changes in the base current, the collector / emitter voltage being held at a constant value.

1.1 OBJECTIVE OF STUDY

a) This project is aimed at promoting better learning. It involves Design and construction of the computer Aided Bipolar Junction Transistor curve tracer which has been carefully developed to aid the 3rd or 4th year Electrical Engineering student understand the principles of BJT transistor and their action. This experimental project (described in this report) is meant to encourage industrious individuals to build simple inexpensive apparatus that would be valuable for the training of students.

b) If a good practical circuit that uses a BJT needs to be designed, its design needs to take account of testability due to the errors in fabrication of ICs or the general concept of retailers selling used parts which are bad. These points to the fact that testing ICs (including BJTs) is an integral aspect of good circuit practical design.

1.2 SIGNIFICANCE

a) Curve tracing is a valuable and powerful tool for failure analysts and reliability engineers.

b) It provides an objective and non-destructive way to examine electronic components.

c) A design engineer might use the Transistor curve tracer to collect data that characterizes the electrical properties of the BJT.

d) A packaging Engineer might need to curve trace to verify the correct continuity in a transistor

e) A semiconductor failure analyst's job is to determine the root cause of failures in integrated circuits. Frequently, failures are received from the field marked as "functional failure" or "device replaced, "unit now working". While these statements indicate a failure, its exact location in the device is left to the analyst to find. Non functionality only says so much, we need to know more specifically where the problem lies. A BJT curve tracer is usually employed at this point to test each pin individually and objectively. Supply current can also be measured under various conditions to give more information. Eventually an analyst can confirm and narrow down the possible location of a given failure before proceeding with destructive procedures such as decapsulation.

f) A reliability engineer might use a curve tracer to tell him which pins are susceptible to damage after he applies certain kinds of environmental and electrical tests. The results of these tests, and subsequent failure analysis, tell the reliability engineer where the weak spots are in the design. This allows him to make recommendations to improve the reliability and survivability of the product.

g) This project centered on the design and construction of the Computer Aided Bipolar Junction Transistor Curve Tracer (CABCT), is a useful project for both students and professionals using the BJT.

1.3 STATEMENT OF THE PROBLEM

A plot of characteristic curves gives a more complete picture of what can be expected from a functional Bipolar Transistor than just passive testing of its terminals. The characteristic curves are also used to predict the performance of a BJT. But it is uneconomic having an oscilloscope just to view this curves. Retailers and buyers of the BJT want to be sure that the BJT they purchase really works at its optimum. Students are left to measure and plot the various parameters with graphs and pencils when a more understanding of these curves are needed. This project is aimed at reducing the above problems and promotes better and faster learning and other circuit work.

1.4 SCOPE

This project is limited to bipolar junction Transistors only and focuses on a specific characteristic of the BJT under test, namely collector/ emitter voltage against collector current with the base current remaining constant.

1.5 LITERATURE REVIEW ON TRANSISTOR CURVE TRACER

There have been a few projects on the Transistor tester/curve tracer and some of them are described as followed.

1.5.1 AGILIENT TECHNOLOGIES - The University of Georgia Athens, GA

Together with a PC, the Agilent E3631A power supply can measure an I/V curve for a wide variety of devices and even capture full families of curves for power transistors. The E3631A can capture the family of curves of a power transistor by plotting I against V in the manner just described while applying the base current from another of its voltage outputs. Equipment Required

- Function Generator such as the Agilent 33120A
- Digital Multimeter such as the Agilent 34401A
- DC Power Supply such as the Agilent E3631A
- Agilent VEE software

1.5.2 MULTITRACE SYSTEM

The MultiTrace system is a sophisticated DC characterization tool. It consists of a digital sampling curve tracer and a high capacity switch matrix. Its purpose is to automate the collection of curve trace data from devices with many pins. The MultiTrace features Windows software which is used to configure the tester and to store and view the results. The system is fully integrated and includes a standard fixture that supports up to 625 pins. The MultiTrace features a Standard fixture box that features a PGA ZIF socket with 441 or 625 pins. The MultiTrace makes a fully integrated system which features eight power supplies, a switch matrix and windows software in one package.

1.5.3 NPN-PNP TRANSISTOR TESTER - DAVID JOHNSON AND ASSOCIATES

This is a BJT NPN and PNP tester and no provision was made for the outputting of characteristic curves of the transistor.

1.5.4 THE GOOTEE CURVE TRACER

Advanced Transistor Curve Tracer and Electronic Component and Device Tester that includes built-in Triple-Output Variable Power Supply and Signal Generator. It also has features to display transistor I-V curve families, for multiple (up to 16) base or gate currents, simultaneously, on your existing oscilloscope. It also:

- Easily spot bad components just by glancing at their "signature".
- Troubleshoot more quickly. Test components, IN-CIRCUIT or out.
- MATCH transistors, or other devices, to select "matched pairs".
- Display on your oscilloscope: current vs. voltage curves ("signatures") for diodes, capacitors, resistors, inductors, plus test points in circuits, etc.

1.6 ADVANTAGES OF THE CABCT OVER ALL OTHER TRANSISTOR CURVE TRACERS

All except one (the multitrace transistor tester) of the transistor tester equipments discussed above are analogue operated which means they have go along with the oscilloscope – which is hardly available and expensive. The above

Transistor tester types all have their different advantages but how far can such advantages go if there isn't much economical advantage? The CABCT System is a fully programmable digital sampling curve tracer. This means that the voltage and current data are stored in the computer as a list of values instead of being displayed on a CRT as a glowing dot. This digital approach offers many advantages over an analog curve tracer:

1.) Since the current and voltage only need to be present when they are sampled, continuous stimulation of the device is unnecessary. Analog curve tracers must constantly sweep all of the desired range of voltage in order to display an entire curve trace, this constant power can cause heating and possible damage. The CABCT requires only milliseconds for each step but can be programmed to be longer. Typically a pin under test is subjected to current for less than 200ms.

2.) All data for each device is stored in a separate file on a hard disk. This means that the curve traces can be re-displayed at any time after it has been acquired even if the device is no longer available. An analog curve tracer simply cannot display a curve unless the device is actually hooked up. The CABCT can store thousands of data and setup files.

3.) Multiple devices can be displayed at once. This means that a good and failed characteristic can be compared graphically, pin by pin. Curve traces can automatically be compared according to your tolerances, pins on large IC's can be sorted on a pass fail basis. On an analog curve tracer comparison could only be done by flipping a toggle switch between two devices and visually assessing the difference.

4.) Data is permanently retained for future checking. Old control device data can be reused for comparison to a new failure. This eliminates the need to stock, and the risk of damage to, costly (and sometimes rare) control devices. Data from an analog curve tracer frequently takes the form of hand written notes or screen photos. This method of recording irrevocably obscures the precision of the measurements, making it very difficult for another analyst to interpret the results accurately.

CHAPTER 2

MATERIALS AND SYSTEM DESIGN

2.0 INTRODUCTION

This chapter describes the materials and methods used for the design, construction and testing processes of the **CABCT**. The materials used are described under the following sub headings:

a) Overall system design

b) Electronic components and units/ subunits used

c) Tools used

d) Software used

2.1 OVERRALL SYSTEM DESIGN

The Computer Aided Bipolar Junction Transistor Curve Tracer (CABCT) consists of a peripheral hardware, connected to the printer interface port of the IBM PC, and software which the PC runs to operate this hardware. So it has two principal aspects – Hardware and Software. The block diagram of the Hardware aspect is shown in Fig 2.0.

To display the characteristics on the computer, we must be able to sweep the horizontal of the graph with the voltage Vce changing from 0 to a level above saturation but below the breakdown level. This can be accomplished by sending a train of signals via the parallel port to

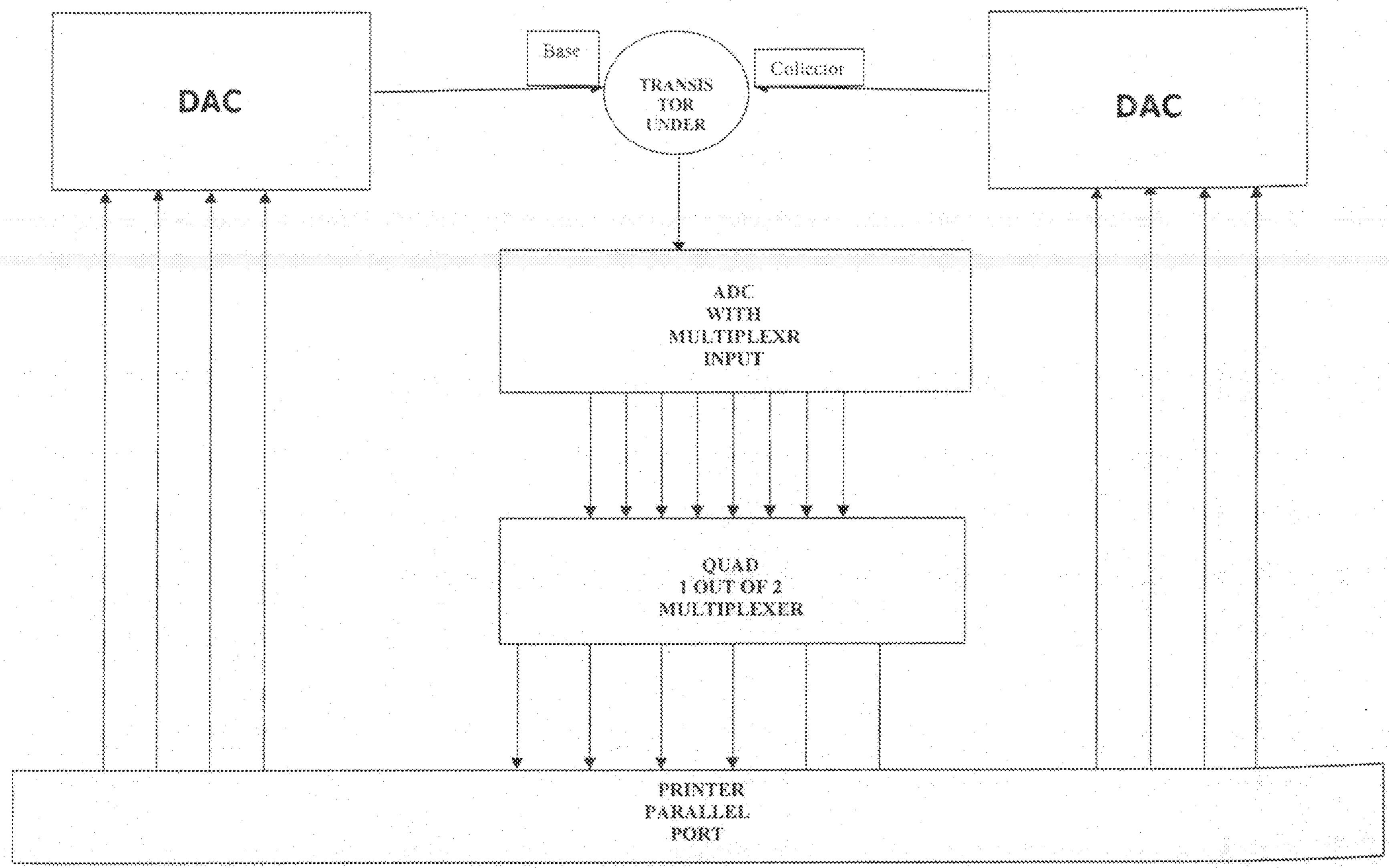


FIG 2.0. **BLOCK DIAGRAM OF THE CABCT**

the collector using a DAC (digital to analogue converter). The voltage for the vertical can be accomplished by applying the voltage drop across a small known resistor in the collector circuit to the parallel port. This quantity to be measured is converted from the voltage signal by a mathematical equation I = V/R already programmed in the software. Each of these measurements is taken for each increment in the base current generated by the computer using a DAC. The ADC (Analogue to digital converter) then transforms the measured voltages to digital form for the computer to decode. The software then integrates these values into a sequence that draws out the graph.

2.2 ELECTRONIC COMPONENTS AND UNITS/ SUBUNITS USED

The following sub circuits discussed below make up the CABCT circuit.

2.2.1 DIGITAL TO ANALOGUE CONVERTER

The output of a digital computer is useful as a control signal or for the generation of varying currents and voltages for the biasing of the transistor under test in this **CABCT.** But a transistor recognizes only analogue signals and in order for the computer digital output signal to be understood by the transistor, it has to be converted into an analogue signal. The Digital to analogue converter was use for this purpose in this circuit.

2.2.1.1 OPERATION OF A DAC

A DAC (DIGITAL TO ANALOGUE CONVERTER) accepts a digital input code and transforms it into an analogue voltage. The digital input is usually in the form of a binary number with some fixed numbers of digits. Especially when used in connection with a computer, these binary numbers is called a binary word of computer word. The digits are called bits of the word. The DAC converts a digital word into an analogue voltage by scaling the analogue output to be zero when all bits are zero and some maximum value when all the bits are 1. The input code usually appears in parallel i.e. simultaneously on a set of input lines. However it may also appear in serial – as a train of levels or pulses on a single line.

For the purpose of our work here 2 DACs are used i.e.

- DAC0801 8 bit Digital to Analogue Converter.
- L291B 5 bit Digital to Analogue Converter.

2.2.1.2 **DAC0801** GENERAL DESCRIPTION

The DAC0801is a monolithic 8-bit high-speed current-output digital-to-analog converter (DAC). The DAC0801 features high compliance complementary current outputs to allow differential output voltages of 20 Vp-p (20 volts peak to peak) with simple resistor loads. The nonlinearities of better than 0.1% over temperature minimizes system error accumulations. The noise immune inputs of the DAC0801 will accept TTL levels with the logic threshold pin, VLC, grounded. Changing the VLC potential will allow direct interface to other logic families. The performance and characteristics of the device are essentially unchanged over the full 4.5V to 18V power supply range; power dissipation is only 33 mW with 5V supplies and is independent of the logic input states. Its connection diagrams are shown below.

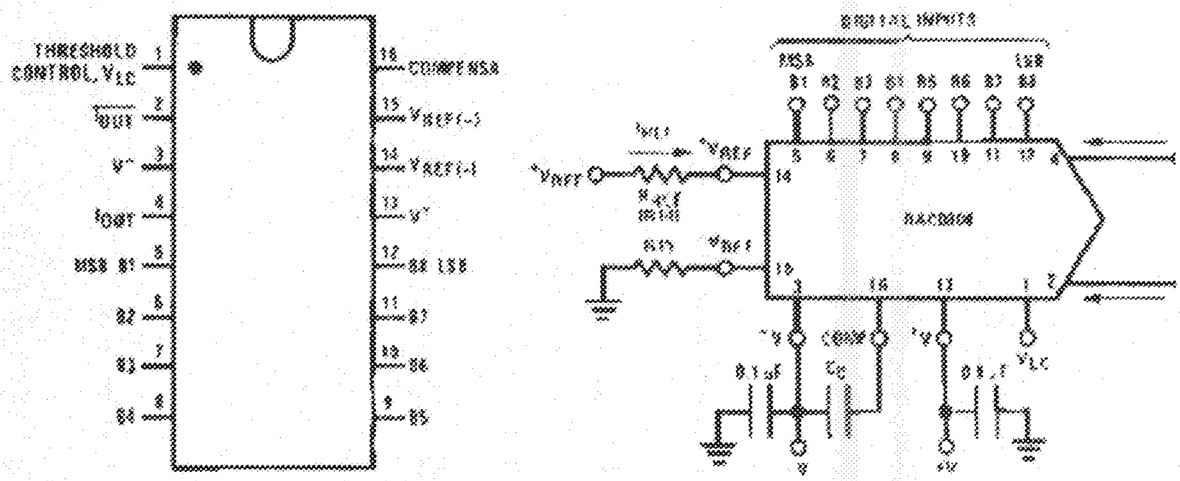


Figure 2.1. Connection diagrams for DAC0801

Where

V_{REF} = 10.000V

R_{REF} = 5.000k

2.2.1.3 **L291B** GENERAL DESCRIPTION

The L291, a monolithic LSI circuit in a 16-lead dual in-line plastic package contains an error amplifier, a position amplifier and a 5-bit D/A converter accepting a binary code and generating a bipolar output current, the polarity of which depends on the SIGN input. For our use here, only the DAC will be used. Its block and connection diagrams are shown below

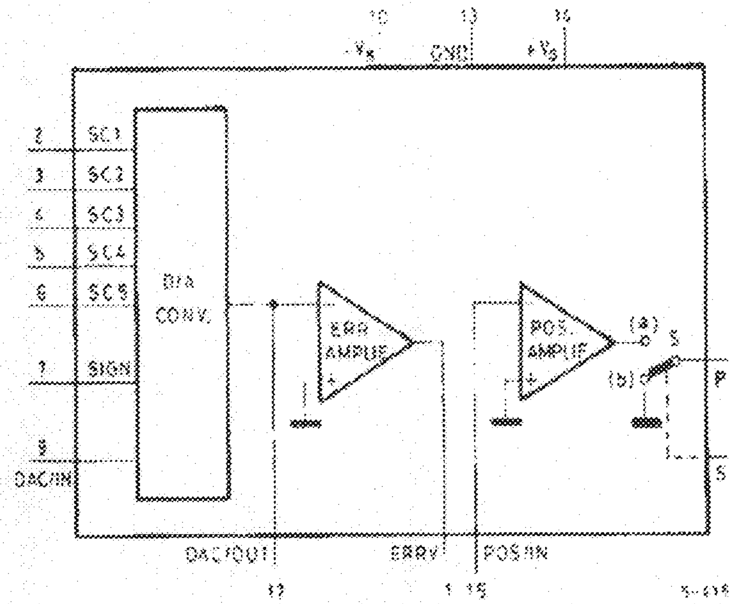


Figure 2.2. Block Diagram of the L291B

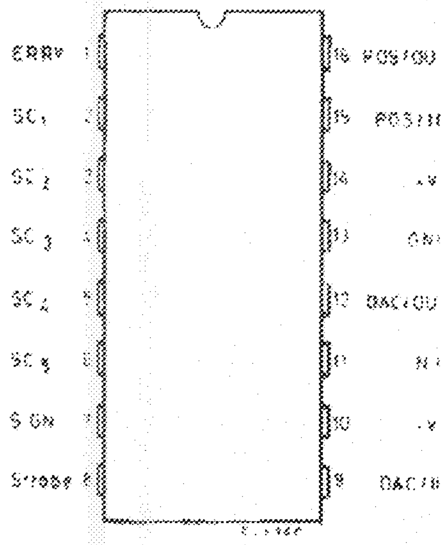


Figure 2.3. Connection Diagram of L291B

The amplitude of the output current is a multiple of a reference current Iref.

The maximum output current is

IFS = ± (31/16) Iref

The following table shows the value of Io for different input codes. Note that the input bits are active low.

This D/A converter has a maximum linearity error or equal to ± 1/2 LSB (or ± 1.61% Full Scale); that guarantees its monotonicity.

2.2.2 ANALOGUE TO DIGITAL CONVERTER (ADC)

The voltage changes which results in varying currents at the collector of the transistor under test is analogue and for it to be monitored in a digital form, by the computer, there has to be a signal conversion from analogue to digital signals at the point of measurement. This is achieved in this circuit with the aid of an Analogue to digital converter (ADC).

2.2.2.1 OPERATION OF AN ADC

An **ADC** takes the instantaneous value of an analogue input signal and then produces as its output a code digital word that with a weight that correspond to the level of the analogue. ADC will contain some uncertainty over the conversion. This is because the analogue input is a continuous signal and can take any value within a defined range, whereas the digital output can only exist as a fixed number of codes. The uncertainty of an ADC is called quantizing error and will be _+ 0.5LBC.

An important parameter of an ADC is the conversion time; the time interval between the command, being given to the ADC to begin the conversion, and the appearance at the output, of the complete digital equivalent of the analogue value. The speed of conversion varies with the type of ADC and can be as short as a few nano seconds for the ultra fast type or as slow as several milliseconds.

A wide variety of methods are used in analogue- to-digital conversion. These range from the slow and inexpensive to the very fast types which are therefore relatively costly. The common methods are

- voltage to frequency
- parallel or flash conversion
- single ramp and counter

- Dual\ triple ramp
- Successive approximation

The method used in this project is the successive approximation converter. This is a popular method for use in microprocessor system since it is relatively fast, has good accuracy, and can be software controlled. The method requires some programming logic (software in the microprocessor if required), a register to hold the result, a DAC and a fast microprocessor.

In this project **ADC0804 8-bit A/D converter** IC was used.

2.4.2.2 **ADC0804** GENERAL DESCRIPTION

The ADC0804 is a CMOS 8-bit successive approximation A/D converter that use a differential potentiometric ladder. This converter is designed to allow operation with the NSC800 and INS8080A derivative control bus with TRI-STATE output latches directly driving the data bus. These A/Ds appear like memory locations or I/O ports to the microprocessor and no interfacing logic is needed and its acess time is 135ns. Differential analog voltage inputs allow increasing the common-mode rejection and offsetting the analog zero input voltage value. In addition, the voltage reference input can be adjusted to allow encoding any smaller analog voltage span to the full 8 bits of resolution.

Features

Easy interface to all microprocessors, or operates "stand alone". Differential analog voltage inputs n Logic inputs and outputs meet both MOS and TTL voltage level specifications. Works with 2.5V (LM336) voltage reference it has an On-chip clock generator and operates with a range of 0V to 5V analog input voltage range with single 5V supply. No zero adjust required Operates ratiometrically or with 5 VDC, 2.5 VDC, or analog span adjusted voltage reference. It has a resolution of 8 bits with a Total error of ±1/4 LSB, ±1/2 LSB and ±1 LSB. Has a Conversion time of 100 µs.

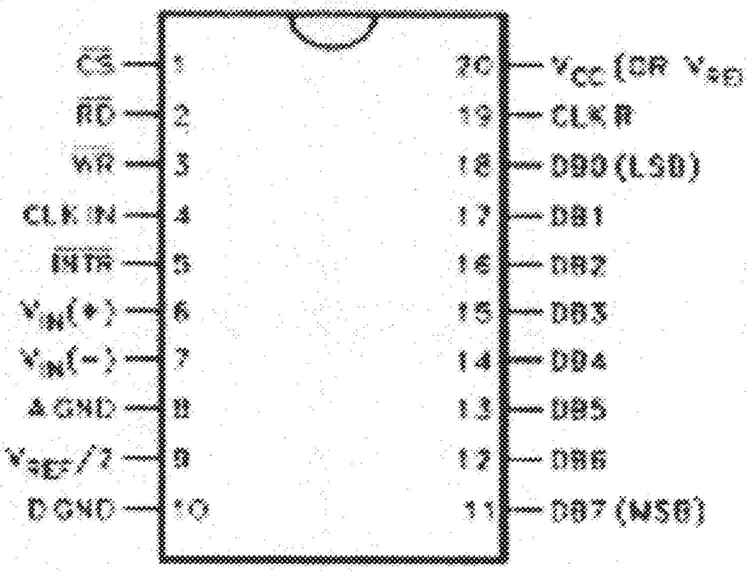


Figure 2.4 ADC0804 pin diagram

2.2.3 MULTIPLEXER

The interface characteristic of the input port of the printer interface, the status port, is such that only 5 lines feed back into the computer. The ADC converter converts the analogue information into eight bits. This means that an interface circuit is required to connect the ADC to the printer port. This was achieved in this project by using a 2 input 4 – bit multiplexer, the 74157 IC as shown below which takes the 8 bit

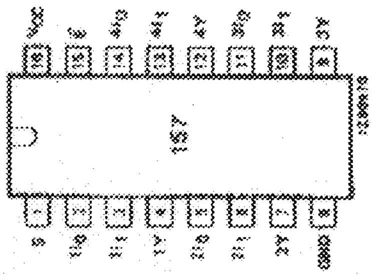
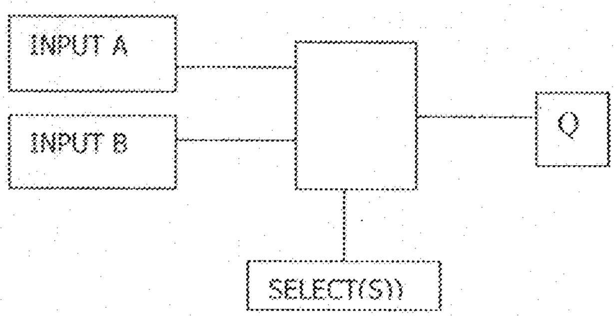
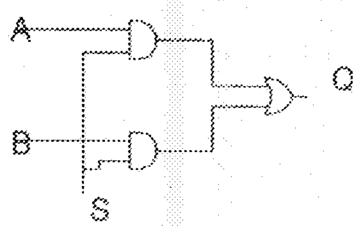


Figure 2.5. Connection diagram of the 74157 IC

of the ADC and sends it 4 bits at a time into the printer port with the aid of the input output program executed by the computer. The 74157 is a quad 2-input multiplexers which selects 4 bits of data from two sources under the control of a common data select input (S). The four outputs present the selected data in the true (non-inverted) form.

The 74157, 2 input 4 – bit multiplexer was designed from the smallest multiplexer i.e the 2 input, 1 – bit multiplexer. Considering the block diagram, the truth table and the logic circuit of a 2 input 1 bit multiplexer shown below, The 2 input – 4 bit multiplexer could be understood better



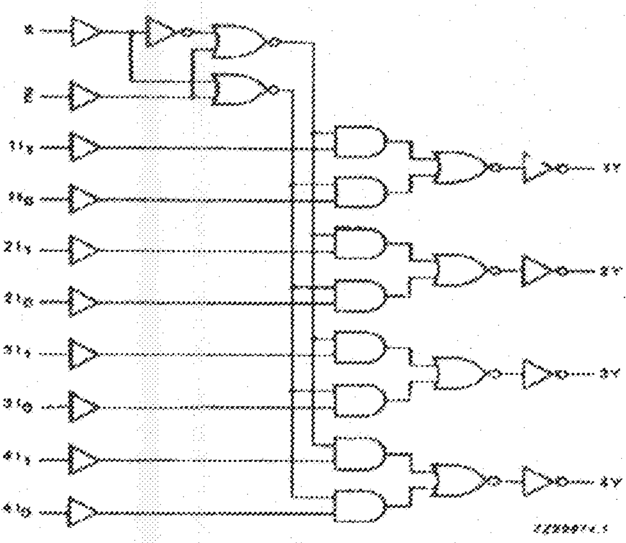


(a)Block Diagram of a 2 input 1 bit mux

(b)Logic circuit Diagram 2 input 1 bit mux

SELECT(S)	INPUT(A)	INPUT(B)	OUTPUT(Q)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

(c)The truth table of a 2 input 1 bit mux



(d)Block diagram for 2 input 4 bit multiplexer

Figure 2.6. The 2 input 4 – bit multiplexer

When the select line is in logic 0, input A passes to the output Q. this produces the truth table shown above. Therefore the output 1Y, 2Y, 3Y and 4Y of the 4 bit multiplexer are shown below.

The logic equations are:

$$1Y = E.(1I1 .S + 1I0 .S)$$

$$2Y = E.(2I1 .S + 2I0 .S)$$

$$3Y = E.(3I1 .S + 3I0 .S)$$

$$4Y = E.(4I1 .S + 4I0 .S)$$

2.2.4 THE PRINTER INTERFACE PORT OPERATION

The computer connects with the CABCT through an interface known as the parallel port. The parallel port has 25 pins which perform various functions. It is called the Printer interface port because it is normally used for carrying out the printer operations but could be employed in connecting other external circuits to the computer. When a PC sends data to a printer or other device using a parallel port, it sends 8 bits of data (1 byte) at a time. These 8 bits are transmitted **parallel** to each other, as opposed to the same eight bits being transmitted **serially** (all in a single row) through a serial port. The standard parallel port is capable of sending 50 to 100 kilobytes of data per second. The figure below shows the port map of the printer interface port. The printer port on the IBM PC is a 25 pin connector, often referred to as a DB-25 connector. **DB-25** is a 25-pin connector cable made for connecting the printer to the computer through its parallel port.

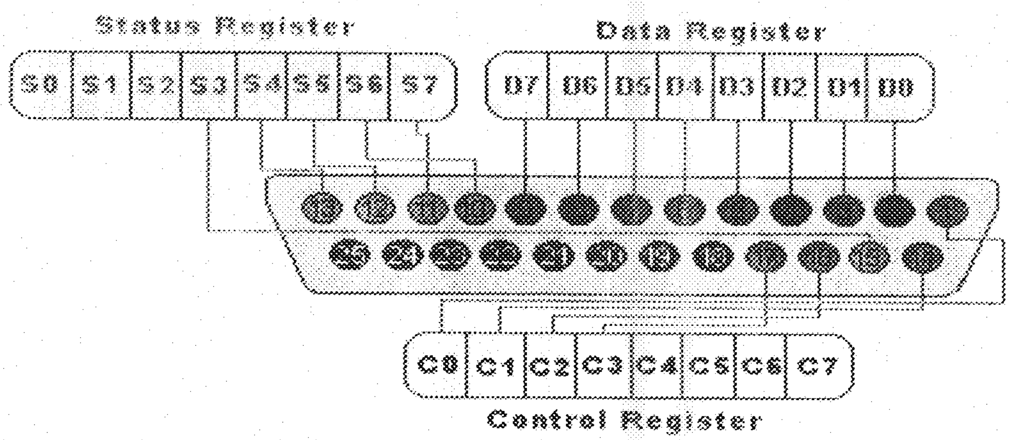


Figure 2.7 DB – 25 PORT

The Figure shows the pin-out designations for the connector and the meaning of the pins. Note that only a little more than half of the pins are use. The others are not connected inside the computer or are grounded to the chassis. The **data output** is comprised of eight binary bits as shown in the figure. The **control port** is also an output port. The output lines are latched, meaning that whatever data you place on them stay there until you change it or turn off the computer. As shown in the figure, the **status port** has five incoming lines. Four of The five status lines are the only ones that feed back into the computer from the CABCT. The pins and their functions are tabulated as followed.

Table 2.4 Printer Parallel Port Pins And Their CABCT Allocation

Pin No (DB25)	**Signal name**	**Direction**	**Register - bit**	**CABCT Name**
1	nStrobe	Out	Control-0	
2	Data0	In/Out	Data-0	DAC1(Bit 0)
3	Data1	In/Out	Data-1	DAC1 (Bit 1)
4	Data2	In/Out	Data-2	DAC1(Bit 2)
5	Data3	In/Out	Data-3	DAC1(Bit 3)
6	Data4	In/Out	Data-4	DAC2(Bit 0)
7	Data5	In/Out	Data-5	DAC2(Bit 1)
8	Data6	In/Out	Data-6	DAC2(Bit 2)
9	Data7	In/Out	Data-7	DAC2(Bit 3)

10	nAck	In	Status-6	DB3
11	Busy	In	Status-7	
12	Paper-Out	In	Status-5	DB2
13	Select	In	Status-4	DB1
14	Linefeed	Out	Control-1	Mux
15	nError	In	Status-3	DB0
16	nInitialize	Out	Control-2	DAC L291B
17	nSelect-Printer	Out	Control-3	
18-25	Ground	-	-	GROUND

The PC addresses, or accesses, its various I\O ports by using a unique address code. Each device or board in the computer has an address that no one else in the PC shares with it. The parallel port contained on the multi-I\O card has the starting address of **888** or **632** all in base 10 numbering. Usually, you specify the address of the port when you install the board. So depending on the adapter or card, the starting address can be **888** or **632**. Cordially since there are up to three port in the printer interface- output, status and control ports, therefore the starting address as mentioned above is used for the output port. The next address **889** or **633** is used for status port. While the next address to the status port, **890** or **634** is used for the control port.

2.2.5 THE DC POWER SUPPLY

The circuit of the project requires two different DC voltage supplies of +5v and +9v. It is necessary to supply the D.C voltages to the device from a 9V battery and with the aid of a resistor achieve a voltage division which supplies the 5V for the counter and ADC. The voltage divider equation which was used was as shows

$$V_{5v} = (V_{in} * R_{5v}) / (R_1 + R_{5v})$$

Where: V_{in} = voltage coming in (9V)

R_1 = Resistor needed for dividing voltage

R_{5v} = Resistance of circuit needing 5V

With R_{5v} as about 700ohms the value of the resistor will be

$$R_1 = 700 *(9v-5v) / 5v$$

$$= 560\text{ohms}$$

2.3 TOOLS USED

Tools used in the course of this work are listed in the appendix.

2.4 SOFTWARE USED

A computer, unlike pre-programmed machines is a *general purpose* device. It is not pre-programmed to take any specific action other than to initialize itself when you turn it on. A **program** is a list of instructions, together with any fixed information required to carry out those instructions. This applies to computers, of course, but also to any other subject that involves fixed instructions. Programs can range from the ridiculously simple to the hideously complex, with all possible conditions in between. Thus, in order to design a program for a computer, one must determine three basic elements:

1. The instructions that must be performed.
2. The order in which those instructions are to be performed.
3. The fixed data required to perform the instructions.

You must determine, clearly and in detail, exactly what you want the computer to do before you start telling the computer to do it. Remembering that the computer will carry out the instructions you give it, *exactly as given*. It can't tell what you wanted; it can only do what you said. Before your new program ever gets anywhere close to a computer, there are several steps you must take. These steps are:

- **Define the problem** – One must be able to clearly state what the computer is to accomplish or produce as the end result of the activities it will carry out.
- **Define the solution** – One needs to look at what information you have available and what information you still need, which will apply to that output. You also need to define the equations, logical procedures, or

other methods you will need to use to manipulate the raw input data into becoming the final desired output.

- **Map the solution.** - The third step is to lay out the solution in its proper sequence. Remember that the order in which actions are taken is just as important as the actions themselves. The solution procedure needs to be organized into its proper sequence, taking choices and alternatives into account.

However, one will need to consider the possible languages available, and the specific computer platform(s) as well. Different languages are often optimized for different kinds of tasks, so it is important to choose a language that is well suited to the task. In this project the programming language **VISUAL BASIC** was used to configure the software for the **CABCT.**

CHAPTER THREE

TESTING AND DISCUSSION OF RESULTS

3.1 INTRODUCTION

This chapter lists the various tests carried out on the CABCT that had been designed and constructed. The test results are also discussed briefly.

3.2 TESTING

In the construction of the CABCT, testing was carried out at all stages of assembly. The simulation of each module was made on a software design package and testing was done with the virtual instrument provided in the package. These are some steps taken while testing

- Each of the modules on the breadboard was tested by applying test signals to the inputs and then the outputs were monitored with LEDs, digital multimeter and oscilloscope (to view the waveforms)
- The desired outputs from each of the units were calculated theoretically with the use of textbooks and other materials available.
- The waveforms of each of the outputs were observed from electrical simulation software which drew out the ideal waveforms. These waveforms were compared to those drawn in datasheets and textbooks.

After testing all the modules separately, each unit was then assembled into a complete system on the breadboard and then connected to the PCs parallel port via the DB25 serial cable. Next the CABCT control programs were coded, tested and debugged. Finally the testing of the complete system was done by applying a test transistor to the circuit and viewing its waveform on the screen.

3.3 PRESENTATION OF TEST RESULTS

The test result was tabulated as shown in figure 3.1 and 3.2. Where the different waveforms got both theoretically and practically were tabulated in table 3.3 for comparison.

Table 3.3 Table For Comparison Of Various Input And Output Values For The **Dac1** And **Dac2**

DAC1 INPUT	DAC1 OUTPUT	DAC2 INPUT	DAC2 OUTPUT
0000	3.90mA	0000	3.43v
0001	3.96mA	0001	3.52v
0010	4.01mA	0010	3.61v
0011	4.25mA	0011	3.70v
0100	4.27mA	0100	3.80v
0101	4.35mA	0101	3.89v
0110	4.37mA	0110	3.99v
0111	5.35mA	0111	4.08v
1000	5.37mA	1000	4.17v
1001	5.44mA	1001	4.26v
1010	5.47mA	1010	4.36v
1011	5.74mA	1011	4.46v
1100	5.78mA	1100	4.56v

1101	5.81mA	1101	4.66v
1110	5.83mA	1110	4.76v
1111	5.88mA	1111	4.86v

WAVEFORMS OF **TRANSISTOR UNDER TEST**

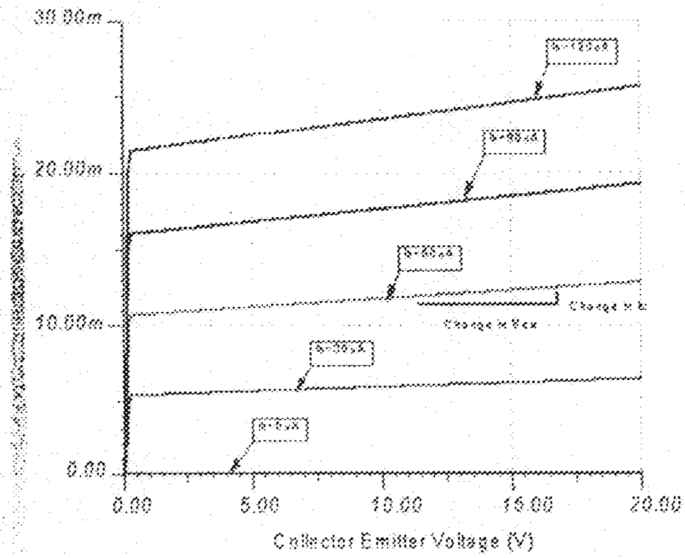


Figure 3.1 WAVEFORM FOR A BC107 TRANSISTOR (FROM DATASHEETS)

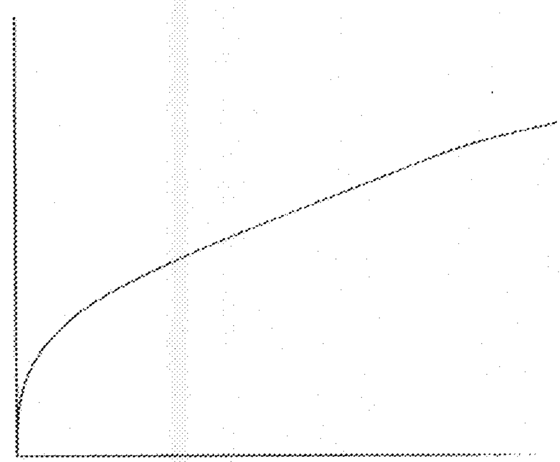


Figure 3.2 WAVEFORM FOR A BC107 TRANSISTOR (FROM THE CABCT)

3.4 DISCUSSION OF RESULTS

From the results gotten so far, it has been seen that the output of DAC1 falls within the range of 3.90mA to 5.88mA. Also the output of the collector DAC – DAC2 ranges from 3.43v to 4.88volts. This result signifies that the characteristic curve plotted will fall within this range and may produce only a small portion of the entire characteristic curve the transistor under test has. This is due partly to the biasing of the DACs and the nature of the DAC ICs. It will therefore serve as a recommendation to others interested in improving on this work to work on increasing the range of Base and collector currents and voltages fed into the transistor under test.

3.5 PROBLEMS ENCOUNTERED

- There was difficulty in obtaining some parts like the DAC and ADC for instance
- There was unavailability of essential test instruments like the oscilloscope.
- Inadequate time for the project to be carried out.
- Difficulty in interfacing different parallel ports as they have different features: some bidirectional, normal mode (unidirectional), enhanced mode, extended capability mode.
- Unstable power supply affected the pace of this project
- The narrow range of input voltage the ICs would accept without burning up.

3.6 SUMMARY

The purpose of the study was to design, construct and test a computer aided BJT (Bipolar junction Transistor) curve tracer. Seven main units were employed namely:

a) The **DAC (DIGITAL TO ANALOG) - 1** unit

b) The **DAC (DIGITAL TO ANALOG) - 2** unit

c) The **TEST BJT** unit

d) The **ADC (ANALOGUE TO DIGITAL)** unit

e) The **MULTIPLEXING** unit

f) The COMPUTER **PRINTER PORT INTERFACE**

g) The **POWER SUPPLY** unit

h) The **SOFTWARE PROGRAM**

Voltages and various base currents were fed into the collector and Base of the transistor under test. A plot of the collector voltage against its current (which was measured by finding the voltage drop across a resistor in the circuit) was done with the aid of the ADC, the printer parallel port and a software program.

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

4.1 INTRODUCTION

This chapter concludes the study based on the materials available, the methods used and the results obtained. A number of recommendations have also been made based on the results obtained and the conclusion of the studies

4.2 CONCLUSION

A transistor curve tracer which is functional and affordable for the use of viewing BJT transistor curves is possible to be designed and constructed by students with the use of a few electronic components.

4.3 RECOMMENDATION

Being the first attempt, the CABCT lacks some of the advanced features of the conventional oscilloscope; however there is abundant room for improvement in the following areas

- To obtain a faster sampling rate, faster ADCs should be employed.
- For better accuracy ADCs with higher resolution should be used.
- For better accuracy DACs well chosen and properly biased should be selected for use.
- A wider range of characteristic curves should be worked on

- To achieve faster speed of operation the circuit should be constructed in form of a plug in card for ISA or PCI or PCMCIA slots so that the circuit can be interfaced directly to the computer bus.
- Coding the program in assembly language could facilitate faster sampling rate than when in high level languages.
- The instrument could be built as a stand alone microprocessor system that can capture and store and display the digitized waveform in its own memory like the hand held computer games

The department of electrical computer engineering can be of immense help to the students by the following ways:

- The design and construction of electronics project should be a regular practice to all students of the electrical computer department right from their intermediate level, so as to get them familiar with handling project works.
- The department should assist the students financially in carrying out mini projects and the final year project that consumes so much money.
- The department should endeavour to seasonally equip themselves with electrical equipments and allow students access them whenever a practical or project is carried out.

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APPENDIX B

Tools Used

The table of components used is as shown below

No.	PART	VALUE	QUANTITY
1.	Analogue to Digital converter	ADC0804	1
2.	Digital to Analogue converter	DAC0801	1
		L291B	1
3.	Resistors		
4.	Capacitors		
5.	Battery	9V	2
6.	Computer interface	DB25 cable	1
7.	Wires		1 roll
8.	Vero board		1
9.	Multiplexer	74157	1
10.	Transistor	BC107	4

Resistors: All resistors are ¼ watt, 5% components.

Capacitors: Capacitors are components that are used to store an electrical charge and are used in timer circuits

LEDs: Light Emitting Diodes (LED) is an optical source. (A LIGHT SOURCE) LEDs produce red, green, yellow, or orange light. They are used in a range of products.

Integrated Circuits: These were for different functions like analogue to digital conversion, Digital to analogue conversions and multiplexing functions.

Hookup Wires: A wire is needed to make connections between some components. While on design on breadboard stage, for easy identification, I needed wires with many different colors of insulation

APPENDIX C

VISUAL BASIC SOFTWARE

```
Private Declare Sub vbOut Lib "WIN95IO.DLL" (ByVal nPort As Integer, ByVal
nData As Integer)
Private Declare Sub vbOutw Lib "WIN95IO.DLL" (ByVal nPort As Integer, ByVal
nData As Integer)
Private Declare Function vbInp Lib "WIN95IO.DLL" (ByVal nPort As Integer) As
Integer
Private Declare Function vbInpw Lib "WIN95IO.DLL" (ByVal nPort As Integer) As
Integer

Dim Current As Double
Dim L, MAX_VNO, MAX_INO As Single
Dim ReadV As IntegerPrivate Sub Form_Load()
Width = Screen.Width * 1 ' Set width of form.
Height = Screen.Height * 1   ' Set height of form.
Left = (Screen.Width - Width) / 2   ' Center form horizontally.
Top = (Screen.Height - Height) / 2  ' Center form vertically.
End Sub

Function DrawGraph(MY As Integer, MX As Integer, Xval, Yval, SFlag)
If SFlag = 1 Then Picture1.Line (0, Picture1.Height)-(0, Picture1.Height)
```

```
With Form2
X = Xval * (Picture1.Width / MX)
Y = Picture1.Height - (Yval * (Picture1.Height / MY)) 'the subtraction inverts the
y axis
Picture1.Line -(X, Y), &HFF00&
End With
End Function

Private Sub Command1_Click()
TxTableDB.Recordset.MoveFirst
If Text1.Text = "" Then
Label2.Visible = False
Command2.Visible = False
MsgBox "You have not entered any number! Please enter a valid transistor
number!!", vbDefaultButton2 + vbExclamation
Else
'This code finds the corresponding transistor number
'if an exact number is not found it finds the nearest
'and then alerts you of this problem
Text1.Text = UCase(Text1.Text)
TxTableDB.Recordset.FindFirst "TYPE = '" + Text1.Text + "'"
```

```
If (TxTableDB.Recordset.NoMatch = True) Then
MsgBox "not found"
Else
Text2.Text = TxTableDB.Recordset.Fields("Package")
Text3.Text = TxTableDB.Recordset.Fields("IcMAX")
Text4.Text = TxTableDB.Recordset.Fields("VceMAX")
Text5.Text = TxTableDB.Recordset.Fields("HFE")
Label2.Visible = True
Command2.Visible = True
End If
End If
End Sub

Function DrawGraph(MY As Integer, MX As Integer, Xval, Yval, SFlag)
If SFlag = 1 Then Picture1.Line (0, Picture1.Height)-(0, Picture1.Height)

With Form2
X = Xval * (Picture1.Width / MX)
Y = Picture1.Height - (Yval * (Picture1.Height / MY)) 'the subtraction inverts the
y axis
Picture1.Line -(X, Y), &HFF00&
End With
```

```
End Function
Private Sub Command2_Click()
V_Count = 0
I_Count = 0
V_Value = Val(Text4.Text)
While V_Value > VtableDB.Recordset.Fields("Voltage") Or Not
VtableDB.Recordset.EOF
  VtableDB.Recordset.MoveNext
  V_Count = V_Count + 1
Wend
If V_Value < VtableDB.Recordset.Fields("Voltage") Then
  VtableDB.Recordset.MovePrevious
  V_Count = V_Count - 1
End If

I_Value = Val(Text3.Text)
While I_Value > CTableDB.Recordset.Fields("Current") Or Not
CTableDB.Recordset.EOF
  CTableDB.Recordset.MoveNext
  I_Count = I_Count + 1
Wend
If I_Value < CTableDB.Recordset.Fields("Current") Then
```

```
 CTableDB.Recordset.MovePrevious
 I_Count = I_Count - 1
End If
'the loop that sends the values to the appropriate ports
VtableDB.Recordset.MoveFirst 'Move to voltage start (VtableDB)
CTableDB.Recordset.MoveFirst 'Move to Current start (CtableDB)

For L = 1 To I_Count
  'send current out and then wait
  vbOut 888, CTableDB.Recordset.Fields("Binary")
  For M = 1 To V_Count
    'send voltage out till you reach the end
    sentv = VtableDB.Recordset.Fields("Voltage")
    vbOut 888, VtableDB.Recordset.Fields("Binary")
    VtableDB.Recordset.MoveNext
    'V-Take values and store in the graph tables
    'V-It is added in order not to wipe the other four bits
    vbOut 889, 0

    ReadV = vbInp(890) * 16 'the multiplication shifts the value by 4bits
    vbOut 889, 2 'send data through control pin to toggle MUX
    ReadV = ReadV + vbInp(890)
```

```
ReadV = Invert(ReadV)
StatusDB.Recordset.FindFirst "Binary= " + Str(ReadV)
DrawGraph 8, 8, ReadV, (sentv - ReadV) / 560, M 'this draws a line
GraphDB.Recordset.AddNew
GraphDB.Recordset.Fields("Voltage") = ReadV
GraphDB.Recordset.Fields("Current") = (sentv - ReadV) / 560
GraphDB.Recordset.Update
Next M
VtableDB.Recordset.MoveFirst 'Move to voltage start
CTableDB.Recordset.MoveNext
Next L
End Sub
```