CERTIFICATION OF APPROVAL

Automation: Handwriting Recognition for Data Entry

by

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

ADLI SHAHRUL BIN BAHARUDIN

ABSTRACT

The purpose of this report is to present the research and descriptions of project "Automation: Handwriting Recognition for Data Entry". The objective of this project is to automate the process of handwriting recognition for data entry. The automated process will have the data automatically loaded and automatically located for the next step to take place. The research and development in this project consisted of designing a platform for examination booklet, finding a suitable circuit to control the platform from microcontroller, establishing a serial communication between microcontroller and personal computer, and also finding a suitable method as a means to determine the correct location of the data sheet. This report is divided into four main parts which are introduction, literature review, methodology and results and discussions. Introduction will cover a brief description of background study, problem statement and objectives as well as scope of study. The literature review will cover all findings and supporting information just as the name. Methodology will revolve around procedure identification and tool required in this project. Results and discussions will present some research, progress and test conducted during the time period. In this project, an automated platform which was controlled via RS232 on the Personal Computer was developed. The positioning of the examination booklet was determined based on the location of UTP oval logo viewed from the first webcam and by utilizing Normalized Cross Correlation method for the secondary program (ICDE) to take place.

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS

HandRec: Handwriting Recognition for Data Entry

ICDE: Imaging Coursework Data Entry

ROI: Region of Interest

GUI: Graphical User Interface

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Handwriting recognition is the ability of a computer to receive intelligible handwritten input. Handwriting analysis and recognition have received extensive attention in both academic and industrial fields. Basically handwriting recognition can be categorized into two classes which are online handwriting recognition and offline handwriting recognition. Online recognition systems use a pressure-sensitive pad that records the pen's pressure and velocity, for example, a personal digital assistant. In offline recognition, the system input is a digital image of handwritten letters and numbers.

Handwriting recognition requires tools and techniques that recognize complex character patterns and represent imprecise, commonsense knowledge about the general appearance of characters, words, and phrases. Neural networks and fuzzy logic are complementary tools for solving such problems. Neural networks, which are highly nonlinear and highly interconnected for processing imprecise information, can finely approximate complicated decision boundaries.

This project will be an improvement from a previous work by Poo Hwei Nee entitled, "Handwriting Recognition for Data Entry (HandRec)" [1]. Hwei Nee succeeded in building "Handwriting Recognition for Data Entry (HandRec)". In order to demonstrate a system which is able to input handwritten data from a form on to a database, an application example which is called Imaging: Coursework Data Entry (ICDE) was created. The objective of Coursework Data Entry (ICDE) is to develop a system that was able to input video images of handwritten student ID and course work marks and produce a student coursework database.

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1.2 Problem Statement

In the previous project, the work was more focused on the handwriting recognition by using neural network method. The system gave 100% accuracy when tested with the training set, 93.83% when tested with trained inputs and 88.5% when tested with handwriting of other subjects never seen before by the network. Besides recommending additional feature extraction method to improve the recognition system, it was suggested to include a paper feeder as part of the system. The feeder would have to be able to automate the process of data entry from Final Exam booklets to a database.

1.3 Objectives and Scope of Study

1.3.1 Objectives

- To design an automated process of feeding papers for data entry.
- To utilize web cameras to recognize and locate reference logo.

1.3.2 Scope of Study

The main tasks which will be carried out are more on designing a platform for automating the process of data entry from Final Exam booklets to a database and interconnect the Handwriting Recognition program with the automation part.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Character Recognition

Character recognition is not new in today's technology. There are series of research and developments were conducted years ago and still going on. The need for an automated character recognition system is ever increasing. There are already a number of attempts to create an offline handwriting recognition system. Each of these approaches has its strength and weaknesses. Several methodologies have been developed for character recognition system, which include Neural Networks statistical methods like the Hidden Markov model and Fuzzy Logic.

2.2 Imaging: Coursework Data Entry Program (ICDE)

This was the program created by Poo Hwei Nee during her Final Year Project entitled Handwriting Recognition for Data Entry (HandRec) [1]. The program captures images of student's exam ID and total marks from examination booklet by utilizing two webcams, extracts features from those images by using some features extraction method, by applying neural network method to recognize the numbers from the images and display the result on the GUI itself. Even though this program successfully can recognize the numbers from the images, it has reliability issue. Sometimes, it requires many trials in order to get the correct output. It works fine with MATLAB 6.5.

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2.3 MATLAB

MATLAB is a numerical computing environment and programming language created by The MathWorks. MATLAB allows easy matrix manipulation, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs in other languages. Although it specializes in numerical computing, an optional toolbox interfaces with the Maple symbolic engine, allowing it to be part of a full computer algebra system.

2.4 Normalized Cross Correlation

Correlation is the process of comparing one reference signal with other signal to determine the similarities of both signals [2]. The correlation between two signals (cross correlation) is a standard approach to feature detection as well as a component of more sophisticated techniques. Normalized cross-correlation is computed in the spatial domain. An algorithm for obtaining normalized cross correlation from transform domain convolution has been developed by Lewis [3]:

$$c(u,v) = \sum_{x,y} f(x,y)t(x-u,y-v)$$

Where $c(u,v)$ is the correlation result, $f(x,y)$ is the target image pixel value, $t(x,y)$ is the reference image pixel value.

2.5 Web Camera

A webcam is a real-time camera which images can be accessed using the World Wide Web, instant messaging, videoconferencing and video streaming. Webcam software typically captures the images as JPEG or MPEG files and uploads them to the Web server.

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2.6 Image Acquisition Using VCAPG2

VCAPG2 is developed by Kazuyuki Kobayashi [4] from Hosei University. VCAPG2 is a DirectShow based video capture DLL that support various types of video capture cards.
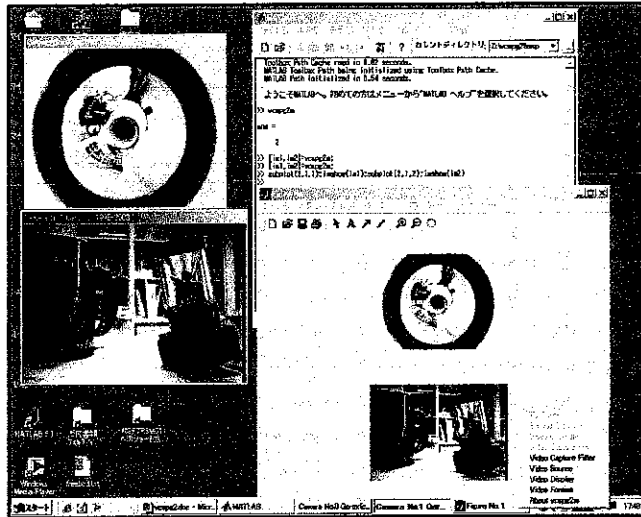
Figure 1 - Screenshot of two cameras grabbing images under MATLAB

VCAPG2 is a new version of MATLAB resident video capture program, which employs Microsoft's DirectShow libraries rather than the older Video for Windows (VfW) library. It runs on Windows 2000 or Windows XP utilizing MATLAB version 6.1 or later. In order to run VCAPG2, DirectX runtime libraries must be installed. VCAPG2 requires a video capture device, such as a USB camera to be installed and working properly. The code has been developed and tested with DirectX 8.1 and 9.0 with MATLAB6.1/6.5. Some of the features of the algorithm are:

- Up to 6 video capture cards can grab images at one command.

- Supported video capture devices are including IEEE1394 based DV CAM, USB Camera as well as old VFW based Camera.

- VCAPG2 can run up to almost twice as fast as VfW based program such as VCAPG which is available both source and binary code from

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http://www.ikko.k.hosei.ac.jp/~matlab/matkatuyo/ which is published by Kazuyuki Kobayashi.

2.7 PIC Microcontroller

The PIC 16F84 is an 18 pin integrated circuit produced by Microchip Technology Inc. It is just one integrated circuit in a large selection of programmable interface controllers that Microchip produces which are essentially self-contained CPUs complete with RAM and ROM.

The 16F84 is CMOS based and fully static. It also has 64 bytes of data EEPROM which can be programmed and read from both the programmer and the code, allowing persistent data to be kept safe whilst it is powered down. There is also 68 bytes of data RAM for storing runtime, 13 I/O pins for interfacing external components, timer, counter and watchdog [5].

The architecture of this microcontroller is based on Harvard design which has two completely separate instructions and data memories and busses, featuring a two-stage pipeline. The RISC instruction set consists of 35 instructions, most of which take a single cycle each.

Besides, PIC16F84 also supports serial communication by using RS232 and MAX232 as the interface to normalize the personal computer logic voltage to the PIC logic voltage. RS232 serial communication is a Universal Asynchronous Receiver Transmitter (UART) protocol that does not require synchronization clock for data transfer. The protocol is declared in the header of the PIC code.

2.8 DC Motor

There are several types of motors available in the market. Based on research, automation and robotic projects always implement servomotor to make certain part moving as desired. The reason why DC motor being used in this project rather than servomotor is because DC motor can provide enough torque to move heavy loads. The 12V DC motor used in this project is from car's power window motor. It has higher torque to move the chain of the conveyor belt of the platform.

2.9 H-Bridge Theory

Several configurations of motor drive circuits are available. The H-Bridge configuration allows control over the rotation torque and direction of the motor and can also be used for other resistive or inductive loads requiring control over the polarity of the drive voltage produced. The circuit consists of four switches connected in an H arrangement. By opening and closing the four switches in the correct sequence, the direction of current flow is reversed and hence, the direction of rotation.
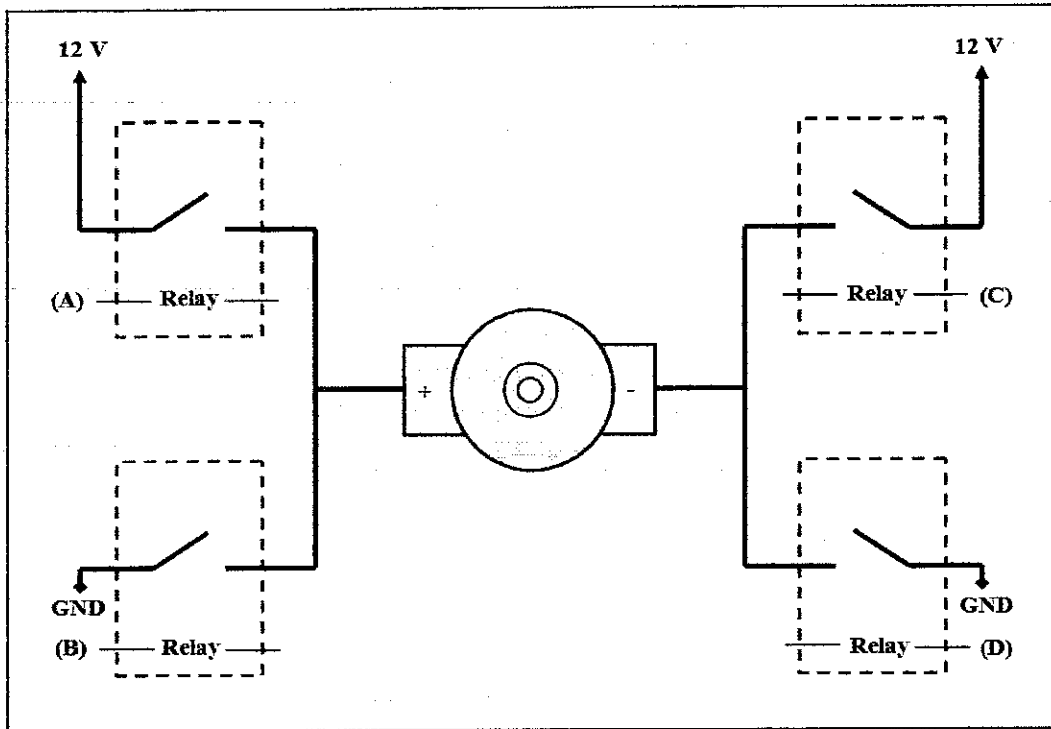
Figure 2- H-Bridge Concept [6]

In Figure 2, closing switch SA and SD and opening SB and SC will allow current to flow from left to right in the motor; while opening SA and SD and closing SB and SC will result in the opposite direction of current flow through the motor. Table 1 summarizes the switch state for reverse and forward motion of the motor.

Table 1- Summary of H- Bridge Operation

Motor Action	SA	SB	SC	SD
FORWARD	Close	Open	Open	Close
REVERSE	Open	Close	Close	Open

CHAPTER 3

METHODOLOGY

3.1 Procedure

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          │  Primary Research Work–      │
          │  Literature Review           │
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          │  Data Gathering and          │
          │  Research                    │
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│ Utilize X-Y  │ │ Utilize      │ │ Design the       │
│ Precision    │ │ 3DCrane      │ │ platform based   │
│ Table        │ │              │ │ from specification│
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          │  Selection of suitable       │
          │  platform                    │
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          │  Design driving and          │
          │  microcontroller circuit     │
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          │  Combine the program with    │
          │  the automation part         │
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          │  Oral Presentation           │
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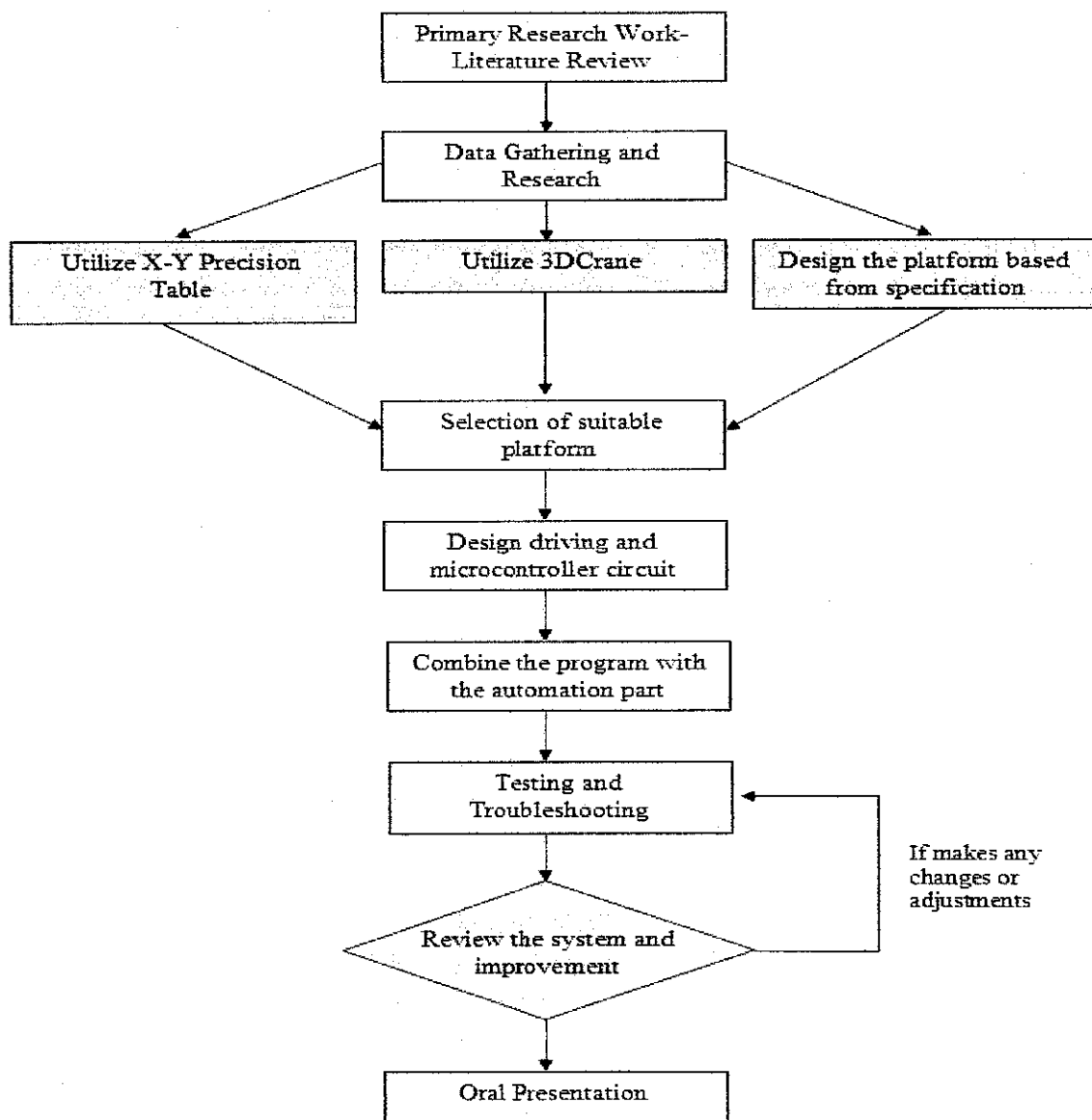Figure 3 – Procedure

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The following part will explain each of the tasks to be completed in order for the successful conclusion of the project:

3.1.1 Primary research Work- Literature Review

The scope of the literature review included the basic principle of the neural network, programming the microcontroller, MATLAB communication and the digital image processing. During this time, previous project entitled Imaging: Handwriting Recognition for Data Entry (HandRec) was studied and understood. Besides, other researches which were related to the objectives of this project also were done.

3.1.2 Data Gathering and Research

As the project began, lab equipment such as Precision X-Y Table and 3DCrane set were utilized. Due to some problem which would be discussed later in this report, the only option left was to build a new hardware

When constructing the hardware, many things also needed to be considered such as a circuit to interface the hardware with the microcontroller. Some research on how to control the DC Motor need to be done as soon as possible. As a result, H Bridge circuit was chosen to control the DC Motor.

A method of image detection, normalized cross correlation method was found suitable to be implemented in this project as a means to determine the correct location of the data sheet.

3.1.3 Testing and Troubleshooting

In this section, testing and troubleshooting of ICDE program, the microcontroller program and also the platform were conducted. Many alteration and modification were done on the platform to make sure it worked well.

The final part would be to integrate the platform and the software together and make the communication from the computer available. This was the most important step as each of the circuits, programs and platform would behave differently. So, most of the troubleshooting time would be spent on during integrating each parts.

3.1.4 Review the System and Improvement

After everything was completed, the system would be reviewed to see if there was any improvement could be done and also to add finishing touches on it. It would be tested for the final time to make sure there was no problem occurred especially during last minute.

3.1.5 Final Report and Presentation

The final report and presentation was done as scheduled.

3.2   Program/Software Used

- MATLAB 6.5.1
- Eagle Layout Editor 4.13
- PIC C Compiler
- WARP13

3.3   Equipment, Component and Hardware

- Rubber mat
- 12V DC power window motors
- Steel Bars
- 2 USB Webcams (AVF and Logitech)
- 16F84A microcontrollers
- RS232
- MAX232
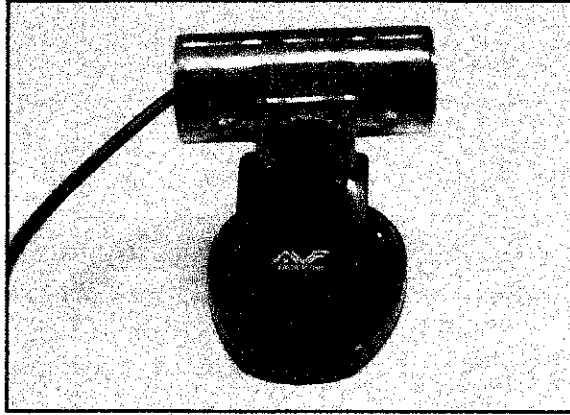- Capacitors, diodes, crystal oscillator
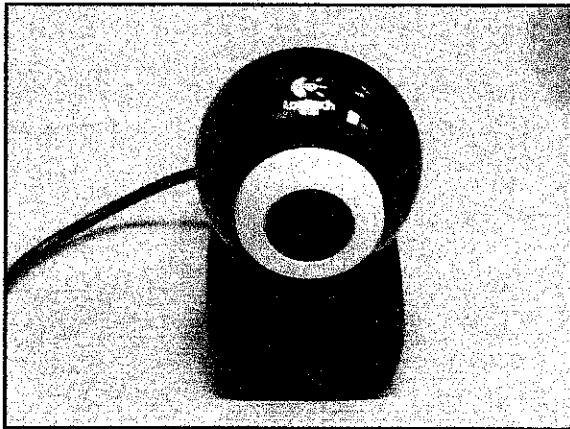- Power Supply

Figure 4 - Webcam 1 (AVF)
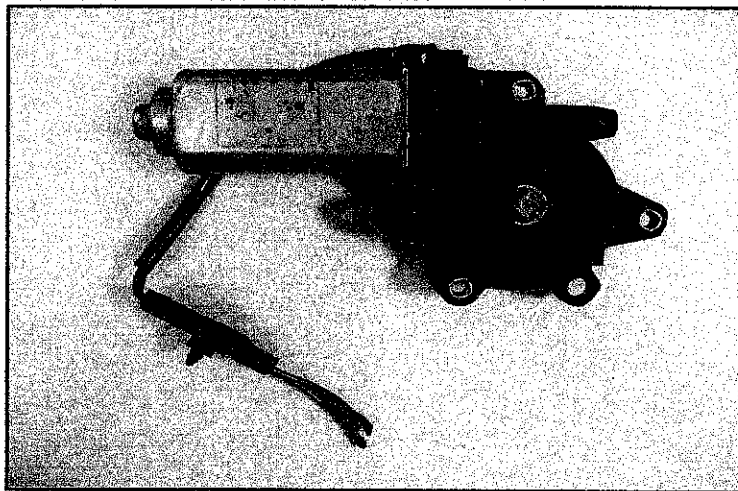

Figure 5 – Webcam 2 (Logitech)

Figure 6 – 12V Power Window Motor

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Running The GUI of Imaging: Coursework Data Entry Program (ICDE)
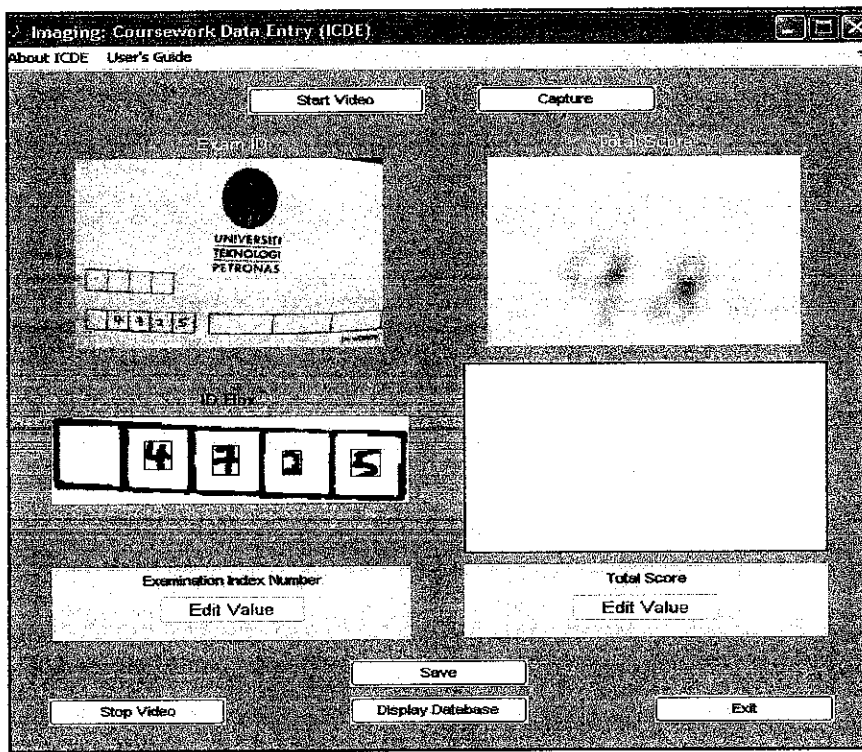

Figure 7 – GUI of ICDE

In early stage of this project, ICDE was tested with MATLAB 7.0. When tested with UTP exam booklet, the program was unable to display the desired result. It only showed the Region of Interest (ROI) of the exam ID while the total result on the booklet was not displayed although the program was run several time.
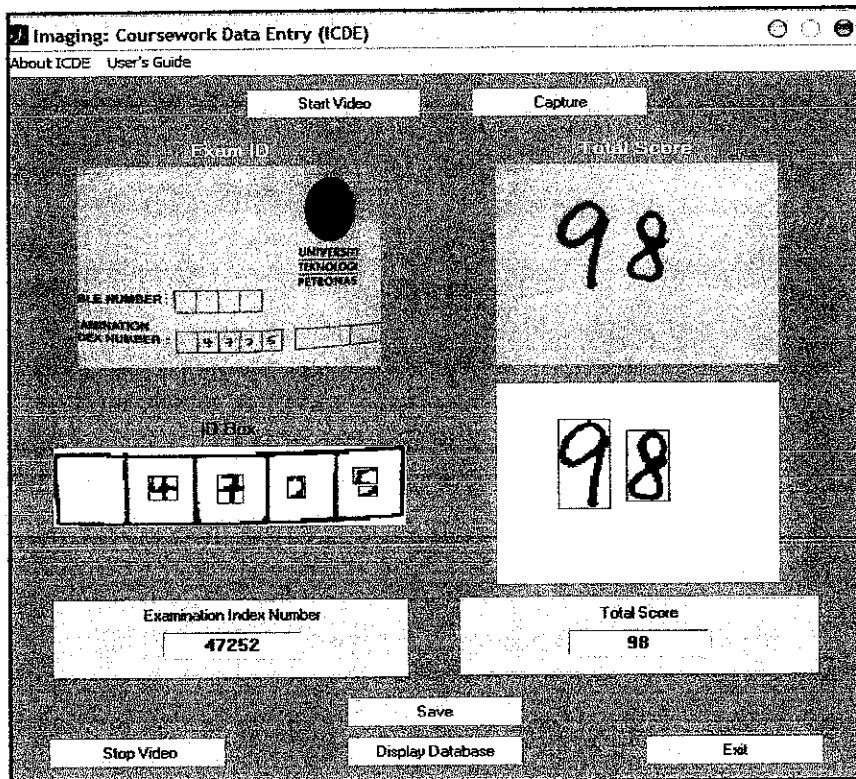
Figure 8 - First run of ICDE GUI (MATLAB 6.5.1)

When testing with MATLAB 6.5.1, ICDE seemed working as what it should be. The result was obtained after several times adjusting the location of the webcams and capturing the images. The UTP's logo and exam ID must be aligned properly and the webcams also must capture only certain portion of the exam booklet to avoid any problem.

As an example, for the total exam result on the booklet, the webcam must capture exactly the total exam result inside the 'box'. If a single line of the 'box' was captured together, the program was unable to produce total exam result from the booklet.

In the first run, the program recognized 4725 as 47252 but in the second run, it displayed correct Examination Index Number. The results were then displayed in Microsoft Excel.
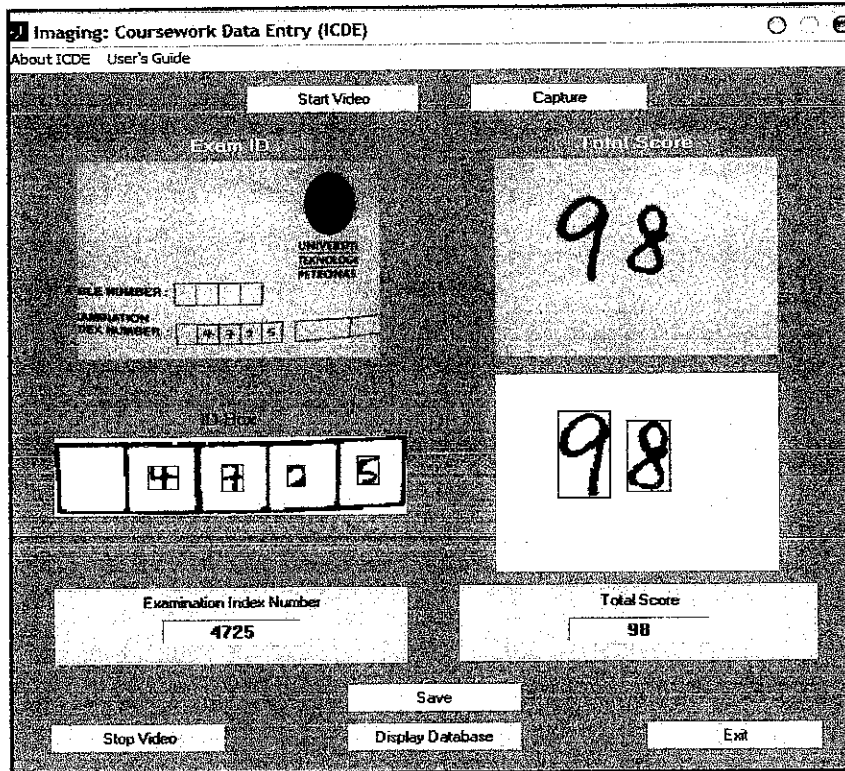
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Figure 9 - Second run of ICDE (MATLAB 6.5.1)

Figure 10 – The results displayed in Microsoft Excel

4.2 Hardware Approach

In this project, a lot of research and survey were done to get the correct platform for the project. Although there were many options available for this project, only few options were feasible to be used. They were the X-Y Precision Table, the 3D Crane and new platform. Below were the discussions for the options available for this project:
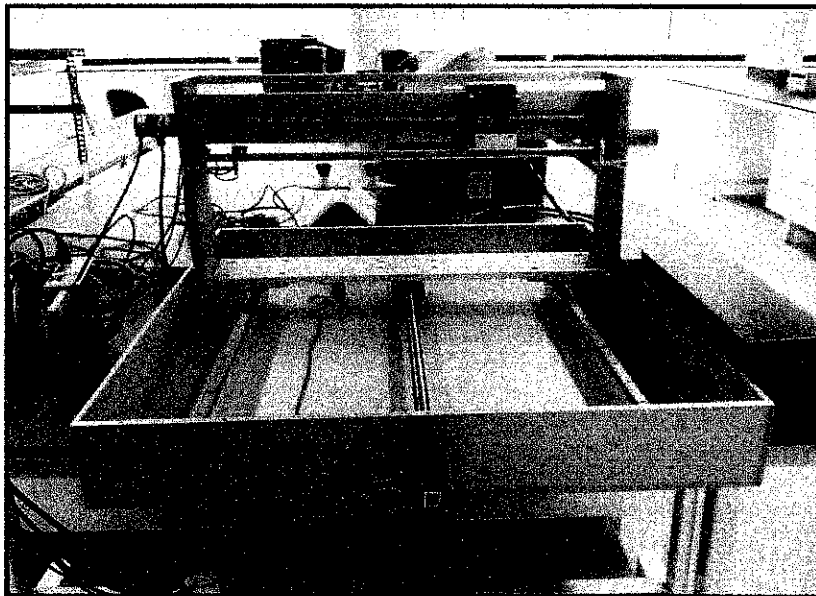
4.2.1 The X-Y Precision Table

Figure 11 - X-Y Precision table at Control System Lab

This was the first platform which supposed to be used in this project. It consists of a complete set of pneumatic X-Y precision table, power supply and an OMRON controller. The only task left which should be done are adding a Perspex on the precision table, writing a program to control the movement of the precision table in X-Y axis and improving the previous Handwriting Recognition For Data Entry MATLAB (HandRec) program.

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Advantage:

Platform was complete

Disadvantage:

None, as this is supposed to be the actual platform.

After surveying, it was found that this X-Y precision table could not be used due to the condition was inoperable.
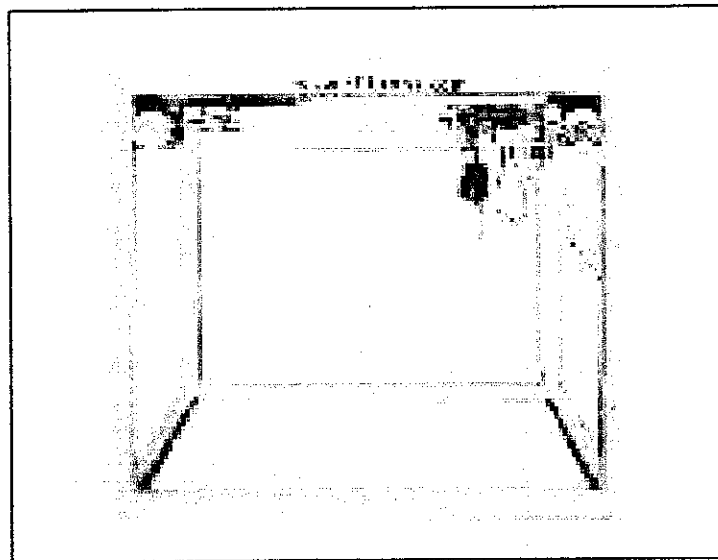
4.2.2 The 3DCrane

Figure 12 – 3DCrane

The 3DCrane is a non-linear electromechanical system which has a complex dynamic behavior and creates challenging control problems. The system is controlled from a PC

and delivered with hardware and software which can be easily mounted and installed in a laboratory.

The software operates under Microsoft Windows NT using MATLAB and RTWT toolbox package. The 3DCrane setup consists of a payload hanging on a pendulum-like lift-line wound by a motor mounted on a cart.
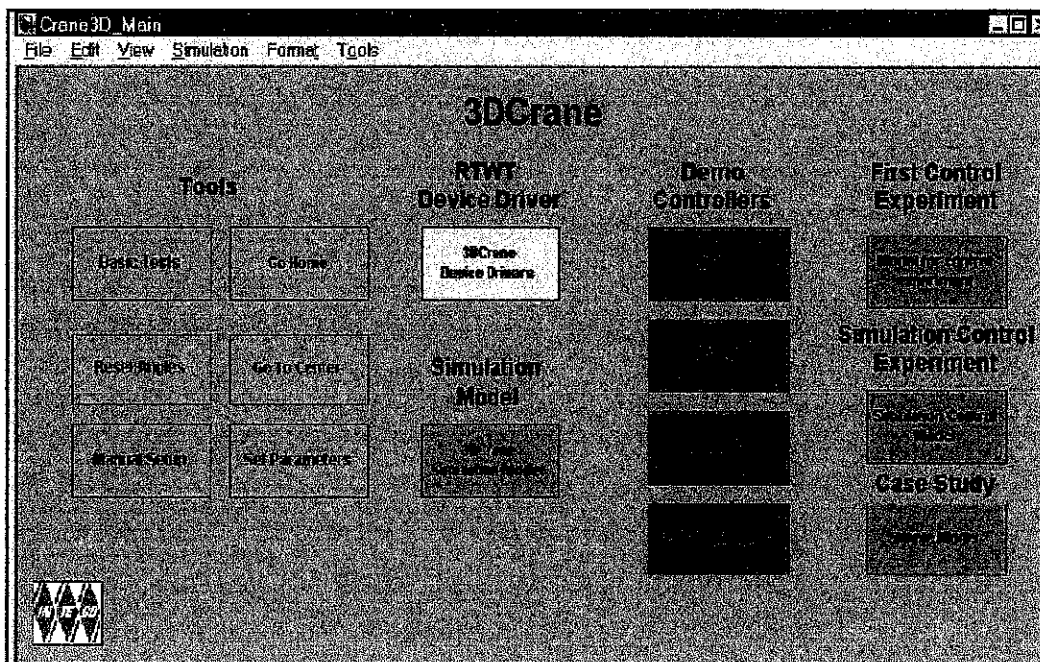

Figure 13 – 3DCrane Main Control Window
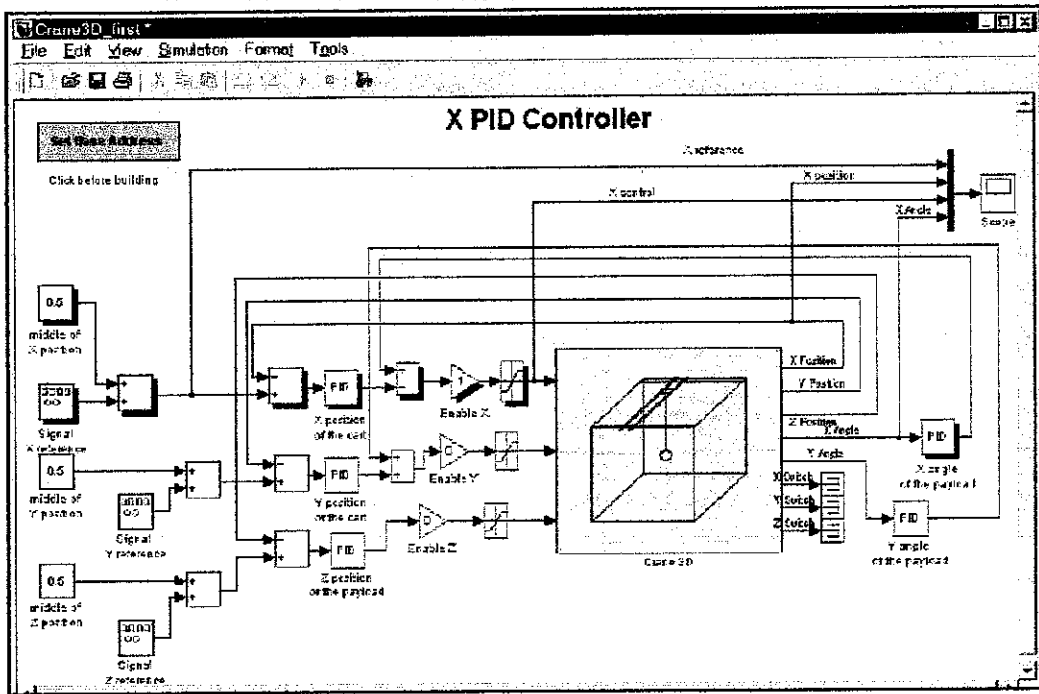
Figure 14 - Example of experiment / demo for the 3DCrane

Advantages:

- The hardware is already available in a complete set and it is still working perfectly.
- It has 3 axes which are X, Y, Z. This will provide more features as the Z axis will be used for "zooming" the webcam.
- The cost of the Final Year Project will be reduced significantly as this is just a programming project.

Disadvantages:

- The 3DCrane is huge and not suitable for short range movement.
- The oscillation of the pendulum is great for short distance movement.

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Due to not many things could be done with the 3DCrane, it was decided to build a new platform.

4.2.3 New Platform

Advantages:

- It is smaller compared with the other options and the size is suitable for UTP Examination Booklet.
- Easily improved from time to time as the platform is an open-ended type and ready for future improvement.

Disadvantages

- Time, cost and energy consuming for the research and development compared with other options.

This was the option chosen for the project. It consisted of research and development for the hardware and software parts.

4.3 The Platform Design

The main goals for the platform design were to design as simple as possible platform and to minimize the cost of the equipment used to build the platform. Some sketches and designs were done with the help from technicians.

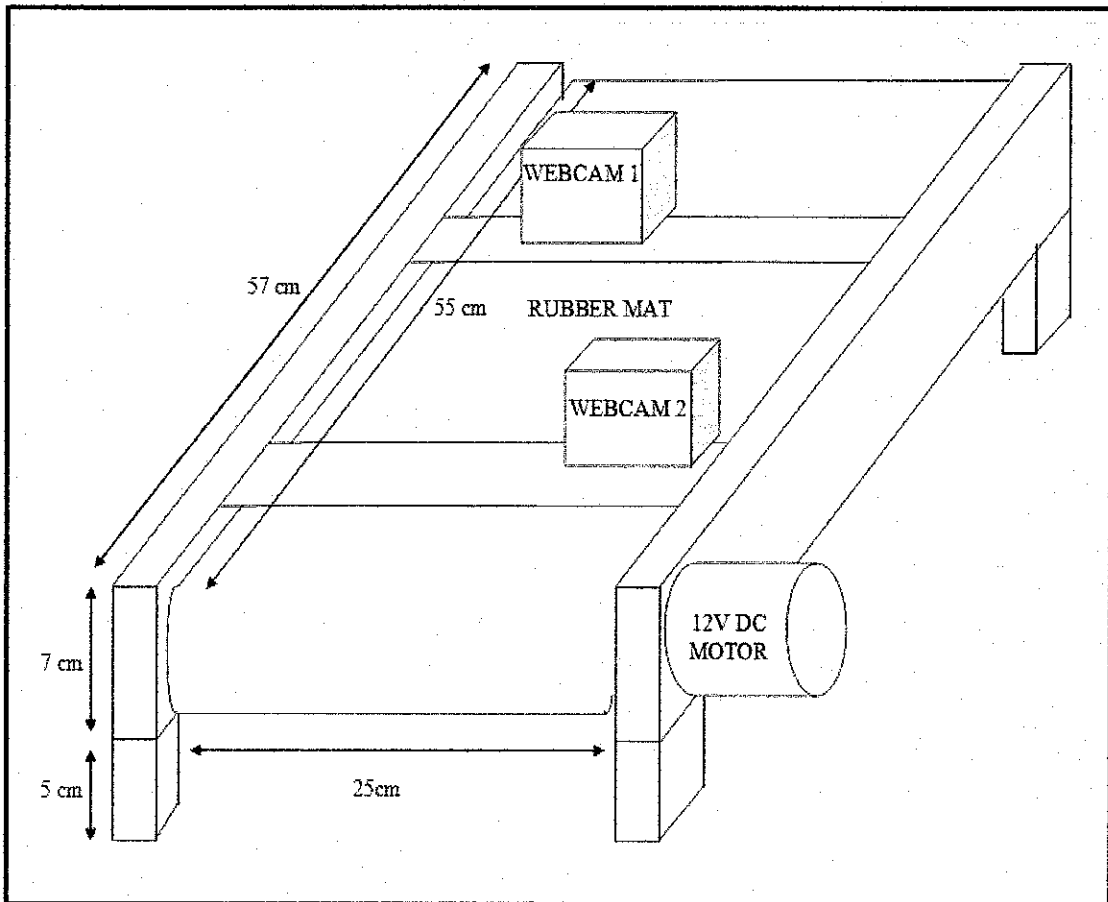Figure 15 – Platform for exam booklet

This was the design of the platform which would be used to move the exam booklet in Y-axis (up and down). It used a conveyor belt system. The movement of the conveyor belt was controlled by a DC motor. This platform would operate based on the instruction given from a microcontroller 16F84A. The microcontroller was connected with a computer by using RS-232 serial port.

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4.4 Actual Platform
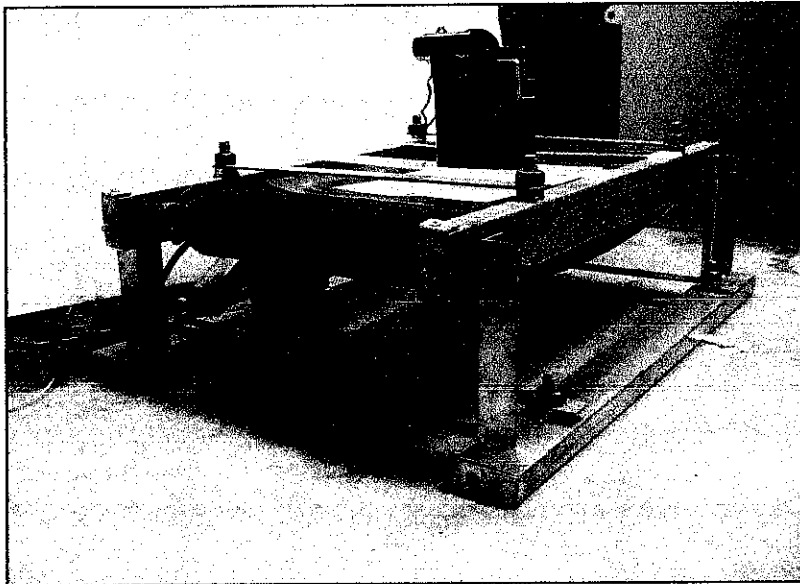
Figure 16 -The actual conveyor belt platform with webcams brackets

The platform design was slightly different from the initial design. This was due to the addition of chain as the mechanism to move the conveyor belt instead of connecting the DC motor directly to the roller. To support webcams bracket, Perspex were put on top of the platform and stuck with double sided tape. One of the advantages of using Perspex was it could reduce the shadow effect during image capturing process.
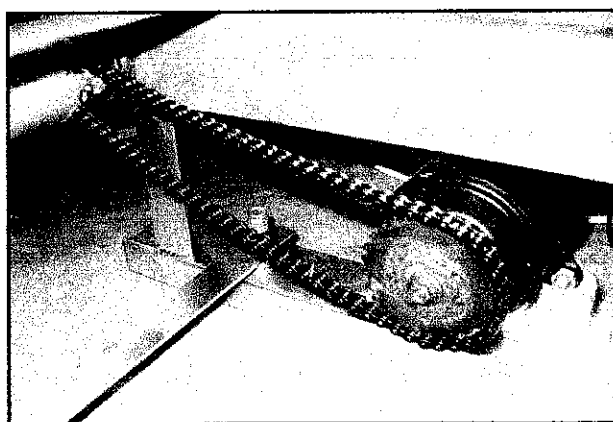
Figure 17 -The chain mechanism for the conveyor belt

4.5 PIC 16F84A Microcontroller

The movement of the platform was determined by these chips. It was programmed by using C Language. The main task for the first 16F84A was to communicate with the PC while the second 16F84A was used to control the movements of the motors.
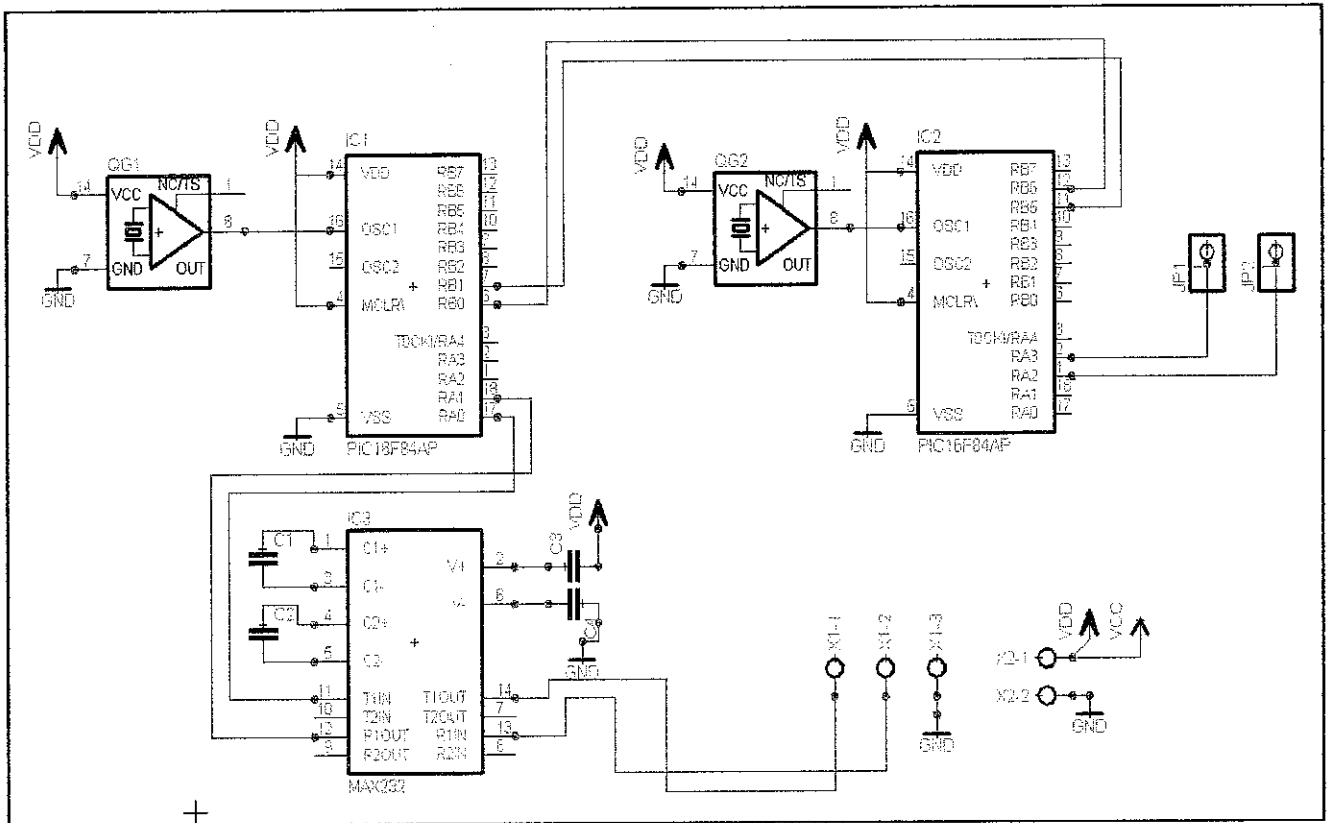
Figure 18 – Schematics of microcontroller circuit [8]

By sending streams of bits that represent character values from PC into the communication pin of the first microcontroller, the program of the first microcontroller determined the states of outputs for certain character values.

Table 2: Character Translation Communications

Character Input	Output Pin
i	RB0 high
k	RB1 high

Figure 19 - PCB Layout of the microcontroller circuit [8]

4.6 RS-232 Serial Port

The RS-232 is a standard developed by the Electronic Industries Association (EIA) and other interested parties, specifying the serial interface between Data Terminal Equipment (DTE) and Data Communications Equipment (DCE). The RS-232 sta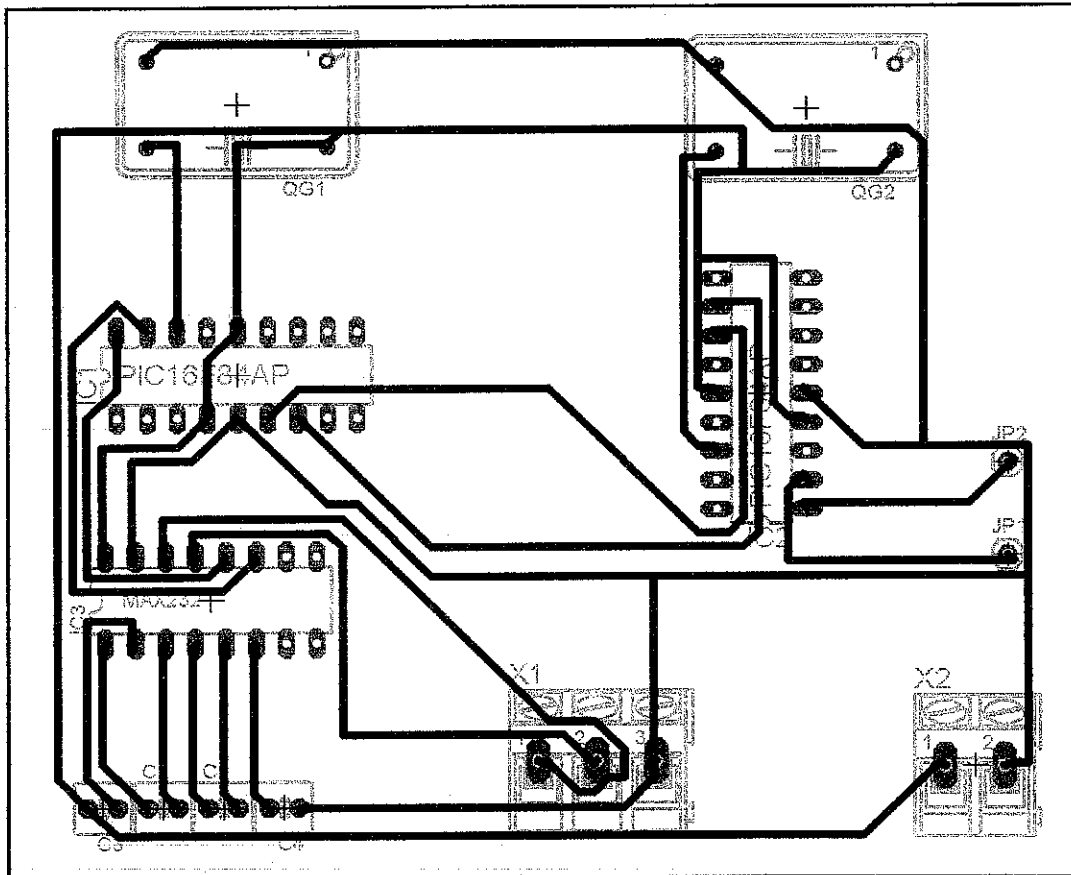ndard includes voltage levels, connectors, function of each electrical signal and some recipes for common kinds of terminal-to-modem connections.

The most frequently encountered revision of this standard is called RS-232C. Parts of this standard have been adopted for use in serial communications between computers and printers, modems, and other equipment. The serial ports on standard IBM-compatible personal computers follow RS-232.
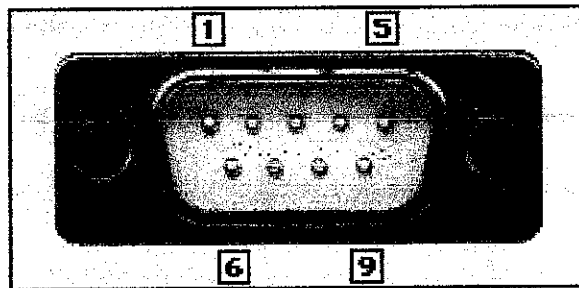

Figure 20 – Serial Port

In MATLAB, there are serial port commands available which are used to construct serial port object (SERIAL), connect serial port object to device (FOPEN), and to disconnect serial port object from device (FCLOSE).

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4.7 The H Bridge Circuit
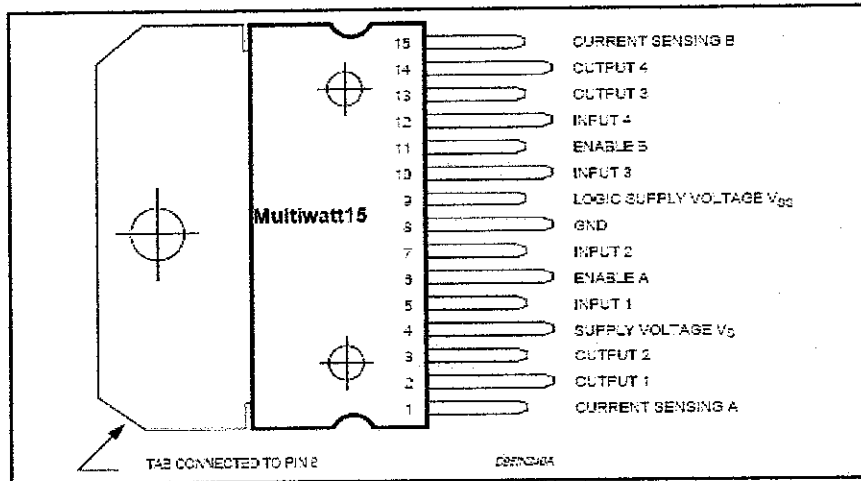
Figure 21 – L298N Pin Connection

In this project, instead of building an H-Bridge circuit by using MOSFET transistors, an integrated circuit was used. This was due to time constraint and the availability of the motor driver integrated circuit such as L298N. The L298N consist of an integrated monolithic circuit which is a high voltage, high current dual full-bridge designed to accept TTL logic levels and drive inductive loads. The L298N has the following specifications:

- Operating supply of up to 46V
- Total DC current up to 4A
- Over temperature protection
- Logical input up to 1.5V

The H Bridge circuit was used to control the DC motors from the microcontroller at the proper voltage level [7].
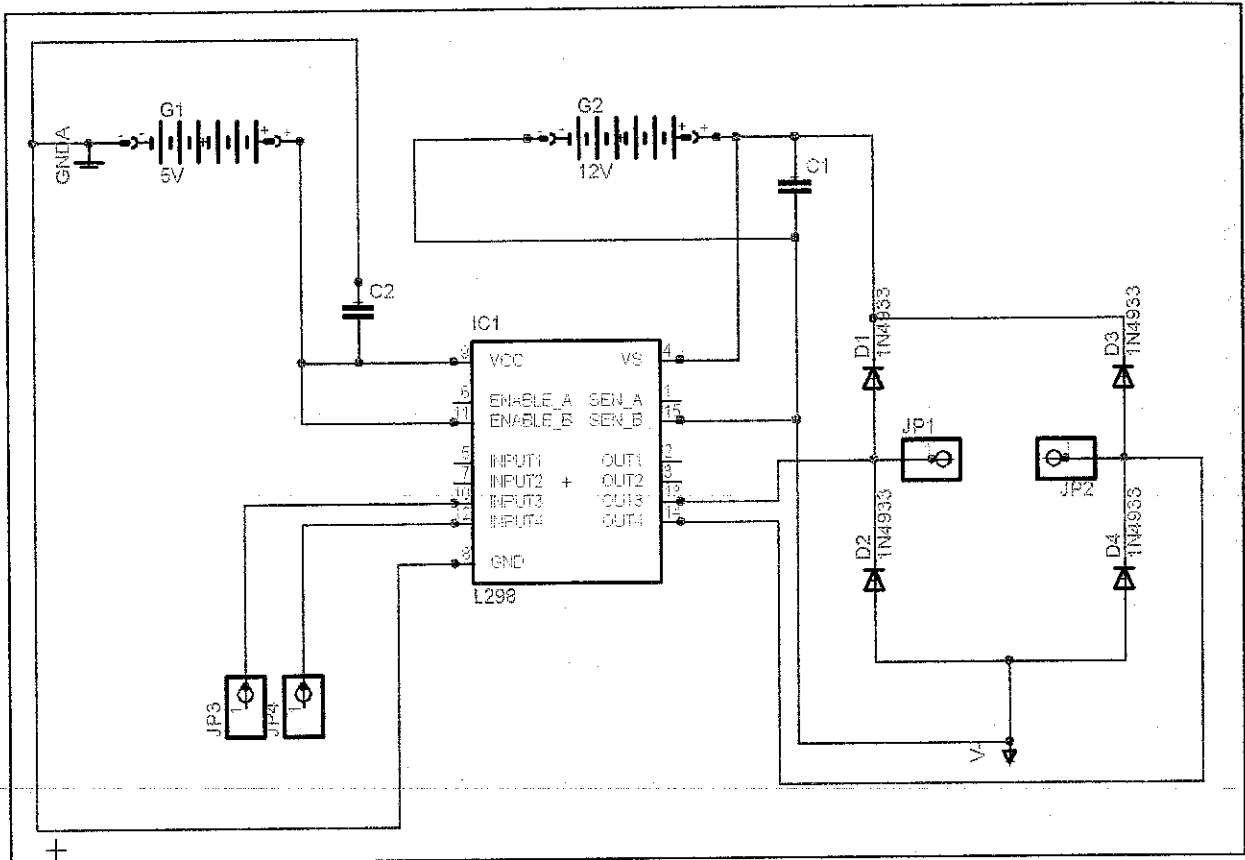
Figure 22 – Schematics of H Bridge Circuit

Figure 22 showed the L298N controlled the drive train of the motor. Pin 10 and Pin 12 determine the direction of the motor, whether to move forward or reverse direction. Pin 11 however, will determine if the power output stages of L298N (in this case, B is the power output stage) is ON or OFF.

After some testing with the platform, it was found that the DC motor from the platform tended to pull out very large current of more than 2A just to make it moved. This was due to heavy load of the mechanism itself. The H Bridge circuit could only withstand maximum 2A of current rating with this configuration.

To solve this problem, a series of test were conducted. The problem was solved by paralleling the outputs of the H Bridge circuit (Pin 2 with Pin 14 and Pin 3 with Pin 13) as in the datasheet. Based on this configuration, the current rating of the driver can be increased further to 4A.
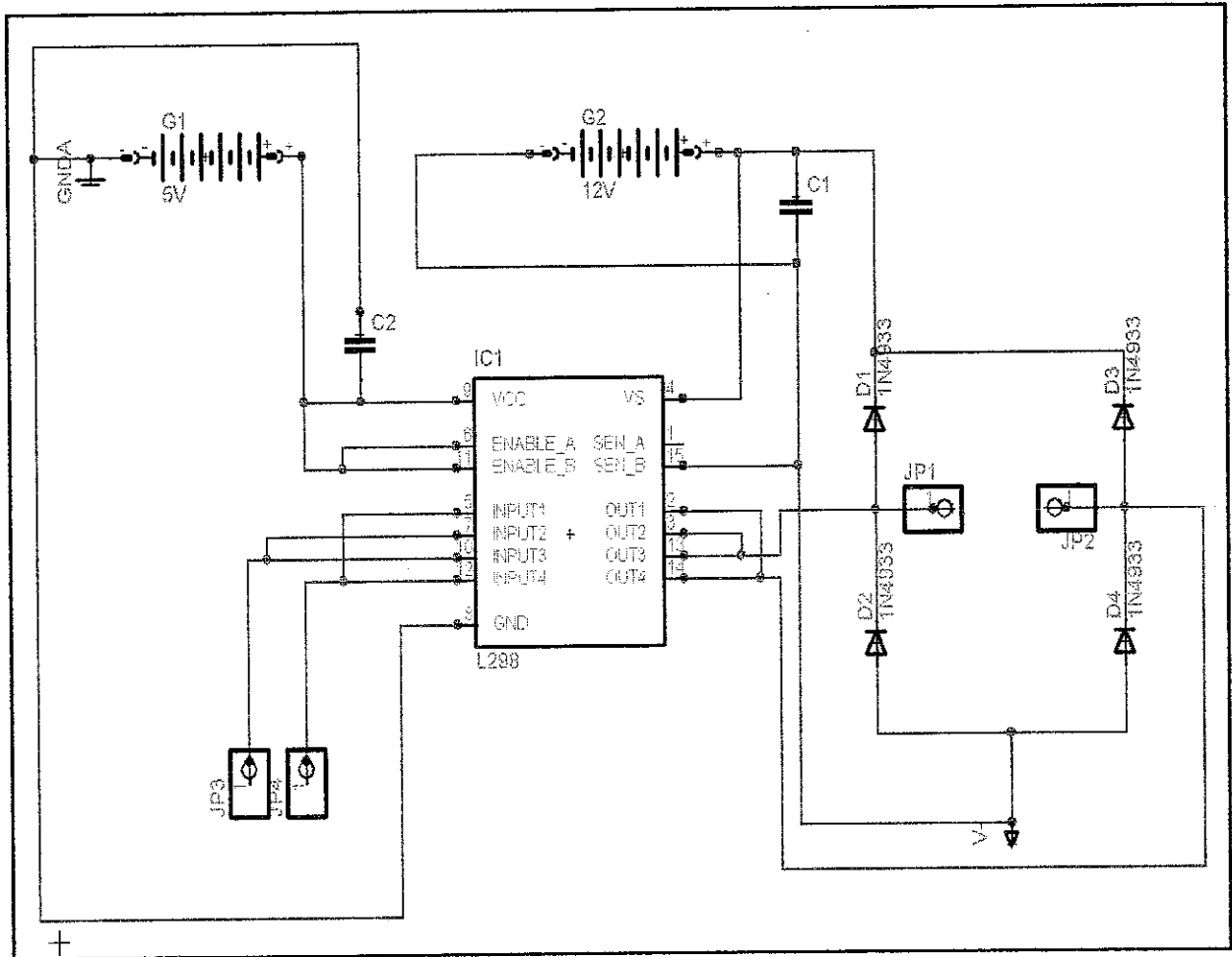
Figure 23 - Parallel Output Configuration of L298N
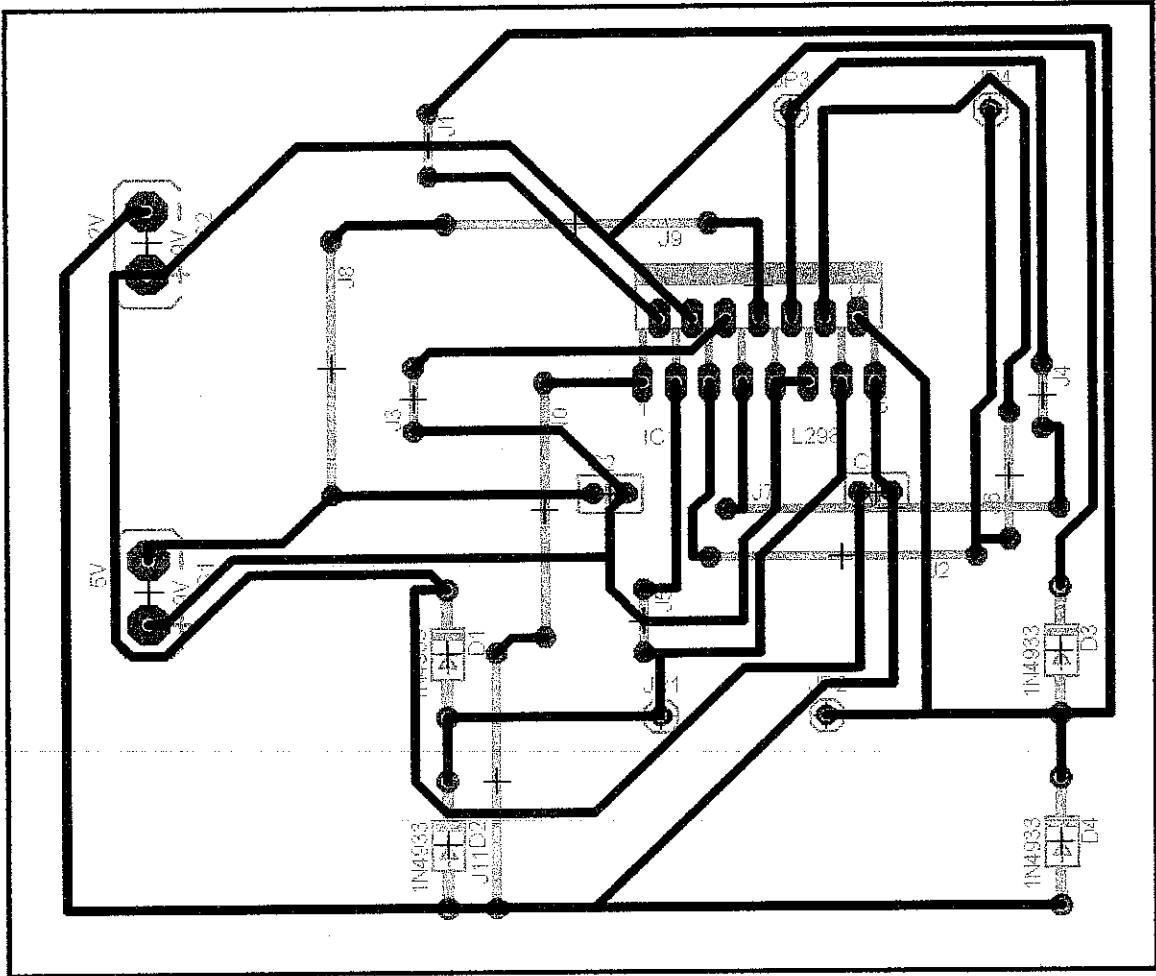
Figure 24 - PCB Layout of the H- Bridge Circuit

4.8 Normalized Cross Correlation
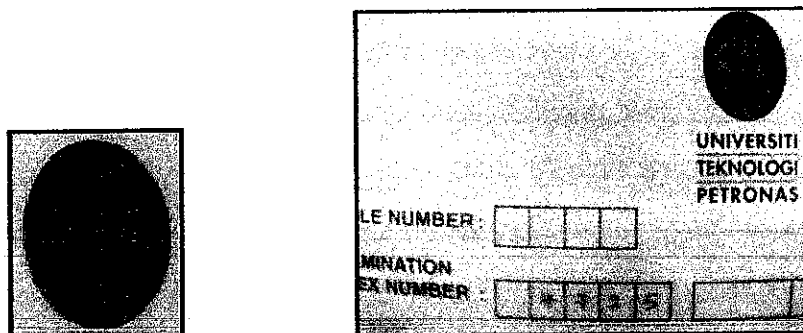
Figure 25 - a) UTP Oval Logo   b) Image Viewed From Webcam 1

Figure 25(b) showed the images that can be viewed from Webcam 1 while Figure 25(a) showed the UTP oval logo which was already stored in a MATLAB Work folder. When the program was initiated, the image as in Figure 25 (b) would be captured by Webcam 1 and saved in the MATLAB Work folder as image1.jpg. The images of UTP oval logo and image1.jpg would be then read by MATLAB and converted to grayscale before the normalized cross correlation process took place.
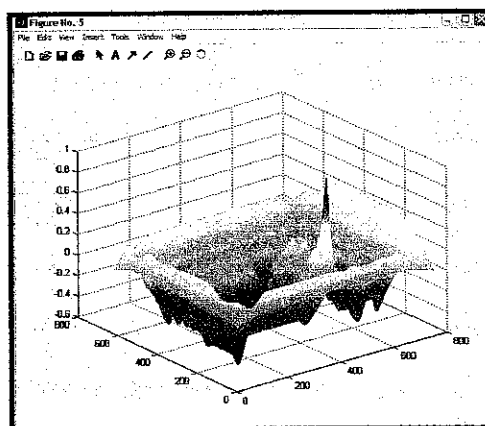
Figure 26- Normalized Cross Correlation

The normalized cross-correlation was calculated and displayed in a surface plot. The peak of the cross-correlation matrix occurred where the UTP oval logo and image1.jpg were best correlated. normxcorr2 function only works on grayscale images.

After the images are successfully correlated, ICDE GUI will then be called. Capturing and recognizing the Exam ID and Total Marks are done within this program.

4.9 Results of Normalized Cross Correlation

These were the result obtained when tested with predetermined set points (vertical=a, horizontal=b). The predetermined set points were obtained by running the program several times, listing the best combination of set points and running again the program to test whether the set points were valid.

4.9.1 UTP Oval Logo at Correct Position
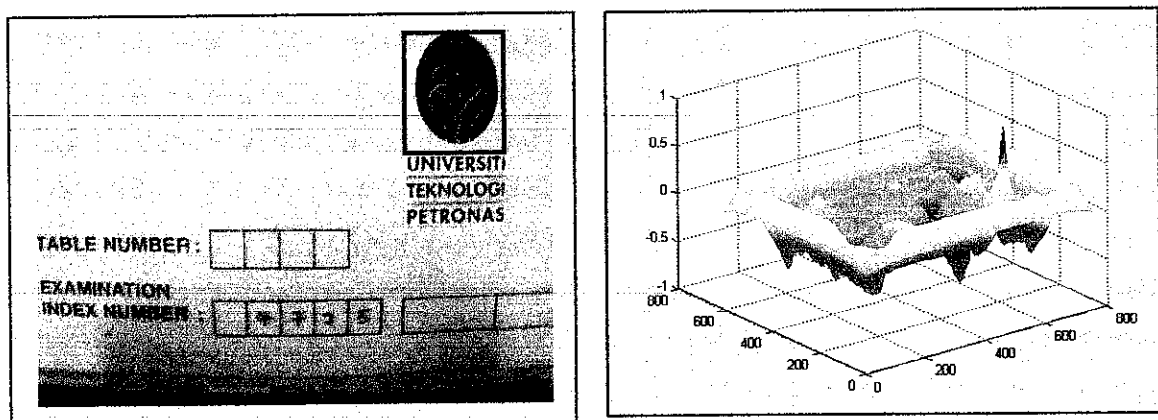
Figure 27 - Normalized Cross Correlation (For Correct Position)

Normalized cross correlation found the highest peak at (210,572). ICDE program is called.

Set condition: (((a <= 250) && (a >= 150)) && ((b <= 630) && (b >= 500)))

Although the examination booklet was placed at correct position, sometimes, the normalized cross correlation cannot correlate the image of examination booklet with UTP oval logo (reference image) at the correct peak location.

4.9.2 UTP Oval Logo at Slightly Upper Position
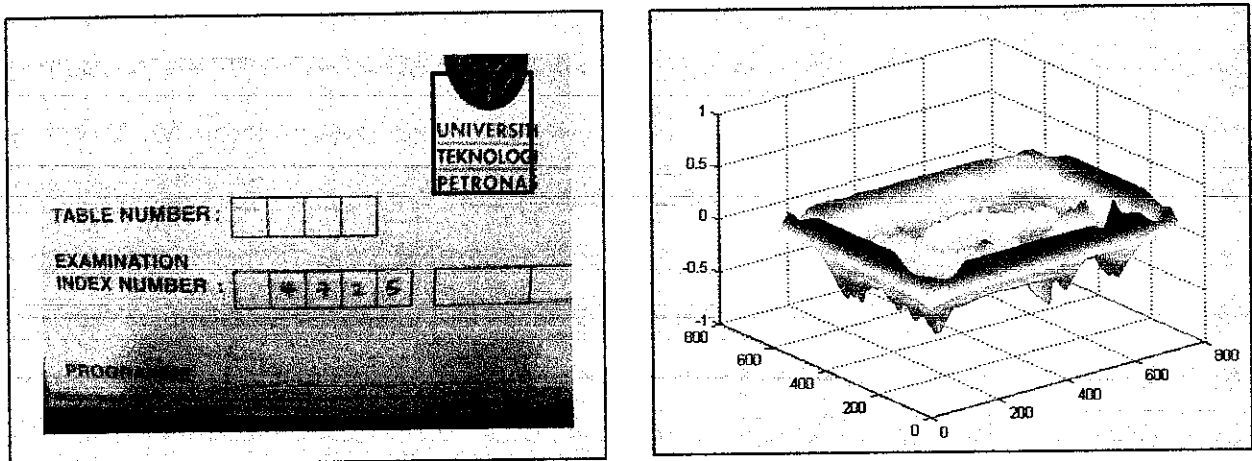
Figure 28- Normalized Cross Correlation (For Slightly Upper Position)

Normalized cross correlation found the highest peak at (135,547). Conveyor moves down 0.5 second.

4.9.3 UTP Oval Logo at Slightly Lower Position
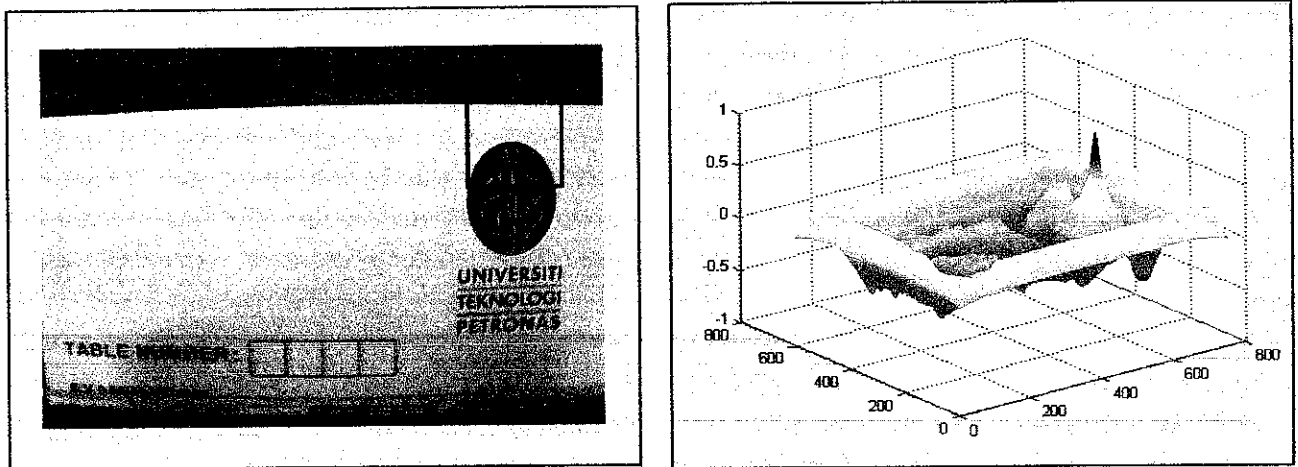
Figure 29 - Normalized Cross Correlation (For Slightly Lower Position)

Normalized cross correlation found the highest peak at (**398**,572). Conveyor moves up 0.5 second.

Set condition: If ((a>=250) && ((b <= 630) && (b >= 500)))

4.9.4 UTP Oval Logo at Slightly Left Position
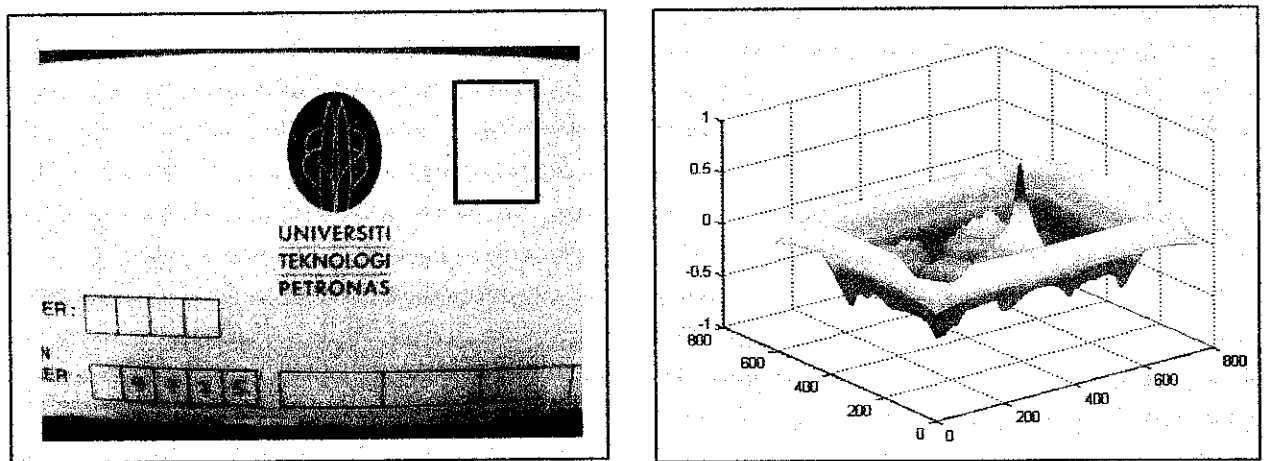
Figure 30 - Normalized Cross Correlation (For Slightly Left Position)

Normalized cross correlation found the highest peak at (159,**292**).

Error message will be displayed. User must place the examination booklet at correct position.

Set condition: If ((b<=500) && ((a <= 250) && (a >= 150)))

4.9.5 UTP Oval Logo Out of Range
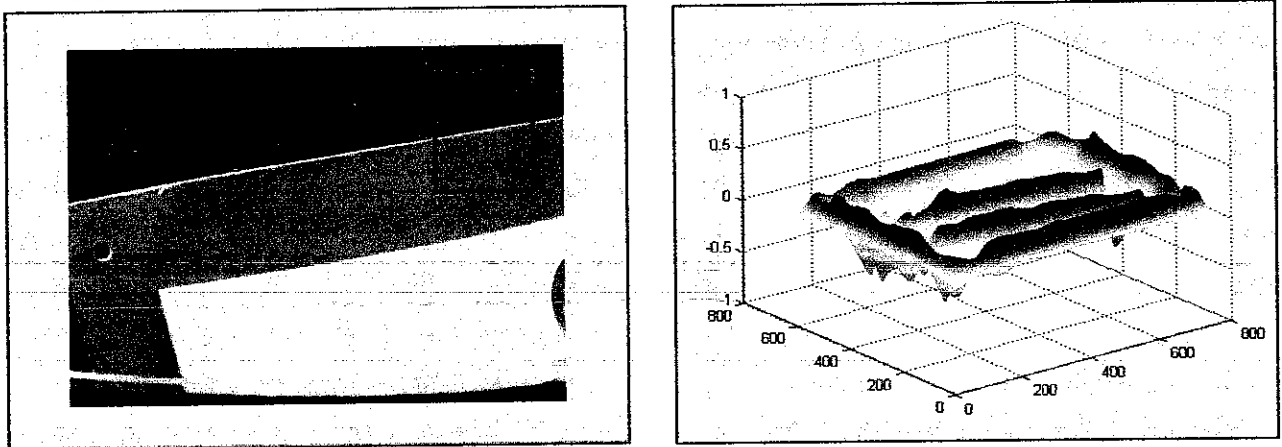
Figure 31 - Normalized Cross Correlation (Out of Range)

Error message will be displayed. User must place the examination booklet at correct position.

Set condition: If (a >= 250); if (a <= 150); if (b <= 500); if (b >= 630)

4.10 Overview of the System

| PC | → Serial Comm | 16F84 uC with MAX232 | → | 16F84 uC | → | H-Bridge circuit | → | Power window motor |

MATLAB & Image Processing   Microcontrollers   5V-12V   Platform

Figure 32 - System Block Diagram

4.11 System Flowchart
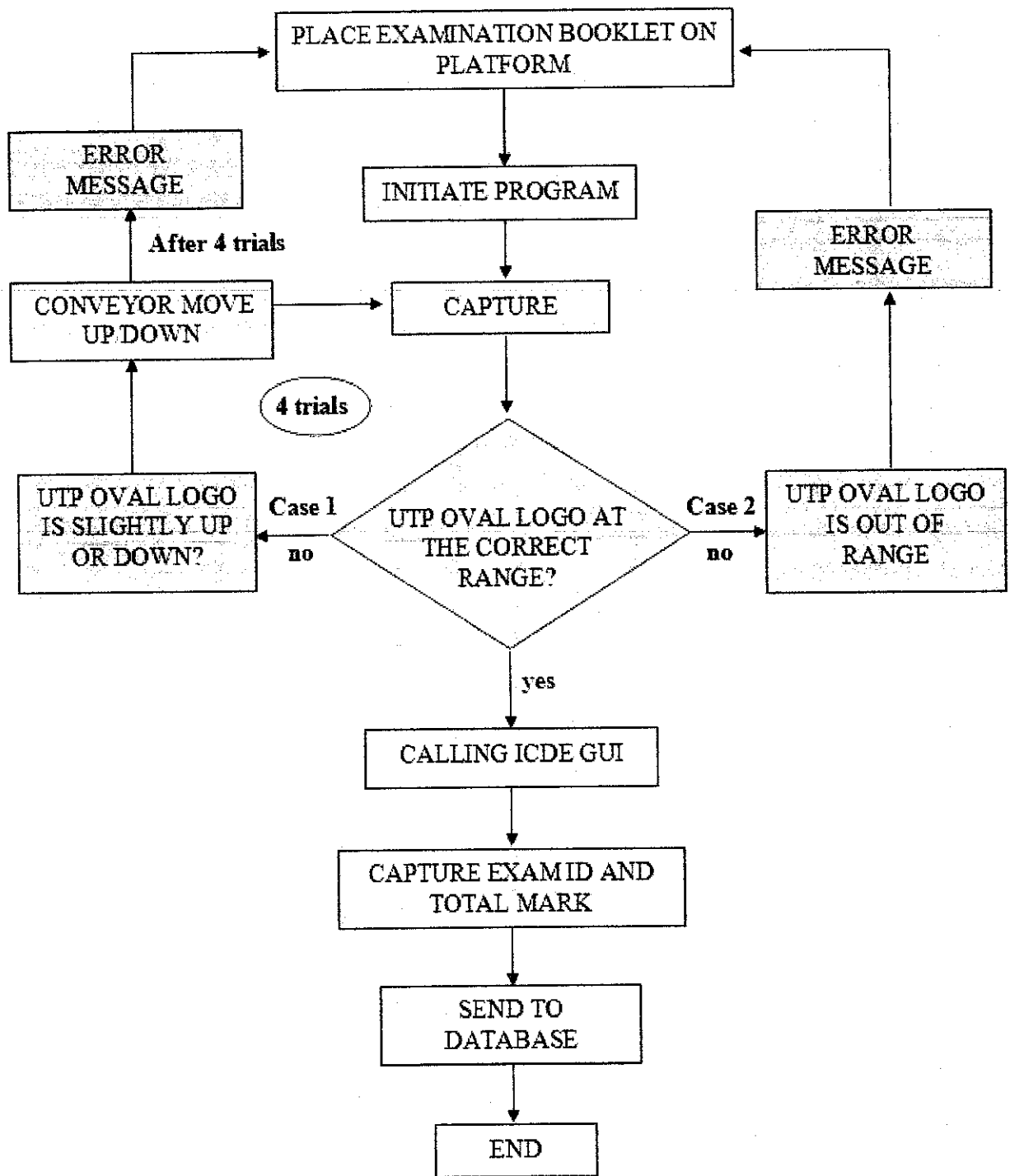
Figure 33- Flowchart of the System

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CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As an improvement or continuation of previous project, the objective of this project was to design an automated process of feeding paper for data entry. A platform for examination booklet was built to integrate with ICDE program. In designing this platform, a series of research and development were conducted. The platform was constructed using steels and welded together. There was a DC motor bracket on the right side of the platform. To make the rubber mat moving, the DC motor was connected with the upper roller by using chain. When the DC motor moved clockwise or counter clockwise, it would cause the rubber mat moved. To support webcams bracket, Perspex were put on top of the platform.

To establish a communication between computer and microcontroller, a serial port communication was used. By sending streams of bits that represent character values from PC into the communication pin of the first microcontroller, the program of the first microcontroller determined the states of outputs for certain character values.
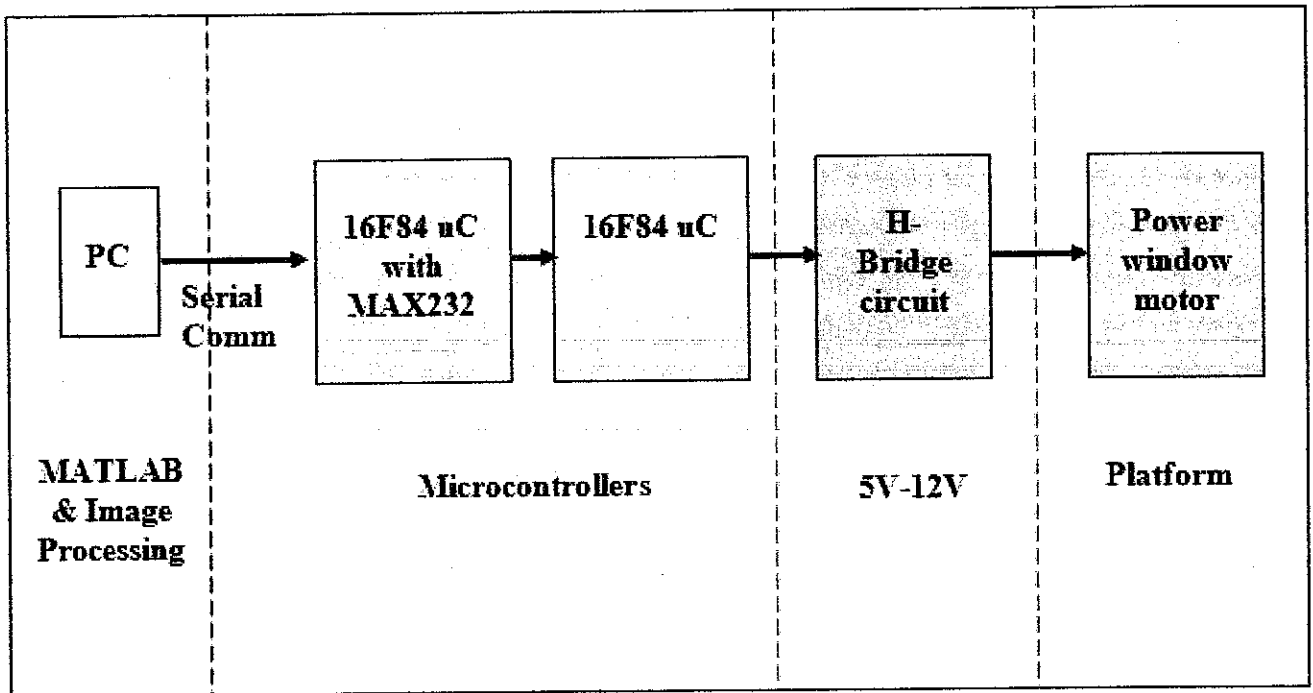
To control the DC motor from the microcontroller, an H Bridge circuit was used. In this project, the parallel configuration of H Bridge circuit was selected to increase the current rating up to 4A.

The normalized cross correlation method was chosen as a means to determine the correct location of the data sheet. This was one of important aspect in this project due to the location of data sheet would represent the location of UTP oval logo as well as the ROI.

If the location of data sheet was not correct, ICDE could not perform the recognition of the exam ID from the booklet.

5.2 Recommendations

As a recommendation for this project, an improvement of the platform design especially on the material selected for the platform should be considered. The light weight material for example, can reduce the weight of the platform and also make it portable. The motor bracket design should be improved to reduce unwanted vibration when the motor is moving as experienced in this project.

Other than that, platform which utilizes a single webcam but with greater accuracy should also be considered. The sketch of the platform can be referred in the Appendix E.

For ICDE, the accuracy of the recognition could be improved by using some feature extraction method such as Euler Method. The system still has trouble recognizing the digit '8'. Thus, Euler Method, an additional feature extraction method needs to be considered to improve the program. The Neural Network of the program also needs to be updated to reflect learning ability of Neural Network as and when there is a correction to input data.

REFERENCES

1. Poo Hwei Nee, "Handwriting Recognition for Data Entry", B. ENG. (HONS) Electrical and Electronics Engineering, Universiti Teknologi Petronas, 2005.

2. Sanjit K. Mitra, "Digital Signal Processing - A Computer Based Approach", Mc Graw Hill, Third Edition, 2006

3. J.P Lewis, "Fast Normalized Cross-Correlation, In Vision Interface", 1995

4. Kazuyuki Kobayashi, VCAPG2, Hosei University.

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6. http://www.dprg.org/tutorials/1998-04a/

7. Timothy Thien Ching Kae, "Robotic Lawn Mower", B. ENG. (HONS) Electrical and Electronics Engineering, Universiti Teknologi Petronas, 2006.

8. Fadliyanto,"Pan and Tilt Platform for Object Tracking utilizing Web Cam", B. ENG. (HONS) Electrical and Electronics Engineering, Universiti Teknologi Petronas, 2006

APPENDICES

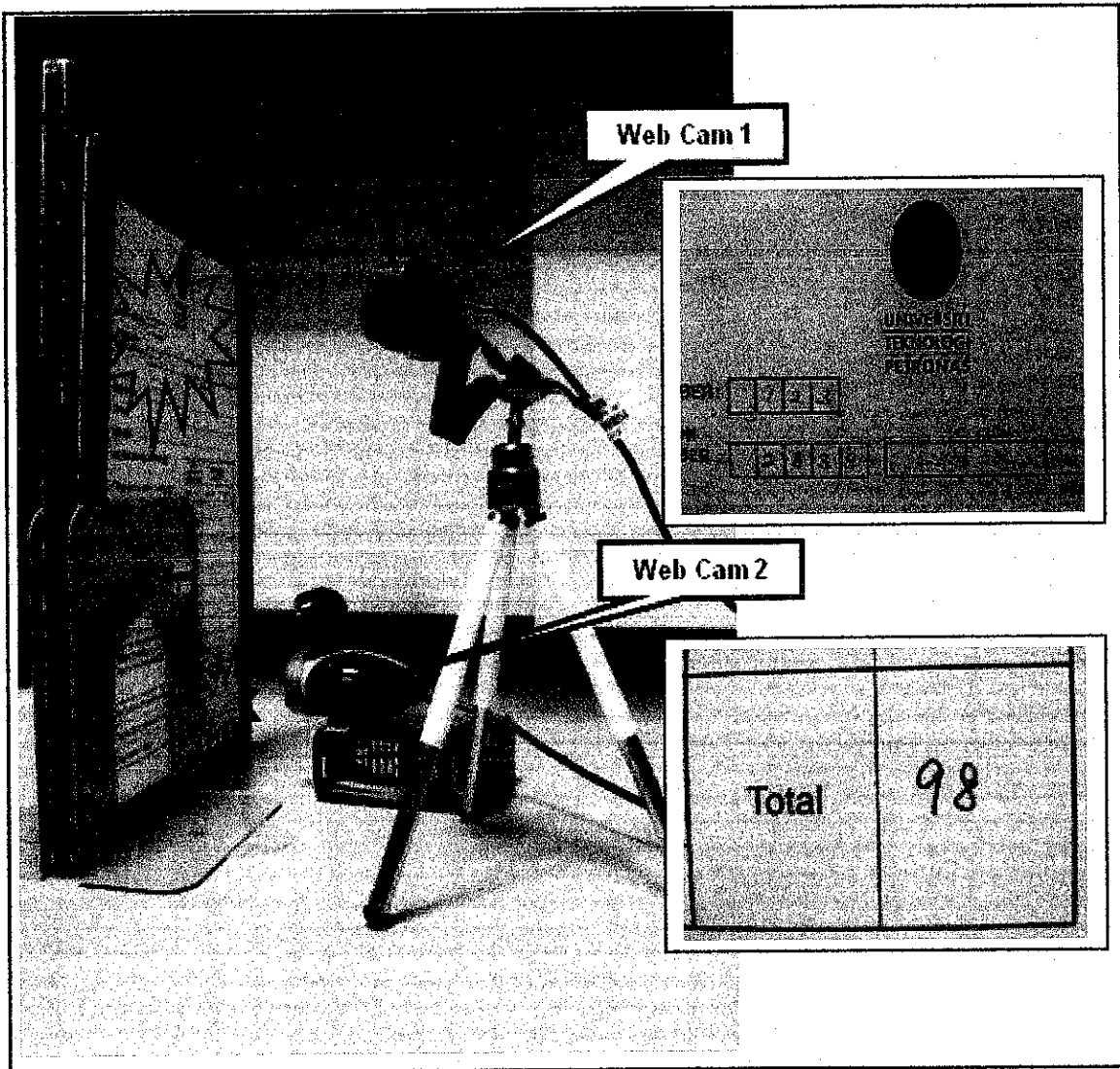# APPENDIX A

HARDWARE ARRANGEMENT OF PREVIOUS PROJECT

Figure 34- Hardware Arrangement of Previous Project (ICDE) [1]

APPENDIX B
PIC 16F84A DATASHEET

PIC16F84A

18-pin *Enhanced* Flash/EEPROM 8-Bit Microcontroller

Devices Included in this Data Sheet:

- PIC16F84A
- Extended voltage range device available (PIC16LF84A)

High Performance RISC CPU Features:

- Only 35 single word instructions to learn
- All instructions single cycle except for program branches which are two-cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- 1024 words of program memory
- 68 bytes of data RAM
- 64 bytes of data EEPROM
- 14-bit wide instruction words
- 8-bit wide data bytes
- 15 special function hardware registers
- Eight-level deep hardware stack
- Direct, indirect and relative addressing modes
- Four interrupt sources:
  - External RB0/INT pin
  - TMR0 timer overflow
  - PORTB<7:4> interrupt on change
  - Data EEPROM write complete

Peripheral Features:

- 13 I/O pins with individual direction control
- High current sink/source for direct LED drive
  - 25 mA sink max. per pin
  - 25 mA source max. per pin
- TMR0: 8-bit timer/counter with 8-bit programmable prescaler

Special Microcontroller Features:

- 1000 erase/write cycles *Enhanced* Flash program memory
- 1,000,000 typical erase/write cycles EEPROM data memory
- EEPROM Data Retention > 40 years
- In-Circuit Serial Programming (ICSP™) - via two pins
- Power-on Reset (POR), Power-up Timer (PWRT), Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Code-protection
- Power saving SLEEP mode
- Selectable oscillator options

Pin Diagrams

PDIP, SOIC

SSOP
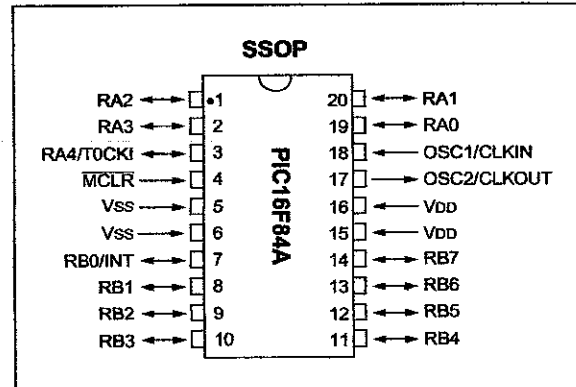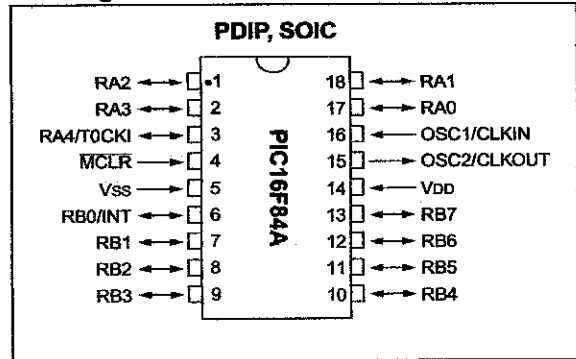
CMOS *Enhanced* Flash/EERPOM Technology:

- Low-power, high-speed technology
- Fully static design
- Wide operating voltage range:
  - Commercial: 2.0V to 5.5V
  - Industrial: 2.0V to 5.5V
- Low power consumption:
  - < 2 mA typical @ 5V, 4 MHz
  - 15 µA typical @ 2V, 32 kHz
  - < 0.5 µA typical standby current @ 2V

Preliminary

APPENDIX C
MAX232 DATASHEET

/M/XI/M

+5V-Powered, Multichannel RS-232 Drivers/Receivers

General Description

The MAX220–MAX249 family of line drivers/receivers is intended for all EIA/TIA-232E and V.28/V.24 communications interfaces, particularly applications where ±12V is not available.

These parts are especially useful in battery-powered systems, since their low-power shutdown mode reduces power dissipation to less than 5µW. The MAX225, MAX233, MAX235, and MAX245/MAX246/MAX247 use no external components and are recommended for applications where printed circuit board space is critical.

Applications

Portable Computers

Low-Power Modems

Interface Translation

Battery-Powered RS-232 Systems

Multidrop RS-232 Networks

AutoShutdown and UCSP are trademarks of Maxim Integrated Products, Inc.

Next-Generation Device Features

♦ **For Low-Voltage, Integrated ESD Applications**
MAX3222E/MAX3232E/MAX3237E/MAX3241E/MAX3246E: +3.0V to +5.5V, Low-Power, Up to 1Mbps, True RS-232 Transceivers Using Four 0.1µF External Capacitors (MAX3246E Available in a UCSP™ Package)

♦ **For Low-Cost Applications**
MAX221E: ±15kV ESD-Protected, +5V, 1µA, Single RS-232 Transceiver with AutoShutdown™

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX220CPE	0°C to +70°C	16 Plastic DIP
MAX220CSE	0°C to +70°C	16 Narrow SO
MAX220CWE	0°C to +70°C	16 Wide SO
MAX220C/D	0°C to +70°C	Dice*
MAX220EPE	-40°C to +85°C	16 Plastic DIP
MAX220ESE	-40°C to +85°C	16 Narrow SO
MAX220EWE	-40°C to +85°C	16 Wide SO
MAX220EJE	-40°C to +85°C	16 CERDIP
MAX220MJE	-55°C to +125°C	16 CERDIP

Ordering Information continued at end of data sheet.
Contact factory for dice specifications.

Selection Table

Part Number	Power Supply (V)	No. of RS-232 Drivers/Rx	No. of Ext. Caps	Nominal Cap. Value (µF)	SHDN & Three-State	Rx Active in SHDN	Data Rate (kbps)	Features
MAX220	+5	2/2	4	0.047/0.33	No	—	120	Ultra-low-power, industry-standard pinout
MAX222	+5	2/2	4	0.1	Yes	—	200	Low-power shutdown
MAX223 (MAX213)	+5	4/5	4	1.0 (0.1)	Yes	✔	120	MAX241 and receivers active in shutdown
MAX225	+5	5/5	0	—	Yes	✔	120	Available in SO
MAX230 (MAX200)	+5	5/0	4	1.0 (0.1)	Yes	—	120	5 drivers with shutdown
MAX231 (MAX201)	+5 and +7.5 to +13.2	2/2	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; same functions as MAX232
MAX232 (MAX202)	+5	2/2	4	1.0 (0.1)	No	—	120 (64)	Industry standard
MAX232A	+5	2/2	4	0.1	No	—	200	Higher slew rate, small caps
MAX233 (MAX203)	+5	2/2	0	—	No	—	120	No external caps
MAX233A	+5	2/2	0	—	No	—	200	No external caps, high slew rate
MAX234 (MAX204)	+5	4/0	4	1.0 (0.1)	No	—	120	Replaces 1488
MAX235 (MAX205)	+5	5/5	0	—	Yes	—	120	No external caps
MAX236 (MAX206)	+5	4/3	4	1.0 (0.1)	Yes	—	120	Shutdown, three state
MAX237 (MAX207)	+5	5/3	4	1.0 (0.1)	No	—	120	Complements IBM PC serial port
MAX238 (MAX208)	+5	4/4	4	1.0 (0.1)	No	—	120	Replaces 1488 and 1489
MAX239 (MAX209)	+5 and +7.5 to +13.2	3/5	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; single-package solution for IBM PC serial port
MAX240	+5	5/5	4	1.0	Yes	—	120	DIP or flatpack package
MAX241 (MAX211)	+5	4/5	4	1.0 (0.1)	Yes	—	120	Complete IBM PC serial port
MAX242	+5	2/2	4	0.1	Yes	✔	200	Separate shutdown and enable
MAX243	+5	2/2	4	0.1	No	—	200	Open-line detection simplifies cabling
MAX244	+5	8/10	4	1.0	No	—	120	High slew rate
MAX245	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, two shutdown modes
MAX246	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, three shutdown modes
MAX247	+5	8/9	0	—	Yes	✔	120	High slew rate, int. caps, nine operating modes
MAX248	+5	8/8	4	1.0	Yes	✔	120	High slew rate, selective half-chip enables
MAX249	+5	6/10	4	1.0	Yes	✔	120	Available in quad flatpack package

/M/XI/M _____ *Maxim Integrated Products* 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

TOP VIEW

DIP/SO

CAPACITANCE (µF)					
DEVICE	C1	C2	C3	C4	C5
MAX220	0.047	0.33	0.33	0.33	0.33
MAX232	1.0	1.0	1.0	1.0	1.0
MAX232A	0.1	0.1	0.1	0.1	0.1
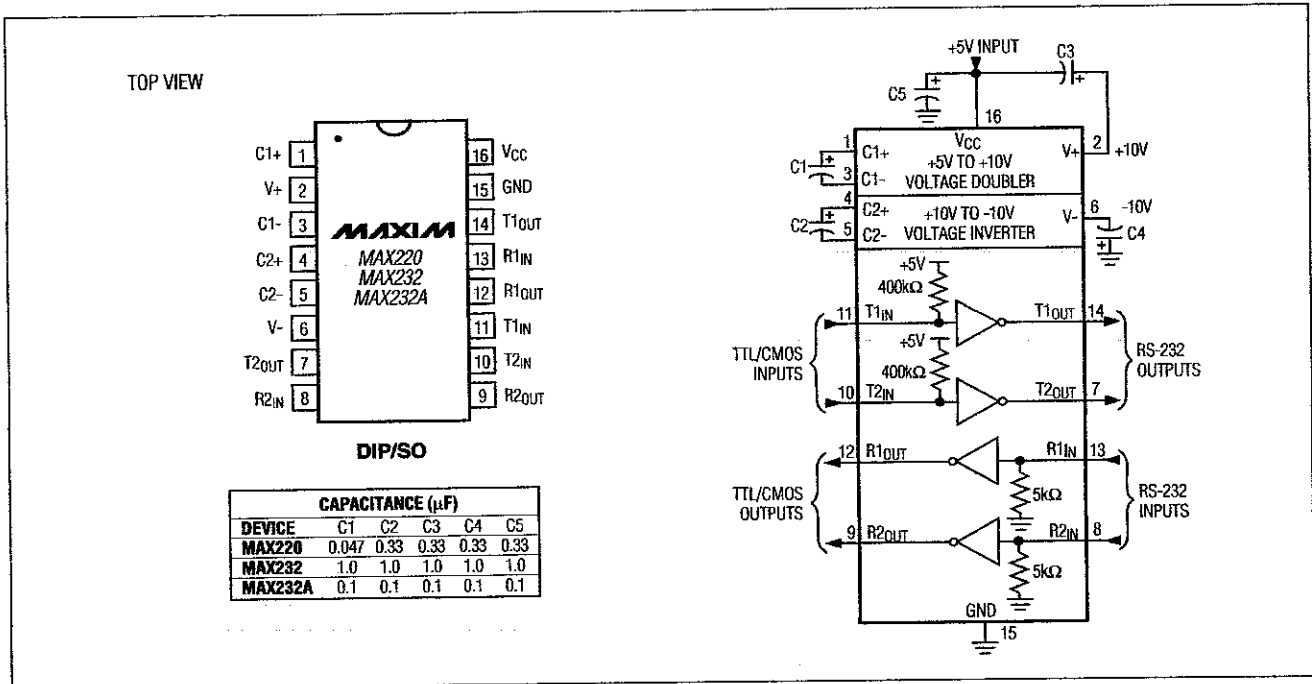
Figure 5. MAX220/MAX232/MAX232A Pin Configuration and Typical Operating Circuit

TOP VIEW

DIP/SO

SSOP

( ) ARE FOR MAX222 ONLY.
PIN NUMBERS IN TYPICAL OPERATING CIRCUIT ARE FOR DIP/SO PACKAGES ONLY.
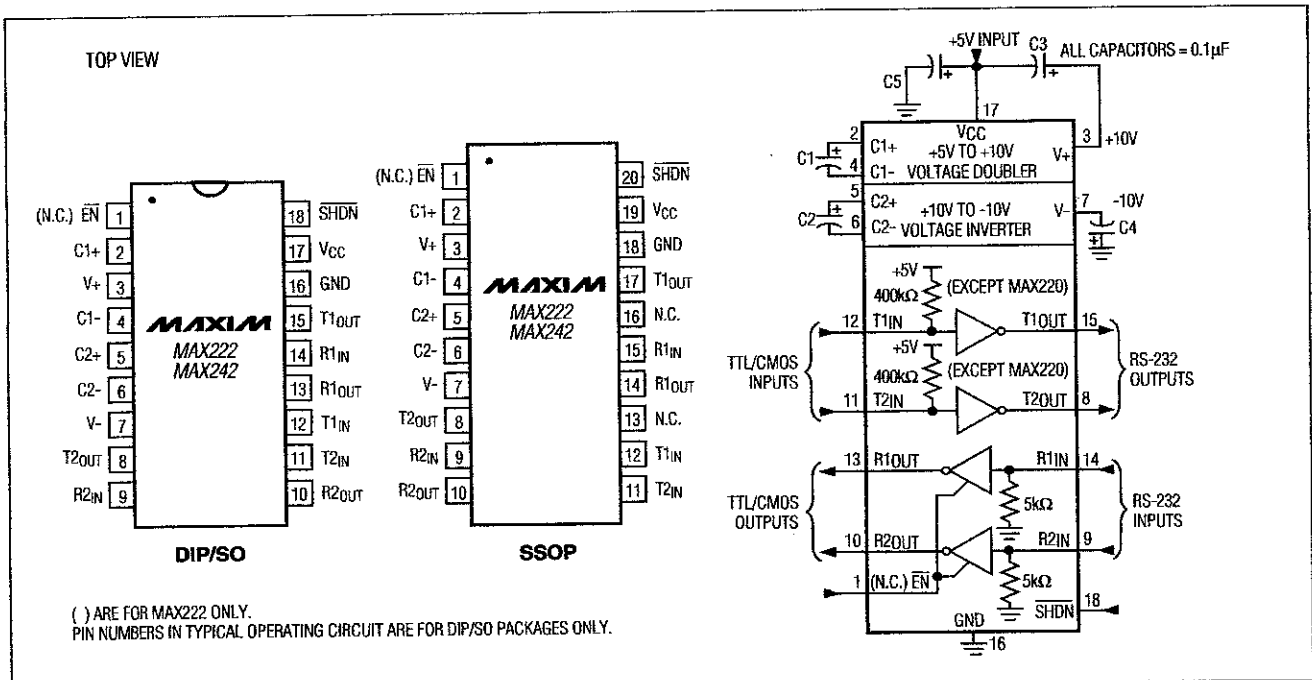
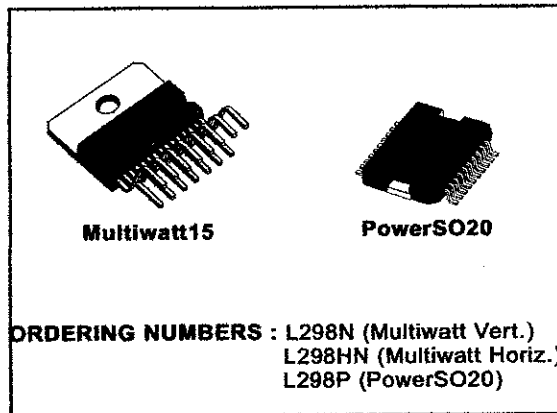Figure 6. MAX222/MAX242 Pin Configurations and Typical Operating Circuit

APPENDIX D
L298N DATASHEET

DUAL FULL-BRIDGE DRIVER

- OPERATING SUPPLY VOLTAGE UP TO 46 V
- TOTAL DC CURRENT UP TO 4 A
- LOW SATURATION VOLTAGE
- OVERTEMPERATURE PROTECTION
- LOGICAL "0" INPUT VOLTAGE UP TO 1.5 V
 (HIGH NOISE IMMUNITY)

DESCRIPTION

The L298 is an integrated monolithic circuit in a 15-lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the con-

Multiwatt15   **PowerSO20**

ORDERING NUMBERS : L298N (Multiwatt Vert.)
                   L298HN (Multiwatt Horiz.)
                   L298P (PowerSO20)

nection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

BLOCK DIAGRAM
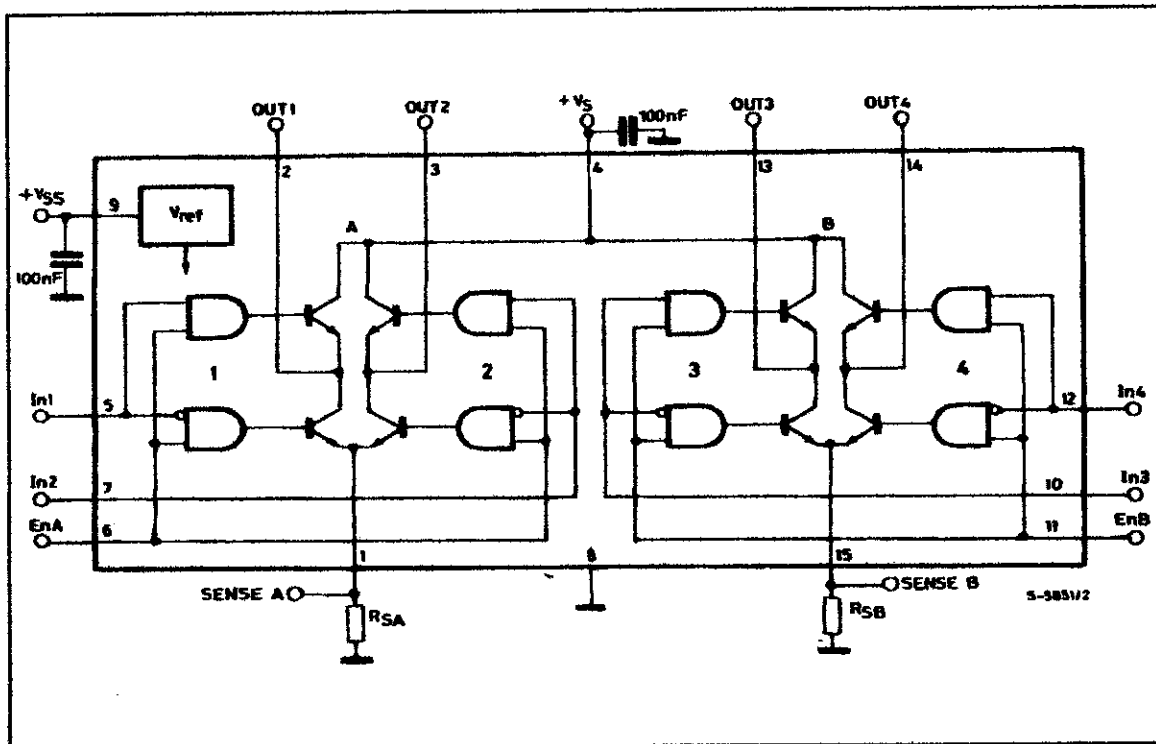
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Power Supply	50	V
V_{SS}	Logic Supply Voltage	7	V
V_i, V_{en}	Input and Enable Voltage	−0.3 to 7	V
I_O	Peak Output Current (each Channel) — Non Repetitive (t = 100µs) —Repetitive (80% on –20% off; t_{on} = 10ms) —DC Operation	3 2.5 2	A A A
V_{sens}	Sensing Voltage	−1 to 2.3	V
P_{tot}	Total Power Dissipation (T_{case} = 75°C)	25	W
T_{op}	Junction Operating Temperature	−25 to 130	°C
T_{stg}, T_j	Storage and Junction Temperature	−40 to 150	°C

PIN CONNECTIONS (top view)
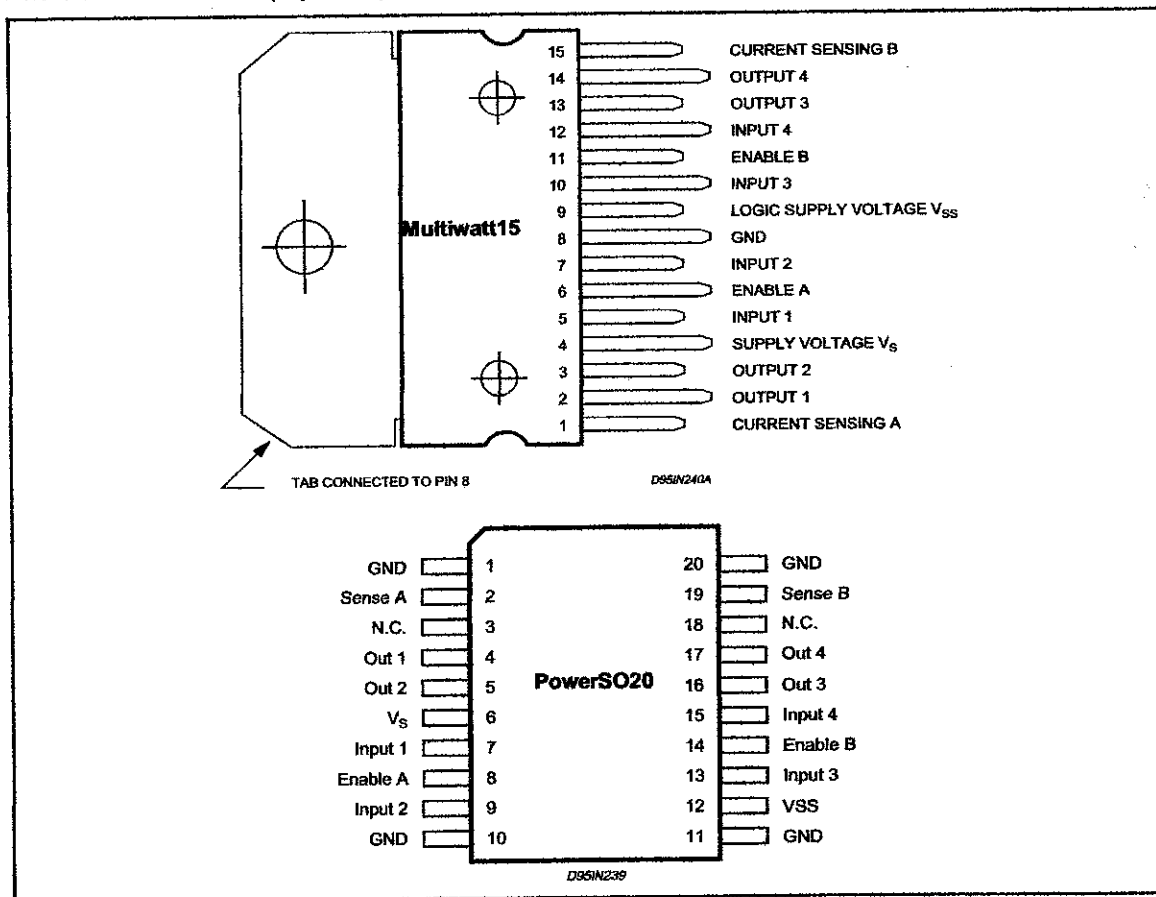
THERMAL DATA

Symbol	Parameter		PowerSO20	Multiwatt15	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	Max.	–	3	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient	Max.	13 (*)	35	°C/W

(*) Mounted on aluminum substrate

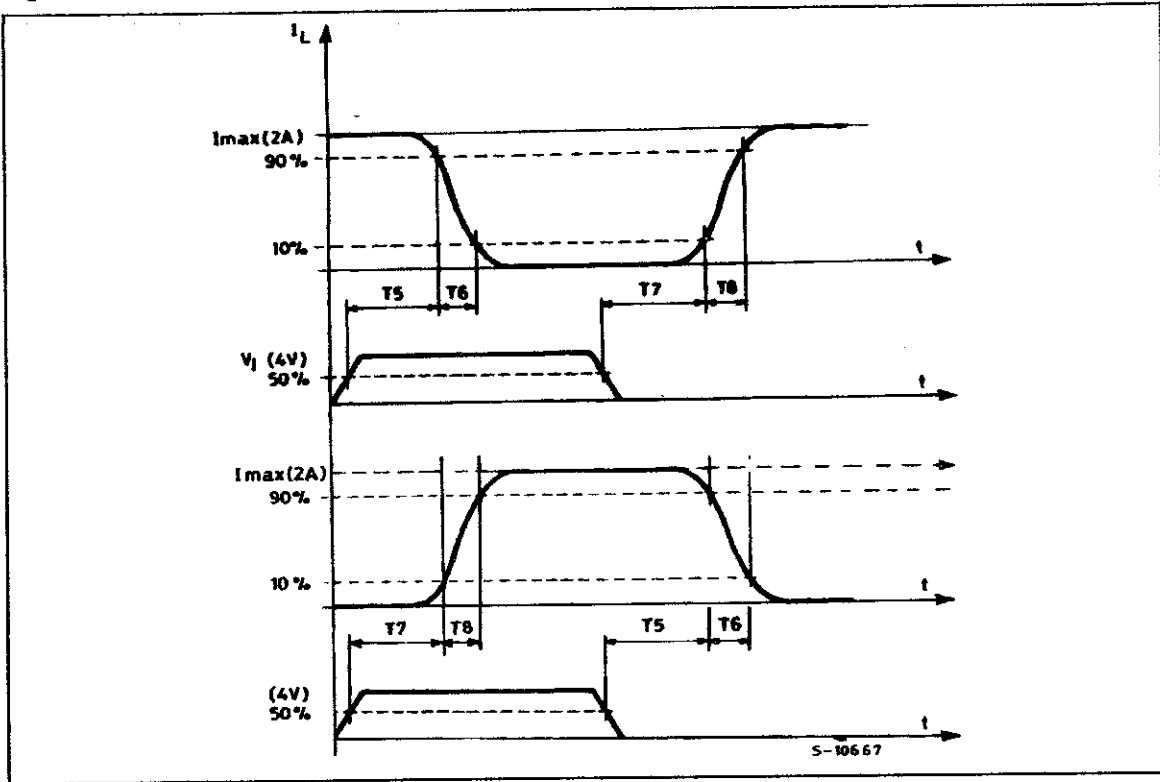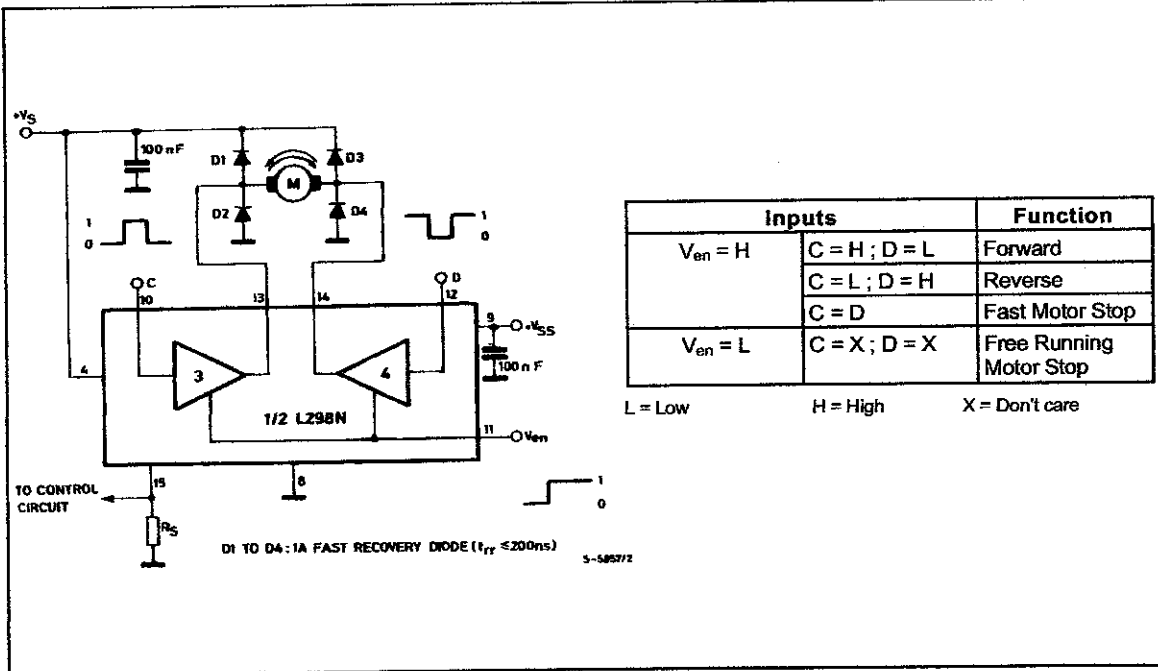**Figure 5** : Sink Current Delay Times vs. Input 0 V Enable Switching.

Figure 6 : Bidirectional DC Motor Control.

Inputs		Function
$V_{en} = H$	C = H ; D = L	Forward
	C = L ; D = H	Reverse
	C = D	Fast Motor Stop
$V_{en} = L$	C = X ; D = X	Free Running Motor Stop

L = Low   H = High   X = Don't care

D1 TO D4 : 1A FAST RECOVERY DIODE ($t_{rr} \leq 200ns$)

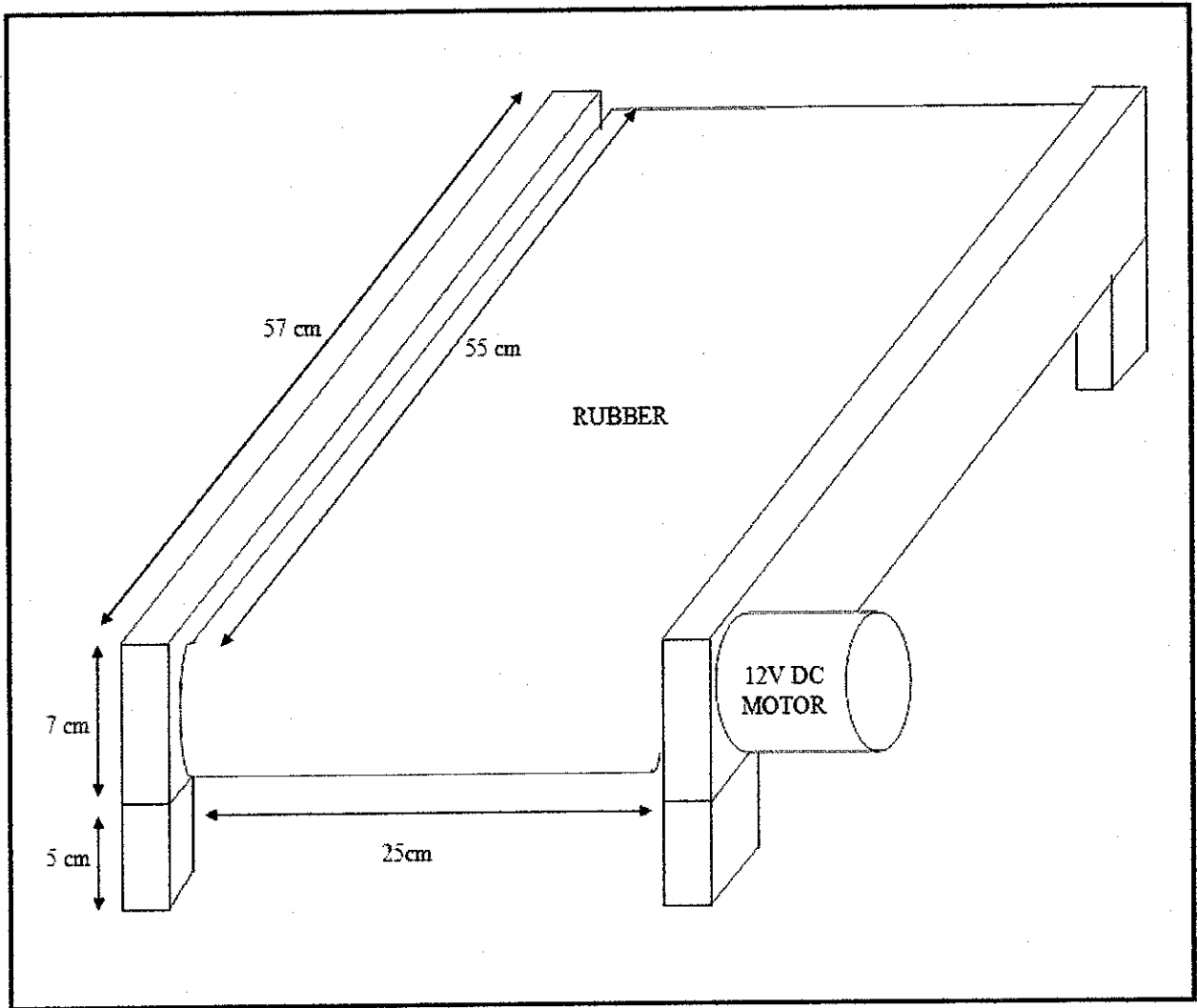# UTILIZING SINGLE WEBCAM PLATFORM (Y-AXIS)

Figure 35- Platform for Y-axis

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UTILIZING SINGLE WEBCAM PLATFORM (X-AXIS)
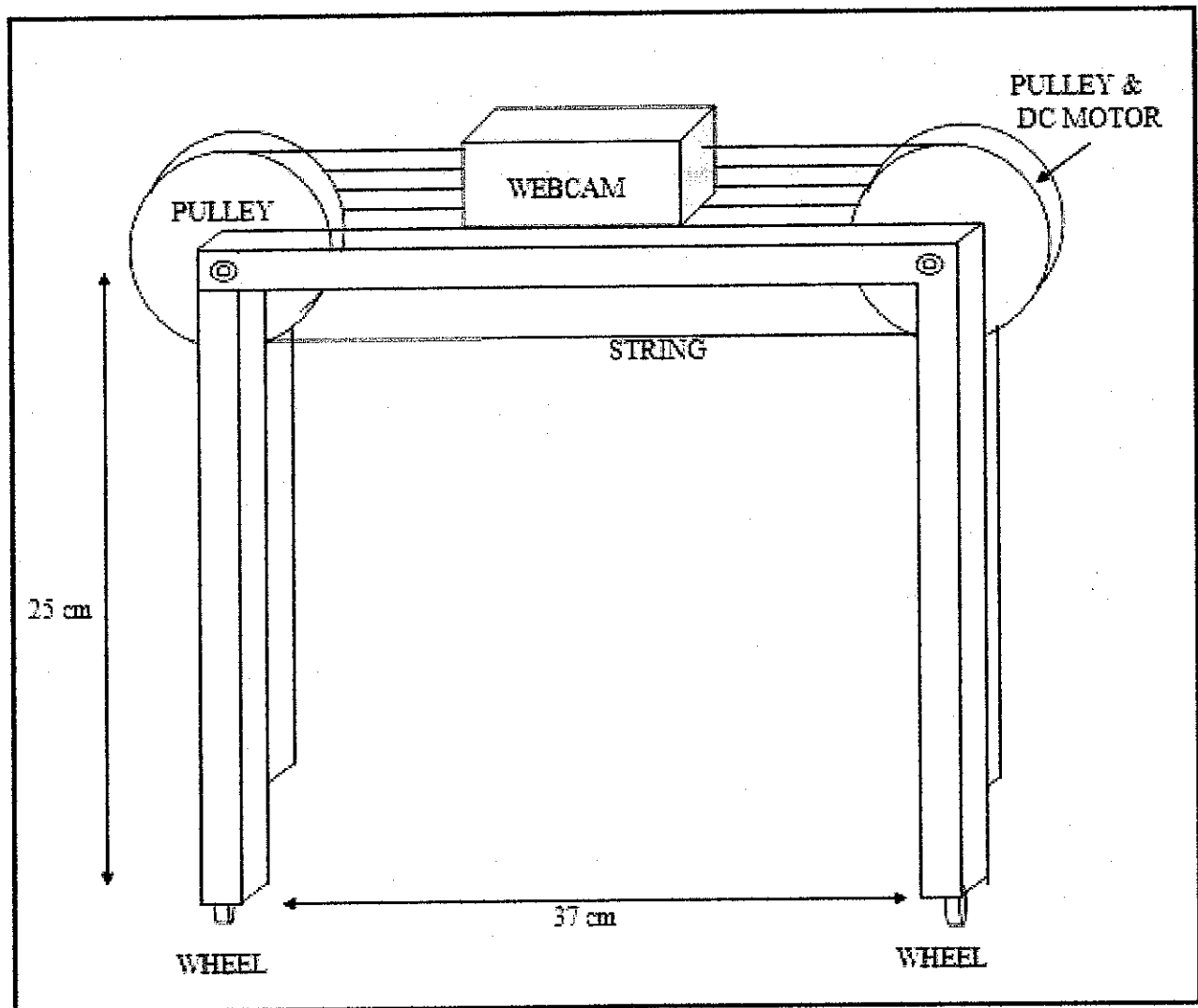
Figure 36- Platform for X-axis

APPENDIX F

COMMUNICATION PROGRAM

```c
#include <16F84A.h>
#use delay(clock=4000000)
#use rs232(baud=9600, xmit=PIN_A0,rcv=PIN_A1)
#fuses XT,NOWDT,NOPROTECT

void main(void)
{
  char con;
  char sta;
  set_tris_b (0x00);
  output_low(PIN_B0);
  output_low(PIN_B1);

  while(1)                      //endless loop
  {

  con = getch();

  if (con=='i')
  {
  output_high(PIN_B0);         // up-->ON
  delay_ms(500);
  output_low(PIN_B0);
  }

  else if (con=='k')
  {
  output_high(PIN_B1);         // down-->ON
  delay_ms(500);
  output_low(PIN_B1);
  }

  else
  {
  output_low(PIN_B0);
  output_low(PIN_B1);
  }
  }
}
```

APPENDIX G

DC MOTOR PROGRAM

```c
#include <16F84A.h>
#use delay(clock=4000000)
#fuses XT,NOWDT,NOPROTECT

void delay_var (char n);

void main(void)
{
  set_tris_b (0xff);
  set_tris_a (0x00);
  output_a(0x00);
  while(1)                       // endless loop
  {

    if (input(PIN_B5))           //  up
    {
      while (input(PIN_B5));
      output_high(PIN_A2);       //
      output_low(PIN_A3);        //
      delay_ms(5000);
    }

    else if (input(PIN_B6))      //  down
    {
      while(input(PIN_B6));
      output_high(PIN_A3);       //
      output_low(PIN_A2);        //
      delay_ms(5000);
    }

    else
    {
      output_low(PIN_A3);
      output_low(PIN_A2);
    }
  }
}

// end of main
```

APPENDIX H

MATLAB PROGRAM

```
%calling vcapg2
clc;
clear all;
close all;
vcapg2(1);

%confirmation to initiate the program
conf=input('\n\n\n Initiate Program?\n Press (y : yes or n : no):','s');
if(conf=='y')
    inp=vcapg2(1);
    figure
    imshow(inp)
  end
if (conf=='n')
    clc;
    close all;
    clear all;
    break;
  end

%save the image captured as image1.jpg in a folder
imwrite(inp,'image1.jpg','jpg')

%read the captured image and UTP oval logo image from a folder
I = imread('image1.jpg');
I2 = imread('oval.png');

%convert both images to grayscale
Igray=rgb2gray(I);
I2gray=rgb2gray(I2);

%set the rectangular area for both images
rect_Igray = [9 5 650 450];
rect_I2gray = [12 7 120 160];

%cropping both images
sub_I = imcrop(Igray,rect_Igray);
sub_I2 = imcrop(I2gray,rect_I2gray);

%perform normalized cross correlation and display the highest peak location
c = normxcorr2(sub_I2,sub_I);
```

figure, surf(c),shading flat, title('Normalized Cross Correlation of Image Captured with Reference Image')

```
%display the location value of the highest peak
[t mi] = max(c);
[t mj] = max(t);
mi = mi(mj);


%check whether the UTP oval logo is in the correct region
a= mi;
b= mj;


while(1)

    if(((a <= 250) && (a >= 150)) && ((b <= 630) && (b >= 500)))
    fprintf('\n Normalized cross correlation successfully found the highest peak at
(%i,%i)\n\n\n', mi, mj);
        clear vcapg2;
        gui;
        break;


    elseif((a <= 150) && ((b <= 630) && (b >= 500)))
    fprintf('\n Error:\n\n Program will retry to locate UTP Oval logo...\n\n\n');
        clear all;
        movedown;
        pause(1);
        recapture;
        pause(2);
        break;


    elseif((a >= 250) && ((b <= 630) && (b >= 500)))
    fprintf('\n Error:\n\n Program will retry to locate UTP Oval logo...\n\n\n');
        clear all;
        moveup;
        pause(1);
        recapture;
        pause(2);
        break;


    elseif((b <= 500) && (a <= 250) && (a >= 150))
    fprintf('\n Error:\n\n UTP Oval Logo is out of range\n Please readjust the
examination booklet and make sure it is aligned properly\n The highest peak was found at
(%i,%i)\n\n\n', mi, mj);
        clear vcapg2;
        break;
```
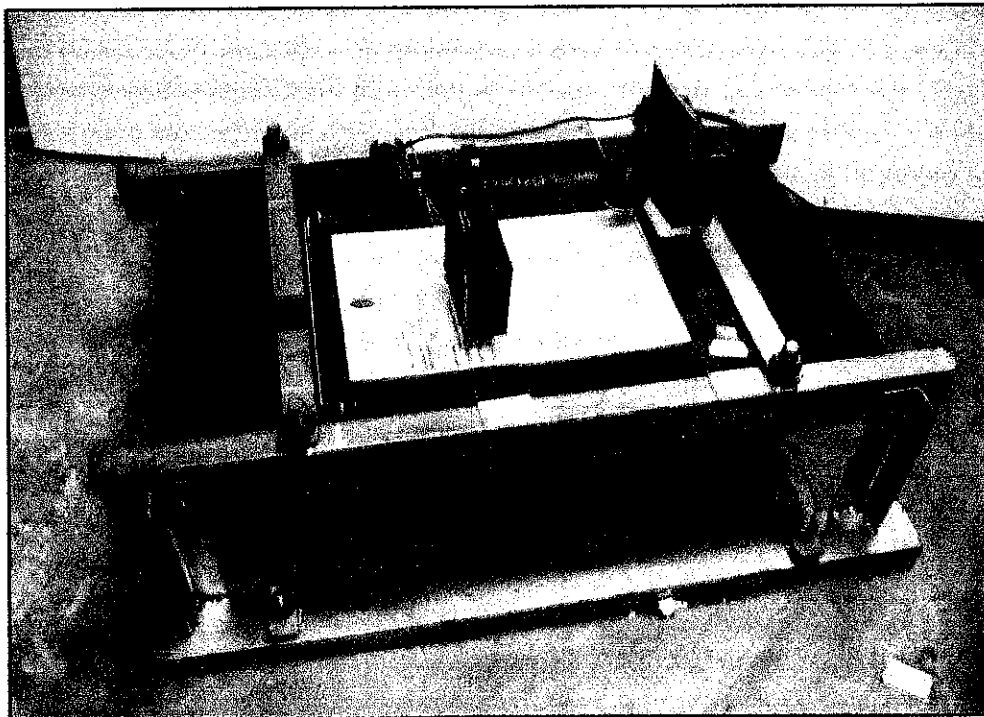
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```
    elseif(a>=250)
    fprintf('\n  Error:\n\n  UTP  Oval  Logo  is  out  of  range\n  Please  readjust  the
examination booklet and make sure it is aligned properly\n The highest peak was found at
(%i,%i)\n\n\n', mi, mj);
    clear vcapg2;
    break;


    elseif(a <= 150)
    fprintf('\n  Error:\n\n  UTP  Oval  Logo  is  out  of  range\n  Please  readjust  the
examination booklet and make sure it is aligned properly\n The highest peak was found at
(%i,%i)\n\n\n', mi, mj);
    clear vcapg2;
    break;


    elseif (b <= 500)
    fprintf('\n  Error:\n\n  UTP  Oval  Logo  is  out  of  range\n  Please  readjust  the
examination booklet and make sure it is aligned properly\n The highest peak was found at
(%i,%i)\n\n\n', mi, mj);
    clear vcapg2;
    break;


    elseif (b >= 630)
    fprintf('\n  Error:\n\n  UTP  Oval  Logo  is  out  of  range\n  Please  readjust  the
examination booklet and make sure it is aligned properly\n The highest peak was found at
(%i,%i)\n\n\n', mi, mj);
    clear vcapg2;
    break;

  end;

  end;
```
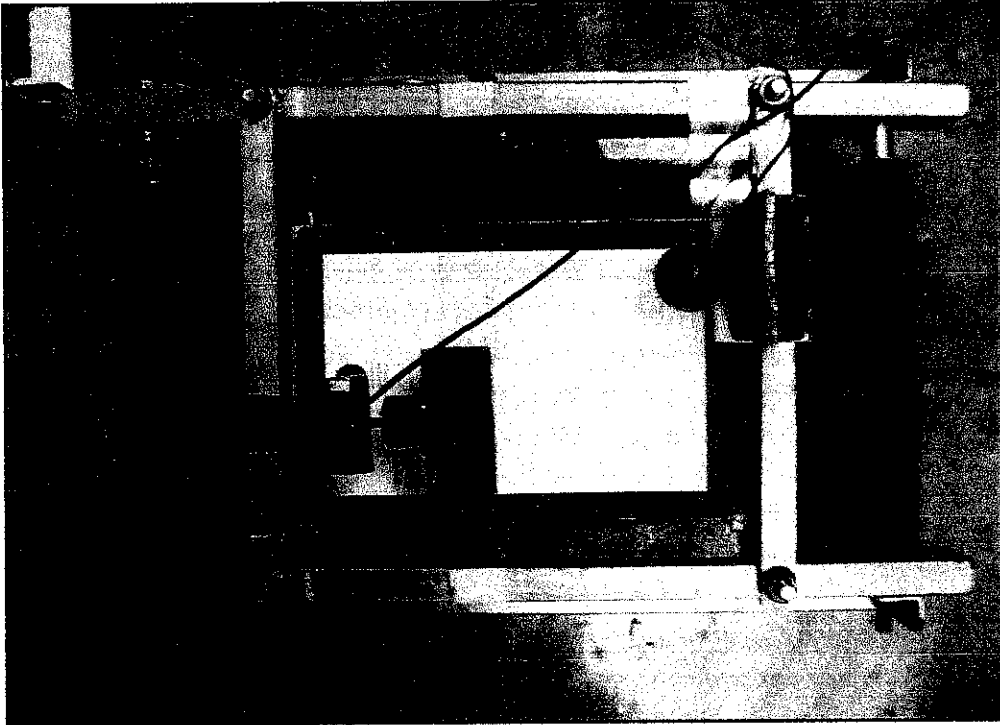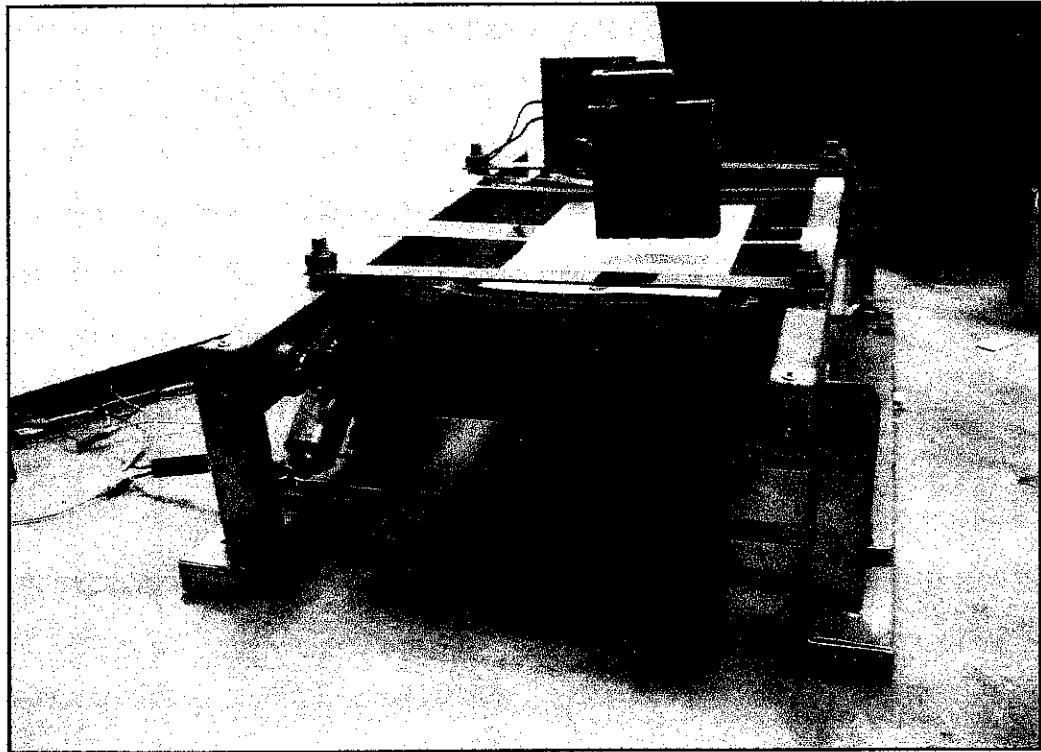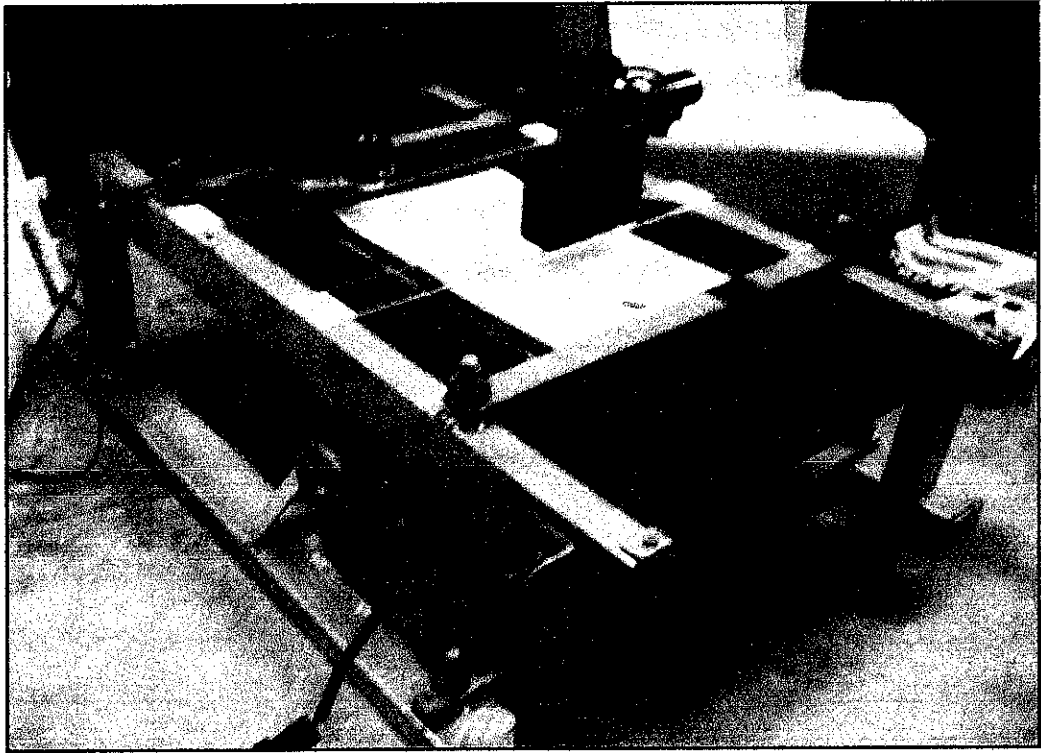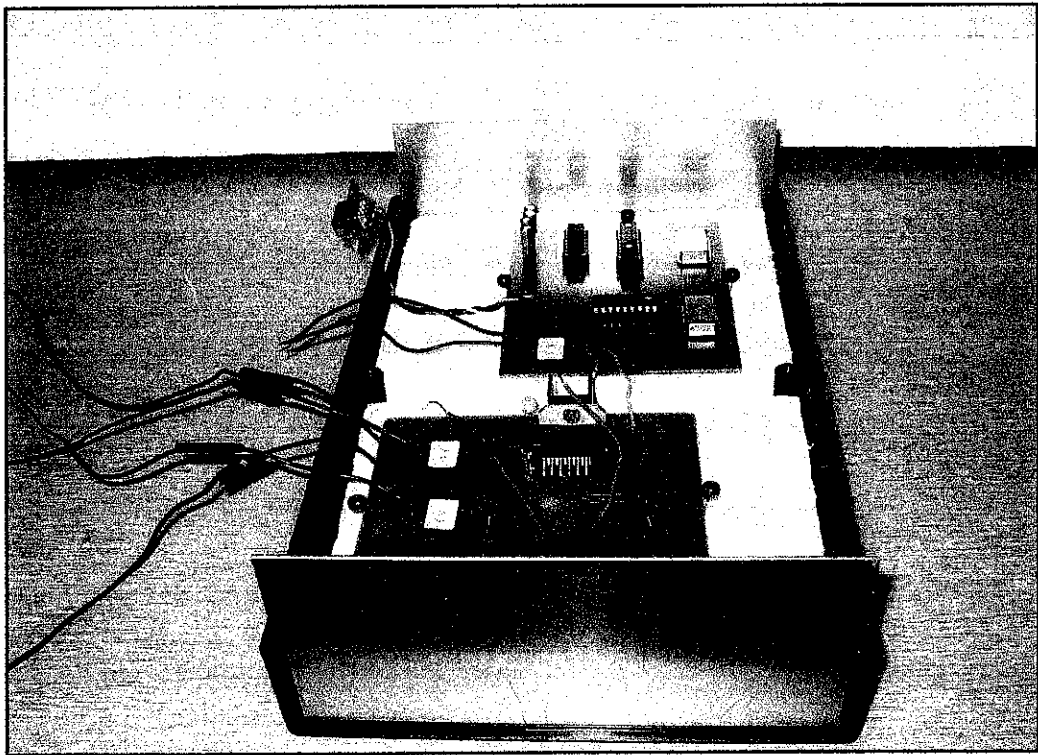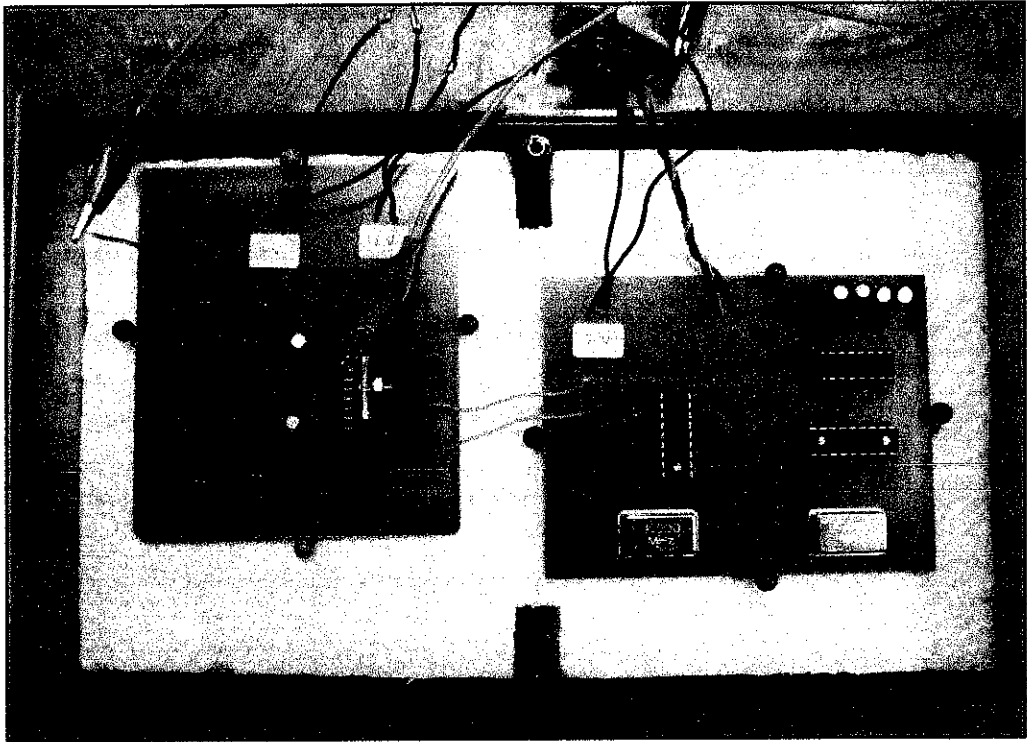
APPENDIX I
PLATFORM & CIRCUITS

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Figure 37 - Platform & Circuits

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