Projectile Detecting Mechanism For Electromagnetic Launcher

by

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Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hones)
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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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In partial fulfilment of the requirement for the
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Approved by,

28/05/04

(Miss Suhaila Badarol Hisham)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
June 2004

CERTIFICATION OF ORGINALITY

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.

NOORASITA ISMAIL

ABSTRACT

Electromagnetic launcher is a device capable of launching projectile aimed at a location specified by the user. The sole purpose of a launcher is to fire a projectile, while for general application in physics and engineering; the launcher can also be used to carry out more complex functions including a broad range of military applications, the launch of aircraft into flight, the launch of objects directly into space and the acceleration of materials to extremely high velocities. In recent studies, most of launchers do not have the capability in realignment. By using a condenser microphone circuit, this paper presents the process to design or to measure the actual position of a projectile. In addition, Lab View software will be used as the controller for this sensing mechanism. This is actually a smart way to find the position of the projectile instead of using radar system, which requires a higher cost. Another application that can be relate with this projectile detecting mechanism is that it can be used in Olympics games especially in shot put games where this games required to detect the ball being thrown. The measurement can be further improved by replaced the old fashion measurement (using measuring tape) with this system.

ACKNOWLEDGEMENT

Special thanks go to my helpful supervisors, Mr. Zainal Arif Burhanuddin and Miss Suhaila Badarol Hisham. The supervision and support that they gave have truly helped the progress and smoothness of this final year project. Their co-operation is very much appreciated.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Electromagnetic Launcher is a device capable of launching projectiles aimed at a location specified by the user. One of the requirements of this project is to understand the working principles of this launcher. Research was conducted on the theory involved, the control system to be used and also the components required, so that at the end of the project, a model or prototype can be fabricated.

1.2 PROBLEM STATEMENT

From previous designs, most of the launchers do not have the capability in realignment. This project is trying to improve on the previous designs by adding a control system to realign and control the launcher.

1.3 OBJECTIVES AND SCOPE OF STUDY

In order to ensure the objectives of this project are fulfilled, a proper working schedule was planned for the time period given. This project was divided into two, according to the number of semesters. For the first semester, the task to be accomplished was to design the location sensing mechanism. The control systems to be used also have to be designed by writing a program in any C or assembly language. For the second semester, more focus is given on the physical launcher. A model of the launcher needs to be built based on the data obtained from research of previous design.

The scope of study for this project is actually focusing more on the design for location sensing mechanism, which consists of four-condenser microphones connected to Lab View software. This configuration will be used to detect the actual position of the projectile.

CHAPTER 2

LITERATURE REVIEW/THEORY

In order to design the location sensing mechanism, the information on distance and direction (angle) are required. A position can be specified either by using rectangular (Cartesian) co-ordinates (Refer to Figure 1.1) or by polar co-ordinate (Refer to Figure 1.2). Position on flat surfaces can be specified using two-dimensions co-ordinates. There are two types of distance sensing:

1) Fixed point
2) Moving point

Fixed point and moving point are referred to the frame of reference whether it is fixed or moving.

Position is related to

1) Distance (the difference between two positions)
2) Velocity (rate of change of distance)
3) Acceleration. (rate of change of velocity)

2.1 SENSING MECHANISM (CONDENSER MICROPHONE)

A condenser (or capacitor) microphone uses a lightweight membrane and a fixed plate that act as opposite sides of a capacitor (Refer to Figure 2.1). Sound waves pressing against this thin polymer film causes it to move. This movement produces a change in the capacitance of the circuit, creating a changing electrical output according to the amplitude of the sound. The charge on the membrane depends only upon the spacing and shows no appreciable resonance to skew the frequency response. The capacitance of the parallel plate membrane structure is given by:

$$C = Q/V = \varepsilon_O (A/d)$$

C= capacitance Q= charge on the membrane V= biasing voltage ε_O = permittivity of free space d= distance of the parallel plate A= area of either plate

When the spacing changes, the charge changes, producing an electric current through the resistor R.

$$i_{signal} = \frac{\Delta Q}{\Delta t} = \varepsilon_0 A V \frac{\Delta\left[\frac{1}{d}\right]}{\Delta t}$$

where $\Delta Q / \Delta t$ is the change in charges with respect to time and $\varepsilon_o \Delta V \frac{\Delta \frac{1}{d}}{\Delta t}$ is the change in voltage and distance with respect to time. The voltage measured across the resistor is an electrical image of the sound pressure (i signal), moving the membrane.

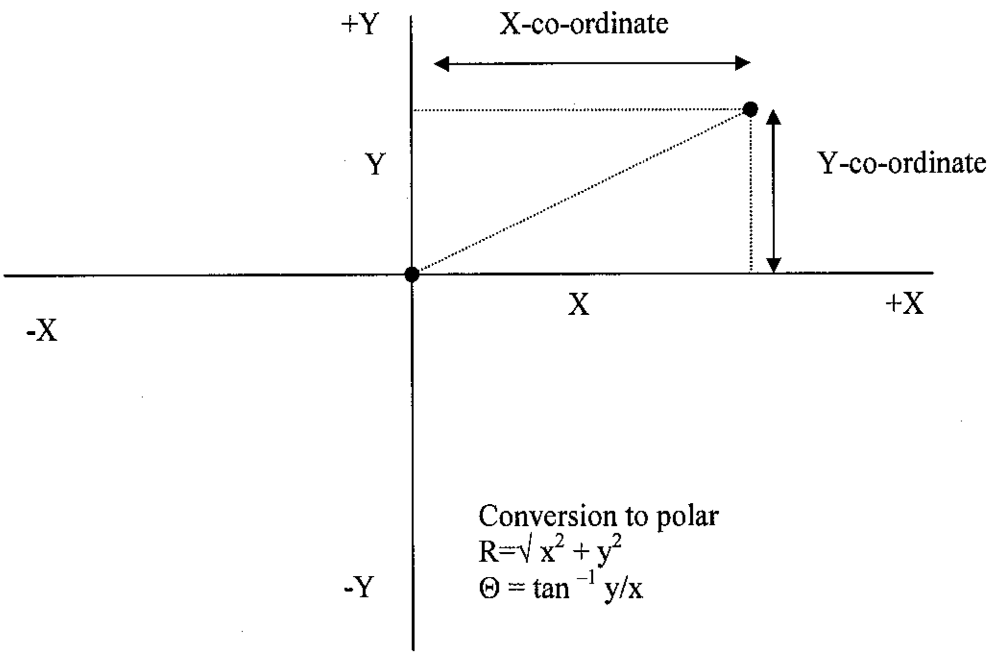

Figure 1.1 The Cartesian co-ordinate system. It uses measurements in two directions at right angles to each other as reference axes, and the position of a point is plotted by finding its distance from each axis.

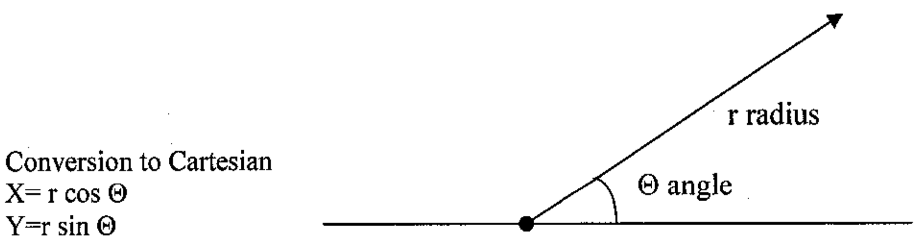

Figure 1.2: Polar co-ordinates make use of a fixed point and its direction. The distance from the fixed point, and the angle between this line and the fixed direction, are used to establish a two-dimensional position.

The plates are charged to a total charge of:

$$Q = CV = \frac{\text{(Area of plate)(voltage)}}{\text{(Plate spacing)}}$$

where C is the capacitance and V is the voltage of the biasing battery or power supply.

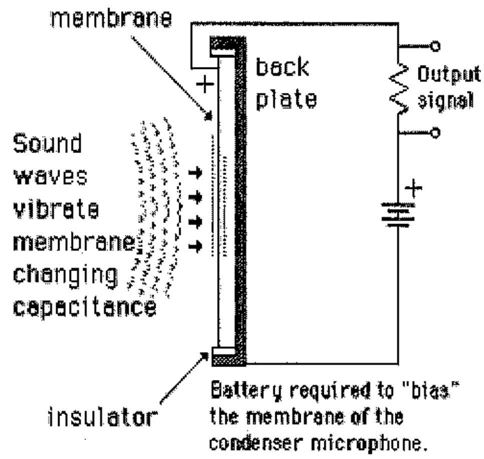

Figure 2.1: Diagram of a condenser microphone

2.2 SOUND WAVE

Sound is a compression waveform that moves through air or other materials. Sound waves are created by the vibration of an object and are detected when the waves cause a sensor to vibrate. Sound waves have amplitude, a velocity, a wavelength, and a frequency. The Figure 2.2 below shows the transverse wave.

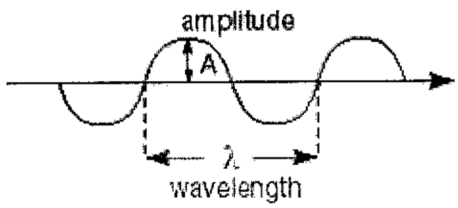

Figure 2.2: Amplitude and wavelength in a waveform

The amplitude of a sound wave represents its loudness. Since sound is a compression wave, its loudness or amplitude would correspond to how much the wave is compressed. The speed or velocity of sound in air is approximately 1000 feet per second (300 m/s), which is equivalent to about 680 mph. The speed or velocity of sound depends on the density of the material in which it is travelling. The greater the density of the material, the faster the velocity or speed of sound. Sound travels faster in water than in air, and it travels much faster in steel.

2.2.1 Wavelength and Frequency

Wavelength is the distance from one crest to another of a wave. Since sound is a compression wave, the wavelength is the distance between maximum compressions. Since that is so difficult to draw or visualize, we usually refer to the frequency of sound, instead of its wavelength. The relationship between velocity, wavelength and frequency is:

$$\text{velocity} = \text{wavelength} \times \text{frequency}$$

Since the velocity of sound is approximately the same for all wavelengths, frequency is often used to better describe the effects of the different wavelengths.

2.3 SOUND WAVE POWER INTENSITY

A sound wave is introduced into a medium by the vibration of an object. For example, a vibrating guitar string forces surrounding air molecules to be compressed and expanded, creating a pressure disturbance consisting of an alternating pattern of compressions and rarefactions. The disturbance then travels from a particle to another particle through the medium, transporting energy as it moves. The amount of energy, which is transferred to the medium, is dependent upon the amplitude of vibrations. The greater amplitude of vibration thus imparts more energy to the medium, causing air particles to be displaced a greater distance from their rest positions. Subsequently, the amplitude of vibration of the particles is increased according to the increased amount of energy being carried by the particles.

Intensity is defined as the energy transported by a wave per unit time across unit area and it is also proportional to the square of the amplitude. The greater the amplitude of vibrations of the particles, the greater the rate at which energy is transported through it, and the more intense the sound wave is.

$$Intensity = \frac{Energy}{Time * Area}$$

or

$$Intensity = \frac{Power}{Area}$$

As the sound wave carries its energy through a two-dimensional or three-dimensional medium, the intensity of the sound wave decreases with increasing distance from the source. This decrease in intensity with increasing distance is explained by the fact that the wave is spreading out over a circular (2 dimensions) or spherical (3 dimensions) surface. Thus the energy of the sound wave is being distributed over a greater surface area. Figure 2.3 shows that the sound wave in a 2-dimensional medium is spreading out in space over a particular pattern. Since energy is conserved and the area through which this energy is transported is increasing, the power measured on a per area basis must decrease. The mathematical relationship between intensity and distance is sometimes referred to as an inverse square relationship where the intensity of a sound decreases, as the distance from the source increases. In enclosed spaces, this effect is reduced due to reflections of sound waves from the walls. However, if the source is in an open area where sound can radiate out freely in all directions, the above inverse relationship between intensity and distance applies.

$$I \alpha \frac{1}{r^2}$$

I= intensity of sound waves
r=radius/ distance

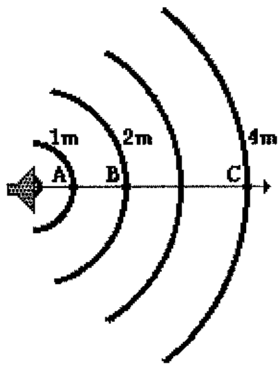

Figure 2.3: Sound wave pattern in 2-dimensional areas.

2.4 SAMPLING CONSIDERATION

Signal that is continuous with respect to time (infinite amount of points) need to be converted into a series of discrete samples (finite amount of points). The samples are taken at a rate referred to as the sampling rate. The faster the sampling rate, the more points will be acquired and the better the representation of the signal will be. Otherwise a problem known as aliasing will be occurred. Figure 2.4 shows an original analog signal, its discrete time signal and its sampling period.

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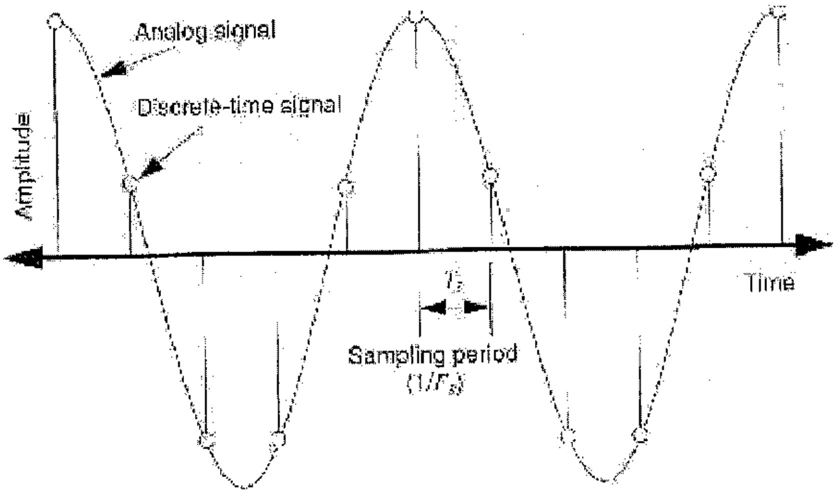


Figure 2.4: An example of an analog signal, its discrete time signal and its sampling period.

2.5 LAB VIEW SOFTWARE

Labview is a software, which provides a set of icons that represents controls and functions, available in the menu of the software. These icons will be utilised in what is called visual programming. The user interface, which is called a VI, consists of two parts- a front panel and a diagram. Front panel is where ones can build a user interface with have the capability of control the front panel objects. All the code and wiring diagram can be found on block diagram panel. These interfaces are similar to that of an instrument where a front panel is used for input and output controls, and to display data.

Labview can also be used to perform system simulations, since it contains many commonly used filters, digital signal processing toolbox, and statistical functions. Labview compiles program codes almost as efficient as C or Matlab and therefore one can perform complete simulations within a VI.

Lab View can also be used to integrate real circuit and software by using a Data Acquisition (DAQ) card. Data acquisition is the process of making measurements of physical phenomena and storing them in coherent fashion. Data acquisition deals with the elements shown in Figure 2.5 below.

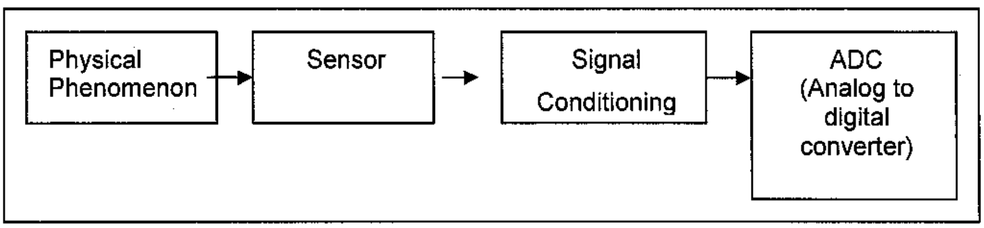


Figure 2.5: Elements of data acquisition process

For the purpose of data acquisition, several important points need to be considered about the sensors:

- The nature of the signal it produces- voltage, amplitude range, frequency response, impedance, accuracy requirement, the kind of signal conditioning required, applicable analog to digital converter, etc.
- How susceptible the sensor is to pick up noise or to loading effects from data acquisition hardware?
- How the sensor is calibrated with respect to physical phenomena?
- What kind of power or other utilities it might require?
- What will happen if the data acquisition equipment is turned off while power is still applied to the sensor?

In order to configure the input channels and to make signal connections, it must first be determined whether the signal sources are floating or ground-referenced. These two types of signals sources are discussed below.

2.5.1 Floating Signal Sources

A floating signal source is not connected to the building ground system but instead has an isolated ground-reference point. Examples of floating signal sources are outputs of transformers, thermocouples, battery-powered devices, optical isolator outputs, and isolation amplifiers. An instrument or device that has an isolated output is also a floating signal source. The ground reference of a floating signal must be tied to the device to establish a local or onboard reference for the signal. Otherwise, the measured input signal will vary as the source floats out of the common-mode input range.

2.5.2 Ground-Referenced Signal Sources

A ground-referenced signal source is connected to the building system ground and therefore, is already connected to a common ground point with respect to the device, assuming that the computer used for controlling purposes is plugged into the same power system. Non-isolated outputs of instruments and devices plugged into a building power system fall into this category. The difference in ground potential between two instruments connected to the same building power system lies typically between 1 and 100 mV but it can be much higher if the power distribution circuits are not properly connected. If a grounded signal source is improperly measured, this difference may appear as an error in the measurement. The connection instructions for grounded signal sources are designed to eliminate this ground potential difference from the measured signal. Input configurations for both types of signal sources are recommended in Appendix 2.

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 METHODOLOGY

Work in this project can be divided into two mains activities:

1) Design process and
2) Implementation of the plan and schematic flow process.

There are seven steps in design process, which are:

- Evaluate problem statement
- Define the problems
- Conduct a research
- Analyze existing solution
- Generate possible solution
- Select the best solution
- Design the selected solution.

3.2 EVALUATE PROBLEM STATEMENT AND DEFINE THE PROBLEMS.

3.2.1 Requirement of the launcher

This launcher will be operated according to the design requirement stated below. First, the user will enter the required position coordinates. The controller will use this data to rotate the platform (the platform is a flat surface that is able to rotate the launcher in x and y direction) accordingly. When the platform reaches the desired position, the projectile will be launched from the launcher. As soon as the projectile hits the target area, the sensor mechanism will detect the location of the projectile hit and send the signal back to the controller. The feedback signal obtained will be used to recalibrate or realign the platform. Then, the launcher will continue with the next projectile. The flow diagram on operating principles of this launcher can be seen in Figure 3.1.

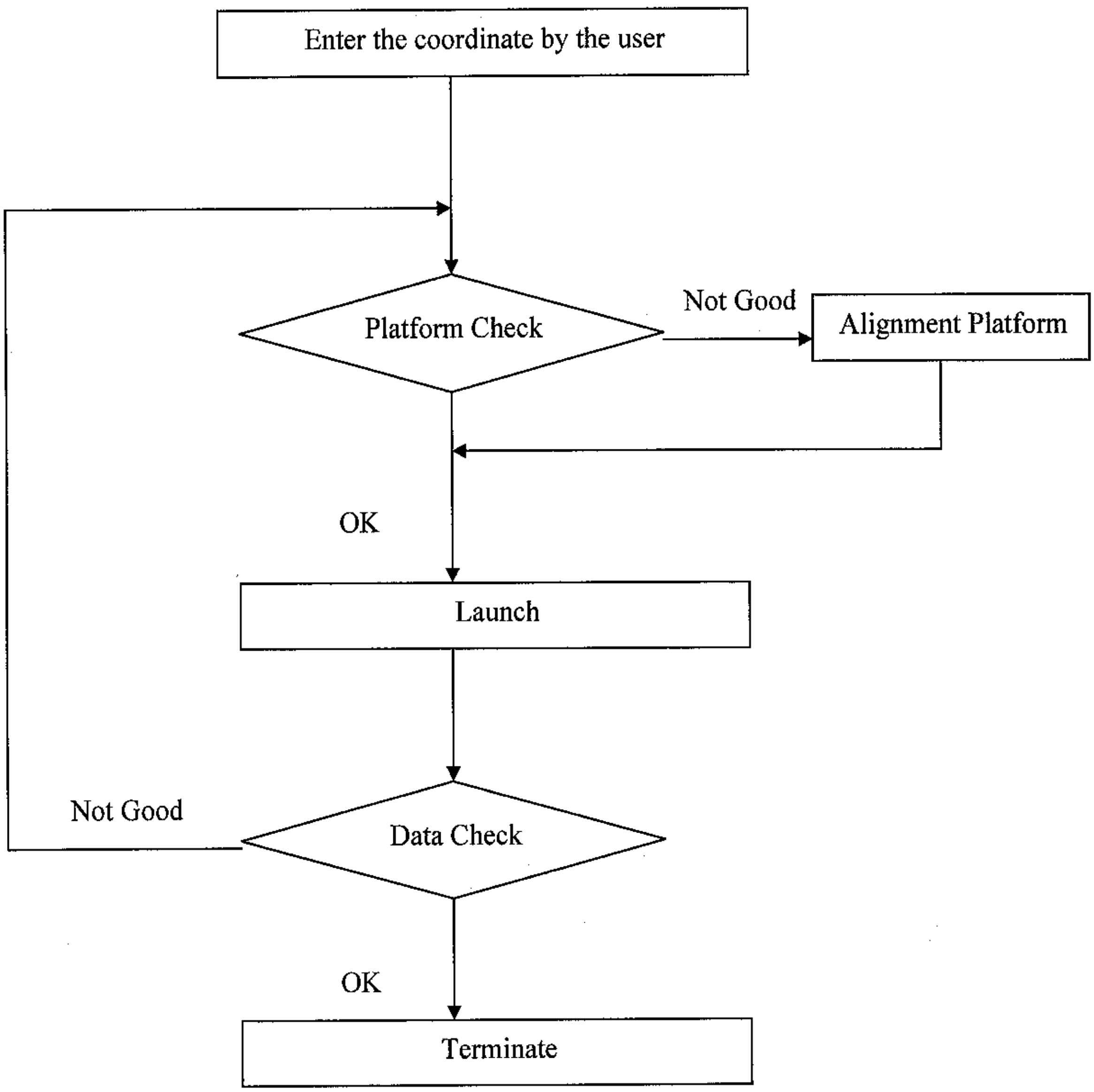


Figure 3.1: Flow diagram on operating principle of the launcher

3.3 CONDUCT A RESEARCH AND ANALYZE EXISTING SOLUTION

During the earlier stage of this project, it is required to find a suitable sensing mechanism to detect the exact location for the projectile. Three types of sensors has been chosen and tested: (i) inductive proximity sensor, (ii) ultrasonic transducer and (iii) condenser microphone circuit.

3.3.1 Inductive proximity sensor

Inductive proximity sensor was the first type of sensor chosen for this project. Based on further research, this sensor was found to be unsuitable due to the fact that it has the ability to detect only for limited distances. The standard sensing distance for proximity sensor is only about 30 mm, which is not sufficient for this project.

3.3.2 Ultrasonic Transducer

Ultrasonic sound is transmitted from a transducer, reflected by a nearby object, and then received by another transducer. The advantage of using sound is that it is not sensitive to objects of different color and light reflective properties. Another advantage of using ultrasonic is that the frequency of sound can be particularly chosen. For example, the circuit sensitivity can be limited to a certain range of frequency and this frequency will have the same frequency as the output of the transmitter. After deciding to use this type of sensor, a circuit for the ultrasonic transducer is constructed and the functionality of the circuit is tested. The diagram for ultrasonic transducer circuit is shown in Appendix 3.

From the test conducted, several findings were obtained:

- The transmitter circuit worked successfully, emitting an ultrasonic signal of 40 kHz.
- On the receiver part, the signal measured at the tone decoder (pin 5) without having any interference was nearly 40 kHz. This shows that the receiver can receive the transmitted signal from the transmitter
- The output measured at the amplifier when there is interference shows an increase in amplitude from the original signal. This shows that the receiver can detect an object across its transducer.
- However, the circuit is very sensitive to external interference.

The circuit was then slightly modified (refer to Figure 3.2) where the transmitter was eliminated since the frequency generated comes from the projectile itself. On the receiver part, the transducer was replaced by a condenser microphone since the transducers did not have the ability to detect generated signal from the projectile. A filter circuit replaced the tone decoder (LM 567) and the comparator (LM 311) was also removed. The tone decoder was removed because it is limiting the sensitivity of the circuit to 40kHz, which is equivalent to the output of the transmitter.

The modified circuit was again tested. Unfortunately, this circuit failed to function properly. The condenser microphone could not detect any external signal created. On the oscilloscope, no signal was observed. From these observations, it was concluded that the circuit only works for signal generated at a frequency of 40 kHz. This is due to the fact that originally, timer 555 on the transmitter part produces a frequency of 40 kHz and it is also the frequency that can be detected by the receiver. However this may be difficult to be achieved by the projectile.

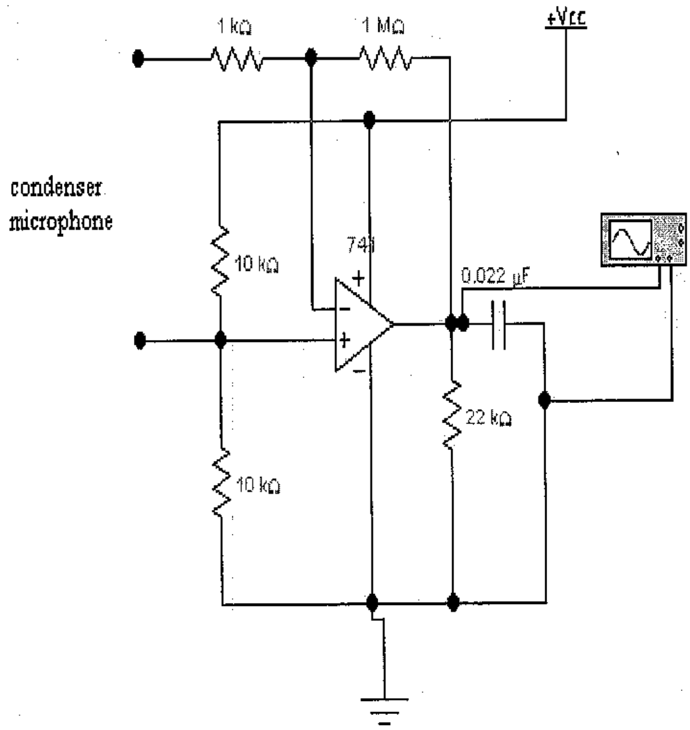


Figure 3.2: Modified circuit from ultrasonic transducer schematic

3.3.3 Condenser microphone circuit

Therefore another circuit was constructed, taken from the FM microphone hobby kit circuit. The diagram of this circuit is shown in Figure 3.3. For this circuit, a transistor is used to amplify the input signal. The circuit was then constructed and tested successfully. The signal measured at capacitor C3, showed an increase in amplitude and frequency from the original signal when interference occurred. In other words the circuit was able to detect the presence of the projectile.

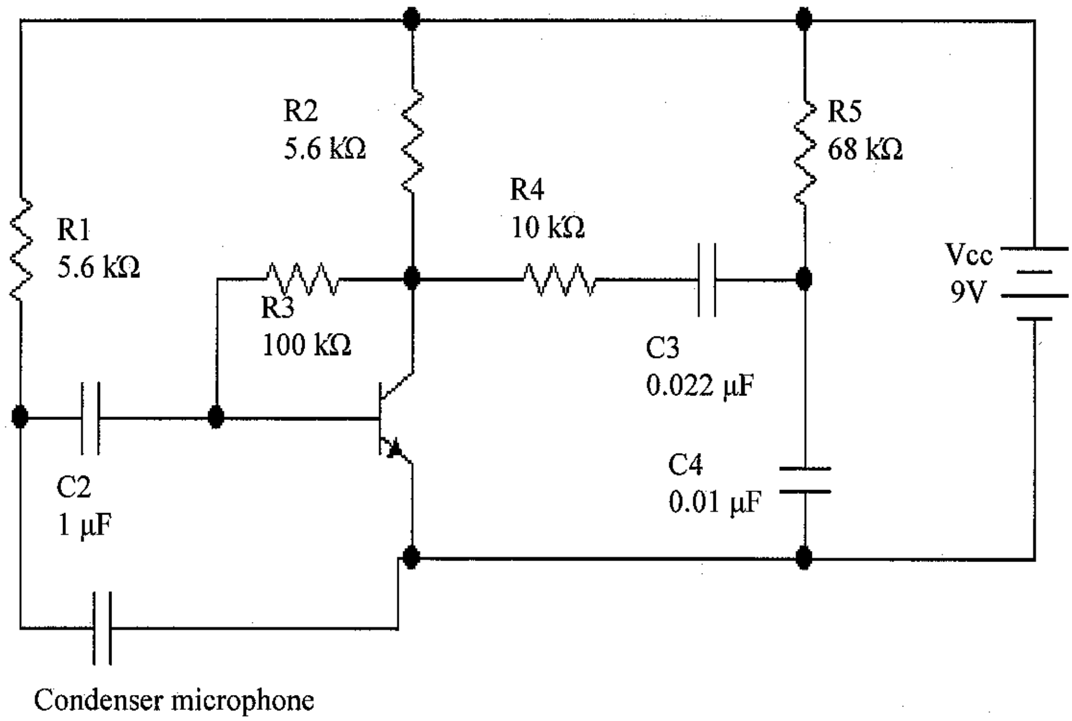


Figure 3.3: Schematic for condenser microphone

3.4 GENERATE POSSIBLE SOLUTION AND SELECT THE BEST SOLUTION

Condenser microphone circuit was finally chosen for this project.

3.5 DESIGN THE SELECTED SOLUTION

The process involved in the implementation of the design of sensing mechanism is per below:

3.5.1 Assemble the components based on the circuit

A few circuit for examples ultrasonic transducer and condenser microphone circuit have been modified in order to get the correct circuit that fulfilled the requirements of the project. After the chosen circuit has been finalized, the components need to be assembled and the whole set-up will be tested.

3.5.2 Testing functionality of the circuit

The circuit will be tested with a single microphone. An object e.g. ball bearing will be used as a projectile to test the circuit. The output waveform from the oscilloscope will be monitored to ensure that this circuit function accordingly. For example, if the distance of the object varies, the output waveform from the oscilloscope should also vary. If the single microphone circuit works, it will be reassembled again but this time by using four-condenser microphones.

3.5.3. Working out the algorithm.

Using the circuit tested in (2), the result obtained will be used to generate an algorithm for the sensing mechanism.

3.5.4 Implement the algorithm into PIC microcontroller or Lab View

The algorithm obtained will then be implemented in a PIC microcontroller or in Lab View as a control mechanism for the platform, where a servo motor will be employed to realign the platform.

3.7TESTING THE CIRCUIT

3.7.1 Experiment Using Condenser Microphone Circuit

An experiment has been conducted to test the functionality of the condenser microphone circuit. The equipment used were:

- Oscilloscope,
  [type Tektronix TDS 3012B]
- Power supply
- Retort Stand
- Ball bearing
- Measuring tape
- Condenser microphone circuit
- Multimeter

The procedure for this experiment is per below:

1) The circuit was set up as shown in Figure 3.4
2) Condenser microphone circuit was connected to a 9 V power supply. Output from this circuit was then connected to the oscilloscope.
3) Using a measuring tape, distances from the circuit to the retort stand were measured. The distance between these two objects was incremented by 0.05-meter ranging from 0-1 meter. Therefore, in total 20 points of measurement were taken.
4) A ball bearing was placed at the top of the retort stand and the height of the retort stand was recorded.
5) The output voltages, which represent the amplitude from the circuit was observed via the oscilloscope as soon as the ball bearing was released from the retort stand.
6) The experiment was repeated for distance each of the 20 points of interval, ranging from 0-1 meter.

Some assumptions have been made for this experiment. The height of the retort stand will be kept constant at 0.6 meter for each experiment. Also, the ball bearing is assumed to be released with the same amount force each time (free fall).

3.8 APPARATUS/EQUIPMENT USED

The components /tools required for this project is per below:

- Electric and Electronics components such as condenser microphone, oscilloscope, power supply, etc.

The software involved is:

- Lab View for graphical user interface
- Data Acquisition Card (DAQ)

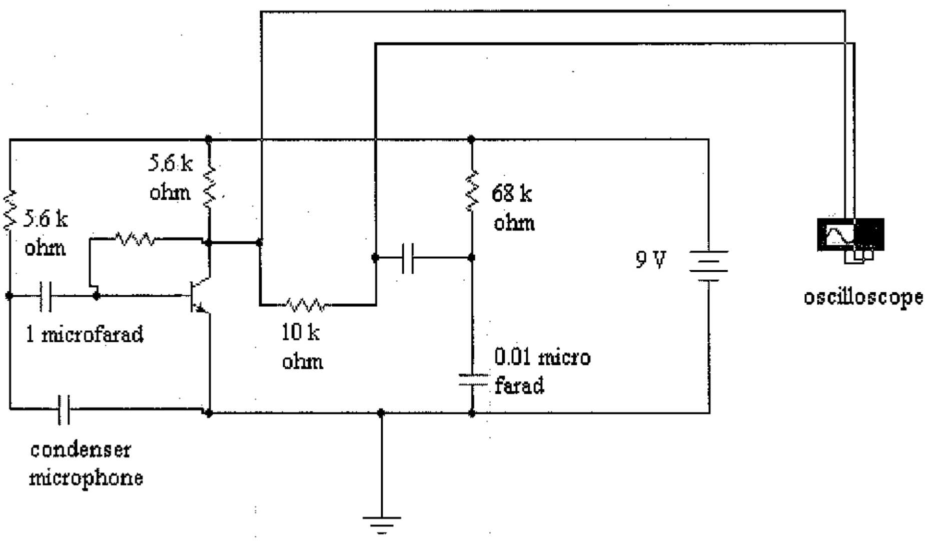


Figure 3.4: Circuit construction for condenser microphone

3.9 IMPLEMENTING THE ALGORITHM INTO LAB VIEW

After completing the functionality test on the condenser microphone, the circuit (refer to Figure 3.4) needs to be integrated with Lab View software via DAQ card. The DAQ is connected from a computer to the circuit board using a 68-pin cable. In general, all 68 pins are used for analog inputs and outputs, triggering, digital inputs and outputs, a 5-V dc supply, and counters. Lab View provides some pre-programmed Vis for sending voltages readily to the circuit board and sampling a signal into a Lab View program. The most important of these Vis for analog circuit measurements are

(i) AI Acquire Waveform.vi and

(ii) AO Update Channel.vi. AI Acquire Waveform.vi samples the acquire voltage a number of specified times. Refer to Figure 3.5 below:

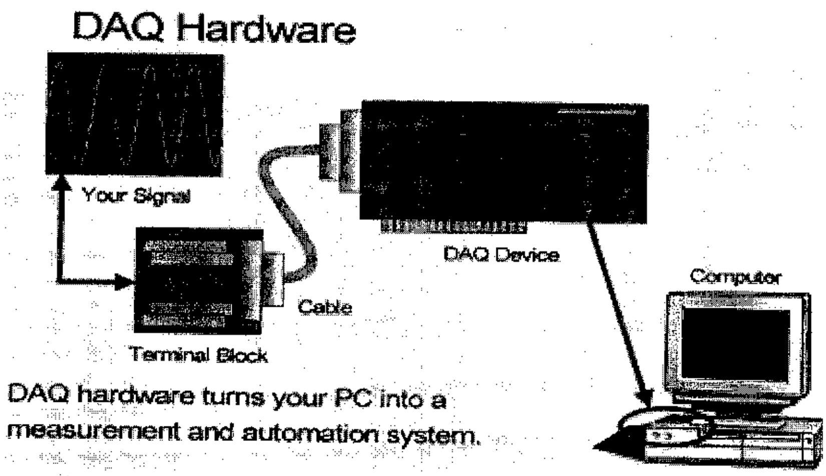


Figure 3.5: DAQ Hardware.

A typical DAQ system has three basic hardware: a terminal block, a cable, and a DAQ device.

3.9.1 Terminal block

Terminal block provides a gateway to connect the signal for a DAQ system. The block has screw or spring terminals for connecting the signals and a cable connector between the terminal block to DAQ device. Terminal blocks can have 100, 68, or 50 terminals. The terminal block is chosen depends on two factors, the capability of the device itself and the number of signals that need to be measured. For example, terminal blocks with 68 terminals offer more ground terminals for signal connection compared with one with only 50 terminals. Having more ground terminals avoids the need to overlap wires to reach a ground terminal, which may cause interference between the signals. The layout of the screw terminals is shown in Figure 3.6 below. Terminal blocks can be shielded or non-shielded. Shielded terminal blocks offer better protection against noise. Some terminal blocks have extra features, such as cold-junction compensation, which is necessary to properly measure a thermocouple.

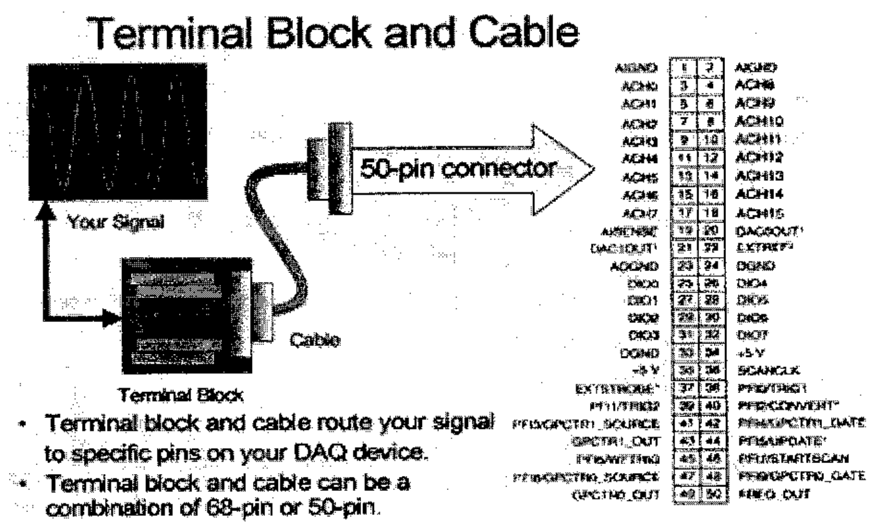


Figure 3.6: Terminal block and cable

3.9.2 Cable

Cable transports the signal from the terminal block to DAQ device. The cables come in 100,68, or 50-pin configurations. Choice of configuration depends on the terminal block and the DAQ device chosen. Cables, like the terminal blocks, can be either shielded or non-shielded

3.9.3 DAQ Device

The DAQ card used for this project is NI-PCI-6034 E Series shown in Figure 3.7 below. A typical E Series device consists of 16 analog input multifunction DAQ channels, two analog output channels, eight digital lines, and two counters. The signal measured using the DAQ device can be transferred to the computer through a variety of different bus structures. For example, a user can have a

(i) DAQ device that plugs into the PCI bus of his/her computer,
(ii) A DAQ device connected to the PCMCIA socket of his/her laptop,
(iii) A DAQ device connected to the USB port of a computer, or
(iv) The PXI/CompactPCI form factor to have a portable, versatile, and rugged measurement system.

For this project, DAQ card is connected through PCI bus of the computer.

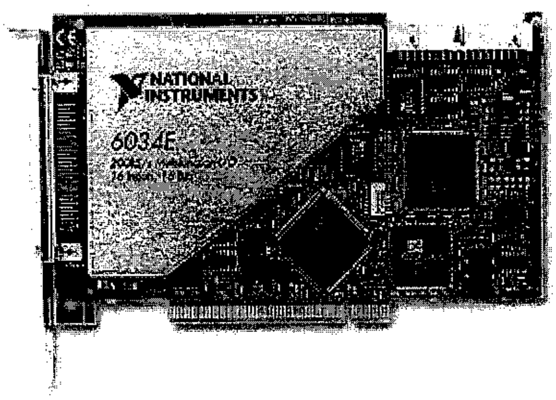
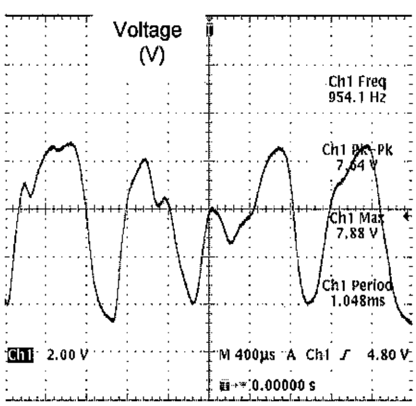


Figure 3.7: NI-PCI-6034 E Series

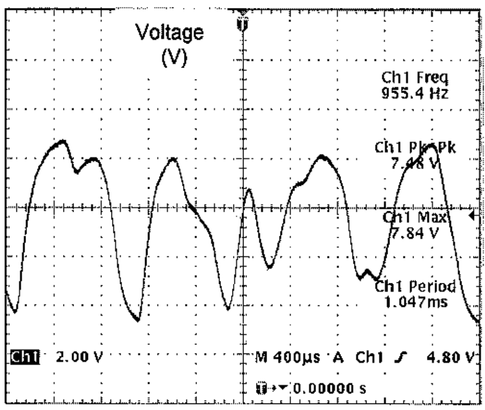
CHAPTER 4

RESULTS AND DISCUSSION

The condenser microphone circuit was finally chosen for this project. The next step taken was to conduct the experiment discussed in Chapter 3 using this circuit (refer to Chapter 3; Experiment on condenser microphone). The main objective of the experiment is to test the functionality of the circuit, focussing on its capability to detect a projectile from varying distances. The graph below was a graph of voltage (V) vs. time (s). The results obtained are per below:

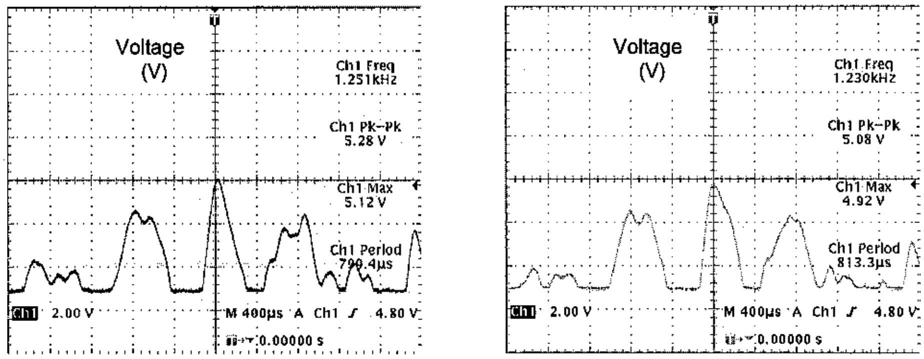


(i)



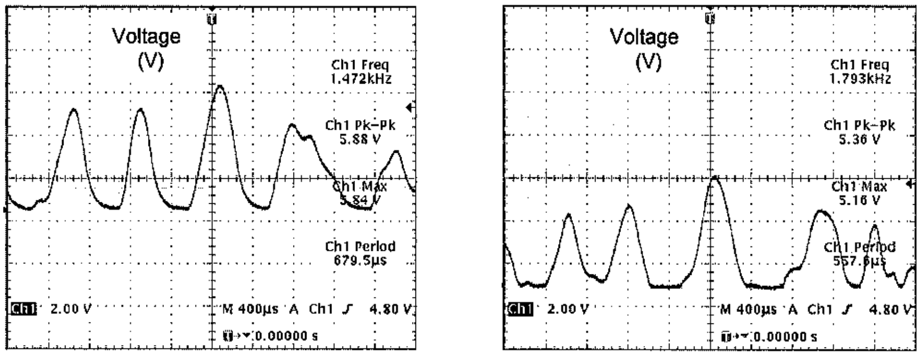
(ii)

Figure 4.1 (i) and (ii): Amplitude obtained for one-meter distance



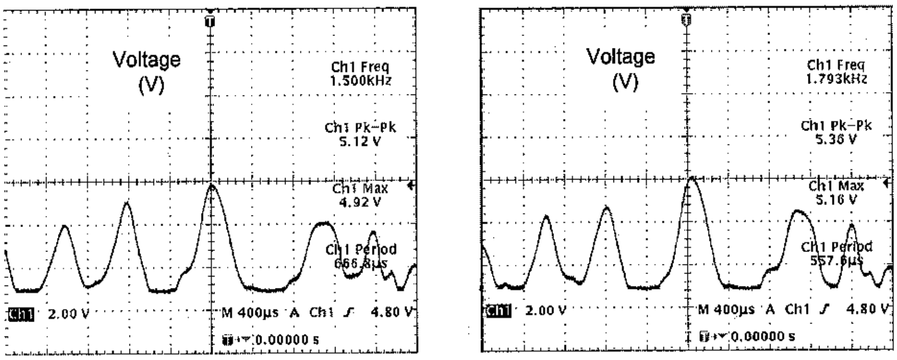
(i) (ii)

Figure 4.2 (i) and (ii): Amplitude obtained for two-meter distance



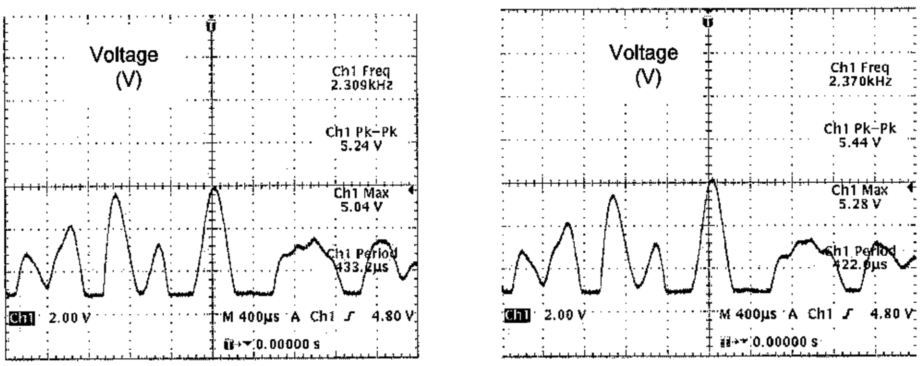
(i) (ii)

Figure 4.3 (i) and (ii): Amplitude obtained for three-meter distance



(i) (ii)

Figure 4.4 (i) and (ii): Amplitude obtained for four-meter distance



(i) (ii)

Figure 4.5 (i) and (ii): Amplitude obtained for five-meter distance.

For this experiment, two separate readings were obtained for every distance to minimise the error. From the graphs, it can be seen that the shape of the signal is nearly the same for every distance. However, the maximum voltage, peak-to-peak voltage, and its period decreased as the distance were increased. Therefore, this experiment may need to be conducted again due to several reasons. From Figure 4.2 (i) and (ii), it has been shown that the amplitude of the generated signal from a projectile 2-meter away was very low compared to the signal from a projectile 3-meter away. Theoretically, as the distance increases the amplitude of the signal should decrease. The frequency of the signal showed some instability, making it quite difficult to predict the behaviour of the sound propagating from the projectile to the microphone.

From these observations, it can be concluded that the circuit is very sensitive to external interference. Therefore, in order to get an accurate result, the experiment should be conducted in a place that with less noise and ideally, it should be conducted in an open area. A possible explanation as to why the signal observed on the oscilloscope was not stable is perhaps due to the sound wave from the projectile bouncing to the near wall and then reflected which interrupt the desired signal. The echo created by the projectile can also be minimised by making sure that the projectile do not bounce from the target more than once so that only the first portion created by the projectile is captured.

The experiment was repeated and this time around, it is conducted in an open space area, which is at the top of Block 23 to be exact. The main objective of this experiment was to gather data and compare this to previous data.

Figure 4.6 shows the waveform pattern taken from the experiment conducted in a closed area whereas Figure 4.7 shows the waveform pattern taken from the experiment conducted in the open area. It can be seen that in a closed area, the pattern of the signal shows that there were no maximum amplitude since the pattern are nearly the same for every second and the walls are affecting the pattern of the signal rendering it unsuitable for this project.

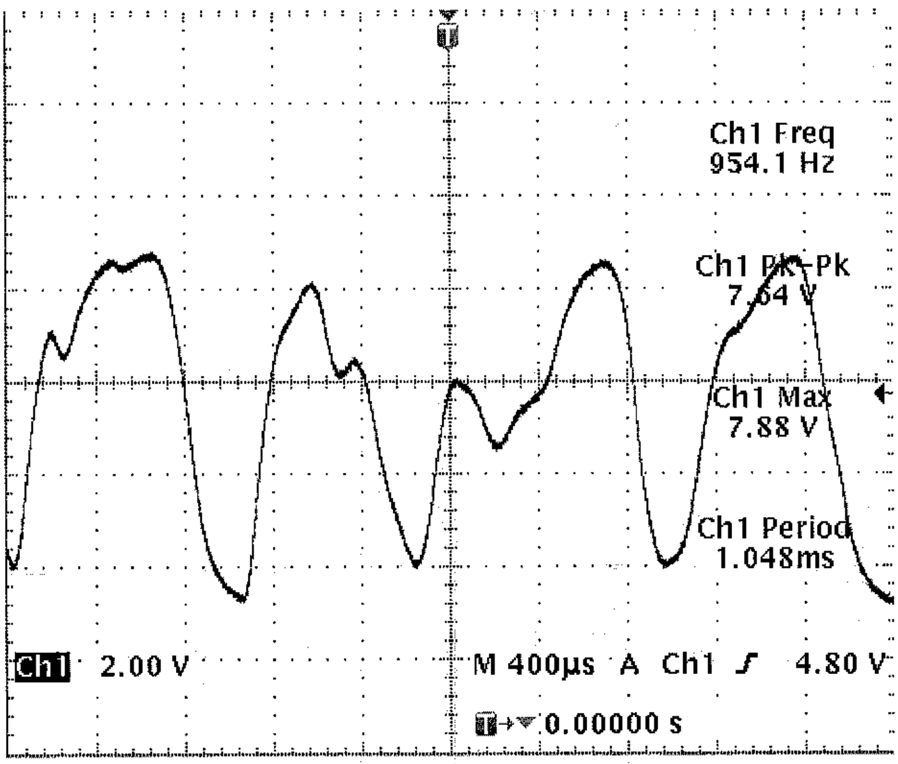


Figure 4.6: Waveform obtained at closed area

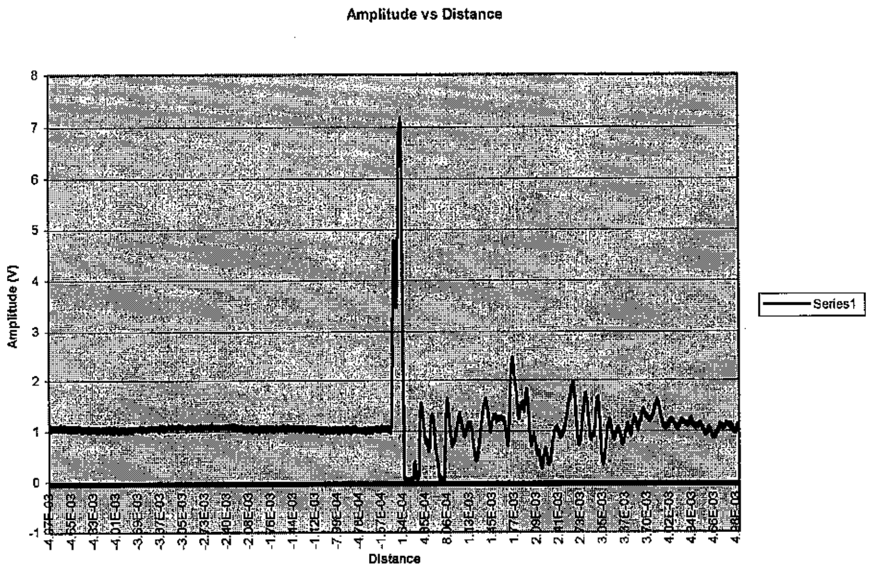


Figure 4.7: Waveform obtained at open area.

The data obtained from the second experiment was analysed. Measurements taken every 0.5 m were record and their corresponding signal pattern was analysed and plotted. From Appendix 4 we can see that every waveform gave similar patterns with amplitude of each waveform decreases as the distance of the sensor from the source of the signal (projectile) increases. This observation was accepted, as it is coherent with the inverse theory relationship stated before.

Distance (cm)	Max (V)
5	7.18
10	6.08
15	6.2
20	6.12
25	5.6
30	4.9
35	4.52
40	4.4
45	3.36
50	3.44
55	3.24
60	2.72
65	2.72
70	2.44
75	2.28
80	2.2
85	1.92
90	1.84
95	1.8
100	1.84

Table 4.1: Summarized data of maximum amplitude (voltage) for every measurement taken.

The maximum value of amplitude (voltage) is used in order to obtain the equation to be used in Lab View programming. The data from the table above were plotted. Using the inverse theory, $I \alpha 1/r^2$, the graph should be an exponential graph as in Figure 4.8 where the amplitude decreases as distance increases. On top of that, the echo from the waveform implies that the signal does not have the possibility of approaching negative values. However, this circuit can only give reliable result within a one-meter range. Outside of this range the data shows that the waveform captured is not stable.

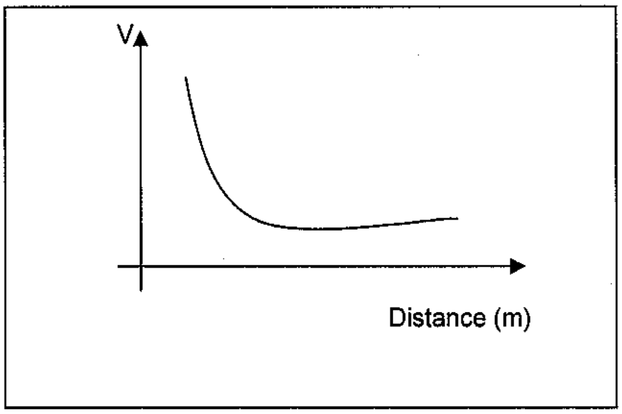


Figure 4. 8: Exponential graph

From these observations, two different equations can be obtained.

1) For testing area within one-meter;

   The equation obtained is linear using curve fitting, the equation obtained is

$$y = -0.2859x + 6.7422 \quad \text{(i)}$$

2) Testing area more than one-meter

   The equation obtained is exponential:

$$y = 7.6876\left(\exp^{-0.0785x}\right) \quad \text{(ii)}$$

Figure 4.9 and Figure 4.10 below show the linear and exponential function for the equation stated above.

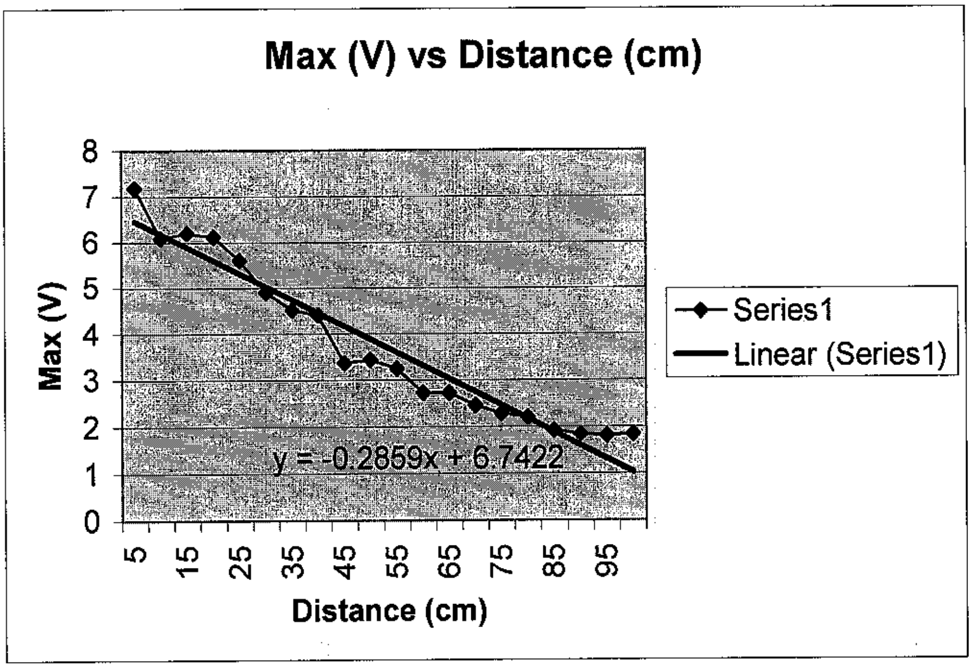


Figure 4.9: Linear graph for case one

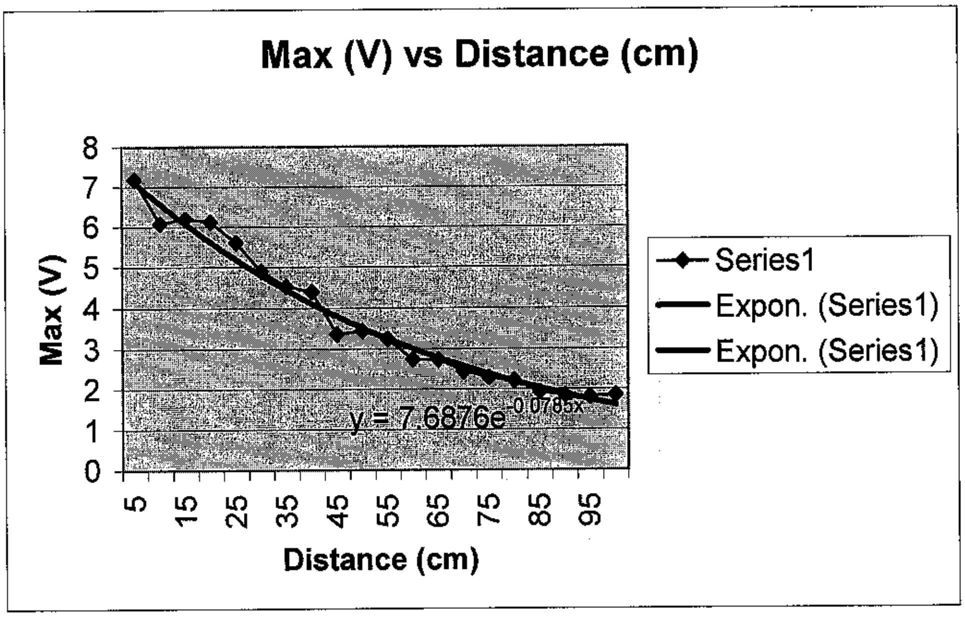


Figure 4.10: Exponential graph for case two

4.1 CONTROLLING MECHANISM

There are two methods that can be used to control the launcher: (i) using Lab View software or (ii) PIC microcontroller. However, Lab View software was finally chosen for this project since this software is user friendly and also more interesting because of having a graphical environment. This software can be used to the platform but the system may be a bit bulky since it has to be connected to a computer. Another method that can be used to control the operation of the platform is by using PIC microcontroller. The type of PIC microcontroller of interest here is the PIC 16F84. One of the basic operations of PIC microcontroller is its use to control motion based on the input from the sensor. Knowledge in C or assembly language is a prerequisite before a user can fully make use of the controller.

The Lab View program was designed by using equations (i) and (ii). The block diagram and control panel for this program are shown in Figure 4.11 and 4.12 below. For this program, the input signal is generated by a function generator, allowing user to control the amplitude of input signal through the Vi environment. By specifying the amplitude, the program will give the distance value based on the formula specified in the program. Note that this initial program is valid for only one sensor.

After completing the initial program, the next plan is to come up with equations for a four-condenser microphone circuit since this project requires the use of a four-condenser microphone circuit to get the co-ordinates for the projectile. Therefore, another equation needs to be derived to integrate the four-condenser microphones. After obtaining the required equation, it will be used in the Lab View program. The calculation and equation involved are per below:

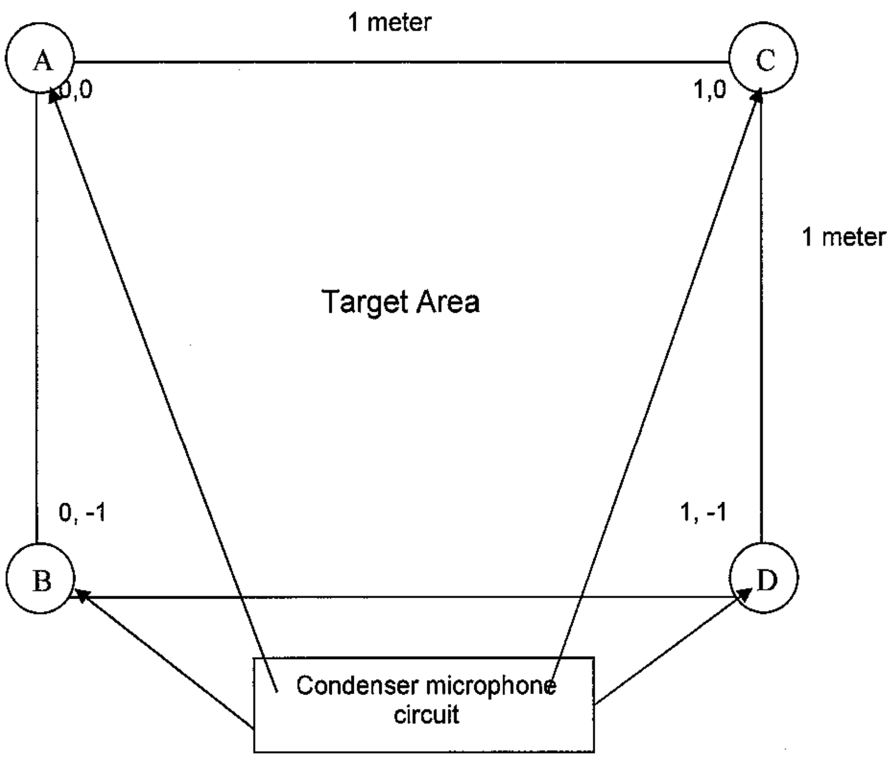


Figure 14.13: Target area consisting of four-condenser microphone

Equation for circle starting at origin (0,0):

$$x^2 + y^2 = r^2 \quad \text{(iii)}$$

where r stands for radius of the circle.

Equation for circle starting at (h, k) point:

$$(x-h)^2 + (y-k)^2 = r^2 \quad \text{(iv)}$$

The intersection between four sensors can be seen in Figure 4.14.

For intersection between sensor A and sensor B:

$$x^2 + y^2 = A^2 \rightarrow (i)$$
$$x^2 + (y + 50)^2 = B^2 \rightarrow (ii)$$

Sub (i) into (ii)

$$x^2 + y^2 + 100y + 2500 = B^2$$
$$A^2 + 100y + 2500 = B^2$$
$$100y = B^2 - A^2 - 2500$$

Solve for x and y

$$y = \frac{B^2 - A^2 - 2500}{100} \quad \text{(v)}$$
$$x = (A^2 - y^2)^{1/2} \quad \text{(vi)}$$

For intersection between sensor A and sensor C:

$$x^2 + y^2 = A^2 \rightarrow (i)$$
$$(x - 50)^2 + y^2 = C^2 \rightarrow (ii)$$

Sub (i) into (ii)

$$x^2 + y^2 - 100x + 2500 = C^2$$
$$A^2 - 100x + 2500 = C^2$$
$$100x = A^2 - C^2 + 2500$$

Solve for x and y

$$x = \frac{A^2 - C^2 + 2500}{100} \quad \text{.............} \quad \text{(vii)}$$
$$y = \left(A^2 - x^2\right)^{1/2} \quad \text{.............} \quad \text{(viii)}$$

For intersection between sensor C and sensor D:

$$(x - 100)^2 + y^2 = C^2 \rightarrow (i)$$
$$(x - 100)^2 + (y + 50)^2 = D^2 \rightarrow (ii)$$

From (i)

$$(x - 100)^2 = C^2 - y^2 \rightarrow (iii)$$

Sub (iii) into (ii)

$$100y = D^2 - C^2 - 2500$$

Solve for x and y

$$y = \frac{D^2 - C^2 - 2500}{100} \quad \text{.................} \quad (ix)$$
$$x = \left(C^2 - y^2\right)^{1/2} \quad \text{.................} \quad (x)$$

For intersection between sensor B and sensor D:

$$(x)^2 + (y + 100)^2 = B^2 \rightarrow (i)$$
$$(x - 50)^2 + (y + 100)^2 = D^2 \rightarrow (ii)$$

From (i)

$$(y + 100)^2 = B^2 - x^2 \rightarrow (iii)$$

Sub (iii) into (ii)

$$(x - 50)^2 + B^2 - x^2 = D^2$$

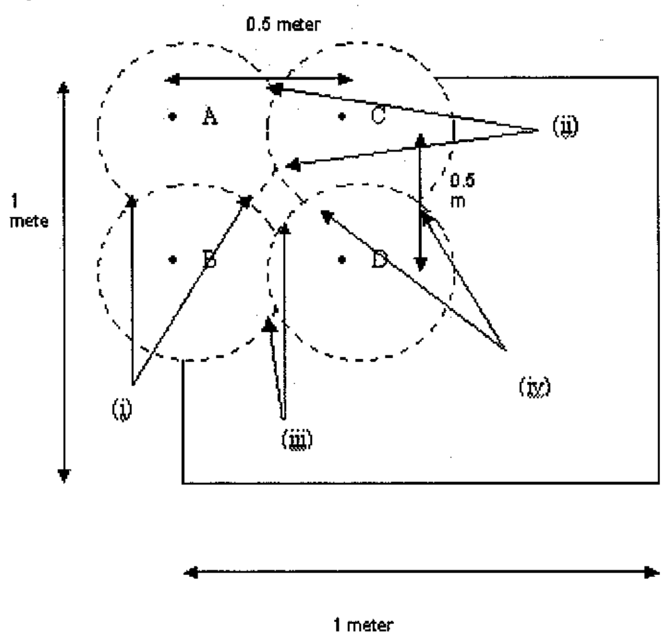
Solve for x and y

$$x = \frac{B^2 - D^2 + 2500}{100} \quad \text{.......................} \quad (xi)$$

$$x = \left(B^2 - x^2\right)^{1/2} \quad \text{.......................} \quad (xii)$$

The front panel and the diagram of this programming are shown in Appendix 5.

A DAQ card was connected to the circuit but the experiment was conducted in the lab using only one condenser microphone via PCI bus of the computer. The result was recorded and the output (distance) obtained from the Lab View program showed invalid result since the equation used in the program make use of data obtained in an open area.



Notes:

(i)	Intersection between sensor A and sensor B
(ii)	Intersection between sensor A and sensor C
(iii)	Intersection between sensor B and sensor D
(iv)	Intersection between sensor C and sensor D

Figure 4.14: The intersection between four-condenser microphones sensor

4.2 FURTHER IMPROVEMENT

This project can be improved further by making the target location viewed in 3-dimension instead of only 2-dimension, as shown in this project. This project can also be successfully implemented by exploring the advanced functionalities available in Lab View software.

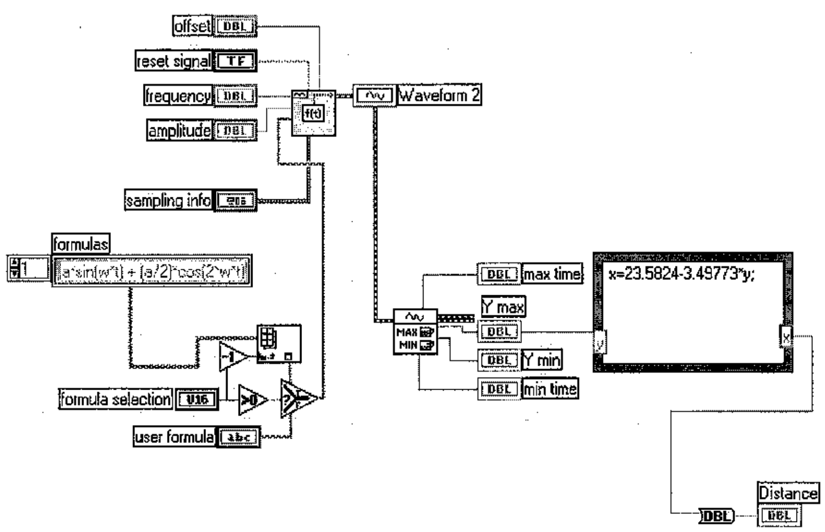


Figure 4.11 (i): Block Diagram for linear equation

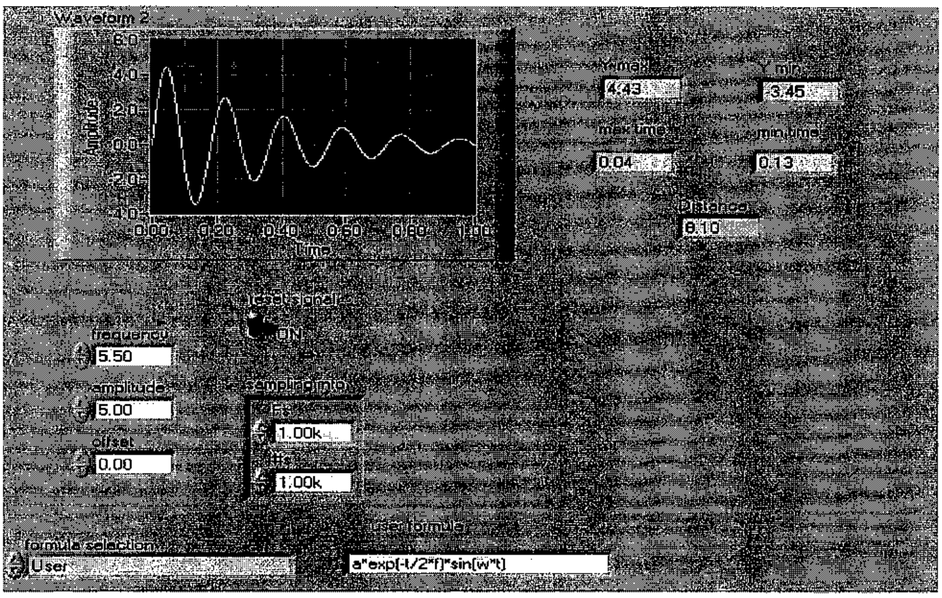


Figure 4.11 (ii): Front panel for Linear equation

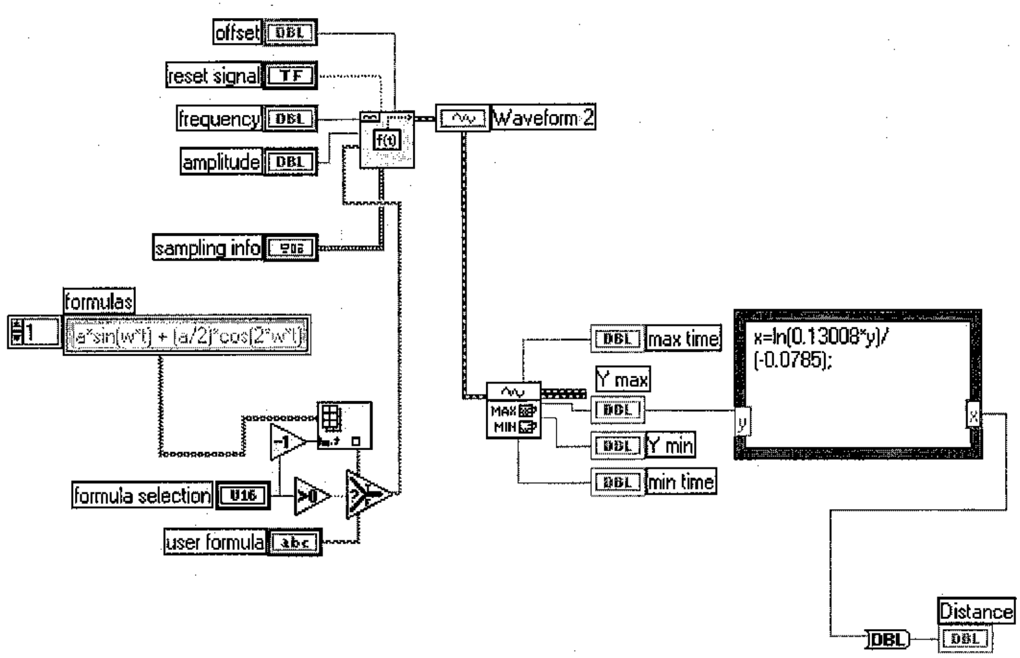


Figure 4.12 (i): Block diagram for exponential equation

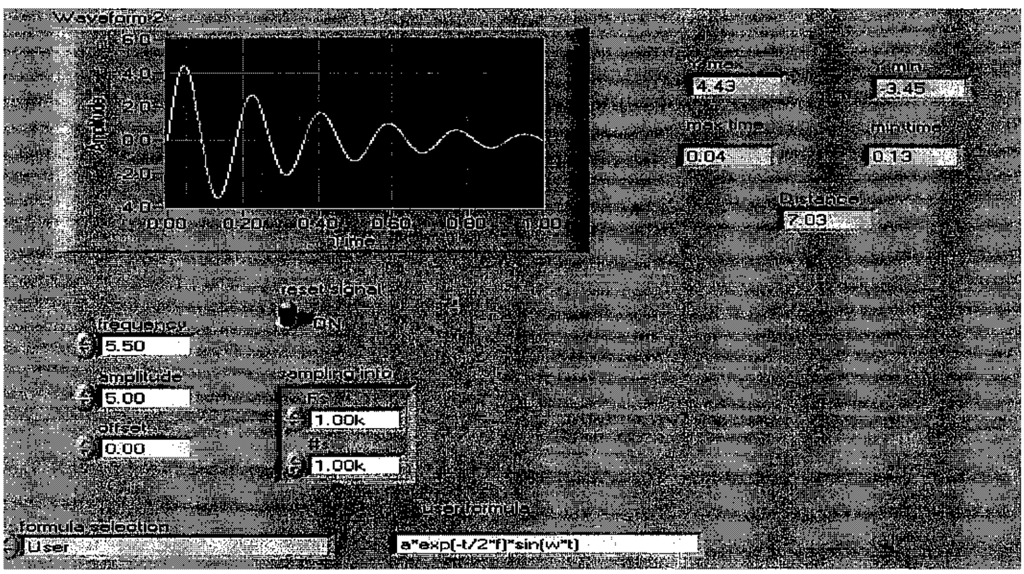


Figure 4.12 (ii): Front panel for exponential equation

CONCLUSION

Through this report, the progress and findings obtained throughout this project encompass the different parts of implementing the controlling mechanism of the launcher.

Experimental result obtained using one condenser has been used as the initial steps to create an algorithm for four-condenser microphone circuit. This algorithm has been successfully implemented in Lab View software to find the co-ordinate of the projectile.

As a conclusion, this project on Electromagnetic Launcher Controlling mechanism, can be successfully implemented in real situation by taking it a step further and improving on the equipments used.

REFERENCES

1. Henry Kolm, Kevin Fine, Fred Williams and Peter Mongeau, *Overview of Electromagnetic Guns,* Massachusetts Institute of Technology Cambridge, Massachusetts, 1980

2. National Instruments, *Hands-On Introduction to LabVIEW Graphical Development Environment Seminar,* May 2003

3. *www.osha.gov/dts/ctc/gas_detec_instruments/toc.html*

4. Electronics Hobby Kit, FM Microphone

5. http://www.leang.com/robotics/info/articles/minison/minison.html

6. Kenneth L. Ashley, *Analog Electronics with Lab View,* Prentice Hall Ptr, 2003

7. Vilma A. Oliveira, Manoel L.Aguiar and Wilson da Silva Jr, *Computer in Control and Instrumentation Teaching and Learning,* Department of Electrical.USP Sao Carlos.

8. C. Giancoli, Douglas, *Physics Fifth edition,* Prentice Hall, New Jersey, 1998

APPENDICES

Appendix 1: Gantt chart for first and second semester

Appendix 2: Input configuration for floating signal sources and ground referenced signal.

Appendix 3: Schematic diagram of ultrasonic transducers.

Appendix 4: Captured Waveform for 20 points. (1 meter range)

Appendix 5: The front panel and block diagram of four-condenser microphone circuit.

Milestone for the First Semester of Final Year project

No	Details /Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Selection of project title															
	- Topic assinged to students															
2	Preliminary research work															
	- project planning															
	- research on sensors															
	- research on platform															
3	Submission of Preliminary report															
4	Detailed Design Work															
	- Programming PIC															
	- Build model/ prototype															
5	Submission of progress report															
6	Testing and Refinement															
	- Model/Prototype testing															
7	Submission of Interim Report Final Draft															
8	Submission of Interim Report															
9	Oral Presentation															

- Progress
- Suggested Milestone
- Summary

Appendix 1a(i): Milestone for the First Semester of Final Year project

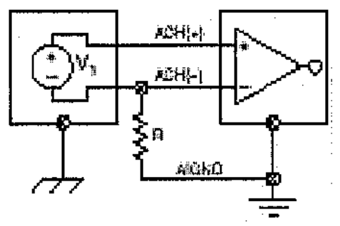
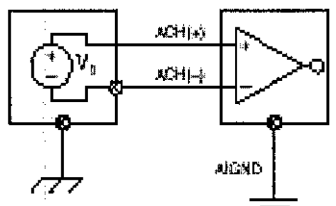
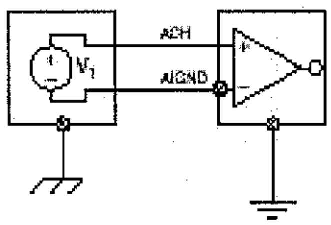
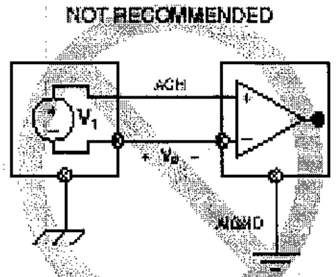
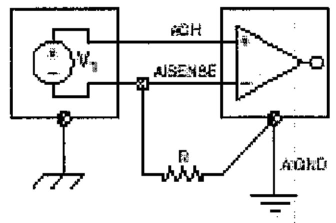
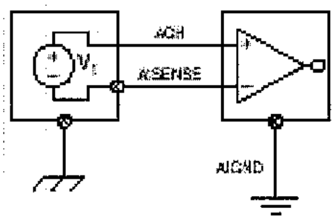
Milestone for the second Semester of Final Year project

No	Details /Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Project work Continue																
	- research on launcher																
2	Submission of Progress Report 1																
3	Build the launcher																
4	Submission of Progress Report 2																
5	Testing and refinement																
	- Prototype testing																
6	Submission of Dissertation Final draft																
7	Oral Presentation																
8	Submission of Project dissertation																

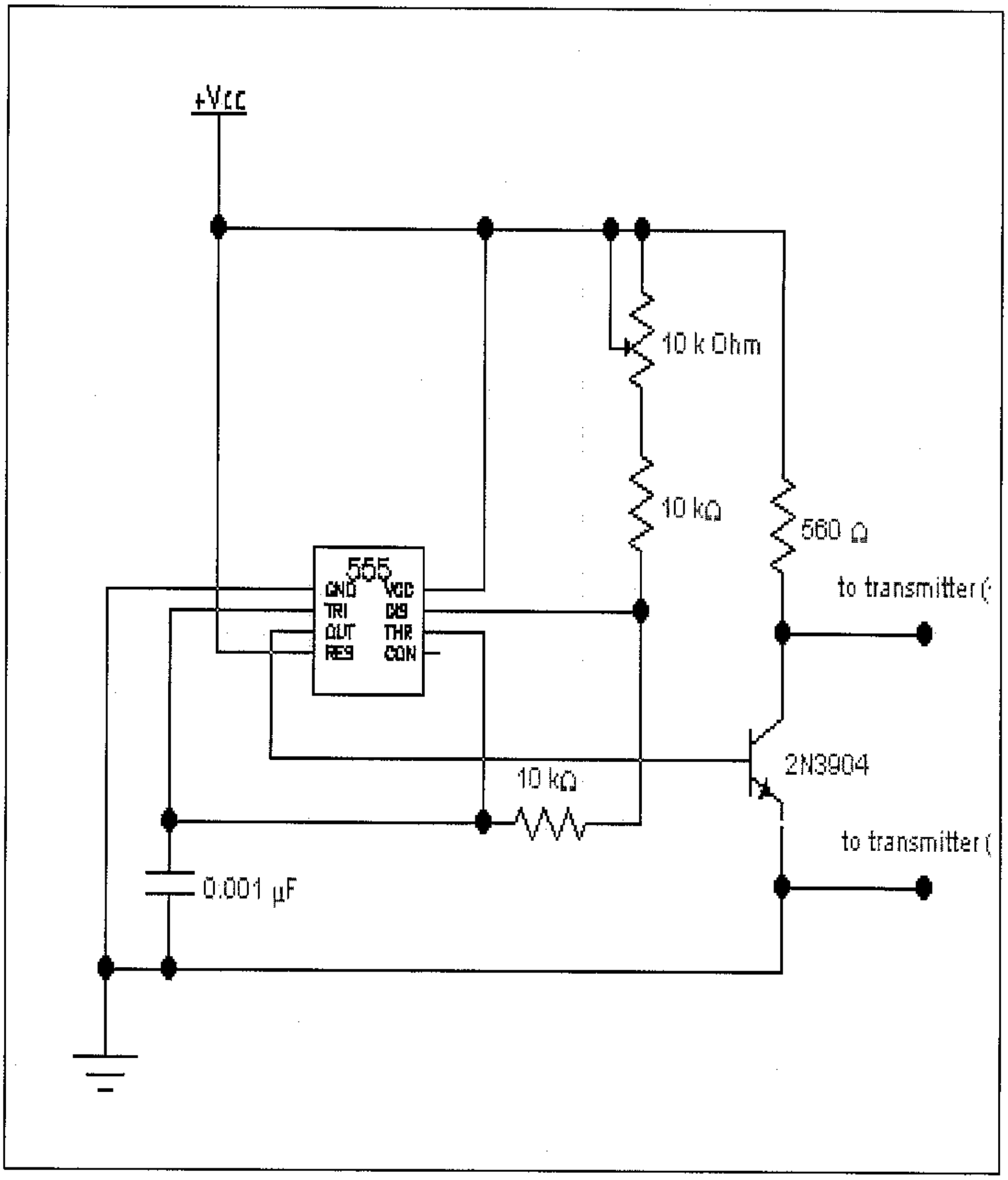
Progress
Suggested Milestone
Summary

Appendix 1a(ii): Milestone for the second Semester of Final Year project

APPENDIX 2: Configuration for floating signal sources and ground-referenced signal.

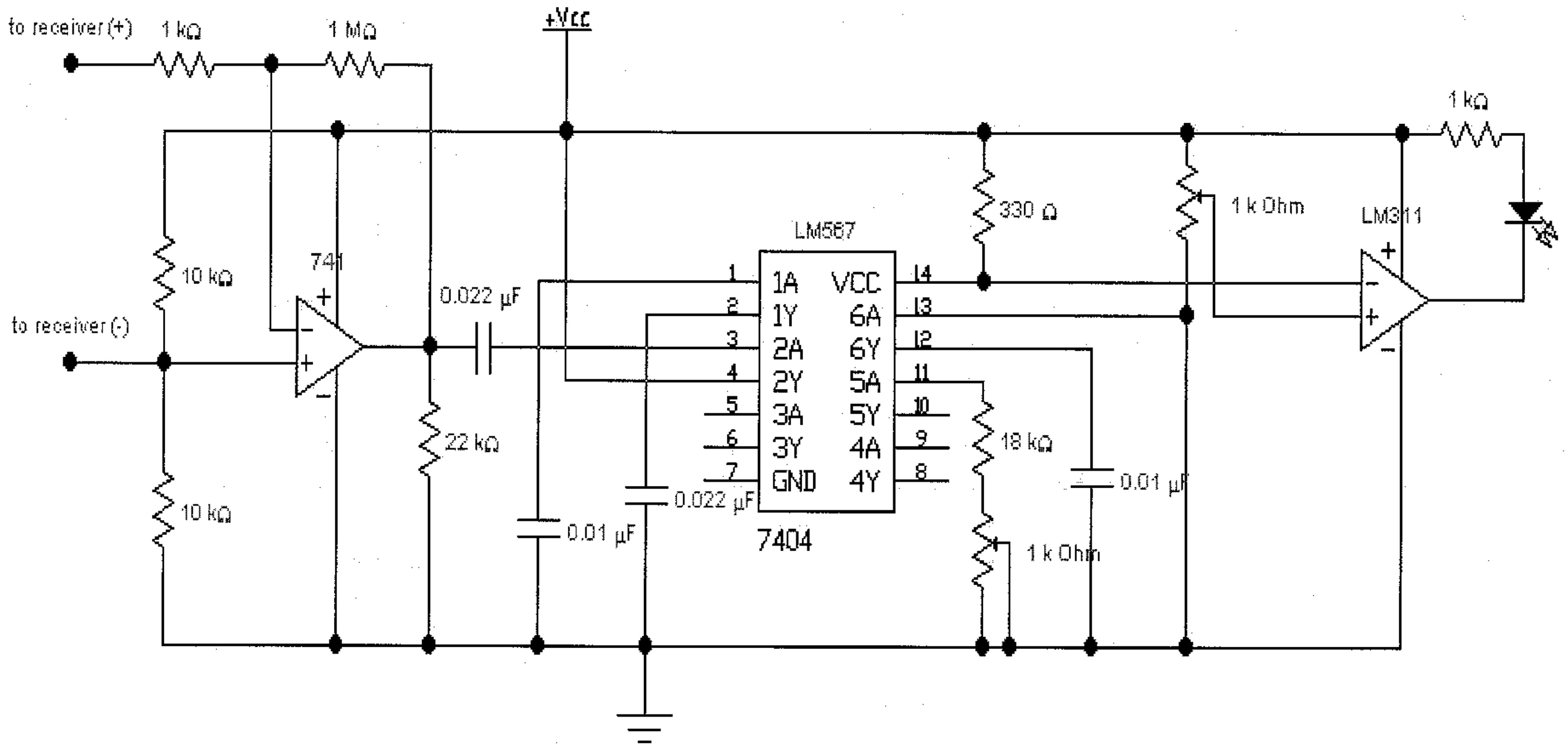
Input	Signal Source Type	
	Floating Signal Source (Not Connected to Building Ground)	**Grounded Signal Source**
	Examples • Ungrounded Thermocouples • Signal Conditioning with Isolated Outputs • Battery Devices	Examples • Plug-in Instruments with Nonisolated Outputs
Differential (DIFF)	 See text for information on bias resistors.	
Single-Ended — Ground Referenced (RSE)		NOT RECOMMENDED  Ground-loop losses, V_g, are added to measured signal.
Single-Ended — Nonreferenced (NRSE)	 See text for information on bias resistors.	

APPENDIX 3: ULTRASONIC TRANSDUCER (TRANSMITTER PART)



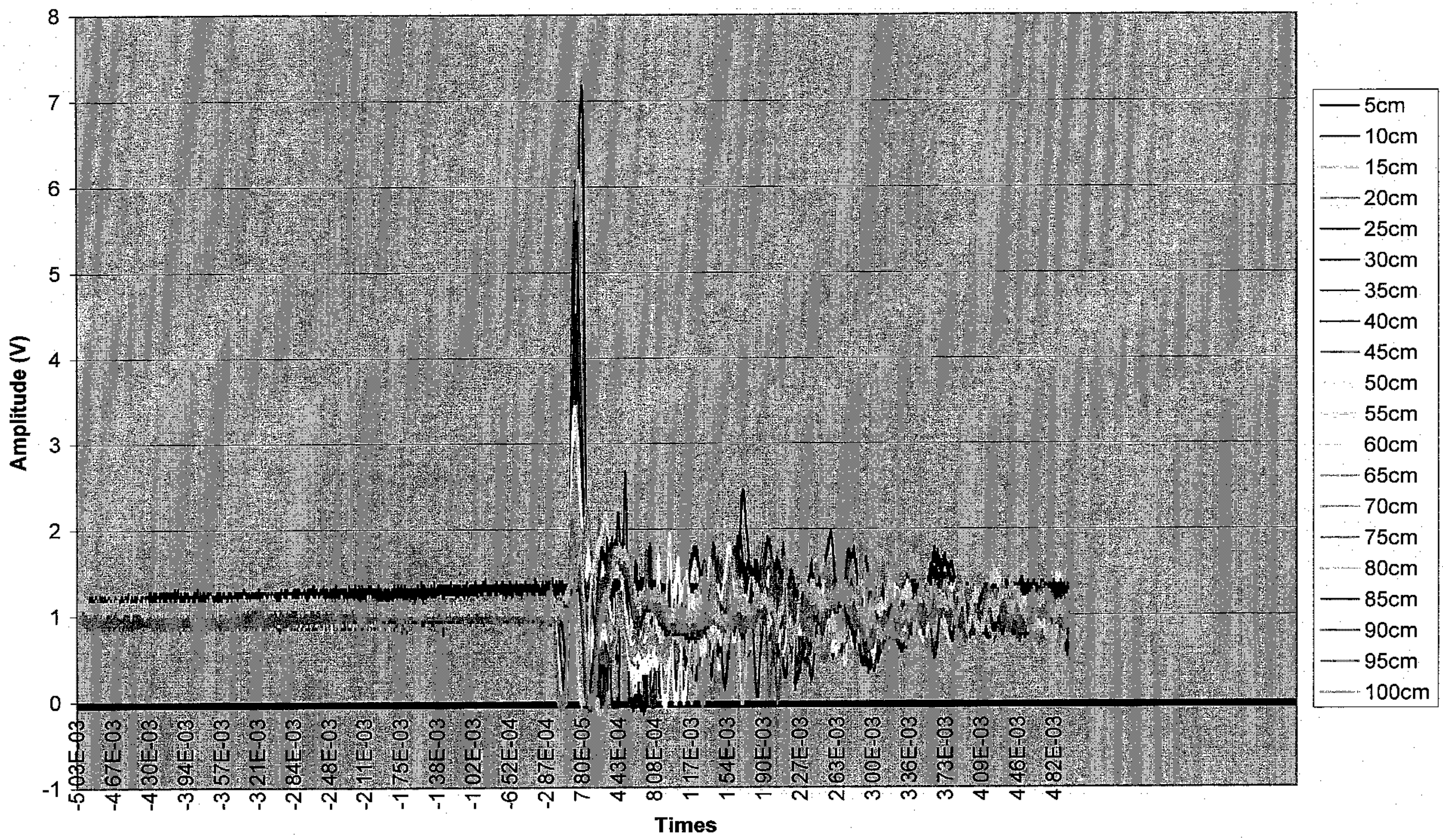
Transmitter Part for Ultrasonic transducer

APPENDIX 3: ULTRASONIC TRANSDUCER (RECEIVER PART)



Receiver part for Ultrasonic Transducer

Appendix 4: CAPTURED WAVEFORM FOR 20 POINTS (1 METER RANGE)



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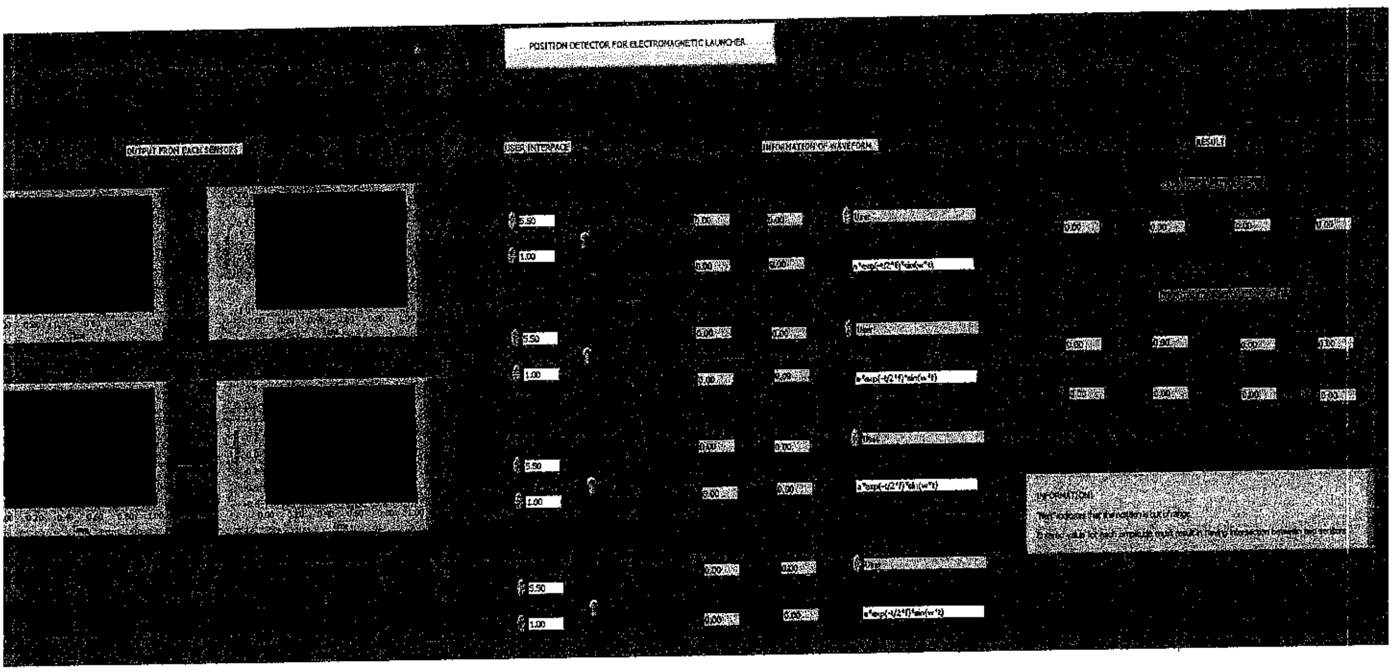

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