OBJECT TRACKING

By

ANIS SYAFIRIN BINTI EZHAR

FINAL PROJECT REPORT

Submitted to the Department of Electrical & Electronic Engineering
in Partial Fulfilment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical and Electronics Engineering)

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved:

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Mr Abu Bakar Sayuti Bin Hj. Mohd Saman
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

December 2012

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.

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Anis Syafirin Binti Ezhar

ABSTRACT

‘Object tracking’ is an important task within the field of computer vision. The prevention of theft, the focusing of light to the actor or model automatically during theatre, award show, and concerts, then the law enforcement operation such as search and rescue, prison yard security and helicopter chases. It is needed for simple object tracking designed for simple technique to keep low cost and limited processing power. This project is to develop simple object tracking by using infrared signal. The technique that can be implemented is by allowing the object to be tracked through transmitted infrared. Tracker detects infrared signal and more pointer (spotlight) towards object and the position is the feedback to control system which actuated by means of stepper motor. The adjustment can be in different elements using control system such as P, PI, PD and PID controller. This project successfully can detect the object maximum up to 3.2m.

ACKNOWLEDGEMENTS

This dissertation was completed during my final year of study at Department of Electrical & Electronics Engineering, PETRONAS Institute of Technology, Malaysia, in the period of May 2012 to January 2013.

Foremost, I would like to express my deep gratitude to my supervisor, Mr Abu Bakar Sayuti Bin Hj. Mohd Saman. He gave me the suggestions to this work and opportunity to carry out this research work under his guidance. His continual support and constructive criticism in numerous valuable discussions always inspired me in my technical and personal development.

Furthermore, my personal sincere thank goes out to all my colleague at PETRONAS Institute of Technology especially to all Electrical & Electronics Engineering Department students of batch January 2008 for inspiring discussions, idea, and above all, for the pleasing study environment which I really enjoyed during my stay here.

A very important part of this work goes to my family especially my parents, Ezhar Bin Mustafa and Rosilah Binti Salleh, who have given me on-going and continuously encouragement, trust, and supports.

Finally, this work was financially supported by my sponsorship, Majlis Amanah Rakyat (MARA). Thank you for this support.

6th December 2012

Anis Syafirin binti Ezhar

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1.0 INTRODUCTION

1.1 Background of Study

Particularly, it is very important to evaluate safety and reliability of security system. Theft always occurred around less stringent security system and unluckily sometimes these criminals managed to escape. This project has the same concept or the idea which can prevent the theft as it can be employed in security to detect theft. For example, mounted the closed-circuit television (CCTV) (refer Figure 1.1) to replace the spotlight which it can detect the object or human movement in order to implement this security issue. Besides that, from the view of entertainment industry, this concept also can be applied in award shows, fashion shows, theatre, concerts and many more such as focusing the light to the actor (refer Figure 1.2) or model throughout the events. As a result, the events will go smoothly without any disturbance and also it will save costs to hire less professional staff in order to accomplish the occasion. Moreover, applications in law enforcement also have similar theory such as can be operated in search and rescue, prison yard security and helicopter chases (refer Figure 1.3).

Figure 3: Safety purpose

Figure 1: A light focusing to the actor

Figure 2: Closed circuit television (CCTV)

In its simplest form, tracking can be defined as the problem of estimating the trajectory of an object in the image plane as it moves around a scene. There are two main types of techniques that can be used for object tracking.

The first one is the video/image and the next one is the sensors. The core of the project is finding and researching on object tracking algorithm. There are tracking algorithms namely centroid, edge, multiple target track, phase correlation and combined scenelock used for video.

On the other hand, the object tracking algorithms for sensors are interacting multiple model expectation maximization, multiple hypothesis algorithm and joint probabilistic data association algorithm [25]. For this project, sensors is chose as the best alternative due to its simple processing, easy to implement, and low cost compare to video/image which is an advanced technology that required high computing processing. Practically, the sensors technique can be done by using microcontroller, actuator and infrared sensors where it can be model in a closed loop control system as a one dimension diagram.

1.2 Problem Statement

In football match, the cameraman having difficulties to capture every movement of football player as it is unpredictable. Sometimes, they cannot capture all the moment and also can miss the important part of match. This project is about to ease the cameraman, or enable to capture every movement by football player while moving in variety of speed, angles and position.

1.3 Objectives

The objective of this project basically is to design and build a simple object tracking system based on a small microcontroller system, simple actuator which is stepper motor and sensors that used infrared sensors. For all this hardware, an algorithm is assign to each of them to study their effectiveness.

1. To design and build a simple object tracking system based on small microcontroller system, simple actuator (stepper motor) and sensors (infrared sensor).
2. To implement algorithms based on hardware above to study their effectiveness.

1.4 Scope of Work

The scope of this project consists of research, experimenting, analysis and implementing a working circuit to ensure the best result. The effective algorithm will be presented in this paper to study their effectiveness. A comparison study between algorithms is to show performance of various objects tracking algorithm. Furthermore, basic knowledge is applied to develop efficient tracking and hardware implementation. The hardware can be done by using Arduino Uno which is simple to use and popular, hybrid stepper motor and infrared sensors. Infrared sensors are chosen because it is easy to implement in small scale, cheap, very directional and requires line of sight.

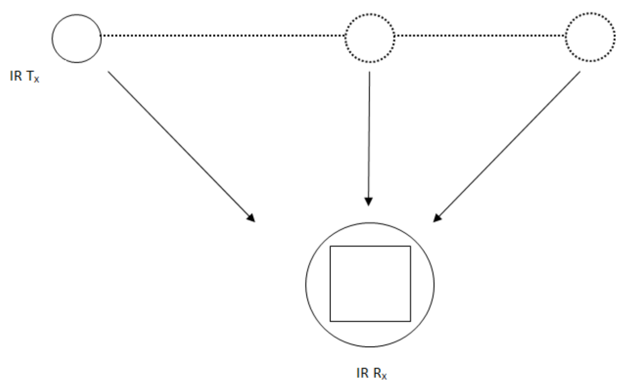


Figure 4: Layout of project setup

2.0 LITERATURE REVIEW

2.1 Related previous project

The previous related works regarding object tracking similar to the objectives of this project is discussed as below.

Firstly, a journal entitled ‘The Infrared Tracking Project’ by Arun Israel, Reda Dehy (2004), published by Cornell University ECE 176 Final Project is a project based on tracking the object by using infrared sensors. The implementation of the project is able to maintain with an objectively fast moving object by applying triangulation algorithm. The problem encountered by them is that the sensor has limited range and there are errors on motor control code.

Secondly, a journal on ‘Object tracking in a multi sensor’ whose the author is Sebatian de Vlaam (2004) issued by Smart Sensor Solutions, Networked Embedded Systems is a project which the algorithm used is phase correlation. The application of the researched done is it competent to detect the object with a Passive Infrared sensor via analog input. The unwelcome matter is it has long warm-up time.

‘Moving Object Tracking in Video’ and ‘Object Tracking and Segmentation in a Closed Loop’ are the projects conducted by Yiwei Wang, John F. Doherty, Robert E. Van Dyck and Kostantinos E. Papoutsakis, Antonis A. Argyros occlusion respectively. Both projects are related to the video and camera usage and implementing point-tracking and motion estimation algorithms. However, the camera motion cannot contend with occlusion.

Lastly, a journal entitled ‘Object tracking method in distributed surveillance system’ by Boryslav Larin (2011) collaborated with department of applied Mathematics and Information Software Engineering is a research on tracking the movement of human. It allows the process information by nodes observe the location when the object goes out of the sight of camera. Since it use camera as a tracker, it unable to immaculate the accuracy of the objects in partial or complete occlusions.

2.2 Overview of an Object Tracking

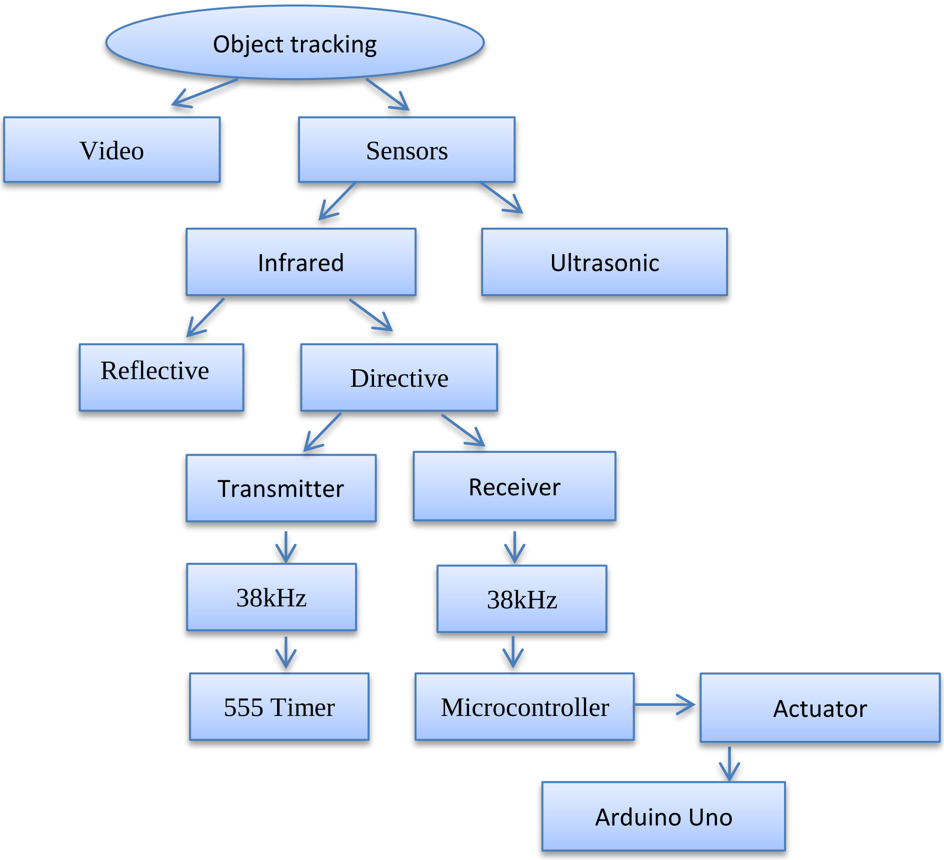


Figure 5: Concept of object tracking

Object tracking is a system that is improved to detect an object moving via infrared sensors which comprises of Arduino Uno microcontroller and stepper motor. Commonly, according to the related projects, they consist of different types of components such as ultrasonic sensor, DC Servo Motor, Motor Driver Circuitry, Stepper Motor, PIC Microcontroller, Arduino Microcontroller and power supply. [11-14]

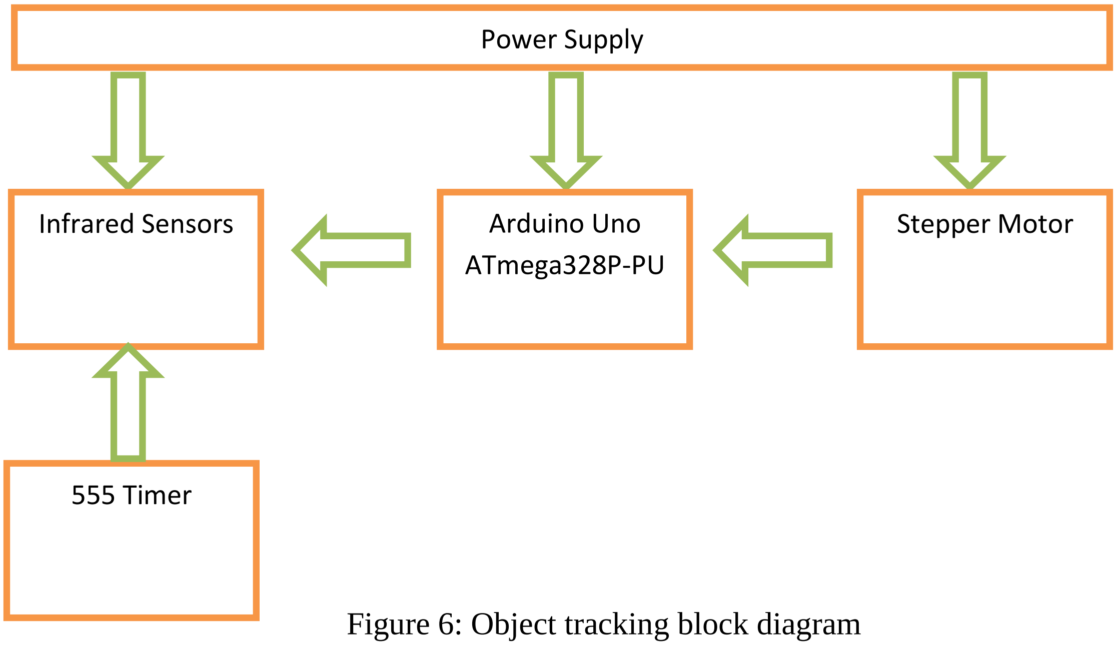


Figure 6: Object tracking block diagram

Explanation of the block diagram

i) 555 timer: Build 555 timer circuit to create a range of ±38kHz frequency. Hence, it will provide the frequency to infrared transmitter (as the output)
ii) Infrared transmitter: Using LED Infrared transmitter to transmit the
iii) Infrared receiver: Using digital infrared receiver
iv) Microcontroller: Arduino Uno
v) Stepper motor: has good accuracy movement
vi) Power supply: +9v, +6v

2.3 Infrared Sensors

There are two types of infrared sensors which are directive and reflective sensor (refer Figure 2.4).Directive means it will be tracking directly and in order to do so, emitter and receiver play their roles.

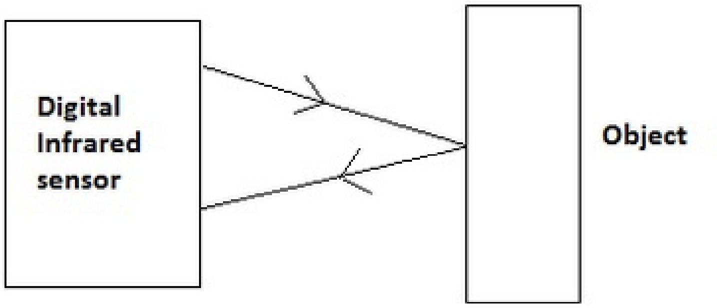


Figure 7: The reflection of digital infrared sensor on the object

In the aspect of analysing and processing purposes, sensors play an important role by obtaining the analogue outputs from the system. The output is used to come out with suitable and appropriate action and react to it in the fastest way. With the need for the robot system to be able to detect the obstacle, 2 types of sensors can be used which are the IR sensors and ultrasonic sensors.

Infrared (IR) sensor is one of the most easy to operate upon, simple yet instrumental tool for implementing intelligence in a robot system. It radiation has longer wavelength than visible light. To put it in the simplest way, for any objects that generate heat likes living things, it will also generate infrared radiation. In this project, the focus is given on mid-infrared (30 to 120 THz) because this range is the range that is practically find in many applications such as remote control, radio, etc. [17] The basic concept of IR obstacle detection is to transmit the IR signal (radiation) in a direction and a signal is received at the IR receiver when the radiation bounces back from a surface of the object. The IR receiver can be a photodiode (phototransistor) or a readymade module which decodes the signal. The object here can be anything that has shape and size. [18]

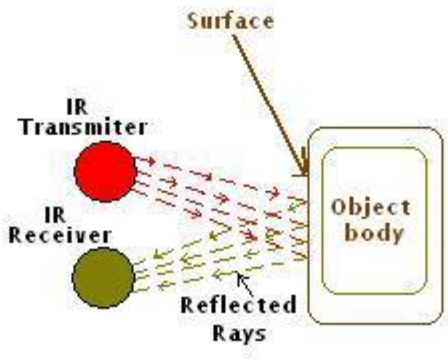
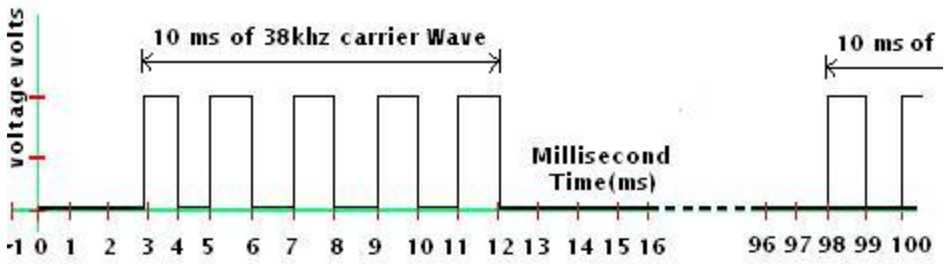


Figure 8: IR sensor concept

When choosing particular IR receiver module, it need to be transmit to the modulated wave with the same carrier frequency of that of an IR receiver module.



ON state = 10 ms   OFF state = 90 ms

Figure 9: Modulating a 38kHz carrier signal

From Figure 2.6, the modulation process is explained that is quite similar to OOK (ON-OFF Keying) modulation where the carrier signal is ON for certain period of time. It is essential for the carrier signal to be transmitted for a short while and remains OFF for longer period of time because the receiver will treat it as a noise and ignores receiving the transmitted signal. [19] IR transmitter can be create in two ways either by using 7555 (compatible with 555) timer IC to generate a 38 kHz carrier signal or by using microcontroller inbuilt wave generation module. Meanwhile, for IR receiver, it consists of IC packages known as TSOP (Thin small outline package). Once the transmitter and receiver are established, both should be placed side by side at certain angle which is usually ±45º in order for the detection to happen in a proper way. [20] However, since the IR radiation may bounce back from the surrounding objects when the obstacle is to be detected in one direction, thick enclosure is needed. The enclosure can be made out of plastic or metal material that is black.

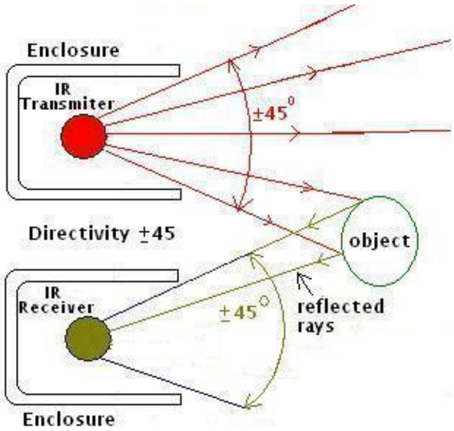


Figure 10: IR sensors concept with enclosure

On the other hand, ultrasonic sensors work by creating high frequency sound waves signal and then received back by the sensor. For this type of sensor, the sensitivity and accuracy to determine the distance can decrease by the shapes and the density or consistency of the material such as foam on the surface of a fluid. [18] Then, by identifying the time interval between signalling and receiving the signal by the detector, the sensors can calculate the distance to an object (assume the speed of the sound in the air is already known) by using the formula [19]

$$D = v_s \cdot \frac{t_{propagation}}{2}$$

Where $v_s = 340\ m/s$ and is the speed of the acoustic waves in the air and $t_{propagation}$ is the total propagation delay of acoustic waves. It is important to notice that the speed of sound varies with altitude and temperature. At sea level and room temperature, it is approximately 344.2 m/s. It will increase with temperature and decrease with altitude. Ultrasonic sensor can determine the distance to an object between 3 cm and 3 m away. For an object that is closer than 3 cm, it will result in the sound waves echoing back to the sensor before the detector is ready to receive. The ultrasonic sensor actually consists of two parts which are an emitter that produces a 40 kHz sound wave and a detector which detects 40 kHz sound waves and sends an electrical signal back to the microcontroller. However, the problem that occur with this approach is to convert the data obtain into a digital format that can be processed by the microcontroller. To overcome this, 8 bits analogue-digital converter is needed.

2.4 555 Timer

555 timer is an IC used for precise timing as well can generate the waveform or oscillations. In this project NE555N which operates on arrange from 0^0 to 70^0 centigrade; has been connected in astable mode. Astable mode is a circuit that output a quasi-rectangular waveform that can produce a frequency. NE555N timer manages to work on 5volt to 18volt power supply. The frequency can flexibly alter or adjustable by the selection of resistor and capacitor (R1,R2 and C). Hence, the percentage of NE555N duty cycle also dependable on the values of R1, R2 and C. The output of this IC is Infrared Transmitter LED which required a range of frequency around 38kHz. [21]

Inside 555 Integrated Chip consists of twenty-five transistors, sixteen resistors and two diodes so that the operational vary depend on the application. From the block diagram, 555 timer enclosed with 2 comparators resistive divider network flip-flop and a discharge transistor. One of the comparator is a threshold and control input. It is able to control until 0.6667Vcc and this matter conveniently when the threshold voltage exceeds the high input cause the comparator to set the flip flop. Pin 7 is the location of the discharge transistor collector. There are two conditions happen:

- When Q is High: capacitor will be discharged and the Q output from the flip flop will fill up the transistor.
- When Q is Low: capacitor will be charged and opened transistor.

Pin 3 is undertaken as the output of the flip flop opposite signal. The function of the reset pin is to avert the flip flop from its activities and it is connected to voltage supply. A 0.3333V fixed voltage and the trigger input is attached to lower comparator. Once 0.333V is not achieved, the comparator output increase and flip flop is reset. Pin 1 and 8 is recognised as ground and supply respectively. [21]

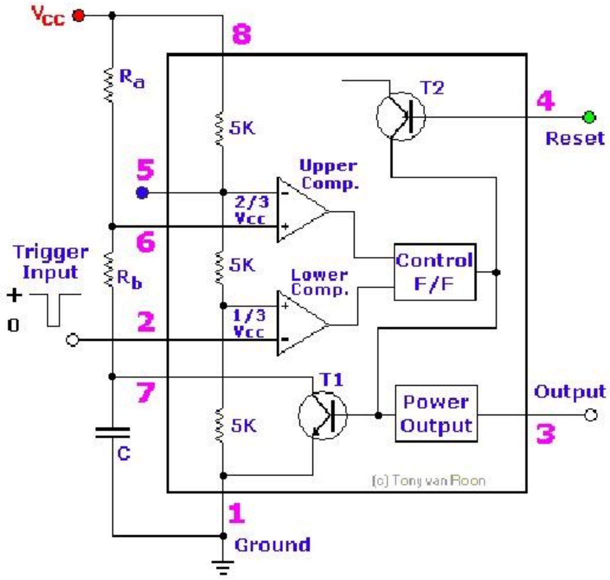
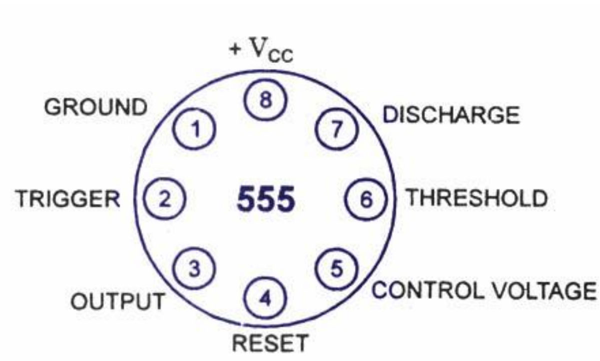
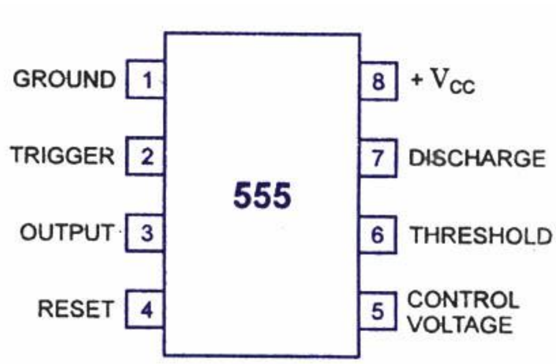


Figure 11: 555 timer block diagram



8-pin T package



8-pin V package

The descriptions of 555 Timer pin diagram as follows:

Pin 1: Ground; this pin need to connect directly to ground (0 volt)

Pin 2: Trigger; voltage lower 0.3333V, the output goes high.

Pin 3: Output; approximately 1.7volt less than supply and the output for astable mode get
pulses. Output high: Isource; when low: Isink, which both can reach up to 200mA.

Pin 4: Reset; latch is reset and the output will be low. Connect reset to Vcc if reset no need to
be used.

Pin 5: Control voltage; voltage control 555timer permit 0.6667Vcc voltage divider point.

10nF capacitor connected to ground when it is unused.

Pin 6: Threshold; related to upper comparator input which reset the output when voltage on the timing capacitor elevates greater than 0.6667Vcc.

Pin 7: Discharge; as a soon as output is low, it serve discharge path from the timing capacitor to ground

Pin 8: Vcc, Power supply which NE555 (5-18V)

There are three modes operated by 555 timer such as monostable, astable and bistable. In this project, the astable is constructed. Astable mode means no stable as the output continually alternate constantly between low and high states which called as pulse or square wave. [22]

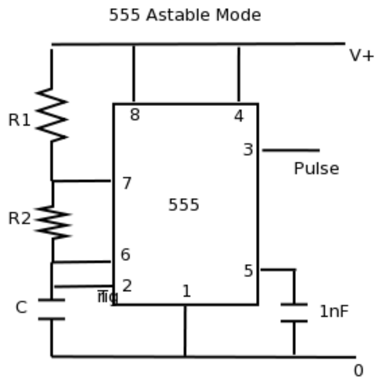


Figure 12: Basic Astable mode configuration

Pulse Time High, $t_1 0.69 * (R_1 + R_2) * C$

Pulse Time Low, $t_2 0.69 * R_2 * C$

Period of the Pulse $t = f^{-1} = 0.69 * (R_1 + 2R_2) * C$

Frequency $f = 1.44 / (R_1 + 2R_2) * C$

Duty Cycle Percentage d = *High time/Pulse Period = High/t %* or

$$\frac{T1}{T1 + 12} * 100\%$$

For the percentage of duty cycle, it is recommended at 67% and it is a must to ensure that it is above 50%. [23]

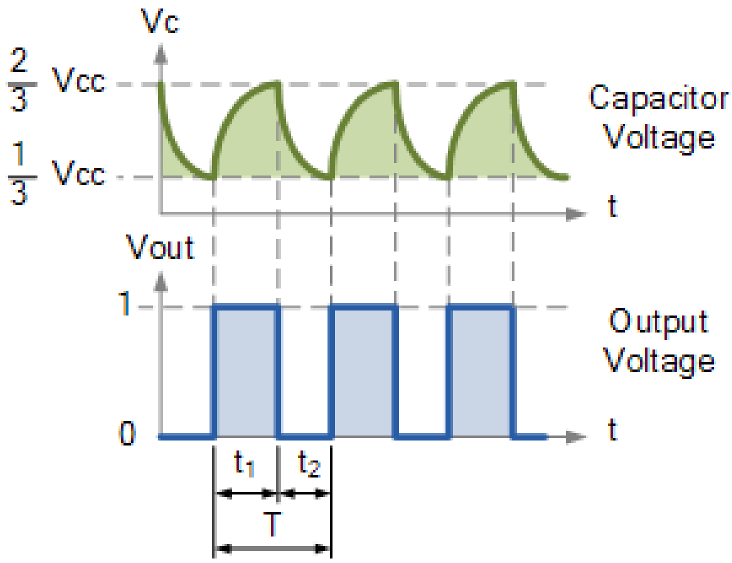


Figure 13: Astable mode waveform (capacitor and output voltage)

2.5 Arduino Microcontroller

There are many types of microcontroller chip exist nowadays for example, ATMEGA, Arduino, Parallax, and Microchip (PIC Microcontroller). Arduino is chosen because it is inexpensive, able to simplify the process or operational with microcontrollers, and also can run on windows, mac and linux (cross platform) which is simple and clear programming environment. Arduino is a physical piece of hardware; necessitate employing in a programming environment to a community and philosophy. Arduino presented in many hardware varieties such as Arduino Microcontroller such as Arduino Mega 2560, UNO, NG, Diecimila, Duemilanove, Mega ADK, Lilypad, Mini and Nano, please refer to Table 2.1 [15-16]. Arduino UNO is selected since Arduino projects can be stand-alone or can be communicate with software and it is the most practicable also suitable for basic purpose. [15]

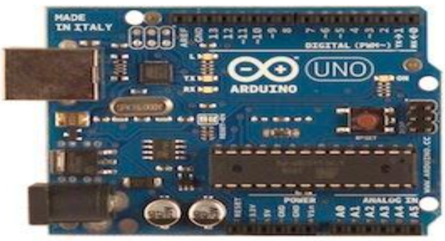
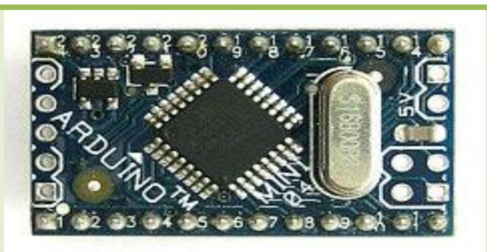
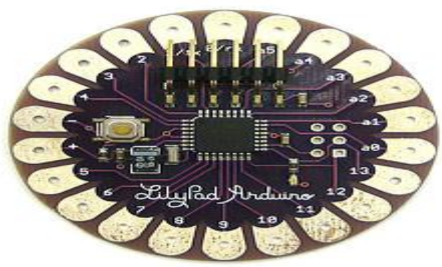
 **Arduino Uno**	 **Arduino MEGA**
 **ArduinoProMini**	 **Arduino Nano**
 **Arduino Bluetooth**	 **ArduinoLilypad**

Table 1: Arduino hardware varieties

Characteristics	
It capable run on Windows, Mac OS X, Linux The languages: Wiring/Arduino, C/C++ Provided getting started guides which are clear step-by-step instructions, from download to blinking LED. Knowledge base: • Many simple examples included with download • Good reference guide to the commands • Large knowledge base on Arduino site and elsewhere	
Advantages	**Disadvantage**
• Can be run as I/O board, using Firmata firmware • Very large knowledge base • Simple language, but expandable using C/C++ • Multiple models, for shields, breadboards,wearables, extra I/O pins • Many shield modules • Large number of open source derivative boards	• C language constructs (semicolons, brackets, case sensitivity) are confusing

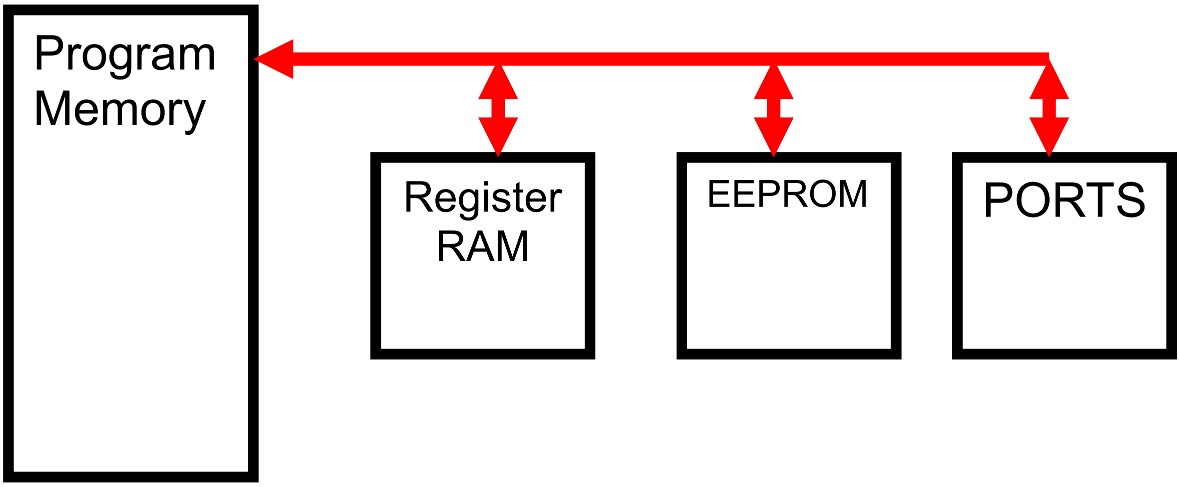
Table 2: Characteristics of Arduino

Arduino Mega	Arduino Uno
Applicable for implementing a big project	Suitable for a small project applications
Has more output (54)	Has 13 output

Table 3: Comparison of features among two Arduinos

Arduino can do to sense stuff for example using sensors such as push buttons, touch pads, tilt switches, variable resistors (for volume knob or sliders), photoresistors in favour of sensing light levels, thermistors, LM35 chip measure the temperature surrounding, ultrasound and infrared sensor (for proximity range finder). Besides that, Arduino also be able to do stuff for instance lights (LED), motors, speakers, and displays on Liquid Crystal Display (LCD).

2.6 Arduino Internal Architecture



RAM: Random Access Memory which is temporary meaning that when the system is off the data will disappear

EEPROM: Functioning to read only memory and it is store the data permanently

Program memory will instruct the port to work accordingly.

Arduino ATmega328P-PU pinout

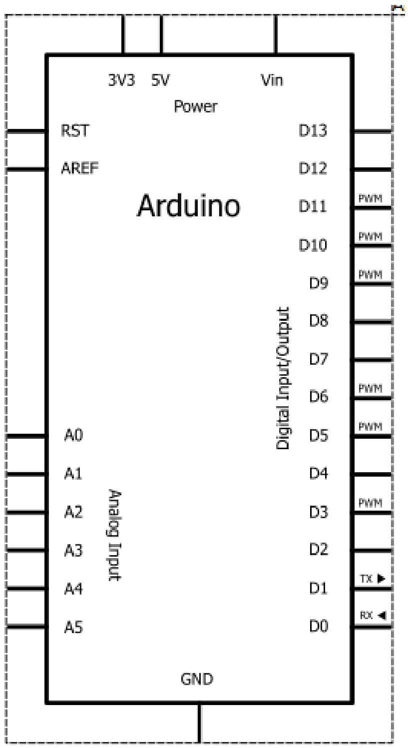


Figure 14: Arduino Pins ATmega328

Pins 0-13: Digital pins which are able the input and output can detect high “1”, and low “0”
Pins 14-19: (A0-A5),Analog pin also can function as input and output. Once there is voltage, they can measure in 1024 steps. It is useful for light, temperature, sound measurement (sense).
Pins 3,5,6,9,10,11: Special pins as its roles as Pulse Width Modulation (PWM) output. Pins 0 and 1 are act as in and out. Pins 11 is serial data output (MISO), 12 and 13 are serial data input (MOSI) and serial clock (SCK) respectively.

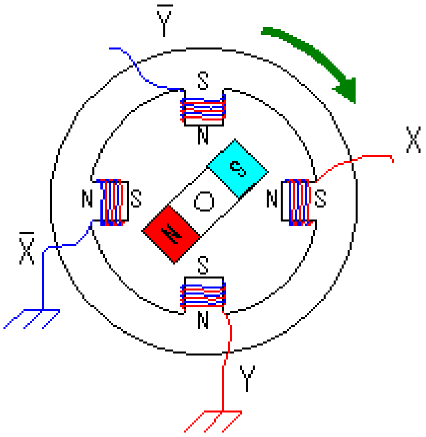
2.7 Actuator

In this project, there are two options on the selection of the actuator can be used which are stepper motor and DC servo motor. For the ease of choosing the comparison between both of them from various characteristics is summarized below. The first one is the stability. On stepper motor, the stability provided is very high and it can drive a wide range of frictional and inertial loops. Stepper motor is chose because its accuracy movement

Characteristic	Stepper Motor		DC Servo Motor	
	Advantages:	Limitation	Advantages:	Limitation
Stability	Stable. Can drive a wide range of frictional and inertial loops			Requires “tuning” to stabilize feedback loop
Efficiency		Low. Motor draws substantial power regardless of load	High. It can approach 90% at light loads	
Safety	Safe. If anything breaks, the motor stop			Motor “runs away when something breaks. Safety circuits are required
Output Power		Low	High	
Life	Long life.			Limits life to 2000 hours (brush)
Torque to inertia ratio		Low. Cannot accelerate loads very rapidly	High. It can rapidly accelerate loads.	
Overload	Safe. Motor cannot be damaged by mechanical overload			Motor can be damaged by sustained overload
Feedback	Needs no feedback. The motor is also the position transducer	No feedback to indicate missed steps		Requires “tuning” to stabilize feedback loop

Table 4: Comparison of actuator

2.8 The Operation of Stepper Motor



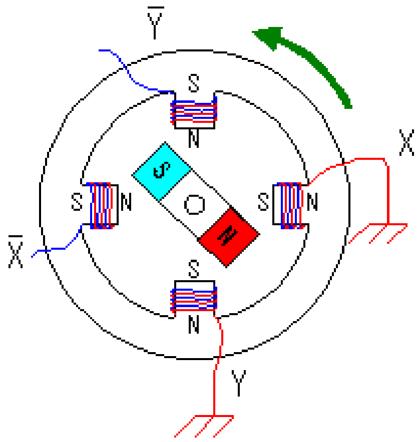
X	$\bar{X}$	Y	$\bar{Y}$
0	1	0	1
1	0	0	1
1	0	1	0
0	1	1	0

Clockwise control

X, $\bar{X}$, Y and $\bar{Y}$ are controlled in the following order.

X	$\bar{X}$	Y	$\bar{Y}$	Step angle
0	1	0	1	0°
1	0	0	1	90°
1	0	1	0	180°
0	1	1	0	270°

"0" means grounding.



X	$\bar{X}$	Y	$\bar{Y}$
0	1	0	1
0	1	1	0
1	0	1	0
1	0	0	1

Counterclockwise control

X, $\bar{X}$, Y and $\bar{Y}$ are controlled in the following order.

X	$\bar{X}$	Y	$\bar{Y}$	Step angle
0	1	0	1	0°
0	1	1	0	-90°
1	0	1	0	-180°
1	0	0	1	-270°

"0" means grounding.

2.9 Wire Connection Diagrams

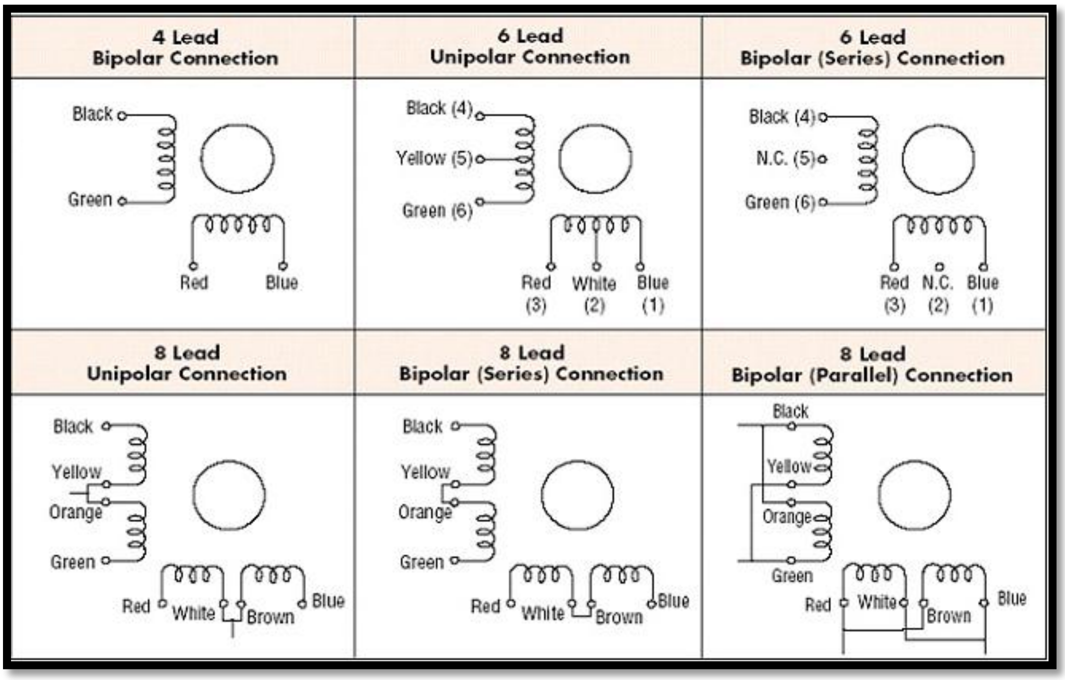


Figure 15: Wire connection diagrams

3.0 METHODOLOGY

3.1 Project Work

For starter, the methodology explained will just describe the general flow during the period of this project. Firstly, the project will start with the preliminary research work in order to get more clear view on this project and identify problem statement in accordance to the project. After that, it will continue with the literature review that will focus on the object tracking and the implementation of the algorithms to the hardware. Then, it is followed by the experimental work where the construction coding for selected algorithm to the microcontroller and the result obtain will be evaluate and further analysis will be done to identify the area that need to be modified. The project work contains several keys activities. Refer to Figure 14.

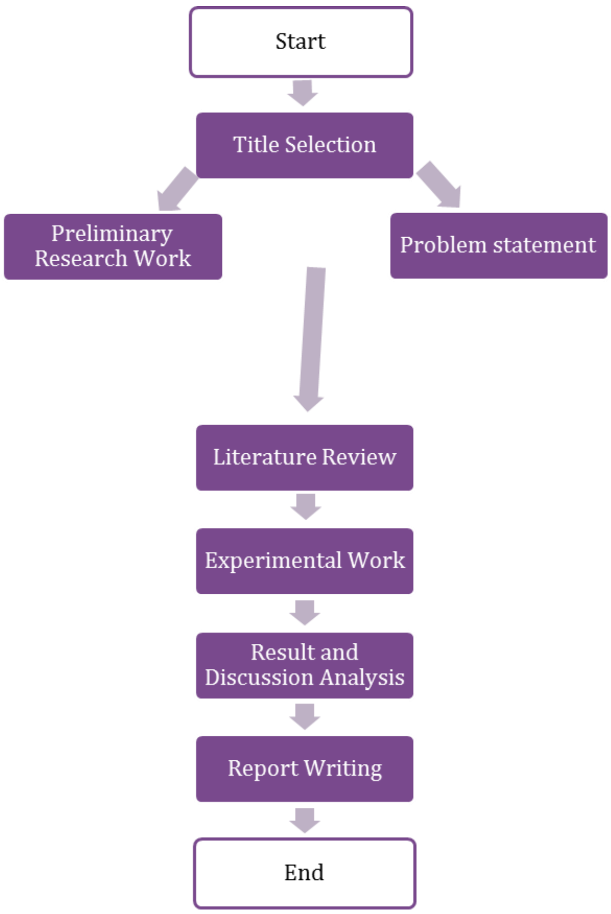


Figure 16: Project activities flow

3.2 Object Tracking Closed-Loop Control System

Below is the closed-loop control system (refer Figure 15) where inside the dot line is microcontroller Arduino Uno. SP can be defined as the set point, for positioning sensors used are infrared and the actuator is stepper motor

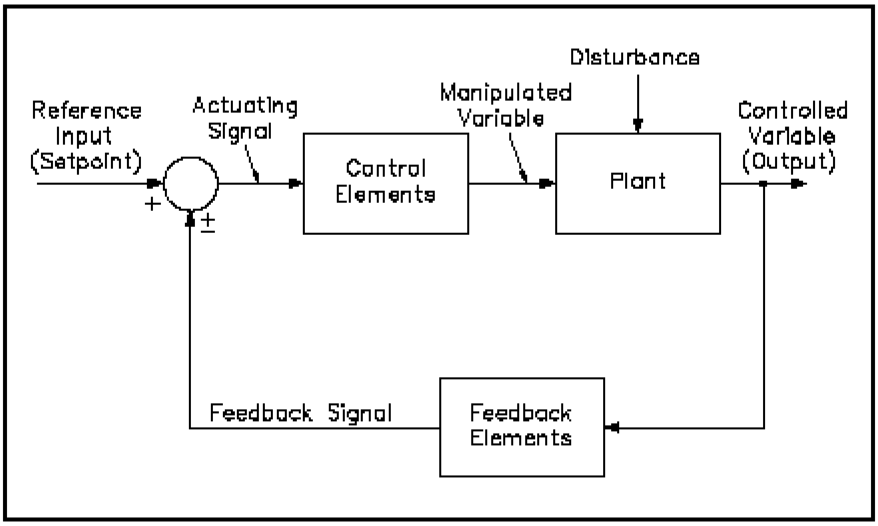


Figure 17: General closed loop system block diagram

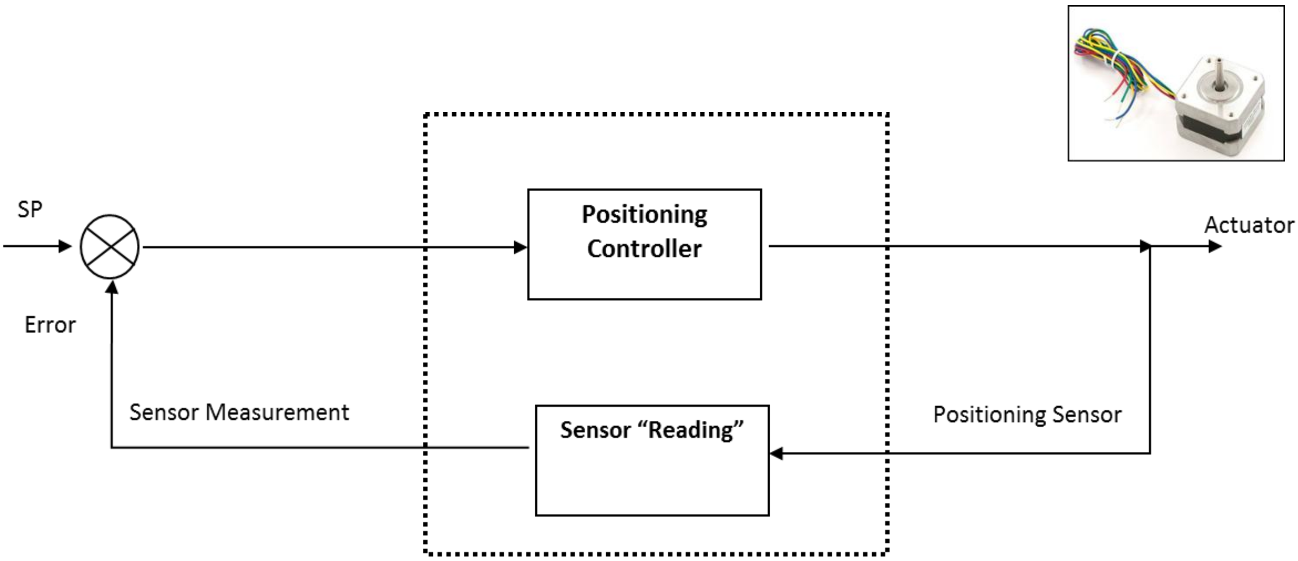


Figure 18: Object tracking closed loop system block diagram

Pseudo code for stepper motor control

1) Initialize ports

   Pin 1-4 outputs to stepper motor

   Pin 1 to wire A, Pin 2 to wire B, Pin 3 to A’, Pin 4 to B'

   Pin 13 output to LED

   Pin 5 input from infrared sensor (receiver), which receives signal from infrared transmitter
2) Pin 5 – gets signal from infrared
3) Pin 1-4 – stepper motor turns clockwise approximately in 180 degrees for 1100, 0110, 0011, 1001

3.3 Gantt Chart

No	Detail/Week	1	2	3	4	5	6	Mid-Semester Break	7	8	9	10	11	12	13	14
1.	Selection of Project Topic: Object Tracking															
2.	Preliminary Research Work: Research on literatures related to the topic															
3.	Submission of Extended Proposal Report															
4.	Proposal Defense															
5.	Submission of Extended Proposal Defense															
6.	Project work continues: Further investigation on the project and do modification if necessary															
7.	Submission of Interim Report Draft															
8.	Submission of Interim Report Final Draft															

Figure 20: Gantt chart for FYP1

3.4 Key Milestone

FINAL YEAR PROJECT 1															
No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Completion of preliminary research work (Set up Arduino Microcontroller)														
2	Completion of Interim Report (Draft and Final)														

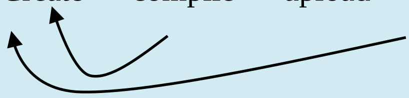
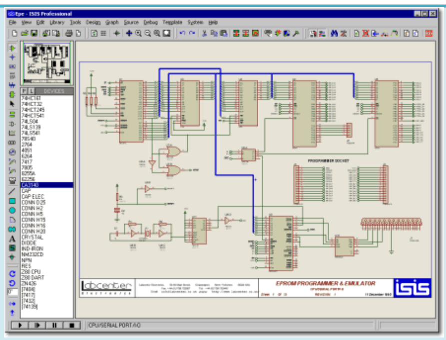
FINAL YEAR PROJECT 2															
No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
3	Connect Microcontroller to Stepper Motor														
4	Integration sensor into Microcontroller and Stepper Motor														
5	Completion of results analysis and discussion														
6	Completion of final documentation														

Figure 21: Key milestone for FYP1 and FYP2

3.5 Tools and Hardware Required

Software	Hardware
Arduino Integrated Development Environment (IDE)	Stepper Motor
Fritzing Software	Stepper Motor Circuitry
ISIS Professional 7.10	Voltage Regulator Circuitry
IronCAD 10.0	Battery / Power Supplies
	Arduino Uno Microcontroller
	USB Cable
	Infrared Sensors
	Sensors Circuitry
	555 Timer (NE555N)
	Jumpers

Table 5: Tools and hardware required

Software	Characteristics
 Arduino Integrated Development Environment (IDE)	The steps involved are: Create → compile → upload → run → finish  It allows the process of programming to be much faster [24] Designed with C/C+ library There are two functions : • setup() • loop()
Fritzing Software	Able to generate a Printed Circuit Board (PCB) design in order to record Arduino-based prototype. It is an Electronic Design Automation (EDA) and breadboard based prototype.
 ISIS Professional 7.10	Utilise the tools also for Printed Circuit Board (PCB) layout to generate a professional schematic Retain a basic simulation also can be implement for microcontroller

Hardware

	
Stepper Motor	Power Supply +9V and +6V
	
Arduino Uno Rev3	**USB cable**
	
NE55N	Jumper (Male to male)

4.0 RESULTS AND DISCUSSION

4.1 Infrared Receiver

4.1.1 Construction of Digital Infrared Receiver Circuitry

The goal of building infrared circuitry is to evaluate and identify the maximum distance that can be reached and detected by Digital infrared receiver.

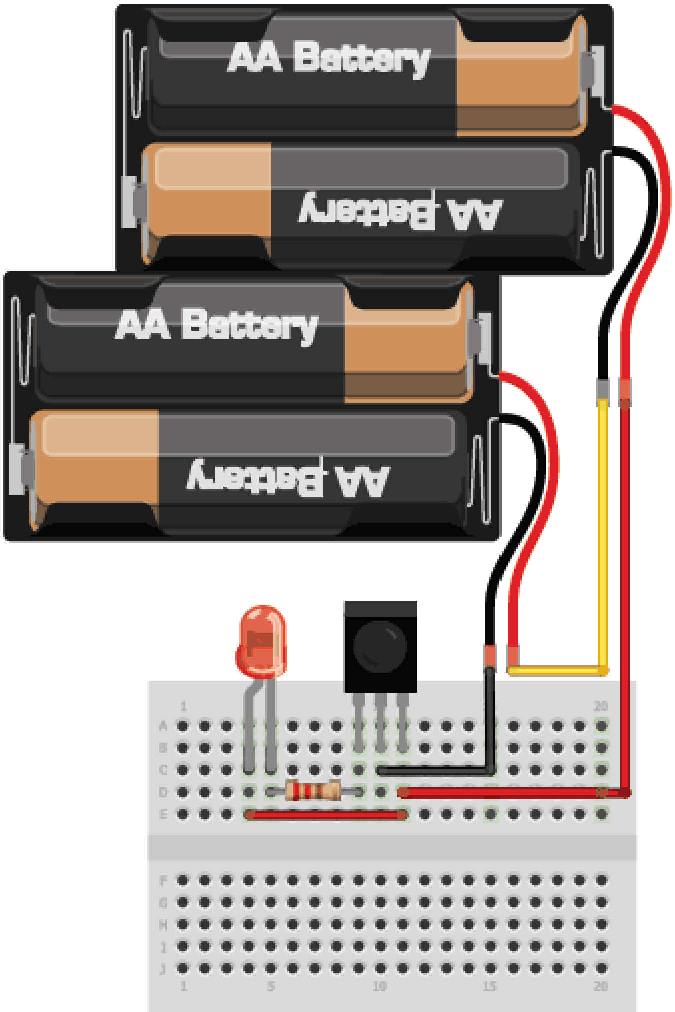


Figure 22: Schematics of digital infrared receiver circuitry[26]

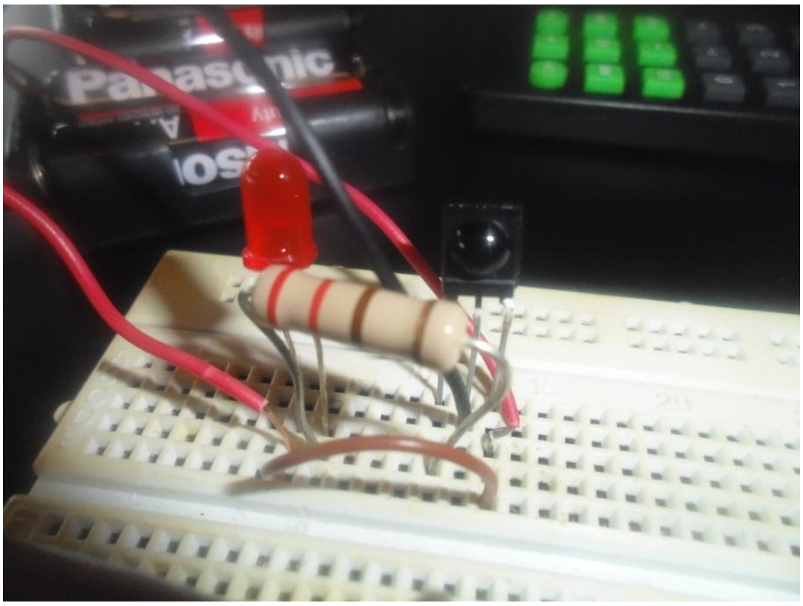


Figure 23: Digital infrared receiver circuitry

Angle degree (θ)	0	45	90	135	180	225	270	315	360
Distance max (cm)	40	22	21	17	31	320	37	36	35.5

Table 6: Result of maximum angle and distance

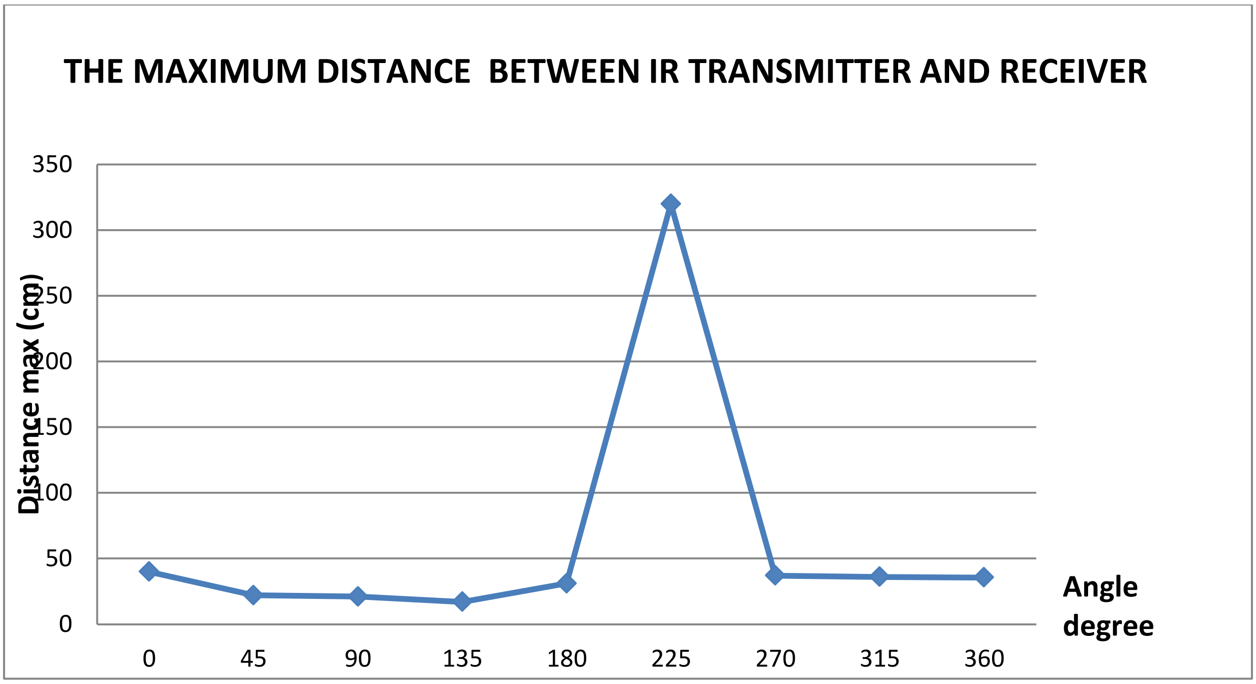


Figure 24: Maximum distance (cm) vs Angle (degree)

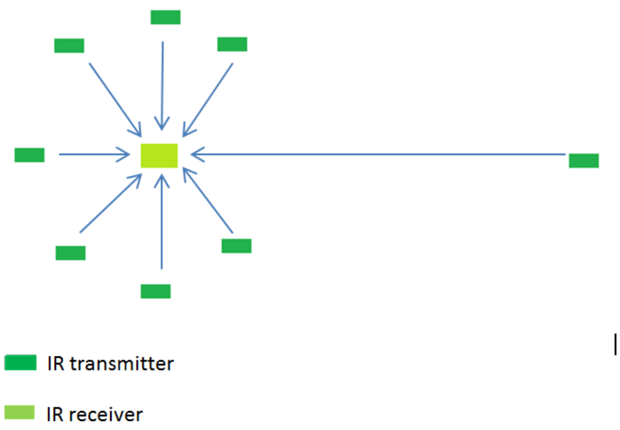


Figure 25: Layout of experimental IR receiver and IR transmitter

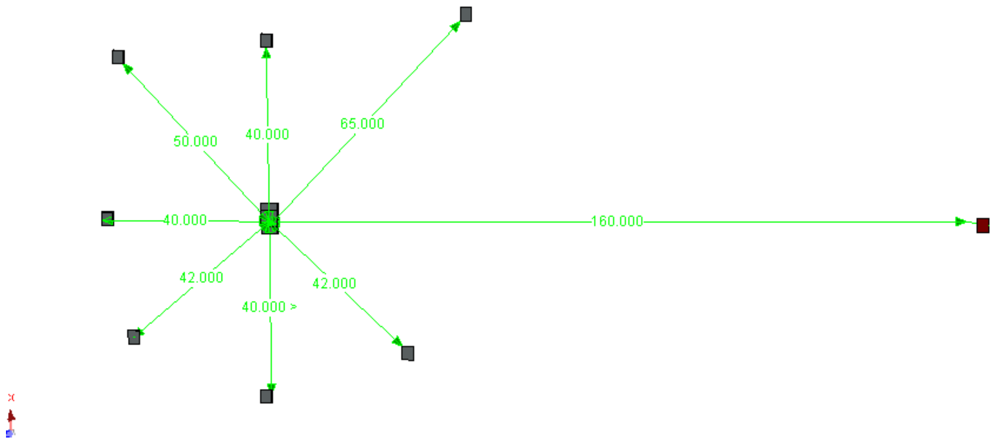


Figure 26: Distance between IR receiver and IR transmitter in different angles (IronCAD)

4.2 Infrared Transmitter

4.2.1 Construction of Infrared Transmitter Circuitry

Calculation of 555 timer

In order to select the value of 1R1, R2 and C, it is required to calculate as the formula stated before.

Select R1 to be 10kΩ and R2 is 14kΩ

$$f = \frac{1.44}{(10k + 2(14k)) * 1n} = 37.8947kHz$$

After that, sketch and design the circuit using ISIS Professional 7.0 software and Fritzing software. The schematic is shown below.

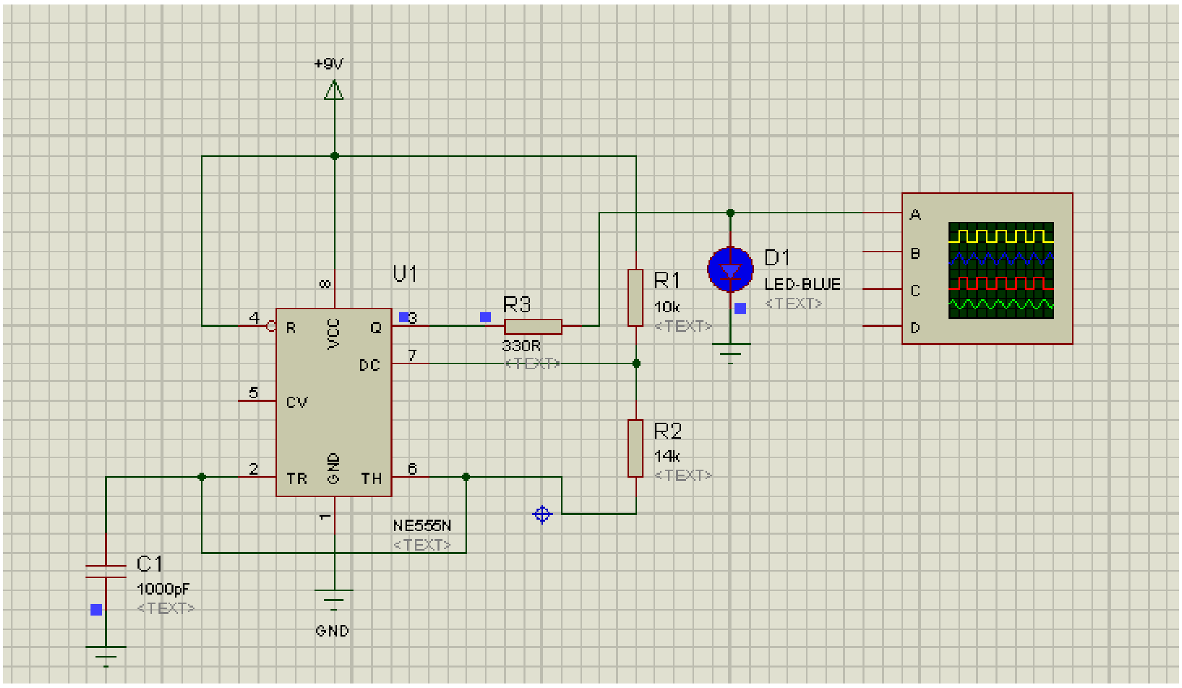


Figure 27: Schematics of 555 timer circuitry using ISIS Professional 7.0

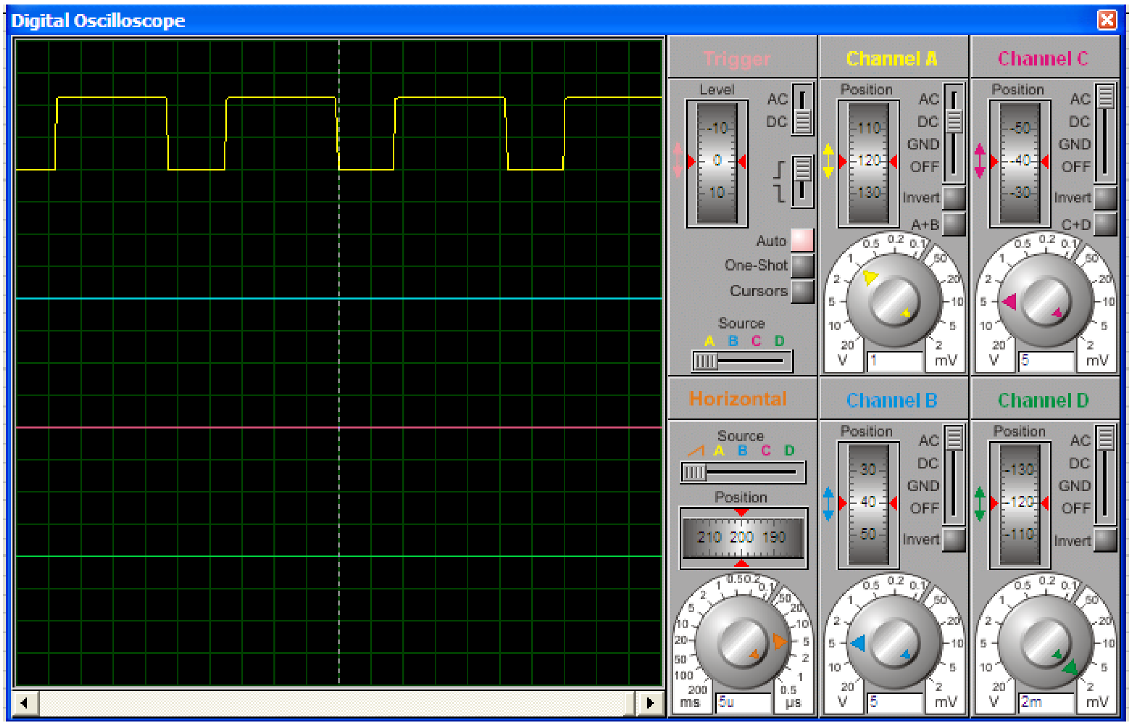


Figure 28: Graph obtained from simulation

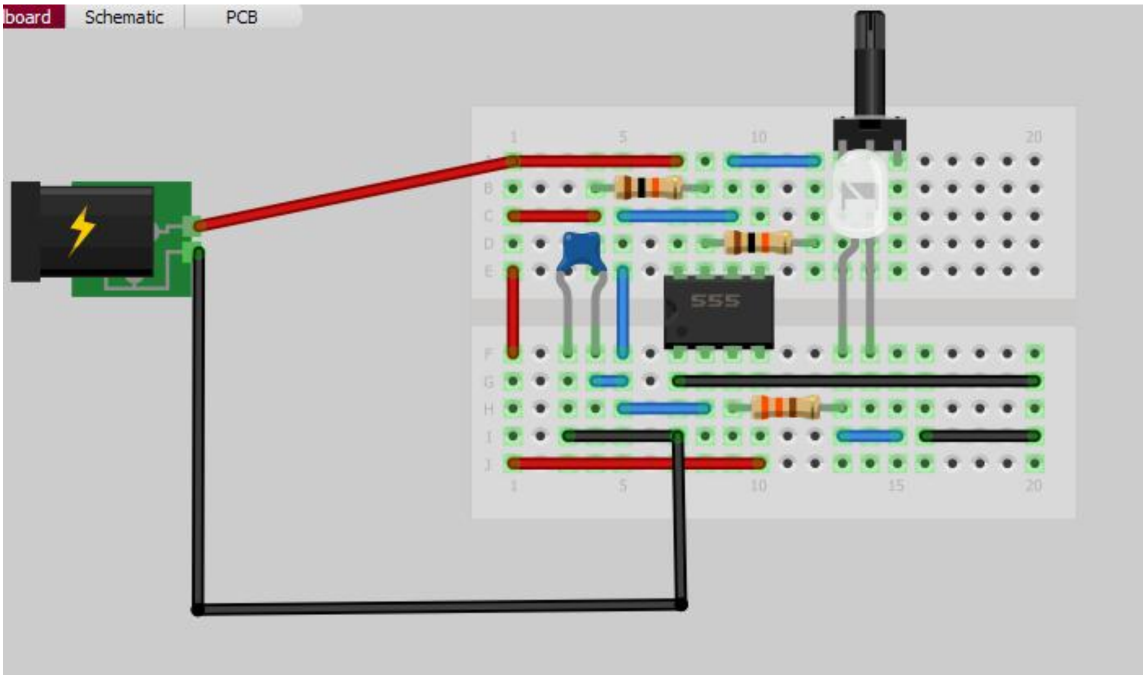


Figure 29: Schematics of 555 timer circuitry using Fritzing

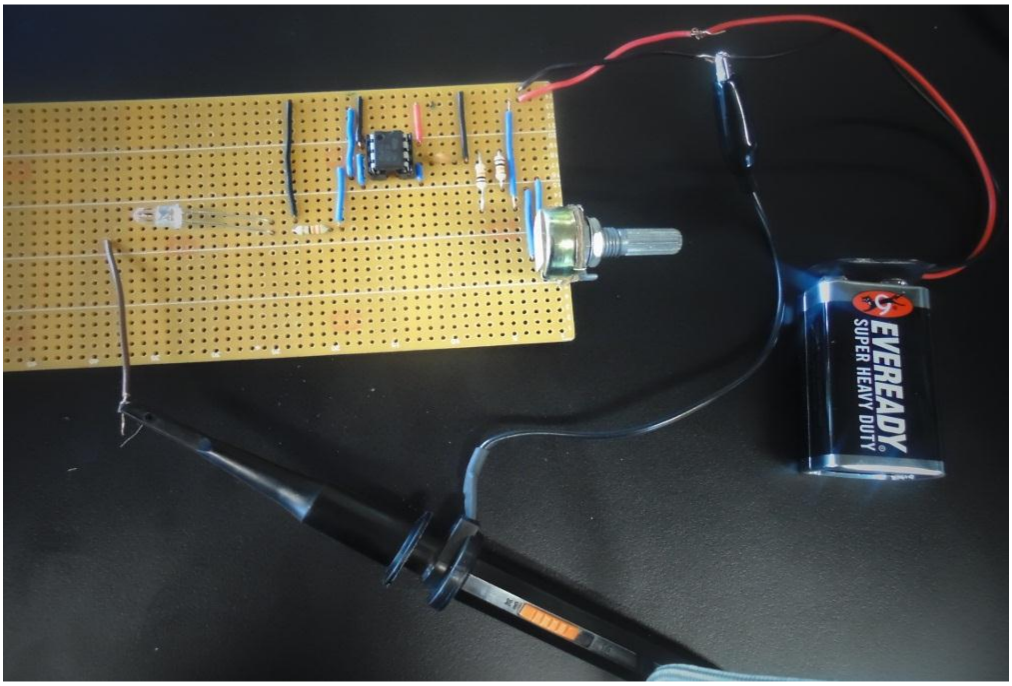


Figure 30: 555 timer circuitry connected to digital infrared transmitter

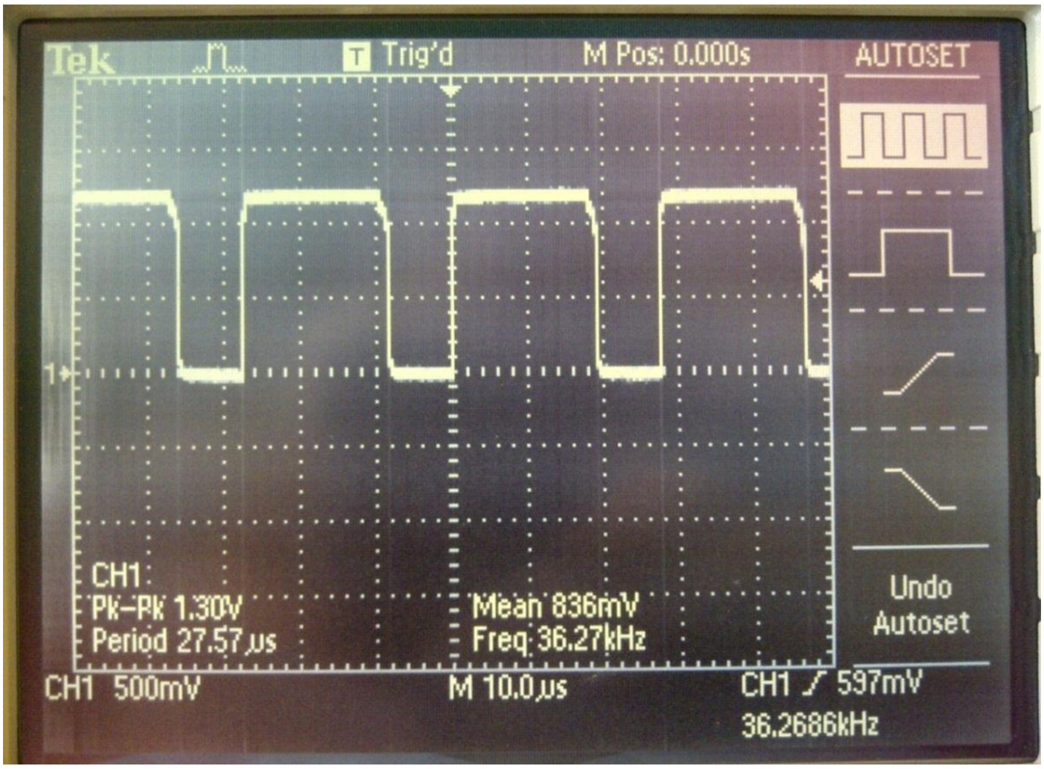


Figure 31: Graph obtained from digital oscilloscope

Maximum distance	3.2m
Frequency (mean)	36.2530kHz
Time	18μs
Output Voltage	1.3V

Table 7: IR transmitter efficiency to transmit

Reading	Desired Frequency	Actual Frequency	Percentage Error (%)
1	$37.8947kHz$	$36.2168kHz$	4.63
2	$37.8947kHz$	$36.2266kHz$	4.59
3	$37.8947kHz$	$36.2362kHz$	4.58
4	$37.8947kHz$	$36.3165kHz$	4.35
5	$37.8947kHz$	$36.2686kHz$	4.48

Table 8: Percentage errors from several trials

The percentage of error can be calculated using this formula:

$$\%Error = \frac{|Desiredvalue - Actualvalue|}{Actualvalue} x100$$

There are some errors due to human errors, systemic errors and random errors such as the calibration of digital oscilloscope has systemic error ±5%, the experimental condition and surroundings.

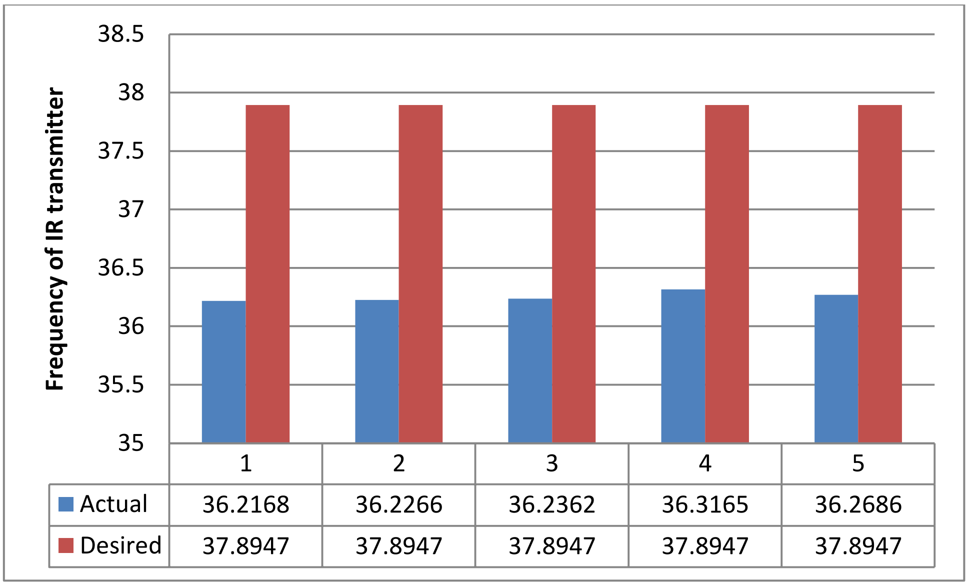


Figure 32: Graph of actual vs desired frequency value

4.3 Stepper Motor

4.3.1 Construction of Stepper Motor Circuitry

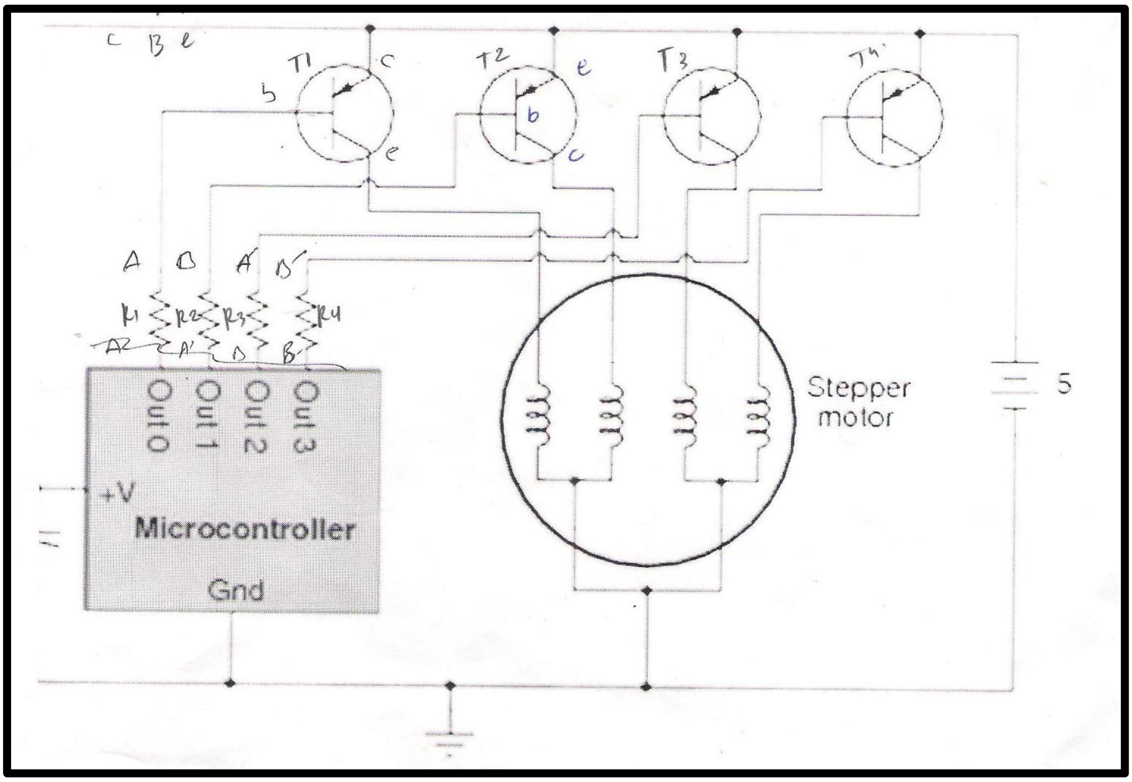
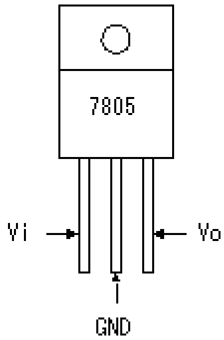
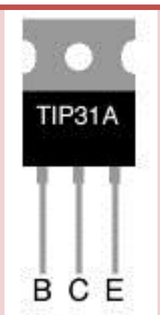


Figure 33: Schematic of stepper motor circuitry

The purpose of integrating the voltage regulator (LM78050V) is to regulate the 9V batteries output into a constant 5V voltage as stepper motor voltage input is 5V. Hence, it will prevent from letting the stepper motor impairment.

The components employed in the stepper motor circuitry are

 +9V battery and battery snap	 Voltage Regulator (LM78050V)
 Four Power Transistors	 Four Resistors (1kΩ)
 Stepper Motor	 Capacitors (100nF)

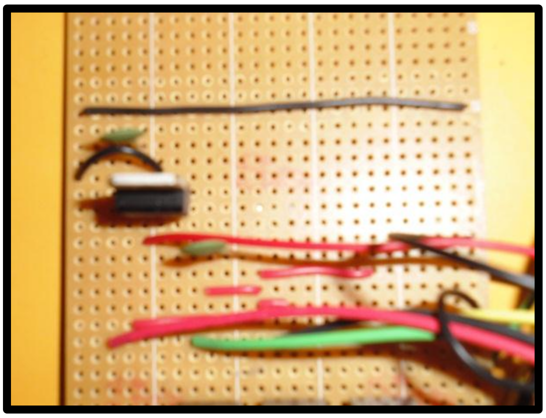


Figure 34: Voltage regulator circuitry

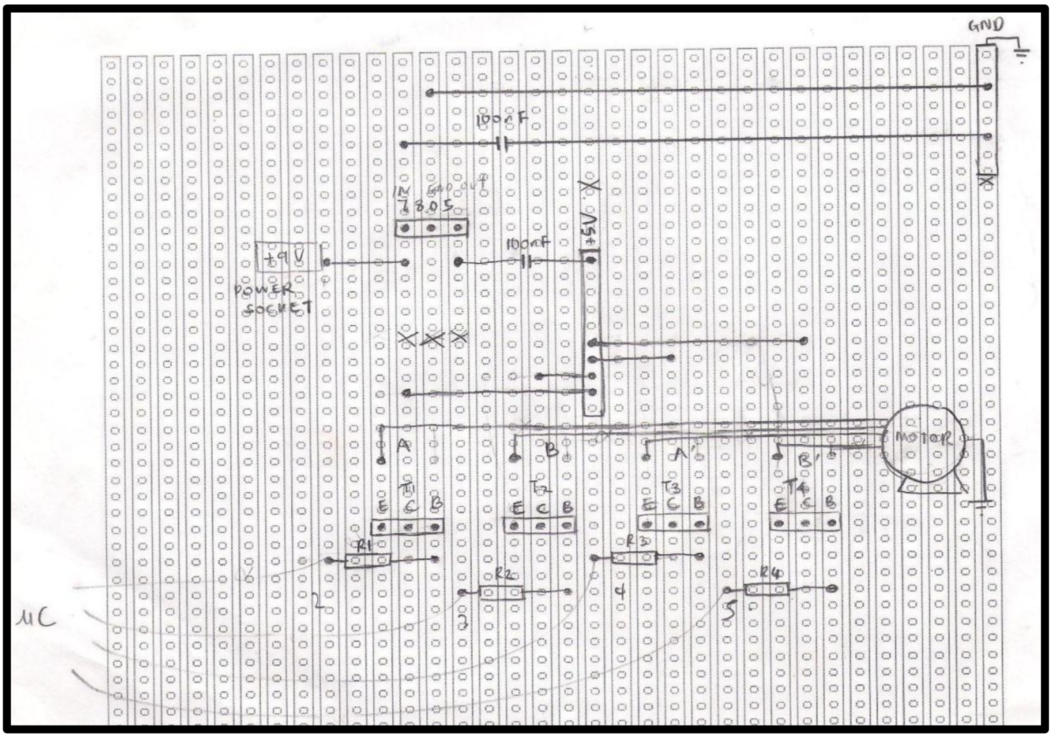


Figure 35: Schematic diagram of stepper motor and voltage regulator (veroboard)

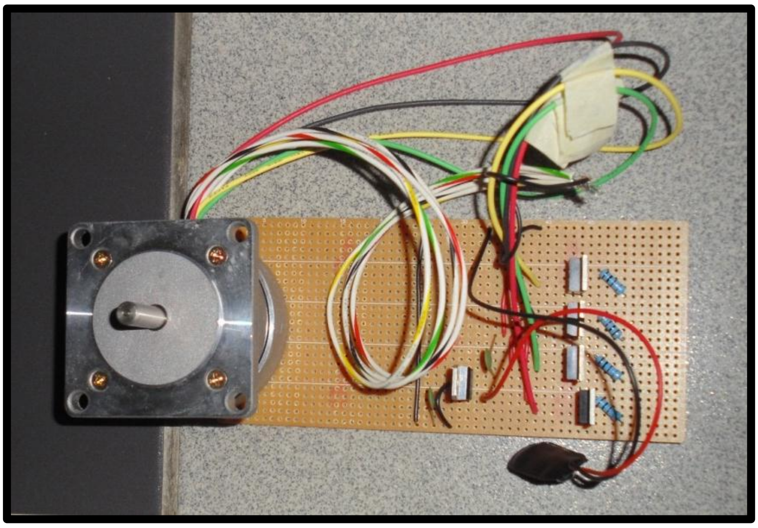


Figure 36: Circuit of stepper motor and voltage regulator

4.3 Integration of Stepper motor circuitry and Infrared receiver circuitry

The approach used is the infrared detection and tracking algorithm in Arduino Uno code, pin 5 as the input of infrared receiver. Once the digital infrared receiver caught signal, the output will be the rotation of the stepper motor. In this case, the stepper motor will turn in clockwise direction. From the project, if I want to relate this to real situation, transmitter can be described as an object that is detected by the sensor which is in this case is IR receiver. Consequently, to show that the microcontroller will further analysed data obtained from the IR receiver (input data) the output is the moving stepper motor in 180 degree approximately.

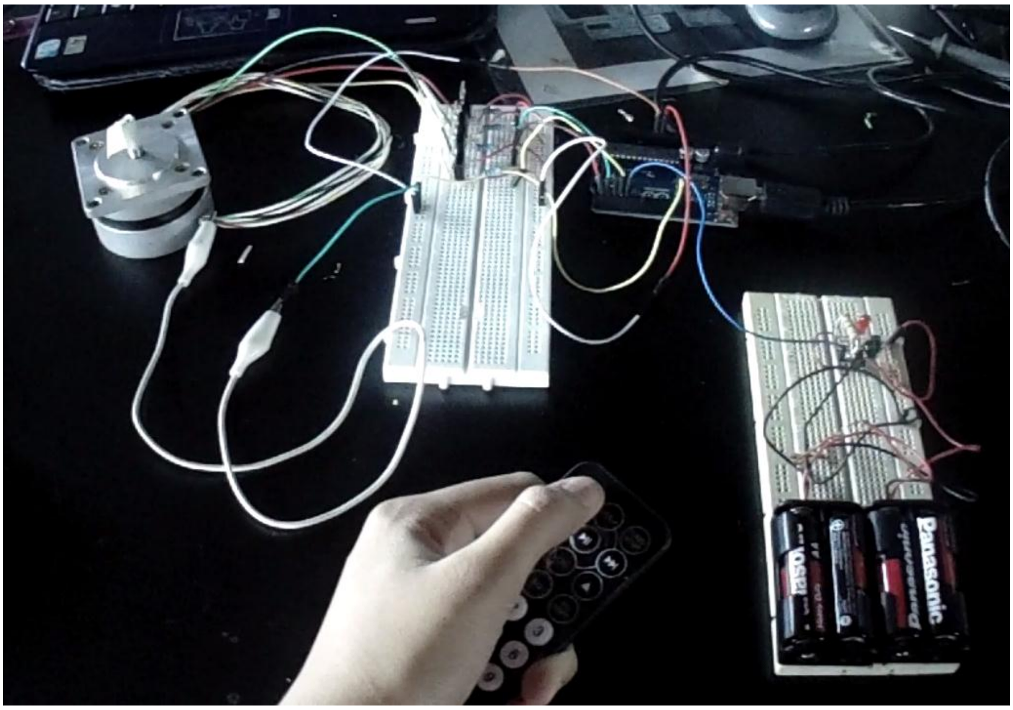


Figure 37: The integration of stepper motor and IR receiver circuitry to Arduino

Problem encountered

Sometimes, when infrared transmitter transmits to IR digital receiver, it delays a few minutes, such as the stepper motor will rotate to clockwise direction not precisely in the same time when the infrared receiver acquire the signals.

5.0 CONCLUSION

5.1 Conclusion

At the end of this project, it is shown that the object tracking is worked accordingly. The method used is infrared search and track (IRST) and closed loop system PID controller involving the stepper motor, Arduino Uno and infrared transmitter and receivers. The improvement can be further do by increasing the tracking accuracy with better algorithm such as PI controller and using the most sensitive infrared transmitter and receiver. For future extension work, complex coding can define the stability and precision of the stepper motor rotation and reaction. Adding more infrared receivers can control variety of angles and directions.

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.

APPENDIX A

DATASHEET OF STEPPER MOTOR

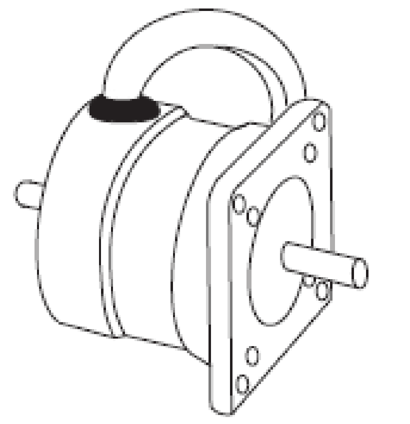
Data Pack B *Issued March 2002* **314-2258**

RS Data Sheet

Hybrid stepper motors

Size	Rear shaft	No. of wires	RS stock no.
17	No		440-420
	Yes		440-436
	No	6	191-8299
	No		191-8306
23	No	8	440-442
	Yes	8	440-458
	No	8	191-8328
	No	8	191-8334
	No	8	191-8340
	No	8	191-8356
	No	8	191-8362
	No	8	191-8378
	No	8	191-8384
	Yes	8	440-464
	No	8	440-470

1.8• step angle



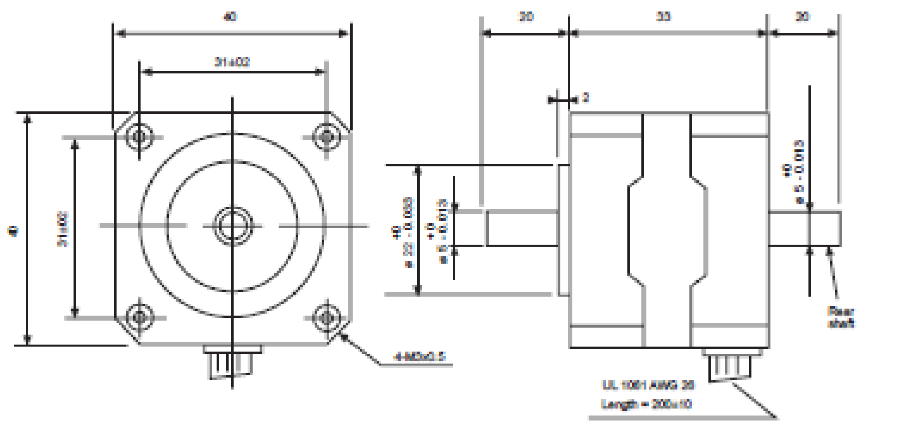
These 4 phase hybrid stepper motors are capable of delivering much higher working torques and stepping rates than permanent magnet (7.5° and 15°) types. Whilst at the same time maintaining a high detent torque even when not energised. This feature is particularly important for positional integrity. Many of the motors are directly compatible with the RS stepper motor drive boards (RS stock nos. 217-3611 & 255-9065)

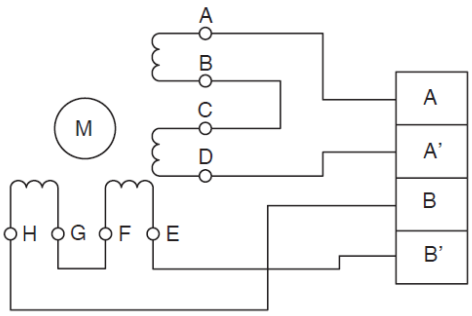
Size 34 motors and a number of size 23 motors are supplied in 8-lead configuration which allows the maximum flexibility when connecting to the drive boards.

Rear extension shafts are provided on three of the motors to enable connection of other drive requirements and feedback devices

Size 17

RS stock no. 440-436 with rear shaft shown





Step	A	B	A'	B'
1	on	on		
2		on	on	
3			on	on
4	on			on

Technical Specification

RS stock no.	440-420	440-436	440-442	440-458	440-464	440-470
Rated voltage (V)	5	12	5	12	3	2.5
Rated current (I)	0.5	0.16	1	0.6	2	4.5
Resistance (Ω)	10	75	5	20	1.5	0.56
Inductance (mH)	6	36	9	32	4.5	2.8
Detent torque (mNm)	5	4	30	30	40	100
Holding torque (mNm)	70	70	500	500	1274	2450
Step angle accuracy (%)	5	5	5	5	5	5
Step angle	1.8	1.8	1.8	1.8	1.8	1.8
Insulation class	B	B	B	B	B	B
NEMA frame size	17	17	23	23	40	40
Rear shaft	No	Yes	No	Yes	Yes	No

APPENDIX B

DATASHEET OF POWER TRANSISTOR (TIP31A)

SavantIC Semiconductor **Product Specification**

Silicon NPN Power Transistors **TIP31/31A/31B/31C**

DESCRIPTION

·With TO-220C package

·Complement to type TIP32/32A/32B/32C

APPLICATIONS

·Medium power linear switching applications

PINNING

PIN	DESCRIPTION
1	Base
2	Collector;connected to mounting base
3	Emitter

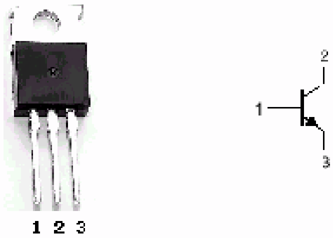


Fig.1 simplified outline (TO-220C) and symbol

ABSOLUTE MAXIMUM RATINGS(T_C=25℃)

SYMBOL	PARAMETER		CONDITIONS	VALUE	UNIT
V_{CBO}	Collector-base voltage	TIP31	Open emitter	40	V
		TIP31A		60	
		TIP31B		80	
		TIP31C		100	
V_{CEO}	Collector-emitter voltage	TIP31	Open base	40	V
		TIP31A		60	
		TIP31B		80	
		TIP31C		100	
V_{EBO}	Emitter-base voltage		Open collector	5	V
I_C	Collector current (DC)			3	A
I_{CM}	Collector current-Pulse			5	A
I_B	Base current			1	A
P_C	Collector power dissipation		T_C=25℃	40	W
			T_a=25℃	2	
T_j	Junction temperature			150	℃
T_{stg}	Storage temperature			-65~150	℃

APPENDIX C

DATASHEET OF VOLTAGE REGULATOR (LM7805)

Electrical Characteristics (LM7805)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 10V, C_I = 0.1μF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		4.8	5.0	5.2	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 7V to 20V		4.75	5.0	5.25	
Regline	Line Regulation(1)	T_J = +25°C	V_O = 7V to 25V	–	4.0	100	mV
			V_I = 8V to 12V	–	1.6	50.0	
Regload	Load Regulation(1)	T_J = +25°C	I_O = 5mA to 1.5A	–	9.0	100	mV
			I_O = 250mA to 750mA	–	4.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	0.03	0.5	mA
		V_I = 7V to 25V		–	0.3	1.3	
$\Delta V_O/\Delta T$	Output Voltage Drift(2)	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	42.0	–	μV/V_O
RR	Ripple Rejection(2)	f = 120Hz, V_O = 8V to 18V		62.0	73.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(2)	f = 1kHz		–	15.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	230	–	mA
I_{PK}	Peak Current(2)	T_J = +25°C		–	2.2	–	A

APPENDIX D

DATASHEET OF DIGITAL INFRARED RECEIVER

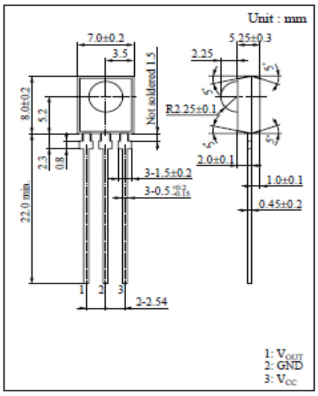
Photo IC

Panasonic

PNA4601M Series (PNA4601M/4602M/4608M/4610M)

Bipolar Integrated Circuit with Photodetection Function

For infrared remote control systems



■ Features

- Extension distance is 8 m or more
- External parts not required
- Adoption of visible light cutoff resin

■ Absolute Maximum Ratings (Ta = 25°C)

Parameter	Symbol	Ratings	Unit
Power supply voltage	V_{CC}	– 0.5 to +7	V
Power dissipation	P_D	200	mW
Operating ambient temperature	T_{opr}	–20 to +75	°C
Storage temperature	T_{stg}	– 40 to +100	°C

■ Main Characteristics (Ta = 25°C V_{CC} = 5V)

Parameter		Symbol	Conditions	min	typ	max	Unit
Operating supply voltage		V_{CC}		4.7	5.0	5.3	V
Current consumption		I_{CC}	Note 3	1.8	2.4	3.0	mA
Maximum reception distance		L_{max}	Note 1	8	10		m
Low-level output voltage		V_{OL}	Note 2		0.35	0.5	V
High-level output voltage		V_{OH}	Note 3	4.8	5.0	V_{CC}	V
Low-level pulse width		T_{WL}	Note 1	200	400	600	μs
High-level pulse width		T_{WH}	Note 1	200	400	600	μs
Carrier frequency	PNA4601M	f_0			36.7		kHz
	PNA4602M				38.0		
	PNA4608M				56.9		
	PNA4610M				33.3		

Note 1) Fig. 1 burst wave, L = L_{max}, 16 pulses
Note 2) Fig. 2 continuous wave, L ≤ L_{max}
Note 3) Light shut off condition

Carrier wave : f_0

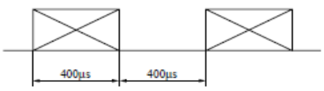


Fig.1

Carrier wave : f_0

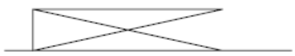


Fig.2

Panasonic 1

APPENDIX E

DATASHEET OF 555 TIMER (NE555N)

signetics

TIMER | 555

LINEAR INTEGRATED CIRCUITS

DESCRIPTION

The NE/SE 555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200mA or drive TTL circuits.

FEATURES

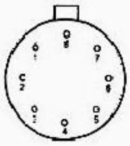
- TIMING THROUGH NINE DECADES
- OPERATES IN BOTH ASTABLE AND MONOSTABLE MODES
- ADJUSTABLE DUTY CYCLE
- HIGH CURRENT OUTPUT CAN SOURCE OR SINK 200mA
- OUTPUT CAN DRIVE TTL
- TEMPERATURE STABILITY OF 0.05% PER °C
- NORMALLY ON AND NORMALLY OFF OUTPUT

APPLICATIONS

PRECISION TIMING
PULSE GENERATION
SEQUENTIAL TIMING
TIME DELAY GENERATION
PULSE WIDTH MODULATION
PULSE POSITION MODULATION
MISSING PULSE DETECTOR

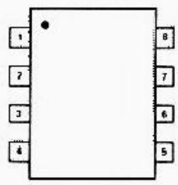
PIN CONFIGURATIONS (Top View)

T PACKAGE



ORDER PART NOS. SE555T/NE555T

V PACKAGE

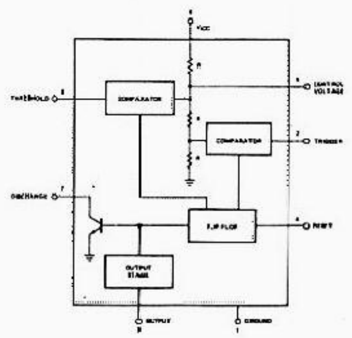


ORDER PART NOS. SE555V/NE555V

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	+18V
Power Dissipation	600 mW
Operating Temperature Range	
NE555	0°C to +70°C
SE555	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60 seconds)	+300°C

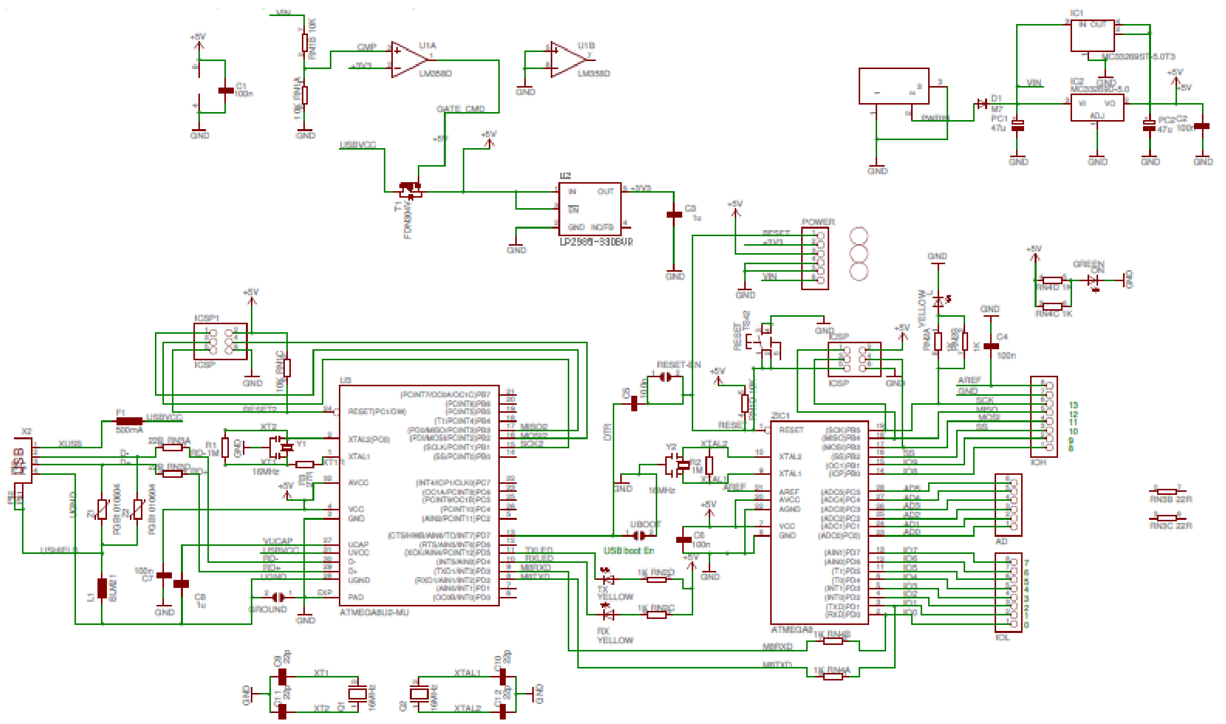
BLOCK DIAGRAM



1

APPENDIX F

LAYOUT OF CONFIGURATIONS OF ARDUINO UNO



APPENDIX G

DATASHEET OF ATMEGA328P-PU

Features

- High Performance, Low Power AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 20 MIPS Throughput at 20 MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 4/8/16/32K Bytes of In-System Self-Programmable Flash progam memory (ATmega48PA/88PA/168PA/328P)
  - 256/512/512/1K Bytes EEPROM (ATmega48PA/88PA/168PA/328P)
  - 512/1K/1K/2K Bytes Internal SRAM (ATmega48PA/88PA/168PA/328P)
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C[1]
  - Optional Boot Code Section with Independent Lock Bits
    In-System Programming by On-chip Boot Program
    True Read-While-Write Operation
  - Programming Lock for Software Security
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
    Temperature Measurement
  - 6-channel 10-bit ADC in PDIP Package
    Temperature Measurement
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Byte-oriented 2-wire Serial Interface (Philips I^2C compatible)
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
  - 23 Programmable I/O Lines
  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
  - 1.8 - 5.5V for ATmega48PA/88PA/168PA/328P
- Temperature Range:
  - -40°C to 85°C
- Speed Grade:
  - 0 - 20 MHz @ 1.8 - 5.5V
- Low Power Consumption at 1 MHz, 1.8V, 25°C for ATmega48PA/88PA/168PA/328P:
  - Active Mode: 0.2 mA
  - Power-down Mode: 0.1 µA
  - Power-save Mode: 0.75 µA (Including 32 kHz RTC)

8-bit AVR® Microcontroller with 4/8/16/32K Bytes In-System Programmable Flash

ATmega48PA
ATmega88PA
ATmega168PA
ATmega328P

Summary

Rev. 8161DS–AVR–10/09

APPENDIX H

ARDUINO STEPPER MOTOR AND INFRARED CONTROL CODE

```
/*
  Stepper_motor_1
  Driving RS stepper motor - left right - using pattern aray instead of
  silly bit set/reset.
*/

/* Stepper motor's parameters */
#define STEPS   200  // # steps for full 360 degree
                     // 1.8 degree per step -> 200 STEPS
#define MINDELAY 4  // Minimum delay between bit-changes that work for this SM

// Pin 13 has an LED connected on most Arduino boards.
int led = 13;
int pin1 = 1;
int pin2 = 2;
int pin3 = 3;
int pin4 = 4;
int ir_rx = 5;
//int dly = 10;
int sig = 0;
byte pattern[4] = {B11001100, B01100110, B00110011, B10011001};


// the setup routine runs once when you press reset:
void setup()
{
  // initialize the digital pin as an output.
  pinMode(pin1, OUTPUT);
  pinMode(pin2, OUTPUT);
  pinMode(pin3, OUTPUT);
  pinMode(pin4, OUTPUT);
  pinMode(led, OUTPUT);
}


void stepper_turn(byte dir, byte deg)
{
  int i,j,n;
  for(j=0; j<deg*STEPS/360/4; j++) {
      for(i=0; i<4; i++) {
        if(dir)    // Clock wise
            n=3-i;
        else
            n=i;
        digitalWrite(pin1, bitRead(pattern[n],0));
        digitalWrite(pin2, bitRead(pattern[n],1));
        digitalWrite(pin3, bitRead(pattern[n],2));
        digitalWrite(pin4, bitRead(pattern[n],3));
        delay(MINDELAY);
        // off unnecessary current flow at the end of each turn


        // off unnecessary current flow at the end of each turn
        digitalWrite(pin1, 0);
        digitalWrite(pin2, 0);
        digitalWrite(pin3, 0);
        digitalWrite(pin4, 0);
        delay(MINDELAY);
    }
  }
}

// the loop routine runs over and over again forever:
void loop()
{
  int x;
  sig = ~sig;
  digitalWrite(led, sig);   // Toggle the LED
  //read input pin
  x = digitalRead(ir_rx);
```

```
  // move motor
  if(x) {
    // turn clock wise 180 degrees
    stepper_turn(1,180);
  }
  else {
    // turn ACW 180 deg
    //stepper_turn(0,180);
  }
  delay(20);        // smaller = faster reaction
}
```