SELF MOVING TROLLEY USING INFRARED SENSORS

By

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FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Electrical Electronics Engineering Programme
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Approved:

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Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
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JUNE 2007

CERTIFICATION OF ORIGINALITY

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

Shafaf bt Rohaizak

ABSTRACT

This report embodies the work done by the author for her Final Year Project titled '*Self-Moving Trolley Using Infrared Sensors*'. In the modern world, due to technological advancements and increased comforts, people want to get things done very easily. Accordingly, this project aims to ease consumers while doing their shopping. Instead of having to manually push the trolley, they can make the trolley follow them around. The self-moving trolley is activated using IR sensors. A PIC microcontroller is programmed to enable the trolley to perform simple functions like move forward, stopping and turning. The direction of the dc motors used is controlled by H bridge circuits. A section of this report will be devoted to explain the results obtained after testing the designed circuits.

ACKNOWLEDGEMENTS

In The name of Allah the Most Beneficent, the Most Merciful

The author would like to give special recognition to Dr Mumtaj Begam Kasim for allowing the author to do her Final Year Project under her supervision. Her countless number of assistance and guidance had motivated the author throughout the duration of the project. Without her relentless effort to guide and supervise, the project will not have been completed.

Very special thanks to Dr. John Ojur Dennis, who has helped the author with the IR sensor circuits. To Mr. Patrick Sebastian, his help in giving ideas and programming skills is highly appreciated.

To Ms. Siti Hawa who has given the author numerous technical supports as a lab technician. She had reviewed the provisional draft for the final report and continuously provided thorough and insightful comments for the benefit of the author.

Lastly, to all others whose names the author has failed to mention, but has in one way or another contributed to the accomplishment of this project. Naturally, remaining errors of commission or omission remain my responsibilities.

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LIST OF ABBREVIATIONS

IR	Infrared
PWM	Pulse Width Modulation
TX	Transmitter
RX	Receiver
PIC	Programmable Integrated Circuit
IC	Integrated Circuit

CHAPTER 1
INTRODUCTION

1.1 Background of Study

1.1.1 Infrared Discovery

The discovery of infrared radiation is ascribed to William Herschel, in the early 19th century. Hershell published his results in 1800 before the UK Royal Society. He used a prism to refract light from the sun and detected the infrared, beyond the red part of the spectrum, through an increase in the temperature recorded on a thermometer. He was suprised at the result and called them "Calorific Rays". The term Infrared did not appear until late in the 18th century [1]. A part of the electromagnetic spectrum can be observed from Figure 1.1 below.

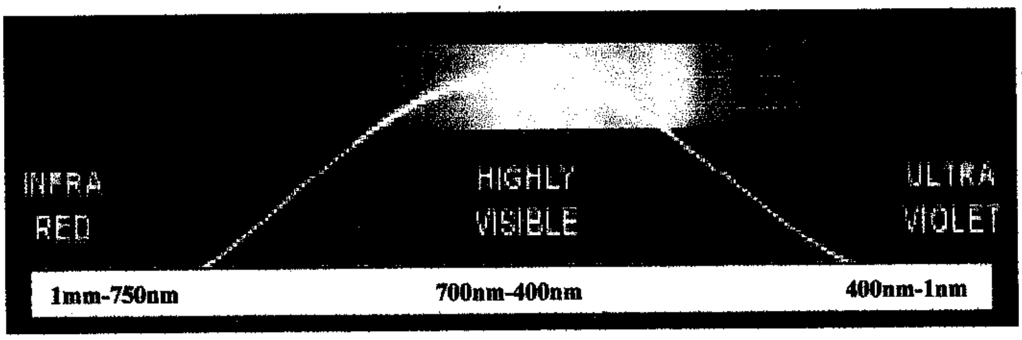


Figure 1.1: The Light Spectrum

Infrared is an energy radiation with frequency below our eyes sensitivity, so we can not see it. The name **infra** means "below red" (from the *Latin infra,* 'below'), red being the color of visible light of longest wavelength. Infrared radiation spans three orders of magnitude and has wavelength between approximately 750nm and 1mm. [2]

Infrared radiation is easily generated and does not suffer electromagnetic interference, so it is nicely used in communication and control. But at the same time it is not perfect, some other light emission could contain infrared as well, and that can interfere during communication. Nowadays, infrared radiation finds intense application in medical filed and even in military. Among the applications are night vision goggles, other imaging devices, heating, communication and even for biological systems [3]. The most common application of the infrared sensor is through the application of remote controls. In this project, IR sensors are used as medium of communication between the person holding the transmitter and the trolley.

1.1.2 Basic features of PIC 16F877A

PIC Microcontroller is used in this project as the 'brain' of the trolley. The PIC receives input from IR sensors and outputs logic signals of 1s and 0s through predetermined ports, according to the code programmed. The outputs will control the H Bridge circuits, which in turn will control the electric motors of the trolley.

PIC 16F877A is chosen in this project because it is low in cost despite of its powerful functions. Microchip Technology manufactures a variety of microcontrollers in the PIC family that have different combinations of features. The MCU uses the Reduced Instruction Set (RISC) Architecture. The core blocks are similar to those of microprocessor. The main difference in the MCU is that it also incorporates onboard

RAM, EPROM (for program and data storage), and peripherals which would be externally interfaced on a microprocessor systems.

The I/O ports has bidirectional pins that can be set up for input (the MCU reads the data on the pins) or output (the MCU sets the value on the pins). For output, each pin has internal latches to continue to drive the output that is set on them by the MCU program. Figure 1.2 shows a generic layout of the architecture of the MCU.

One useful peripheral is the Capture/Compare/ PWM(CCP). This module allows the MCU to watch an input until it reaches a certain value, and then take some action. It is especially useful for implementing Pulse Width Modulation. The PWM technique is widely used for controlling speed of DC motors. Details on the functions of the PIC 16F1877A can be found in Appendix C.

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes

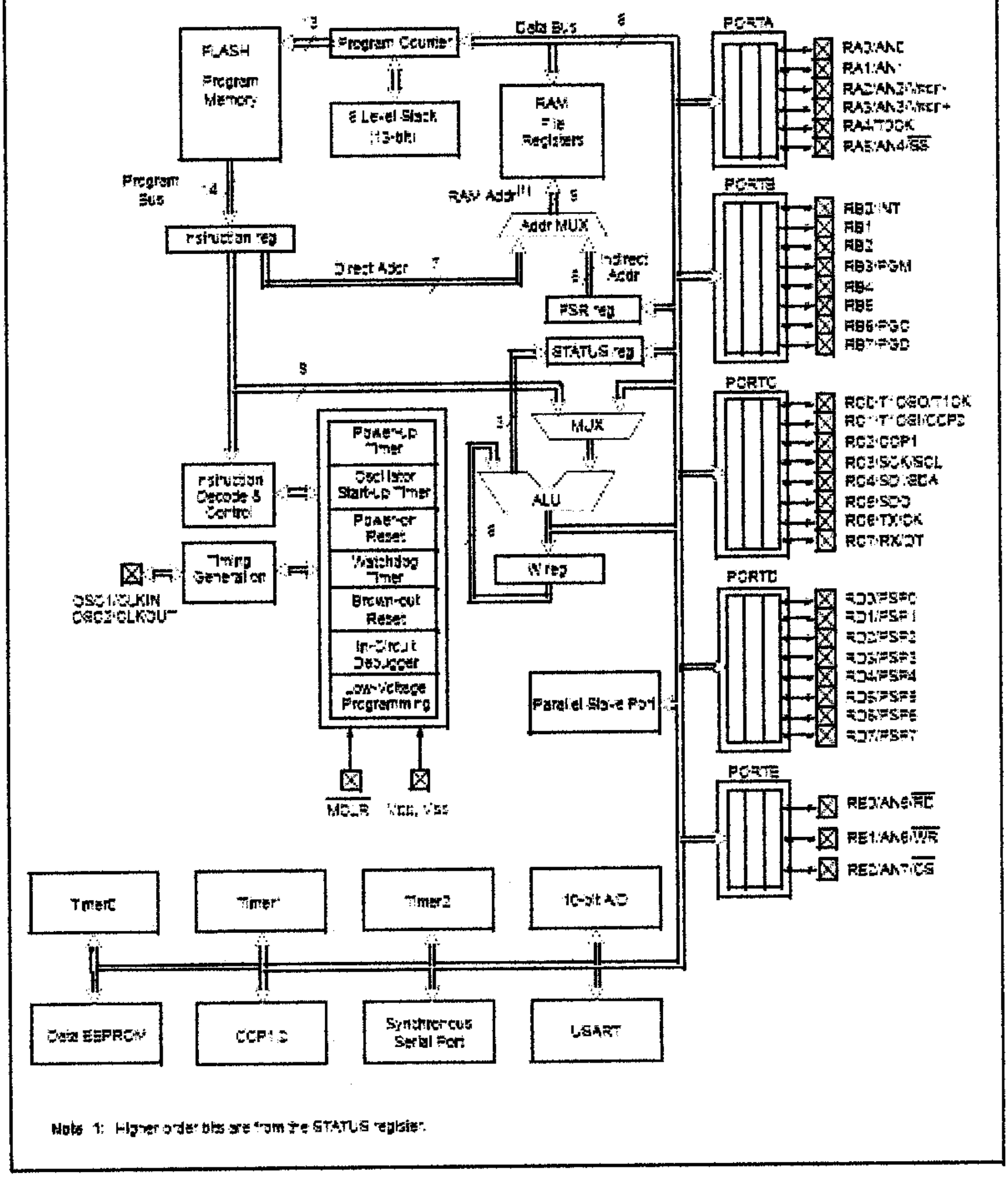


Figure 1.2: The Architecture of the PIC 16F877A. [4]

1.2 Problem Statement

Shopping carts provided at the hypermarkets for consumers might ease the trouble of carrying the load using baskets. However, these shopping carts can be quite difficult to maneuver once it is fully loaded as it will be very heavy to push. In addition, consumers are unable to anticipate what lies in front of them while pushing the trolley. This usually will result to people accidentally knocking on some things or even worse, another person while pushing their trolley. In addition to that, this contraption could especially help the disabled people to handle their shopping carts on their own. If required, with alterations, the prototype trolley could be extended for use in warehouses to handle goods.

This project was initiated to offer a solution for ease of consumers while doing their shopping in hypermarkets. The IR transmitter is carried by the shopper. The self-moving trolley is attached with two IR receivers to detect the signal. When the shopper moves away from the trolley in a straight direction, the receiver will send the signal to the PIC to activate the motor control circuit. Using PWM technique, speeds of motors will be controlled according to desired conditions.

This trolley will be programmed to face the shopper always. If the shopper turns, the trolley will also turn to follow him/her around. This action of turning will be realized by the usage of two different receivers attached at the front portion of the trolley. Both should always detect the IR signal at all time. Thus, when the shopper turns to the left, the signal on the right side of the trolley will not be detected. The PIC will interpret this to control circuit for the wheel on the right only. Consequently, the trolley will turn to the left, facing the shopper once again. Figure 1.3 (a), (b) and (c) illustrates, from top view, the movements of the trolley depending on the movements of the shopper.

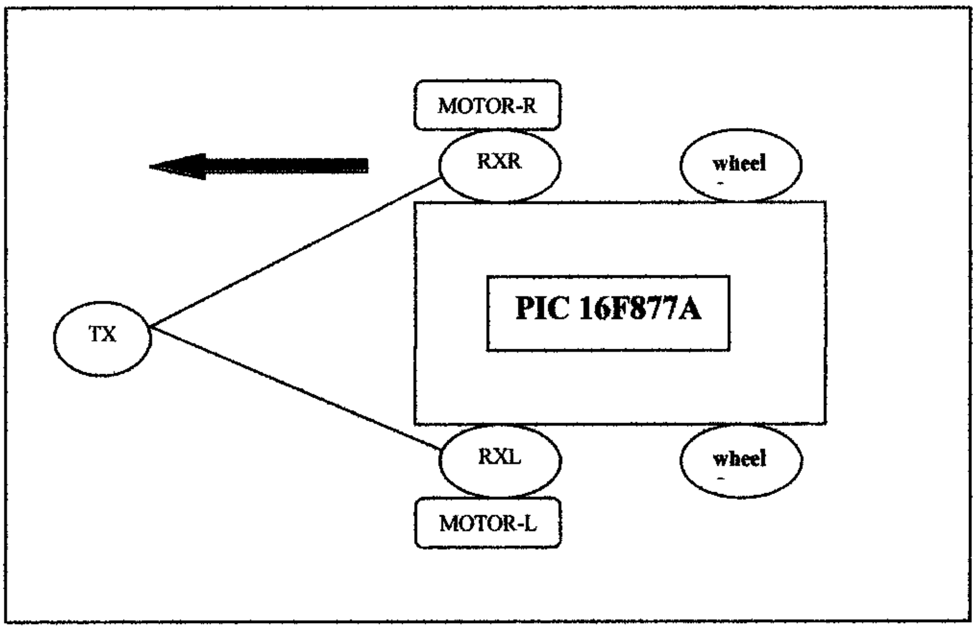


Figure 1.3(a): Trolley at Default

In Figure 1.3(a), when the sensors are turned ON, trolley will move forward. The trolley will follow the transmitter in a straight path until the transmitter is switched off. The PIC activates the motor control circuits to rotate both front wheels at PWM of 100%.

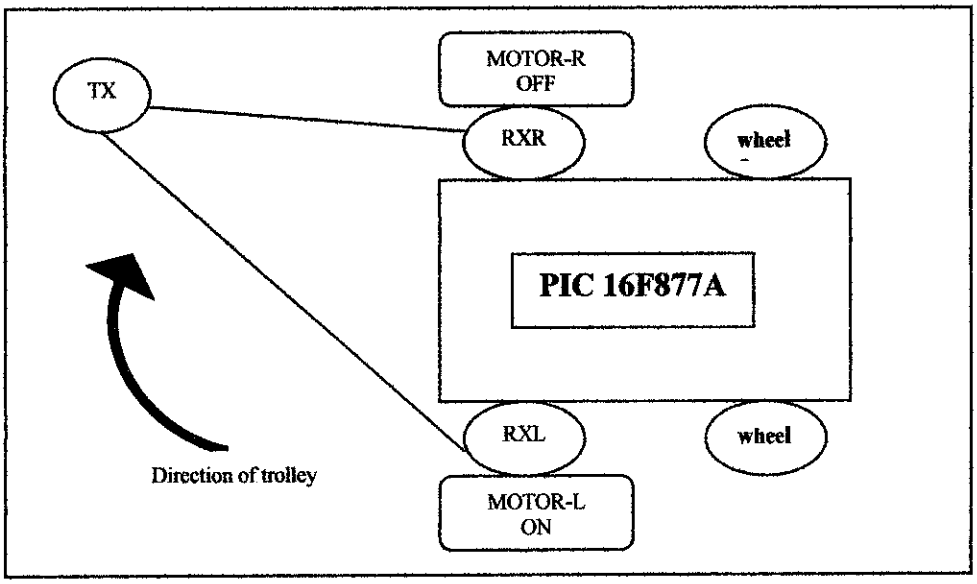


Figure 1.3(b): Production of a Right Turn by the Trolley

In Figure 1.3(b), when TX moves to the right, the left receiver will not be able to detect the signal. The PIC will activate the motor control circuit on the left side of the trolley. Speed of MOTOR-R will be reduced to 50% of PWM and MOTOR-L will maintain at 100%. This will produce a right turn movement of the trolley.

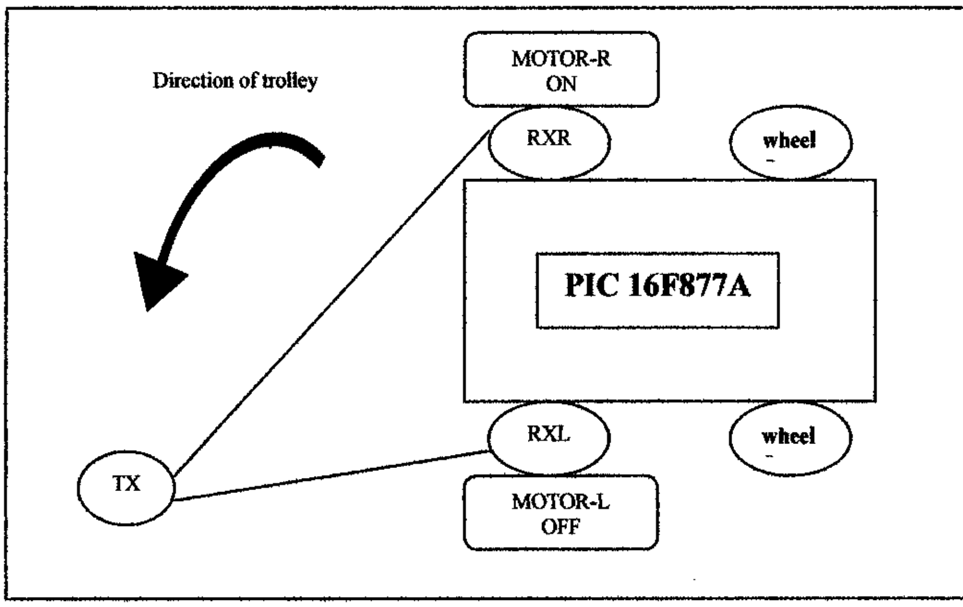


Figure 1.3(c): Production of a Left Turn by the Trolley

In Figure 1.3(c), when TX moves to the left, the right receiver will not be able to detect the signal. The PIC will activate the motor control circuit on the left side of the trolley only. Speed of MOTOR-L will be reduced to 50% of PWM and MOTOR-R will maintain at 100%. This will produce a right turn movement of the trolley. All operations are summarized in Table 1.

Table 1: Directions of Trolley and the Associated PWM Ratio

Direction	**Left detector**	**Right detector**	**PWM duty ratio**	
			Left Motor	**Right Motor**
Forward	0	0	100%	100%
Right Turn	1	0	100%	50%
Left Turn	0	1	50%	100%
Stop	1	1	0%	0%

1.3 Objectives and Scope of Study

1.3.1 Objectives of the Project

- To design and build a model of a platform resembling a trolley
- To attain knowledge in depth about the PIC 16F877A peripherals and its applications, especially the PWM technique
- To program PIC microcontroller in C language and be able to compile using PIC C Compiler Software
- To construct IR transceiver circuits that can be applicable for a distance of approximately 1meter.
- To construct motor control circuits using H Bridge ICs to control dc motor speed and directions

1.3.2 Scope of Study

To implement this project, knowledge on IR sensors is essential. Many IR circuits are studied, constructed and compared before choosing the best circuits with the desired characteristics. Laboratory works were done on a continuous basis to attain knowledge and understand how the IR radiation is transmitted and received.

The trolley is programmed using a PIC microcontroller, thus the scope of study would primarily focused on PIC microcontroller and C language programming. The main software used was the PIC C Compiler to compile the codes that have been programmed.

Methods of how to control the speed and direction of dc motors has to be understood fully before choosing the best method. There are many methods of controlling dc motors, but the one preferred to be used in this project is the Pulse Width Modulation technique. Besides that, the H bridge chip, a dual motor control IC must also be understood in depth since this chip is used to drive the dc motors.

1.3.3 Feasibility of the Project Within Scope and Time Frame

The first half of the project period concentrated more on the research and literature review. Laboratory work were done to try out many IR circuits are constructed just to familiarize the author with the operation of IR sensors. Besides that, the author also studied extensively on PIC microcontroller to ensure complete understanding before programming the PIC in FYP 2.

The second half of the project has been concentrated on the construction of circuits and also the implementation of algorithm for the trolley. Since most robotic designs usually are collaborative work, the trolley design process would be better if it was a team effort.

CHAPTER 2

LITERATURE REVIEW AND/ OR THEORY

2.1 Operations of IR Circuits

IR transmitters are used to pulsate its infrared in a certain frequency. The IR receiver module (the TV, VCR or stereo "tunes" to this certain frequency and ignores all other IR received). For infrared remote controls, the best frequency for the job is between 30 and 60kHz, the most used is around 38kHz. If the frequency is 38kHz, this means that the InfraRed light emitted by IR diodes is pulsated at 36 thousand times per second, when transmitting logic level "1" and silence for "0" [5].

To generate a 38 kHz pulsating infrared is quite easy, the more difficult part is to receive and identify this frequency. It means that remote controls have an output pin that goes high (+5V) when there is a pulsating 38 kHz infrared in front of it, and zero volts when there is not this radiation.

2.2 IR transmitter

A light-emitting diode (LED) is a semiconductor device that emits incoherent narrow-spectrum light when electrically biased in the forward direction. This effect is a form of electroluminescence. The color of the emitted light depends on the composition and condition of the semiconducting material used, and can be ultraviolet, visible or infrared [6]. In 1955, Rubin Braunstein first person first reported on infrared emission from gallium arsenide (GaAs) and other semiconductor alloys. Because the voltage versus current characteristics of an LED are much like any diode (that is approximately exponential), a small voltage change results in a huge change in current. Added to deviations in the process this means that a voltage source may barely make one LED light while taking another of the same type beyond its maximum ratings and potentially destroying it.

Since the voltage is logarithmically related to the current it can be considered to remain largely constant over the LEDs operating range. Thus the power can be considered to be almost proportional to the current. To try and keep power close to constant across variations in supply and LED characteristics the power supply should be a current source. In cases where high efficiency is not required an approximation to a current source made by connecting the LED in series with a current limiting resistor to a voltage source is generally used [6]. Most LEDs have low reverse breakdown voltage ratings, so they will also be damaged by an applied reverse voltage of more than a few volts. Thus the LED may be tested in series with a resistor on a sufficiently low voltage supply to avoid the reverse breakdown. Figure 2.1 shows the IR LED that is used in this project.

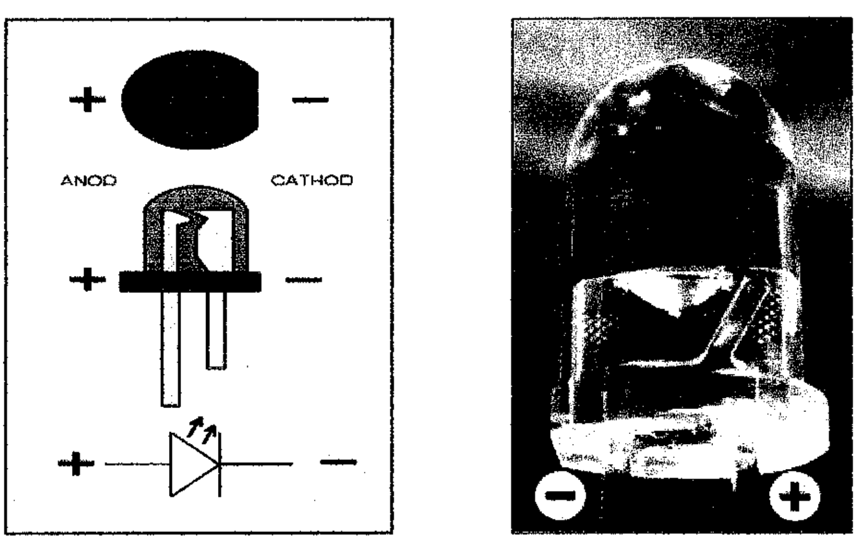


Figure 2.1 : Close-up of a typical IR LED, showing the internal structure [6]

2.3 IR Receiver

Infrared sensor is one of the most basic and cheapest sensors around. The IR detector being used is a photo detector and a preamplifier in one package. It has an ACTIVE LOW output. Figure 2.2 shows the type of IR photo detector used in this project whereas Figure 2.3 shows the internal structure of the device.

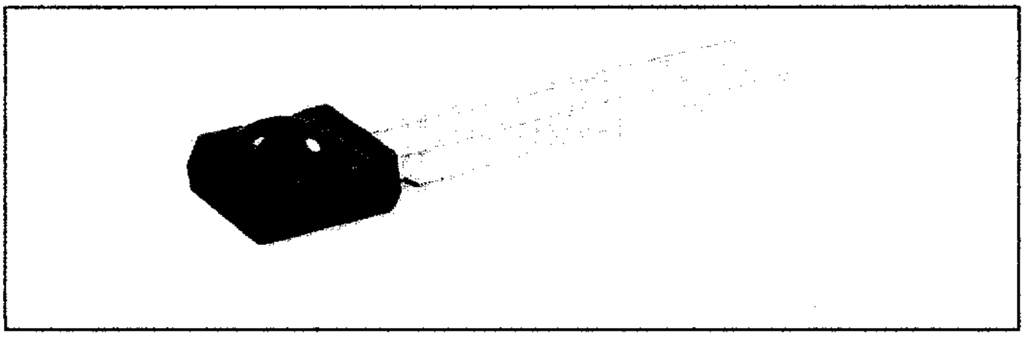


Figure 2.2: IR photo detector used (model TSOP 4138) [7]

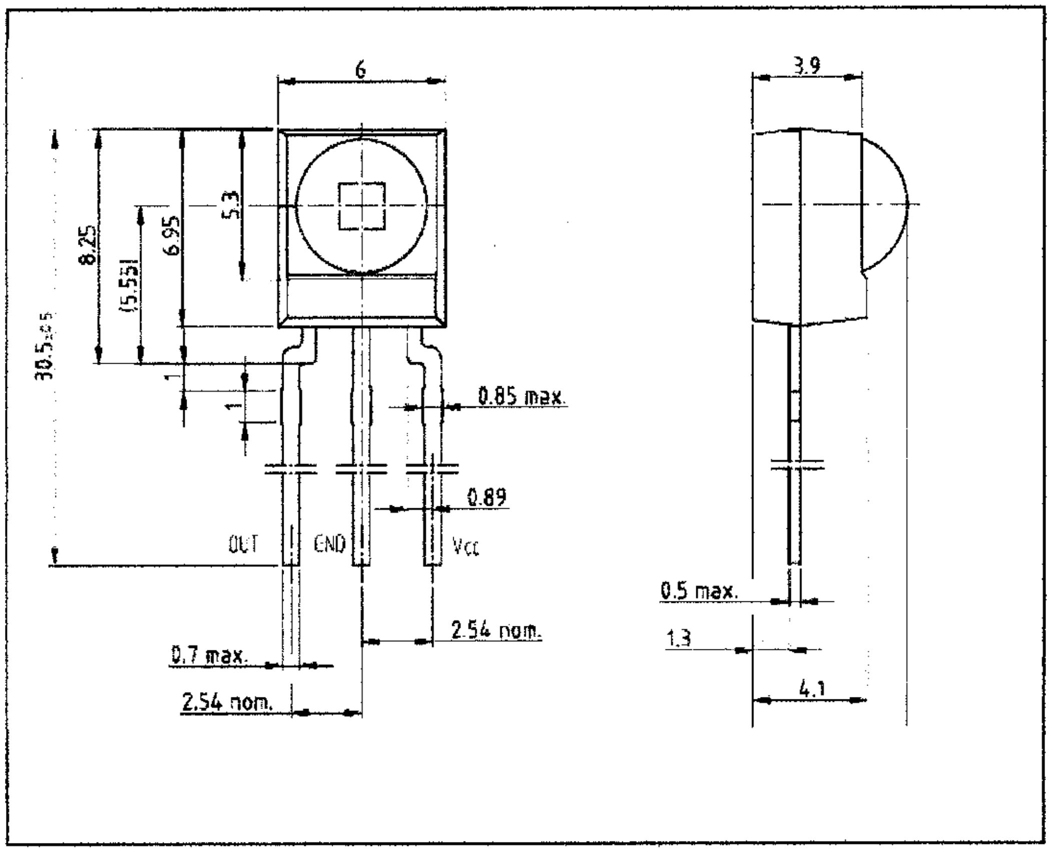


Figure 2.3: Internal Structure of TSOP 4138. [7]

In the market there are numerous types of infrared diodes that can be use. One common problem with infrared sensor is false triggering. This happens when the detector accidentally detects ambient infrared from the surrounding and interprets it as an obstacle. This problem can be solved by few methods; one is by software and another one by hardware. In software the polling method can be use to identify which receiver is actually detecting the correct signal. This can led to reliable detection.

By hardware, there are detectors in market which only detects infrared signal in a specific band of frequency. Figure 2.4 shows the frequency dependence of responsivity. This is a more reliable solution to the problem. The only problem with this method is the transmitted infrared signal needs to be modulated at the frequency detectable by the detector. Having this the infrared can be use as one of the reliable sensors at a good distance.

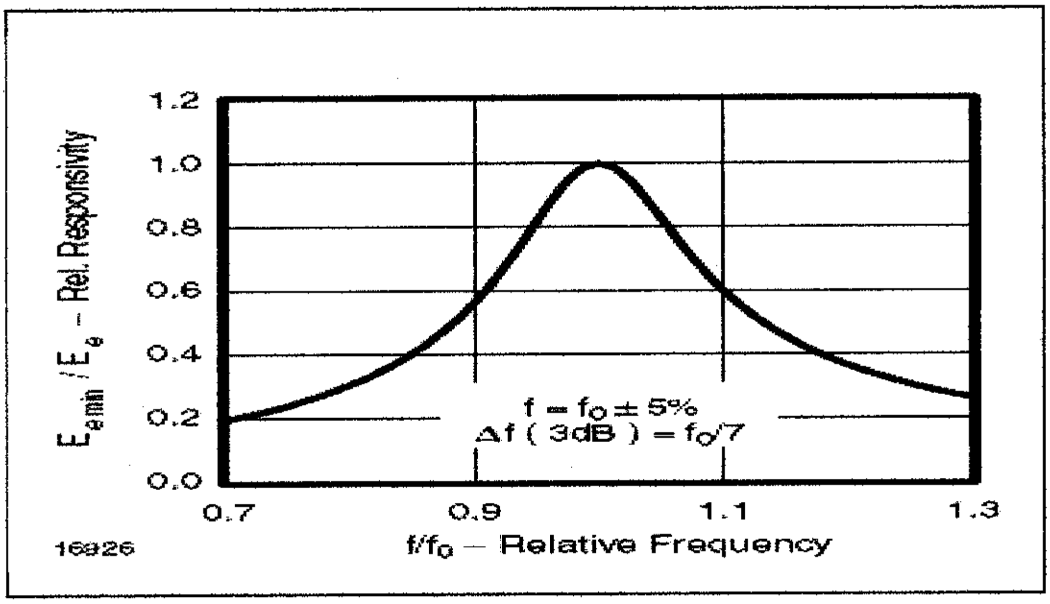
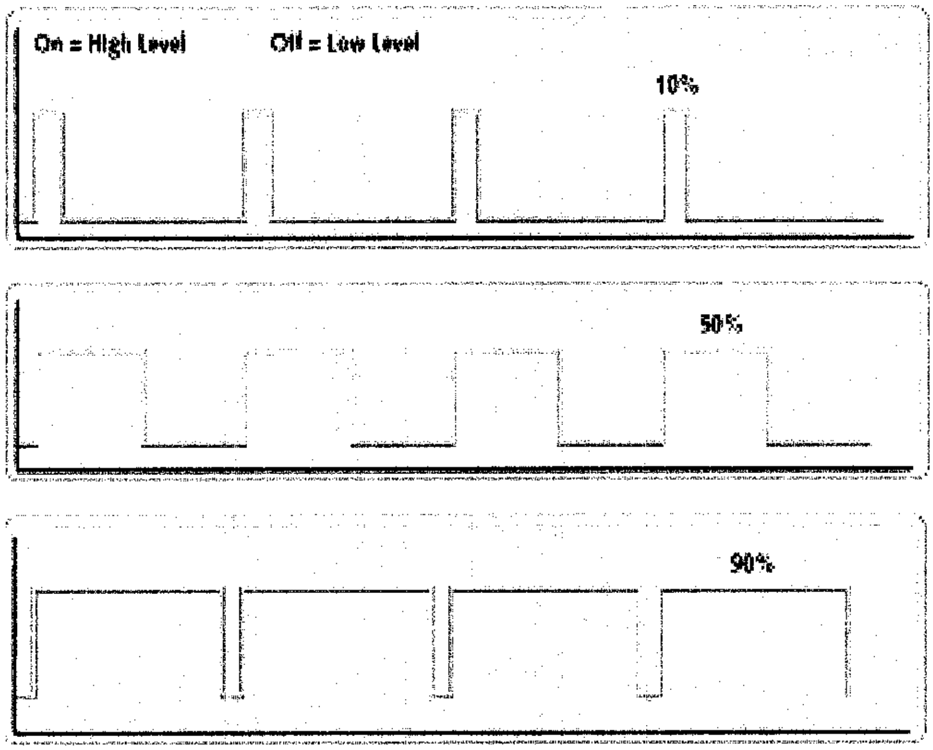


Figure 2.4: Frequency Dependence of Responsivity [7]

2.4 Pulse Width Modulation (PWM)

This technique is used to vary the duty cycle in order to control the speed of the dc motors. PWM is a way of digitally encoding analog signal levels. Through the use of high-resolution counters, the duty cycle of a square wave is modulated to encode a specific analog signal level. The PWM signal is still digital because, at any given instant of time, the full DC supply is either fully on or fully off. The voltage or current source is supplied to the analog load by means of a repeating series of on and off pulses. The on-time is the time during which the DC supply is applied to the load, and the off-time is the period during which the supply is switched off. Given a sufficient bandwidth, any analog value can be encoded with PWM. [8]

Figure 2.5 on the next page shows three different level of PWM signals. The first figure shows a PWM output at a 10% duty cycle. That is, the signal is on for 10% of the period and off the other 90%. The middle figure shows PWM duty cycle at 50% and the last figure 90% duty cycles, respectively.



2.4 H-Bridge Theory

The dc motors used must be driven by the L298 Dual Full Bridge Driver IC. This integrated monolithic circuit in a 15 lead Multiwatt circuit. It is a high voltage, high current dual full bridge driver designed to accept standard TTL logic levels and drive inductive load such as dc motors.

In theory, there are four switching elements within the bridge. These four elements are often called, high side left, high side right, low side right, and low side left (when traversing in clockwise order).

The switches are turned on in pairs, either high left and lower right, or lower left and high right, but never both switches on the same "side" of the bridge. If both switches on one side of a bridge are turned on it creates a short circuit between the battery plus and battery minus terminals. This phenomenon is called shoot through in the Switch-Mode Power Supply (SMPS) literature. If the bridge is sufficiently powerful it will absorb that load and batteries will simply drain quickly. Usually however, the switches in question melt.

To power the motor, the two switches which are diagonally opposed are turned on. The current flows and the motor begins to turn in a "positive" direction. If the high side right and low side left switches are turn on, current flow the other direction through the motor and the motor turns in the opposite direction.

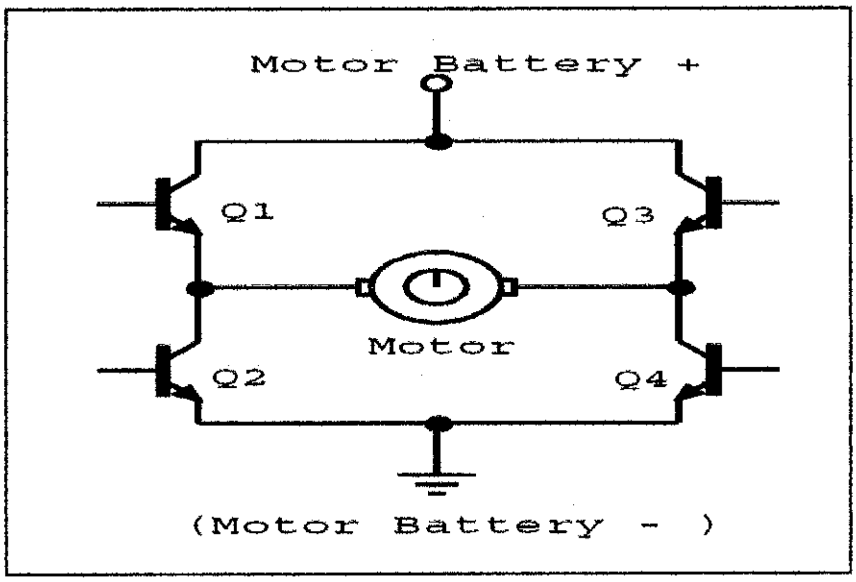


Figure 2.6: H Bridge Theory [9]

Table 2.1 : Operation of Switches in H Bridge IC

High Side Left	High Side Right	Lower Left	Lower Right	Quadrant Description
On	Off	Off	On	Motor goes Clockwise
Off	On	On	Off	Motor goes Counter-clockwise
On	On	Off	Off	Motor "brakes" and decelerates
Off	Off	On	On	Motor "brakes" and decelerates

The last two rows describe a maneuver when the motor is "short circuited" which causes the motors generator effect to work against itself. The turning motor generates a voltage which tries to force the motor to turn the opposite direction. This causes the motor to rapidly stop spinning and is called "braking" on a lot of H-bridge designs.

CHAPTER 3
METHODOLOGY/PROJECT WORK

3.1 Procedure Identification

The project scope of work includes laboratory experiments, computer programming, simulations, and product design. Procedures of all the work were split into phases to allow the author to focus on only one part of the project at a time. Figure 3.1 on the next page shows the overall system of the Self Moving Trolley. It can be seen that this project comprises of both hardware and software.

The hardware includes the IR transmitter and IR receiver circuits, 9V DC to 5V DC regulator circuits and the H-Bridge motor control circuit. The software part is programming the PIC microcontroller and simulation of the circuits using Multisim. Integration between the hardware and software part is also the main issue in this project. The following 5 phases described in depth the work done by the author:

Phase 1: Planning phase

Phase 1 involves the planning of a specific outline of the proposed work, requirements and deliverables of the project. All basic requirements, background study, problem statements, clear objectives and scope of project need to be identified and clearly defined.

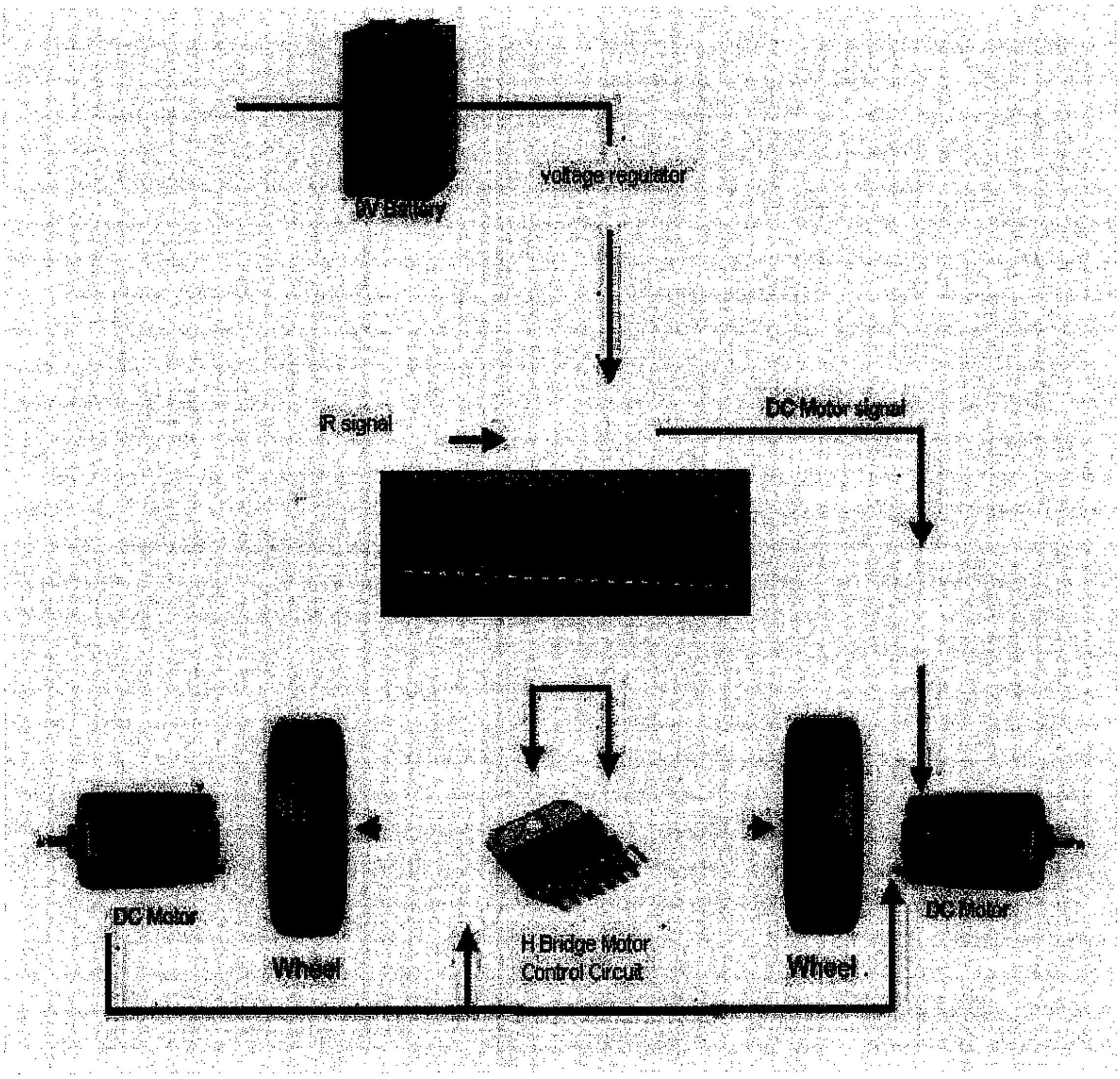


Figure 3.1: Overall View of the System

Phase 2: Research and Literature Review

Phase 2 encompassed of literature review and background research on the topic, choosing a methodology and implementation process for the completion of the project. Information regarding IR sensors, PIC 16F877A and H bridge circuits on different samples and subjects is collected through articles, journals, books, and websites. The best information and methods are selected based on objectives, scope of study and relevancy of project.

Phase 3: Construction of circuits

The circuits are simulated using Multisim. When the results are achieved, electronic components are ordered on-line or purchased through vendor catalogues. During this phase, time is mostly spent in the Projects Laboratory to construct and test the circuits built. Circuits are constructed initially on bread board before being implemented on Vero boards. Figure 3.2 shows the circuits constructed. Refer Appendix A for circuit schematics.

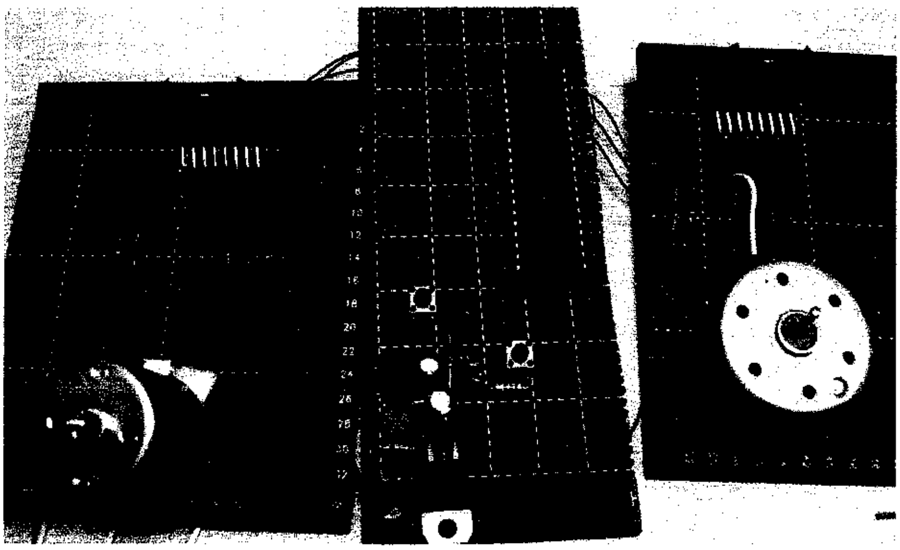


Figure 3.2: Circuits constructed

Phase 4: Programming the PIC 16F877A microcontroller

Phase 4 of the project is writing a program in C language. Firstly, a pseudo code has to be developed to visualize how the whole system shall work. The coding is then written based on the algorithm. PIC C compiler Software is used to write and compile the C code written. Since the author had no background on C language programming, consultation with lecturers are of utmost important besides self study from the internet. After compiling, the code is burnt onto the PIC using the Warp 13 Board. Refer Appendix for the C code written. Figure 3.3 summarizes the steps involved in programming the PIC.

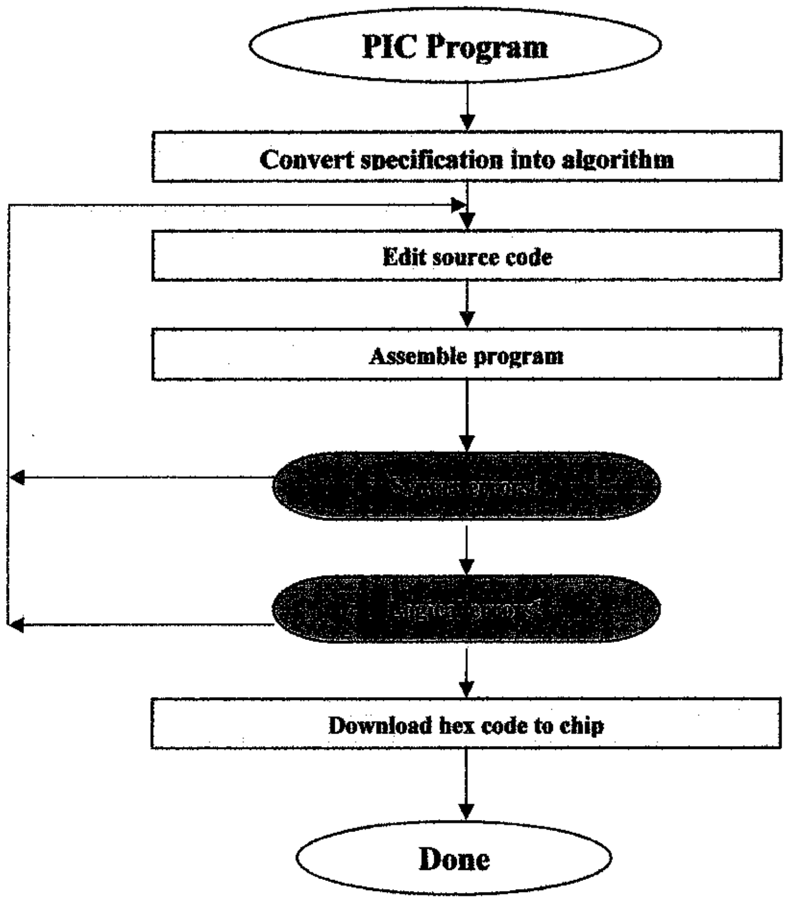


Figure 3.3: Process Flow for Programming Using PIC microcontroller

Phase 5 : Building the model

The body or structure of the trolley is designed on paper to get the exact measurements. Structure is built using Perspex. Work was done in the workshop for over a week. The wheels use parts from toy car.

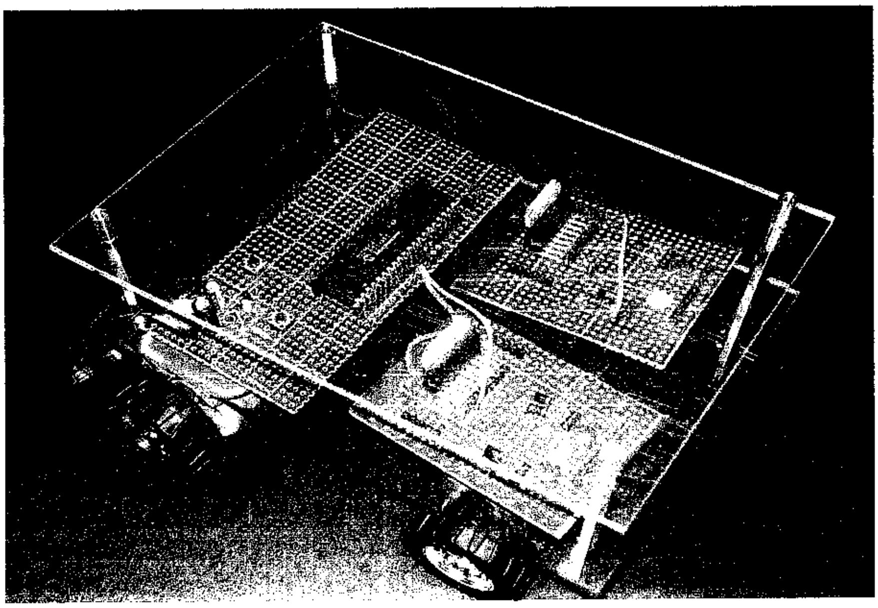


Figure 3.4: The Model of the Self Moving Trolley

Phase 5: Documentation

Reports will be produced as a requirement of the study and as a platform of discussions, findings and future references. The reports include Progress Report and Weekly Reports. The final Report is viewed and checked by the supervisor before submission to the FYP committee.

3.2 Tools Required

Tools needed throughout the implementation of this project consist of hardware and software. Below is the list of the tools needed:

Hardware:

- Warp 13 Board — the Warp 13 Board is used to burn the C code onto the microcontroller. Figure 3.5 shows the PIC burning process.

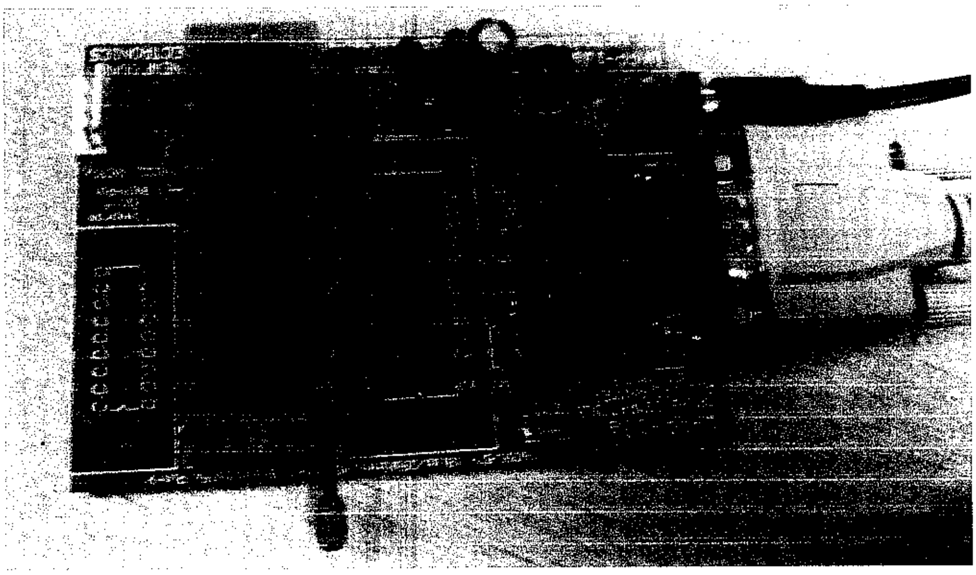


Figure 3.5 : Burning the PIC using Warp 13 Board

Software:

- PIC C Compiler — For the C code, this project will use this software to convert from high level language to hexadecimal machine code. Figure 3.6 shows the PICC Compiler interface.
- Multisim — Simulations of circuits are done using this software
- ORCAD — for drawing the circuits to be included in the report. Refer Appendix for circuit diagrams.

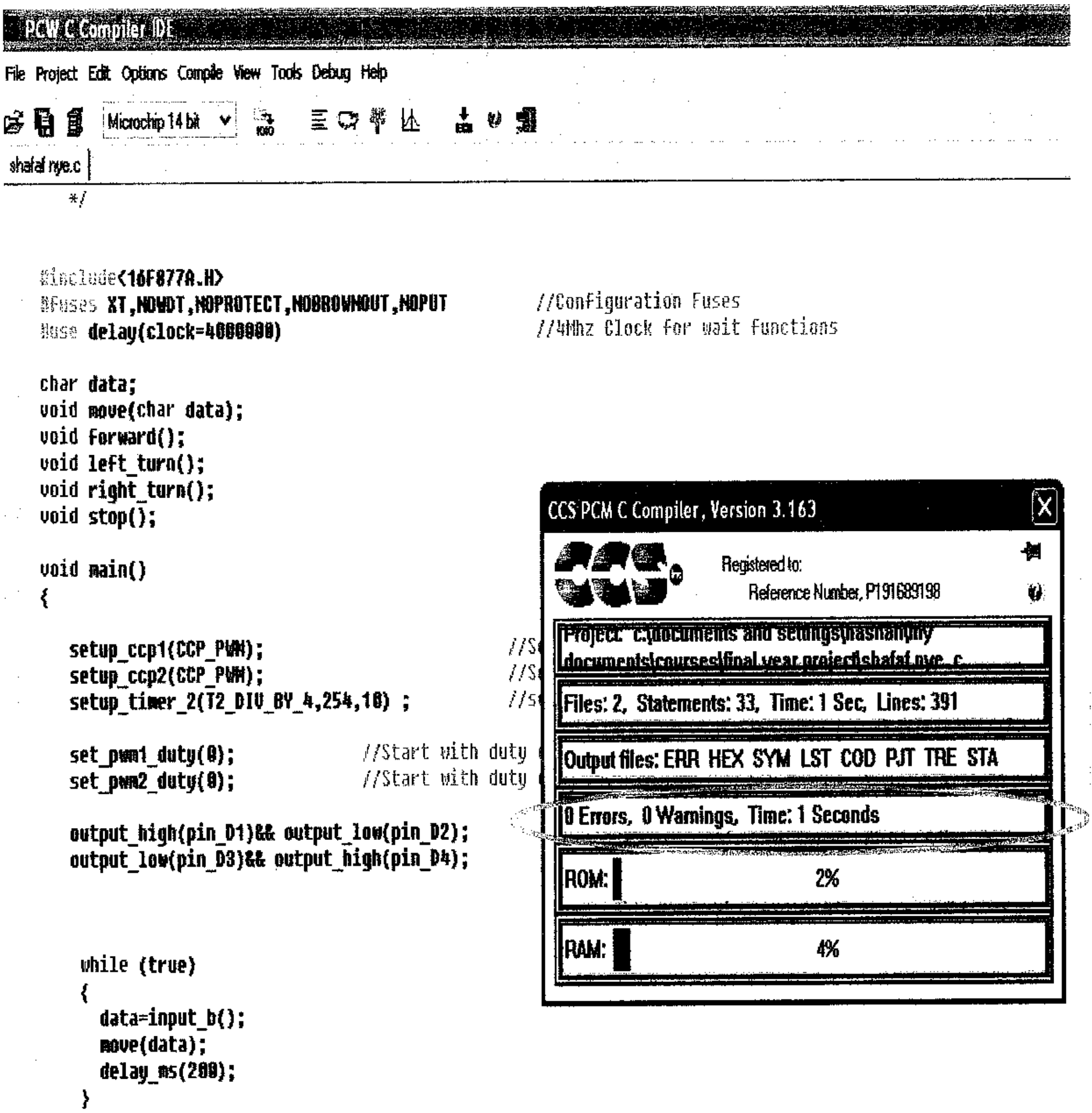


Figure 3.6 : Compiling the C code using PIC C Software

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Results

To operate the sensor, the circuits have to be supplied with 9V DC. This voltage is then regulated to 5V DC. The transmitter and receiver have to be properly aligned to enable the receiver circuit to detect the transmitted signal. The transmitter has an LED indicator to show when a valid transmission has been propagated. IR transmitter and receiver have to have the same frequency for it to respond to each other.

The IR receiver circuit is actually an astable timer circuit. An astable timer is achieved by adding resistor R2 to the circuit and configuring as shown in Figure 4.1. Trigger terminal and threshold terminal are connected so that self trigger is formed, operating as a multi vibrator. The period is the sum of charge time and discharge time. Since frequency is the reciprocal of period, the following formula applies;

$$F = \frac{1}{T} = \frac{1.44}{(R_1 + 2R_2)\,C_1} \qquad (1)$$

From equation (1), the appropriate values of capacitors and resistors can be chosen to design an astable timer circuit with frequency of approximately 38 kHz. By trial an error, the author had chosen these values of resistors and capacitors and plugged the value into equation (1).

$R_1 = 1.0$ k ohm

$R_2 = 1.2$ k ohm

$C_1 = 10$ n F

Using the above values into the equation to find frequency yields:

$$F = \frac{1}{T} = \frac{1.44}{(R_1 + 2R_2)\,C_1}$$

$$F = \frac{1}{T} = \frac{1.44}{(1K + 2 \times 1.2K)\,10n}$$

$$= 42.35\ K$$

$$\simeq 38\ k\ Hz$$

These values are suitable to be used. Thus it is simulated in the Multisim software. Figure 4.1 show the circuit simulated using Multisim. The green LED lights up when simulation starts, indicating that there is a flow of current in output pin (pin 3) of the 555 timer. An oscilloscope is connected at the pin 3 to measure the value of the output frequency. Figure 4.2 shows the output waveform of the astable timer circuit.

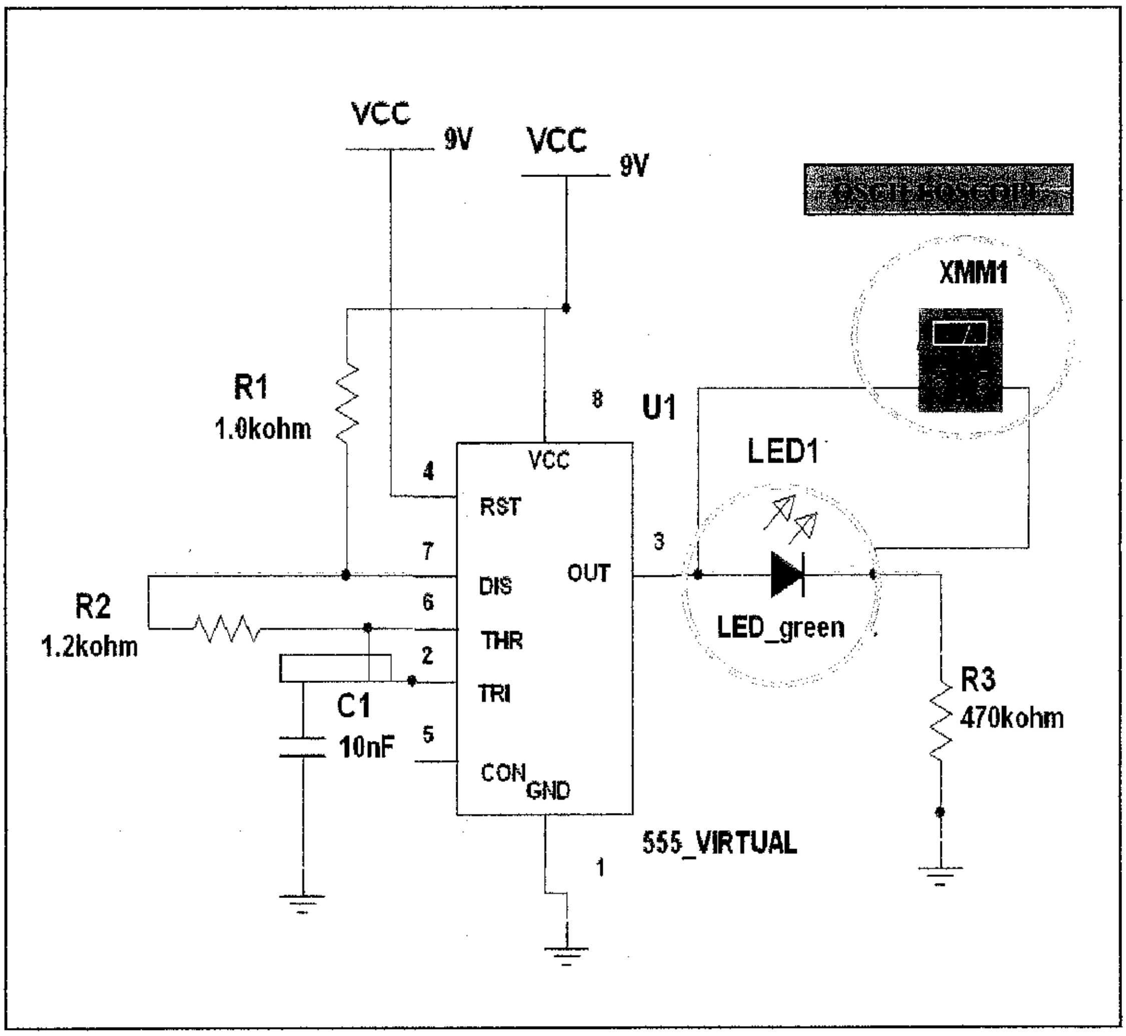


Figure 4.1: The Transmitter Circuit Which Produces 42 kHz of Signal

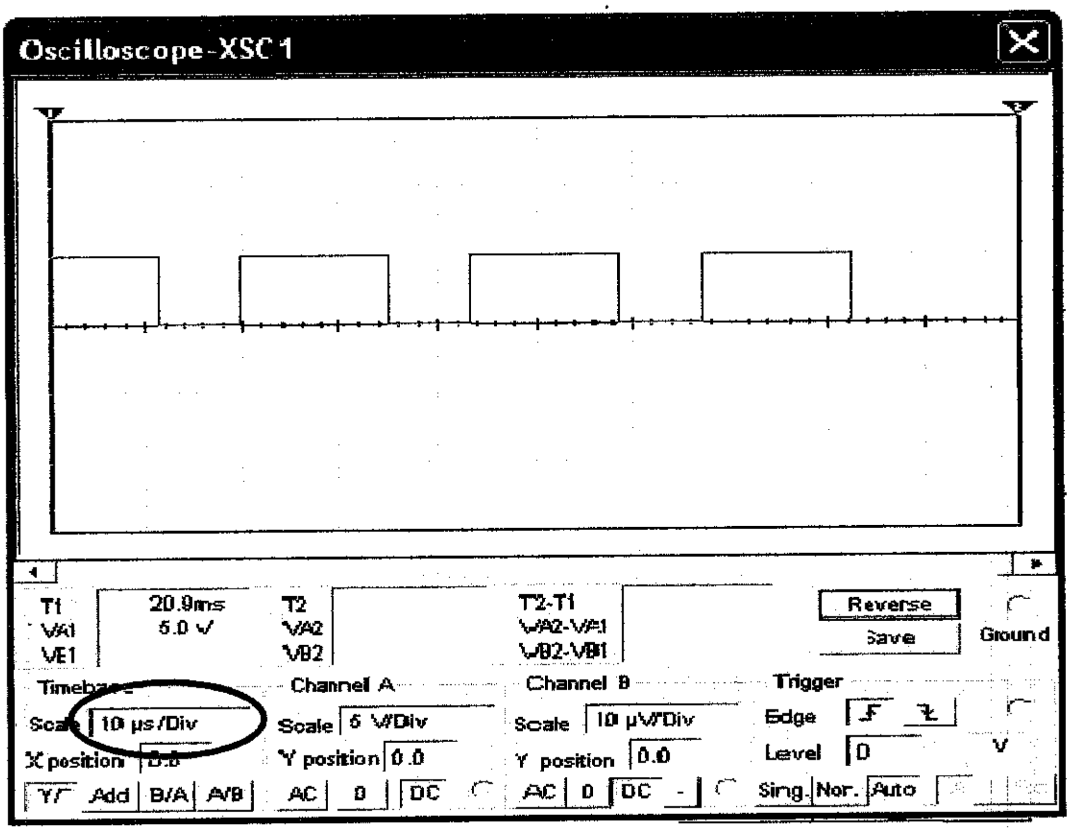


Figure 4.2: Simulation Results of 42 kHz

In the above figure, the simulation results shows that the output signal produced is 42 k Hz. the waveform is produced by the 555 timer at output pin 3. The y-axis is the voltage while the x- axis represents the time base. To obtain the frequency, we refer to the time axis. This is because the frequency is inversely proportional to the period.

From the graph, it can be seen that the period for 1 full cycle is 2.4. Since the scale for x-axis is 10μ per division, we multiply to get 2.4 by this 10μ per division. Thus:

Period is

$2.4 \times 10\mu$ /division $= 2.4 \times 10^{-5}$

Since frequency is the reciprocal of period:

$$F = \frac{1}{\text{Period}}$$

$$= \frac{1}{2.4 \times 10^{-5}}$$

$$= 41.67 \text{ k Hz}$$

$$\simeq 42 \text{ k Hz}$$

Thus the calculation proves that the frequency produced is 42 k Hz.

After the simulation, the circuit was constructed. The below figure, Figure 4.3 shows the green LED of regulator circuit was illuminated. This indicates that the regulator circuit is working. The red LED indicates that the IR transmitter circuit is transmitting the 42 kHz of signal. The blue arrow shows the IR LED used. It is connected in series with the red indicator LED.

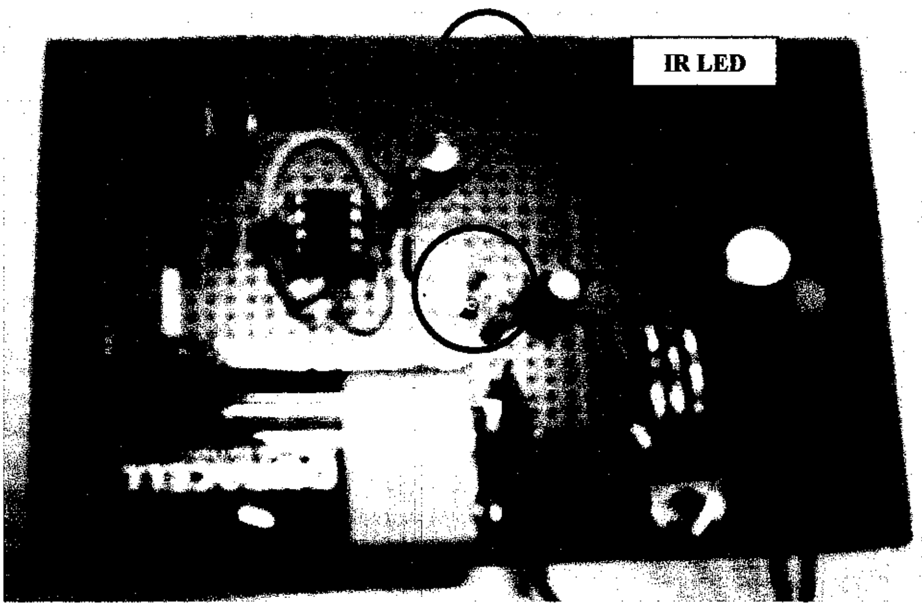


Figure 4.3: The Voltage Regulator and IR Transmitter Circuit

4.2 Discussion

IR transceiver circuits have to be of the same frequency value for them to operate and communicate with each other. The IR receiver module used in this project has a carrier frequency of 38 kHz. This is why the transmitter circuit constructed also has to propagate signal of this frequency. In designing the transmitter circuit, exact value of 38 kHz could not be achieved. The closest value to be designed is 42 kHz. This value is considered acceptable since the receiver has a band pass frequency that accepts signal close to 38k Hz. The sensitivity of the receiver is however reduced but acceptable since this project does not require long range IR transmission.

The software part was verified to be clear of error during compilation using PIC C Compiler Software. During the development of the coding, the author had tested the program part by part to ensure that each part is error free. The coding can be found in Appendix B.

Since the motor control circuit did not work most probably because of hardware failure. The wire wrapping technique could have a short circuit and causes the circuit not to work. Although this circuit had been used and proved to work in other projects, implementation in this project should emphasize more on the connections of the L298 H Bridge pins.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The Self Moving Trolley using Sensors is a project meant to ease the shopping experience for customers in supermarkets. The project has been completed within the time frame. Some of the objectives are met while some others need more modifications for it to be achieved. The proposed modifications are provided in the recommendations part. Below are the conclusions that can be made regarding this project:

The first objective of building a model of a trolley was achieved by building the platform using Perspex. This is to show the inner part of the trolley, i.e. the circuits. Furthermore, Perspex is light in weight and can easily be obtained from the Electrical store in UTP. However, this model is not working due to hardware error. The author will however troubleshoot and work on this issue until the day of project presentation.

The second objective is to learn and apply the knowledge gain on PIC microcontroller in this project. The author was exposed to the PWM method to control the speed of dc motors.

The third objective was to learn to program in C language. In addition to that, the author also attained knowledge on using the hardware associated with PIC, which is the Warp 13 board and Warp 13 software.

The fourth objective is to construct IR transceiver circuits. The IR transmitter circuit worked smoothly to produce frequency of 42 kHz. The IR receiver module used is most sensitive to this frequency range.

The final objective is to construct motor control circuit and varying the speed. The PWM duty ratio is varied in the C code in order to control the motor speed. From the code compiled using PIC C Compiler, there is no error in the program.

5.2 Recommendations

Even when most objectives are achieved, the objective of making the trolley move was not realized. Thus, concentration should be more on the hadware part since the programming part had been verified to have no problem. Circuits could be implemented on PCB to allows easier troubleshooting.

Since the motor control circuit did not work, in order to save time and make the trolley move, this project could in the future uses a ready made motor controller kit. This kit allows users to safely interface two DC motors to a host microcontroller using only 4 control lines. This will reduce possibility of error due to poor connection.

In case this contraception is to be used for long range, an IR receiver with higher sensitivity and wider acception angle can be chosen.

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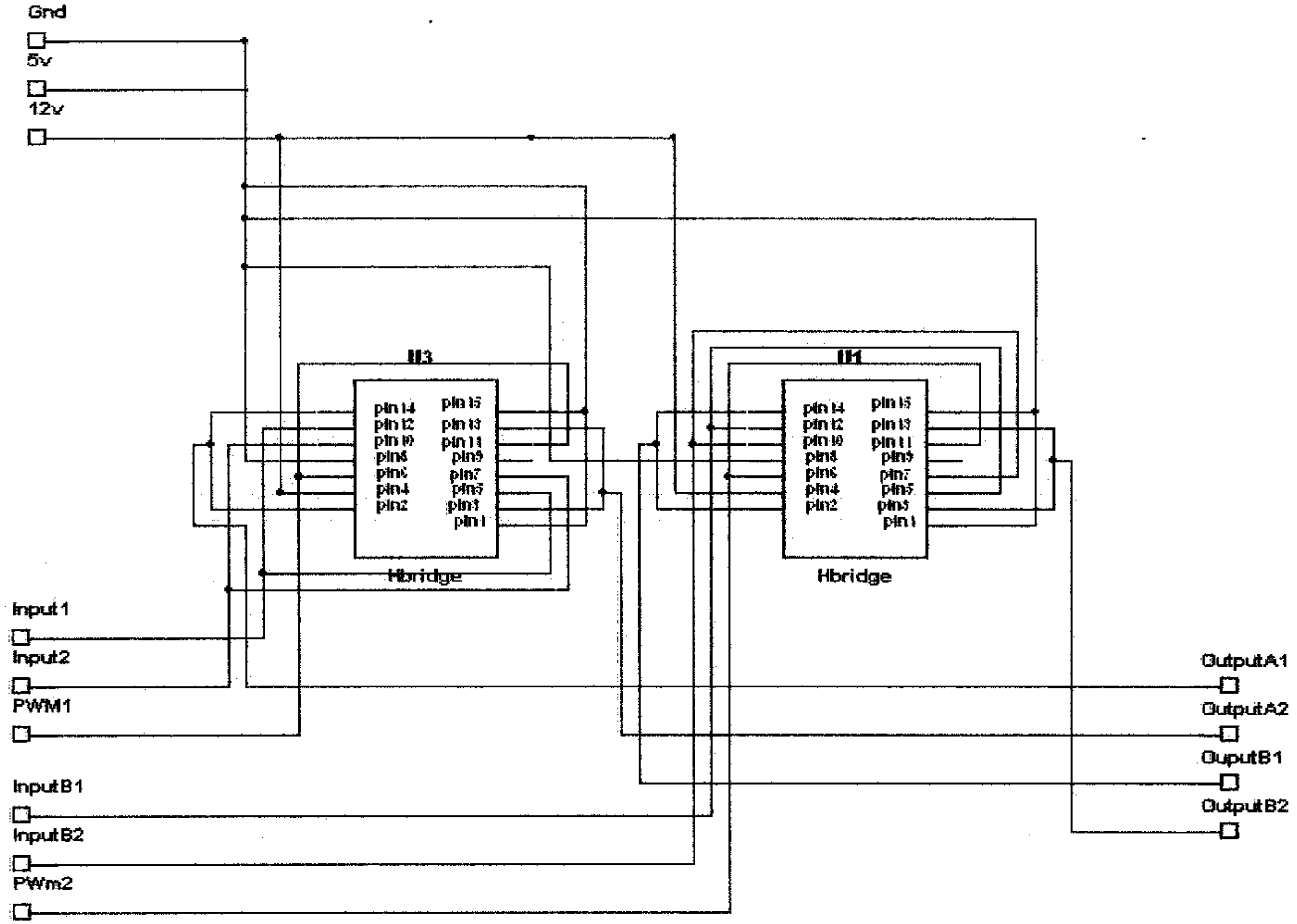
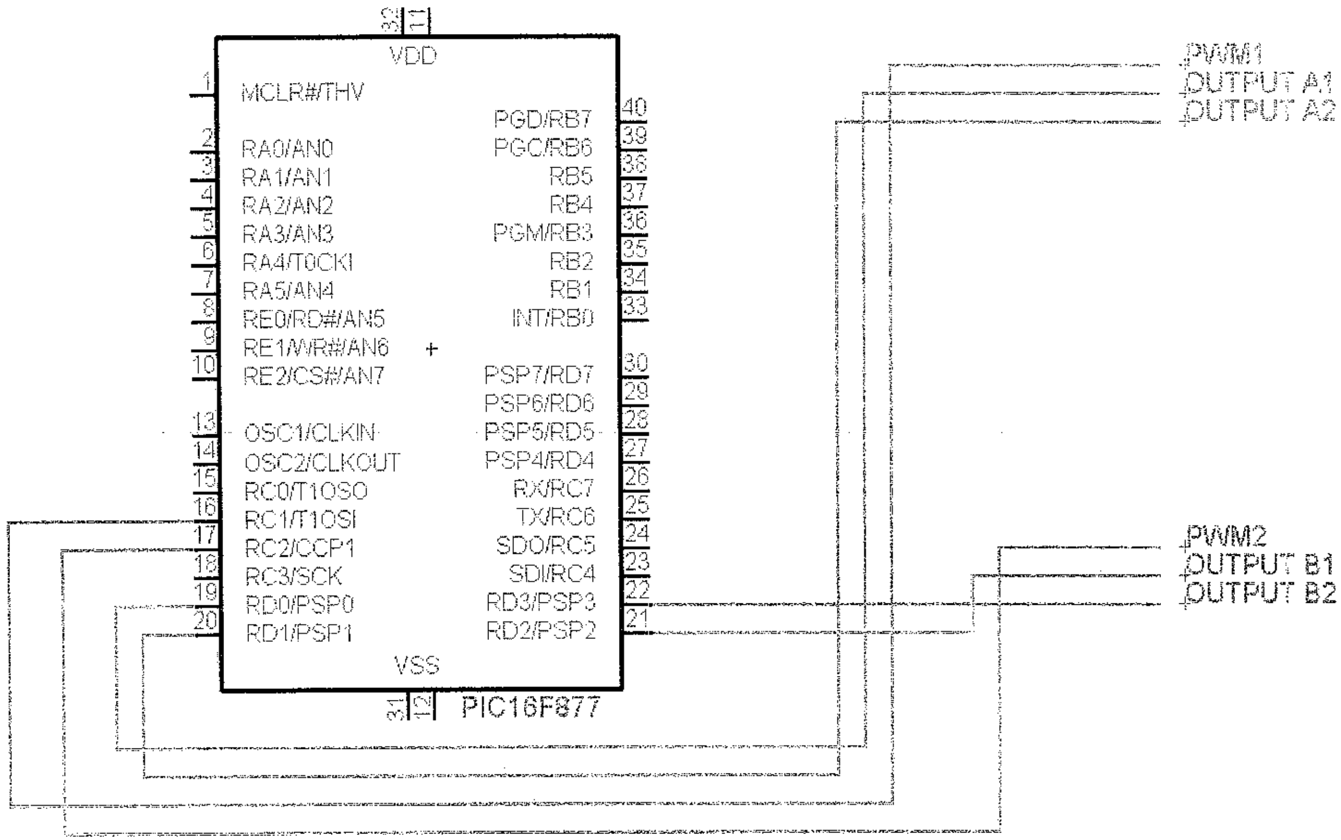
APPENDIX A
CIRCUIT SCHEMATIC

REGULATOR CIRCUIT




VDD
MCLR#/THV
RA0/AN0
RA1/AN1
RA2/AN2
RA3/AN3
RA4/T0CKI
RA5/AN4
RE0/RD#/AN5
RE1/WR#/AN6
RE2/CS#/AN7
OSC1/CLKIN
OSC2/CLKOUT
RC0/T1OSO
RC1/T1OSI
RC2/CCP1
RC3/SCK
RD0/PSP0
RD1/PSP1
PGD/RB7
PGC/RB6
RB5
RB4
PGM/RB3
RB2
RB1
INT/RB0
PSP7/RD7
PSP6/RD6
PSP5/RD5
PSP4/RD4
RX/RC7
TX/RC6
SDO/RC5
SDI/RC4
RD3/PSP3
RD2/PSP2
VSS
PIC16F877
PWM1
OUTPUT A1
OUTPUT A2
PWM2
OUTPUT B1
OUTPUT B2

APPENDIX B
C CODE

```
/* Shafaf Rohaizak  4310
   FYP C Coding
   Self Moving Trolley Using Infrared Sensors */
// This program is to control motor speed using the PWM technique



#include<16F877A.H>
#fuses XT,NOWDT,NOPROTECT,NOBROWNOUT,NOPUT     //Configuration Fuses
#use delay(clock= 400000)                          //4Mhz Clock for wait functions


char data;
void move(char data);
void forward();
void left_turn();
void right_turn();
void stop();

void main()
{
        setup_ccp1(CCP_PWM);                    //Set up PWM on CCP1
        setup_ccp2(CCP_PWM);                    //Set up PWM on CCP2
        setup_timer_2(T2_DIV_BY_4,254,10) ;  //set up Timer2 for 4901Hz  PWM

        set_pwm1_duty(0);                         //Start with duty cycle of 0%
        set_pwm2_duty(0);                         //Start with duty cycle of 0%

        output_high(pin_D1);                      //set direction for motor1
        output_high(pin_D2);                      //set direction for motor2
```

```
   while (true)
   {
    data=input_b();
          move(data);
    delay_ms(200);
         }

}

void move ( char data)
{ switch(data)

  {
     case 0x00 :  forward();
                  delay_ms(500);
     break;

     case 0x01 :  left_turn();
                  delay_ms(500);
     break;

     case 0x02 :  right_turn();
                 delay_ms(500);
     break;

     case 0x03 :  stop();
                 delay_ms(500);
     break;

  }
```

```
}

void forward ()
 {
   set_pwm1_duty(1024);
   set_pwm2_duty(1024);
 }

void left_turn ()
 {
   set_pwm1_duty(32);
   set_pwm2_duty(1024);
 }

void right_turn ()
 {
   set_pwm1_duty(1024);
   set_pwm2_duty(32);
 }

void stop ()
 {
   set_pwm1_duty(0);
   set_pwm2_duty(0);
 }

// end of program
```

APPENDIX C
ELECTRONICS DATASHEET

SCRIPTION

555 monolithic timing circuit is a highly stable controller capable oducing accurate time delays, or oscillation. In the time delay e of operation, the time is precisely controlled by one external stor and capacitor. For a stable operation as an oscillator, the running frequency and the duty cycle are both accurately rolled with two external resistors and one capacitor. The circuit be triggered and reset on falling waveforms, and the output cture can source or sink up to 200mA.

ʌTURES

rn-off time less than 2µs

ax. operating frequency greater than 500kHz

ning from microseconds to hours

erates in both astable and monostable modes

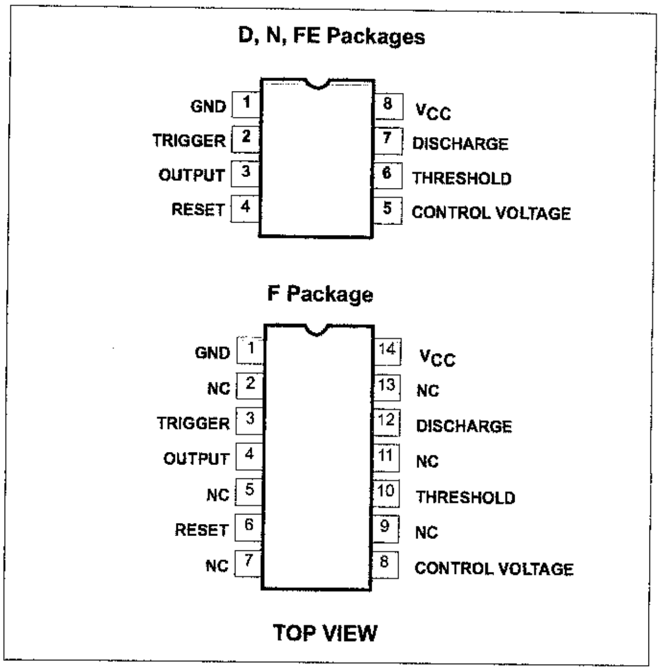
gh output current

justable duty cycle

L compatible

mperature stability of 0.005% per °C

PIN CONFIGURATIONS



PLICATIONS

ecision timing

lse generation

quential timing

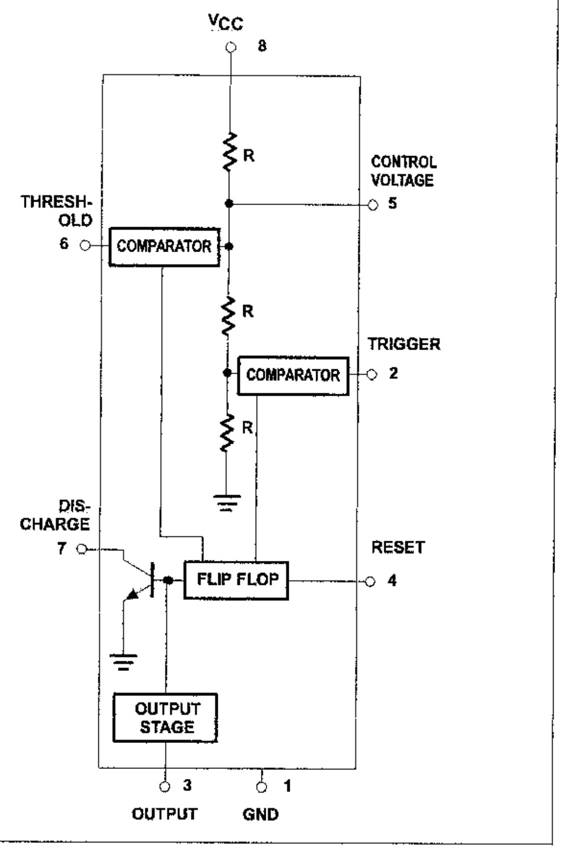
ne delay generation

lse width modulation

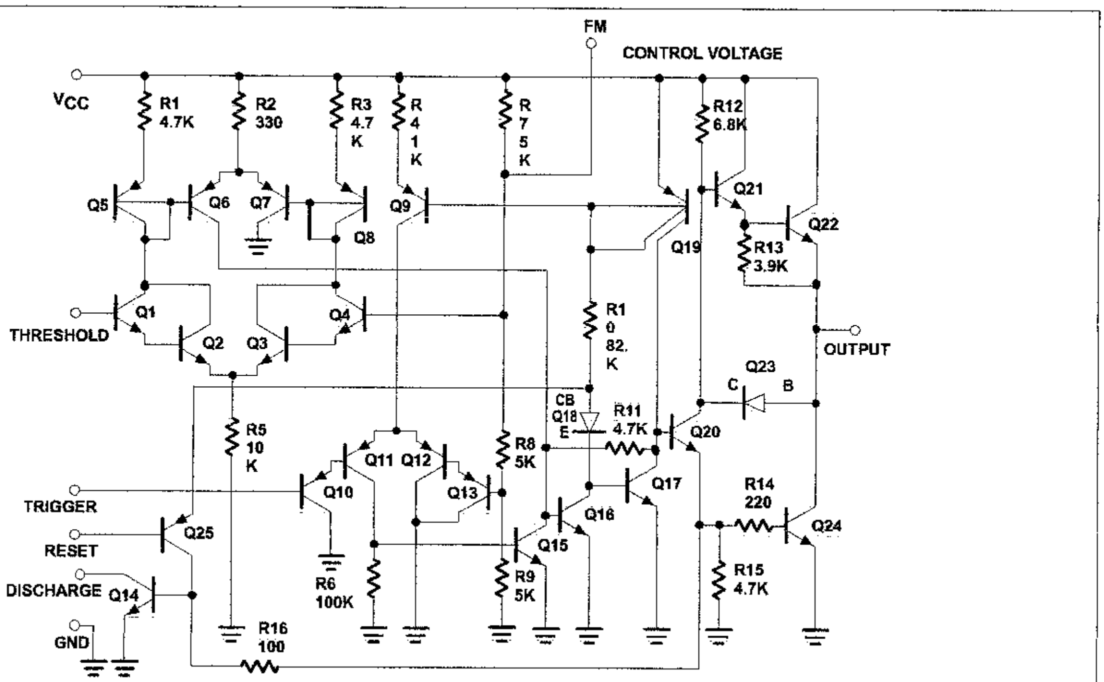
DERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
n Plastic Small Outline (SO) Package	0 to +70°C	NE555D	0174C
n Plastic Dual In-Line Package (DIP)	0 to +70°C	NE555N	0404B
n Plastic Dual In-Line Package (DIP)	-40°C to +85°C	SA555N	0404B
n Plastic Small Outline (SO) Package	-40°C to +85°C	SA555D	0174C
n Hermetic Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	SE555CFE	
n Plastic Dual In-Line Package (DIP)	-55°C to +125°C	SE555CN	0404B
'in Plastic Dual In-Line Package (DIP)	-55°C to +125°C	SE555N	0405B
n Hermetic Cerdip	-55°C to +125°C	SE555FE	
'in Ceramic Dual In-Line Package (CERDIP)	0 to +70°C	NE555F	0581B
'in Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	SE555F	0581B
'in Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	SE555CF	0581B

ıCK DIAGRAM



JIVALENT SCHEMATIC



TE: Pin numbers are for 8-Pin package

SOLUTE MAXIMUM RATINGS

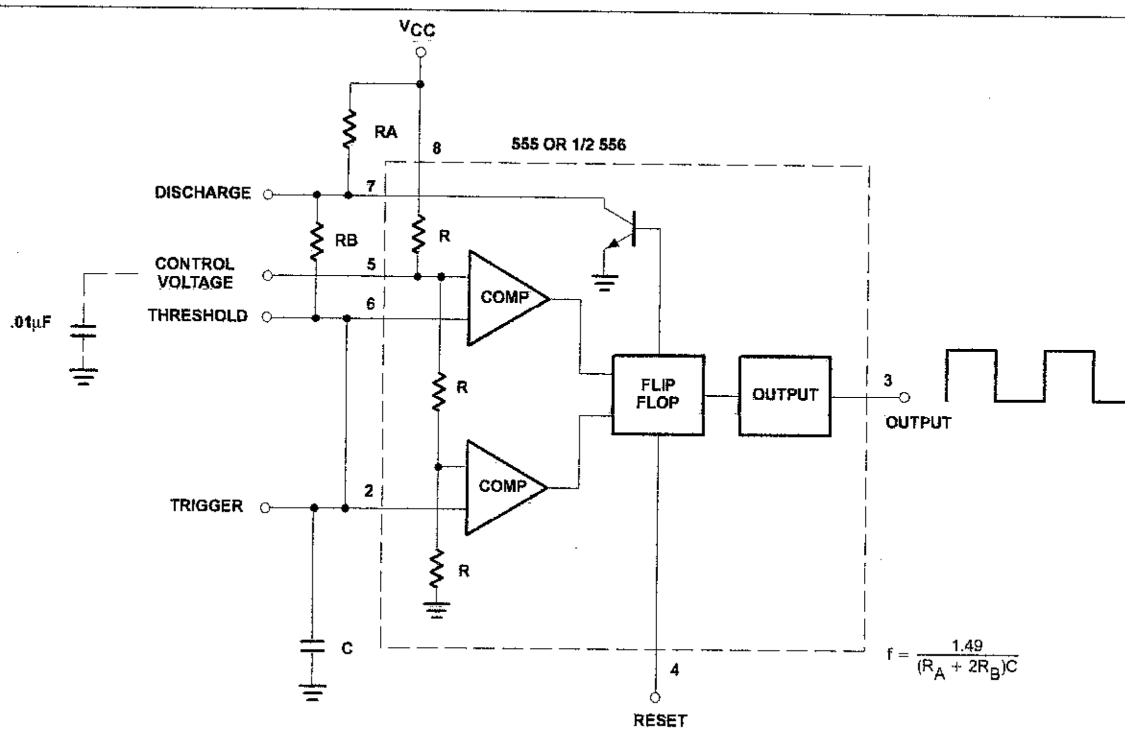
SYMBOL	PARAMETER	RATING	UNIT
	Supply voltage		
:	SE555	+18	V
	NE555, SE555C, SA555	+16	V
	Maximum allowable power dissipation[1]	600	mW
	Operating ambient temperature range		
	NE555	0 to +70	°C
	SA555	-40 to +85	°C
	SE555, SE555C	-55 to +125	°C
G	Storage temperature range	-65 to +150	°C
LD	Lead soldering temperature (10sec max)	+300	°C

ES:

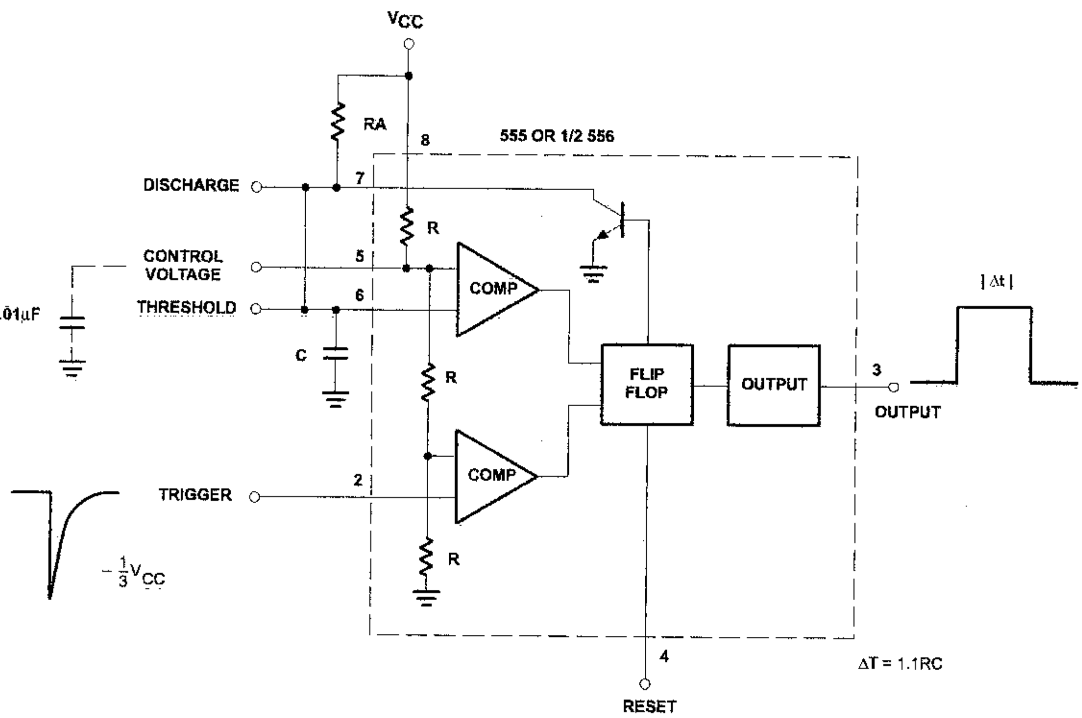
he junction temperature must be kept below 125°C for the D package and below 150°C for the FE, N and F packages. At ambient temperatures above 25°C, where this limit would be derated by the following factors:

D package 160°C/W
FE package 150°C/W
N package 100°C/W
F package 105°C/W

PICAL APPLICATIONS



Astable Operation



Monostable Operation

ICAL APPLICATIONS

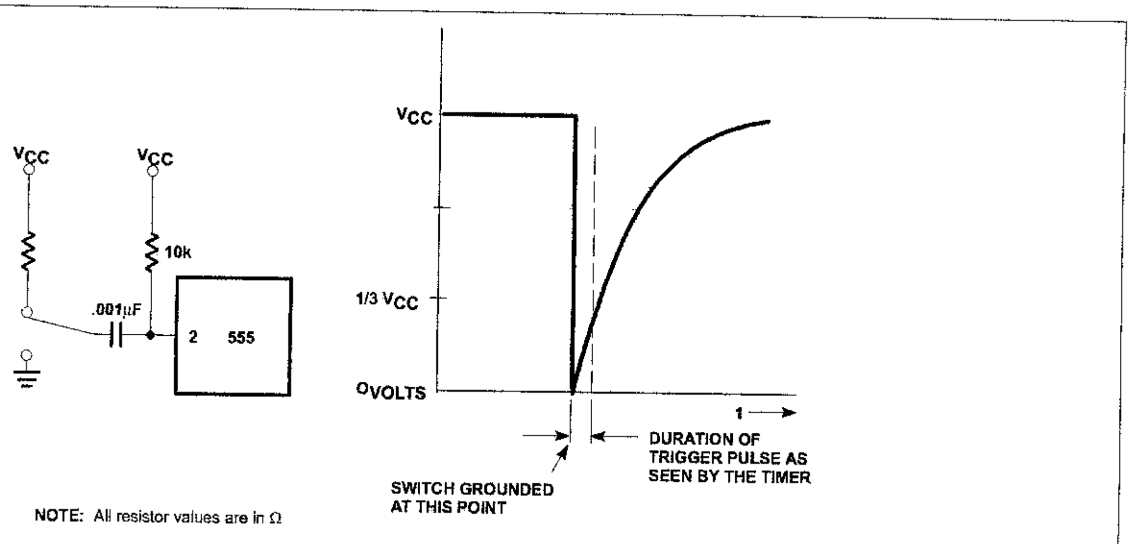


Figure 1. AC Coupling of the Trigger Pulse

ger Pulse Width Requirements and Time ys

o the nature of the trigger circuitry, the timer will trigger on the tive going edge of the input pulse. For the device to time out rly, it is necessary that the trigger voltage level be returned to voltage greater than one third of the supply before the time out l. This can be achieved by making either the trigger pulse ently short or by AC coupling into the trigger. By AC coupling gger, see Figure 1, a short negative going pulse is achieved the trigger signal goes to ground. AC coupling is most ently used in conjunction with a switch or a signal that goes to d which initiates the timing cycle. Should the trigger be held ithout AC coupling, for a longer duration than the timing cycle tput will remain in a high state for the duration of the low r signal, without regard to the threshold comparator state. This to the predominance of Q_{15} on the base of Q_{16}, controlling ate of the bi-stable flip-flop. When the trigger signal then s to a high level, the output will fall immediately. Thus, the t signal will follow the trigger signal in this case.

Another consideration is the "turn-off time". This is the measurement of the amount of time required after the threshold reaches 2/3 V_{CC} to turn the output low. To explain further, Q_1 at the threshold input turns on after reaching 2/3 V_{CC}, which then turns on Q_5, which turns on Q_6. Current from Q_6 turns on Q_{16} which turns Q_{17} off. This allows current from Q_{19} to turn on Q_{20} and Q_{24} to given an output low. These steps cause the 2μs max. delay as stated in the data sheet.

Also, a delay comparable to the turn-off time is the trigger release time. When the trigger is low, Q_{10} is on and turns on Q_{11} which turns on Q_{15}. Q_{15} turns off Q_{16} and allows Q_{17} to turn on. This turns off current to Q_{20} and Q_{24}, which results in output high. When the trigger is released, Q_{10} and Q_{11} shut off, Q_{15} turns off, Q_{16} turns on and the circuit then follows the same path and time delay explained as "turn off time". This trigger release time is very important in designing the trigger pulse width so as not to interfere with the output signal as explained previously.

MICROCHIP

PIC16F87X

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

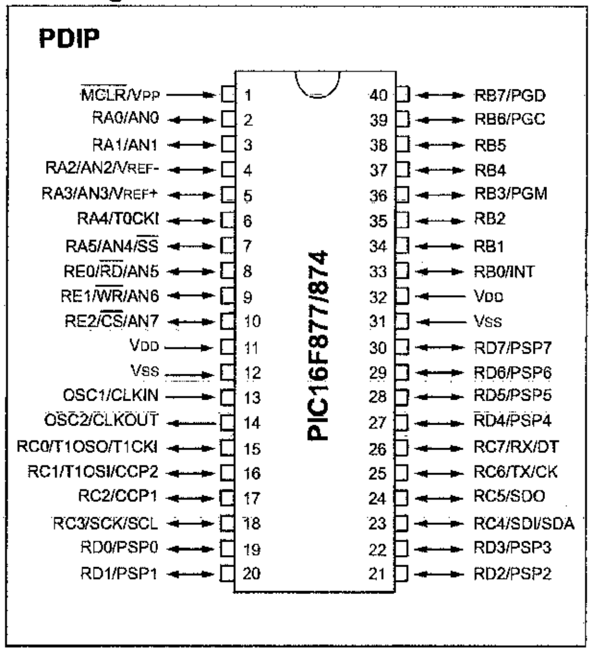
Devices Included in this Data Sheet:

- PIC16F873
- PIC16F874
- PIC16F876
- PIC16F877

Microcontroller Core Features:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory,
Up to 368 x 8 bytes of Data Memory (RAM)
Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature ranges
- Low-power consumption:
  - < 0.6 mA typical @ 3V, 4 MHz
  - 20 μA typical @ 3V, 32 kHz
  - < 1 μA typical standby current

Pin Diagram



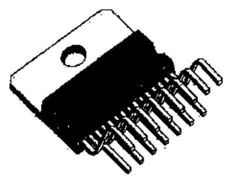
Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during SLEEP via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

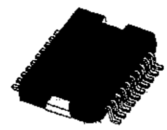
L298

DUAL FULL-BRIDGE DRIVER

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



Multiwatt15



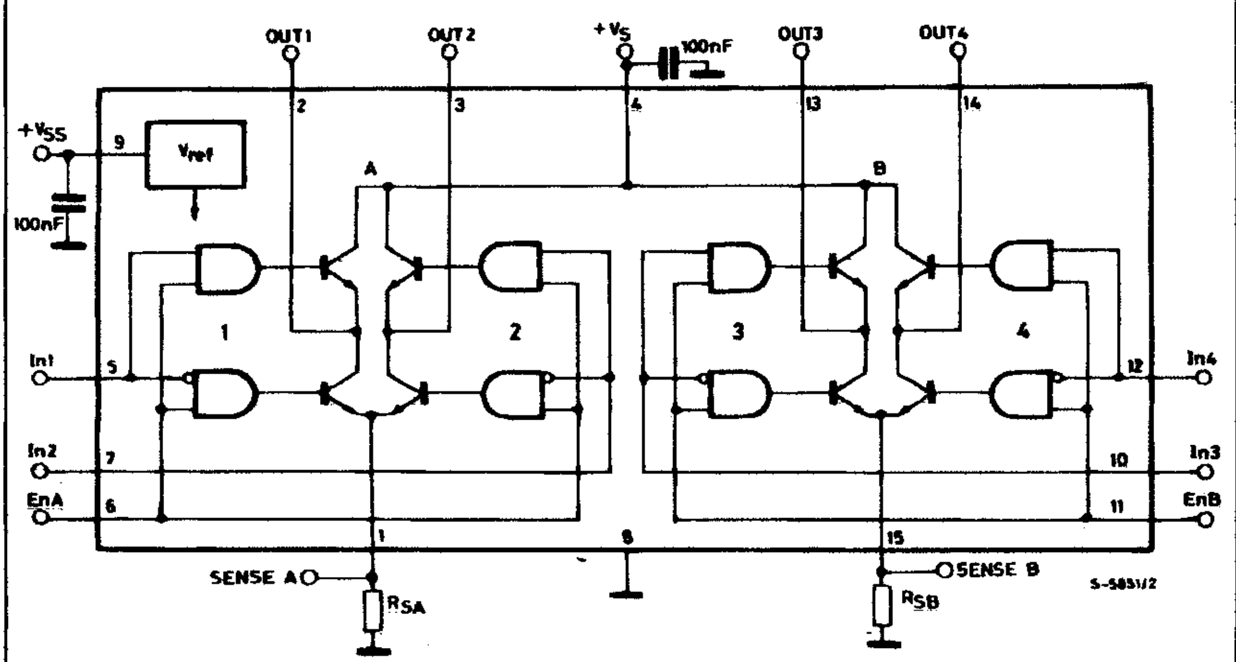
PowerSO20

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

DESCRIPTION

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

BLOCK DIAGRAM



PIN FUNCTIONS (refer to the block diagram)

MW.15	PowerSO	Name	Function
1;15	2;19	Sense A; Sense B	Between this pin and ground is connected the sense resistor to control the current of the load.
2;3	4;5	Out 1; Out 2	Outputs of the Bridge A; the current that flows through the load connected between these two pins is monitored at pin 1.
4	6	V_S	Supply Voltage for the Power Output Stages. A non-inductive 100nF capacitor must be connected between this pin and ground.
5;7	7;9	Input 1; Input 2	TTL Compatible Inputs of the Bridge A.
6;11	8;14	Enable A; Enable B	TTL Compatible Enable Input: the L state disables the bridge A (enable A) and/or the bridge B (enable B).
8	1,10,11,20	GND	Ground.
9	12	VSS	Supply Voltage for the Logic Blocks. A100nF capacitor must be connected between this pin and ground.
10; 12	13;15	Input 3; Input 4	TTL Compatible Inputs of the Bridge B.
13; 14	16;17	Out 3; Out 4	Outputs of the Bridge B. The current that flows through the load connected between these two pins is monitored at pin 15.
–	3;18	N.C.	Not Connected

ELECTRICAL CHARACTERISTICS (V_S = 42V; V_{SS} = 5V, T_j = 25°C; unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_S	Supply Voltage (pin 4)	Operative Condition	V_{IH} +2.5		46	V
V_{SS}	Logic Supply Voltage (pin 9)		4.5	5	7	V
I_S	Quiescent Supply Current (pin 4)	V_{en} = H; I_L = 0 V_i = L V_i = H		13 50	22 70	mA mA
		V_{en} = L V_i = X			4	mA
I_{SS}	Quiescent Current from V_{SS} (pin 9)	V_{en} = H; I_L = 0 V_i = L V_i = H		24 7	36 12	mA mA
		V_{en} = L V_i = X			6	mA
V_{iL}	Input Low Voltage (pins 5, 7, 10, 12)		–0.3		1.5	V
V_{iH}	Input High Voltage (pins 5, 7, 10, 12)		2.3		VSS	V
I_{iL}	Low Voltage Input Current (pins 5, 7, 10, 12)	V_i = L			–10	µA
I_{iH}	High Voltage Input Current (pins 5, 7, 10, 12)	V_i = H $\leq V_{SS}$ –0.6V		30	100	µA
V_{en} = L	Enable Low Voltage (pins 6, 11)		–0.3		1.5	V
V_{en} = H	Enable High Voltage (pins 6, 11)		2.3		V_{SS}	V
I_{en} = L	Low Voltage Enable Current (pins 6, 11)	V_{en} = L			–10	µA
I_{en} = H	High Voltage Enable Current (pins 6, 11)	V_{en} = H $\leq V_{SS}$ –0.6V		30	100	µA
$V_{CEsat (H)}$	Source Saturation Voltage	I_L = 1A I_L = 2A	0.95	1.35 2	1.7 2.7	V V
$V_{CEsat (L)}$	Sink Saturation Voltage	I_L = 1A (5) I_L = 2A (5)	0.85	1.2 1.7	1.6 2.3	V V
V_{CEsat}	Total Drop	I_L = 1A (5) I_L = 2A (5)	1.80		3.2 4.9	V V
V_{sens}	Sensing Voltage (pins 1, 15)		–1 (1)		2	V

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

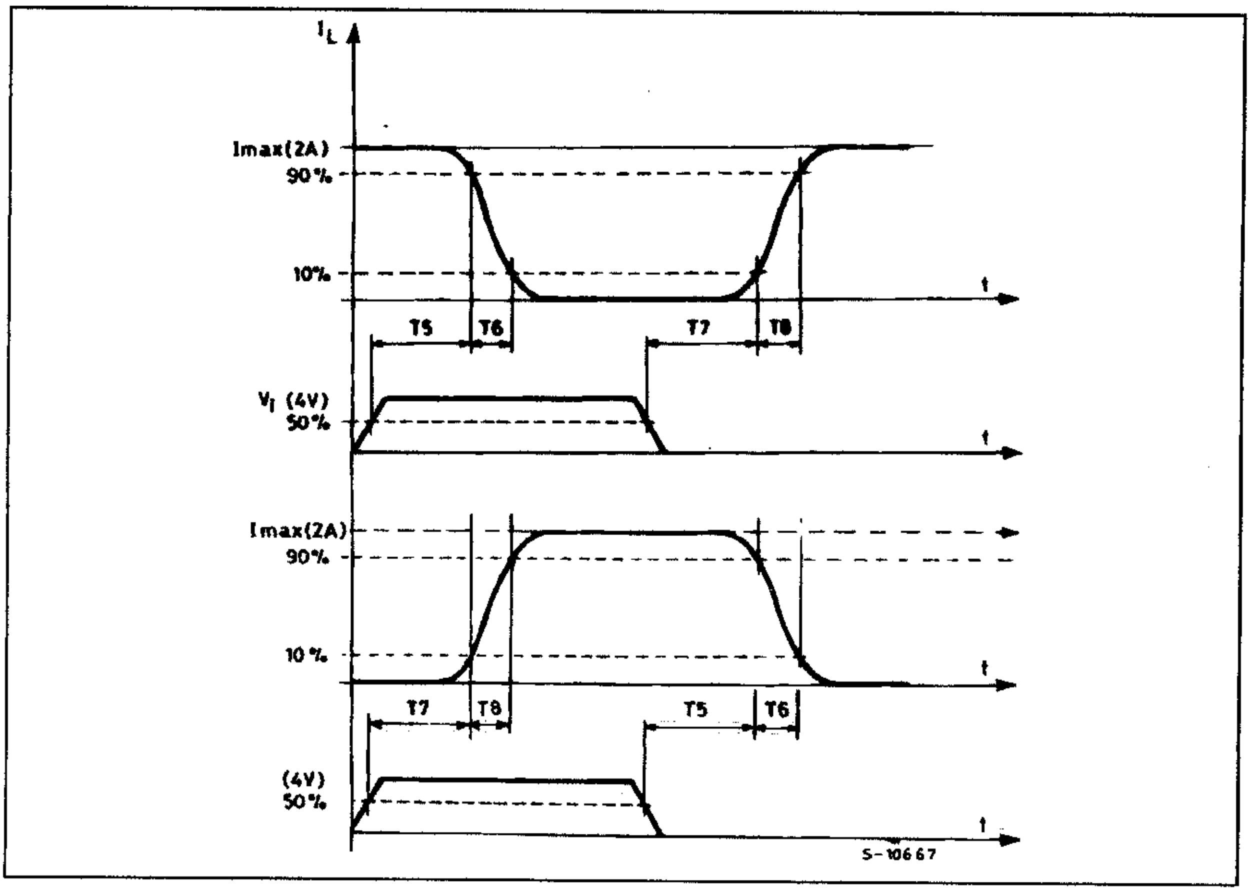
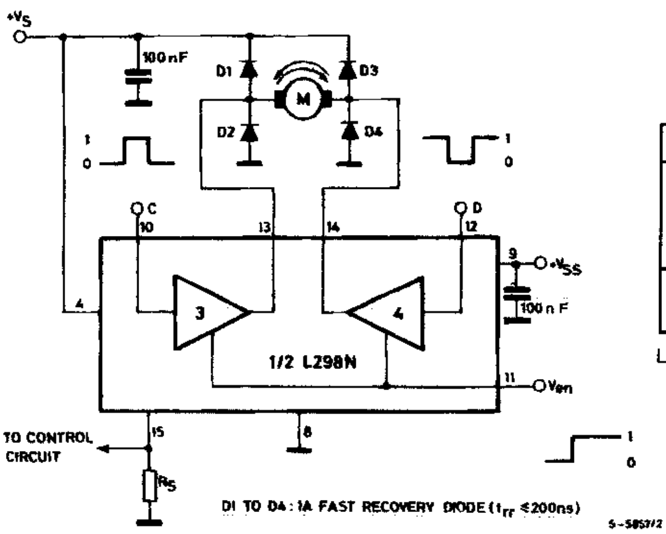


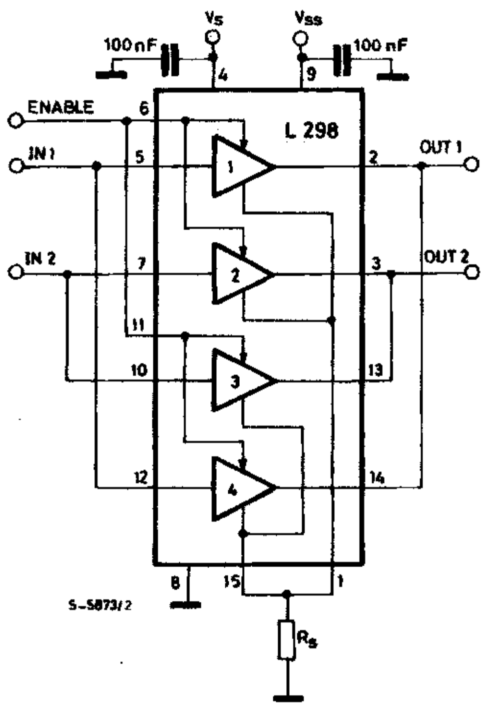
Figure 6 : Bidirectional DC Motor Control.



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

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

Figure 7 : For higher currents, outputs can be paralleled. Take care to parallel channel 1 with channel 4 and channel 2 with channel 3.



APPLICATION INFORMATION (Refer to the block diagram)

1.1. POWER OUTPUT STAGE

The L298 integrates two power output stages (A ; B). The power output stage is a bridge configuration and its outputs can drive an inductive load in common or differenzial mode, depending on the state of the inputs. The current that flows through the load comes out from the bridge at the sense output : an external resistor (R_{SA} ; R_{SB}.) allows to detect the intensity of this current.

1.2. INPUT STAGE

Each bridge is driven by means of four gates the input of which are In1 ; In2 ; EnA and In3 ; In4 ; EnB. The In inputs set the bridge state when The En input is high ; a low state of the En input inhibits the bridge. All the inputs are TTL compatible.

2. SUGGESTIONS

A non inductive capacitor, usually of 100 nF, must be foreseen between both Vs and Vss, to ground, as near as possible to GND pin. When the large capacitor of the power supply is too far from the IC, a second smaller one must be foreseen near the L298.

The sense resistor, not of a wire wound type, must be grounded near the negative pole of Vs that must be near the GND pin of the I.C.

Each input must be connected to the source of the driving signals by means of a very short path.

Turn-On and Turn-Off : Before to Turn-ON the Supply Voltage and before to Turn it OFF, the Enable input must be driven to the Low state.

3. APPLICATIONS

Fig 6 shows a bidirectional DC motor control Schematic Diagram for which only one bridge is needed. The external bridge of diodes D1 to D4 is made by four fast recovery elements ($t_{rr} \leq 200$ nsec) that must be chosen of a VF as low as possible at the worst case of the load current.

The sense output voltage can be used to control the current amplitude by chopping the inputs, or to provide overcurrent protection by switching low the enable input.

The brake function (Fast motor stop) requires that the Absolute Maximum Rating of 2 Amps must never be overcome.

When the repetitive peak current needed from the load is higher than 2 Amps, a paralleled configuration can be chosen (See Fig.7).

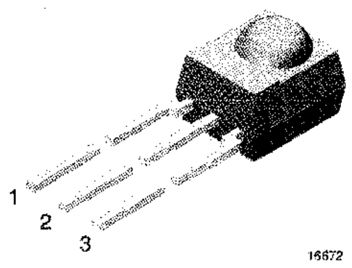
An external bridge of diodes are required when inductive loads are driven and when the inputs of the IC are chopped ; Shottky diodes would be preferred.

IR Receiver Modules for Remote Control Systems

Description

The TSOP41.. - series are miniaturized receivers for infrared remote control systems. PIN diode and preamplifier are assembled on lead frame, the epoxy package is designed as IR filter.

The demodulated output signal can directly be decoded by a microprocessor. The main benefit is the operation with short burst transmission codes and high data rates.



Features

- Photo detector and preamplifier in one package
- Internal filter for PCM frequency
- Improved shielding against electrical field disturbance
- TTL and CMOS compatibility
- Output active low
- Low power consumption
- High immunity against ambient light

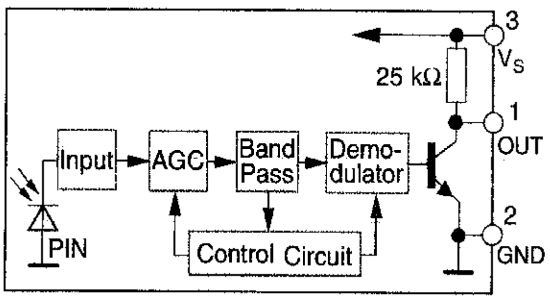
Special Features

- Enhanced data rate of 4000 bit/s
- Operation with short bursts possible (≥ 6 cycles/burst)

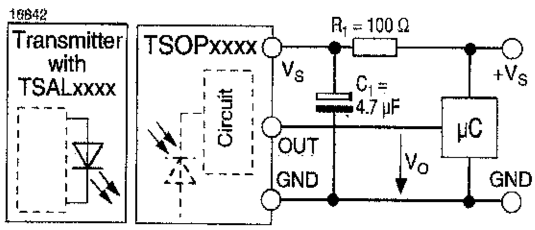
Parts Table

Part	Carrier Frequency
TSOP4130	30 kHz
TSOP4133	33 kHz
TSOP4136	36 kHz
TSOP4137	36.7 kHz
TSOP4138	38 kHz
TSOP4140	40 kHz
TSOP4156	56 kHz

Block Diagram



Application Circuit



$R_1 + C_1$ recommended to suppress power supply disturbances.

The output voltage should not be hold continuously at a voltage below $V_O = 3.3$ V by the external circuit.

ɜolute Maximum Ratings

= 25 °C, unless otherwise specified

Parameter	Test condition	Symbol	Value	Unit
ɔly Voltage	(Pin 3)	V_S	- 0.3 to + 6.0	V
ɔly Current	(Pin 3)	I_S	5	mA
ıut Voltage	(Pin 1)	V_O	- 0.3 to + 6.0	V
ıut Current	(Pin 1)	I_O	5	mA
tion Temperature		T_j	100	°C
ıge Temperature Range		T_{stg}	- 25 to + 85	°C
ʼating Temperature Range		T_{amb}	- 25 to + 85	°C
ɜr Consumption	($T_{amb} \leq 85$ °C)	P_{tot}	50	mW
ɜring Temperature	t ≤ 10 s, 1 mm from case	T_{sd}	260	°C

ɔtrical and Optical Characteristics

= 25 °C, unless otherwise specified

Parameter	Test condition	Symbol	Min	Typ.	Max	Unit
ly Current (Pin 3)	$V_S = 5$ V, $E_v = 0$	I_{SD}	0.8	1.2	1.5	mA
	$V_S = 5$ V, $E_v = 40$ klx, sunlight	I_{SH}		1.5		mA
ly Voltage (Pin 3)		V_S	4.5		5.5	V
mission Distance	$E_v = 0$, test signal see fig.3, IR diode TSAL6200, $I_F = 250$ mA	d		35		m
ıt Voltage Low (Pin 1)	$I_{OL} = 0.5$ mA, $E_e = 0.7$ mW/m², f = f_o, test signal see fig. 1	V_{OL}			250	mV
ınce (30 - 40 kHz)	Pulse width tolerance: $t_{pi} - 5/f_o < t_{po} < t_{pi} + 6/f_o$, test signal see fig.3	$E_{e\ min}$		0.2	0.4	mW/m²
ınce (56 kHz)	Pulse width tolerance: $t_{pi} - 5/f_o < t_{po} < t_{pi} + 6/f_o$, test signal see fig.3	$E_{e\ min}$		0.3	0.5	mW/m²
ınce	Test signal see fig. 1	$E_{e\ max}$	30			W/m²
ivity	Angle of half transmission distance	$\varphi_{1/2}$		± 45		deg

Typical Characteristics (T_{amb} = 25 °C unless otherwise specified)

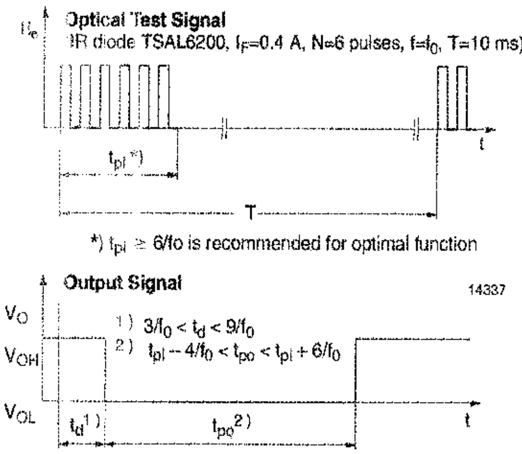


Figure 1. Output Function

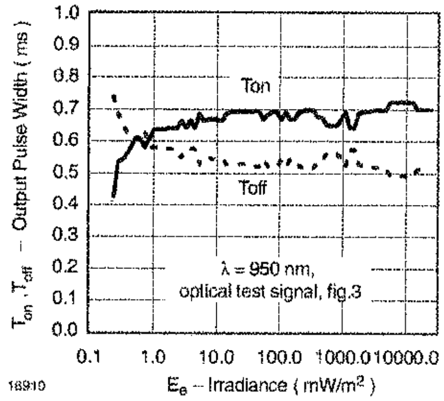


Figure 4. Output Pulse Diagram

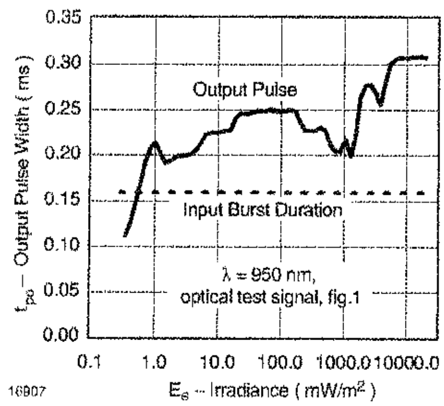


Figure 2. Pulse Length and Sensitivity in Dark Ambient

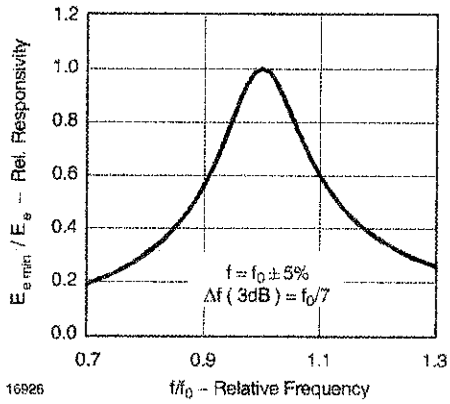


Figure 5. Frequency Dependence of Responsivity

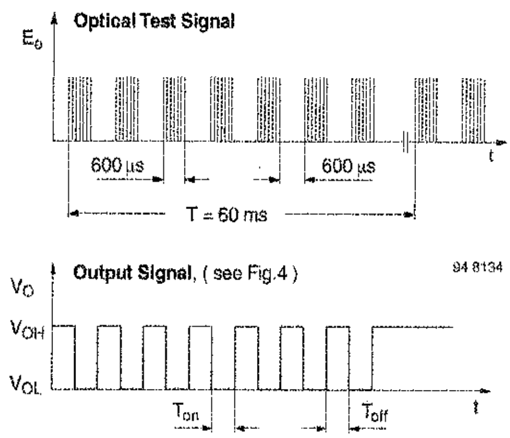


Figure 3. Output Function

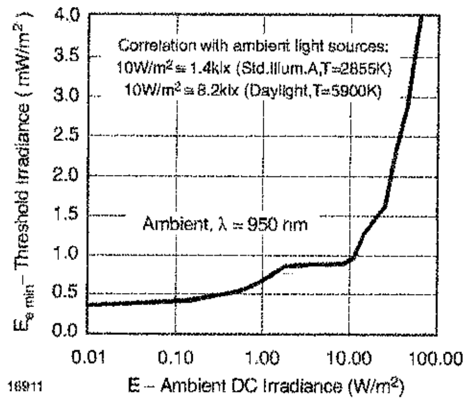


Figure 6. Sensitivity in Bright Ambient

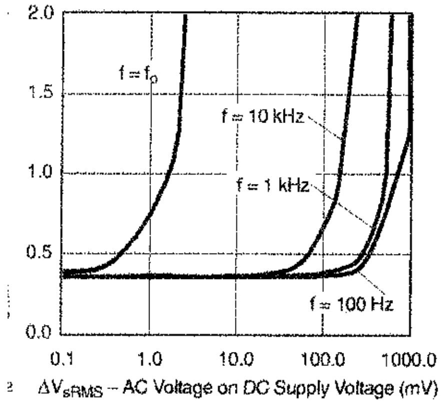


Figure 7. Sensitivity vs. Supply Voltage Disturbances

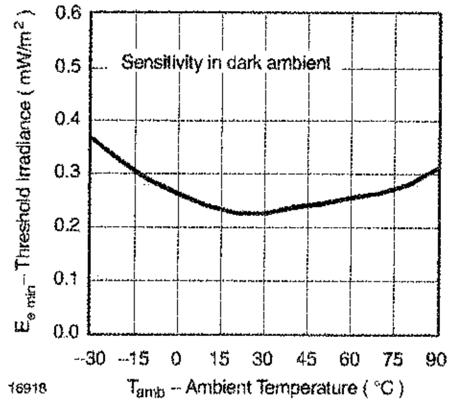


Figure 10. Sensitivity vs. Ambient Temperature

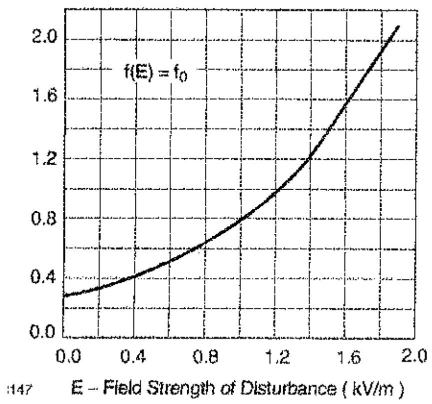


Figure 8. Sensitivity vs. Electric Field Disturbances

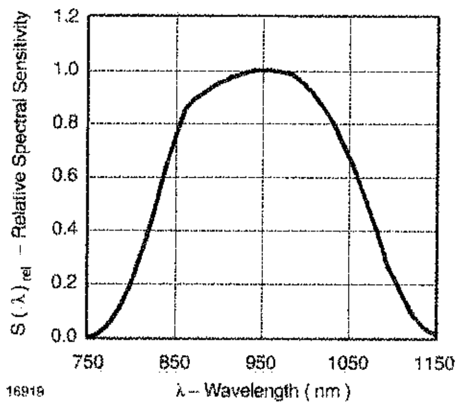


Figure 11. Relative Spectral Sensitivity vs. Wavelength

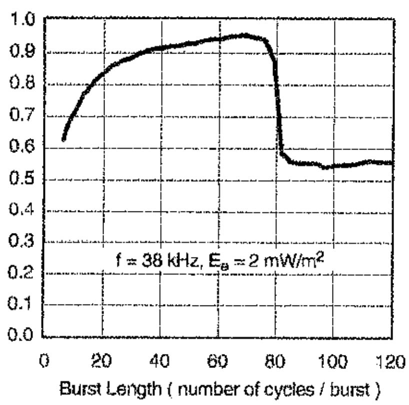


Figure 9. Max. Envelope Duty Cycle vs. Burstlength

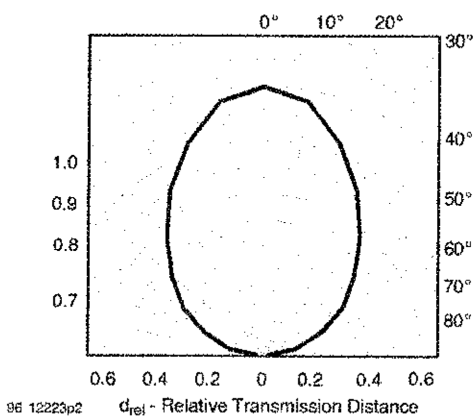


Figure 12. Directivity

Suitable Data Format

The circuit of the TSOP41.. is designed in that way that unexpected output pulses due to noise or disturbance signals are avoided. A bandpass filter, an integrator stage and an automatic gain control are used to suppress such disturbances.

The distinguishing mark between data signal and disturbance signal are carrier frequency, burst length and duty cycle.

The data signal should fulfill the following conditions:

• Carrier frequency should be close to center frequency of the bandpass (e.g. 38 kHz).

• Burst length should be 6 cycles/burst or longer.

• After each burst which is between 6 cycles and 70 cycles a gap time of at least 10 cycles is necessary.

• For each burst which is longer than 1.8 ms a corresponding gap time is necessary at some time in the data stream. This gap time should have at least same length as the burst.

• Up to 2200 short bursts per second can be received continuously.

Some examples for suitable data format are: NEC Code, Toshiba Micom Format, Sharp Code, RC5 Code, RC6 Code, RCMM Code, R-2000 Code, RECS-80 Code.

When a disturbance signal is applied to the TSOP41.. it can still receive the data signal. However the sensitivity is reduced to that level that no unexpected pulses will occur.

Some examples for such disturbance signals which are suppressed by the TSOP41.. are:

• DC light (e.g. from tungsten bulb or sunlight)

• Continuous signal at 38 kHz or at any other frequency

• Signals from fluorescent lamps with electronic ballast (an example of the signal modulation is in the figure below).

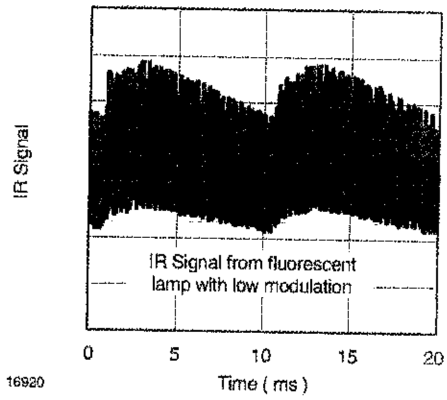


Figure 13. IR Signal from Fluorescent Lamp with low Modulation