Double M - Electric wheelchair

By

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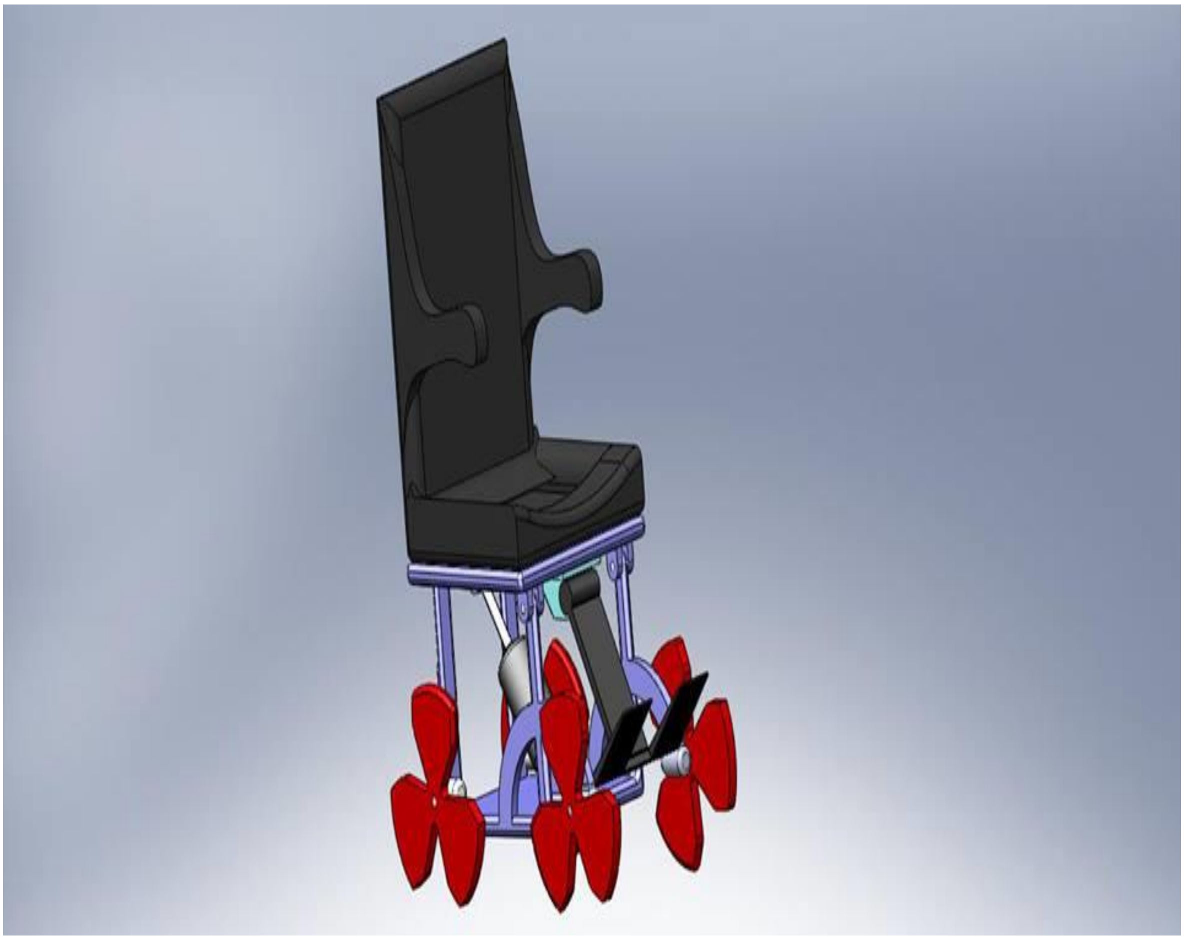

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Dedication

We only have to remember the smile on their faces when we met them for the first time. We only have to remember how excited they were when we told them about our **FYP** "**F**inal **Y**ear **P**roject". We only have to remember their words “we are here for you; we want you to be here for us "

We only have to remember the staff at “E.P.E.D.F.U” to make our dream came into reality.

Members of the staff at “E.P.E.D.F.U” represented for us more than just an inspiration; they taught us that everyone among us can achieve a dream. They helped us dream about tomorrow when we saw their dreams about today.

Acknowledg

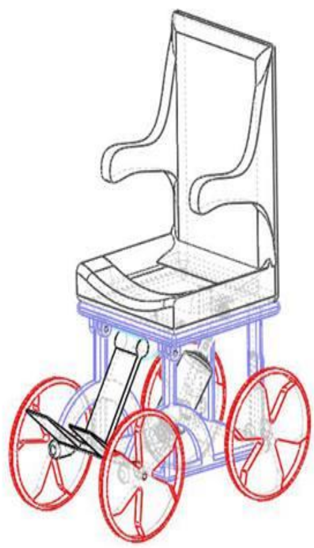
First and foremost, we would like to thank our Final Year Project (FYP) supervisors, Professor **Saber Mohamed** and professor **Amr Abdulla**, for them support and assistance in guiding us throughout this project. Besides just putting up with us, they were always able to give us insightful feedback, whatever the problem was.

Abstract

In our final year project, we are looking at a problem that a small portion of the population faces, this portion represents the “disabled”. Before choosing the topic of our project, the whole group members were determined to make use of our final year project for a good cause. Noticing that the disabled people in Middle East get very little attention from authorities, we decided to aim our project towards them in order to help as much as we can. Our influence might end up being minimal, but remember that a ten kilometer walk starts with a small step.
Disabled people rely heavily on their wheelchairs for transportation. The wheelchair frees them from their burdens and constraints and provides them with mobility. It has become a necessity to all, such that they cannot live without it anymore. For all these reasons, and in order to start a change, we decided to concentrate our effort on pinpointing the weaknesses in wheelchairs and improving them as much as we can
Our project will mainly feature one major idea in accordance with a few minor ones. The major idea that we will be trying to implement is to introduce wheelchair that can climb the stairs.
And also the price of this type is very expensive and is not manufactured in Middle East

Chapter 1

Introduction



1.1 Problem Definition

From about two years one of members is asked from disabled student who lives in student housing to help him with others to climb stairs with his wheelchair to the first floor.
Here, my friend ask them and me why is there no electric wheelchair can climb stairs?
And also if it is found how price? And why do not all disabled people use electric wheelchair?
Here, we decide that our project will be electric wheelchair that can climb stairs.

1.2 Management

The problem we are facing and trying to solve is the problem disabled people face whenever they get on their wheelchairs.
. How can electric wheelchair be available for largest number of disabled people in Middle East?
. How can make its cost lower as possible?
. How can make it climb stairs? And also make it safety by the meaning of mechanical and electric solution?

These questions describe this problem, which is best defined as the limited range that disabled people face when using their wheelchair. What we aimed for through our Final Year Project is to solve this problem. By new mechanical design that able to climb stairs with high safety and lower cost as possible. And use our study to tame this design electrically by using our knowledge of power electronics and machines.

Initially we will use to dc motors and also two batteries and power electronics components to control system and the wheelchair is fully controlled by a joystick placed near the left hand rest. Next to the right hand rest there is a control panel that contains all of the switches and battery charge level indicator. So in general, we have achieved our goal of building and implementing our design and as a result, we lay today our hands wheelchair that can climb stairs safety and also very cheaper from others in the same manner

Chapter 2

Literature Review

2.1 Electric Wheelchair

Electric wheelchairs appeared in the 1950s. Today's models are better described as electronic chairs rather than electric chairs. Electronic circuitry allows for a control of speed and a precise control of direction.

2.2 Basic Styles

Many of today's sophisticated electric wheelchairs conform to two basic styles.
The first is called the traditional style and consists of a power source mounted behind or underneath the seat of the wheelchair. As the name implies, the traditional unit looks very much like a manual wheelchair. The second design is known as a platform chair. In this design, the seating area, which can often be raised or lowered, sits on top of the power source.

2.3 Indoor vs. Outdoor Use

There are several groups of powered wheelchairs, based on the intended use. Wheelchairs designed strictly for indoor use have a smaller area between the wheels, allowing them to negotiate the tighter turns and more confined spaces of the indoor world. Other designs allow the electric wheelchair to be used both indoors and outdoors, on sidewalks, driveways, and hard, even surfaces.

Finally, some electric wheelchairs are able to negotiate more rugged terrain such as uneven, stony surfaces.

2.4 Methods of Propulsion

Wheelchairs are classified according to the drive wheel location relative to the system Centre of gravity (chair and user). The following are the three basic methods of propulsion:

- **Rear Wheel Drive Wheelchair**

This is the most common method of drive for an electric wheelchair. The drive wheels are located behind the center of gravity while the front wheels are casters. This method makes the wheelchair fast, but can give a poor turning capability when compared to front and mid wheel drive chairs.

- **Center Wheel Drive Wheelchair**

This method of drive is the best method of drive for an electric wheelchair. The drive wheels are directly below the center of gravity while the front and rear wheels are casters. The wheelchair can be a little unsteady when starting and stopping but it could not be suitable for uneven surfaces.

- **Front Wheel Drive Wheelchair**

This method of drive gives a lower top speed than rear wheel drive chairs, but offers a good turning capability. The drive wheels are in front of the center of gravity while the rear wheels are casters.

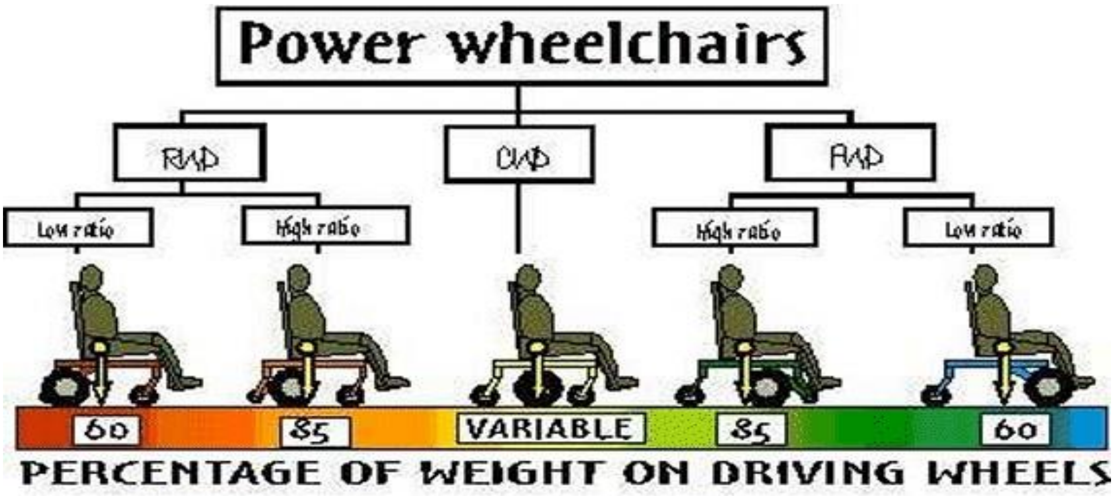
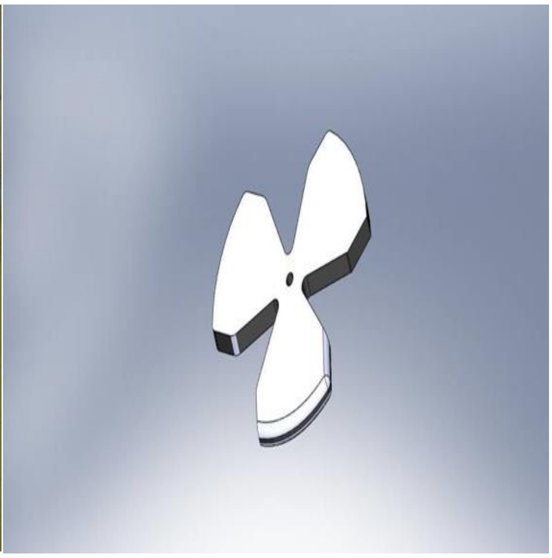


Figure 2.1: Methods of propulsion

Chapter 3

Mechanical solution



3.1 Electric wheelchair climbing stairs type

The first moment we chose making "Electric wheelchair climbing stairs" as a graduation project we decide to make it in a new design with new technique not like these in markets. The major reason for this decision is the price of "Electric wheelchair ". It is very high in average 80,000 L.E and this high price is due to all electric wheelchairs use large amount of high power motors (two motors used for normal motion and other motors used for climbing stairs) figure 3.1 shows this type of wheelchair.

Figure 3.1: Electric wheelchair climbing stairs

3.2 Our vision for climbing design

We start with this point how to reduce the power and number of motors in our electric wheelchair we make a design that let the wheelchair use the same motors for normal motion and climbing stairs. The design in figure3. 2.1, 3.2.2 and 3. 2.3

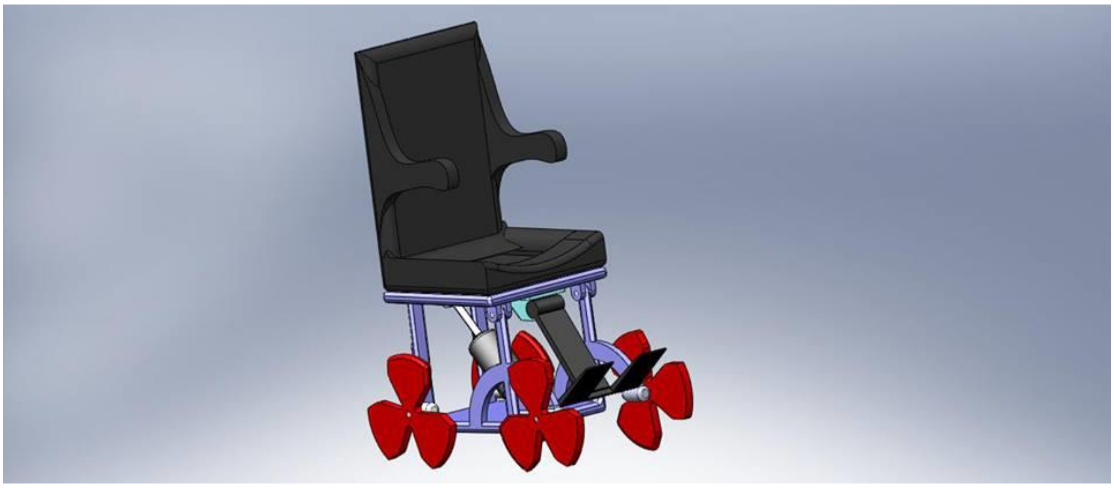


Figure 3.2.1

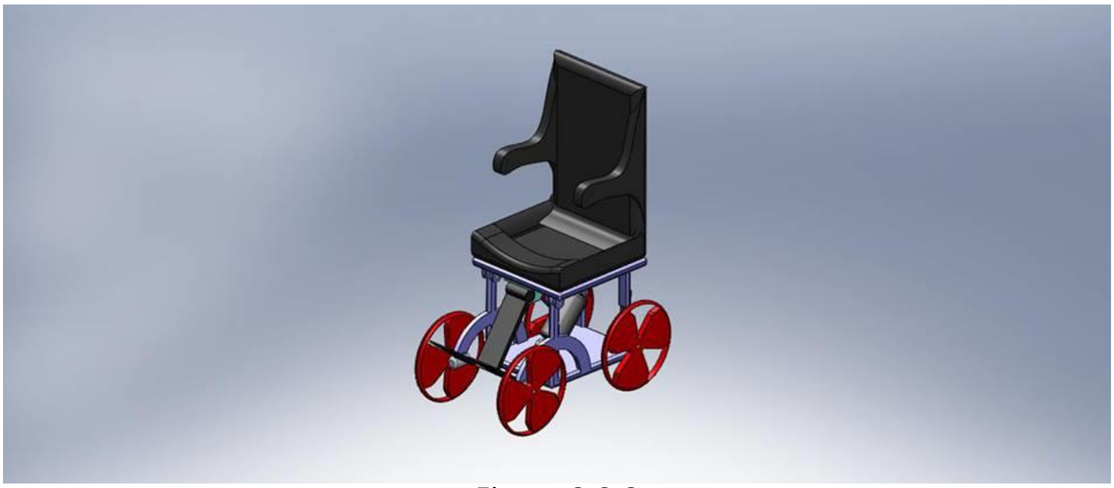


Figure 3.2.2

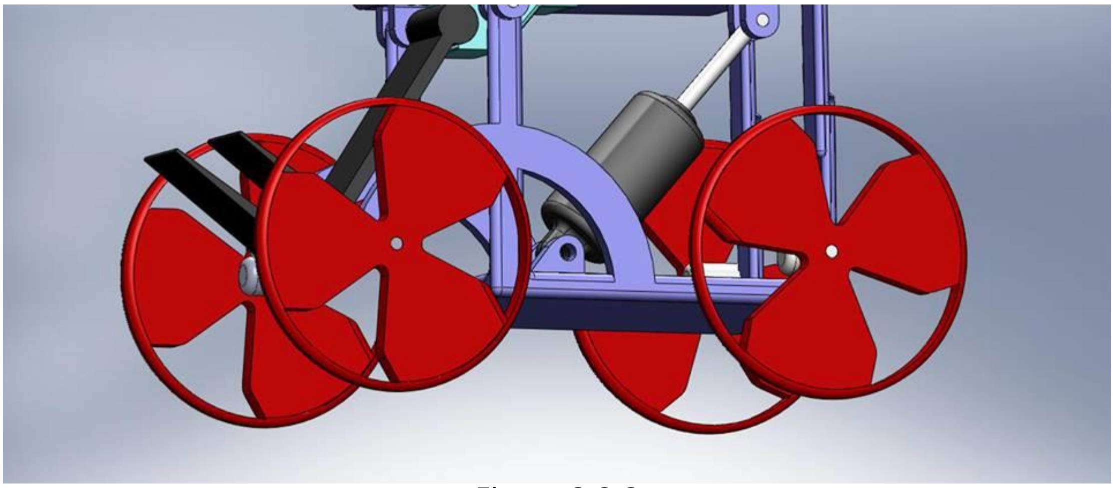


Figure 3.2.3

3.3 Electric wheel design

The difference we made is that the motors will not changes .the shape of the wheels will changes from it's normal shape in figure 3.3 to the Tri-Star shape in figure3.4.

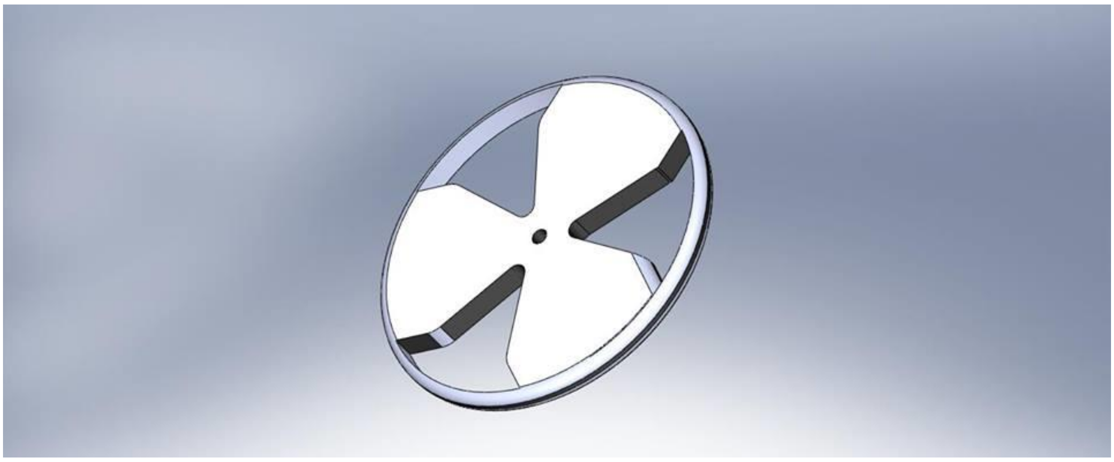


Figure 3.3: wheel in normal motion

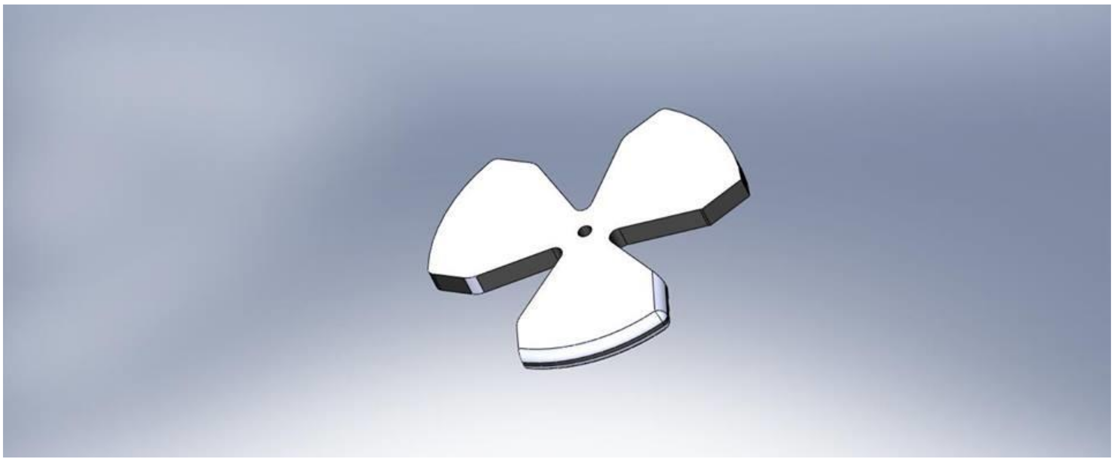


Figure 3.4: the Tri-Star shape

And this will give the wheelchair the ability to climb the stairs easily

The wheel turns to this shape by the way that some parts of the wheel go inside other parts in the same wheel.

We had an electrical vision for this process but there wasn't ability for making the mechanical parts because it need very advanced machines likes that used in factories so we decide to make it manual as a start.

.Electrical vision for wheel

Our electrical vision is very similar to the operation of cd room in computers we will use two small motors in each part of the three parts of Tri-Star wheel and these motors will pull the parts in and out .

3.4 seat level changes

While ascending or descending the stairs the seat level changes by angle equal to the inclination angle of stairs that max. Angle is equal to 28.2.

There's two ways to change the level:

First technique is spontaneous. The seat is designed by away that give it's level the ability to be changed spontaneous when the wheelchair start ascending the stairs by the effect of the weight. This technique is actually used in power wheelchair type. Figure 3.5

Figure 3.5: power wheelchair

Second technique is hydraulic. It is more save and used in all other types of electric wheelchair.

3.5Choosing the DC Motors

In order to choose the required DC motors that can do the job, we conducted a theoretical study that aims to helping us choose the optimal type and size of DC motors.

MOTOR SIZED

* M = 150 kg "total mass" * V_{max} = 9 km/hr. = 2.5 m/s

*A_{front} = 1.45*0.60 = 1 m^2 * R = 0.17 m "wheel radius "

Calculation of rpm at v_{max}

rpm = v_{max} *60/ 2πR = $\boxed{140.7 \text{ rpm}}$

Case 1 **In flat rood**

. **F_{aire} = air resistance = 0.5 c_d A_{front} p v_{max}^2**

*** c_d = resistance coefficient of air " max = 1" * p = air pressure = 1.2041**

- F_{aire} = .5 * 1* 1* 1.2041* 2.5 = 4 N

. **F_R = rolling resistance = M g c_r**

*** $c_{r\,=}$ rolling coefficient = 0.1 as max * g = 9.8 m/s^2**

- F_R = 150 * 9.8 * .1 = 147 N

At equilibrium

$\Sigma F_x = F_t - F_R - W_x = 0$

$F_t = F_R + F_{air} = 151$ N

power of two motors

$P = F_t * v = 151 * 2.5 = \boxed{377.5 \text{ watt}}$

Case 2 **where inclination: $\alpha_{max} = 30^\circ$**

Maximum angle of inclination: $\alpha_{max} = 30^\circ$. According to the international laws for transportation the maximum slope angle should not exceed 37°

at

* $V_{= 0.5\ m/s}$

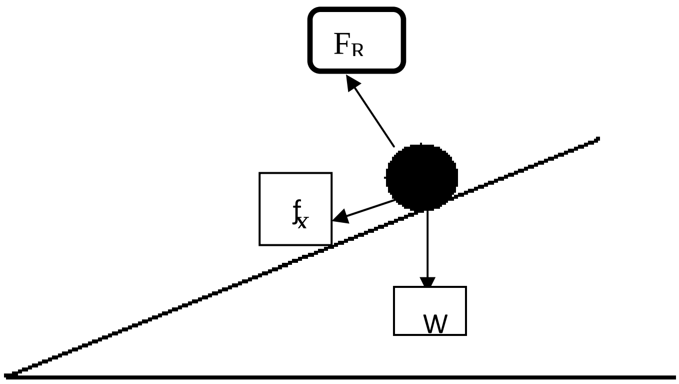
*assuming there is no acceleration during climbing.

Weight of the Wheelchair

W= M × g = 150 × 9.81 = 1471.5 N "total weight "

Friction force

$F_x = \mathbf{c_r} * W \cos(30^\circ) = .1 * 1471.5\ 0.866025 = 127.44$ N



Weight in the direction of the movement

$W_x = W \sin(30^\circ) = 735.75$ N

At equilibrium

$\Sigma F_x = F_t - F_R - W_x = 0$

$\mathbf{F_t} = F_R + W_x = 861$ N

Torque at the wheel "Here torque is max."

$T_{max} = F_t \times R = 861 \times 0.17 =$ $\boxed{150.7\ N.m}$ say 160 N.M

power of two motors

$P = F_t * v = 861 * .5 =$ $\boxed{430.5\ watt}$

so

p = 1.25 * 430.5 **=** $\boxed{539\ watt}$ 1.25 is a safty factor

and also slide angle at v_{max}. Is about 7.5^0

Case 3 **in case of stairs** "up"

. Slide angle of stairs in max. Design = 28.2^0
this means that the power needed is less than case 2

For one motor	
Power	300 watt
Torque	80 N.M
Rpm	**150** rpm

Table 3.1: dc motor size

Chapter 4

Electrical Solution and Implementation

4.1 Electric wheelchair Battery

There are three different battery types used in wheelchair .they are "wet", "Gel" and "AGM" types. Their properties listed below:

. Wet batteries

Wet batteries use the chemical reaction between lead and sulphuric acid to create Electrical energy .these batteries need to be filled with distilled water, and they do have a higher maintenance, but are higher than Gel or AGM batteries.

Advantages:

Cheaper
Less vulnerable to overcharging

Great performance with careful maintenance

Lighter per Ah compared to most Gel or AGM's

Disadvantages:

Require maintenance

Battery acid can leak, causing corrosion and damage to chair and wiring

Not approved for airline travel

High rate of self-discharge when left sitting (6-7% per month)

• Gel Batteries

Gel batteries contain a mixture of sulphuric acid, fumed silica, pure water, and phosphoric acid, which forms a thixotropic gel. As there is no liquid in the battery, they do not leak or require maintenance like wet batteries

Advantages:

No maintenance

Cannot leak

Operate better than wet batteries in low temperatures
Less gas released when charging than wet batteries

Approved for air travel

Longer life cycle than wet batteries

Disadvantages:

Expensive

More weight per Ah than wet batteries.

Susceptible to overcharging

• AGM batteries

AGM batteries have an absorbent glass mat sandwiched between the plates, saturated with acid electrolyte, but with none free to spill. This type of batteries reduces the chance of battery damage caused by vibration and jarring.

Advantages:

No maintenance

Can’t spill or leak

Shock resistant

Minimal gasses released when charging.

Low self-discharge rate (3% per month at 77’F)

Disadvantages:

Highest cost

Susceptible to overcharging

New technology

We will use two 12v lead acid battery (wet) connected in series to get 24v to the motors.

Figure 4.1: Batteries of the wheelchair

4.2 Battery Charge Level Detector

We designed a circuit that indicates the charge condition of a 12 volt lead acid battery. We connected the circuit to the terminals of one battery. It is composed of four LEDs where each LED represents an approximate 25% change in charge condition, so that 3 LEDs indicate 75%, 2 LEDs indicate 50%, etc.

When the yellow and the green LEDs are off, the driver of the wheelchair needs to turn the internal combustion ON in order to recharge the batteries.

Figure4.2: Battery charge level indicator

4.3 Battery charge and discharge

We should monitor the amount of charge in the battery making sure that they never charge over 80% and never under 20% of their capacity. In this way, the batteries will last a couple of hundred thousand miles.

4.4 Electric Wheelchair DC Motor

Most power wheelchairs currently utilizes PM motors with iron magnets, brushes and indirect drive trains. Recent innovations within the power wheelchair industry include the use of rare earth magnets; and brushless, gearless, direct drive motors. Rare earth magnets support much higher magnetic fields than iron magnets. Motors utilizing rare-earth magnets are smaller and lighter and more powerful than analogous motors with iron magnets.

Brushless motors are more efficient than brush motors (brushes introduce electrical power loss). Brushes are also subject to wear and require regular inspection and replacement.

Gearing and belts in the indirect drive train are a source of mechanical power loss. Highly efficient, gearless, direct drive motors have recently appeared in the power wheelchair market. These motors can be mounted in close to the drive wheels and allow good access to the under seat compartment. However, these motors tend to be relatively large and expensive.

The following list includes some of the motor technologies that have been suggested.

• A brushless, gearless motor entirely contained within the power wheelchair’s drive wheel.

• Pancake stepping motors efficiently generate high torque, even at high speeds. These motors are durable and reliable.

Disc-armature DC motors have high power to weight ratio and efficiency.

- Alternating current, three phases, squirrel cage induction motors (SCIM) are inexpensive, efficient, highly reliable, and have a torque speed characteristic very adequate for vehicle propulsion.

So we can choose BLD motor to support high power to weight ratio.

In prototype we can get or compound dc motor with gear box and self-braking. As in figure4.3

figure4.3: compound dc motor with gear box and self-braking

Chapter 5

Control Design and Implementation

5.1 PWM and Speed Control Principle

The diagram below shows a summary of the electrical and control system of our wheelchair

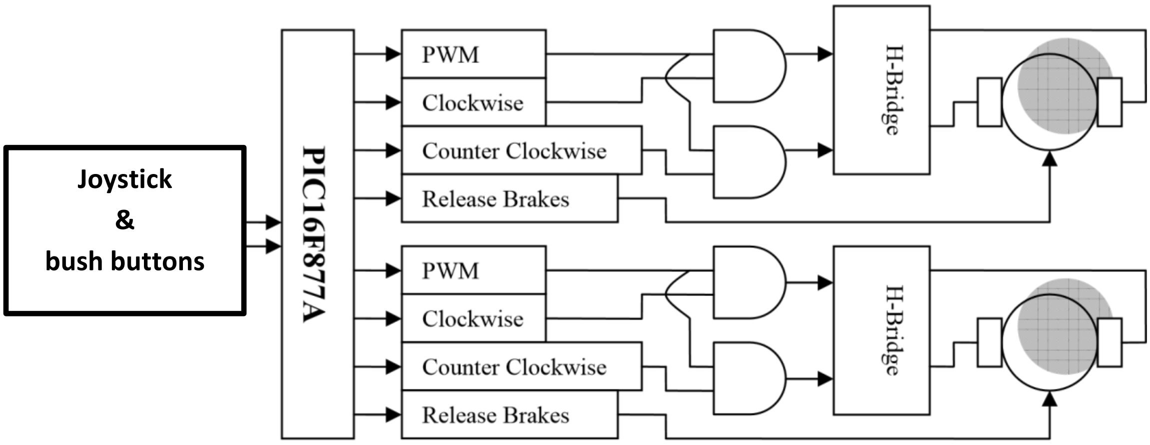


Figure 5.1: electric and control system

to control the speed of the DC motors; one needs a variable voltage DC power source. However if you take a 24v motor and switch ON the power to it, the motor will start to speed up: motors do not respond immediately so it will take a small time to reach full speed. If we switch the power off sometime before the motor reaches full speed, then the motor will start to slow down. If one switches the power on and off quickly enough, the motor will run at some speed that is between zero and full speed. Therefore, PWM switches the motor on in a series of pulses. To control the motor speed it varies

(Modulates) the width of the pulses; from here came then naming: Pulse Width Modulation.

The PWM signal is a square wave that has a duty cycle

$$= \frac{time\ of\ high\ in\ a\ period}{time\ of\ the\ period} * 100$$

In essence, as the duty cycle increases the speed of the motor increases. For example, if the duty cycle is 0%, the motor will not rotate. If the duty cycle is 50%, the motor would rotate half its speed. If the duty cycle is 100%, the motor would be rotating at full speed.

Since the PWM signal is a square wave, then it should have a frequency. The normal operational frequency for DC motors is between 2 KHz and 6 KHz. By trial and error, we found that for our DC motors, the best frequency is 2 KHz.

5.2 Control Components

. Microcontroller

The microcontroller is the brain of the wheelchair; without it, the machine won't be able to move. Its main job is to take as input some signals from a joystick and generate two PWM signals: one for each motor. These PWM signals enter the H-Bridges in order to be able to control the speed of the rotation of the DC motors. Therefore, the main use of the PIC is for DC motors speed control. In addition to that, the microcontroller should also control the steering mechanism of the wheelchair and should coordinate between the DC motors. Therefore, the microcontroller should control the speed and direction of rotation of each motor.

. Pic 16f877a

The decision fell on PIC16F877A because of its capability of generating two PWM signals at the same time. And supports us with sufficient digital and analog inputs. Also, the PIC is a very efficient and powerful microcontroller with so many pins that can be easily programmed. Besides, the components are cheap and do the job perfectly.

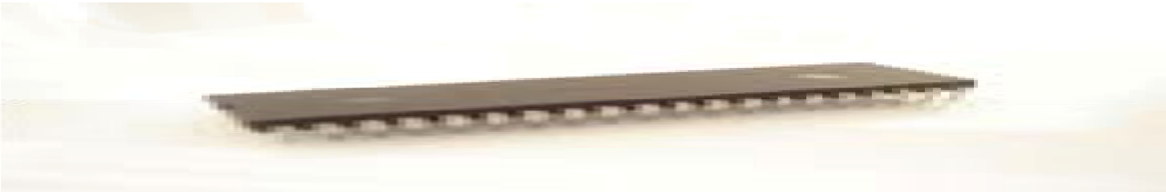


Figure 5.2: PIC16F877A

. Microcontroller I/O

Input*:* joystick, four bush buttons and one switch as in fig

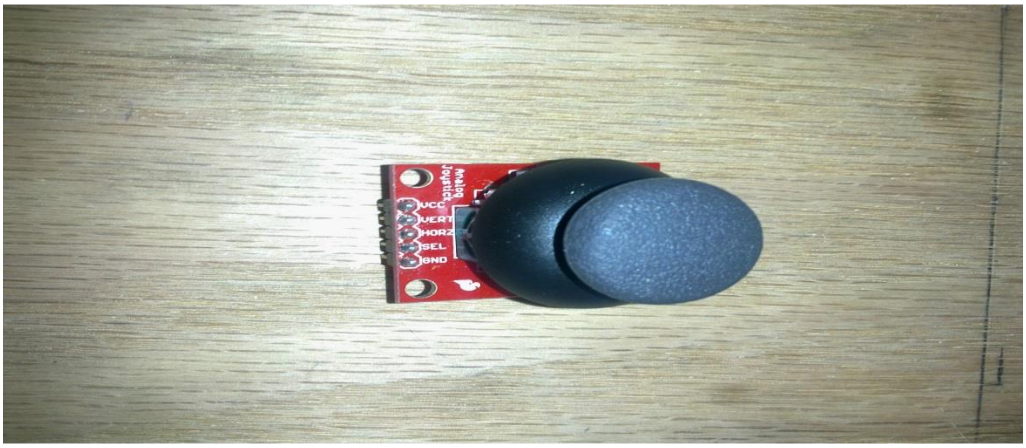


Figure 5.2: analog joystick

Joystick*:* The joystick that is used in the project has two potentiometers

(Forward/Backward, right/left). The voltage of these potentiometers ranges between 0-5V. If the joystick is still (nothing is applied on it), the two voltages would be 2.5V. Also, the joystick can rotate 360°. These facts give the user the ability to go in any direction at different speeds according to the combination to the two voltages across the potentiometers.
Switch; is used as enable for stairs mode .when it is energized means stairs mode is available.

Four Bush buttons as follow

1st	**To increase the speed up by increasing input voltage by 20% for every bushing (4 rang)**
2nd	To decrease the speed up by decreasing input voltage by 20% for every bushing (4 rang)
3d	When switch is energized (enable for stairs mode) wheelchair climbs the stairs up by bush this button
4th	When switch is energized (enable for stairs mode) wheelchair climbs the stairs down by bush this button button

Table 5.1: input Bush buttons

***Outputs**:* There are two sets of outputs; the first is for the right motor, while the second is

- PWM signal: this is the signal that specifies the speed of the motor.
- Clockwise: if ON, it means that the motor should run clockwise. If OFF, it means that the motor should NOT run

clockwise.
If OFF, it means that the motor should NOT run counter clockwise

Release Brakes: if ON, the brakes of the motor are released. The brakes are always released whenever the motor should be rotating

in each set, “Clockwise” and “Counter Clockwise” outputs can NOT be ON together. If one of which was ON, the brakes should be released. However, if both were OFF, it means that the motor is OFF and the brakes should be applied.

Note that the two DC motors should either be rotating clockwise together or counter clockwise together, or not rotating at all. It is impossible for one to be rotating clockwise while to other is rotating counter clockwise. But it is possible for one to be rotating in a certain direction while the other is not rotating at all: in this case the wheelchair should be steering either to the right or left.

- **Control Algorithm**

The control starts from the joystick where there the two potentiometers discussed before.

The joystick is responsible for generating two output voltages:

V1: the voltage across the forward/Backward potentiometer.

V2: the voltage across the right/left potentiometer.

According to the combination of V1 and V2, the direction of motion is known as follow

V1	V2	Right Motor	Left Motor	Direction
0 : 1	2 : 3	Backward	Backward	Backward
4 : 5	2 : 3	forward	forward	forward
2 : 3	0 : 1	Backward	forward	right
2 : 3	4 : 5	forward	Backward	left
4.2 : 4.8	0.2:0.8	NA	forward	right
4.2 : 4.8	4.2 : 4.8	forward	NA	left
2 : 3	2 : 3	NA	NA	NA

Table5.2: the direction of motion

- **Assigned Pins in the PIC Microcontroller**

We need three analog inputs, five digital inputs, one reference voltage, two PWM signals, and sex digital outputs:

- *Analog inputs: An0 (A0), An1 (A1) and An2 (A3)*
- *Digital inputs: D4, D5, D6, D7, C7*
- *2 PWM signals: C1 and C2*
- *2 Release Brakes: A2 and A5 (we can use self-braking motor)*
- *2 Clockwise: D0 and D2*
- *2 Counter Clockwise: D1 and D3*

5.3 DC Motor-Driver H-Bridge Circuit

A very popular circuit for driving DC motors is called an H-Bridge. It's called that because it looks like the capital 'H' on classic schematics.

The great ability of an H-Bridge is that the motor can be driven forward and backward at any speed, optionally using a completely independent power source.

Its simple conceptual schematic is as follows:

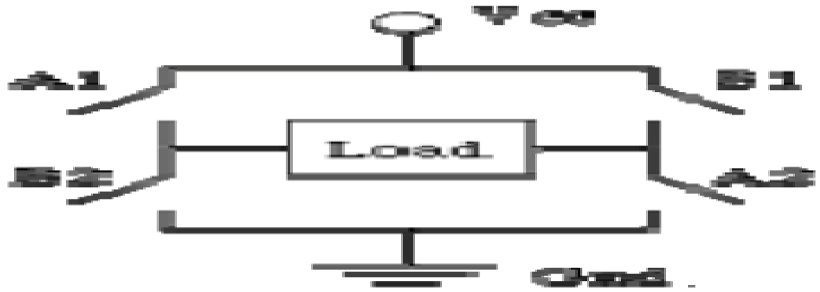


Figure 5.3: Simple conceptual schematic of an H-Bridge

A basic H-Bridge has 4 switches, relays, transistors, or other means of completing a circuit to drive a motor. In the above diagram, the switches are labeled A1, A2, B1, and B2. Since each of the four switches can be either open or closed, there are $2^4 = 16$ combinations of switch settings. Many are not useful and in fact, several should be avoided since they short out the supply current (e.g., A1 and B2 both closed at the same time). There are four combinations that are useful:

Table: Four Useful Connections

Closed Switches	Polarity	Effect
A1 & A2	Forward	Motor spins forward
B1 & B2	Reverse	Motor spins backward
A1 & B1	Brake	Motor acts as a brake
None	Free	Motor floats freely

Table5.3: Useful Connections O/p

The fourth case will be like the third case as we use a self-braking motor. If power is cut off the motor stops immediately.

5.3.1 Operation of the H Bridge

As we said earlier, an H-bridge is a configuration of four switching devices that allows you to change the direction of current flow through a load, in our case through a DC motor. This is done by selecting which pair of MOSFET is on and which pair is off.

The H-bridge requires that there be two MOSFETs located between the battery and the

DC motor and two MOSFETs located between the load and the system ground return. The MOSFETs are turned on in pairs, either high left and lower right, or lower left and high right, but never both MOSFETs are on the same "side" of the bridge. If both switches on one side of a bridge are turned on, this creates a short circuit between the battery plus and battery minus terminals. If the bridge is sufficiently powerful it will absorb that load and the batteries will simply drain quickly.

Referring to the circuit in figure 9 below:

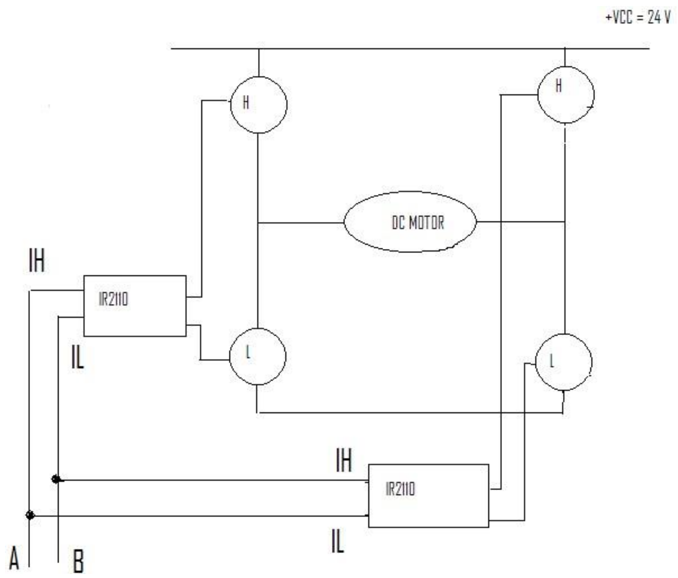


Figure 5.4: Conceptual design

Each driver has a high input and a low input as well as a high output and a low output. So we connect the high input of the first driver to the low input of the second driver and vice versa. We also connect the high output and the low output of one driver to the high MOSFET and the low MOSFET of the same side respectively.

“A” and “B” are the two logic input to the circuit. One of them is the PWM signal and the other one is set to zero. When we activate one of the high side MOSFET and its diagonally opposite low side MOSFET we have to make sure that the remaining MOSFETs are not operating. For this, one PWM enters in either in “A” or “B”. For example, if “A” is now set to “1” and “B” is set to “0”, the high input of one driver with the low input of the second driver are activated thus activating two diagonally opposite MOSFETs while the others are off. Once we want this motor to run in the opposite direction we set the PWM at A to zero then we send the PWM signal through B. Therefore, at any time we want the motor to switch direction, a passage by zero is obligatory.

in our prototype we will use IC L298 .this ic contains two H-bridge , AND gates and can carry current up to 2A so it can be used for control the speed and direction of small dc motor like we used in our prototype .

5.3.2 The Main Components

In order for the PIC16F877A to operate and provide required result, certain connections should be made. Some of these connections are imposed by the datasheets of certain components while the others are the result of desired circuit functionality.

5.3.2.1 Use of 16 MHz Crystal

The PIC16F877A needs frequency in order to operate, thus the crystal will provide the PIC with a frequency equal to 16 MHz

5.3.2.2 Use of Regulator

The PIC16F877A requires a voltage of 5V in order to operate, but since we only have a 24V DC supply we need a regulator LM7805 to provide the PIC with the required 5V. However, we cannot directly connect the 24 V to the regulator because it cannot handle such a high voltage. Therefore, we connect a resistor, between the regulator and the 24VDC, for voltage drop. The value of this resistor is chosen upon testing so that the input to this regulator is around 12V.

A 330µF capacitor is also connected between one terminal of the resistor and the ground to prevent a direct application of voltage to the regulator; instead it provides a soft starting.

5.3.2.3 AND Gate

The DC motors of the wheelchair should be able to operate in both rotational directions

(Clockwise and counter clockwise). Therefore, we need two PWM signals for each H Bridge to control the direction. The following table shows how the inputs of the H-Bridge affect the direction of rotation of the motors:

H-bridge Input 1	H-bridge Input 2	Direction of Rotation
PWM	0	Clockwise
0	PWM	Counter Clockwise

Table5.4: H-Bridge inputs and direction of rotation

However, the microcontroller that we are using (PIC16F877A) can only generate two PWM signals (one for each motor). Therefore, in order to be able to change the direction of rotation and still use only one PIC16F877A for both motors, AND gates should be used. For each H-Bridge, two AND gates are needed: the PWM signal for that H-Bridge

(Motor) enters both AND gates as the first input. The second input is the “clockwise” and “counter clockwise” bits to AND gate #1 and #2 respectively. The following figure shows clearly the diagram of the AND gates: PWM

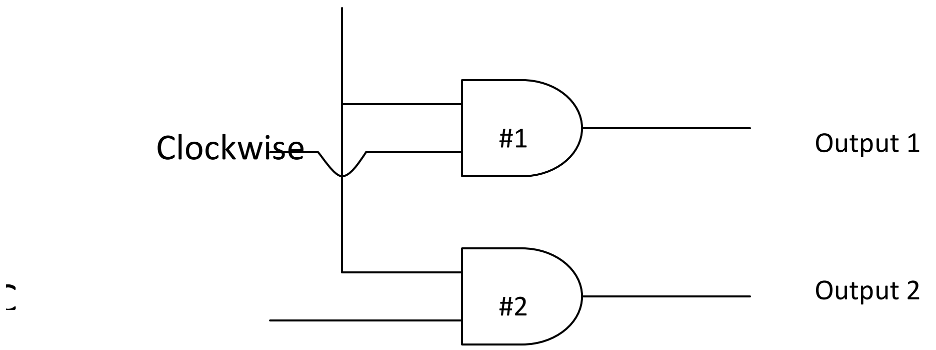


Figure 5.5: AND Gate conceptual operation

Clockwise	Counter Clockwise	Output1	Output2
1	0	PWM	0
0	1	0	PWM

Table 5.5: Summary Table of AND Gate

In this way, the PWM enters only one of the inputs of the H-bridge while the other input is zero. This will cause the motor to rotate clockwise or counter clockwise depending on the relative bits

5.3.2.4 Types of Capacitors Used

In this H Bridge, three types of capacitors were used while each type was performing a different task.

- *Back up Capacitors*

Each time the DC motor turns ON or OFF, an instantly drop of voltage power outage may occur in the batteries. The capacitor, like the battery, can be continuously trickle charged until power delivery is needed.

Immediately upon power outage, two 10000 µF chemical capacitors connected in parallel with the battery will deliver the back-up power to the DC motor. Once operating, the battery can deliver uninterrupted power to the DC motor and the capacitors can be idled.

- *Ceramic Capacitors*

Ceramic capacitors are small in size and value, ranging from a few Pico Farads to 1 µF.

Not polarized, so either end can go to ground.

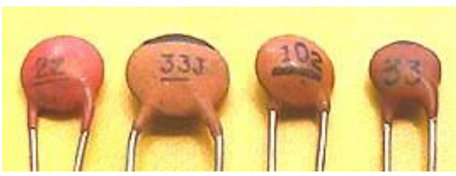


Figure 5.6: Ceramic capacitors

These capacitors are used because the DC Motor generates a lot of “noise” from the brushes that are used to turn the motor. There is also a large amount of voltage spikes that are generated in controlling the motor because when the coils of the DC motor receive 24 V from the battery, they send high frequency parasites, and thus a need for ceramic capacitors is a must since these capacitors are high frequency filters.

Ceramic capacitors are placed in parallel with the back up capacitors as well as right at the output of the regulator so that the parasite is not transmitted throughout the circuit.

- *Chemical Capacitors*

These capacitors are polarized and care should be taken while placing them in the circuit. If they are connected incorrectly they can be damaged, and in some extreme cases they can explode.

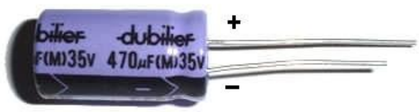
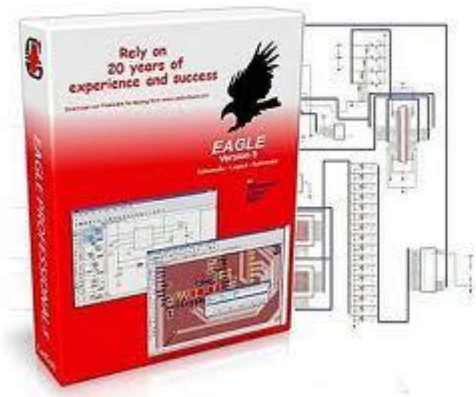


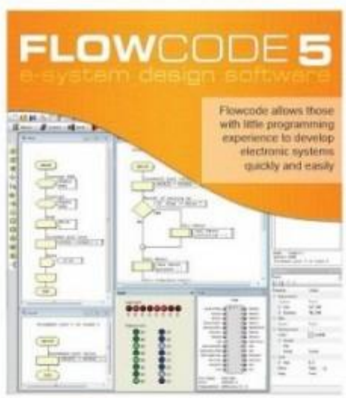
Figure 5.7: Chemical capacitors

This type of capacitor is used as a filter to bypass low frequency signals

Chapter 6

Programs used in project





6.1 Mikroc – program

This program is used for programming the pic microcontroller by c – language. Allow you do any program by the meaning of c-language. Output program in appendix **B**.

6.2 Flow code - program

It's used for programming the microcontroller by a relative new language called flow code (very similar to the flow chart) . flow code is very easy , fast learning and can make complex program in short time . Output program in appendix **B**.

6.3 proteus - program

This is a simulation program we used it to simulate our circuit and make sure that circuit works well and give the required output.

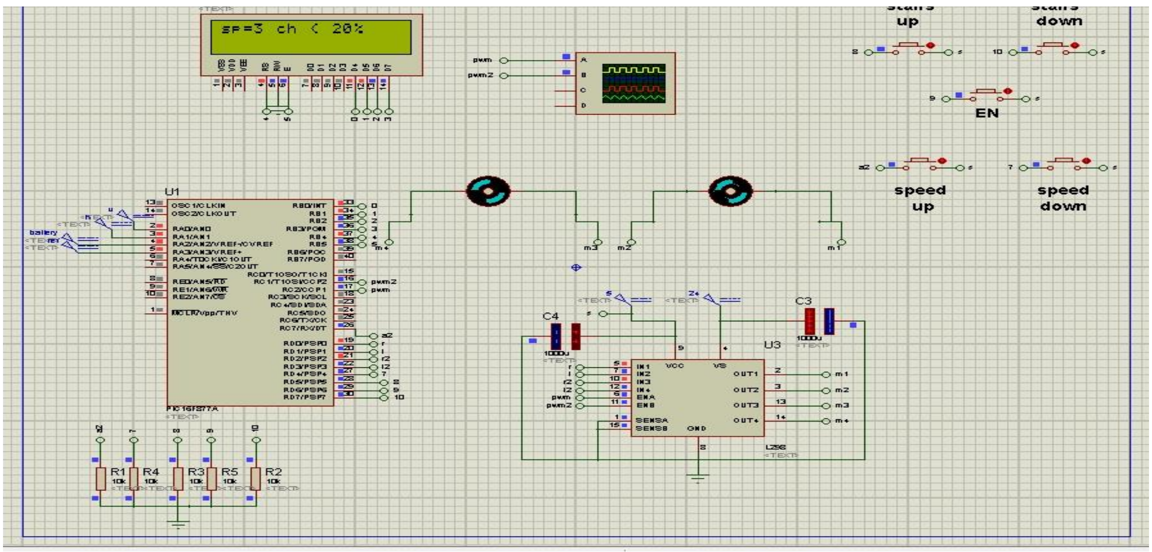


Figure 6.1: proteus simulation

6.4 Eagle - program

We used this program to make the PCB circuit for our project

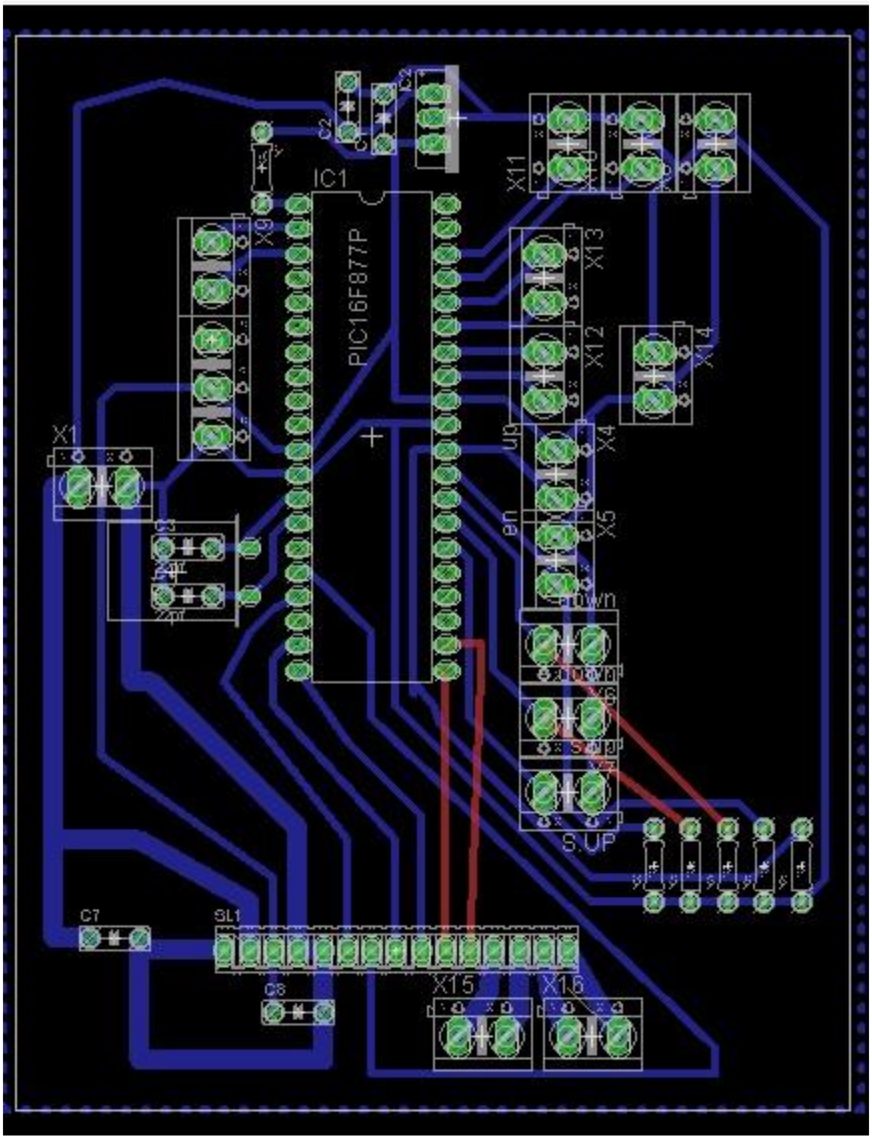


Figure 6.2: Eagle program diagram

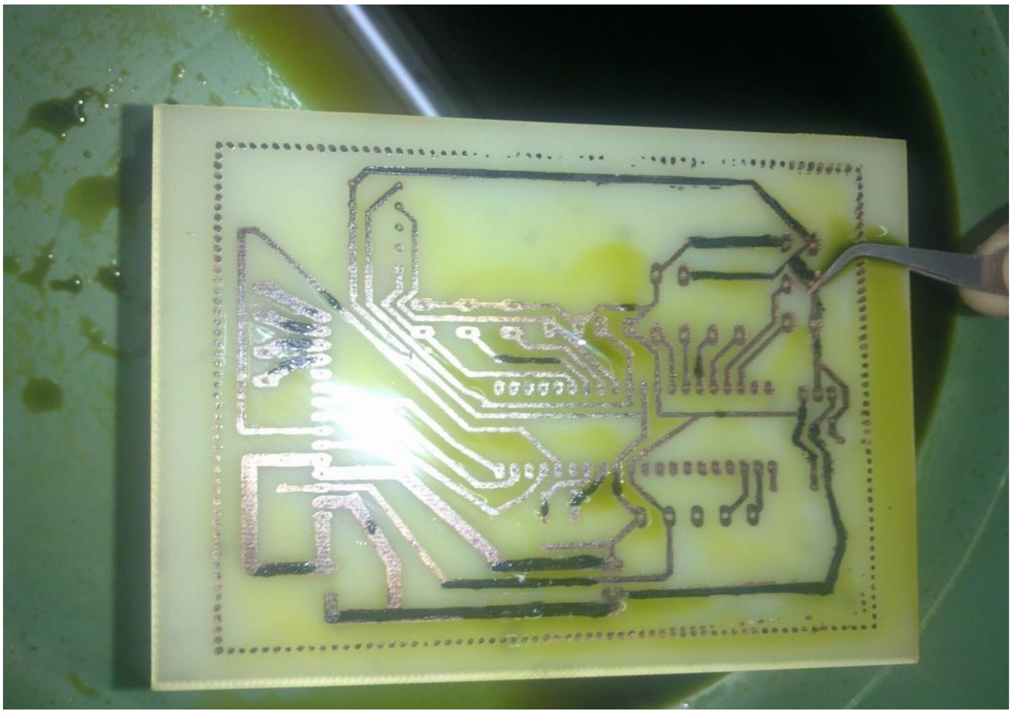


Figure 6.3: PCB

6.5 Solid work - program

This program is used to design the mechanical parts and matching them.

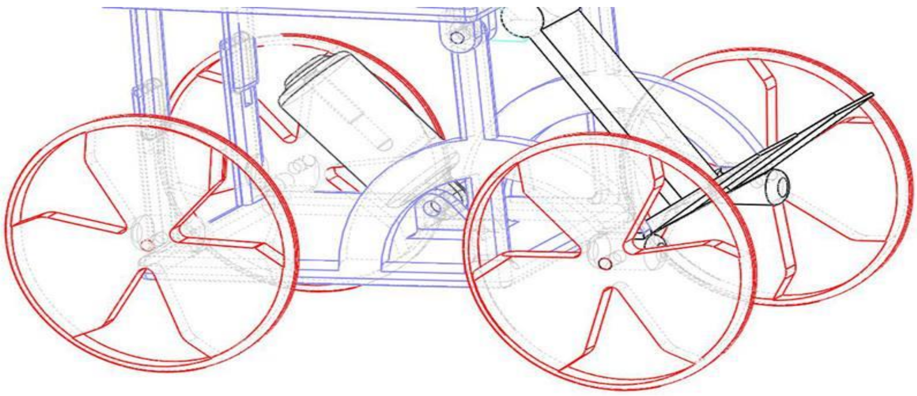


Figure 6.4.1: solid work program output

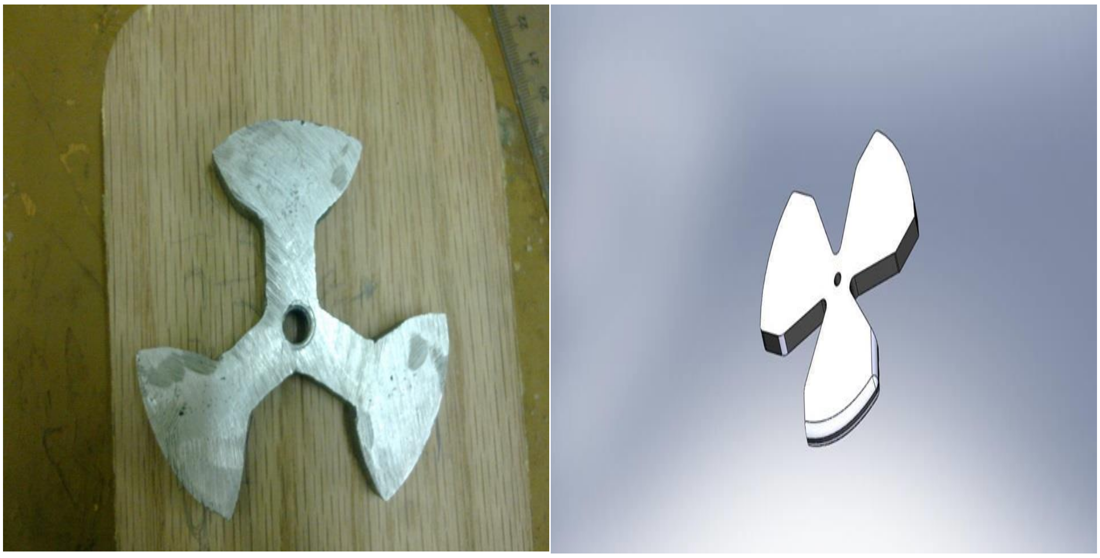


Figure 6.4.2: solid work program practical output

Appendix A

Components datasheet

PIC16F87XA Data Sheet

MICROCHIP

PIC16F87XA Data Sheet

28/40/44-Pin Enhanced Flash Microcontrollers

 DS39582B

PIC16F87XA

28/40/44-Pin Enhanced Flash Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

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 other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

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
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^{2}C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (VREF) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

CMOS Technology:

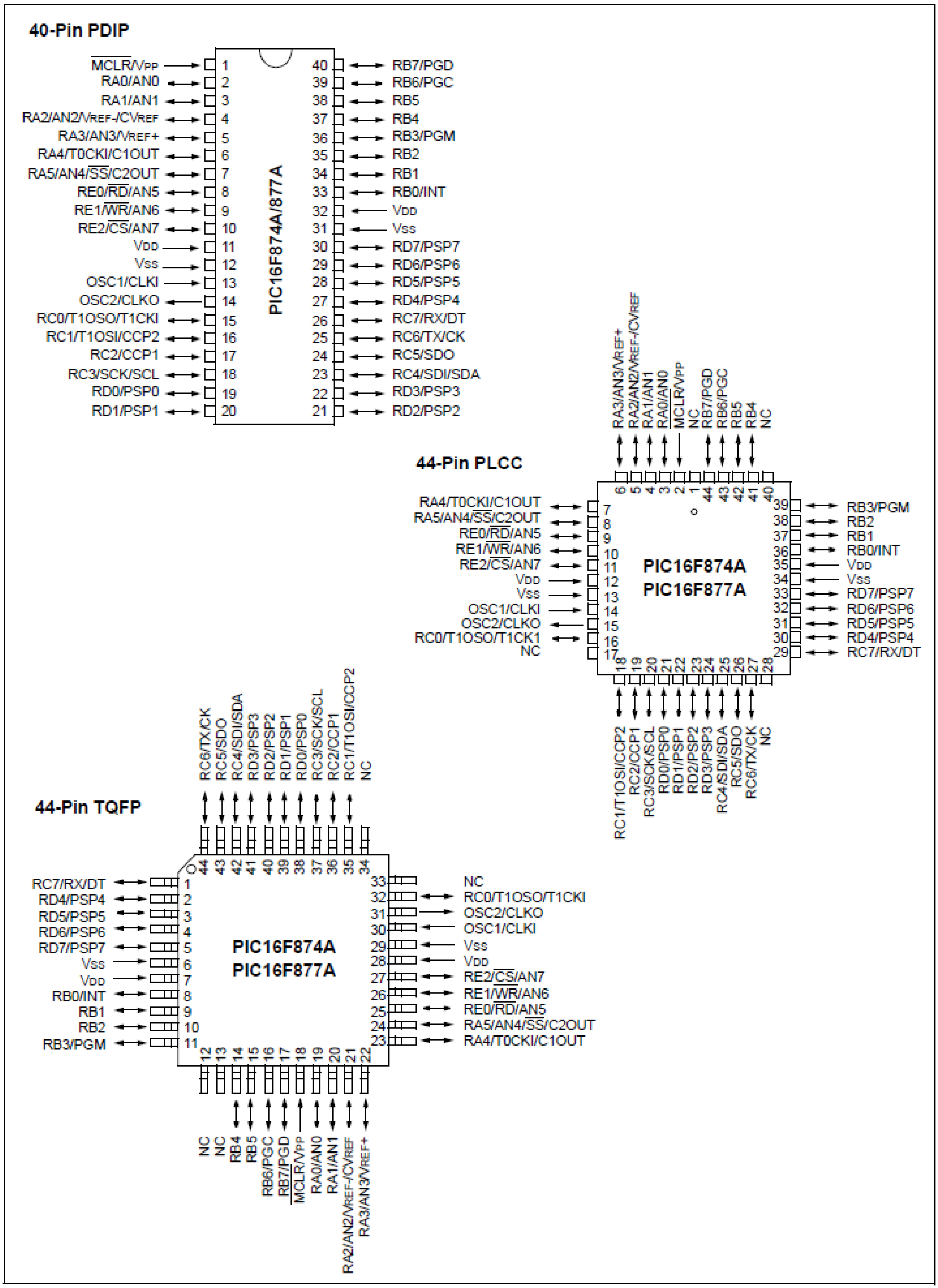
- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I^{2}C			
PIC16F873A	7.2K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

 DS39582B-page 1

PIC16F87XA

Pin Diagrams (Continued)



 DS39582B-page 3

11.0 ANALOG-TO-DIGITAL CONVERTER (A/D) MODULE

The Analog-to-Digital (A/D) Converter module has five inputs for the 28-pin devices and eight for the 40/44-pin devices.

The conversion of an analog input signal results in a corresponding 10-bit digital number. The A/D module has high and low-voltage reference input that is software selectable to some combination of VDD, VSS, RA2 or RA3.

The A/D converter has a unique feature of being able to operate while the device is in Sleep mode. To operate in Sleep, the A/D clock must be derived from the A/D's internal RC oscillator.

The A/D module has four registers. These registers are:

- A/D Result High Register (ADRESH)
- A/D Result Low Register (ADRESL)
- A/D Control Register 0 (ADCON0)
- A/D Control Register 1 (ADCON1)

The ADCON0 register, shown in Register 11-1, controls the operation of the A/D module. The ADCON1 register, shown in Register 11-2, configures the functions of the port pins. The port pins can be configured as analog inputs (RA3 can also be the voltage reference) or as digital I/O.

Additional information on using the A/D module can be found in the PICmicro® Mid-Range MCU Family Reference Manual (DS33023).

REGISTER 11-1: ADCON0 REGISTER (ADDRESS 1Fh)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	—	ADON
bit 7							bit 0

bit 7-6 **ADCS1:ADCS0:** A/D Conversion Clock Select bits (ADCON0 bits in **bold**)

ADCON1 <ADCS2>	ADCON0 <ADCS1:ADCS0>	Clock Conversion
0	**00**	FOSC/2
0	**01**	FOSC/8
0	**10**	FOSC/32
0	**11**	FRC (clock derived from the internal A/D RC oscillator)
1	**00**	FOSC/4
1	**01**	FOSC/16
1	**10**	FOSC/64
1	**11**	FRC (clock derived from the internal A/D RC oscillator)

bit 5-3 **CHS2:CHS0:** Analog Channel Select bits

000 = Channel 0 (AN0)
001 = Channel 1 (AN1)
010 = Channel 2 (AN2)
011 = Channel 3 (AN3)
100 = Channel 4 (AN4)
101 = Channel 5 (AN5)
110 = Channel 6 (AN6)
111 = Channel 7 (AN7)

Note: The PIC16F873A/876A devices only implement A/D channels 0 through 4; the unimplemented selections are reserved. Do not select any unimplemented channels with these devices.

bit 2 **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit

When ADON = 1:
1 = A/D conversion in progress (setting this bit starts the A/D conversion which is automatically cleared by hardware when the A/D conversion is complete)
0 = A/D conversion not in progress

bit 1 **Unimplemented:** Read as '0'

bit 0 **ADON:** A/D On bit

1 = A/D converter module is powered up
0 = A/D converter module is shut-off and consumes no operating current

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
- n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

PIC16F87XA

REGISTER 11-2: ADCON1 REGISTER (ADDRESS 9Fh)

R/W-0	R/W-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	ADCS2	—	—	PCFG3	PCFG2	PCFG1	PCFG0
bit 7							bit 0

bit 7 **ADFM:** A/D Result Format Select bit
1 = Right justified. Six (6) Most Significant bits of ADRESH are read as '0'.
0 = Left justified. Six (6) Least Significant bits of ADRESL are read as '0'.

bit 6 **ADCS2:** A/D Conversion Clock Select bit (ADCON1 bits in shaded area and in **bold**)

ADCON1 <ADCS2>	ADCON0 <ADCS1:ADCS0>	Clock Conversion
0	00	FOSC/2
0	01	FOSC/8
0	10	FOSC/32
0	11	FRC (clock derived from the internal A/D RC oscillator)
1	00	FOSC/4
1	01	FOSC/16
1	10	FOSC/64
1	11	FRC (clock derived from the internal A/D RC oscillator)

bit 5-4 **Unimplemented:** Read as '0'

bit 3-0 **PCFG3:PCFG0:** A/D Port Configuration Control bits

PCFG <3:0>	AN7	AN6	AN5	AN4	AN3	AN2	AN1	AN0	VREF+	VREF-	C/R
0000	A	A	A	A	A	A	A	A	VDD	VSS	8/0
0001	A	A	A	A	VREF+	A	A	A	AN3	VSS	7/1
0010	D	D	D	A	A	A	A	A	VDD	VSS	5/0
0011	D	D	D	A	VREF+	A	A	A	AN3	VSS	4/1
0100	D	D	D	D	A	D	A	A	VDD	VSS	3/0
0101	D	D	D	D	VREF+	D	A	A	AN3	VSS	2/1
011x	D	D	D	D	D	D	D	D	—	—	0/0
1000	A	A	A	A	VREF+	VREF-	A	A	AN3	AN2	6/2
1001	D	D	A	A	A	A	A	A	VDD	VSS	6/0
1010	D	D	A	A	VREF+	A	A	A	AN3	VSS	5/1
1011	D	D	A	A	VREF+	VREF-	A	A	AN3	AN2	4/2
1100	D	D	D	A	VREF+	VREF-	A	A	AN3	AN2	3/2
1101	D	D	D	D	VREF+	VREF-	A	A	AN3	AN2	2/2
1110	D	D	D	D	D	D	D	A	VDD	VSS	1/0
1111	D	D	D	D	VREF+	VREF-	D	A	AN3	AN2	1/2

A = Analog input D = Digital I/O
C/R = # of analog input channels/# of A/D voltage references

Legend:
R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'
- n = Value at POR '1' = Bit is set '0' = Bit is cleared x = Bit is unknown

Note: On any device Reset, the port pins that are multiplexed with analog functions (ANx) are forced to be an analog input.

11.1 A/D Acquisition Requirements

For the A/D converter to meet its specified accuracy, the charge holding capacitor (CHOLD) must be allowed to fully charge to the input channel voltage level. The analog input model is shown in Figure 11-2. The source impedance (RS) and the internal sampling switch impedance (RSS) directly affect the time required to charge the capacitor CHOLD. The sampling switch (RSS) impedance varies over the device voltage (VDD); see Figure 11-2. **The maximum recommended impedance for analog sources is 2.5 kΩ.** As the impedance is decreased, the acquisition time may be decreased. After the analog input channel is selected (changed), this acquisition must be done before the conversion can be started.

To calculate the minimum acquisition time, Equation 11-1 may be used. This equation assumes that 1/2 LSb error is used (1024 steps for the A/D). The 1/2 LSb error is the maximum error allowed for the A/D to meet its specified resolution.

To calculate the minimum acquisition time, TACQ, see the PICmicro® Mid-Range MCU Family Reference Manual (DS33023).

EQUATION 11-1: ACQUISITION TIME

$$T_{ACQ} = \text{Amplifier Settling Time} + \text{Hold Capacitor Charging Time} + \text{Temperature Coefficient}$$

$$= T_{AMP} + T_C + T_{COFF}$$

$$= 2\ \mu s + T_C + [(\text{Temperature} - 25°C)(0.05\ \mu s/°C)]$$

$$T_C = C_{HOLD}\ (R_{IC} + R_{SS} + R_S)\ \ln(1/2047)$$

$$= -120\ pF\ (1\ k\Omega + 7\ k\Omega + 10\ k\Omega)\ \ln(0.0004885)$$

$$= 16.47\ \mu s$$

$$T_{ACQ} = 2\ \mu s + 16.47\ \mu s + [(50°C - 25°C)(0.05\ \mu s/°C)]$$

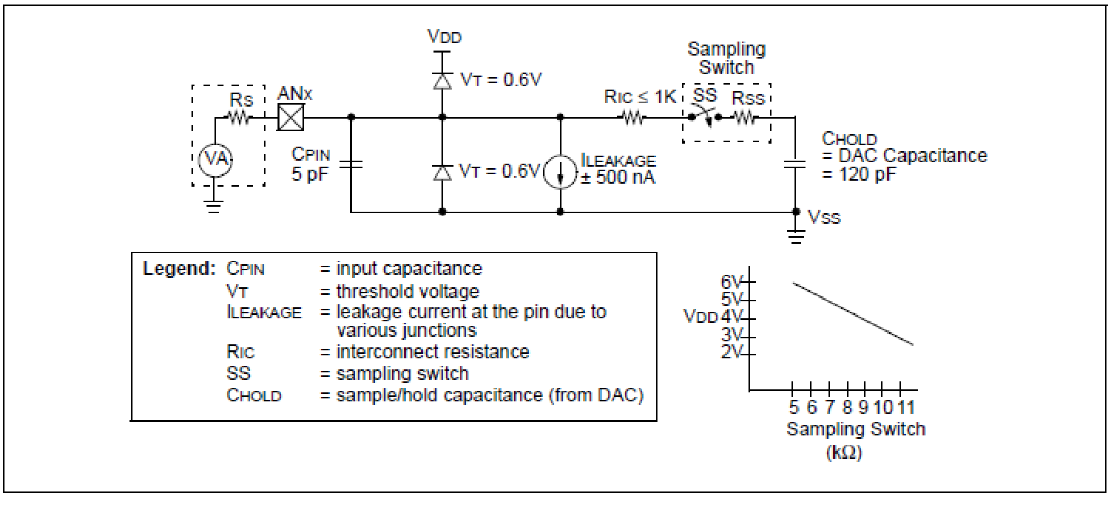
$$= 19.72\ \mu s$$

Note 1: The reference voltage (VREF) has no effect on the equation since it cancels itself out.

2: The charge holding capacitor (CHOLD) is not discharged after each conversion.

3: The maximum recommended impedance for analog sources is 2.5 kΩ. This is required to meet the pin leakage specification.

FIGURE 11-2: ANALOG INPUT MODEL



5V Regulator Datasheet

FAIRCHILD
SEMICONDUCTOR®

www.fairchildsemi.com

MC78XX/LM78XX/MC78XXA

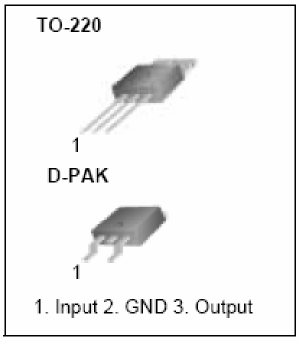
3-Terminal 1A Positive Voltage Regulator

Features

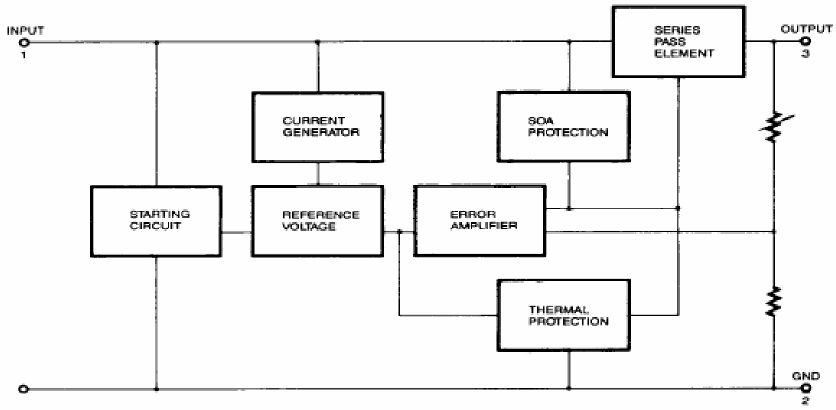
- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

Description

The MC78XX/LM78XX/MC78XXA series of three terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.



Internal Block Digram



Rev. 1.0.1

12V Regulator Datasheet

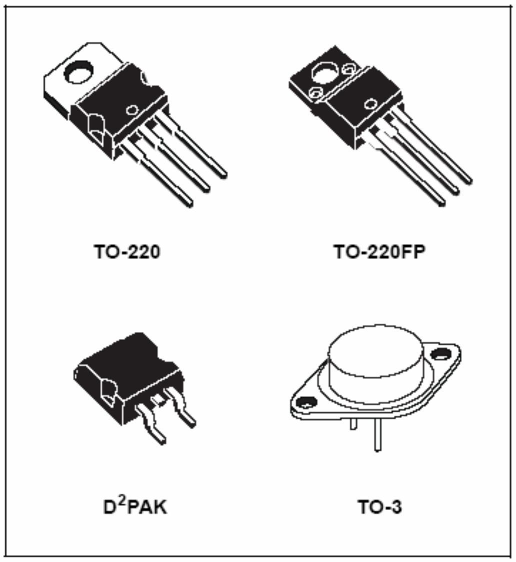
L7800 SERIES

POSITIVE VOLTAGE REGULATORS

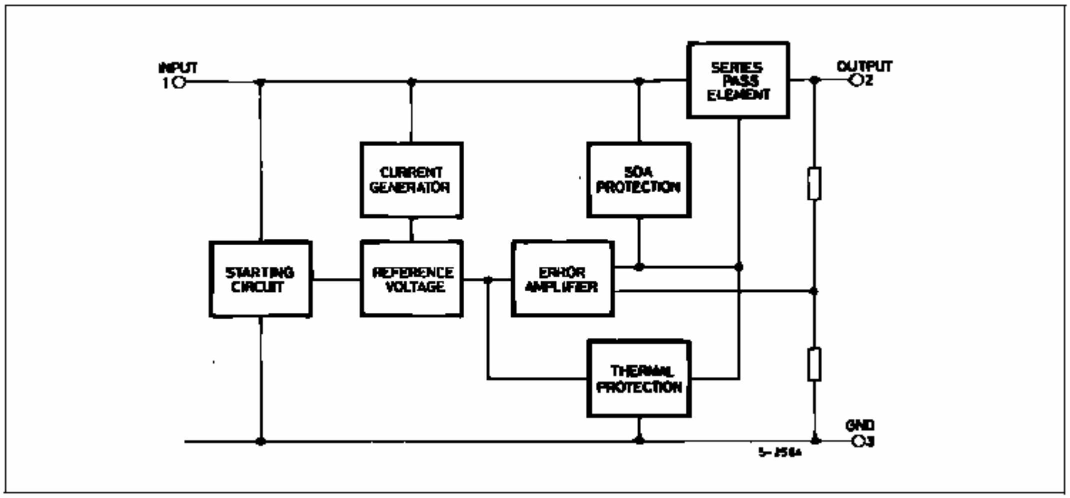
- OUTPUT CURRENT TO 1.5A
- OUTPUT VOLTAGES OF 5; 5.2; 6; 8; 8.5; 9; 12; 15; 18; 24V
- THERMAL OVERLOAD PROTECTION
- SHORT CIRCUIT PROTECTION
- OUTPUT TRANSITION SOA PROTECTION

DESCRIPTION

The L7800 series of three-terminal positive regulators is available in TO-220, TO-220FP, TO-3 and D^2PAK packages and several fixed output voltages, making it useful in a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltage and currents.



SCHEMATIC DIAGRAM



February 2003 1/29

Driver Datasheet "MOSFET"

International
IOR Rectifier

Data Sheet No. PD60147-R

IR2110/IR2113 (S)

HIGH AND LOW SIDE DRIVER

Features

- Floating channel designed for bootstrap operation
  Fully operational to +500V or +600V
  Tolerant to negative transient voltage
  dV/dt immune
- Gate drive supply range from 10 to 20V
- Undervoltage lockout for both channels
- 3.3V logic compatible
  Separate logic supply range from 3.3V to 20V
  Logic and power ground ±5V offset
- CMOS Schmitt-triggered inputs with pull-down
- Cycle by cycle edge-triggered shutdown logic
- Matched propagation delay for both channels
- Outputs in phase with inputs

Product Summary

V_{OFFSET} (IR2110)	500V max.
(IR2113)	600V max.
I_O+/-	2A / 2A
V_{OUT}	10 - 20V
$t_{on/off}$ (typ.)	120 & 94 ns
Delay Matching	10 ns

Packages

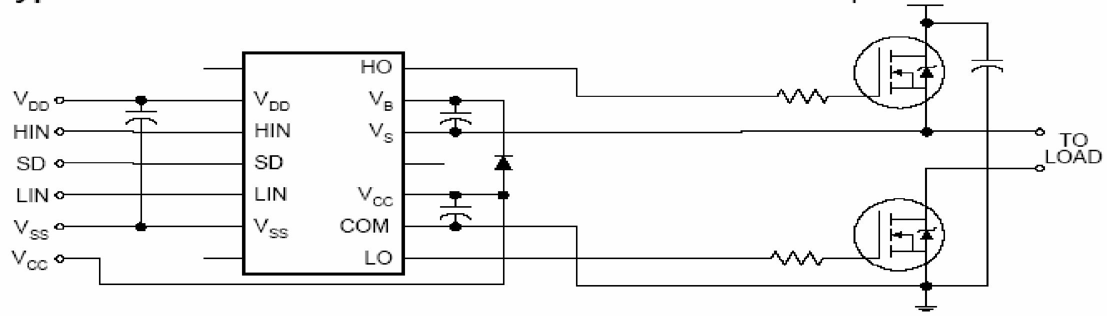
14-Lead PDIP
IR2110/IR2113

16-Lead SOIC
IR2110S/IR2113S

Description

The IR2110/IR2113 are high voltage, high speed power MOSFET and IGBT drivers with independent high and low side referenced output channels. Proprietary HVIC and latch immune CMOS technologies enable ruggedized monolithic construction. Logic inputs are compatible with standard CMOS or LSTTL output, down to 3.3V logic. The output drivers feature a high pulse current buffer stage designed for minimum driver cross-conduction. Propagation delays are matched to simplify use in high frequency applications. The floating channel can be used to drive an N-channel power MOSFET or IGBT in the high side configuration which operates up to 500 or 600 volts.

Typical Connection



(Refer to Lead Assignments for correct pin configuration). This/These diagram(s) show electrical connections only. Please refer to our Application Notes and DesignTips for proper circuit board layout.

www.irf.com 1

Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are absolute voltages referenced to COM. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions. Additional information is shown in Figures 28 through 35.

Symbol	Definition		Min.	Max.	Units
V_B	High side floating supply voltage	(IR2110)	-0.3	525	V
		(IR2113)	-0.3	625	
V_S	High side floating supply offset voltage		V_B - 25	V_B + 0.3	
V_{HO}	High side floating output voltage		V_S - 0.3	V_B + 0.3	
V_{CC}	Low side fixed supply voltage		-0.3	25	
V_{LO}	Low side output voltage		-0.3	V_{CC} + 0.3	
V_{DD}	Logic supply voltage		-0.3	V_{SS} + 25	
V_{SS}	Logic supply offset voltage		V_{CC} - 25	V_{CC} + 0.3	
V_{IN}	Logic input voltage (HIN, LIN & SD)		V_{SS} - 0.3	V_{DD} + 0.3	
dV_s/dt	Allowable offset supply voltage transient (figure 2)		—	50	V/ns
P_D	Package power dissipation @ $T_A \le +25°C$	(14 lead DIP)	—	1.6	W
		(16 lead SOIC)	—	1.25	
R_{THJA}	Thermal resistance, junction to ambient	(14 lead DIP)	—	75	°C/W
		(16 lead SOIC)	—	100	
T_J	Junction temperature		—	150	°C
T_S	Storage temperature		-55	150	
T_L	Lead temperature (soldering, 10 seconds)		—	300	

Recommended Operating Conditions

The input/output logic timing diagram is shown in figure 1. For proper operation the device should be used within the recommended conditions. The V_S and V_{SS} offset ratings are tested with all supplies biased at 15V differential. Typical ratings at other bias conditions are shown in figures 36 and 37.

Symbol	Definition		Min.	Max.	Units
V_B	High side floating supply absolute voltage		V_S + 10	V_S + 20	V
V_S	High side floating supply offset voltage	(IR2110)	Note 1	500	
		(IR2113)	Note 1	600	
V_{HO}	High side floating output voltage		V_S	V_B	
V_{CC}	Low side fixed supply voltage		10	20	
V_{LO}	Low side output voltage		0	VCC	
V_{DD}	Logic supply voltage		V_{SS} + 3	V_{SS} + 20	
V_{SS}	Logic supply offset voltage		-5 (Note 2)	5	
V_{IN}	Logic input voltage (HIN, LIN & SD)		V_{SS}	V_{DD}	
T_A	Ambient temperature		-40	125	°C

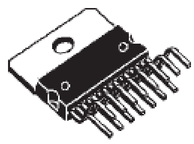
Note 1: Logic operational for V_S of -4 to +500V. Logic state held for V_S of -4V to $-V_{BS}$. (Please refer to the Design Tip DT97-3 for more details).
Note 2: When V_{DD} < 5V, the minimum V_{SS} offset is limited to $-V_{DD}$.

DUAL FULL-BRIDGE DRIVER"L298" Data sheet

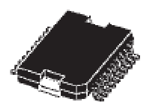
L298

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



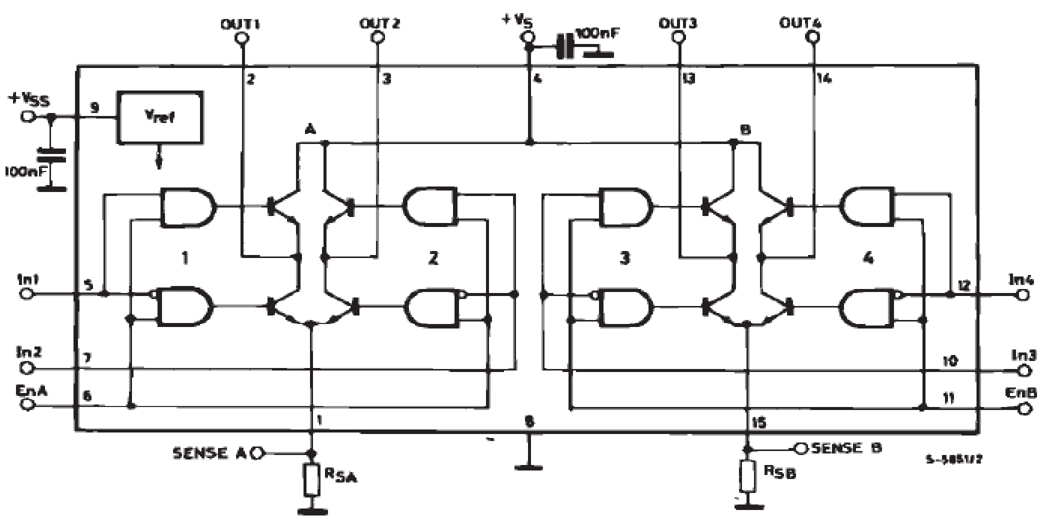
PowerSO20

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



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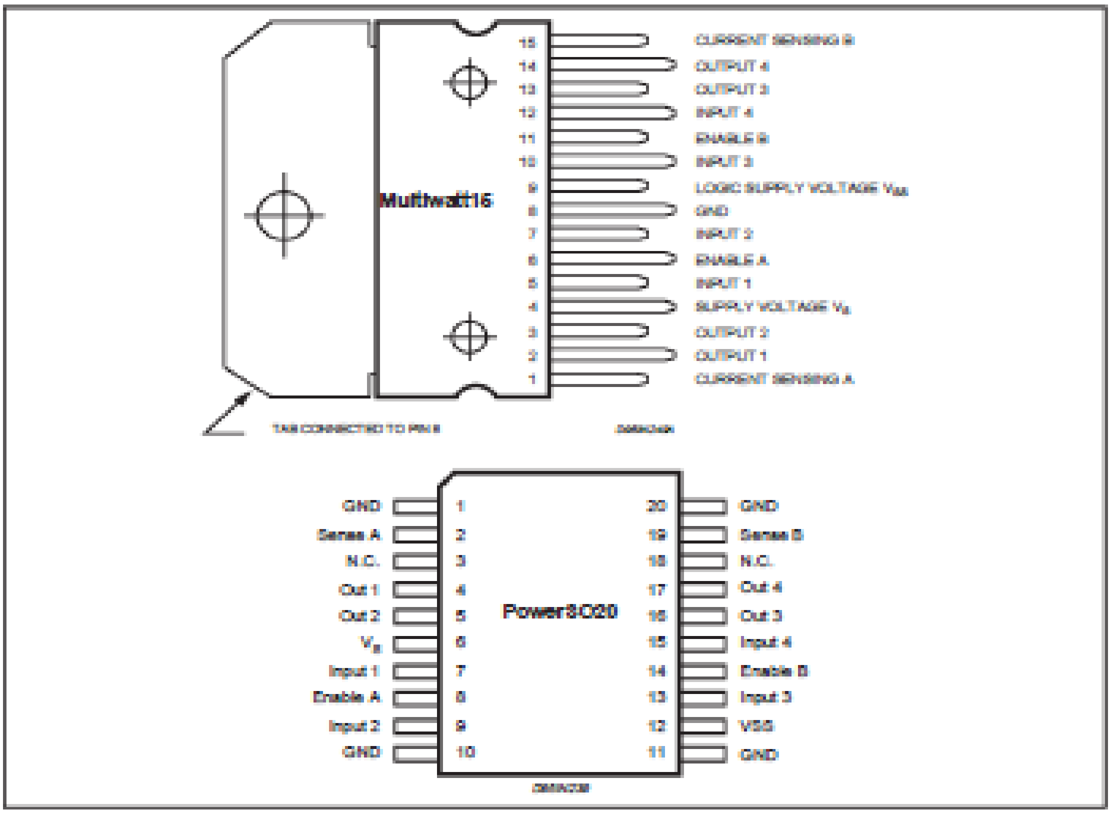
ABSOLUTE MAXIMUM RATINGS

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

PIN CONNECTIONS (top view)



THERMAL DATA

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

(*) Mounted on aluminum substrate

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)	Vi = H ≤ 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 ≤ 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

L298

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
T_1 (V_i)	Source Current Turn-off Delay	0.5 V_i to 0.9 I_L (2); (4)		1.5		μs
T_2 (V_i)	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		0.2		μs
T_3 (V_i)	Source Current Turn-on Delay	0.5 V_i to 0.1 I_L (2); (4)		2		μs
T_4 (V_i)	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.7		μs
T_5 (V_i)	Sink Current Turn-off Delay	0.5 V_i to 0.9 I_L (3); (4)		0.7		μs
T_6 (V_i)	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.25		μs
T_7 (V_i)	Sink Current Turn-on Delay	0.5 V_i to 0.9 I_L (3); (4)		1.6		μs
T_8 (V_i)	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.2		μs
fc (V_i)	Commutation Frequency	I_L = 2A		25	40	KHz
T_1 (V_{en})	Source Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (2); (4)		3		μs
T_2 (V_{en})	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		1		μs
T_3 (V_{en})	Source Current Turn-on Delay	0.5 V_{en} to 0.1 I_L (2); (4)		0.3		μs
T_4 (V_{en})	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.4		μs
T_5 (V_{en})	Sink Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (3); (4)		2.2		μs
T_6 (V_{en})	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.35		μs
T_7 (V_{en})	Sink Current Turn-on Delay	0.5 V_{en} to 0.9 I_L (3); (4)		0.25		μs
T_8 (V_{en})	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.1		μs

1) 1)Sensing voltage can be –1 V for t ≤ 50 μsec; in steady state V_{sens} min ≥ –0.5 V.
2) See fig. 2.
3) See fig. 4.
4) The load must be a pure resistor.

Figure 1 : Typical Saturation Voltage vs. Output Current.

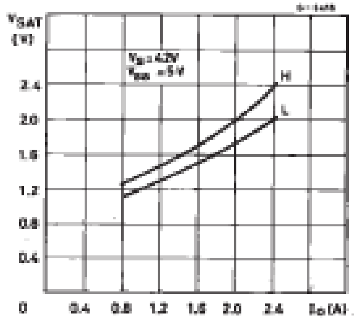
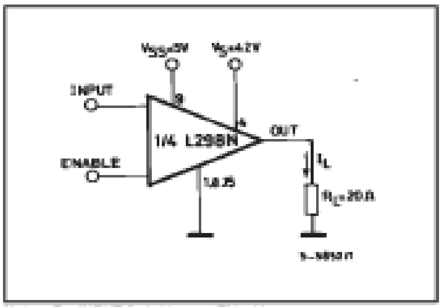


Figure 2 : Switching Times Test Circuits.



Note : For INPUT Switching, set EN = H
For ENABLE Switching, set IN = H

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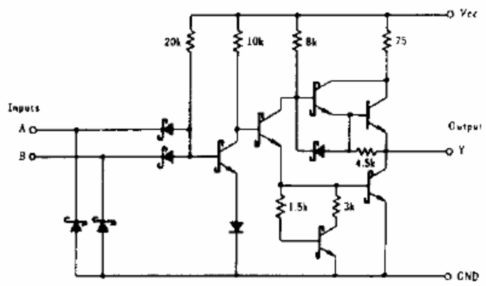
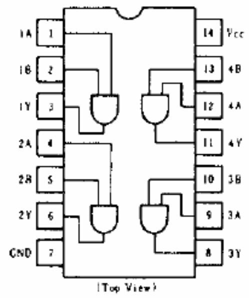
AND Gate Datasheet

HD74LS08 ●Quadruple 2-input Positive AND Gates

■CIRCUIT SCHEMATIC(¼)



■PIN ARRANGEMENT



■ELECTRICAL CHARACTERISTICS ($Ta = -20 \sim +75°C$)

Item	Symbol	Test Conditions		min	typ*	max	Unit
Input voltage	V_{IH}			2.0	–	–	V
	V_{IL}			–	–	0.8	V
Output voltage	V_{OH}	$V_{CC}=4.75V$, $V_{IH}=2V$, $I_{OH}=-400\mu A$		2.7	–	–	V
	V_{OL}	$V_{CC}=4.75V$, $V_{IL}=0.8V$	$I_{OL}=8mA$	–	–	0.5	V
			$I_{OL}=4mA$	–	–	0.4	
Input current	I_{IH}	$V_{CC}=5.25V$, $V_I=2.7V$		–	–	20	μA
	I_{IL}	$V_{CC}=5.25V$, $V_I=0.4V$		–	–	−0.4	mA
	I_I	$V_{CC}=5.25V$, $V_I=7V$		–	–	0.1	mA
Short-circuit output current	I_{OS}	$V_{CC}=5.25V$		−20	–	−100	mA
Supply current	I_{CCH}	$V_{CC}=5.25V$		–	2.4	4.8	mA
	I_{CCL}			–	4.4	8.8	
Input clamp voltage	V_{IK}	$V_{CC}=4.75V$, $I_{IN}=-18mA$		–	–	−1.5	V

* $V_{CC}=5V$, $Ta=25°C$

■SWITCHING CHARACTERISTICS ($V_{CC}=5V$, $Ta=25°C$)

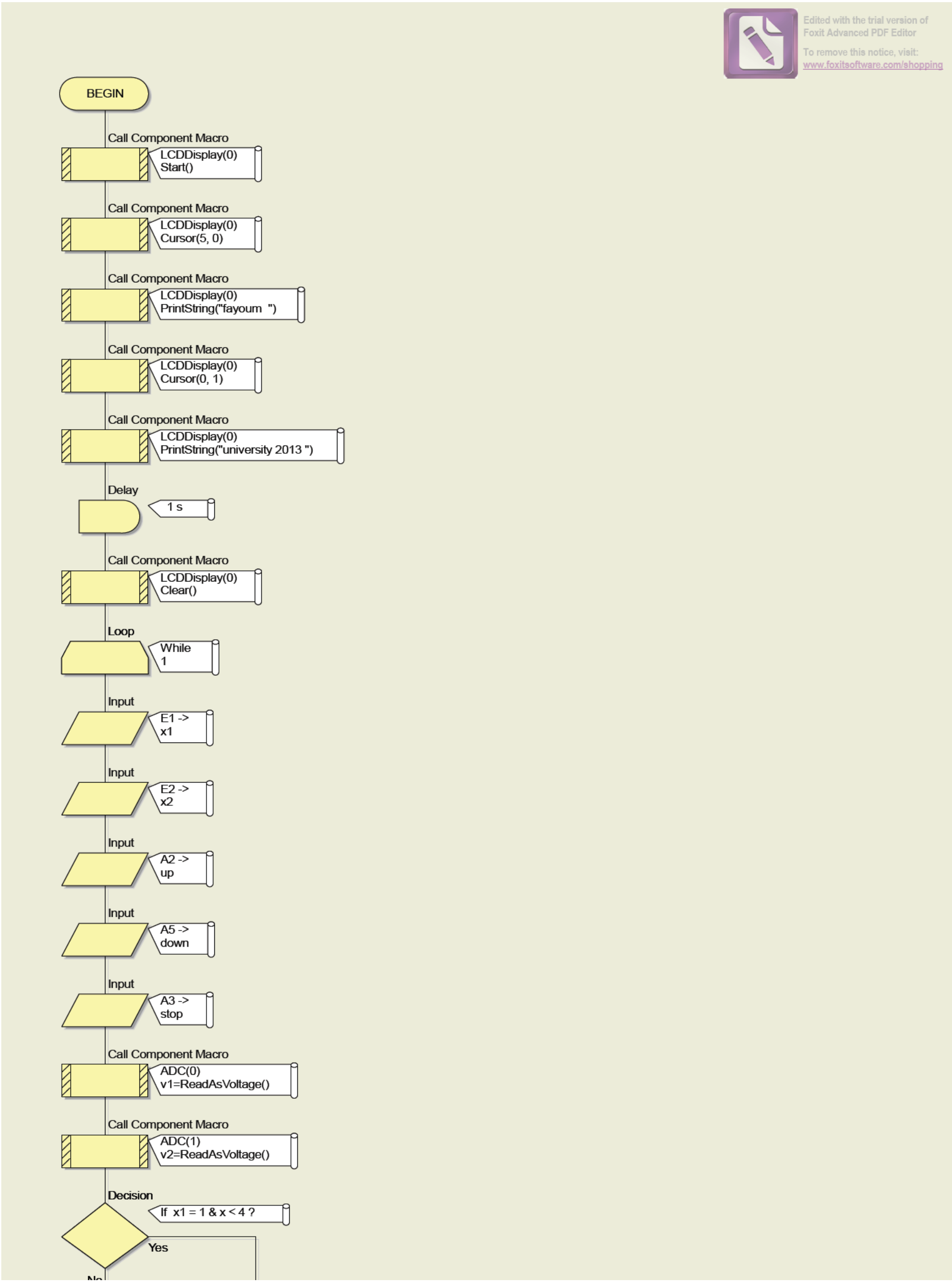
Item	Symbol	Test Conditions	min	typ	max	Unit
Propagation delay time	t_{PLH}	$C_L=15pF$, $R_L=2k\Omega$	–	8	15	ns
	t_{PHL}		–	10	20	

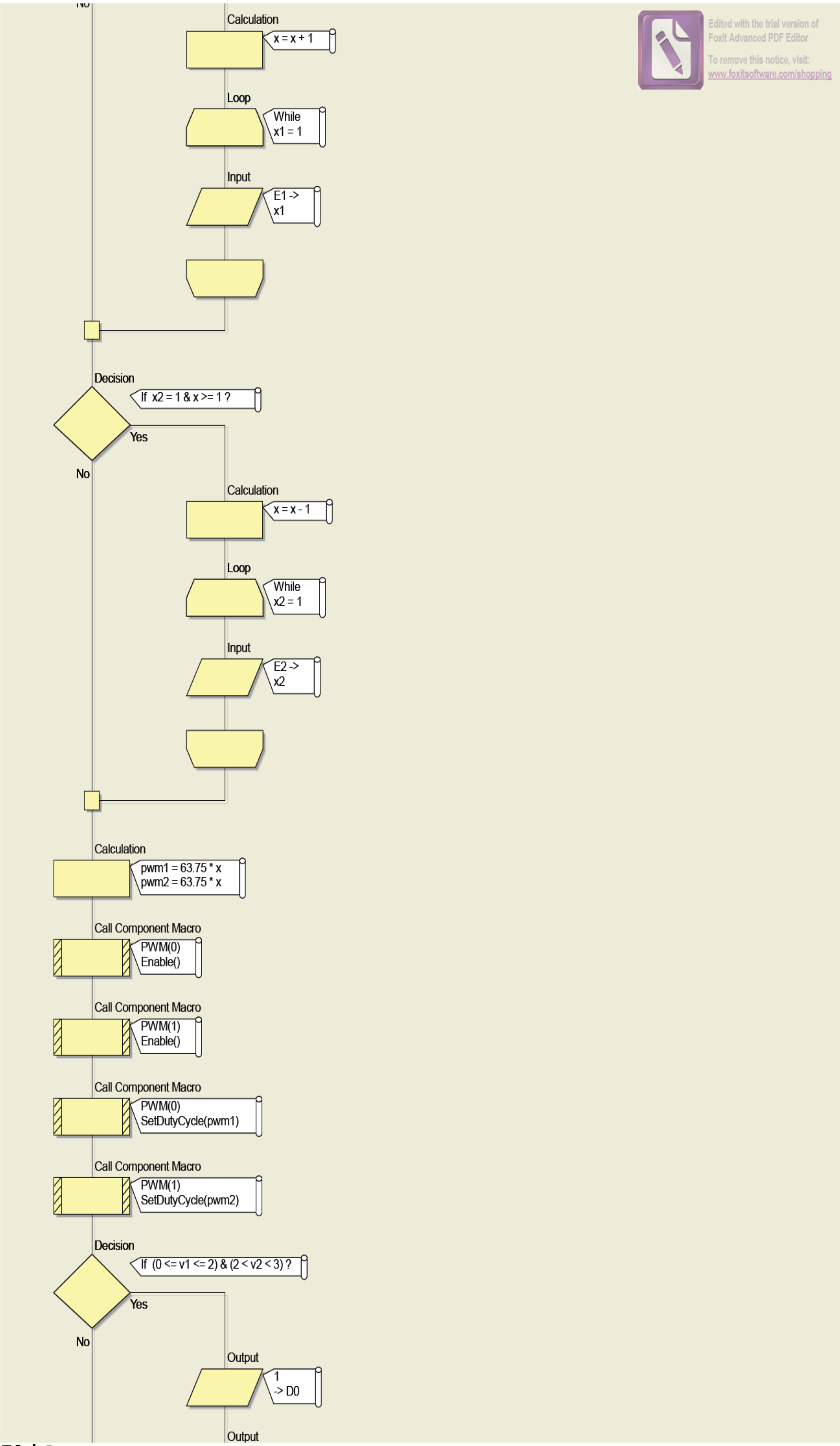
Note) Refer to Test Circuit and Waveform of the Common Item

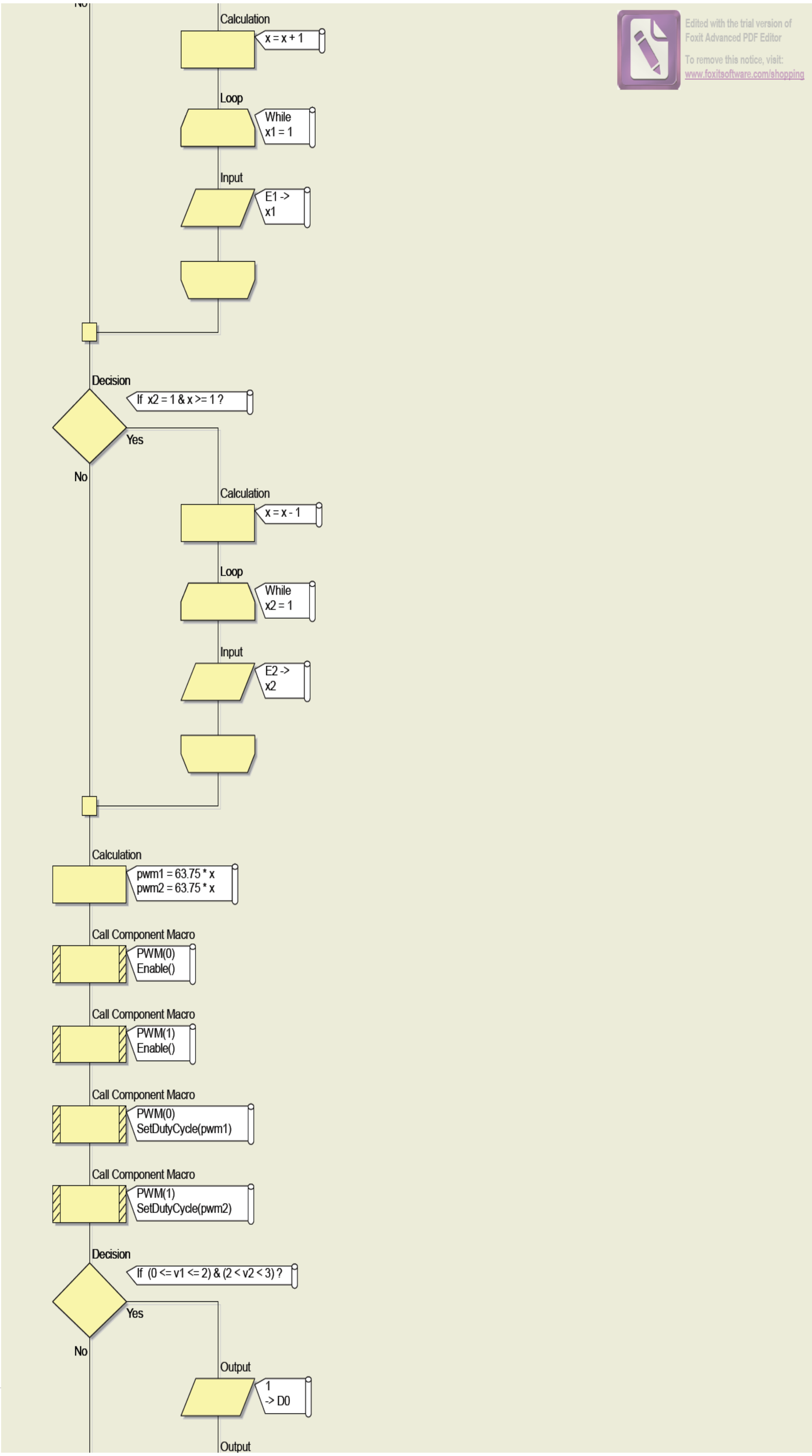
Appendix B

Codes

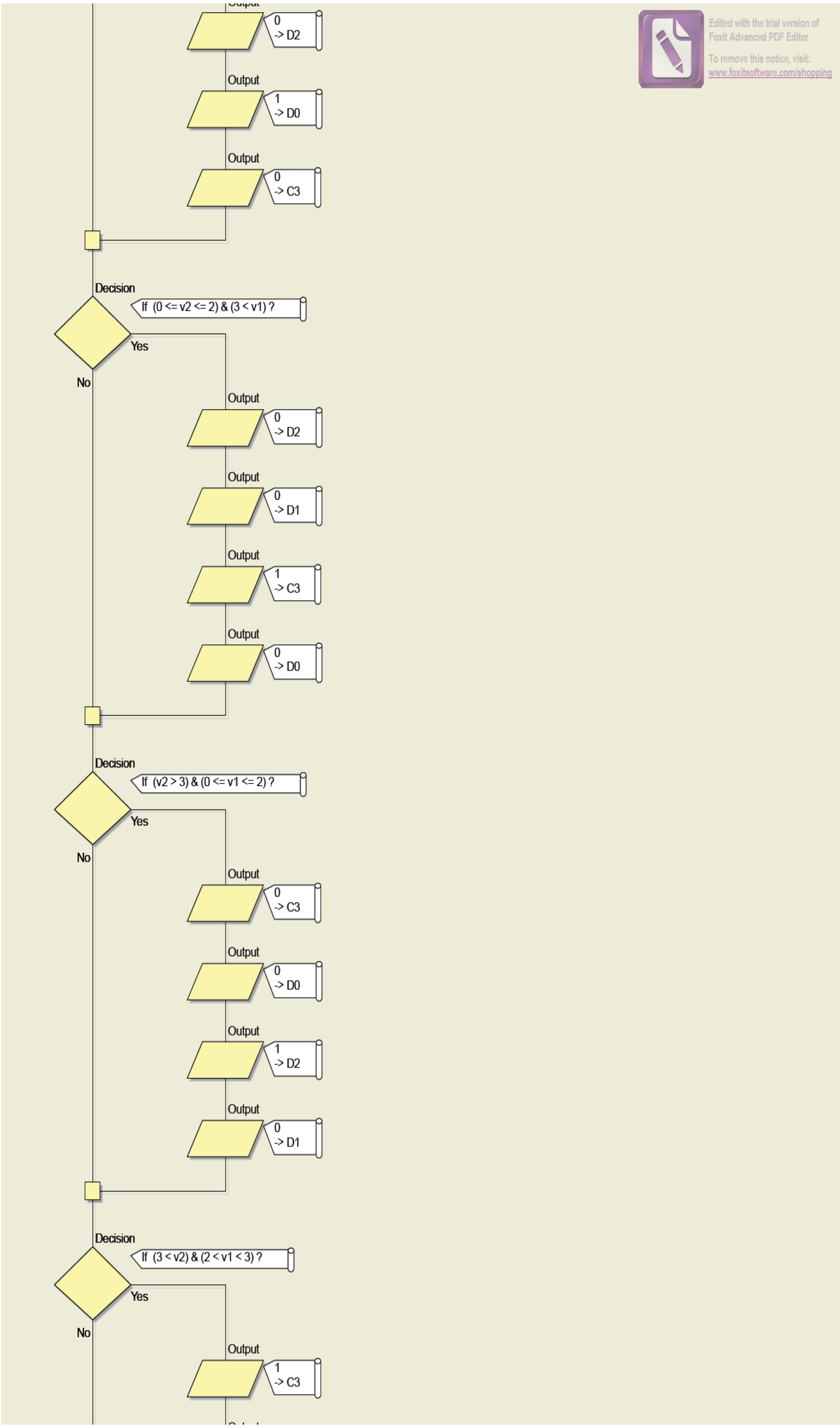
Flow code program

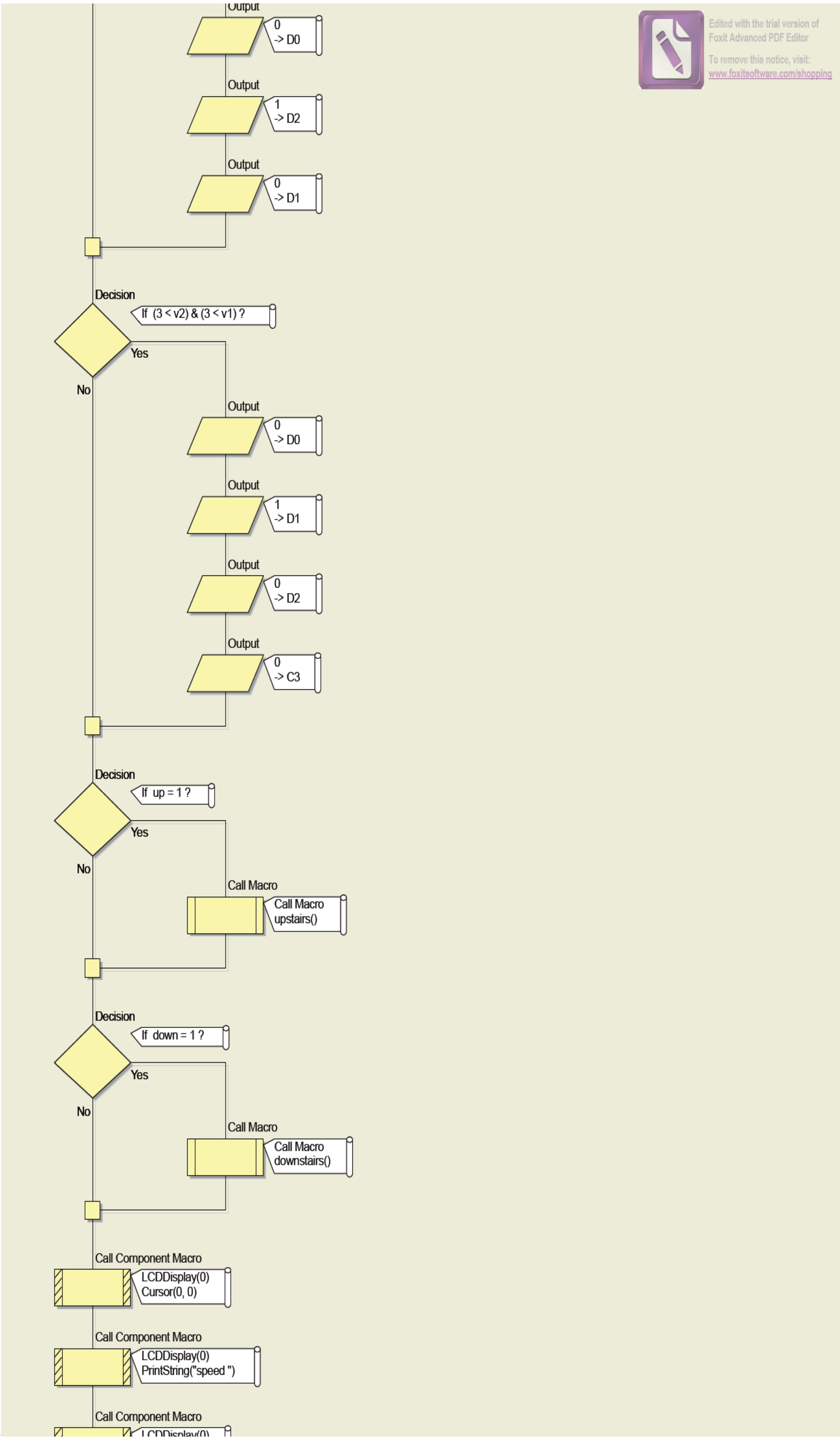


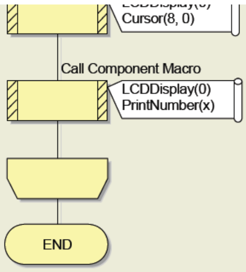

No
Calculation
x = x + 1
Loop
While
x1 = 1
Input
E1 ->
x1
Decision
If x2 = 1 & x >= 1 ?
Yes
No
Calculation
x = x - 1
Loop
While
x2 = 1
Input
E2 ->
x2
Calculation
pwm1 = 63.75 * x
pwm2 = 63.75 * x
Call Component Macro
PWM(0)
Enable()
Call Component Macro
PWM(1)
Enable()
Call Component Macro
PWM(0)
SetDutyCycle(pwm1)
Call Component Macro
PWM(1)
SetDutyCycle(pwm2)
Decision
If (0 <= v1 <= 2) & (2 < v2 < 3) ?
Yes
No
Output
1
-> D0
Output



No
Calculation
x = x + 1
Loop
While
x1 = 1
Input
E1 ->
x1
Decision
If x2 = 1 & x >= 1 ?
Yes
No
Calculation
x = x - 1
Loop
While
x2 = 1
Input
E2 ->
x2
Calculation
pwm1 = 63.75 * x
pwm2 = 63.75 * x
Call Component Macro
PWM(0)
Enable()
Call Component Macro
PWM(1)
Enable()
Call Component Macro
PWM(0)
SetDutyCycle(pwm1)
Call Component Macro
PWM(1)
SetDutyCycle(pwm2)
Decision
If (0 <= v1 <= 2) & (2 < v2 < 3) ?
Yes
No
Output
1
-> D0
Output

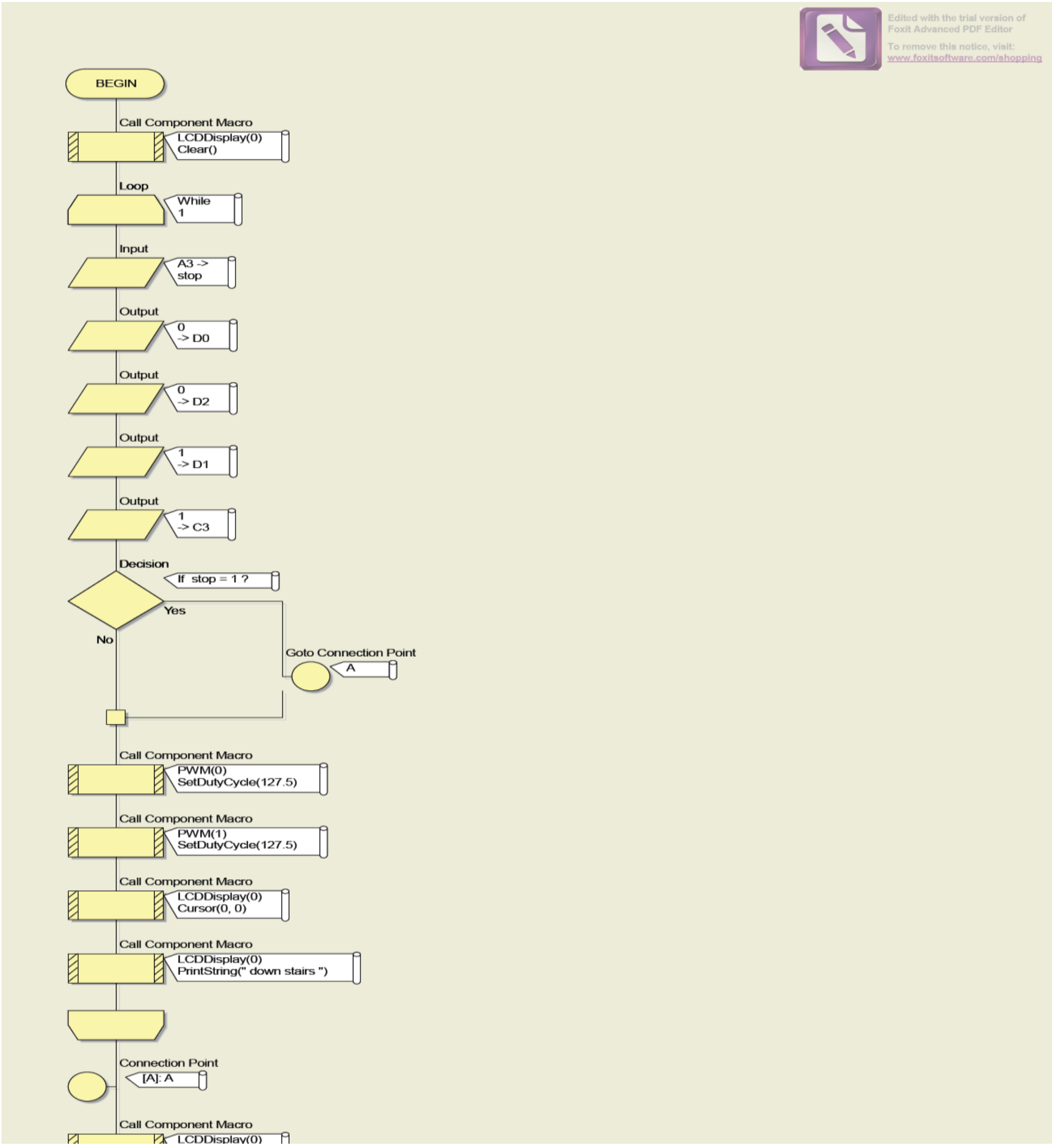

0
-> D2
Output
1
-> D0
Output
0
-> C3
Decision
If (0 <= v2 <= 2) & (3 < v1) ?
Yes
No
Output
0
-> D2
Output
0
-> D1
Output
1
-> C3
Output
0
-> D0
Decision
If (v2 > 3) & (0 <= v1 <= 2) ?
Yes
No
Output
0
-> C3
Output
0
-> D0
Output
1
-> D2
Output
0
-> D1
Decision
If (3 < v2) & (2 < v1 < 3) ?
Yes
No
Output
1
-> C3

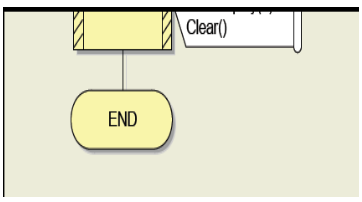

Output
0
-> D0
Output
1
-> D2
Output
0
-> D1
Decision
If (3 < v2) & (3 < v1) ?
Yes
No
Output
0
-> D0
Output
1
-> D1
Output
0
-> D2
Output
0
-> C3
Decision
If up = 1 ?
Yes
No
Call Macro
Call Macro
upstairs()
Decision
If down = 1 ?
Yes
No
Call Macro
Call Macro
downstairs()
Call Component Macro
LCDDisplay(0)
Cursor(0, 0)
Call Component Macro
LCDDisplay(0)
PrintString("speed ")
Call Component Macro


Cursor(8, 0)
Call Component Macro
LCDDisplay(0)
PrintNumber(x)
END

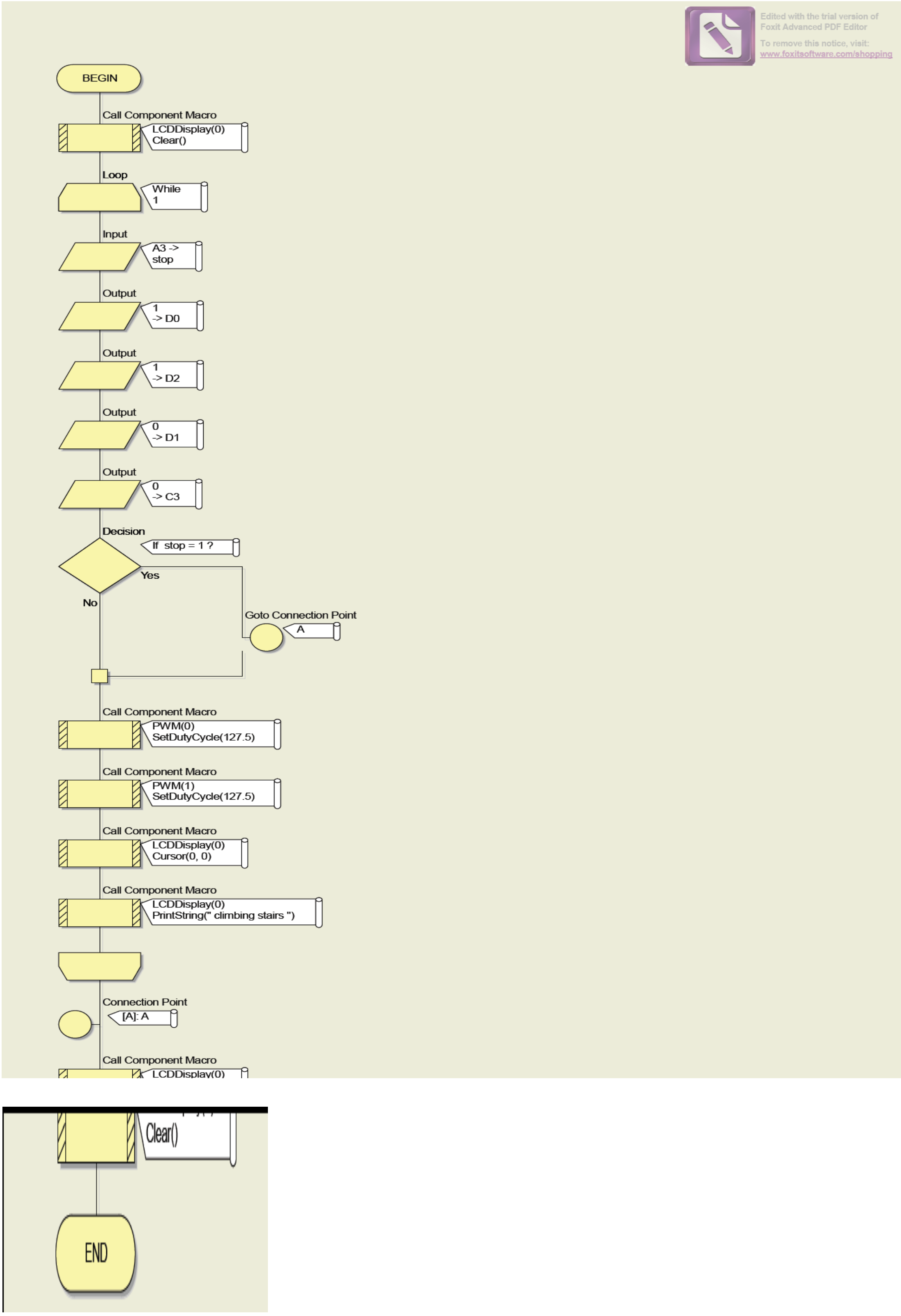
.Macros

1. Down





2. Up


BEGIN
Call Component Macro
LCDDisplay(0)
Clear()
Loop
While
1
Input
A3 ->
stop
Output
1
-> D0
Output
1
-> D2
Output
0
-> D1
Output
0
-> C3
Decision
If stop = 1 ?
Yes
No
Goto Connection Point
A
Call Component Macro
PWM(0)
SetDutyCycle(127.5)
Call Component Macro
PWM(1)
SetDutyCycle(127.5)
Call Component Macro
LCDDisplay(0)
Cursor(0, 0)
Call Component Macro
LCDDisplay(0)
PrintString(" climbing stairs ")
Connection Point
[A]: A
Call Component Macro
LCDDisplay(0)
Clear()
END

Mikroc program code

```
  float vv; hh; bb;                       // for sample value of joystick
  unsigned short int x=105, y=105 ;        // to control pwm value for both motors
  unsigned short int i;                   // variable to control lcd

// function to display variation of speed on lcd

void display() {

if (x==105 || y==105){
      Lcd_Out(1,1,"sp=1");
      }
      if (x==155|| y==155){

      Lcd_Out(1,1,"sp=2");
      }
      if (x==205 || y==205){

      Lcd_Out(1,1,"sp=3");
      }
      if (x==255 || y==255){

      Lcd_Out(1,1,"sp=4");
      }
  }

  // function to display stairs mode "enable , up and down" on lcd

  void display1() {
if (bb<980 ) {
    Lcd_Out(2,1," stairs mode off ");
    }
    else{
      Lcd_Out(1,5," stairs mode");

      if (rd5_bit==1){

      Lcd_Out(1,5," stairs mode");
      Lcd_Out(2, 2, "up");

     }
         if (rd7_bit==1){

      Lcd_Out(1,5," stairs mode");
      lcd_out(2 , 2 ,"down")     ;
      }
   }
   }
  //sbit for lcd
sbit LCD_RS at RB4_bit;
sbit LCD_EN at RB5_bit;
sbit LCD_D7 at RB3_bit;
sbit LCD_D6 at RB2_bit;
sbit LCD_D5 at RB1_bit;
sbit LCD_D4 at RB0_bit;

 // Pin direction

sbit LCD_RS_Direction at TRISB4_bit;
sbit LCD_EN_Direction at TRISB5_bit;
sbit LCD_D7_Direction at TRISB3_bit;
sbit LCD_D6_Direction at TRISB2_bit;
```

```
sbit LCD_D5_Direction at TRISB1_bit;
sbit LCD_D4_Direction at TRISB0_bit;

  //main function

void main() {
  adcon1=0b1000001;                // to determine which bins ar analog
  trisc.f7 =1;                      // make bin 7 of port c input
  trisd = 0b11110000;               // bins 0123 out & 4567 input
    //initialize lcd & both pwm channels
  Lcd_Init();
  PWM1_Init(2500);
  PWM2_Init(2500);
  PWM1_Start();
  PWM2_Start();
  PWM1_Set_Duty(x);
  PWM2_Set_Duty(y);
  Lcd_Cmd(_LCD_CURSOR_OFF);
   // infinit loop
  while(1) {
    //counter to control lcd clearness
  i = i +1;
    if(i==50){
    i=0;
    Lcd_Cmd(_LCD_CLEAR);
    }

    // reading analog values as sampling
  vv = ADC_Read(0);
  hh = ADC_Read(1);
  bb = ADC_Read(2);

  if (bb<980 ) {
    Lcd_Out(1,6,"ch < 20%");
         }
   // condition to ensure stairs mode is off
  if(rd6_bit==0) {

  display();              // calling function that display speed variation

  // conditions to control directions according to joystick volt
if(vv>341  && vv<430 ){
  if ( hh>171 && hh<256) {
  rd0_bit=1;
  rd2_bit=1;
  rd1_bit=0;
  rd3_bit=0;
  }
  if(  hh>358&& hh<410){
  rd0_bit=1;
  rd2_bit=0;
  rd1_bit=0;
  rd3_bit=0;
  }
  if(hh>18 && hh<68){
  rd0_bit=0;
  rd2_bit=0;
  rd1_bit=1;
  rd3_bit=0;
  }
  }

```

```
  if(vv>=0 && vv<86 && hh>171 && hh<256){
 rd0_bit=0;
 rd2_bit=0;
 rd1_bit=1;
 rd3_bit=1;
 }

  if(vv>171 && vv<256){
  if(hh>341 && hh<430)   {
 rd0_bit=1;
 rd2_bit=0;
 rd1_bit=0;
 rd3_bit=1;
 }

  if( hh>=0  && hh<86){
 rd0_bit=0;
 rd2_bit=1;
 rd1_bit=1;
 rd3_bit=0;
 }
  }
  if(vv>=86 && vv<=340&& hh>=86 && hh<=340){
 rd0_bit=1;
 rd2_bit=1;
 rd1_bit=1;
 rd3_bit=1;
 }

  // to control pwm with 20% up or down by bush the bush  bottoms
 if (rc7_bit==1&& x<255 &&  y<255){
 delay_ms(10);
 if (rc7_bit==1){
 Lcd_Cmd(_LCD_CLEAR);
 x = x + 50 ;
 y = y + 50 ;
 PWM1_Set_Duty(x);
 PWM2_Set_Duty(y);
 display();
 while(rc7_bit==1){}           // to make it response only for positive edge
 }
 }
 if (rd4_bit==1 && x>106 &&  y>107){
 delay_ms(10);
 if (rd4_bit==1){
  Lcd_Cmd(_LCD_CLEAR);
 x = x - 50 ;
 y = y - 50 ;
 PWM1_Set_Duty(x);
 PWM2_Set_Duty(y);
 display() ;
  while(rd4_bit==1){}
 }
 }
 }

// stairs mode swith is bushed
 else{

  if (bb>980 ) {

display1();
```

```

 // for braking
   if (rd5_bit==0&&rd7_bit==0 ) {

  display1();
  rd0_bit=1;
  rd2_bit=1;
  rd1_bit=1;
  rd3_bit=1;

  }
    // up
   if (rd5_bit==1&&rd7_bit==0 ) {
  delay_ms(10);
  if (rd5_bit==1){
  PWM1_Set_Duty(155);
  PWM2_Set_Duty(155);

  display1();
  rd0_bit=0;
  rd2_bit=0;
  rd1_bit=1;
  rd3_bit=1;

  }
  Lcd_Cmd(_LCD_CLEAR);
  }
  else {

  rd1_bit=0;
  rd3_bit=0;
  }

    if (rd5_bit==0&&rd7_bit==1 ) {
  delay_ms(10);
  if (rd7_bit==1 ) {
  PWM1_Set_Duty(100);
  PWM2_Set_Duty(100);
  display1();
  rd0_bit=1;
  rd2_bit=1;
  rd1_bit=0;
  rd3_bit=0;
    }
  Lcd_Cmd(_LCD_CLEAR);
  }

  else {
  rd0_bit=0;
  rd2_bit=0;
  }
  }
 else{
 display1();
  rd0_bit=1;
  rd2_bit=1;
  rd1_bit=1;
  rd3_bit=1;
}
  }

  }
```

```
248:    }
```

Reference

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