ALL TERRAIN PATH TRACKING ROBOT WITH AUTOMATIC FIRE EXTINGUISHER

A PROJECT REPORT

Submitted by

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of

Bachelor of Engineering

in

Electronics and Instrumentation Engineering

KUMARAGURU COLLEGE OF TECHNOLOGY

ANNA UNIVERSITY, CHENNAI-600 025

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ABSTRACT

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In this project we design a multi-purpose robot that can track a particular path, laid on any kind of track (even on stairs) and can also automatically extinguish fire within its vicinity. This project is aimed for applications of the robot as a Carry Robot or a Monitoring Robot or a Guiding Machine.

In Industries that are more liable to fire accidents, it is very difficult to use conveyor belts for the purpose of carrying things. Also difficulties are experienced if things have to be shifted up or down stairs. In these cases, this robot can help effectively. This robot is designed using a pre-programmed microcontroller, IR Path sensing circuit, Fire sensing circuit, Driver circuit for the DC motors and Driver circuit for the water pump. A Display has also been interfaced with the microcontroller to display the current robotic movements and details about the sensed signals, if any. The microcontroller used here is a 40 pin 8-bit CMOS Flash Microcontroller, PIC16F877.

The robot follows a black, non-reflecting path and in the case of sensing a reflected signal, it recognizes the deviation from the black path and aligns itself to it. Also it can sense fire within a particular proximity and in such a case it can pump water over the fire at speeds proportional to the closeness of the fire. The robot is provided with four belted wheels (the two wheels on either side being belted) driven by DC motors. This mechanism helps the robot to move on all terrains and even on stairs.

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CHAPTER 1

INTRODUCTION

1.1. INTRODUCTION

The term robot comes from the Czech word *robota,* generally translated as "forced labor". This describes the majority of robots fairly well. Most robots in the world are designed for heavy, repetitive manufacturing work. They handle tasks that are difficult, dangerous or boring to human beings.

1.2. OBJECTIVE

The objective of this project is to design a robot controlled by a micro controller to move along a laid path on any terrain and also to extinguish fire automatically.

1.3. EXISTING SYSTEM AND NEEDS

In Manufacturing Industries, it is very much essential to move the intermediate components from one machine to the other or from one room to another room or sometimes up or down stairs. In these kind of needs the method of carrying, already in application is the Conveyor belt.

DISADVANTAGES OF USING CONVEYOR BELTS

- It is not easy to carry things across floors
- The belts are usually made of materials that can catch fire; In some industries fire accidents are likely to occur and in such cases the goods being carried get damaged along with the belt.

So we need something in industries that can carry loads across the various terrains, which can automatically extinguish fire on its way out.

These features have been provided in this All Terrain Path Tracking Robot with Automatic Fire Extinguisher.

CHAPTER 2

OVERALL SYSTEM

2.1. GENERAL DESCRIPTION

The robot has a number of blocks to perform its functions of path tracking on any terrain and fire extinguishing. The main blocks of the robot are as shown on the Fig.1

BLOCK DIAGRAM

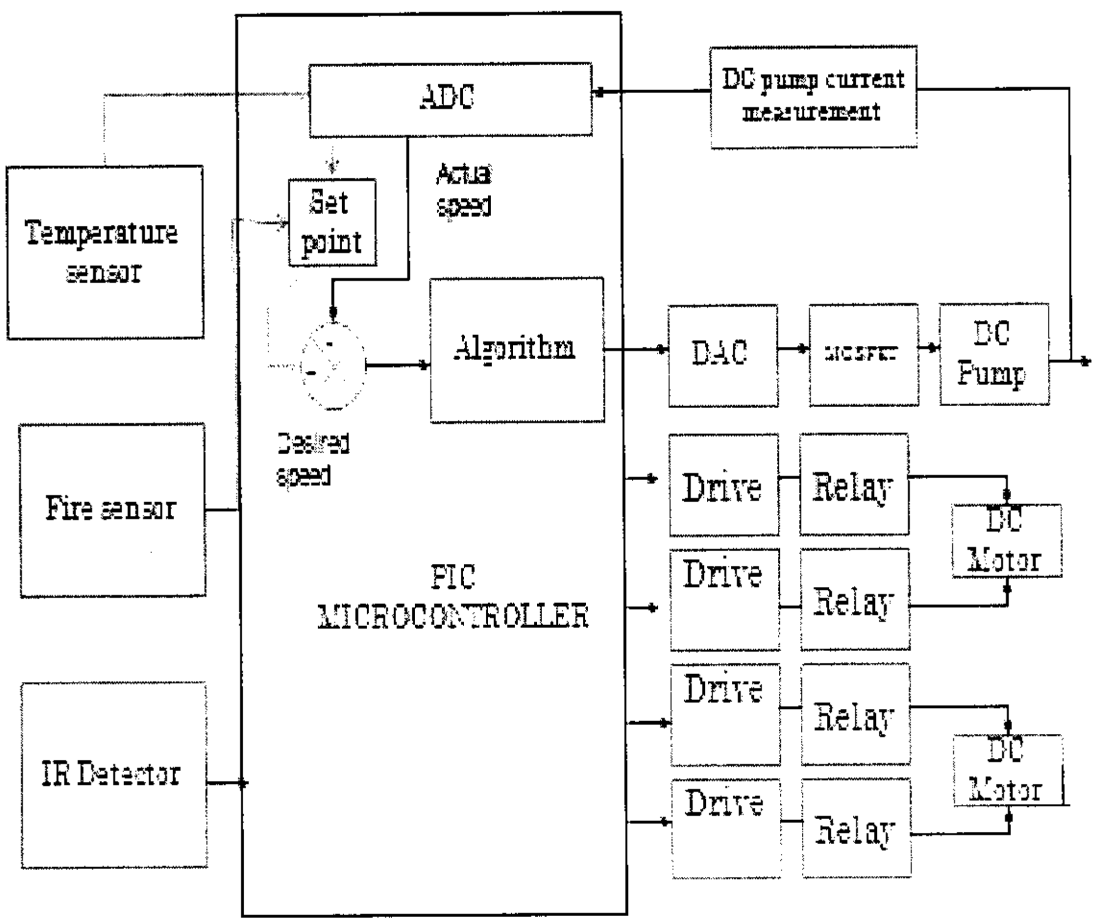

Fig.1

The fire extinguishing system will detect the fire (digital) and temperature (analog) and based on their values, it gives a set point for the DC water pump which is set to put off the fire. MOSFET is used as the pump drive. This closed loop constitutes a control system with negative feedback. The DC pump current which is directly proportional to the speed of the pump is given as feedback to this block.

The IR path detector unit consists of an IR transmitter and a detector. There are two such units present, one on the left and the other on the right end of the robot's base. This unit will sense the black path laid on the ground and its output is given to the PIC microcontroller. The microcontroller decides the action of the robot's wheels based on the path detected. The DC motors are used to drive the wheels of the robot. The relays are the drives that control the forward and reverse movements of the wheels.

CHAPTER 3

ROBOT COMPONENTS

3.1. POWER SUPPLY UNIT

The power supply unit built using filters, rectifiers, and then voltage regulators. Starting with an ac voltage, a steady dc voltage is obtained by rectifying the ac voltage, then filtering to a dc level, and finally, regulating to obtain a desired fixed dc voltage. The regulation is usually obtained from an IC voltage regulator unit, which takes a dc voltage and provides a somewhat lower dc voltage, which remains the same even if the input dc voltage varies, or the output load connected to the dc voltage changes.

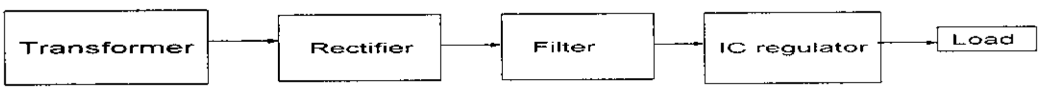

Fig. 2

The ac voltage, typically 120 V rms, is connected to a transformer, which steps that ac voltage down to the level for the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit can use this dc input to provide a dc voltage that not only has much less ripple voltage but also remains the same dc value even if the input dc voltage varies somewhat, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of a number of popular voltage regulator IC units.

3.1.1. COMPONENTS OF THE POWER SUPPLY

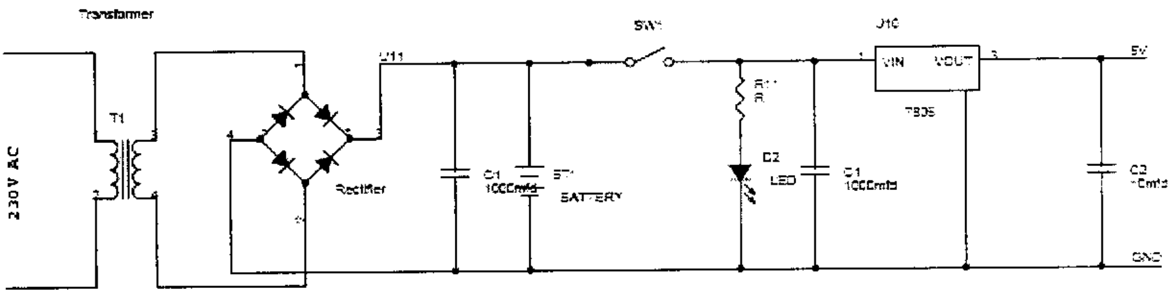

Fig. 3

TRANSFORMER

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.

RECTIFIER

The four diodes are connected to form a circuit called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

If there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.

The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. this path is indicated by the solid arrows.

One-half cycle later, the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5). Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

IC VOLTAGE REGULATOR

The fixed voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated output dc voltage, Vo, from a second terminal, with the third terminal connected to ground. For a selected regulator, IC device specifications list a voltage range over which the input voltage can vary to maintain a regulated output voltage over a range of load current. The specifications also list the amount of output voltage change resulting from a change in load current (load regulation) or in input voltage (line regulation).

FEATURES OF REGULATOR

- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection

- Internal short circuit current limit
- Available in the aluminum TO-3 package

3.2. IR PATH DETECTION SYSTEM

The path detection system makes use of the IR absorption and reflection principle which says, black coloured materials absorb the IR rays completely, whereas white coloured materials reflect back the IR rays.

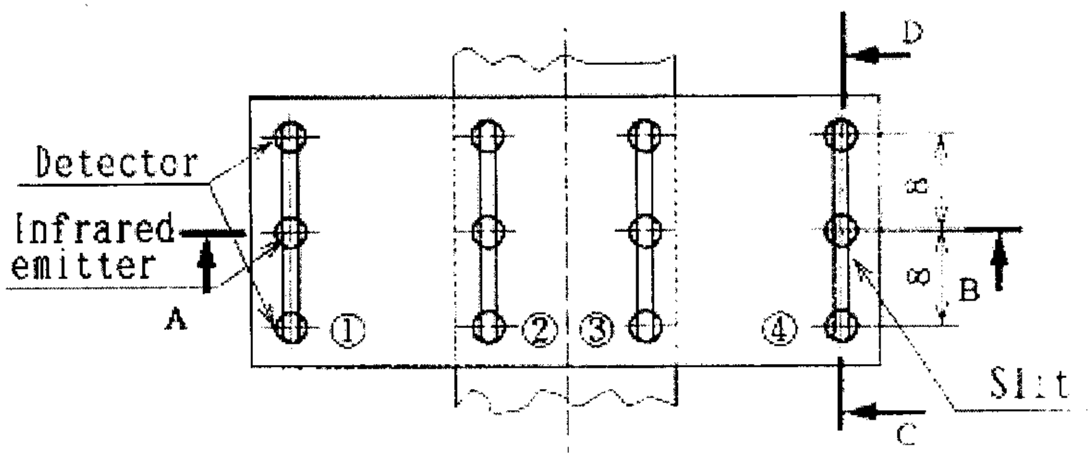

Fig. 4

The robot is designed to move on a pre-laid path which consists of two black paths with white paths, in between and besides them as shown in the fig.5

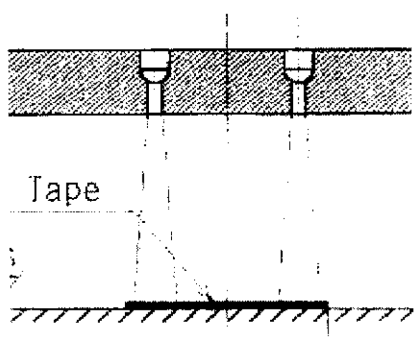

Fig. 5

The infrared ray sensor used here can detect a light of 6 mm width radiated from an emitter with a 2 mm slit.

Infrared transmitter is one type of LED which emits infrared rays generally called as IR Transmitter. Similarly IR Receiver is used to receive the IR rays transmitted by the IR transmitter. One important point is both IR transmitter and receiver should be placed straight line to each other.

The transmitted signal is given to IR transmitter whenever the signal is high, the IR transmitter LED is conducting it passes the IR rays to the receiver. The IR receiver is connected with comparator. The comparator is constructed with LM 358 operational amplifier. In the comparator circuit the reference voltage is given to inverting input terminal. The non inverting input terminal is connected IR receiver. When interrupt the IR rays between the IR transmitter and receiver, the IR receiver is not conducting. So the comparator non inverting input terminal voltage is higher then inverting input. Now the comparator output is in the range of +5V. This voltage is given to microcontroller or PC and led so led will glow.

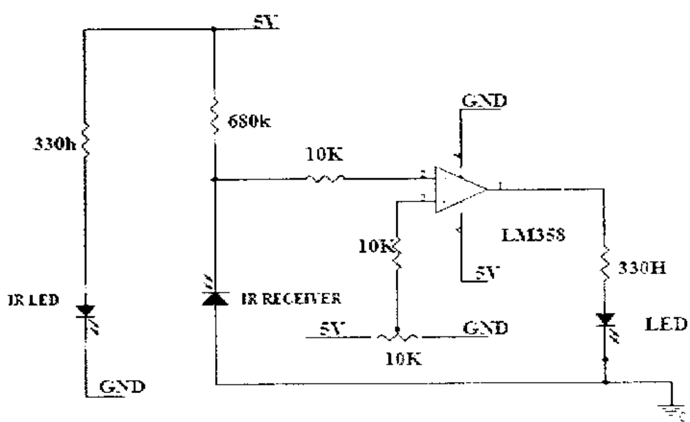

Fig. 6

When IR transmitter passes the rays to receiver, the IR receiver is conducting due to that non inverting input voltage is lower than inverting input. Now the comparator output is GND so the output is given to microcontroller or PC.

International Commission on Illumination (CIE) recommended the division of optical radiation into the following three bands:

- IR-A: 700 nm–1400 nm
- IR-B: 1400 nm–3000 nm
- IR-C: 3000 nm–1

The human eye is markedly less sensitive to light above 700 nm wavelength, so shorter frequencies make insignificant contributions to scenes illuminated by common light sources. But particularly intense light (e.g., from lasers, or from bright daylight with the visible light removed by colored gels) can be detected up to approximately 780 nm, and will be perceived as red light. The onset of infrared is defined (according to different standards) at various values typically between 700 nm and 800 nm.

3.2.1.DC MOTOR FORWARD AND REVERSE CONTROL

There are totally four DC motors driving four wheels of the robot. Of them, two wheels on either side are belted and are connected in parallel. Relays are used to drive these motors. Two relays are present to control the direction of movement of wheels on one side. Hence totally there are four relays to control the direction of wheels on both the sides.

The sequence of operation of the working of the robot's movements is made clear in the flowchart shown below.

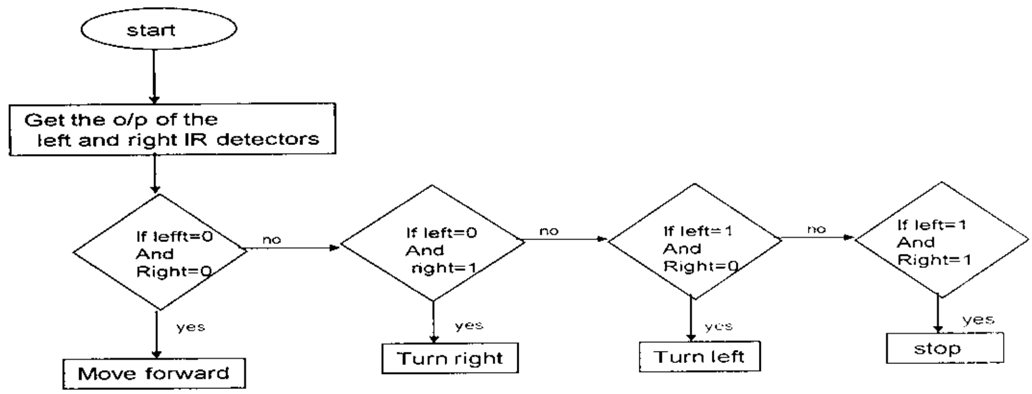

Fig. 7

The microcontroller is programmed to turn the wheels and align them to the black forward path. If the wheels deviate from the black path, then a correction is made to their direction as shown in the Fig.8

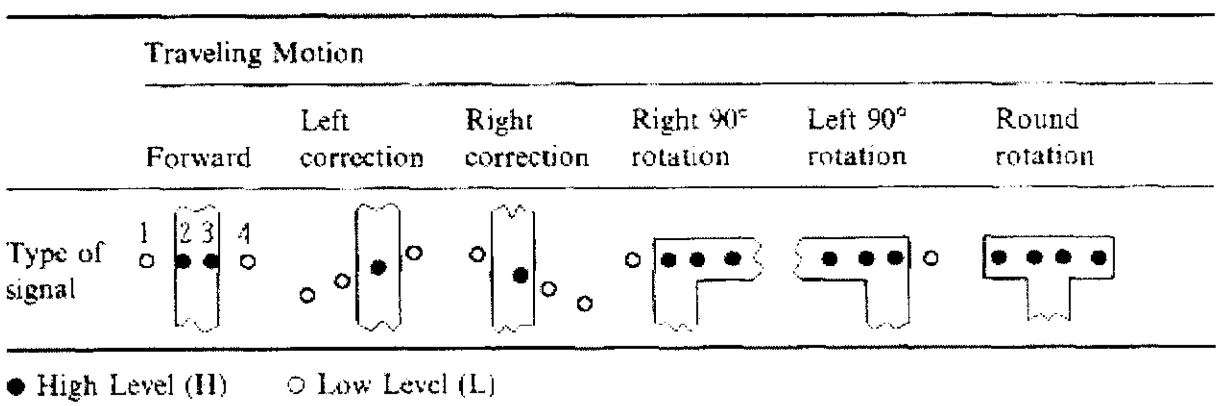

Fig.8

3.2.2. DC MOTORS' DRIVE USING RELAYS

This circuit shown in fig.9 is designed to control the motor in the forward and reverse direction. It consists of two relays named as relay1, relay2. The relay ON and OFF is controlled by the pair of switching transistors. A Relay is nothing but electromagnetic switching device which consists of three pins. They are Common, Normally close (NC) and normally open (NO). The common pin of two relay is connected to positive and negative terminal of motor through snubber circuit respectively. The relays are connected in the collector terminal of the transistors T2 and T4.

When high pulse signal is given to either base of the T1 or T3 transistors, the transistor is conducting and shorts the collector and emitter terminal and zero signals is given to base of the T2 or T4 transistor. So the relay is turned OFF state.

When low pulse is given to either base of transistor T1 or T3 transistor, the turned OFF. Now 12v is given to base of T2 or T4 transistor so the transistor is conducting and relay is turn ON. The NO and NC pins of two relays are interconnected so only one relay can be operated at a time.

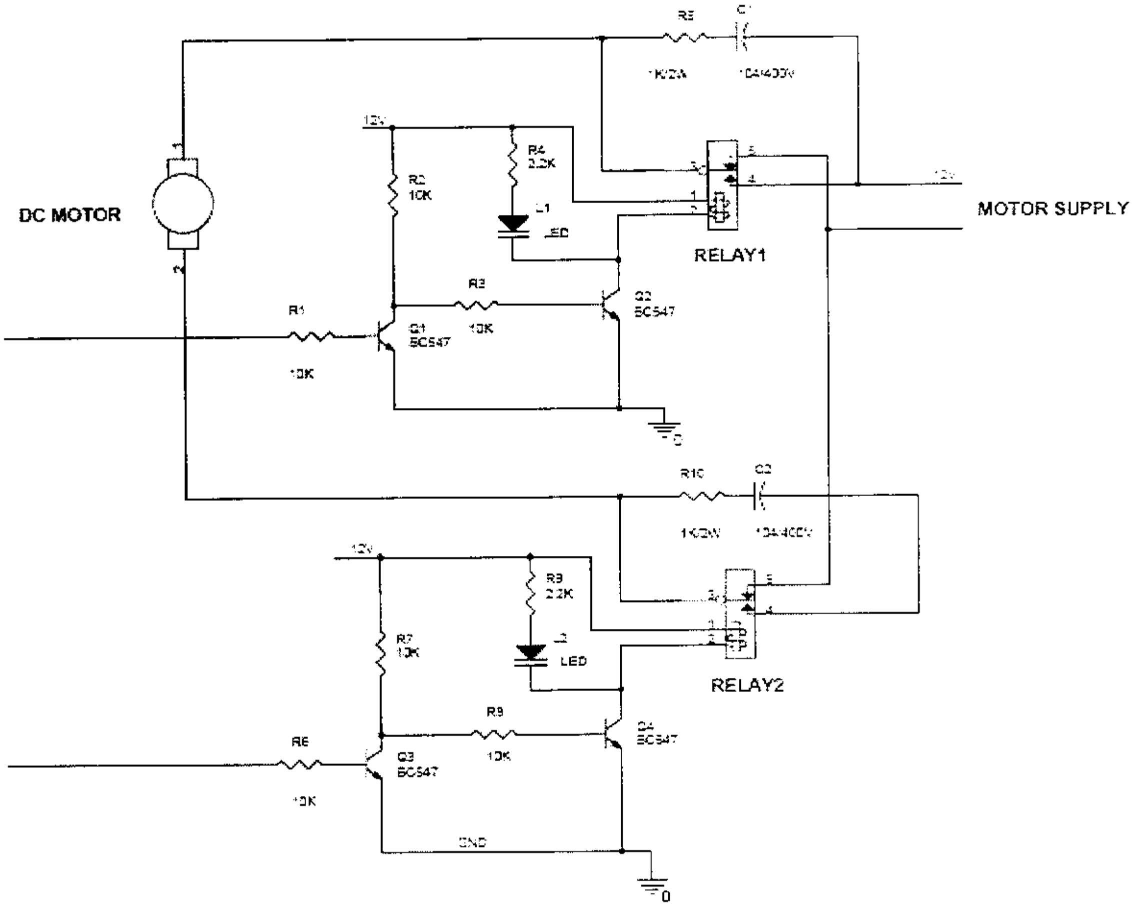

Fig. 9

The series combination of resistor and capacitor is called as snubber circuit. When the relay is turn ON and turn OFF continuously, the back emf may fault the relays. So the back emf is grounded through the snubber circuit.

When relay 1 is in the ON state and relay 2 is in the OFF state, the motor is running in the forward direction.

When relay 2 is in the ON state and relay 1 is in the OFF state, the motor is running in the reverse direction.

3.3. FIRE EXTINGUISHING SYSTEM

3.3.1. FIRE SENSING BLOCK

The flame sensor is used to detect the flame occurrence. When the sensor detects the fire it is short circuited. When there is no fire the sensor becomes an open circuit. BPVIO is the flame sensor used here. It is a high speed and very high sensitive PIN photodiode. Due to its water clear epoxy, the device is sensitive to visible and infrared radiation. It is used as a wide band detector for demodulation of fast signals, industrial electronics, measurement, control circuits and fast interrupters.

The circuit diagram is as shown in the fig.10. The flame sensor is connected with the resistor. This connection forms the voltage divider network which is connected with inverting input terminal of the comparator. The reference voltage is given to non inverting input terminal. The comparator is constructed with LM 741 operational amplifier.

When there is no fire, the flame sensor acts as an open circuit. So the inverting input terminal voltage is greater than non inverting input terminal (reference voltage). Now the comparator output is -12V which is given to the base of the switching transistor BC547. So the transistor is cutoff region. The 5v is given to 7404 IC. The 7404 is the hex inverter with buffer. Hence zero voltage is given to the microcontroller.

When there is fire, the flame sensor acts as a short circuit. So the inverting input terminal voltage is less than non inverting input terminal (reference voltage). Now the comparator output is +12V which is given to the base of the switching transistor BC547. So the transistor is turned ON. The zero voltage is given to 7404 IC. Hence +5v voltage is given to microcontroller. It is mainly used to prevent the fire accident.

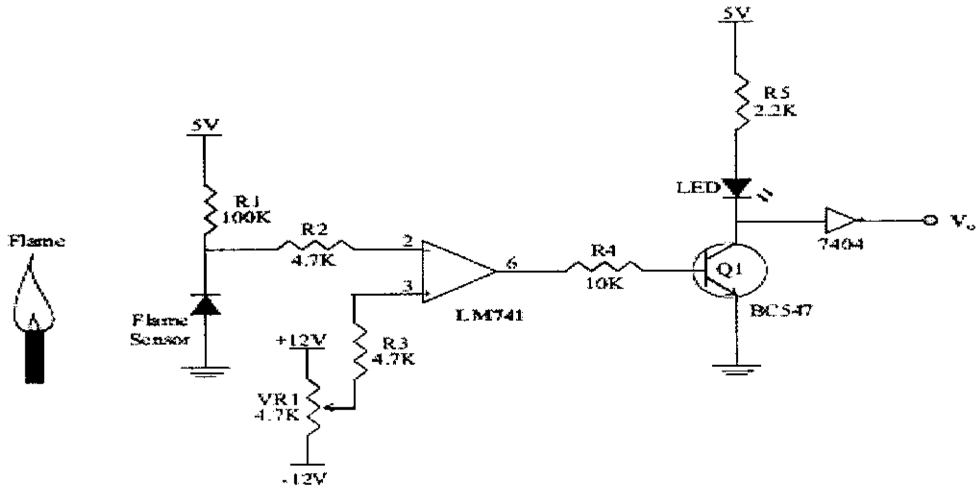

Fig. 10

3.3.2. TEMPERATURE MEASURING BLOCK

In this circuit, the sensor used to measure temperature is the thermistor. The circuit just consists of the sensor connected with the microcontroller through a 1E5W resistor. Here temperature is measured as an analog value. The parameter, temperature is taken into account to get an approximation of how far the fire is, from the robot.

3.3.3. SPEED CONTROL OF DC MOTOR

If fire has been detected, then the temperature is checked. If the temperature is low, then the fire is considered to be a little far from the robot and hence, the DC pump speed is kept low. Whereas, if the temperature is found to be high, then it is considered that the fire is nearer, and so, the pump speed is kept high.

The table below indicates how the DC pump speed is varied according to the temperature and fire.

FIRE DETECTOR O/P	TEMPERATURE SENSOR'S O/P	DC PUMP SPEED
0	Not considered	OFF
1	Low	Low
1	High	High

Table 1

The flowchart below explains the sequence of operation for the Automatic fire extinguishing system.

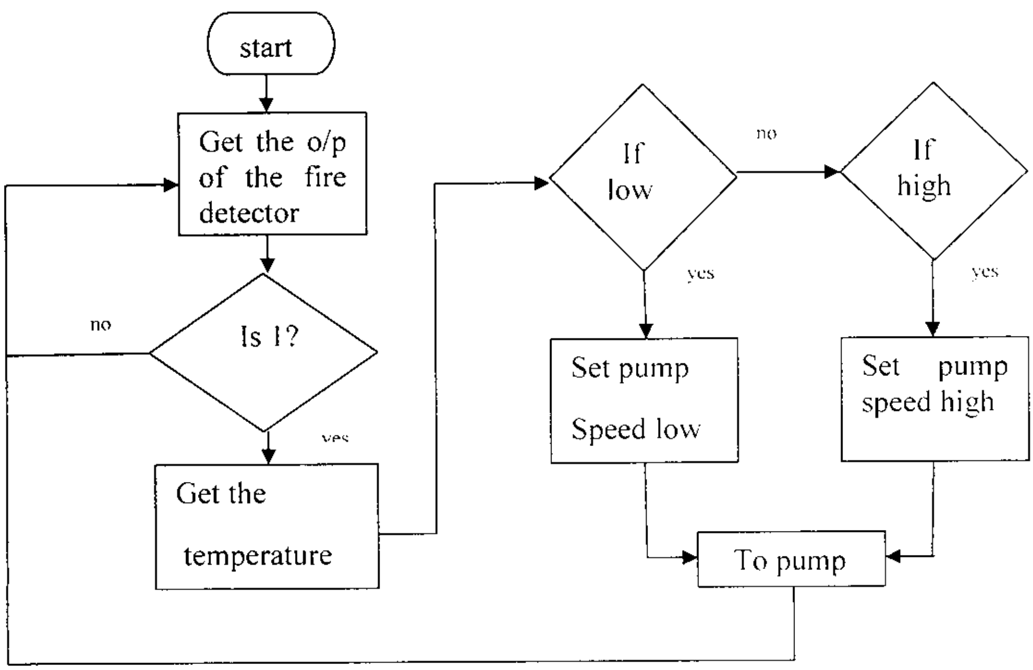

Fig. 11

3.3.4. DC PUMP DRIVE- MOSFET

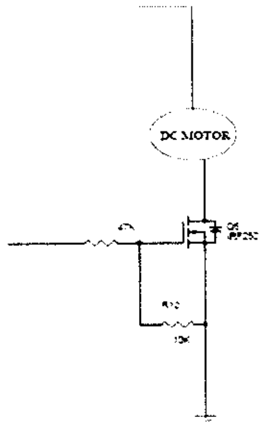

Fig.12

The Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET, MOS-FET, or MOS FET), is by far the most common field-effect transistor in both digital and analog circuits. The MOSFET is composed of a channel of n-type or p-type semiconductor material (see article on semiconductor devices), and is accordingly called an NMOSFET or a PMOSFET (also commonly nMOSFET, pMOSFET, NMOS FET, PMOS FET, nMOS FET, pMOS FET).

The 'metal' in the name (for transistors up to the 65 nanometer technology node) is an anachronism from early chips in which the gates were metal; They use polysilicon gates. IGFET is a related, more general term meaning insulated-gate field-effect transistor, and is almost synonymous with "MOSFET", though it can refer to FETs with a gate insulator that is not oxide. Some prefer to use "IGFET" when referring to devices with polysilicon gates, but most still call them MOSFETs. With the new generation of high-k technology that Intel and IBM have announced [1], metal gates in conjunction with the high-k dielectric material replacing the silicon dioxide are making a comeback replacing the polysilicon.

Usually the semiconductor of choice is silicon, but some chip manufacturers, most notably IBM, have begun to use a mixture of silicon and germanium (SiGe) in MOSFET channels. Unfortunately, many semiconductors with better electrical properties than silicon, such as gallium arsenide, do not form good gate oxides and thus are not suitable for MOSFETs.

The gate terminal in the current generation (65 nanometer node) of MOSFETs is a layer of polysilicon (polycrystalline silicon; why polysilicon is used will be explained below) placed over the channel, but separated from the channel by a thin insulating layer of what was traditionally silicon dioxide, but more advanced technologies used silicon oxynitride. The next generation (45 nanometer and beyond) uses a high-k + metal gate combination. When a voltage is applied between the gate and source terminals, the electric field generated penetrates through the oxide and creates a so-called "inversion channel" in the channel underneath. The inversion channel is of the same type — P-type or N-type — as the source and drain, so it provides a conduit through which current can pass. Varying the voltage between the gate and body modulates the conductivity of this layer and makes it possible to control the current flow between drain and source.

3.3.5. HOW THE SYSTEM IS A CLOSED LOOP CONTROL SYSTEM?

The fire extinguishing system in this robot represents a closed loop control system. This is made clear in the Fig.13.

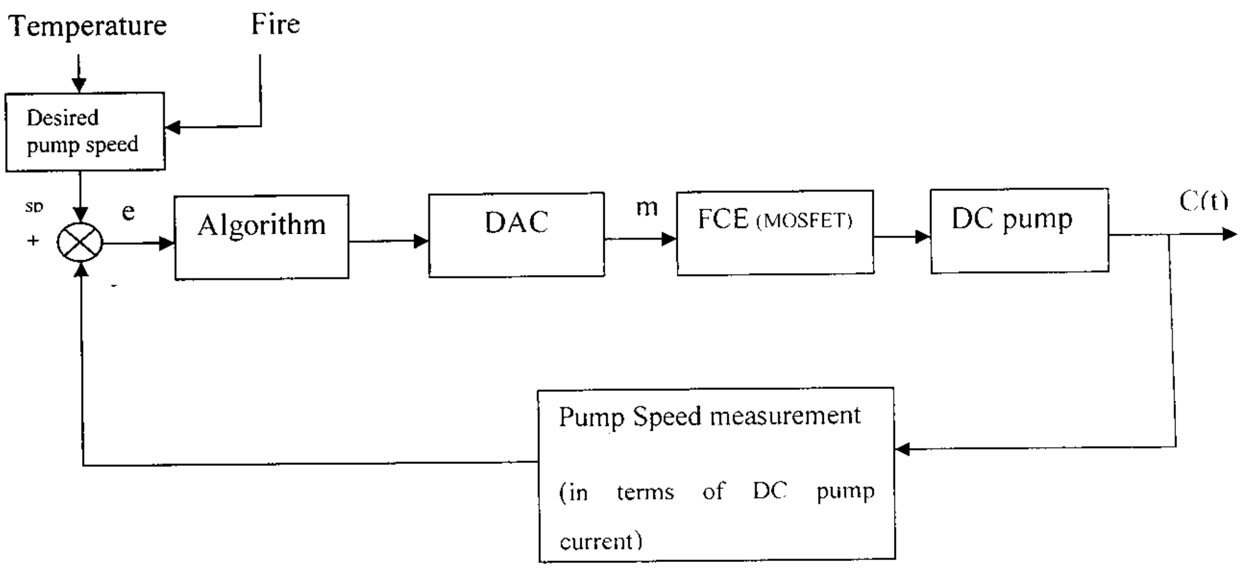

Fig.13

CHAPTER 4

METHOD AND CONTROL

4.1. MICROCONTROLLER

4.1.1. INTRODUCTION TO MICROCONTROLLER

Microcontrollers are destined to play an increasingly important role in revolutionizing various industries and influencing our day to day life more strongly than one can imagine. Since its emergence in the early 1980's the microcontroller has been recognized as a general purpose building block for intelligent digital systems. It is finding using diverse area, starting from simple children's toys to highly complex spacecraft. Because of its versatility and many advantages, the application domain has spread in all conceivable directions, making it ubiquitous. As a consequence, it has generate a great deal of interest and enthusiasm among students, teachers and practicing engineers, creating an acute education need for imparting the knowledge of microcontroller based system design and development. It identifies the vital features responsible for their tremendous impact, the acute educational need created by them and provides a glimpse of the major application area.

A microcontroller is a complete microprocessor system built on a single IC. Microcontrollers were developed to meet a need for microprocessors to be put into low cost products. Building a complete microprocessor system on a single chip substantially reduces the cost of building simple products, which use the microprocessor's power to implement their function, because the microprocessor is a natural way to implement many products. This means the idea of using a microprocessor for low cost products comes up often. But the typical 8-bit microprocessor based system, such as one using a Z80 and 8085 is expensive. Both 8085 and Z80 system need some additional circuits to make a microprocessor system. Each part carries costs of money. Even though a product design may requires only very simple system, the parts needed to make this system as a low cost product.

To solve this problem microprocessor system is implemented with a single chip microcontroller. This could be called microcomputer, as all the major parts are in the IC. Most frequently they are called microcontroller because they are used they are used to perform control functions.

The microcontroller contains full implementation of a standard MICROPROCESSOR, ROM, RAM, I/0, CLOCK, TIMERS, and also SERIAL PORTS. Microcontroller also called "system on a chip" or "single chip microprocessor system" or "computer on a chip".

A microcontroller is a Computer-On-A-Chip, or, if you prefer, a single-chip computer. Micro suggests that the device is small, and controller tells you that the device' might be used to control objects, processes, or events. Another term to describe a microcontroller is embedded controller, because the microcontroller and its support circuits are often built into, or embedded in, the devices they control.

Today microcontrollers are very commonly used in wide variety of intelligent products. For example most personal computers keyboards and implemented with a microcontroller. It replaces Scanning, Debounce, Matrix Decoding, and Serial transmission circuits. Many low cost products, such as Toys, Electric Drills, Microwave Ovens, VCR and a host of other consumer and industrial products are based on microcontrollers. Microcontroller is a general purpose device, which integrates a number of the components of a microprocessor system on to single chip. It has inbuilt CPU, memory and peripherals to make it as a mini computer. A microcontroller combines on to the same microchip:

- ➢ The CPU core
- ➢ Memory(both ROM and RAM)
- ➢ Some parallel digital

4.2. PIC (16F877)

4.2.1. INTRODUCTION TO PIC

The microcontroller that has been used for this project is from PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complimentary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory.

The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques.

Various microcontrollers offer different kinds of memories. EEPROM, EPROM, FLASH etc. are some of the memories of which FLASH is the most recently developed. Technology that is used in pic16F877 is flash technology, so that data is retained even when the power is switched off. Easy Programming and Erasing are other features of PIC 16F877.

4.2.2. 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

- Pin out compatible to the PIC16C73/74/76/77
- Interrupt capability (up to 14 internal/external
- 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 EPROM/EEPROM technology
- Fully static design
- In-Circuit Serial Programming (ICSP) via two pins
- Only single 5V source needed for programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.5V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial and Industrial temperature ranges
- Low-power consumption:

  < 2mA typical @ 5V, 4 MHz

  20mA typical @ 3V, 32 kHz

  < 1mA typical standby current

4.2.3. 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 addresses detection.
- Brown-out detection circuitry for Brown-out Reset (BOR)

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4.2.4. GENERAL DESCRIPTION

- 40pins controller
- Having 5 ports namely
  - Port A for analog signal
  - Port B for digital signal
  - Port C for digital signal

    - Port D for digital signal
    - Port E for analog signal

- for C-programming
- Wide availability in market
- In-built Analog to Digital Converter
- In-built PWM
- Soft Multiple I/O Channels
- A number of peripherals can be used
- Memory are testing, compilation, simulation

Various ports of the PIC microcontroller are as shown in the Fig.14

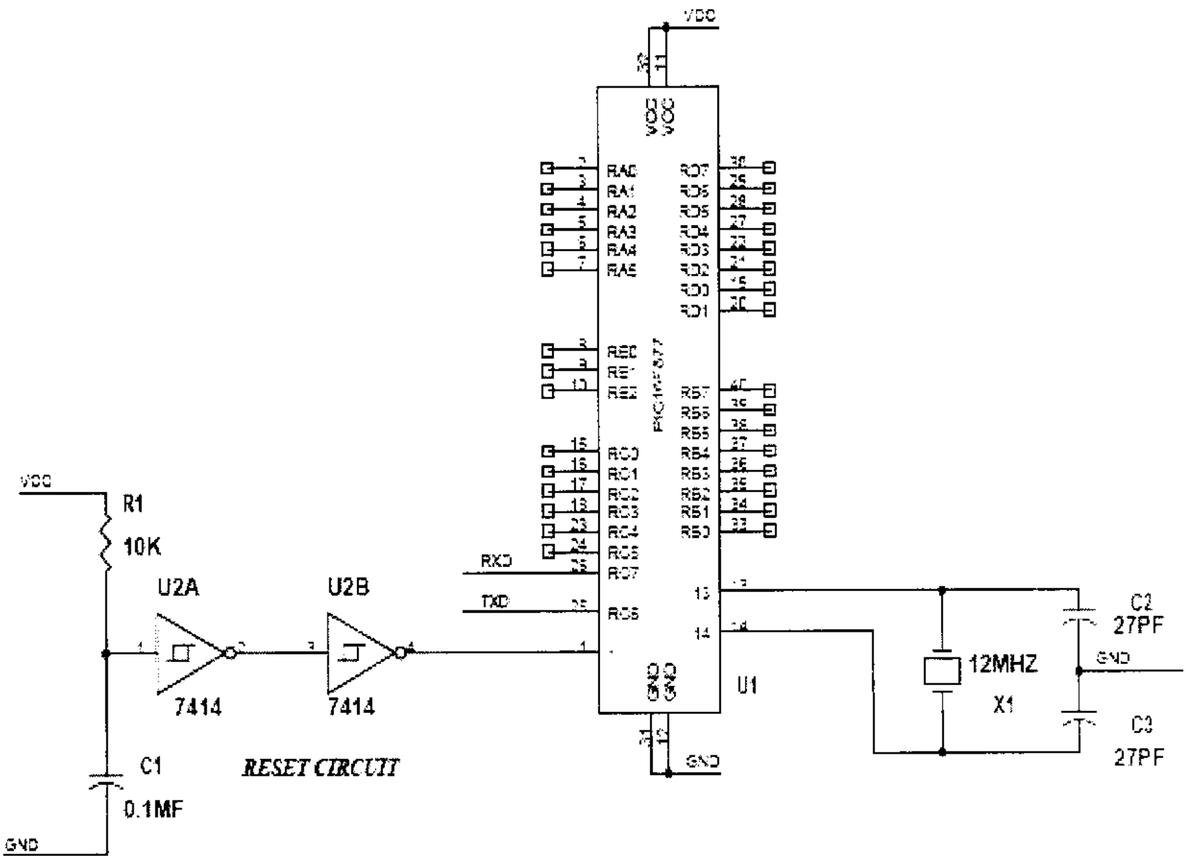


Fig. 14

4.2.5. PIN DIAGRAM

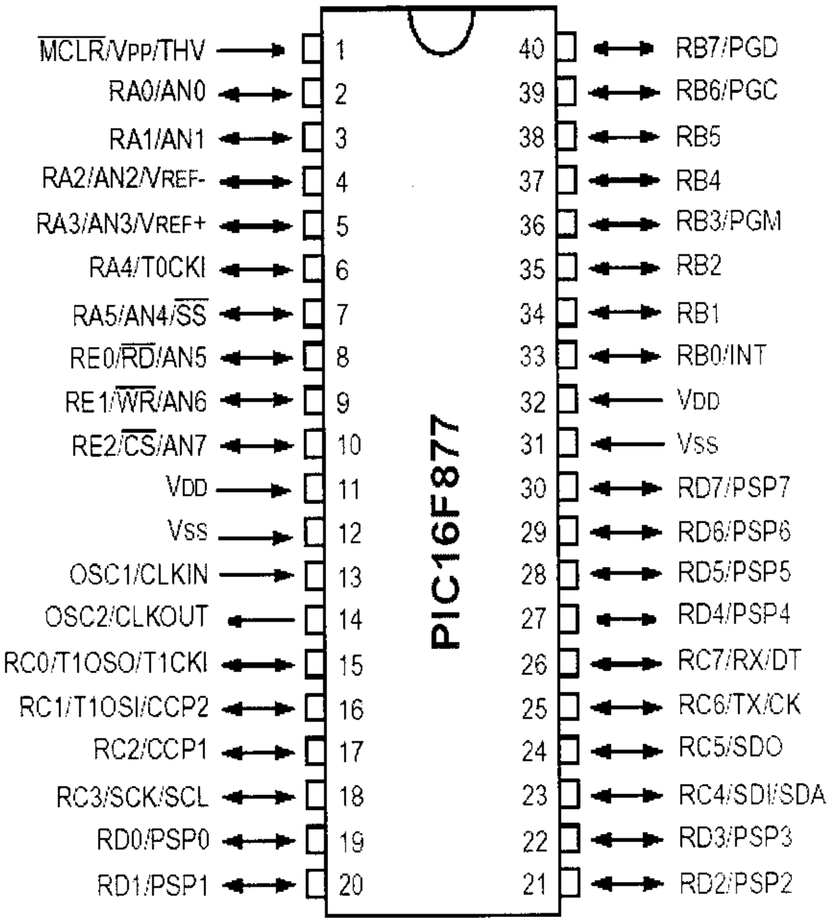


Fig. 15

4.2.6. PIN DESCRIPTIONS

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	13	14	30	I	ST/CMOS(4)	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	14	15	31	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
$\overline{MCLR}$/VPP/THV	1	2	18	I/P	ST	Master clear (reset) input or programming voltage input or high voltage test mode control. This pin is an active low reset to the device.
						PORTA is a bi-directional I/O port.
RA0/AN0	2	3	19	I/O	TTL	RA0 can also be analog input0
RA1/AN1	3	4	20	I/O	TTL	RA1 can also be analog input1
RA2/AN2/VREF-	4	5	21	I/O	TTL	RA2 can also be analog input2 or negative analog reference voltage
RA3/AN3/VREF+	5	6	22	I/O	TTL	RA3 can also be analog input3 or positive analog reference voltage
RA4/T0CKI	6	7	23	I/O	ST	RA4 can also be the clock input to the Timer0 timer/counter. Output is open drain type.
RA5/$\overline{SS}$/AN4	7	8	24	I/O	TTL	RA5 can also be analog input4 or the slave select for the synchronous serial port.
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	I/O	TTL/ST(1)	RB0 can also be the external interrupt pin.
RB1	34	37	9	I/O	TTL	
RB2	35	38	10	I/O	TTL	
RB3/PGM	36	39	11	I/O	TTL	RB3 can also be the low voltage programming input
RB4	37	41	14	I/O	TTL	Interrupt on change pin.
RB5	38	42	15	I/O	TTL	Interrupt on change pin.
RB6/PGC	39	43	16	I/O	TTL/ST(2)	Interrupt on change pin or In-Circuit Debugger pin. Serial programming clock.
RB7/PGD	40	44	17	I/O	TTL/ST(2)	Interrupt on change pin or In-Circuit Debugger pin. Serial programming data.
						PORTC is a bi-directional I/O port.
RC0/T1OSO/T1CKI	15	16	32	I/O	ST	RC0 can also be the Timer1 oscillator output or a Timer1 clock input.
RC1/T1OSI/CCP2	16	18	35	I/O	ST	RC1 can also be the Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output.
RC2/CCP1	17	19	36	I/O	ST	RC2 can also be the Capture1 input/Compare1 output/PWM1 output.
RC3/SCK/SCL	18	20	37	I/O	ST	RC3 can also be the synchronous serial clock input/output for both SPI and I²C modes.
RC4/SDI/SDA	23	25	42	I/O	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I²C mode).
RC5/SDO	24	26	43	I/O	ST	RC5 can also be the SPI Data Out (SPI mode).
RC6/TX/CK	25	27	44	I/O	ST	RC6 can also be the USART Asynchronous Transmit or Synchronous Clock.
RC7/RX/DT	26	29	1	I/O	ST	RC7 can also be the USART Asynchronous Receive or Synchronous Data.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as an external interrupt.
2: This buffer is a Schmitt Trigger input when used in serial programming mode.
3: This buffer is a Schmitt Trigger input when configured as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).
4: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

Table 2

4.2.7. I/O PORTS:

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

PORT A AND THE TRISA REGISTER:

PORT A is a 6-bit wide bi-directional port. The corresponding data direction register is TRISA. Setting a TRISA bit (=1) will make the corresponding PORT A pin an input, i.e., put the corresponding output driver in a Hi-impedance mode. Clearing a TRISA bit (=0) will make the corresponding PORTA pin an output, i.e., put the contents of the output latch on the selected pin.

PORT B AND TRISB REGISTER:

PORT B is an 8-bit wide bi-directional port. The corresponding data direction register is TRISB. Setting a TRISB bit (=1) will make the corresponding PORT B pin an input, i.e., put the corresponding output driver in a hi-impedance mode. Clearing a TRISB bit (=0) will make the corresponding PORT B pin an output, i.e., put the contents of the output latch on the selected pin. Three pins of PORT B are multiplexed with the Low Voltage Programming function; RB3/PGM, RB6/PGC and RB7/PGD. The alternate functions of these pins are described in the Special Features Section. Each of the PORT B pins has a weak internal pull-up. A single control bit can turn on all the pull-ups.

This is performed by clearing bit RBPU (OPTION_REG<7>). The weak pull-up is automatically turned off when the port pin is configured as an output. The pull-ups are disabled on a Power-on Reset.

PORT C AND THE TRISC REGISTER:

PORT C is an 8-bit wide bi-directional port. The corresponding data direction register is TRISC. Setting a TRISC bit (=1) will make the corresponding PORT C pin an input, i.e., put the corresponding output driver in a hi-impedance mode. Clearing a TRISC bit (=0) will make the corresponding PORT C pin an output, i.e., put the contents of the output latch on the selected pin. PORT C is multiplexed with several peripheral functions. PORT C pins have Schmitt Trigger input buffers.

PORT D AND TRISD REGISTERS:

This section is not applicable to the 28-pin devices. PORTD is an 8-bit port with Schmitt Trigger input buffers. Each pin is individually configurable as an input or output. PORT D can be configured as an 8-bit wide microprocessor Port (parallel slave port) by setting control bit PSPMODE (TRISE<4>). In this mode, the input buffers are TTL.

PORT E AND TRISE REGISTER:

PORT E has three pins RE0/RD/AN5, RE1/WR/AN6 and RE2/CS/AN7, which are individually configurable as inputs or outputs. These pins have Schmitt Trigger input buffers. The PORT E pins become control inputs for the microprocessor port when bit PSPMODE (TRISE<4>) is set. In this mode, the user must make sure that the TRISE<2:0> bits are set (pins are configured as digital inputs). Ensure ADCON1 is configured for digital I/O. In this mode the input buffers are TTL. PORT E pins are multiplexed with analog inputs. When selected as an analog input, these pins will read as '0's. TRISE controls the direction of the RE pins, even when they are being used as analog inputs. The user must make sure to keep the pins configured as inputs when using them as analog inputs.

CHAPTER 5

PCB DESIGNING PROCESS

5.1. PRINTED CIRCUIT BOARD

Making of printed circuit board is as much as an art as a technique, particularly when they are to be fabricated in very small numbers. There are several ways of drawing PCB patterns and making the final boards, but the methods most likely to interest people in need of just a few PCB's has to be simple and economical.

The making of PCB essentially involves two steps:

1. Preparing the PCB drawing
2. Fabricating the PCB itself from the drawing

The industrial method of making a PCB drawing with complete placement of parts, taking a photographic negative of the drawing, developing the image of the negative formed on the photo-sensitized copper plate, and dissolving the excess copper by etching of a standard practice being followed in large scale operations. However in small scale operations where large numbers of copies are not required, the cost saving procedure presented here may be adopted.

The procedure has its own advantages, as the lateral inversion problem is overcome. Also, tracing of the circuit and fault finding is made easy, as the PCB exactly look for positions to drill holes and place various components.

5.1.1. PCB DRAWING

Making of the PCB, drawing involves some preliminary considerations such as placement of components (in the same order as the circuit diagram on a piece of paper, location of holes, deciding the diameters of various holes, the optimum areas each component should occupy, the shape and location of the islands for connecting two or more overcrowding of components at a particular place. There is no other way to arrive at the correct conclusions than by trial and error. For anchoring leads of components, 1mm diameter holes, and for fixing PCB holding screws to the chassis 3mm holes are recommended.

This sketch may be redrawn neatly on a fresh piece of paper, if desired. This sketch is the mirror image of the PCB pattern desired; it shows the components on the other side of the laminate.

The mirror image of this sketch, the PCB pattern, can now be drawn with the help of a thick tracing paper. The sketch redrawn on a tracing paper would not appear as a PCB pattern when viewed from the other side. To save time and effort, the sketch may be made on the tracing paper itself right in the beginning.

Alternatively, the PCB pattern can be drawn from the sketch with the help of a carbon paper. A fresh carbon paper may be placed facing up on a flat surface and covered with a plain sheet of paper. On this sheet the sketch may be placed. Now by carefully tracing the sketch with a ball pen or a hand pencil, the mirror image of the sketch may be obtained on the lower sheet of the paper.

5.1.2. PCB FABRICATION

The copper-clad PCB laminate may now be prepared by rubbing away the oxide, grease and dirt, etc with a fine emery paper or a sand paper. On this the final PCB drawing may be traced this time by using the carbon paper in the normal way (face down on the laminate). Clips should be used to prevent the carbon and the paper from slipping while the pattern is being traced on the laminate. Only the connecting lines in PCB islands and holds should be traced; the positions of components need not be traced. The components position can be marked on the PCB reverse side, if desired.

CHAPTER 6

TESTING AND DISCUSSION

6.1. INTRODUCTION

Testing is an important phase in doing a project. The testing should be done during each and every stage of the project to avoid failure of the whole mechanism due to the fault in a module. This can cause loss in terms of money and also manual work. Here careful testing should be done.

6.2. EXPERIMENTATION

In this project, testing is done in the following modules: Power supply module, IR Path detection module, DC Motor drive module, Fire detector module, Temperature measurement module, DC pump drive module.

The Power supply module is tested for its output voltage and current values. Then it is connected to the other modules through various meshes based on the voltage and current values required for each of those modules.

In the IR Path detection module, voltage levels are verified with the detectors facing the black and the white paths. Then it is verified that this module is connected to the microcontroller at the required level of voltage.

The DC motor drive circuit is checked, if the correct relays get the operating voltages for the needed action of the wheels.

The fire detector module is checked, if it is giving the output voltage on the occurrence of fire.

For various values of temperature, the corresponding output voltages are noted and it is checked, if the pump speed varies accordingly. The experimental data obtained is tabulated below.

TEMPERATURE (deg celcius)	O/P VOLTAGE (mV)
32	23
38	65
42	108
50	226
56	293

Table 3

6.3. PERFORMANCE

In this project, we have used 12V and 5V input supply voltages for the various blocks. The Power Supply unit provides these required voltages.

In the path detection system, when both the IR detectors face black, they keep moving forward. When one of the detector face white, the wheel corresponding to that side stops moving and the other wheel moves in order to align to the black path. On the occurrence of fire, the DC water pump pumps water at various speeds according to the temperature of the fire.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1. CONCLUSION

The All Terrain Path Tracking robot with Automatic Fire Extinguisher has been successfully tested. It has roles at various applications, not only in Industries but on other areas also, as indicated below.

- As discussed earlier, this robot has been designed mainly for the application as a Carry robot in Industries.
- The robot can play role as a Guiding machine at places like Hospitals, Research Centres, etc
- Also, the robot can be used as an Automatic Monitoring robot in Industries, Mining areas, etc

APPENDIX A

HARDWARE

LM358

• Internally Frequency Compensated for Unity Gain

• Large DC Voltage Gain: 100dB

• Wide Power Supply Range:

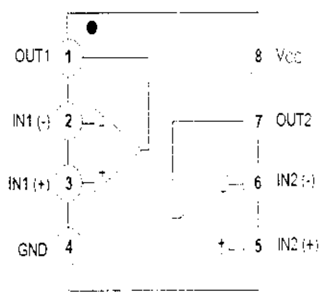
LM258/LM258A, LM358/LM358A: 3V~32V (or ±1.5V~ 16V)

LM2904 : 3V~26V (or ±1.5V ~ 13V)

• Input Common Mode Voltage Range Includes Ground

• Large Output Voltage Swing: 0V DC to Vcc -1.5V DC

• Power Drain Suitable for Battery Operation.



Pin diagram of LM358

The LM358 consists of two independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltage. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. Application areas include transducer amplifier, DC gain blocks and all the conventional OP-AMP circuits which now can be easily implemented in single power supply systems.

SERIES VOLTAGE REGULATOR- LM7805C

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

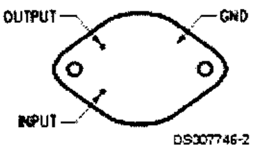
The LM78XX series is available in an aluminum TO-3 package which will allow over 1.0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating. Considerable effort was expanded to make the LM78XX series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the out put, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply. For output voltage other than 5V, 12V and 15V the LM117 series provides an output voltage range from 1.2V to 57V.

FEATURES

- Output current in excess of 1A
- Internal thermal overload protection
- No external components required

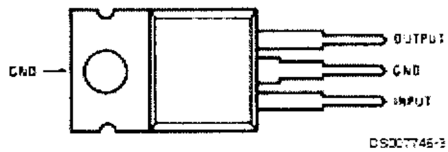
- Output transistor safe area protection
- Internal short circuit current limit
- Available in the aluminum TO-3 package

Metal Can Package
TO-3 (K)
Aluminum



Bottom View

Plastic Package
TO-220 (T)



Top View

Connection diagrams

Voltage Ranges

LM7805C - 5V

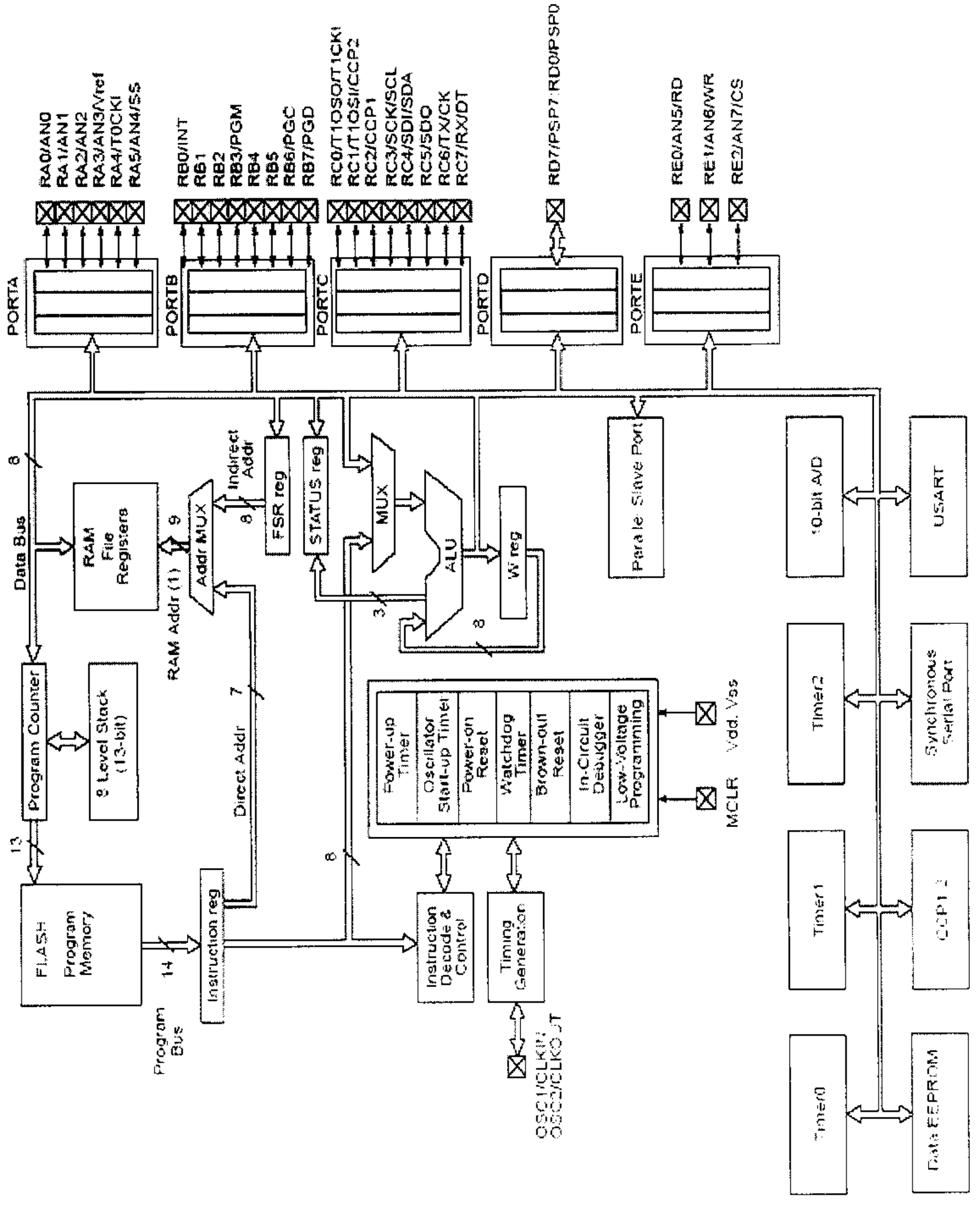
LM7812C - 12V

LM7815C - 15V

PIC 16F877

ARCHITECTURE

The complete architecture of PIC 16F877 is shown in the figure below.



Note 1: Higher order bits are from the STATUS register.

ADDRESSING MODES:

DIRECT ADDRESSING:

In direct addressing, the operand is specified by an 8-bit address field in the instruction. Only internal data RAM and SFR's can be directly addressed.

INDIRECT ADDRESSING:

In Indirect addressing, the instruction specifies a register that contains the address of the operand. Both internal and external RAM can indirectly address.

The address register for 8-bit addresses can be either the Stack Pointer or R0 or R1 of the selected register Bank. The address register for 16-bit addresses can be only the 16-bit data pointer register, DPTR.

INDEXED ADDRESSING:

Program memory can only be accessed via indexed addressing this addressing mode is intended for reading look-up tables in program memory. A 16 bit base register (Either DPTR or the Program Counter) points to the base of the table, and the accumulator is set up with the table entry number. Adding the Accumulator data to the base pointer forms the address of the table entry in program memory.

Another type of indexed addressing is used in the" case jump " instructions. In this case the destination address of a jump instruction is computed as the sum of the base pointer and the Accumulator data.

REGISTER INSTRUCTION:

The register banks, which contains registers R0 through R7, can be accessed by instructions whose opcodes carry a 3-bit register specification. Instructions that access the registers this way make efficient use of code, since this mode eliminates an address byte. When the instruction is executed, one of four banks is selected at execution time by the row bank select bits in PSW.

REGISTER - SPECIFIC INSTRUCTION:

Some Instructions are specific to a certain register. For example some instruction always operates on the Accumulator, so no address byte is needed to point OT ir. In these cases, the opcode itself points to the correct register. Instructions that register to Accumulator as A assemble as Accumulator - specific Opcodes.

IMMEDIATE CONSTANTS:

The value of a constant can follow the opcode in program memory For example. MOV A, #100 loads the Accumulator with the decimal number 100. The same number could be specified in hex digit as 64h.

CONTROL WORDS

REGISTERS ASSOCIATED WITH TIMER0:

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR. BOR	Value on all other resets
01h,101h	TMR0	Timer0 module's register								xxxx xxxx	uuuu uuuu
0Bh,8Bh, 10Bh,18Bh	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
81h,181h	OPTION_REG	$\overline{\text{RBPU}}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111

Legend: x = unknown, u = unchanged, - = unimplemented locations read as '0'. Shaded cells are not used by Timer0

T1CON:TIMER1 CONTROL REGISTER (ADDRESS 10h)

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	T1CKPS1	T1CKPS0	T1OSCEN	$\overline{\text{T1SYNC}}$	TMR1CS	TMR1ON
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7-6 : **Unimplemented:** Read as '0'

bit 5-4 : **T1CKPS1:T1CKPS0**: Timer1 Input Clock Prescale Select bits

11 = 1:8 Prescale value

10 = 1:4 Prescale value

01 = 1:2 Prescale value

00 = 1:1 Prescale value

bit 3 : **T1OSCEN**: Timer1 Oscillator Enable Control bit

1 = Oscillator is enabled

0 = Oscillator is shut off (The oscillator inverter is turned off to eliminate) Power drain)

bit 2 : **T1SYNC**: Timer1 External Clock Input Synchronization Control bit

TMR1CS = 1

1 = Do not synchronize external clock input

0 = Synchronize external clock input

TMR1CS = 0

This bit is ignored. Timer1 uses the internal clock when TMR1CS = 0.

bit 1 : **TMR1CS**: Timer1 Clock Source Select bit

1 = External clock from pin RC0/T1OSO/T1CKI (on the rising edge)

0 = Internal clock (FOSC/4)

bit 0 : **TMR1ON**: Timer1 On bit

1 = Enables Timer1

0=StopsTimer1

T2CON:TIMER2 CONTROL REGISTER (Address 12h)

U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7 : Unimplemented: Read as '0'

bit 6-3: TOUTPS3:TOUTPS0: Timer2 Output Postscale Select bits

0000 = 1:1 Postscale

0001 = 1:2 Postscale

0010 = 1:3 Postscale

1111 = 1:16 Postscale

bit 2 : TMR2ON: Timer2 On bit

1 = Timer2 is on

0 = Timer2 is off

bit 1-0: T2CKPS1:T2CKPS0: Timer2 Clock Prescale Select bits

00 = Prescaler is 1

01 = Prescaler is 4

1x=Prescaleris16

CCP1 MODULE:

Capture/Compare/PWM Register1 (CCPR1) is comprised of two 8-bit registers: CCPR1L (low byte) and CCPR1H (high byte). The CCP1CON register controls the operation of CCP1. The special event trigger is generated by a compare match and will reset Timer1.

CCP2 MODULE:

Capture/Compare/PWM Register1 (CCPR2) is comprised of two 8-bit registers: CCPR2L (low byte) and CCPR2H (high byte). The CCP2CON register controls the operation of CCP2. The special event trigger is generated by a compare match and will reset Timer1 and start an A/D conversion (if the A/D module is enabled).

CCP1CON REGISTER/CCP2CON REGISTER (ADDRESS: 17h/1dh)

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	CCPxX	CCPxY	CCPxM3	CCPxM2	CCPxM1	CCPxM0
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7-6: Unimplemented: Read as '0'

bit 5-4: CCPxX:CCPxY: PWM Least Significant bits

Capture Mode: Unused

Compare Mode: Unused

PWM Mode: These bits are the two LSbs of the PWM duty cycle. The Eight msb's are found in CCPRxL

bit 3-0: CCPxM3:CCPxM0: CCPx Mode Select bits

0000 = Capture/Compare/PWM off (resets CCPx module)

0100 = Capture mode, every falling edge

0101 = Capture mode, every rising edge

0110 = Capture mode, every 4th rising edge

0111 = Capture mode, every 16th rising edge

1000 = Compare mode, set output on match (CCPxIF bit is set)

1001 = Compare mode, clear output on match (CCPxIF bit is set)

1010 = Compare mode, generate software interrupt on match (CCPxIF bit Is set. CCPx pin is unaffected)

1011 = Compare mode, trigger special event (CCPxIF bit is set, CCPx pin is unaffected; CCP1 resets)

TMR1; CCP2 resets TMR1 and starts an A/D conversion (if A/D module is Enabled)

11xx = PWM mode

PIR1 REGISER(ADDRESS 0Ch):

R/W-0	R/W-0	R-0	R-0	R/W-0	R/W-0	R/W-0	R/W-0
PSPIF(1)	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF
bit7							bit0

R = Readable bit
W = Writable bit
- n= Value at POR reset

bit 7 : PSPIF(1): Parallel Slave Port Read/Write Interrupt Flag bit

1 = A read or a write operation has taken place (must be cleared in Software)

0 = No read or write has occurred

bit 6 : ADIF: A/D Converter Interrupt Flag bit

1 = An A/D conversion completed

0 = The A/D conversion is not complete

bit 5 : RCIF: USART Receive Interrupt Flag bit

1 = The USART receive buffer is full

0 = The USART receive buffer is empty

bit 4 : TXIF: USART Transmit Interrupt Flag bit

1 = The USART transmit buffer is empty

0 = The USART transmit buffer is full

bit 7 : SSPIF: Synchronous Serial Port (SSP) Interrupt Flag

1 = The SSP interrupt condition has occurred, and must be cleared in Software before returning from the interrupt service routine. The Conditions that will set this bit are:

SPI- A transmission/reception has taken place.

I2C Slave- A transmission/reception has taken place.

I2C Master- A transmission/reception has taken place.

The initiated start condition was completed by the SSP module.

The initiated stop condition was completed by the SSP module.

The initiated restart condition was completed by the SSP module.

The initiated acknowledge condition was completed by the SSP module.

A start condition occurred while the SSP module was idle (Multimaster System).

A stop condition occurred while the SSP module was idle (Multimaster System).

0 = No SSP interrupt condition has occurred.

bit 2 : CCP1IF: CCP1 Interrupt Flag bit

Capture Mode

1 = A TMR1 register capture occurred (must be cleared in software)

0 = No TMR1 register capture occurred

Compare Mode

1 = A TMR1 register compare match occurred (must be cleared in Software)

0 = No TMR1 register compare match occurred

PWM Mode

Unused in this mode

bit 1 : TMR2IF: TMR2 to PR2 Match Interrupt Flag bit

1 = TMR2 to PR2 match occurred (must be cleared in software)

0 = No TMR2 to PR2 match occurred

bit 0 : TMR1IF: TMR1 Overflow Interrupt Flag bit

1 = TMR1 register overflowed (must be cleared in software)

0 = TMR1 register did not overflow

Note 1: PSPIF is reserved on 28-pin devices; always maintain this bit

Clear.

ADCON1 REGISTER(ADDRESS 9Fh)

U-0	U-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	—	—	—	PCFG3	PCFG2	PCFG1	PCFG0
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7 : ADFM: A/D Result format select

1 = Right Justified. 6 most significant bits of ADRESH are read as '0'.

0 = Left Justified. 6 least significant bits of ADRESL are read as '0'.

bit 6-4 : Unimplemented: Read as '0'

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

APPENDIX B

PROGRAM

CODING:

```
#include<pic.h>
#include"pic_lcd8.h"
#include"pic_adc.h"

#define left RB2
#define right RB3
#define right1 RB4
#define right2 RB5
#define left1 RB6
#define left2 RB7
#define fire RC0

void right_turn();
void left_turn();
void forward();
void stop();
```

```
unsigned char temp,current,v;

unsigned int temp0,temp1,temp2,temp3,y,msb,lsb;

unsigned int j;

float x;


void pwm_dutycycle()

{

        temp3=temp2;

        lsb=temp3 & 0x03;

        if(lsb==0x00)  lsb=0x0c;

        else if(lsb==0x01) lsb=0x1c;

        else if(lsb==0x02) lsb=0x2c;

        else if(lsb==0x03) lsb=0x3c;

        msb=temp3>>2;

        TMR2ON=1;

}
```

```
void main()
{
        TRISB=0B00001111;
        TRISC=0x01;
        TRISD=0x00;
        TRISA=0xFF;
        ADCON1=0x00;
        Lcd8_Init();
        Lcd8_Display(0x80,"INTELLIGENT FIRE",16);
        Lcd8_Display(0xc0,"FIGHTING ROBOT",16);
        GIE=1;
        PEIE=1;
        TMR2IE=1;
        T2CON=0x05;
        TMR2ON=0;
        PR2=0xFA;
        Delay(65000);
        Delay(65000);
        left=right=left1=left2=right1=right2=1;
```

```
Lcd8_Command(0x01);
Lcd8_Display(0x80,"I:   T:     P       ",16);
v=Adc8_Cha(1);
while(1)
{
        current=Adc8_Cha(0);
        temp=Adc8_Cha(1);
        Lcd8_Decimal3_1(0x82,current);
        temp=v-temp;
        Lcd8_Decimal3(0x88,temp);

        if(!left && !right) forward();
        else if(left && !right) right_turn();
        else if(right && !left) left_turn();
        else if(left && right) stop();
        if (fire)
        {
                x=255-temp;
                y=(x/255)*100;
```

```
                Lcd8_Decimal3(0x8d,y);
                temp2=(float)(x/255)*1000;
            }
            else temp2=0;
            pwm_dutycycle();
        }
}

void forward()
{
        left1=0;left2=1;
        right1=1;right2=0;
        Lcd8_Display(0xc0,"     FORWARD     ",16);
}

void right_turn()
{
        left1=1;left2=1;
        right1=0;right2=1;
```

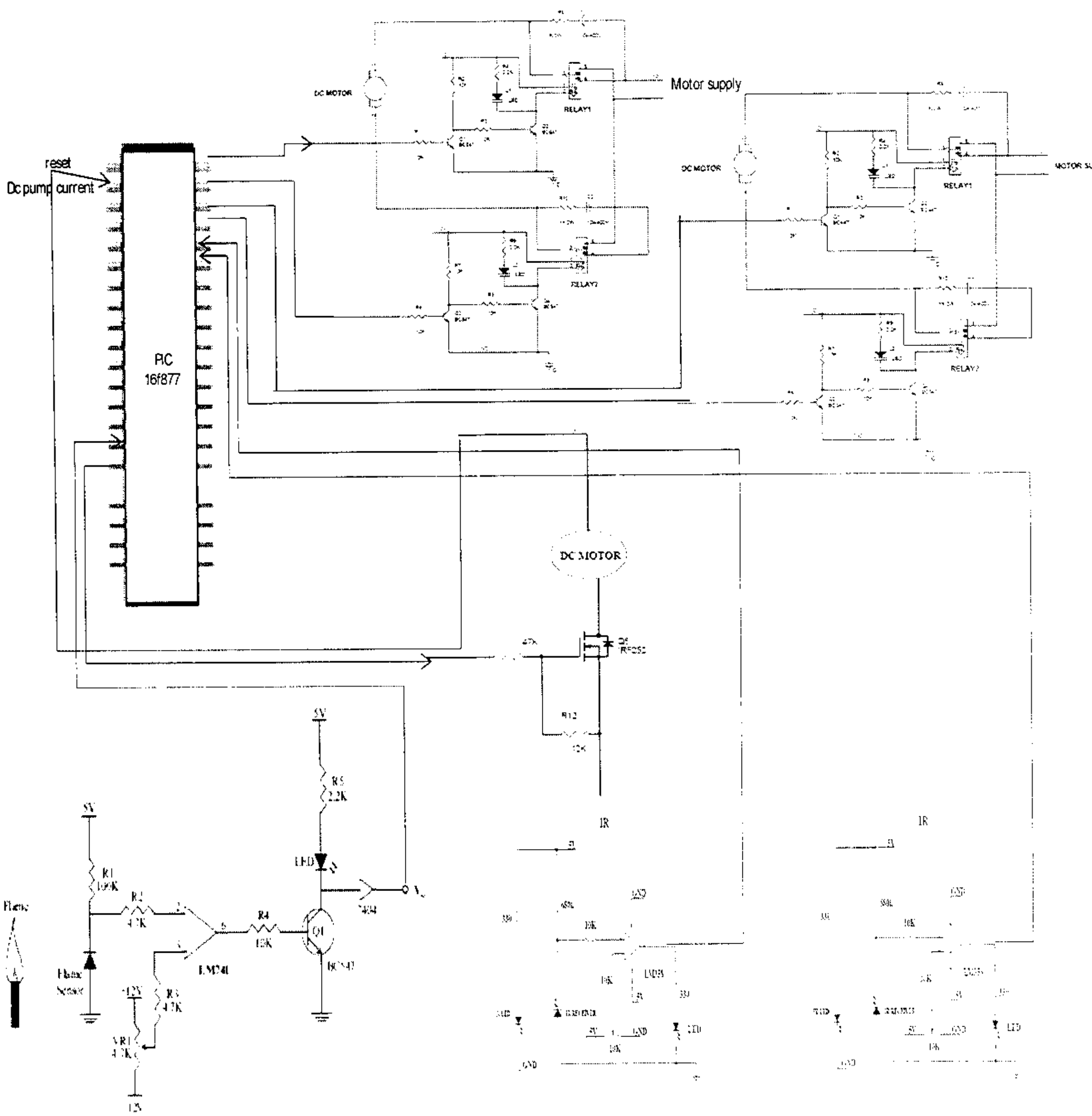
```
        Lcd8_Display(0xc0,"      RIGHT           ",16");
}

void left_turn()
{
        left1=1;left2=0;
        right1=1;right2=1;
        Lcd8_Display(0xc0,"      LEFT           ",16);
}

void stop()
{
        left1=left2=1;
        right1=right2=1;
        Lcd8_Display(0xc0,"        STOP          ",16);
}
```

```
void interrupt timer2(void)
{
	if(TMR2IF==1)
	{
		TMR2ON=0;
		TMR2IF=0;
		PR2=0xFA;
		CCPR2L=msb;
		CCP2CON=lsb;
		CCPR1L=msb;
		CCP1CON=lsb;
		T2CON=0x05;
	}
}
```

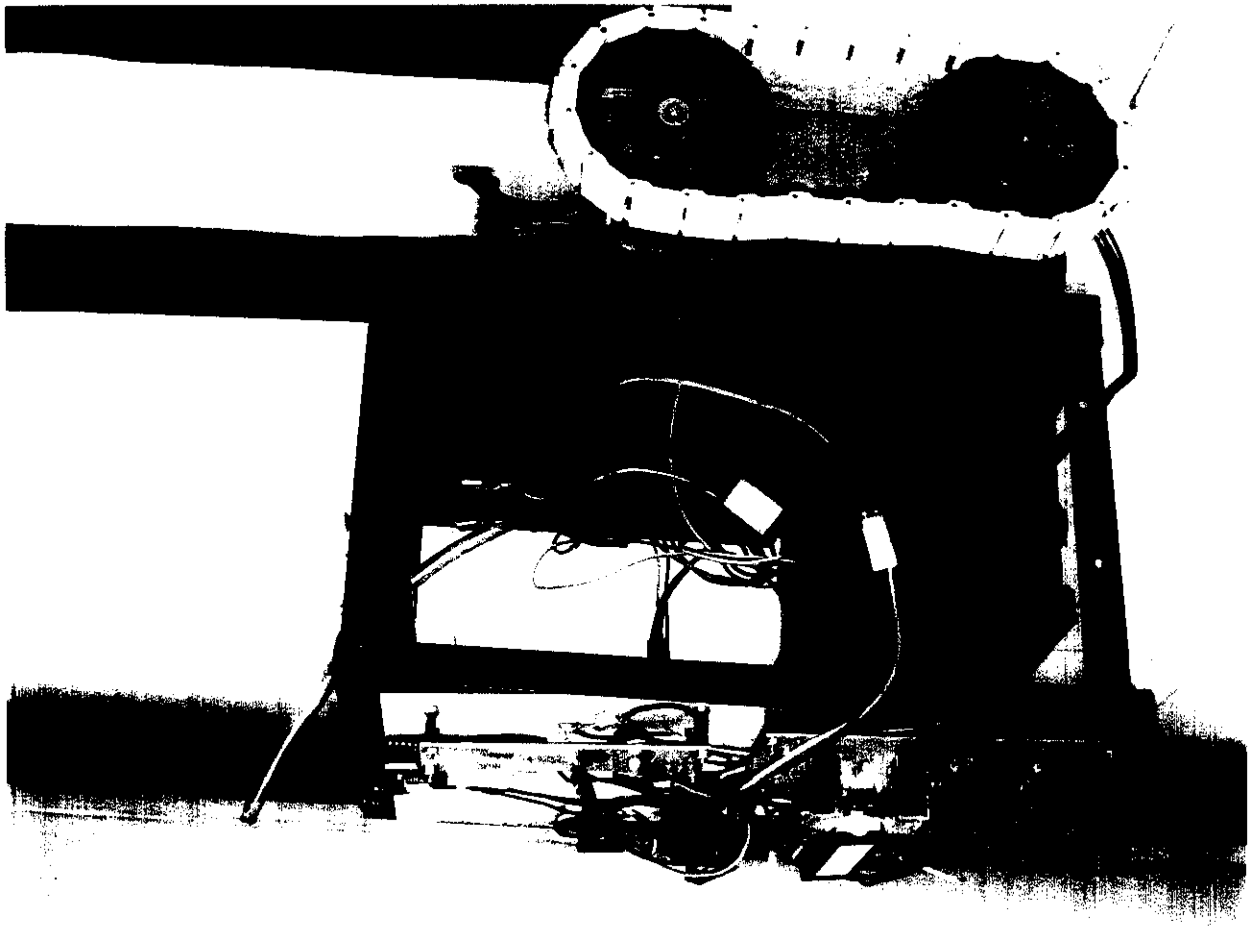
APPENDIX C

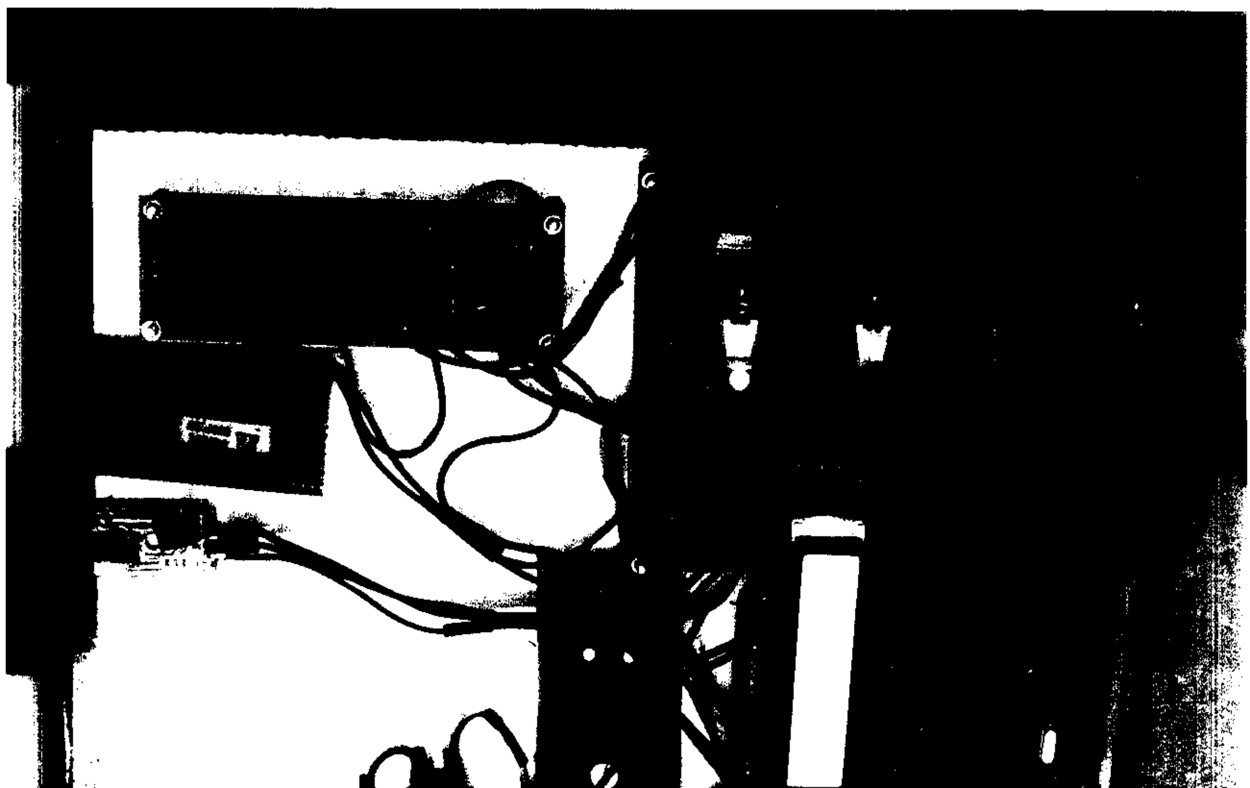
CIRCUIT DIAGRAM

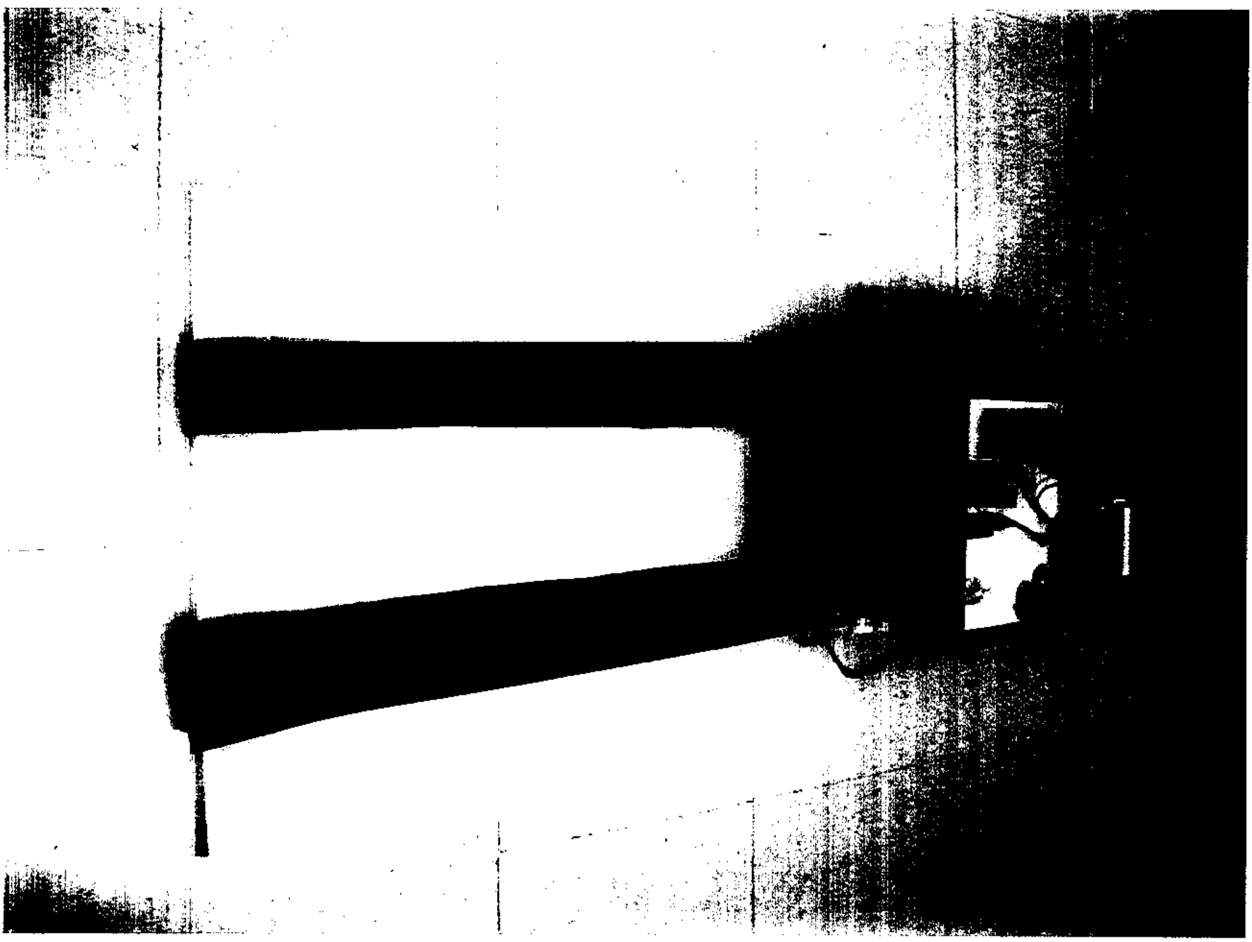
OVERALL CIRCUIT DIAGRAM



PHOTOGRAPHS







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