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Automatic Fire Fighting Robot

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Abstract-Researches and experiments in the field of robotics are progressing tremendously. Robotic technology has influenced most of the industrial and domestic areas and has given release to the humans doing heavy, risky, and tedious jobs.The aim of this paper is to build a working model of a fire sensitive robot which is simple as well as efficient. One of the biggest challenges in building your own robot is controlling its motors. You can find a new or surplus motors and gearboxes in many places, and low-cost microcontrollers and books on how to use them around. However microcontrollers cannot directly drive dc motors, leaving robotics beginners with the possibly overwhelming challenge of building their own motor controller. This task is even more complicated if the motors require bidirectional operation and speed control.
The robot is build with PIC16F73, L293D, LDR and thermistor. Two DC series motors are used to control the rear wheels and the single front wheel is free. The role of LDR is to sense the presents of light were as thermistor is to sense the presence of fire. The microcontroller controls the speed of the motors with the help of H-bridge driver L293D.

Keywords - Robotics, PIC16F73, sensors

I. INTRODUCTION

A robot is a virtual or mechanical artificial agent. In practice, it is usually an electro-mechanical machine which is guided by computer or electronic programming, and is thus able to do tasks on its own. Another common characteristic is that by its appearance or movements, a robot often conveys a sense that it has intent or agency of its own

Although the appearance and capabilities of robot vary vastly, all robot share the feature of a mechanical movable structure under some form of control. This control of robot involves three distinct phase- perception, processing and action. In common the preceptors are sensors mounted on the robot, processing is done by on-board microcontroller or processor and task (action) is performed using motor or with some other actuators.

Detecting fire has many uses in the world of robotics. We use fire detection to identify a burning fire that we can put out. In this project a thermistors is attached with the robotic system. The robot detects the presence of fire on its way and changes its direction according to that. When it reaches the fire it stops and switches ON the water pump relay. This is very much applicable in number of fields of both industries and military applications.

The movements of robot is controlled by the MCU through proper DC motor driving mechanisms which are used to control the rotation of the DC geared motors which are connected to the tires of the robot.

II. BLOCK DIAGRAM

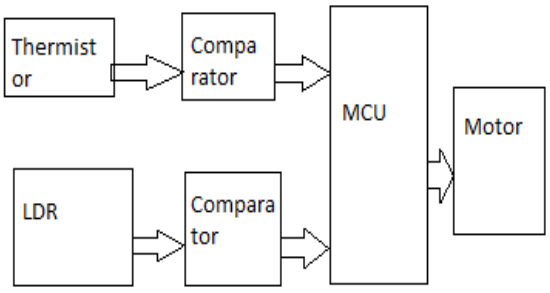

Fig.2.1 Block diagram

2.1 Fire Sensor

For detecting the fire, a fire sensor is attached with this system. Thermistors can be used for this purpose. The heat produced at the time of fire is detected and the output from fire sensor is fed to the Microcontroller unit.

2.2 Light Detectors

Light detectors are used to find the presence of light. A photo resistor or light dependent resistor or cadmium sulfide (CdS) cell is a Resistor whose resistance decreases with increasing incident light intensity. It can also be referred to as a photoconductor. A photo resistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

2.3 Voltage Comparator

A comparator is a device which compares two voltages or currents and switches its output to indicate which is larger.

An operational amplifier (op-amp) has a well balanced difference input and a very high gain. The parallel in the characteristics allows the op-amps to serve as comparators in some functions.

A standard op-amp operating in open loop configuration (without negative feedback) can be used as a comparator. When the non-inverting input (V+) is at a higher voltage than the inverting input (V-), the high gain of the op-amp causes it to output the most positive voltage it can. When the non-inverting input (V+) drops below the inverting input (V-), the op-amp outputs the most negative voltage it can. Since the output voltage is limited by the supply voltage, for an op-amp that uses a balanced, split supply, (powered by $\pm V_S$) this action can be written:

2.4 Interfacing Circuits

The output of the sensor is fed to the controlling system by using certain switching circuits. These are called as the interfacing ones. Normally transistor based switching circuits are used. Operational amplifiers based instrumentation techniques and circuits are used here.

2.5 MCU (Microcontroller Unit)

MCU is the microcontroller unit, which controls all the functions of other blocks explained here. MCU takes or read data from the light sensors and controls all the functions of the whole system by manipulating these data.

Microcontroller analysis signal from the sensors and determined the movement of the robot and the action of relay. MCU cannot drive a motor or a relay directly. So the respective relay interfacing circuits are used for that purpose.

2.6 Motor Driver

Motor driver circuit is required to provide an interface between the 5V logic signal from the microcontroller & the high current / high voltage power side to drive the motor, because motor is an electromechanical device, which convert electrical energy to rotation/ mechanical energy. For this energy conversion large current excitation is required. These much energy cannot be provided by the logical signal pins from the microcontroller. So a motor interface is used here. The motor drive section should have the capability for accepting the low level logical signal from the controller and to provide necessary voltage and current excitation to the motor. Usually high current transistor switches or relays or ICs with motor drive packages are used for this purpose. Here bidirectional motor drive is required so an H-bridge based circuitry is used.

2.7 DC Geared Motor

Motor is used to drive the light robot. The motor should have torque and rpm to meet the requirement like move the vehicle by carrying battery and circuit load. DC motors are the best choice for this purpose. But DC motors are always comes with high rpm 2000 to 3000, and with lesser torque. So usually geared DC motors are used. Geared DC motors are well suitable because which have lesser rpm like 30 or 45 and have sufficient torque to drive the all mechanical load. A 12V motor is preferable because which can be easily connected to 12V battery. Hence we use geared dc motor for drive the light robot.

2.8 Visual Indications

Different colored LEDs are used here as the visual indicators. RED and GREEN LEDs are used here. A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. Introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness.

2.9 Car Battery

An automotive battery is a type of rechargeable battery that supplies electric energy to an automobile. Usually this refers to an SLI battery (starting, lighting, and ignition) to power the starter motor, the lights, and the ignition system of a vehicle's engine. An automotive battery may also be a traction battery used for the main power source of an electric vehicle.

III. CIRCUIT DIAGRAM

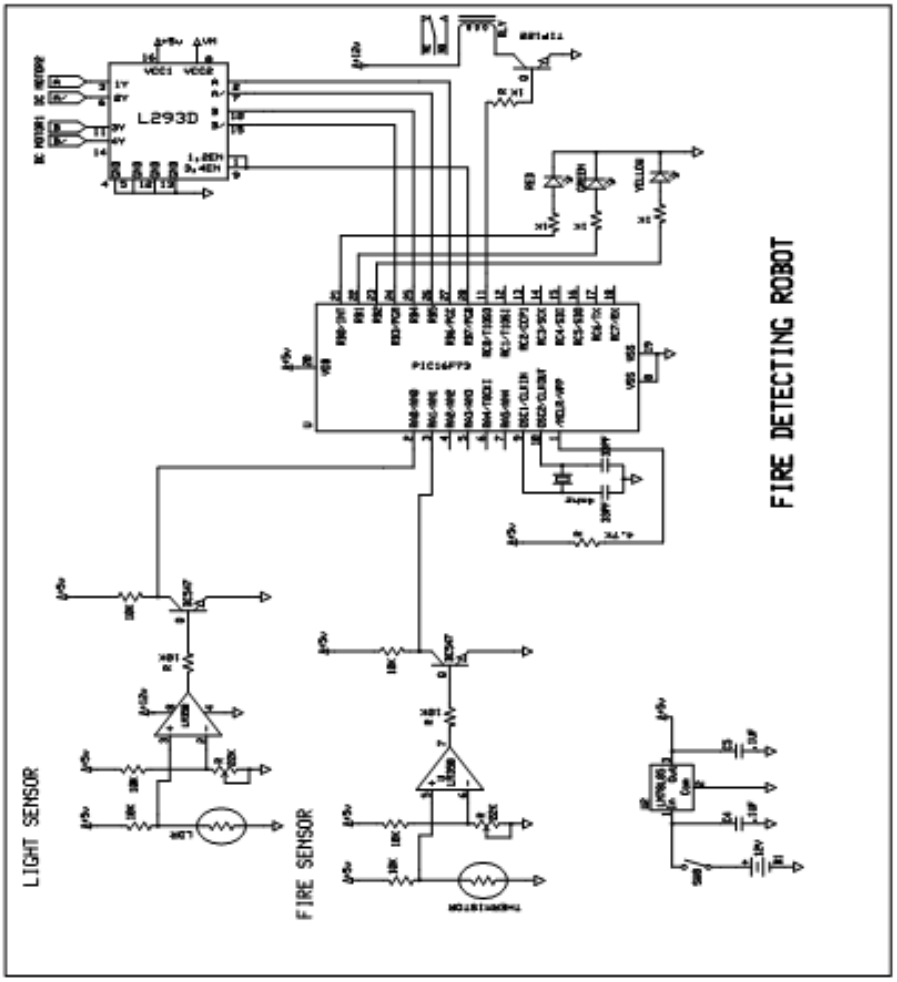

Fig 3.1 Circuit Diagram

The LDR and the 10K resistor are combined to form a voltage divider. The output of this volt divider is decreased when the light intensity increased.A positive volt comparator using opamp is used in this circuit. A 22 K variable is used to adjust the reference voltage. The output of LDR circuit is connected to the noninverting terminal of comparator. If the light intensity increases then the voltage at the non inverting terminal is decreased. And the output of the comparator becomes zero when the non inverting voltage less than reference volt.

The output of voltage comparator is connected to an NPN transistor switch and the output of NPN transistor is connected to RA0/AN0 of MCU. Logic high at the pin indicates the presents of light.LDRs or Light Dependent Resistors are very useful especially in light sensor circuits. Normally the resistance of an LDR is very high But when they are illuminated with light the resistance drops to a few ohms.

The LM158 series 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 voltages. 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 amplifiers, dc gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM158 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies. The LM358 and LM2904 are available in a chip sized package using National's micro SMD package technology.

3.1. BC 547

This NPN transistor is designed for use as general purpose amplifiers and switches requiring collector currents to 300 mA.

3.2 Fire Sensor

The thermistor and the 10K resistor are combined to form a voltage divider. The thermistor having negative temperature coefficient is used in this project. So the output of this volt divider is decreased when the temperature increased.

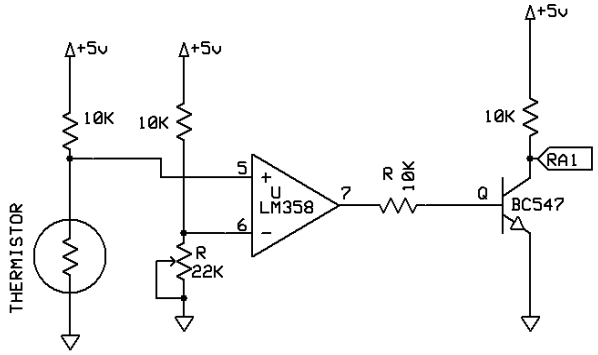

Fig 3.2: Fire sensor

A positive volt comparator using opamp is used in this circuit. A 22 K variable is used to adjust the reference voltage. The output of LDR circuit is connected to the non inverting terminal of comparator. If the light intensity increases then the voltage at the non inverting terminal is decreased. And the output of the comparator becomes zero when the non inverting voltage less than reference volt.

The output of voltage comparator is connected to an NPN transistor switch and the output of NPN transistor is connected to RA1/AN0 of MCU. Logic high at the pin indicates the presents of fire.

3.3 Thermistor

A Thermistor is a type of resistor whose resistance varies significantly with temperature. The word is a portmanteau of thermal and resistor. They are widely used as inrush current limiters, temperature sensors, self-resetting over current protectors, and self-regulating heating elements.

Thermistors can be classified into two. If the resistance of the thermistor increases with increasing temperature the device is called a positive temperature coefficient (PTC) Thermistor or posistor. If the resistance decreases with increasing temperature they are called as negative temperature coefficient (NTC) thermistors.

Thermistor differ from resistance temperature detectors (RTD) in that the material used in a thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges, while thermistors typically achieve a higher precision within a limited temperature range [usually −90 °C to 130 °C].

3.4 MCU

PIC 16F873 is the control unit of this project. If the light sensing circuit detects the presents of light MCU changes the direction of the robot towards it. This is made possible by controlling the DC motor through necessary interfacing circuits.

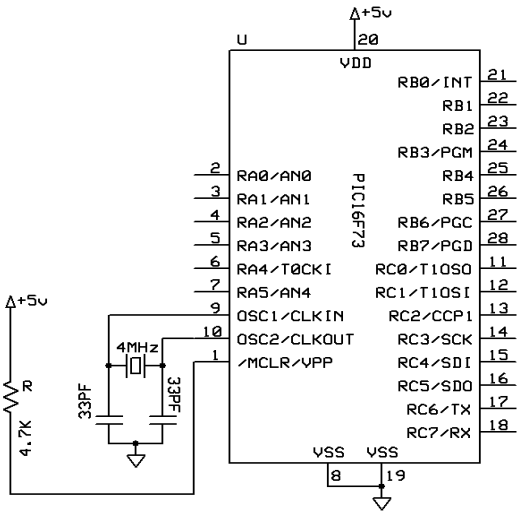

Fig 3.3: Microcontroller unit

Here the popular microcontroller PIC 16F73 from MICROCHIP Corporation is used as the CPU of the system. PIC microcontrollers are the most popular 8 bit microcontroller in the world. They are available in wide variety in pin outs, memory capacity and have lots of integrated peripherals like ADCs, SERIAL modules.

The PIC 16F73 is available in 28 pin DIP package and have program memory capacity of 4Kb and ram of 368 bytes. They are working in clock speed range of 0 Hz to 20 MHz and the operation is fully static also. They have 3 I/O ports named as PORTA, PORTB and PORTC. Among these PORT A is 6 bit wide and all other ports are 8 bit wide. Most of the peripheral I/O functions are multiplexed with PORTC pins. The ADC inputs are available in PORT A.

The PIC controllers have 14 bit wide program memory space by which an instruction occupies only one memory space. This allows more program density. These are addressed with a 13 bit wide program counter during execution .The program memory is addressed from 0000h to 1fffh and the reset vector is at 0000h and interrupt vector is at 0004h. The program counter points the address of the memory location to be executed next and increments in every machine cycles. One machine cycle consists of 4 clock cycles.

Generally they are low power devices and works in voltage range of 2v to 5.5v. They have 13 interrupt sources like external pulse interrupt and serial receive interrupt etc. These chips are supplied with in circuit serial programming facility and are flash technology also. The flash memory can be re written 1000 times.

Speed of operation of MCU depends on the clock provided. In this project 4MHz clock is used with two 33 pF capacitors. 1st pin (master clear) of the IC is connected to +5V through 4.7K resistor.

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

3.5 Motor Control Circuit

Two DC motor are used in this system. But MCU cannot control the DC motor directly. So it controls them through interfacing IC L293D.The connections of the IC are made as per the circuit diagram. 1,2 EN and 3,4 EN pins are shorted and connected to RB7 of the MCU. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2 EN and drivers 3 and 4 enabled by 3,4 EN. When an enable input is high, the associated drivers are enabled. So their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications. In this system RB3, RB4, RB5 and RB6 are the motor control pins of the MCU which are connected as per the circuit diagram.

3.6 Motor Driver (L293d)

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo- Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input become high, the associated drivers will get enabled, and their outputs will become active. These outputs are in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

3.7 H-BRIDGE

The H-bridge (or "full bridge") is so named because it has four switching elements at the "corners" of the H and the motor forms the cross bar. The basic bridge is shown in the figure to the right.The key fact to note is that there are, in theory, four switching elements within the bridge. These four elements are often called, high side left, high side right, low side right, and low side left (when traversing in clockwise order).

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

To power the motor, you turn on two switches that are diagonally opposed. In the picture to the right, imagine that the high side left and low side right switches are turned on. The current flow is shown in green.The current flows and the motor begins to turn in a "positive" direction. If the polarity changed current flows the other direction through the motor and the motor turns in the opposite direction.

3.8DC Motor

An Electric motor is a machine, which converts electric energy into mechanical energy. Its action is based on the principle that when a current carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's Left Hand rule.

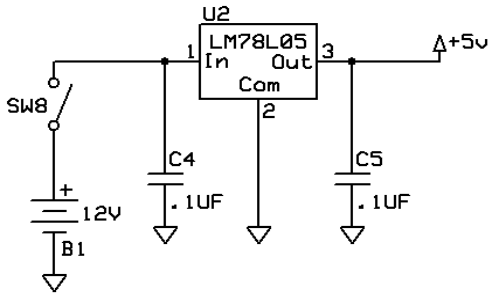

Fig 3.4: power supply

The above circuit is the power supply unit of this section. It consists of a 12 V battery, voltage regulator IC 7805 and capacitors as filters. This circuit can provide fixed +5V.

3.9 IC Voltage Regulators

The power supply is the most indispensible part of any project. IC regulators are versatile and relatively inexpensive. The regulated circuit is used to maintain constant output level. The integrated circuit regulator, some time called the three terminal regulators contains the circuitry of reference source error amplitude control device and overloaded protection all in a single IC chip. They are connected between output of the filter and input of the load.

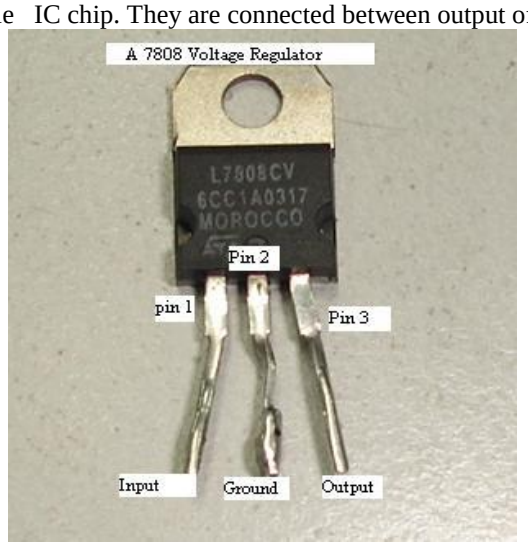

Fig 3.5: IC regulator

The 78xx series consist of three terminal +ve voltage regulators. With adequate heat sinking they can deliver output current in excess of 1A. For proper operation, there should be a common ground between the input and output voltages.

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, V_O, from a second terminal, with the third terminal connected to ground. The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5

IV. WORKING

A robot is a mechanical intelligent agent which can perform tasks on its own, or with guidance. In practice a robot is usually an electro-mechanical machine which is guided by computer and electronic programming. The fire detecting robot moves towards the path of fire, it consists of an LDR, thermistor, voltage comparator, digital interface, an MCU, motor interface, DC geared motor, relay interface and relay.

Thermistor is used as fire sensor and LDR as the light detector. The sensors are mounted on the robot. The thermistor used here has a negative temperature coefficient. So the resistance of the thermistor decreases with increase in the temperature. This fire sensor is connected as a part of a voltage divider and is connected to an opamp based comparator. The reference voltage of the comparator can be adjusted using the resistor network. This sensor will give an analog voltage that is proportional to the intensity of light. The output of the comparator is interfaced with the MCU through a digital interface.

The light sensor enables a robot to detect light. They vary their resistance based on how much light they are exposed to, i.e. its resistance decreases with increasing incident light intensity. The LDR is connected as a part of a voltage divider circuit and connected to an op amp based voltage comparator. The resistance of LDR is very much less at the presence of light and very much high in absence. The reference voltage is adjusted by the resistor network. This sensor will give an analog voltage that is proportional to the intensity of light. The output of the comparator is interfaced with the MCU through a digital interface.

Proper programs are done inside the MCU to perform as per the corresponding output from the sensors. The robot will rotate in a direction to search for the light due to fire. If the light is sensed the MCU will allow the robot to follow the light due to fire. It switches ON the water pump relay whenever it sense fire.

The movements of robot is controlled by the MCU through proper DC motor driving mechanisms which are used to control the rotation of the DC geared motors which are connected to the tires of the robot. Motor driver circuit is required to provide an interface between the 5V logic signal from the microcontroller & the high current and high voltage power side to drive the motor, because motor is an electromechanical device, which converts electrical energy to rotation/ mechanical energy. For this energy conversion large current excitation is required. These much energy cannot be provided by the logical signal pins from the microcontroller. So a motor interface is used here.

Red, yellow, and green visual indications are also attached here, RED LED becomes turned ON when the robot stop its movement. GREEN LED indicates the free movement. Yellow LED indicates the presents of fire. The power supply required for the working of the robotic system is obtained from the 12V car battery.

V. CONCLUSION

This paper deals with a robot which can fight against fire.The PIC controller is mainly used to control the robot.

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