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Microcontroller-Based Automatic Power Off and Bill Metering System

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ABSTRACT

In this paper, we implemented a system by which we can measure the consumption of electricity and also the system can OFF the device, when it's not working for longer time. This implemented model is based on embedded system. An embedded system is anything that runs software, which is not a computer. It is a special purpose computer to perform one or few dedicate function. In this system, two operations are performed simultaneously. If any device connected to the circuit, the circuit automatically offs the device, when it is not in used and shows the bill of the power consumed by the device in the rupees. When the device is in working condition, the supply of power goes on, when it is not in used the power cut off, at the same time it shows how much power is consumed in that working period. The devices is connected to the circuit via relay and placed in the vicinity of the sensor. When the temperature of the device is increased beyond the certain limit, the sensor gives output to the comparator IC. The comparator compares output to the predefined value and produce output to the microcontroller. Then the microcontroller gives signal to the relay and the relay cut off the device from the mains. At the same time, bill is generated. If the relay disconnect the device from the mains, at the same time the microcontroller gives signal to the stepper motor to stop and the bill is displayed on the LCD screen.

Keywords: auto-power off, bill metering system, embedded system, microcontroller

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INTRODUCTION

We use a lot of electronic devices in our day today life. Now-a-days these devices are being a part of our life. Nobody is intact of these devices. Of course these devices are useful, but sometimes it gives reverse effect on our economic condition, if it is used unnecessary.

There are so many devices are in the market which control the power supply and save the power, but at the same time they cannot show how much power is to be used for particular purpose. In day today life we use electric fan, iron, microwave oven, electric heater etc. sometime people forget to switch off these devices, resulting unnecessary power consumption. Here we introduce a circuit, which not only control the unnecessary use of power but also shows how much power is to be used.

Our circuit " Auto power off & Bill metering system", which means it cut the power when the power is not required and also shows how much power is used when it is in working condition. Our circuit is based on Embedded System. An embedded system is anything that runs software, which is not a computer. It is a special purpose computer to perform one or few dedicate function. It is usually embedded as part of a complete device including hardware and mechanical parts. On the other hand, a general-purpose computer, such as a personal computer, can do much variety of tasks depending on programming. Embedded systems control many of the common devices in use today [1].

Since the embedded system is dedicated to specific tasks, design engineers can modify it, reducing the size and cost of the product, or increasing the reliability and performance [2]. Some embedded systems are mass-produced, benefiting from economies of scale.

In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability [3]. For example, Handheld computers share some elements with embedded systems — such as the operating systems and microprocessors which power them — but are not truly embedded systems [4], because they allow different applications to be loaded and peripherals to be connected. To test the implemented system here we use a soldering rod as a device. When it is in working condition the supply of power goes on, when it is not in used the power cut off, at the same time it shows how much power is consumed in that working period.

BLOCK DIAGRAM DESCRIPTION

Figure 1 shows the block diagram of implemented system. First we enter the load into the microcontroller according to the rating of our appliance used. The appliance is directly connected with the main supply 230v. The appliance is placed in the vicinity of the temperature sensor.

The sensor senses the temperature of the device (soldering rod) and produces the proportional voltage and it is given to the input of comparator. The comparator compares this voltage with the reference value which is already set in the comparator. If the input value is less than the set point value, comparator produces zero output and gives it to the microcontroller. In that case the microcontroller will not give any signal to the relay and the appliance is remaining ON. If the input value is more than that of set point value, comparator compares and produces logic 1 output, then the comparator output gives signal to the relay and it turns off the appliance.

Now for the bill metering system we use a stepper motor. The stepper motor depends upon the appliance. When the appliance is ON the stepper motor starts to rotate. The obstacle is mounted on the stepper motor. When the obstacle is fall between the IR transmitter and IR receiver, it breaks the light continuity between them and calculates it as one count.

The receiver gives the signal to the microcontroller. For one count, microcontroller produces 0.01 units (which are already preset) with amount which we get on the LCD display.

HARDWARE DESCRIPTION

Microcontroller

The microcontroller is a 40 pin IC, but in our circuit few pins are used to perform specific functions. The microcontroller used in this project is P89V51RD2. A microcontroller is a small computer on a single integrated circuit consisting of a simple CPU combined with support functions such as a crystal oscillator, timers, watchdog, serial and analog I/O etc. [5]

Program memory is in the form of NOR flash or OTP ROM is also included on chip, as well as a, typically small, read/write memory [6]. All the other components are used in our circuit are connected to the microcontroller. The components are LCD, ULN2803 driver IC LM324 comparator IC.

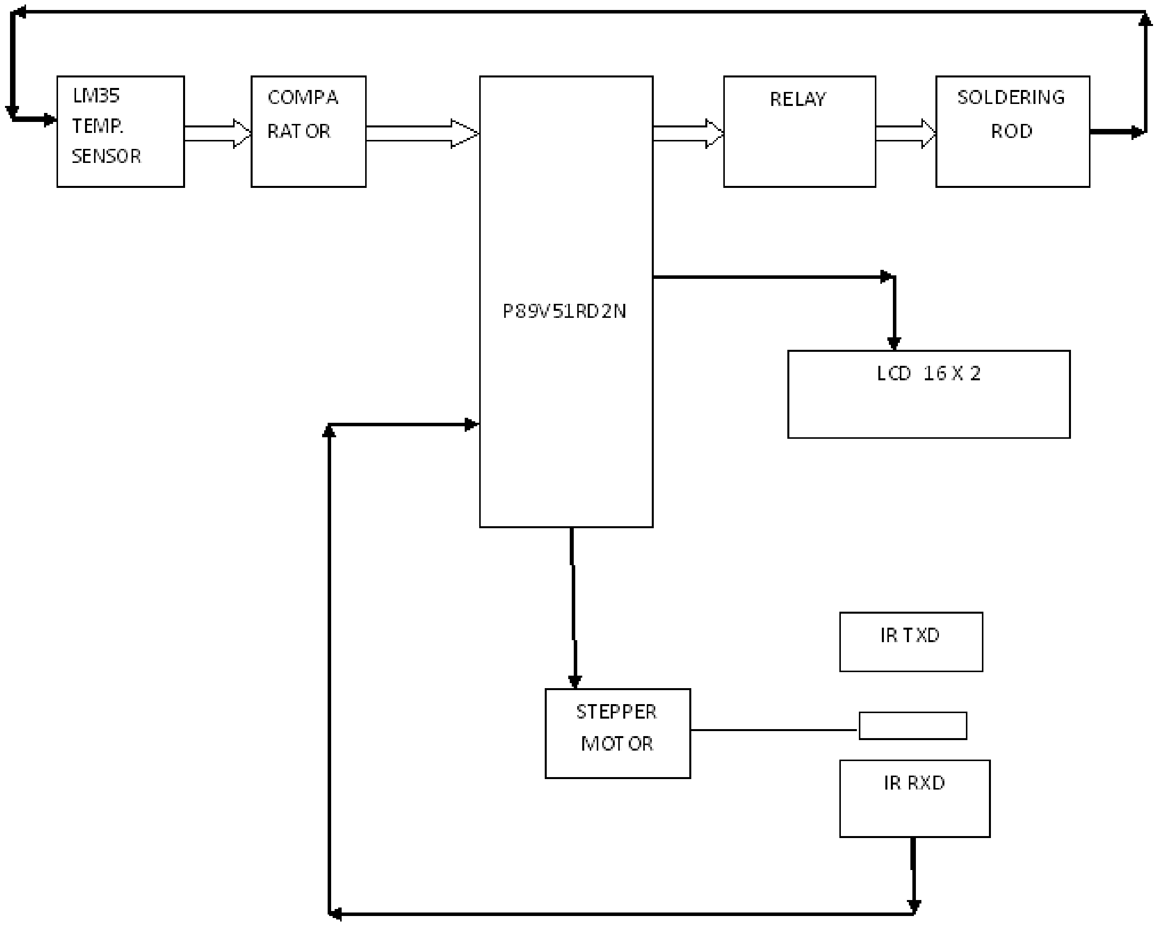

Fig. 1. *Block diagram of automatic power off and bill metering system.*

LM324 Comparator IC

These devices consist of four separate high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages [7]. Operation from split supplies also possible, if the difference between the two supplies is 3 V to 32 V (3 V to 26 V for the LM2902), and VCC is at least 1.5 V more positive than the input common-mode voltage [8]. The low supply-current drain is independent of the magnitude of the supply voltage [9].

ULN2803 Driver IC

The ULN2803A is a very high-voltage, high-current Darlington pairs transistor array. The device consists of 8 NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of each and every Darlington pair is 500 mA. The Darlington pairs can also be connected in parallel for higher current capability. The applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. The ULN2803A has a 2.7-kΩ series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices.

Stepper Motor

A stepper motor is a brushless, synchronous electric motor that can divide a full rotation into a large number of steps [10]. The motor's position can be controlled accurately, without any feedback mechanism (see Open-loop controller). Stepper motors are similar to switched reluctance motors (which are very large stepping motors with a reduced pole count, and generally are closed-loop commutated.) [11]

LCD (Liquid Crystal Display)

Liquid crystal display is important device in embedded system. It offers higher flexibility to user as it can display the required data on it. A liquid crystal display (LCD) is a thin, flat panel used for electronically displaying information or message such as text, images, and moving pictures. It is used as monitors for computers, televisions, instrument panels, and other devices ranging from aircraft cockpit displays, to every-day consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones.

LM35 Temperature Sensor

The LM35 series are accurate integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 has an advantage over linear temperature sensors. The LM35 does not require any external calibration to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full -55 to +150°C temperature range. Low price is assured by trimming and calibration at the wafer level.

Relay

A relay is electrically worked as switches. The current flowing through the loop of the hand-off makes a magnetic field which draws in a lever and changes the switch contacts. The loop current can be on or off so relay have two switch positions and they are double throw (changeover) switches. Relays permit one circuit to switch a moment circuit which can be totally separate from the first. For instance a low voltage battery circuit can utilize a transfer to switch a 230V AC mains circuit. There is no electrical association inside the hand-off between the two circuits; the connection is magnetic and mechanical.

IC7805 Regulator IC

This circuit is a little +5V control supply, which is valuable when exploring different avenues regarding computerized gadgets. Little cheap divider transformers with variable yield voltage are accessible from any hardware shop and store. Those transformers are effortlessly accessible, yet as a rule their voltage direction is extremely poor, which makes then not exceptionally usable for computerized circuit experimenter unless a superior control can be accomplished somehow. The accompanying circuit is the response to the issue. This circuit can give +5V yield at around 150 mA current, however it can be expanded to 1 A when decent cooling is added to 7805 controller chip. The circuit has over-burden and terminal security.

IR Transmitter and IR Receiver

The infrared phototransistor goes about as a transistor with the base voltage dictated by the measure of light hitting the transistor. Subsequently it goes about as a variable current source. More prominent measure of IR light cause more noteworthy streams to move through the authority emitter leads. The phototransistor is wired in a comparable setup to the voltage divider. The variable current going through the resistor causes a voltage drop in the draw up resistor. This voltage is measured as the yield of the device.

IR reflectance sensors contain a coordinated infrared transmitter and infrared recipient combine. This device worked by measuring the measure of light that is reflected into the collector. Since the collector likewise reacts to encompassing light, the gadget works best when all around protected from surrounding light, and when the separation between the sensor and the intelligent surface is small(less than 5mm). IR reflectance sensors are regularly used to distinguish white and dark surfaces. White surfaces by and large reflect well, while dark surfaces reflect inadequately. One of such applications is the line devotee of a robot.

Circuit Description

The Figure 2 shows the whole implemented circuit diagram. The whole implemented circuit is divides into 4 separate circuit connections.

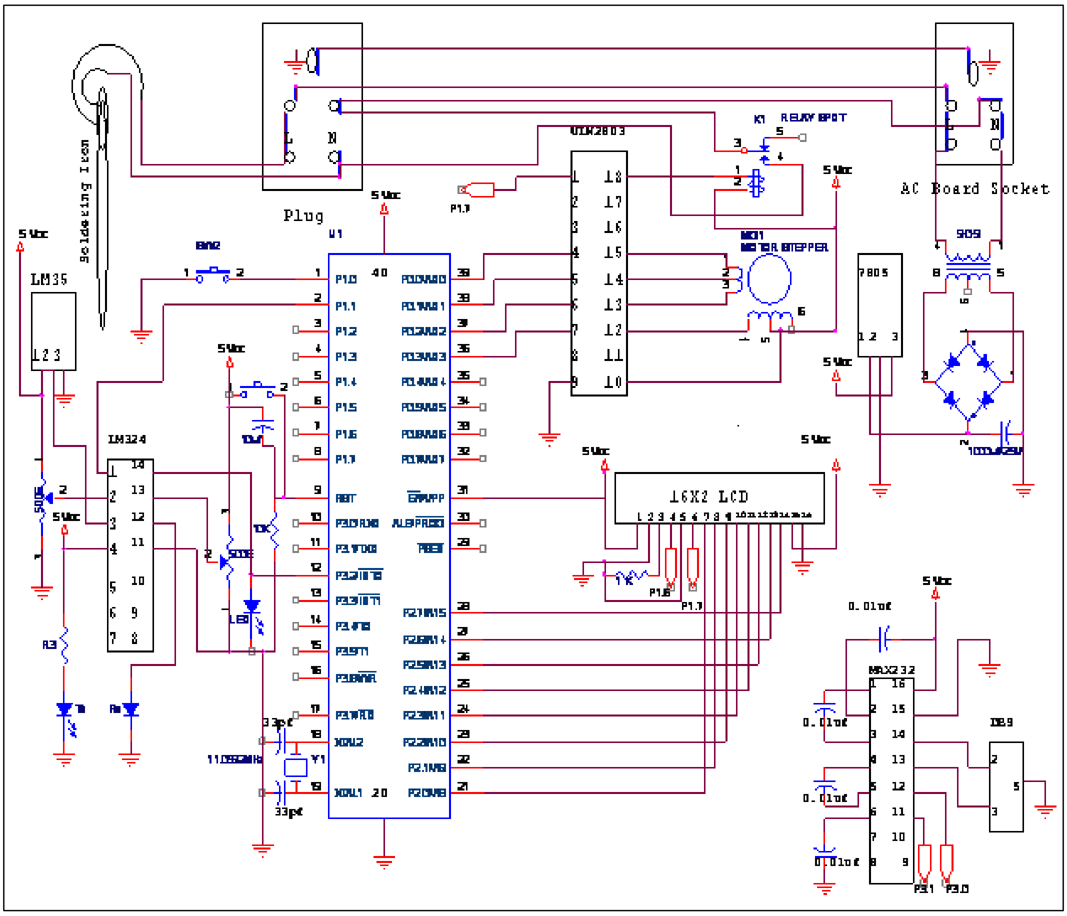

Fig. 2. *Circuit diagram of automatic power off and bill metering system.*

Power Supply

Our project circuit requires +5volts power supply. For this we make separate power supply section with the help of Transformer(R-CORE) and Rectifier. The regulator IC7805, capacitor, resistor makes separate power supply section. More importantly for our purposes, the +5 volt supply will be used as the primary reference for regulating all of the other power supplies that we build.

We can do this very easily if we use operational amplifiers as the controlling elements in the power supply circuits. The +5 volt power supply is based on the commercial 7805 voltage regulator IC. This IC contains all circuitry needed to accept any input voltage from 8 to 18 volts and produces a steady +5 volt output, accurate to within 5% (0.25 volt).

It contains current-limiting circuitry and thermal overload protection, so that the IC won't be damaged in case of excessive load current; it will reduce its output voltage instead. Figure 3 shows the power supply of whole circuit.

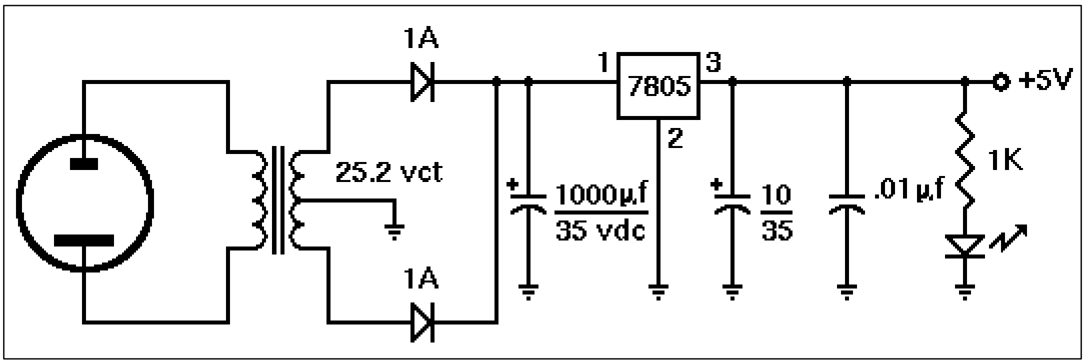

Fig. 3. *Power supply.*

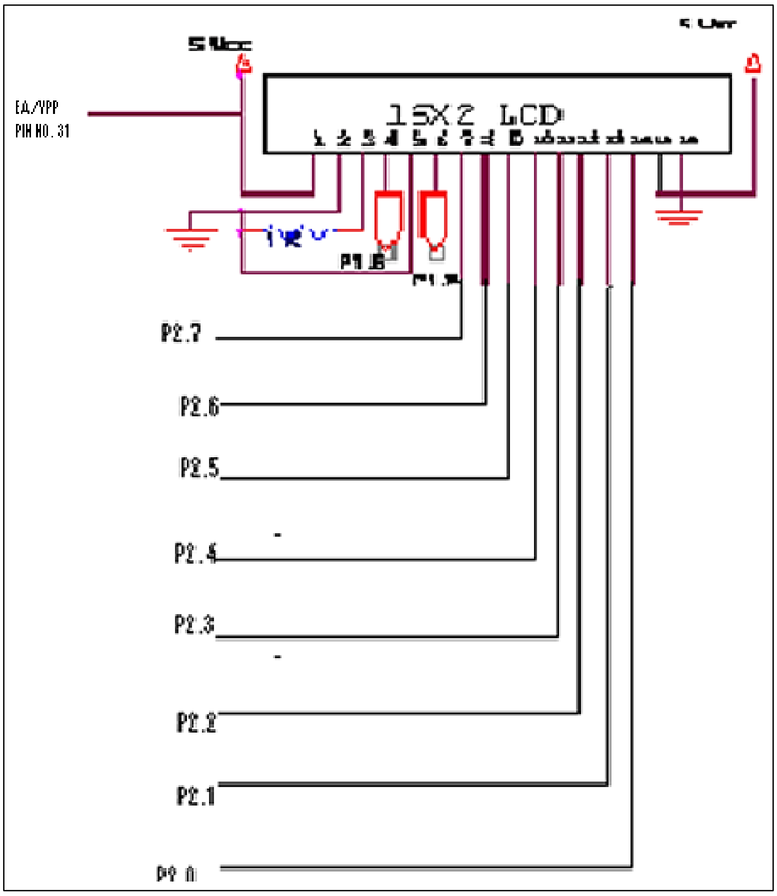

Fig. 4. ***C****onnection of LCD with microcontroller.*

Connection of LCD with Microcontroller

The LCD used here is 16x2 characters LCD. This LCD has 16 pins. Pin No. 2, 5 & 16 are ground. Pin no. 1 and 15 are connected to the +5V supply. Pin no.1 is connected to the pin no. 31 of microcontroller which is EA/VPP. Pin no. 3 is connected to the 1 K resistor. The pin no. 4 and 6 which are RS and EA are connected to the port pin no. P1.6 and P1.5 of microcontroller respectively. From pin no. 7 to 14 (data lines) of LCD are connected to the port pins of microcontroller i.e. P2.0,P2.1,P2.2,P2.3,P2.4,P2.5,P2.6, P2.7. Figure 4 shows the connection of LCD with microcontroller.

Connection of LM324 Comparator IC to Microcontroller

The LM324 comparator IC is 14 pin IC. It has 4 comparator, but here we are using only two comparators that is of pin nos.

1,2,3 and pin nos. 12,13,14. Lm35 & IR Receiver is connected to the comparator 1, 2,3 and comparator 12, 13, 14 resp. LM35 is used as a temperature sensor. It has three pins: - 1. VCC, 2. Output, 3. GROUND. Pin no.1 is connected to the +5 V supply, pin no. 2 is connected to the LM324 IC & pin no.3 is ground. Pin no. 1 of comparator is output pin connected to port pin P1.1 of microcontroller. Pin no. 3 of comparator is connected to pin no. 2 of LM35. Pin no.2 of comparator is connected to the POT 1. Pin no. 14 of comparator is output pin connected to the port pin P3.2 (INT0) of microcontroller. Pin no.12 is connected to the IR receiver. Pin no. 13 is connected to the POT 2. Figure 5 shows the connection of LM324 comparator IC to microcontroller.

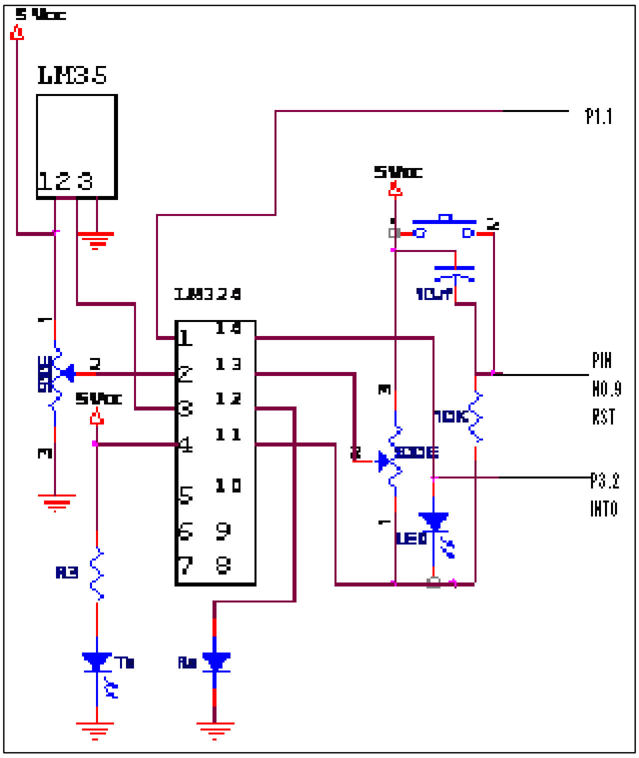

Fig. 5. *Connection of LM324 comparator IC to microcontroller.*

Connection of ULN2803 IC with the Microcontroller

The ULN2803 driver IC is used to drive stepper motor & relay because the current required for this two components is more than microcontroller, so we can use this driver IC. It is an 18 pin IC. Pin no. 1 of ULN2803 is connected to the port pin P1.7 of microcontroller. The pin no.18 of IC gives an output signal to the relay. The pin no, 4, 5, 6, 7 takes input from the microcontroller through port pins P0.0, P0.1, P0.2. P0.3 and gives output through the pin no.10, 12, 13, 15 which are then connected to the 4 windings A,B,C,D of the stepper motor. The stepper motor rotate with certain delay.

- To produce delay:

1 revolution = 48 steps
1 revolution requires 1 minute
Therefore,
48 steps =60 seconds
1 step = 60/48
Delay =1.25 seconds

- The step angle for stepper motor is =360/48 (Step angle = 7.5 degree)

Figure 6 shows the connection of ULN2803 IC with the microcontroller.

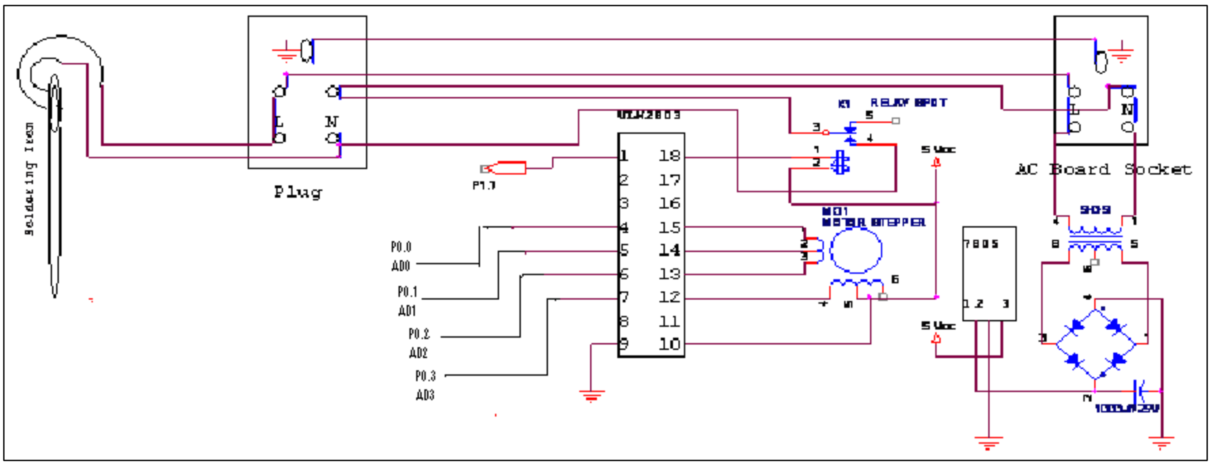

Fig. 6. *Connection of ULN2803 IC with the microcontroller.*

WORKING OF IMPLEMENTED CIRCUIT

First the implemented circuit is connected with the power supply. The transformer used here is a center tap transformer, it gives +5 V supply to the circuit. The working of whole circuitry is dividing into two parts: Automatic power off and bill metering system Both occur simultaneously. The device used is soldering rod whose power consumption is measured and displayed on LCD screen. This soldering rod is connected to the circuit via relay. Now the soldering rod is placed in the vicinity of LM35 (temperature sensor), which has three pins: Vcc, Output & Ground. As if the soldering rod (device) is not picked up from the vicinity of LM 35 for a long time the temperature rises continuously, therefore the output pin no.2 gives voltage to the pin no.3 of LM 324 comparator IC. The LM 324 IC has four comparators. It is a 14 pin IC. We use only two comparators. First comparator has pin 1,2,3,4 which is used for LM35. And second comparator has pin 12,13,14,15 which is used for IR receiver. Now in first comparator pin no.1 is for output. The output from LM 35 goes to the pin no.3 of LM324. On pin no.2 we take a reference voltage with the help of pot. The LM 324 compares this both voltages and produces an output to the microcontroller.

Since LM35 produce a voltage of 1mvv for 1 degree c temperature. The reference voltage is set as 0.44volt. If the voltage produce by LM35 is exceeds from 0.44 volts then Lm324 produces an output to the microcontroller pin p1.1. Now the microcontroller gives the signal to relay. The relay is not directly connected to the microcontroller. To drive the relay we use ULN2803 driver IC. The pin p1.7 of the microcontroller gives input to the pin no.1 of ULN2803. The relay is connected to the pin no.18 of ULN2803. The microcontroller gives high signal to relay. Then relay disconnects the device from mains. Now in second section which calculate bill which contains stepper motor, it rotates till the appliance is ON.

Stepper motor can't be connecting directly to the microcontroller because stepper motor requires more current, so we require driver IC. Stepper motor is rotate by step angle of 1.7 degree. On the shaft of the motor a fan is mounted and on the upper and lower side of the fan, IR transmitter and receiver are placed. The port pins P0.0, P0.1, P0.2, P0.3 of microcontroller is connected to the four pins of motor by means of driver IC. When the signal from port 0 goes to the driver IC 4 inputs 4,5,6,7 then the corresponding 4 output 12,13,14,15 pins of driver IC gives signal to the stepper motor. At the same time the IR transmitter transmit pulse to the IR receiver. When the fan, which is mounted on the stepper motor, cuts the light continuity between IR TXD & IR RXD, the IR RXD gives signal to the pin no.12 of LM324. LM324 takes input from the IR RXD & POT and produce output to the microcontroller through pin no.14 of LM324. The microcontroller port pin P3.2 which is INT0, receives signal and LED glow, which shows the one interrupt.

CALCULATION

For finding the amount of bill consumed by the device i.e. soldering rod, the following calculation is to be done.

1. Units

Units = Load(in watts)*Time(min)/1000*60

If, Load = 25 W, Time =1 min, then

Units = 1/2400 of a unit in 1 revolution.

1 revolution complete in 1 min

2. Bills: Number of units in 1 min=1/2400

Bill for 1 unit = 5 Rs

Total bill = units *5 Rs

FUTURE ENHANCEMENT

The implemented system plays an important role in consuming power. It can also shows, how much amount of power is consumed by an electronic device. In future by using different technologies we can enhance the circuit so it can perform so many task in the future. These are as follows.

- In future, the bill which is displayed on the LCD screen can also be obtained in a printed form.
- In future, this circuit can also be advanced by adding a feature of touch-screen.
- By enhancing the circuit, it can also be used in the areas where the stealing of electricity usually happens.
- By doing modification in the circuit we can use in the car engine.
- In place of soldering rod, we can also use other devices by using different sensors.

CONCLUSION

In this paper, we have implemented a circuit which can be used to save power consumption. At the same time we can find the consumption of powers on the LCD screens which we have used in the circuit. By this circuit, we can stop unnecessary use of power. So many devices are available to control the consumption of power, but the same time they cannot show how much power is used. Here this circuit will show the consumption of power in rupees, so we can save the money by saving the consumption of power. Our project is mainly based on an embedded system. This project performs both the function, cutoff the power, and show the bill in rupees at the same time. But using different types of sensors we can consume the power of other devices.

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