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Model Design for an Efficient Multi Functional Power Saver

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Abstract: We have designed a system which acts as power saver cum temperature display. It provides power to the fan and works only when somebody is in the room. In the absence of persons in the room, power is turned off and fan stops rotating. In addition, when somebody is in the room it will display the temperature and set the fan speed based on the temperature. The higher the temperature the higher the speed of the fan. The study details the design procedure along with construction and test information. A block of the entire power saver has been done. The block shows connections of the different modules. PCB design and testing of the entire system is analyzed.

Keywords: Power Saver, Fan, Printed Circuit Board, Modules

1. Introduction

The electricity that we use comes from nuclear power plants, coal or oil, HEP and geothermal. Some of these energy resources are non renewable and hence get depleted over time with continued use. It is on these grounds that energy needs to be conserved and proper management techniques need to be employed.

We are consuming disproportionate amount of energy and this day is not far when our non renewable resources will expire. Governments are overburdened for importing coil and oil. International Energy Agency (2011) projected that global energy demand will rise from 12,300 million tons in 2008 to 16,800 million tons of oil by the year 2035. This accounts for 35% increase. This means each year energy demand rises by1.5 % for the period 2008-2020. More than half of the increase is attributed to fossil fuel (oil, coal and natural gas) and they continue to remain dominant.

Burning of fossil fuel creates pollution and this in turn has growing and adverse effects on complex control mechanisms which regulates earth's climate, [1]. According to world energy outlook (2013) global energy-related CO_2 emissions increased by 1.4% to reach 31.6 Giga tones (Gt) in 2012, a historic high [3]. Non-OECD Countries now account for 60% of global emissions, up from 45% in 2000. In 2012, China made the largest contribution to the increase in global CO_2. Consuming less energy by being more efficient in the way you run your home will naturally save money at the same time you will be helping protect the environment and safeguarding the future [6]. In addition it mitigates social impacts associated with energy production like ozone layer depletion; acid rains, global warming, oil spills, water pollution etc. [7]

Energy conservation extends lifetime of equipment and reduces maintenance cost by operating less hours and at less than maximum capacity [9].

1.1. Objectives

The study was aimed at

- Saving energy by switching on the fan only when the room is occupied by people and going off when people leave the room.
- Increasing or decreasing the rotations of fan according to the ambient temperature. If the temperature goes lower than 25°C, The fan goes off irrespective of whether the room is occupied or not.
- Giving a digital display on a LCD of the room temperature

1.2. Rationale

Over time man has been faced with challenge of power management owing to its diminishing supplies. The mains electricity is the source of power at home and its efficient utilization brings more benefits like reducing electricity bills which leads to saving of money [10].

One way employed is by switching off units when not in use [4]. This leads to a low power dissipation inform of heat and in turn increases life time of electrical equipment. Many electronic gadgets nowadays are modeled with inbuilt power management schemes. ICS for instance have power saving modes like sleep mode, idle and standby mode. These modes increase efficiency in energy consumption [11].

For mechanical devices, it is however difficult to have such power saving schemes, and hence the need to come up with hybrid devices which operate upon instructions executed by controlling equipment. In other words controlling devices are used to run the mechanical ones in accordance to certain programmes.

Microcontroller based designs form the basic building blocks of a control system [15]. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems [10]. Microcontrollers usually contain from several to dozens of general purpose input/output pins (GPIO). GPIO pins are software configurable to either an input or an output state. When GPIO pins are configured to an input state, they are often used to read sensors or external signals. Configured to the output state, GPIO pins can drive external devices such as LEDs or motors [2].

Many embedded systems need to read sensors that produce analog signals. This is the purpose of the analog-to-digital converter (ADC). Since processors are built to interpret and process digital data, i.e. 1s and 0s, they are not able to do anything with the analog signals that may be sent to it by a device. So the analog to digital converter is used to convert the incoming data into a form that the processor can recognize.

In addition to the converters, many embedded microprocessors include a variety of timers as well. One of the most common types of timers is the Programmable Interval Timer (PIT). A PIT may either count down from some value to zero, or up to the capacity of the count register, overflowing to zero. Once it reaches zero, it sends an interrupt to the processor indicating that it has finished counting. This is useful for devices such as thermostats, which periodically test the temperature around them to see if they need to turn the air conditioner on, the heater on, etc.

Micro-controllers have proved to be highly popular in embedded systems since their introduction in the 1970s. An embedded system is a computer system with a dedicated function within a larger mechanical or electrical system, often with real time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts [14]. By contrast, a general-purpose computer, such as a personal computer (PC), is designed to be flexible and to meet a wide range of end-user needs. Embedded systems control many devices in common use today.

Modern embedded systems are often based on microcontrollers (i.e. CPUs with integrated memory and/or peripheral interfaces) but ordinary microprocessors (using external chips for memory and peripheral interface circuits) are also still common, especially in more complex systems [13]. In either case, the processor(s) used may be types ranging from rather general purpose to very specialized in certain class of computations, or even custom designed for the application at hand. A common standard class of dedicated processors is the digital signal processor (DSP).

The key characteristic, however, is being dedicated to handle a particular task. Since the embedded system is dedicated to specific tasks, design engineers can optimize it to reduce the size and cost of the product and increase the reliability and performance [16]. Some embedded systems are mass-produced, benefiting from economies of scale. [17] designed an Energy Efficiency Model for Cloud Computing. In 2016 [18] studied A Novel Algorithm for Efficient Downlink Packet Scheduling for Multiple-Component-Carrier Cellular Systems.

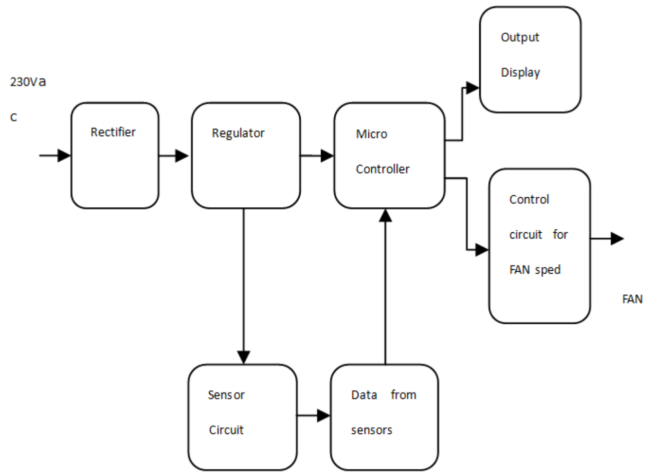

Figure 1. *Multi Function Power saver Block Diagram.*

The block diagram for multi function power saver is shown in the above figure 1, in system level. The 230V ac is rectified, the regulator provides a constant 5V DC which is required for the Micro controller and sensors. The data from the sensors is processed by the micro controller and accordingly the speed of the fan is controlled. The temperature and the fan speed are displayed on a LCD.

2. Design Procedure

The design consists of, a power supply, a transistor, a relay, resistors, capacitors and LEDs. In this design section we will go step by step on how different components are used in the system, how they perform and their features.

For any electronic device we require power supply in it, which is very essential requirement for any circuit. Here we are using a 5V regulated dc supply in the circuit. To obtain

5V dc supply procedure is as follows.

2.1. Power Supply

Power supply is a supply of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

A power supply may include a power distribution system as well as primary or secondary sources of energy such as:

- Conversion of one form of electrical power to another desired form and voltage, typically involving converting AC line voltage to a well-regulated lower-voltage DC for electronic devices. Low voltage, low power DC power supply units are commonly integrated with the devices they supply, such as computers and household electronics; for other examples, see switched-mode power supply, linear regulator, rectifier and inverter (electrical).
- Batteries
- Chemical fuel cells and other forms of energy storage systems
- Solar power
- Generators or alternators

A brief description:-

- Transformer - steps down high voltage AC mains to low voltage AC.
- Rectifier - converts AC to DC, but the DC output is varying.
- Smoothing - smooth the DC from varying greatly to a small ripple.
- Regulator - eliminates ripple by setting DC output to a fixed voltage.

2.2. Current Limiting Resistor for LED

A suitable value for a current limiting resistor is calculated as follows.

The supply voltage is 5 volts. The current that we want to flow through the LED is 5mA. Assume that the forward voltage drop will be 1.5 V.

BY KVL, the voltage drop across the resistor must be

5 -1.5=3V.

By Ohm's Law, this voltage drop equals iR .

Therefore:

5- 1.5 = R*5mA

Rearranging terms gives:

R = (5- 1.5)/5mA

R = 3.5/5mA = 0.7 K Ω = 700 Ω.

So, if we select R value as 700 Ω, then the current flowing through the LED is limited to 5 mA

Figure 2 below depicts a current limiting resistor for LED. It is used to calculate a suitable value for a current limiting resistor.

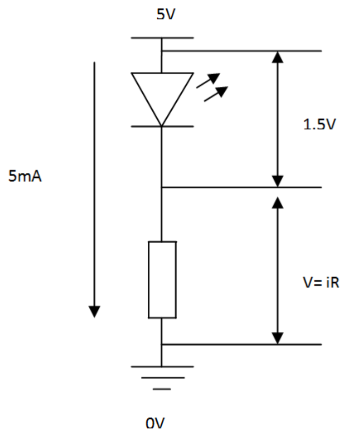

Figure 2. *Current Limiting Resistor for LED.*

3. Circuit Description

The following Hardware and software is used in this system.

3.1. Hardware

1) Micro Controller
2) MOSFET
3) Power Supply 5V
4) LEDs
5) Diodes
6) Opto Coupler

3.2. Software Tools

1) Express PCB/Pads
2) C cross compiler for AVR micro

The complete Circuit for the system is shown in the figure 3 below.

Some of the components in this system require DC5V for their operation, for example the micro controller. Hence we have designed a 5V regulator.

The major power source is mains 230V ac. For the regulator design we need a lower ac voltage. We have used a transformer to accomplish this task. The transformer stepped down the 230v ac to an acceptable level. This stepped down ac voltage was converted to DC with the help of a bridge rectifier. The output of the regulator is DC. However this DC has some ac contents in it. This ac content is called ripples. With the help of a smoothing capacitor these ripples are removed. Now we have a DC voltage. However this DC voltage is not a regulated DC. It means that this voltage is not constant. This gets varied depending on the load and the mains supply voltage. We have used a regulator IC which provides a constant DC with constant current. The DC voltage is 5V with a current of 1A.

The major circuit elements are the motion detector sensor and the temperature sensor. The output of these sensors is DC voltage. The output voltage is dependent on the movement of the person for motion sensor and temperature for temperature sensor. The output voltage is directly proportional to the temperature. The output produces10mV per Deg C. Means suppose if the temperature is 25 Deg C then the output will be 250mV. This information is given to Micro Controller for further processing.

The control circuit consists of a micro controller, AVR ATmega8. This Micro controller receives the information from the temperature sensor. Based on the information the micro controller sends output PWM. The micro drives the output Opto coupler.

The Opto Coupler drives the MOSFET. Whenever the output of the micro is low the opto coupler is ON. When the output of the micro is low, the opto coupler if OFF. The opto is connected to the micro at the cathode end.

The MOSFET is a N type MOSFET which is ON when the gate receives high and is OFF when the gate is low. When the Opto Coupler is on, it turns off the MOSFET. When the Opto Coupler is OFF, the MOSFET is turned ON. When the opto is ON, the output is pulled to low. When the Opto is off the output is pulled high with the pull up resistor.

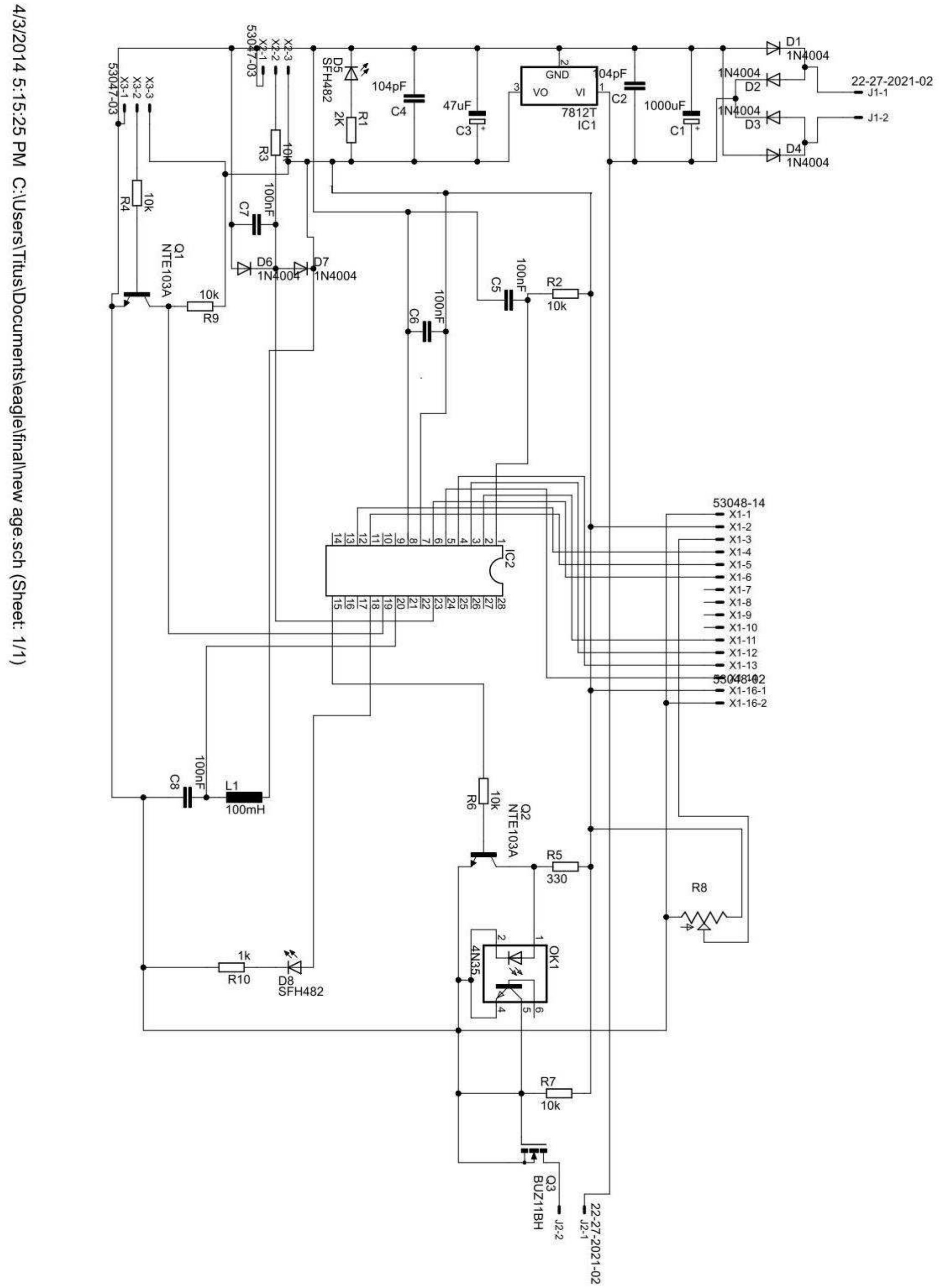

Figure 3. *Complete Circuit Design.*

Figure 3 above shows the complete Circuit diagram of the design.

3.3. Speed Control of Motor Using MOSFET

The speed of a DC motor is directly proportional to the supply voltage, so if we reduce the supply voltage from 12 Volts to 6 Volts, the motor will run at half the speed. How can this be achieved when the battery is fixed at 12 Volts?

The speed controller works by varying the average voltage sent to the motor. It could do this by simply adjusting the voltage sent to the motor, but this is quite inefficient to do. A better way is to switch the motor's supply on and off very quickly. If the switching is fast enough, the motor doesn't notice it, it only notices the average effect.

When the switch is closed, the motor sees 12 Volts, and when it is open it sees 0 Volts. If the switch is open for the same amount of time as it is closed, the motor will see an average of 6 Volts, and will run more slowly accordingly.

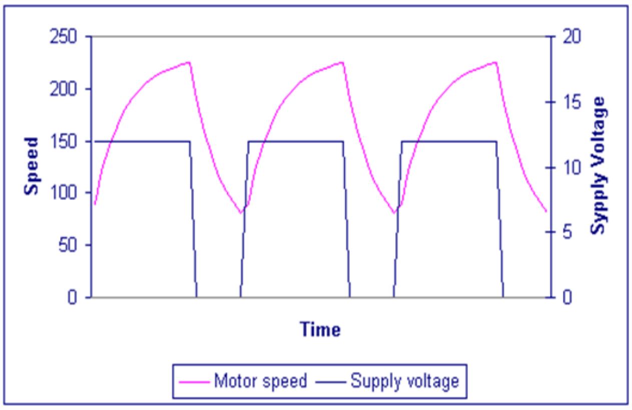

Figure 4. *Relationship between speed and voltage of a motor.*

This on-off switching is performed by power MOSFETs. A MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor) is a device that can turn very large currents on and off under the control of a low signal level voltage.

We can see that the average speed is around 150 rev per min, although it varies quite a bit. If the supply voltage is switched fast enough, it won't have time to change speed much, and the speed will be quite steady (Figure. 4 above). This is the principle of switch mode speed control. Thus the speed is set by PWM – Pulse Width Modulation.

4. PCB Design

A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. PCBs can be single sided (one copper layer), double sided (two copper layers) or multi-layer.

Conductors on different layers are connected with plated-through holes called vias. Advanced PCBs may contain components - capacitors, resistors or active devices - embedded in the substrate. Virtually every electronic product is constructed with one or more printed-circuit boards (PCBs).

The PCBs hold the ICs and other components and implement the interconnections between them. PCBs are created in abundance for portable electronics, computers, and entertainment equipment. They are also made for test equipment, manufacturing, and spacecraft. This is shown as figure 5 below as layout print.

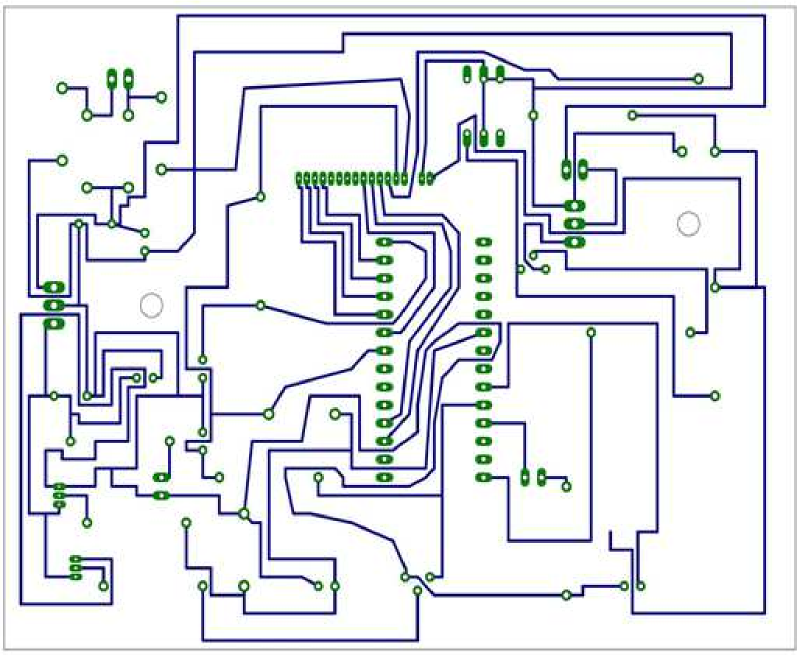

Figure 5. *Layout Print.*

A special material glass epoxy is used. FR-4 glass epoxy is a popular and versatile high-pressure thermoset plastic laminate grade with good strength to weight ratios. With near zero water absorption, FR-4 is most commonly used as an electrical insulator possessing considerable mechanical strength. The material is known to retain its high mechanical values and electrical insulating qualities in both dry and humid conditions. These attributes, along with good fabrication characteristics, lend utility to this grade for a wide variety of electrical and mechanical applications.

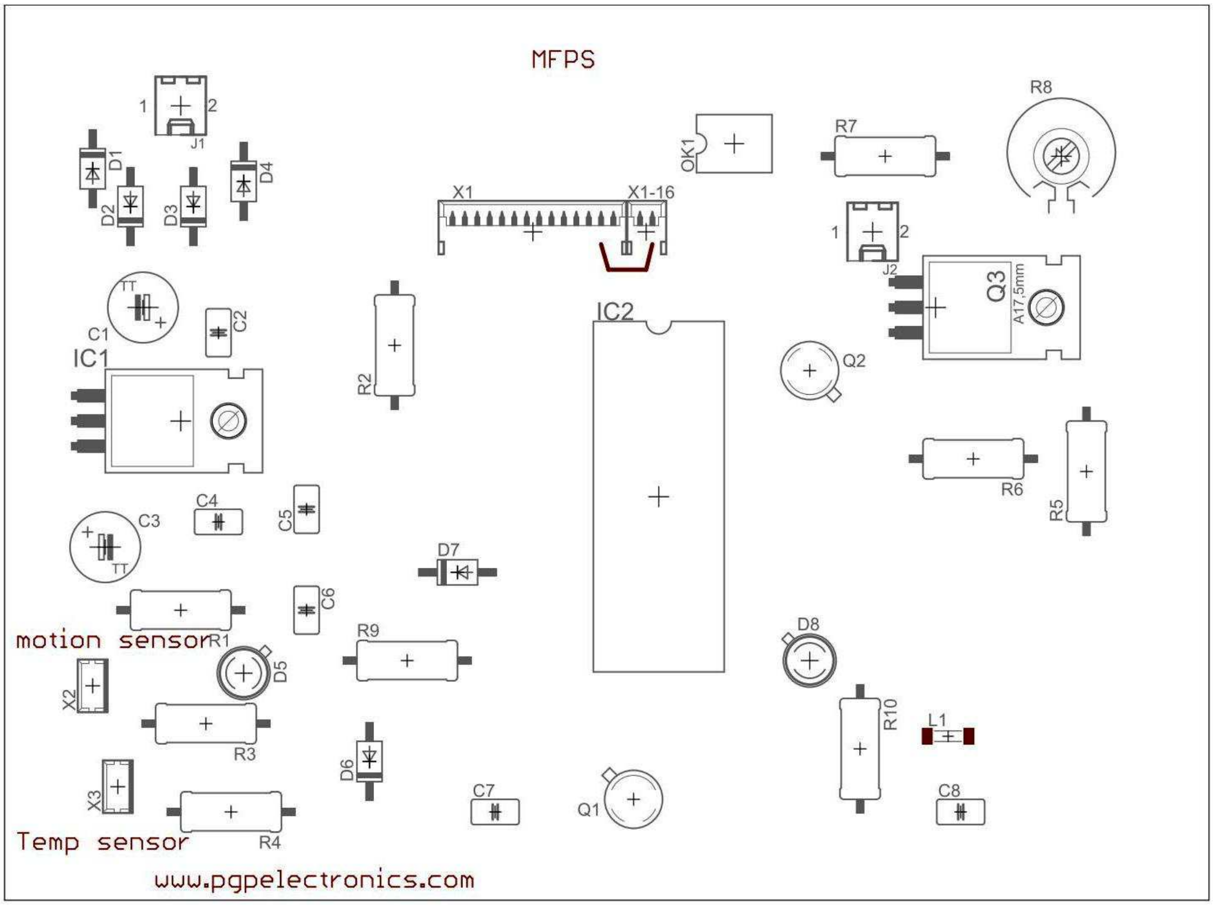

Figure 6. *Component Side.*

Figure 6 shows the component side diagram for the system.

5. Coding

In order to come up with a standard design of the MFPS, a computer program using C was written and run so as to obtain desired values for the Temperature and the corresponding fan speed

```
#include<avr/io. h>
void adcinit();
#include<util/delay. h>
#include "lcd. h"
int main()
{
DDRD=0xFF;
DDRB=0x00;
DDRC=0x00;
LCDInit(0x00);
LCDWriteString("welcome");
_delay_ms(5000);
LCDClear();
while(1)
{
if((PINB&0x01)==0x01)
{
LCDWriteStringXY(0,0,"Person Entered");
LCDWriteStringXY(0,1,"Fan ON");
fancontrol();
}
else if((PINB&0x01)==0x00)
{
LCDClear();
LCDWriteStringXY(0,0,"Person Left");
LCDWriteStringXY(0,1,"Fan off");
PORTD=0x00;
}
}
}
void adcinit()
{
```

```
ADCSRA|=((1<<ADEN)|(1<<ADPS2)|(1<<ADPS1));
ADMUX|=(0<<REFS0)|(0<<REFS1);
}
void adc_read()
{
ADCSRA|=(1<<ADSC);
ADMUX|=(1<<MUX0);
return ADC;
}
void fancontrol()
{
int data;
data=adc_read;
if(data>0 && data<171)
{
LCDClear();
LCDWriteString("Fan off");
PORTD=0x00;
}
if(data>171 && data<178)
{
LCDClear();
LCDWriteString("Fan Speed 1"); // MININMUM SPEED
OF FAN (1)
PORTD=0x01;
_delay_ms(40);
PORTD=0x00;
_delay_ms(40);
}
if(data>178&& data<184)
{
LCDClear();
LCDWriteString("Fan Speed 2");
PORTD=0x01;
_delay_ms(60);
PORTD=0x00;
_delay_ms(60);
}
if(data>184&& data<205)
{
LCDClear();
LCDWriteString("Fan Speed 3");
PORTD=0x01;
_delay_ms(80);
PORTD=0x00;
_delay_ms(80);
}
if(data>205 && data<245)
{
LCDClear();
LCDWriteString("Fan Speed 4");
PORTD=0x01;
_delay_ms(100);
PORTD=0x00;
_delay_ms(100);
}
if(data>245 && data<273)
{
LCDClear();
LCDWriteString("Fan Speed 5");
PORTD=0x01;
_delay_ms(120);
PORTD=0x00;
_delay_ms(120);
}
if(data>273 && data<300)
{
LCDClear();
LCDWriteString("Fan Speed 6");
PORTD=0x01;
_delay_ms(140);
PORTD=0x00;
_delay_ms(140);
}
if(data>300 && data<328)
{
LCDClear();
LCDWriteString("Fan Speed 7");
PORTD=0x01;
_delay_ms(160);
PORTD=0x00;
_delay_ms(160);
}
if(data>328 && data<355)
{
LCDClear();
LCDWriteString("Fan Speed 8");
PORTD=0x01;
_delay_ms(180);
PORTD=0x00;
_delay_ms(180);
}
ata>355 && data<1023)
{
LCDClear();
LCDWriteString("Fan Speed 9");
PORTD=0x01;
_delay_ms(200);
PORTD=0x00;
_delay_ms(200);
}
}
```

5.1. Testing Process

All the components used in the design were tested before the completed design was tested. This included the Power Supply (Design 5V, 500mA Power supply.) Components tested in the power supply were Transformer, Rectifier, Capacitor and Regulator.

5.2. Results

Table 1 below depicts sample results for temperature and corresponding fan speed when the MFPS was tested

5.3. Schematic Diagrams of the MFPS

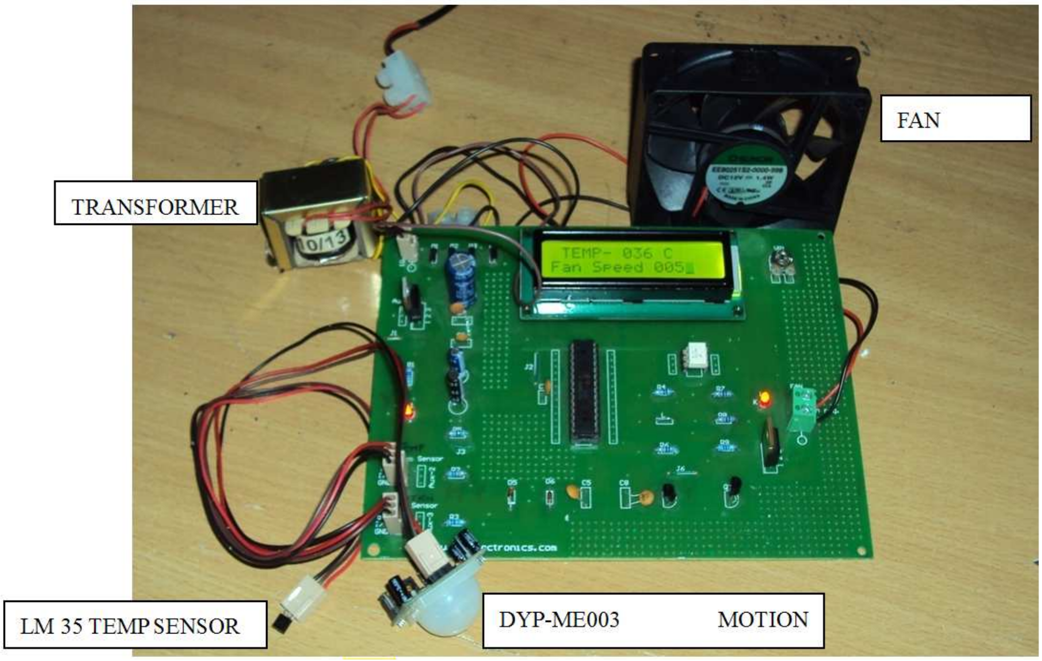

Figure 7. *Discrete Component Diagram of MFPS.*

Figure 8. *Complete MFPS.*

Figures 7 and 8are the Schematic diagrams of the MFPS depicting both the Discrete Component Diagram and Complete MFPS respectively.

6. Conclusion

The rectified output stabilized at 12 volts for a mains supply of 230v however with power surges in the primary coil, higher levels of voltage could be detected. These power transients are minimized by the large electrolytic capacitor of 1000 uF. Minimal power loses in form of heat by transformer and the 7805 was noted. The CRO waveform of the regulated power showed semblance with other dc sources. No ripples were observed and output was a constant 5v 500ma.

A temperature change once detected by LM35 Temperature Sensor, a suitable output voltage is relayed to ADC for conversion. Its output varies linearly well with ambient temperature. The data is used by the program in the AT mega 8 microcontroller to set the fan rotations. Low speeds of rotations were observed at low temperatures which increased with increasing room temperature. The temperature was displayed on the LCD screen. No adjustments were done on the default settings of DYP-ME003 PIR Motion Sensor since it could detect slight movements of the body at distance of around 5metres.

During soldering the microcontroller was placed in housing. This is to ensure that several microcontrollers can be programmed to fit in the same PCB should there be detected an error in the code during run time. Extraction of soldered microcontroller pins is rather time consuming and can lead to damage on current routes of PCB that's why the it's advisable to solder housing instead of soldering the microcontroller directly.

No delays were observed in the switching components especially the MOSFET which controls the switching on and off of the fan. The response of display to changes is satisfactory.

Table 1. *Sample results for Temperature and corresponding fan speed when the MFPS was tested.*

Temp (°C)	**24 and *below***	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*
Speed	*OFF*	*I/OFF*	*2*	*3*	*3*	*3*	*4*	*4*	*4*	*4*	*4*	*4*	*5*	*5*	*5*

Table 1. *Continue.*

Temp (°C)	39	40	41	42	43	44	45	46	47	48	49	50	51	52 and Above
Speed	5	6	6	6	6	7	7	7	7	8	8	8	8	9

Acknowledgements

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