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Design and Construction of an Improved Automatic Voltage Switcher System for Cold Chain Rooms

Mwebaza Chriton[1], Mwanga David[2], Mukasa Paul[3] , Okello Bonny[4], Kamuhanda Success[5], Martha Tusabe[6], Kemigisha Priscilla[7], Kibirige David[8], Kasango Ramadhan[9] ,Makumbi David[10], Kanyana Ruth[11]

Department of Biomedical Engineering, Ernest Cook Ultrasound Research and Education Institute (ECUREI)
Kampala, Uganda
mwebazachriton@gmail.com[1],mwangadavid41@gmail.com[2], mukpaul2017@gmsil.com[3], bonnyokello0@gmail.com[4], ksaxes64@gmail.com[5], marthatusabe@gmail.com[6],priscillakemigisha48@yahoo.com[7], semkibirige@gmail.com[8],kasangoramadhan@gmail.com[9],makumbidavid92@gmail.com[10], kanyanaruth@gmail.com[11],

***Abstract**: The Automatic Voltage Switcher AVS works by monitoring the voltage for a short period to ensure the power has stabilized before re-connecting. The device has a start-up delay period to provide protection against power-back surges commonly experienced after resumption of power in a power cut situation. The Surge and spike protection is in place to basically ensure protection. However, the current AVS30 has only one output terminal hence one cannot connect two or more power extensions to it at the same time, has no fan or heat sink to dissipate heat. In this paper, a design of an improved Automatic Voltage Switcher is constructed and tested to help provide solution to the above mentioned differences. The improved design in this paper has one earthing shared by both the input and output terminal which reduces leakages. It also has two output terminal as compared to the original which has one output.*

Keywords— Automatic Voltage Switcher, surges, protection, stability, current, cold rooms, heat sink

1. Introduction

One of the causes of mechanical faults and physical damage in cold chain equipment such as freezers, refrigerators and refrigerator trucks is power problem. The power problems lead to malfunctioning of the equipment hence they can no longer be used again. These problems include surges, spikes, lightning strikes, brown-outs, power-cuts or black-outs, power-back surges, main over-voltage, and complete failure. To reduce on the damages caused by power problems, automatic voltage switchers (AVS) where put in place to protect the cold chain equipment [1]. These devices work by automatically disconnecting the power of the equipment in case the mains power supply fluctuates outside the set tolerances which are normally 190V and 260V. There are so many types of Automatic Voltage Switcher AVS which include AVS 13/15 MICRO, AVS 13RL MICRO, AVS 30 MICRO, AVS 100, AVS 3P-0 and AVS 303. The commonly used one is the AVS 30 MICRO as it provides protection against power-back surges, over voltage, brown-outs, surges, spikes hence reducing mechanical faults in the equipment. It is rated at 30 Amps and works by switching off the equipment connected to it if the mains power goes outside pre-set acceptable limits and will re-connect automatically when the mains power returns to normal [2]. The re-connection occurs after a delay to guarantee stability of the mains.
The AVS 30 has an in-built micro-processor is able to perform the above activities. This AVS has one input and one output hence you can only connect one extension to it; therefore, one has to incur costs to buy more of them in order to meet their needs. It is expensive to buy many of them as each device costs one hundred fifty thousand Uganda shillings. Both the input and output terminals are earthed which can lead to leakages hence shocks [3]. The AVS 30 has no fan or heat sink to dissipate heat from its circuit which is not good, leading to an increase in the junction temperature within it. Therefore, there is need to improve the existing AVS 30 by putting in place more output terminals, a heat sink and putting up one earth for both terminals. In this paper this improvement was implemented.

2. Design of the project

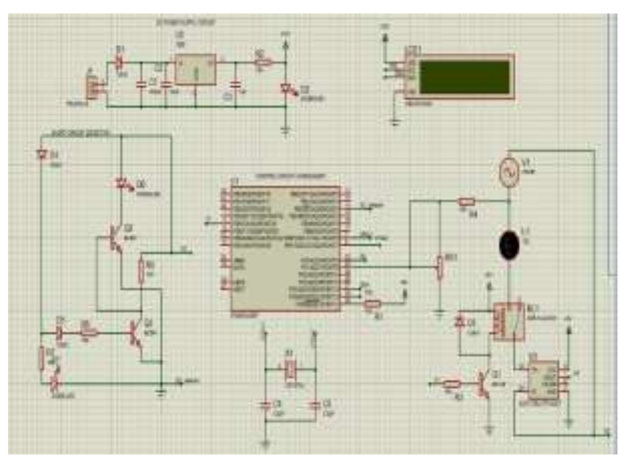

Figure 1: Circuit diagram of the project

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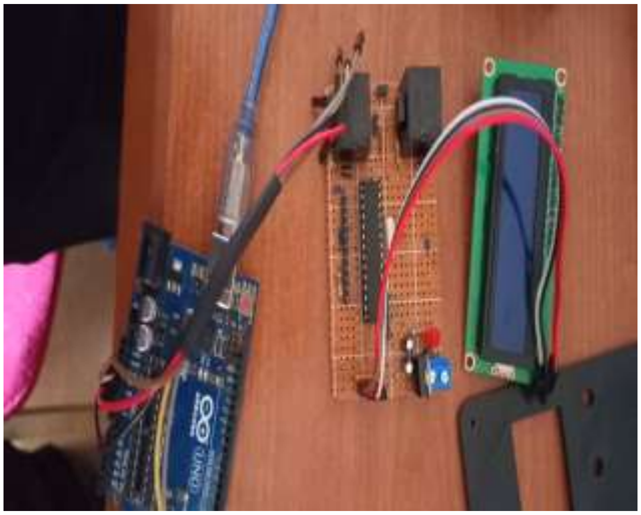

Figure 2: showing the Vero board connected with the LCD screen

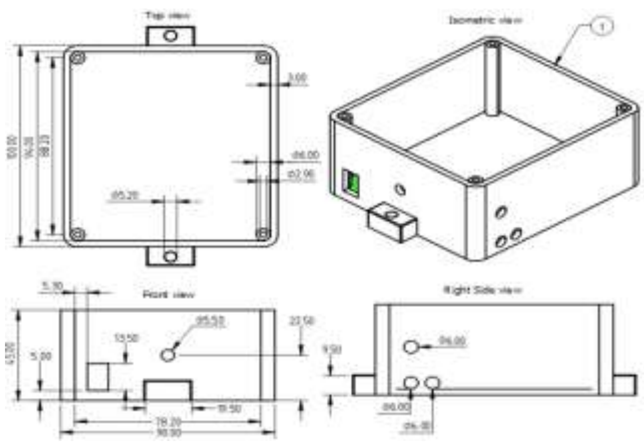

Figure 3: showing the 3D dimensions of the prototype

Figure 4: showing the prototype

In this project, Arduino Uno AT mega 328p is used as controller and a code was written which controlled the entire operation of the project. The code below was used.

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
//I2C pins declaration
LiquidCrystal_I2C lcd(0x27, 20, 4);

int VIN=A2;
int pot=A3;

const float VCC   = 5.0;// supply voltage is from 4.5 to 5.5V. Normally 5V.
const int model = 1;   // enter the model number (see below)
float cutOffLimit = 1.01;// set the current which below that value, doesn't matter. Or set 0.5

float sensitivity[] ={
0.185,// for ACS712ELCTR-05B-T
0.100,// for ACS712ELCTR-20A-T
        0.066// for ACS712ELCTR-30A-T

        };
const float QOV =   0.5 * VCC;// set quiescent Output voltage of 0.5V
float voltage;// internal variable for voltage


int led_red= 2;
int led_green= 3;
int led_blue= 4;

int relay_1=8;
int relay_2=9;

int stc=12;
int stc_d=13;

void setup()
{
pinMode(stc,OUTPUT);
pinMode(stc_d,INPUT);
pinMode(led_red,OUTPUT);
pinMode(led_green,OUTPUT);
pinMode(led_blue,OUTPUT);

pinMode(relay_1,OUTPUT);
pinMode(relay_2,OUTPUT);

lcd.init(); //initialize the lcd
lcd.backlight();//To Power ON the back light
lcd.setCursor(0,0);
lcd.print(" Welcome to the");
lcd.setCursor(0,1);
lcd.print("-Advanced AVS30-");
```

```
delay(3000);
lcd.clear();


}
void loop()
{
lcd.clear();
  int pot_val=analogRead(pot);
  float voltage_raw =   (5.0 / 1023.0)* analogRead(VIN);// Read the voltage from sensor
  voltage =  voltage_raw - QOV + 0.012 ;// 0.000 is a value to make voltage zero when there is no current

  if(voltage<0)
  {
    voltage=0;
  }

    if(relate>220)
    {
digitalWrite(relay_1,LOW);
digitalWrite(led_red,LOW);
digitalWrite(led_green,HIGH);
digitalWrite(led_blue,LOW);
lcd.setCursor(0,0);
lcd.print("Voltage:");
lcd.print(relate);
lcd.print(" V");
lcd.setCursor(0,1);
lcd.print("High voltage!!");

    }
    else if((relate>=200)&&(relate<220))
    {
digitalWrite(relay_1,HIGH);
digitalWrite(led_red,HIGH);
digitalWrite(led_green,LOW);
digitalWrite(led_blue,LOW);
lcd.setCursor(0,0);
lcd.print("Voltage:");
lcd.print(relate);
lcd.print(" V");
lcd.setCursor(0,1);
lcd.print("Normal voltage");

    }
    else if((relate<200))
    {
lcd.setCursor(0,0);
lcd.print("Voltage:");
lcd.print(relate);
lcd.print(" V");
lcd.setCursor(0,1);
lcd.print("Low voltage!!");
digitalWrite(relay_1,LOW);
digitalWrite(led_red,LOW);
digitalWrite(led_green,LOW);
digitalWrite(led_blue,HIGH);
    }
    else
    {
lcd.setCursor(0,0);
lcd.print("System error!!");
    }
delay(500);
lcd.clear();

    }
```

3. Operation of the prototype

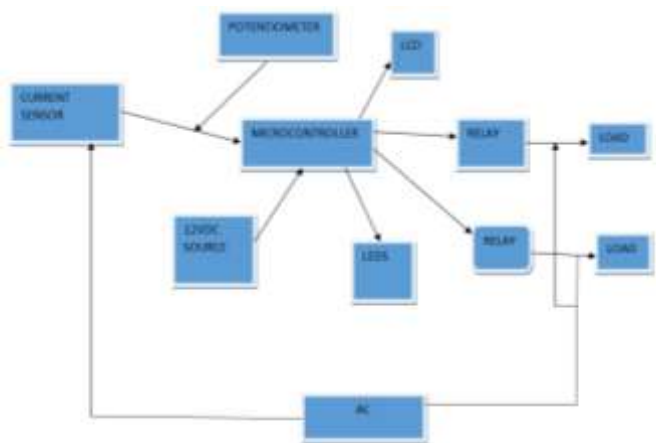

Figure 5: Principle of operation of the prototype

In this paper a 12VDC source provides source of power to circuit components
AC (L) goes through current sensor, such that the current sensor signals voltage fluctuations to microcontroller. Microcontroller powers different LEDS depending on the signal sent by current sensor, and then LCD displays different parameters like low voltage, normal voltage and high voltage. The potentiometer is used for demonstrating fluctuations from power source.
During low voltage, the microcontroller does not power the relay switch and the load is not energized. During normal voltage, the microcontroller energizes the relay switch so as to power the Load. During high voltage, the microcontroller does not energize the relay switch and load is not powered.

Functional test
When the voltage is low the blue LED will be on and the green and red LEDs will be off as shown below. During this time the fridge will be off until the power stabilises.

Figure 6: showing what happens when the voltage is low

When the voltage is in range the green LED will be on as the blue and red LEDs will be off as shown in the image below. During this time the fridge will be on as the power is in range.

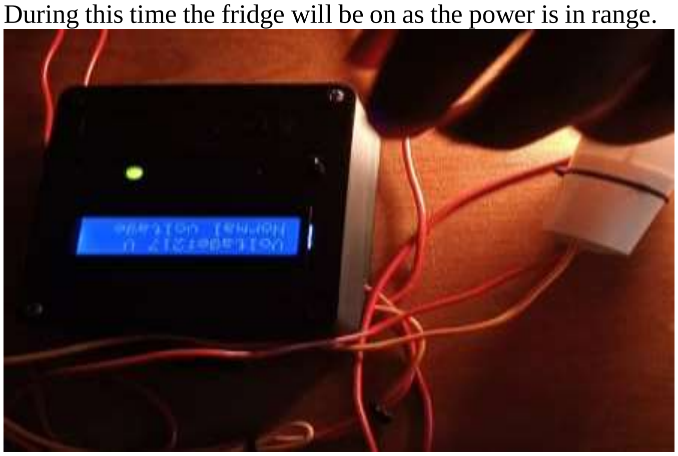

Figure 7: showing what happens when the voltage is in range

When the voltage is high the red LED will be on and the blue and green LEDs will be off as shown in the image below. During this time the fridge will be off until the power stabilises

Figure 8: showing what happens when the voltage is above range

4. Conclusion

The improved AVS was able to disconnect the power to the cold room whenever the mains power fluctuated outside the set tolerance of 190V and 260V, this was tested by adjusting the potentiometer. The heat sink was able to cool the circuit and the shared earthing for both input and output terminal made the system less prone to leakages.

References

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