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Development of Automatic Transfer Switch(ATS) with Overvoltage and Undervoltage protection

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Abstract - The need to protect electrical appliances from electrical power fluctuation cannot be over emphasized. Most homes and office complexes where single-phase supply is needed are supplied with two or three phases of power supply to allow change from one phase to another when there is fluctuation or complete outage of power supply on a particular phase. This action is done manually and results in electric shock and damages. The automatic phase selector system automatically selects and switch from one phase to the other in a RED-YELLOW-BLUE sequence and operates within a voltage range of 160V - 220V. When voltage supply on a phase is below 160V or above 220V, this system automatically disconnects the load from the phase and connects to another where the required condition is met. The system was developed using Atmega328P microcontroller, ULN2003AN transistor switch, relays, 78XX series regulators, liquid crystal display and an audio alarm unit that produces a beep sound whenever there is a change from one phase to another. The load is connected on this phase and remains on it when the condition of operation is met. This sequence provides protection and guarantees continuous power supply for single-phase appliances and the designed system performed satisfactorily.

***Key Words*:** ATS, phase, relays, microcontroller, overvoltage, undervoltage

1.INTRODUCTION

Automatic transfer switch (ATS) serves as an interface between power sources in order to maintain a continuous supply of electricity to the load. The switch automatically senses power failure on the power utility line, sends signal to the microcontroller. At the moment the microcontroller will process this information and based on that, the automatic switch disconnect the utility line and then transfer the load to the next available source, thereby restoring power to the load. The switch will sensor to monitor the condition of the utility power source. Over the years, some research works have been carried out to improve the design of ATS so as to achieve reliability and flexibility.
These works includes the development of a pre-integrated digital power switching system which is efficient, flexible and user's friendly. In this project we designed an ATS for residential as well as for industrial uses. This work comprises of a power supply, a relay switching, microcontroller, LCD, and sensors. The microcontroller is configured to monitor the under voltage and over voltage for all three phase, it will check all phase one by one and switch the load with first normal condition power supply, and also to provide at least one alarm to an operator to provide information if no source is available or all phase is fault. The microcontroller will display this all information on interfaced LCD display.

Advantages

- No men power required
- Automatic operation
- Easy to use
- Fast working
- LCD display for user

Application

- Industry
- Public place
- Power Plant
- Hybrid system
- In homes
- Offices
- Workshops

2. METHODOLOGY USED

A. Block diagram

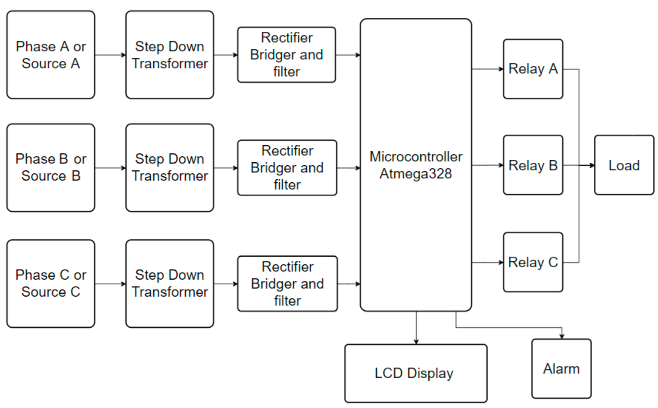

Fig 1: Block digaram

The block diagram of the project as shown in Figure 1 has the following sections:

1) Power Supply and sensor section.

We are using three different individual input 220 volt main supply. This supply will be connected with step down transformer input point. The transformer will step down this

220 volt to 12 volt. Rectifier Bridge and filter connected with 12 volt for convert in pure dc. This 12 volt pure dc will be connect with voltage divider circuit for measure voltage about particular source.

2) Switching section

Switching section will be combination of three relay switch. All three relay will be connect in series sequence means we can say all relay common pin will be connected with load and relay NO pin will be connect with separately with power source. The trigger pin of each relay section will be connect with microcontroller digital pin. The relay trigger on and off will be depends on that microcontroller pin.

3) Control Section

The sensing unit was integrated into a microcontroller and C language was used to program the operation of microcontroller. The microcontroller will read all source voltage one by one and it will check for voltage related fault one by one for all source. Once microcontroller will check first , if its normal voltage level then microcontroller will trigger on first relay and first source will connected , otherwise microcontroller will follow same steps for next source.

4) LCD display

We are using 16X2 LCD display and RS pin of the LCD module is connected to digital pin 9 of the Arduino. R/W pin of the LCD is grounded. Enable pin of the LCD module is connected to digital pin 8 of the Arduino. In this project, the LCD module and Arduino are interfaced in the 4-bit mode. This means only four of the digital input lines (DB4 to DB7) of the LCD are used. This method is very simple, requires less connections and you can almost utilize the full potential of the LCD module. Digital lines DB4, DB5, DB6 and DB7 are interfaced to digital pins 7, 6, 5 and 4 of the Arduino. The 10K potentiometer is used for adjusting the contrast of the display.

5) Alarm

Once microcontroller will not able to find any source in normal condition, the load will be turn off and alarm will activate for emergency alert. The alarm connected with microcontroller pin number 2. Once microcontroller will send high pulse to alarm section the buzzer will activate and will give buzzer sound.

B. Flow chart

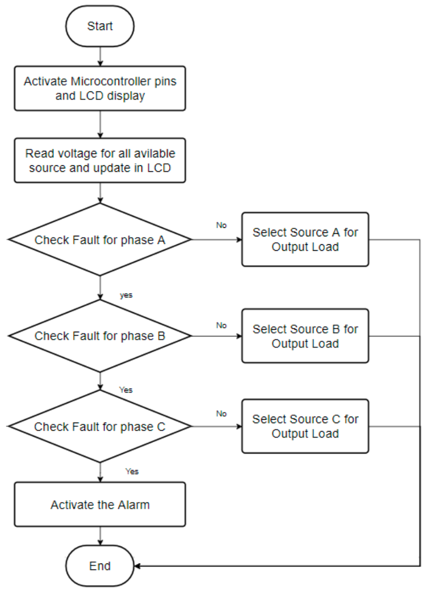

Fig 2: Flow chart

Figure 2 shows the flow chart of the project which explains the different steps to find the undervoltage and overvoltage conditions in 3 different phases and the corresponding result is displayed in the LCD screen. For eg. If there is a fault in phase A, the control shifts to Phase B and if there is a fault in phase B, control shifts to phase C and so on. The cycle repeats so that there is continuous supply to the load.

3. LITERATURE SURVEY

[1] The main aim in designing our project is to provide continuous power supply for the load with the three different sources (Mains, Solar, and Generator). No person is needed to pick any available source to supply to load. During this system, the AC mains is employed continuously as supply to the load, if by some cause AC mains power supply fails then load gets supply from Solar. We are using generator as third option of power supply to take care of continuous power supply. When three sources are failed to supply the power to the load then we will get intimated by buzzer.

[2] This paper presents a real laboratory design and construction of Automatic Transfer Switch (ATS) with three phase selector. The design method involves the use of electromechanical type relays, and comparators, etc. The ATS designed demonstrates its ability to perform automatic power change over activities easily without any human interaction.

[3] In this paper designed to provide uninterrupted power supply to load. In this system we designed automatic phase changeover switch by using logic gates i.e. IC7400 and auto selection is achieved by using a set of relays. This project can be implemented in colleges, hospitals, houses, banks etc. where the load is single phase and the power supply is 3 phase.

[4] This paper presents a real laboratory design and construction of Automatic Transfer Switch (ATS) with three phase selector. The design method involves the use of electromechanical type relays, and comparators, etc. The ATS designed demonstrates its ability to perform automatic power change over activities easily without any human interaction. Based on the test results, the whole system performed according to the designed aim and objectives. The automatic transfer switching circuit was able to switch between the two power supply sources according to the set priority and also automatically switches on the generator and switches it

[5] This paper presents the design and construction of an automatic power change-over switch that switches Power supply from main supply to another standby supply and it does this automatically using microcontroller. This device eliminates the challenge of a manual change-over system. A voltage sensing circuits, relay, LCD, were all coordinated using a microcontroller. Also the advancement in this paper is prevention of single phasing. An automatic power changeover system designed and implemented basically disconnects load from its power source and transfers it to a standby power source, in the advent of a power failure. This transfer is done at a very high switching speed such that minimal change occasioned by the transfer process goes unnoticed. It also incorporates a generator shutdown terminal that switches off the generator after the Mains power supply has been restored. This process is controlled by a microcontroller that keeps sensing to detect the availability of power supply on the Main supply line. The system is also fitted with an AC voltmeter that correctly reads the analogue voltage supplied by the power source and displays it on a seven segment display module.

4. HARDWARE USED

- Microcontroller (Atmega328)
- LCD display (16X2)
- Step down Transformer (0-12)
- Transistor (BC547)
- Relay (SPDT 12V)
- Rectifier (1N4007)
- Filter (1000uF)
- Connecting Wire
- Resistor
- LED
- Load Lamp
- PCB Board

5. DESIGN SPECIFICATIONS

For the selection of step down transformer:
Secondary voltage of a transformer= 12V (V_2)
Primary voltage of a transformer = 220/240V AC (V_1)
Secondary current of a transformer = 500mA (I_2)

We know that, for a transformer

$$\frac{V2}{V1} = \frac{I1}{I2}$$

Primary current of the transformer,

$$I1 = \frac{V2*I2}{V1} = \frac{12*500m}{240} = 2.5mA$$

The Transformer Utilization Factor (TUF) of a rectifier circuit is defined as the ratio of the DC power available to the load resistor to the AC rating of the secondary coil of the transformer.

$$TUF = \frac{Pdc\ (or\ Power\ delivered)}{VA\ rating\ of\ the\ transformer}$$

TUF for a bridge diode rectifier (Centre tapped) is 0.693.

Power delivered (P_{dc}) = $V_2 * I_2$ = 500m * 12 = 6VA

VA rating of the transformer (AC) :

$$PAC = \frac{6VA}{0.693} = 8.67VA$$

But, $P_{AC} = I_{AC} * V_2$

Where I_{AC} is the source current of the transformer.

$$Iac = \frac{Pac}{V2} = 722mA$$

Thus, we select a transformer of rating 240/12V, 50Hz,1A

Peak Inverse Voltage (PIV) of a center tapped full rectifier is given by: PIV= 2 Vmax

We know that Vmax = $Vrms * \sqrt{2}$ = 16.97 V

So, PIV = 2 * 16.97 = 33.94V

Thus, a full wave bridge rectifier chip that can withstand 33.94V was selected.

IN4007 can withstand upto 1000V.

Design of filter capacitor:

$$Ripple\ factor\ Y = \frac{rms\ value\ of\ component}{dc\ value\ of\ load\ voltage} = \frac{1}{4\sqrt{3}\ fCRL}$$

For a bridge rectifier,

$$\text{RL} = \frac{VL}{IL} = \frac{\text{V2}}{I2}$$

= 24 Ω

Assuming Y of 10%,

We get, C= 1202µF

Thus, a standard capacitor value of 1000µF was selected for the design.

6. SOFTWARE USED

Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module.

The following code is flashed to the Arduino board.

```
#include "LiquidCrystal.h"

const int rs = 2, en = 3, d4 = 4, d5 = 5, d6 = 6, d7 = 7;

LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

int v1 = A0;

int v2 = A1;

int v3 = A2;

void setup()

{

 lcd.begin (16,2);

 lcd.clear();

pinMode(A0,INPUT);

 pinMode(A1,INPUT);

 pinMode(A2,INPUT);

 pinMode(9,OUTPUT);

 pinMode(10,OUTPUT);

 pinMode(11,OUTPUT);

}

void loop()

{

int P1_V_Value = analogRead(v1);

 int P2_V_Value = analogRead(v2);

 int P3_V_Value = analogRead(v3);

int v1_map = map (P1_V_Value, 0, 880, 0, 220);

int v2_map = map (P2_V_Value, 0, 880, 0, 220);

int v3_map = map (P3_V_Value, 0, 880, 0, 220);

 if((v1_map > 160) && (v1_map < 240)){

 digitalWrite(11,HIGH);

 digitalWrite(10,LOW);

 digitalWrite(9,LOW);

lcd.clear();

lcd.setCursor(0, 0);

lcd.print("Phase 1 Active");

lcd.setCursor(0, 1);

lcd.print(v1_map);

}

else if((v2_map > 160) && (v2_map < 240)){

digitalWrite(10,HIGH);

digitalWrite(11,LOW);

digitalWrite(9,LOW);

lcd.clear();

lcd.setCursor(0, 0);

lcd.print("Phase 2 Active");

lcd.setCursor(0, 1);

lcd.print(v2_map);

}

else if((v3_map > 160) && (v3_map < 240)){

digitalWrite(9,HIGH);

digitalWrite(10,LOW);

digitalWrite(11,LOW);

lcd.clear();

lcd.setCursor(0, 0);

lcd.print("Phase 3 Active");

lcd.setCursor(0, 1);

lcd.print(v3_map);

}

else{

digitalWrite(11,LOW);

digitalWrite(10,LOW);

digitalWrite(9,LOW);

lcd.clear();

lcd.setCursor(0, 0);

lcd.print("No phase Active");

}
```

delay(500);

7. WORK DONE AND FUTURE WORKS

A. Work done

In this Project, an automatic transfer switch was designed and developed to help control power supply to electrical equipment, with the aim of preventing the equipment from damage as a result of under and over voltage supply.

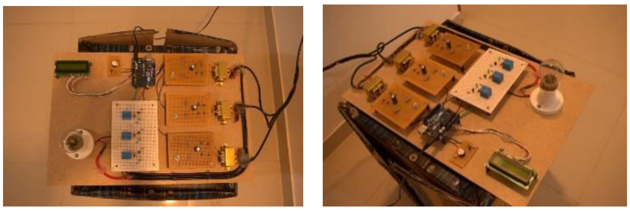

Fig 3: Experimental setup

The performance of the designed work as demonstrated by the prototype as shown in figure 3 shows high efficiency of operation with respect to the desired aim. The system is applicable to electrical equipment operating within 160V and 220V power supply.

B. Results

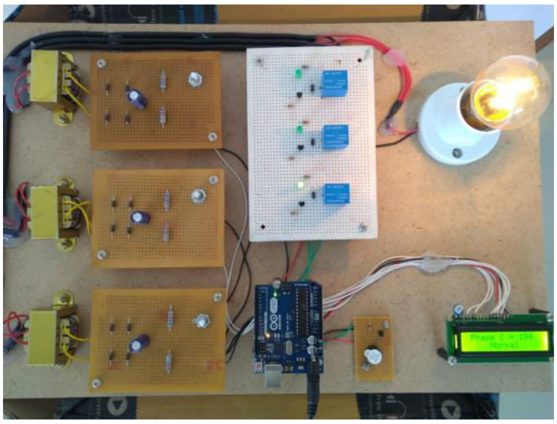

Fig 4: With phase C active and under normal conditions

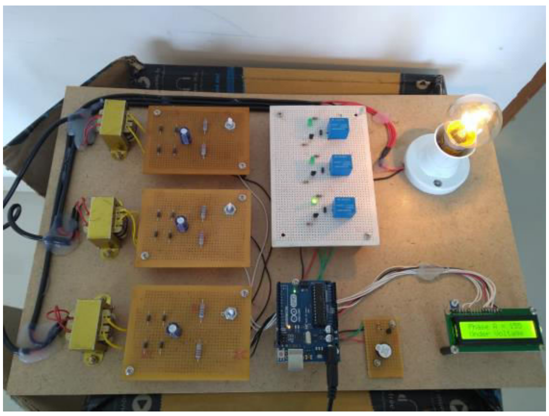

Fig 5:With phase A undervoltage, phase C active

Results obtained are shown below in Figure 4 and 5. Figure 4 shows the bulb glowing under normal conditions of phase A (with voltage 194V). Results are displayed on the LCD screen. Figure 5 shows the bulb glowing with phase C active as phase A is having undervoltage (i. e 154V) Results are displayed on the LCD screen.

C. Future works

This is complete setup for automatic transfer Switch. But in future we can add many other functions in this project. In future we can add IOT part in this implementation. With help of IOT, user will able to see all source status from anywhere of world location. In this implementation with minimum changes we can add many function and features in this project for increased functionality of this implementation.

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