International Journal of Research in Engineering, Science and Management
Volume 4, Issue 6, June 2021
https://www.ijresm.com | ISSN (Online): 2581-5792

Substation Monitoring and Control System with Voice Alerts

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***Abstract*: The purpose of this paper is to acquire the remote electrical parameters like voltage, current and frequency and send these real time values over network using phone along with temperature at power station. This is also designed to protect the electrical circuitry by operating a relay. This relay gets activated whenever the electrical parameters exceed the predefined values. The relay can be used to switch off the main electrical supply. User can send commands in the form of SMS messages to read the remote electrical parameters. This system also can automatically update the real time electrical parameters periodically (based on time settings). in the form of SMS. This system can be designed to send SMS alerts whenever the relay trips or whenever the voltage or current exceeds the predefined limits. This makes use of a microcontroller, as this is a prototype of the proposed project, for demonstration purpose we have used Arduino Uno here. The controller can efficiently communicate with the different sensors being used. When we give supply to our prototype all the sensors start sensing the current, voltage, frequency and temperature and update all the real time values to the server as well as show on the display. If any of the values exceeds pre-defined values, it sends a fault alert to the relay and buzzer as well as update it on the display.**

***Keywords*: Arduino compiler for embedded C programming, hardware components, microcontroller, real time monitoring, three-phase supply.**

1. Introduction

Electricity is an extremely handy and useful form of energy. It plays an ever-growing role in our modern industrialized society. The electrical power systems are highly non-linear, extremely huge and complex networks. Such electric power systems are unified for economic benefits, increased reliability and operational advantages. They are one of the most significant elements of both national and global infrastructure, and when these systems collapse it leads to major direct and indirect impacts on the economy and national security. A power system consists of components such as generators, lines, transformers, loads, switches and compensators. However, a widely dispersed power sources and loads are the general configuration of modern power systems. Today electricity still suffers from power outages and blackouts due to the lack of automated analysis and poor visibility of the utility over the grid. WSN will give the utility provide the needed view by collecting information from the different sub-systems of the grid. A sensor node will decide information or to slightly delay this notification (whether to immediately notify the sink about this information.). As complexity of distribution network has grown, automation of substation has become a need of every utility company to increase its efficiency and to improve quality of power being delivered.

To Improve the quality of power with suffer solution it is necessary to be familiar with what sort of constraint has occurred. Additionally, if there is any inadequacy in the protection, monitoring and control of a power system. The system might become unstable. Therefore, it necessary a monitoring system that can automatically detect, monitor, and classify the existing constraints on electrical lines.

Salient objectives of the project:

- To improve quality of power
- To improve reliability and compatibility
- Real time monitoring
- Remote sensing of observant parameters
- To maintain continuity of supply

Block diagram of the prototype:

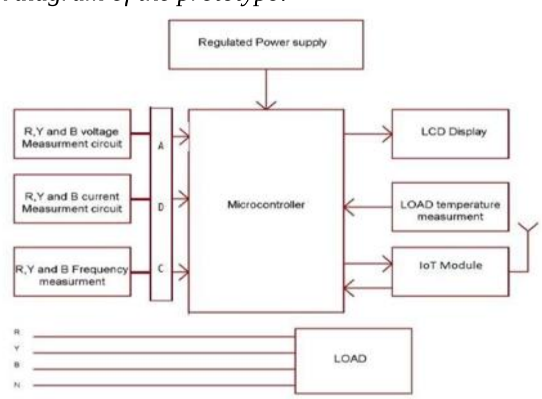

Fig. 1. Block diagram of project

2. Working Principle of Operation

Here in the proposed prototype, we have used Arduino Uno

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as our primary microcontroller. It will work as the heart of the system; all other measurement circuitries will be interfaced through this. Besides the microcontroller we have used current sensor, voltage sensor, temperature sensor, frequency measurement unit, buzzer and relay; and to demonstrate the load we have used a fan and a bulb. Alongside we also have used a supply unit consisting of a transformer, which converts 230 Volt AC to 12 Volt AC then it is passed through bridge rectifier unit which converts this 12 Volt AC to 12 Volt DC which is pulsating in nature which is then fed to the capacitor which work as a filter, makes the pulsating DC to smooth DC. As a lot of our components like Arduino Uno and some of the sensors as well require 5 Volt regulated DC, that is why this 12 Volt DC is fed to 7805 Voltage regulator which makes it to 5 Volt regulated DC. In case of buzzer and relay need high amount of current for operation, we must make some arrangements for that. For that amplification arrangement in case of relay we have used a relay driver and for buzzer we have used two BC 547 transistor in Darlington pair configuration. For operation of the green and red LEDs which work as an indicator they also need large amount of current for their amplified current requirement we have used two BC 547 transistors one for each When we give supply to our prototype the display shows welcome message and simultaneously all sensors start sensing the current, voltage, frequency and temperature and update all the real time values to the server as well as shows on the display. It compares all the real time values with the predefined values, if any of the values exceeds pre-defined values it sends a fault alert to the relay and buzzer as well as update it on the display. If the fault exists for the pre-set time, then relay isolates the loads from the rest of the system. In the meantime, comparison goes on as before, if the fault gets cleared relays reconnect the loads with the rest of the system.

A. Interfacing with Arduino

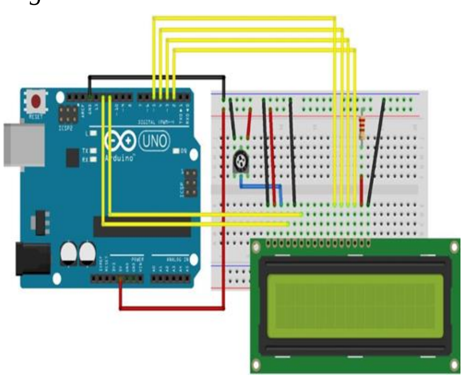

Fig. 2. Interfacing of 16*2 LCD Module with Arduino

B. Hardware Implementation

1) Current measurement unit

- ACS712 current sensor: 185mv/A output sensitivity, supply voltage=8V, output voltage=8V, storage temp=-65˚C t0 165˚C
- Pin no: VCC=+5v, OUT, GND

Working principle:

- Current Sensor detects the current in a wire or conductor and generates a signal proportional to the detected current either in the form of analogy output.
- Current-carrying conductor also gives rise to a magnetic field in its surrounding. In Indirect Sensing, the current is measured by calculating this magnetic field by applying either Faraday's law or Ampere law. Here either a Transformer or Hall effect sensor or fibreoptic current sensor are used to sense the magnetic field.
- ACS712 Current Sensor uses Indirect Sensing method to calculate the current. To sense current a liner, low-offset Hall sensor circuit is used in this IC.

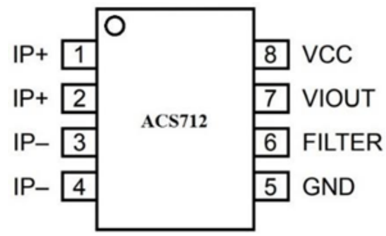

Fig. 3. Pin diagram of ACS712

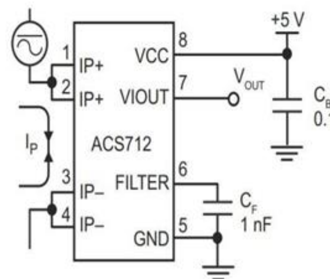

Fig. 4. Application connection pin-out of ACS712 & application connection of ACS712

2) Voltage measurement unit

In this project prototype for voltage measurement purpose, we have used ZMPT101B Voltage sensor module.

3) ZMPT101B voltage sensor

Single-phase AC active output voltage mutual inductance module equipped with ZMPT101B series of a high-precision voltage transformer and high-precision op-amp current, easy to 250v within the AC power signal acquisition. ZMPT101B voltage sensor module is a voltage sensor made from the ZMPT101B voltage transformer. It has high accuracy, good consistency for voltage and power measurement and it can measure up to 250V AC. It is simple to use and comes with a multi turn trim potentiometer for adjusting the ADC output. Its most important characteristics would be,

- High galvanic isolation
- Wide Range
- High accuracy
- Good Consistence

ZMPT101B is a high precision voltage Transformer. This module makes it easy to monitor AC mains voltage up to 1000 volts. A tiny little thing the size of a bouillon cube. Holds up to 4kV per breakdown voltage, the ratio of turns is 1: 1, but this is a current transformer of 2mA: 2mA. That is, we feed it a current and remove the current. The input current is simply set by the resistor in series R1, and a sampling resistor R2 is used in parallel to obtain the output voltage.

Fig. 5. Voltage sensor

Code:

```
#include "ZMPT101B.h"
#include "ACS712.h"
// ZMPT101B sensor connected to A0 pin of Arduino
ZMPT101B voltage Sensor(A0);
// 5 amps version sensor (ACS712_05B) connected to A1 pin of Arduino
ACS712 current Sensor (ACS712_05B, A1);
void setup ()
{
Serial. Begin (9600);
// calibrate () method calibrates zero point of sensor,
// It is not necessary, but may positively affect the accuracy
// Ensure that no current flows through the sensor at this moment
Serial.println("Calibrating... Ensure that no current flows through the sensor at this moment"); delay (100);
voltageSensor.calibrate();
currentSensor.calibrate();
Serial.println("Done!");
}
void loop ()
{
// To measure voltage/current we need to know the frequency of voltage/current
// By default, 50Hz is used, but you can specify desired frequency
// as first argument to getVoltageAC and getCurrentAC () method, if necessary
float U = voltageSensor.getVoltageAC();
float I = currentSensor.getCurrentAC();
// To calculate the power, we need voltage multiplied by current
float P = U * I;
Serial.println(String ("U = ") + U + " V");
Serial.println(String ("I = ") + I + " A");
Serial.println(String ("P = ") + P + " Watts");
delay (1000);
}
```

4) Frequency measurement unit

Frequency is number of cycles (complete turns) per 1 second. Its main unit of measurement is Hertz (Hz). Period is time required to complete 1 cycle (turn), its main unit is second. Frequency =1/Period. Home alternating current (AC) frequency is 50. For frequency of 50Hz the period is 20 milliseconds. The AC input is connected to the circuit as shown where diode 1N4007 is used to eliminate negative half cycles because the PC817 optocoupler maximum reverse voltage is 6V. The Figure 6.20 Connection Diagram of ZMPT101B with being Interfaced with Arduino Uno Figure 6.21 Connection Diagram of ZMPT101B along withACS712 being Interfaced with Arduino Uno optocoupler is connected to AC main through 120k ohm resistor (and the 1N4007 diode) which limits the current that passes through the optocoupler LED (IF). With the 120k ohm resistor and with source of 220V, the peak forward current is equal to (neglecting diode voltages): 220x√2/120k = 2.59 mA and the RMS current (half wave) = 2.59/2 = 1.3 mA.

Signal period:

Period (in µs) = Timer1_Value/Timer1_CLK = Timer1_Value/16000000/8

Period (in µs) = 8 x Timer1_Value/16000000

Period (in ms) = 8 x Timer1_Value/16000

Signal frequency:

Frequency = 1/Period

Frequency (in Hz) =16000000/ (8x Timer1_Value)

Single-phase AC active output voltage mutual inductance module equipped with ZMPT101B series of a high-precision voltage transformer and high-precision op-amp current, easy to 250v within the AC power signal acquisition. ZMPT101B voltage sensor module is a voltage sensor made from the ZMPT101B voltage transformer. It has high accuracy, good consistency for voltage and power measurement and it can measure up to 250V AC. It is simple to use and comes with a multi turn trim potentiometer for adjusting the ADC output. Its most important characteristics would be withACS712 being Interfaced with Arduino Uno.

5) LM 35 temperature sensor

LM35 is a temperature sensor that outputs an analogy signal which is proportional to the instantaneous temperature. The output voltage can easily be interpreted to obtain a temperature reading in Celsius. The advantage of lm35 over thermistor is it does not require any external calibration. The coating also protects it from self-heating. Low cost and greater accuracy. LM35 can measure from -55 degrees centigrade to 150-degree centigrade. The accuracy level is very high if operated at optimal temperature and humidity levels. The conversion of the output voltage to centigrade is also easy and straight forward. The input voltage to LM35 can be from +4 volts to 30 volts. It consumes about 60 microamperes of current.

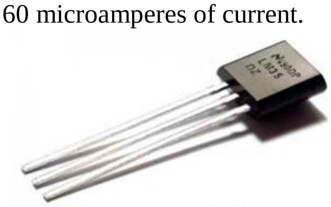

Fig. 6. LM 35 temperature sensor

C. Interfacing with Arduino

Here, LM35 output is given to Analog pin A1 of Arduino UNO.

This Analog voltage is converted to its digital form and processed. To get the temperature reading.

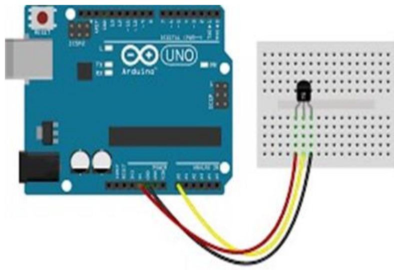

Fig. 7. Interfacing of LM35 sensor with Arduino

Code:

```
const int lm35_pin = A1; /* LM35 O/P pin */
 void setup () {
 Serial. Begin (9600);
}
 void loop ()
 {
 int temp_adc_val;
 float temp_val;
temp_adc_val = analogRead(lm35_pin);
/* Read Temperature */
 temp_val = (temp_adc_val * 4.88); /* Convert adc value to equivalent voltage */
 temp_val = (temp_val/10); /* LM35 gives output of 10mv/°C */
 Serial. Print ("Temperature = ");
 Serial. Print (temp_val);
 Serial. Print (" Degree Celsius\n")
Delay (1000);
}
```

D. Advantages & Applications

Advantages:

- Helpful for Fault Management
- Reduced Hazards
- Real time monitoring
- Cost Effective
- Remote Access

Applications:

- This system can be implemented in industries.
- This system can be used to monitoring and controlling the home appliances.

3. Result

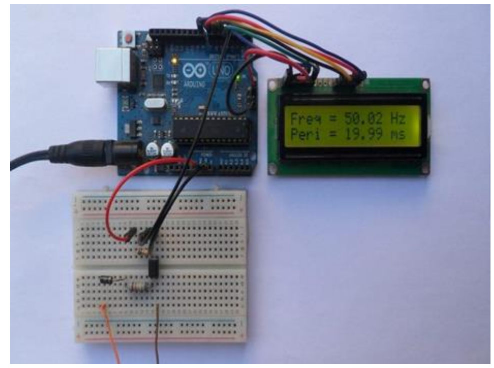

Fig. 8. Hardware setup

4. Conclusion

Monitoring means acquiring significant parameters from the assets of interest. The acquired data is feasible to be used for analyses and diagnose the condition of the assets which is of great use for maintenance scheduling, failure management and controlling system and this method minimizes time contact between human and high voltage device. As it is known, most substation devices have high voltage and generate electromagnetic that can harm human health. This proposed system is specially designed for monitoring the condition of substation transformers which are deployed at dispersed locations. There are many parameters to be quantified and monitored periodically It is quite costly and difficult to monitor the parameters by appointing a person at all locations and furthermore the data would also be error. if the monitoring is manual. The greatest issue is to have all the transformers data at a single sink when the data is collected manually. Through our proposed system all the problems discussed above can be reduced to some great extent.

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