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Research Article

GSM BASED SUBSTATION MONITORING AND CONTROL

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Abstract

The purpose of this article is to present real-time data on the substation's equipment, including the substation's temperature as well as transformer temperature, voltage, and current levels. This uses an electromagnetic relay, which is activated if the values surpass the predetermined values. To read the remote electrical characteristics, a user can transmit commands via GSM via SMS messaging. This allows operators to remotely or centrally monitor and control the substation.

Keywords: Substation control, Real-time, Equipment status, Remote Control, Efficiency, Downtime, Reliability, Fault detection, Quick response, Cost-effective.

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1. INTRODUCTION

An essential and practical source of energy is electricity. It is becoming more and more important in today's industrialized society. Electrical power systems are massive, intricate networks that are highly non-linear. Power leaves the generator and travels to a transmission substation, where massive transformers raise the voltage from the generator to extraordinarily high levels. Transformers are then used to lower the voltage level, and electric power distribution systems are used to provide power to consumers. In order to provide consumers with safe power in this day and age, substation monitoring and management are essential. On the other hand, because of its extensive coverage, affordability, and simplicity of deployment, GSM technology has become a well-liked substitute for substation monitoring and control. Real-time substation monitoring and control from a distance is made possible by GSM-based substation monitoring and control systems. The operator may monitor and control the substation parameters from a distance thanks to these systems, which use GSM technology to transfer data between the substation and the control center. Several sensors are used to continually sense a variety of characteristics, including voltage, temperature, and current. The Arduino receives the outputs from various sensors. Arduino is preprogrammed to

use wireless communication technologies like GSM to notify the intermediate or main station if the parameters above a predetermined threshold value. Therefore, keeping an eye on the distribution side's current, voltage, and other essential factors can help to enhance both the output generated at the main station and the quality of power distributed to customers. The primary goal of the proposed research is to employ the sensors in conjunction with the microcontroller to enhance the power delivery's compatibility and reliability by quickly identifying and isolating faults and preserving a steady voltage level. An essential component of the power distribution system, a substation is crucial to the secure and dependable distribution of electricity. Substation control and monitoring are essential to the power grid's effective operation. Researchers have presented a paper on the topic of Remote Microcontroller Based Monitoring of Substation and Control System through GSM Modem [1-5]. The proposed project, which is GSM cellular network-based substation control, will assist utility companies by ensuring that their local substation faults are promptly identified and reported to their concerned departments via GSM, ensuring that the duration of power interruption is reduced. The microcontroller will communicate with the substation's

installed sensors and carry out instructions. SMS messages will be used to transmit the measured parameters. This can also be indicated by SMS alerts. As a result, the sub-station's monitoring and operational effectiveness will significantly improve. A paper on GSM-based substation monitoring and control system with fault diagnosis was presented by researchers [5-10]. Their system uses GSM technology to transfer data between the substation and the control center and has a fault diagnosis module to assist in locating and identifying substation faults.

2. SYSTEM ARCHITECTURE

The Figure 1 shown below depicts the system architecture of the proposed paper.

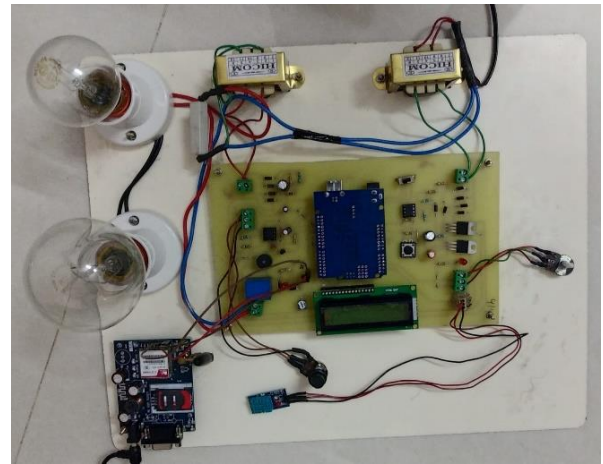


Figure 1: Prototype of GSM based substation monitoring and control

Using a step-down transformer, 230 volts AC is reduced to 12 volts AC; 12 volts AC is then rectified to 12 volts DC; the IC7805 regulator maintains a steady 5 volts DC, which is then supplied to the microcontroller. Together with the sensors that are attached to it, this microcontroller performs certain tasks.

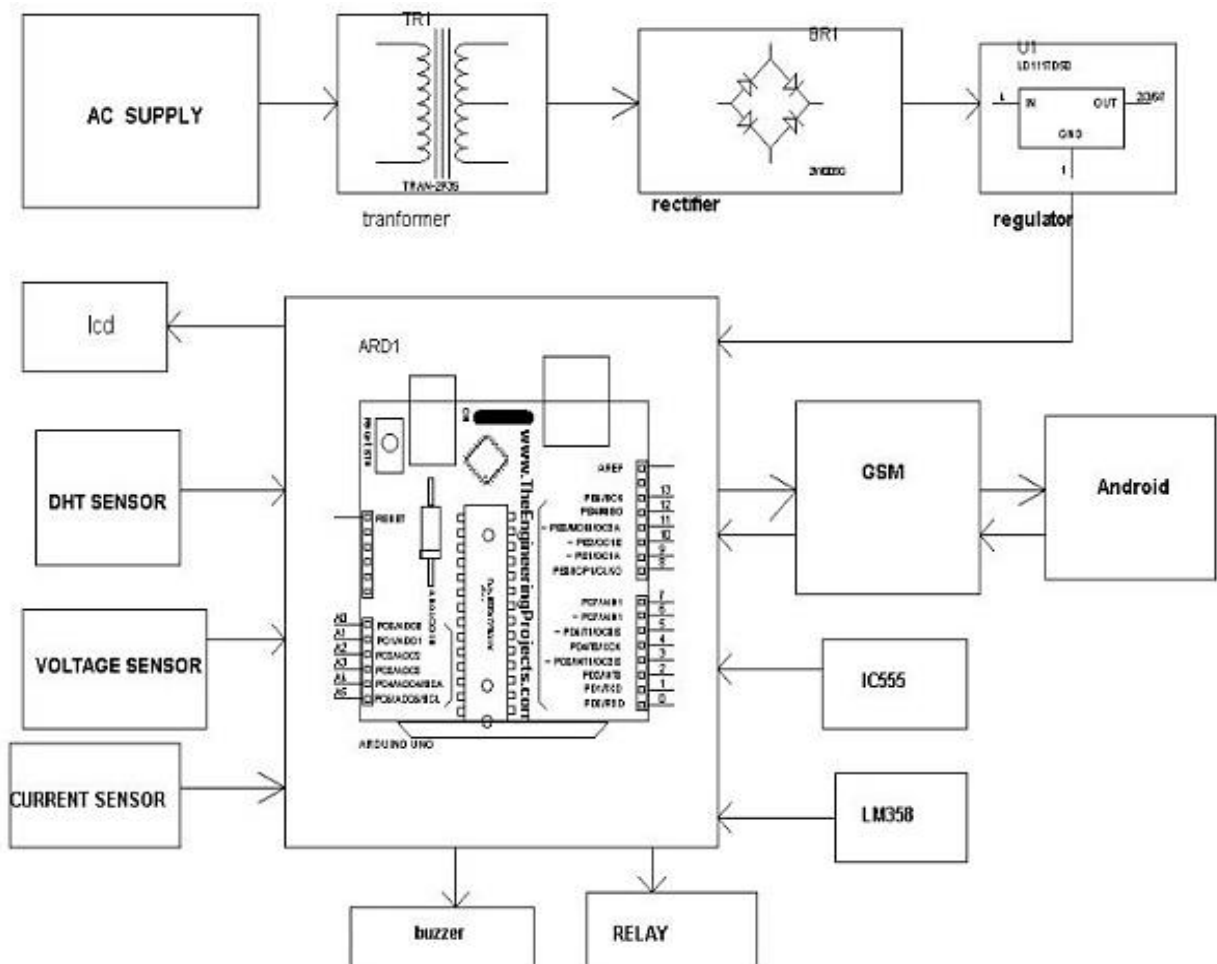


Figure 2: Technical block diagram

1. Arduino UNO

Developed by Arduino.cc, the Arduino Uno is an open-source microcontroller board built around the Microchip ATmega328P microcontroller. The board has sets of input/output (I/O) pins, both digital and analog, that can be interfaced to different expansion boards and other circuits. The Arduino IDE (Integrated Development Environment) can be used to program the board, which contains six analog and fourteen digital pins. Several features allow the Arduino/Genuino Uno to communicate with other microcontrollers, computers, or other Arduino/Genuino boards.

Digital pins 0 (RX) and 1 (TX) of the ATmega328 are used for UART TTL (5V) serial communication. Simple text data can be transferred to and from the board via the serial monitor included in the Arduino Software (IDE). When data is transferred through the USB-to-serial chip and USB connection to the computer, the board's RX and TX LEDs will flash (but not for serial communication on pins 0 and 1). Any digital pin on the Uno can be used for serial communication thanks to a Software Serial library.



Figure 3: Arduino UNO

2. GSM Module

The European Telecommunications Standards Institute (ETSI) created the GSM (Global System for Mobile Communications, formerly known as Groupe Special Mobile) standard to specify the protocols for second-generation (2G) digital cellular networks used by mobile phones. The standard was initially implemented in Finland in July 1991. GSM phones use a SIM card to identify the user's account. GSM is a wireless network technology based on TDMA. By simply transferring the SIM card, users of the GSM network can swiftly transfer their phone number from one GSM phone to another. A GSM module's interfaces have nominal power supply is 3.8 V, a serial bi-directional bus and ten general-purpose I/O ports on CMOS 2, 8 V and the hands-free set, speaker, microphone, and digital voice interface all use analog audio.



Figure 4: GSM Module

3. Step Down Transformer

Without changing the frequency or the quantity of electrical power being transported from one winding to another via the magnetic circuit, transformers can change the voltage and current levels of their supply. Two electrical wire coils, referred to as the Primary winding and the Secondary winding, make up a single-phase voltage transformer. Power is typically taken by the transformer's primary side and delivered by its secondary side.



Figure 5: Step down transformer

4. LCD Display

An electronic display module with a variety of uses is the LCD (Liquid Crystal Display) screen. A 16x2 LCD display is a fairly simple module that is frequently utilized in many circuits and gadgets. These modules are better than other multi-segment LEDs and seven-segment LEDs. The reasons are as follows: LCDs are inexpensive; they are simple to program; they can display animations, special and even custom characters (unlike in seven segments), and more.

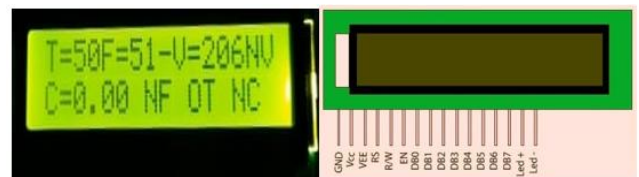


Figure 6: LCD display

5. Buzzer

An extremely popular piezo buzzer, also known as a piezo transducer, working at DC voltage is depicted in the figure below. It has a hole on the top face that allows sound to pass

through and is covered in a cylindrical plastic coating. Through the hole, one can see a yellow metallic disc that is crucial to the sound production process.



Figure 7: Buzzer

6. Relay



Figure 8: Relay

A coil of wire encircling a soft iron core, an iron yoke that offers a low resistance path for magnetic flux, a moveable iron armature, and one or more sets of contacts (the relay shown has two) make up a basic electromagnetic relay. The armature is mechanically connected to one or more sets of movable contacts and is hinged to the yoke. It is secured by a spring so that the magnetic circuit has an air gap when the relay is de-energized.

7. Bridge Rectifier

An alternating current (AC) to direct current (DC) converter that converts mains AC input to DC output is called a bridge rectifier. Power sources that supply the required DC voltage for electronic devices or components frequently use bridge rectifiers. Any regulated solid-state switch or four or more diodes can be used to build them. A suitable bridge rectifier is chosen based on the load current requirements. As seen in the image, this bridge rectifier rectifies the input using diodes. Because the diode only permits current to travel in one direction, it is a unidirectional device.

8. Voltage Regulator LM7805

The integrated circuit 7805 is a voltage regulator. It belongs to the fixed linear voltage regulator integrated circuit (IC) 78xx class. A circuit's voltage source could fluctuate and fail

to produce a fixed voltage output. The output voltage is kept constant by the voltage regulator integrated circuit. 7805 offers a controlled power source at +5V. Depending on the corresponding voltage levels, capacitors of appropriate values can be connected at the input and output pins.

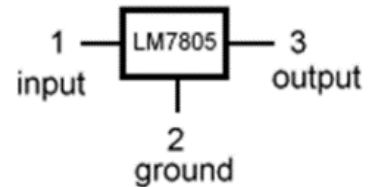
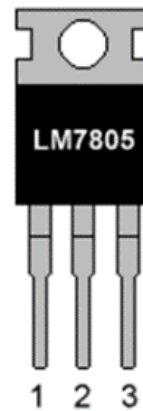


Figure 9: LM7805 Regulator

9. LM358 Comparator

There are two primary electronic components in a zero-crossing detection circuit. The first is an operational amplifier, and the second is passive electronic parts like capacitors and resistors. It finds an AC signal's zero-voltage reference point or a sine wave that represents the signal's zero-crossing point. The key active part of this circuit is the operational amplifier (Op-amp). To compare the AC signal with zero voltage reference signals, we use an op-amp as a comparator.

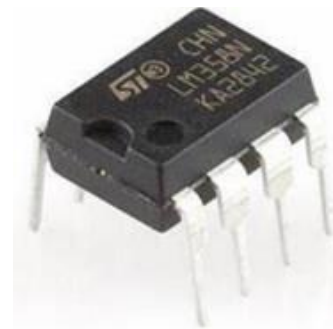


Figure 10: LM358 comparator

10. IC 555 Timer

The 555 Timer IC can be linked in two different ways: either in its bistable mode, which creates a flip-flop-style switching action, or in its monostable mode, which creates a precision timer with a set time period. However, we can also connect the 555 timer IC in an astable mode to create a very stable 555 oscillator circuit that produces extremely accurate free-running waveforms. The output frequency of this circuit can be changed using an externally connected RC tank circuit that consists of just two resistors and a capacitor.

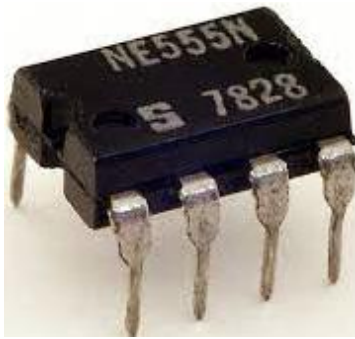


Figure 11: IC555 Timer

11. DHT Sensor

The DHT11 is a digital sensor for humidity and temperature. It is an inexpensive digital sensor that measures humidity and temperature. Any micro-controller, including Arduino, Raspberry Pi, and others, may readily interface with this sensor to get instantaneous temperature and humidity readings. This sensor employs a thermistor and a capacitive humidity sensor to measure the ambient air.

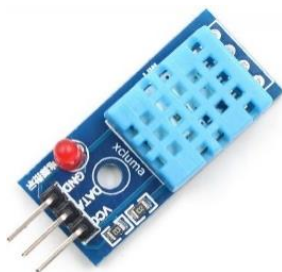


Figure 12: DHT11 Sensor

12. Software Used

a. Arduino IDE software

Writing code and uploading it to the board is made simple by this open-source Arduino software (IDE). It uses a port to connect to the Arduino hardware in order to upload programs. C++ is the programming language for the Arduino. Here, we have combined the Arduino IDE with the Arduino UNO because it works with a variety of circuit boards.

3. METHODOLOGY

The main microcontroller in the suggested prototype is an Arduino Uno. It will serve as the central component of the system, serving as the interface for all other measuring circuits. A buzzer, relay, temperature sensor, voltage sensor, current sensor, frequency measuring unit, and lightbulb are used to show the load. Additionally, a supply unit comprising a transformer that transforms 230 volts of AC into 12 volts of AC is used. This is followed by a bridge rectifier unit that transforms the 12 volts of AC into 12 volts of pulsating DC, which is then fed to a capacitor that functions as a filter and transforms the pulsating DC into smooth DC.

A 7805 Voltage regulator converts 12 Volt DC into 5 Volt regulated DC, which is needed for components like the Arduino Uno and some sensors. Relay drivers are used for relays, while two BC 547 transistors in a Darlington pair configuration are used for buzzers, both of which require a significant amount of current to operate.

When the supply is applied, it shows the parameter values while all of the sensors simultaneously begin to sense the temperature, voltage, frequency, and current and refresh the display with all of the current readings. It updates the display and sends a fault alarm to the relay and buzzer if any of the real-time values exceed the predefined values. Relay isolates the loads from the rest of the system if the problem persists for the predetermined amount of time. Relays reconnect the loads to the rest of the system if the problem is resolved while the comparison continues as before.

3.1. EXPERIMENTAL RESULTS

Following the circuitry's effective implementation, experimental findings were collected. The transformer receives 230V AC power, which it transforms into 12–14V AC. This voltage is then sent to the rectifier circuit, which transforms the AC voltage into DC voltage, producing a rectifier output of 12V DC. Voltage regulators IC 7812 and 7805 are utilized because they provide constant 12 v DC and 5 v DC, and a filter circuit is used to remove ripples from the output. We need 12 v constant for the relay and buzzer and 5 v DC constant for the Arduino. The output detected by the sensors is displayed in Figures 13, 14, and 15.

The relay will be engaged if any of the values exceed the predetermined values. At the same time, the user or operators will be informed of the fault values via GSM (Global System for Mobile Communication). Here, the voltage is expressed in volts. The relay goes off, the buzzer sounds, and the load is disconnected when the time value of the voltage crosses the top and lower bounds of the predetermined range. The relay will be turned off and the buzzer will be activated if the current in real time exceeds the predetermined value. As a result, the load will disconnect. The relay will be turned off and the buzzer will be activated if the real-time frequency value surpasses the upper or depletes the lower value of the preset range. As a result, the load will disconnect. The suggested system's temperature is expressed in degrees celsius (°C). The relay will be switched off and the buzzer will be turned on when the operating temperature rises above the predetermined temperature. As a result, the load will disconnect.



Figure 13: Over current output

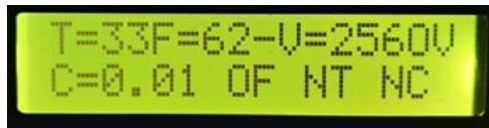


Figure 14: Over frequency output



Figure 15: Over temperature output

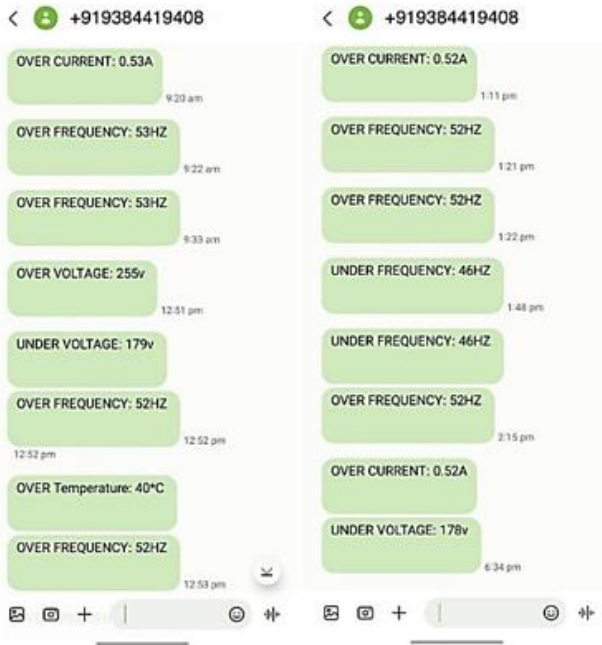


Figure 16: SMS output

4. CONCLUSION

Therefore, the goal of "GSM based substation monitoring and control" is to keep an eye on the state of substation transformers, which are spread out across several places. There are numerous criteria that need to be checked on a regular basis. Appointing a person to monitor the metrics at every place is very expensive and challenging, and if the monitoring is done by hand, the data would also be prone to errors. Electricity will be provided whenever and wherever it is needed thanks to the ongoing development and implementation of these technologies, which will also increase power systems' dependability and safety.

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None.

CONFLICT OF INTEREST

None.

REFERENCES

1. Velasquez, J. L., Villafañila, R., Lloret, P., Molas, L., Sumper, A., Galceran, S., & Sudrià, A. (2007, October). Development and implementation of a condition monitoring system in a substation. In *2007 9th International Conference on Electrical Power Quality and Utilisation* (pp. 1-5). IEEE..
2. Lloret, P., Velásquez, J. L., Molas-Balada, L., Villafañila, R., Sumper, A., & Galceran-Arellano, S. (2007, October). IEC 61850 as a flexible tool for electrical systems monitoring. In *2007 9th International Conference on Electrical Power Quality and Utilisation* (pp. 1-6). IEEE.
3. Sacerdotianu, D., Hurezeanu, I., Marinescu, A., Manolea, G., & Purcaru, I. (2010, May). Modern equipment for monitoring and diagnosis of transformer substations implemented in electric retechnologized substations in Romania. In *3rd International Conference on Modern Power Systems MPS 2010* (pp. 18-21).
4. Pal, D., Meyur, R., Menon, S., Reddy, M. J. B., & Mohanta, D. K. (2018). Real-time condition monitoring of substation equipment using thermal cameras. *IET Generation, Transmission & Distribution*, 12(4), 895-902.
5. Hanafi, D., Ribuan, M. N., Wibowo, I. A., Hashim, H., & Ismail, M. I. (2011). Simulation of substation integrated monitoring system using LabVIEW. *health*, 6, 7.
6. Arvind, D., Khushdeep, S., & Deepak, K. (2008, April). Condition monitoring of power transformer: A review. In *2008 IEEE/PES Transmission and Distribution Conference and Exposition* (pp. 1-6). IEEE..
7. Cahn, A., Hoyos, J., Hulse, M., & Keller, E. (2013, October). Software-defined energy communication networks: From substation automation to future smart grids. In *2013 IEEE International conference on smart grid communications (SmartGridComm)* (pp. 558-563). IEEE.
8. Pankajavalli, D. P., Karthick, G. S., Sridhar, M., & Muniyappan, A. (2017). A System for Monitoring the Electricity Sub-Station using Internet of Things. *International Journal of Advance Research in Science & Engineering, Volume*, (6).
9. Sachan, A. (2012). Microcontroller based substation monitoring and control system with gsm modem. *IOSR Journal of Electrical and Electronics Engineering*, 1(6), 13-21.
10. Velasquez, J. L., Villafañila, R., Lloret, P., Molas, L., Sumper, A., Galceran, S., & Sudrià, A. (2007, October). Development and implementation of a condition monitoring system in a substation. In *2007 9th International Conference on Electrical Power Quality and Utilisation* (pp. 1-5). IEEE. Amit Sachan, "Microcontroller based substation monitoring and control system with GSM modem" ISSN: 2278-1676 Volume 1, Issue 6 (July-Aug. 2012), PP 13-21