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Single Phase Auto-Reclosing Relay of Three-Phase Transmission Line with IoT and SCADA

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A B S T R A C T

In this paper, the Auto-Reclosing Relay (ARR) was designed and implemented with monitoring on the Internet of Things (IoT) and local SCADA systems. This system detects the faulty phase depending on the values of the angles of the actual impedances (postive sequence). The hardware of this system includes three PZEM-004T modules that are used to measure the electrical power parameters and the ESP8266 is employed to gather data from detectors and send it via the web to the Blynk server and to local SCADA via USB cable. The local SCADA system of the power line is used to monitor and control in HMI which is programmed by using C# language.This paper gives a complete description of the compact system (ARR, SCADA and IoT),which works in an acurate and successful mechanism.

1. Introduction

There are three types of faults that usually occur in the line system; permanent fault, semi-permanent fault, and transient fault [1]. Approximately 70-80% of faults on the overhead power lines are transient. [2]. A transient fault, like an insulator or birds, is one that is cleared by immediately tripping one or more circuit breakers to separate the cause and does not reoccur when reclosing the line. Approximately 30% of defects are permanent in character. The bulk of faults can be properly eliminated by using tripping and auto-resetting correctly. This opening the phase for a short period of time, facilitating the defective source as well as the fault arc to become disconnected before auto-reclosing the line . Therefore, autoreclosing can significantly decrease outage time due to faults and save continuity of service.In additional that improving transient stability in the power system[3]–[5] and reduce stress to circuit breakers[6]. Additionally, using the Arduino-based auto-reclosing [7] with successful Successful fast speeds automatic reset on power lines may protect the line against serious faults and serves a significant role in attempting to preserve system stability.On the most of power stations and power lines are using the SCADA system [8]to maintain and stability system, thus a The major goal of managing and monitoring equipment in the field, majority of which are located in remote locations. Different system circumstances and variables could be properly determined, observed, and controlled effectively, in addition to collecting data, manufacturing, and control action execution when needed in real-time.

Elements such as detectors and actuators with computer programmes such as the Human Machine Interface (HMI), data acquisition, interconnected communication of information, displaying or monitoring and controlling [9], [10]. SCADA performs four basic roles by combining physical elements such as detectors and actuators with computer programmes such as the Human Machine Interface (HMI), data acquisition, interconnected communication of information, displaying or monitoring and controlling. [9], [10]. SCADA relies on a number of components to execute out these operations properly. Both Field Instrument Devices (FIDs), which include actuators and sensors, and Remote Terminal Units (RTUs), which concern microprocessors, are examples of these components.In modern systems, the Internet of Things environment (IoT) is used to transmute signals or monitoring and control in wide range[11], especially in a smart power grid that is controlled and management by smart system[12].

The IoT is an advanced pathway in the IT sector. it is an innovation in data transmission from thing to thing, human-to-human, and human-to-things. It was founded in 1998, and Kevin Ashton coined the term "Internet of Things" in 1999 [13]. The IoT is an advanced pathway in the IT sector. it is an innovation in data transmission from thing to thing, human-to-human, and human-to-things. It was founded in 1998, and Kevin Ashton coined the term "Internet of Things" in 1999 [13]. Rather than individuals, smart gadgets may transport data, communicate data, and place orders. Connectivity for everything is an invention that allows people to share information at any time, from anyplace. Figure 1 depicts the three layers of Iot technology.

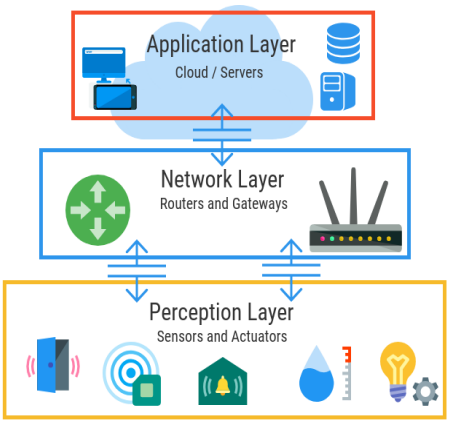

Fig. 1. IoT layers [14].

MTUs in this case, the Arduino, IoT server, and the link to the internet in the instance of a router-provided Wi-Fi connection. The benefits of IoT and SCADA systems include remote assessment/control, real-time monitoring, and alarms[15], sharing , modifying and visualisation of data, system optimising, trend analysis, adaptability, and enhanced efficiency [16]. This work presents the single-phase auto-reclosing relay system with IoT and SCADA aspects of the work using a prototype.

2. System Design and Implementation

The proposed system includes the electrical devices installed in Table1, including the loads in the laboratory, in addition to a power source 380/.220V, 50. Hz, is used to evaluate the system's performance.

Table 1. Electrical parts.

Type	No.
Three phase source	1

PZEM-004T-100A	3
CT	3
Relay 10 A	3
ESP8266	1
USB Cable	1
Push button	1
Indictor light	3
PC	1
Smart phone	1

In this proposed system, three systems, auto-reclosing relay (ARR), local SCADA, and internet of things (IOT) system, which operating at the same time and with the same hardware were combined, with a difference in some software that is compatible with each system. Figure 2 shows the block diagram of the three integrated systems.

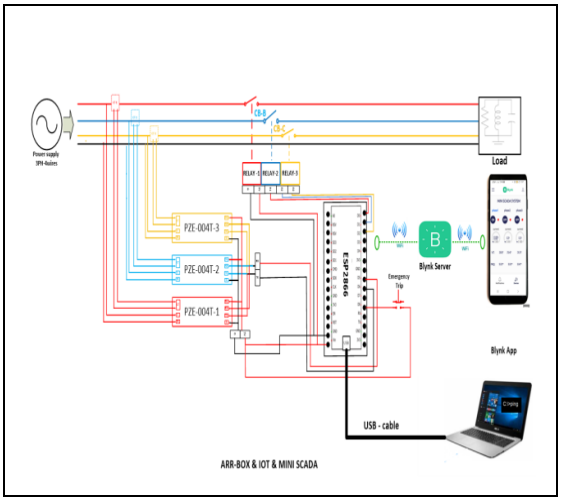

Fig. 2. Block Diagram of Compact ARR-SCADA-IOT system.

3. Hardware Implementation

The proposed system for auto-reclosing relay (ARR) with local SCADA, and IoT platform for control This work describes displaying and assessing some selected parameters, as illustrated in "Figure 1" above .This system consists of ; three PZEM-004T sensor components , one ESP8266 module , and three relays. The ZEM-004T can be defined as a modern, advanced electronic piece produced by Peacefair company, through which electrical parameters can be measured measured such as (Voltage, Frequency, PF, Current ,power and energy) and these features and functions make it a recommendable unit for the implementation of laboratory projects.PZEM-004T with a separate CT module can be used in the case of high current, which enabled, the cable can be passed through it without the need to remove the power cable .it can be used to measure current up to 100 ampere [17].

Transistor-transistor logic (TTL) serial communication is used for the PZEM-004T's output. The TTL interface on this module is a passive interface that needs an external 5V power source to function.

This implies that for the module to be able to communicate, all ports (5V, RX, TX, GND) must be connected. It don't have to add extra circuits because this sensor does not have an analog voltage level like the three previous indicators performed. Additionally, we are able to access the measurements via the PZEM004T library[18], to get the assessment value.

The single phase auto-reclosing (SPAR) system assessment is one of the primary means of enhancing the transient stability in the power system . In order to detect the faulty phase and using to trip and auto-reclosing technique (T/R) , emergency trip for three phase ,as well as sending the Blynk cloud received measured data from the PZEM-004T. The microcontroller Nodemcu ESP8266 communicates with the PZEM-004T through RS-232 and interacts with the ESP8266 module.

The programming interface for this Nodemcu microcontroller depends on the Arduino IDE software environment, and it congregates all of the measurements collected to three PZEM004T modules and sends it to the web server of the Blynk cloud via wireless internet, allowing consumers access to information to monitor in actual time and all variables Monitoring points can be accessed from anywhere in the world by using a computer (PC) or mobile devices connected to the the World Wide Web. Figure 3 illustrates the real-world vision of the suggested system.

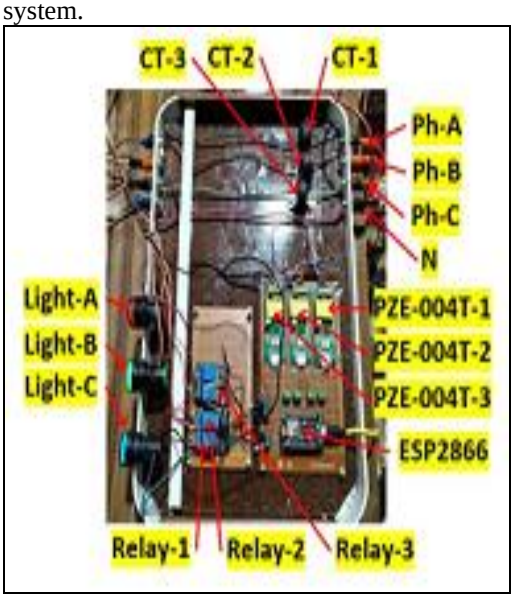

Fig. 3. Auo-Reclosing Relay (ARR) box

The developed IoT system utilized in this research depends on a physical unit, with the PZEM-004T serving as the primary unit utilized for measuring a number electrical power parameters. These parameters include frequency, voltage, current, active power, as well as a power factor.

In this work all devices above are connected to HMI by USB cable for build a local SCADA system , HMI is one of the important parts of the SCADA system,thus in this project has been used the laptop as HMI of the system. The implanted software for the Nodemcu will be programmed in the subsection that follows to perform the tasks required by the system.

4. Software Implementation

In this sophisticated structure, three PZEM-004T parts are used for collecting and determining electrical variables at a monitoring point. Following data collection and variable reading, sent to the ESP2866 the communication protocol used by the microcontroller, after calculating impedance angles send to the Blynk server and local SCADA system (HMI) to display, and to distinguish between the healthy and faulty state, then releasing the command for connect or disconnect single or three phase . An algorithm is planned and uploaded on the ESP2866 microcontroller as shown in Figure 4.

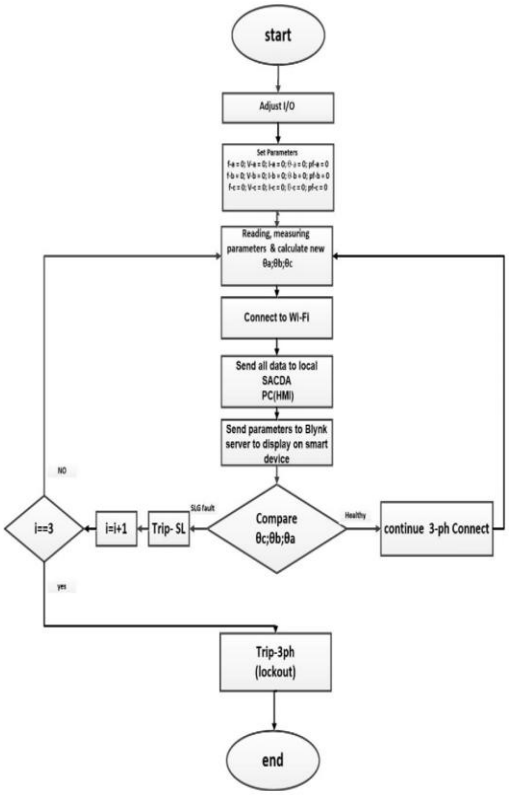

Fig. 4. Flowchart of Proposed (ARR-SCADA-IOT)

A Flowchart of the the suggested system for variable observing and auto-reclosing relay is explained in the points below:

Step-1:Setting I/O of the ESP2866 microcontroller for the purpose of obtaining the measured parameters from PZEM-004T unites.

Step-2:

a) Set up the parameters of three PZEM-004T unites as zero value.

b) All parameters would update continually in real time in the next task is prepared to do.

Step-3: Read parameters and send to the ESP2866 microcontroller to calculate impedances angles of three phases

Step-4: Connect ESP2866 microcontroller to the Wi-Fi network, to deal with IoT technology.

Step-5: Send all data to the local SACDA PC(HMI) by using USB cable to display all parameters on the monitor.

Step-6: Send parameters to Blynk server to display on a smart device.

Step-7: Comparing the angles of the impedances that were calculated in real time with the values according to the program that was programmed and uploaded on the ESP2866 microcontroller and then taking a decision to continue to connect of three power lines at the health condition, or disconnect the faulty line and return it to work after a delay time for extinguishing the electric arc and repeat for twice , and then disconnection and lockout of the three lines in case the fault persists for the third time.

5. Experimental Results and Discussion

The prototype of proposed system was connected in the laboratory as shown in Figure 5 below.

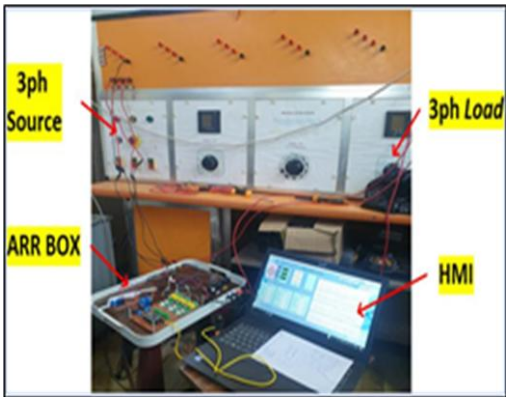

Fig. 5. Prototype in power laboratory

All measurements of electrical parameters; frequency, voltage, current, active power, power factor, and angles of impedances are displayed in real time on the HMI of local SCADA system and IoT platform in Blynk.App on the smart phone as shown below in figure 6 and figure 7 respectively.

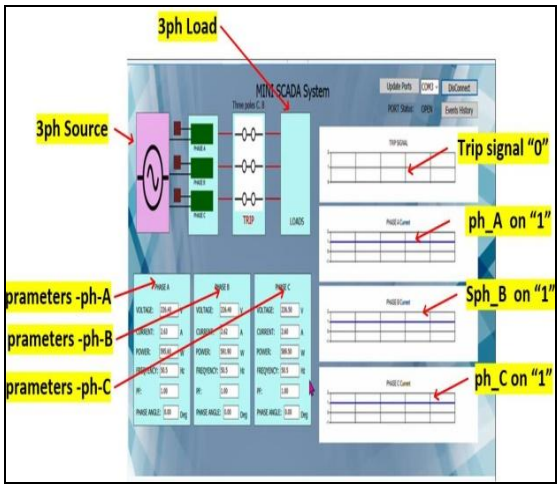

Fig. 6. Electrical parameters in HMI

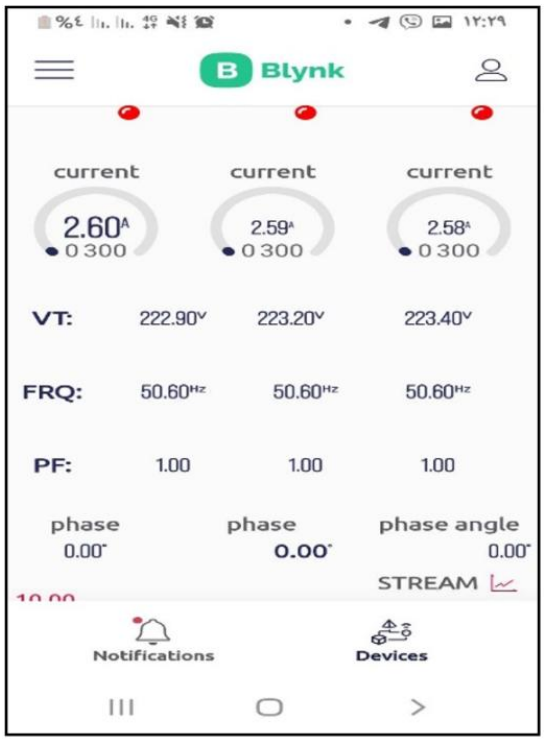

Fig. 7 . Display electrical parameters in Blynk App in real time.

6. Results Discussion

The prototype of the local SCADA system was connected in the laboratory, and the system was operated and tested.All cases that were tested in (ARR- Box) above will be displayed results on the (HMI) of the designed system, in addition to the ability to control the opening of all circuit breakers through the HMI screen as the figures below:

- Case1, three-phase are energized state. the electrical parameters (V, I, pf, w and the angles of actual impedance) in real time in HMI.
- Case2,single-shot auto-reclosing state. Figure (4.19) shows that in HMI.
- Case3:Multi-shots auto-reclosing and locked out state and display that in HMI.
- Case4 , emergency trip order from HMI and locked out state. On the practical side, a prototype was built and set up in real-time utilizing a PZE-004T and microcontroller board (ESP2866) programmed by IED software with control and monitoring by IoT environment and local SCADA system.

7. Conclusion

The results of this adaptive prototype Auto-Reclosing to recognize at transient fault occurrence based on the angles of actual impedances (in the positive sequence only), can distinguish the exact faulty phase and the system.This prototype is designed and implemented with a local SCADA system with pc using c# language program and IOT by using a smartphone uses the Blynk app and Wi-Fi to monitoring and control system. This model is a low-cost and is easily applicable model for auto-reclosing system.This compact system measure and monitor three-phase voltages , currents , pf , frequency and phase angles . The model is a low cost and easily applicable model for auto-reclosing system .This work is brought to enhance stability, synchronism, and reliability during the transient faults of OHTL. Thus, it leads to increase the continuity of the electric power system, especially to hydropower plants which connected to the grid.

References

[1] M. Y. Lada, M. S. A. Khiar, S. A. Ghani, M. R. M. Nawawi, N. H. Rahim, and L. O. M. Sinar, "Automatic recloser circuit breaker integrated with GSM technology for power system notification," AIP Conf. Proc., vol. 1660, no. 1, p. 090016, 2015.

[2] M. Mahmood and A. Eng, "Using Graphical User Interface NEPLAN to Calculate the Transmission Lines Faults in Power System," Int. J. Sci. Eng. Investig., vol. 6, no. 60, pp. 261–267, 2017.

[3] E. Prasetyo, "Impact of Auto-Reclosing on Transmission to Dynamic Response of PSS Equipped Generator in Cirebon," in Proc., pp. 95–100, 2020.

[4] S. Teimourzadeh, M. Davarpanah, F. Aminifar, and M. Shahidehpour, "An adaptive auto-reclosing scheme to preserve transient stability of microgrids," IEEE Trans. Smart Grid, vol. 9,

no. 4, pp. 2638–2646, 2018, doi: 10.1109/TSG.2016.2615096.

[5] W. E. Sastra Wibawa, M. Zainuddin, S. Humena, Syafaruddin, and S. Manjang, "The impact of the auto-reclose using leader-follower control scheme on transmission power system stability enhancement," in Proc. 2nd Int. Conf. High Voltage Eng. Power Syst. (ICHVEPS), 2019, pp. 10–14, doi: 10.1109/ICHVEPS47643.2019.9011039.

[6] J. Blumschein, Y. Yelgin, and A. Ludwig, "Adaptive autoreclosure to increase system stability and reduce stress to circuit breakers," in Proc., pp. 1–8.

[7] S. Morzaria and S. Surve, "Arduino based autorecloser for three phase AC system," Int. J. Eng. Res. Technol., vol. 5, no. 1, pp. 1–3, 2017.

[8] R. H. McClanahan, "The benefits of networked SCADA systems utilizing IP-enabled networks," Rural Electr. Power Conf. Papers, no. 02, pp. 0–7, 2002, doi: 10.1109/REPCON.2002.1002297.

[9] G. Yadav and K. Paul, "Architecture and security of SCADA systems: A review," Int. J. Crit. Infrastruct. Prot., vol. 34, p. 100433, 2021.

[10] L. O. Aghenta and M. T. Iqbal, "Development of an IoT based open source SCADA system for PV system monitoring," in Proc. 2019 IEEE Canadian Conf. Electr. Comput. Eng. (CCECE), 2019, pp. 1–4.

[11] K. P., "A sensor based IoT monitoring system for electrical devices using Blynk framework," J. Electron. Informatics, vol. 2, no. 3, pp. 182–187, 2020, doi: 10.36548/jei.2020.3.005.

[12] I. T. Journal, "Transmit power control for optimization of wireless sensor networks," Inf. Technol. J., no. November, 2014, doi: 10.3923/itj.2008.876.882.

[13] R. Porkodi and V. Bhuvaneswari, "The Internet of Things (IoT) applications and communication enabling technology standards: An overview," in Proc. 2014 Int. Conf. Intell. Comput. Appl., 2014, pp. 324–329.

[14] NetBurner, "Architectural frameworks in the IoT civilization." [Online]. Available: https://www.netburner.com/learn/architectural-frameworks-in-the-iot-civilization/

[15] C. Server, M. P. Sharma, P. Kantha, and C. Science, "Realization of an IoT system for real-time remote surveillance of multi-sensor network and control of multiple appliances using 'Blynk'," in Proc., pp. 1367–1372, 2020.

[16] B. Gopika and S. George, "IoT based smart energy management system using Pzem-004t sensor & Node MCU," Int. J. Innov. Technol. Explor. Eng., vol. 9, no. 7, pp. 45–48, 2021.

[17] R. Khwanrit, S. Kittipiyakul, J. Kudtonagngam, and H. Fujita, "Accuracy comparison of present low-cost current sensors for building energy monitoring," in Proc. 2018 Int. Conf. Embedded Syst. Intell. Technol. & Inf. Commun. Technol. Embedded Syst. (ICESIT-ICICTES), 2018, pp. 1–6.

[18] N. M. Khoa, L. Van Dai, D. D. Tung, and N. A. Toan, "An advanced IoT system for monitoring and analysing chosen power quality parameters in micro-grid solution," Arch. Electr. Eng., vol. 70, no. 1, 2021.