

GSM Monitoring and Protection of Power Transformer

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Abstract:

Over the past years electricity has become the vital element in any country's growth. In addition to it, the per capita income and industrial or trade expansion also depends upon the electricity generation of that region. However, in Pakistan, over a decade, electricity generation has become a difficult task to achieve due to certain political and financial constraints. As a result, the only hope for betterment would come by working on the distribution side so as to bridge the gap between the electricity demand and generation. This paper proposes a protection mechanism which would protect the distribution transformer for effective monitoring and protection of the power system. The sole objective of the proposed methodology is to work on a GSM based monitoring mechanism to ensure protection of the power system against phase faults. Moreover, an ease is also created at the management to easily de-energize and re-energize the power system over GSM whenever a fault occurs. Effectual guarding of the transformer would cut down the maintenance costs and power losses at a massive extent.

Index Terms—Electricity Demand, Power Transformer, Protection, GSM

I. Introduction

Worldwide, the overall power losses and energy losses are dependent on the fact that their energy management systems are not efficient in terms of protection. Electricity rates have kept on increasing in Pakistan all the time. Pakistan is facing huge energy crisis and the demand of electricity is increasing exponentially. The electricity shortfall has hit the record level of 7,075 MW and it's not looking to be resolved in near future. Total electricity consumption has touched 18,000 MW in recent times due to increase in use of electrical appliances, particularly, the usage of air conditioners require additional 3,500 MW of electricity, which further widened the demand and supply gap. Electricity providing companies are making all possible efforts for electricity generation and it has also launched a massive media campaign to educate consumers about imposing energy discipline and persuading them to conserve energy, through print display ads, public service messages but another main question arises that inspite of having a power generation capacity of 21,143 MW why are we facing such energy crisis, this is because of insufficient energy and power systems. Lack of information at the sub-station regarding the status of the network has been identified as the major drawback to its effective monitoring, working and protection. Major shortfalls and discontinuity in the supply of electricity are

a result of such information lacks that our energy system is facing now a days. Moreover, transformer being the most expensive equipment in the entire system hierarchy, we cannot afford to spend our monetary resources on it again and again.

This paper proposes to develop and design such a system that would not only reduce the losses but also protect the equipment of which our system consists of. The main focus of our project is to ensure efficient monitoring and protection of distribution transformer over GSM [6].

It also proposes designing a power transformer, relays (Differential and DTOC), for the purpose of protection from faults [13]. Moreover, it also includes a microcontroller (Arduino Mega) in order to interface the GSM module (SIM 900) [9].

The task of protection would be achieved by the relay. Constant monitoring and update regarding the status of the transformer would be achieved by sending SMS over the GSM. This way the main aim of our project, which is, constant monitoring and protection of power transformer would be completed without the much involvement of any manpower is fulfilled [17].

This system will help us to identify problems before any catastrophic Failure, thus resulting a long life service for transformers. This system is based on embedded system as we are using microcontroller as discussed before. Embedded systems are self-contained programs that are embedded within a piece of hardware. Embedded systems are usually set to a specific task Another way to think of an embedded system is as a computer system that is created with optimal efficiency, thereby allowing it to complete specific functions as quickly as possible [10]. It has also the advantages of significant cost savings, power consumption and greater reliability.

II. Literature Review

In earlier days, conventional methods were used to monitor the electrical system and ensure its protection. The example of a conventional remote operating and monitoring system includes the protection equipment that serves as a server, the PC in the office serves as a client and both these equipment communicated by 1 to 1 [1]. By this, a record of the current and voltage data can be kept that is fetched by the relay equipment but a drawback was that whenever the relay equipment was activated by some power failure, there was a requirement of the presence of manpower 24/7 at PC who would set or change values of the protection relay after the detection on any abnormal occurrence that is, a fault. It is important that the

information in the relay can be accessed from an office for the mechanism to perform the function [2]. Although the remote operating and monitoring system has outstanding features, the PC and the protection system are connected with each another, and while operating this system, it is compulsory that the operator looks at the PC browser continually all the time [1]. In addition, to acquire the information from a number of relays the operator must specify the address for each relay in order to access it, which is a lot more complicated and time consuming. Thus, there is a need to design such a protection and monitoring system that is free from all these drawbacks and limitations [3].

The main and the most expensive equipment in any power system assembly is a transformer, whether it is power or distribution. Transformer core faults mainly refer to the heating of the core due to damage in the lamination. If any portion of the core lamination is damaged or the lamination of the core is bridged by any conducting material, it causes sufficient amount of eddy current to flow through, it hence allowing the core to overheat. Usually, the insulation of the bolts fail, that are used for tightening the core lamination together, also allowing sufficient eddy current to flow through the bolt and causing the core to heat up. This type of insulation failures cause severe local heating, that further cause severe core losses but they do not affect the magnitude of the input or output current. Excessive over heating of the transformer core leads to the breakdown in transformer insulating oil along with the evolution of gases. In the contrary, these types of faults cannot be detected by the normal protection schemes that are designed for transformers.

The external faults of a transformer have further two categories: symmetrical faults and unsymmetrical faults, most occurring being the unsymmetrical ones. As all these faults are asymmetrical faults they do not affect each of the three phases equally. In order to remove these faults the easiest method is to utilize the symmetrical components [7]. In symmetric sequence methods the electrical system is seen as a superposition of three components:

- A positive sequence component in which all the phases are in the same order as the original system
- A negative sequence component in which the phases are in opposite order as in the original system
- Zero sequence component which is not really of a three phase system but all the phases are in phase with respect to each other [4]

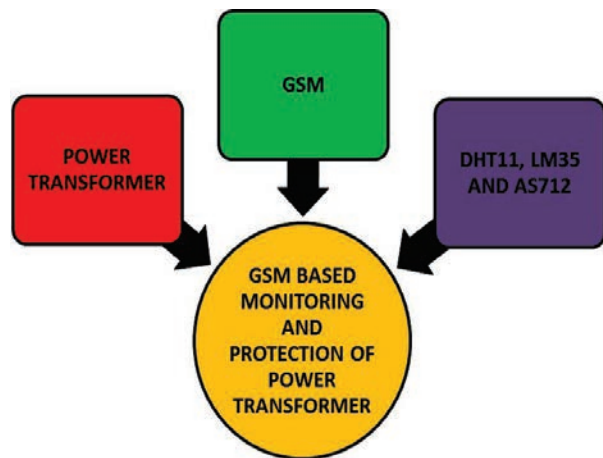
Under voltages and over voltages are also counted as faults to our equipment that can cause severe harm and damage to it [8]. Under voltage is defined as incoming line voltage at the point of use which is smaller than the Public Service Commission's mandates legal limits or smaller than the voltage rating of the connected equipment [3].

The fact that the devices and electrical equipment could be damaged, the low line voltage is considered as a safety hazard. Over voltages are defined as the incoming line voltage at the point of use which is larger than the Public Service Commission's mandated legal limits and is also greater than the voltage limits of the connected equipment [3]. Over voltage is the main reason for premature failure of the connected equipment and is a major problem faced by the industrial sector. The main causes for over voltages include inadequate size of power distribution systems, abrupt reductions of load and slow reaction time for distribution systems [9].

Power system protection is a separate branch of electrical power engineering that deals with the protection of electrical power systems from faults through the isolation of faulted parts from the rest of the system [2]. The objective of a protection scheme is to keep the power system stable by isolating only the components that are facing fault, while leaving the remaining network still in operation.

III. Proposed Methodology

This paper proposes the methodology that should be used to effectually monitor and protect power transformer by using GSM as a communication protocol. To achieve our task of successful monitoring and protection of distribution transformer via GSM, the method of differential protection would be adopted, due to the reliability factor, as we would be designing a Definite Time over Current (DTOC) Relay and Differential Relay for effective protection. Also, data transmission would be achieved by interfacing GSM module with microcontroller.



A. Calculations

According to our requirement, we needed to design a 700 VA 220/110V step down transformer. In order to perform the design calculations of transformer we need to know the primary voltage, secondary voltage and the VA rating of the transformer to be designed are 220V, 110V and 700VA respectively.

The current of the primary (input) and secondary (output)

side are calculated by the following relation shown in (1) and the results were calculated to be 3.18A and 6.36A for primary and secondary current.

$$I = \text{Power (VA)} / \text{Voltage (V)} \quad (1)$$

Further ahead, after calculating the currents, the turn ratio can be calculated easily by utilizing (2) and that turned out to be 2.

$$N_p/N_s = V_p/V_s \quad (2)$$

In order to design the transformer, core being the major component in a transformers construction, the core area needs to be calculated at first. The formula for core area (CA) calculation is stated in (3)

$$CA = 1.152 \times \sqrt{V_s \times I_s} \quad (3)$$

Where V_s is secondary voltage and I_s is secondary side current. In this case, the voltage for secondary side is 110V and the current for secondary end is 6.36A. The core area was 30.4703 cm².

These were some certain initial calculations that were done in order to get an idea regarding transformer modelling. Dense and complete calculations were not kept in regard as the sole purpose is the monitoring and protection at the transformer end.

Once done with these calculations, parameters like flux density and window size area were kept ideal or ignored as per say, as the dimensions of transformer required for our project were in VA that is, quiet minimum.

B. Hardware Design of Transformer

This section of the paper proposes all the steps that were taken to complete the hardware implementation of the proposed methodology. Starting from the calculations and chose the bobbin of length 2-inch and width 2.5-inch. Bobbin is also used for E-I stacking of the transformer core. After the selection of bobbin we use the enamel copper wire. Reason for selecting the copper wire was due to its high conductivity, efficiency and less losses. According to the American wire gauge (AWG) standard we chose the wire size of 18 and 22. We gave 275 turns on the primary side and on the secondary sides the number of turns were nearly 175, matching our theoretical readings of transformer. After a layer of equal turns has been wound, an insulating paper was placed in between before starting another layer of winding. The paper at the end of each layer of wire is used so that we can insulate it from the previous one. Although there is no specific rule but, primary winding should be placed first or nearer to the core as there is less current and high voltage and secondary should on upper side as high current and low voltage side is there.

After the winding of the transformer, varnish was applied to the winding so that no moisture etc. can enter the winding and damage the transformer from inside. When the core is completely filled, an extra amount of core is

fitted to reduce the magnetostriction losses and reduce the humming sound. After the insertion of core, varnish was again applied to the core for the reduction of eddy current losses and to dissipate heat as well as save the core from rusting and foreign particles.

C. Simulink Models of Relays

The Differential relay and Definite Time Overcurrent relay were implemented on Simulink block of MATAB in order to understand its working and tripping process. The figure below shows the internal logic diagram of both the relays. The time setting and pickup current setting were accordingly and so were the faults applied. These relays were tested in a three phase power system due to software limitations. The output current waveforms are also displayed in the figures below that show how the relay operates and trip according to the respective time and current settings.

The internal circuitry Simulink models of both the relays comprised of discrete time RMS value blocks, which after certain constant and mathematical operations were fed to the S-R Flip Flops as an input. Their collective outputs were fed to a three input AND gate and the output was denoted as the circuit breaker.

Differential relay had two input, the HV side and the LV side according to the relay operation. Whereas the Definite Time Overcurrent relay had three input with an additional component known as the counter to keep track of specimen time.

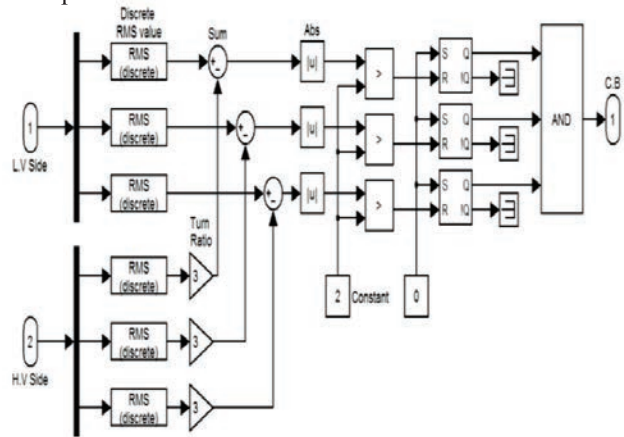


Figure 2: Logic Circuit of Differential Relay

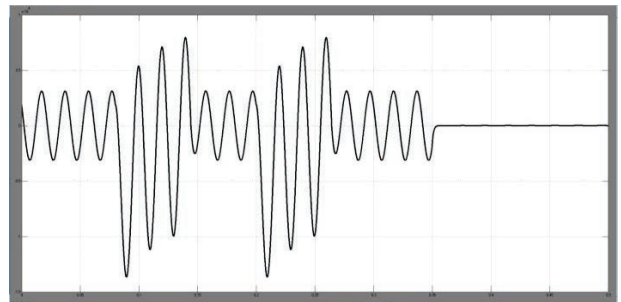


Figure 3: Current Waveform Differential

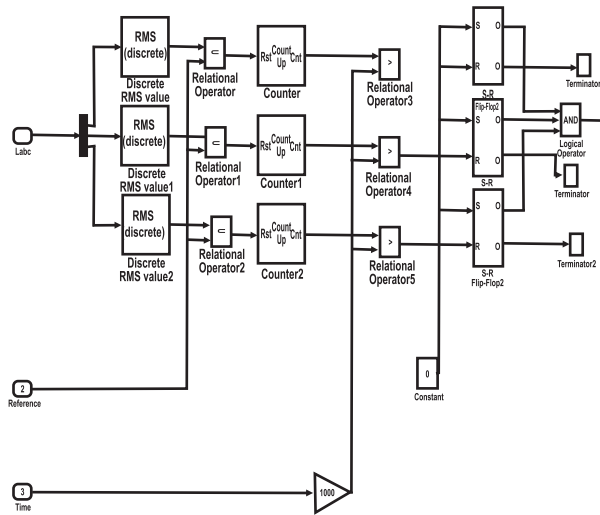


Figure 4: Logic Circuit of DTOC Relay

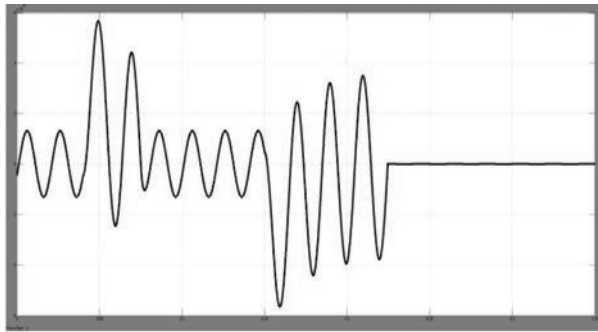


Figure 5: Current Waveform DTOC

D. Integration

GSM module, LM35, ACS712, LCD 16x2 and DHT11 were interfaced with the Arduino mega board. The figure below shows the block diagram of the methodology proposed in this paper.

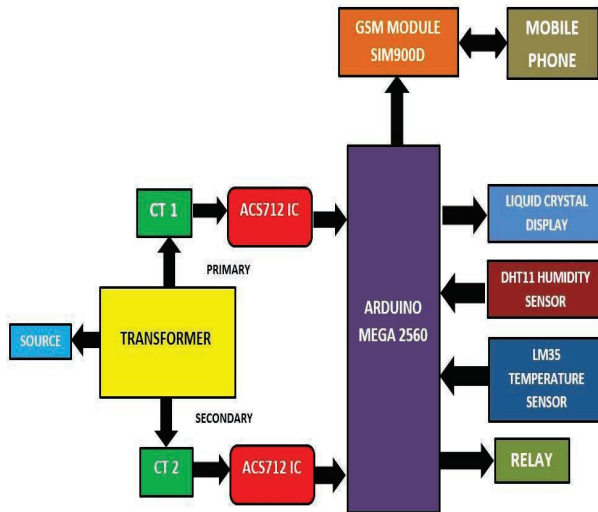
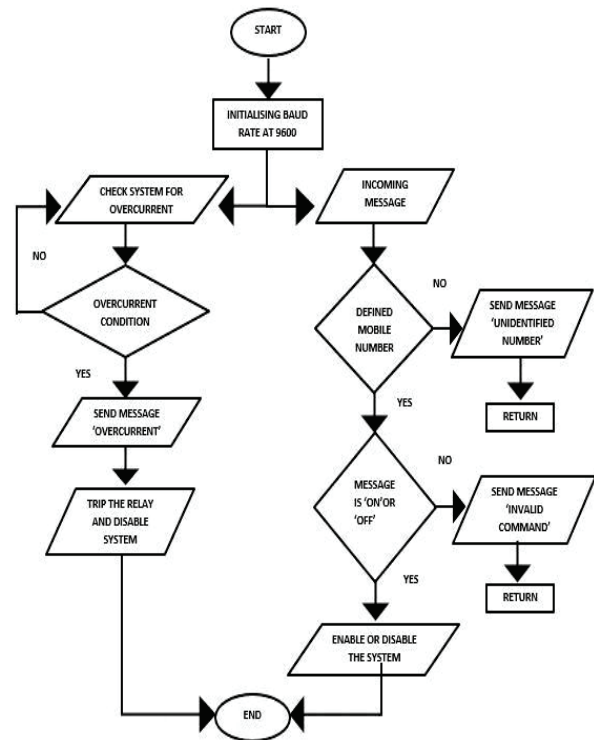


Figure 6: Block Diagram

GSM Module SIM900D was used to effectively energize

and de energize the system according to the command sent through Short Message Service (SMS) via the designated personnel. In case of over current, over loading, over voltage, high humidity or high temperature the GSM module would generate a message and send to the designated person informing him about the nature of the fault that has occurred and the status of the system that it had be turned off. Subsequently, the relay would also be tripped and turned off. On the contrary, the person would have the ability to turn off or on the system by sending in the required command to the GSM module. This task is simply achieved by parsing the message strings received at both ends. This entire information is also displayed on the LCD simultaneously.

The flowchart of GSM implementation is mentioned in the figure below.



IV. Results Generated

As a result of the methodology proposed in this paper, effectual and accurate protection of power transformer was done along with constant monitoring of its status.

V. Conclusion

Cutting down power and increasing reliability, GSM based protection system of power transformer plays a vital role in monitoring the electric distribution system.

In future, this protection scheme can also be applied to fulfil the purpose of protection for a three phase power system. In addition to it differential protection scheme can also be incorporated in order to protect a number of power transformers installed in a particular area.

VI. References

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