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Transformer Protection using PlC and GSM Technology

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Abstract- Distribution transformers of substation are one of the most important equipment in power system network. Because of, the large number of transformers and various components over a wide area in power systems, the data acquisition, condition monitoring, automatic controlling are the important issues. This paper presents design and implementation of automatic control circuits which is used in PLC automation to monitor as well as diagnose condition of transformers, like load currents, temperature and voltages. The proposed on-line monitoring system integrates a solid state device named PLC (programmable logic controllers) and sensor packages. The suggested plc monitoring system will help to detect the internal fault as well as external fault of transformer and also diagnose these faults with the help of desired range of parameters which is setting by programme.

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I. Introduction

Now day's protection of equipments in power system is a very important aspect. The power system equipments are valuable and important for well operation of power system network. A Transformer is such equipment which is one of the most important machines in the power system network. High reliability is must for a transformer even in adverse condition. For this condition PLC automation is used; various types of faults in a transformer can be detected and rectified. The Power system without a transformer is like a human without heart. So the protection of a transformer is of utmost importance. The Relays here are provided for sensing the fault current and provide the protection to the transformer. The user gets a message in the form of a SMS (short service message) with the help of a GSM module interfaced with a PLC.

II. Fault Detection in Transformer

a) Under Voltage

The under voltage fault is when the voltage value gets below some percentage of the rated value according to the countries electrical standards. Here in India according to IES the rated permissible voltage is as below

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- Above 33kV (-) 12.5% to (+) 10%.
- Up to 33kV (-) 9.0% to (+) 6.0%.
- Low voltage (-) 6.0% to (+) 6.0%

The faults can be detected using a voltage sensor or a Potential Transformer. So there is a PT connected to a transformer which steps down the voltage. The voltage is then converted to current through V to I converter and then that current is fed to the PLC. The fed current from the V to I converter will be in the range of 4 to 20 MA.

b) Over Voltage

The over voltage fault occurs when the value of voltage exceeds some percentage of the rated value as per the countries electrical standards. In India the electrical standards are as shown above.

Due to sudden disconnection of a large load there is possibility of an increase in voltage. Over voltage in the power system generally causes an increase in stress on the insulation of transformer. Here also PT is used which steps down the voltage. Then the voltage is converted to current using V to I converter. This output current from the V to I converter will be in the range of 4 to 20 MA.

c) Over Load/ Over Current

Over loading is when over current stats flowing on the secondary side of a transformer. The over load or the over current fault occurs when the current in a transformer exceeds its rated current value. Sometimes due to sudden increase in the load more amount of current gets drawn which is higher than the rated current of our transformer. This condition occurs for a very short time as it is a harmful condition for our transformer and is tripped rapidly. So a CT is used which steps down the current and gives input to our PLC in the range of 4 to 20 MA.

d) Temperature

When the temperature inside transformer goes above a rated value it is harmful for the windings. The transformer rated on a 24-hour average ambient temperature of 30°C (86°F). Increase in over current and over voltage leads to increase in the temperature of transformer oil which might weaken the breakdown strength of the winding insulation. This temperature increase can be a result of high current, seasonal change, region of operation. Due to high temperature the insulation can break down and following which a short circuit may occur. This fault can be detected using a temperature transducer.

e) Phase to Phase Fault

This type of fault occurs when one phase gets shorted to the other. This gives rise to high current to flow compared to the earth fault current.

II. PLC (Programmable Logic Controllers)

1. Components of the PLC system

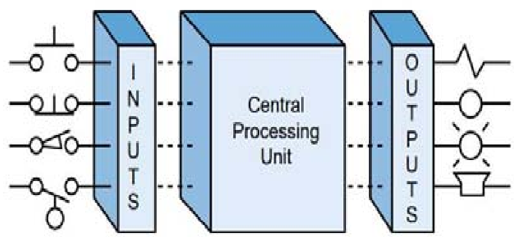

Figure 1: Programmable Controller Block diagram

a) CPU or processor

The main processor i.e. Central Processing Unit or CPU) is a microprocessor-based system that executes the control program after reading the status of inputs and then sends commands to outputs.

b) I/O section

The I/O modules or Input/output modules act as "Real Data Interface" between field and CPU. The PLC determines the real status of devices, and controls the devices by the means of the I/O cards.

c) Programming device

A CPU card can be connected with a programming device through a communication link via a programming port on the CPU.

d) Operating station

An operating station provides an "Operating Window" to the process. It is usually a separate device (generally a PC), That is loaded with HMI (Human Machine Interface) software.

III. PLC Hardware

The hardware of PLC is made of CPU, Memory, Input/output, Power supply unit, and programming device. Below is a diagram showing the components of PLC and its functioning.

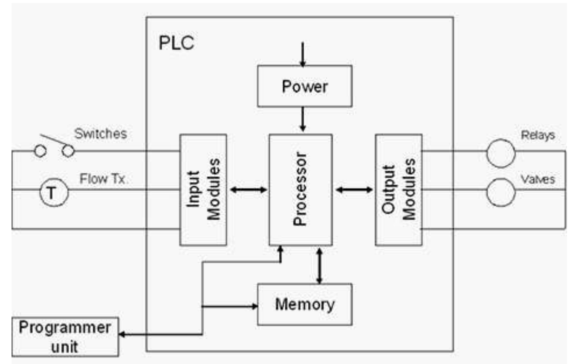

Figure 2: Hardware components of PLC

The heart of the "PLC" is in the centre, i.e. the Processor or CPU (Central Processing Unit)

a) *The CPU* executes the PLC program, data storage, and data exchange with I//O modules. It processes the input data and according to program produces output data.

b) *Input and output modules* are the medium for data exchange between devices and CPU. It tells CPU the exact status of devices and also acts as a medium to control them.

c) *A programming device* is a PC loaded with programming software, which allows a user to create, transfer and make changes in the PLC software.

d) *Memory* provides the storage media for the PLC program as well as for different data. The processed data is also stored in the memory only.

e) *Power supply* is generally isolated. Most of the PLCs work at 220VAC or 24VDC.

IV. GSW

Figure 3: Sim 900A module

GSM: - Global System for Mobile communication (GSM) has been the best trustable and access wireless communication systems and is used widely. We can communicate with the user by using a mobile phone over GSM network. The GSM is interfaced with a Programmable Logic Controller (PLC) and the GSM is connected to mobile phone.

The GSM sends data in the form of SMS (short message service) message to indicate if any fault occurs or if there is any abnormal condition. The GSM module can also send the user the status and alarms. This GSM Modem can accept any GSM network operator SIM card. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications.

Applications like SMS Control, data transfer, remote control and logging can be developed easily. The modem can either be connected to PC serial port directly or to any microcontroller or PLC. It can be used to send and receive SMS .Components that are needed to interface the GSM with PLC are RS485 to RS232 converter, RS232 cable, SMPS for PLC power supply, GSM module and PLC.

V. Design of PLC based Transformer Protection

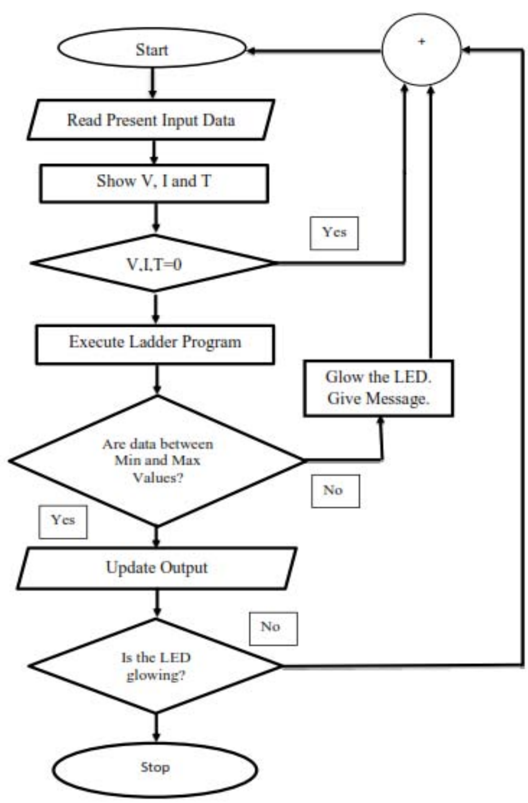

Figure 4: Block diagram of Transformer protection using PLC

The Transformer protection using PLC consists of different blocks of function as shown above.

a) CT

The current through the transformer is passed through CT and following which the CT steps down the current to the range of 4 to 20 MA.

b) Rectifier

The output of CT is connected to a rectifier and so the current is fed to the PLC after rectifying through a rectifier. Here Schottky diode is used for rectifying for low voltage drop by the rectifier. The normal diode has high voltage which decreases the accuracy.

c) PT

The voltage through the transformer steps down using a potential transformer. This voltage is then fed to the VI converter for PLC input

d) V to I converter

The VI converter converts the change in voltage to subsequent change in current.

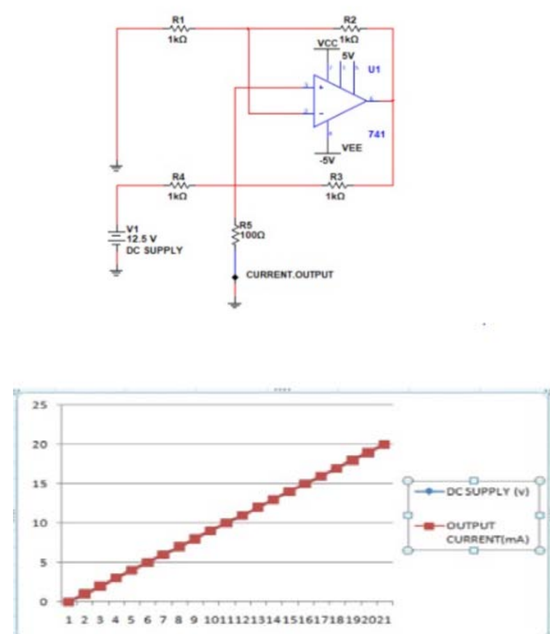

Figure 5: V to I converter circuit diagram and graph

The main need of the V to I converter is because the PLC we used only accepts current input in the analog channel with range of 4 to 20mA. The 1k ohm resistors across the op-amp converts the voltage to current by the means of ohms law and further the 1k ohm makes the rated current value up to 12mA.

e) Temperature transducer

The temperature transducer is used for sensing the temperature the sending the temperature data to the PLC to compare it with the reference set by the user in downloaded program.

f) PLC

The PLC is fed with the current and voltage through CT and VI converter in form of 4 to 20 MA. The program is downloaded to the PLC with the calculated reference of fault and to trigger the tripping command when the value exceeds the reference limit set by the user.

When the parameters being tested are in rated condition the the PLC will trigger the healthy output signal to the healthy system indicated LED. During fault the parameters V and I will exceed its lower or upper limit with respect to the PLC's fed reference input. During this condition the PLC will immediately trigger the respective trigger pulse.

g) PLC Output

During the time of fault the PLC triggers signal pulse to the trip circuit and alarm circuit. Here there is a LED as an indication for the faulty condition. Each colour LED states different type of fault. Further the PLC sends the command to the GSM module fed with a program to send the fault message.

h) GSM

The GSM when gets a command from the PLC about the occurred fault and the nature of fault. Further according to the programmed GSM and fed message about the respective fault the message of the fault is send to the user. Thus the fault message is displayed on the users mobile phone.

VI. Characteristic Data

Transformer rating:-230/12 V, 60VA

CT turns ratio:-1/450

Voltage (V)	Current (I)	V to I (DC) (mA)	I to I (DC) (mA)
160	2.4	9.56	4.23
180	2.7	10.70	4.82
200	3	11.77	5.45
220	3.3	11.89	5.96
230	3.5	11.93	6.37
240	3.6	11.95	6.63
250	3.8	11.98	6.94

Figure 6: Proposed Model

VII. Conclusion

In this proposed system we have designed a protection system of transformer based on PLC that is used to observe and control the current, voltage and temperature of a power and distribution transformer on both the primary and secondary sides. The proposed PLC system which has been designed to monitor the transformer's required parameter. It continuously monitors these parameters throughout its operation. When the PLC identify any change in the level of voltage, current or temperature values exceeding the upper or lower limit of rating respectively, the transformer has been made shut-down in order to protect from damages with the help of relays in the system. The system not only controls the transformer in the substation by shutting it down, but also displays the values throughout the process for users on HMI screen of PLC. This demand that the proposed design of the PLC system makes the transformer more robust against the adverse issues which makes the voltage, current or temperature to peak. Hence the distribution is made more secure, reliable and highly efficient by means of the proposed system. From this model we protect the distribution or power transformer from the adverse condition hence total life span of the transformer increase up to some extent.

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