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Analysis of Transformer Protection Systems Using Smart Relays for Electrical Energy Stability

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ABSTRACT

A transformer is an electrical device that is used to change the voltage from one level to another in order to transfer electrical energy from one place to another. One of the main benefits of a transformer is to reduce power loss in the electrical network. Transformers can be used to stabilize the electric voltage and keep the electric voltage within safe limits. The protection system on the transformer is very important to prevent damage or failure to the transformer which can cause disruption of the electricity supply or even fire. This protection will work to cut off electrical connections and prevent damage to the transformer. Overload interference occurs if the current read on the Smart Relay LCD is more than 10 A so that the contactor will work after a disturbance of 5 seconds and the green indicator light will turn off. Whereas for Overheat interference on the transformer if the temperature exceeds 45^0C then the contactor will work to turn off the system with a duration of 1-2 seconds then the green indicator light and the system will OFF. The voltage drop disturbance occurs if the voltage read on the Smart Relay LCD is less than 15 kV on the primary side of the transformer and less than 300 V on the secondary side of the transformer so that the contactor will work to cut off the voltage after a disturbance occurs for 8-10 seconds then the green indicator light will turn off.

Keywords: Transformer, Smart Relay, Protection System, Trip, Drop Voltage.

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1. Introduction

Electric machines are electrical components consisting of generators, motors and transformers. Electric machines are widely used for distributing electric power from power plants to loads or customers [1]–[4]. One type of electric machine that is widely used is a transformer. A transformer is an electrical device that is used to change the voltage from one level to another in order to transfer electrical energy from one place to another. This transformer has a very important role in maintaining the stability of electrical energy. One of the main benefits of a transformer is to reduce power loss in the electrical network. When electricity flows through the network, electrical energy will be lost due to resistance in the cable and network. In a transformer, the electric voltage is increased so that the electric current can be reduced thereby reducing the power loss. Transformers can be used to stabilize the electric voltage and keep the electric voltage within safe limits. In a very large power grid, electrical energy needs to be transferred from power plants to city centers or areas far from power plants. In this case, a transformer is used to convert the mains voltage to a level suitable for long distance travel without experiencing significant loss of power. Overall, the transformer is very important in maintaining the stability of electrical energy in the electrical network. With the right transformer, electrical energy can be transferred efficiently and voltage stability can be maintained to prevent damage to electrical equipment and ensure a stable and safe supply of electricity.

The protection system on the transformer is very important to prevent damage or failure to the transformer which can cause disruption of the electricity supply or even fire [5]–[8]. Several protection systems that are commonly used in transformers include Overcurrent Protection which works by detecting excessive current in the transformer. When the current exceeds a specified threshold, the protection will work to cut off the electrical connection and prevent the transformer from causing greater damage. Overvoltage protection operates when the voltage on the transformer exceeds a specified limit. This can occur due to failure of the voltage stabilizer equipment or due to lightning and disturbances in the electrical network. This protection will work to cut off electrical connections and prevent damage to the transformer. Over temperature Protection operates when the temperature in the transformer exceeds a specified limit. This can happen because too much current flows in the transformer or because of a coolant leak. This protection will work to cut off electrical connections and prevent damage to the transformer.

Differential Protection operates when there is an imbalance between the incoming and outgoing currents in the transformer. This can occur due to damage to insulation or disconnected power cables. This protection will

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work to cut off electrical connections and prevent the transformer from further damage. The output from the sensor will be connected to the smart relay analog input. The transformer is the main component in this system. This component is connected to a contactor that has been controlled by the Zelio smart relay [9]–[12]. Therefore it is necessary to make an analysis of a smart relay-based transformer protection system to maintain the stability of electrical energy.

2. Methods

2.1. Research Scheme

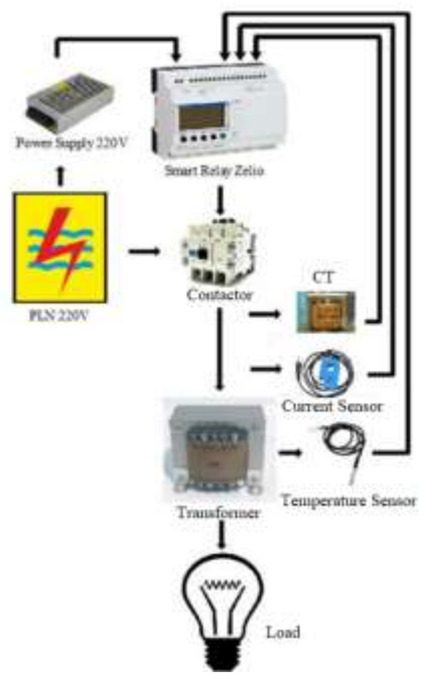


Figure 1. Research Scheme

The scheme of this study is described as shown in Figure 1. The following describes some of the electrical components used in this study. The power source from PLN 220V voltage is used for the main source of the system. The Power Supply is a rectifier component from 220VAC to 24VDC and is used to power the Zelio Smart Relay. Zelio Smart Relay is a tool that is used as a receiver, data processor and data viewer [13]–[16]. The contactor is a component that is used for the output of the smart relay and is used as a breaker for the power source in the event of a disturbance. The 350mA transformer as a measurement transformer is a component used to read voltage values. The SCT current sensor is used to read the value of the current going to the transformer. The output of this current sensor is a DC voltage with a very small value. This is intended to be read by the smart relay's analog input, so the output of this current sensor must be given an op-amp circuit first. The DS18B20 temperature sensor functions to detect the temperature of the transformer oil. This temperature sensor requires 5VDC voltage to work. How to install this temperature sensor by dipping the tip of the sensor in the oil that soaks the transformer. The output from this sensor is in the form of direct voltage / DC. Then the output from the sensor will be connected to the smart relay analog input. The transformer is the main component in this system. This component is connected to a contactor that has been controlled by the Zelio smart relay. The incandescent lamp functions as a load from the transformer, which will later be connected to the secondary side of the 5A transformer.

2.2. Programs on smart relays

The control system in this study is a Zelio smart relay, so smart relay programming is needed so that the system can run as desired. The way this system works is by pressing a button or switch, the system will be ON and the contactor will work to flow voltage and current to the transformer. Then the SCT 013 current sensor will read the current flowing from the contactor to the transformer. The current sensor must be calibrated according to the set point determined by the smart relay and displayed on the smart relay LCD. In addition to the current sensor, this system also uses a measuring transformer to measure the voltage flowing from the contactor to the transformer and is calibrated by a smart relay, which has set its set points and then displayed on the smart relay LCD. The temperature sensor here is used to measure the oil temperature in the transformer. the temperature sensor used type DS1820B with waterproof specifications will be immersed in transformer oil and will measure the oil temperature and then calibrated by a smart relay which has set points set and displayed on the smart relay LCD. The three sensors if one of the sensors passes the set point that has been determined through the initial calibration, then the smart relay will order the contactor to OFF or cut off the voltage flowing to the transformer. so that if this contactor is OFF it will indicate that the system is having a disturbance then the disturbance will be displayed on the smart relay LCD screen

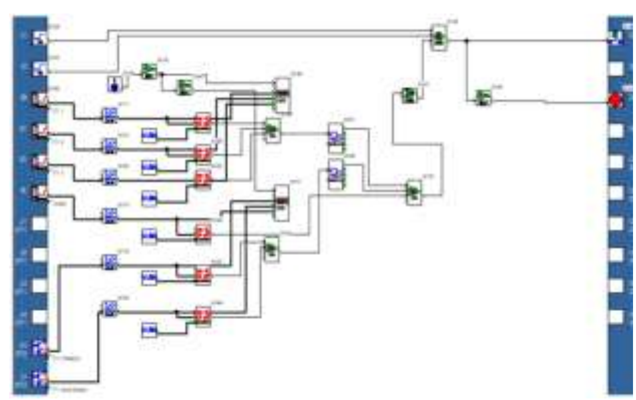


Figure 2. Programs on Smart Relay

3. Results

The test results of this system are in the condition of the standby indicator lamp on the yellow panel will light up indicating that it is already there the voltage source has entered. For the condition of the lamp indicator on the panel a green light indicates that the system is running normally on the Primary side (High Voltage) and on the Secondary side (Low Voltage). Over Load interference occurs if the current read is more than equal to $\geqslant$

10 A on the Primary side (High Voltage) duration of occurrence interruption for about 5 seconds. Then the contactor will trip. For Primary side voltage drop disturbance (High Voltage) occurs if the read voltage is less than equal to ⩽ 15 kV whereas for the Secondary side (Low Voltage) if the measured voltage is less than equal to ⩽ 300 V fault duration approx. voltage drop for 20 seconds. Then the contactor trips. For overheating problems on the transformer if the measured temperature is more than > 45 C then the contactor will trip with a duration of less than 5 seconds.

Table 1. Test Results Under Normal Conditions

Condition	Figure	Result
Normal Condition (<10A HV>15kV LV>300V T = 31 C)		Primary Side IR = 7A IS = 6A IT = 8A
		HV = 19kV LV = 349 V Temp = 31 C
		Green Indicator Lamp ON

Table 2. Test Results Under Overload Conditions

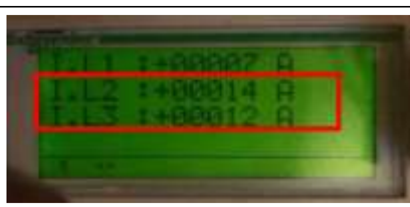
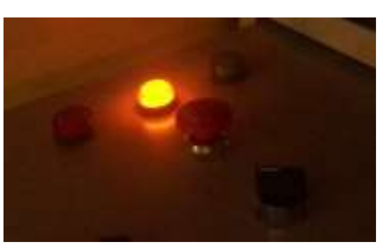
Condition	Figure	Result
Overload Condition (>10A Trip Time = 5 s)		Primary Side IR = 7A IS = 14A IT = 12A Trip Time = 5s
		Green Indicator Lamp OFF

Table 3. Test Results Under Overheat Conditions

Condition	Figure	Result
Overheat Condition (> 45 C Trip Time = 1 s)		Oil Temp = 58 C Trip Time = 1s
		Green Indicator Lamp OFF

Table 4. Test Results During The Voltage Drop Condition

Condition	Figure	Result
Voltage Drop (HV = <15 kV LV = < 300V Trip Time = 10 s)		HV = 0 kV Trip Time = 1s
		LV = 45 V
		Green Indicator Lamp OFF

4. Conclusion

Operation of the ON-OFF and Emergency systems using direct input has been running smoothly. The transformer voltage output can be read by the sensor and displayed on the smart relay LCD screen. Set point used for overload fault ⩾10 A with 5 second fault time, then the contactor will be OFF. For overheat fault set points ⩾ 45 C' with a fault time of 1-2 seconds, the contactor will be OFF. As for the voltage drop fault set point, the Primary side (High Voltage) ⩽ 15 kV on the Secondary side (Low Voltage) ⩽ 110V with a disturbance duration of 8-10 seconds each then the contactor will be OFF.

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