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A New Analysis Detects Short Circuit Faults In 1 Phase Networks

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ABSTRACT
This paper is designed to detect the location of short circuit faults in a 1-phase electrical network system. The power supply source with a voltage of 12 V is converted into two voltage sources, namely positive voltage (+) and negative voltage (-), which are used to supply a parallel resistance circuit to measure the voltage difference. The voltage difference is forwarded to the op amp IC TL084 CN (using only 1 op amp). The output of the op amp is sent to the interface (ADC) to convert analogue signals into digital ones that can be received by a PC via an RS 232 cable or USB serial. After the data is received by the PC, the next step is data processing using the Visual Basic 6.0 application, which is carried out after the calibration process to ensure that the results obtained are accurate and reliable in detecting the location of short circuit faults precisely.

Keywords : ***Short circuit, electrical fault detection, and Analysis.***

INTRODUCTION

The protection system plays a very important role in ensuring the continuity and reliability of the distribution of electrical energy, both in the industrial, office, and household sectors (Ramadhan, 2024). This system can protect equipment from being damaged when a disturbance occurs and limit the spread of the disturbance so that it does not have a wider impact, which can cause damage to other equipment or even disruption to the distribution network as a whole (Karta, 2020). With an effective protection system, the potential for losses can be minimized, especially for important equipment such as electronic devices in office buildings (Aryza11, 2018).

The use of cables in the electrical system is inseparable because cables function as a connector and means of distributing power from the center to consumers, such as households and other installations (Wijaya, 2019). In general, cables are installed in walls to prevent potential hazards, but cables often experience interference, such as short circuits between cables that can interfere with the electrical system and threaten human safety. Therefore, an efficient device is needed to detect short circuit interference and its location on the cable (Auliq, 2021).

LITERATURE REVIEW

An insulator is a material that can separate electricity from two or more electrical conductors, to prevent short circuits (Fuaddy, 2024). Each type of insulating material has its own characteristics and uses, but all have the potential to be damaged, which can cause electrical breakdown or short circuits. Damage to insulation can be caused by various factors, both from within the system (internal factors) and from outside (external factors). The main failure or damage to electrical insulators is caused by corona at high voltage, the presence of deposits pollutants and temperature changes (Triwibawa, 2024). One example comes from a short circuit in a cable that can damage the insulation due to the heat generated (Rachman, 2017).

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In cable insulation made of solid materials, damage can occur due to several conditions, such as mechanical failure caused by physical pressure or tension, electromechanical failure that occurs due to the interaction between electric and mechanical fields, extreme thermal conditions that can damage the properties of the insulating material, the formation of streamers that can lead to arcing or sparks, or even erosion that occurs due to harsh environments. If solid insulation experiences electrical penetration, which is a condition where high voltage manages to penetrate the insulation layer, then this will cause quite serious damage to the material. This electrical penetration often leaves a mark in the form of permanent damage to the insulation structure, known as permanent interference. This permanent interference can reduce the effectiveness of the insulation in preventing unwanted electrical flow, and often risks reducing the overall performance of the electrical system, causing further potential hazards if not repaired immediately.

Based on the duration of occurrence, disturbances are divided into transient (temporary) disturbances and permanent disturbances (Hermansyah et al, 2018). Transient disturbances are temporary disturbances that occur in a short time after being reconnected. The causes of this disturbance include lightning, birds, leaves, kite strings, and so on. Meanwhile, permanent disturbances are disturbances that persist even though the circuit breaker disconnects and reconnects the transmission line. The causes of this disturbance include overvoltage that exceeds the insulation strength, mechanical damage to the insulation, deterioration of the insulation due to moisture/heat, and operational errors.

Based on its symmetry, disturbances in the electric power system can be divided into two main categories, namely asymmetric disturbances and symmetric disturbances (Paramadita et al, 2019). Asymmetric disturbances cause an imbalance in the voltage and current flowing in each phase, which means that the electrical conditions in each phase become unbalanced. This asymmetric disturbance is divided into three types, namely single-phase short circuit to ground, two-phase short circuit, and two-phase short circuit involving the ground. In contrast, symmetrical disturbances are disturbances in three-phase electricity that occur evenly in all phases, which means that even though the disturbance occurs, the current and voltage in each phase remain balanced after the disturbance (Toguan, 2024).

This disorder consists of:

1. Three-phase short circuit fault
   This fault is rare, but is the most severe fault because the fault current on each line is the same size.
2. Three-phase short circuit to ground fault This fault is also known as non-system fault.
   a. Single Phase Power System Disruption to Ground
      A single fault from phase to ground can be depicted in Figure 1. In this fault there is the following relationship:

$$Ib = 0 \quad Ic = 0 \; Va = 0$$

$$Ia1 = Ia2 = Ia0 \text{……………,………………..(2.1)}$$

$$Ia1 = \frac{Vf}{Z1 + z2 + z0} \text{……………………………..(2.2)}$$

This equation is used for phase to ground faults. So :

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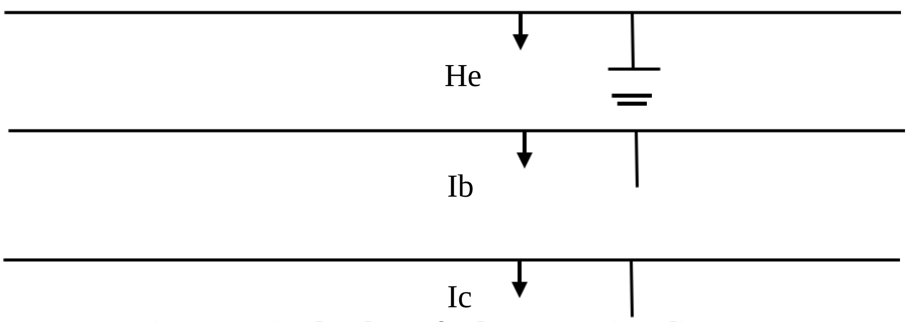

Figure 1.Single phase fault connection diagram to ground

Equations 2.1 and 2.2 show that all three circuits must be connected in series with the fault point to simulate a single phase to ground fault.

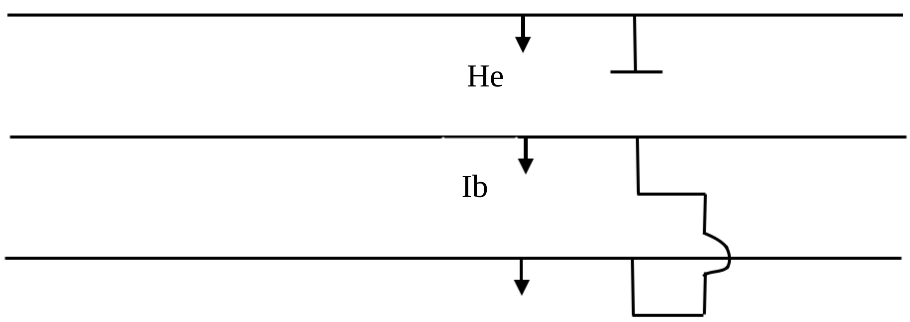

Figure 2.Phase to phase fault connection diagram

b. Interphase Power System Faults

As shown in Figure 3., for interphase fault, each phase of the three lines is connected to the fault. In this fault, there are the following relationships:

Vb = Vc He = 0 Ib = -Ic

The equations used for interphase faults in isolated generators have the same form.

$$Yes1 = Va2 \text{..........} \quad \text{.................(2.3)}$$

$$He1 = \frac{Vf}{z1+z2} \quad \text{.......................(2.4)}$$

In order to simulate an inter-phase fault, the positive and negative sequence nets must be connected in parallel at the fault point, as shown by equations (2.3) and (2.4).

c. Double faults in the power system from phase to ground

As shown in figure 2.3, for a multiple phase to ground fault, the phases are connected to each other. In this fault, there are the following relationships:

Vb = Vc = 0

He = 0

METHODS

This study uses a GUI-based short circuit fault location detector designer. The computer

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is used to see the location of the short circuit fault. The current interface converts analog signals to digital, allowing the computer to read signals from the device. The action of this resistor divides the voltage between the resistor resistance and the cable resistance. In addition, the OP AMP acts as a voltage amplifier.

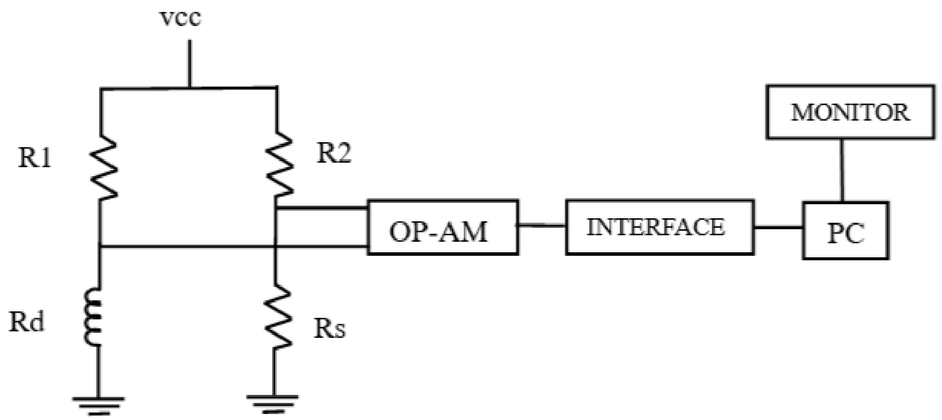

Figure 4.Short Circuit Detector Block Diagram

RESULTS AND DISCUSSION

Results

Circuit Design

This chapter designs and builds a tool to identify the location of short circuit faults. Hardware and software are needed to build this system. Some hardware includes amplifiers, resistors, and power supplies that increase the voltage to be read by analog-to-digital (ADC) hardware. ADC is the third part of the hardware, and some other aspects that need to be explained in this chapter are determining the specifications.

1. **Power Supply Circuit**
   The power supply circuit is used to provide enough power so that the entire circuit can perform its function properly. The power supply circuit consists of several parts, namely:
   a. Voltage Reducer
      This center tap (CT) type step down transformer is used to reduce the 220 V AC voltage to 12 V AC voltage, which is the amount of current that will be used to supply the tool circuit. Then the output voltage is directed to the diode and stabilized to 12 V with a 12 V regulator IC (7812).
   b. Voltage Rectifier
      As a full-wave rectifier, silicon diodes are used. These diodes convert AC waves into DC waves with a frequency of 2 times 50 Hz, or 100 Hz. These diodes also submit positive waves and center tap (CT) as negative outputs, with a diode current capacity of 1 A so that the diode is not too heavy. Although a unidirectional wave has been produced by the diode, there is still a ripple wave, or an impure state.
   c. Filter
      The filter used in this study is an electrolytic capacitor. The selected electrolytic capacitor

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plays an important role in the filtering process or filtering of the output voltage produced by the diode, with the aim of smoothing the voltage wave so that it becomes more stable and smooth. This ensures that the output produced is a cleaner and more controlled direct current (DC), with the desired voltage value, which is 5 VDC. The capacitor used has a capacitance value of 220µF and a maximum working voltage of 25V, making it suitable for this application. After the capacitor was installed, it was measured that the DC voltage at the output increased significantly to 16.12 Volts, which indicates a change in the quality and stability of the voltage due to the installation of this component.

By knowing the ripple voltage and load current, where the load current is determined based on the maximum current used, which is 500 mA. So, the value of the capacitor can be determined, which is 220.9 µF so that the value of the selected capacitor is 220 µF according to the type of capacitor on the market. In the use of IC regulator, additional capacitors are installed at the output to perform further filtering processes, so that the resulting voltage is in accordance with the specifications listed in the datasheet of the IC regulator used. In this case, the IC regulator used is type 7812, which has a certain capacitor value to ensure optimal output voltage stability and quality.

d. IC Regulator

The IC regulator used in this circuit is the LM7812 type, which functions to provide a stable output voltage of 12 VDC. This IC has three terminals or legs, each of which has a different function. The first leg functions to receive input voltage (Vin) from the positive (+) pole of the battery, while the second leg functions as a ground terminal (GND) connected to the negative (-) pole of the battery. The third leg, which is the output terminal (Vout), produces a stable output voltage. The main function of the LM7812 regulator IC is to keep the output voltage constant at 12V. To achieve this stability, an additional circuit is needed that functions to balance and stabilize the voltage, ensuring that the voltage received by the device remains safe and according to needs.

2. Single Power Supply

The power supply circuit provides the power needed to ensure the circuit functions properly. The main parts include:

a. A step-down transformer converts 220V AC voltage to 12V.
b. A full diode rectifier converts AC voltage to DC, although it still has ripple.
c. Electrolytic capacitors are used as filters to produce a stable DC voltage.
d. The IC regulator (7812) stabilizes the voltage to 12V.

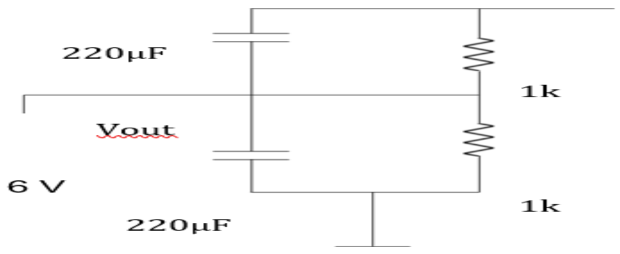

Figure 5.Single power supply

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3. Resistors

Resistors function as voltage dividers to produce voltage differences that will be further processed by the Op-Amp. Resistor value calculations are carried out to ensure the appropriate voltage.

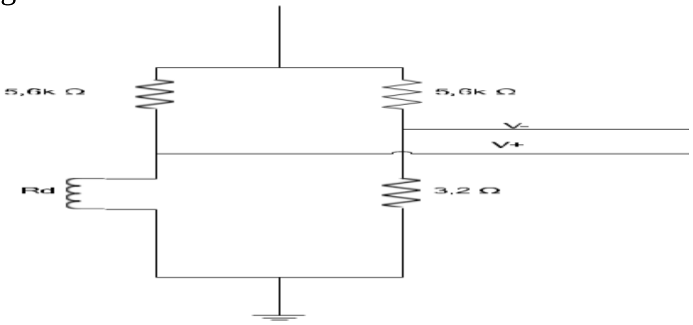

Figure 6.Voltage divider circuit

4. Op-Amp

Operational amplifiers function as voltage amplifiers with characteristics such as large input impedance, small output, and high voltage gain. The circuit uses the IC TL084 CN, with the gain calculating the voltage difference between the positive and negative inputs. The characteristics of Op-Amp are:

- Large Input Impedance (Zi) =∞
- Output Impedance (Z0) is small = 0
- High Voltage Gain (Av) =∞
- Band Width = wide frequency response∞
- V0 = 0 if V1 = V2 and does not depend on the size of V1.
  The operational characteristics of the amplifier (Op-Amp) are not dependent on temperature.

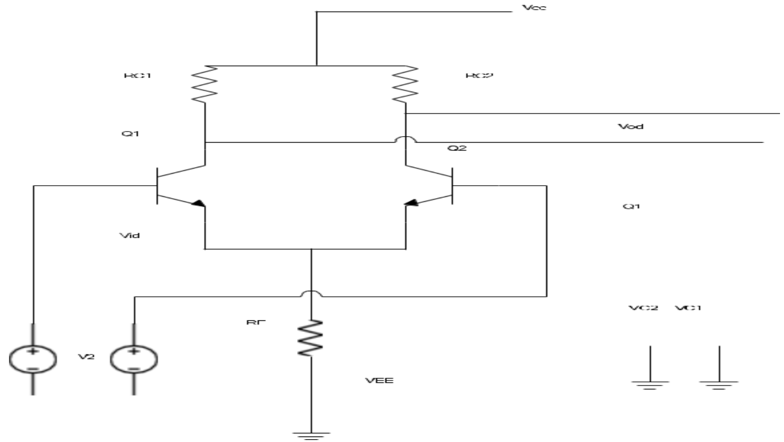

Figure 7. Basic Op-Amp Cirucuit

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5. **ADC (Analog to Digital Converter)**
   Converts analog signals received from Op-Amp into digital data. The data is sent to the PC via a serial USB cable for further processing.

6. **Data Communication Media**
   A serial USB cable is used to transfer data to Visual Basic software, which displays the interference distance after calibration is performed.

Software

This program is designed using Visual Basic 6.0 with components such as buttons, labels, and MS Comm for data communication. The main display of this application is designed to display the results of disturbance measurements directly, making it easier for users to monitor and analyze the data received. The MS Comm component is used to connect the measuring device to the computer, allowing data to be sent and received in real-time.

General steps to create a program:

1) Place the required components in the form window using the tools in the toolbox window, arrange the component layout.
2) Set component properties through the properties window.
3) Write the program code in the code window, according to the event of an incident that will be felt by the component. For example, click and so on.

Designing the main form for the tool bar display:

1) Place the control command buttons that function as buttons to view data.
2) Labels are used to write descriptions.
3) Textbox is used to write facility names or numbers.
4) MS Comm is used for computer communication with external devices connected to available applications.

Design Weaknesses

1. This design can only measure or detect the location of short circuit faults on 1 phase network path only.
2. If we want to measure using a different type of cable and a different diameter, we must calibrate the tool and determine the resistance ratio.

Circuit Works as a Whole

This circuit is specifically designed to detect the location of short circuit faults in a single-phase network. In this design, two voltages are needed, namely positive (+) and negative (-). A single power supply that provides 12V voltage will be converted into two voltage sources, namely positive (+) and negative (-). This voltage is used to supply a parallel resistor circuit that functions to find the voltage difference to be measured. The voltage difference is then sent to the op amp for processing. The op amp used is the IC TL084 CN which has four op amps, but only one op amp is used. After processing, the voltage output from the op amp is forwarded to the interface (ADC). Because the signal generated by the op amp is still an analog signal, while the PC can only receive digital signals, an interface circuit (ADC) is needed so that the PC can receive the signal. The cable used to transmit this signal is an RS 232 cable or a USB serial cable.

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After the PC receives a signal via a USB serial cable, the signal will be processed using the Visual Basic 6.0 program. Before the tool is tested, calibration is first carried out so that the data produced is in accordance with the actual distance. Each type of cable used, be it a stranded or single cable with a small or large diameter, will be calibrated so that the data results are in accordance with real conditions. After the calibration process in Visual Basic, the tool can measure the distance where the short circuit occurs, and the results will be displayed in Visual Basic 6.0.

CONCLUSION

Based on the discussion and working method of the designed circuit, several conclusions can be drawn, namely:

1. From the design that has been made, it can be seen that the difference in voltage or resistance produced can indicate the location of a single-phase short circuit fault, which is then displayed via Visual Basic.
2. In interface design, data that was originally in the form of an analog signal can be converted into a digital signal so that it can be displayed on a PC.
3. This design can provide accurate measurement results if the length of the measured cable is more than 20 meters.
4. The larger the diameter of the cable, the greater the resistance. Therefore, the cable used should have a small diameter, such as a stranded cable.

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