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Monitoring and Protection System for Overvoltage, Undervoltage and Unbalance Voltage

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ABSTRACT

The biggest loss in the industry that caused the industry to experience financial losses that should have been the target of achieving 90% - 100% production was a decrease of up to 40%, due to the production machines not running due to excessive loads used resulting in overvoltage disturbances, voltage drops or unbalanced voltages. To overcome voltage disturbances, a monitoring tool and protection system are needed with a method that can cut off the load automatically when a disturbance occurs, namely by using a contactor as a load breaker from the source and then controlled. using a microcontroller that utilizes relays and voltage sensors. So that the results obtained in the manufacture of tools that refer to SPLN and NEMA then obtained overvoltage disturbances ranging from 399V - 413V, then a voltage drop occurs at 320V - 328V, while the voltage test is not balanced in the R phase which is different from the S phase and T phase, and the percentage of unbalance voltage is 3%, then the tool will cut off the load and it is hoped that from the results that have been carried out it can return the achievement target in the industry.

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1. INTRODUCTION

The electric power system has various types of components, including energy sources, energy generators, transmission systems, distribution systems and load centers. There are also various sources of electricity, namely water, steam, gas and other sources. This energy source is converted by the generating system into electrical energy which is transmitted through the distribution network. The distribution network as a divider of electrical energy to load according to consumer needs, this distribution network is directly related to consumers such as companies and housing, so that it determines the continuity of the flow of electric power to consumers. Therefore, the need for electrical power must be designed as well as possible, especially regarding its quality or reliability in distributing electrical energy so that it can guarantee high consumer satisfaction and consumers can see the value of voltage and current.

Securing electric power so that it remains in good condition, a system is needed that can prevent overvoltage, undervoltage, short circuit and voltage differences between the phases will cause a voltage imbalance in one of the phases. Therefore, a protective device will be designed that can cut off the network and can be monitored in case of problems such as overvoltage, undervoltage, unbalance voltage and short circuit.

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To secure electrical loads that are sensitive to damage, protection is needed, especially in this case, voltage disturbances [2–5].

2. RESEARCH METHOD

In this stage, the hardware that will be used will be explained, to make it easier to design this final project, a flow chart is made which can be seen in Figure 1.

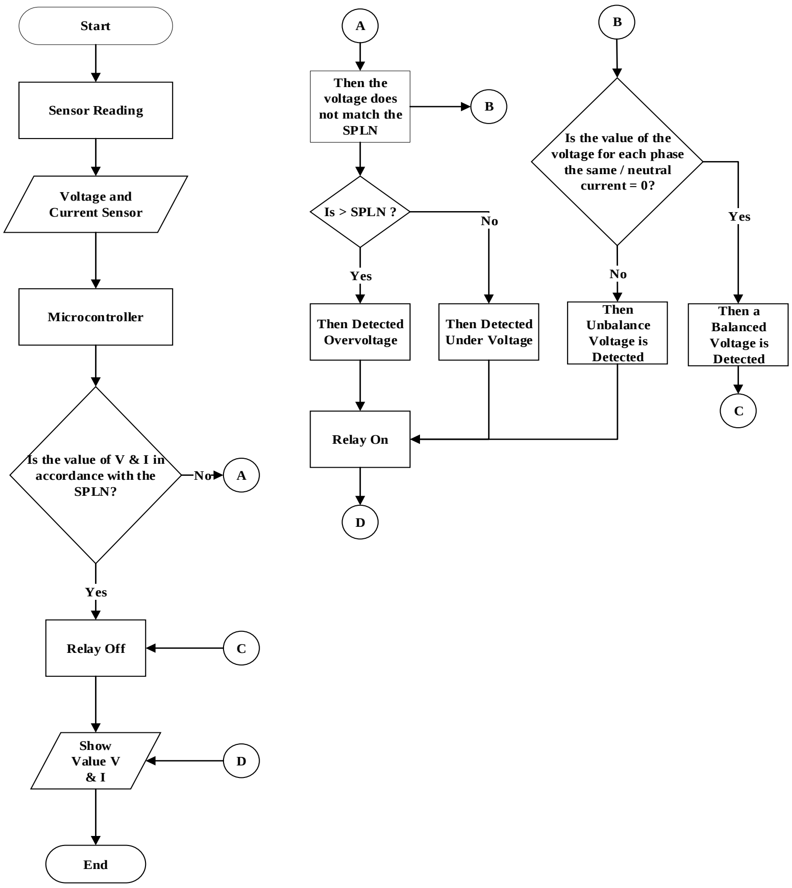

Figure 1. Tool work system

2.1. Microcontroller Design

STM32F407VGTx is a microcontroller based on a high-performance ARM Cortex-M4 32-bit RISC core with an operating frequency of up to 168 MHz. The core of the Cortex-M4 features a single-precision floating point unit (FPU) that can support all single-precision, process data instructions, and ARM data types. The STM32F407VGTx also includes high-speed embedded memories (flash memory up to 1 Mbyte for SRAM up to 192 Kbytes) for back-up of SRAM up to 4 Kbytes. The wide range of I/O and peripherals is connected by two APB buses, two AHB buses, and a 32-bit multi-AHB bus matrix. The following is an image of the STM32F407VGTX microcontroller pin shown in Figure 2.

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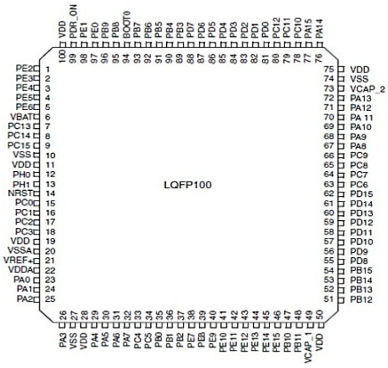

Figure 2. Microcontroller STM32F407VGTx

2.2. Voltage Sensor

The voltage sensor is used to obtain the voltage parameters between the phases, so that the phase-neutral voltage can be seen in each phase, the manufacture of the voltage sensor can be seen in the circuit in Figure 3.

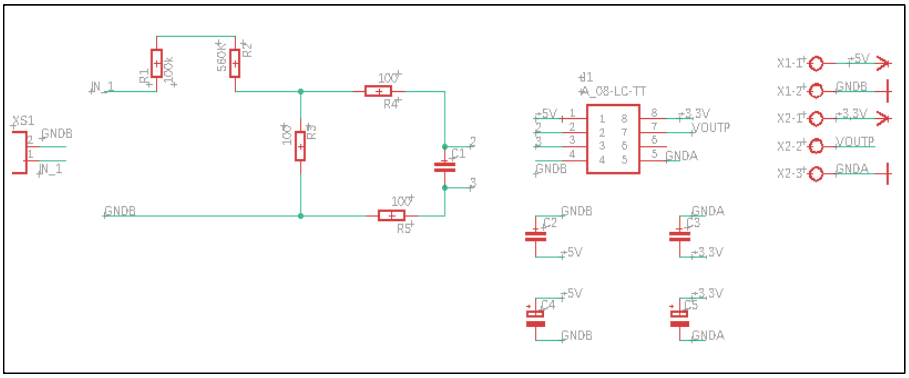

Figure 3. Voltage sensor circuit each phase

In accordance with the picture above, it can be explained that the voltage in each input phase is at IN_1 and GNDB to read the voltage value, then divided the voltage until the maximum input voltage to the AMC1100 IC is 250mV, according to the AMC1100 IC datasheet.

2.3. Current Sensor

The current sensor used is ACS712, which is used to determine the reverse current flowing in the neutral by using it in series with the neutral circuit. To find the value of the ADC value using the equation theory as follows:

$$\mathrm{ADC} = \frac{2^{n}}{V_{R}} x V_{in} \qquad (2.1)$$

Meanwhile, to find the value of Vout (DAC) using the following equation:

$$V_{out}(DAC) = \frac{V_{ref}(DAC)}{2^{n}} \times V_{in}(DAC) \qquad (2.2)$$

Information:

2^{n} = 12 bit (4096)
VR = Voltage Referensi (3V)
$V_{ref}(DAC)$ = Voltage Referensi (3V)

2.4. Relay Driver Design

The relay driver is used to disconnect and connect the contactor, the relay driver is used to switch the contactor when disconnecting and connecting the load. The relay driver circuit can be seen in Figure 4.

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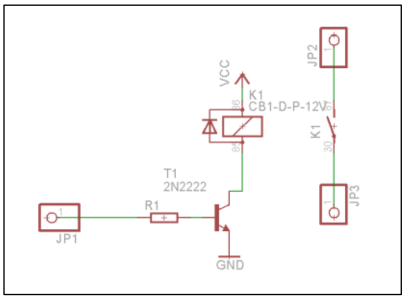

Figure 4. Relay driver circuit

From the picture above, the relay driver used is 5VDC and to drive it using a 2N222 transistor.

3. RESULTS AND DISCUSSION

In this section, the author explains the results of the study as well as provides a comprehensive discussion.

3.1. Overvoltage Test

In the overvoltage test using a variac by increasing the voltage greater than the normal voltage. Then on microcontroller the program is set to take action when there is an overvoltage for approximately 1 minute and the relay can work by disconnecting the load, so that the relay can be used as a protection system when the voltage experiences overvoltage. The following picture of the overvoltage test of the R, S, T phases can be seen in Table 1 and Figure 5.

Tabel 1. Overvoltage test result data

Number	Overvoltage Test				
	R (V)	S (V)	T (V)	Contactor	Condition
1	385	387	384	Normally Close	Normal
2	387	389	386		
3	390	389	389		
4	392	391	392		
5	395	397	394		
6	398	398	396		
7	400	399	400	Normally Open (Trip)	Overvoltage
8	402	403	402		
9	404	404	401		
10	408	408	408		
11	413	411	411		

Figure 5. Overvoltage test

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In Table 1, if there is an overvoltage, the condition is declared overvoltage which can be observed every time there is a disturbance starting from 399V to 413V. In these conditions the relay will work to cut off the load.

3.2. Undervoltage Test

In the undervoltage test using a variac by lowering the voltage less than the normal voltage, when there is a voltage drop for approximately 1 minute and the relay can work by disconnecting the load, so that the relay can be used as a protection system when the voltage experiences undervoltage. The following picture of the undervoltage test of the R, S, T phases can be seen in Table 2 and Figure 6.

Tabel 2. Undervoltage test result data

Number	Undervoltage Test				
	R (V)	S (V)	T (V)	Contactor	Condition
1	382	381	380	Normally Close	Normal
2	371	364	363		
3	362	356	353		
4	360	353	350		
5	358	352	349		
6	338	331	330	Normally Open (Trip)	Undervoltage
7	339	333	332		
8	333	327	325		
9	332	323	324		
10	329	323	322		
11	329	322	320		

Figure 6. Undervoltage test

In Table 2, when it can be analyzed if there is an overvoltage, the condition is declared undervoltage which can be observed in the table in each phase there is an undervoltage disturbance ranging from 320V to 328V. In this condition the relay will work Normally Open so that the contactor can cut off the load.

3.3. Unbalance Voltage

In testing the unbalance voltage using a variac by testing various inputs and the relay works by disconnecting the load, so that the relay can be used as a protection system when the voltage experiences an unbalance voltage. The following picture of the unbalance voltage test of the R, S, T phases can be seen in the Table 3 and Figure 7.

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Tabel 3. Unbalance voltage test result data

Number	Unbalance Voltage Test				
	R (V)	S (V)	T (V)	Contactor	Condition
1	374	374	371	Normally Close	Normal
2	374	373	372		
3	371	374	371		
4	369	369	366		
5	370	343	363	Normally Open (Trip)	Undervoltage
6	372	341	361		
7	370	355	367		
8	371	353	366		
9	370	354	365		
10	371	351	365		

Figure 7. Unbalance voltage test

In Table 3 it can be analyzed that there is an unbalanced voltage disturbance by adjusting the voltage in one phase that is different from the other so that it can be seen in Table 3, namely in phase S, disturbances occur starting from number 5 to number 10, and if the unbalance voltage is more than 3%, the voltage will trip. In this condition the relay will work Normally Open so that it can cut off the load.

4. CONCLUSION

After testing the tool, the author can conclude that the protective device that has been made obtained test results at undervoltage 320V - 328V, then the overvoltage test is 399V - 413V, while the unbalance voltage test is in the R phase which is different from the S phase and T phase, and the percentage of unbalanced voltage is 3%, so it has a tolerance of -10% and +5% of the nominal voltage which refers to the SPLN and NEMA standards.

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