Design And Analysis Development Of RL Component On Power Use In 3 Phase Motor Loads With Virtual Instrument

Edy Sumarno, Ariyawan Sunardi, Yunines, Rubiyanto
Electrical Enggineering – Pamulang University, Tangsel - Indonesia

Email : dosen00591@unpam.ac.id

Abstract. The development of science and technology must be accompanied by the development of human resources. With reliable human resources and understanding the technology, it will certainly be easier for them to apply their knowledge to the rapid development of the technological world. Understanding of a component is very necessary can analyze the use of each component in an electric power system. Among these components are Resistors and Inductors, the electrical power system components need to know their characteristics so that they can be applied properly to the equipment. The purpose of this study is to obtain the characteristics of the R load and L load on the performance of the 3 phase motor and its effect on the power consumption of the 3 phase motor, so that the power consumption and maintenance costs of the 3 phase motor can be minimized. The research methodology is by installing resistor and inductor circuits in the R, S and T phases that lead to 3 phase motor as the main motor coupled with a 3 phase delta motor which is given DC voltage as a load, while for current and voltage measurement using current transformers and voltage transformers are then analyzed with Data Acquisition System (DAS). On the current vs power of the 0.014 Henry inductor, the load is 0 to 80 VDC averaging 782 mA of current. At a load of 0 to 80 VDC shows a power of 299 watts.

Keywords : resistors, inductors, 3 phase induction motor

1. Introduction

Human development and progress cannot be separated from the field of technology. The development of science and technology must be accompanied by the development of human resources as well. With human resources who understand and understand the technology, it will certainly be easier for them to apply their knowledge to the rapid development of the technological world. The technology field is certainly not separated from the field of power electronics which is very closely related to electrical equipment, where electrical equipment is widely used in industrial environments, buildings, supermarkets, hospitals, vehicles, electronic equipment and many other scopes, which are closely related with the use of electrical equipment. Among the electronic components include Resistors and Inductors, we need to learn about the electronic components so that their use can be applied well to electronic equipment. There are many ways to study the characteristics of resistor (R) and inductor (L) components, which are coupled with a 3 phase motor load and coupled with a DC motor as a braking simulation, this is the case in many industries that use 3 phase motor applications for the production
process. With this research, it can be observed Resistor and Inductor load characteristics for the performance of the 3 phase motor and its effect on the 3 phase motor power consumption, so that the power consumption efficiency and engine maintenance costs can be minimized. The design of the module making research is limited to the discussion of the analysis of resistor and inductor components on the power consumption of the 3 phase motor load. Analyze, measure and study the working principles of this module through practice, with the help of Virtual Instrument.

2. Theory
2.1. Resistor Component.
This element receives energy by absorbing, causing heat. Often also referred to as resistance, resistance, conductor or resistance, where the resistor has a function as a current inhibitor, current divider and voltage divider. The resistor value depends on the resistance of the type of resistor (which depends on the material), resistor length and cross sectional area, mathematically the resistor formula is:

\[ R = \frac{\rho L}{A} \]  

Where
\[ \rho = \text{Density} \]
\[ L = \text{The length of the resistor (m)} \]
\[ A = \text{Area of cross section (m}^2\text{)} \]

If a resistor is passed by a current at the two ends of the resistor there will be a potential or voltage difference. The law obtained from this experiment is Ohm's Law.

\[ I \rightarrow R \rightarrow -I \]

Figure 1. Resistor symbol

The voltage through the resistor element is directly proportional to the current flowing on the element and can be written:

\[ V = I \cdot R \]  

Where:
\[ V = \text{Voltage (Volt)} \]
\[ I = \text{Current (Volt)} \]
\[ R = \text{Element resistance (Ohm)} \]

The resistor load connected to the voltage source is alternating, so the voltage at the ends of the resistor can be expressed by the formula:

\[ V = V_m \cdot \sin \omega t \]  

By ignoring the induced GGL arising on the resistor, the amount of electric current flowing through the resistor can be determined by the equation:

\[ I = \frac{V}{R} \]

By changing the amount \( V_m/R = I_m \) (maximum current), then the equation can be written:
\[ I = I_m \sin \omega t. \]  \[5\]

2.2. Inductor Components.

Inductors are electronic components that function to produce magnetic fields, induced voltages or induced currents. Inductors work according to Faraday’s law. Inductors are nothing but wire turns in a coke or metal core. When an electric current (I) passes through this wire winding, there will be a magnetic flux \(N\Phi\) around the inductor which is proportional to the strong electric current passing through it. The following figure shows the types of inductors that are often found in electronic components. Inductors are often called Chokes. Inductor symbols can be seen in Figure 2 below:

![Figure 2. Inductor Symbols](image)

The current passing through an inductor will produce a magnetic field whose magnitude is directly proportional to the flowing electric current. Unlike capacitors which change in voltage increase on both conductor plates when it is charged an electric charge, a change in the electrical current increases when a voltage is applied to the conductor, this increase in electric current creates an induction of energy in the magnetic field. In other words, the inductor regulates changes in electric current and by not changing the voltage. The ability of this inductor is called inductor inductance with Henry (H) unit and is given an L symbol. For smaller sizes it is usually expressed in units of milli Henry (mH), micro Henry (µH), nano Henry (nH) and pico Henry (pH).

An inductor has a core with a core cross-sectional area (A), the number of wire turns per unit length (l). So if an inductor with N winding wire is connected to a number of magnetic fluxes (Φ) then the inductor will have a total magnetic flux of \(N\Phi\) and a current of i flowing through it will produce magnetic flux induction which is opposite to the direction of the electric current. According to Faraday’s law, all changes in magnetic flux will produce an induced voltage of magnitude:

\[
V_L = N \frac{d\Phi}{dt} = \frac{\mu N^2 A}{l} \frac{di}{dt} \]  \[6\]

Where:
- \(N\) = The number of turns
- \(A\) = Wide area of the core (m²)
- \(\Phi\) = Magnetic flux (WB)
- \(\mu\) = Permeability of core material
- \(l\) = Inductor length (m)
- \(\frac{di}{dt}\) = Rate of change in current in units (A/s).

The rate of change in magnetic field \(\frac{d\Phi}{dt}\) which induces a voltage is proportional to the rate of change of electric current \(\frac{di}{dt}\).

Personal Computer (PC) is a computer unit that is used as a medium to visualize the results of measurements. This Personal Computer is connected to the NI USB-6009 measurement module. Before connecting with the NI USB-6009 measurement module, the computer must be installed with
the NI LabVIEW program / software. LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a software developed by National Instrument in the form of visual programming where program users simply enter logic in an executable field. Like other programming languages, namely C++, MATLAB, Visual basic, LabVIEW also has the same functions and roles, the difference is that LabVIEW uses graphic-based programming languages or block diagrams while other programming languages are text based. The LabVIEW program is known as VI or Virtual Instrument. NI USB-6009 is a very portable instrument for use in analyzing a series and electrical quantities, measuring and retrieving data from a device under study. The shape and size of NI USB-6009 is also very practical, making it easier to carry and use for research.

3. Research Methods
The design of RL component analyzers for power usage on 3 phase motors based on virtual instruments, the power source used is a 3 phase source, and is regulated by 3 AC Variable Transformers or also called slide regulators. Each transformer variable has a capacity of 1000 VA, and is installed one by one according to the phase sequence (R S T). The voltage setting is set from 0 Volts to 250 Volts, set manually by rotating the variable knob. In the installation of the transformer variable, the neutral phase input is combined into one and connected from the transformer variable to another transformer variable, while the R phase input is connected to the transformer variable 1, the S phase input to transformer variable 2, the T phase input to the transformer variable 3, the RST output from each variable transformer is connected to the motor drive terminal according to the motor phase sequence. Giving a load on one phase (phase R) by installing resistor (R) or inductor (L) components with certain variable values is intended to determine the change in current (I), voltage (V) and power (P) on the motor drive. The research flow can be seen in Figure 3 below.
4. RESULT AND DISCUSSION

After designing and making tools, the next step is to test the tools that have been made. This test is done by analyzing the results of the voltage waveform and the input current of the 3 phase motor. In the graph making process, the scale used is a scale with units per unit. Following are the calculation per unit to graph the measurement results in LabVIEW:

\[
\text{per unit} = \frac{V_{\text{rms}}}{V_{\text{basis}}} \quad [7]
\]

Where:

- \( V_{\text{rms}} \): measured RMS voltage (Peak Voltage x 0.707)
- \( V_{\text{basis}} \): Motor base voltage value (380 VAC)

After the calculation is done graphs are made, as for the graphs obtained as seen in Figure 4 below:
The voltage measurement wave as seen in Figure 3 shows the voltage with an angle of 120°, and the voltage peak is equal to and below 1 according to the measurement results where the measured voltage between phases is 380 VAC. Current waves per phase have different peak differences, the current in phase R still has the lowest value compared to other phases. For more details, see Figure 5 below.

In Figure 4, it can be seen that phase R current has the lowest peak current compared to other phases, this is the same as manual measurement where the current in phase R has the lowest value, and has a phase difference of 120°. From the results of the measurement of phase R fluctuations when given a resistance of 2 Ohm, 4 Ohm, 6 Ohm, and 8 Ohm, can be seen in Figure 6 below.
From the graph of phase R fluctuations in VDC voltage when given a resistance of 2 Ohm, 4 Ohm, 6 Ohm, and 8 Ohm, different current fluctuations in the results of the research were obtained, as shown in the R phase fluctuations graph when given a load as heavy as 8 Ohm has the highest peak current of 1297 mA and when given of 6 Ohm resistor, the current generated is 873 mA, at the voltage motor of 200 VDC. From the results of the measurement of VAC voltage fluctuations on VDC voltage phase R and given of resistance of 2 Ohm, 4 Ohm, 6 Ohm, and 8 Ohm, can be seen in Figure 7 below.

Based on the graph of fluctuations, the phase R voltage is given a resistance of 2 Ohm, 4 Ohm, 6 Ohm, and 8 Ohm, it is obtained different voltage fluctuations from each experiment, as shown in the graph above in phase R when given of 8 Ohm has the lowest voltage drop is 367 VAC when the motor is 200 VDC, and the highest voltage is 378 VAC in the resistance of 0 Ohm. The results of the measurement of power fluctuations against VDC phase R voltage when given a resistance of 2 Ohm, 4 Ohm, 6 Ohm, and 8 Ohm, can be seen in Figure 8 below.
Figure 8 Graph of power fluctuations against VDC phase R voltage is given a load of resistance as large as 2 Ohm, 4 Ohm, 6 Ohm, and 8 Ohm. Graph of power fluctuations against VDC voltage in phase R which is given a resistance of 2 Ohm, 4 Ohm, 6 Ohm, and 8 Ohm produces different power fluctuations in each experiment, as shown in the graph above the R phase when given a resistance of 6 Ohm, power of 322 Watts and when given a resistance of 0 Ohms, power of 479 Watts. While when given a voltage of 0 VDC with a resistance of 0 Ohm, power of 300 Watts, while when given resistance 2 Ohm, 4 Ohm, 6 Ohm, and 8 Ohms, power of 260 Watts. Graph measurement results of current fluctuations against VDC voltage with inductor of 0.003 Henry, 0.007 Henry, 0.010 Henry, and 0.014 Henry. Can be seen in Figure 9 below.

Figure 9 Graph of current fluctuations against VDC voltage with an inductor of 0.003 Henry, 0.007 Henry, 0.010 Henry, and 0.014 Henry. On the graph of current fluctuations with inductor interference, at of 0 VDC to 60 VDC the current does not experience a significant current increase, which is equal to 800 mA. When given of 80 VDC to 200 VDC, the current has a varying increase in each inductor quantity. The highest current increase occurs when the inductor is 0.007 Henry, resulting in a current of 1570 mA. Graph measurement results of voltage fluctuations against VDC voltage with inductor of 0.003 Henry, 0.007 Henry, 0.010 Henry, and 0.014 Henry. Can be seen in Figure 10 below.
Figure 10 Graph of voltage fluctuations against VDC strain with inductor of 0.003 Henry, 0.007 Henry, 0.010 Henry, and 0.014 Henry.

On the graph of VAC voltage fluctuations on VAC voltage is given an inductor of 0.007 Henry resulting in a voltage of 383.34 VAC and an inductor of 0.010 Henry, resulting in a voltage of 381 Vac. While is 200 VDC, the highest voltage occurs when the inductor is 0.007 Henry, resulting in a voltage of 380.49 Vac. This voltage fluctuation occurs because of the influence of the inductor and VDC voltage. Graph measurement results of power fluctuations against VDC voltage with inductor of 0.003 Henry, 0.007 Henry, 0.010 Henry, and 0.014 Henry. Can be seen in Figure 11 below.

Figure 11 Graph of power fluctuations with inductor of 0.003 Henry, 0.007 Henry, 0.010 Henry, and 0.014 Henry.

On the graph of power fluctuations with varying inductor loads there is an increase in power starting from a load of 100 VDC, at a load of 0 to 80 VDC the average power is 300 Watts, while in the inductor load is 0.007 Henry, the power is 597 Watts, while at normal state of power is 479 watts.

5. Summary
From the results of the RL component analysis of the power usage on the load of 3-phase motors based on virtual instruments by providing varying resistor loads and inductors on 3 phase motor input can affect changes in current magnitude, voltage magnitude and power magnitude. Fluctuations in changes in current magnitude, voltage magnitude and power magnitude in 3-phase motors are affected by the magnitude of the load given to both resistors and inductors. Graph results and current waves, voltage waves and power in the testing of resistors and inductors depends on the material, and the type of motor to be tested. The use of 1 phase type transformer variables affects the results of the voltage magnitude and the amount of input current in the motor varies from phase to phase, this is because the transformer variable has an output voltage that cannot be set simultaneously.
References

[1] Bonggas L Tobing. (2012). Peralatan Tegangan Tinggi. *Jakarta; PT Erlangga*.

[2] Bagus Artaha. (2007) Perancangan simulator coveyor untuk digunakan pada praktikum otomasi sistem produksi. *Bandung : Universitas Kristen Parahyangan*.

[3] Eka Nugraha. (2015). Perancangan Simulator Sistem SCADA Pusat Pembangkit Listrik Tenaga Nuklir Jenis Fast Breeder Reaktor. Bandung ; Universitas Pendidikan Indonesia.

[4] Hendri Ardiansyah, dkk. (2013). Perancangan simulator sistem pengepakan dan penyortiran barang berbasis PLC Twido TWDLMDA20DTK. , Jurnal Reka Elkomika. Vol 1 No 4.

[5] Muhammad Subekti et al. (2018). The simulator development for RDE Reactor. J phys..Conf. Ser.962012054.

[6] Reinaldo Steven Restianto Sadiyoko. (2018). Perancangan dan Realisasi Simulator Sistem Load Shedding. Universitas Kristen Maranatha.

[7] Seflahir Dinata. (2018). Perancangan Human Machine Interface Simulator Gardu Induk 150 kV. Jurnal Electrical Power Instrumentation and Control. Vol 1. No 1.