BACHELOR THESIS – ME141501

PERFORMANCE ANALYSIS OF SINGLE PHASE INDUCTION MOTOR FEEDBACK BIFILAR WINDING

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Asked To Meet One Of Terms
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on
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Study Program S-1 Department of Marine Engineering
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PERFORMANCE ANALYSIS OF SINGLE PHASE INDUCTION MOTOR FEEDBACK BIFILAR WINDING IN LABORATORY SCALE OF MARINE ELECTRICAL AND AUTOMATION SYSTEM

Name	**: Damas Setyadi**
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ABSTRACT

Electrical machines have become one of the technologies that are environmentally friendly. Bifilar wound is one of the type electric machine that included in electric motor. Because of the double winding in stator this motor have better performance compare with the usual single phase motor. Performance analysis for this motor single phase bifilar wound is obtain through analysis of comparison between several data such as torque, rotation and efficiency. Condition to taking the data is when the motor single phase bifilar wound is unloaded and loaded. The other condition is when the rotation of motor single phase bifilar wound is clockwise and counterclockwise. Data that is analysed rotation, current, power and torque. From the analysis clockwise condition have slower rotation but give bigger power and torque than counterclockwise. Average rotation for clockwise 2319.82 RPM and for counterclockwise is 2478.99 RPM. Average power for clockwise 350,892 watt and for counterclockwise is 346,196 watt. Average power for clockwise 350,892 watt and for counterclockwise is 346,196 watt. Average torque for clockwise 1,298 N/m^2 and for counterclockwise is 1,272 N/m^2. This make clockwise is better performance than counterclockwise.

Keywords: Single Phase Induction Motor, Bifilar Wound, Performance Analysis

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PREFACE

Praise be to Allah the Almighty God for all His mercy and guidance, the writer can finish the thesis entitled "Motorcycle Performance Analysis of Biplar Functional Scale Base Scale Laboratory of Ship and Automation Electricity" well in order to qualify on the Thesis Course (ME141501) Department Shipping System Engineering, Faculty of Marine Technology, ITS.

During the process of preparation of this thesis the authors get much help and moral support from various parties, therefore the authors convey thanks to:

1. Mother and father, along with beloved sister who always give prayers, moral and material support to the author.
2. Arini Natasya that give author prayer, moral and support.
3. Mr. Eng. M. Badrus Zaman, S.T., M.T. and Mr. Semin, S.T., M.T., Ph.D. as Head and Secretary of Department of Engineering of Shipping System FTK - ITS.
4. Mr. Ir. Sardono Sarwito, M.Sc. as the supervisor 1 who has guided and provided many inputs during the process of preparing the thesis.
5. Mr. Indra Ranu Kusuma, ST. M.Sc. as supervisor 2 who have guided author during the process of preparing the thesis..
6. Barracuda family '13 who always accompany and encourage in completing the study in the Department of Engineering FTK Shipping System - ITS.
7. All technicians, members and graders of the Marine Electrical and Automation System (MEAS) Laboratory who have provided support and assistance to the author during the process of thesis preparation.

The authors hope criticism and suggestions that are constructive for the sake of relevant research in the future. Hopefully this thesis can provide benefits to the readers.

Surabaya, January 2018

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CHAPTER I
INTRODUCTION

1.1 Background

Electrical machines have become one of the technologies that are environmentally friendly it is due to the characteristics of the electrical machine that does not cause exhaust emissions such as combustion engines that use fossil fuels because electric engines use electric current as main sources different with combustion engines that use fuel fossil as the main source of power.

One of the electric machines which are often used on ships to help facilitate the work is an electric motor, the electric motor itself is an electric machine that serves to convert electrical energy into mechanical energy in the form of rotational motion. The electric motor can be broadly differentiated into two types of AC motors and DC motors depending on the voltage source used. AC motor is more often used, because using easily available AC current that is sourced from a generator on board. The another benefit of the motor with current AC or induction motor is from the economic aspect. Induction motor or AC motor is cheaper than DC motor.

AC motors can be divided into 2 types. The types is synchronous AC motors and AC induction motors. AC induction motors can be divided again into a single phase AC induction motor and three phase AC induction motors. Single phase induction motor winding bifilar a single phase induction motor that type of capacitor start induction motor. These single phase induction motors often are used for small load such as fresh water pump and blower fan. Because single phase motor have small power compare with three phase motor.

AC motors usually have one cable windings on the stator, but for bifilar motor has two wires for winding so that the stator windings to the motor stator windings on a longer and have more winding. Magnet field thus generated from a more powerful induction compare with ordinary single phase induction motor. Because the magnetic field of the stator in the motor is double and that make the magnetic field is magnified too.

1.2 Statement of Problems

The backgrounds have in previous describe the formulation of problems that will be created are as follows :

1. How is the performance, starting, Conrolling rotation, reverse rotation, efficiency and torque of the motor feedback bifilar winding single-phase induction?
2. What is the aplication that is suit for electric motor single phase bifilar wound in ship?

1.3 Research Limitation

Research limitation of this thesis is as follows :

1. Analysis of the character of the motor is done only on single phase motor induction feedback bifilar wound is in Laboratory of Marine Electrical and Automation System DTSP FTK ITS
2. The calculation of the torque of the single phase motor induction feedback bifilar wound by calculating the relationship between power and rotation of a single phase induction motor winding bifilar obtained from the observational data.
3. Analysis of performance is only observe when motor is in clockwise and counterclockwise condition.

1.4 Research Aims

The research objective of the writing is as follows :

1. Know the performance, starting, rotation control, reverse rotation, efficiency and torque of the motor feedback bifilar winding single phase induction of the data that has been taken when clockwise and counterclockwise condition.
2. Know the motor feedback applications of single phase induction bifilar winding on the ship.

1.5 Research Benefit

Research benefits that is can be getting out of this thesis is as follows :

1. To know the performance and characteristics of the motor feedback bifilar winding induction single phase is expected to be used as a reference in the choice of induction motors to be used in accordance with the needs of the ship.

2. Can know the characteristics of a single phase induction motors feedback bifilar winding in its original condition through practical methods.

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CHAPTER II
LITERATURE REVIEW

2.1 Electric Motors

The electric motor is one of the important elements in electrical appliances. The electric motor is a device to convert electrical energy into mechanical energy. A tool that serves conversely, converting mechanical energy into electrical energy is called a generator or dynamo. The use of electric motor can easily be found in the ship for example motor for oil pump, fresh water pump, motor for blower, and much more that need small power to active the equipment.

The electric motors are commonly used in the world Marine is asynchronous electric motors, due to the current source that is easy to obtain. AC current obtained directly from the output of the generator so that the asynchronous motor can immediately take current from the generator without any treatment process before getting into the motor. There is so many kinds of electric motors and can be seen in figure 2.1 for the distribution of types of electric motors.

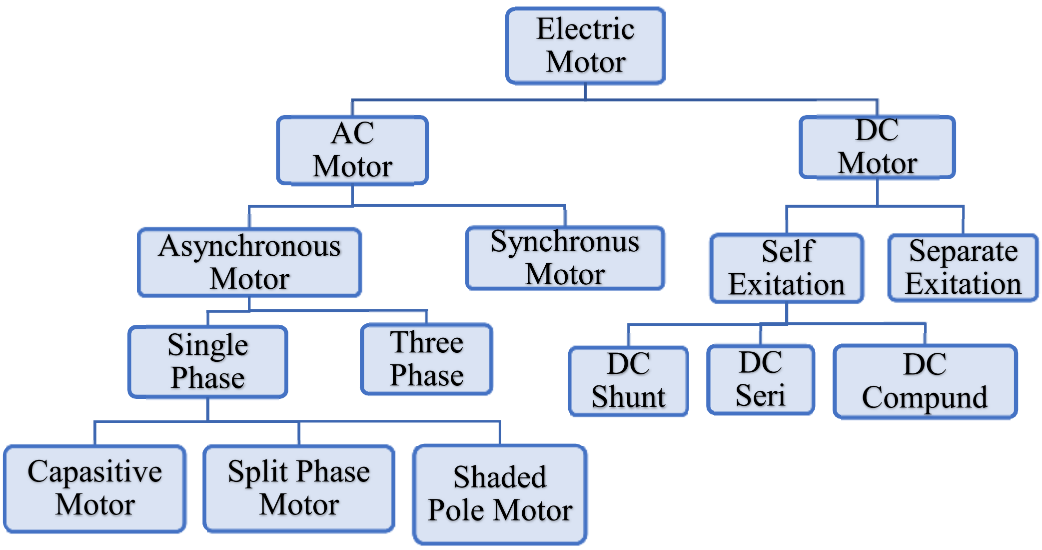


Figure 2.1 Types of Motor Electric

From the distribution of electric motors in Figure 2.1 can be seen that the AC motor divided into two synchronous motors and asynchronous motors. Asynchronous motors can also be called an induction motor due to the workings of this motor there is give current induction for the motor. Motor feedback bifilar winding is a single phase induction motor. The type of single phase is motor capasitor start

2.2 Single Phase Induction Motor

Induction motors are one type of electric motor that requires supply of power from the AC power outlet. The different between single phase induction motor with three phase induction motor is three phase induction motors are in need of three phases in the motor running. Phase induction motors used in normal phase 3 is R, S and T. The naming of this phase is based on the power source. As for the single phase induction motor only requires one phase of the power source.

Phase that used in the single phase motor is RN, SN or TN. N in the phase is neutral. Neutral is different from ground. Ground is tool that is have purpose for a safety used for eliminate electrical leakage if there is an electrical equipment that has electrical leakage. Ground here to eliminate electrical leakage so that it does not damage equipment or injure a living thing which is adjacent to the equipment.

As for the neutral is the central point of a power plant using a star system in the form of a transformer or not in the transformer. If the system use a delta circuit then the system does not have neuutral because in the delta circuit there is no neutral system and have RST only to generate neutral on this system can be said to require a transformer which is a delta circuit for the input and the output is a star circuit, on this output neutral arise. Neutral here is used as a loop electrical current to appliances.

Single phase induction motor can be divided into four types there are split phase induction motor, shaded pole motor, induction motor capasitive and universal motor. The motor capasitive can be divided again into three types there a motor capasitive start, motor capasitive run and motor capasitive start run. Type of the motor that use in this thesis is single phase induction motor that is classified into motor capasitive start .

2.3 Induction Motors Capacitive

Induction motor capacitive is have same work principle with the other induction motor. Which makes a different is i the induction motor capasitive there is additional component that is attach to motor that is capasitor. Induction motor capasitive can be divided into three type that is motor capacive start, motor capacitive run and motor capacive start run.

2.3.1 Motor Capacitive Start

Motor capacitive start is an incarnation of a split phase motor, but has a capacitor that is connected in series with auxiliary winding and centrifugal switch, constructively identical with split phase motor, the different is only in one unit coupling capacitor to increase the initial (start). As said at the beginning of the working principle of the starting capacitor motor is the an induction motor, that is if the primary winding is given a current source there will be a rotating magnetic field (magnetic flux) that exist and the same size, there is no resultant force. But with the auxiliary winding and the capacitor is no phase difference between the two windings, this is going and the resultant magnetic flux different styles forwards or backwards depending on the magnitude of the resultant force itself and generally occurs resultant force in a clockwise direction so that the motor can be turned to the right.

Once the motor rotates 75% of the nominal rotation centrifugal switch work decided auxiliary winding circuit and the motor works only with a major rotation. Figure capasitif start motor circuit is shown in Figure 2.2.

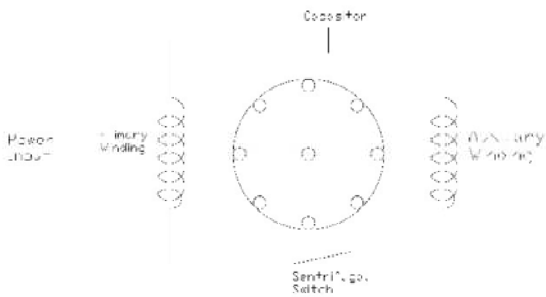


Figure 2.2 Motor Capacitive Start

The advantage of this type of motor capacitive start compared with split phase motor types are:

- Have stronger coupling.
- Larger power factor (approaching 1)

The most important parts of the motor capacitive starts are:

- Stator (main and auxiliary winding point) in the grooves of the stator
- Rotor
- Bearings laxative (ball bearing)
- Close the stator and the frame body
- Capacitors
- The ends of the motor terminal

2.3.2 Motor Capacitive Run

This motor has a capacitor connected in series with the auxiliary winding, connected in parallel with the primary winding and is directly connected in parallel to a power source. The main winding, auxiliary winding and the capacitor stays connected to the grid circuit when the motor is running. Primary wound and auxailiary wound have the number of windings but the diameter of the wire is not the same between primary wound and auxiliary wound. The primary wound wire diameter is greater in diameter compare between auxiliary winding. This type of motor have initial coupling not so good, but for the running coupling (running torque) is evenly good.

Motor Capacitor Run is the same as the motor capacitor start, unless the auxiliary winding and a capacitor connected in series all the time, so it is no longer needed centrifugal switch. The advantage capacitors are permanently installed on the motor are :

- Improving the capacity of the load on the motor.
- The power factor of the motor so high.
- High efficiency.
- Reduce the noisy of the motor so it become smooth.

2.3.3 Motor Capacive Start Run

This type of electric motor is a combination of a motor capacitor motor capacitor start and running, because is the combination between motor capasitive start and motor capasitive run so this motor have the advantages both of types the motor. This motor have larger initial coupling and coupling path evenly because there is two capasitor in this motor. The capasitor is for start is different from the capasitor for running.

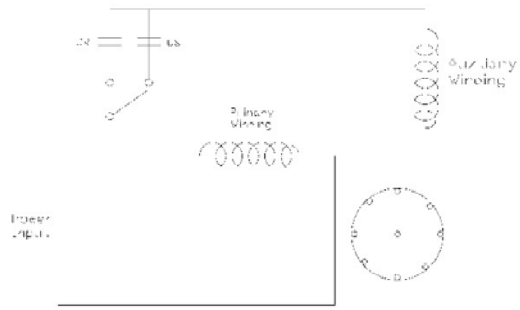


Figure 2.3 Motor Capacitive Run

2.4 Wound Motor

Wound motor is a motor that has the windings on the rotor. Unlike the squirel cage rotor which is composed of conductive rods that are placed in the groove of the rotor. The conductor rods made of copper, alloy or aluminum. The ends of the conductor rods short circuited by a short connecting ring, so that the shape of a bird cage. While the motor phase winding serpentine consists of many, this winding is inserted into the grooves of the rotor core. On the type of rotor convolution we can adjust the speed of the motor by controlling the rotor resistance in the windings of the motor.

Rotor squirel cage can be regarded as a windings that is arranged in series with full step or bias can be called full pitch. This winding that is aranged in series was formed by the pair - the pair conductor rod ends - ends held together by short circuit rings. If we compare between the motor stator and the motor stator bush cage there are some differences as follows :

1. Characteristics squirel cage induction motor rotor is fixed, while the induction motor with wound rotor is still possible variations in characteristics by adding an external circuit via the slip ring / brush.

2. The number of poles on the rotor cage adjusts to the number of poles in the stator windings, while the number of poles on the rotor is already certain. An advantage of the induction motor with wound rotor is able to plus resistance from outside. This is particularly advantageous for motor starting on a heavy load as well as a regulator of motor rotation. Rotor induction motor circuit with wrap, equipped with outer resistance or external resistance. Weakness in the starting torque overcome by the construction of a double squirrel cage and deep bar cage.

2.5 Parts of Motor Capacitor Start

2.5.1 Rotor

Rotor is the rotating part of motor, this part comprising : a rotor core, winding rotor and rotor grooves. Rotor function is to change the force of the stator into mechanical energy Two types of rotor that is often used is the rotor winding and rotor cage.

- Rotor cage: iron laminations have slots connected aluminum or copper short at the end.
- Rotor winding: rotor has windings as stator and it is in wounded. The winding is usually connected with star circuit for three phase motor.

2.5.2 Stator

The stator is the stationary part of the motor and a current from the source. In this motor, there are two types of stator windings, the primary stator winding and auxiliary stator winding. Order the stator is made of cast iron and is the home of all parts of the generator. The circular stator order in which connections to the side of construction will ensure the generator against vibrations. Stator core made of ferromagnetic material or soft iron are arranged in layers where the magnetic flux is formed in this area. While the stator winding is made of copper are arranged in the grooves, stator winding function where the formation of electromotive force.

2.5.3 Centrifugal Switches

Centrifugal switch is to disconnect between the auxiliary winding grid after rotor rotation is reaches 75% maximum rotation of the motor.

2.5.4 Capacitor

Capacitors in single phase motor is used to assist starting of the motor. Because single phase motor capasitor start can not self starting.

2.6 Rotation Control of Electric Motor Single Phase

To control the rotation of motor a single phase induction motor only just have two types there are in the set direction of rotation of single phase induction motor and adjust the speed of rotation of single phase induction motor.

2.6.1 Direction Control of Rotation Single Phase Induction Motors

Single phase induction motor is a motor capacitor winding bifilar are included in this type of single phase AC electric motor. Motor capacitor is commonly encountered in daily use for our lives ranging from small objects to large objects. Beside in our daily life, single phase motor is use in marine specially in ship. Equipment that use single phase motor is fresh water pump and oil water separator. Construction on the motor capacitor is very simple and small power with a voltage of 220 Volts AC. This simple construction that makes a single-phase induction motor capacitor is often used. From this simple construction makes the price of a single-phase capacitor induction motor is cheaper than the three phase motors and DC motors.

This capacitor motor stator consists of two windings / windings. One primary winding and an auxiliary winding. This motor has a capacitor connected in series with auxiliary winding and parallel with the prymary winding. The function of the capacitor itself is to increase the coupling or torque head start, reducing the initial startup current motors, as well as sharpen shifting phase difference between the main winding and auxiliary winding to near 90^0. To reverse or change the motor rotation is very easy, simply by reverse the polarity of the primary winding or auxiliary winding.

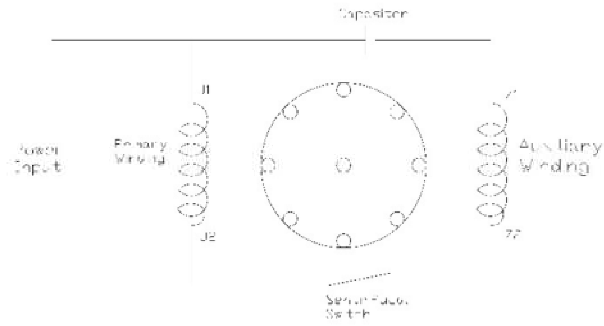


Figure 2.4 Starting circuit at single phase motor bifilar wound

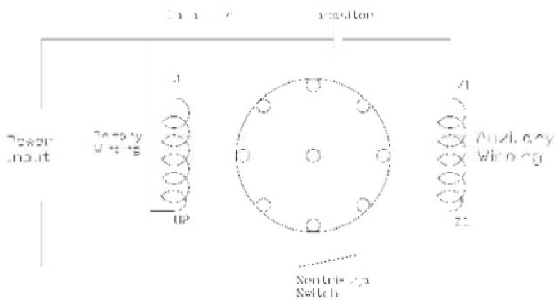


Figure 2.5 Circuit that control direction of rotation use main winding

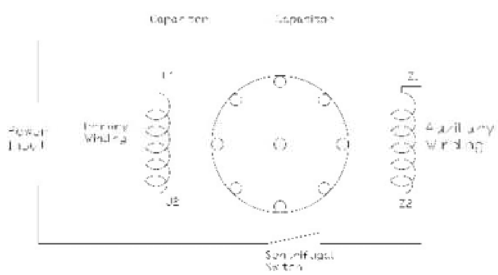


Figure 2.6 Circuit that control direction of rotation use auxiliary winding

To change or reverse the direction of rotation of the motor by reverse the polarity of the voltage, then it is same to reverse the polarity of the primary windings and auxiliary windings. And the result of motor rotation direction will remain the same or unchanged.

2.6.2 Control Rotation Speed of Single Phase Induction Motors

Control rotation of the motor can be done in two ways, that is by adjusting the voltage going into the induction motor and the adjust of related variables with a single phase induction motor rotation. Related variables that is affect the control rotation is frequency and the number of magnetic poles of the motor.

2.6.2.1 Controlling Rotation With Voltage

Voltage input controlling is the easiest way to adjust the rotation speed of the motor. By adjusting the input voltage to the motor so the motor rotation will follow the incoming voltage. The relationship between voltage and rotation of the motor is directly proportional, if the voltage is given the greater the rotation of the motor is also accelerated. In this case the voltage is also proportional to the torque, if the voltage applied to the small motor torque generated by the motor also is small to and it is applies for the otherwise. If the voltage applied to the motor, the greater the torque that can be generated by the motor. It is a deficiacy of the rotating control using the setting voltage into the motor.

2.6.2.2 Controlling Rotation With Frequency and Total Magnetic Pole

In frequency electrical equipment is important, no doubt in the motor frequency is an important component in the controlling of motor rotation. In addition to the frequency of the number of magnetic poles in the induction motor also has a major influence in controlling rotation of the induction motor.

The relationship between the frequency and the number of magnetic poles can be seen from the equation :

$$Ns = {}^{120\,f}/_{p}$$

Where :

Ns = *Rotation of Motor*

120 = *Constanta*

f = *Frequency*
p = *Total Magnetic Pole*

So to set the motor rotation can be set on the frequency of entering into a motor or a set number of poles that are used by the motor. The relationship of the frequency of the rotation of the motor is directly proportional, if the frequency the greater the rotation of the motor will be faster and will be slow rotation of the motor when a given frequency vanishingly small. In contrast to the number of magnetic poles of the motor the less the number of pole motor, the faster rotation of the motor but it will be slower when the number of poles that is applied to the motor is increasing.

2.7 Torque in Electric Motor Single Phase

The concept of torque in physics, also called moments, starting from the work of Archimedes to the liver. Informal, torque can be thought as a rotational force. Rotational analog of force, mass, and acceleration are torque, moment of inertia and angular acceleration. The force acting on a lever, multiplied by the distance from the midpoint of the liver, is the torque. Styles in a corner at a right angle to the straight lever. In the electric motor torque is the force required to work. The higher torque produced by the increasingly heavy burden that can be imposed on the electric motor.

Induction motors, AC motors are most commonly used in the industry - and marine industry because of many advantages of an induction motor. The most visible is the excellence in terms of economics. In an AC motor, the rotor does not receive power source by conduction but with induction. Therefore, the AC motor of this kind is also known as an induction motor. The formula to calculate the torque on the electric motor derived from the relationship between power and rotation of the induction motor.

Calculation of torque is obtained using the equation :

$P = \tau \; x \; \omega$

$\tau = {}^{P}/_{\omega}$

Where :

P = *Power*

τ = *Toque*

ω = *2 π n/60 (n/60 = rps)*

n = *Rotation of Rotor*

2.8 Power in Electric Motor Single Phase

In physics, power is the speed for doing work. Power equal to the amount of energy spent per unit time. In the SI system, the unit of power is the joule per second (J / s), or watts. Integral power versus time defining the work done. Because of the integral depends on the trajectory of force and torque, so work depends trajectory calculation.

As the concepts of basic physics, power requires a change to the object and the specific time when changes arise. It is different from the concept of work, which only measures the change in the condition of the objects.

Electric motor output power is the multiplication of the motor torque generated by the angular velocity of the output shaft. Power on the moving vehicle is the product of wheel traction force to the vehicle speed. The speed at which the light bulb converts electrical energy into light and heat is measured in watts. The higher the value, the energy required per unit of time working is increasing too.

The equation can be used to measure the power is :

$P = (\tau x N)/975$

Where :

P = *Power*

τ = *Torque*

N = *Rotation (RPM)*

975 = *Constanta for Kilowatt*

2.9 Efficiency Electric Motor Single Phase

Efficiency should not be confused with *effectiveness*. System that wastes most of its input power but produces exactly what it is meant to is effective but not efficient. The term "efficiency" makes sense only in reference to the wanted effect.

Energy efficiency is the work done with the aim of reducing the amount of energy required, using a piece of equipment or even a system related to energy. The efficiency is directly related to the use of power to the electric motors. The higher the efficiency, the smaller the energy required for the same load on the motor. Thus the input power of the motor will be equal to the output power. Then the energy is wasted or lost energy in the motor can be reduced and can produce greater power by using the same electrical energy that is given to the motor. The higher efficiency make the motor is more expensive because of the design and the chosing material for the electrical motor.

The efficiency value of the motor can be obtained from the equation :

$$\eta = \frac{P\ output}{P}\ x\ 100\%$$

Where :

η = *Efficiency*

P = *Power*

CHAPTER III
METHODOLOGY

The research methodology is the basic framework of the stage of completion of the final project. The research methodology necessary for the research process can run as expected, so as to obtain the maximum results necessary to have steps or processes sequentially.

3.1 Identification and Statement of Problems

Phase identification and formulation of the problem is about how it works and a series of single-phase induction motors feedback bifilar winding. Once known, it can be determined the method to be used.

3.2 Literature Review

The next stage is to study literature with the aim to summarize the basic theories, general and specific references, as well as to acquire a variety of other supporting information related to this final project. This literature study can be obtained from books, journals, papers or on the internet that supports the discussion of this thesis. In addition it could also do Dialogue with stakeholders and competent in this discussion.

3.3 Collecting Data

Collecting data in this bachelor thesis is use observation and sampling method. Collecting data with 10 times with same variable for unloaded condition and 5 times for loaded condition. This apply for both clockwise condition and counterclockwise condition. Data in this bachelor thesis is to measure several parameters required to analysis performance of single phase induction motor feedback bifilar winding. The parameter that is obtained to know rotation control, starting current, power and torque in all condition.

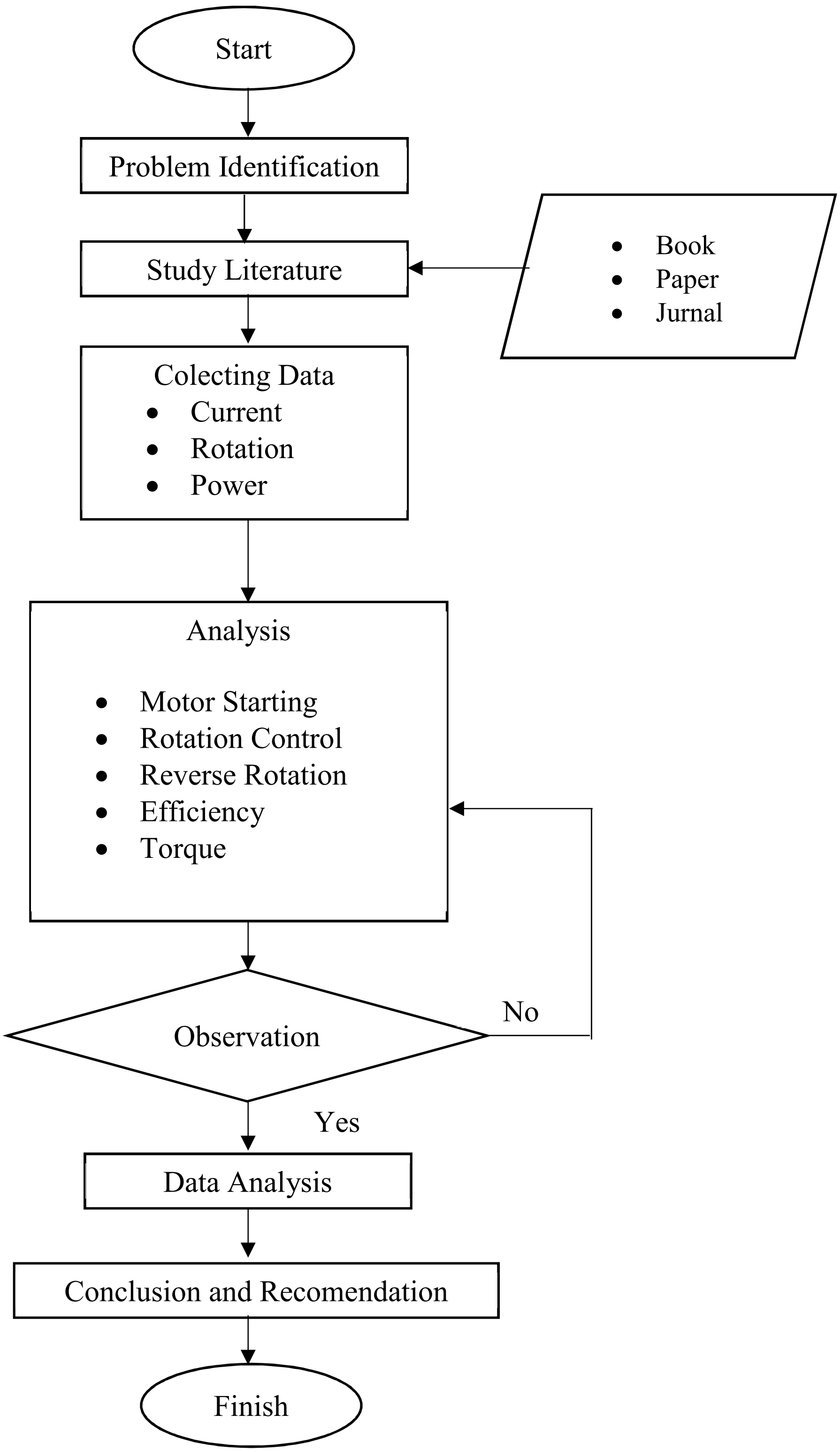
3.4 Analysis and Discussion

At the stage of analysis and discussion is to analyze the results of calculation from data that obtained from data that is collected. From the analysis and discussion of the data it is show performance single-phase induction motors feedback winding bifilar No. 64-100. Performance that is intended is rotation control, starting current, power analysis and torque analysis in all condition along with explain about error or deviation that occurs in analysis and discussion why it can be happend.

3.5 Conclusions and Recomendation

After analysis author drawn conclusion about performance analysis of single phase induction motor feedback bifilar winding. This stage show conclusion of performance analysis single phase induction motor feedback bifilar winding. From all of condition author drawn conclusion from all of analysis and discussion along with if there is error or deviation that occurs in this observation. Author make recomendation after all conclusion is taken. Recomendation is to develop of this bachelor thesis and giving problem solving from mistake that author make in this bachelor thesis.

Flow Chart Metodologi Penelitian



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CHAPTER IV
DATA ANALYSIS

4.1 Obervation Equipments

4.2.1 Single Phase Motor Bifilar Wound

In the bachelor thesis to be performed using a single phase motors bifilar winding. These motors will be analyzed how the characteristics of this motor.

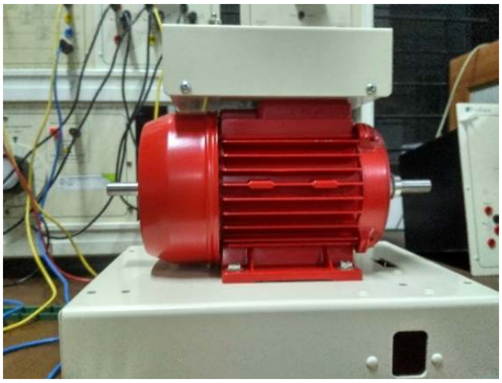

Figure 4.1 Single Phase Motor Bifilar Wound

Observation on bifilar single phase motors using two condition of observation. The observation is in the clockwise circuit and counterclockwise circuit. There is different for these two circuit. The different is for the circuit in the capasitor and the auxiliary winding. For clockwise first main winding is connect with capasitor and first auxiliary winding. For counter clockwise is second main winding is connect with capasitor and first auxiliary winding.

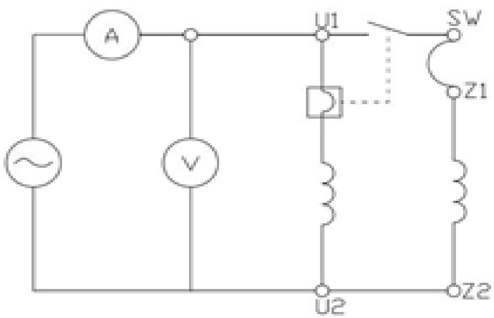

Figure 4.2 Rotation Clockwise Circuit

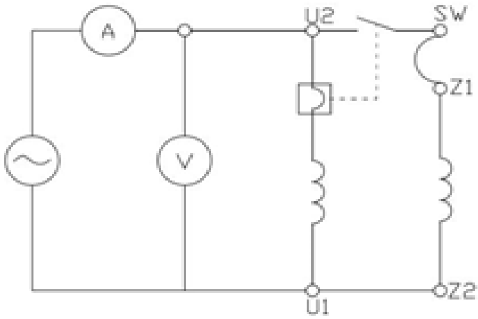

Figure 4.3 Rotation Counterclockwise Circuit

4.2.2 Clampmeter

Clampmeter in this bachelor thesis conducted used as a measure of the current in the main winding and the auxiliary winding.

Figure 4.4 Clampmeter

4.2.3 Tachometer

Tachometer in this bachelor thesis is useful for measuring rotation of the motor. Measurements were made as much as ten times by providing five input variables voltage of electri motor single phase bifilar wound is 33 volt, 44 volt, 55 volt, 66 volt and 77 volt. This is for electric motor single phase bifilar wound without load. If using load the input voltage is 60 volt,70 volt, 80 volt, 90 volt and 100 volt.

Figure 4.5 Tachometer

4.2.4 Variable AC/DC Supply

Variable AC / DC Supply in this bachelor thesis is useful to provide input voltage of the electric motor single phase bifilar wound. Input Voltage that granted is 33 volt, 44 volt, 55 volt, 66 volt and 77 volt. This input voltage is for electric motor single phase bifilar wound without load. And for the load input Voltage that granted is 110 volt, 120 volt, 130 volt, 140 volt and 150 volt. Because we use generator so we give the input voltage for the generator too. Value of the input voltage is 60 volt, 70 volt, 80 volt, 90 volt and 100 volt.

Figure 4.6 Variable AC/DC Supply

4.2.5 Single and Three Phase Measurements

In this bachelor thesis used a single and three phase measurements brands Feedback in Laboratory of Marine Electrical and Automation System. The data can be obtained from this tool is Voltage, Current, cos φ, power, and frequency. However, data that will be taken only for observation is just for the power.

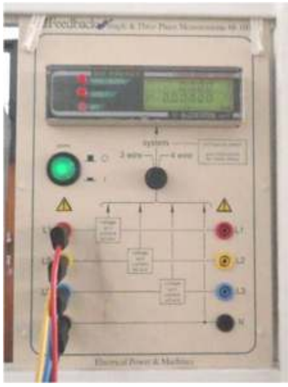

Figure 4.7 Single and Three Phase Measurements

4.2.6 Load Unit

Three Phase Syncronus Motor/Generator – Wound Rotor in this bachelor thesis is act for load unit. Motor is couple with this generator. Generator is giving resistance and make motor show result in loaded condition.

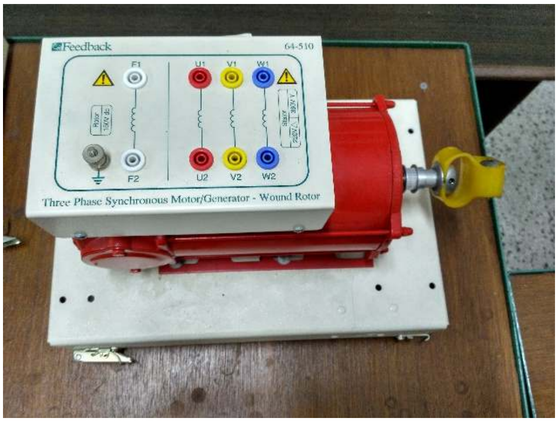

Figure 4.8 Three Phase Syncronus Motor/Generator – Wound Rotor

4.2 Obeservation Result

This observation is when the electric motor single phase bifiliar wound is unloaded and loaded. For unloaded and loaded condition is observed using two circuit that is clockwise and counterclockwise. The obsevation result can be shown in the chart and data of the observation is in the attachment.

4.2.1 Unloaded Condition

Unloaded condition is when author observe single phase induction motor feedback bifilar winding without load. Load in this bacelor thesis is three phase syncronus motor/generator. This is motor act like generator.

4.2.1.1 Comparison Chart of Rotation Between Clockwise and Counterclockwise in Unloaded Condition

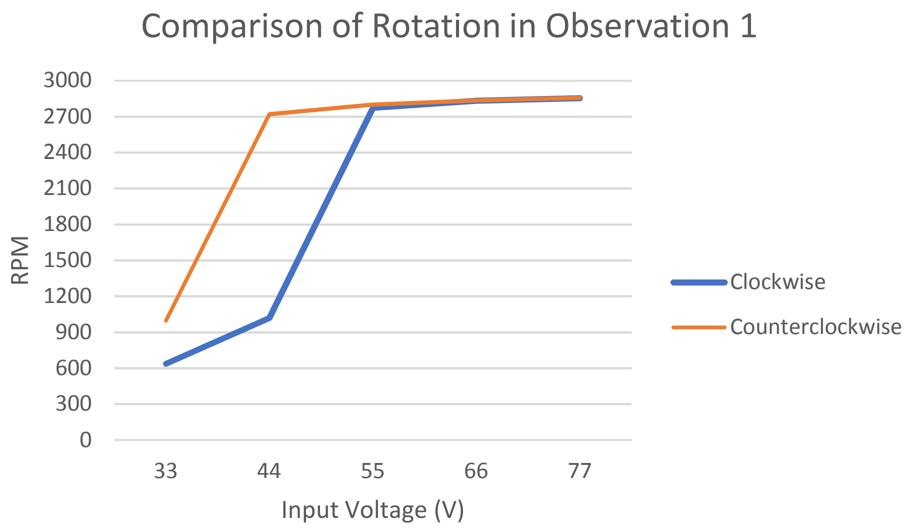

Chart 4.1 Chart of Rotation in Observation 1

Chart 4.1 rotation of motor when clockwise condition is slower than counterclockwise condition thats make counterclockwise has faster rotation than clockwise. This is because clockwise have bigger torque so when motor is in the clockwise condition it has slower rotation.

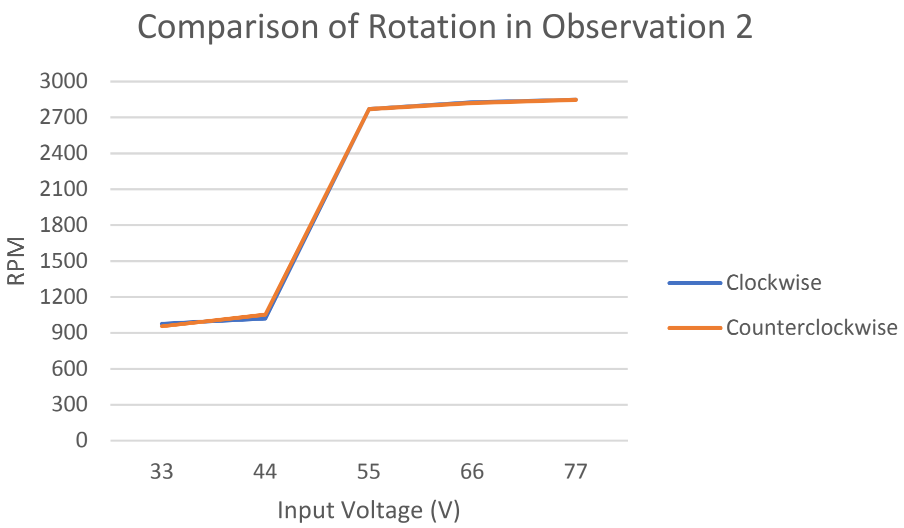

Chart 4.2 Chart of Rotation in Observation 2

Chart 4.2 rotation of motor when clockwise condition is almost same with counterclockwise condition but clockwise condition is still slower than counterclockwise condition. This is because clockwise have bigger torque so clockwise condition have slower rotation.

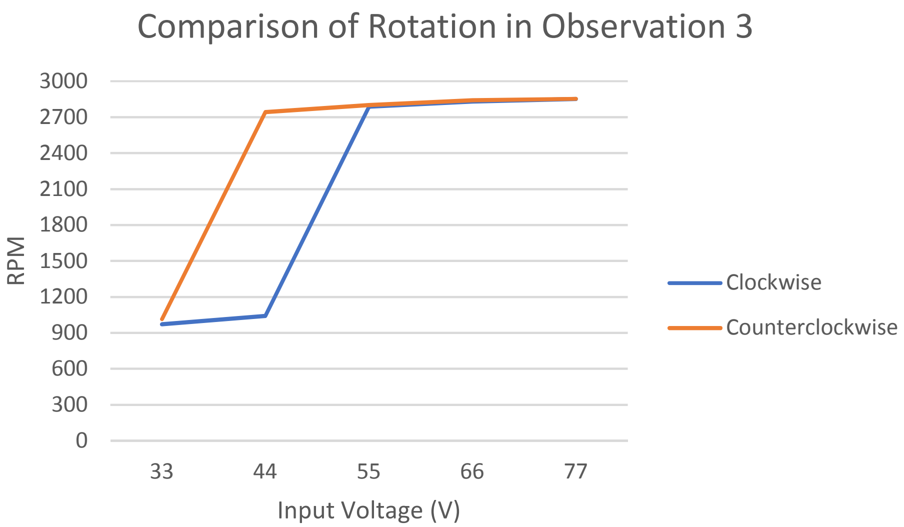

Chart 4.3 Chart of Rotation in Observation 3

Chart 4.3 rotation of motor when clockwise condition is slower than counterclockwise condition thats make counterclockwise has faster rotation than clockwise. This is because clockwise have bigger torque so when motor is in the clockwise condition it has slower rotation.

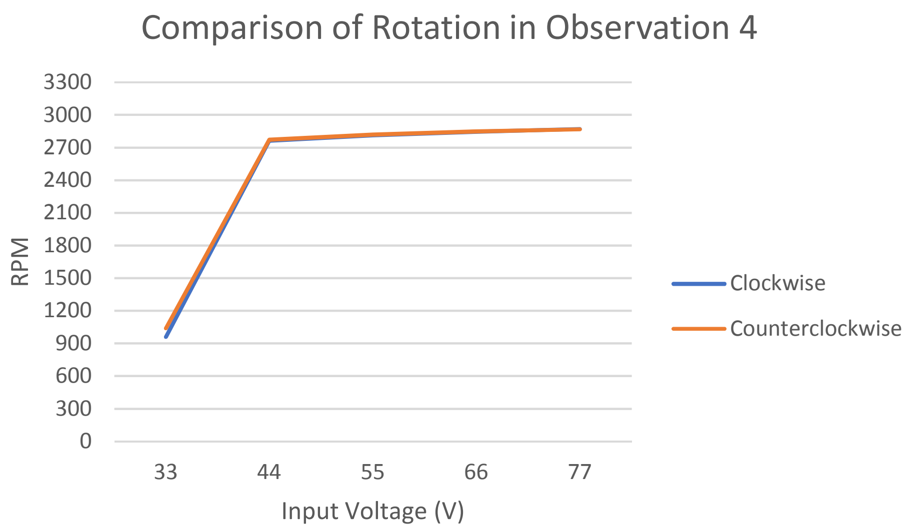

Chart 4.4 Chart of Rotation in Observation 4

Chart 4.4 rotation of motor when clockwise condition is almost same with counterclockwise condition but clockwise condition is still slower than counterclockwise condition. This is because clockwise have bigger torque so clockwise condition have slower rotation.

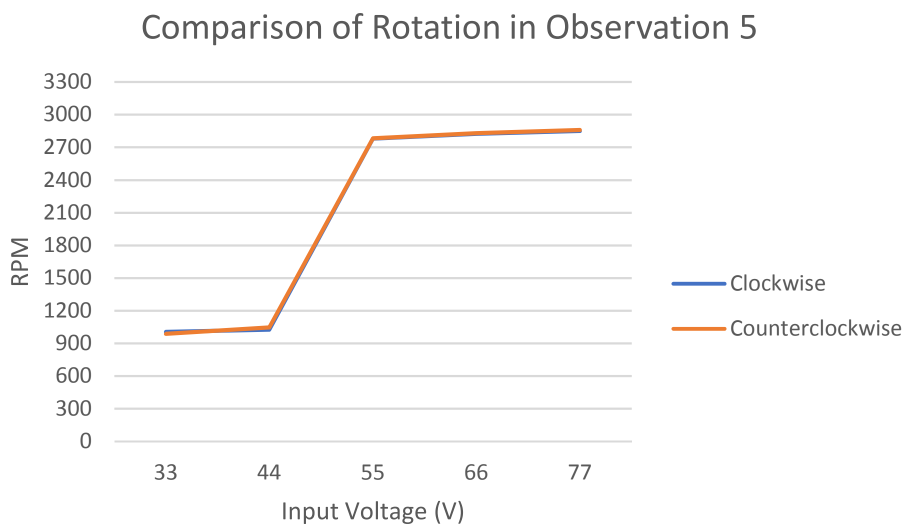

Chart 4.5 Chart of Rotation in Observation 5

Chart 4.5 rotation of motor when clockwise condition is almost same with counterclockwise condition but clockwise condition is still slower than counterclockwise condition. This is because clockwise have bigger torque so clockwise condition have slower rotation.

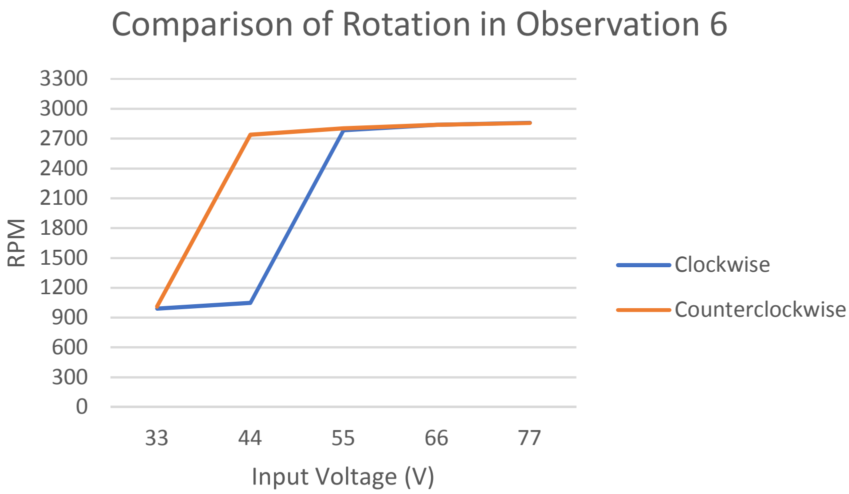

Chart 4.6 Chart of Rotation in Observation 6

Chart 4.6 rotation of motor when clockwise condition is slower than counterclockwise condition thats make counterclockwise has faster rotation than clockwise. This is because clockwise have bigger torque so when motor is in the clockwise condition it has slower rotation.

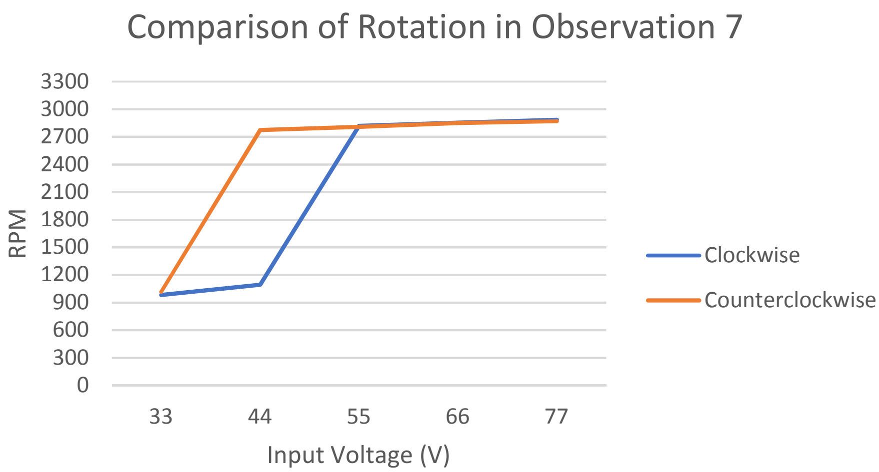

Chart 4.7 Chart of Rotation in Observation 7

Chart 4.7 rotation of motor when clockwise condition is slower than counterclockwise condition thats make counterclockwise has faster rotation than clockwise. This is because clockwise have bigger torque so when motor is in the clockwise condition it has slower rotation.

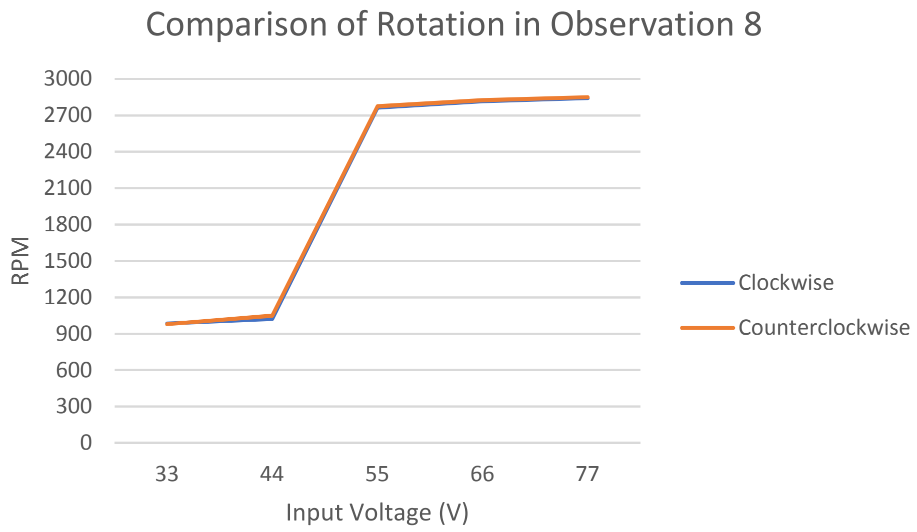

Chart 4.8 Chart of Rotation in Observation 8

Chart 4.8 rotation of motor when clockwise condition is almost same with counterclockwise condition but clockwise condition is still slower than counterclockwise condition. This is because clockwise have bigger torque so clockwise condition have slower rotation.

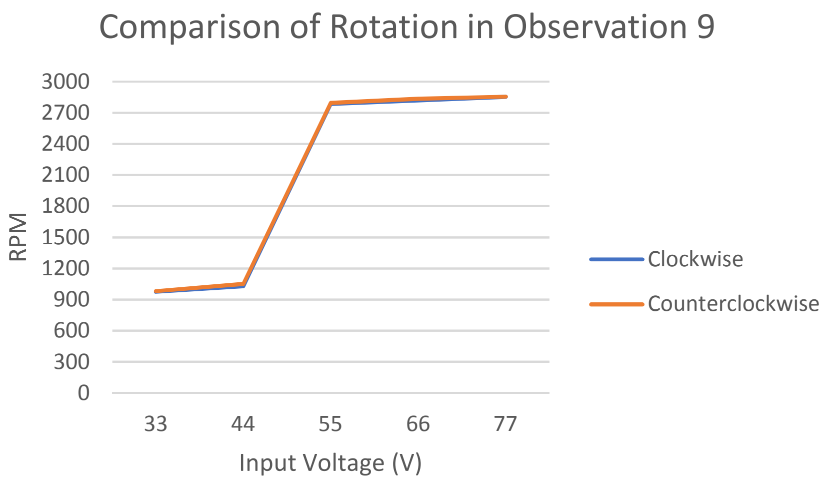

Chart 4.9 Chart of Rotation in Observation 9

Chart 4.9 rotation of motor when clockwise condition is almost same with counterclockwise condition but clockwise condition is still slower than counterclockwise condition. This is because clockwise have bigger torque so clockwise condition have slower rotation.

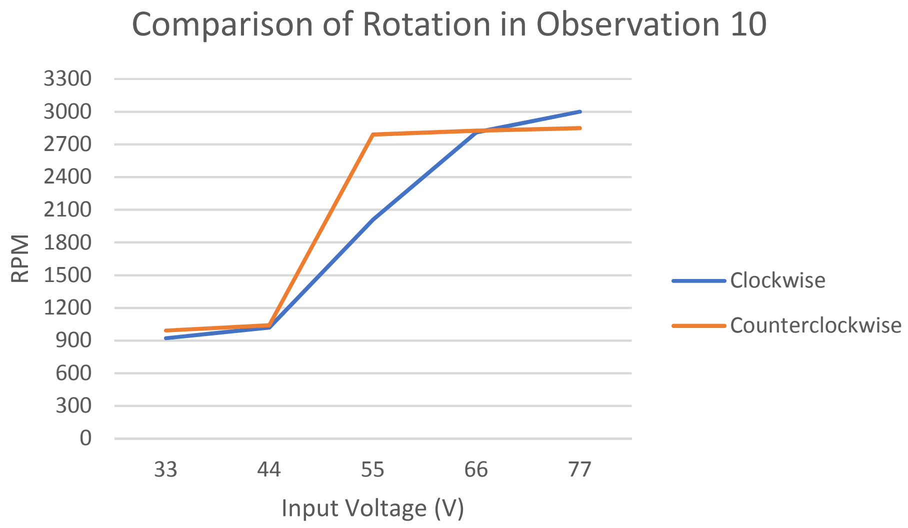

Chart 4.10 Chart of Rotation in Observation 10

Chart 4.10 rotation of motor when clockwise condition is slower than counterclockwise condition thats make counterclockwise has faster rotation than clockwise. This is because clockwise have bigger torque so when motor is in the clockwise condition it has slower rotation. But there is anomally when input voltage at 77 volt. This is because lack of accuracy from author to control voltage input.

From the chart 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9 and 4.10 comparison rotation between clockwise condition and counterclockwise condition, the author make conclusion that clockwise condition is has slower rotation for same input voltage. There are anomaly that make the clockwise is faster than counterclockwise, this is because lack of accuracy from author to control voltage input.

4.2.1.2 Comparison Chart of Current Between Clockwise and Counterclockwise in Unloaded Condition

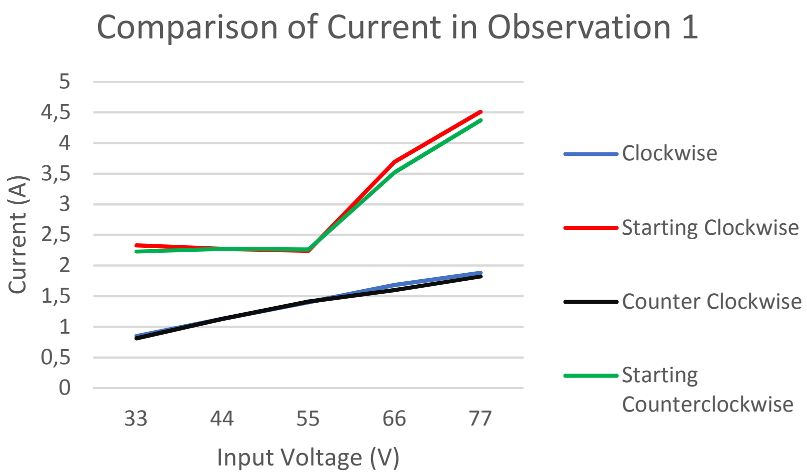

Chart 4.11 Chart of Comparisson Current in Observation 1

Chart 4.11 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times of normal current.

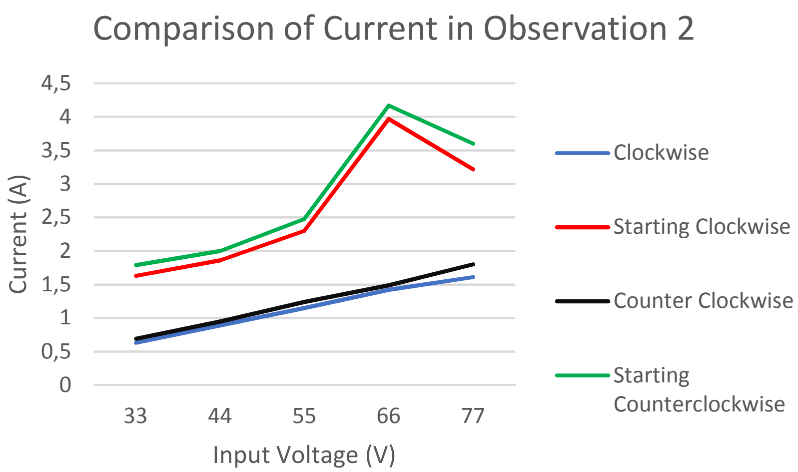

Chart 4.12 Chart of Comparisson Current in Observation 2

Chart 4.12 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times of normal current.

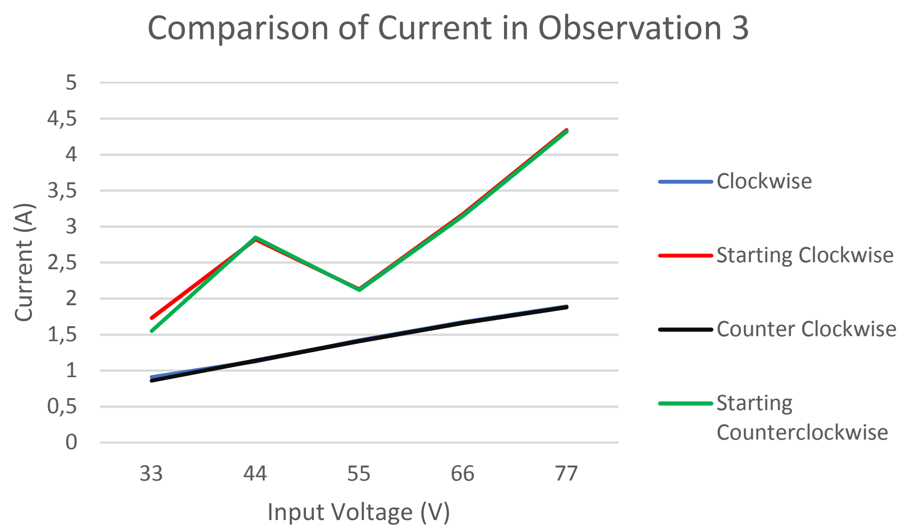

Chart 4.13 Chart of Comparisson Current in Observation 3

Chart 4.13 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times of normal current.

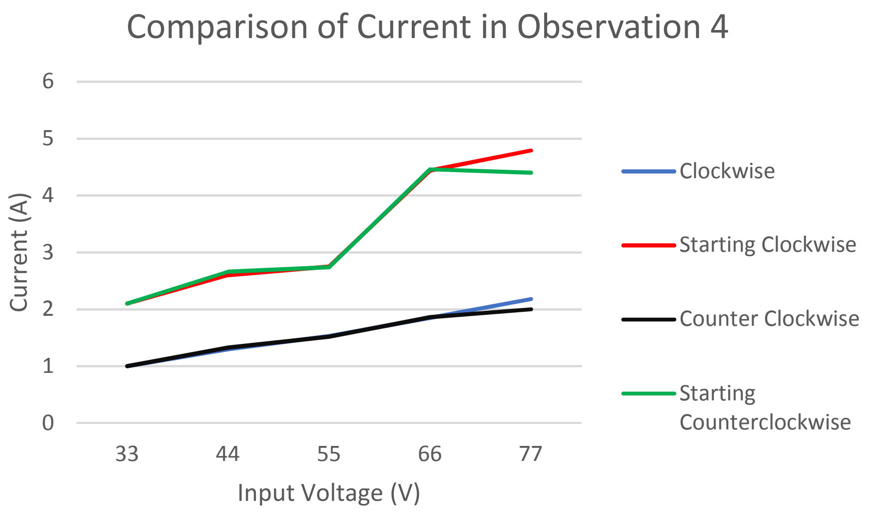

Chart 4.14 Chart of Comparisson Current in Observation 4

Chart 4.14 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times of normal current.

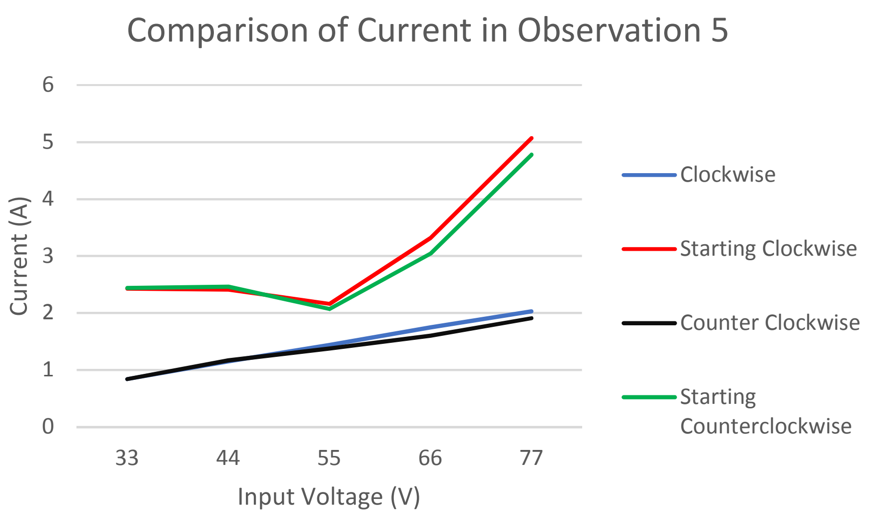

Chart 4.15 Chart of Comparisson Current in Observation 5

Chart 4.15 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times of normal current.

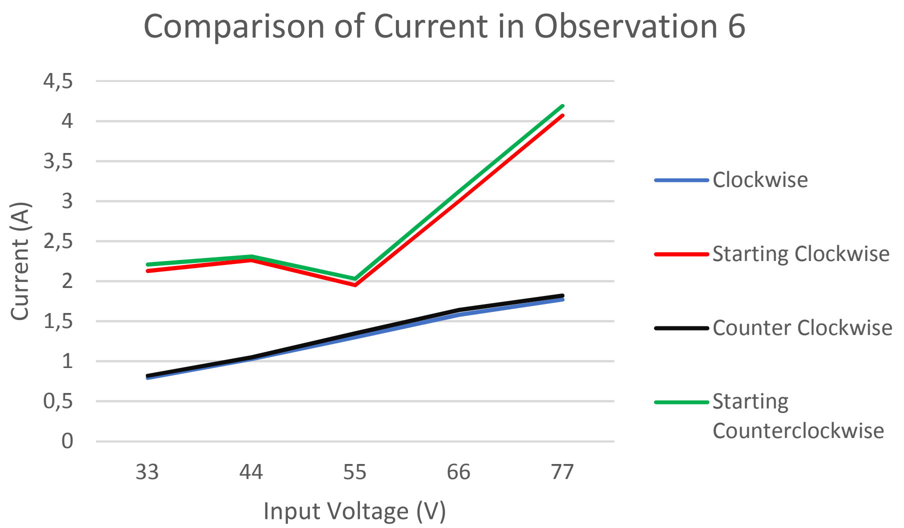

Chart 4.16 Chart of Comparisson Current in Observation 6

Chart 4.16 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times of normal current.

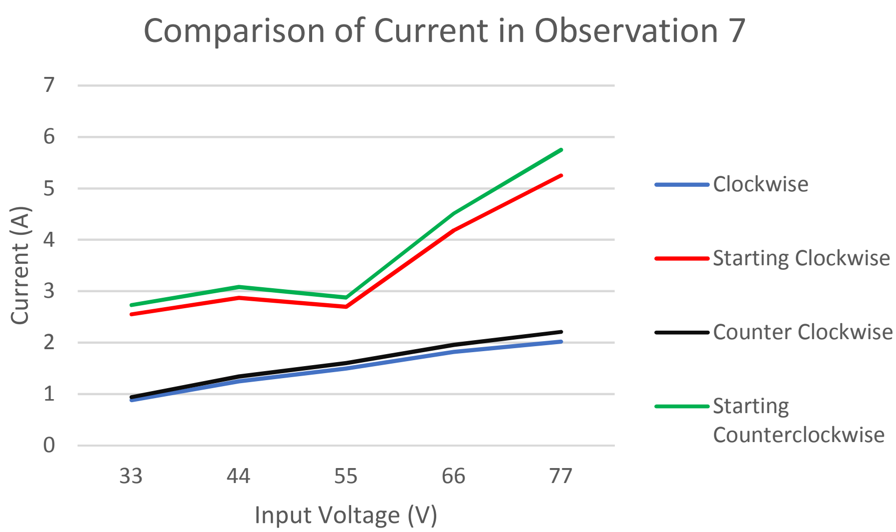

Chart 4.17 Chart of Comparisson Current in Observation 7

Chart 4.17 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times of normal current.

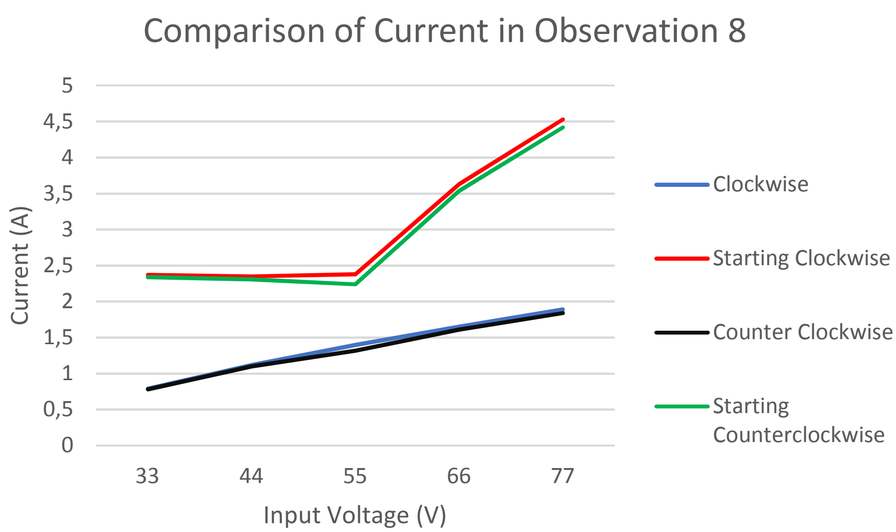

Chart 4.18 Chart of Comparisson Current in Observation 8

Chart 4.18 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times of normal current.

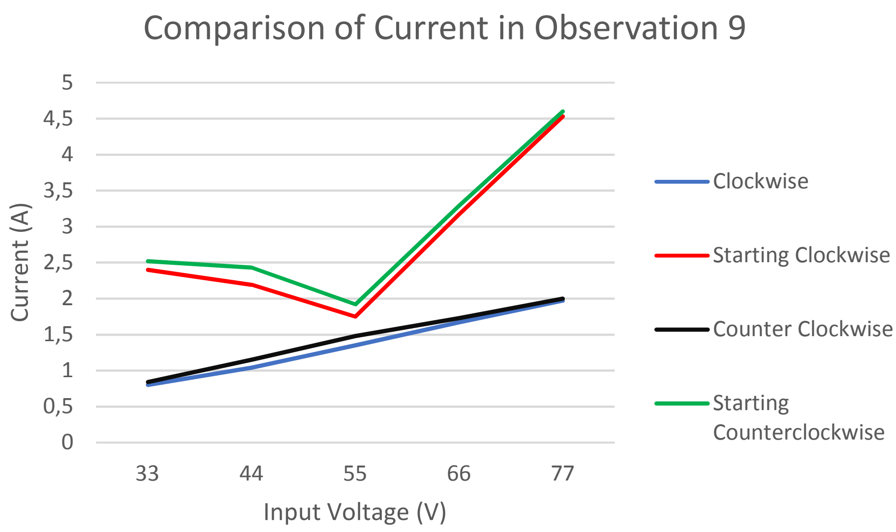

Chart 4.19 Chart of Comparisson Current in Observation 9

Chart 4.19 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times of normal current.

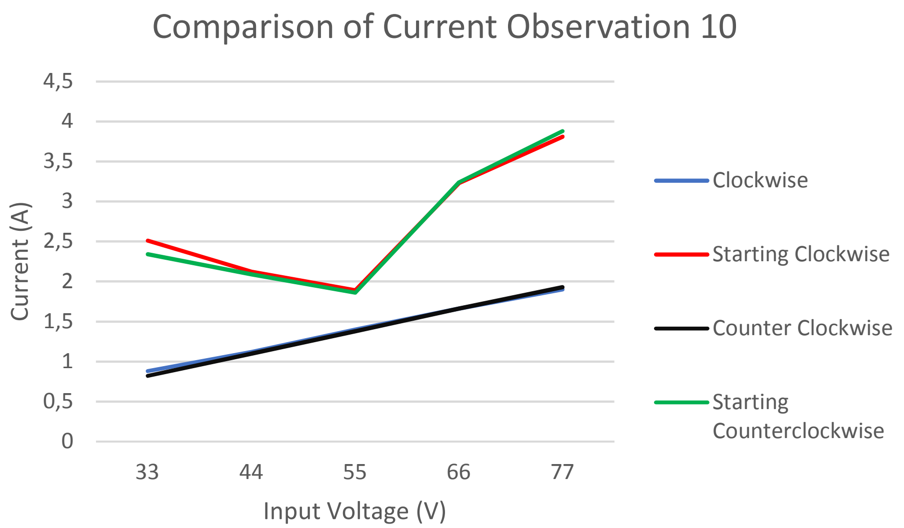

Chart 4.20 Chart of Comparisson Current in Observation 10

Chart 4.20 show for starting current is always bigger than normal current this apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current. Pattern of the starting current is random but in this obeservation is from 1,5 until 3,0 times bigger than normal current so every observation can have different shape of chart. But this value is still smaller than theory thats mentions 3 until 7 times than normal current.

From the chart 4.11, 4.12, 4.13, 4.14, 4.15, 4.16, 4.17, 4.18, 4.19 dan 4.20 comparison of current author make conclusion that starting current for single phase motor bifilar wound is two until three times from the normal current. This is apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current.

4.2.1.3 Comparison Chart of Power Between Clockwise and Counterclockwise in Unloaded Condition

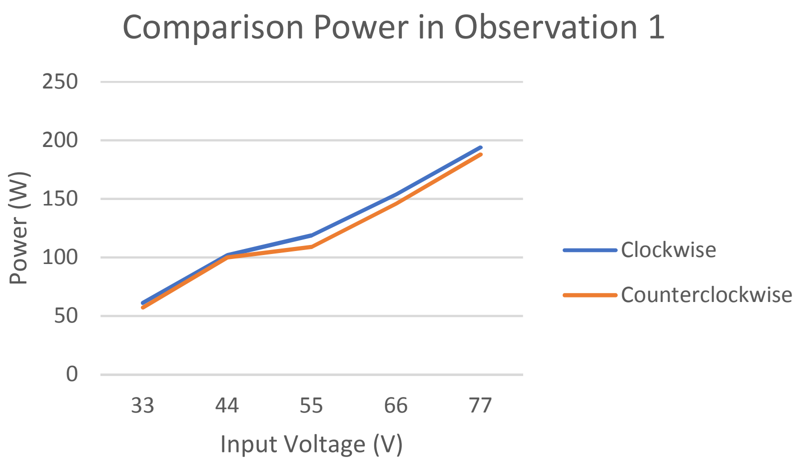

Chart 4.21 Chart of Power in Observation 1

Chart 4.21 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger voltage that input to the single phase motor bifilar wound, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V\ x\ I\ x\ cos\ \varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.21 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

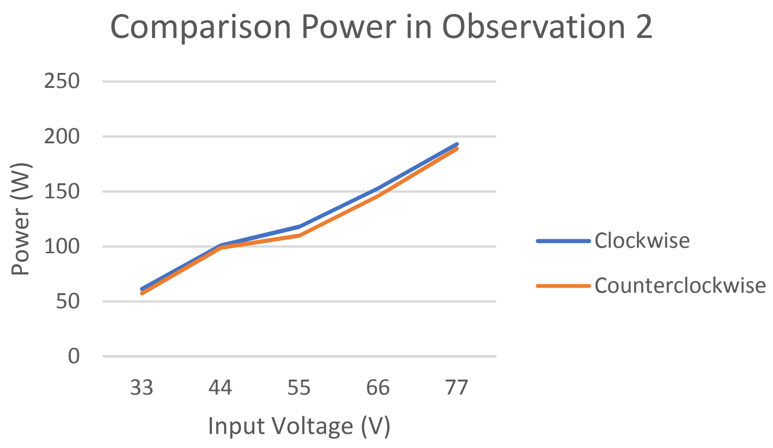

Chart 4.22 Chart of Power in Observation 2

Chart 4.22 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger voltage that input to the single phase motor bifilar wound, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V\ x\ I\ x\ cos\ \varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.22 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

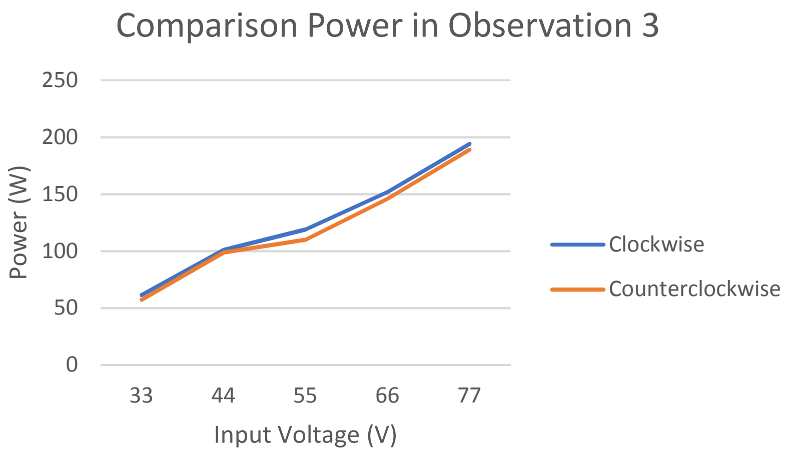

Chart 4.23 Chart of Power in Observation 3

Chart 4.23 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger voltage that input to the single phase motor bifilar wound, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V\,x\,I\,x\,cos\,\varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.23 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

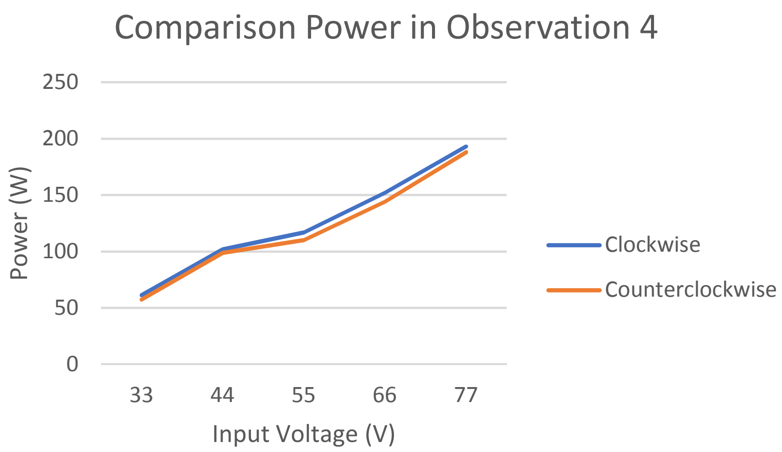

Chart 4.24 Chart of Power in Observation 4

Chart 4.24 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger voltage that input to the single phase motor bifilar wound, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V\,x\,I\,x\,cos\,\varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.24 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

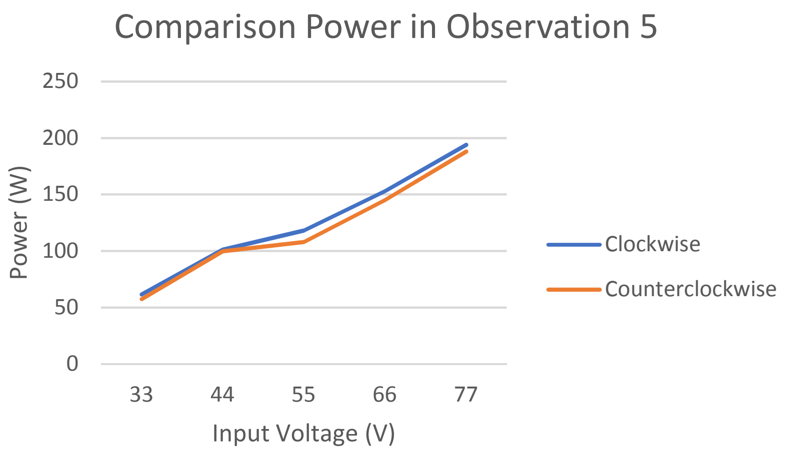

Chart 4.25 Chart of Power in Observation 5

Chart 4.25 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger voltage that input to the single phase motor bifilar wound, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V \, x \, I \, x \, cos \, \varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.25 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

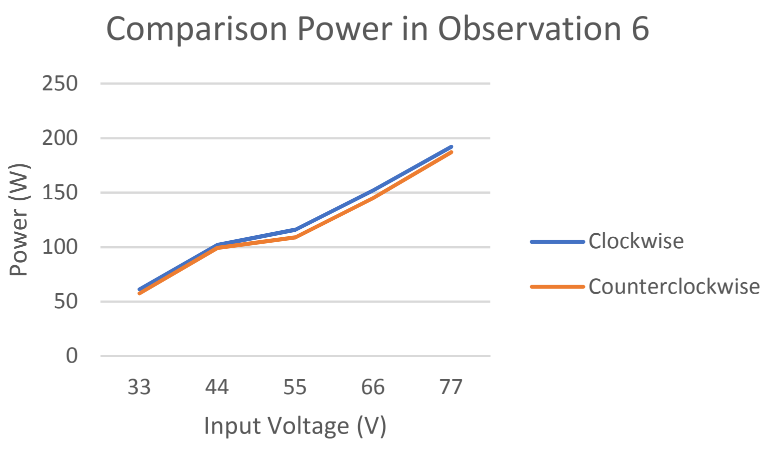

Chart 4.26 Chart of Power in Observation 6

Chart 4.26 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger voltage that input to the single phase motor bifilar wound, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V\ x\ I\ x\ cos\ \varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.26 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

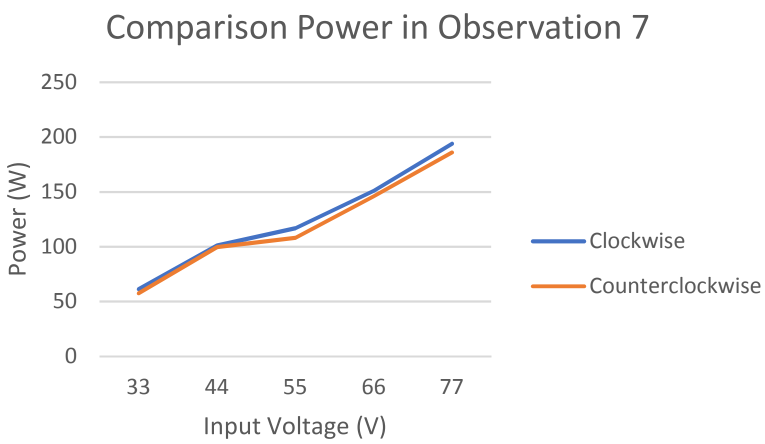

Chart 4.27 Chart of Power in Observation 7

Chart 4.27 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger voltage that input to the single phase motor bifilar wound, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V\ x\ I\ x\ cos\ \varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.27 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

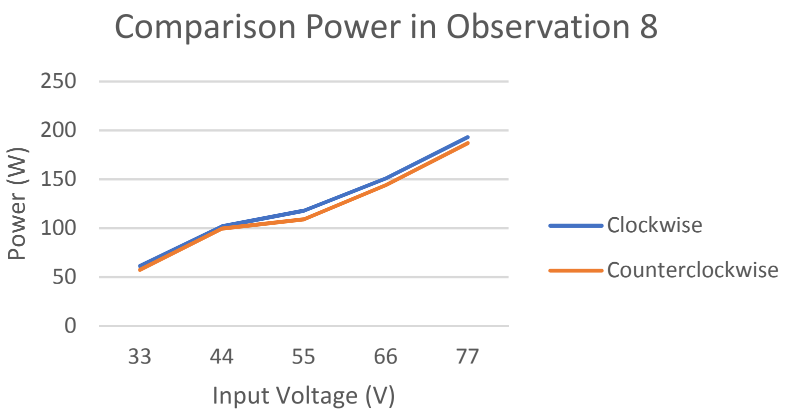

Chart 4.28 Chart of Power in Observation 8

Chart 4.28 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger voltage that input to the single phase motor bifilar wound, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V\ x\ I\ x\ cos\ \varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.28 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

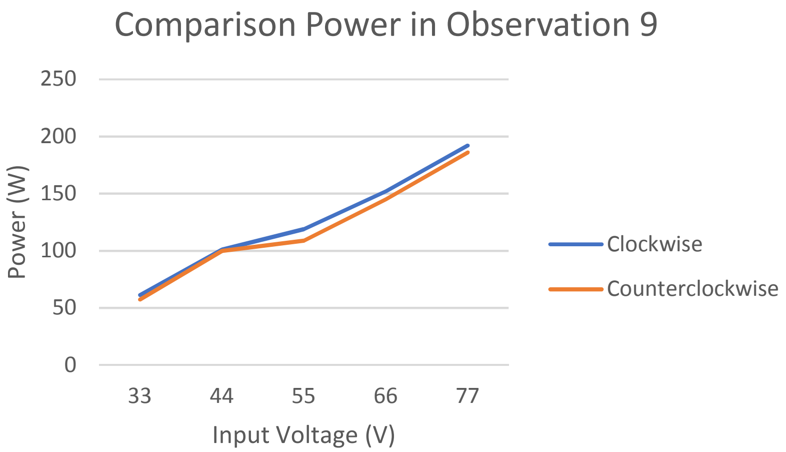

Chart 4.29 Chart of Power in Observation 9

Chart 4.29 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger voltage that input to the single phase motor bifilar wound, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V\, x\, I\, x\, cos\, \varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.29 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

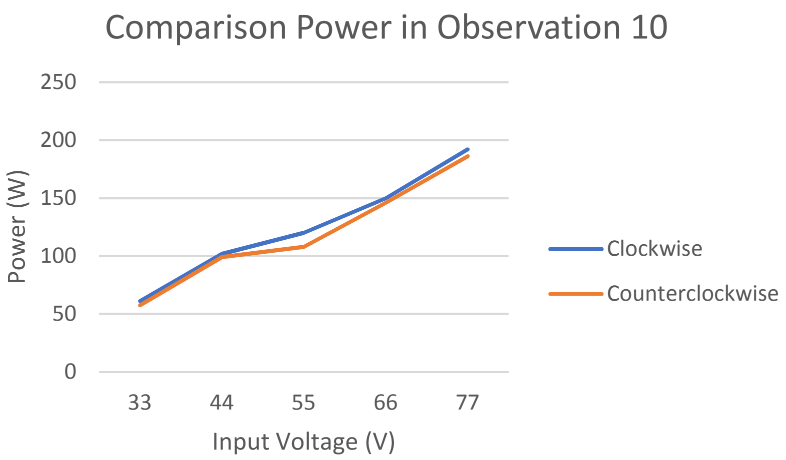

Chart 4.30 Chart of Power in Observation 10

Chart 4.30 show when input voltage is increase, power of single phase motor bifilar wound is increase too. This is because bigger the voltage that input to the single phase induction motor feedback bifilar winding, bigger power that single phase motor bifilar wound can generate. It can be prove from equation $P = V\, x\, I\, x\, cos\, \varphi$, when voltage is increase power of single phase motor bifilar wound is increase too. From chart 4.30 clockwise condition have bigger power from counterclockwise condition this is because clockwise have slower rotation than counterclockwise condition this can make clockwise condition have bigger power and can be shown by equation $P = {}^{\tau}/_{\omega}$ so clockwise condition have bigger torque and smaller omega so the power is bigger than counterclockwise condition.

From chart 4.21, 4.22, 4.23, 4.24, 4.25, 4.26, 4.27, 4.28, 4.29 and 4.30 author make conclusion power and input voltage is directly proportional. When input voltage is increase, power is increase too.

4.2.1.4 Comparison Chart of Omega in Clockwise and Counterclockwise in Unloaded Condition

Clockwise Condition

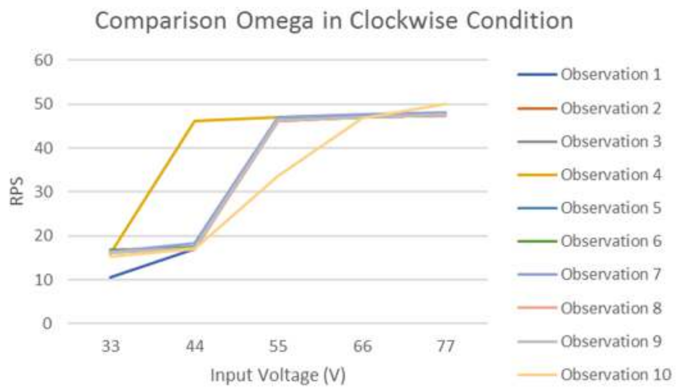

Chart 4.31 Chart of Comparison Omega in Clockwise Condition

Chart 4.31 is show rotation of single phase induction motor feedback bifilar winding is have significant increasing when reach 55 volt. This is because when reach 55 volt sentrifugal switch is function so rotation of single phase induction motor feedback bifilar winding is increasing. There is anomaly in observation 4 and 10. This is because lack of accuracy from author to control voltage input.

Counterclockwise Condition

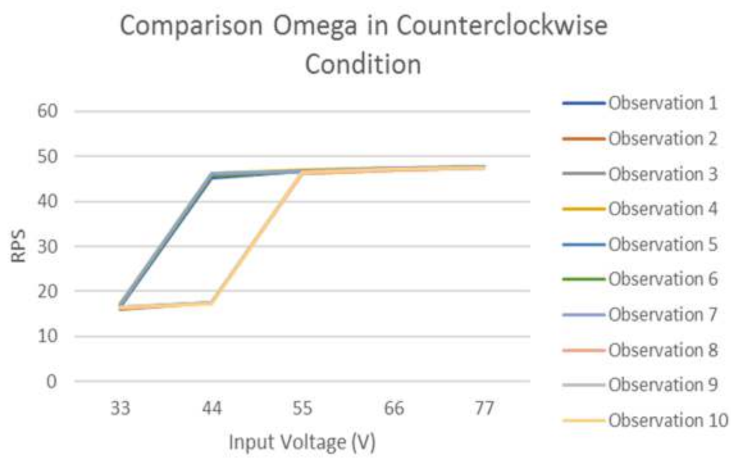

Chart 4.32 Chart of Comparison Omega in Counter Clockwise Condition

Chart 4.32 is show rotation of single phase induction motor feedback bifilar winding is have significant increasing when reach 44 volt. This is because when reach 44 volt sentrifugal switch is function so rotation of single phase induction motor feedback bifilar winding is increasing. Diferent with clockwise condition, input current for counterclockwise condition have bigger value. So sentrifugal switch is active in 44 volt. There is anomaly in observation 2 and 10. This is because lack of accuracy from author to control voltage input.

4.2.1.5 Comparison Chart of Torque Between Clockwise and Counterclockwise in Unloaded Condition

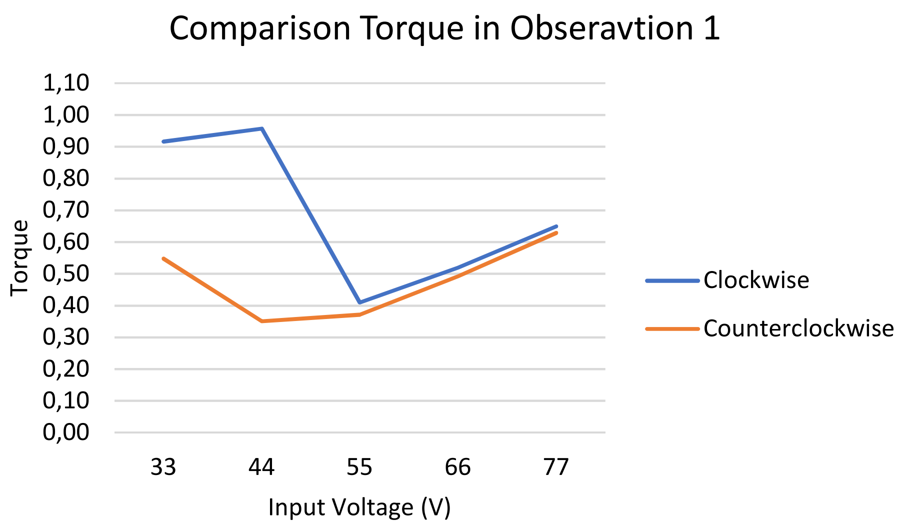

Chart 4.33 Chart of Torque in Observation 1

Chart 4.33 show that torque of single phase induction motor feedback bifilar winding is increasing from 33 volt to 44 volt after that decreasing in 55 volt and increasing again at 66 volt until 77 volt. This is because sentrifugal switch is active. Deviation in counterclockwise condition is lack accuracy from author control voltage input.

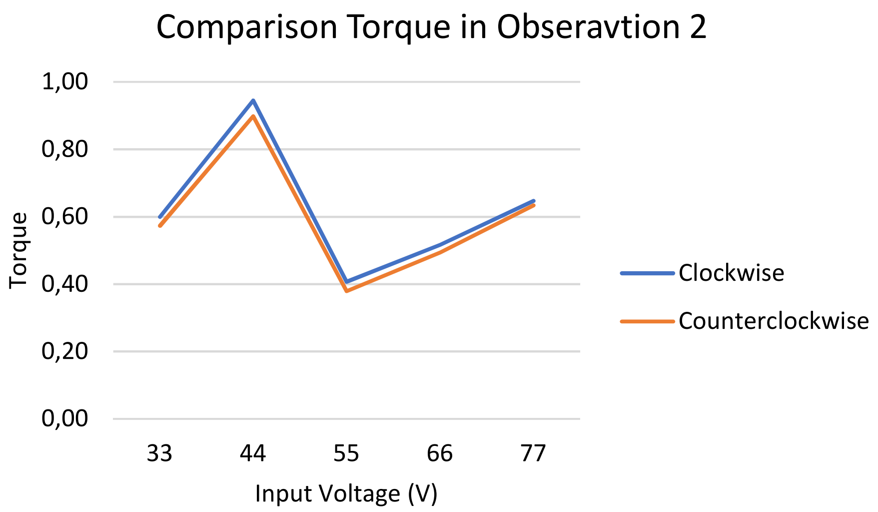

Chart 4.34 Chart of Torque in Observation 2

Chart 4.34 show that torque of single phase induction motor feedback bifilar winding is increasing from 33 volt to 44 volt after that decreasing in 55 volt and increasing again at 66 volt until 77 volt. This is because sentrifugal switch is active.

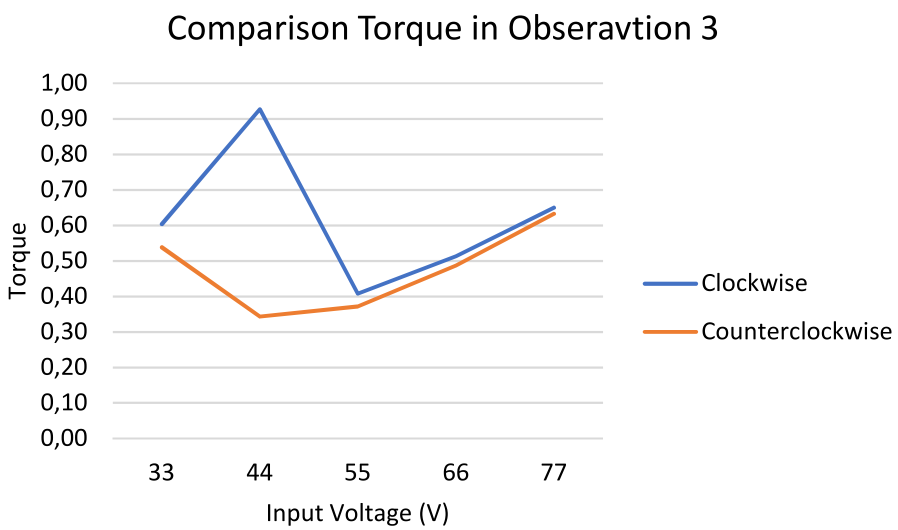

Chart 4.35 Chart of Torque in Observation 3

Chart 4.35 show that torque of single phase induction motor feedback bifilar winding is increasing from 33 volt to 44 volt after that decreasing in 55 volt and increasing again at 66 volt until 77 volt. This is because sentrifugal switch is active.

Deviation in counterclockwise condition is lack accuracy from author control voltage input.

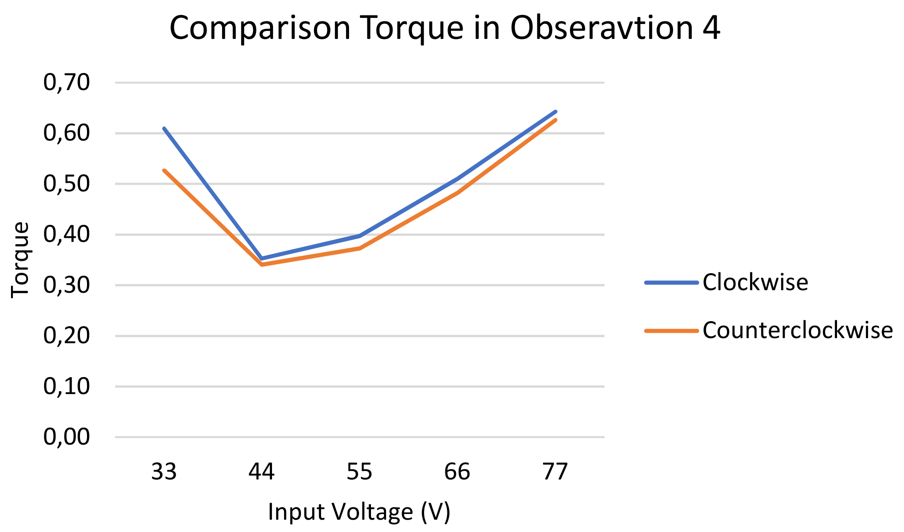

Chart 4.36 Chart of Torque in Observation 4

Chart 4.36 show decreasing in 33 volt to 44 volt and increasing again at 55 volt until 77 volt. This deviation is from lack of accuracy author to collect data.

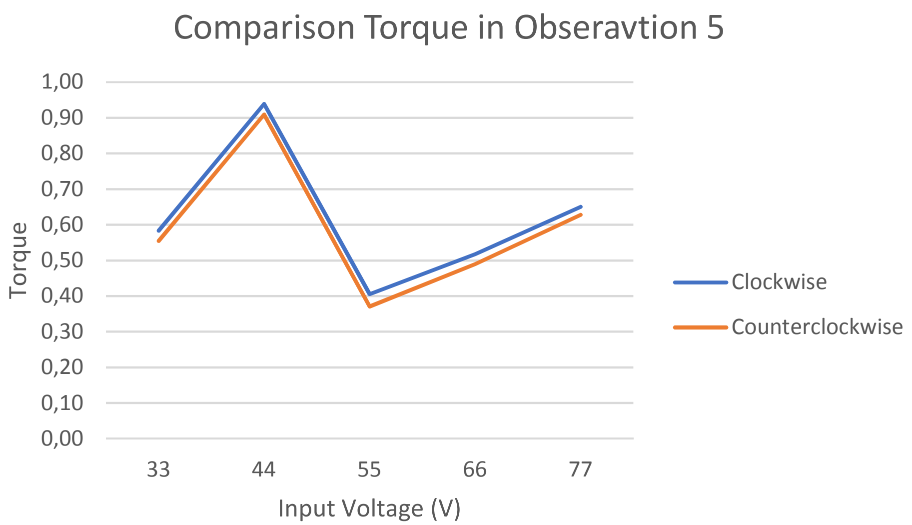

Chart 4.37 Chart of Torque in Observation 5

Chart 4.37 show that torque of single phase induction motor feedback bifilar winding is increasing from 33 volt to 44 volt after that decreasing in 55 volt and increasing again at 66 volt until 77 volt. This is because sentrifugal switch is active.

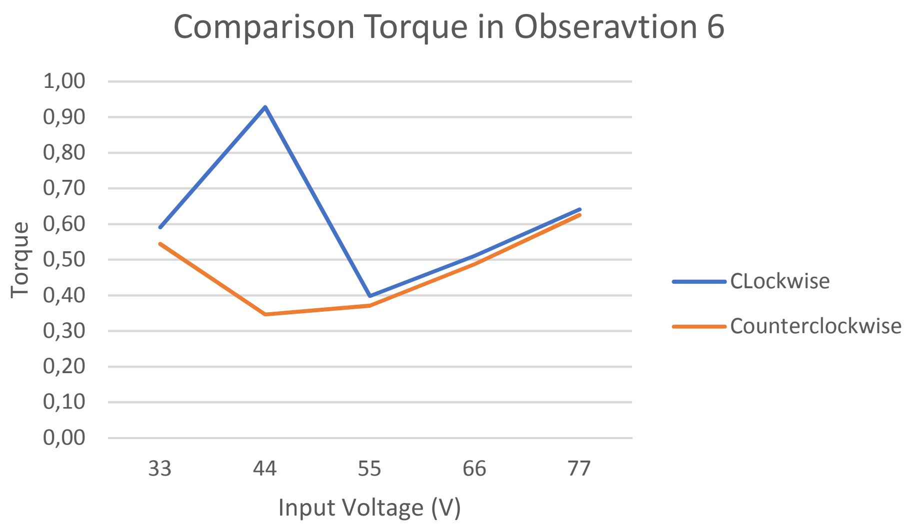

Chart 4.38 Chart of Torque in Observation 6

Chart 4.38 show that torque of single phase induction motor feedback bifilar winding is increasing from 33 volt to 44 volt after that decreasing in 55 volt and increasing again at 66 volt until 77 volt. This is because sentrifugal switch is active. Deviation in counterclockwise condition is lack accuracy from author control voltage input.

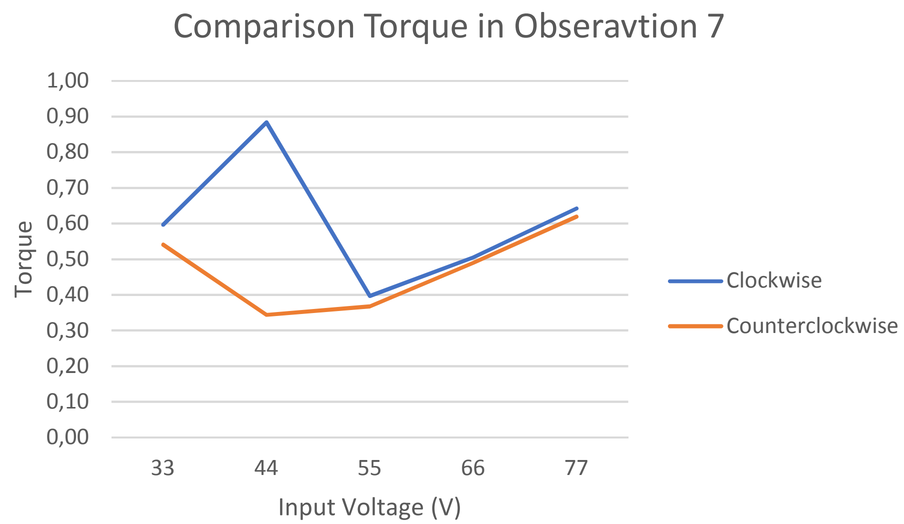

Chart 4.39 Chart of Torque in Observation 7

Chart 4.39 show that torque of single phase induction motor feedback bifilar winding is increasing from 33 volt to 44 volt after that decreasing in 55 volt and increasing again at 66 volt until 77 volt. This is because sentrifugal switch is active. Deviation in counterclockwise condition is lack accuracy from author control voltage input.

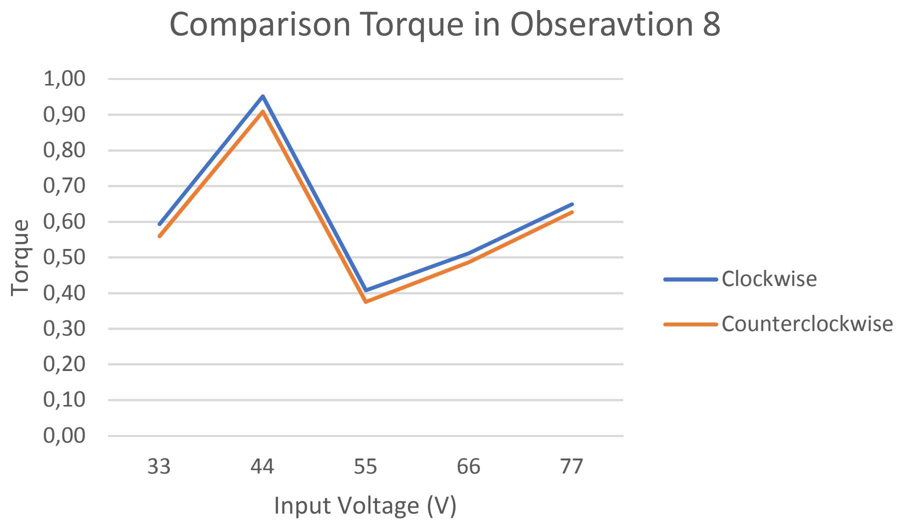

Chart 4.40 Chart of Torque in Observation 8

Chart 4.40 show that torque of single phase induction motor feedback bifilar winding is increasing from 33 volt to 44 volt after that decreasing in 55 volt and increasing again at 66 volt until 77 volt. This is because sentrifugal switch is active.

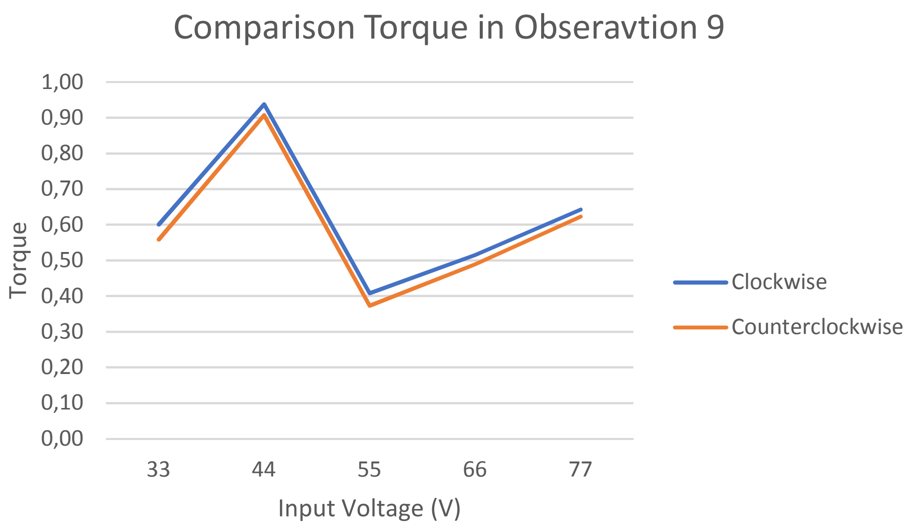

Chart 4.41 Chart of Torque in Observation 9

Chart 4.41 show that torque of single phase induction motor feedback bifilar winding is increasing from 33 volt to 44 volt after that decreasing in 55 volt and increasing again at 66 volt until 77 volt. This is because sentrifugal switch is active.

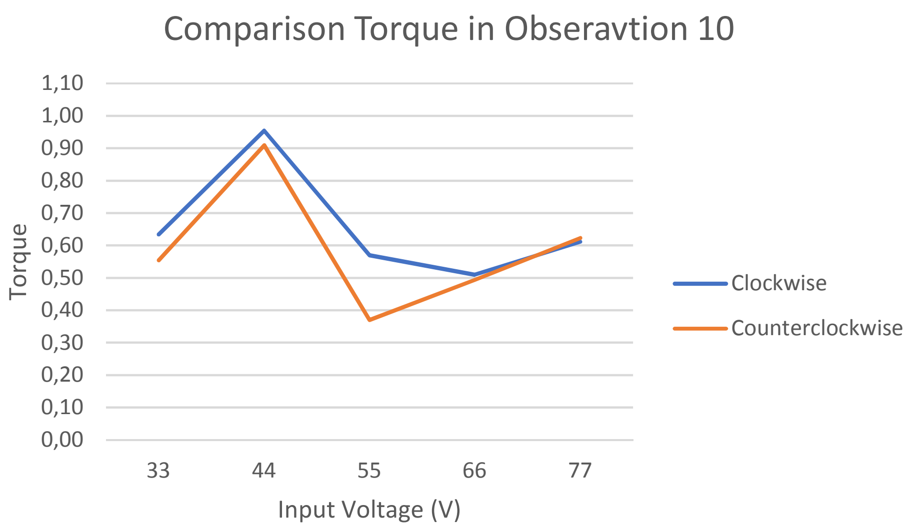

Chart 4.42 Chart of Torque in Observation 10

Chart 4.42 show that torque of single phase induction motor feedback bifilar winding is increasing from 33 volt to 44 volt after that decreasing in 55 volt and increasing again at 66 volt until 77 volt. This is because sentrifugal switch is active. Deviation in 66 volt is lack of accuracy author in control of voltage input.

From chart 4.33, 4.34, 4.35, 4.36, 4.37, 4.38, 4.39, 4.40, 4.41 and 4.42 author make conclusion that at 44 volt sentrifugal switch is active that make torque in 33 volt to 44 volt is increasing and decreasing at 55 volt after that increasing again at 66 volt until 77 volt.

4.2.2 Loaded Condition

Loaded condition is when author observe single phase induction motor feedback bifilar winding is working with load. Load in this bacelor thesis is three phase syncronus motor/generator. This is motor act like generator.This observation data is use five observation to obtain the data. Data that is taken is voltage, current, rotation, load factor, power input and power output. From data that have been taken can determine to make calculation for omega and efficiency for the single phase motor bifilar wound. Data that is observed is for input voltage 110 volt, 120 volt, 130 volt, 140 volt and 150 volt. That input voltage is for the electric motor single phase bifilar wound and for the generator that is for the load, input voltage is 60 volt, 70 volt, 80 volt, 90 volt and 100 volt. Data is taken five times.

4.2.2.1 Chart Comparison in 110 Volt for Clockwise Condition

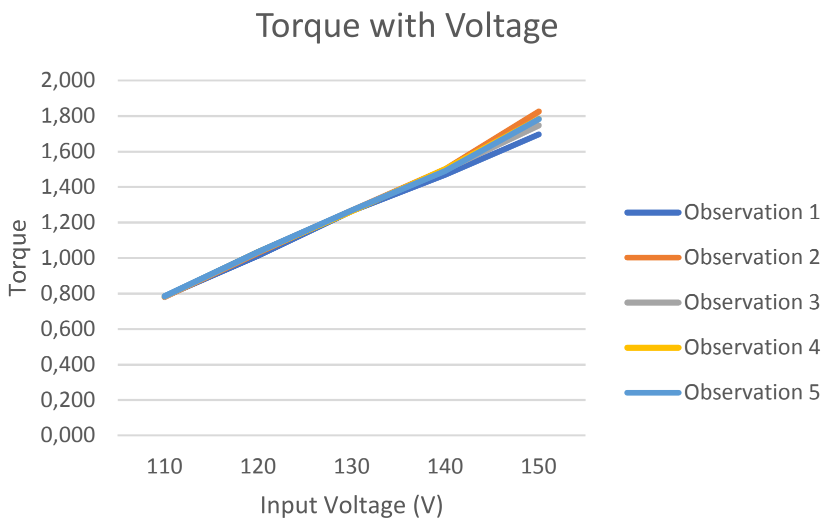

Chart 4.31 Chart of Torque and Voltage for 110 Volt

From chart 4.31 torque is directly proportional with input voltage. All of data in chart 4.31 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

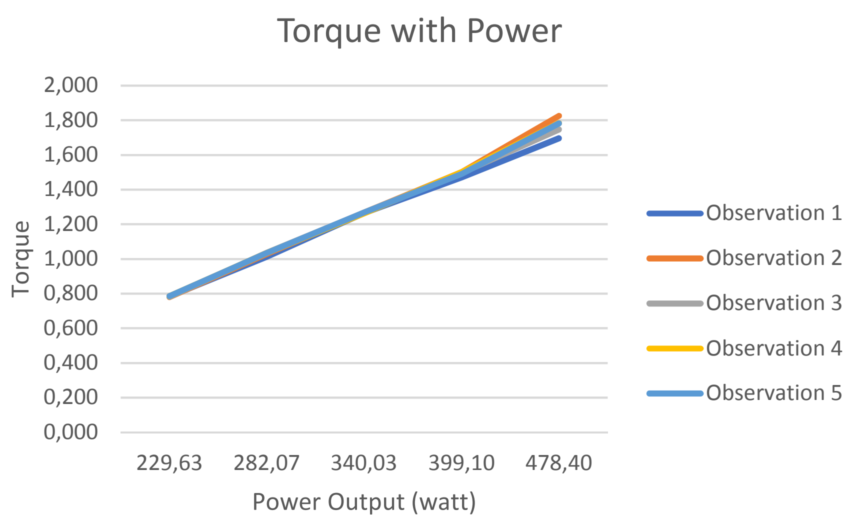

Chart 4.32 Chart of Torque and Power for 110 Volt

From chart 4.32 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

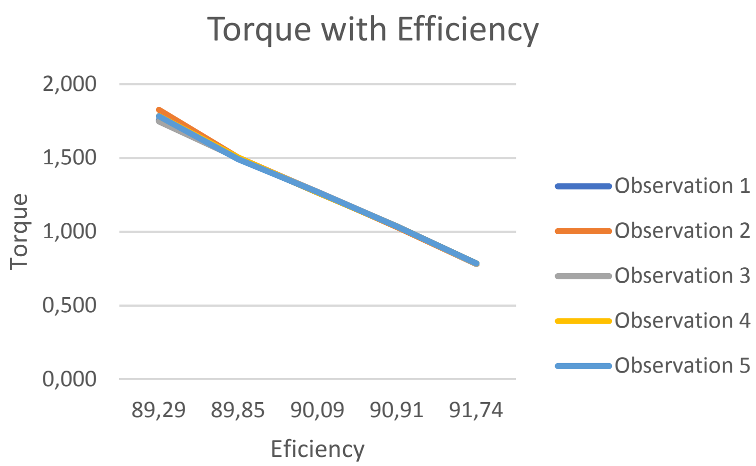

Chart 4.33 Chart of Torque and Efficiency for 110 Volt

From chart 4.33 torque is inversely proportional with efficiency. All of data in chart 4.31 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

4.2.2.2 Chart Comparison in 120 Volt for Clockwise Condition

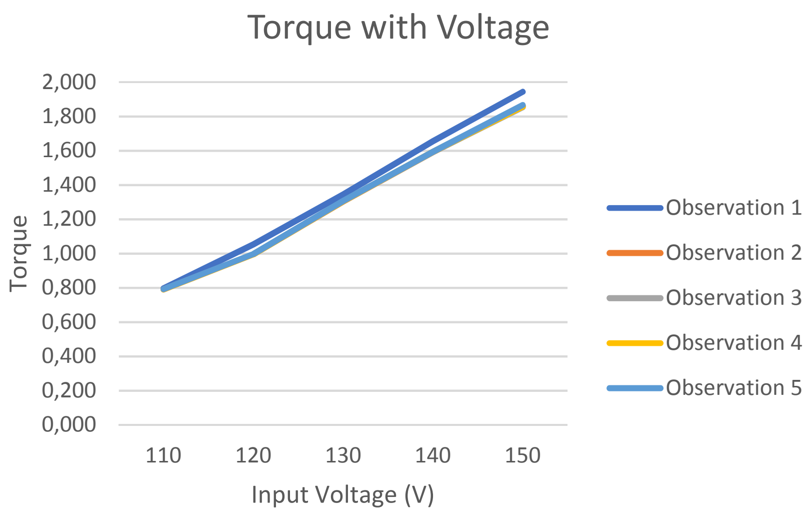

Chart 4.34 Chart of Torque and Voltage for 120 Volt

From chart 4.31 torque is directly proportional with input voltage. All of data in chart 4.34 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

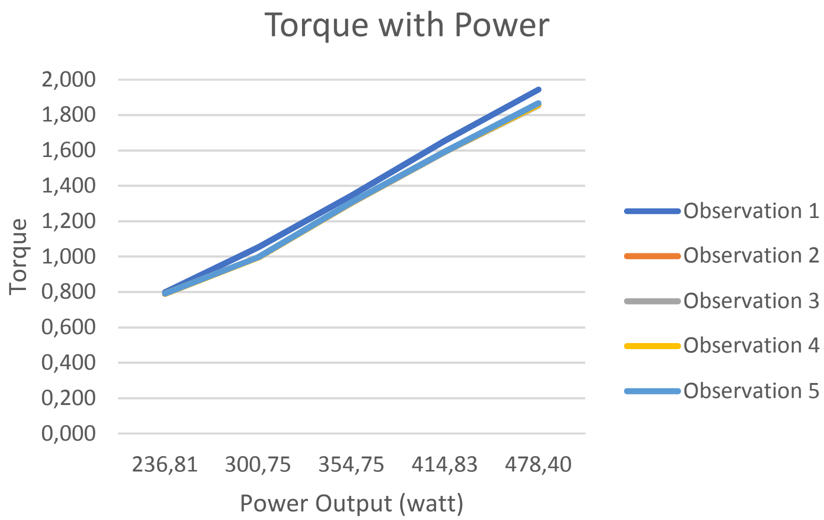

Chart 4.35 Chart of Torque and Power for 120 Volt

From chart 4.35 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

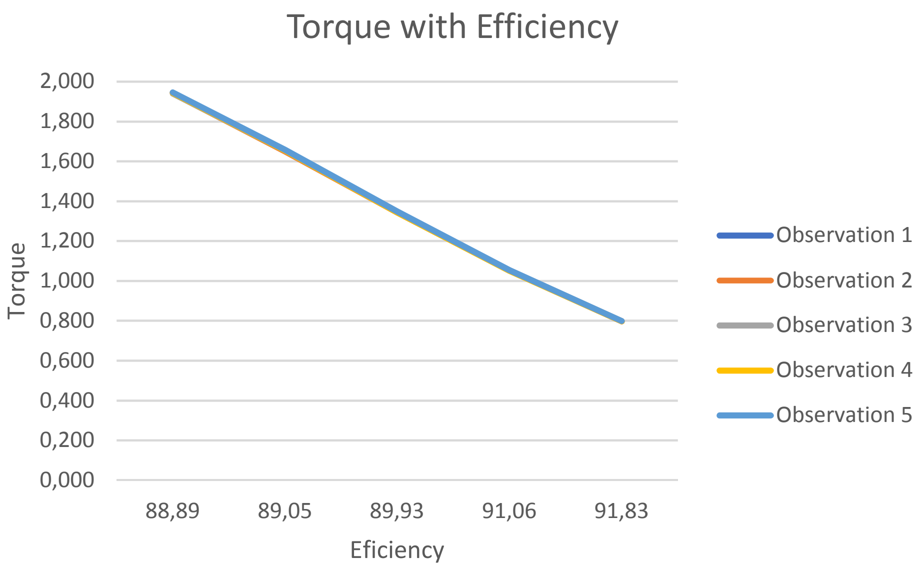

Chart 4.36 Chart of Torque and Efficiency for 120 Volt

From chart 4.36 torque is inversely proportional with efficiency. All of data in chart 4.31 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

4.2.2.3 Chart Comparison in 130 Volt for Clockwise Condition

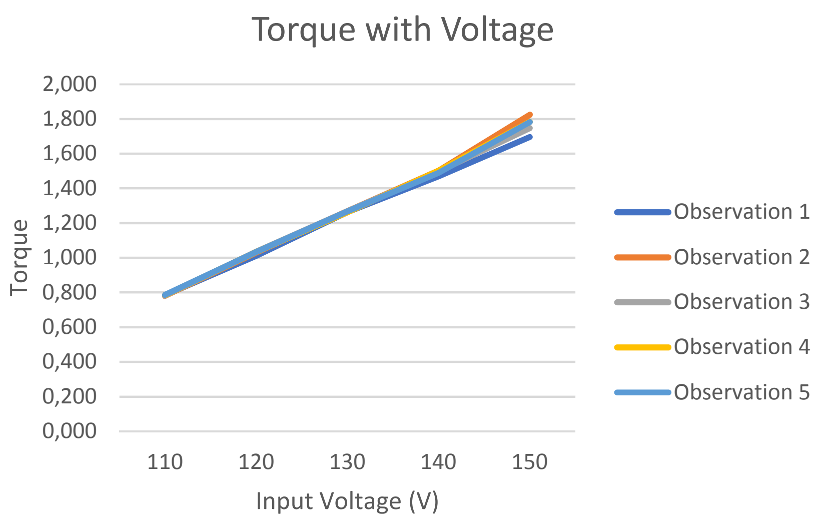

Chart 4.37 Chart of Torque and Voltage for 130 Volt

From chart 4.37 torque is directly proportional with input voltage. All of data in chart 4.37 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

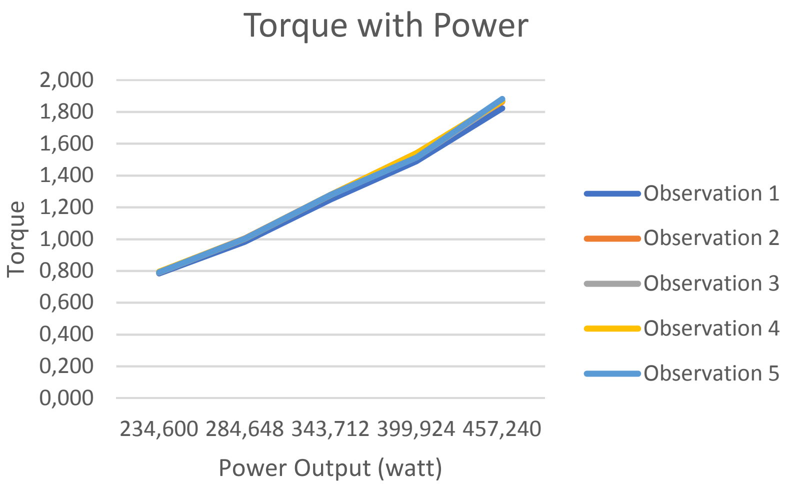

Chart 4.38 Chart of Torque and Power for 130 Volt

From chart 4.38 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

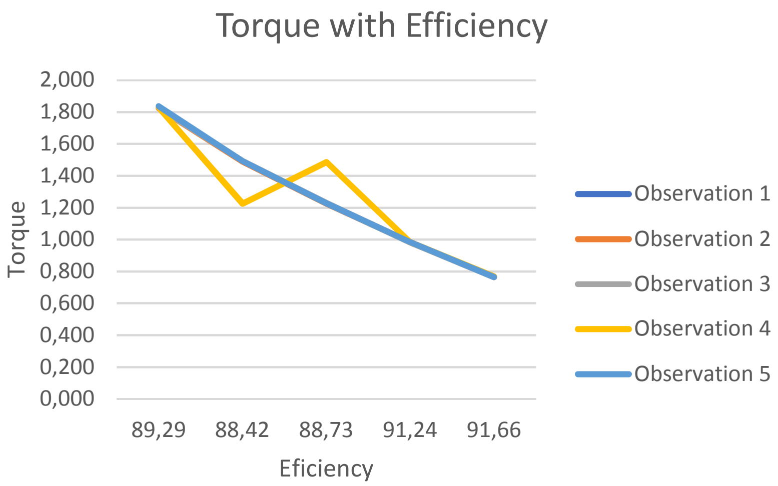

Chart 4.39 Chart of Torque and Efficiency for 130 Volt

From chart 4.39 torque is inversely proportional with efficiency. All of data in chart 4.31 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

4.2.2.4 Chart Comparison in 140 Volt for Clockwise Condition

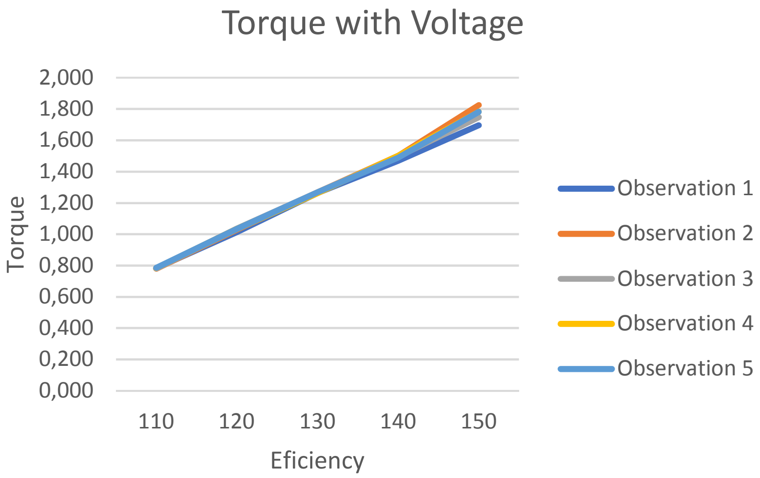

Chart 4.40 Chart of Torque and Voltage for 140 Volt

From chart 4.40 torque is directly proportional with input voltage. All of data in chart 4.40 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

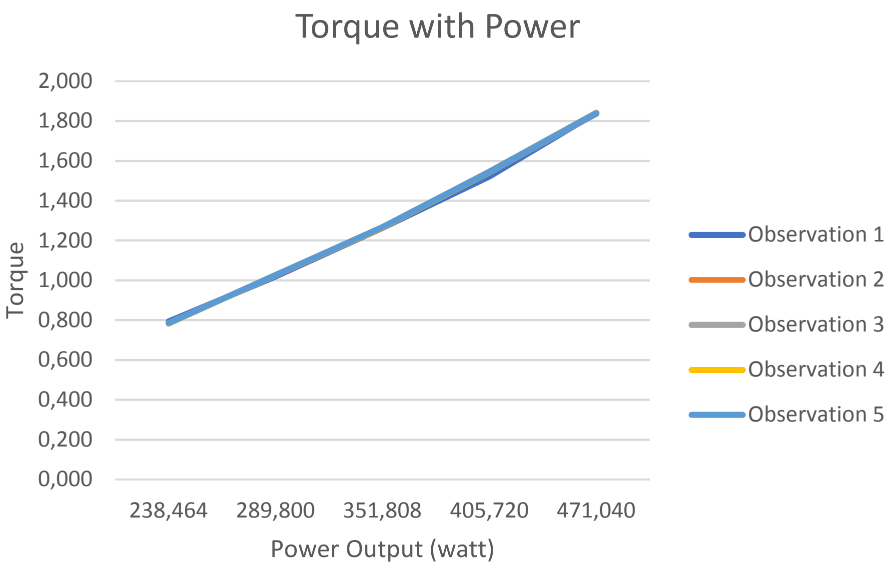

Chart 4.41 Chart of Torque and Power for 140 Volt

From chart 4.41 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

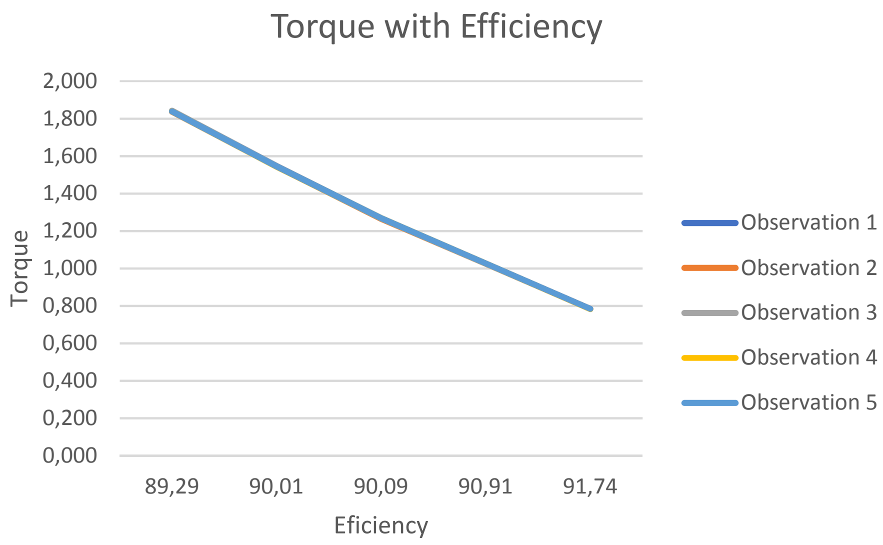

Chart 4.42 Chart of Torque and Efficiency for 140 Volt

From chart 4.42 torque is inversely proportional with efficiency. All of data in chart 4.31 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

4.2.2.5 Chart Comparison in 150 Volt for Clockwise Condition

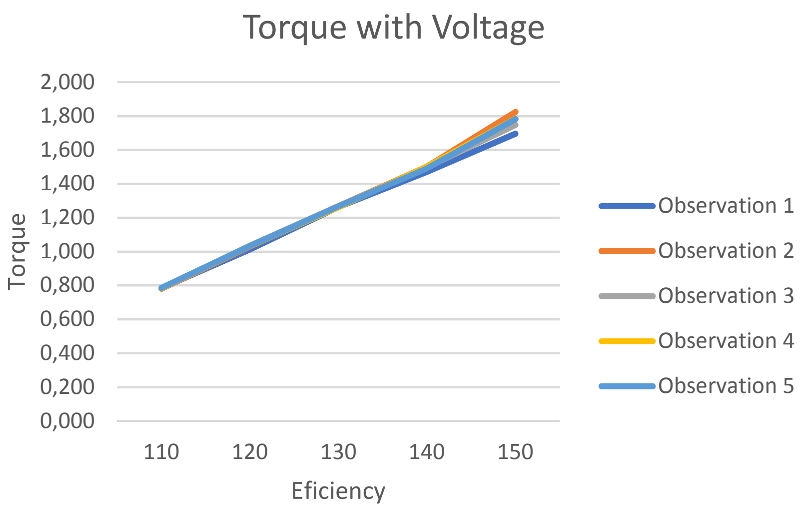

Chart 4.43 Chart of Torque and Efficiency for 150 Volt

From chart 4.43 torque is directly proportional with input voltage. All of data in chart 4.43 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

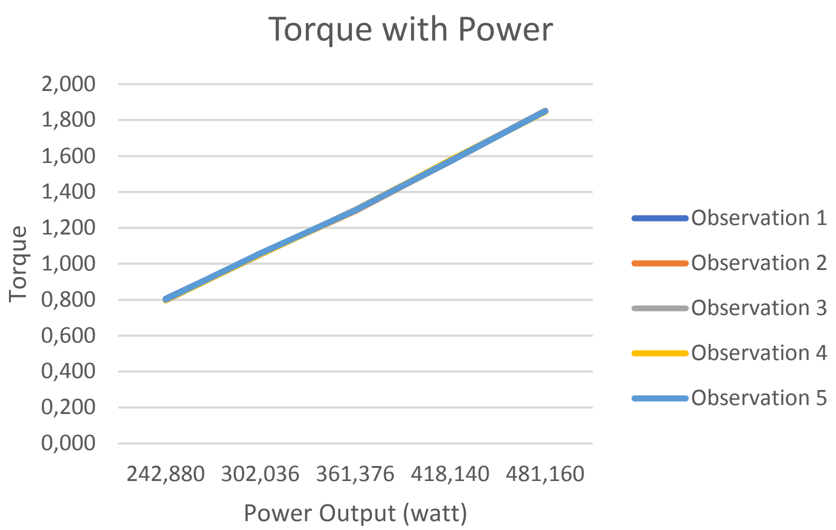

Chart 4.44 Chart of Torque and Power for 150 Volt

From chart 4.44 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

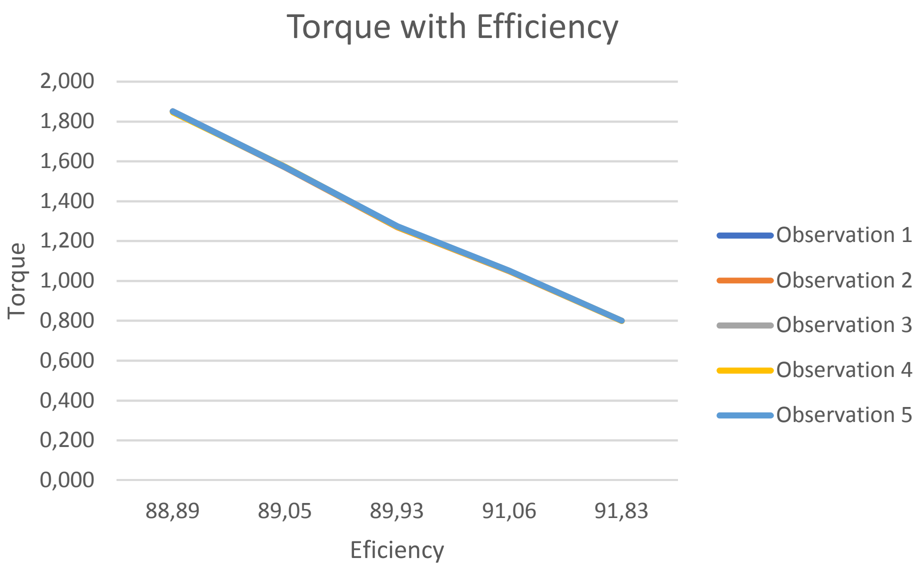

Chart 4.45 Chart of Torque and Efficiency for 150 Volt

From chart 4.45 torque is inversely proportional with efficiency. All of data in chart 4.31 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

From chart 4.31, 4.34, 4.37, 4.40 and 4.43 is comparison of torque and input voltage, author make conclusion torque is directly proportional with input voltage. All of data in chart 4.31, 4.34, 4.37, 4.40 and 4.43 show when input voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

From chart 4.32, 4.35, 4.38, 4.41 and 4.44 is comparison of torque and power, conclusion from author torque single phase induction motor feedback bifilar winding is directly propotional with power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

From chart 4.33, 4.36, 4.39, 4.42 and 4.45 that is comparison torque with efficiency can take conclusion that torque is inversed with the efficiency. That is caused by power output for the single phase induction motor feedback bifilar winding. When power output is decrease, so the rotation for the single phase motor bifilar wound single phase bifilar wound is decreasing too. This is make torque is inversely with rpm because rpm is directly propotional with efficiency.

4.2.2.6 Chart Comparison in 110 Volt for Counterclockwise Condition

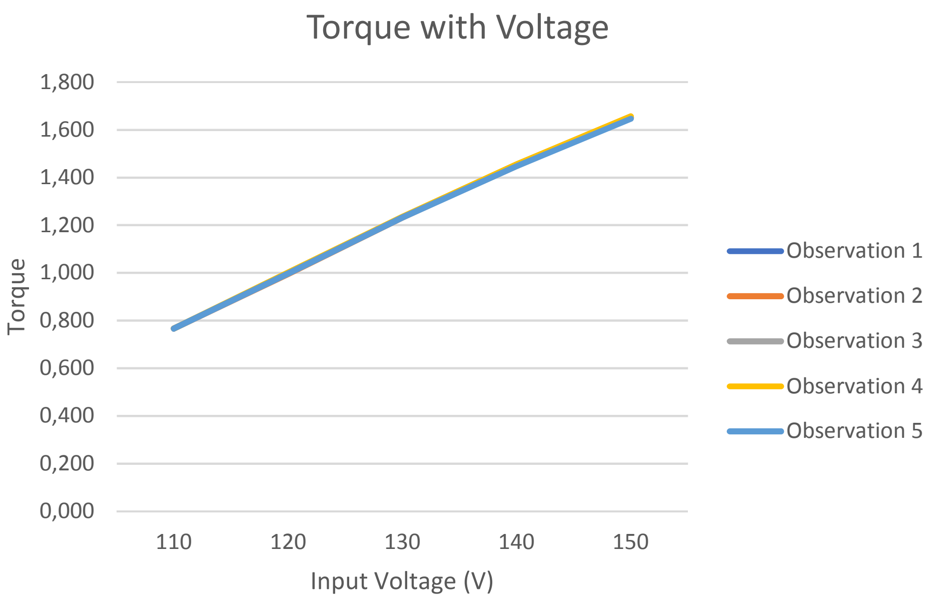

Chart 4.46 Chart of Torque and Voltage for 110 Volt

From chart 4.46 torque is directly proportional with input voltage. All of data in chart 4.46 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

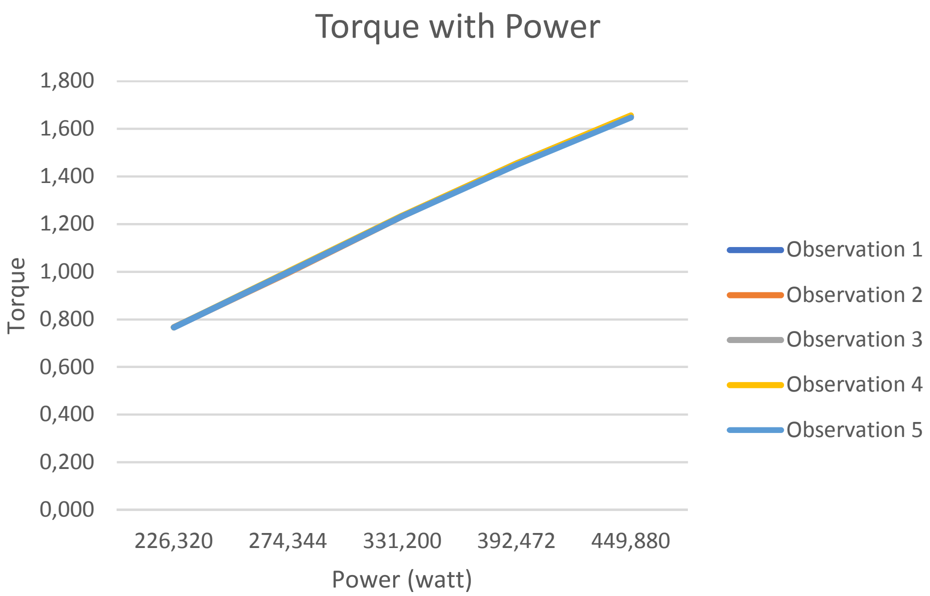

Chart 4.47 Chart of Torque and Power for 110 Volt

From chart 4.47 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

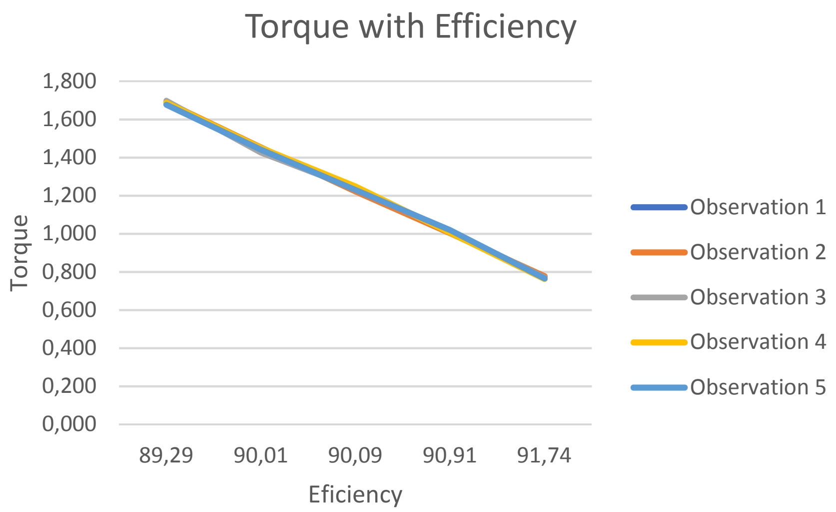

Chart 4.48 Chart of Torque and Efficiency for 110 Volt

From chart 4.48 torque is inversely proportional with efficiency. All of data in chart 4.31 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

4.2.2.7 Chart Comparison in 120 Volt for Counterclockwise Condition

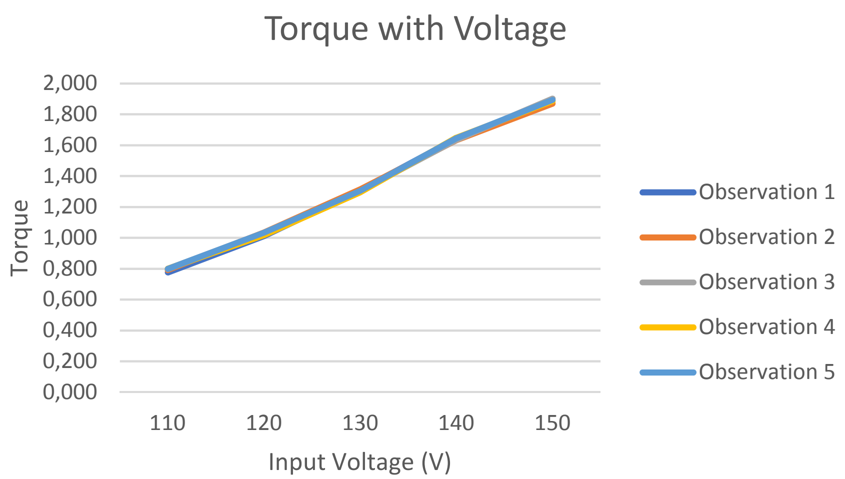

Chart 4.49 Chart of Torque and Voltage for 120 Volt

From chart 4931 torque is directly proportional with input voltage. All of data in chart 4.49 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

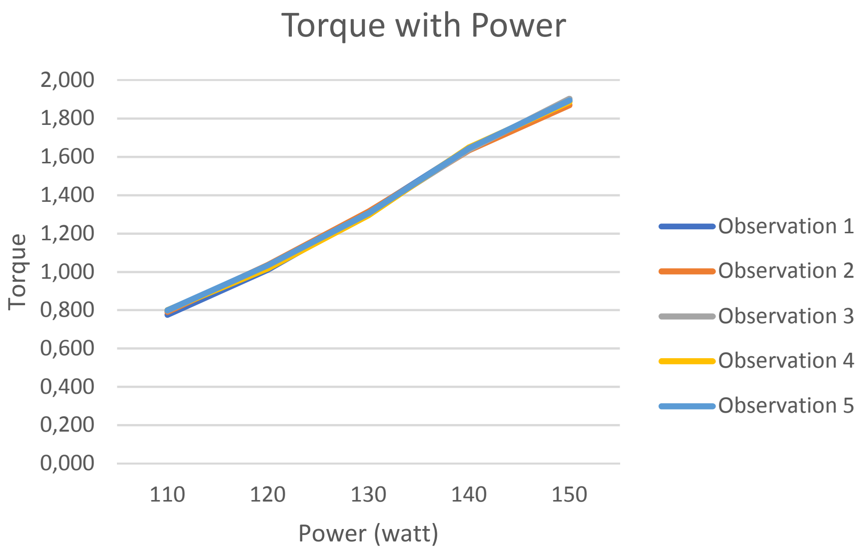

Chart 4.50 Chart of Torque and Power for 120 Volt

From chart 4.50 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

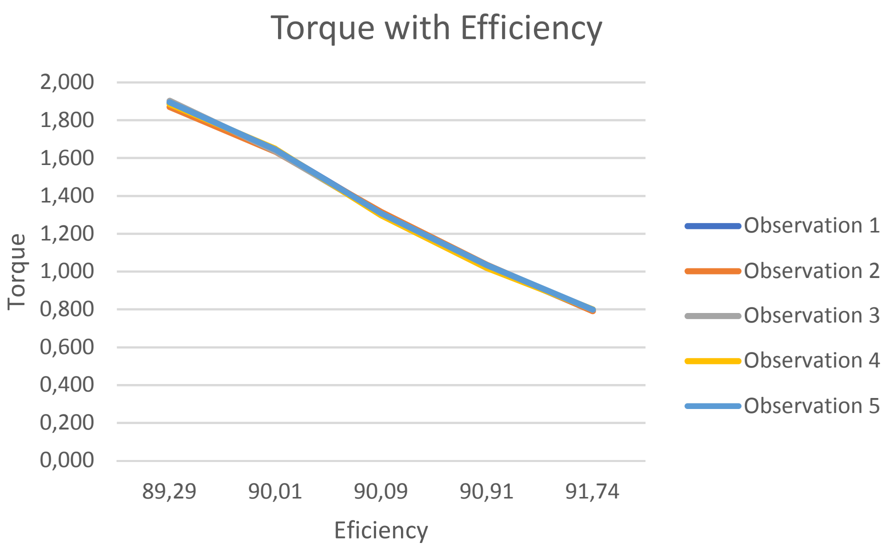

Chart 4.51 Chart of Torque and Efficiency for 120 Volt

From chart 4.51 torque is inversely proportional with efficiency. All of data in chart 4.31 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

4.2.2.8 Chart Comparison in 130 Volt for Counterclockwise Condition

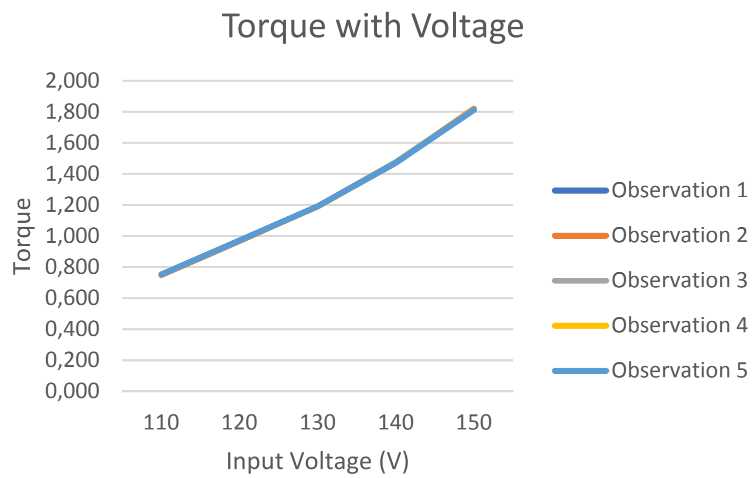

Chart 4.52 Chart of Torque and Voltage for 130 Volt

From chart 4.52 torque is directly proportional with input voltage. All of data in chart 4.52 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

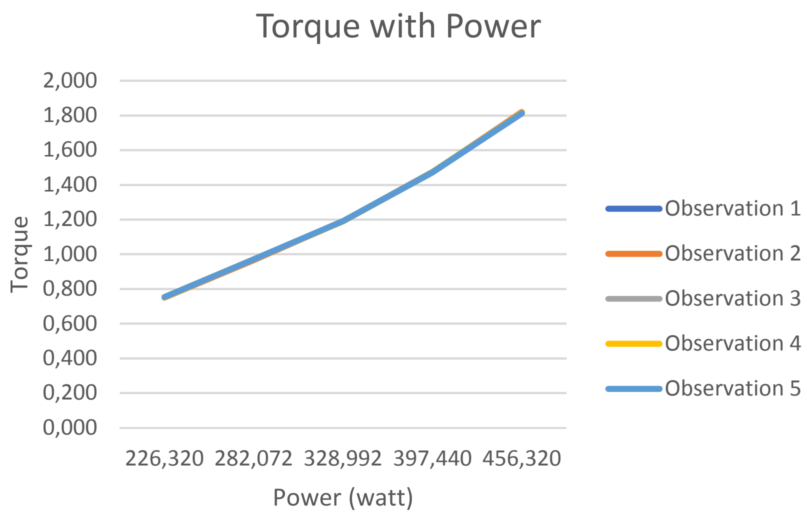

Chart 4.53 Chart of Torque and Power for 130 Volt

From chart 4.53 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

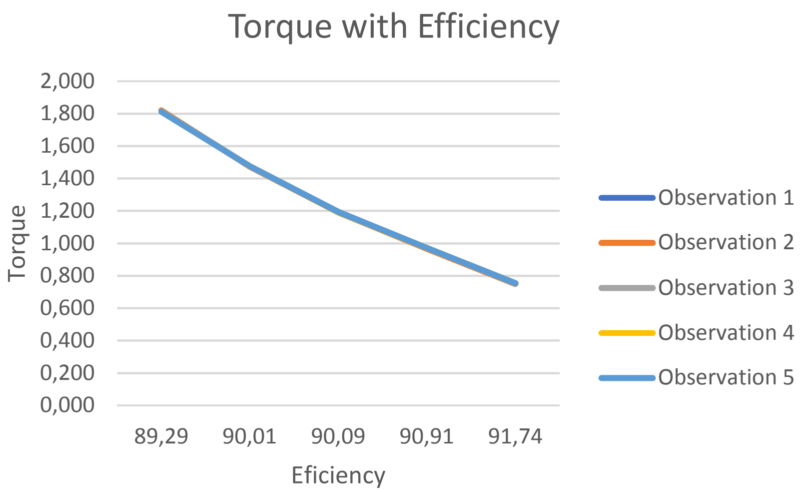

Chart 4.54 Chart of Torque and Efficiency for 130 Volt

From chart 4.54 torque is inversely proportional with efficiency. All of data in chart 4.31 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

4.2.2.9 Chart Comparison in 140 Volt for Counterclockwise Condition

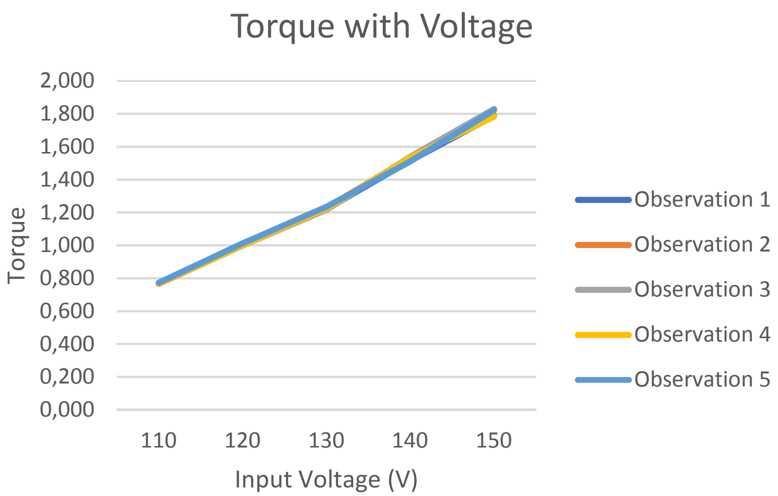

Chart 4.55 Chart of Torque and Voltage for 140 Volt

From chart 4.55 torque is directly proportional with input voltage. All of data in chart 4.55 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

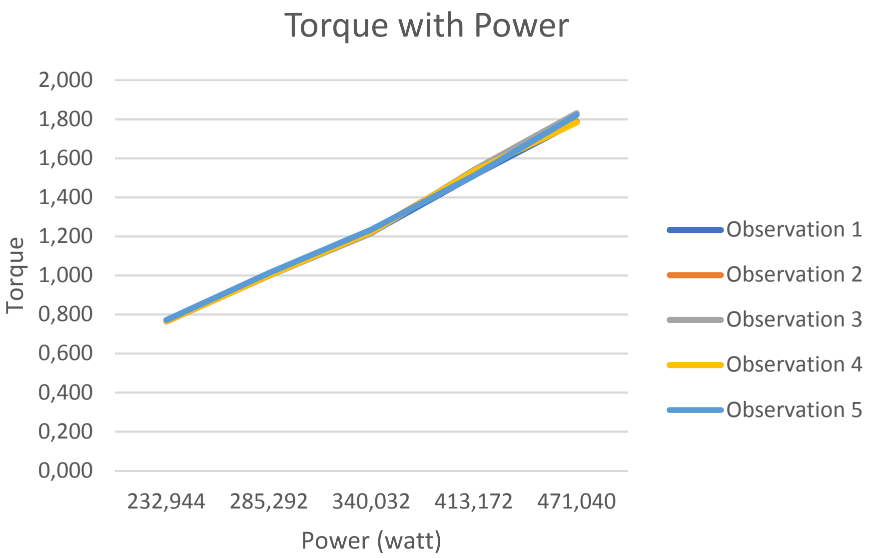

Chart 4.56 Chart of Torque and Power for 140 Volt

From chart 4.56 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

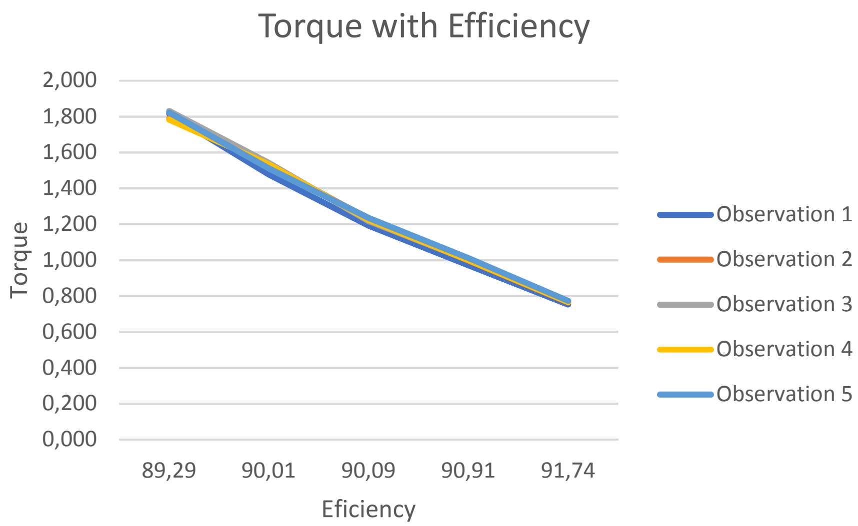

Chart 4.57 Chart of Torque and Efficiency for 140 Volt

From chart 4.57 torque is inversely proportional with efficiency. All of data in chart 4.31 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

4.2.2.10 Chart Comparison in 150 Volt for Counterclockwise Condition

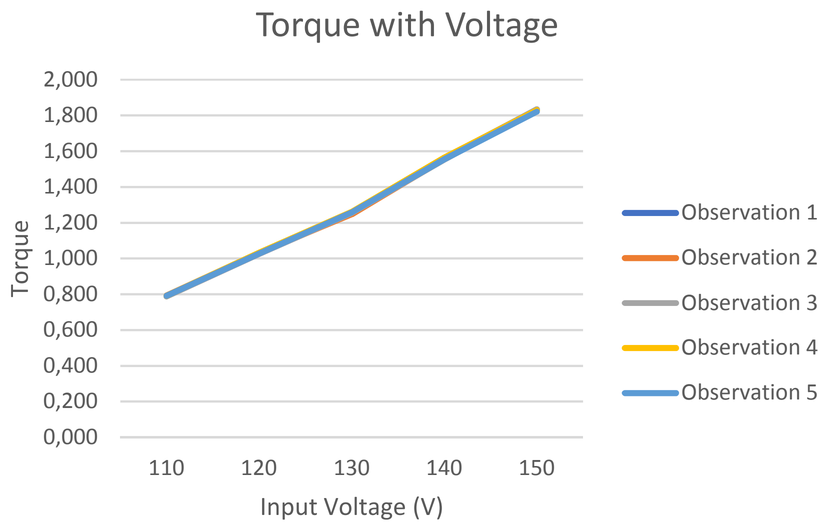

Chart 4.58 Chart of Torque and Voltage for 150 Volt

From chart 4.58 torque is directly proportional with input voltage. All of data in chart 4.58 show when inout voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

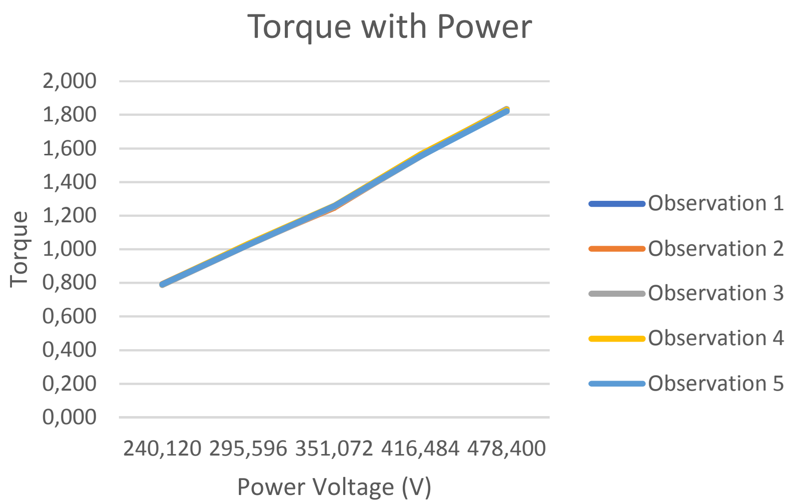

Chart 4.59 Chart of Torque and Power for 150 Volt

From chart 4.59 Torque single phase induction motor feedback bifilar winding is directly propotional with Power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

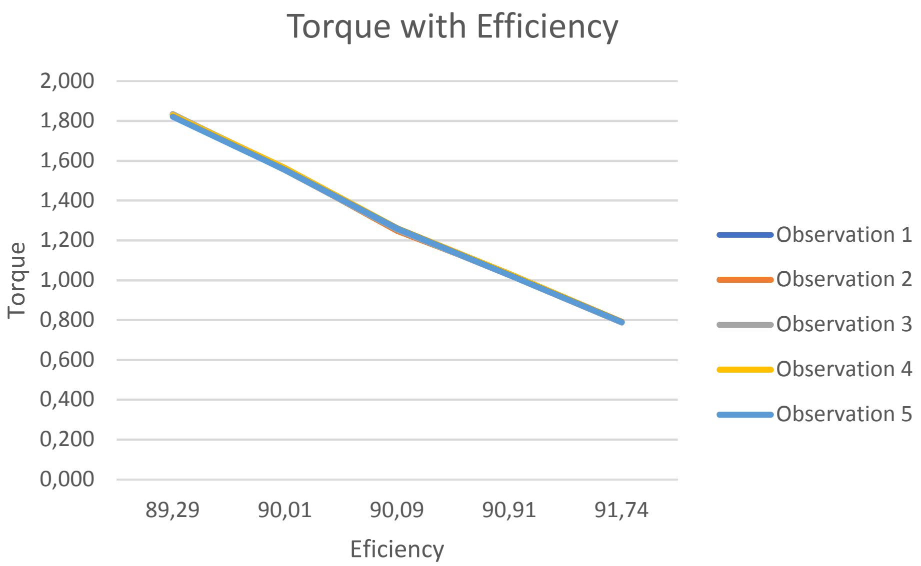

Chart 4.60 Chart of Torque and Efficiency for 150 Volt

From chart 4.60 torque is inversely proportional with efficiency. All of data in chart 4.60 show when efficiency is increasing, torque of single pahse motor feedback bifilar wound is decrease. Because when voltage input is increase so rotation is increase too. This is make torque is decrease when efficiency is increase.

From chart 4.46, 4.49, 4.52, 4.55 and 4.58 is comparison of torque and input voltage, author make conclusion torque is directly proportional with input voltage. All of data in chart 4.46, 4.49, 4.52, 4.55 and 4.58 show when input voltage is increasing, torque of single pahse motor feedback bifilar wound is increase too.

From chart 4.47, 4.50, 4.53, 4.56 and 4.59 is comparison of torque and power, conclusion from author torque single phase induction motor feedback bifilar winding is directly propotional with power. This is affected from input voltage that is supply to single phase induction motor feedback bifilar winding. This is can be prove from equation $P = (\tau x N)/975$.

From chart 4.48, 4.51, 4.54, 4.57 and 4.60 that is comparison torque with efficiency can take conclusion that torque is inversed with the efficiency. That is caused by power output for the single phase induction motor feedback bifilar winding. When power output is decrease, so the rotation for the single phase motor bifilar wound single phase bifilar wound is decreasing too. This is make torque is inversely with rpm because rpm is directly propotional with efficiency.

CHAPTER V
SUMMARY

5.1 Summary

After doing observation and taking data of single phase induction motor feedback bifilar winding from the condition unloaded and loaded and also clockwise and counterclockwise that is in Laboratory of Marine Electrical and Automation System DTSP FTK ITS so author witdrawn conclusion as follow :

1. Rotation in average for clockwise is 2112.22 RPM and counterclockwise 2276.6 RPM for unloaded condition. For loaded condition in clockwise is 2527.424 RPM and in counterclockwise is 2681.384 RPM.
2. Starting current for single phase motor bifilar wound is two until three times from the normal current. This is apply for clockwise condition and counter clockwise condition. Starting current for this observation in average is 2,17 times bigger than normal current.
3. Power of clockwise condition is bigger than counterclockwise condition this is apply for unloaded condition and loaded condition.
4. Sentrifugal switch active when motor single phase feedback bifilar wound is in unloaded condition and in 44 volt to 55 volt. It is show from chart result.
5. Torque is inversed with the efficiency. That is caused by power output for the single phase motor bifilar wound. When power output is decrease, so the rotation for the single phase induction motor feedback bifilar winding is decreasing too. This is make torque is inversely with rpm because rpm is directly propotional with efficiency.
6. Efficiency is directly propotioal with rpm. This is happened because rpm is inversely propotional with the torque. This is because when power output is decrease, so the rotation for the single phase motor bifilar wound single phase bifilar wound is decreasing too.
7. This single phase induction motor feedback bifilar winding can have power 481.16 at 150 volt, so this motor can be use for use under 481.16 watt like fresh water pump and blower fan that need small power.

5.2 Recomendation

1. There is some deviation that occurs in observation. This is because author is lack of accuracy when control voltage input for motor single phase
2. This single phase induction motor feedback bifilar winding is have high power for single phase motor but it still lack in power that use for heavy equipment in ship.
3. Further analysis of single phase induction motor feedback bifilar winding is can be couple with osiloscope.

REFERENCE

1. Muhammad Rashid, 2011. Power Electronic Handbook. Waltham : Butterworth-Heinemann.
2. Raditya Arindya. 2013. *Penggunaan dan Pengaturan Motor Listrik*. Yogyakarta : Graha Ilmu.
3. Stallcup, James G. 1987. *Motors and Transformers*. San Fransisco : American Technical Publiser, Inc.
4. Theraja B.L, Theraja A.K. 2005. *Electrical Technology*. New Delhi : S.Chand & Company LTD.
5. Zuhal. 1995. *Dasar Teknik Tenaga Listrik dan Elektronika Daya*. Jakarta : PT. Gramedia Pustaka Utama.
6. Wijaya, M., 2001. *Dasar- Dasar Mesin Listrik.* Jakarta: Djambatan.

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ATTACHMENT

Table 4.1 Observation Data of Rotation Clockwise in RPM in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	638 RPM	1018 RPM	2775 RPM	2832 RPM	2853 RPM
Observation 2	977 RPM	1021 RPM	2771 RPM	2826 RPM	2849 RPM
Observation 3	972 RPM	1041 RPM	2788 RPM	2832 RPM	2852 RPM
Observation 4	961 RPM	2764 RPM	2814 RPM	2845 RPM	2870 RPM
Observation 5	1006 RPM	1028 RPM	2781 RPM	2825 RPM	2849 RPM
Observation 6	990 RPM	1050 RPM	2785 RPM	2840 RPM	2860 RPM
Observation 7	982 RPM	1092 RPM	2819 RPM	2855 RPM	2887 RPM
Observation 8	985 RPM	1024 RPM	2765 RPM	2818 RPM	2842 RPM
Observation 9	975 RPM	1029 RPM	2787 RPM	2819 RPM	2854 RPM
Observation 10	921 RPM	1021 RPM	2011 RPM	2812 RPM	3000 RPM

Table 4.2 Observation Data of Rotation Clockwise in RPS in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	10,63 RPS	16,97 RPS	46,25 RPS	47,20 RPS	47,55 RPS
Observation 2	16,28 RPS	17,02 RPS	46,18 RPS	47,10 RPS	47,48 RPS
Observation 3	16,20 RPS	17,35 RPS	46,47 RPS	47,20 RPS	47,53 RPS
Observation 4	16,02 RPS	46,07 RPS	46,90 RPS	47,42 RPS	47,83 RPS
Observation 5	16,77 RPS	17,13 RPS	46,35 RPS	47,08 RPS	47,48 RPS
Observation 6	16,50 RPS	17,50 RPS	46,42 RPS	47,33 RPS	47,67 RPS
Observation 7	16,37 RPS	18,20 RPS	46,98 RPS	47,58 RPS	48,12 RPS
Observation 8	16,42 RPS	17,07 RPS	46,08 RPS	46,97 RPS	47,37 RPS
Observation 9	16,25 RPS	17,15 RPS	46,45 RPS	46,98 RPS	47,57 RPS
Observation 10	15,35 RPS	17,02 RPS	33,52 RPS	46,87 RPS	50,00 RPS

Table 4.3 Observation Data of Rotation Counterclockwise in RPM in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	998 RPM	2720 RPM	2801 RPM	2835 RPM	2856 RPM
Observation 2	956 RPM	1052 RPM	2771 RPM	2821 RPM	2847 RPM
Observation 3	1015 RPM	2743 RPM	2802 RPM	2842 RPM	2854 RPM
Observation 4	1040 RPM	2772 RPM	2818 RPM	2850 RPM	2868 RPM
Observation 5	988 RPM	1048 RPM	2784 RPM	2830 RPM	2860 RPM
Observation 6	1010 RPM	2740 RPM	2805 RPM	2840 RPM	2857 RPM
Observation 7	1016 RPM	2773 RPM	2807 RPM	2849 RPM	2870 RPM
Observation 8	979 RPM	1048 RPM	2775 RPM	2825 RPM	2850 RPM
Observation 9	982 RPM	1051 RPM	2794 RPM	2834 RPM	2855 RPM
Observation 10	992 RPM	1040 RPM	2790 RPM	2827 RPM	2850 RPM

Table 4.4 Observation Data of Rotation Counterclockwise in RPS in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	16,63 RPS	45,33 RPS	46,68 RPS	47,25 RPS	47,60 RPS
Observation 2	15,93 RPS	17,53 RPS	46,18 RPS	47,02 RPS	47,45 RPS
Observation 3	16,92 RPS	45,72 RPS	46,70 RPS	47,37 RPS	47,57 RPS
Observation 4	17,33 RPS	46,20 RPS	46,97 RPS	47,50 RPS	47,80 RPS
Observation 5	16,47 RPS	17,47 RPS	46,40 RPS	47,17 RPS	47,67 RPS
Observation 6	16,83 RPS	45,67 RPS	46,75 RPS	47,33 RPS	47,62 RPS
Observation 7	16,93 RPS	46,22 RPS	46,78 RPS	47,48 RPS	47,83 RPS
Observation 8	16,32 RPS	17,47 RPS	46,25 RPS	47,08 RPS	47,50 RPS
Observation 9	16,37 RPS	17,52 RPS	46,57 RPS	47,23 RPS	47,58 RPS
Observation 10	16,53 RPS	17,33 RPS	46,50 RPS	47,12 RPS	47,50 RPS

Table 4.5 Observation Data of Current in Clockwise in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	0,85 A	1,13 A	1,4 A	1,68 A	1,88 A
Observation 2	0,63 A	0,89 A	1,15 A	1,42 A	1,61 A
Observation 3	0,91 A	1,13 A	1,42 A	1,67 A	1,89 A
Observation 4	1 A	1,3 A	1,53 A	1,85 A	2,18 A
Observation 5	0,84 A	1,15 A	1,44 A	1,75 A	2,03 A
Observation 6	0,79 A	1,03 A	1,3 A	1,58 A	1,77 A
Observation 7	0,88 A	1,25 A	1,5 A	1,82 A	2,02 A
Observation 8	0,79 A	1,12 A	1,4 A	1,65 A	1,89 A
Observation 9	0,8 A	1,04 A	1,35 A	1,67 A	1,97 A
Observation 10	0,88 A	1,12 A	1,4 A	1,66 A	1,9 A

Table 4.6 Observation Data of Starting Current in Clockwise in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	2,33 A	2,27 A	2,24 A	3,69	4,51
Observation 2	1,63 A	1,86 A	2,30 A	3,97	3,22
Observation 3	1,73 A	2,82 A	2,13 A	3,17 A	4,34 A
Observation 4	2,10 A	2,60 A	2,75 A	4,44 A	4,79 A
Observation 5	2,43 A	2,41 A	2,16 A	3,32 A	5,07 A
Observation 6	2,13 A	2,27 A	1,95 A	3,00 A	4,07 A
Observation 7	2,55 A	2,87 A	2,70 A	4,18 A	5,25 A
Observation 8	2,37 A	2,35 A	2,38 A	3,63 A	4,53 A
Observation 9	2,40 A	2,19 A	1,75 A	3,17 A	4,53 A
Observation 10	2,51 A	2,12 A	1,89 A	3,23 A	3,81 A

Table 4.7 Observation Data of Current in Counterclockwise in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	0,81 A	1,13 A	1,41 A	1,6 A	1,82 A
Observation 2	0,69 A	0,95 A	1,24 A	1,49 A	1,8 A
Observation 3	0,86 A	1,14 A	1,41 A	1,66 A	1,88 A
Observation 4	1 A	1,33 A	1,52 A	1,86 A	2 A
Observation 5	0,84 A	1,17 A	1,38 A	1,6 A	1,91 A
Observation 6	0,82 A	1,05 A	1,35 A	1,64 A	1,82 A
Observation 7	0,94 A	1,34 A	1,6 A	1,96 A	2,21 A
Observation 8	0,78 A	1,1 A	1,32 A	1,61 A	1,84 A
Observation 9	0,84 A	1,15 A	1,48 A	1,73 A	2 A
Observation 10	0,82 A	1,1 A	1,38 A	1,66 A	1,93 A

Table 4.8 Observation Data of Starting Current in Counterclockwise in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	2,23 A	2,27 A	2,26 A	3,52 A	4,37 A
Observation 2	1,79 A	2,00 A	2,48 A	4,17 A	3,60 A
Observation 3	1,55 A	2,85 A	2,12 A	3,15 A	4,32 A
Observation 4	2,10 A	2,66 A	2,74 A	4,46 A	4,40 A
Observation 5	2,44 A	2,46 A	2,07 A	3,04 A	4,78 A
Observation 6	2,21 A	2,31 A	2,03 A	3,12 A	4,19 A
Observation 7	2,73 A	3,08 A	2,88 A	4,51 A	5,75 A
Observation 8	2,34 A	2,31 A	2,24 A	3,54 A	4,42 A
Observation 9	2,52 A	2,43 A	1,92 A	3,29 A	4,60 A
Observation 10	2,34 A	2,09 A	1,86 A	3,24 A	3,88 A

Table 4.9 Observation Data of Power in Clockwise in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	61,2 Watt	102 Watt	119 Watt	154 Watt	194 Watt
Observation 2	61,3 Watt	101 Watt	118 Watt	153 Watt	193 Watt
Observation 3	61,4 Watt	101 Watt	119 Watt	152 Watt	194 Watt
Observation 4	61,3 Watt	102 Watt	117 Watt	152 Watt	193 Watt
Observation 5	61,4 Watt	101 Watt	118 Watt	153 Watt	194 Watt
Observation 6	61,2 Watt	102 Watt	116 Watt	152 Watt	192 Watt
Observation 7	61,3 Watt	101 Watt	117 Watt	151 Watt	194 Watt
Observation 8	61,2 Watt	102 Watt	118 Watt	151 Watt	193 Watt
Observation 9	61,3 Watt	101 Watt	119 Watt	152 Watt	192 Watt
Observation 10	61,1 Watt	102 Watt	120 Watt	150 Watt	192 Watt

Table 4.10 Observation Data of Power in Counterclockwise in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	57,2 Watt	99,9 Watt	109 Watt	146 Watt	188 Watt
Observation 2	57,3 Watt	98,9 Watt	110 Watt	146 Watt	189 Watt
Observation 3	57,2 Watt	98,5 Watt	109 Watt	145 Watt	189 Watt
Observation 4	57,3 Watt	98,8 Watt	110 Watt	144 Watt	188 Watt
Observation 5	57,3 Watt	99,7 Watt	108 Watt	145 Watt	188 Watt
Observation 6	57,5 Watt	99,3 Watt	109 Watt	145 Watt	187 Watt
Observation 7	57,5 Watt	99,8 Watt	108 Watt	146 Watt	186 Watt
Observation 8	57,3 Watt	99,7 Watt	109 Watt	144 Watt	187 Watt
Observation 9	57,4 Watt	99,8 Watt	109 Watt	145 Watt	186 Watt
Observation 10	57,5 Watt	99 Watt	108 Watt	146 Watt	186 Watt

Table 4.11 Observation Data of Omega in Clockwise in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	66,78	106,55	290,45	296,42	298,61
Observation 2	102,26	106,86	290,03	295,79	298,20
Observation 3	101,74	108,96	291,81	296,42	298,51
Observation 4	100,58	289,30	294,53	297,78	300,39
Observation 5	105,29	107,60	291,08	295,68	298,20
Observation 6	103,62	109,90	291,50	297,25	299,35
Observation 7	102,78	114,30	295,06	298,82	302,17
Observation 8	103,10	107,18	289,40	294,95	297,46
Observation 9	102,05	107,70	291,71	295,06	298,72
Observation 10	96,40	106,86	210,48	294,32	314,00

Table 4.12 Observation Data of Omega in Counterclockwise in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	104,46	284,69	293,17	296,73	298,93
Observation 2	100,06	110,11	290,03	295,26	297,99
Observation 3	106,24	287,10	293,28	297,46	298,72
Observation 4	108,85	290,14	294,95	298,30	300,18
Observation 5	103,41	109,69	291,39	296,21	299,35
Observation 6	105,71	286,79	293,59	297,25	299,03
Observation 7	106,34	290,24	293,80	298,20	300,39
Observation 8	102,47	109,69	290,45	295,68	298,30
Observation 9	102,78	110,00	292,44	296,63	298,82
Observation 10	103,83	108,85	292,02	295,89	298,30

Table 4.13 Observation Data of Torque in Clockwise Condition at RPS in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	0,916	0,957	0,410	0,520	0,650
Observation 2	0,599	0,945	0,407	0,517	0,647
Observation 3	0,604	0,927	0,408	0,513	0,650
Observation 4	0,609	0,353	0,397	0,510	0,642
Observation 5	0,583	0,939	0,405	0,517	0,651
Observation 6	0,591	0,928	0,398	0,511	0,641
Observation 7	0,596	0,884	0,397	0,505	0,642
Observation 8	0,594	0,952	0,408	0,512	0,649
Observation 9	0,601	0,938	0,408	0,515	0,643
Observation 10	0,634	0,954	0,570	0,510	0,611

Table 4.14 Observation Data of Torque in Counterclockwise Condition at RPS in Unloaded Condition

Observation	Input Voltage				
	33 Volt	44 Volt	55 Volt	66 Volt	77 Volt
Observation 1	0,548	0,351	0,372	0,492	0,629
Observation 2	0,573	0,898	0,379	0,494	0,634
Observation 3	0,538	0,343	0,372	0,487	0,633
Observation 4	0,526	0,341	0,373	0,483	0,626
Observation 5	0,554	0,909	0,371	0,490	0,628
Observation 6	0,544	0,346	0,371	0,488	0,625
Observation 7	0,541	0,344	0,368	0,490	0,619
Observation 8	0,559	0,909	0,375	0,487	0,627
Observation 9	0,558	0,907	0,373	0,489	0,622
Observation 10	0,554	0,909	0,370	0,493	0,624

Table 4.15 Observation Data for 110 Volt in Observation 1 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,18	230,74	2811	251,50
0,92	70,00	4,40	283,36	2614	311,70
0,92	80,00	4,60	338,56	2558	375,80
0,92	90,00	4,81	398,27	2536	443,27
0,92	100,00	5,00	460,00	2503	515,20

Table 4.16 Observation Data for 110 Volt in Observation 2 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,16	229,63	2813	248,69
0,92	70,00	4,38	282,07	2618	307,74
0,92	80,00	4,62	340,03	2560	378,12
0,92	90,00	4,82	399,10	2539	448,58
0,92	100,00	5,20	478,40	2504	543,46

Table 4.17 Observation Data for 110 Volt in Observation 3 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,17	230,18	2814	251,13
0,92	70,00	4,40	283,36	2615	310,56
0,92	80,00	4,61	339,30	2554	382,39
0,92	90,00	4,80	397,44	2537	449,50
0,92	100,00	4,99	459,08	2510	514,17

Table 4.18 Observation Data for 110 Volt in Observation 4 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,18	230,74	2810	251,27
0,92	70,00	4,39	282,72	2612	310,48
0,92	80,00	4,60	338,56	2561	376,48
0,92	90,00	4,81	398,27	2534	447,25
0,92	100,00	5,10	469,20	2513	527,85

Table 4.19 Observation Data for 110 Volt in Observation 5 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,19	231,29	2814	252,80
0,92	70,00	4,40	283,36	2619	328,70
0,92	80,00	4,61	339,30	2556	377,98
0,92	90,00	4,79	396,61	2543	440,91
0,92	100,00	5,10	469,20	2515	529,26

Table 4.20 Observation Data for 120 Volt in Observation 1 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,29	236,81	2835	257,88
0,92	70	4,67	300,75	2728	330,28
0,92	80	4,82	354,75	2518	394,48
0,92	90	5,01	414,83	2394	465,85
0,92	100	5,2	478,40	2351	538,20

Table 4.21 Observation Data for 120 Volt in Observation 2 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,29	236,81	2838	257,88
0,92	70	4,67	300,75	2731	330,28
0,92	80	4,82	354,75	2522	394,48
0,92	90	5,01	414,83	2401	465,85
0,92	100	5,2	478,40	2354	538,20

Table 4.22 Observation Data for 120 Volt in Observation 3 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,29	236,81	2832	258,12
0,92	70	4,67	300,75	2729	330,82
0,92	80	4,82	354,75	2521	393,77
0,92	90	5,01	414,83	2395	460,87
0,92	100	5,2	478,40	2356	535,81

Table 4.23 Observation Data for 120 Volt in Observation 4 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,29	236,81	2838	258,12
0,92	70	4,67	300,75	2734	330,82
0,92	80	4,82	354,75	2524	393,77
0,92	90	5,01	414,83	2396	460,87
0,92	100	5,2	478,40	2352	535,81

Table 4.24 Observation Data for 120 Volt in Observation 5 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,29	236,81	2832	258,12
0,92	70	4,67	300,75	2726	330,82
0,92	80	4,82	354,75	2515	393,77
0,92	90	5,01	414,83	2391	460,87
0,92	100	5,2	478,40	2349	535,81

Table 4.25 Observation Data for 130 Volt in Observation 1 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,15	229,08	2856	249,93
0,92	70	4,42	284,65	2764	311,97
0,92	80	4,58	337,09	2624	379,90
0,92	90	4,83	399,92	2563	452,31
0,92	100	4,99	459,08	2397	514,17

Table 4.26 Observation Data for 130 Volt in Observation 2 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,15	229,08	2858	249,47
0,92	70	4,42	284,65	2761	312,60
0,92	80	4,58	337,09	2628	374,84
0,92	90	4,83	399,92	2566	449,11
0,92	100	4,99	459,08	2405	516,47

Table 4.27 Observation Data for 130 Volt in Observation 3 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,15	229,08	2863	249,93
0,92	70	4,42	284,65	2767	311,97
0,92	80	4,58	337,09	2618	379,90
0,92	90	4,83	399,92	2558	452,31
0,92	100	4,99	459,08	2402	514,17

Table 4.28 Observation Data for 130 Volt in Observation 4 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,15	229,08	2848	250,38
0,92	70	4,42	284,65	2765	330,19
0,92	80	4,58	337,09	2627	375,52
0,92	90	4,83	399,92	2569	444,60
0,92	100	4,99	459,08	2399	517,84

Table 4.29 Observation Data for 130 Volt in Observation 5 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,15	229,08	2863	249,93
0,92	70	4,42	284,65	2762	311,97
0,92	80	4,58	337,09	2623	379,90
0,92	90	4,83	399,92	2559	452,31
0,92	100	4,99	459,08	2387	514,17

Table 4.30 Observation Data for 140 Volt in Observation 1 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,27	235,70	2871	256,92
0,92	70	4,53	291,73	2716	320,91
0,92	80	4,79	352,54	2661	391,32
0,92	90	4,98	412,34	2547	458,11
0,92	100	5,12	471,04	2445	527,56

Table 4.31 Observation Data for 140 Volt in Observation 2 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,27	235,70	2869	256,92
0,92	70	4,53	291,73	2718	320,91
0,92	80	4,79	352,54	2664	391,32
0,92	90	4,98	412,34	2550	458,11
0,92	100	5,12	471,04	2451	527,56

Table 4.32 Observation Data for 140 Volt For Observation 3 in Loaded Condition

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,27	235,70	2873	257,62
0,92	70	4,53	291,73	2719	338,41
0,92	80	4,79	352,54	2657	392,73
0,92	90	4,98	412,34	2548	458,40
0,92	100	5,12	471,04	2443	531,33

Table 4.33 Observation Data for 140 Volt in Observation 4 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,27	235,70	2875	257,15
0,92	70	4,53	291,73	2714	319,74
0,92	80	4,79	352,54	2658	397,32
0,92	90	4,98	412,34	2552	466,36
0,92	100	5,12	471,04	2447	527,56

Table 4.34 Observation Data for 140 Volt in Observation 5 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,27	235,70	2870	256,92
0,92	70	4,53	291,73	2713	320,91
0,92	80	4,79	352,54	2656	391,32
0,92	90	4,98	412,34	2550	458,11
0,92	100	5,12	471,04	2448	527,56

Table 4.35 Observation Data for 150 Volt in Observation 1 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,38	241,78	2885	263,29
0,92	70	4,67	300,75	2735	330,28
0,92	80	4,81	354,02	2659	393,67
0,92	90	5,05	418,14	2543	469,57
0,92	100	5,23	481,16	2483	541,31

Table 4.36 Observation Data for 150 Volt in Observation 2 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,38	241,78	2889	264,26
0,92	70	4,67	300,75	2741	348,87
0,92	80	4,81	354,02	2663	394,37
0,92	90	5,05	418,14	2545	464,85
0,92	100	5,23	481,16	2487	542,75

Table 4.37 Observation Data for 150 Volt in Observation 3 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,38	241,78	2890	263,78
0,92	70	4,67	300,75	2735	329,62
0,92	80	4,81	354,02	2659	398,98
0,92	90	5,05	418,14	2543	472,92
0,92	100	5,23	481,16	2483	538,90

Table 4.38 Observation Data for 150 Volt in Observation 4 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,38	241,78	2888	263,29
0,92	70	4,67	300,75	2736	330,28
0,92	80	4,81	354,02	2660	393,67
0,92	90	5,05	418,14	2541	469,57
0,92	100	5,23	481,16	2490	541,31

Table 4.39 Observation Data for 150 Volt in Observation 5 in Loaded Condition for Clockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,38	241,78	2883	263,78
0,92	70	4,67	300,75	2732	329,62
0,92	80	4,81	354,02	2653	398,98
0,92	90	5,05	418,14	2542	472,92
0,92	100	5,23	481,16	2485	538,90

Table 4.40 Calculation Data for 110 Volt in Observation 1 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60,00	4,18	230,74	2811	251,50	294,22	0,92	0,784
70,00	4,40	283,36	2614	311,70	273,60	0,91	1,036
80,00	4,60	338,56	2558	375,80	267,74	0,90	1,265
90,00	4,81	398,27	2536	443,27	265,43	0,90	1,500
100,00	5,00	460,00	2503	515,20	261,98	0,89	1,756

Table 4.41 Calculation Data for 110 Volt in Observation 2 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60,00	4,16	229,63	2813	248,69	294,43	92,34	0,780
70,00	4,38	282,07	2618	307,74	274,02	91,66	1,029
80,00	4,62	340,03	2560	378,12	267,95	89,93	1,269
90,00	4,82	399,10	2539	448,58	265,75	88,97	1,502
100,00	5,20	478,40	2504	543,46	262,09	88,03	1,825

Table 4.42 Calculation Data for 110 Volt in Observation 3 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60,00	4,17	230,18	2814	251,13	294,53	91,66	0,782
70,00	4,40	283,36	2615	310,56	273,70	91,24	1,035
80,00	4,61	339,30	2554	382,39	267,32	88,73	1,269
90,00	4,80	397,44	2537	449,50	265,54	88,42	1,497
100,00	4,99	459,08	2510	514,17	262,71	89,29	1,747

Table 4.43 Calculation Data for 110 Volt in Observation 4 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60,00	4,18	230,74	2810	251,27	294,11	91,83	0,785
70,00	4,39	282,72	2612	310,48	273,39	91,06	1,034
80,00	4,60	338,56	2561	376,48	268,05	89,93	1,263
90,00	4,81	398,27	2534	447,25	265,23	89,05	1,502
100,00	5,10	469,20	2513	527,85	263,03	88,89	1,784

Table 4.44 Calculation Data for 110 Volt in Observation 5 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60,00	4,19	231,29	2814	252,80	294,53	91,49	0,785
70,00	4,40	283,36	2619	328,70	274,12	86,21	1,034
80,00	4,61	339,30	2556	377,98	267,53	89,77	1,268
90,00	4,79	396,61	2543	440,91	266,17	89,95	1,490
100,00	5,10	469,20	2515	529,26	263,24	88,65	1,782

Table 4.45 Calculation Data for 120 Volt in Observation 1 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,29	236,81	2835	257,88	296,73	91,83	0,798
70	4,67	300,75	2728	330,28	285,53	91,06	1,053
80	4,82	354,75	2518	394,48	263,55	89,93	1,346
90	5,01	414,83	2394	465,85	250,57	89,05	1,656
100	5,2	478,40	2351	538,20	246,07	88,89	1,944

Table 4.46 Calculation Data for 120 Volt in Observation 2 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,29	236,81	2838	257,88	297,04	91,83	0,797
70	4,67	300,75	2731	330,28	285,84	91,06	1,052
80	4,82	354,75	2522	394,48	263,97	89,93	1,344
90	5,01	414,83	2401	465,85	251,30	89,05	1,651
100	5,2	478,40	2354	538,20	246,39	88,89	1,942

Table 4.47 Calculation Data for 120 Volt in Observation 3 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,29	236,81	2832	258,12	296,42	91,74	0,799
70	4,67	300,75	2729	330,82	285,64	90,91	1,053
80	4,82	354,75	2521	393,77	263,86	90,09	1,344
90	5,01	414,83	2395	460,87	250,68	90,01	1,655
100	5,2	478,40	2356	535,81	246,59	89,29	1,940

Table 4.48 Calculation Data for 120 Volt in Observation 4 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,29	236,81	2838	258,12	297,04	91,74	0,797
70	4,67	300,75	2734	330,82	286,16	90,91	1,051
80	4,82	354,75	2524	393,77	264,18	90,09	1,343
90	5,01	414,83	2396	460,87	250,78	90,01	1,654
100	5,2	478,40	2352	535,81	246,18	89,29	1,943

Table 4.49 Calculation Data for 120 Volt in Observation 5 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,29	236,81	2832	258,12	296,42	91,74	0,799
70	4,67	300,75	2726	330,82	285,32	90,91	1,054
80	4,82	354,75	2515	393,77	263,24	90,09	1,348
90	5,01	414,83	2391	460,87	250,26	90,01	1,658
100	5,2	478,40	2349	535,81	245,86	89,29	1,946

Table 4.50 Calculation Data for 130 Volt in Observation 1 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,15	229,08	2856	249,93	298,93	91,66	0,766
70	4,42	284,65	2764	311,97	289,30	91,24	0,984
80	4,58	337,09	2624	379,90	274,65	88,73	1,227
90	4,83	399,92	2563	452,31	268,26	88,42	1,491
100	4,99	459,08	2397	514,17	250,89	89,29	1,830

Table 4.51 Calculation Data for 130 Volt in Observation 2 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,15	229,08	2858	249,47	299,14	91,83	0,766
70	4,42	284,65	2761	312,60	288,98	91,06	0,985
80	4,58	337,09	2628	374,84	275,06	89,93	1,225
90	4,83	399,92	2566	449,11	268,57	89,05	1,489
100	4,99	459,08	2405	516,47	251,72	88,89	1,824

Table 4.52 Calculation Data for 130 Volt in Observation 3 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,15	229,08	2863	249,93	299,66	91,66	0,764
70	4,42	284,65	2767	311,97	289,61	91,24	0,983
80	4,58	337,09	2618	379,90	274,02	88,73	1,230
90	4,83	399,92	2558	452,31	267,74	88,42	1,494
100	4,99	459,08	2402	514,17	251,41	89,29	1,826

Table 4.53 Calculation Data for 130 Volt in Observation 4 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,15	229,08	2848	250,38	298,09	91,49	0,768
70	4,42	284,65	2765	330,19	289,40	86,21	0,984
80	4,58	337,09	2627	375,52	274,96	89,77	1,226
90	4,83	399,92	2569	444,60	268,89	89,95	1,487
100	4,99	459,08	2399	517,84	251,10	88,65	1,828

Table 4.54 Calculation Data for 130 Volt in Observation 5 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,15	229,08	2863	249,93	299,66	91,66	0,764
70	4,42	284,65	2762	311,97	289,09	91,24	0,985
80	4,58	337,09	2623	379,90	274,54	88,73	1,228
90	4,83	399,92	2559	452,31	267,84	88,42	1,493
100	4,99	459,08	2387	514,17	249,84	89,29	1,838

Table 4.55 Calculation Data for 140 Volt in Observation 1 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,27	235,70	2871	256,92	300,50	91,74	0,784
70	4,53	291,73	2716	320,91	284,27	90,91	1,026
80	4,79	352,54	2661	391,32	278,52	90,09	1,266
90	4,98	412,34	2547	458,11	266,59	90,01	1,547
100	5,12	471,04	2445	527,56	255,91	89,29	1,841

Table 4.56 Calculation Data for 140 Volt in Observation 2 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,27	235,70	2869	256,92	300,29	91,74	0,785
70	4,53	291,73	2718	320,91	284,48	90,91	1,025
80	4,79	352,54	2664	391,32	278,83	90,09	1,264
90	4,98	412,34	2550	458,11	266,90	90,01	1,545
100	5,12	471,04	2451	527,56	256,54	89,29	1,836

Table 4.57 Calculation Data for 140 Volt in Observation 3 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,27	235,70	2873	257,62	300,71	91,49	0,784
70	4,53	291,73	2719	338,41	284,59	86,21	1,025
80	4,79	352,54	2657	392,73	278,10	89,77	1,268
90	4,98	412,34	2548	458,40	266,69	89,95	1,546
100	5,12	471,04	2443	531,33	255,70	88,65	1,842

Table 4.58 Calculation Data for 140 Volt in Observation 4 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,27	235,70	2875	257,15	300,92	91,66	0,783
70	4,53	291,73	2714	319,74	284,07	91,24	1,027
80	4,79	352,54	2658	397,32	278,20	88,73	1,267
90	4,98	412,34	2552	466,36	267,11	88,42	1,544
100	5,12	471,04	2447	527,56	256,12	89,29	1,839

Table 4.59 Calculation Data for 140 Volt in Observation 5 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,27	235,70	2870	256,92	300,39	91,74	0,785
70	4,53	291,73	2713	320,91	283,96	90,91	1,027
80	4,79	352,54	2656	391,32	277,99	90,09	1,268
90	4,98	412,34	2550	458,11	266,90	90,01	1,545
100	5,12	471,04	2448	527,56	256,22	89,29	1,838

Table 4.60 Calculation Data for 150 Volt in Observation 1 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,38	241,78	2885	263,29	301,96	91,83	0,801
70	4,67	300,75	2735	330,28	286,26	91,06	1,051
80	4,81	354,02	2659	393,67	278,31	89,93	1,272
90	5,05	418,14	2543	469,57	266,17	89,05	1,571
100	5,23	481,16	2483	541,31	259,89	88,89	1,851

Table 4.61 Calculation Data for 150 Volt in Observation 2 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,38	241,78	2889	264,26	302,38	91,49	0,800
70	4,67	300,75	2741	348,87	286,89	86,21	1,048
80	4,81	354,02	2663	394,37	278,73	89,77	1,270
90	5,05	418,14	2545	464,85	266,38	89,95	1,570
100	5,23	481,16	2487	542,75	260,31	88,65	1,848

Table 4.62 Calculation Data for 150 Volt in Observation 3 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,38	241,78	2890	263,78	302,49	91,66	0,799
70	4,67	300,75	2735	329,62	286,26	91,24	1,051
80	4,81	354,02	2659	398,98	278,31	88,73	1,272
90	5,05	418,14	2543	472,92	266,17	88,42	1,571
100	5,23	481,16	2483	538,90	259,89	89,29	1,851

Table 4.63 Calculation Data for 150 Volt in Observation 4 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,38	241,78	2888	263,29	302,28	91,83	0,800
70	4,67	300,75	2736	330,28	286,37	91,06	1,050
80	4,81	354,02	2660	393,67	278,41	89,93	1,272
90	5,05	418,14	2541	469,57	265,96	89,05	1,572
100	5,23	481,16	2490	541,31	260,62	88,89	1,846

Table 4.64 Calculation Data for 150 Volt in Observation 5 in Loaded Condition for Clockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega	Eff (%)	Torque (N/m^2)
60	4,38	241,78	2883	263,78	301,75	91,66	0,801
70	4,67	300,75	2732	329,62	285,95	91,24	1,052
80	4,81	354,02	2653	398,98	277,68	88,73	1,275
90	5,05	418,14	2542	472,92	266,06	88,42	1,572
100	5,23	481,16	2485	538,90	260,10	89,29	1,850

Table 4.65 Observation Data for 110 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,15	229,08	2823	249,70
0,92	70,00	4,30	276,92	2625	304,61
0,92	80,00	4,52	332,67	2569	369,27
0,92	90,00	4,73	391,64	2589	435,12
0,92	100,00	4,98	458,16	2603	513,14

Table 4.66 Observation Data for 110 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,16	229,63	2821	250,30
0,92	70,00	4,29	276,28	2630	303,90
0,92	80,00	4,47	328,99	2572	365,18
0,92	90,00	4,76	394,13	2591	437,88
0,92	100,00	5,01	460,92	2606	516,23

Table 4.67 Observation Data for 110 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,12	227,42	2820	247,89
0,92	70,00	4,34	279,50	2629	307,45
0,92	80,00	4,51	331,94	2564	368,45
0,92	90,00	4,67	386,68	2590	429,60
0,92	100,00	5,02	461,84	2599	517,26

Table 4.68 Observation Data for 110 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,08	225,22	2821	245,49
0,92	70,00	4,29	276,28	2624	303,90
0,92	80,00	4,56	335,62	2567	372,53
0,92	90,00	4,74	392,47	2587	436,04
0,92	100,00	4,99	459,08	2600	514,17

Table 4.69 Observation Data for 110 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60,00	4,10	226,32	2823	246,69
0,92	70,00	4,35	280,14	2626	308,15
0,92	80,00	4,50	331,20	2572	367,63
0,92	90,00	4,72	390,82	2590	434,20
0,92	100,00	4,98	458,16	2610	513,14

Table 4.70 Observation Data for 120 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,27	235,70	2841	256,92
0,92	70	4,59	295,60	2739	325,16
0,92	80	4,7	345,92	2522	383,97
0,92	90	5	414,00	2406	459,95
0,92	100	5,09	468,28	2367	524,47

Table 4.71 Observation Data for 120 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,26	235,15	2840	256,32
0,92	70	4,61	296,88	2738	326,57
0,92	80	4,72	347,39	2524	385,61
0,92	90	4,97	411,52	2408	457,19
0,92	100	5,04	463,68	2369	519,32

Table 4.72 Observation Data for 120 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,3	237,36	2842	258,72
0,92	70	4,6	296,24	2740	325,86
0,92	80	4,68	344,45	2523	382,34
0,92	90	4,98	412,34	2408	458,11
0,92	100	5,12	471,04	2365	527,56

Table 4.73 Observation Data for 120 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,31	237,91	2840	259,32
0,92	70	4,53	291,73	2738	320,91
0,92	80	4,65	342,24	2523	379,89
0,92	90	5,02	415,66	2407	461,79
0,92	100	5,08	467,36	2368	523,44

Table 4.74 Observation Data for 120 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,3	237,36	2839	258,72
0,92	70	4,61	296,88	2742	326,57
0,92	80	4,69	345,18	2525	383,15
0,92	90	5,01	414,83	2410	460,87
0,92	100	5,1	469,20	2366	525,50

Table 4.75 Observation Data for 130 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,1	226,32	2871	246,69
0,92	70	4,38	282,07	2774	310,28
0,92	80	4,47	328,99	2638	365,18
0,92	90	4,8	397,44	2574	441,56
0,92	100	4,96	456,32	2401	511,08

Table 4.76 Observation Data for 130 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,08	225,22	2870	245,49
0,92	70	4,36	280,78	2775	308,86
0,92	80	4,47	328,99	2637	365,18
0,92	90	4,79	396,61	2574	440,64
0,92	100	4,98	458,16	2405	513,14

Table 4.77 Observation Data for 130 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,1	226,32	2869	246,69
0,92	70	4,38	282,07	2773	310,28
0,92	80	4,47	328,99	2636	365,18
0,92	90	4,8	397,44	2575	441,56
0,92	100	4,96	456,32	2404	511,08

Table 4.78 Observation Data for 130 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,1	226,32	2872	246,69
0,92	70	4,38	282,07	2773	310,28
0,92	80	4,47	328,99	2639	365,18
0,92	90	4,8	397,44	2576	441,56
0,92	100	4,96	456,32	2406	511,08

Table 4.79 Observation Data for 130 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,1	226,32	2870	246,69
0,92	70	4,38	282,07	2772	310,28
0,92	80	4,47	328,99	2636	365,18
0,92	90	4,8	397,44	2577	441,56
0,92	100	4,96	456,32	2405	511,08

Table 4.80 Observation Data for 140 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,2	231,84	2885	252,71
0,92	70	4,48	288,51	2726	317,36
0,92	80	4,64	341,50	2674	379,07
0,92	90	4,9	405,72	2561	450,75
0,92	100	5	460,00	2459	515,20

Table 4.81 Observation Data for 140 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,18	230,74	2884	251,50
0,92	70	4,43	285,29	2730	313,82
0,92	80	4,68	344,45	2676	382,34
0,92	90	4,96	410,69	2560	456,27
0,92	100	5,01	460,92	2461	516,23

Table 4.82 Observation Data for 140 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,22	232,94	2887	253,91
0,92	70	4,43	285,29	2728	313,82
0,92	80	4,62	340,03	2671	377,44
0,92	90	4,99	413,17	2563	459,03
0,92	100	5,12	471,04	2458	527,56

Table 4.83 Observation Data for 140 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,19	231,29	2884	252,10
0,92	70	4,43	285,29	2725	313,82
0,92	80	4,66	342,98	2677	380,70
0,92	90	4,97	411,52	2562	457,19
0,92	100	4,99	459,08	2460	514,17

Table 4.84 Observation Data for 140 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,23	233,50	2886	254,51
0,92	70	4,49	289,16	2728	318,07
0,92	80	4,7	345,92	2675	383,97
0,92	90	4,89	404,89	2560	449,84
0,92	100	5,1	469,20	2460	525,50

Table 4.85 Observation Data for 150 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,35	240,12	2905	261,73
0,92	70	4,6	296,24	2752	325,86
0,92	80	4,78	351,81	2673	390,51
0,92	90	5,03	416,48	2551	462,71
0,92	100	5,2	478,40	2494	535,81

Table 4.86 Observation Data for 150 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,36	240,67	2903	262,33
0,92	70	4,61	296,88	2751	326,57
0,92	80	4,75	349,60	2676	388,06
0,92	90	5,02	415,66	2550	461,79
0,92	100	5,18	476,56	2490	533,75

Table 4.87 Observation Data for 150 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,34	239,57	2907	261,13
0,92	70	4,59	295,60	2754	325,16
0,92	80	4,77	351,07	2675	389,69
0,92	90	5,01	414,83	2552	460,87
0,92	100	5,21	479,32	2496	536,84

Table 4.88 Observation Data for 150 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,36	240,67	2904	262,33
0,92	70	4,62	297,53	2752	327,28
0,92	80	4,79	352,54	2671	391,32
0,92	90	5,05	418,14	2554	464,55
0,92	100	5,19	477,48	2493	534,78

Table 4.89 Observation Data for 150 Volt in Loaded Condition for Counterclockwise

Cos φ	Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)
0,92	60	4,36	240,67	2907	262,33
0,92	70	4,59	295,60	2750	325,16
0,92	80	4,79	352,54	2676	391,32
0,92	90	5,02	415,66	2554	461,79
0,92	100	5,18	476,56	2500	533,75

Table 4.90 Calculation Data for 110 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60,00	4,15	229,08	2823	249,70	295,47	91,74	0,775
70,00	4,30	276,92	2625	304,61	274,75	90,91	1,008
80,00	4,52	332,67	2569	369,27	268,89	90,09	1,237
90,00	4,73	391,64	2589	435,12	270,98	90,01	1,445
100,00	4,98	458,16	2603	513,14	272,45	89,29	1,682

Table 4.91 Calculation Data for 110 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60,00	4,16	229,63	2821	250,30	295,26	91,74	0,778
70,00	4,29	276,28	2630	303,90	275,27	90,91	1,004
80,00	4,47	328,99	2572	365,18	269,20	90,09	1,222
90,00	4,76	394,13	2591	437,88	271,19	90,01	1,453
100,00	5,01	460,92	2606	516,23	272,76	89,29	1,690

Table 4.92 Calculation Data for 110 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60,00	4,12	227,42	2820	247,89	295,16	91,74	0,771
70,00	4,34	279,50	2629	307,45	275,17	90,91	1,016
80,00	4,51	331,94	2564	368,45	268,37	90,09	1,237
90,00	4,67	386,68	2590	429,60	271,09	90,01	1,426
100,00	5,02	461,84	2599	517,26	272,03	89,29	1,698

Table 4.93 Calculation Data for 110 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60,00	4,08	225,22	2821	245,49	295,26	91,74	0,763
70,00	4,29	276,28	2624	303,90	274,65	90,91	1,006
80,00	4,56	335,62	2567	372,53	268,68	90,09	1,249
90,00	4,74	392,47	2587	436,04	270,77	90,01	1,449
100,00	4,99	459,08	2600	514,17	272,13	89,29	1,687

Table 4.94 Calculation Data for 110 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60,00	4,10	226,32	2823	246,69	295,47	91,74	0,766
70,00	4,35	280,14	2626	308,15	274,85	90,91	1,019
80,00	4,50	331,20	2572	367,63	269,20	90,09	1,230
90,00	4,72	390,82	2590	434,20	271,09	90,01	1,442
100,00	4,98	458,16	2610	513,14	273,18	89,29	1,677

Table 4.95 Calculation Data for 120 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,27	235,70	2841	256,92	297,36	91,74	0,793
70	4,59	295,60	2739	325,16	286,68	90,91	1,031
80	4,7	345,92	2522	383,97	263,97	90,09	1,310
90	5	414,00	2406	459,95	251,83	90,01	1,644
100	5,09	468,28	2367	524,47	247,75	89,29	1,890

Table 4.96 Calculation Data for 120 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,26	235,15	2840	256,32	297,25	91,74	0,791
70	4,61	296,88	2738	326,57	286,58	90,91	1,036
80	4,72	347,39	2524	385,61	264,18	90,09	1,315
90	4,97	411,52	2408	457,19	252,04	90,01	1,633
100	5,04	463,68	2369	519,32	247,96	89,29	1,870

Table 4.97 Calculation Data for 120 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,3	237,36	2842	258,72	297,46	91,74	0,798
70	4,6	296,24	2740	325,86	286,79	90,91	1,033
80	4,68	344,45	2523	382,34	264,07	90,09	1,304
90	4,98	412,34	2408	458,11	252,04	90,01	1,636
100	5,12	471,04	2365	527,56	247,54	89,29	1,903

Table 4.98 Calculation Data for 120 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,31	237,91	2840	259,32	297,25	91,74	0,800
70	4,53	291,73	2738	320,91	286,58	90,91	1,018
80	4,65	342,24	2523	379,89	264,07	90,09	1,296
90	5,02	415,66	2407	461,79	251,93	90,01	1,650
100	5,08	467,36	2368	523,44	247,85	89,29	1,886

Table 4.99 Calculation Data for 120 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,3	237,36	2839	258,72	297,15	91,74	0,799
70	4,61	296,88	2742	326,57	287,00	90,91	1,034
80	4,69	345,18	2525	383,15	264,28	90,09	1,306
90	5,01	414,83	2410	460,87	252,25	90,01	1,645
100	5,1	469,20	2366	525,50	247,64	89,29	1,895

Table 4.100 Calculation Data for 130 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,1	226,32	2871	246,69	300,50	91,74	0,753
70	4,38	282,07	2774	310,28	290,35	90,91	0,972
80	4,47	328,99	2638	365,18	276,11	90,09	1,192
90	4,8	397,44	2574	441,56	269,41	90,01	1,475
100	4,96	456,32	2401	511,08	251,30	89,29	1,816

Table 4.101 Calculation Data for 130 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,08	225,22	2870	245,49	300,39	91,74	0,750
70	4,36	280,78	2775	308,86	290,45	90,91	0,967
80	4,47	328,99	2637	365,18	276,01	90,09	1,192
90	4,79	396,61	2574	440,64	269,41	90,01	1,472
100	4,98	458,16	2405	513,14	251,72	89,29	1,820

Table 4.102 Calculation Data for 130 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,1	226,32	2869	246,69	300,29	91,74	0,754
70	4,38	282,07	2773	310,28	290,24	90,91	0,972
80	4,47	328,99	2636	365,18	275,90	90,09	1,192
90	4,8	397,44	2575	441,56	269,52	90,01	1,475
100	4,96	456,32	2404	511,08	251,62	89,29	1,814

Table 4.103 Calculation Data for 113 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,1	226,32	2872	246,69	300,60	91,74	0,753
70	4,38	282,07	2773	310,28	290,24	90,91	0,972
80	4,47	328,99	2639	365,18	276,22	90,09	1,191
90	4,8	397,44	2576	441,56	269,62	90,01	1,474
100	4,96	456,32	2406	511,08	251,83	89,29	1,812

Table 4.104 Calculation Data for 130 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,1	226,32	2870	246,69	300,39	91,74	0,753
70	4,38	282,07	2772	310,28	290,14	90,91	0,972
80	4,47	328,99	2636	365,18	275,90	90,09	1,192
90	4,8	397,44	2577	441,56	269,73	90,01	1,473
100	4,96	456,32	2405	511,08	251,72	89,29	1,813

Table 4.105 Calculation Data for 140 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,2	231,84	2885	252,71	301,96	91,74	0,768
70	4,48	288,51	2726	317,36	285,32	90,91	1,011
80	4,64	341,50	2674	379,07	279,88	90,09	1,220
90	4,9	405,72	2561	450,75	268,05	90,01	1,514
100	5	460,00	2459	515,20	257,38	89,29	1,787

Table 4.106 Calculation Data for 140 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,18	230,74	2884	251,50	301,86	91,74	0,764
70	4,43	285,29	2730	313,82	285,74	90,91	0,998
80	4,68	344,45	2676	382,34	280,09	90,09	1,230
90	4,96	410,69	2560	456,27	267,95	90,01	1,533
100	5,01	460,92	2461	516,23	257,58	89,29	1,789

Table 4.107 Calculation Data for 140 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,22	232,94	2887	253,91	302,17	91,74	0,771
70	4,43	285,29	2728	313,82	285,53	90,91	0,999
80	4,62	340,03	2671	377,44	279,56	90,09	1,216
90	4,99	413,17	2563	459,03	268,26	90,01	1,540
100	5,12	471,04	2458	527,56	257,27	89,29	1,831

Table 4.108 Calculation Data for 140 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,19	231,29	2884	252,10	301,86	91,74	0,766
70	4,43	285,29	2725	313,82	285,22	90,91	1,000
80	4,66	342,98	2677	380,70	280,19	90,09	1,224
90	4,97	411,52	2562	457,19	268,16	90,01	1,535
100	4,99	459,08	2460	514,17	257,48	89,29	1,783

Table 4.109 Calculation Data for 140 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,23	233,50	2886	254,51	302,07	91,74	0,773
70	4,49	289,16	2728	318,07	285,53	90,91	1,013
80	4,7	345,92	2675	383,97	279,98	90,09	1,236
90	4,89	404,89	2560	449,84	267,95	90,01	1,511
100	5,1	469,20	2460	525,50	257,48	89,29	1,822

Table 4.110 Calculation Data for 150 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,35	240,12	2905	261,73	304,06	91,74	0,790
70	4,6	296,24	2752	325,86	288,04	90,91	1,028
80	4,78	351,81	2673	390,51	279,77	90,09	1,257
90	5,03	416,48	2551	462,71	267,00	90,01	1,560
100	5,2	478,40	2494	535,81	261,04	89,29	1,833

Table 4.111 Calculation Data for 150 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,36	240,67	2903	262,33	303,85	91,74	0,792
70	4,61	296,88	2751	326,57	287,94	90,91	1,031
80	4,75	349,60	2676	388,06	280,09	90,09	1,248
90	5,02	415,66	2550	461,79	266,90	90,01	1,557
100	5,18	476,56	2490	533,75	260,62	89,29	1,829

Table 4.112 Calculation Data for 150 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,34	239,57	2907	261,13	304,27	91,74	0,787
70	4,59	295,60	2754	325,16	288,25	90,91	1,025
80	4,77	351,07	2675	389,69	279,98	90,09	1,254
90	5,01	414,83	2552	460,87	267,11	90,01	1,553
100	5,21	479,32	2496	536,84	261,25	89,29	1,835

Table 4.113 Calculation Data for 150 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,36	240,67	2904	262,33	303,95	91,74	0,792
70	4,62	297,53	2752	327,28	288,04	90,91	1,033
80	4,79	352,54	2671	391,32	279,56	90,09	1,261
90	5,05	418,14	2554	464,55	267,32	90,01	1,564
100	5,19	477,48	2493	534,78	260,93	89,29	1,830

Table 4.114 Calculation Data for 150 Volt in Loaded Condition for Counterclockwise

Volt (V)	Current (A)	Pout (Watt)	Rpm	P In (Watt)	Omega (RPS)	Eff (%)	Torque (N/m^2)
60	4,36	240,67	2907	262,33	304,27	91,74	0,791
70	4,59	295,60	2750	325,16	287,83	90,91	1,027
80	4,79	352,54	2676	391,32	280,09	90,09	1,259
90	5,02	415,66	2554	461,79	267,32	90,01	1,555
100	5,18	476,56	2500	533,75	261,67	89,29	1,821

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Author born in Kudus March 3, 1995 is the first child of 2 siblings. The author took a formal education in SDN 3 Bulungcangkring and graduated in 2007. After completing education at the basic level the author continued his education in SMP 1 Kudus and graduated in 2010. After that the author continued his education in SMA 1 Kudus and graduated in 2013. Author is accepted in Marine Enginering Institut Teknologi Sepuluh Nopember after graduating from high school and accepted by SNMPTN and graduated in 2018.