NOVEL DESIGN OF ELECTRICAL MACHINE FOR CEILING FAN

By

MUHAMMAD ZULHILMI BIN HASHIM

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Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved:

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Dr. Taib Bin Ibrahim

Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Muhammad Zuhilmi Bin Hashim

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ABSTRACT

Demands for electrical energy have increases every year. This demand inclination effect the cost to generate electricity. As a consumer we need to use an efficient electrical appliance to avoid waste of energy. Ceiling fan is among the most use electrical appliance. Conventional ceiling fan is not very efficient. The mechanical rotation of the fan blade is not fully utilized. The kinetic energy from the rotation of the fan blade can be capture and converted back to electrical energy. The purpose of this paper is to describe the development of novel design electrical energy for ceiling fan that capable of harnessing the waste kinetic energy. Various literature reviews have been conducted to study the effect of different configuration and parameter such as blade design, core shape design, relation between number of poles and efficiency and winding configuration of the electrical machine. For this project permanent magnet is use as source of excitation. Permanent magnet especially neodymium magnet (NdFeB) provide high flux density that suit the purpose of motor and generator. The model is design using AutoCAD to replicate the actual dimensions and then simulate using finite design element software (Ansys Maxwell) to study the flux distribution and back EMF characteristic. As for the charger circuit, the design and simulation is done by using Multism. The charger circuit can give indication when the battery need to be charge and when the battery is fully charged. The charger circuit is capable of charging 12V lead acid battery. Based on the results, the ceiling fan model need to further study to improve the performance and efficiency. After complete the design simulation the model than will be fabricate and test to determine whether the actual result is as per the theoretical or not.

Table of Contents

List of figure

List of Table

1 Introduction

1.1 Background Study

Nowadays electricity is one of the most important energy in human's life. People are so depended on electricity because of the convenience that came from the advancement of technology. Moving toward to become develop country, Malaysia has experienced advancement in technology and increase of population. The energy consumption in Malaysia has increased for the past years. In ten years, the production of electricity is almost double to cater for the consumer demand. In 2010 to 2012 electricity consumption have reduces [1]. This decreasing trend may be contributed by people awareness to use high efficient electrical machine. Electrical machine manufacturer should make afford to produce more efficient electrical machine. In long term this products should help reduce energy consumption thus reducing demand to produce more electricity.

Every households need to take responsible to use efficient electrical appliances. Use of efficient electrical appliances can significantly reduce the cost usage by cut off some of the utility bills. This paper focuses on improving efficiency of conventional ceiling fan. Efficiency of electrical machine is depending on the useful power output divided by the total power output.

Geographically Malaysia is located at equatorial and experience hot-humid tropical climate all year round. In order to cope with this climatic condition most houses have either ceiling fan or air-conditioner. Air-conditioner can provide better comfort but because of the high price and high maintenance not many people can afford to use it. According to survey, almost all house in Malaysia have ceiling fan in their house [2]. This shows that ceiling fan is one of the most used electrical appliances.

Figure 1-1 shows daily load pattern for Malaysian grid [1]. High demand of electricity is between 10:30 to 16:30 mainly contributed by high usage of machines in industries and also due to be the hottest time of the day. During these time most of house and office fully utilize their air conditioning and fan. Air conditioner and ceiling fan is the main energy consumer in houses [2]. Use of high efficiency ceiling can help reduces the demand for electricity during peak hours.

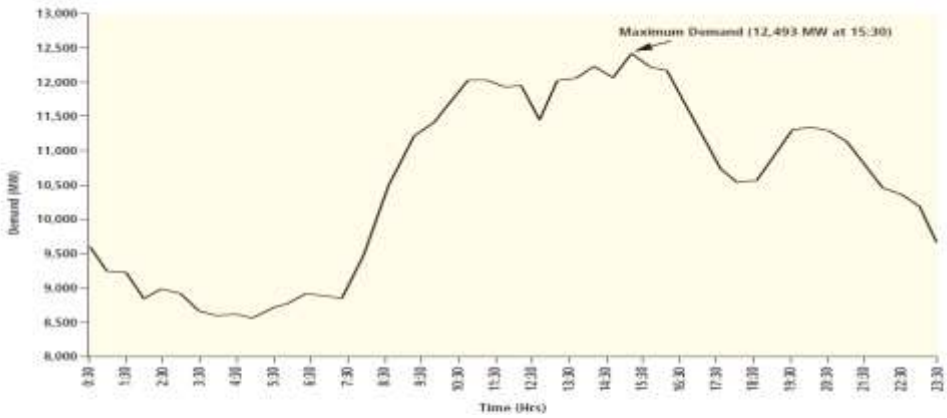


Figure 1-1 Load Pattern For Peninsular Malaysia Grid [1]

1.2 Problem Statement

Ceiling fan has been used since in the early 1860s, in early day they use a stream of running water and then combine with turbine to drive a system of belts which turn the fan blade[3]. Throughout the years ceiling fan have gone so much improvement from the design of blade to the type of motor used. People usually compare ceiling fan with air-conditioner but most people in Malaysia rely on ceiling fan as a cooling appliance [4]. Air-conditioner can provide much better cooling than ceiling fan but its consume more electricity energy [2]. An average income family prefer ceiling fan as their cooling appliance.

In the market today most conventional ceiling fan use a single phase induction motor. Many manufacturers tend to use this type of motor simply to cut cost but single phase induction motor is less efficient compere to other type of motor. The drawback of single phase induction motor is low power factor and low pulsating torque. By generating back electricity form the waste kinetic energy of the rotating blades, the overall efficiency of the ceiling fan should be improved.

1.3 Objectives

The main of objective of this paper is to propose a new method to harness waste kinetic energy from the fan blade and design an electrical machine that have motor and generator properties. The other sub-objectives are:-

a. To conduct literature review on ceiling fan technology system.
b. To simulate the design by using finite element method.
c. To simulate electrical circuit for charging system.

1.4 Scope of Study

This project aims to develop an electrical machine that can harness the waste kinetic energy to produce electrical energy. This project will cover:

a. Study on past paper on ceiling fan technology system.
b. Proposed a design model for the ceiling fan using CAD software.
c. Run simulation on the model to produce theoretical result.

1.5 Project Relevancy and Feasibility

Major part of this project requires the understanding in the electrical and electronics field mainly in power electrical. Most of the design and testing steps need the knowledge in electrical machine due to dealing with generator and motor. The knowledge of using design and simulation software also important to obtain theoretical result. This project also involve standard problem solving approach in design simulation, fabrication and testing.

This project will be conducted in two semesters which separate in three phases:-

i. Design simulation
ii. Fabrication
iii. Testing

For the first semester will concentrate on design simulation of the ceiling fan model by using AutoCAD and Ansys Maxwell. The following semester will be focuses on the fabrication and testing of the ceiling model.

2 Literature Review

2.1 Introduction

In order to design the electrical machine for ceiling fan, various literature reviews of past studies need to be conducted in order to produce a good machine design. Different type of electrical machines will be studied and compare to select the best machine type which will be used for the ceiling fan system. Several design configurations will be studied to be compare to produce an efficient machine.

2.2 Types of Electrical Machine

Throughout the years, motor in ceiling fan has gone through so much improvement, since the late 1890s celling fan has utilized alternating current (AC) motor. These motor are extremely inefficient, require more energy to produce mechanical power and also releasing heat in the process. The heat causes the laminated steel in the core to separate and leading to vibration and rattling. Currently core of the motor is a permanent magnet which is more efficient than the electromagnetic. Blade designs also evolve from a simple two flat wood to aerodynamic shape blade. Enhancement in blade design reduces the vibration, noise and also increase the ceiling fan efficiency [5].

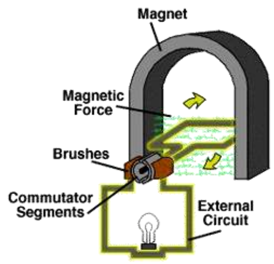


Figure 2-1 Simple Electrical Machine [6]

Motor and generator is also known as electrical machine. In this paper the term will use interchangely. Figure 2-1 shows simple electrical machine consists of magnet and a rotating loop of wire within the magnetic force.

Basically the rotating parts are called rotor and the stationary parts are call rotor. Brushes and commentator are used to collect produced electricity. Electrical energy is produce when the rotor is rotated and cut the magnetic force thus voltage will induced into the wire [6].

There are various types of electrical machine use for ceiling fan. Each machine has their own advantages and disadvantages depending on the applications. Electrical machine used in ceiling fan can be divided in AC machine and DC machine. These machines describe as follow:

A. DC machine is also known as commutating machinery. This type of machine is similar to AC machine in principal but the different is that in DC machine have a mechanism to convert the internal AC voltage to DC voltage.
    a. Advantages
        i. Can control the speed
        ii. Better torque-speed characteristic
        iii. compact
    b. Disadvantages
        i. the brushes need maintenance
        ii. spark hazard

B. AC induction machine is commonly use in the conventional ceiling fan. In the induction machines no electrical connection are required to the rotor to produce magnetic field. The transfer energy between the rotation and stationary part are by means of electromagnetics induction thus no DC field current is required to run the machine [7].
    a. Advantages
        i. Simple design
        ii. Low cost and easy maintenance
        iii. Wide range of power rating

b. Disadvantages
    i. Run with lagging power factor

C. Permanent magnet is use at rotor or stator depending on the machine configuration to produced magnetic field. The magnetic field produced by permanent magnet is much strong than produced by electromagnetics. Since the magnetic field produced by permanent magnet have introduce considerable magnetic reluctance, the air gap reluctance and coil are insignificant so that make the design less complex [8]. Permanent magnet in machine is it can provide high power density and high efficiency [9]. An ideal magnet should have high coercively which is resistance to loss of magnetism.

Currently there four type of magnet commonly used in electrical machine; they are ferrite, alnico, samarium-cobalt and neodymium magnet.

a. Advantages
    i. Under continuous operation permanent magnet machine have better torque/volume and torque/weight ratio
    ii. No need of external current for excitation field
b. Disadvantages
    i. permanent magnet is very expensive
    ii. high cogging torque

2.3 Ceiling Fan Development

Various studies have been done to overcome inefficiency of electrical machine in the conventional ceiling fan. Previously efficiency of ceiling fan does not get much attention however in current unsteady global economy many manufacturers focusing to enhance their product efficiency. Some variable parameters of the machine are modified to observe the effect on the machine performance. The studied parameter is reviewed in this paper includes the blade design, core shape design, relation between number of poles and efficiency and winding configuration.

Study done by [10] shows that good design blade can reduce energy consumption as they tested aerodynamically shape blade. This shape is similar to the shape of aircraft propeller. They also proved that, by using lighter material such as steel sheet can conserved more energy compare to wooden blade.

Many factors can contribute to inefficiency of ceiling fan for examples winding configuration, type of excitation used and effect of cogging force. Cogging force I the interaction between permanent magnets of the rotor and the stator slots of the permanent magnet. This unwanted force disturbs the machine operations. Cogging force strength varies with motor speed, at low speed the force is more apparent however at high speed the inertia reduces the effect of cogging force [11].

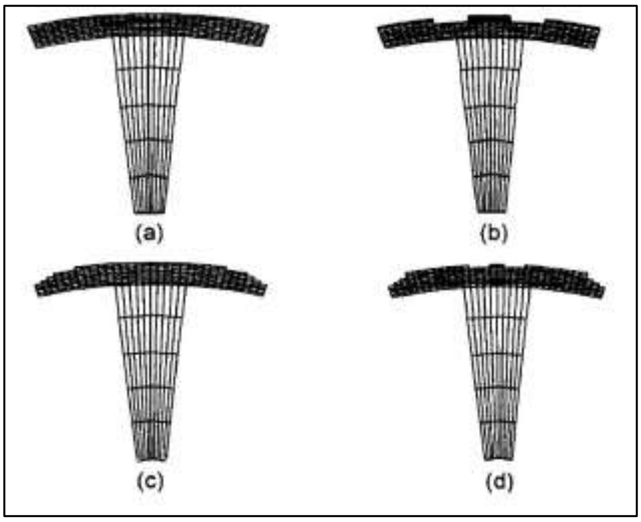


Figure 2-2 Core Shape Of BLDC Motor [12]

The research on the effect of core shape of the stator toward the performance of the motor in term of its efficiency done by [12] have shown that both rounded and optimal core were better in increasing the efficiency as many as 90% as compared to the basic core design. Figure 2-2 shows four different core shapes design of the stator:

a. Basic core
b. Grooved core
c. Rounded core
d. Optimal core

Variations in determine number of pole and number of slot are effecting the cogging force in the machine [11, 13]. Research done by [14] shows the effect of number of pole to efficiency, as per figure 2-3, he conclude that using 8 poles is the best choice considering efficiency and cost of production. Increase number of pole will increase cost of production wise consideration must be made before deciding number of pole used.

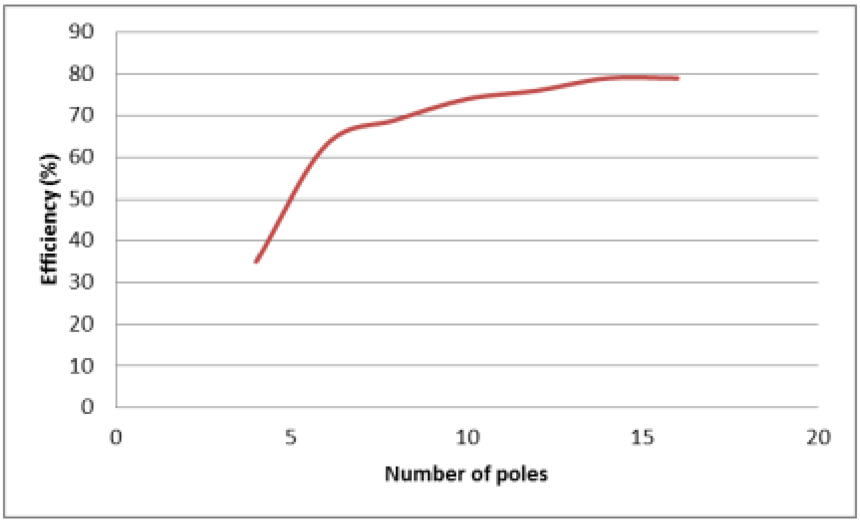


Figure 2-3 Variation Of Efficiency With Number Of Poles [14]

Another research done by Li Zhu et al. show the relation between number of pole, slot number and peak cogging torque [13]. As per figure 2-4 peak cogging torque increase with respect of permanent magnet pole number and slot number increase.

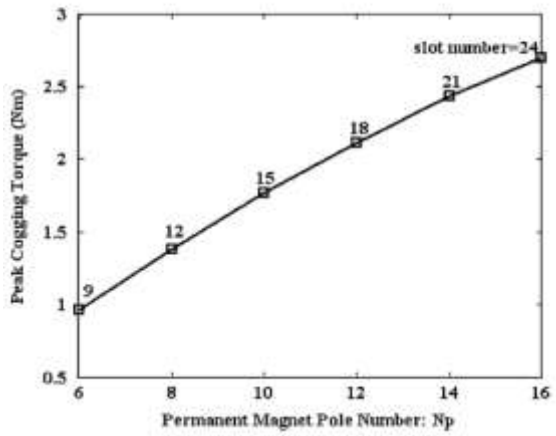


Figure 2-4 Variation of cogging torque with combination of slot number and pole [13]

Cogging force is effected by the angle of skewed permanent magnet. The skew angle is directly proportional to the cogging force intensity. Fazil M. et al have conducted an experiment to see the relationship between skewed permanent magnet and cogging force. They tested the cogging for at an angle of 30°, 45° and 60° and they found that the skew angle increases the cogging force reduces [15]. The drawback of this technique is make the production cost increases because of it difficult to mass produce magnetize the permanent magnet, increase leakage inductance, increase stray losses and also reduce the torque output of the machine [16, 17].

The electrical machines winding configuration contribute a significant effect to the performance and winding factor. The research about efficiency of three different winding configuration show in figure 2-5 (a. distributed winding, b. single layer concentrated winding, c. double concentred winding) made by [18, 19] indicate that concentrated winding would have an advantage by only required two-third of the total pole pitch length for its slot pitch. However, concentrated winding configuration will lead to a poor winding factor as compared to distributed winding configuration which having winding factor of one. Nevertheless, with the better combination of the number of pole and slot of the concentrated winding configuration a higher winding factor can be achieved.

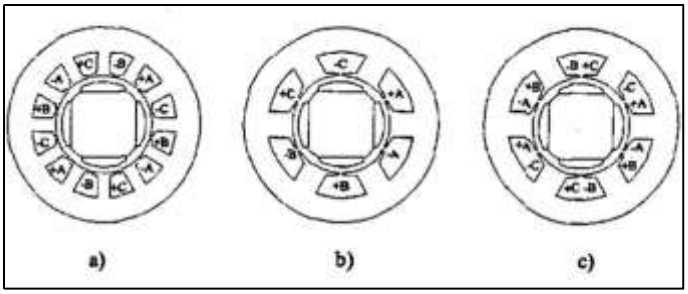


Figure 2-5 Winding Configuration Of 4-pole Motor [18]

2.4 Conclusion

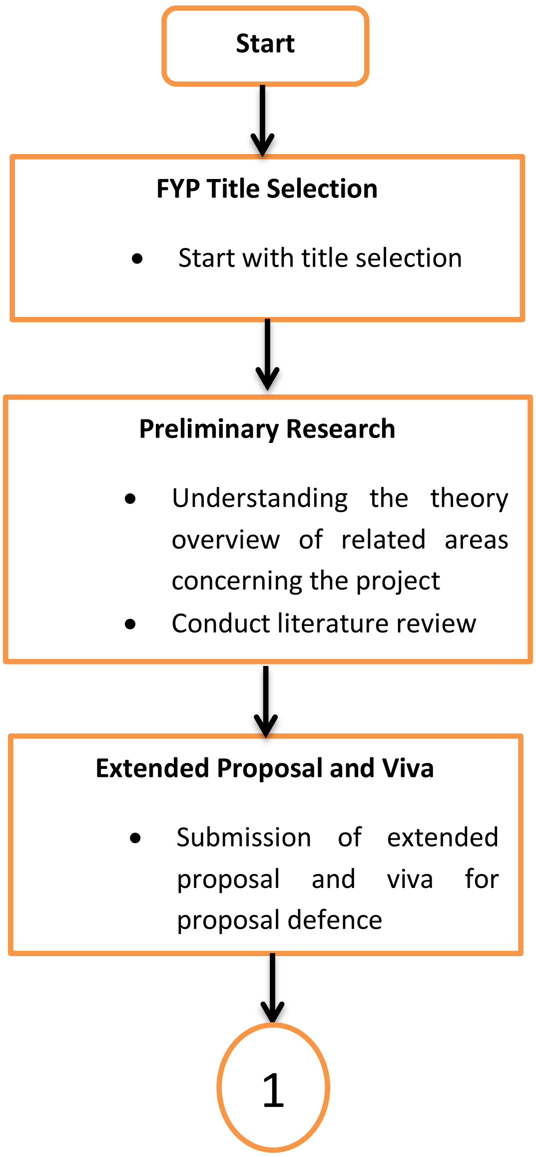
Based on the literature review, permanent magnet machine is selected to be used in designing the novel ceiling fan system. Various configuration of the permanent magnet machine such as core shape design, relation between number of poles and efficiency and winding configuration had been studied to find the best configuration of design which can produce higher performance and efficient.

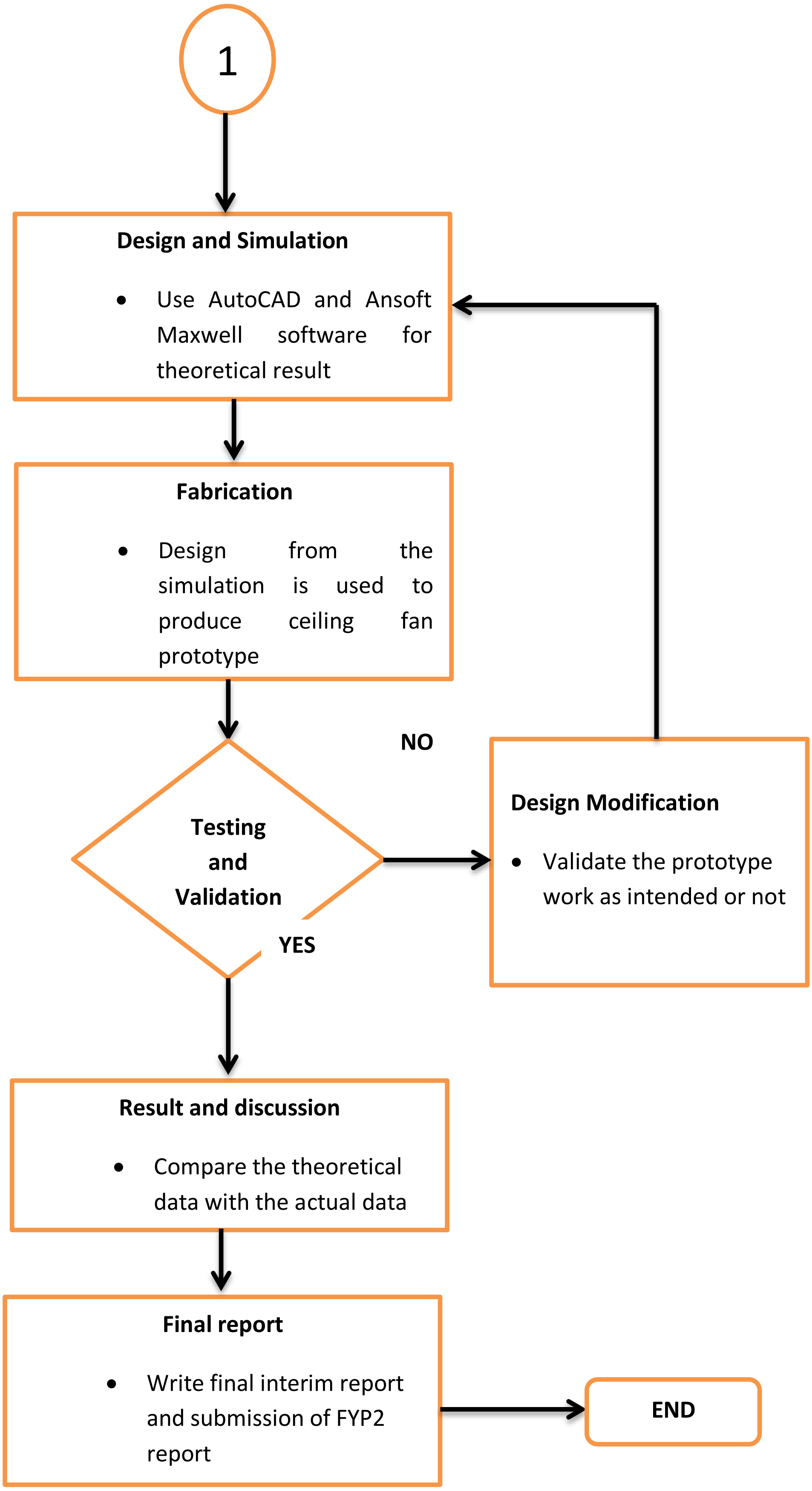
3 Methodology

3.1 Introduction

A decent project should have good planning and scheduling in order to achieve the project objectives within the specified time frame. A process flow chart and Gantt chart will describe the overall project.

3.2 Process Flow of Final Year Project





1
Design and Simulation
Use AutoCAD and Ansoft Maxwell software for theoretical result
Fabrication
Design from the simulation is used to produce ceiling fan prototype
NO
Testing and Validation
YES
Design Modification
Validate the prototype work as intended or not
Result and discussion
Compare the theoretical data with the actual data
Final report
Write final interim report and submission of FYP2 report
END

3.3 Tools

List of software used for the project:

i. AutoCAD (to design model for the electrical machine)
ii. Ansoft Maxwell (to simulate and analyse the design model)
iii. Microsoft Office (to writing the report and tabulate the result data)

3.4 Key milestones

In order to address the objectives of this project, the following are the key milestones in conducting this project:-

- Obtain desired result from the design simulation
- Able to produce working prototype
- Able to finish the project within the time allocated

3.5 Conclusion

In this chapter, the research methodology of the case study is defined. There are four stages on how the case studies will be performed:

a. Conduct literature review on various design configuration of the ceiling fan
b. Produce a new design for ceiling fan
c. Carry out simulation for the proposed design
d. Fabricate the model to get the actual result

The project flow chart as well as related Gantt chart is produce in order to achieve the objective of the case study within the timeframe. Tools which will be used throughout the case study also defined.

4 Design Model

4.1 Introduction

Based on the literature review discussed, there are many factors which can affect the performance of the permanent magnet machine such as core shape design, relation between number of poles and efficiency and winding configuration. In this chapter will discuss on the ceiling fan design model for simulation, charger circuit and 3D design for prototype

4.2 Novel Ceiling Fan

In the process of developing novel ceiling fan various software were used. The model was produced by using AutoCAD which can replicate the actual dimension of the model. This is very important that the design is produce as accurate as possible to the prototype because at the end the result from simulation need to be compare to the prototype. The finished model than transfer to Ansys Maxwell software for simulation purpose. Ansys Maxwell is the finite element analyse software that is used to analyse magnetostatic, electrostatic and transient behaviour of the designed model. This software also can perform meshing application which can simulate the flux distribution, flux density and also back EMF current.

The design for novel ceiling fan consist of both generator and motor part as one unit. The ceiling fan will use permanent magnet as the source of magnetic flux. For this model will use neodymium magnet also known as NdFeB. NdFeB is preferred because of the high concentration of magnetic flux produce and also easy to manufacture.

The motor part will operate as the normal conventional ceiling fan which will receive electricity from the power source. The motor stator winding will generate magnetic flux thus causes the permanent magnet at the rotor part to rotate based on principle of normal permanent magnet motor. The kinetic energy produce by motor rotor is capture back by attach generator rotor with the motor rotor.

In this configuration there will be magnetic flux interference that produces by both permanent magnets. Aluminium is preferred material to use as separator due to the ability to act as a good magnetic flux insulator. Aluminium is place between the motor magnet and generator magnet to prevent magnetic flux leakage. The motor rotor and generator rotor are rotate at the same time. The rotating permanent magnet at generator rotor will induce current in the generator stator coil winding. The generated current will be channel back for other suitable electrical appliance.

Figure 4-1 show the novel ceiling fan that produce using AutoCAD. The rotor for both motor and generator are attached together as one moving part.

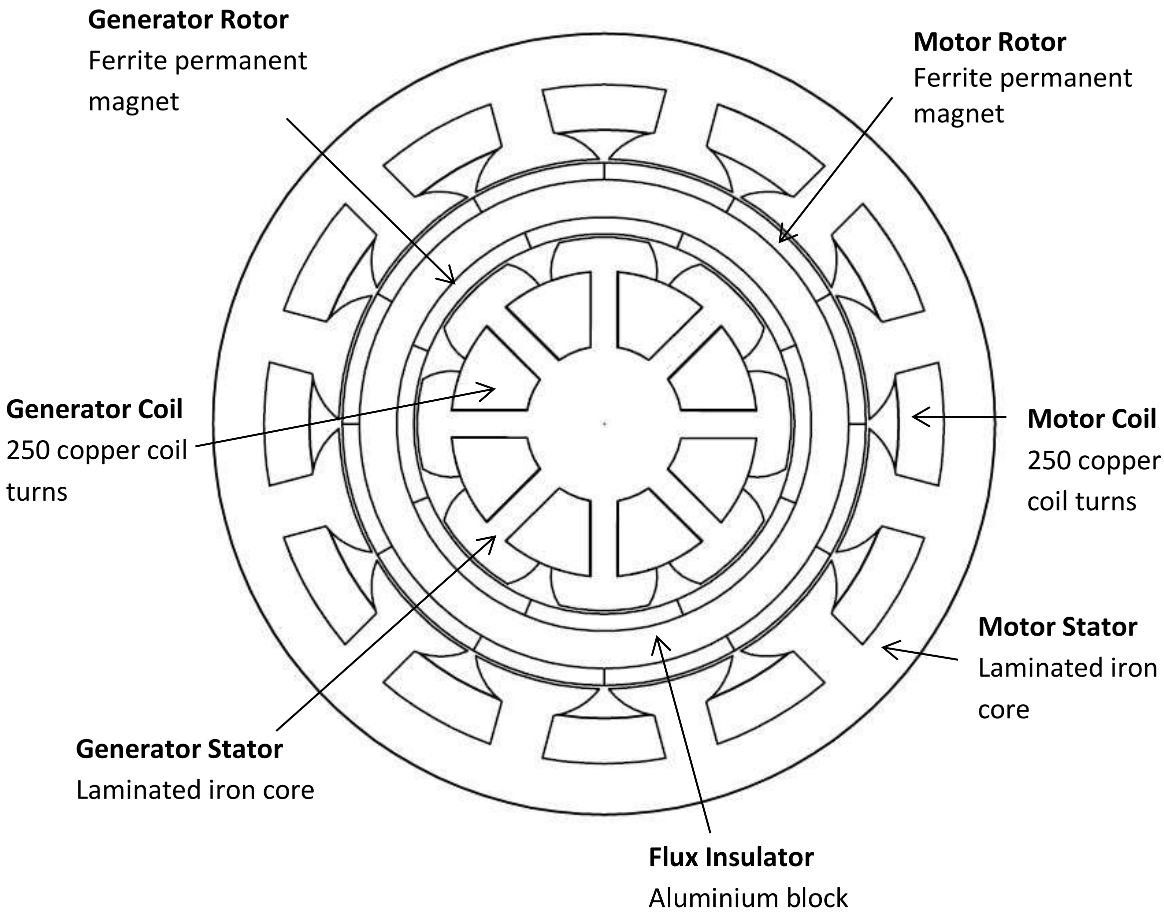


Figure 4-1 Novel Ceiling Fan Model

The design parameters shown in table 4-1 were used in to produce the model drawing. The finish drawing was exported to Ansys Maxwell for the design simulation.

Table 1 Parameter For Novel Ceiling Fan Model

	Parameters	Dimension (mm)
1	Aluminium	11
Motor (outer part)		
1	Back iron thickness	15
2	Stator outer diameter	230
3	Stator inner diameter	156
4	Number of pole/slot	6/12
5	Slot angle	2
6	Air gap	1
7	Permanent magnet thickness	5
8	Stator tooth length	13
9	Stator tooth width	15.8
10	Number of coil turn	250
Generator (inner part)		
1	Stator outer diameter	110
2	Number of pole/slot	4/8
3	Slot angle	5
4	Air gap	1
5	Permenent magnet thickness	5
6	Stator tooth length	22.1
7	Stator tooth width	7.8
8	Number of coil turn	250

4.3 Charger Circuit

Battery charger is a device used to put energy into a battery cell by forcing an electric current through it. For this project lead acid battery is selected as storage when there is no load connected to the generator. Lead acid battery is chosen because the ability to tolerated overcharging, very reliable and cheap.

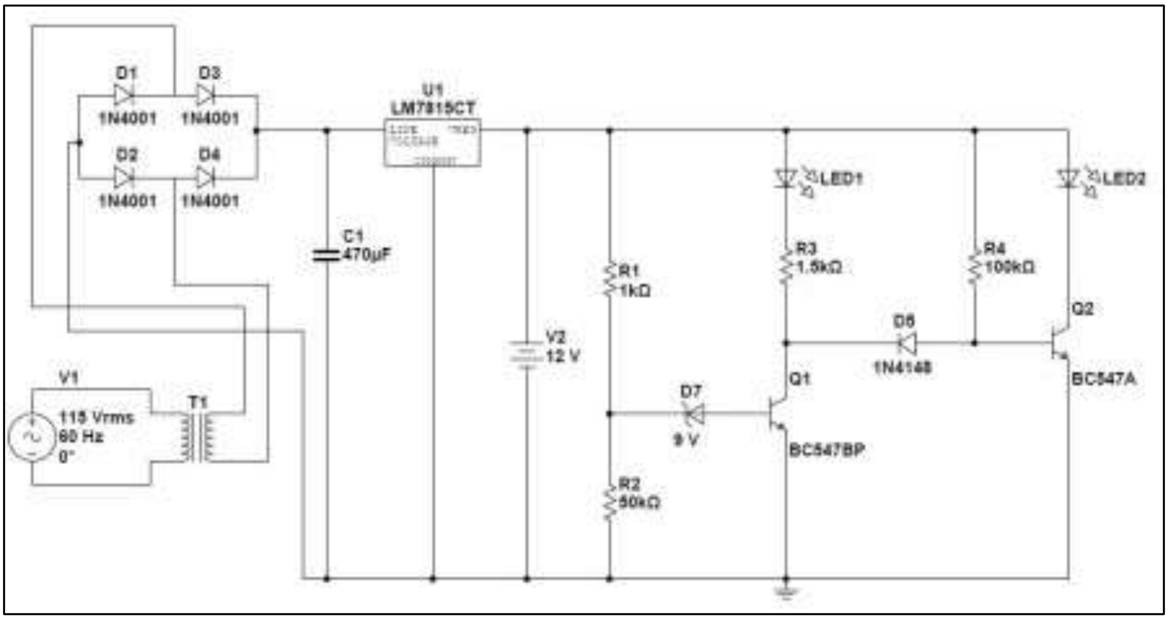


Figure 4-2 Charger Circuit

In the figure 4-2 shows charger circuit for lead acid battery. Input for this charger comes from generator side of the ceiling fan. The input is step down by the transformer to produce about 15vrms then the alternating current is channel to bridge rectifier. Bridge rectifier is a full wave rectifier circuit using the combinations of four diodes to form a bridge. It has the advantages that convert both the half cycle of alternating current (AC) into direct current (DC). The DC input than supply the voltage regulator for obtaining a regulated voltage. 12V rechargeable lead acid battery is connected at the output of voltage regulator and chargers when the ceiling fan operated. This charger circuit also indicate the charging status. The green LED is glow when the battery is charged when the voltage rise more than 10V. When the battery goes below 10V the green LED stop glowing and the red LED will glow indicating that the battery has been drained and need to recharge.

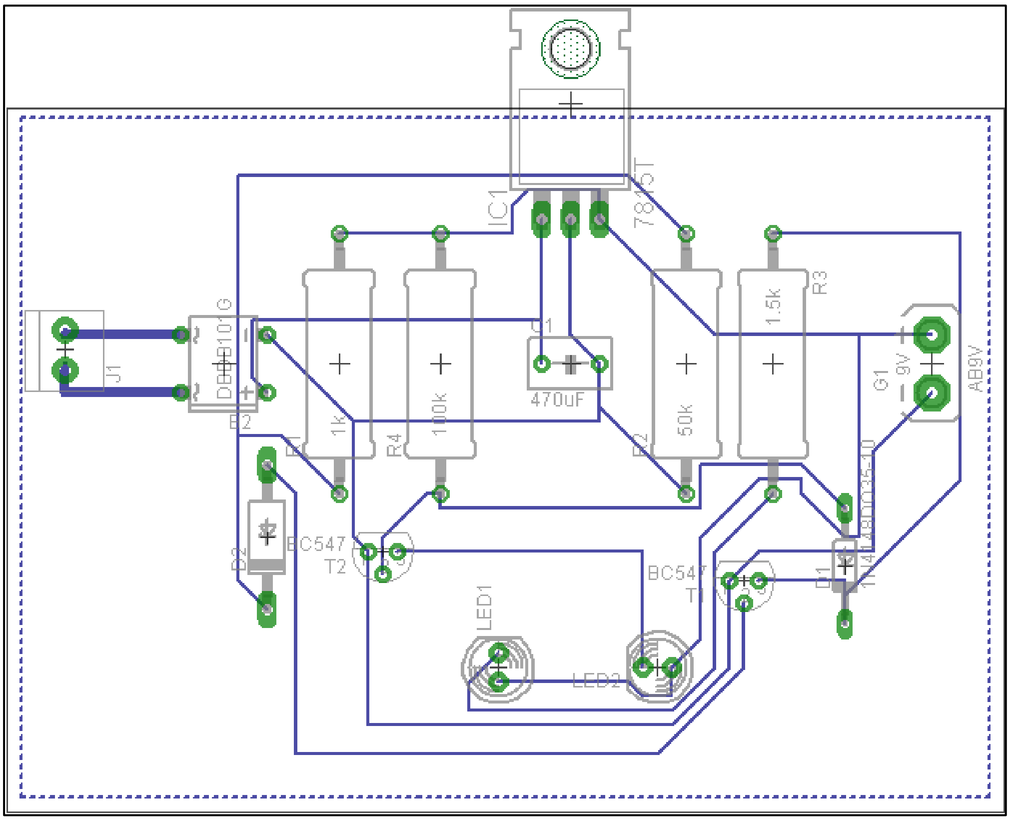


Figure 4-3 PCB Charger Circuit

Figure 4-3 shows lead acid battery charger circuit that have been converted to printed circuit board (PCB) by using eagle software. PCP supports mechanically and electrically connects electronics components using conductive track that etched from copper sheets laminated onto a non-conductive substrate. The purpose of using PCB is to minimize human error when soldering the components and also the circuit is less likely to short with other component due to poor soldering technique. Table 4-2 below shows the components need for construction of lead acid charger circuit.

Table 4-2 Charger Circuit Components

Components	Quantity
Step down transformer	1
Bridge rectifier (1N4007)	4
Capacitor (470µF, 50V)	1
Voltage regulator LM7815	1
12V rechargeable lead acid battery	1
Diode (1N4148	1
LED Zener diode 9V	1
Transistor (BC547)	2
Red LED	1
Green LED	1
Resistors (50k, 10kΩ, 1.5kΩ, 100kΩ Each ¼ Watt)	1

4.4 Prototype

In designing the ceiling fan model there is great uncertainty as the new design will actually work as desired or not. New design often have unexpected problems. The first prototype is produce to test the concept of the model. It is design to observe whether the model is working as per plan or not. Figure 4-4 and figure 4-5 shows the complete assembly of the parts which consist of motor stator and rotor, generator stator and rotor and also the aluminium which hold the permanent magnet.

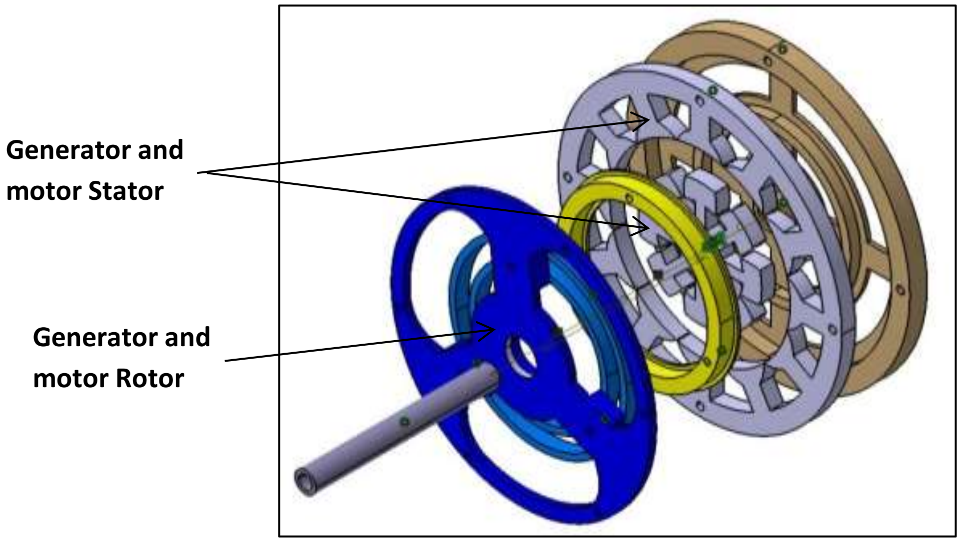


Figure 4-4 Exploded View

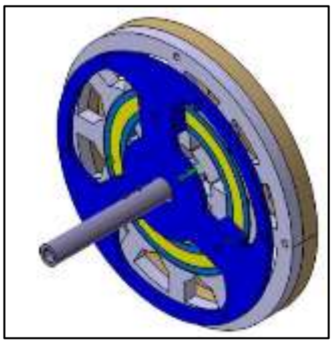


Figure 4-5 Isometric View

For this model it is divided into two main parts which is stator and rotor. For the rotor part is design to have a fail save design which will hold the permanent magnet in place even if the magnet is detach from its position as shown in figure 4-6 and figure 4-7.

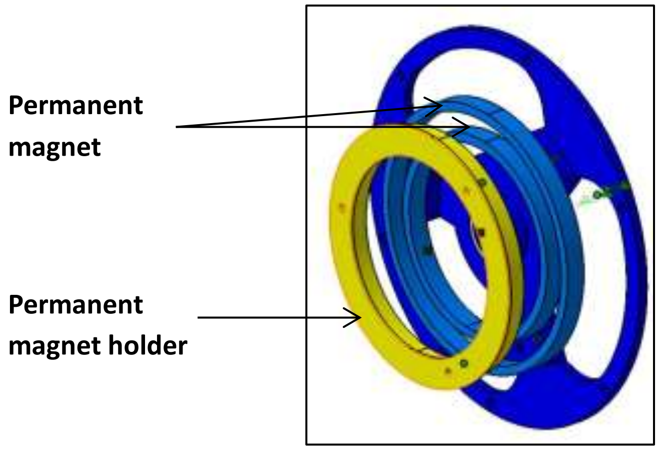


Figure 4-6 Rotor Part

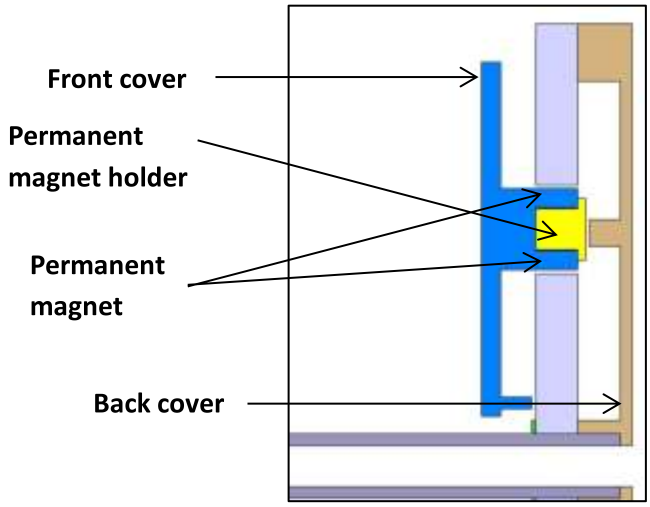


Figure 4-7 Cross Section Rotor

As for the stator, the motor and generator stator is attach to the back holder and shaft to make it stationary when the rotor is rotating as shown in figure 4-8.

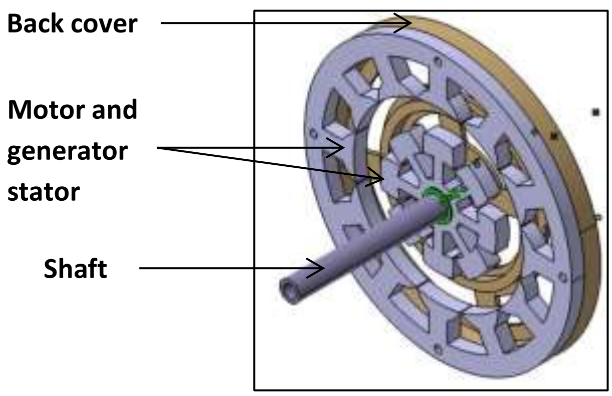


Figure 4-8 Stator Part

4.5 Conclusion

This chapter explained the stages of producing the proposed ceiling fan model design. The operational idea of the design is further elaborated and the process proceeds with the creation of drawing and 3D model of the ceiling fan model using AutoCAD software. The drawing will be used for the simulation stage of the design in next chapter.

5 Result

5.1 Introduction

In this section will discuss the simulation steps to obtain the model characteristic. The target is to obtain and study the flux distribution and the back EMF of the ceiling fan machine. Actual configuration and dimension is used to simulate the real condition of the machine. The charger circuit also simulated to confirm the operational of the circuit.

5.2 Design Simulation

Finish model from AutoCAD is imported to Ansys Maxwell and then 2D transient analyse is used as shown in figure 5-1.

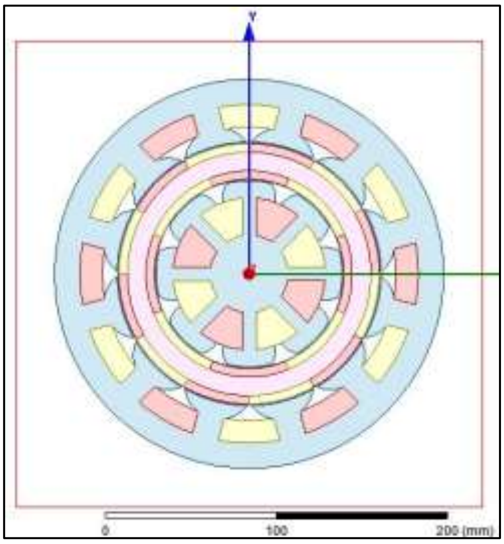


Figure 5-1 Motor And Generator Combine

Due to possibility creating error, motor and generator part is separated. With separate part analysis, adjustment of model parameter can be done without affecting other part. Figure 5-2 and figure 5-3 shows the separated motor and generator part.

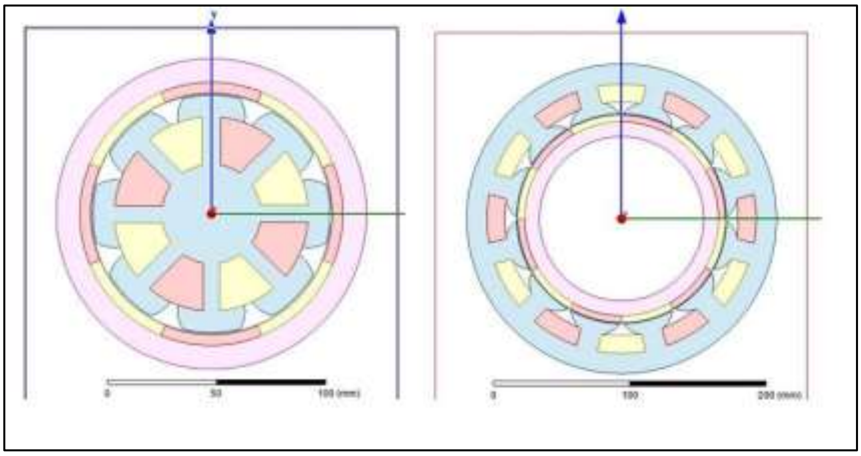


Figure 5-2 Generator And Motor Model

5.3 Simulation Result

5.3.1 Celling Fan Model

Before begin the analysis, the models need to assign the boundary, excitation, mesh operation and setup the analysis. All model were mesh before begin the analysis process. Figure 5-3 shows the meshed models. The number of mesh affect the accuracy of the result produced. The higher the number of meshing, the better the solution become but the drawback is more time needed to complete the analysis. In this simulation meshing operation is limited to 1000 maximum elements due to the capability of computer.

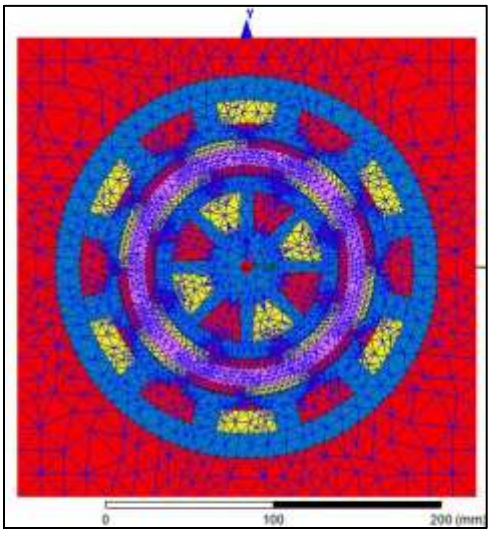


Figure 5-3 Combine Mesh Model

After completed the meshing operation all model can perform flux distribution and flux density operation. Both operation need to be done correctly in order to proceed to back EMF analysis. In order to simulate the flux distribution the models is in simulated static condition with no current flow to coil. The flux distribution results are shows in figure 5-4.

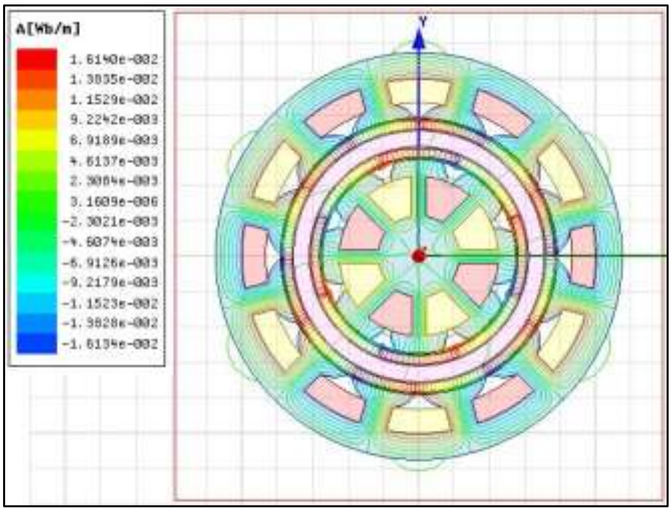


Figure 5-4 Combine Model Flux Distribution

Flux density strength show how concentrate the flux line are in certain area. The flux density is higher it get closer to the magnetic pole. The more concentrate the flux line the higher the flux density produce. The figure 5-5 below shows flux density result.

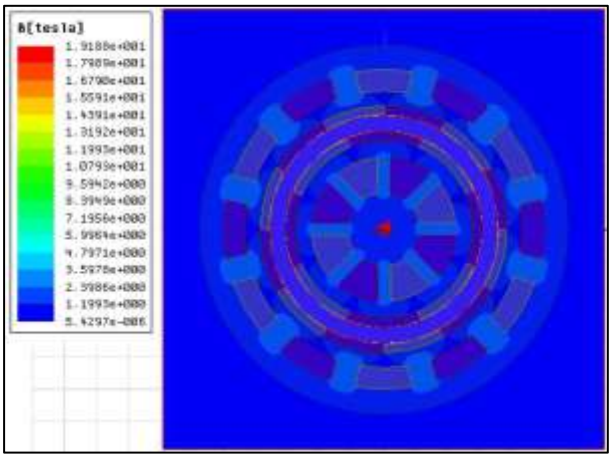


Figure 5-5 Combine Model Flux Density

For the back EMF, the result is obtained by using the data from the mash analysis, flux distribution and flux density. The winding coil needs to be introduced on the design model which set to be 500 turns of coil for each of the teeth. The current at the winding is set to 0A.

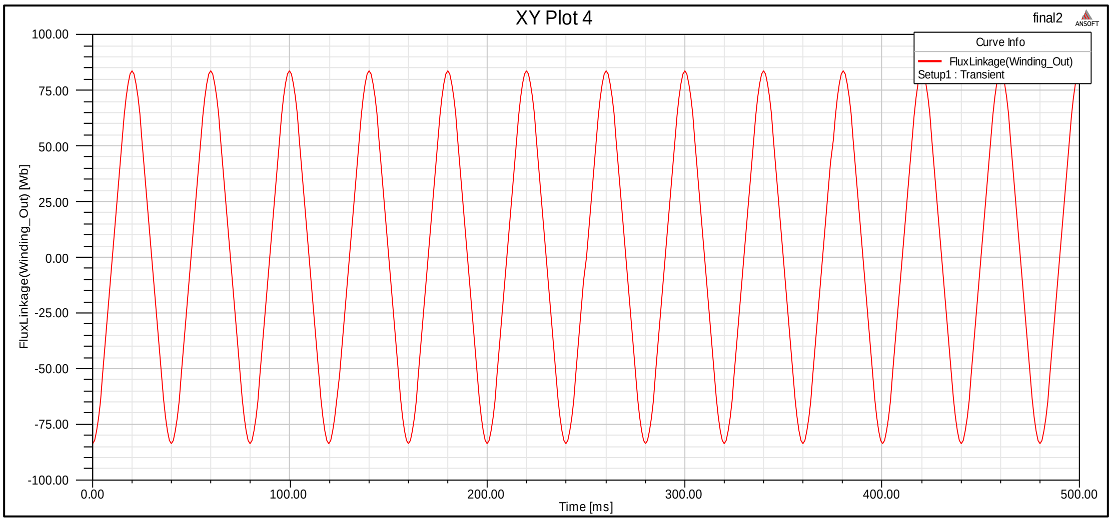


Figure 5-6 Flux Linkage At Motor Winding

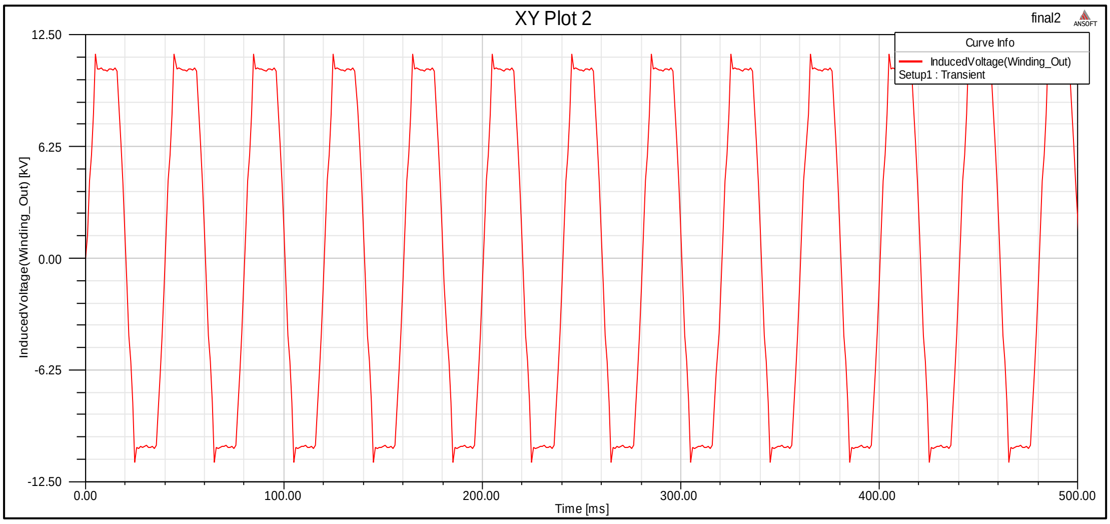


Figure 5-7 Induced Voltage At Motor Winding

Flux leakage is the amount of magnetic flux from the coil multiply by the number of coils turn. From the simulation result in figure 5-6, the voltage induced from the stator winding is proportional with the flux linkage. The induced voltage for the motor part is in AC voltage the value of 7.5kVrms as observed from the graph in the figure 5-7. Due to the simulation is done on 2D transient analysis, the default setting for the model is 1 meter. In the prototype design the height is 7mm so to get the actual result value for the induced voltage can be calculated as below:

$$Vrms = \frac{Vrms,1m}{1000} \times heigh(mm)$$

$$Vrms = \frac{7.5kV}{1000} \times 7 = 52.5V$$

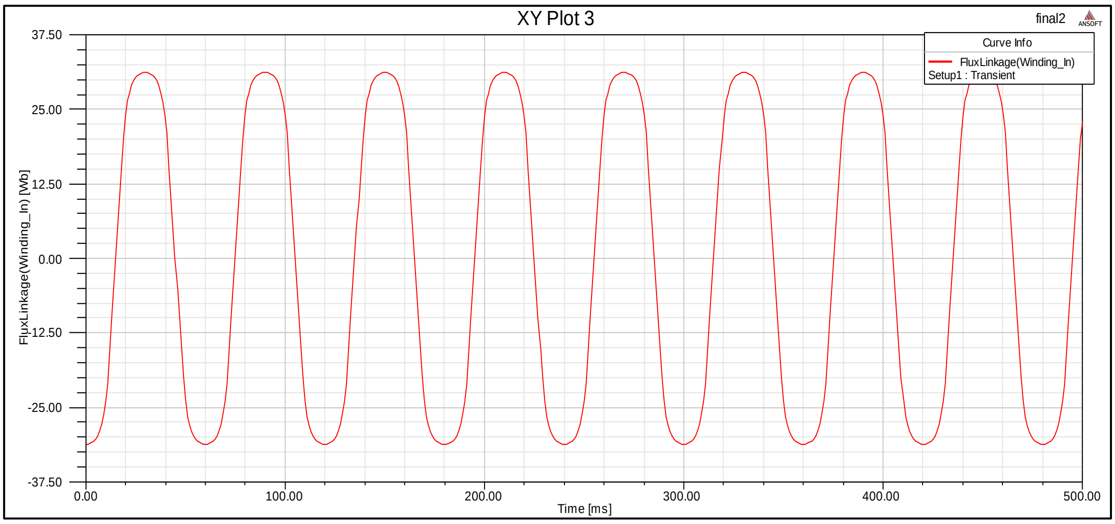


Figure 5-8 Flux Leakage At Generator

As for the generator part the result for flux linkage and induced voltage is shown in figure 5-8 and figure 5-9. Based on the simulation result in figure 5-9 the induced voltage for generator is 3.5kVrms. The height of the generator is similar to motor which is 7mm so the actual value for the induced voltage is calculated as follows:

$$Vrms = \frac{Vrms,1m}{1000} \times heigh(mm)$$

$$Vrms = \frac{3.5kV}{1000} \times 7 = 24.5V$$

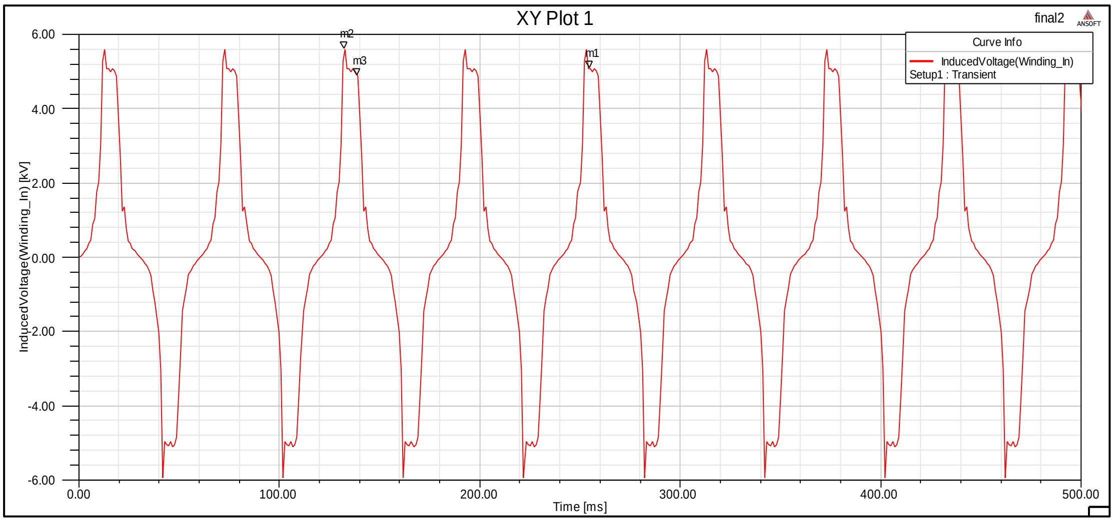


Figure 5-9 Induced Voltage At Generator

5.3.2 Lead Acid Battery Charger Circuit

Simulation for lead acid battery charger is by using Multisim software. This software can simulate all parameter in the charger circuit. The circuit is constructing in the Multisim based on the proposed circuit. Figure 5-10 show the overall charger circuit.

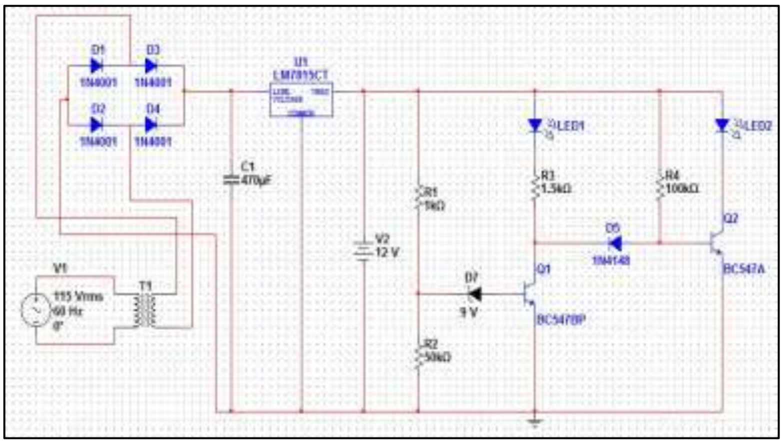


Figure 5-10 Lead Acid Charger Circuit

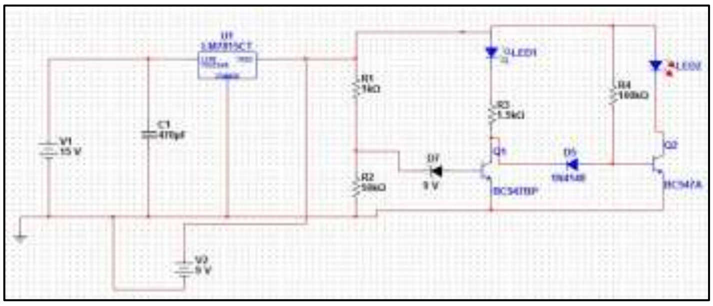


Figure 5-11 Lead Acid Charger (Circuit discharging)

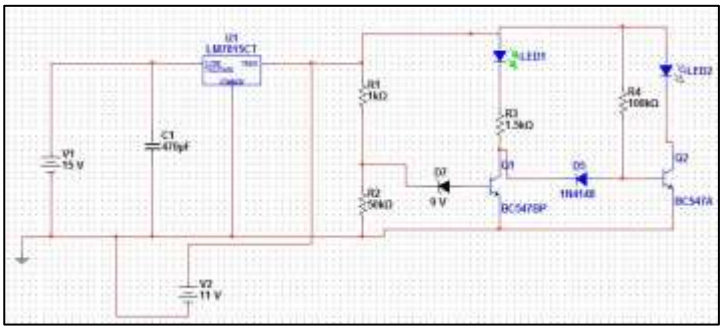


Figure 5-12 Lead Acid Charger Circuit Discharging (Charged)

Operation of the circuit is simulated by introducing 15VDC to the voltage regulator. For discharging simulation as shown in figure 5-11, the rechargeable battery is set to 9V to simulate battery is drained and need to recharge. As for the charged simulation all parameters are same with discharging but the difference is the rechargeable battery is set to 11V to indicate the battery is fully charge. The simulation is successful when both green and red LED is glowing as per intended. After get all the simulation result the circuit is tested on the PCB board to simulate the circuit with actual parameters. The actual test is conducted by using Autotransformer as a source to simulate input from generator and also lead acid battery with the capacity of 7.2Ah. The battery time for fully charge can be estimated as per calculation below:

$$\text{Charging Time of battery} = \frac{\text{Battery Ah}}{\text{Charging Current}}$$

$$\text{Charging Time of battery} = \frac{7.2\text{ Ah}}{0.8\text{A}} = 9\text{hours}$$

The actual test also gives positive result as the LEDs operate as expected and for the battery fully charge takes around 12 hours.

5.4 Conclusion

This chapter explained the simulation stages of the proposed design by using Ansoft Maxwell finite element software. The drawing design were imported from AutoCAD into Ansoft Maxweel for simulation. The component material and magnetic characteristics of the permanent magnet rotor is defined before simulation begin. The results obtained are focused on the flux distribution, flux density and the back EMF. The charger circuit simulation produces the intended result, the green LED is illuminate to indicate charged condition and when red LED illuminate indicate that the battery need to be charge.

6 Conclusion

The purpose of this project is to develop a novel design electrical machine of ceiling fan that is capable of harnessing wasted kinetic energy from the rotation of ceiling fan blade and convert the energy back to electricity. Based on the literature review the proposed design model configuration is selected to give the most efficiency and less complex to avoid higher cost of production. The motor part of the ceiling fan perform the normal function of the ceiling fan while the added generator system will capture the wasted kinetic energy from the rotation of ceiling fan blade to be converted back into electrical energy. The permanent magnet which is neodymium have selected to be as a source of excitation because it have the characteristic to have high coercivity and high flux density. The proposed ceiling fan design model is simulated to observe and study the flux distribution behaviour and back EMF produced by the machine. The simulation result obtained shows that it is possible to develop an electrical machine consists combination of motor and generator that can harness the waste kinetic energy from the motor rotation to produce electricity. The actual prototype unfortunately did not been fabricate even though the 3D model have been produced. This is because the permanent magnet and electrical steel fail to arrive in time for fabrication. The simulation results need to be compare to the actual result to verify the performance of the prototype.

7 Future Work

For future work the design can be further improve to increase the efficiency and maximize the performance. The selection of design material can be further discussed to find the most effective and to reduce cost of production. The successful design can be mass produce to create an alternative to the consumer.

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Appendices

APPENDIX A FYP Gantt Chart

Activities	Week No													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FYP 1														
Title Proposal														
Literature Review														
Design simulation														
Fabrication														
Prototype Testing and Validation														
Documentation														

Activities	Week No													
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
FYP 2														
Title Proposal														
Literature Review														
Design simulation														
Fabrication														
Prototype Testing and Validation														
Documentation														