Design and Modelling of a Bi – Toroid Transformer

By

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16808

Dissertation submitted in partial fulfillment of the requirements for the Bachelor of Engineering (Hons)

(Electrical and Electronic Engineering)

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CERTIFICATION OF APPROVAL

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Approved by,

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January 2015

CERTIFICATION OF ORIGINALITY

This is to certify 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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(KISHNU PRUMAKARAM)

ABSTRACT

Bi Toroid transformer is invented for obtaining efficiency beyond 100%. The structure of a Bi Toroid transformer is different from a Conventional transformer because it has one primary coil and two secondary coils. It is designed using two different cores, material wise and size wise. The secondary core is designed to be less reluctance than the primary core. This is done by using larger and higher relative permeability for the secondary core. This will ensure that the secondary core is less reluctance than the primary core. Thus, the induced EMF will not couple back to the primary side. This will ensure that secondary coils induced EMF will follow the less reluctance path. This will boost the efficiency of the transformer past the 100% mark.

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CHAPTER 1

INTRODUCTION

1.1 Background

Transformer is an electrical device that transfers energy from a device to another through electromagnetic induction. Electromagnetic induction can cause losses and make efficiency rate lesser (typical transformer efficiency – 90% to 99%).[1] The lesser the efficiency more energy lost occurs.

Conventional Transformer

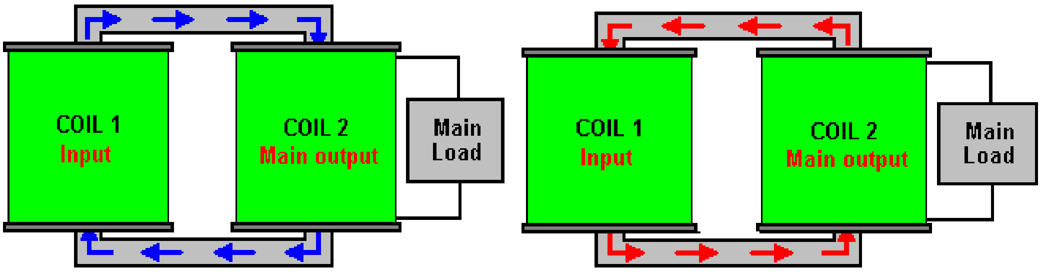


Figure 1 Conventional Transformer pulse movements

When a pulse of input power is delivered to Coil 1 (Primary coil), it creates a magnetic wave which passes though Coil 2 (Secondary winding) and back to Coil1 again as shown by the blue arrows. This magnetic pulse generates an electrical output in Coil 2, which flows through the electrical load providing it with the power which it needs to operate.

The pulse in Coil 2 also generates a magnetic pulse, and unfortunately, it runs in the opposite direction, opposing the operation of Coil 1 and causing it to have to boost its input power in order to overcome this backward magnetic flow, apart from losses occurred during the operation. So, this is what makes electrical efficiency of a conventional transformer will always be less than 100%

Bi Toroid Transformer

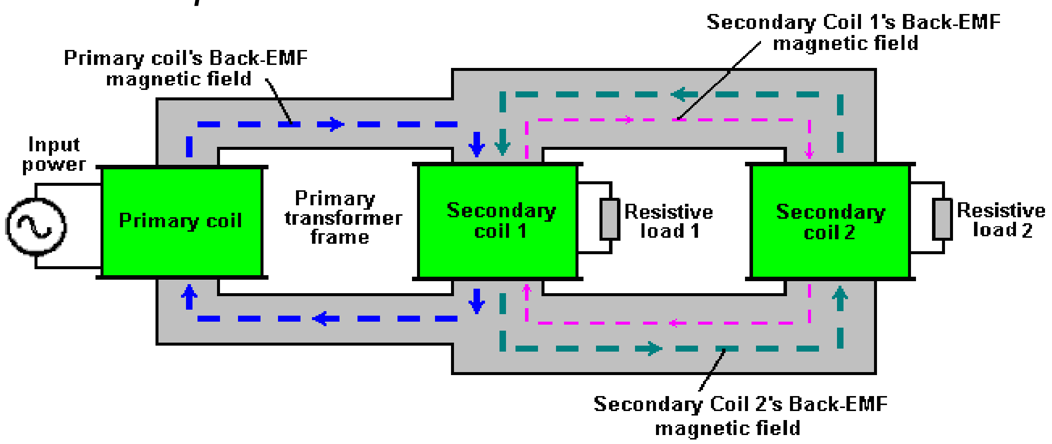


Figure 2 Bi Toroid Transformer Pulse Movements

Bi Toroid Transformer is designed and invented by a Canadian Inventor, Mr. Thane Heins (Patent No: CA2594905A1). It consists of one primary coil and two secondary coils. Primary core and Secondary core made from different materials and differs in size. Secondary core is designed to be less reluctant. So, the return pulse takes a much easier path which does not lead back to Coil 1 at all since secondary coil is made of less reluctant core. This boosts the efficiency of the transformer. The inventor also claimed that the device has been able to generate electricity. Thus, the efficiency has go beyond 100%.

1.2 Problem Statement

This device has been patented and claimed to generate electricity because the efficiency is higher than 100%. If the device is really capable of generating electricity, it can be used to address energy scarcity problem. However, not much have been understood and reviewed of the source of the additional energy produced by the device, I.e. where the extra energy coming from? How it is possible to achieve the efficiency above 100% and what are the limitations of the device?

1.3 Objectives

1. To design, test and analyze a Bi – Toroid transformer using ANSYS software.
2. To understand how it works by using ANSYS software

1.4 Scope of Study

1. More focus given on the materials used to design the transformer and the windings.
2. Experiments will be carried out to understand how this device work by using ANSYS software

1.5 Relevance and Feasibility

The study conducted based on transformers, the materials used and the effects of it on efficiency of the transformer and how to improve it. In addition, the valuation and the suitable factor to increase the efficiency are done based on past research papers and experiments conducted.

CHAPTER 2

LITERATURE REVIEW

2.1 Conventional Transformer

A conventional transformer is a device that has two or more coils of wire physically wrapped around the laminated core. They consists mainly two cores, primary and secondary. The primary is connected to an ac power source and the secondary is open circuited

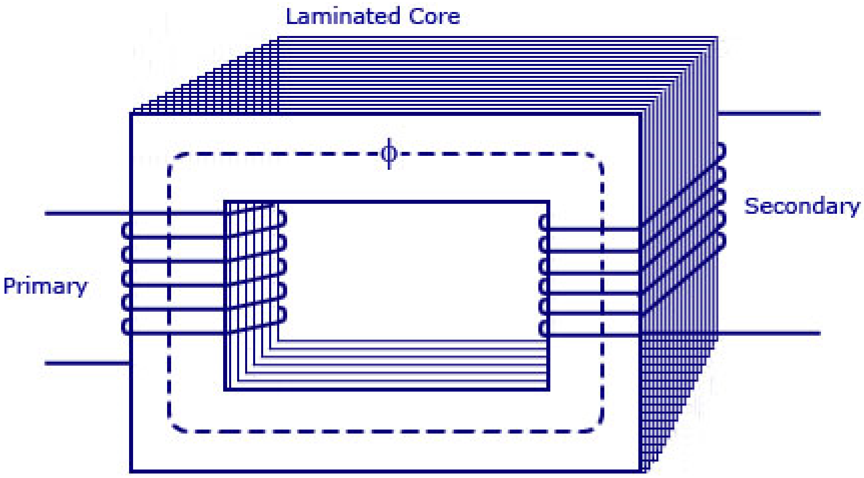


Figure 3 Conventional Transformer

Operating Principle

The operating principal of the transformer is based on Faraday's Law. There are 2 laws of Faraday, first law states that any changes that happened in a magnetic field of a coil of wire will cause an electromagnetic field (emf) to be induced in the coil. As for the second law of Faraday, it is stated that the magnitude of electromagnetic field (emf) induced in the coil is equal to the rate of change of flux that linkages with the coil.[2] The induced voltage is given by,

$$\boldsymbol{e_{ind} = N\frac{d\bar{\phi}}{dt}} \quad \textbf{(1)}$$

where $\bar{\phi}$ is the average flux per turn in a coil and N is is the number of turns in the coil. Therefore,

$$\boldsymbol{\bar{\phi} = \frac{\lambda}{N}} \quad \textbf{(2)}$$

where λ is the flux linkage in the coil across where the voltage is being induced, and it is the sum of the flux passing through each turn in the coil added. Thus,

$$\boldsymbol{\lambda = \sum_{i=1}^{N} \phi_i} \quad \textbf{(3)}$$

Transformer works using the principle of Faraday's law where it uses electromagnetic induction of two coils, the primary and secondary coils. When there is a current change occurs in primary side, the secondary side also will have changes in current. Subsequently, EMF induced in the secondary coil due to Faraday's Law of Electromagnetic induction.[2] Basically, transformers are based on two principles

1. Magnetic field (electromagnetism) can be produced by an electric current.
2. Voltage induced in the end of the coil (electromagnetic induction) by changing magnetic field within a coil of wire.

So, as a result, the induced voltage in each winding depends on the number of turns in that winding.

Losses in a conventional transformer that have to be taken into account[3]**:**

1. **Copper / I^2R losses** are the resistive heating losses in the primary and secondary windings of the transformer[3].
2. **Eddy current losses** are the losses due to resistive heating in the core of the transformer[3].
3. **Iron / Hysteresis losses** are due to lagging of the magnetic molecules within the core because of the alternating magnetic flux and it is associated with the rearrangement of the magnetic domains in the core during each half cycle[3].
4. **Leakage flux**es are the fluxes that escape the core and only pass through one windings of the transformer[3].

The force of power loss in a transformer decides its efficiency. The efficiency of a transformer is reflected in power (wattage) loss between the primary and secondary windings. At that point the resulting efficiency of a transformer is equivalent to the proportion of the power ratio of the secondary winding, to the power input of the primary winding, and is thus high.

Due to this problem (losses), the efficiency of a transformer is always below 100%, typical efficiency of a conventional transformer is 91%-99%.[4][1] Efficiency of a transformer can be calculated as:

$$\boldsymbol{efficiency, \eta} = \frac{\boldsymbol{Output\ power}}{\boldsymbol{Input\ power}} \times \mathbf{100}\% \qquad \mathbf{(4)}$$

2.**2 Bi Toroid Transformer**

Bi Toroid Transformer is a special transformer that has developed by a Canadian Inventor, Thane Heins (patent no: CA2594905A1). It differs with a conventional transformer in terms of number of coils and number of cores. A Bi Toroid transformer has on primary coil and two secondary coils whereas a conventional transformer only has one primary coil and one secondary coil.

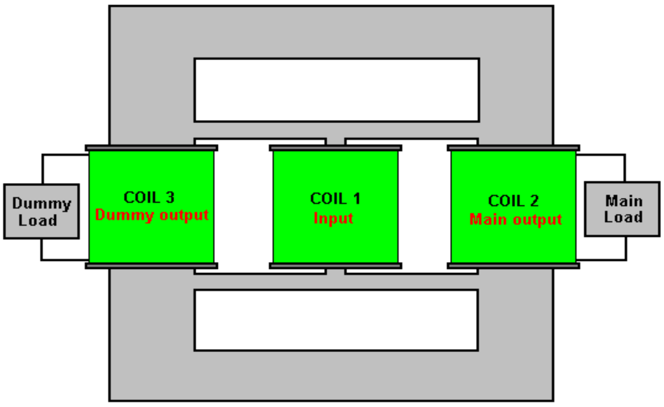


Figure 4 Bi Toroid Transformer

Operating Principle

A Bi Toroid transformer is designed to have one primary side and two secondary sides. Apart from that, it has two different cores in terms of size and materials. The secondary core is bigger in size and as for material; it has higher permeability material than the primary side. This will ensure that the secondary core will have much lesser reluctance than the primary core, thus, the pulse generated from the core wont couple back. By doing this, the efficiency will increase dramatically.

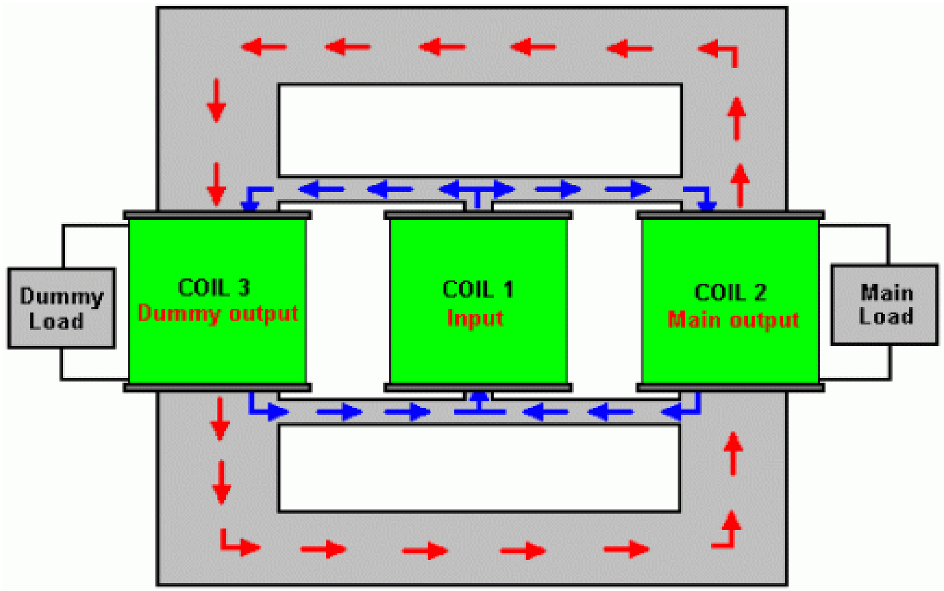


Figure 5 Bi Toroid Operating Principle

A common transformer has an efficiency around (91-99) % depending on the various issues[5]. Apart from that, it only has one primary side and one secondary side. As for a Bi-Toroid transformer, the efficiency can go up to 100% or more and it has one primary coil and two secondary coils. The secondary cores have lower reluctance than the primary core. By doing this, the electromagnetic fields (EMF) will not couple back with the primary core because of the higher reluctance flux path[1]. So, the desired output on no-load will be achieved as same as the input with near no load power factor.[6]

As for the reluctance, it can be adjusted by using different cores or by just using different sizes for the primary side and the secondary side. The bigger the size, the lower the reluctance. The other way is to use different cores for primary and secondary sides. This can be done by using higher reluctance core for example iron with lower permeability on the primary side and using permalloy which has high permeability and lower reluctance on the secondary sides.[1][7]

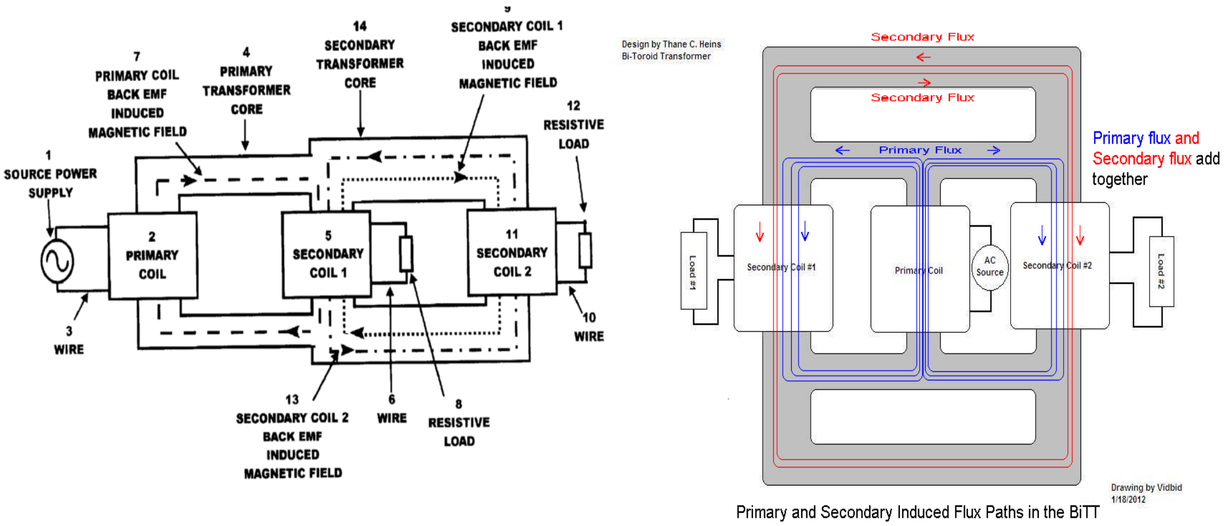


Figure 6: Bi Toroid Transformers

2.3 Materials used for the cores

One of the main criteria in order to design a Bi-Toroid transformer is by using different materials. Other than using different materials, different sizes of cores can be applied to design the Bi-Toroid transformers but it would not be as effective as using different types of materials as the different permeability of the cores will be more efficient than different sizes of the same cores. [1]

The primary core consist of normal transformer iron core which has permeability around 200 while the secondary cores consists of permalloy which has permeability around 100 000[1][7]. Permalloy is made of roughly 80% Nickel and 20% iron so that makes it reluctance low. [8]. Permeability can be calculated as below,

$$\textbf{Permeability}(\mu) = \textbf{Flux Density}(B) \times \textbf{Magnetizing Force}(H) \quad \textbf{(5)}$$

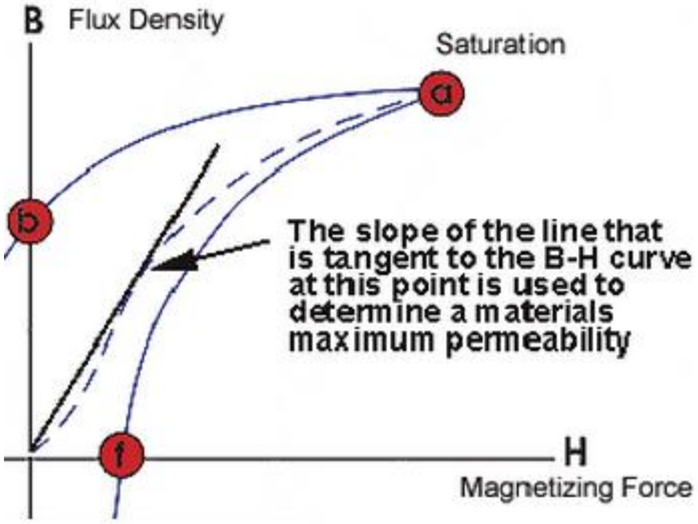


Figure 7: Permeability Graph

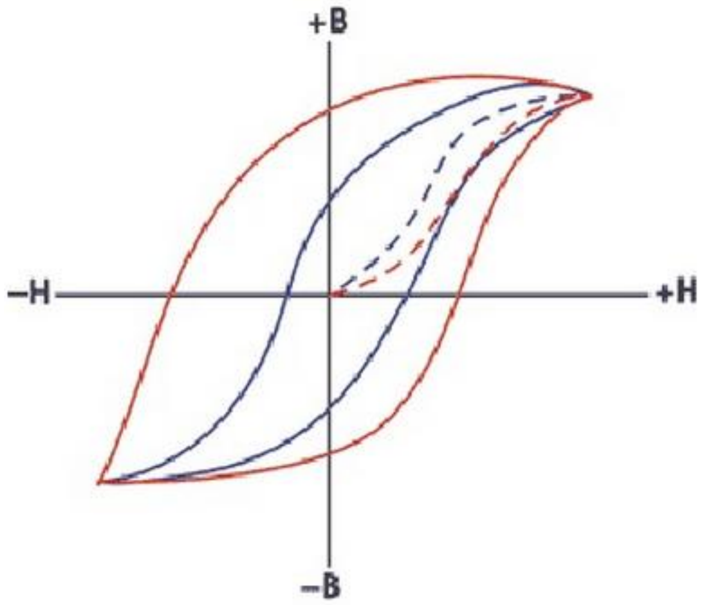


Figure 8: Hysteresis Loop (Iron VS Permalloy)

Iron has the wider hysteresis loop, that means it has higher reluctance and lower permeability as for Pemalloy, it has narrower loop, that means it has lower reluctance and higher permeability.[9]

2.4 Power Factor (PF)

Power factor (pf) is the ratio of the real power (W) and apparent power (VA). The power factor will be in the range of 0-1. When the power is reactive power (usually inductive load), the power factor will be '0' while, when the power is real power (resistive load), the power factor will be'1'.[10]

$$\boldsymbol{PF} = \boldsymbol{P}(\mathbf{W}) \ / \ |\boldsymbol{S}(\mathbf{VA})| \qquad \textbf{(7)}$$

PF = Power Factor
P = Real Power (w)
S = Apparent Power (VA)

For sinusoidal current, the power factor PF is equal to the absolute value of the cosine of the apparent power phase angle φ

$$\boldsymbol{PF = \cos\varphi} \quad \textbf{(8)}$$

PF = Power Factor
$\cos\varphi$ = Apparent power phase angle

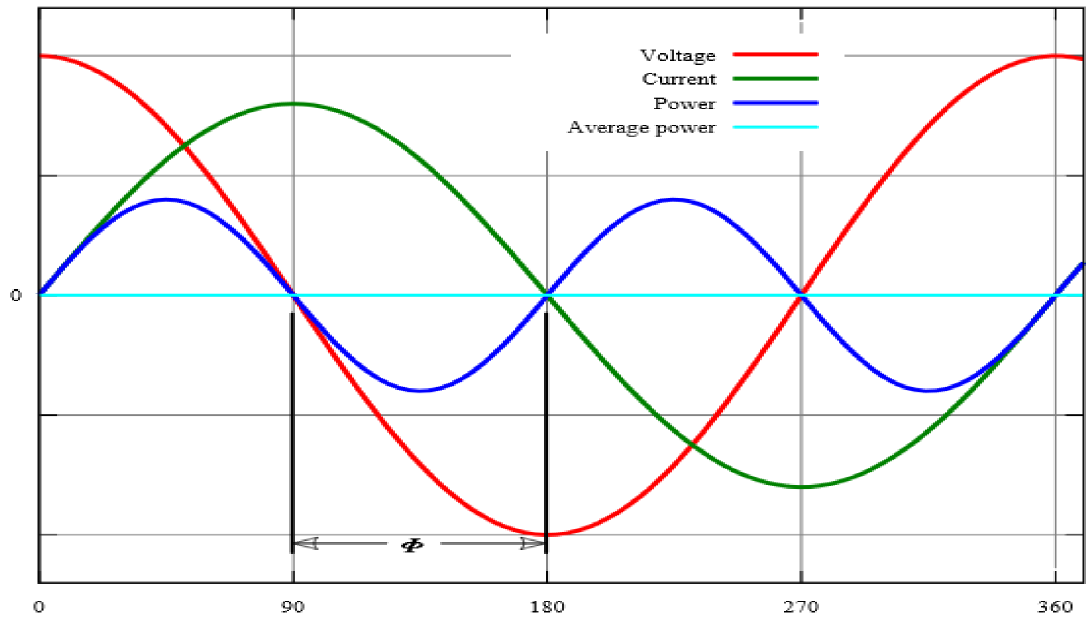


Figure 9 Power Factor Graph

Phase angle $\varphi = 90^{o}$, so, cos 90 = 0. That means no real power consumed and purely reactive power consumed. So, this will make the real power = 0.

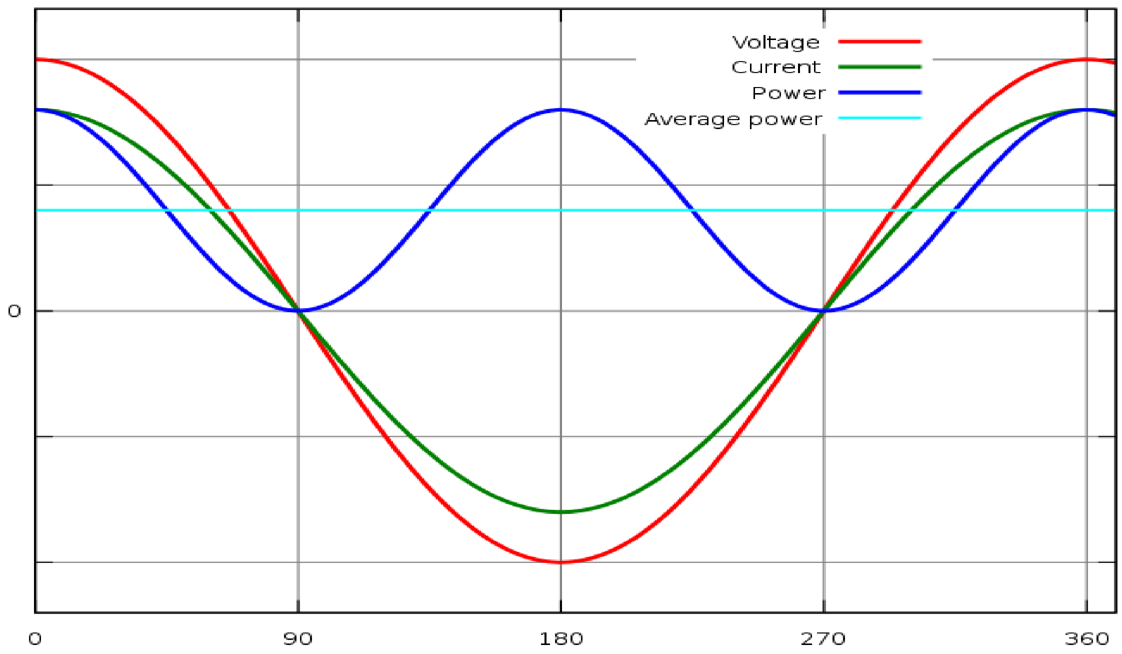


Figure 10 Power Factor Graph 2

Phase angle $\varphi = 0^o$, so, cos 0 = 1. That means no reactive power consumed and purely real power consumed.

2.5 Testing/Experiments

There are several experiments and testing conducted by Thane Heins in order to proof that a bi toroid transformer can achieve efficiency above 100%. Below are the experiment conducted.

Power Factor (pf) testing/experiment

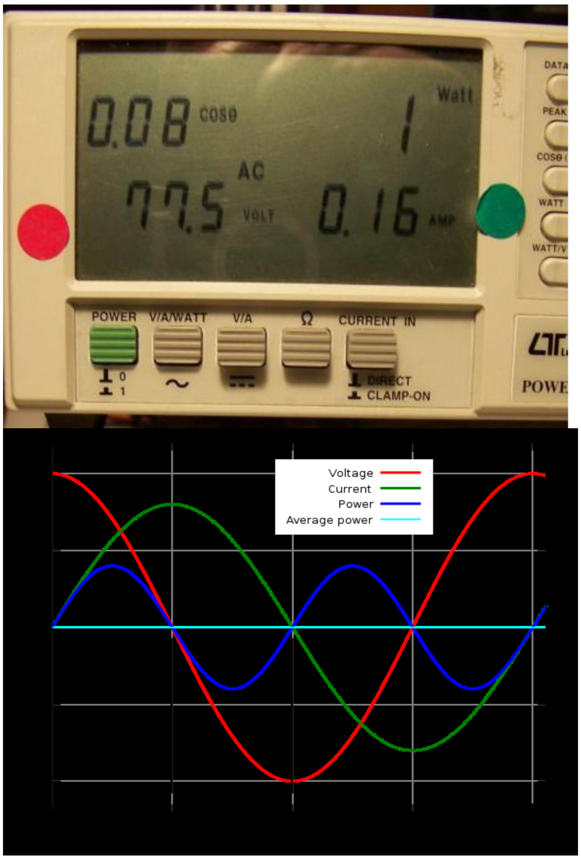


Figure 11: Bi Toroid Sine Waves

Voltage and Current 90 degrees apart, so pf=0

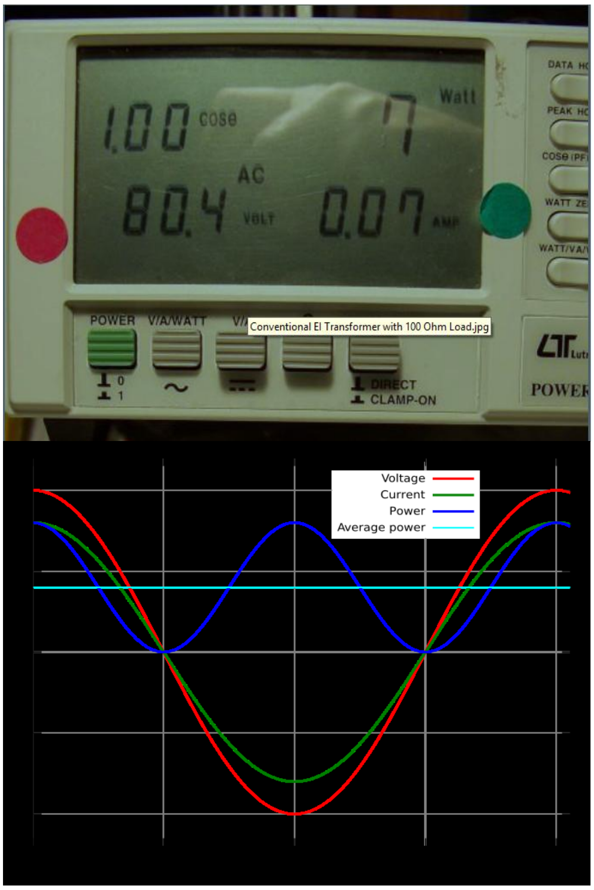


Figure 12: Conventional Transformer Sine Waves

Voltage and Curent in phase, so pf=1

The power factor(pf) for Bi-Toroid transformer must be '0' or nearly '0' since it consumes reactive power and not real power as a conventional transformer does and that's the reason of the power factor (pf)=1.[11]

Efficiency Test (Conventional Transformer)

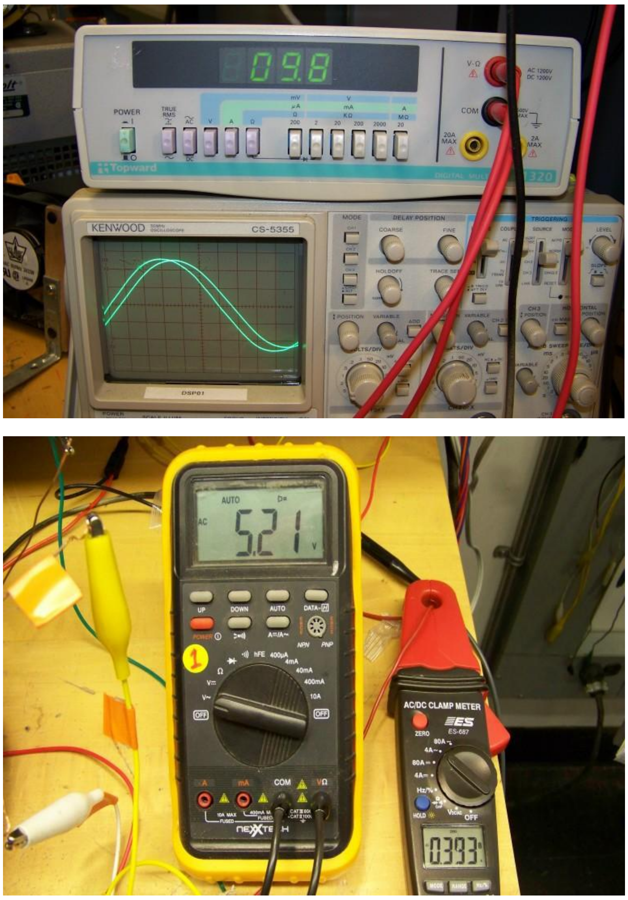


Figure 13 Conventional Transformer Efficiency Test

Input Voltage = 9.8 Volts

Input Current = 0.393 Amps

Power Factor = 0.95 / 18 degrees

Load = 10 Ohms

Load Voltage = 5.21 Volts

Load Power = 2.71 Watts

Input Power = 3.66 Watts

<u>**Efficiency = 74 %**</u>

Efficiency Test(Bi Toroid Transformer)

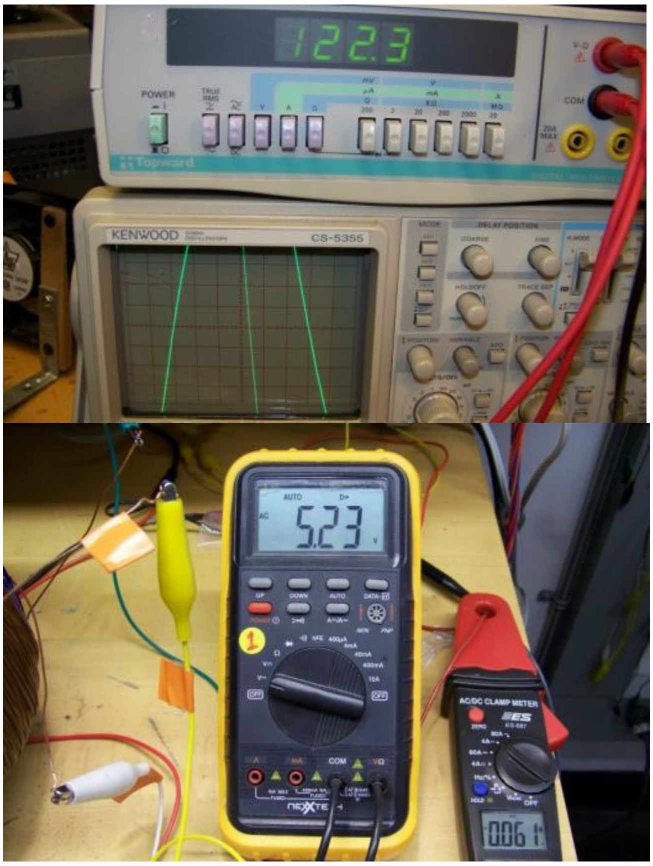


Figure 14 Bi Toroid Transformer Efficiency Test

Input Voltage = 122.3 Volts

Input Current = 0.061 Amps

Power Factor = 0.021 / 78 degrees

Load = 10 Ohms

Load Voltage = 5.23 Volts

Load Power = 2.74 Watts

Input Power = 1.55 Watts

<u>Efficiency = 177 %</u>

CHAPTER 3

METHODOLOGY

For this project, more studies will be done on the past research about the Bi-Toroid transformers. The materials used to design the core and the windings will be the main edge. Apart from that the experiments and tests involved to determine the efficiency of the transformer also will be vital.

3.1 Tools and Software

ANSYS software will be used to design and simulate the Bi-Toroid transformer. From the software, the design (prototype) will be analyzed. The main analysis on the prototype is the efficiency rate of the transformer with the respect of losses. All these analysis will be conducted using ANSYS software.

3.2 Flow Chart

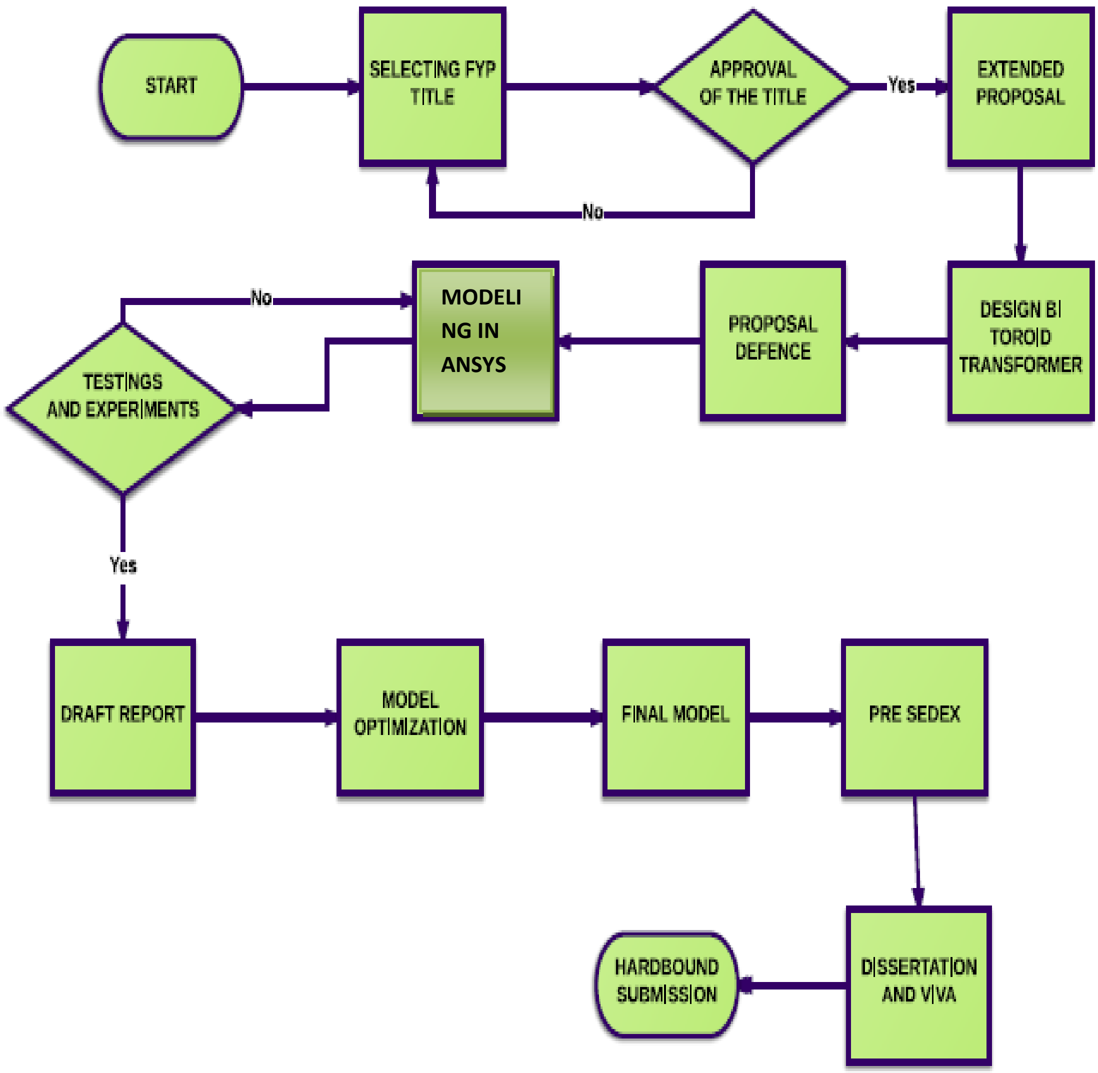


Figure 15 Flow Chart

At the early stage of the project, studies will be done on the Bi Toroid and the conventional transformers. The research is conducted to acquire better understanding on the subject through literature reviews, journals reading, and internet research. The right materials and windings studied in order to design a Bi Toroid transformer. Once the transformer is designed with a proper design, the vital part occurs, experiments and testing. All the required tests and experiments should be carried out in order to obtain the desired results. All these experiments and results will be obtained by using

ANSYS software. Once the result obtained, the final model for pre sedex should be done by optimizing the model and a draft report should be completed. The hardbound submission is the end of the process once dissertation and viva are done.

3.3 No Load Test

Conventional Transformer and Bi Toroid transformer are placed on No Load and the output observed and the readings will be taken using oscilloscope and multimeters.

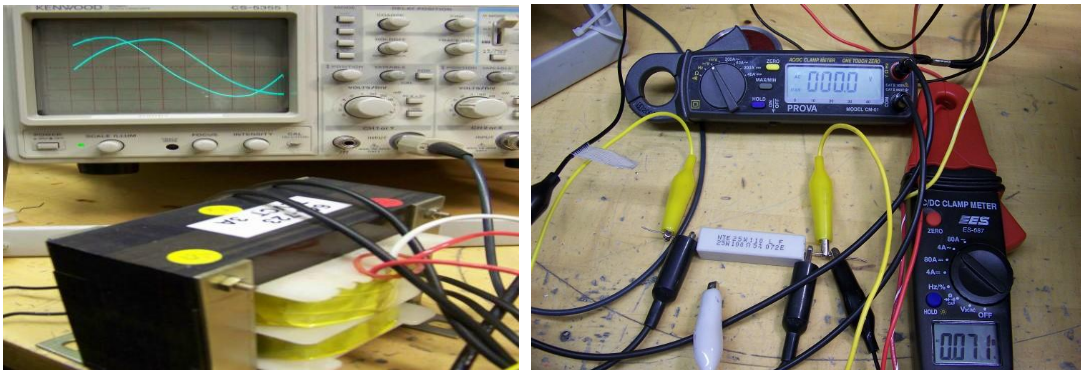


Figure 16 No Load Test

3.4 On Load Test

Both the Bi Toroid Transformer and the Conventional Transformer will be placed on Load and the output observed and reading will be taken.

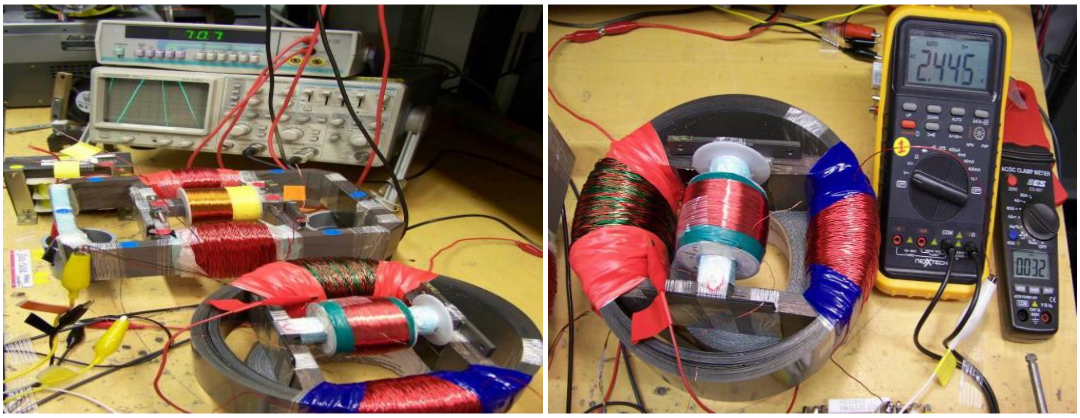


Figure 17 On Load Test

3.5 Gantt Chart

Table 1 Gantt Chart

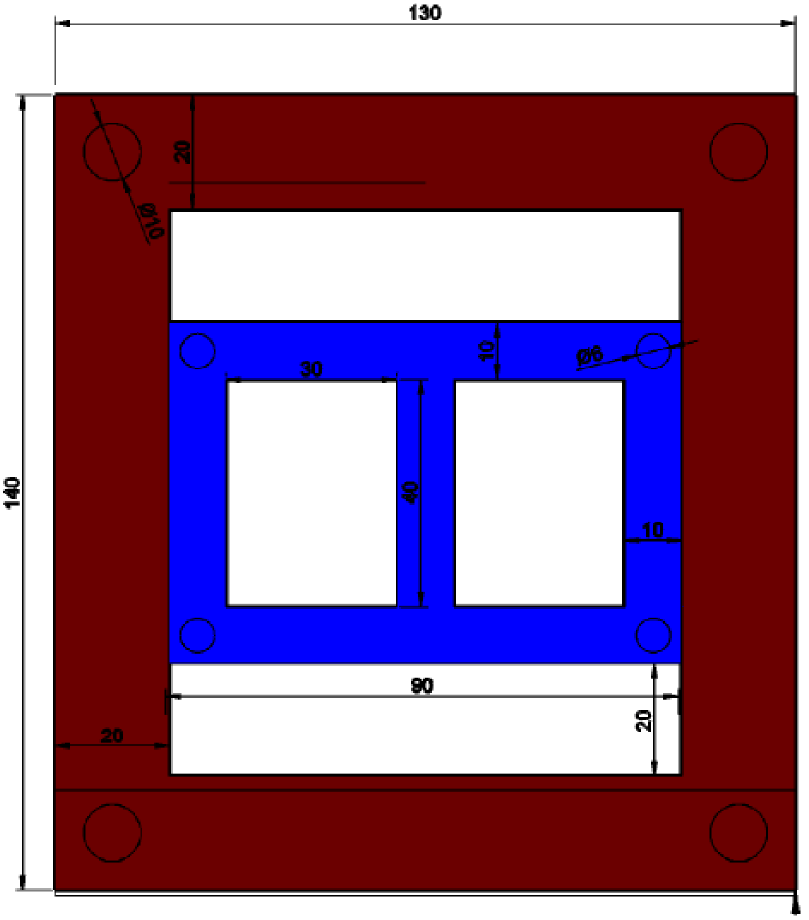
Project Flow	2	3	4	5	6	7	8	9	10	11	12	13	14
FYP 1													
Selecting Topics													
Prepare project plan & Gantt chart													
Preparation of literature review 1) Understand the requirements/tools 2) Windings,Core,Dimensioning													
Extended Proposal					Δ								
Familiarization with calculations and materials for designing													
Proposal Defence								Δ					
Develop Methodology for the experiment													
Start Designing													
Analyze the result													
Interim Report (Hard Copy & Soft Copy)												Δ	Δ

FYP2													
Determine the required parameters involved in testing													
Test the prototype using ANSYS software													
Analyze results								Δ					
Draft report								Δ					
Final Touches													
Final presentation													Δ
Final report													Δ

Δ **Key Milestone**

CHAPTER 4

DESIGN OF THE TRANSFORMER CORE (AutoCAD)



Width = 35mm
Red = Permalloy
Blue = Silicon steel

Bracket
Thickness = 1mm
width = 10mm
length = 130mm

This is the proposed design of the Bi Toroid transformer. It consists of two different cores with different materials respectively. The primary core is made of silicon steel whereas the secondary coil is made of permalloy. The size of the secondary core is twice the size of the primary core; this is due to reluctance, the secondary core is less reluctant than the primary core.

3D ANSYS SOFTWARE DESIGN

Bi – Toroid Transformer

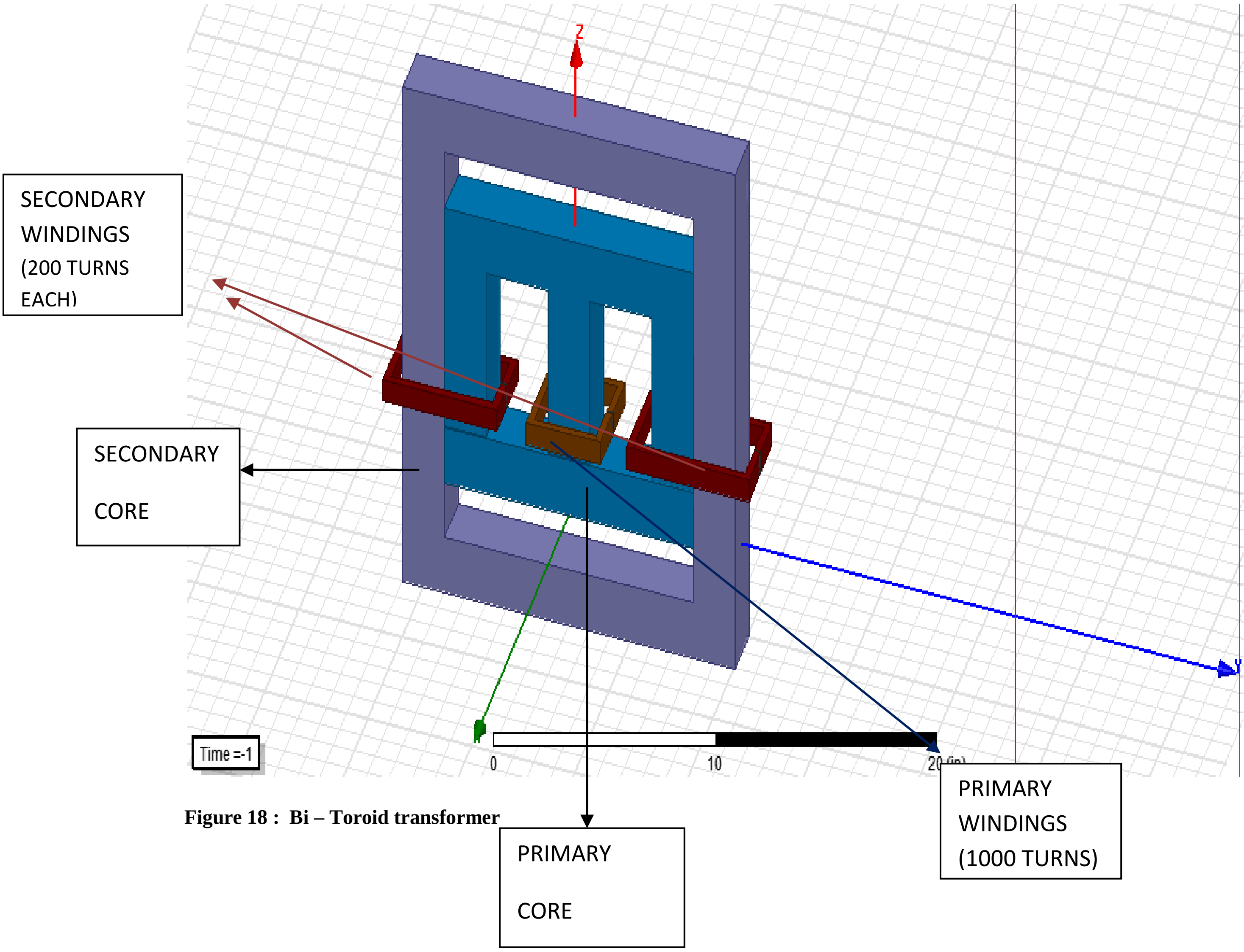


Figure 18 : Bi – Toroid transformer

Conventional Transformer

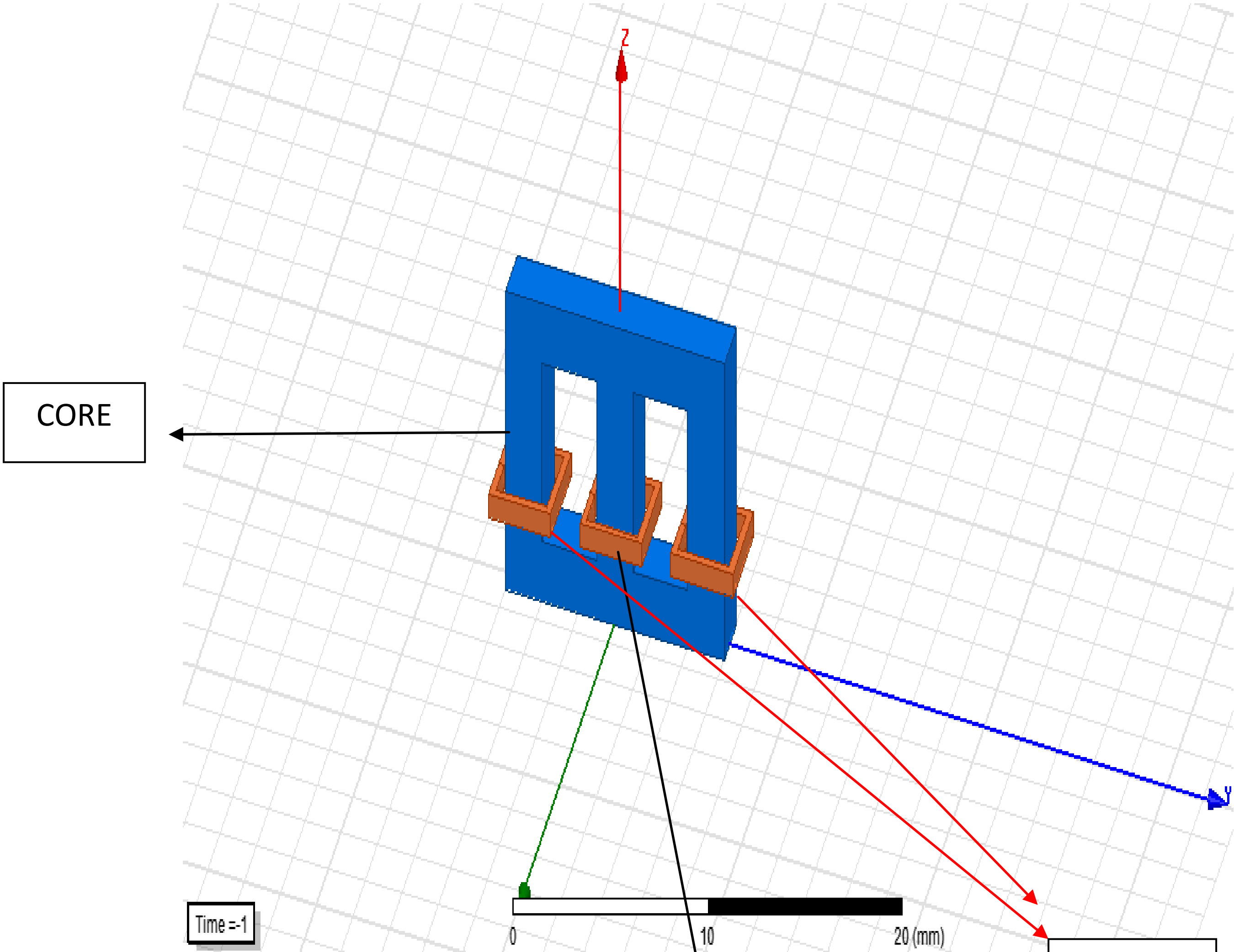


Figure 19 Conventional transformer

CHAPTER 5

RESULTS AND FINDINGS

BP & BH curves

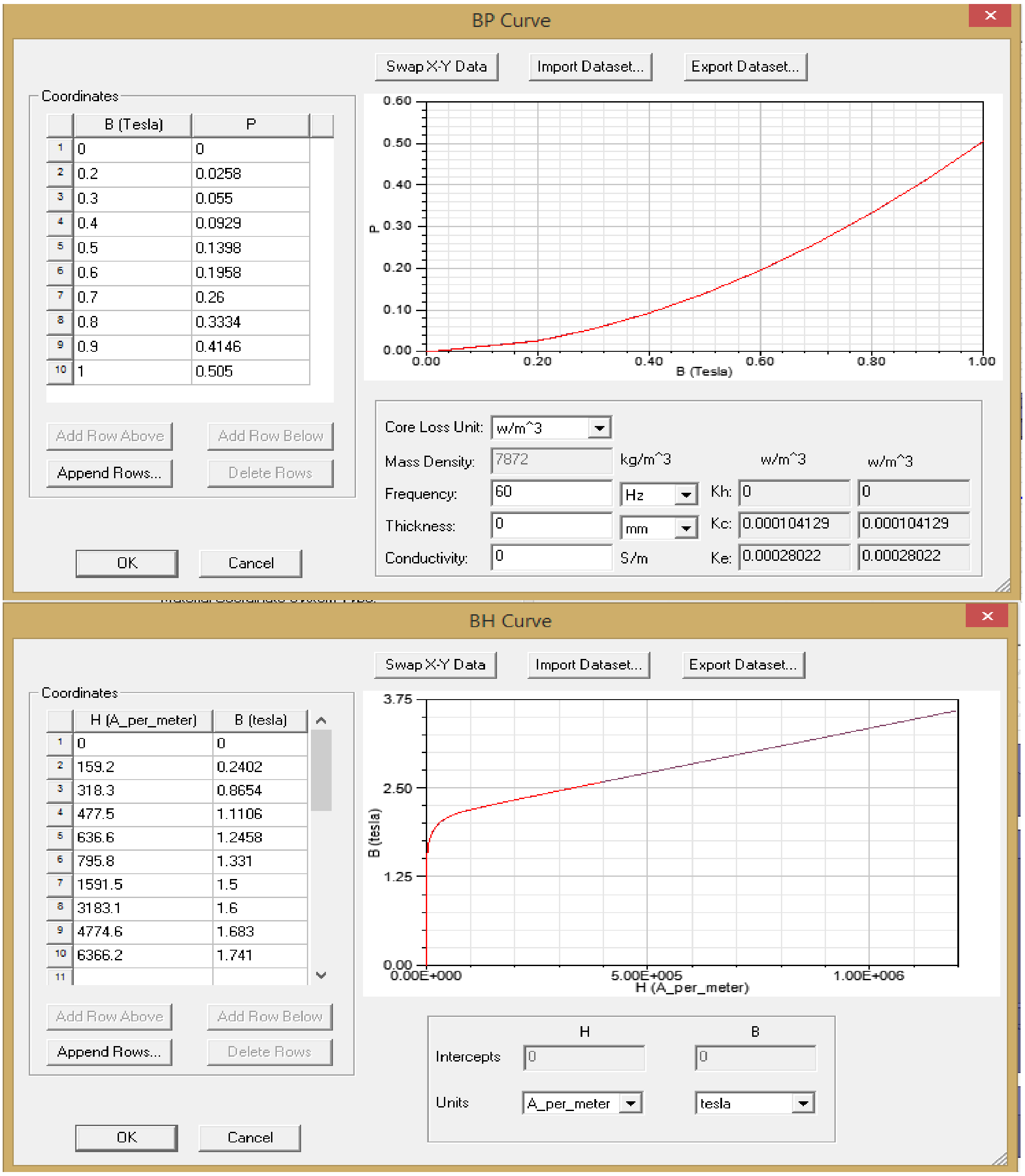


Figure 20 : BH & BP Curves

Power Factor Testing (Bi-Toroid)

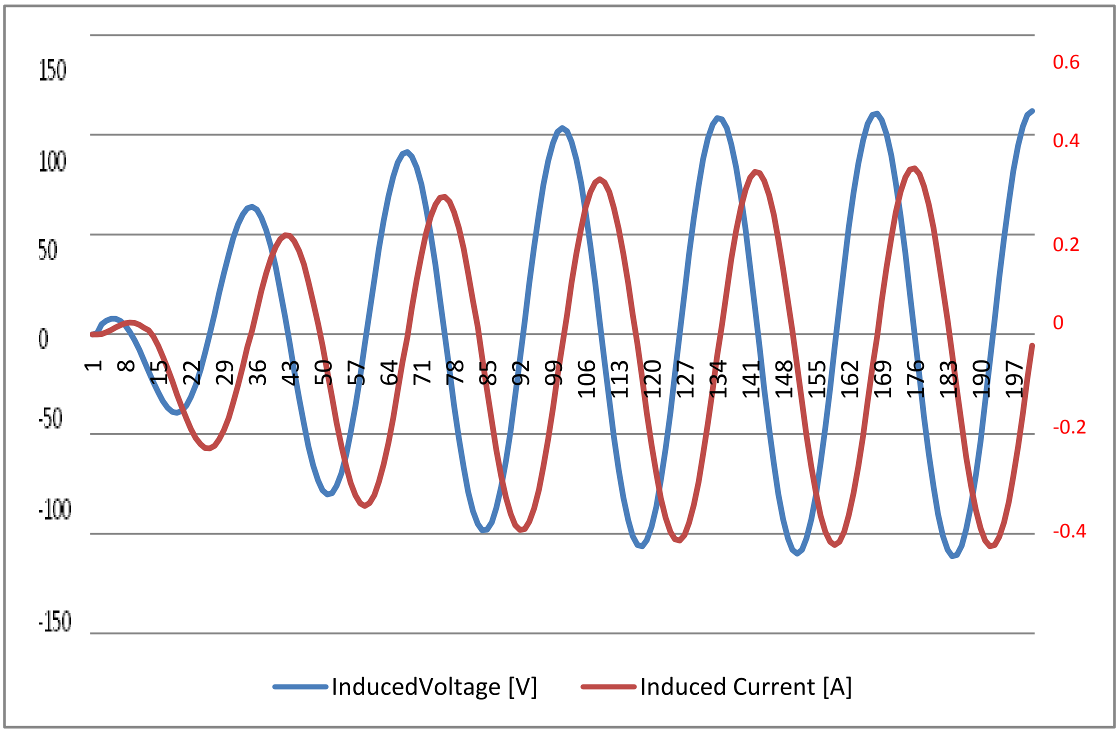


Figure 21 PF graph (Bi-Toroid)

The current and voltage are not in phase, almost 90⁰ apart. So the pf is small, nearly 0. So it consumes reactive power to supply real power.

Power Factor Testing (Conventional)

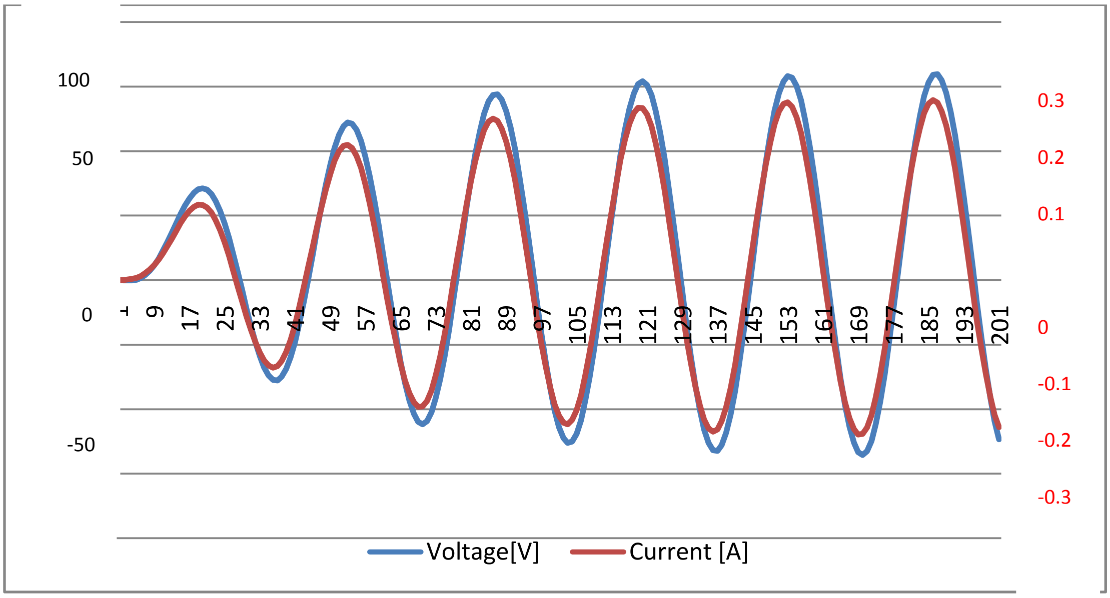


Figure 22 PF graph (Conventional)

The current and voltage are in phase, so, the pf is nearly 1. It consumes real power to supply real power.

Efficiency Calculations

Bi Toroid Calculations

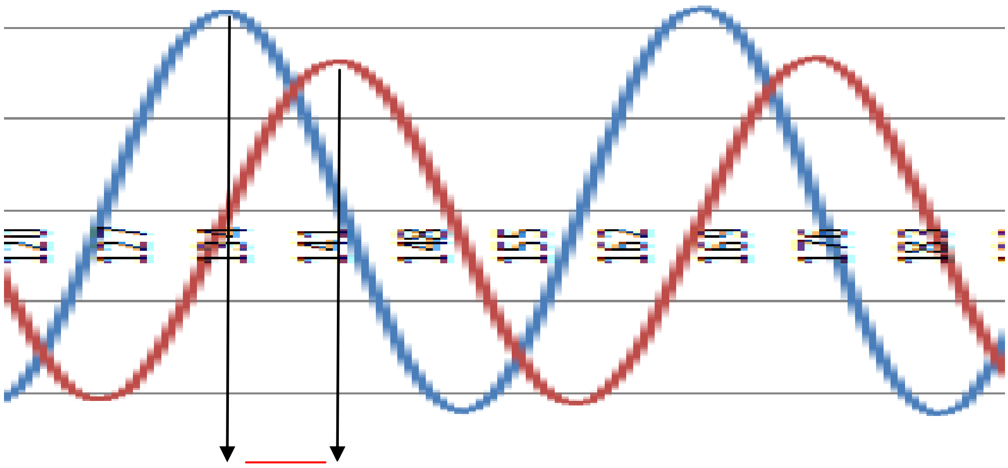


Figure 23 PF (Bi - Toroid

From the above graphs, it shows that the current and voltage for a Bi-Toroid transformer are almost 90^o apart on the primary side. This means:

PF = cos φ

= cos 85^o

= 0.087

So, the power factor for the Bi-Toroid transformer is nearly ‘0’.

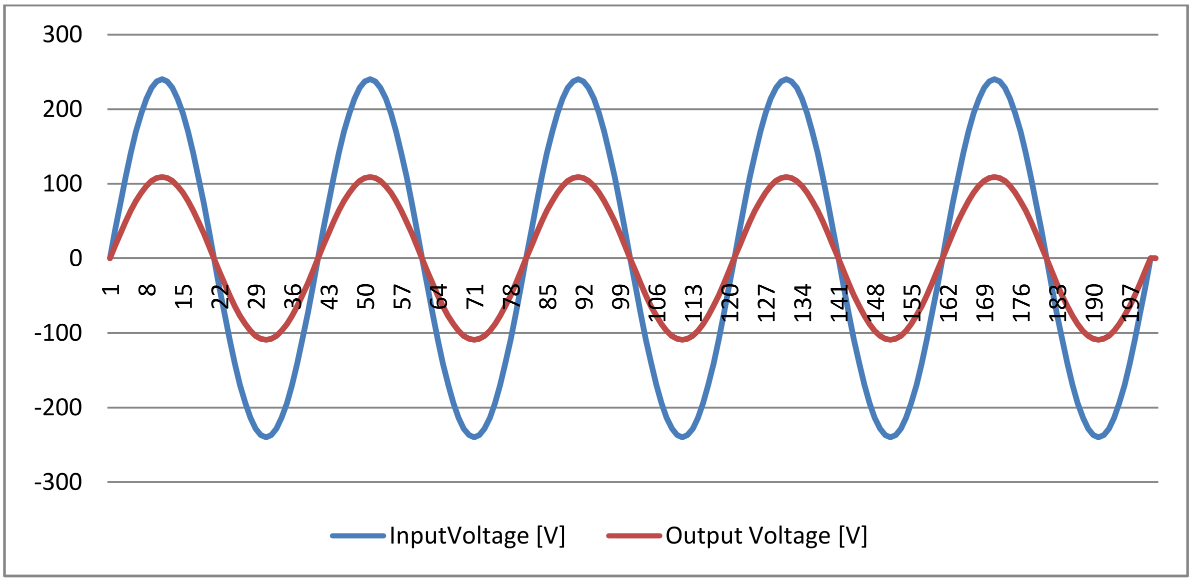


Figure 24 Voltages (Bi - Toroid)

The above graph shows the input/output voltages of the Bi – Toroid transformer. The input voltage is 240 V while the output voltage is 105 V.

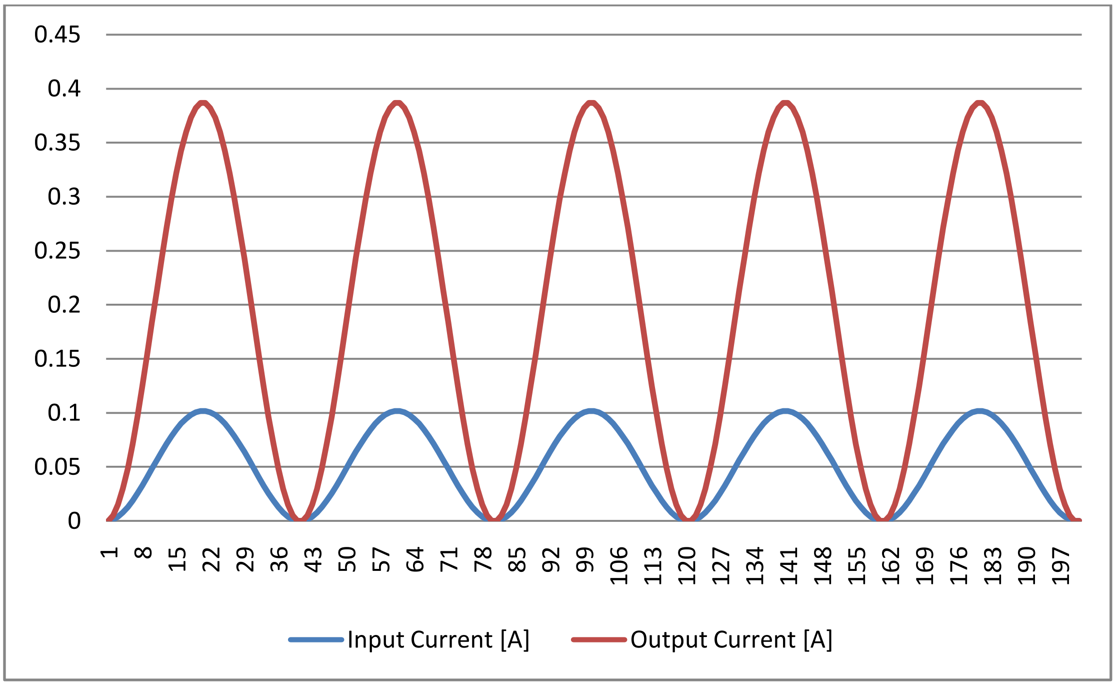


Figure 25 Currents (Bi- Toroid)

The above graph shows the input/output currents of the Bi – Toroid transformer. The input current is 0.1 A while the output current is 0.38 A.

Power Calculations

$$\boldsymbol{P = V_P \times I_P \times \cos\varphi} \qquad \textbf{(9)}$$

Input Power

P = 240 x 0.1 x 0.087

= <u>2.088 W</u>

Output Power

P = 105 x 0.3829 x 0.087

= **<u>3.497 W</u>**

Efficiency

$$P = {}^{3.497}/_{2.088} \times 100$$

= **<u>168 %</u>**

Conventional Calculations

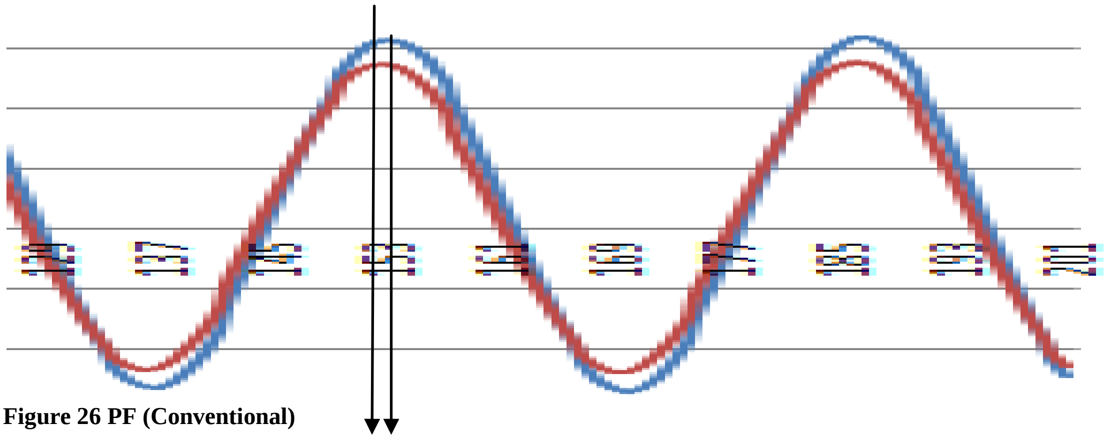


Figure 26 PF (Conventional)

Φ

From the primary side, the output waveform shows that the current and voltage are in phase and it's almost 0^o apart.

PF = cos φ

= $\cos 15^o$

= 0.96

So, the power factor for the Conventional transformer is nearly '1'.

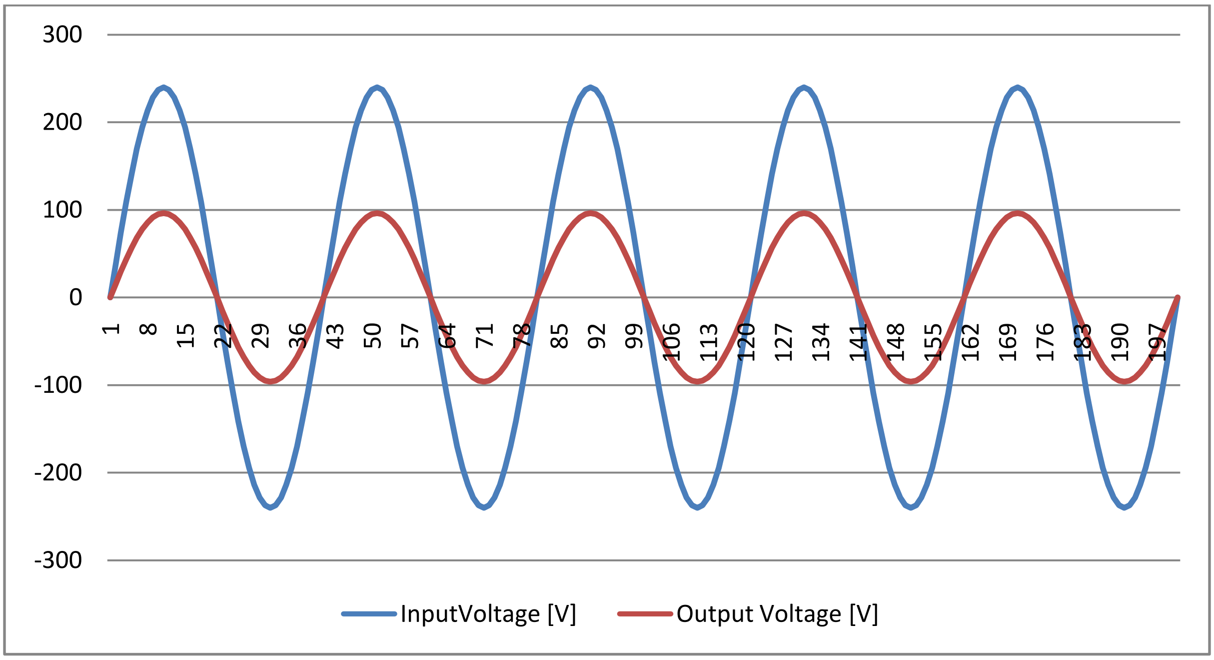


Figure 27 Voltages (Conventional)

The above graph shows the input/output voltages of the Conventional transformer. The input voltage is 240 V while the output voltage is 96 V.

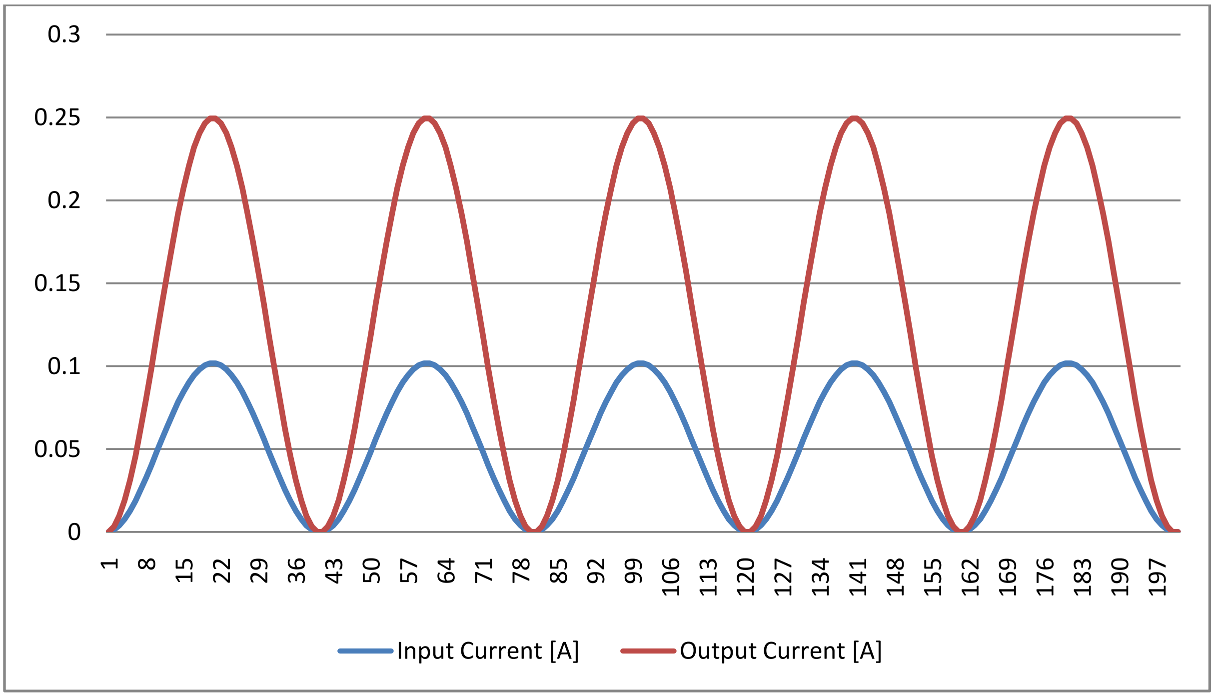


Figure 28 Currents (Conventional)

The above graph shows the input/output currents of the Conventional transformer. The input current is 0.1 A while the output current is 0.25 A.

Input Power

P = 240 x 0.1 x 0.96

= 23.04 W

Output Power

P = 96 x 0.2450 x 0.96

= **22.5792 W**

Efficiency

$$P = {}^{22.5792}/_{23.04} \times 100$$

= **98 %**

Calculations (Simplified)

Table 2 Data Gathered

	CONVENTIONAL	**BI-TOROID**
INPUT VOLTAGE (V)	240	240
INPUT CURRENT (A)	0.1	0. 1
OUTPUT VOLTAGE (V)	96	105
OUTPUT CURRENT (A)	0.245	0. 3829
LOSSES (mW)	560	750

Table above is the simplified version of the parameters obtained via ANSYS software. The input voltages and the input current injected for both the transformers are the same, 240 V and 0.1 A respectively. The output voltage acquired for Conventional transformer is 96 V while the output voltage obtained for Bi-Toroid transformer is 105 V. As for current, Conventional transformer showed output current of 0.245 A while the Bi-Toroid transformer showed 0.3826 A. Both transformers obtained less core losses, 560mW and 750mW respectively.

Table 3 Power & Efficiency

	CONVENTIONAL	**BI-TOROID**
PIN (VpIp.cosϴp)	23.040 W	2.088 W
POUT (VsIs.cosϴs)	22.579 W	3.497 W
EFFICIENCY	**98%**	**168%**

Table above shows the efficiency rate of both Conventional transformer and Bi – Toroid transformer. Efficiency rate for the conventional transformer is 98% while the efficiency rate for the Bi – Toroid transformer is 168%. It proves that Bi – Toroid transformer can achieve efficiency beyond 100%.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

CONCLUSION

As a conclusion, a proper study regarding a Bi Toroid transformer should be carefully conducted because the Bi-Toroid transformer can achieve its 100% or more efficiency if the correct methods followed. The choosing of the materials depending on its permeability and reluctance, the different sizes of the cores, secondary core must be larger than the primary core, as well as the number of turns involved in primary side and two secondary coils are vital in order to achieve the desired objectives.

RECOMMENDATION

Permalloy used as the material for the secondary core. It is chosen because of its high permeability and very low reluctance properties. Since, there are less availability of this materials possibly due to its usage, it is hard to conduct a proper research or studies in this materials in person. So, it is recommended that different materials like this would be made available for students to enhance or develop something new.

Apart from that, in this modern world, technologies are developing to be on par with the living standards that improving from time to time. Portable electronics product plays a vital part in today's generation such as mobile phones, cameras and ipads. Sadly, all these products use a rechargeable battery that means, it will drain out of charges with use. The more you use, the faster it will run out of power[12].

In order to counter this problem, portable power bank discovered. It can charge a device up to four times depending on the size of the battery. But, there is a minus point with portable power bank. It will supply power according to its size that means it has limitations. A 7500mAh power bank can supply up to its maximum capacity which is 7500mAh only and have to be recharged in order to perform again.

A Bi Toroid transformer can be used in developing a power bank. Since its efficiency is more than 100%, it just needed to be charged once. The transformer will supply extra voltage and the extra voltage can be used to automatically recharge the power bank without being recharged manually. It can be used forever without being worried about the capacity of the power bank.

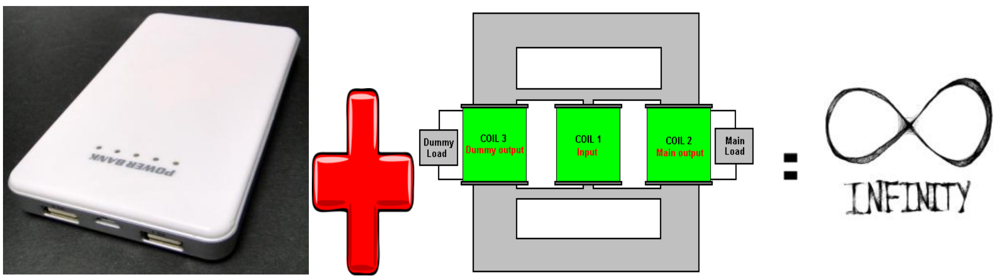


Figure 29 Application of Bi Toroid Transformer

SUGGESTED FUTURE WORKS

The studies and research conducted above are one of the preliminary assessments. The design and modeling in ANSYS is just to prove that the Bi – Toroid transformer can achieve the objective which is to obtain efficiency beyond 100 %. Hence can harvest its own energy. This is not possible without the prototype. So, the prototype must be fabricated to make sure the theoretical results obtained through simulation are no fluke.

CHAPTER 6

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