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Project report

on

Single Phase Shell Type Transformer

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Dedicated to

Our parents

and

Our honorable course teacher

Acknowledgement

We express our gratitude and sincere thanks to our teacher Shadat Hossain, department of Electrical and Electronics Engineering for his gracious efforts and keen pursuit, which has remained as a valuable asset for the successful of our project report. His dynamism and diligent enthusiasm have been highly instrumental in keeping my spirits high. His flawless and forthright suggestions blended with an innate intelligent application have crowned my task with success. We truly appreciate and value his esteemed guidance and encouragement from the beginning to the end of this thesis. We are indebted to him for having helped us shape the problem and providing insights towards the solution.

At last, but not the least we are highly thankful to The Almighty, who has given us the courage and wisdom throughout this whole journey.

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Chapter-01

Abstract

A transformer construction provides a magnetic circuit, known more commonly as the "transformer core", which is designed to provide a path for the magnetic field to flow around. This magnetic path is necessary for the induction of voltage between the two input and output windings. We have made a transformer which contains 220 volts for high voltage side and 24-volts for low voltage side. If we use it as a step-down transformer, then input voltage will be 220 volts and the output voltage will be 24 volts and if we use it as a step-up transformer, then the input voltage will be 24 volts and output voltage will be 220 volts. We have used E-type and I-type cores and we have used copper wires as windings and we used a bobbin which is made of pressboard. Transformer works on the principle of Faraday's law of electromagnetic induction and mutual induction.

Chapter-02

Introduction

2.1 Description

Transformer is a device that is used to transfer electrical energy from one circuit to another circuit without changing the frequency of the electrical energy. The transformer consists of two or more coils of insulated wire, known as windings, which are wound around a magnetic core made of iron or other magnetic materials. The two windings are electrically insulated from each other and are connected by a magnetic field that is created by the current flowing through the windings. When an alternating current (AC) flows through the primary winding, it generates a magnetic field in the core, which in turn induces an alternating current in the secondary winding. The voltage of the secondary winding is determined by the ratio of the number of turns in the primary winding to the number of turns in the secondary winding. Therefore, transformers can be used to increase or decrease the voltage of an AC power supply. Transformers are widely used in electrical power systems to step up the voltage of electricity generated at power plants for transmission over long distances, and then step down the voltage to a lower level for distribution to homes and businesses. They are also used in electronic devices such as power supplies and audio equipment to convert AC voltage to DC voltage or to adjust the voltage level.

2.2 Objectives

- To know about the structure and making of a transformer.
- To know about the practical using of Faraday’s electromagnetic induction law and mutual induction law.
- To know about the working principle of a transformer.
- To demonstrate a small project of a transformer.
- To design a transformer with any kind of value of input and output.

Chapter-03

Background

3.1 Description

Transformers are made on the electromagnetic induction law. Faraday's Law states that a time-varying magnetic field through a loop of wire will induce an electromotive force (EMF) in the wire, which can cause a current to flow. The magnitude of the induced EMF is proportional to the rate of change of the magnetic field, and the direction of the induced current is such that it opposes the change in the magnetic field that produced it. Mathematically, Faraday's Law can be expressed as:

$$EMF = \mathrm{N}\frac{\mathrm{d}\Phi}{dt}$$

A transformer consists of two coils of wire, known as the primary and secondary windings, that are wound around a common magnetic core. When an alternating current (AC) flows through the primary coil, it generates a magnetic field that fluctuates with the frequency of the AC. This changing magnetic field induces an electromotive force (EMF) in the secondary coil, according to Faraday's Law of Electromagnetic Induction. The EMF in the secondary coil causes a current to flow, which can be used to power a load or device.

3.2 Motivation

The purpose of this project is to make a transformer. We want to use the voltage in our electric devices as much we need. Because using of higher voltage in lower voltage devices will be harmful for the devices and if we use lower voltage in higher voltage devices, then the device will not give enough output. To solve this problem, transformers are being used. In another case, when current produced in power plant, it needs to send to the users but the user’s devices always stay far away from the power plant. That’s why we need to send the current from the power plant to users but because of long distance, the resistance of conductor interrupts the current and the voltage which is produced in the plant can’t help to reduce this resistance. To reduce this resistance, we use a step-up transformer which add higher voltage and this voltage helps to send the current to user’s device and users can’t use this higher voltage. Here we use step-down transformer which helps to make the voltage as much the user’s device demands. This is why transformer is an important device in electrical and electronic engineering and that’s why we have made a transformer to know about transformer deeply.

Chapter-04

Literature Review

4.1 The Transformer

We have made a transformer which contains 220 volts for high voltage side and 24 volts for low voltage side. We have used a bobbin which contains length of 5cm and 3.5 cm width. We know the flux density in core 1.2 $Wb\backslash m^2$ or tesla. So, we can find the required quantity to make a transformer.

4.2 Turns for Per Voltage

At first, we have to find the number of turns for per voltage by using E.M.F. equation-

$$E=4.44\ f\ \Phi_m\ N$$

In this case,

- The length and width of the transformer is about respectively 5cm and 3.5 cm. So, the area will be-

$A= (5cm * 3.5cm) = 0.00175\ m^2$

- The flux density of the core, $B_m = 1.2\ Wb/m^2$.
- We know the flux in core,

$\Phi_m = B_m * A= (0.00175\ m^2 * 1.2\ Wb\backslash m^2) = 2.1\ mWb$.

- We know the frequency of the current, f = 50 Hz.

❖ We want to find the number of turns for per voltage.

So, E= 1 volt.

Now we find the number of turns for per volt from the equation of E.M.F.;

$E=4.44\ f\ \Phi_m\ N$

or, $N = E/4.44\ f\ \Phi_m$

or, N = 1v / (4.44 * 50 Hz * 2.1 mWb)

or, N = 2.15 turns needed to produce one volt.

- Voltage for per division is = (1 / 2.15) = 0.465 volt.

4.3 High Voltage Side of The Transformer

We have selected 220 volts for high voltage side.

So, the voltage of the high voltage side, V_{HVS} = 220 volts

Then,

- The number of turns of high voltage side windings,

$$N_{HVS} = (V_{HVS} * \text{turns for per voltage})$$
$$= (220 * 2.15)$$
$$= 473 \text{ turns}$$

We have selected the VA of our transformer is 50 VA and the efficiency of the transformer is 90%.

- The high voltage side current, $I_{HVS} = VA / (90\% \text{ of } V_{HVS})$

$$= 50 \text{ VA} / (90\% \text{ of } 220 \text{ volts})$$
$$= 0.253 \text{ A}$$

4.4 Low Voltage Side of The Transformer

We have selected 24 volts as the voltage of low voltage side.

So, the voltage of the low voltage side, V_{LVS} = 24 volts.

Then,

- The number of turns of low voltage side windings,

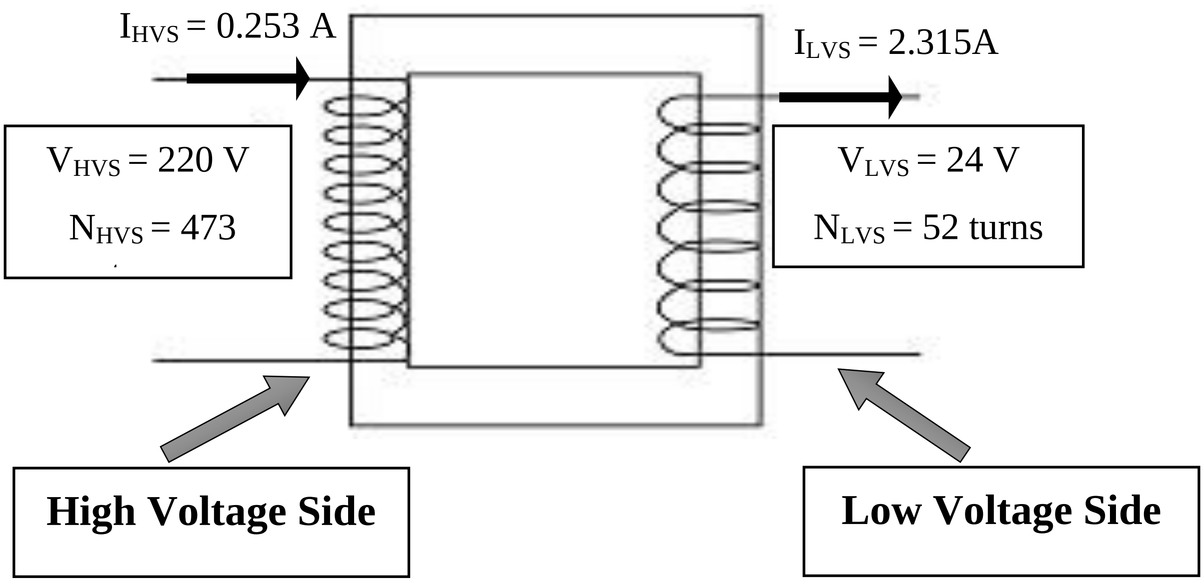
$$N_{LVS} = (V_{LVS} * \text{turns for per voltage})$$
$$= (24 * 2.15)$$
$$= 52 \text{ turns}$$

We have selected the VA of our transformer is 50 VA and the efficiency of the transformer is 90%.

- The low voltage side current, $I_{LVS} = VA / (90\% \text{ of } V_s)$

$$= 50 \text{ VA} / (90\% \text{ of } 24 \text{ volts})$$
$$= 2.315 \text{ A}$$

4.5 The Transformer with It's All Values



Chapter-05

Materials Explanation

5.1 Bobbin:

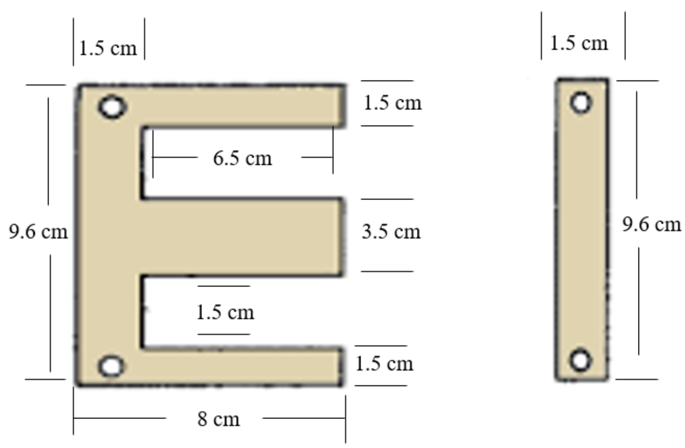
We have made a bobbin from pressboard which contains the length of 5 cm and the width of 3.5 cm.

5.2 Windings:

We have selected copper wire for windings because it's a good conductor. Our transformer requires 2.15 turns for per voltage and we have selected 220 volts for high voltage side and 24 volts for low voltage side. That's why we need 473 turns for high voltage side and we need 48 turns for low voltage side. Now we need to select the gauge of the wire with depending on the amount of current. From the calculation, we know the high voltage side current will be 0.253 A and we have selected 28 number gauge from Standard Wire Gauge (SWG) which can carry 0.344 Ampere current maximum. Again, we know the low voltage side current will be 2.315 Ampere and that's why we have selected 18 number gauge from SWG which can carry 3.6 Amperes maximum. Because we always need to select the wire which can carry current more than the exact value of the current of the circuit. Because if we select the gauge which can carry less current than the exact value of the current, then because of the over flowing of the current, the windings will be burned. That's why we select the gauge which can carry the current which is more than the exact value of the current.

5.3 Cores:

To make the transformer we need cores for magnetic circuit. We have selected silicon steel to make core.



We are making shell type transformer that's why we need E-type and I-type core to make the transformer. The measurement of the cores is given in the picture. The thickness of the core is 0.5 mm and the total thickness of the core is 5cm.

5.4 Other Materials:

We need masking tape, waxed paper, sand paper and heat thermal shrinking paper for the winding.

Chapter-06

Proposed Method

This project is about making of a transformer which contains 220 volts for high voltage side and 24 volts for low voltage side. Transformers were invented on the basis of faraday's electromagnetic Induction Law. Faraday's Law states that a time-varying magnetic field through a loop of wire will induce an electromotive force (EMF) in the wire, which can cause a current to flow. We have used the equation of E.M.F. to measure the turns for per voltage. Then we have measured the total turns for primary and secondary windings. Then we have measured the amount of current of both sides. Measuring the current, we have selected the standard wire gauge for both sides with considering the amount of current. We have used pressboard to make the bobbin and we have used copper wire for both windings and we have used silicon core.

Chapter-07

Methodology

7.1 Description

A transformer is a device that is used to transfer electrical energy from one circuit to another by means of electromagnetic induction. It consists of two or more coils of wire, known as the primary winding and the secondary winding, that are wrapped around a common magnetic core. When an alternating current flows through the primary winding, it creates a magnetic field that induces a voltage in the secondary winding.

7.2 Faraday's Electromagnetic Induction Law

Faraday's Law states that a time-varying magnetic field through a loop of wire will induce an electromotive force (EMF) in the wire, which can cause a current to flow. The magnitude of the induced EMF is proportional to the rate of change of the magnetic field, and the direction of the induced current is such that it opposes the change in the magnetic field that produced it. Mathematically, Faraday's Law can be expressed as:

$$EMF = \mathrm{N}\frac{\mathrm{d}\Phi}{dt}$$

A transformer consists of two coils of wire, known as the primary and secondary windings, that are wound around a common magnetic core. When an alternating current (AC) flows through the primary coil, it generates a magnetic field that fluctuates with the frequency of the AC. This changing magnetic field induces an electromotive force (EMF) in the secondary coil, according to Faraday's Law of Electromagnetic Induction. The EMF in the secondary coil causes a current to flow, which can be used to power a load or device. The ratio of the number of turns in the primary coil to the number of turns in the secondary coil determines the voltage transformation ratio of the transformer. For example, if there are 10 turns in the primary coil and 100 turns in the secondary coil, the voltage in the secondary coil will be 10 times higher than the voltage in the primary coil. Similarly, if there are 100 turns in the primary coil and 10 turns in the secondary coil, the voltage in the secondary coil will be 1/10th of the voltage in the primary coil.

7.3 Flux in Transformer

When current flows in conductor it produces magnetic flux around the conductor. In transformer there are two types of flux start producing. One is mutual flux and another one is leakage magnetic flux and there are two leakage flux produce and one is for primary and another one is for secondary.

7.3.1 Main Flux

The Flux which is produced from the primary current and which completes it's own circuit through the core.

7.3.2 Leakage Flux

The flux which completes it circuit through air and it can't enter into core is called leakage flux.

7.4 Power Losses in Transformer

The total power losses in a transformer can be calculated as the sum of the copper losses, iron losses, stray losses and dielectric losses. Power losses can have significant effects on the performance and efficiency of a transformer. So, it is important to consider them when designing and operating transformers.

7.4.1 Copper Losses ($I^2 R$)

These losses are caused by the resistance of the transformer windings to the flow of current. When current flows through the windings, it encounters resistance, which generates heat. This heat is proportional to the square of the current (I^2) and the resistance (R) of the windings. Copper losses can be reduced by using larger gauge wire or by reducing the current flow through the transformer.

7.4.2 Iron Losses

Iron losses are caused by the alternating magnetic field in the transformer core, which induces eddy currents and hysteresis losses in the core material.

7.4.3 Eddy Current Loss

Eddy currents are generated in the core material due to the changing magnetic field, and these currents produce heat and this heat is the reason of iron losses.

7.4.4 Hysteresis Losses

Hysteresis losses are caused by the energy dissipated when the magnetic domains in the core material are repeatedly magnetized and demagnetized as the alternating current flows through the windings.

Iron losses can be reduced by using high-quality core material with low hysteresis losses and by laminating the core to reduce eddy currents.

7.4.5 Stray Losses

Stray losses occur due to the leakage of magnetic flux from the core. The magnetic field is not perfectly contained within the core, and some of it leaks out into the surrounding materials. This leakage generates eddy currents in the surrounding materials, which generate heat. This heat energy is lost and is known as stray loss.

7.4.6 Dielectric Losses

Dielectric losses occur due to the electric properties of the insulating material used in the transformer. When an electric field is applied to the insulating material, it experiences some resistance and generates heat. This heat energy is lost and is known as dielectric loss.

Chapter-08

Step-up and Step-down Condition

We can connect transformer in two ways:

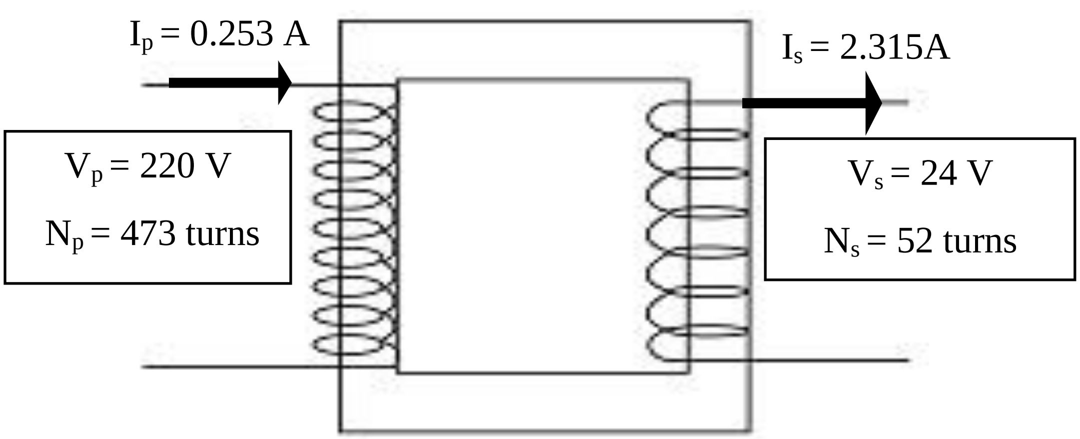
I. <u>As step-down:</u> In this way, the high voltage side will be the primary side of the transformer and the low voltage side will be the secondary side of the transformer.

II. <u>As step up:</u> In this way, the low voltage side will be the primary side of the transformer and the high voltage side will be the secondary side of the transformer.

8.1 The Transformer as Step-down Condition

If we connect our transformer as step down then the transformer will be 220/24.

- The primary voltage V_p will be 220 volts and the secondary volage V_s will be 24 volts.
- The number of primary windings N_p will be 473 turns and the number of turns of the secondary windings N_s will be 52 turns.
- The primary current I_p will be 0.253 A and the secondary current I_s will be 2.315 A.

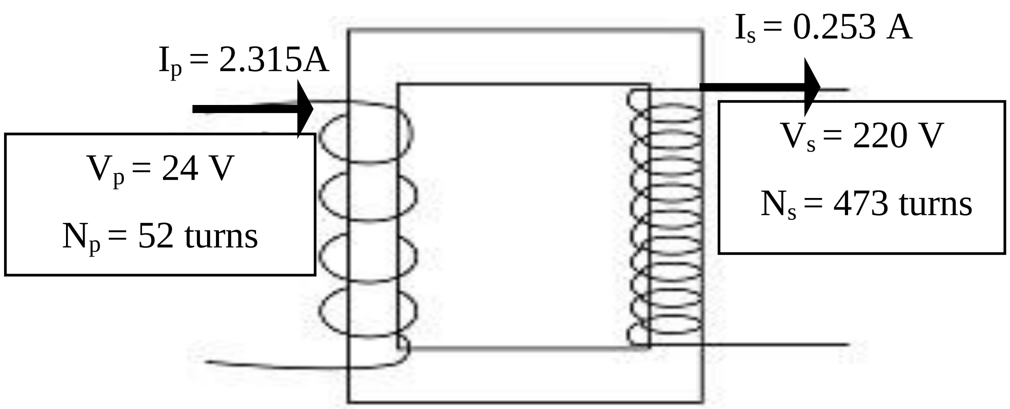


Step-down condition

8.2 The Transformer as Step-up Condition

If we connect our transformer as step up, then the transformer will be 24/220.

- The primary voltage V_p will be 24 volts and the secondary volage V_s will be 220 volts.
- The number of primary windings N_p will be 52 turns and the number of turns of the secondary windings N_s will be 473 turns.
- The primary current I_p will be 2.315 A and the secondary current I_s will be 0.253 A.

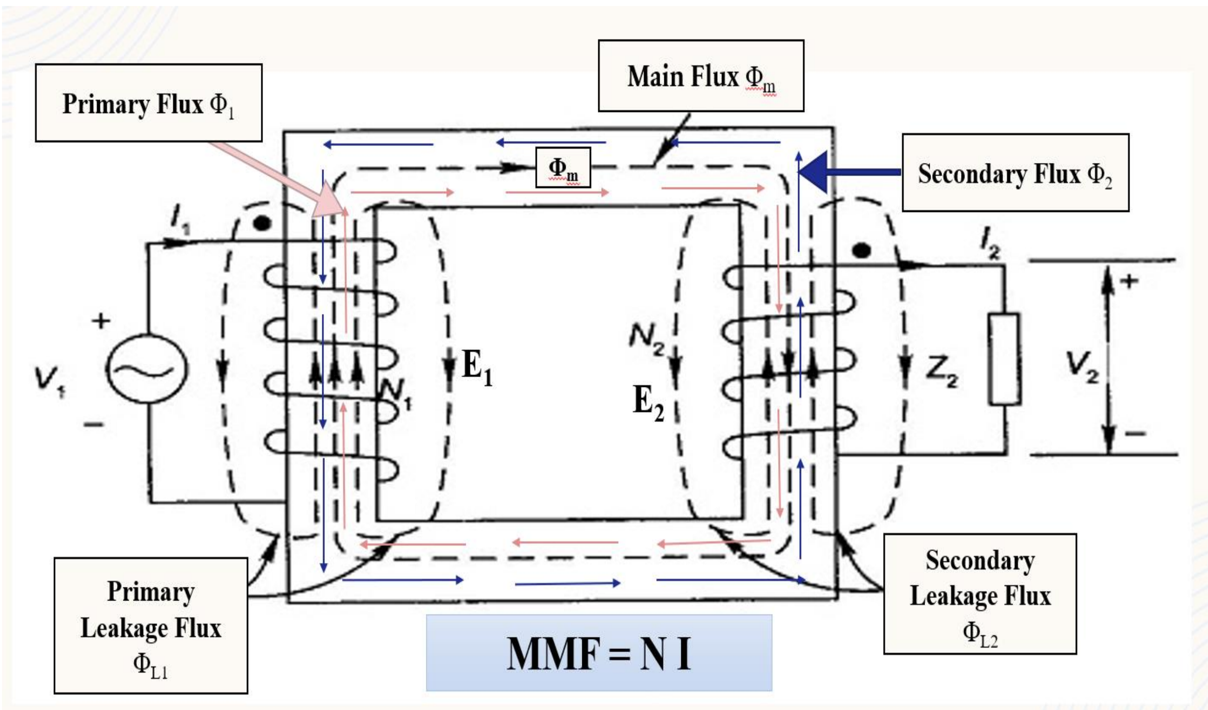


Step-up condition

Chapter-09

Result and Discussion

We have made a shell type single phase transformer which contains 220/24 as step down and 24/220 as step-up. Our transformer contains 2.15 turns to produce one voltage and that's why the High voltage winding is made of 473 turns which can carry 0.253 A current and the low voltage winding is made of 24 turns which can carry 2.315 A current.



When we connect any transformer with the source and if we connect any load at secondary side then the transformer will stay at on load condition. In this case, at primary side will get voltage V_1 and because of this primary voltage, the primary current I_1 will flow at primary side and because of this current and the number of turns a magnetomotive force (MMF = N_1I_1) will be produced and this force will create a magnetic flux which is called main flux (Φ_m) and this magnetic flux will complete it's own circuit through the core and this flux will be deducted by the primary windings and secondary windings. Because of this deduction, two self-induced EMF will be produced which are E_1 and E_2. E_1 is for primary and E_2 is for secondary. When we will connect any load with the secondary, then the secondary side will be closed and because of the E_2 a current (I_2) will flow in the secondary and because of this current and the number of turns, a magnetomotive force (MMF = N_2I_2) will be produced and because of this force a magnetic flux will be produced which is called secondary flux (Φ_2). But the direction of the secondary flux is opposite to the main flux and that's why secondary flux will oppose the main flux and that's why the main flux will be decreased. But if the main flux will be decreased the self-induced EMF of primary E_1 will be decreased. But the E_1 is opposite in direction to the V_1. So, if the E_1 decreases then the V_1 will face a less obstacle to flow and that's why it will flow more current in the primary which called I'_2. Because it is produced with respect to the secondary current I_2. Because of this extra current I'_2 and the number of turns of the primary windings a new magnetomotive force ($MMF = N_1I'_2$) will be produced which will create a new magnetic flux of primary which is called primary flux. This flux is opposite in direction to the secondary flux and the magnitude of this flux is similar to the secondary flux. So, this primary flux will oppose the secondary flux and they both will be vanished. So, only main flux will stay and there is no other flux to oppose it and that's why it's value of the magnitude will be same as the starting moment's value and it will be unchanged. And the transformer will supply the current and voltage as we expect. And if we disconnect the load then there will not flow any current in secondary and that's why there will not be produced any secondary flux and that's why there will not anything to interrupt the main flux. So, the main flux will be same. So, the main flux always stays constant in load condition and in no-load condition. That's why we called transformer as "Constant Flux Machine".

But there also two other fluxes are produced which are called leakage flux [primary leakage flux (Φ_{L1}) and secondary leakage flux (Φ_{L2})]. These are also the part of main flux but they can't enter into the core. They complete their circuit through air. We know main flux is deducted by the primary and secondary. So, when the main flux starts deducted by the primary then, primary leakage flux Φ_{L1} starts to be produced at primary and when main flux is deducted by the secondary then, secondary leakage flux Φ_{L2} starts to be produced at secondary. Because of these leakage fluxes Φ_{L1} and Φ_{L2}, two leakage reactance starts to be produced which are X_1 and X_2.

This is how a single-phase transformer works.

Chapter-10

Social Economy Impact

10.1 Description

The social economy impact of transformers is significant, as they play a crucial role in the production, distribution, and consumption of electrical power.

10.1.1 Improved Access to Electricity

Transformers are critical components of electrical power systems that help convert voltage levels to facilitate efficient transmission. The installation of transformers in underserved areas can improve access to electricity and promote economic development.

10.1.2 Job Creation

The production and maintenance of transformers can create employment opportunities in the manufacturing, transportation, and installation sectors. This can help support local economies and reduce unemployment.

10.1.3 Energy Efficiency

Transformers are designed to minimize energy loss during transmission, which can lead to cost savings for both electricity providers and consumers. This can help lower energy costs for households and businesses, making electricity more affordable and accessible.

10.1.4 Environmental Benefits

The use of transformers can reduce greenhouse gas emissions by improving the efficiency of electrical power systems. This can help promote sustainability and reduce the impact of energy production on the environment.

10.1.5 Increased Reliability

Transformers help maintain the stability and reliability of electrical power systems by regulating voltage levels and preventing power outages. This can improve the quality of life for people by reducing the frequency and duration of power interruptions, particularly in critical areas like hospitals and emergency services.

10.2 Future Plan

We are planning to research on the latest transformer technologies and innovations and develop new designs that can improve efficiency, reduce energy loss or increase power output. This can involve studying the use of new materials, exploring new manufacturing techniques or incorporating smart control systems.

Chapter-11

Conclusion

Transformer is an important device that is used over the whole world for many applications. The use of a transformer to transmit power over large distances have benefitted the world by supplying electricity over remote regions. The key theory that gave way to this important technology was Faraday's law of induction. By applying the law of induction, a transformer was designed to transform electrical energy by changing the number of turns around a core. Over the 100 years, transformers are still evolving to fit many special purposes such as the current transformer and pulse transformer. Despite some of the energy losses, transformers are still one of the highly efficient instruments used for power distribution. Therefore, ranging from small household appliances to large industry a transformer is used to obtain the desired voltage by changing the input current and voltage.

Chapter-12

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