DESIGN AND CONSTRUCTION OF A 200VA, 230/110V, 50Hz, SHELL TYPE TRANSFORMER

BY

EKANEM .E. CHARLES
(2005/21865EE)

A FINAL YEAR PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE AWARD OF THE BACHELOR OF ENGINEERING (B. ENG.) DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING

NOVEMBER 2010.

DESIGN AND CONSTRUCTION OF A 200VA, 230/110V, 50Hz, SHELL TYPE TRANSFORMER

BY

EKANEM .E. CHARLES
(2005/21865EE)

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

NOVEMBER 2010.

DECLARATION

I hereby declare that this work was done by me and that it has never been submitted elsewhere for the purpose of awarding degree to the best of my knowledge. I also hereby relinquish the copyright to the federal university of Technology, Minna.

Ekarem Charles 12/11/10

Name of student   Date

CERTIFICATION

This is to certify that this project work was carried out by Ekanem Edem Charles of Matric No. 2005/21865EE of the department of Electrical and Computer Engineering in the Federal University of Technology Minna.

Prof. O. Usifo 28/10/10

Project Supervisor   Signature and Date

Professor Ola Usifo

....

Project Co-ordinator   Signature and date

Engr A. G. Raji .... (Jan 11, 2011)

Head of Department   Signature and Date

Engr Dr. G. I. Igbalo 1/12/10

External Examiner   Signature and date

DEDICATION

First of all, this work is dedicated to the Almighty God, my beloved parent, Chief/Mrs E.E Ekanem, my siblings and all who have been of great support.

ACKNOWLEDGEMENT

First and foremost, I am thankful to God, the most gracious and merciful for helping me complete this work. It is my belief in him that helped me persevere at times when it seemed impossible to go on.

I am indebted to my father and my mother for teaching me the importance of hard work and perseverance and for instilling in me the confidence that I could succeed at whatever I chose to do.

I wish to express my deep sense of gratitude and indebtedness to **Prof. Oria Usifo**, Department of Electrical/Computer Engineering, F.U.T, Minna for introducing the present topic and for his inspiring guidance, constructive criticism and valuable suggestions throughout the project work.

I am also thankful to all staff members of Department of Electrical/Computer Engineering, F.U.T Minna. I would like to express special thanks to the Engineers at the Department of works F.U.T Minna for providing me with information on my topic which helped me a lot in the completion of this project.

Lastly I would like to show much appreciation to my beloved parent Chief/Mrs E,E Ekanem for their love, support and guidance throughout my course of study and bringing me this far and my siblings.

ABSTRACT

A good transformer construction and design is important in other to achieve efficiency in the transmission and distribution of power. In this project, a 200VA, 230/110V, 50Hz, single phase, shell type transformer was being constructed. The primary and secondary coils were first wound, the laminated core was constructed and the terminals were brought out for circuit connections from the windings.

After the construction, short circuit and open circuit tests were conducted to ensure that the transformer was in a proper working condition.

Table of Contents

CHAPTER ONE

1.0 INTRODUCTION

1.1 TRANSFORMER

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors the transformer's coils. A varying current in the first or primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic field through the secondary winding. This varying magnetic field induces a varying electromotive force (EMF) or "voltage" in the secondary winding. This effect is called mutual induction.

If a load is connected to the secondary, an electric current will flow in the secondary winding and electrical energy will be transferred from the primary circuit through the transformer to the load. In an ideal transformer, the induced voltage in the secondary winding (V_s) is in proportion to the primary voltage (V_p), and is given by the ratio of the number of turns in the secondary (N_s) to the number of turns in the primary (N_p) as follows:

$$V_s / V_p = N_s / N_p$$

By appropriate selection of the ratio of turns, a transformer thus allows an alternating current (AC) voltage to be "stepped up" by making N_s greater than N_p, or "stepped down" by making N_s less than N_p.

In the vast majority of transformers, the windings are coils wound around a ferromagnetic core, air-core transformers being a notable exception.

Transformers range in size from a thumbnail-sized coupling transformer hidden inside a stage microphone to huge units weighing hundreds of tons used to interconnect portions of power grids. All operate with the same basic principles, although the range of designs is wide. While new technologies have eliminated the need for transformers in some electronic circuits, transformers are still found in nearly all electronic devices designed for household ("mains") voltage. Transformers are essential for high voltage power transmission, which makes long distance transmission economically practical.

1.2 AIM AND OBJECTIVES

- To make proper research on transformer
- To design a 200VA shell type transformer with 230 volt at input terminal (primary coil side) and 110 volt at output terminal (the secondary terminal).
- To construct the transformer at a minimal cost using the best available materials.
- To construct the transformer with minimum losses
- To construct the transformer with high efficiency and performance

1.3 SCOPE OF STUDY

- Learn from colleagues
- Learn from technician outside school and within school.
- Research on transformer
- Construct the transformer.

1.4 METHODOLOGY

The design and construction process involves the following

1. Winding of the primary and secondary coils having mutual inductance on the former.
2. Construction of the laminated core in alternate layers in the absence of narrow gaps
3. Bringing out terminals for circuit connections from the windings
4. Transformer tests (Open circuit and short circuit tests)

1.5 APPLICATIONS

Transformers are used in following areas:

1. A major application of transformers is to increase voltage before transmitting electrical energy over long distances through wires. Wires have resistance and so dissipate electrical energy at a rate proportional to the square of the current through the wire. By transforming electrical power to a high-voltage (and therefore low-current) form for transmission and back again afterward, transformers enable economic transmission of power over long distances. Consequently, transformers have shaped the electricity supply industry, permitting generation to be located remotely from points of demand. All but a tiny fraction of the world's electrical power has passed through a series of transformers by the time it reaches the consumer

2. Transformers are also used extensively in electronic products to step down the supply voltage to a level suitable for the low voltage circuits they contain. The transformer also electrically isolates the end user from contact with the supply voltage.
3. Signal and audio transformers are used to couple stages of amplifiers and to match devices such as microphones and record players to the input of amplifiers. Audio transformers allowed telephone circuits to carry on a two-way conversation over a single pair of wires. A balun transformer converts a signal that is referenced to ground to a signal that has balanced voltages to ground, such as between external cables and internal circuits.
4. In impedance matching during amplifier construction.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 AN IDEAL TRANSFORMER

A simple transformer consists essentially of two coils of insulated wire. In most transformers, the wires are wound around an iron-containing structure called the core. One coil, called the primary, is connected to a source of alternating current that produces a constantly varying magnetic field around the coil. The varying magnetic field, in turn, produces an alternating current in the other coil. This coil, called the secondary, is connected to a separate electric circuit.

The ratio of the number of turns in the primary coil to the number of turns in the secondary coil which is the turns ratio, determines the ratio of the voltages in the two coils. For example, if there is one turn in the primary and ten turns in the secondary coil, the voltage in the secondary coil will be 10 times that in the primary. Such a transformer is called a step-up transformer. If there are ten turns in the primary coil and one turn in the secondary the voltage in the secondary will be one-tenth that in the primary. This kind of transformer is called a step-down transformer. The ratio of the electric current strength, or amperage, in the two coils is in inverse proportion to the ratio of the voltages; thus the electrical power (voltage multiplied by amperage) is the same in both coils.

The impedance (resistance to the flow of an alternating current) of the primary coil depends on the impedance of the secondary circuit and the turns ratio. With the proper turns ratio, the transformer can, in effect, match the impedances of the two circuits. Matched impedances are important in stereo systems and other electronic systems because they permit the maximum amount of electric power to be delivered from one component to another [1].

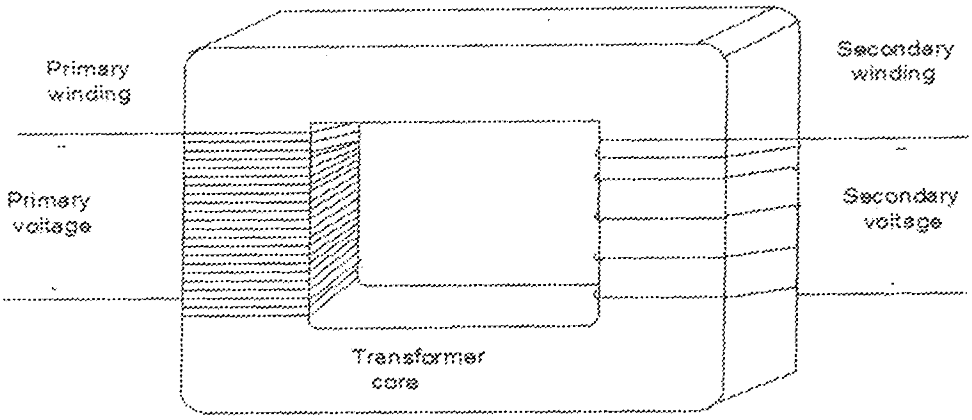

Fig2.1 schematic diagram of an ideal transformer

2.2 HISTORY

The phenomenon of electromagnetic induction was discovered independently by Michael Faraday and Joseph Henry in 1831. However, Faraday was the first to publish the results of his experiments and thus received credit for the discovery. The relationship between electromotive force (EMF) or "voltage" and magnetic flux was formalized in an equation now referred to as "Faraday's law of induction". The magnitude of the EMF in volts is the absolute value of the rate of change of magnetic flux (Φ_B) in weber with time. Faraday's experiments included winding a pair of coils around an iron ring, thus creating the first toroidal closed-core transformer [2].

2.2.1 INDUCTION COILS

The first type of transformer to see wide use was the induction coil, invented by Rev. Nicholas Callan of Maynooth College, Ireland in 1836. He was one of the first researchers to realize that the more turns the secondary winding has in relation to the primary winding, the larger is the increase in EMF. Induction coils evolved from scientists' and inventors' efforts to get higher voltages from batteries. Since batteries produce direct current (DC) rather than alternating current (AC), induction coils relied upon vibrating electrical contacts that regularly interrupted the current in the primary to create the flux changes necessary for induction. Between the 1830s and the 1870s, efforts to build better induction coils, mostly by trial and error, slowly revealed the basic principles of transformers.

In 1876, Russian engineer Pavel Yablochkov invented a lighting system based on a set of induction coils where the primary windings were connected to a source of alternating current and the secondary windings could be connected to several "electric candles" (arc lamps) of his own design. The coils Yablochkov employed functioned essentially as transformers.

Induction coils with open magnetic circuits are inefficient for transfer of power to loads. Until about 1880, the paradigm for AC power transmission from a high voltage supply to a low voltage load was a series circuit. Open-core transformers with a ratio near 1:1 were connected with their primaries in series to allow use of a high voltage for transmission while presenting a low voltage to the lamps. The inherent flaw in this method was that turning off a single lamp affected the voltage supplied to all others on the same circuit. Many adjustable transformer designs were introduced to compensate for this problematic characteristic of the series circuit, including those employing methods of adjusting the core or bypassing the magnetic flux around part of a coil.

Between 1884 and 1885, Ganz Company engineers Károly Zipernowsky, Ottó Bláthy and Miksa Déri had determined that open-core devices were impracticable, as they were incapable of reliably regulating voltage. In their joint patent application for the "Z.B.D." transformers, they described the design of two with no poles: the "closed-core" and the "shell-core" transformers. In the closed-core type, the primary and secondary windings were wound around a closed iron ring; in the shell type, the windings were passed through the iron core. In both designs, the magnetic flux linking the primary and secondary windings traveled almost entirely within the iron core, with no intentional path through air. When employed in electric distribution systems, this revolutionary design concept would finally make it technically and economically feasible to provide electric power for lighting in homes, businesses and public spaces. Bláthy had suggested the use of closed-cores, Zipernowsky the use of shunt connections, and Déri had performed the experiments. Bláthy also discovered the transformer formula, $V_s/V_p = N_s/N_p$,[citation needed] and electrical and electronic systems the world over continue to rely on the principles of the original Z.B.D. transformers. The inventors also popularized the word "transformer" to describe a device for altering the EMF of an electric current, although the term had already been in use by 1882. In 1886, the Ganz Company installed the world's first power station that used AC generators to power a parallel-connected common electrical network, the steam-powered Rome-Cerchi power plant [2].

2.3 CLASSIFICATION OF TRANSFORMERS

Transformers can be classified in many different ways; an incomplete list is:

- By power capacity: from a fraction of a volt-ampere (VA) to over a thousand MVA;
- By frequency range: power-, audio-, or radio frequency;
- By voltage class: from a few volts to hundreds of kilovolts;
- By cooling type: air-cooled, oil-filled, fan-cooled, or water-cooled;
- By application: such as power supply, impedance matching, output voltage and current stabilizer, or circuit isolation;
- By purpose: distribution, rectifier, arc furnace, amplifier output, etc.;
- By winding turns ratio: step-up, step-down, isolating with equal or near-equal ratio, variable, and multiple windings.

2.4 TYPES OF TRANSFORMER CONSTRUCTION

There are two general types of transformers

1. Core type transformer
2. Shell type transformer

These two differ by the manner in which the windings are wound around the magnetic core.

The magnetic core is a stack of thin silicon-steel laminations about 0.35 mm thick for 50 Hz transformer. In order to reduce the eddy current losses, these laminations are insulated from one another by thin layers of varnish. In order to reduce the core losses, transformers have their magnetic core made from cold-rolled grain-oriented sheet steel (C.R.G.O). This material, when magnetized in the rolling direction, has low core loss and high permeability [2].

2.4.1 CORE TYPE TRANSFORMER

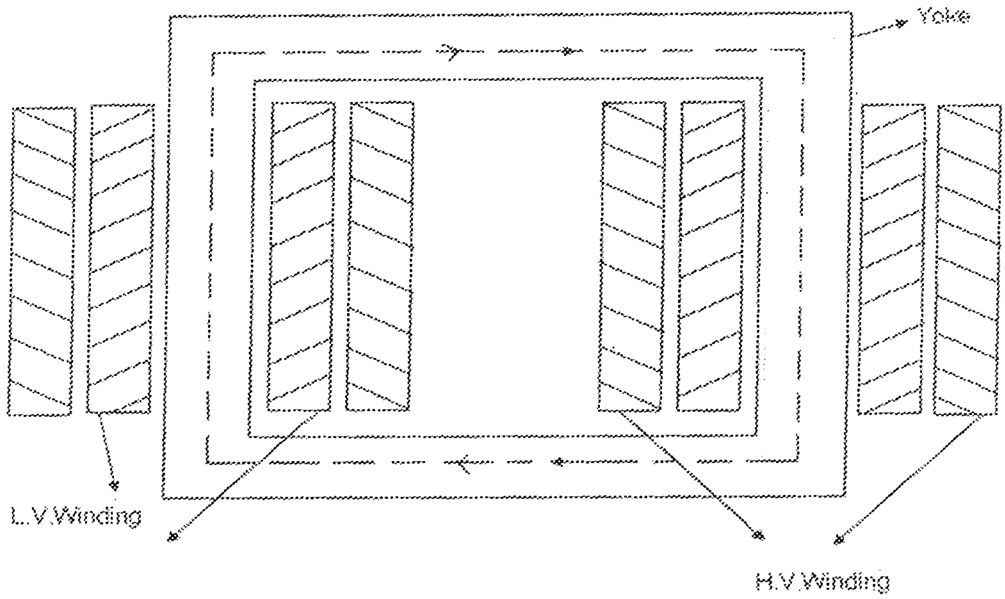

fig 2.2 A core-type Transformer

In the core-type, the windings surround a considerable part of steel core as shown in fig (a). The core type transformers require more conductor material and less iron when compared to shell-type. The vertical portions of the core are usually called limbs or legs and the top and bottom portions are called the yoke. For single phase transformers, core-type has two legged core. In order to reduce leakage flux, half of the L.V. winding is placed over one leg and other half over other leg. For H.V. winding also, half of the winding is placed over one leg and the other half over the other leg. L.V. winding is placed adjacent to the steel core and H.V. winding outside, in order to minimize the amount of insulation required.

2.4.2 SHELL TYPE TRANSFORMER

In the core-type, the steel core surrounds a considerable part of the windings as shown in figure below. Shell-type transformer has three legged core. The L.V. and H.V. windings are wound on the central limb. In order to reduce leakage flux, the windings are interleaved or sandwiched. The shell type transformers require more iron and less conductor material when compared to core-type.

There are two types of windings employed for transformers.

1. concentric coils.
2. Interleaved coils.

The concentric coils are used for core-type transformers while the interleaved coils for shell-type.

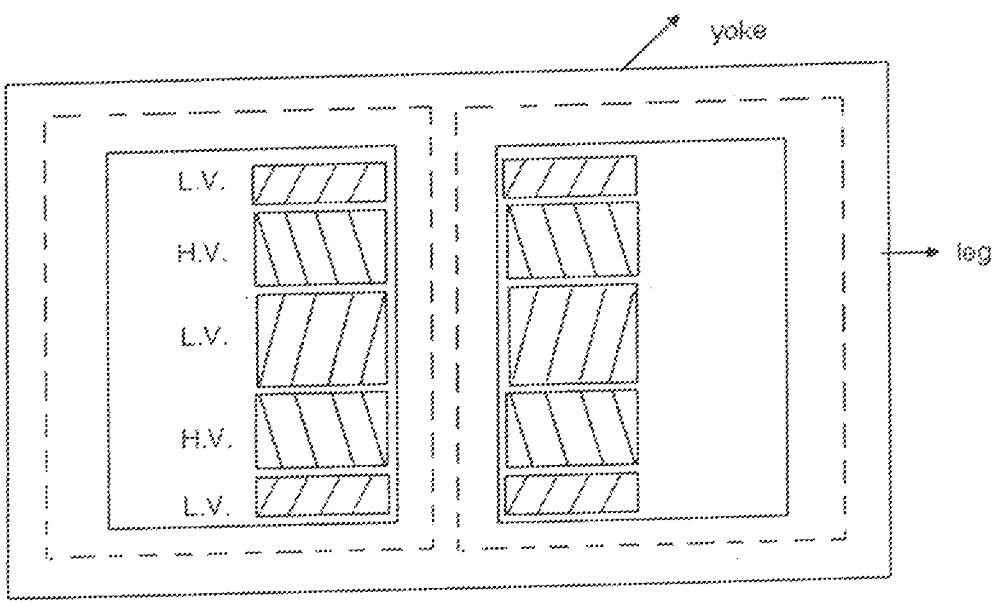

Fig2.3 A Shell type transformer

2.5 TYPES OF TRANSFORMERS

Polyphase transformers

For three-phase supplies, a bank of three individual single-phase transformers can be used, or all three phases can be incorporated as a single three-phase transformer. In this case, the magnetic circuits are connected together, the core thus containing a three-phase flow of flux. A number of winding configurations are possible, giving rise to different attributes and phase shifts. One particular polyphase configuration is the zigzag transformer, used for grounding and in the suppression of harmonic currents.

Audio transformers

Audio transformers are those specifically designed for use in audio circuits. They can be used to block radio frequency interference or the DC component of an audio signal, to split or combine audio signals, or to provide impedance matching between high and low impedance circuits, such as between a high impedance tube (valve) amplifier output and a low impedance loudspeaker, or between a high impedance instrument output and the low impedance input of a mixing console.

Instrument transformers

Instrument transformers are used for measuring voltage and current in electrical power systems, and for power system protection and control. Where a voltage or current is too large to be conveniently used by an instrument, it can be scaled down to a standardized, low value.

Instrument transformers isolate measurement, protection and control circuitry from the high currents or voltages present on the circuits being measured or controlled.

Current transformers

is a transformer designed to provide a current in its secondary coil proportional to the current flowing in its primary coil.

Voltage transformers (VTs):

Also referred to as "potential transformers" (PTs), are designed to have an accurately known transformation ratio in both magnitude and phase, over a range of measuring circuit impedances. A voltage transformer is intended to present a negligible load to the supply being measured. The low secondary voltage allows protective relay equipment and measuring instruments to be operated at a lower voltage [2].

2.6 PRINCIPLE OF OPERATION

In its most basic form a transformer consists of a primary coil winding, secondary winding and a core that supports the coils or windings. The primary winding is connected to a 50 hertz ac voltage source. The magnetic field (flux) builds around the primary winding. The magnetic field around the primary winding cuts the secondary winding and induces an alternating voltage into the winding. This voltage causes alternating current to flow through the load. The voltage may be stepped up or down depending on the design of the primary and secondary windings.

The simplified description above neglects several practical factors, in particular the primary current required to establish a magnetic field in the core, and the contribution to the field due to current in the secondary circuit.

Models of an ideal transformer typically assume a core of negligible reluctance with two windings of zero resistance. When a voltage is applied to the primary winding, a small current flows, driving flux around the magnetic circuit of the core. The current required to create the flux is termed the magnetizing current; since the ideal core has been assumed to have near-zero reluctance, the magnetizing current is negligible, although still required to create the magnetic field. The changing magnetic field induces an electromotive force (EMF) across each winding. Since the ideal windings have no impedance, they have no associated voltage drop, and so the voltages V_P and V_S measured at the terminals of the transformer, are equal to the corresponding EMFs. The primary EMF, acting as it does in opposition to the primary voltage, is sometimes termed the "back EMF". This is due to Lenz's law which states that the induction of EMF would always be such that it will oppose development of any such change in magnetic field [4].

2.7 CONSTRUCTIONAL FEATURES

This transformer design and construction is done based on the following features:

1. Winding
2. Cores
3. Terminal
4. Coolant

2.7.1 WINDING

The conducting material(copper wire) used for the windings depends upon the application, but in all cases the individual turns must be electrically insulated from each other to ensure that the current travels throughout every turn. For small power and signal transformers, in which currents are low and the potential difference between adjacent turns is small.

If the secondary coil is attached to a load that allows current to flow, electrical power is transmitted from the primary circuit to the secondary circuit. Ideally, the transformer is perfectly efficient; all the incoming energy is transformed from the primary circuit to the magnetic field and into the secondary circuit. If this condition is met, the incoming electric power must equal the outgoing power:

$P_{incoming} = I_p V_p = P_{outgoing} = I_s V_s$

giving the ideal transformer equation

$V_s / V_p = N_s / N_p = I_p / I_s$

This copper wire is wound around the coil casing in one direction up to the desired number of turns and the starting ends are brought out and also the finishing end, which finally form the input terminal. After this as been achieved the winding is insulated before the secondary winding begins. The secondary winding then start by bringing out the starting end and wound for the desired number of turns and finishing end is brought out to form the output terminal [3].

2.7.2 CORE

Laminated steel core

Transformers for use at power or audio frequencies typically have cores made of high permeability silicon steel. The steel has a permeability many times that of free space, and the core thus serves to greatly reduce the magnetizing current, and confine the flux to a path which closely couples the windings. Early transformer developers soon realized that cores constructed from solid iron resulted in prohibitive eddy-current losses, and their designs mitigated this effect with cores consisting of bundles of insulated iron wires. Later designs constructed the core by stacking layers of thin steel laminations, a principle that has remained in use. Each lamination is insulated from its neighbors by a thin non-conducting layer of insulation. The universal transformer equation indicates a minimum cross-sectional area for the core to avoid saturation.

The effect of laminations is to confine eddy currents to highly elliptical paths that enclose little flux, and so reduce their magnitude. Thinner laminations reduce losses, but are more laborious and expensive to construct. Thin laminations are generally used on high frequency transformers, with some types of very thin steel laminations able to operate up to 10 kHz.

One common design of laminated core is made from interleaved stacks of E-shaped steel sheets capped with I-shaped pieces, leading to its name of "E-I transformer". Such a design tends to exhibit more losses, but is very economical to manufacture. The cut-core or C-core type is made by winding a steel strip around a rectangular form and then bonding the layers together. It is then cut in two, forming two C shapes, and the core assembled by binding the two C halves togetherwith a steel strap.

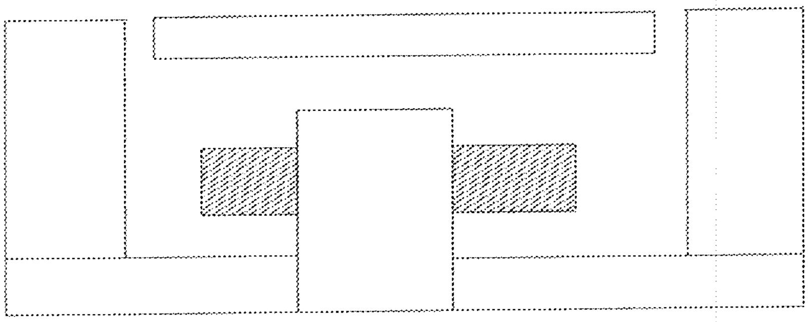

Fig 2.4 an assembly of cores

2.7.3 COOLANT

This type of transformer discuss in this project is been cooled by natural air. But transformers generally have different way of cooling according to applications and constructions. High temperatures will damage the winding insulation. Small transformers do not generate significant heat and are cooled by air circulation and radiation of heat. Power transformers rated up to several hundred kVA can be adequately cooled by natural convective air-cooling, sometimes assisted by fans. In larger transformers, part of the design problem is removal of heat. Some power transformers are immersed in transformer oil that both cools and insulates the windings. The oil is a highly refined mineral oil that remains stable at transformer operating temperature. Indoor liquid-filled transformers are required by building regulations in many jurisdictions to use a non-flammable liquid, or to be located in fire-resistant rooms. Air-cooled dry transformers are preferred for indoor applications even at capacity ratings where oil-cooled construction would be more economical, because their cost is offset by the reduced building construction cost.

2.7.4 TERMINALS

Very small transformers like the on constructed in this project will have wire leads connected directly to the ends of the coils, and brought out to the base of the unit for circuit connections. Larger transformers may have heavy bolted terminals, bus bars or high-voltage insulated bushings made of polymers or porcelain. A large bushing can be a complex structure since it must provide careful control of the electric field gradient without letting the transformer leak oil.

2.8 TRANSFORMER LOSSES

Transformer losses reduces the efficiency of its performance. Transformer losses are divided into losses in the windings, termed copper loss, and those in the magnetic circuit, termed iron loss. Losses in the transformer arise from.

Winding resistance

Current flowing through the windings causes resistive heating of the conductors. At higher frequencies, skin effect and proximity effect create additional winding resistance and losses.

Hysteresis losses

Each time the magnetic field is reversed, a small amount of energy is lost due to hysteresis within the core. For a given core material, the loss is proportional to the frequency, and is a function of the peak flux density to which it is subjected.

Eddy currents

Ferromagnetic materials are also good conductors, and a core made from such a material also constitutes a single short-circuited turn throughout its entire length. Eddy currents therefore circulate within the core in a plane normal to the flux, and are responsible for resistive heating of the core material. The eddy current loss is a complex function of the square of supply frequency and inverse square of the material thickness. Eddy current losses can be reduced by making the core of a stack of plates electrically insulated from each other, rather than a solid block; all transformers operating at low frequencies use laminated or similar cores [2].

Magnetostriction

Magnetic flux in a ferromagnetic material, such as the core, causes it to physically expand and contract slightly with each cycle of the magnetic field, an effect known as magnetostriction. This produces the buzzing sound commonly associated with transformers, and can cause losses due to frictional heating.

Mechanical losses

In addition to magnetostriction, the alternating magnetic field causes fluctuating forces between the primary and secondary windings. These incite vibrations within nearby metalwork, adding to the buzzing noise, and consuming a small amount of power.

Stray losses

Leakage inductance is by itself largely lossless, since energy supplied to its magnetic fields is returned to the supply with the next half-cycle. However, any leakage flux that intercepts nearby conductive materials such as the transformer's support structure will give rise to eddy currents and be converted to heat. There are also radiative losses due to the oscillating magnetic field, but these are usually small [2].

CHAPTER THREE

3.0 DESIGN AND CONSTRUCTION

The block diagram consists of the input power supply unit, the input indicator unit, the main circuit, the output unit and the output indicator unit.

The block diagram is shown below

BLOCK DIAGRAM

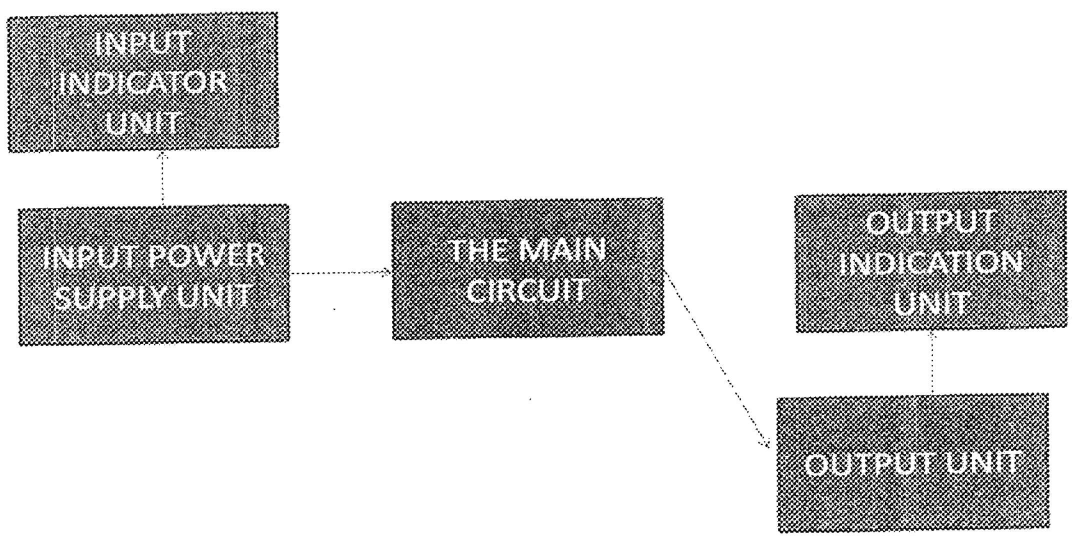

fig 3.1 block diagram of 200VA transformer of 230/110V

3.1 DESIGN PARAMETERS

Single phase transformer

Rated power: An = 200VA

Primary voltage: V_{1n} = 230V

Secondary voltage: V_{2n} = 110V

Frequency: f = 50Hz

Design analysis

The design analysis involves a 200VA with 230V as input voltage stepping it down to 110V.

Q = rated KVA= 0.2

Factor K for single phase shell transformer = 1.1

Thickness of core sheet = $0.5mm$

Density of steel = $7.55 \times 10^3 \ kg / m^3$

Efficiency= 0.85

Designing of the core

$$E_t = \frac{V}{N} = K\sqrt{Q}$$

E_t = voltage per turn

Q = rated KVA

3.2 CHOICE OF THE TRADE TYPE LAMINATION

Based on the calculated values, we have to choose the type of lamination that is available in the market.

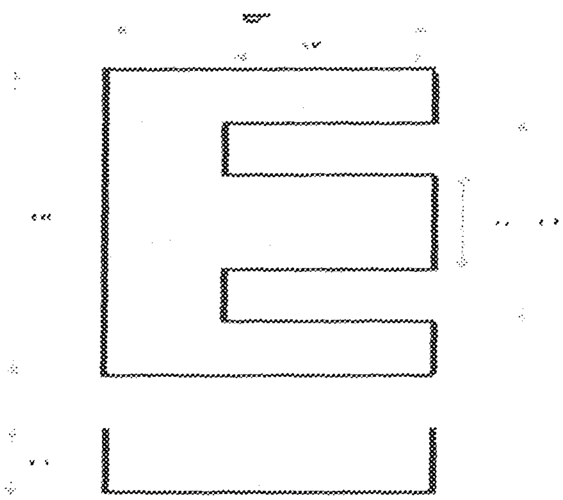

Fig 3.2 lamination dimensions

- Total with = a = 96mm
- Column width = f = 31mm
- Width d = 64mm
- Column height = e = 48mm
- Side height = b = 64mm
- Lamination thickness = 0.5mm

3.3 CALCULATION OF THE WINDING PARAMETERS

We fix a preliminary value for the efficiency $\eta = 0.85$

Calculation of the currents in the windings

$$I_1 = \frac{A_n}{V_{in} x \eta} = \frac{200}{230x0.85} = 1.02A$$

$$I_2 = \frac{A_n}{V_{2n} x \eta} = \frac{200}{110x0.85} = 2.14A$$

We fix a value of the current density in conductors

$J = 3.5\ A/mm^2$

Calculation of the conductor sections and of the relative diameters

$$S_{cu} = \frac{I_n}{J}$$

Copper size for primary side

$$S_{cu1} = \frac{1.02}{3.5} = 0.29mm^2$$

Copper size of secondary side

$$S_{cu2} = \frac{2.14}{3.5} = 0.61mm^2$$

Copper diameter for primary winding

$$d_{c1} = \sqrt{\frac{4xS_{cu1}}{\pi}} = \sqrt{\frac{4x0.29}{\pi}} = 0.608mm$$

Copper diameter for secondary winding

$$d_{c2} = \sqrt{\frac{4xS_{cu2}}{\pi}} = \sqrt{\frac{4x0.61}{\pi}} = 0.88mm$$

3.4 DETERMINATION OF THE PRIMARY AND SECONDARY TURN NUMBERS

Voltage per turn:

And Q is a value in hundreds chosen depending on the power rating of this transformer (200VA)

So for this design are:

K= 0.44 and Q= 2

From e = volt per turn = K x $\sqrt{Q}$

= 1.1 x $\sqrt{0.2}$

= 0.4919 v/turn

Primary number of turns:

Since 0.4919 volts exit in 1 turn, then

230 /0.4919 = 470 turns of primary winding

Secondary number turns:

From $E_2/E_1 = N_2/N_1$

Where E_2 is secondary voltage

E_1 is primary voltage

N_2 is secondary number of turns

N_1 is primary number of turns

$N_2 = (110 \times 470)/230$

$= 225$ turns

Calculation of the total number of lamination of the transformer:

c = thickness of the laminated core

s = thickness of one of the laminations

$$n = \frac{c}{s} = \frac{30}{0.5} = 60$$

3.5 CALCULATION OF FUSE RATING

Output power (P_s) = 200VA

Output Voltage (V_s) = 110V

Maximum Output current = P_s / V_s

= 200 / 110

= 1.82A

Therefore a 2A fuse is suitable for the output supply.

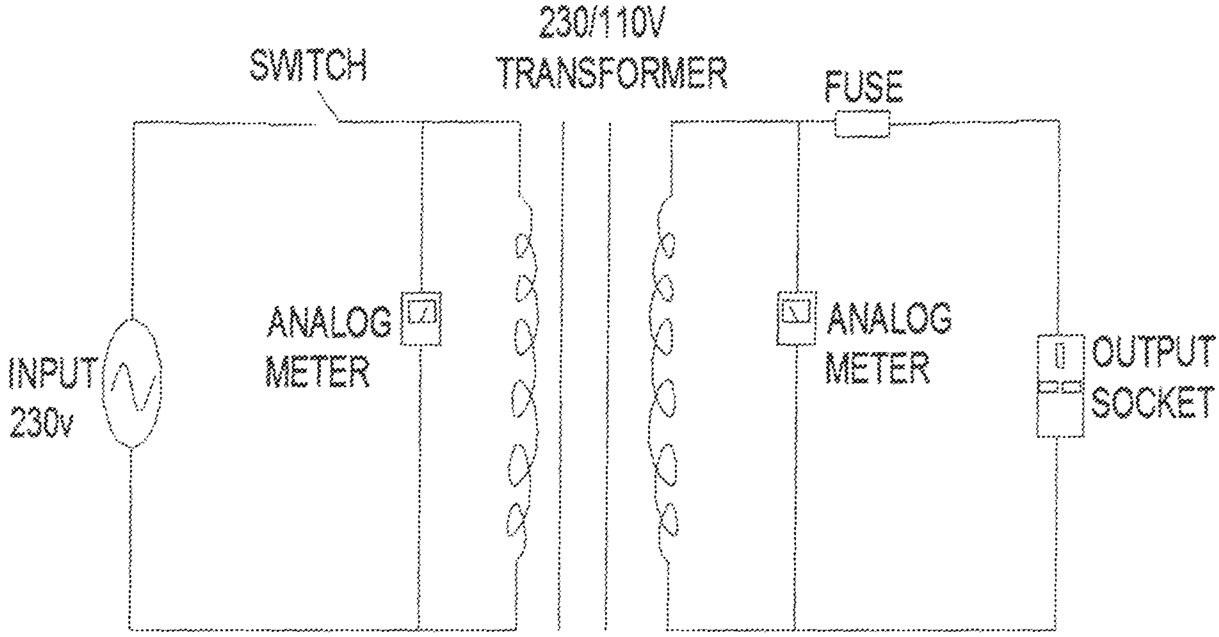

Fig 3.3 circuit diagram

CHAPTER FOUR

4.0 TEST AND RESULT

4.1 FINAL MANUFACTURING DATA

4.1.1 LAMINATION DIMENTIONS (RESULT)

Table 4.1 lamination dimensions

DIMENTION	ABREVIATION	VALVE(mm)
Total width	A	96
Column width	F	31
Width	D	64
Column height	E	48
Side height	B	61
Lamination number	N	60

4.2 WINDING RESULTS

Table 4.2 winding results

DIMENSIONS	ABRIVIATION	VALUES (mm)
Primary conductor diameter	d_{c1}	0.562 (guage 24)
Secondary conductor diameter	d_{c2}	0.8132 (guage 21)
Number of primary turns	N_1	470 turns

Number of secondary turns	N_2	225 turns
Primary winding dimension	D1	3
Secondary winding dimension	D2	5

Results of other parameters

Current density = $J = 3.5\ A/mm^2$

Table 4.5 results of other parameters

Parameter	**Value**
Magnetic core thickness	30mm
Number of lamination	60
Primary current	1.02A
Secondary current	2.14A

Result of fuse rating is 2A

4.3 PERFORMANCE TEST

The test carried out on a transformer helps to ascertain its performance and efficiency when operated properly. The following tests were carried to determine the constant of the equivalent circuit of a transformer which is then used to calculate its performance;

i. Short circuit test

ii. Continuity test

iii. Open circuit test

4.3.1 SHORT CIRCUIT TEST

The short circuit test of a transformer provides the copper losses of the transformer windings when it supports the rated load. Voltage, current, and the input real power measurements enable us to compute equivalent resistance and reactance of windings referred to the primary side when the secondary side of the transformer is short circuited.

In this test one side of the winding is short circuited across its terminal and a reduced voltage i.e low voltage is applied to the other terminal. The reduced voltage has a specific value of rated current to flow in the short circuited terminal. The choice of the terminal to be short-circuited is usually determined by the measuring equipment available for the test.

4.3.2 CONTINIUITY TEST

This test is carried to ensure that no open circuit in the windings during and after construction. This is very important not only during the constructional stage, but also after the construction. This test was carried out by making use of multi-meter to confirm that there is no short circuit along the part of the winding.

4.3.3 OPEN CIRCUIT TEST

This test shows the characteristics behavior of the power equipment to load variation. When the secondary output is loaded, a drop in voltage is observed due to the internal resistance and leakage reactance of the winding at any load condition, the net flux passing through the core is approximately the same at the no load.

4.4 RESULTS OF TEST

These are the results from the tests carried out on the transformer.

Table 4.2 Short Circuit Test

Input voltage(v)	Wattage (watts)	Current(A)
5	2	0.45
10	6	0.69
15	12	0.97

Table 4.3 Open Circuit Test

Primary voltage(V)	108
Secondary voltage (v)	76
Wattage (W)	8
Current (A)	0.06

4.5 BILL OF QUANTITY AND COST ESTIMATE

A bill of quantity was carried out to ascertain the actual cost of materials used in the construction of this transformer.

Table 4.4 bill of quantity and cost estimate

S/NO	DESCRIPTION OF ITEM	QUANTITY	UNIT/RATE (Naira)	TOTAL AMOUNT(Naira)
1	Varnish		50	50
2 3.	Plastic former Copper wire	1 6	50 100	50 600
4	Laminations	7	5	350
5	Analog meter	2	600	1200
6	Casing	1	1900	1150
7.	Fuse	1	50	50
	Total cost			3500

CHAPTER FIVE

5.1 SIGNIFICANCE

The significance of this design and construction includes:

1. To increase voltage before transmitting electrical energy over long distances through wires..
2. To couple stages of amplifiers and to match devices such as microphones and record players to the input of amplifiers.
3. It is used in impedance matching during amplifier construction.
4. Transformers are also used extensively in electronic products to step down the supply voltage to a level suitable for the low voltage circuits they contain.

5.2 LIMITATIONS

The major limitations to the execution of this project are as follows

1. Non uniformity of windings in the primary and secondary sections of the transformer
2. It was difficult to achieve proper stacking of the core elements due to some irregularities in their shape which resulted to air gap

5.3 CONCLUSION

The 200VA, transforner, 230/110V, 50Hz shell type was successfully constructed and various transformer tests were carried out to ensure that it was in proper working condition.

5.4 SUGGESTION FOR FURTHER WORK.

The following suggestions are made for further work in respect of this project.

I. A fuse can be incorporated in the primary side to prevent excess voltage from causing damage to the primary windings .

II. To make the windings more uniform, they can be machine wound for accuracy.

III. Each layer should be coated with varnish to give coil a better mechanical protection and thus gives the transformer a longer life span.

REFERENCES

[1] Oria Usifo "Electrical Networks Design and installation in buildings" 2nd Edition, Fredorus LTD Publishing Division, Benin City Nigeria 2004 pp. 20,126-129.

[2] Wikipedia. "Transformer." http://en.wikipedia.org/wiki/Transformers.

[3] Philips, Catalogue 2004-2005 pp. 2-68.

[4] The New Encyclopaedia Britanica Micropaedia Ready Reference, vol 4, 15th Edition, 1998.

[5] B.L Theraja and A.K Theraja, Electrical Technology, 1999 pp. 919-1050.

[6] Power Transformers by DJ Allan pp. 25-39.

[7] Electrical Power System and Transmission network by Eng. Sayeed Saad. pp. 48-62