COMPUTER AIDED DESIGN OF THREE PHASE TRANSFORMERS

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DECLARATION

I, Shadrack Abiola Adefemi declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the federal university of technology, Minna.

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DEDICATION

This project is dedicated to Almighty God and to the memory of my late uncle Mr. Oladipupo Shadrack and late cousin Lady Sandra Shadrack.

ACKNOWLEDGEMENT

ABSTRACT

This work presents a computer aided design of a three phase core type transformer. The software design platform for the design is java. A java program will utilize the graphic user interface (GUI) variation in the electrical parameter of the transformer under design, in response to variation in the input voltage alteration. The GUI is designed in a way as to allow users enter the reference parameters and the system response automatically calculated and printed out. This would allow the design to predict output of the transformer at varying input parameters.

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CHAPTER ONE

GENERAL INTRODUCTION

1.0   INTRODUCTION

Generating stations generate bulk power at high voltage and transmitted at appreciably high voltage to reduce the amount of conducting material and increase transmission efficiency. However, power distribution is carried out at low voltages and such transformation of a.c from one voltage level to another is carried out by a device known as a transformer. Transformers play a major role in transmission and distribution of power and are also used in rectifiers, starters, furnaces, welding e.t.c.

A transformer is a static piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It is a device that can raise or lower the voltage level in one circuit, but with a corresponding increase or decrease in current [7].

Computer aided design of a three phase transformer is a method by which three phase transformers are designed with the use of programming software packages such as c++, virtual basic, java, matlab to mention but a few. The other method of designing transformers is the manual method, which offers a more laborious process (and comparatively old too) due to its long mathematical calculations which are very error prone, time consuming and less effective when compared to the computer aided method. The physical basis of a transformer is mutual induction between two circuits linked by a common magnetic flux as governed by faraday's law of electromagnetic induction. It has a magnetic core over which two sets of windings, termed as primary and secondary (high voltage and low voltage) are suitably placed. [7]. When one of the windings is connected

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to ac supply, an emf is induced in the other winding, which is proportional to the number of turns. The first coil in which electric energy is feed from the ac supply mains is called the primary winding and the other from which energy is drawn out, is called the secondary winding.
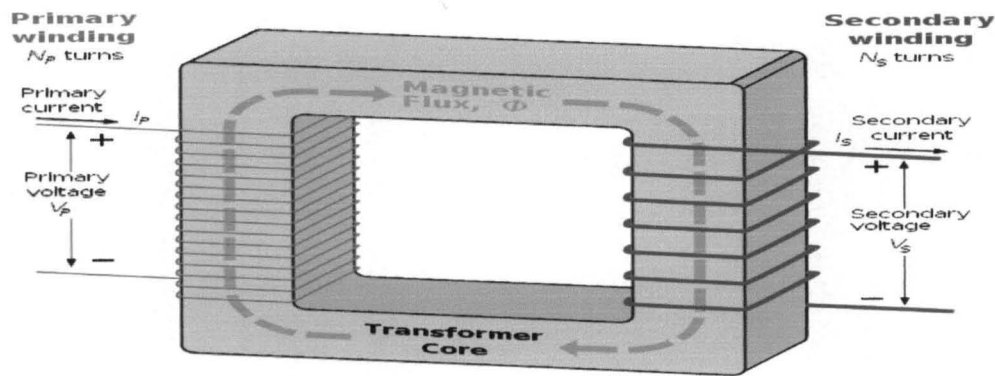
Fig. 1.1 A simple transformer circuit

1.2 AIM AND OBJECTIVES OF PROJECT

The aim of this project is to show a more efficient, cost effective, easy and fast method of designing a three phase transformer by the use of computer aided/ software development method.

- Manual method presents too lengthy process of arriving at the final design.
- Design calculations are very error prone in the manual method when compared to the computer aided method.
- The products final performance is slightly better than the manual method.

1.3 METHODOLOGY

Computer aided design of three phase transformer is a method by which three phase transformers are designed with the use of computer programming softwares such as c++, virtual basic, matlab, java to mention a few. Several predetermined and assumed inputs (specifications), including all necessary mathematical formulae are fed into the

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program which is then run to give certain other values with which actual construction of the transformer can be done.

In this project however, system design would be based wholly on simulation in a java environment. The work presents program that utilizes a graphical user interface to calculate electrical variation in the parameters of the transformer. It is designed in such a way as to allow the user to enter the parameters under investigation. The choice for java stem from its inherent mathematical orientation and easy GUI manipulation. Other software packages like virtual basic and c++ would have been used. However, none of these programs could handle the complex mathematical processes that may be encountered in this engineering analysis.

The main reason for GUI is because it makes things simple for the end users of the program. If GUI were not used, people would have to work from the command line interface, which can be extremely difficult and frustrating. Java 6.1 (netbeans) is used to write this program. The other method of designing transformers is the manual or mathematical method, which offers a more laborious process (and comparatively old too) due to its long mathematical mental calculations which are very error prone and less effective when compared to the computer aided design method.

1.4 SCOPE OF WORK

The scope of this project covers the design of a three phase power distribution (step-down) core type transformer using java programming software. A three phase transformer can be made from three separate single phase transformers or a single connection of three cores to make up one, with the former phasing out because it occupies more floor space, weighs more and costs about 15% more. The basic principle of the three phase transformer is as shown on fig. 1.2 where only the primary windings are

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shown to be interconnected in star and put across a three phase supply. The three cores are 120 degrees apart with their empty legs in contact with each other. The center leg formed by these three, carries the flux produced by the three phase currents I_R, I_Y and I_B, which their sum equals zero.

The main draw back in a 3-phase transformer is that if any one phase becomes disabled, then the transformer has to be removed from service for repairs. However, in the case of a 3 phase bank of single phase transformers, if one transformer goes bad, the system can still be readily replaced by a single spare.

A three-phase transformer is made of three sets of primary and secondary windings, each set wound around one leg of an iron core assembly. Essentially it looks like three single-phase transformers sharing a joined core: Those sets of primary and secondary windings will be connected in either Δ or Y configurations to form a complete unit.
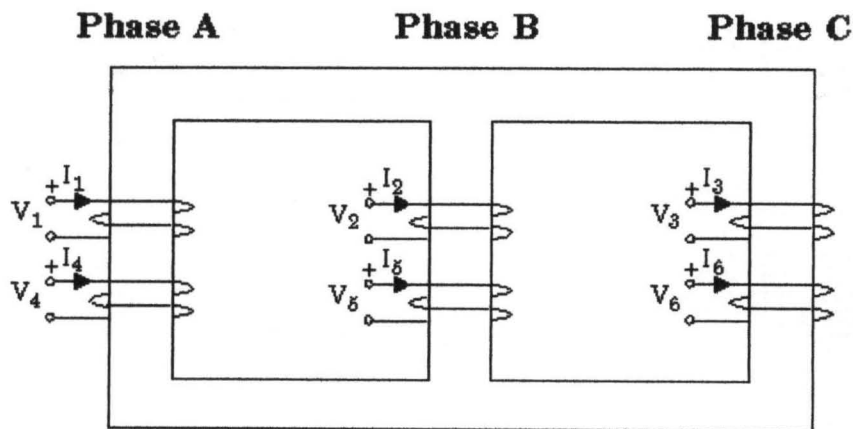
Fig 1.2 Simplified circuit diagram of 3- phase transformer using a three-limb core, two windings per phase

1.5   THREE PHASE TRANSFORMER CONNECTION

Various methods exists as connections for transforming three phase voltages to higher or lower three phase voltages for handling considerable amounts of power.

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The commonest are;

- Star-star connection
- Delta-delta connection
- Star-delta connection
- Delta-star connection

CHAPTER TWO

LITERATURE REVIEW

2.0 THEORETICAL BACKGROUND

A transformer consists of two coils mutually linked together by inductance and a laminated steel core. This core which serves as the magnetic circuit can be constructed in different ways with respect to the windings. Transformers are of two constructional types differentiated from one another by the way the primary and secondary coils are wound on the laminated core. The two types are; the core type and the shell type.

LAMINATED CORES

ESNP0049

L.V. WINDING
H.V. WINDING

CORE TYPE   SHELL TYPE
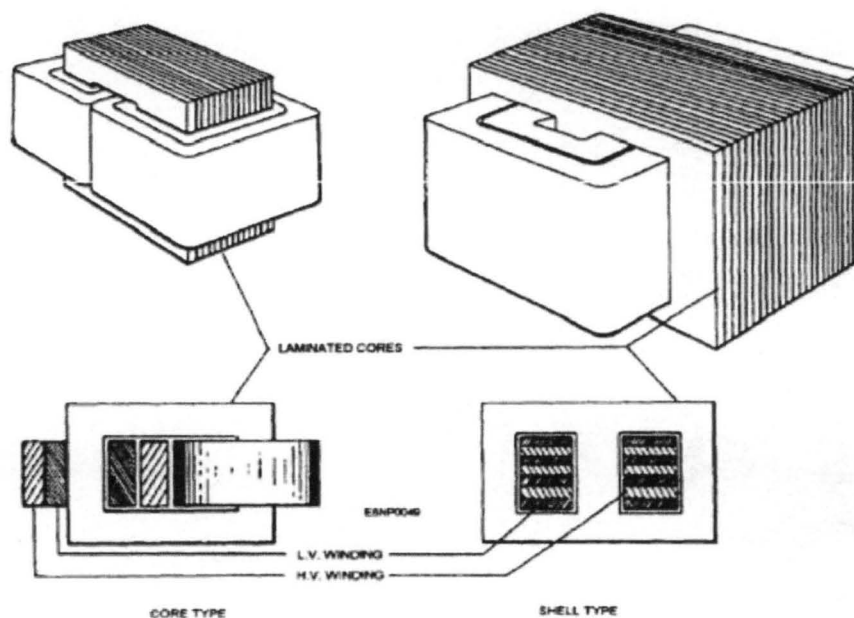
Fig. 2.1 simple section through the types of transformers

The basic difference between these two transformers is:

1) Core type has longer mean length of iron core & shorter mean length of coil turn.

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2) Shell type has shorter mean length of iron core & longer mean length of coil turn.

3) In core type transformers the LV (low voltage) coil is wound next to the core & HV (high voltage) coil. Both windings are wound on the same core after the insulation layer. In Shell type transformers the LV & HV windings are sandwiched between each other.

4) The core type transformer, the windings cover a considerable part of the core while in the shell type, the core surrounds a considerable part of the winding.

2.1   TRANSFORMER CORES

The magnetic core is built up of laminations of high grade silicon sheet steel, which are insulated from each other by a special coating of vanish. The usual thicknesses of laminations are 0.18mm, 0.23mm, 0.27mm, 0.30mm and 0.35mm.

Due to varying flux in the core, there exist two losses: the eddy current and hysteresis losses. In determining the hysteresis loss in the core, the silicon content of the iron and the nature of annealing are very important factors of consideration. Silicon makes the iron brittle, thus making it very brittle. [2]

2.2   WINDINGS AND INSULATION

Transformer windings are made of copper or aluminum wire and/ or strip. For higher current baring capacity, conductors of large cross sectional area are required. Rectangular conductors are generally used for l.v windings and also for h.v windings of large transformers. If the cross-section of the conductor is more than $50mm^2$, it must be stranded to reduce eddy current losses within the conductors, several parallel strips of wire are preferred rather than use one large strip of wire which gives rise to unequal reactance components of the conductor, which can be reduced by transposing the conductor. Conductors of circular section are mainly used windings for h.v windings of

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comparatively small transformers. In order to reduce losses, the diameter of single circular conductor should not exceed 4mm and for a rectangular section, its diameter should not exceed 3.5mm.

Whichever construction method used, between the coil segments, spacers are provided to allow for dissipation of heat from the windings either by ventilation or a liquid cooling medium. Double cotton, single cotton, with an under layer of enamel or synthetic enamel or double paper covering are most commonly used for winding wires. Stripes are generally covered with layers of paper known as EGIP (electrical grade insulating paper). The following are properties of EGIP;

- Flexibility

- Easy to use

- Higher insulation with lesser thickness

- Reasonable heat resistance

- low chloride impurities

Transformer oil is manufactured by refining of petroleum feedstock. Transformer oil feed stock (TOFS) is obtained as first distillate under vacuum distillation of crude oil, after taking out the light cuts like gasoline, kerosene and diesel at atmospheric pressure. Characteristics of TOFS are much dependent on the crude oil origin i.e., hydrocarbon composition [2].

PROPERTIES OF TRANSFORMER OIL

1. Electrical strength

2. Specific resistance

3. Di-electric dissipation factor

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2.3   TRANSFORMER LOSSES

Two components of transformer losses exist;

(a) No-load loss; resulting from the steel materials used for magnetizing core laminations. It also includes eddy current loss and hysteresis loss, dielectric loss and copper loss due to no load current.

(b) Resistive components used for building the primary and secondary windings, are the load losses.

```
                        ┌─────────────────┐
                        │   TOTAL LOSS    │
                        └─────────────────┘
                 ┌────────────┴──────────────┐
        ┌────────────────┐          ┌────────────────┐
        │  NO-LOAD LOSS  │          │   LOAD LOSS    │
        └────────────────┘          └────────────────┘
```

| D-IELECTRIC LOSS AS A FUNCTION OF | COPPER LOSS DUE TO NO-LOAD CURRENT | HYSTERESIS AND EDDY CURRENT LOSS | LOSS DUE TO EDDY CURRENT SET UP IN THE CONDUCTOR | STRAY LOSS IN TANK AND CORE CLAMP | IR LOSS FOR BOTH PRIMARY AND SECONDARY WINDINGS |
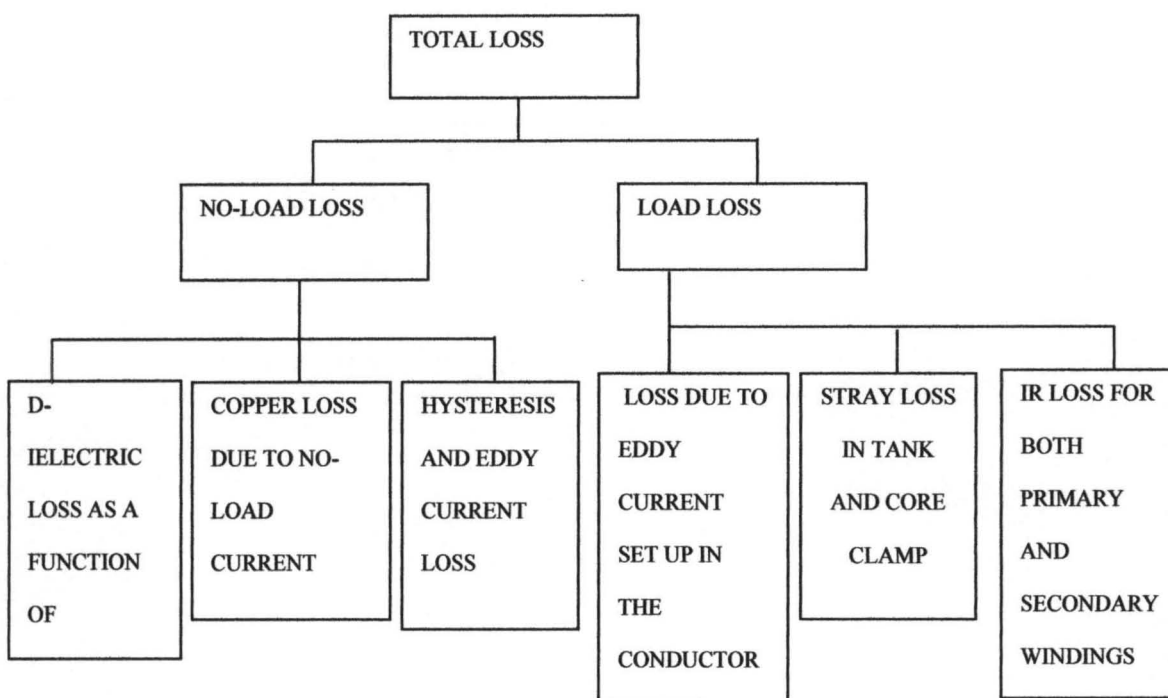
Fig. 2.2 Block diagram showing the various components of transformer losses.

Transformers are generally in tightly fitted sheet metal tanks filled with special insulating oil. This oil has dual functions of providing cooling by circulation and providing b extra insulation not available when transformer is left in the open. Depending on the sizes of transformer, radiators and/or fans are provided for additional cooling. Transformers are further classified according to cooling viz;

a.   Oil filled self cooled

b. Oil filled water cooled

c. Air blast type

2.4   THREE PHASE TRANSFORMERS

Since consumers of electricity require power in large scale, the generated bulk power is usually three phase at generated at 16Kv to about 20Kv. Transmission is then at voltages of about 132Kv to 330 at consumer distribution stage, the voltage is then reduced to 400volts. Three phase transformers are used throughout industry to change values of three phase voltage and current. Since three phase power is the most common way in which power is produced, transmitted, and used, an understanding of how three phase transformer connections are made is essential. In this section it will discuss different types of three phase transformers connections, and present examples of how values of voltage and current for these connections are computed [3].

2.5   THREE PHASE TRANSFORMER CONSTRUCTION

A three phase transformer is constructed by winding three single phase transformers on a single core. These transformers are put into an enclosure which is then filled with dielectric oil. The dielectric oil performs several functions. Since it is a dielectric, a nonconductor of electricity, it provides electrical insulation between the windings and the case. It is also used to help provide cooling and to prevent the formation of moisture, which can deteriorate the winding insulation. All these stages of transmission and distribution, makes use of three phase transformers.

The construction of three phase transformers is basically based on two modes of design:

- Mathematical or manual method

- Computer aided design method

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Both methods are based on the formula for induced emf. The formula connects induced voltage, flux and number of turns. Practically, the magnetic flux and are predetermined, whilst frequency is already known. So the volts per turn are derived from the below formulae (1). By faraday's laws of electro-magnetic induction, a statically mutually induced emf set up in the primary coil.

i.e. $\quad E_P = -\frac{T_P d\Phi}{d_t}$............ (1)

Similarly, statically mutual induced emf, set up in the secondary coil is given by

$$E_S = -\frac{T_s d\Phi}{d_t}$$............ (2)

Where T_p and T_s are the number of turns in the primary and secondary coils respectively and is the common flux linking both windings.

2.6   COMPUTER AIDED DESIGN

Computer aided design a (CAD) is the use of computers to assist in design processes. Specialized software packages exist for various types of design: architectural, engineering, electronic, roadways and woven fabrics to mention but a few. CAD programs usually allow a structure to be built up from several re-useable 3-dimensional components and the components (such as gears) may be able to move in relation to one another. It is normally possible to generate engineering drawings to allow the final the final design to be constructed. Computer aided design is also the modeling of physical systems on computer, allowing both interactive and automatic analysis of design variants and the expression of designs in a form suitable for manufacturing.

2.7   HISTORY OF COMPUTER AIDED DESIGN.

Computer aided design software would not be complete without the mention of mathematician Euclid of Alexandria, who in his 350 BC treatise on mathematics "*The*

Elements" expounded many of the postulates and axioms that are the foundations of the Euclidian geometry upon which today's CAD software are built.

It was more than 2,300 years after Euclid that the first true CAD software, a very innovative system (although of course primitive compared to today's CAD software) called "sketch pad" was developed by Ivan Sutherland as part on his PhD thesis at MIT in the early 1960s. Sketch pad was especially innovative CAD software because the designer interacted with the computer graphically by using a light pen to draw on the computer's monitor. It is a tribute to Ivan Sutherland's ingenuity that even in 2004 when operations which took hours on 1960s computer technology can be executed in less than a millionth of a second and touch sensitive TFT combination display/input devices are readily available. Sketch pad was the world's first CAD software but the first commercial computer aided machining (CAM) software system, a numerical control programming tool named PRONTO, had already been developed by Dr. Patrick j. Hanratty who is most often referred to as "the father of CAD CAM."[5].

CHAPTER THREE

DESIGN AND IMPLEMENTATION

The main aim of designing a transformer is to obtain the information below concerning its circuits, by using the given specifications and selecting the proper and appropriate materials for each part for construction.

This information are;

- The main dimensions of the magnetic circuit i.e. core, yoke and window.

- Design details of electrical circuit i.e. low voltage and high voltage windings

- Performance characteristics i.e. iron losses, copper losses, hysteresis loss, eddy current loss.

- Cooling system required.

Various design equations will be initiated on our program of choice (java), upon which actual design is based. These equations are;

1. Output equation

2. Equations for emf and emf per turn

3.1 DESIGN EQUATIONS

Computer aided design of three phase transformer and indeed any transformer, must first begin with mathematical calculations and formulae which serves as inputs to our design software. For initiating the design of the magnetic circuit (main dimensions of core, yoke and window), the design equations follow thus;

3.2 EMF EQUATION

Emf induced in the primary winding due to the change of main flux is given by;

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$$e_1 = -\frac{T_1 d\Phi}{d_t} \dots\dots\dots\dots\dots\dots \text{(3.0)}$$

Also
$$= \Phi_m \cos wt \dots\dots\dots\dots\dots \text{(3.1)}$$

Thus
$$e_1 = -\frac{T_1 d}{dt}(\Phi_m \cos wt) = T_1 w \Phi_m \sin wt$$

Hence,
$$E_1 max = T_1 w \Phi_m$$

Or r.m.s value of induced emf,
$$E_1 = \frac{T_1(2\pi f)\Phi_m}{\sqrt{2}}$$

Or
$$E_1 = 4.44 f T_1 \Phi_m m \dots\dots\dots\dots\dots \text{(3.2)}$$

Also
$$E_1 = 4.44 f T_1 B_m A_i \ volts \dots\dots\dots\dots \text{(3.3)}$$

Similarly, induced emf in secondary winding
$$E_2 = 4.44 f T_2 B_m A_i \ volts \dots \text{(3.4)}$$

Hence emf per turn
$$E_t = 4.44 f B_m A_i \dots\dots\dots\dots \text{(3.5)}$$

Where, T_1 = number of turns in of the primary winding.

T_2 = number of turns in secondary winding.

Φ_m = maximum value of main flux, Weber

B_m = maximum value of flux density in core, tesla

f = Frequency of supply, H_z

A_i = net cross sectional area core, in m^2

Emf per turn

$$Q = E \ I \times 10^{-3}$$

$$= 4.44 f_m T \times I \times 10^{-3}$$

$$\frac{\Phi_m}{IT} = r = \text{constant}$$

$$Q = 4.44 f \frac{(\Phi_m)^2}{r} \times 10^{-3}$$

$$\Phi_m = \sqrt{\frac{((r)\times 10^{-3})}{4.44f}} \cdot \sqrt{Q}$$

Emf per turn
$$E_t = 4.44 f_m \dots\dots\dots\dots \text{(3.6)}$$

$$= 4.44 f \sqrt{\frac{(r)\times 10^{-3}}{4.44f}} \dots\dots\dots \text{(3.7)}$$

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The ratio of the cross sectional area of the core and the copper area of the windings will be constant for a particular transformer i.e.

$$\frac{A_i}{A_c} = constant \dots\dots\dots\dots \text{(3.8)}$$

Cross sectional area of core,

$$A_i = \frac{\Phi_m}{B_m}$$

Copper area of the windings,

$$A_c = \frac{\Phi_m}{IT} \times \frac{\delta}{B_m}$$

Thus

$$\frac{A_i}{A_c} = \frac{\Phi_m}{IT} = constant \dots\dots \text{(3.9)}$$

As current density, and flux density, B_m is nearly constant,

Substituting for ϕm from eqn. 3.91 into eqn. 3.8

KVA per phase

$$= E_t \times \left(\frac{\Phi_m}{r}\right) \times 10^{-3}$$

Or

$$\phi m = \frac{(KVA \text{ per phase}) \times r}{E_t} \times 10^3 \dots \text{(3.10)}$$

Substituting for ϕm from eqn. 3.10 into eqn. 3.6

$$E_t = 4.44f \times \frac{(KVA \text{ per phase}) \times r}{E_t} \times 10^3 \dots\dots \text{(3.11)}$$

Or

$$E^2{}_t = (4.44fr \times 10^3) \times KVA/phase$$

Hence emf per turn

$$E_t = k\sqrt{\left(\frac{KVA}{3}\right)} \dots\dots\dots\dots \text{(3.12)}$$

Where

$$k = \sqrt{4.44Fr} \times 10^3 \dots\dots\dots \text{(3.13)}$$

$$k = constant$$

Therefore,

$$k = 0.45 \text{ for } 3phase \text{ core type.}$$

There exists a standard table of values for the factor k as shown on table 3.1. Factor K basically depends on the ratio of the cross sectional area of the core to the copper section of the windings and will be different for core and shell types of transformers. The K factor for distribution transformers is less than that of power transformers.

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Table 3.1 values of factor, K

TYPE OF TRANSFORMER	K FACTOR
THREE PHASE CORE TYPE (POWER)	0.6-0.65
THREE PHASE CORE TYPE (DISTRIBUTION)	0.45-0.50

3.3   WINDOW SPACE FACTOR (K_w).

This is defined as the ratio of total area occupied by the copper material of the windings in the window, to the window area. Window space in a transformer is occupied by the following materials [3].

1. Conducting material of the windings (copper).

2. Insulating material over the winding conductor

3. Insulating material (between the core and l.v windings, between the l.v and h.v

4. The insulating oil.

The window space factor (k_w) = $\dfrac{12}{30+kv}$ (1000KVA)

$\dfrac{8}{30+kv}$ (10KVA)

$\dfrac{10}{30+kv}$ (50 - 200KVA)

3.4   OUTPUT EQUATION FOR THREE PHASE TRANSFORMER

Using the equations for emf per turn, cross sectional area of the core can be calculated based on the given specifications. But an additional equation is needed to know the dimensions of the frame (core and window) with the given specification viz the output.

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window space = AW
core to core distance = D
diamerer of winding=d
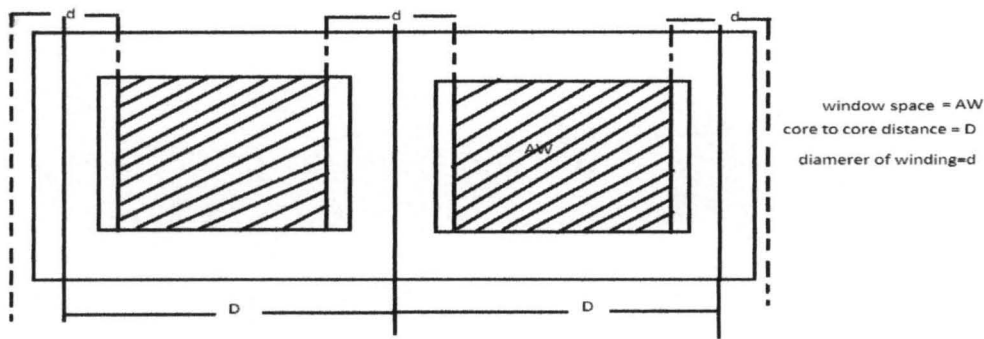
Fig 3.0 3-phase core type transformer structure

Output of a 3 phase transformer, $\qquad$ $\boldsymbol{Q = 3\,V_{ph}\,I_{ph}}$

$$= 3 \times 4.44 f B_m A_i T_{\text{ph}} \times I_{\text{ph}} \ldots\ldots\ldots\ldots\ldots\ldots (3.14)$$

For a three phase transformer in which the window space is occupied by both the windings of two phases, $\qquad$ $Q = 3\,E_{ph}\,I_{ph} \times 10^{-3}$

$$A_w K_w = 2(a_1 T_1 + a_2 T_2) = 4 I_{\text{ph}} T_{\text{ph}}/\delta \ldots\ldots (3.15)$$

$$K_w A_w = \frac{4 I_{ph} T_{ph}}{\delta}$$

Substituting for $I_{ph} T_{ph}$ from eqn. 3.95 in to 3.94, $\quad Q = 3\left(4.44 f_m I_{ph}\right). I_{ph} \times 10^{-3}$

$$\boldsymbol{Q = 3.\,33 f B_m \delta\, K_w A_w A_i \times 10^{-3}}\ \text{KVA} \ldots\ldots (3.16)$$

The above equations hold for both the core type and shell type transformers,

Where;

Q $\qquad$ Output (KVA)

δ $\qquad$ Average value of current density, A/mm^2

k_w $\qquad$ Window space factor

A_w $\qquad$ Net window area

A_i $\qquad$ Net cross-sectional area of the iron core

B_m $\qquad$ Maximum flux density

f Frequency in hertz

3.5   CURRENT DENSITY δ

The highest temperature rise in the transformer is seen to occur in the high voltage windings and as such, the current density to be used for copper windings, is limited due to local heating. A high current density is therefore chosen to allow for reduced cross sectional area thereby reducing cost of design since cost of copper is reduced. However, with high current density, there is a high resistance of the windings, resulting to increased copper losses leading to reduced efficiency and increasing the temperature of the transformer. The current density of the h.v windings should be taken higher compared to that of the l.v windings because cooling conditions are better in the h.v winding and the high internal temperature of the winding may cause deterioration of the insulation of the windings. The following values may be used as average current density for l.v and h.v winding.

Small Distribution transformers oil immersed self cooled ------------1.5 to 2.6 A/mm^2

Medium and large transformers, oil immersed and air blast ---------- 2.4 to 3.4 A/ mm^2

Large transformers, oil immersed   --------------- 5.4 to 6.3 A/ mm^2

3.6   SPECIFIC MAGNETIC LOADING (FLUX DENSITY B_m)

The choice of flux density in the core is basically dependent on the steel grades used for the core and yoke. Normally, the two types of steel used in construction of the core and yoke are hot rolled silicon steel and cold rolled grain oriented steel.

TYPICAL VALUES OF B_m

Using hot rolled silicon steel; Power transformers-----------------------1.1 to 1.4Tesla

Distribution transformers-----------------1.2 to 1.3Tesla

Using cold rolled grain oriented silicon steel, Power transformers----1.5 to 1.7Tesla

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3.7   MAIN DIEMENSIONS OF MAGNETIC CIRCUIT

CORE TYPE TRANSFORMER; The main dimensions of the core type consist of;

1) Diameter of the circumscribed circle, d around the stepped core which depends on the KVA rating of the transformer.

2) Length of the core L, which is equal to the height of the window.

3) Center to center distance, D between the cores, which depends on the width of the window and the diameter of the circum circle and also to some extent on the number of steps in the core.
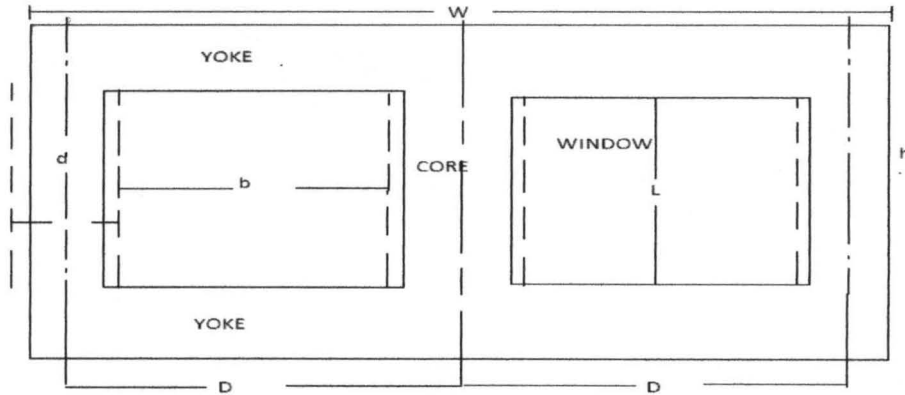
Fig 3.1   core, yoke and window description

To calculate the diameter of the circumscribed circle can be calculated using the following formulae;

Emf per turn $E_t = K \sqrt{KVA}$ per phase

Emf per turn $E_t = 4.44FB_mA_i$, from which A_i(net cross-sectional area) can be found.

Net cross sectional area of the core, $A_i = k\, d^2$

Hence the diameter of the circumscribed circle can be calculated for various values of the stepped cores.

SHELL TYPE TRANSFORMER

Cores of the shell type are rectangular in shape, which gives better cooling for the iron portion but this type is not considered in this project.

3.8   MAIN DIMENSIONS OF WINDOWS

This consists of the height and width of the window.

The window area is determined from the equation;

$$Q = 3.33 \, f \, B_m \delta \, k_w \, A_i A_w \times 10^3 \, KVA$$

Average current density, δ is based also on KVA rating and of the h.v/l.v winding.

Width of window, $(b_w) = D - d$

Area of the window, $(A_w) = L(D - d)$ ----------------------------------- (i)

Height of window can be assumed to vary from 2.5 to 4.0 times the width of the window.

$$\frac{l}{D-d} = 2.0 \text{ to } 4.0 \text{ ----------------------------------- (ii)}$$

From the above, the height and width of the window can be calculated using equations (i) and (ii), Center to center distance between the cores (D) = b_w+d .... (3.17)

3.9   MAIN DIMENSIONS OF THE YOKE.

This consists of the overall length W, width of the yoke and the height of the yoke as shown on fig (3.1)

The overall length of the yoke, W = 2D + 0.9d (for 3- Φ, 3 stepped)............... (3.18)

Sectional area of the yoke Ay can be taken 10 to 15% more than the core section, in order to reduce flux density in the yoke section which in turn reduces the magnetizing current and iron losses occurring in the yoke.

Therefore sectional area of yoke, $A_y = 1.15 \text{ to } 1.25 A_i$

Width of the yoke, $b_y = 0.6d \ (m)$

Height of the yoke $\qquad$ $h_y = \dfrac{A_y}{b_y} \ (m)$

From all the above, the dimensions of the yoke can be calculated.

3.10 STACKING FACTOR
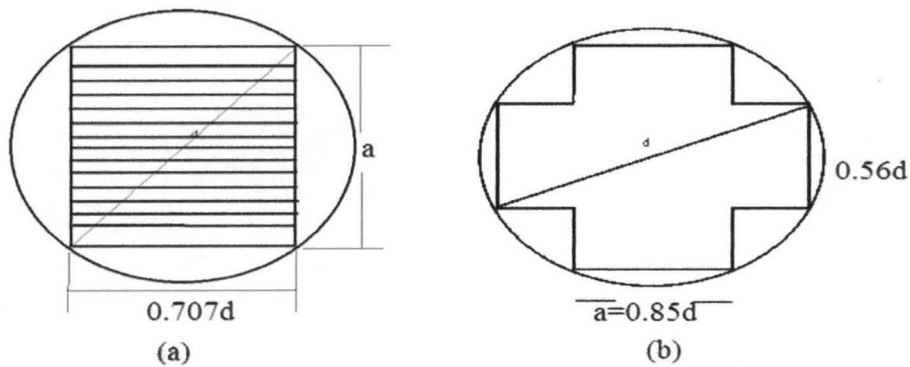
Fig 3.2 (a) Cross section of a square core and (b) cross-section of two stepped core

The stacking factor determines the area of arrangement of the laminations forming the cores.

$$A_i = K_s A_{gi} \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots (3.19)$$

Where

$k_s = stacking\ factor\ which\ is\ between\ (0.85 - 0.9)$

A_{gi} , is the gross iron area of core.

A_i, is the net area of core.

For square section, $\qquad A_{gi} = a^2 = (0.71d)^2 = 0.5d$

$A_i = 0.9 \times 0.5d^2$ $\qquad$ (Where 0.9 = Iron factor)

$$A_i = 0.45d^2$$

For two steps $\qquad A_i = 0.56d^2$

For three steps $\qquad A_i = 0.6d^2$

For four steps $\qquad A_i = 0.62d^2$

3.11 DESIGN OF WINDINGS

The following primary requirements are necessary for the design of the l.v and h.v windings of the transformer.

- The ability to withstand electric stress.

- Ability to withstand voltage surges due to switching and atmospheric disturbances

- Ability to withstand electro-magnetic forces.

- Percent impedance should be with-in tolerable limits.

- temperature rise should not exceed the specified limit

- Minimum cost of the windings.

From the above details, the l.v and h.v windings can be properly designed.

Design of low voltage winding

Number of turns per phase-- $T_{lv} = \frac{V_{lv}}{E_t}$

Current in L.V winding------------------------------------- $I_{lv} = \left(\frac{KVA\,per\,phase\,\times 1000}{v_{ph\,lv}} \right)$ (amps)

Cross-section of conductor -- $a_{lv} = \frac{I_{lv}}{\delta_2}(mm^2)$

Where T_{lv}= number of turns in l.v winding per phase

$\quad\quad V_{lv}$ = Voltage rating of l.v winding per phase

$\quad\quad I_{lv}$= current rating of the l.v winding

δ_2= Current density in the l.v winding (between 1.8 - 2.3A/mm^2)

Design of high voltage windings

Number of turns per phase --- $T_{hv} = T_{lv} \times \frac{V_{hv}}{V_{lv}}$

H.v winding current $\quad\quad$ -------------------------------- $I_{hv} = \frac{KVA\,per\,phase \times 1000}{V_{ph\,hv}}$ (amps)

Cross-sectional area of conductor --------------------------------------- $a_{hv} = \frac{I_{hv}}{\delta_1}(mm^2)$

3.12   LOSSES

HYSTERESIS LOSS

Hysteresis loss occurs in the magnetic frame and depends on the following

The area of hysteresis loop of the magnetic material used for the magnetic frame, which

depends on;

a)   The flux density at which the material is being worked.

b)   The volume of the core and yoke.

c)   The frequency of magnetic flux.

Hysteresis loss ---$\eta V f (B_{max})^n$ **watts**

Where η is a constant known as Steimetz's coefficient and its value for 4% silicon steel

and sheet steel is 275 and 500 respectively.

V is the volume of the core in m^3

$(B_{max})^n$, is the maximum flux density in Tesla.

n is Steimetz's exponent which varies from 1.6 to 2.5.

EDDY CURRENT LOSS

This loss depends on; the thickness of the laminations of the core and yoke, t

The frequency of the flux

Maximum flux density in the core and yoke (B_{max})

The quality of the material for the magnetic frame

Eddy current loss = $k \ B^2 \ max f^2 t^2 V \ watts$

COPPER LOSSES

The copper losses occur in the areas that carry current and consist of the copper

materials i.e. the l.v and H.v windings.

Copper loss in the l.v winding =$I_2^2 r_2$ **watts**

Copper loss in the h.v winding = $I_1^2 r_1$ **watts**

Where r is the resistances in the respective windings

IRON LOSSES

Iron loss in yoke (ly) $= By \times Ny \times Ay \times L \times 7.55 \times 10^{-3} kg \ cm^{-3}$

Iron loss in core(lc) $= Bc \times Nc \times Ay \times L \times 7.55 \times 10^{-3} kg \ cm^{-3}$

Where $\qquad B_c = B_y \frac{Ay}{Ai}$

Total iron losses $l_t = ly + lc$

3.13 COOLING

Various forms of cooling methods are given below depending on the size and type of transformer.

1) Air natural and Air blast cooled (AN and AB): used for small transformers of ratings up to 10 KVA

2) Oil immersed self cooled (ON): used for small medium and large transformers of ratings up to 50 MVA, as the entire piece is immersed into a tank filled with oil. The tank dissipates heat to the surroundings by the various modes of heat exchange in addition to having fins or radiators.

3) Oil immersed water cooled: Used for transformers up to 50 MVA and it is much cheaper than the ones with fins but the water is dangerous for the insulation hence its least preferred.

4) Oil immersed, forced air cooled: supports rating up to 75 MVA but economically supports 50 MVA.

5) Oil immersed forced oil cooled [4].

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              │  SPECIFICATION AND      │
              │  CONSTRAINTS            │
              └─────────────────────────┘
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              ┌─────────────────────────┐
              │ SPECIFY MAXIMUM AND     │
              │ MINIMUM LIMITS OF DESIGN│
              │ PARAMETERS              │
              └─────────────────────────┘
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              ┌─────────────────────────┐
        ┌────▶│ CHOOSE PROPER VALUE OF  │
        │ ┌──▶│ DESIGN PARAMETERS       │
        │ │   └─────────────────────────┘
        │ │              │
        │ │              ▼
        │ │   ┌─────────────────────────┐
        │ │   │ MAGNETIC FRAME DESIGN   │
        │ │   └─────────────────────────┘
        │ │              │
        │ │              ▼
        │ │   ┌─────────────────────────┐
        │ │   │ LOW VOLTAGE WINDING     │
        │ │   │ DESIGN                  │
        │ │   └─────────────────────────┘
        │ │              │
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        │ │   ┌─────────────────────────┐
        │ │   │ HIGH VOLTAGE WINDING    │
        │ │   │ DESIGN                  │
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        └─┴───│ CALCULATE LOSSES        │
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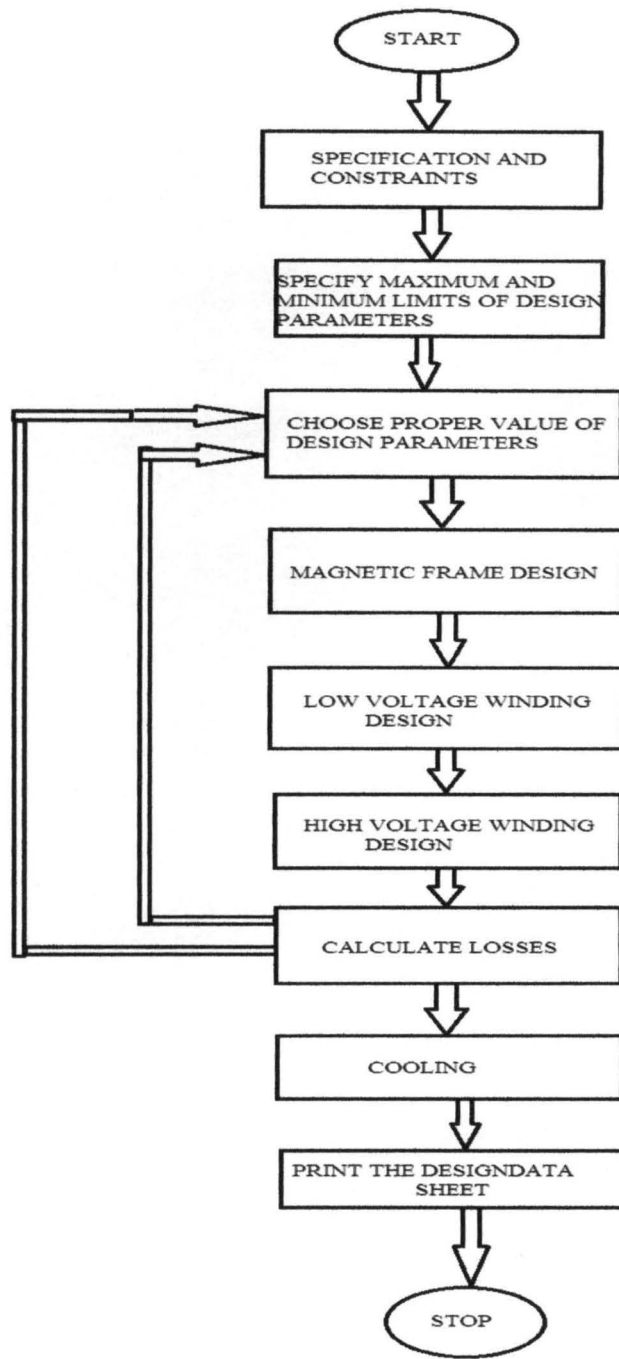
Fig 3.3 flow chart for design implementation

3.14 CHOICE OF PROPER VALUES OF (ASSUMED) DESIGN PARAMETERS

Frequency	$F = 50 \text{Hertz}$
Specific magnetic loading	$B_m = 1.5 \ Tesla$
Current density	$\delta = \frac{2.5A}{mm^2} = 2.5 \times 10^6 \ \frac{A}{m^2}$
Window space factor	$K_w = 0.34$
K-factor	$k = 0.90$
Height of window	$L = 0.75 \text{m}$
Thickness of lamination sheets	$t = 0.3 mm$
Steinmentz's exponent	$n = 2.5$
Steinmentz's coefficient	$\eta = 275$
L.v winding current density	$\delta_1 = \frac{2.5A}{mm^2}$
H.v winding current density	$\delta_2 = \frac{2.3A}{mm^2}$
L.v winding resistance	$r_1 = 7.65$
H.v winding resistance	$r_1 = 0.0081 \Omega$

CHAPTER FOUR

RESULT AND IMPLEMENTATION

4.1   RESULTS AND GUI IMPLEMENTATION

After the formulae have been extracted, the program is run to produce the interface as shown on fig 4.1 the graphic user interface is the final product of our design. The specified inputs (KVA rating, H.V and L.V values) are fed appropriately into the graphic user interface with the precission set to a high degree. Computation is done and all dimensions displayed also on the graphic user interface from which the core diagram and detailed table can be displayed.A specified input of 1000KVA,6600/440volts is shown below.

Fig. 4.1 Graphic user interface for general properties

Electrical Quantity	Value
Power Rating	1000.0kVA
Secondary Voltage	440.0 Volts
Primary Voltage	6600.0 Volts
Emf per turn	8.58099 V
Cross-Sectional Area of Core	0.02577 m^2
Frequency	50 Hz
Specific Magnetic Loading	1.5 Tesla
k factor	0.6
Window Area	5.33479 m^2
Width of window	0.25 m
Core Distance	0.366 meters
Current density	2.5 A/mm^2
Window space factor	0.34
Height of window	0.75 m
Length of yoke	1.09122 m
Area of yoke	0.02963 m^2
Width of yoke	1.30435 m
Height of yoke	0.16151 m
Secondary Turns	29.6043 turns/phase
Secondary Current	1,312.1597 amp
Secondary Conductor Size	570.50422 m^2
Secondary Current Density	2.3 A/mm^2
Primary Turns	769.14231 turns/phase
Primary Current	50.50505 amp

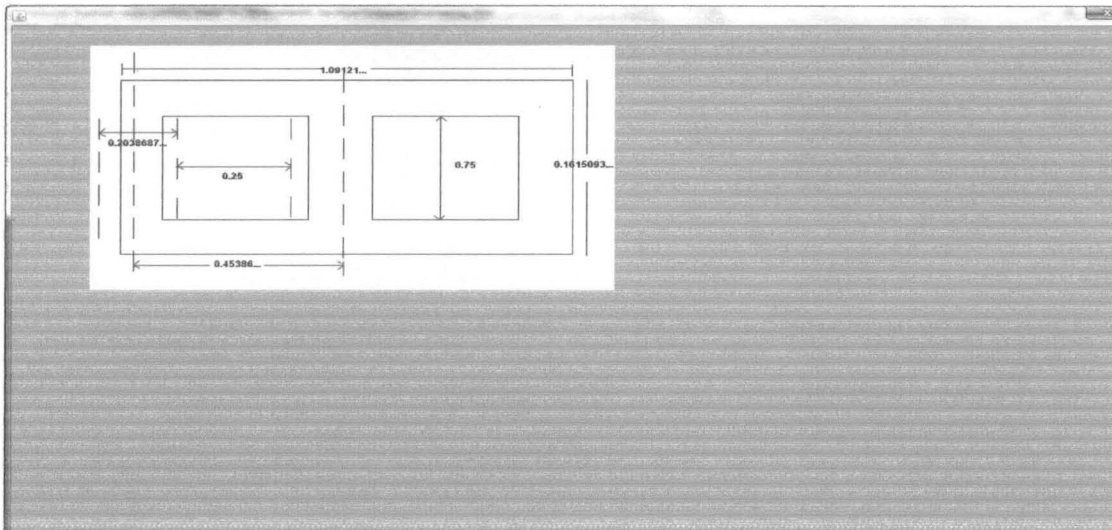Fig 4.2table of GUI results

Fig 4.3dimensions of core diagram

see appendix 1 for source code.

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4.2   DISSCUSSION OF RESULTS

The computer aided design of a three phase transformer is greatly affected by some of the assumed parameters such as the window space factor, the specific magnetic loading, the K- factor, the current density, steimetz's coefficient e.t.c, This is because these values are either chosen from a table corresponding to approximate KVA ratings or calculated, the voltage rating of the windings and type of steel material used.

4.2a   WINDOW SPACE FACTOR

if two transformers of the same KVA rating are designed for voltage (a) 110KV (b) 330KV, then the space in the window needed for the insulation will be more for the transformer with the 330KV compared to the 110KV. As such space available in the window for copper of the windings will be less in the case of transformer of 330KV. Hence the window space factor decreases as the voltage of the h.v winding increases.

4.2b   FLUX DENSITY

There are certain advantages that results from choosing higher values of flux density in the core. These advantages are;

1.   Reduction of core section for same output

2.   Reduced mean length of the turn of windings, as a result, saves copper material.

3.   Reduction in weight of transformer.

4.   Reduction in the overall cost of the transformer.

These advantages clearly indicate that the higher flux density is chosen to achieve an economical design with reduced size.

Disadvantages with high flux density

1.   Increased magnetizing current (large ampere turns requirement).

2.   Higher no load losses.

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3. Saturation of magnetic material.

4. Lower efficiency (because of higher no load losses).

5. Higher temperature rise due to increase of no load losses.

4.2c SPECIFIC MAGNETIC LOADING

Since conditions of cooling are different in the l.v and h.v windings. The l.v winding being an inner winding has power cooling conditions compared to the h.v windings, which is an outer winding. Hence comparatively lower value of current density should be assumed for the l.v winding.

4.3 CHOICE OF CONDUCTOR TYPE

Cross over type, cylindrical type with circular conductor and continuous disc type are generally used for h.v winding. The type of winding to be used is first selected, depending on the rating of the transformer and design limitations. The conductor section is selected depending upon the type of winding i.e. rectangular or circular. Generally for small and medium transformers, with comparatively lesser conductor section, circular conductors are used. For large transformers, rectangular conductors are preferred because of higher current rating.

Electrical grade insulating paper s (EGIP) is used for the covering the bare conductor. This is due to the following qualities;

1. Flexibility.

2. Easy to use.

3. Higher insulation with lesser thickness.

4. High resistance to oil.

5. Reasonable heat resistance.

6. Low chloride impurities.

4.4   CHOICE OF COPPER OR ALUMINUM AS WINDING MATERIAL.

The choice of using copper or aluminum as winding material generally depends on the end users. Most power utilities desire transformers up to 250KVA/11KV with aluminum windings because of its wide availability and economy in cost. But due to some limitations in its inherent properties, higher rating transformers are made with copper winding. However, 22KV and 33KV distribution transformers are always made with copper winding only because of its low conductivity. An aluminum conductor occupies almost double the volume than that of copper winding and hence an aluminum wound transformer always looks bigger in size than copper wound transformer of same KVA rating [4].

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Generally, electric power is needed for economic growth and development of industries, for effective and efficient communications systems, transport in some countries and to make life more comfortable for man and the environment. These advantages of electric power cannot be achieved without the use of transformers as already outlined in previous chapters. Since the world is fast becoming a global village, and power consumption on a steady rise, transformers are now more than ever needed in large numbers on a daily basis. Mass production of transformers is therefore required to meet the growing need for power consumption.

Without the use of computer aided design, mass production would not be possible as the manual method will be a waste of useful man-hours. Due to the assumed parameters such as specific magnetic loading, Current density, Window space factor, K-factor, Height of window, Thickness of lamination sheets Steinmentz's exponent, Steinmentz's coefficient, L.v winding current density, H.v winding current density, L.v winding resistance, H.v winding resistance for which limits are given, choice of values could be slightly different from designer to designer resulting in slightly different dimensions.

The efficiency of a transformer is quite high, usually over 98% at full load. It increases at partial load, sometimes to over 99%. A real transformer is not very far from an ideal transformer, in fact. These figures for efficiency apply to large power and distribution transformers; say above about 5 KVA capacities (product of rated voltage and

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current) with silicon steel cores. It is difficult to measure the efficiency of a transformer directly (by comparing output with input), so the copper and core losses are usually measured or estimated instead. Core losses are usually only about 1/3 of the total [3]. Transformer design is a well-developed subject, and it is important not simply to design a transformer that will do, but one that is economical, efficient and makes the best use of available materials. However, it is not difficult to design a serviceable transformer, and by understanding how this is done we will know better why transformers are as they are. As in all design processes, there are numerous trade-offs between competing requirements, and some sort of optimum is sought. On the other hand, the properties of available materials rigidly limit the possibilities.

The size, shape and material of the core must be chosen, and the number of turns of the low voltage and high voltage windings. The size of the wire and the insulation determines if the windings will fit in the space available. The windings must be arranged for minimum leakage flux. The insulation determines the permissible temperature rise, and means of cooling must balance the loss of energy under load. We will treat only the core and the number of turns, the fundamental parameters, in our analysis. A complete design must, of course, include all these features

5.2   FAILURE OF TRANSFORMERS

The failure of a transformer is caused either due to a reason within the transformer or due to operational hazards. Majority of failures roughly 80% of total, get precipitated as winding failures. Out of which nearly 65% manifest as HV winding failure, 12% as LV winding failure and 16% as failure of both windings. These may be due to many electrical and/ or mechanical reasons, in-correct electrical and mechanical designs, and the use of improper and in adequate insulation materials, drying the winding insulation, poor

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workmanship-lead to all such failures. Loose soldering, bad crimping, uneven temperature rise due to insufficient cooling also contribute to such failures.

Loose clamping of core laminations results in vibration and hence inabrasion of bursts short-circuiting the laminations, thereby permitting the development of heat due to saturation of the magnetic circuit. Nearly 3 to 4% of the failures are caused by failure of the HV bushings. Sparking takes place at the joints of terminations, resulting in damage of bushing fitting threads. Roughly 4to5% of the fault arises due to transformer oil. low oil pilferage, leakage through bad and porous welding, spilling of oil during transit or installation, poor quality of oil used, degradation of oil due to over heating/ ageing, entry of moisture through porous gasket joints or absence of sufficient silica gel, results in degeneration of the insulating strength of oil. Before declaring a transformer fit and ready for service, the following tests are required [3];

- Routine tests

- Type tests

- Special tests

```
                        ┌─────────────────────┐
                        │  SHEDULE OF TESTS   │
                        └─────────────────────┘
```

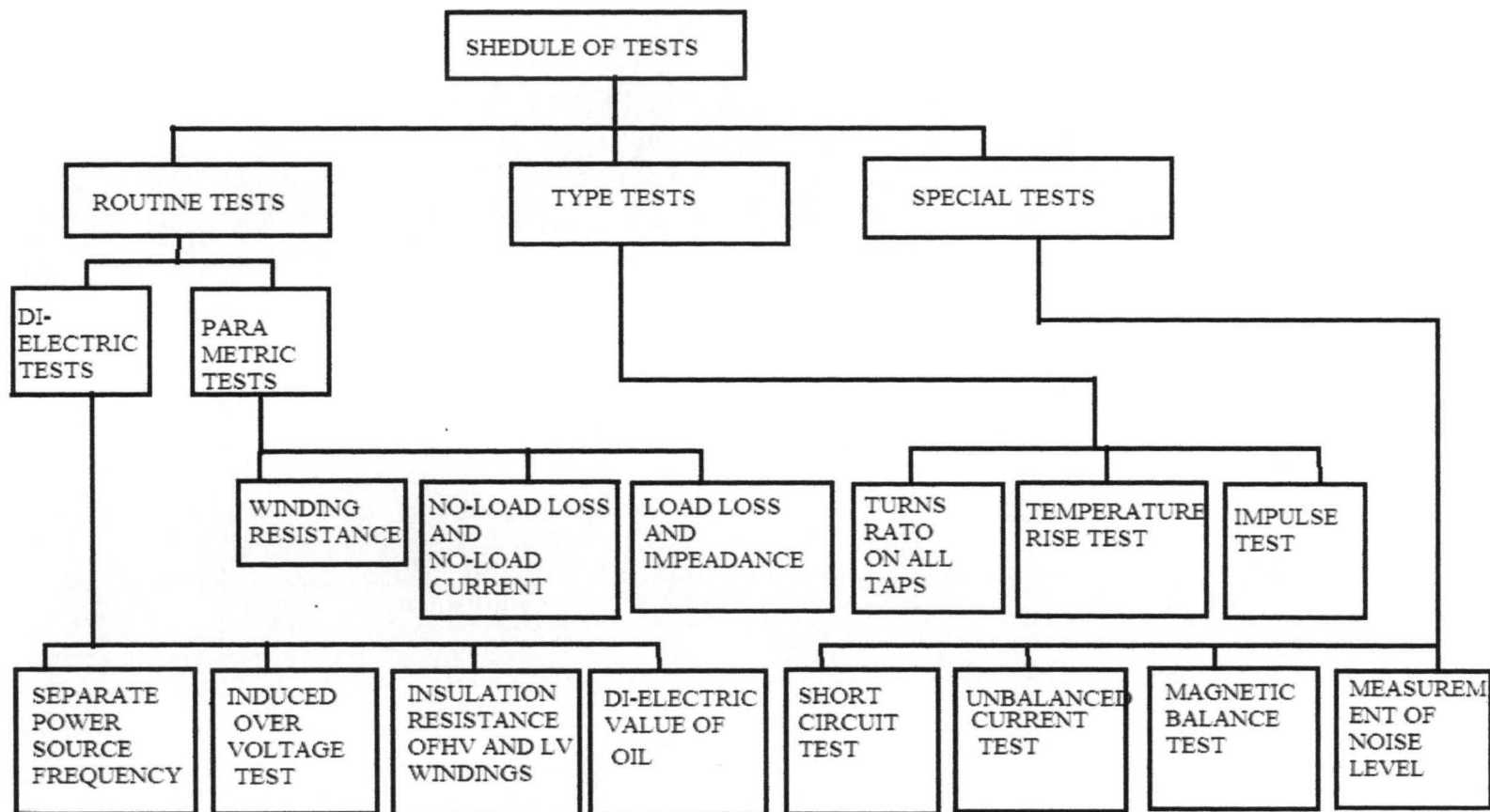| SEPARATE POWER SOURCE FREQUENCY | INDUCED OVER VOLTAGE TEST | INSULATION RESISTANCE OFHV AND LV WINDINGS | DI-ELECTRIC VALUE OF OIL | SHORT CIRCUIT TEST | UNBALANCED CURRENT TEST | MAGNETIC BALANCE TEST | MEASUREMENT OF NOISE LEVEL |

Fig 5.0 Block diagram of scheduled transformer tests

5.2 RECOMMENDATIONS

1) Computer aided designing of transformers is a very specialized subject and as such more work needs be done (by engineers, programmers and people of the academia) to improve upon its efficiency and capabilities.

2) Transformers should be designed and constructed to withstand without damage the thermal stress and dynamic effects of an external short circuit under symmetrical fault condition.

3) A well maintained transformer always enjoys a longer life. A transformer is capital intensive equipment and we must provide it with regular maintenance which depends on the type of transformer, the ratings, connected load and place of installation.

REFERENCES

[1] Engr. (Proff.) Oria Usifo. Electrical High Voltage Engineering, 1st Ed. , Ecas Nig. Ltd., Oshodi Nigeria, 2003. pp.1

[2] Indrajit Dasupta. Design of transformers, 1st Ed Tata MaGraw Hill publishing Ltd., New Delhi, India, 2002. pp. 3-9, 55, 444.

[3] Maintenance an overview on communiqué of electrical maintenance course phase 2

PHCN Afam, September 2008, pp. 2-10

[4] Shrikrishna V. Kulkarni, S.V. Kulkarni and S.A. Khparde. Transformer Engineering design and practice, Marcel Dekker, Inc, India. 2004 pp.15-33

[5] CAD software history, www.cadazz.com/cad-software-history.htm , 8th June 2004

[6] CAD history present and future, wikiversity, en.wikiversity.org/wiki/CAD_history,present_-_future_1st April 2010.

[7] B.K. Theraja and A.K Theraja. A textbook of electrical technology, 5th Ed Schand & CompanyLtd., 2005 pp.1116-1120, 1212.

[8] Y. Daniel Liang, Introduction to java programming with jbuilder .Prentice Hall Upper saddle River, New Jersey, USA, 2000, pp.1-15, 20-50.

[9] Donald Doherty and Michelle M. Manning, SAMS Teach Yourself Java Borland Jbuilder 2. SAMS Borland Press, USA, 1998, pp.7-10, 20-30.

[10] The Java EE5 Tutorial Sun Java Microsystems Inc. New York Cycle, Santa Clara CA, USA. October 2008. pp. 25, 765-780

```java
  public Index(int i)
  {}
  Thread t = new Thread()
  {
    @Override
    public void run()
    {
      //displayData();
    }
  };Computation computation = new Computation();

  static double frequency = 50;
static int integerPart2 = 5;
static int decimalPart2 = 5;
static final double Bm = 1.5;
static final double delta = 2500000;
static final double k = 0.47;
static  double D ;
static final double eL = 0.75;
static final double by = 1.17;
static final double tt = 0.3;
static final double n = 2.5;
static final double N = 275;
static final double d1 = 2.5;
static final double dd2 = 2.3;
static final double r1 = 7.65;
static final double r2 = 0.0081;
static final double Ny = 2;
static final double Nc = 3;
//static final double Q = 40000;

static                                                                     String
Et2="999",Ai2,d2,Aw2,Bw2,L2,W2,Ay2,By2,Hy2,T22,I22,A22,T12,I12,A12,Hloss2,Edloss2,CuLossLu2,c
uLossHu2,Ly2,Lc2,Lt2,Aji,Aki,Ali,Ami;
  String[][]  data  =  {{"Power  Rating",getPower()+"kVA"},{"Secondary  Voltage",getSec()+"
Volts"},{"Primary Voltage",getPrimary()+" Volts"},
              {"Emf  per  turn",Et2},{"Cross-Sectional  Area  of  Core",Ai2},{"Frequency","50
Hz"},{"Specific Magnetic Loading","1.5 Tesla"}
              ,{"k factor","0.6"},{"Window Area",Aw2},{"Width of window",Bw2}
              ,{"Core  Distance","0.366  meters"},{"Current  density","<html>"+"2.5
A/mm<sup>2</sup>"+"</html>"},{"Window space factor","0.34"},{"Height of window",L2}
              ,{"Length  of  yoke",W2},{"Area  of  yoke",Ay2},{"Width  of  yoke",By2},{"Height  of
yoke",Hy2}
```

```java
                ,{"Secondary    Turns",T22},{"Secondary    Current",I22},{"Secondary    Conductor
Size",A22},{"Secondary Current Density","<html>"+"2.3 A/mm<sup>2</sup>"+"</html>"}
                ,{"Primary        Turns",T12},{"Primary          Current",I12},{"Primary    Conductor
Size",A12},{"Primary Current Density","<html>"+"2.5 A/mm<sup>2</sup>"+"</html>"}
                ,{"Hysteresis  loss",Hloss2},{"Steimeitz  Coefficient","2.75"},{"Copper Loss in Low-
voltage",CuLossLu2},{"Copper Loss in High-voltage",cuLossHu2}
                ,{"Iron Loss in yoke",Ly2},{"Iron Loss in core",Lc2},{"Total Iron Loss",Lt2}

,{"<Html>A<sub>I</sub></Html>",Aji},{"<Html>A<sub>I1</sub></Html>",Aki},{"<Html>A<sub>I2</s
ub></Html>s",Ali},{"<Html>A<sub>I3</sub></Html>s",Ami}};
   static double dad ;
   static double ehy ;
   static double bbw;
   static double www;
   static double lll;
   public void displayData()
{
            double kw = 0.34;
        if(getPower() >= 1000)
        {
          kw = 12/(30+getPower());
        }
        else if(getPower() >= 50 && getPower() <= 100)
        {
          kw = 10/(30+getPower());
        }
        else if(getPower() >= 10 && getPower() <=50)
        {
          kw = 8/(30+getPower());
        }


    double Ett = k * Math.sqrt(getPower()/3);
 double Aii = Ett/(4.44 * frequency * Bm);
 double dd = Math.sqrt(Aii/0.62);dad = dd;
 D = eL/3 + dd;
 double Aww = (getPower()*1000)/(3.33 * frequency * Bm * delta*kw* Aii);
 double Bww = D-(dd);bbw = Bww;
 double Ll = Bm*Aii;
 lll = eL;//Ll;
 double Ww = (2*D)+(0.9*dd);www = Ww;
 double Ayy = 1.15 * Aii;
 double Byy = Ll /Ayy;
 double Hyy = Ayy/(0.9*dd);ehy = Hyy;//System.out.println("ehy = "+ehy);
 double Tt2 = ((getSec()/Math.sqrt(3)) )/Ett;
```

```java
double Ii2 = ((getPower()/3) * 1000)/(getSec()/Math.sqrt(3));
double Aa2 = Ii2/dd2;
 double Tt1 = Tt2 * (getPrimary()/(getSec()/Math.sqrt(3)));
 double Ii1 = ((getPower()/3)*1000)/getPrimary();
 double Aa1 = Ii1/d1;
   double V = Aww * Ll;
double Hhloss = N*V*frequency*Math.pow(Bm, n);
double Ed_loss = k * (Bm*Bm)*(frequency*frequency)*(tt*tt)*V;
double Cuu_loss_in_Lu = (Ii2*Ii2)*r2;
 double Cuu_loss_in_Hu = (Ii1*Ii1)*r1;
double Lyy = Byy * Ny * Ayy * Ll * 7.55 * 0.001;
   double Bc = Byy * (Ayy/Aii);
double Lcc = Bc * Ny * Ayy * Ll * 7.55 * 0.001;
double Ltt = Lyy+Lcc;
double Ani = 0.45 * dd* dd;Aji = String.valueOf(Ani)+" Square Section";
double Ani1 = 0.56 * dd* dd;Aki = String.valueOf(Ani1)+" 2 steps";
double Ani2 = 0.60 * dd* dd;Ali = String.valueOf(Ani2)+" 3 steps";
double Ani3 = 0.62 * dd* dd;Ami = String.valueOf(Ani3)+" 4 steps";
   //Computation computation = new Computation();
   NumberFormat nf = new DecimalFormat();
   nf.setMaximumFractionDigits(decimalPart2);
   nf.setMaximumIntegerDigits(integerPart2);
   //System.out.println("Solution is here");
   Et.setText("<html>"+nf.format(Ett)+" V</html>");Et2 = "<html>"+nf.format(Ett)+" V</html>";
   // System.out.println("Power is: "+ getPower());
   //System.out.println("K is: "+ k);
   System.out.println("Et is: "+Et2);
   Ai.setText("<html>"+nf.format(Aii)+"          m<sup><i>2</i></sup></html>");Ai2          =
"<html>"+nf.format(Aii)+" m<sup><i>2</i></sup></html>";
   d.setText("<html>"+nf.format(dd)+" m</html>");d2 = "<html>"+nf.format(dd)+" m</html>";
   Aw.setText("<html>"+nf.format(     Aww)+"          m<sup><i>2</i></sup></html>");Aw2          =
"<html>"+nf.format( Aww)+" m<sup><i>2</i></sup></html>";
     // System.out.println("Aw is: "+"<html>"+ Aw+" mm<sup><i>2</i></sup></html>");
     // System.out.println("");
   Bw.setText("<html>"+nf.format( Bww)+"   m</html>");Bw2   =   "<html>"+nf.format(   Bww)+"
m</html>";
   L.setText("<html>"+nf.format( eL)+" m</html>");L2 = "<html>"+nf.format( eL)+" m</html>";
   W.setText("<html>"+nf.format( Ww)+" m</html>");W2 = "<html>"+nf.format( Ww)+" m</html>";
   Ay.setText("<html>"+nf.format(     Ayy)+"          m<sup><i>2</i></sup></html>");Ay2          =
"<html>"+nf.format( Ayy)+" m<sup><i>2</i></sup></html>";
   By.setText("<html>"+nf.format( Byy)+" m</html>");By2 = "<html>"+nf.format( Byy)+" m</html>";
   Hy.setText("<html>"+nf.format(   Hyy)+"   m</html>");Hy2   =   "<html>"+nf.format(   Hyy)+"
m</html>";
```

```java
    T2.setText("<html>"+nf.format( Tt2)+" turns/phase</html>");T22 = "<html>"+nf.format( Tt2)+"
turns/phase</html>";
    I2.setText("<html>"+nf.format(   Ii2)+"    amp</html>");I22   =   "<html>"+nf.format(   Ii2)+"
amp</html>";
    A2.setText("<html>"+nf.format(       Aa2)+"       mm<sup><i>2</i></sup></html>");A22      =
"<html>"+nf.format( Aa2)+" m<sup><i>2</i></sup></html>";
    T1.setText("<html>"+nf.format( Tt1)+" turns/phase</html>");T12 = "<html>"+nf.format( Tt1)+"
turns/phase</html>";
    I1.setText("<html>"+nf.format(   Ii1)+"    amp</html>");I12   =   "<html>"+nf.format(   Ii1)+"
amp</html>";
    A1.setText("<html>"+nf.format(       Aa1)+"       mm<sup><i>2</i></sup></html>");A12      =
"<html>"+nf.format( Aa1)+" m<sup><i>2</i></sup></html>";
    Hloss.setText("<html>"+nf.format( Hhloss)+"  watt(s)</html>");Hloss2 = "<html>"+nf.format(
Hhloss)+" watt(s)</html>";
    Edloss.setText("<html>"+nf.format( Ed_loss)+"  watt(s)</html>");Edloss2 = "<html>"+nf.format(
Ed_loss)+" watt(s)</html>";
    CuLossLu.setText("<html>"+nf.format(   Cuu_loss_in_Lu)+"    watt(s)</html>");CuLossLu2    =
"<html>"+nf.format( Cuu_loss_in_Lu)+" watt(s)</html>";
    cuLossHu.setText("<html>"+nf.format(   Cuu_loss_in_Hu)+"    watt(s)</html>");cuLossHu2    =
"<html>"+nf.format( Cuu_loss_in_Hu)+" watt(s)</html>";
    Ly.setText("<html>"+nf.format(   Lyy)+"   watt(s)</html>");Ly2   =   "<html>"+nf.format(   Lyy)+"
kg/cm<sup>3</sup></html>";
    Lc.setText("<html>"+nf.format(   Lcc)+"   watt(s)</html>");Lc2   =   "<html>"+nf.format(   Lcc)+"
kg/cm<sup>3</sup></html>";
    Lt.setText("<html>"+nf.format(   Ltt)+"   watt(s)</html>");Lt2   =   "<html>"+nf.format(   Ltt)+"
kg/cm<sup>3</sup></html>";
}
    /** This method is called from within the constructor to
     * initialize the form.
     * WARNING: Do NOT modify this code. The content of this method is
     * always regenerated by the Form Editor.
     */
    @SuppressWarnings("unchecked")
    // <editor-fold defaultstate="collapsed" desc="Generated Code">//GEN-BEGIN:initComponents
    private void initComponents() {

        jLayeredPane1 = new javax.swing.JLayeredPane();
        jPanel1 = new javax.swing.JPanel();
        jLayeredPane2 = new javax.swing.JLayeredPane();
        jLabel29 = new javax.swing.JLabel();
        jLabel43 = new javax.swing.JLabel();
        jLabel44 = new javax.swing.JLabel();
        T2 = new javax.swing.JLabel();
        jLabel46 = new javax.swing.JLabel();
```

```java
jLabel61 = new javax.swing.JLabel();
jLabel62 = new javax.swing.JLabel();
jLabel63 = new javax.swing.JLabel();
A1 = new javax.swing.JLabel();
jLabel65 = new javax.swing.JLabel();
jPanel3 = new javax.swing.JPanel();
jLayeredPane4 = new javax.swing.JLayeredPane();
jLabel66 = new javax.swing.JLabel();
jLabel67 = new javax.swing.JLabel();
Et = new javax.swing.JLabel();
jLabel70 = new javax.swing.JLabel();
jLabel71 = new javax.swing.JLabel();
jLabel72 = new javax.swing.JLabel();
Ai = new javax.swing.JLabel();
jLabel74 = new javax.swing.JLabel();
jLabel75 = new javax.swing.JLabel();
d = new javax.swing.JLabel();
jLabel77 = new javax.swing.JLabel();
jLabel78 = new javax.swing.JLabel();
jLabel79 = new javax.swing.JLabel();
Aw = new javax.swing.JLabel();
jLabel81 = new javax.swing.JLabel();
jLabel84 = new javax.swing.JLabel();
jLabel85 = new javax.swing.JLabel();
jLabel86 = new javax.swing.JLabel();
jLabel87 = new javax.swing.JLabel();
Bw = new javax.swing.JLabel();
L = new javax.swing.JLabel();
jLabel90 = new javax.swing.JLabel();
jLabel91 = new javax.swing.JLabel();
W = new javax.swing.JLabel();
jLabel93 = new javax.swing.JLabel();
jLabel94 = new javax.swing.JLabel();
By = new javax.swing.JLabel();
jLabel96 = new javax.swing.JLabel();
jLabel97 = new javax.swing.JLabel();
jLabel98 = new javax.swing.JLabel();
jLabel99 = new javax.swing.JLabel();
jLabel100 = new javax.swing.JLabel();
jLabel101 = new javax.swing.JLabel();
Ay = new javax.swing.JLabel();
jLabel103 = new javax.swing.JLabel();
jLabel104 = new javax.swing.JLabel();
jLabel105 = new javax.swing.JLabel();
```

```java
jLabel47 = new javax.swing.JLabel();
I2 = new javax.swing.JLabel();
jLabel49 = new javax.swing.JLabel();
jLabel50 = new javax.swing.JLabel();
jLabel51 = new javax.swing.JLabel();
A2 = new javax.swing.JLabel();
jLabel53 = new javax.swing.JLabel();
jPanel2 = new javax.swing.JPanel();
jLayeredPane3 = new javax.swing.JLayeredPane();
jLabel2 = new javax.swing.JLabel();
jLabel3 = new javax.swing.JLabel();
Hloss = new javax.swing.JLabel();
jLabel7 = new javax.swing.JLabel();
Edloss = new javax.swing.JLabel();
jLabel18 = new javax.swing.JLabel();
jLabel20 = new javax.swing.JLabel();
jLabel22 = new javax.swing.JLabel();
CuLossLu = new javax.swing.JLabel();
cuLossHu = new javax.swing.JLabel();
jLabel27 = new javax.swing.JLabel();
Ly = new javax.swing.JLabel();
jLabel28 = new javax.swing.JLabel();
jLabel30 = new javax.swing.JLabel();
Lt = new javax.swing.JLabel();
jLabel34 = new javax.swing.JLabel();
jLabel35 = new javax.swing.JLabel();
jLabel36 = new javax.swing.JLabel();
jLabel37 = new javax.swing.JLabel();
Lc = new javax.swing.JLabel();
jLabel5 = new javax.swing.JLabel();
jLabel6 = new javax.swing.JLabel();
jLabel21 = new javax.swing.JLabel();
jLabel107 = new javax.swing.JLabel();
jLabel39 = new javax.swing.JLabel();
jLabel32 = new javax.swing.JLabel();
jPanel4 = new javax.swing.JPanel();
jLayeredPane5 = new javax.swing.JLayeredPane();
jLabel54 = new javax.swing.JLabel();
jLabel55 = new javax.swing.JLabel();
jLabel56 = new javax.swing.JLabel();
T1 = new javax.swing.JLabel();
jLabel58 = new javax.swing.JLabel();
jLabel59 = new javax.swing.JLabel();
I1 = new javax.swing.JLabel();
```

```java
Hy = new javax.swing.JLabel();
jSeparator2 = new javax.swing.JSeparator();
jLayeredPane6 = new javax.swing.JLayeredPane();
jLabel8 = new javax.swing.JLabel();
power = new javax.swing.JTextField();
jLabel4 = new javax.swing.JLabel();
primary = new javax.swing.JTextField();
jLabel9 = new javax.swing.JLabel();
secondary = new javax.swing.JTextField();
jLabel1 = new javax.swing.JLabel();
jSeparator1 = new javax.swing.JSeparator();
jLabel10 = new javax.swing.JLabel();
jLabel11 = new javax.swing.JLabel();
integerPart = new javax.swing.JComboBox();
decimalPart = new javax.swing.JComboBox();
jButton3 = new javax.swing.JButton();
jButton1 = new javax.swing.JButton();
jButton2 = new javax.swing.JButton();
jLabel12 = new javax.swing.JLabel();
jLabel13 = new javax.swing.JLabel();
jLabel14 = new javax.swing.JLabel();
jLabel15 = new javax.swing.JLabel();
jMenuBar1 = new javax.swing.JMenuBar();
jMenu1 = new javax.swing.JMenu();
jMenuItem2 = new javax.swing.JMenuItem();
jMenuItem1 = new javax.swing.JMenuItem();
jMenuItem3 = new javax.swing.JMenuItem();
jMenu2 = new javax.swing.JMenu();

setDefaultCloseOperation(javax.swing.WindowConstants.EXIT_ON_CLOSE);
setTitle("Project By Shadrack Abiola Adefemi. Matric No: 2006/24383EE, Electrical/Computer
Engineering 2010");

jLayeredPane1.setBackground(new java.awt.Color(51, 153, 255));
jLayeredPane1.setOpaque(true);

jPanel1.setBackground(new java.awt.Color(255, 255, 255));
jPanel1.setBorder(javax.swing.BorderFactory.createTitledBorder(null, "Lv  Winding  Design",
javax.swing.border.TitledBorder.CENTER,        javax.swing.border.TitledBorder.TOP,        new
java.awt.Font("Tahoma", 1, 14), new java.awt.Color(255, 51, 0))); // NOI18N

jLabel29.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel29.setText("T");
jLabel29.setBounds(110, 0, 20, 20);
```

```java
jLayeredPane2.add(jLabel29, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel43.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel43.setText("2");
jLabel43.setBounds(120, 10, 8, 15);
jLayeredPane2.add(jLabel43, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel44.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel44.setText("=");
jLabel44.setBounds(140, 0, 20, 20);
jLayeredPane2.add(jLabel44, javax.swing.JLayeredPane.DEFAULT_LAYER);

T2.setBackground(new java.awt.Color(0, 153, 255));
T2.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
T2.setOpaque(true);
T2.setBounds(170, 0, 200, 30);
jLayeredPane2.add(T2, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel46.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel46.setText("I");
jLabel46.setBounds(390, 0, 7, 20);
jLayeredPane2.add(jLabel46, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel47.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel47.setText("=");
jLabel47.setBounds(420, 0, 20, 20);
jLayeredPane2.add(jLabel47, javax.swing.JLayeredPane.DEFAULT_LAYER);

I2.setBackground(new java.awt.Color(0, 153, 255));
I2.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
I2.setOpaque(true);
I2.setBounds(450, 0, 190, 30);
jLayeredPane2.add(I2, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel49.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel49.setText("a");
jLabel49.setBounds(710, 0, 10, 20);
jLayeredPane2.add(jLabel49, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel50.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel50.setText("2");
jLabel50.setBounds(720, 10, 20, 15);
jLayeredPane2.add(jLabel50, javax.swing.JLayeredPane.DEFAULT_LAYER);
```

```
jLabel51.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel51.setText("=");
jLabel51.setBounds(740, 0, 20, 20);
jLayeredPane2.add(jLabel51, javax.swing.JLayeredPane.DEFAULT_LAYER);

A2.setBackground(new java.awt.Color(0, 153, 255));
A2.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
A2.setOpaque(true);
A2.setBounds(770, 0, 180, 30);
jLayeredPane2.add(A2, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel53.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel53.setText("2");
jLabel53.setBounds(400, 10, 20, 15);
jLayeredPane2.add(jLabel53, javax.swing.JLayeredPane.DEFAULT_LAYER);

javax.swing.GroupLayout jPanel1Layout = new javax.swing.GroupLayout(jPanel1);
jPanel1.setLayout(jPanel1Layout);
jPanel1Layout.setHorizontalGroup(
    jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
    .addComponent(jLayeredPane2,        javax.swing.GroupLayout.DEFAULT_SIZE,        1038,
Short.MAX_VALUE)
    );
jPanel1Layout.setVerticalGroup(
    jPanel1Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
    .addGroup(jPanel1Layout.createSequentialGroup()
        .addComponent(jLayeredPane2,        javax.swing.GroupLayout.PREFERRED_SIZE,        45,
javax.swing.GroupLayout.PREFERRED_SIZE)
        .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
    );

jPanel1.setBounds(10, 150, 1050, 80);
jLayeredPane1.add(jPanel1, javax.swing.JLayeredPane.DEFAULT_LAYER);

jPanel2.setBackground(new java.awt.Color(255, 255, 255));
jPanel2.setBorder(javax.swing.BorderFactory.createTitledBorder(null,                        "Losses",
javax.swing.border.TitledBorder.CENTER,            javax.swing.border.TitledBorder.TOP,        new
java.awt.Font("Tahoma", 1, 14), new java.awt.Color(255, 51, 0))); // NOI18N

jLabel2.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel2.setText("loss");
jLabel2.setBounds(20, 20, 30, 15);
jLayeredPane3.add(jLabel2, javax.swing.JLayeredPane.DEFAULT_LAYER);
```

```java
jLabel3.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel3.setText("H");
jLabel3.setBounds(10, 10, 30, 30);
jLayeredPane3.add(jLabel3, javax.swing.JLayeredPane.DEFAULT_LAYER);

Hloss.setBackground(new java.awt.Color(0, 153, 255));
Hloss.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Hloss.setOpaque(true);
Hloss.setBounds(80, 0, 160, 30);
jLayeredPane3.add(Hloss, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel7.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel7.setText("=");
jLabel7.setBounds(60, 40, 20, 20);
jLayeredPane3.add(jLabel7, javax.swing.JLayeredPane.DEFAULT_LAYER);

Edloss.setBackground(new java.awt.Color(0, 153, 255));
Edloss.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Edloss.setOpaque(true);
Edloss.setBounds(80, 50, 160, 30);
jLayeredPane3.add(Edloss, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel18.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel18.setText("=");
jLabel18.setBounds(50, 10, 20, 20);
jLayeredPane3.add(jLabel18, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel20.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel20.setText("Cu loss in Hv winding");
jLabel20.setBounds(250, 50, 180, 20);
jLayeredPane3.add(jLabel20, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel22.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel22.setText("=");
jLabel22.setBounds(440, 10, 20, 20);
jLayeredPane3.add(jLabel22, javax.swing.JLayeredPane.DEFAULT_LAYER);

CuLossLu.setBackground(new java.awt.Color(0, 153, 255));
CuLossLu.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
CuLossLu.setOpaque(true);
CuLossLu.setBounds(460, 0, 150, 30);
jLayeredPane3.add(CuLossLu, javax.swing.JLayeredPane.DEFAULT_LAYER);

cuLossHu.setBackground(new java.awt.Color(0, 153, 255));
```

```java
cuLossHu.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
cuLossHu.setOpaque(true);
cuLossHu.setBounds(460, 50, 150, 30);
jLayeredPane3.add(cuLossHu, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel27.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel27.setText("=");
jLabel27.setBounds(440, 50, 20, 20);
jLayeredPane3.add(jLabel27, javax.swing.JLayeredPane.DEFAULT_LAYER);

Ly.setBackground(new java.awt.Color(0, 153, 255));
Ly.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Ly.setOpaque(true);
Ly.setBounds(680, 0, 140, 30);
jLayeredPane3.add(Ly, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel28.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel28.setText(" L");
jLabel28.setBounds(620, 10, 30, 20);
jLayeredPane3.add(jLabel28, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel30.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel30.setText("=");
jLabel30.setBounds(650, 10, 20, 20);
jLayeredPane3.add(jLabel30, javax.swing.JLayeredPane.DEFAULT_LAYER);

Lt.setBackground(new java.awt.Color(0, 153, 255));
Lt.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Lt.setOpaque(true);
Lt.setBounds(890, 0, 140, 30);
jLayeredPane3.add(Lt, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel34.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel34.setText("=");
jLabel34.setBounds(870, 10, 20, 20);
jLayeredPane3.add(jLabel34, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel35.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel35.setText(" L");
jLabel35.setBounds(620, 50, 30, 20);
jLayeredPane3.add(jLabel35, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel36.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel36.setText(" y");
```

```
jLabel36.setBounds(630, 20, 20, 15);
jLayeredPane3.add(jLabel36, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel37.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel37.setText("=");
jLabel37.setBounds(650, 50, 20, 20);
jLayeredPane3.add(jLabel37, javax.swing.JLayeredPane.DEFAULT_LAYER);

Lc.setBackground(new java.awt.Color(0, 153, 255));
Lc.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Lc.setOpaque(true);
Lc.setBounds(680, 50, 140, 30);
jLayeredPane3.add(Lc, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel5.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel5.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
jLabel5.setText("loss");
jLabel5.setBounds(20, 60, 40, 15);
jLayeredPane3.add(jLabel5, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel6.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel6.setText("Ed");
jLabel6.setBounds(10, 40, 30, 30);
jLayeredPane3.add(jLabel6, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel21.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel21.setText("Cu loss in Lv winding");
jLabel21.setBounds(250, 10, 180, 20);
jLayeredPane3.add(jLabel21, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel107.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel107.setText(" c");
jLabel107.setBounds(630, 60, 30, 15);
jLayeredPane3.add(jLabel107, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel39.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel39.setText(" T");
jLabel39.setBounds(850, 10, 20, 15);
jLayeredPane3.add(jLabel39, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel32.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel32.setText(" L");
jLabel32.setBounds(840, 10, 30, 20);
jLayeredPane3.add(jLabel32, javax.swing.JLayeredPane.DEFAULT_LAYER);
```

```java
javax.swing.GroupLayout jPanel2Layout = new javax.swing.GroupLayout(jPanel2);
jPanel2.setLayout(jPanel2Layout);
jPanel2Layout.setHorizontalGroup(
    jPanel2Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
    .addComponent(jLayeredPane3,        javax.swing.GroupLayout.DEFAULT_SIZE,        1038,
Short.MAX_VALUE)
    );
jPanel2Layout.setVerticalGroup(
    jPanel2Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
    .addGroup(jPanel2Layout.createSequentialGroup()
        .addComponent(jLayeredPane3,        javax.swing.GroupLayout.PREFERRED_SIZE,        98,
javax.swing.GroupLayout.PREFERRED_SIZE)
        .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
    );

jPanel2.setBounds(10, 340, 1050, 130);
jLayeredPane1.add(jPanel2, javax.swing.JLayeredPane.DEFAULT_LAYER);

jPanel4.setBackground(new java.awt.Color(255, 255, 255));
jPanel4.setBorder(javax.swing.BorderFactory.createTitledBorder(null,  "Hv  Winding  Design",
javax.swing.border.TitledBorder.CENTER,        javax.swing.border.TitledBorder.TOP,        new
java.awt.Font("Tahoma", 1, 14), new java.awt.Color(255, 51, 0))); // NOI18N

jLabel54.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel54.setText("T");
jLabel54.setBounds(110, 0, 30, 20);
jLayeredPane5.add(jLabel54, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel55.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel55.setText("1");
jLabel55.setBounds(130, 10, 10, 15);
jLayeredPane5.add(jLabel55, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel56.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel56.setText("=");
jLabel56.setBounds(140, 0, 30, 20);
jLayeredPane5.add(jLabel56, javax.swing.JLayeredPane.DEFAULT_LAYER);

T1.setBackground(new java.awt.Color(0, 153, 255));
T1.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
T1.setOpaque(true);
T1.setBounds(170, 0, 200, 30);
jLayeredPane5.add(T1, javax.swing.JLayeredPane.DEFAULT_LAYER);
```

51

```java
jLabel58.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel58.setText("I");
jLabel58.setBounds(400, 0, 10, 20);
jLayeredPane5.add(jLabel58, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel59.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel59.setText("=");
jLabel59.setBounds(420, 0, 30, 20);
jLayeredPane5.add(jLabel59, javax.swing.JLayeredPane.DEFAULT_LAYER);

I1.setBackground(new java.awt.Color(0, 153, 255));
I1.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
I1.setOpaque(true);
I1.setBounds(450, 0, 200, 30);
jLayeredPane5.add(I1, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel61.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel61.setText("a");
jLabel61.setBounds(710, 0, 20, 20);
jLayeredPane5.add(jLabel61, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel62.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel62.setText("1");
jLabel62.setBounds(720, 10, 30, 15);
jLayeredPane5.add(jLabel62, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel63.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel63.setText("=");
jLabel63.setBounds(740, 0, 30, 20);
jLayeredPane5.add(jLabel63, javax.swing.JLayeredPane.DEFAULT_LAYER);

A1.setBackground(new java.awt.Color(0, 153, 255));
A1.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
A1.setOpaque(true);
A1.setBounds(770, 0, 190, 30);
jLayeredPane5.add(A1, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel65.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel65.setText("1");
jLabel65.setBounds(410, 10, 30, 15);
jLayeredPane5.add(jLabel65, javax.swing.JLayeredPane.DEFAULT_LAYER);

javax.swing.GroupLayout jPanel4Layout = new javax.swing.GroupLayout(jPanel4);
```

```java
jPanel4.setLayout(jPanel4Layout);
jPanel4Layout.setHorizontalGroup(
    jPanel4Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
    .addComponent(jLayeredPane5,        javax.swing.GroupLayout.DEFAULT_SIZE,        1038,
Short.MAX_VALUE)
);
jPanel4Layout.setVerticalGroup(
    jPanel4Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
    .addGroup(jPanel4Layout.createSequentialGroup()
        .addComponent(jLayeredPane5,        javax.swing.GroupLayout.PREFERRED_SIZE,        45,
javax.swing.GroupLayout.PREFERRED_SIZE)
        .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
);

jPanel4.setBounds(10, 246, 1050, 80);
jLayeredPane1.add(jPanel4, javax.swing.JLayeredPane.DEFAULT_LAYER);

jPanel3.setBackground(new java.awt.Color(255, 255, 255));
jPanel3.setBorder(javax.swing.BorderFactory.createTitledBorder(null,        "Magnetic        Frame
Design",    javax.swing.border.TitledBorder.CENTER,    javax.swing.border.TitledBorder.TOP,    new
java.awt.Font("Tahoma", 1, 14), new java.awt.Color(255, 51, 0))); // NOI18N

jLabel66.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel66.setText("=");
jLabel66.setBounds(60, 0, 20, 20);
jLayeredPane4.add(jLabel66, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel67.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel67.setText("t");
jLabel67.setBounds(50, 10, 6, 15);
jLayeredPane4.add(jLabel67, javax.swing.JLayeredPane.DEFAULT_LAYER);

Et.setBackground(new java.awt.Color(0, 153, 255));
Et.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Et.setOpaque(true);
Et.setBounds(90, 0, 140, 30);
jLayeredPane4.add(Et, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel70.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel70.setHorizontalAlignment(javax.swing.SwingConstants.RIGHT);
jLabel70.setText("A");
jLabel70.setBounds(30, 40, 20, 20);
jLayeredPane4.add(jLabel70, javax.swing.JLayeredPane.DEFAULT_LAYER);
```

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```java
jLabel71.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel71.setText("i");
jLabel71.setBounds(50, 50, 3, 15);
jLayeredPane4.add(jLabel71, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel72.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel72.setText("=");
jLabel72.setBounds(60, 40, 20, 20);
jLayeredPane4.add(jLabel72, javax.swing.JLayeredPane.DEFAULT_LAYER);

Ai.setBackground(new java.awt.Color(0, 153, 255));
Ai.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Ai.setOpaque(true);
Ai.setBounds(90, 50, 140, 30);
jLayeredPane4.add(Ai, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel74.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel74.setText("d");
jLabel74.setBounds(240, 0, 10, 20);
jLayeredPane4.add(jLabel74, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel75.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel75.setText("=");
jLabel75.setBounds(260, 0, 20, 20);
jLayeredPane4.add(jLabel75, javax.swing.JLayeredPane.DEFAULT_LAYER);

d.setBackground(new java.awt.Color(0, 153, 255));
d.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
d.setOpaque(true);
d.setBounds(280, 0, 130, 30);
jLayeredPane4.add(d, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel77.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel77.setHorizontalAlignment(javax.swing.SwingConstants.RIGHT);
jLabel77.setText("A");
jLabel77.setBounds(230, 50, 20, 20);
jLayeredPane4.add(jLabel77, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel78.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel78.setText("w");
jLabel78.setBounds(250, 60, 20, 15);
jLayeredPane4.add(jLabel78, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel79.setFont(new java.awt.Font("Tahoma", 1, 16));
```

```java
jLabel79.setText("=");
jLabel79.setBounds(260, 50, 20, 20);
jLayeredPane4.add(jLabel79, javax.swing.JLayeredPane.DEFAULT_LAYER);

Aw.setBackground(new java.awt.Color(0, 153, 255));
Aw.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Aw.setOpaque(true);
Aw.setBounds(280, 50, 130, 30);
jLayeredPane4.add(Aw, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel81.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel81.setText("E");
jLabel81.setBounds(40, 0, 10, 20);
jLayeredPane4.add(jLabel81, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel84.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
jLabel84.setText("<html>mm<sup><i>2</i></sup></html>");
jLabel84.setBounds(90, 0, 110, 40);
jLayeredPane4.add(jLabel84, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel85.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel85.setText("b");
jLabel85.setBounds(420, 0, 10, 20);
jLayeredPane4.add(jLabel85, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel86.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel86.setText("w");
jLabel86.setBounds(430, 10, 20, 15);
jLayeredPane4.add(jLabel86, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel87.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel87.setText("=");
jLabel87.setBounds(450, 0, 20, 20);
jLayeredPane4.add(jLabel87, javax.swing.JLayeredPane.DEFAULT_LAYER);

Bw.setBackground(new java.awt.Color(0, 153, 255));
Bw.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Bw.setOpaque(true);
Bw.setBounds(470, 0, 150, 30);
jLayeredPane4.add(Bw, javax.swing.JLayeredPane.DEFAULT_LAYER);

L.setBackground(new java.awt.Color(0, 153, 255));
L.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
L.setOpaque(true);
```

```java
L.setBounds(470, 50, 150, 30);
jLayeredPane4.add(L, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel90.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel90.setText("L");
jLabel90.setBounds(420, 50, 9, 20);
jLayeredPane4.add(jLabel90, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel91.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel91.setText("=");
jLabel91.setBounds(450, 50, 20, 20);
jLayeredPane4.add(jLabel91, javax.swing.JLayeredPane.DEFAULT_LAYER);

W.setBackground(new java.awt.Color(0, 153, 255));
W.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
W.setOpaque(true);
W.setBounds(680, 0, 140, 30);
jLayeredPane4.add(W, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel93.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel93.setText("W");
jLabel93.setBounds(630, 0, 20, 20);
jLayeredPane4.add(jLabel93, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel94.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel94.setText("=");
jLabel94.setBounds(660, 0, 20, 20);
jLayeredPane4.add(jLabel94, javax.swing.JLayeredPane.DEFAULT_LAYER);

By.setBackground(new java.awt.Color(0, 153, 255));
By.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
By.setOpaque(true);
By.setBounds(890, 0, 140, 30);
jLayeredPane4.add(By, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel96.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel96.setText("b");
jLabel96.setBounds(830, 0, 10, 20);
jLayeredPane4.add(jLabel96, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel97.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel97.setText("y");
jLabel97.setBounds(840, 10, 20, 15);
jLayeredPane4.add(jLabel97, javax.swing.JLayeredPane.DEFAULT_LAYER);
```

```java
jLabel98.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel98.setText("=");
jLabel98.setBounds(860, 0, 20, 20);
jLayeredPane4.add(jLabel98, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel99.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel99.setText("A");
jLabel99.setBounds(630, 50, 20, 20);
jLayeredPane4.add(jLabel99, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel100.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel100.setText(" y");
jLabel100.setBounds(640, 60, 20, 15);
jLayeredPane4.add(jLabel100, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel101.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel101.setText("=");
jLabel101.setBounds(660, 50, 20, 20);
jLayeredPane4.add(jLabel101, javax.swing.JLayeredPane.DEFAULT_LAYER);

Ay.setBackground(new java.awt.Color(0, 153, 255));
Ay.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
Ay.setOpaque(true);
Ay.setBounds(680, 50, 140, 30);
jLayeredPane4.add(Ay, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel103.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel103.setText("h");
jLabel103.setBounds(830, 50, 10, 20);
jLayeredPane4.add(jLabel103, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel104.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel104.setText("y");
jLabel104.setBounds(840, 60, 20, 15);
jLayeredPane4.add(jLabel104, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel105.setFont(new java.awt.Font("Tahoma", 1, 16));
jLabel105.setText("=");
jLabel105.setBounds(860, 50, 20, 20);
jLayeredPane4.add(jLabel105, javax.swing.JLayeredPane.DEFAULT_LAYER);

Hy.setBackground(new java.awt.Color(0, 153, 255));
Hy.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
```

```java
Hy.setOpaque(true);
Hy.setBounds(890, 50, 140, 30);
jLayeredPane4.add(Hy, javax.swing.JLayeredPane.DEFAULT_LAYER);
jSeparator2.setBounds(170, 40, 0, 2);
jLayeredPane4.add(jSeparator2, javax.swing.JLayeredPane.DEFAULT_LAYER);

javax.swing.GroupLayout jPanel3Layout = new javax.swing.GroupLayout(jPanel3);
jPanel3.setLayout(jPanel3Layout);
jPanel3Layout.setHorizontalGroup(
    jPanel3Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
    .addComponent(jLayeredPane4,        javax.swing.GroupLayout.DEFAULT_SIZE,        1038,
Short.MAX_VALUE)
    );
jPanel3Layout.setVerticalGroup(
    jPanel3Layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
    .addGroup(jPanel3Layout.createSequentialGroup()
      .addComponent(jLayeredPane4,        javax.swing.GroupLayout.PREFERRED_SIZE,        98,
javax.swing.GroupLayout.PREFERRED_SIZE)
        .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
    );

jPanel3.setBounds(10, 10, 1050, 130);
jLayeredPane1.add(jPanel3, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLayeredPane6.setBackground(new java.awt.Color(255, 255, 255));
jLayeredPane6.setOpaque(true);

jLabel8.setBackground(new java.awt.Color(255, 204, 204));
jLabel8.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel8.setForeground(new java.awt.Color(0, 102, 255));
jLabel8.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
jLabel8.setText("Power Rating");
jLabel8.setOpaque(true);
jLabel8.setBounds(10, 10, 130, 30);
jLayeredPane6.add(jLabel8, javax.swing.JLayeredPane.DEFAULT_LAYER);

power.setText("0.00");
power.setBounds(150, 10, 80, 30);
jLayeredPane6.add(power, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel4.setBackground(new java.awt.Color(255, 204, 204));
jLabel4.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel4.setForeground(new java.awt.Color(0, 102, 255));
jLabel4.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
```

```
jLabel4.setText("Frequency = 50 Hertz");
jLabel4.setOpaque(true);
jLabel4.setBounds(330, 60, 230, 30);
jLayeredPane6.add(jLabel4, javax.swing.JLayeredPane.DEFAULT_LAYER);

primary.setText("0.00");
primary.setBounds(150, 60, 80, 30);
jLayeredPane6.add(primary, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel9.setBackground(new java.awt.Color(255, 204, 204));
jLabel9.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel9.setForeground(new java.awt.Color(0, 102, 255));
jLabel9.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
jLabel9.setText("Secondary Voltage");
jLabel9.setOpaque(true);
jLabel9.setBounds(330, 10, 130, 30);
jLayeredPane6.add(jLabel9, javax.swing.JLayeredPane.DEFAULT_LAYER);

secondary.setText("0.00");
secondary.setBounds(480, 10, 80, 30);
jLayeredPane6.add(secondary, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel1.setBackground(new java.awt.Color(51, 153, 255));
jLabel1.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel1.setForeground(new java.awt.Color(255, 255, 255));
jLabel1.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
jLabel1.setText("Set Computational Precision");
jLabel1.setOpaque(true);
jLabel1.setBounds(720, 10, 220, 40);
jLayeredPane6.add(jLabel1, javax.swing.JLayeredPane.DEFAULT_LAYER);

jSeparator1.setOrientation(javax.swing.SwingConstants.VERTICAL);
jSeparator1.setBounds(620, 0, 20, 140);
jLayeredPane6.add(jSeparator1, javax.swing.JLayeredPane.DEFAULT_LAYER);

jLabel10.setBackground(new java.awt.Color(255, 204, 204));
jLabel10.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel10.setForeground(new java.awt.Color(0, 102, 255));
jLabel10.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
jLabel10.setText("Integer Part");
jLabel10.setOpaque(true);
jLabel10.setBounds(630, 60, 110, 30);
jLayeredPane6.add(jLabel10, javax.swing.JLayeredPane.DEFAULT_LAYER);
```

```java
jLabel11.setBackground(new java.awt.Color(255, 204, 204));
jLabel11.setFont(new java.awt.Font("Tahoma", 1, 12));
jLabel11.setForeground(new java.awt.Color(0, 102, 255));
jLabel11.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
jLabel11.setText("Decimal Part");
jLabel11.setOpaque(true);
jLabel11.setBounds(630, 100, 110, 30);
jLayeredPane6.add(jLabel11, javax.swing.JLayeredPane.DEFAULT_LAYER);

integerPart.setModel(new javax.swing.DefaultComboBoxModel(new String[] { "5", "1", "2", "3",
"4", "5", "6", "7", "8" }));
integerPart.setBounds(800, 60, 90, 30);
jLayeredPane6.add(integerPart, javax.swing.JLayeredPane.DEFAULT_LAYER);

decimalPart.setModel(new  javax.swing.DefaultComboBoxModel(new  String[] { "5", "1", "2",
"3", "4", "5", "6", "7", "8" }));
decimalPart.setBounds(800, 100, 90, 30);
jLayeredPane6.add(decimalPart, javax.swing.JLayeredPane.DEFAULT_LAYER);

jButton3.setText("Set");
jButton3.setToolTipText("Click to set integer part precision");
jButton3.addActionListener(new java.awt.event.ActionListener() {
    public void actionPerformed(java.awt.event.ActionEvent evt) {
        jButton3ActionPerformed(evt);
    }
});
jButton3.setBounds(920, 60, 60, 30);
jLayeredPane6.add(jButton3, javax.swing.JLayeredPane.DEFAULT_LAYER);

jButton1.setText("Set");
jButton1.setToolTipText("Click to set precision of floating point");
jButton1.addActionListener(new java.awt.event.ActionListener() {
    public void actionPerformed(java.awt.event.ActionEvent evt) {
        jButton1ActionPerformed(evt);
    }
});
jButton1.setBounds(920, 100, 60, 30);
jLayeredPane6.add(jButton1, javax.swing.JLayeredPane.DEFAULT_LAYER);

jButton2.setText("Compute");
jButton2.setToolTipText("Click to set integer part precision");
jButton2.addActionListener(new java.awt.event.ActionListener() {
    public void actionPerformed(java.awt.event.ActionEvent evt) {
        jButton2ActionPerformed(evt);
```

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```java
            }
        });
        jButton2.setBounds(240, 100, 110, 30);
        jLayeredPane6.add(jButton2, javax.swing.JLayeredPane.DEFAULT_LAYER);

        jLabel12.setBackground(new java.awt.Color(255, 204, 204));
        jLabel12.setFont(new java.awt.Font("Tahoma", 1, 12));
        jLabel12.setForeground(new java.awt.Color(0, 102, 255));
        jLabel12.setHorizontalAlignment(javax.swing.SwingConstants.CENTER);
        jLabel12.setText("Primary Voltage");
        jLabel12.setOpaque(true);
        jLabel12.setBounds(10, 60, 130, 30);
        jLayeredPane6.add(jLabel12, javax.swing.JLayeredPane.DEFAULT_LAYER);

        jLabel13.setFont(new java.awt.Font("Tahoma", 1, 18));
        jLabel13.setText("kVA");
        jLabel13.setBounds(240, 10, 50, 30);
        jLayeredPane6.add(jLabel13, javax.swing.JLayeredPane.DEFAULT_LAYER);

        jLabel14.setFont(new java.awt.Font("Tahoma", 1, 18));
        jLabel14.setText("V");
        jLabel14.setBounds(570, 10, 40, 30);
        jLayeredPane6.add(jLabel14, javax.swing.JLayeredPane.DEFAULT_LAYER);

        jLabel15.setFont(new java.awt.Font("Tahoma", 1, 18));
        jLabel15.setText("V");
        jLabel15.setBounds(240, 60, 50, 30);
        jLayeredPane6.add(jLabel15, javax.swing.JLayeredPane.DEFAULT_LAYER);

        jMenu1.setBackground(new java.awt.Color(255, 255, 255));
        jMenu1.setForeground(new java.awt.Color(0, 51, 153));
        jMenu1.setText("Action");
        jMenu1.setToolTipText("");

        jMenuItem2.setAccelerator(javax.swing.KeyStroke.getKeyStroke(java.awt.event.KeyEvent.VK_P,
java.awt.event.InputEvent.SHIFT_MASK | java.awt.event.InputEvent.CTRL_MASK));
        jMenuItem2.setText("View Table");
        jMenuItem2.setToolTipText("Click to print form");
        jMenuItem2.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                jMenuItem2ActionPerformed(evt);
            }
        });
        jMenu1.add(jMenuItem2);
```

```java
    jMenuItem1.setAccelerator(javax.swing.KeyStroke.getKeyStroke(java.awt.event.KeyEvent.VK_I,
java.awt.event.InputEvent.SHIFT_MASK | java.awt.event.InputEvent.CTRL_MASK));
    jMenuItem1.setText("View Image");
    jMenuItem1.addActionListener(new java.awt.event.ActionListener() {
       public void actionPerformed(java.awt.event.ActionEvent evt) {
          jMenuItem1ActionPerformed(evt);
       }
    });
    jMenu1.add(jMenuItem1);

    jMenuItem3.setAccelerator(javax.swing.KeyStroke.getKeyStroke(java.awt.event.KeyEvent.VK_X,
java.awt.event.InputEvent.SHIFT_MASK | java.awt.event.InputEvent.CTRL_MASK));
    jMenuItem3.setText("Exit");
    jMenuItem3.setToolTipText("Click to close form");
    jMenuItem3.addActionListener(new java.awt.event.ActionListener() {
       public void actionPerformed(java.awt.event.ActionEvent evt) {
          jMenuItem3ActionPerformed(evt);
       }
    });
    jMenu1.add(jMenuItem3);

    jMenuBar1.add(jMenu1);

    jMenu2.setText("About");
    jMenuBar1.add(jMenu2);

    setJMenuBar(jMenuBar1);

    javax.swing.GroupLayout layout = new javax.swing.GroupLayout(getContentPane());
    getContentPane().setLayout(layout);
    layout.setHorizontalGroup(
       layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
       .addComponent(jLayeredPane6,          javax.swing.GroupLayout.DEFAULT_SIZE,          1075,
Short.MAX_VALUE)
       .addComponent(jLayeredPane1,          javax.swing.GroupLayout.DEFAULT_SIZE,          1075,
Short.MAX_VALUE)
    );
    layout.setVerticalGroup(
       layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
       .addGroup(javax.swing.GroupLayout.Alignment.TRAILING, layout.createSequentialGroup()
       .addComponent(jLayeredPane6,          javax.swing.GroupLayout.DEFAULT_SIZE,          140,
Short.MAX_VALUE)
       .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
```

```java
        .addComponent(jLayeredPane1,        javax.swing.GroupLayout.PREFERRED_SIZE,        480,
javax.swing.GroupLayout.PREFERRED_SIZE))
    );

    pack();
  }// </editor-fold>//GEN-END:initComponents

private     void      jMenuItem3ActionPerformed(java.awt.event.ActionEvent      evt)      {//GEN-
FIRST:event_jMenuItem3ActionPerformed
System.exit(0);// TODO add your handling code here:
}//GEN-LAST:event_jMenuItem3ActionPerformed

private     void      jButton3ActionPerformed(java.awt.event.ActionEvent      evt)      {//GEN-
FIRST:event_jButton3ActionPerformed
 integerPart2 = Integer.valueOf(String.valueOf(integerPart.getSelectedItem()));// TODO add your
handling code here:
}//GEN-LAST:event_jButton3ActionPerformed

private     void      jButton1ActionPerformed(java.awt.event.ActionEvent      evt)      {//GEN-
FIRST:event_jButton1ActionPerformed
 decimalPart2 = Integer.valueOf(String.valueOf(decimalPart.getSelectedItem()));// TODO add your
handling code here:
}//GEN-LAST:event_jButton1ActionPerformed

private     void      jButton2ActionPerformed(java.awt.event.ActionEvent      evt)      {//GEN-
FIRST:event_jButton2ActionPerformed
//Computation computation = new Computation();
  //System.out.println("Power at first is: "+ getPower());
  pow = Double.parseDouble(power.getText());
//System.out.println("Power at first 2 is: "+ getPower());
  prima = Double.parseDouble(primary.getText());
  seco = Double.parseDouble(secondary.getText());
  //System.out.println("Ai at first is: "+ Ai);
//System.out.println("power val is: "+ power);
displayData();
//t.start();
}//GEN-LAST:event_jButton2ActionPerformed

private     void      jMenuItem2ActionPerformed(java.awt.event.ActionEvent      evt)      {//GEN-
FIRST:event_jMenuItem2ActionPerformed
TableDisplay td = new TableDisplay(this, true);
td.setVisible(true);
td.validate();
td.repaint();
```

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```java
}//GEN-LAST:event_jMenuItem2ActionPerformed

private     void     jMenuItem1ActionPerformed(java.awt.event.ActionEvent     evt)     {//GEN-
FIRST:event_jMenuItem1ActionPerformed
ImageDisplay td = new ImageDisplay(this, true);
td.setVisible(true);
td.validate();
td.repaint();// TODO add your handling code here:
}//GEN-LAST:event_jMenuItem1ActionPerformed

    /**
     * @param args the command line arguments
     */
    public static void main(String args[]) {
        java.awt.EventQueue.invokeLater(new Runnable() {
            public void run() {
                new Index().setVisible(true);
            }
        });
    }

    // Variables declaration - do not modify//GEN-BEGIN:variables
    private javax.swing.JLabel A1;
    private javax.swing.JLabel A2;
    private javax.swing.JLabel Ai;
    private javax.swing.JLabel Aw;
    private javax.swing.JLabel Ay;
    private javax.swing.JLabel Bw;
    private javax.swing.JLabel By;
    private javax.swing.JLabel CuLossLu;
    private javax.swing.JLabel Edloss;
    private javax.swing.JLabel Et;
    private javax.swing.JLabel Hloss;
    private javax.swing.JLabel Hy;
    private javax.swing.JLabel I1;
    private javax.swing.JLabel I2;
    private javax.swing.JLabel L;
    private javax.swing.JLabel Lc;
    private javax.swing.JLabel Lt;
    private javax.swing.JLabel Ly;
    private javax.swing.JLabel T1;
    private javax.swing.JLabel T2;
    private javax.swing.JLabel W;
    private javax.swing.JLabel cuLossHu;
```

```java
private javax.swing.JLabel d;
private javax.swing.JComboBox decimalPart;
private javax.swing.JComboBox integerPart;
private javax.swing.JButton jButton1;
private javax.swing.JButton jButton2;
private javax.swing.JButton jButton3;
private javax.swing.JLabel jLabel1;
private javax.swing.JLabel jLabel10;
private javax.swing.JLabel jLabel100;
private javax.swing.JLabel jLabel101;
private javax.swing.JLabel jLabel103;
private javax.swing.JLabel jLabel104;
private javax.swing.JLabel jLabel105;
private javax.swing.JLabel jLabel107;
private javax.swing.JLabel jLabel11;
private javax.swing.JLabel jLabel12;
private javax.swing.JLabel jLabel13;
private javax.swing.JLabel jLabel14;
private javax.swing.JLabel jLabel15;
private javax.swing.JLabel jLabel18;
private javax.swing.JLabel jLabel2;
private javax.swing.JLabel jLabel20;
private javax.swing.JLabel jLabel21;
private javax.swing.JLabel jLabel22;
private javax.swing.JLabel jLabel27;
private javax.swing.JLabel jLabel28;
private javax.swing.JLabel jLabel29;
private javax.swing.JLabel jLabel3;
private javax.swing.JLabel jLabel30;
private javax.swing.JLabel jLabel32;
private javax.swing.JLabel jLabel34;
private javax.swing.JLabel jLabel35;
private javax.swing.JLabel jLabel36;
private javax.swing.JLabel jLabel37;
private javax.swing.JLabel jLabel39;
private javax.swing.JLabel jLabel4;
private javax.swing.JLabel jLabel43;
private javax.swing.JLabel jLabel44;
private javax.swing.JLabel jLabel46;
private javax.swing.JLabel jLabel47;
private javax.swing.JLabel jLabel49;
private javax.swing.JLabel jLabel5;
private javax.swing.JLabel jLabel50;
private javax.swing.JLabel jLabel51;
```

```java
private javax.swing.JLabel jLabel53;
private javax.swing.JLabel jLabel54;
private javax.swing.JLabel jLabel55;
private javax.swing.JLabel jLabel56;
private javax.swing.JLabel jLabel58;
private javax.swing.JLabel jLabel59;
private javax.swing.JLabel jLabel6;
private javax.swing.JLabel jLabel61;
private javax.swing.JLabel jLabel62;
private javax.swing.JLabel jLabel63;
private javax.swing.JLabel jLabel65;
private javax.swing.JLabel jLabel66;
private javax.swing.JLabel jLabel67;
private javax.swing.JLabel jLabel7;
private javax.swing.JLabel jLabel70;
private javax.swing.JLabel jLabel71;
private javax.swing.JLabel jLabel72;
private javax.swing.JLabel jLabel74;
private javax.swing.JLabel jLabel75;
private javax.swing.JLabel jLabel77;
private javax.swing.JLabel jLabel78;
private javax.swing.JLabel jLabel79;
private javax.swing.JLabel jLabel8;
private javax.swing.JLabel jLabel81;
private javax.swing.JLabel jLabel84;
private javax.swing.JLabel jLabel85;
private javax.swing.JLabel jLabel86;
private javax.swing.JLabel jLabel87;
private javax.swing.JLabel jLabel9;
private javax.swing.JLabel jLabel90;
private javax.swing.JLabel jLabel91;
private javax.swing.JLabel jLabel93;
private javax.swing.JLabel jLabel94;
private javax.swing.JLabel jLabel96;
private javax.swing.JLabel jLabel97;
private javax.swing.JLabel jLabel98;
private javax.swing.JLabel jLabel99;
private javax.swing.JLayeredPane jLayeredPane1;
private javax.swing.JLayeredPane jLayeredPane2;
private javax.swing.JLayeredPane jLayeredPane3;
private javax.swing.JLayeredPane jLayeredPane4;
private javax.swing.JLayeredPane jLayeredPane5;
private javax.swing.JLayeredPane jLayeredPane6;
private javax.swing.JMenu jMenu1;
```

```java
private javax.swing.JMenu jMenu2;
private javax.swing.JMenuBar jMenuBar1;
private javax.swing.JMenuItem jMenuItem1;
private javax.swing.JMenuItem jMenuItem2;
private javax.swing.JMenuItem jMenuItem3;
private javax.swing.JPanel jPanel1;
private javax.swing.JPanel jPanel2;
private javax.swing.JPanel jPanel3;
private javax.swing.JPanel jPanel4;
private javax.swing.JSeparator jSeparator1;
private javax.swing.JSeparator jSeparator2;
private javax.swing.JTextField power;
private javax.swing.JTextField primary;
private javax.swing.JTextField secondary;
// End of variables declaration//GEN-END:variables} [8][9][10].
```