INFLUENCES OF TRANSFORMER WINDING TO THE PERFORMANCE OF DC-AC INVERTER

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THE INFLUENCES OF TRANSFORMER WINDING TO THE PERFORMANCE OF DC-AC INVERTER

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2012

I declare that this report entitle "Infuences of Transformer Winding to the Performance of DC-AC Inverter" is the result of my own work research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ………………………………….

Name : ……………………………………………………

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" I hereby declare that I have read through this report entitle "Influences of Transformer Winding to the Performance of DC-AC Inverter" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)."

Signature : ………………………………….

Supervisor's Name : …………………………………………………

Date : …………………………………………

Dedicated to my beloved parents..

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ABSTRACT

The study is focusing on the influences of high frequency transformer parameter for DC-AC inverter. In order to carried out this project, a simple DC-AC inverter circuit is design and construct. The transformation of DC voltage from 12Vdc to 240Vac is accomplished by using dc-to-ac inverter circuit and the power is in the range of 5W while assume the input DC voltage is constant. The load used is the incandescent bulb. This project start with the construction of DC-AC inverter which consist of high frequency transformer. The high frequency transformer is used due to the small size and small weight. Practically this is done by using several size of windings and core during construction of high frequency transformer. Other than that, the high frequency transformer is construct with several configuration of windings turns. Besides that this project need to find out suitable and simple DC-AC inverter circuit. Consequently, the operation of selected circuit and each components in the circuit is studied. Lastly analyze the effect of windings size and number of turns and study the operation of the transformer. As a conclusion, this project is to construct DC – AC inverter which be able to convert low input voltage to a high output voltage with the suitable size of wire and number of turns.

ABSTRAK

Kajian ini memberi tumpuan kepada pengaruh frekuensi tinggi untuk pengubah DC-AC inverter. Untuk menjalankan projek ini, satu litar DC-AC inverter yang mudah direka bentuk dan dibina. Transformasi voltan DC dari 12Vdc kepada 240VAC dicapai dengan menggunakan litar DC-AC inverter dan kuasa dalam julat 5W dengan menganggap input voltan DC adalah malar. Beban adalah mentol pijar. Projek ini adalah untuk membina DC-AC inverter yang terdiri daripada pengubah berfrekuensi tinggi. Pengubah berfrekuensi tinggi digunakan kerana saiz yang kecil dan ringan. Secara praktikalnya, ini dilakukan dengan menggunakan saiz beberapa lilitan dan saiz teras yang berbeza semasa pembinaan pengubah berfrekuensi tinggi. Selain daripada itu, projek ini turut membina pengubah berfrekuensi tinggi dengan konfigurasi beberapa bilangan lilitan. Selain itu, projek ini dilakukan untuk mencari litar DC-AC yang sesuai dan mudah. Oleh sebab itu, operasi litar yang dipilih dan setiap komponen dalam litar dikaji. Akhir sekali, kesan saiz dan bilangan lilitan dianalisis dan mengkaji operasi pengubah.

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CHAPTER 1

INTRODUCTION

1.1 DC to AC Inverter basics

A DC to AC inverter is a device that accepts a DC input voltage and produce an AC output. In many applications, it is required to convert a fixed voltage dc source into variable ac source. Typically the output produced is at different voltage level than the input[3].The switch mode dc to ac inverters have been used in various type of applications such as unintenuptible power supplies, communications ring generators, aerospace power systems, and variable speed ac machine drives.[6]

In any type of DC-AC inverter circuit, the selection of power device for a particular application not only the required voltage and current levels but also it's switching characteristics.The key parameters to look for in the transistor are the switching time and current rating. These two parameters greatly affect the maximum switching frequency of the inverter, and also how much current the inverter can be designed for because switching speed and associated power losses are very important in the power electronics circuits. For example, the BJT transistor is minority-carrier device, whereas the MOSFET is a majority-carrier device that does not have minority carrier storage delays, giving the MOSFET advantage in switching speeds. BJT transistor switching time may be magnitude longer than MOSFET. Therefore, the MOSFET generally has lower switching losses.

1.2 Problem Statement

Nowadays the transformer that available in market is choose without study the details on the design and construction of the transformer. To explore this matter, the research is carried out to study the transformer winding configuration and its effects. The main criteria that will be investigate is the type of winding and the number of turns. This will be study in detail for the DC-AC inverter application. Below are some of research question or design ideas:-

i. How to provide the complete information on the design and the construction of transformer?
ii. How to achieve the optimum performance of the transformer?
iii. The increasing of electrical appliances that used AC inversion.

1.3 Project Objectives

The objectives of this undertaken project are:

i. To study the influences of transformer winding to the performance of the DC-AC inverter.
ii. To find the relationship between the transformer windings in terms of size and number of turns.
iii. To determine the suitable number of turns and winding size to achieve the optimum performance of the transformer.

1.4 Project Scopes

The scopes for this project are:

i. Simple DC-AC inverter circuit is construct and used to study the effect of transformer winding.
ii. The inverter output is 240V AC and the maximum power is 5W.
iii. Assuming that the input DC is constant while the load is incandescent bulb.
iv. This project is focusing on two characteristics of the transformer which are windings and number of turns.
v. Range of winding turns.
vi. Range of winding size.

CHAPTER 2

LITERITURE REVIEW

2.1 Introduction of transformer

Generally, a transformer is used to step-up and step-down the voltage. A transformer that increases voltage from primary to secondary (more secondary winding turns than primary winding than primary winding turns) is called a step-up transformer . Otherwise a transformer designed to do just the opposite is called a step-down transformer. For a step down transformer, this transformer converts high-voltage, low-current power into low-voltage, high-current power while for step-up transformer, it converts low-voltage, high-current power into high-voltage, low-current power[1]

The transformer is an electrical machine that allows the transmission and distribution of electrical energy simply and inexpensively, since its efficiency is from 95% to 99%. This means that the transformer changes one ac voltage level to another while keeping the input power. In a step-up transformer the secondary voltage is higher than the primary voltage, to keep the input power equal to the output power which means that the secondary current has to be lower than the primary current[6]. In order to reduce the voltage in power distribution networks, factories, commercial buildings, and residences to a level which the equipment and appliances can operate, step-down transformer are used.

2.2 Transformer windings

There are two types of transformer windings which are concentric windings and sandwich windings. The following are the most important requirements of transformer windings:

i. The windings must be economical.
ii. The heating conditions of the windings should satisfy standard requirements.
iii. The windings must have good mechanical strength to combat the force that originates due to short circuit.
iv. The windings must have the necessary electrical strength during over-voltage.

2.2.1 Concentric windings

Figure 2.1 shows concentric windings which are used for core-type transformers. These windings are further divided as follows[4]:

i. Cross-over winding: used for current up to 20A and suitable for high voltage windings of small transformers.
ii. Helical winding: consists of rectangular strips wound in the form of helix and suitable for low voltage windings of large transformers. Extra insulation between layers is required in addition to insulation of conductors in order to use these coils for high voltage windings.
iii. Continuous disc winding: consists of a number of flat strips wound spirally from inside (radially) outwards. To complete the windings or section of winding between the tappings, the length of used conductors must be sufficient. The conductors can be either single strip or a number of strips in parallel for robust construction for each disc.

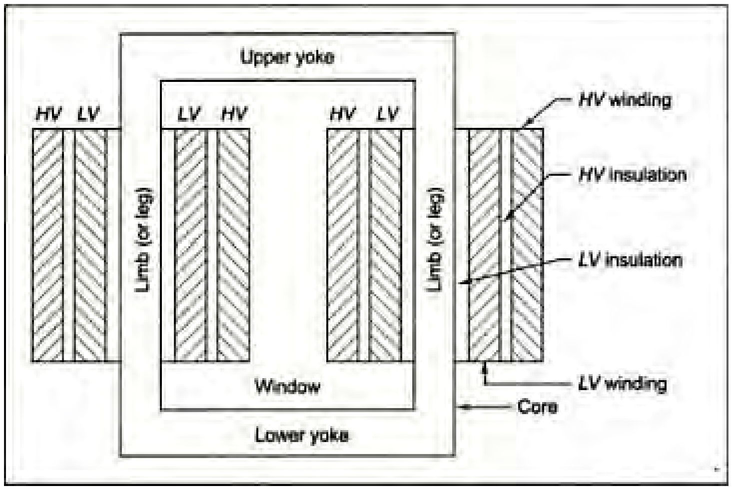

Figure 2.1: Concentric windings

2.2.2 Sandwich windings

Figure 2.2 shows sandwich windings used in shell type transformers. Each high voltage section lies between two low voltage sections when the high voltage and low voltage windings are split into a number of sections. Leakage can easily be controlled in sandwich coils. By proper division of windings, desired value of leakage reactance can be obtained.[4]

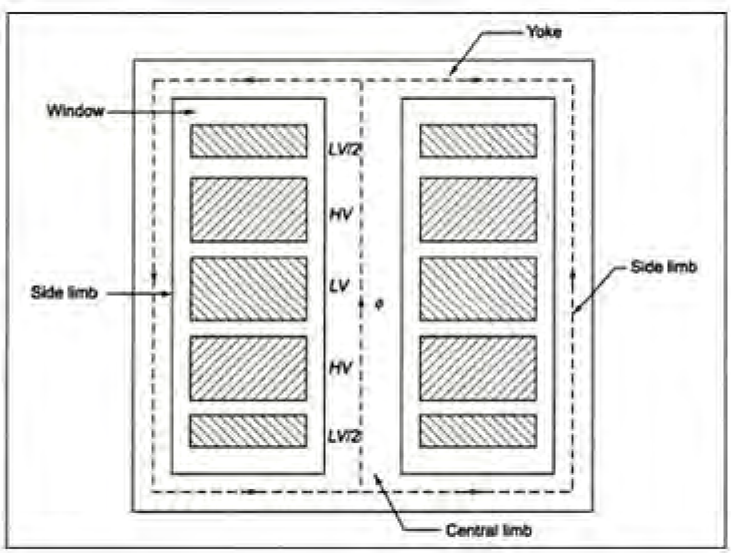

Figure 2.2: Sandwich windings

2.3 Induced e.m.f

An e.m.f is produced or induced in the conductor when relative movement of a conductor and a magnetic flux takes place in such a way that the conductor cuts through lines of force. The magnitude of this e.m.f at any instant is proportional to the rate at which lines of force are cut. There are three ways where the lines of force may be cut by a conductor:

i. The conductor may move in a fixed and constant field, as in D.C dynamo.
ii. A constant field may move relative to a fixed conductor, as in an alternator.
iii. The strength of the field passing through a geometrically closed circuit may vary.

In this last case, during an increase of the strength of the field the extra line of force are conceived to cut the conductor as they are produced, and if this conductor takes the form of a coil of many turns, each line produced or extinguished cuts every turns, and the rate of cutting of lines of force by the whole circuit is equal to the rate of change of the number of lines through it multiplied by the number of turns. It is called the flux linkages when the product of the number of turns in a circuit by the number of lines of force passing through. Hence the e.m.f induced is proportional to the rate of change of flux-linkages. The induced e.m.f is 1 volt when the flux-linkages change at the rate of 100,000,000 per second.

2.4 Exciting current

The flux produced in a magnetic material is not proportional to the magnetizing current, and it follows from this that the time variation of the current required to produce a sinusoidal alternating flux cannot be sinusoidal. From figure 2.3 it is shown that the graph of the hysteresis loop of a magnetic loop for stipulated maximum value of B, it is easy to obtain the wave form or graph of the time variation of the exciting current required to produce a sinusoidal flux[3]. Each point in the sinusoidal flux curve determines a point on the hysteresis loop to which corresponds a value of H, hence of the exciting current. From figure 2.3 it is seen first that the shape of this wave is peaky and not sinusoidal like the flux wave, and secondly that the current passes through its zero values before the flux.

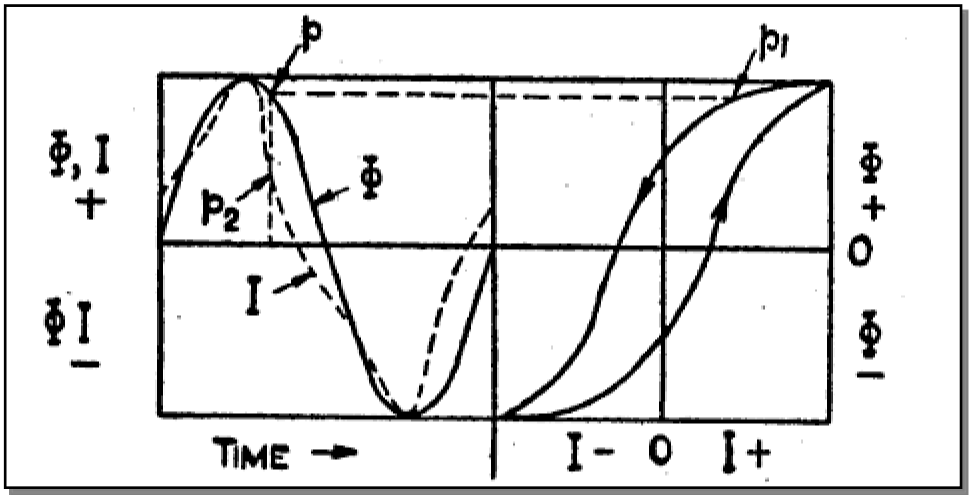

Figure 2.3: Graph of hysteresis loop of a magnetic loop

From figure 2.3 the flux variation is ¼ cycle behind the voltage producing the magnetising current. The lag of this current in the voltage is thus less than ¼ cycle and this means that power must be expanded in sustaining the alternating flux.

2.5 Voltage regulation

The ouput voltage of a transformer varies some with varying load resistances, even with a constant voltage input. The primary and secondary winding inductances affected the degree of variance but among other factors, the primary and secondary windings not the least of which includes winding resistance and the degree of mutual inductance (magnetic coupling). It is good to have the secondary voltage vary as little as possible for wide variances in load current for power transformer applications, where the transformer is seen by the load (ideally) as a constant voltage. The transformer's voltage regulation means that the measure of how well a power transformer maintains constant secondary voltage over a range of load currents. The formula of voltage regulation is shown below:

Regulation percentage = $\frac{E_{no\ load} - E_{full\ load}}{E_{full\ load}}$ (100%) (2.1)

The point at which the transformer is operating at maximum permissible secondary current is called “full-load”. This operating point will be determined primarily by the winding wire size (ampacity) and the method of transformer cooling. A good power transformer should exhibit a regulation percentage of less than 3% while an ideal transformer the voltage regulation is zero[2]. The lower the percentage (closer to zero), the more stable the secondary voltage and the better regulation it will provide[2].

2.6 Practical considerations

2.6.1 Power capacity

To make a transformer to be an ideal transformer, it would have perfect coupling (no leakage current), perfect voltage regulation, perfectly sinusoidal exciting current, no hysteresis or eddy current losses, and wire thick enough to handle any amount of current. Winding conductor insulation is a concern where high voltages are encountered, as they often are in step-up and step-down power distribution transformer. In order to maintain electrical isolation between windings, not only do the windings have to be well insulated from the iron core, but each windings has to be sufficiently insulated from the other.

2.6.2 Energy losses

Generally power loss is caused due to resistance of the wire windings. The windings has three types of loss which are loss due to dc resistance, loss due to induced current arising from alternating flux leakages and circulating loss[7]. There will always be power dissipated in the form of heat through the resistance of current-carrying conductors unless superconducting wires are used. Increasing the gauge of the winding wire is one way to minimize the loss, but only with substantial increase in cost, size, and weight.

Iron is a fair conductor of electricity, but not as good as the copper or aluminium from which wire windings are typically made. As they circulate through the core, these "eddy-currents" must overcome significant electrical resistance. They dissipate power in the form of heat in overcoming the resistance offered by the iron. Hence, it is difficult to eliminate a source of inefficiency in the transformer. When the transformer frequency increase, the energy losses tend to worsen. As the frequency goes up and creating more power lost through resistive dissipation, the effective resistance will be increase due to the skin effect within winding