Chapter I

INTRODUCTION

CHAPTER-I

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1.Ø HISTORICAL

The transformer owes its existence to the pioneering work of H.C. Oersted[7,14,15], who discovered electromagnetism in 182Ø, and to Michel Faraday and Joseph Henry. Andre M. Ampere and Arago demonstrated that the hard steel needles could be made in to permanent magnets by placing them inside the coil carrying a dc current. In 1825 Sturgeon demonstrated that, if soft iron inserted in to a coil carrying a dc current, the iron is magnetized, but magnetization vanishes when the current is switched off. This formed the basis of transformer action.

Michel Faraday performed the experiments and demonstrated that whenever magnetic lines of force pass through or "cut" the winding of a coil, a current is produced in the circuit.

The 'Induction-coil' developed during Faraday's time (still called that in the telephone industry) is today known as "Static -transformer". The transforming characteristics, originally applied to the transformation of magnetic into electrical energy, is now largely applied to the transformation of voltage, current and impedance from one level to another.

For many years after Faradays announcement of discovery of electromagnetic induction, it had no "practical-value". No one thought of the transformer as a means for economical distribution of power.

It took Tesla seven years to put his ideas in actual practice, and made the electrical motor to run on ac-power. He designed a system, and one of many ancillary devices for his system was the transformer.

The Stanley[15] worked out a practical form of transformer and applied. In 1886, he succeeded in lighting some stores in Great Barrington, Mass, at a distance of about half a mile from the generator using 500 volts on the line and transformers to step down the voltage at the receiving end. The success of this installation led the establishment of other alternating current systems.

For several years, there was heated opposition to the "deadly alternating current"[5,15], with its high voltage. Until the later part of 19th century, the power in use was almost direct current. The ac-power was available,but it was considered to be a kind of synthetic electricity. However, the economic advantages were so evident that, it became the accepted system of distribution and with the rise of alternating current system arose the need for transformers.

1.1 NECESSITY AND APPLICATIONS OF TRANSFORMERS

Transformers are passive and among the most efficient devices[4], 95% efficiency being common and 99% being achievable. There is practically no upper limit to their power handling capability, and lower limit is set only by allowable no load loss. Transformers and inductors perform fundamental circuit functions. They are necessary components in electrical system as diverse as distribution terminals for multimega-watt power generating stations to hand-hold radio transmitter operating on fraction of watt.

Transformers are indispensable for voltage transformation in power applications. Their ablity to isolate circuits and to alter ground conventions can often be matched in no other convenient manner. They are needed in frequency selective circuits, whose operations depends on the response of inductances. They are rugged, being capable of withstanding severe environmental conditions.

Transformers are essentially single[4] application devices. Designed for specific requirements, they do not offer optimum performance over a wide range of operation. They are not outstanding performers in applications requiring high fidelity reproduction of audio or video signals. Wideband and high impedance circuits often experience serious degradation when transformers are used.

Transformers don't perform well in circuits which apply dc-magnetization of the core. They are a problem in equipment in which size and weight must be kept to a minimum.

1.2 CLASSIFICATION OF TRANSFORMERS

Transformers can be classified on the basis of[1,16,17]

a) Number of phases

b) Relative position of windings and the magnetic circuit (core)

c) Methods of cooling

d) Ratings, and

e) The service conditions

However the dividing line is more arbitrary than fundamental.

The classification of transformers according to quantity emphasized to transform is as follows.

i) Voltage Transformer

ii) Power Transformer

iii) Current Transformer

iv) Impedance Transformer

v) Pulse Transformer

When the transformers are used in a particular application, they can also be classified accordingly, eg.[2,7]

vi) Rectifier transformer

vii) Converter/Inverter transformers

viii) Auto - transformer

i) Voltage Transformer[7] :

This transformer is designed to achieve accurate voltage ratio, constant over its load range. It is commonly used to supply instruments such as voltmeters, voltage coils on wattmeters, protective relays and the like. It finds uses in stepping-up very low voltages for ease measurement and stepping-down very high voltages to a low levels for safety measurement.

ii) Power Transformer[6,13] :

It is essentially a voltage transformer. It is too, required to achieve an accurate voltage ratio that is substantially constant over its range of loads. The regulations expected to be reasonably good.

The power transformer is widely used of all transformers, and ranges in size from mighty high power component used in distribution system to miniscule types found in charger adapter for pocket calculator. This range includes transformer in radio, TV's, toys and equipment of all kind of home and industry.

iii) Current Transformer[7,17]

A little known in the experimenter circle is the current transformer. It is required to achieve a highly accurate and constant current transformation ratio. It is commonly used to supply wattmeters and protective overcurrent relays. The current transformer is generally placed in series with a high current circuit, and hence sometimes known as 'series-transformer'.

iv) Impedance Transformer[7,17] :

This is common class of transformer variously referred to as impedance, matching, speaker, input, output, or coupling transformers, depending on the specific application. This type of transformer is designed to obtain an accurate impedance transformation, particularly in low frequency amplifiers.

v) Pulse Transformer[9] :

The pulse transformer is basically a transformer which couples a source of electrical pulses to the load with its shape and other properties maintained. Historically, this was developed for use in radar system. Later on it was exploited in the fields like communication, digital electronics and the like. These are used as an effective tool for triggering the semiconductor devices like thyristors, triac etc. Present day pulse transformers cover a wide range of pulses and power levels.

vi) Rectifier Transformer[10] :

Rectifier circuits are among the most common types of transformer loads, however require special attention. They create severe distortion of current waveform in the windings, which heat up to greater extent. This is the reason why the rectifier transformers are designed for greater VA-ratings than for straight loads.

vii) Converter /Inverter Transformers[8,11] :

In the converter and inverter circuits the transformer is the corner stone of the entire function in which it is not only transforms power, but also governs the operational frequency and overall efficiency.

The purpose of the converter is to transfer power from a dc source, frequently low voltage battery, to a load requiring different usually higher dc voltage for this reason it is sometimes called a "dc-transformer'.

Using the same kind of dc-source, the inverter is required to transfer power to a load requiring ac-voltage at different frequencies. This is used to deliver power to the domestic equipments, such as TV sets, radios, kitchen appliances at lower frequency of about 50 Hz, while in aircraft it has to supply power at relatively higher frequencies of 400 Hz or 1000 Hz. This has big advantage that the equipment it powers can be made smaller and lighter.

viii) Auto Transformer[7,16] :

The transformer is based on the characteristics of tapped winding. Electrically it is almost identical with standard two winding transformer. Unfortunately the valuable isolation feature is lost. This is generally used to obtain small increments of voltage above (or below) the input voltage, and closer the output-to-input voltage ratio to 1.0, the better is the performance. Auto-transformers are used in voltage stabilizers.

No matter what they are called, all loaded transformers transmit power and transform voltage, current and impedance. The factor that makes one transformer different from another is simply that, in its design one aspect of transformation is selected for emphasize over others.

"At heart they are all the same"

1.3 TRANSFORMERS IN ELECTRONICS INDUSTRY[3,12] :

The electronics industry has evolved through successful applications of device from vacuum tube to proliferating family of semiconductors. However, The transformer has remained an indispensable part of electronic-circuits, and is called "electronic-transformer". This has features which distinguish it from those used in power utility field.

The basic component of electronic circuits- the transformer entered the commercial and governmental market

areas. Apart from the technical considerations, both the market areas gave stress on cost, reliability, size. These market demand affected profoundly the design and development of electronic transformers. A more difficult requirement arose with the development of mobile, aircraft, missile, satellite and space vehicle system.

The transformer tend to be large and heavy compared with other basic components such as resistors and capacitors, and as a result "miniaturization" has become a dominating motif in the design and construction of transformers, in electronics industry.

1.4 PROPOSED PLAN OF WORK

The transformer stirred the imagination[9,12] of designers since long back. However, in recent years semiconductor devices have caught the imagination of electrical and electronics engineers. While transformers have lost their fascination, the present technology is still based on their successful exploitation.

An attempt will be made to ease some of the difficulties the user and designer face from the limitations of these components, the resolution of which is still painfully evolving. The transformer design is largely an affair of "cut and try". It goes through iterative procedure till the desired performance is achieved. This requires

hours, or even days together. There may be wide range of levels of interest, and to cater for all in one attempt is impossible. However the software route is essentially going to be a practical "how-to-design" approach, proposed on the substantial but simple "how-it-works" frame.

The aim of the Computer Aided Design (CAD) is to avoid routine paper work that takes objectionable time, and a casual experimenter who can't afford to deassemble the work and start a fresh just because of insufficient allowances were made for various mechanical fits, it was proposed to go for the design of various transformers through a "software-approach". The "BASIC" provides sufficient facilities, besides being "easy-to-understand" language, it was decided to develop the software-package in **"BASIC-LANGUAGE".**

From the data available on the use of transformers in various electronic-applications and the mathematical techniques on the design, it was decided to limit the designing to only few transformers, namely

i) Power Transformer
ii) Auto Transformer
iii) Current Transformer
iv) Impedance Transformer
v) Rectifier Transformer
vi) Converter Transformer
vii) Invertor Transformer
viii) Pulse Transformer

Stress will be given mainly on the design of power transformer, which is the most general form of other transformers. In case of other transformers, the software will be prepared in the light of typical applications.

The high cost of transformer is due to the lack of standardization of materials needed, and the process inherent in their manufacture. With this respect, the use of standard EI-stampings will be made as a "core", except for pulse-transformer, where standard grade ferrite pot cores will be suggested being the more suitable.

The "software-approach" to transformer design will not be a instructional project, rather it will deal with the method used in designing transformer to meet one's specific need. The construction-data will be dealt with in broad and general forms.

A great deal of attention will be paid to the mechanical as well as electrical aspect of design. There will be mathematics to be sure, but not calculus , only elementary algebra and arithmatics. With little background of transformer anatomy, with the aid of software package it is expected that one may go for transformer design with his/her own specification in a record minimum time and without too many references in hand.

REFERENCES

1) A Course in Electrical Machine Design
   - A.K.Sawhney.
   Dhanpat Rai & sons, Delhi.

2) Basic Electricity
   - Harry Mileaf.
   B. D. taraporevala sons & Co. Pvt. Ltd., Bombay.

3) Electronic Transformer
   - H. M. Nordenberg.
   Reinhold Publishing Corporation, New York.

4) Handbook of Transformer Applications.
   - William M. Flanagan.
   Mc Graw Hill Book Company, New York.

5) Magnetic Circuits and Transformer
   -M.I.T. Electrical Engineering Staff
   John Wiley & sons, Inc., New York.

6) Modern Power Transformer Practice
   -Edited by R. Feinberg.
   The Macmillan Press Ltd., London.

7) Practical Transformer Design Handbook
   -Eric Lowdon.
   B.P.B. Publications, New Delhi - 6.

8) Principles of Inverter Circuits
   -B. D. Bedford and R. G. Hoft
   John Wiley and sons, Inc., New York.

9) Pulse Transformers : Design and Fabrication
   -M. A. Nadkarni. S. R. Bhat.
   Tata Mc Graw Hill Publishing Co. Ltd., New Delhi.

10) Rectifier Circuits, Theory And Design
   -By Schaefer
   Wiley & Sons. New York.

11) Switching Power Converters
   -Wood P.
   Van Nostrand Reinhold, New York.

12) Transformers For Electronic Circuits
   -Nathan R. Grossner
   Mc Graw Hill Book Company. New York.

13) Transformers For The Electronic Power Industry
-R. Bean et al.
Mc Graw Hill Book Company, New Delhi.

14) Transformer Design
-Dymkov
Translated from Russian By A. Gavirilovetes
MIR Publishers, Moscow.

15) Transformers : Principals and Practice
-J.B. Gibbs
Mc Graw Hill Book Company, London.

16) Transformers
Bharat Heavy Electricals Limited, Bhopal
Tata Mc Graw Hill Publishing Company Ltd., New Delhi.

17) Transformers
-Kenneth L. Gebert, Kenneth R. Edwards
D. B. Taraporevala Sons & Co.Pvt. Ltd., Bombay.

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