Research Paper

Design and Analysis of Transformer Using MATLAB

Engineering

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ABSTRACT
This paper presents a MATLAB program that utilizes a Graphical User Interface (GUI) tocalculate the electrical quantities and the efficiency of a power transformer. The GUI isdesigned in such a way to allow the user to enter the resistances and reactances of the primaryand the secondary sides, the resistance and reactance that represent the core, the rating of thetransformer and the transformer turn ratio. This program performs the calculations with respectto the popular exact and approximate models of transformers for both cases, referred to primaryand to secondary. This allows the user to compare the obtained results and notice the effects ofapproximation on the values. Also, we can check the validity of their solutions ofhomework problems involving transformers.

INTRODUCTION

A transformer is an electrical device that transfers energy from one electrical circuit to another purely by magnetic coupling. Essentially, transformers consist of two electrical conductors called the primary winding and the secondary winding which are coupled magnetically together by a magnetic circuit. A transformer works based on the principle that energy can be efficiently transferred by magnetic induction from one winding to another winding by a varying magnetic field produced by alternating current. The magnetic circuit or core of a transformer is designed to provide a path for the magnetic field, which is necessary for induction of voltages between the windings. A path of low reluctance (that is, low resistance to magnetic lines of force), is normally used for this purpose. In addition to providing a low reluctance path for the magnetic field, the core is designed to prevent the circulation of electric currents within the core. Such circulating currents, called eddy currents cause heating and energy loss in the transformer. In addition, in transformer design, engineers must ensure that compatibility with the imposed design specifications is met, while keeping manufacturing costs low [1, 2]. Consequently, the complexity of transformer design demands reliable and rigorous solution methods.). In view of the challenges, a user-friendly and effective way for calculating the magnetic circuit parameters of power transformers through the use of software is seriously required. Given that MATLAB is one of the most popular mathematical programs used in engineering analysis, in this paper a MATLAB–based software tool will be developed for the design of the magnetic circuits of power transformers. In this case, the software tool will make use of the MATLAB Application Program Interface (API) to extend the functionalities of MATLAB application to include the

Design of the magnetic circuit of power transformers.

Specifically, this paper presents the design of the magnetic circuit of power transformers using MATLAB–based software presented in this paper. Sample design problem is used to demonstrate the effectiveness of the software solution.

Transformer Overview

The major function of power transformers is to transfer electric energy from one circuit(primary) to another circuit (secondary) at a higher or a lower voltage. When used for thepurpose of raising the voltage they are referred to as step-up transformers, and for lowering thevoltage as step-down transformers. Transformers can be modeled as either ideal transformers oractual transformers. In the case of ideal transformer, many assumptions have to be considered.

Some of these assumptions are the magnetic material is infinitely permeable and does notsaturate, negligible core loss, all flux is confined within the magnetic core and each winding hasno resistance. While in the case of actual transformer, these assumptions are no longerapplicable.

Exact Model of Transformer

The exact model of a transformer is shown in Figure 1. The parameters involved are theprimary terminal voltage, P V, secondary terminal voltage, S V, primary current, P I, secondarycurrent, S I, excitation current, F I, primary resistance, RP, secondary resistance, RS, primaryleakage reactance, XP, secondary leakage reactance, XS, core resistance, RC, and magnetizingreactance, XM. Usually it is preferred to reflect the secondary side of the transformer to itsprimary side or the primary side to its secondary side. This will simplify the calculation

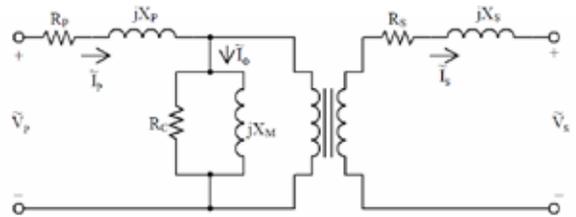**involved and results will be obtained in a faster manner.**

Figure 1. Exact Model of transformer

The transformer exact model when it is referred to its primary is shown in Figure 2. Figure 3shows the transformer exact model when it is referred to its secondary.
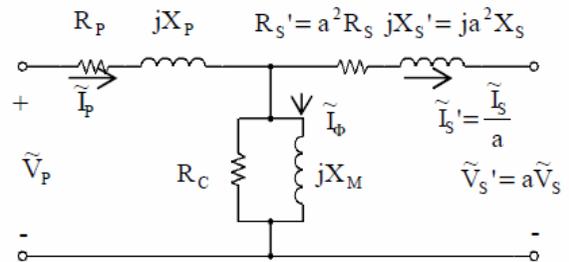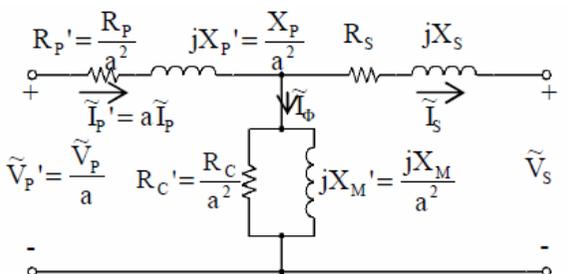

Figure 2

Figure 3

Approximate Models of Transformer
In engineering analysis involving the transformer as a circuit element, it is customary to adoptone of several approximate forms of the equivalent circuit of Figure 1 rather than the full circuit.

The approximations chosen in a particular case depend largely on physical reasoning based onorders of magnitude of the neglected quantities. Figure 4 shows an approximate model that theshunt branch is moved to primary side and the transformer is referred to its primary. Theapproximate model when the shunt branch is moved to secondary side and the transformer isreferred to its primary is shown in Figure 5. Figure 6 shows the model when the shunt branch ismoved to primary and the transformer is referred to its secondary while Figure 7 shows the samecase with the shunt branch moved to secondary.
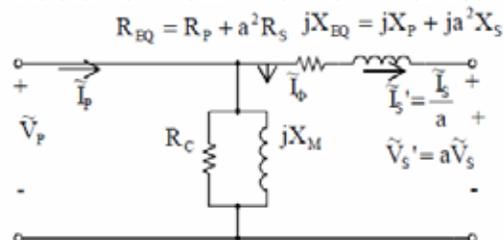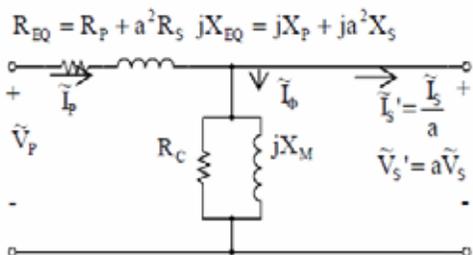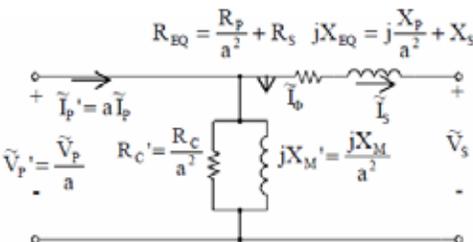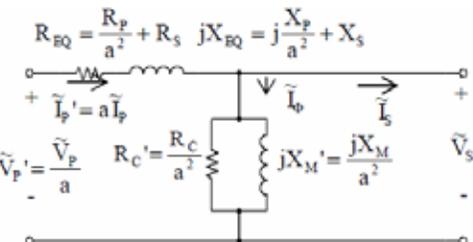

Figure 4

Figure 5

Figure 6

Figure 7

Also, we can use approximate models with negligible shunt branch. Figure 8 shows anapproximate model for this case and the transformer is referred to its primary. The same casewhen transformer is referred to its secondary is shown in Figure 9.
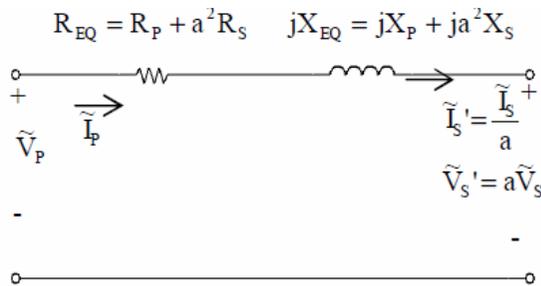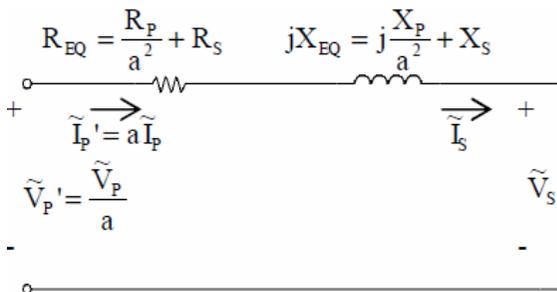

Figure 8

Figure 9

REVIEW OF RELATED WORKS
A transformer has been defined by ANSI/IEEE [3] as astatic electric device consisting of a winding, or two or morecoupled windings, with or without a magnetic core, forintroducing mutual coupling between electric circuits [2]. Transformers operation depends on electromagneticinduction between two stationary coils (the electric circuit)and a magnetic flux of changing magnitude and polarity (themagnetic circuit). In practice, transformers transform

electrical energy into magnetic energy, and then back intoelectrical energy.

Given its importance, transformer design is a big businessin the electric power industry. Basically, the aim oftransformer design is to obtain the dimensions of all parts ofthe transformer in order to supply these data to themanufacturer. The transformer design should be carried outbased on the specifications given, using available materialseconomically in order to achieve low cost, low weight, smallsize and good operating performance. The transformerdesign is worked out using various methods based onaccumulated experience realized in different formulas,equations, tables and charts [4]. Transformer design is acomplex task in which engineers have to ensure thatcompatibility with the imposed specifications is met, whilekeeping manufacturing costs low [1 , 2] In addition, in order

to compete successfully in the global economy, transformermanufacturers need design software capable of producingmanufacturable and optimal designs in a very short time.Over the years, several design procedures for transformershave appeared in many literatures [5, 6, 7]. Some of theliteratures are targeted at transformer design for teachingand hands-on training purposes [8, 9]. Furthermore, otherliteratures presented the development or the use of variouscomputer programs for transformer design [5, 10, 11, 12].Specifically, this paper presents the design of themagnetic circuits of power transformer and theimplementation of sample design problem using theMATLAB–based software presented in this paper.

MATLAB Implementation
Computer simulation provides a simplification of reality due to its role in the design, analysisand evaluation of systems. A variety of software tools is available to simulate engineeringapplications.

The most popular software is MATLAB. One difficulty students have inprogramming MATLAB scripts is in keeping the code organized. Developing a flow chart of thepseudo-code steps helps the students to visualize the operation of the script, which is useful forplanning development and for debugging specific problems. The flow chart for the transformermodel simulation is shown in Figure 10. The segments above the dashed line in the figure dealwith the GUI implementation, and the segments below the dashed line deal with the calculationand result output.
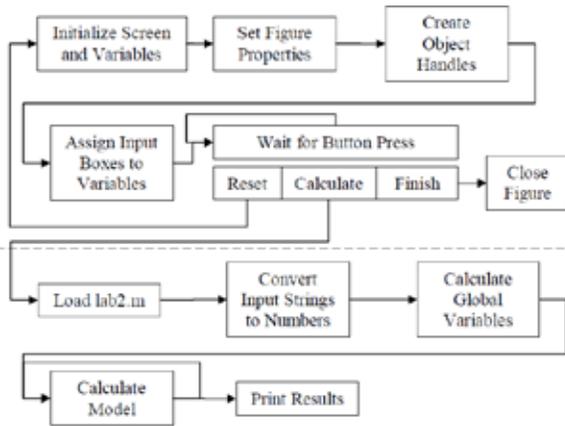

Figure 10 Flow chart of code organization

The development of a MATLAB GUI is not straightforward for electrical engineers with littleprogramming background. A brief discussion follows of a strategy for simple GUIimplementation.

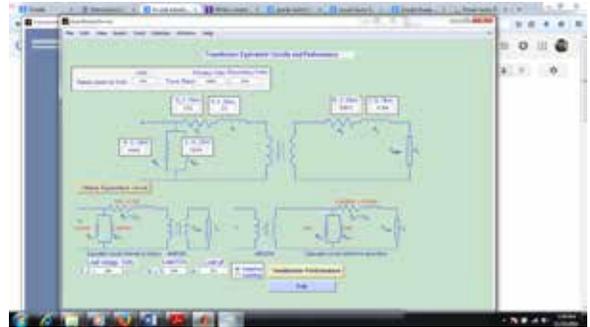**Figure 11 show home window of GUI**

Figure 11. Starting Home Window

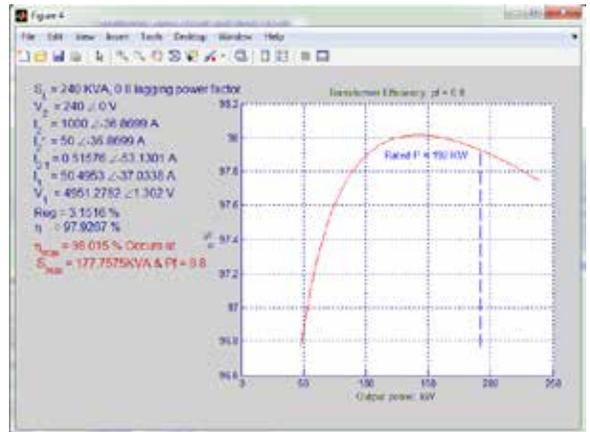**Figure 12 transformer test and performance window.**

Figure 13 Performance analysis window

CONCLUSION

In this paper, a standalone program was developed in
MATLAB for the Analyzing the performance of Transformer. It has shown all steps of writing a MATLAB code to calculate the electricquantities and the efficiency of a given transformer. This code can be modified to be suitable forother engineering applications.The simplicity ofthe mathematical models and the modular nature of theprogram make them relevant for teaching and hands-ontraining on power transformer design. It is also easy toupgrade the programs to accommodate the design of otherkinds of transformers and the use of other designmethodologies and also for incorporating optimizationissues in the program.

REFERENCE

[1] Amoiralis, E. I., Tsili, M. A., &Kladas, A. G. (2009).Transformer design and optimization: a literature survey.Power Delivery, IEEE Transactions on, 24(4), 1999-2024. | [2] Amoiralis, E. I., Tsili, M. A., and Georgilakis, P. S. (2008).The state of the art in engineering methods for transformerdesign and optimization: a survey. Journal of Optoelectronicsand Advanced Materials, 10(5), 1149. | [3] IEEE (2002) IEEE Standard Terminology for Power andDistribution Transformers, IEEE Std C57.12.80-2002. | [4] Mittle VN, Mittal A (1996) Design of electrical machines, 4thedn. Standard Publishers Distributors, NaiSarak, Delhi | [5] Amoiralis. E. I., Georgilakis. P. S., Tsili. M. A., KladasA.G.andSouflaris A. T. (2011) A complete software packagefor transformer design optimization and economic evaluationanalysis . Materials Science Forum Vol. 670 (2011) pp535-546) Trans Tech Publications, Switzerland | [6] Judd F. F., Kressler D. R. (1977), IEEE Trans. Magn., vol.MAG-13, pp. 1058-1069. | [7] Poloujadoff M., Findlay R. D. (1986), IEEE Trans. PowerSys., vol. PWRS-1. | [8] Jewell W. T. (1990) IEEE Trans. Power Sys., vol. 5 , pp.499-505. | [9] Grady W. M., Chan R., Samotyj M. J., Ferraro R. J.,Bierschenk J. L. (1992) IEEE Trans. Power Sys.,vol. 7 (1992),pp. 709-717. | [10] Rubaai A. (11994), IEEE Trans. Power Sys., vol. 9 , pp.1174-1181. | [11] Andersen O. W(1991), IEEE Comput. Appl. Power, vol.4 ,pp. 11–15. | [12] Hernandez C., Arjona M. A., Shi-Hai Dong (2008) IEEETrans. Magn., vol. 44 , pp. 2332-2337. | [13] Ozuomba, S. et al (2004) "Software Development for theDesign of Electric Circuit of 3-Phase Power Transformer"University of Uyo - A draft paper | [14] Oboma, S. O (2003) Development of Computer Program forthe Design of 3-phase Power Transformer, University ofUyo. | |