DESIGN AND CONSTRUCTION

OF SINGLE-PHASE TRANSFORMER TRAINER

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MAY, 2025

CERTIFICATION

This is to certify that this project work was carried out and submitted by OYINLOYE R AMADAN OLAYEMI of Matric No: HND/23/EEE/FT/0011 to the department of Electric al/Electronic Engineering is accepted having confirm with the requirement for the aw ard of Higher National Diploma (HND) program in Electrical/Electronic Engineering.

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DEDICATION

This project is dedicated to almighty Allah the most beneficent the most merciful wh o has destined me to be among those attending this institute of learning. I am saying a big thank you to my beloved parents Mr. and Mrs. Oyinloye for supporting me spirit ually, physically, morally and financially throughout my entire academic career.

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I am able to be where I am today thanks to the tiredness work and support of a ll my lecturers. My profound gratitude goes to my able amiable, capable, articulate su pervisor in person of Engr. A.J Adeoti for his invaluable criticism toward making this project work a success, I am short of words and all am trying to say is a big thank yo u Sir.

I also, acknowledge the effort of the Head of Department in person of Engr. O. A Lawal and all the lecturers in my department for the knowledge impacted in me ma y Almighty Allah reward you all.

ABSTRACT

Many tertiary institutions in Nigeria have limited access to technological equipment, especially in terms of practical equipment in the laboratory. This limitation causes st udents to be unable to think quickly, and has technological impact on the society duri ng and after graduation. This project report presents the design and construction of a single-phase transformer trainer for educational purposes. The trainer is designed to provide a hands-on learning experience for students by allowing them to understand t he principles and operation of transformers, effectively measure and perform differen t transformer tests. The trainer includes a step-down transformer, measurement instr uments, and a load bank, enabling students to conduct experiments and demonstrati ons. The project aims to support students' practical activities and to enhance student s' understanding of transformer theory and applications, providing a practical learnin g experience in electrical engineering education. The objectives of this work were ac complished, and the trainer designed is reliable. Hence, it can be used to bridge and g ive better interpretations to concepts in the field of Electrical/Electronic Engineering ir respective of the population at a particular period.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Trainer means an object that can train, teach and educate. A single-phase tr ansformer trainer is a self-contained set of electrical and electronic circuits that ca n be interlinked/ switch on by students to create a multifunctional and flexible train er instructional aid in the power and machines laboratory. This transformer trainer provides a set of components modules which are specially designed for performin g certain experiments in such a way to understand the principles and operation of t ransformers. It effectively measures and perform different transformer tests.

In any learning institution it has been proven that practical bridges and gives a bett er interpretation and understanding to the theories. For this reason, practical works can be made efficient by developing practical models and training systems for pra ctical hands on (Nasir, Syed Zain 2018).

Transformers play a critical role in the transmission and distribution of electrical po wer by efficiently stepping voltage levels up or down to meet system requirements. Their importance in electrical systems—ranging from power generation stations to household appliances—makes them a key topic in electrical and electronics engine ering education.

A single-phase transformer is one of the simplest types of transformers, primarily u

sed in residential, light commercial, and educational applications. It operates on th e principle of electromagnetic induction, transferring electrical energy between two circuits through a magnetic field. In academic environments, it becomes essential not only to study these theoretical concepts but also to understand how transforme rs behave in practical settings under varying load conditions.

However, students often struggle to connect textbook theory with real-world applica tion without hands-on experience. To bridge this gap, a transformer trainer serves a s an instructional tool that simulates real operating conditions in a safe, controllabl e environment. A well-designed trainer allows students to perform practical tests su ch as open-circuit, short-circuit, efficiency, and load regulation tests.

This project aims to design and construct such a trainer, incorporating measureme nt instruments, safety features, and accessible terminals. The trainer will be house d in a durable casing with clearly labeled components, allowing for multiple experi ments and visual demonstration of transformer principles. This practical approach enhances student engagement and deepens understanding of key transformer cha racteristics, such as voltage transformation ratio, efficiency, losses, and the effects of different load types.

This report outlines the design and construction of a single-phase transformer train er which is an is an essential educational tool used in electrical engineering laborat ories to demonstrate the principles of transformer operation, including voltage tran

sformation, turns ratio, efficiency, and losses. Also, the project supports engineerin g education by enabling effective and safe transformer experimentation in the labo ratory, preparing students for industry-standard knowledge and practices.

1.2 AIM OF THE PROJECT

The aim of this work is to design and construct a single-phase transformer t rainer system that can be used for practical purpose in the laboratory

1.3 OBJECTIVES OF THE PROJECT

The objectives are:

- To design a functional single-phase transformer trainer.
- To demonstrate and understand transformer principles such as turns ratio, v oltage transformation, and efficiency.
- To provide a hands-on learning tool for students.
    - To analyze transformer performance on open circuit and short circuit tes t
    - To evaluate transformer efficiency and losses like no-load losses, load lo

sses, and regulation.

- To develop practical skills in transformer operation and measurement

1.4 STATEMENT OF THE PROBLEM

The lack of practical, hands-on experience with transformers in educational s ettings hinders students' understanding of transformer principles and operation, lea ding to a gap between theoretical knowledge and real-world application Some of th et available Transformer trainer makes use of the analogue measuring instrument with a continuous varying data output display unit where individuals need to work at a very close range to view results whereby parallax error could occur during the time of taking reading from this continuous and fluctuating varying data output. T here is therefore a critical need for an affordable, customizable, and safe single-ph ase transformer trainer that enables students to conduct meaningful experiments, measure performance characteristics accurately, and develop practical skills in tra nsformer operation and analysis. Such a solution would bridge the current educati onal gap while remaining cost-effective for institutional adoption.

1.5 SIGNIFICANCE OF THE STUDY

The significance of this study lies in its potential to enhance the learning experi ence of students by providing hands-on experience with single-phase transformers, eq uipping them with practical skills, and bridging the gap between theoretical concepts a

nd real-world applications, ultimately leading to improved student outcomes and bette r preparation for careers in electrical engineering.

1.6 SCOPE AND LIMITATIONS OF THE STUDY:

This study is limited to the design and construction of a single-phase transf ormer trainer intended for educational use in electrical engineering laboratories. Th e trainer covers basic transformer operations such as step-up and step-down volta ge transformation, open-circuit and short-circuit testing, efficiency analysis, and loa d variation demonstrations. It is designed to operate at standard laboratory voltage levels (e.g., 230V/24V, 50Hz) with moderate current ratings suitable for academic e xperiments. However, the trainer does not support high-power industrial application s, three-phase transformer systems, or advanced digital data acquisition features. Additionally, the design prioritizes safety and simplicity over precision measuremen t, so it may not be suitable for highly accurate or specialized testing. Despite these l imitations, the trainer serves as a robust educational tool for illustrating fundament al transformer principles in a controlled and safe environment.

CHAPTER TWO LITERAT

URE REVIEW

1.1 INTRODUCTION

This chapter is a description of some of major components that are used in t he design and construction of a single-phase transformer trainer. It highlights the pri nciple of operation employed by these components.

1.1.1 Transformer

It is a static electrical device which transforms the electrical energy from one el ectrical circuit to another without any change of frequency through the process of ele ctromagnetic induction. It is interesting to note that the transfer of energy from one ci rcuit to another takes place with the help of mutual induction that is flux induced in t he primary winding gets linked with the secondary winding (Engineering World, 201 9).

2.1.2 Single Phase Transformer

A single-phase transformer is a power transformer that operates on single phas e alternating current. It consists of a primary winding connected to the source of suppl y and a secondary winding to provide electric power to the load. The two windings are wound around a common magnetic core made of laminated silicon steel sheets which provides a low reluctance path for the magnetic flux. Single phase transformers conve rt the alternating voltage from one circuit to another without any direct electrical conne ction between the two circuits. A typical single-phase transformer uses single-phase A C, meaning it operates with a voltage cycle that moves in sync over time. This type of t

ransformer works based on Faraday's law of electromagnetic induction, which states t hat a change in magnetic flux through a coil induces a voltage in the coil.

2.1.3 Faraday's Law of Electromagnetic Induction

Faraday's law states that an electromotive force (EMF) is induced in any closed ci rcuit when there is a change in the magnetic flux through the circuit. This electromagn etic induction effect is the basis for the working of single-phase transformers. When a n alternating current flow through the primary winding, it produces an alternating mag netic flux around the core. According to Faraday's law, this changing flux induces an E MF in the secondary winding.

2.1.4 Single-Phase Transformer Construction and Working Principle

A single-phase transformer is a high-efficiency piece of electrical equipment, an d its losses are very low because there isn't any mechanical friction involved in its o peration. Transformers are used in almost all electrical systems, from low voltage u p to the highest voltage

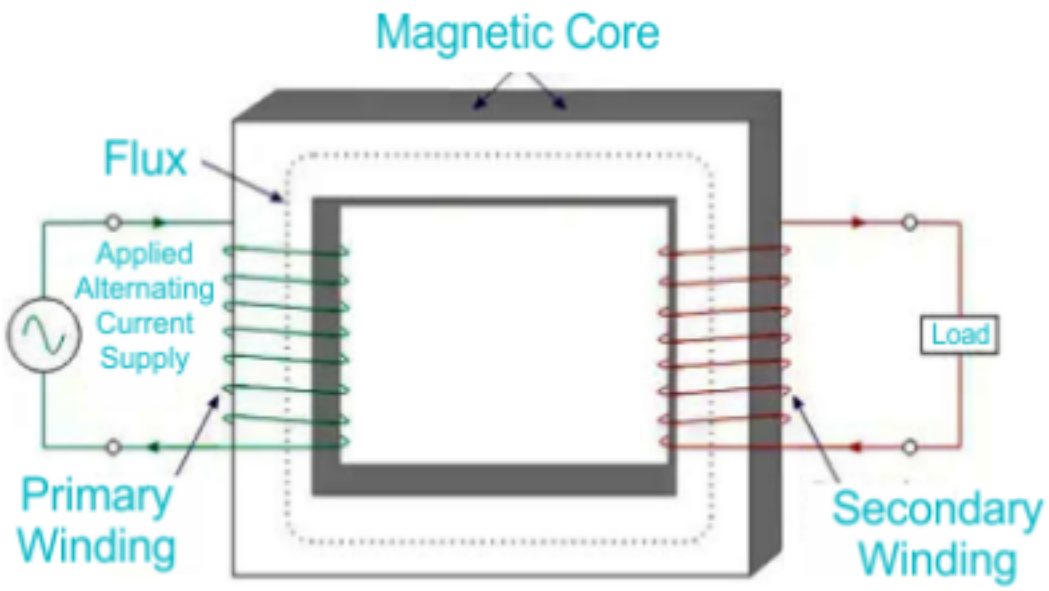

Figure 2.1: Single Phase Transformer Core

The primary coil of the transformer receives the voltage which is alternating in n ature. The alternating current flowing in the coil produces a continuously changing and alternating flux which is produced around the primary winding. Then we have the other coil or the secondary coil which is near to the primary coil which get linked to the prima ry because some alternating flux gets linked. As the flux is changing continuously it ind uces an EMF in the secondary coil according to Faraday's law of electromagnetic induc tion. If the secondary side circuit is closed a current will flow and this is the most basic working of a transformer, (Marshall Brain & Charles W. Bryant. 2007)

The three main part of any transformer are:

i. The primary winding ii. Secondary winding iii. The magnetic core.

2.1.5 Primary Winding

This is the main winding where the incoming alternating current is expected. De pending on the fact that the transformer is either a step up or step-down transformer th e winding construction changes accordingly.

2.1.6 Secondary Winding

This is the winding in which the flux produced by the primary winding get linke d. In this case also depending on the fact that the transformer is either a step up or st ep-down transformer the winding construction changes accordingly.

1.1.7 Classification of Transformer Based on Voltage Levels

- **Step-Up Transformer**

As the name suggest, step up transformer are used to increase the voltage at the sec ondary side of the transformer. This is achieved by having a greater number of turns in the s

econdary side of the transformer as compared to the primary side of the transformer.

➢ **Step- Down Transformer**

As the name suggest, step down transformer are used to decrease the voltage at the secondary side of the transformer. This is achieved by having a smaller number of turns in t he secondary side of the transformer as compared to the primary side of the transformer.

2.2 ARDUINO LCD DISPLAY

The Arduino LCD (Liquid Crystal Display) module is a widely used output device that allows microcontrollers like Arduino to display text, numbers, and simple graphics. The most common type is the 16x2 LCD, which shows 16 characters per line across 2 lines, though other sizes (e.g., 20x4) are also available. These displays are popular due to the ir low power consumption, ease of interfacing, and clear visibility.

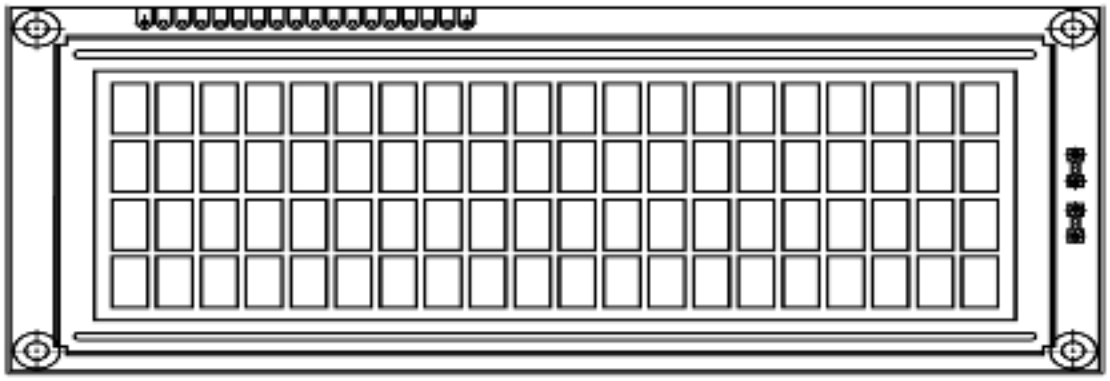

Figure 2.2: Arduino LED
Source: Raj, 2015