

**DESIGN AND CONSTRUCTION
OF SINGLE-PHASE TRANSFORMER TRAINER**

BY

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CERTIFICATION

This is to certify that this project work was carried out and submitted by BELLO HAS SAN ISHOLA of Matric No: HND/23/EEE/FT/0155 to the department of Electrical/Electronic Engineering is accepted having confirm with the requirement for the award 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 who 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. BELLO for supporting me spiritually, 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 all my lecturers. My profound gratitude goes to my able amiable, capable, articulate supervisor in person of Engr. T.K Sule 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 you 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 may 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 students to be unable to think quickly, and has technological impact on the society during 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 the principles and operation of transformers, effectively measure and perform different transformer tests. The trainer includes a step-down transformer, measurement instruments, and a load bank, enabling students to conduct experiments and demonstrations. The project aims to support students' practical activities and to enhance students' understanding of transformer theory and applications, providing a practical learning experience in electrical engineering education. The objectives of this work were accomplished, and the trainer designed is reliable. Hence, it can be used to bridge and give better interpretations to concepts in the field of Electrical/Electronic Engineering irrespective 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 transformer trainer is a self-contained set of electrical and electronic circuits that can be interlinked/ switch on by students to create a multifunctional and flexible trainer instructional aid in the power and machines laboratory. This transformer trainer provides a set of components modules which are specially designed for performing certain experiments in such a way to understand the principles and operation of transformers. It effectively measures and perform different transformer tests.

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

Transformers play a critical role in the transmission and distribution of electrical power 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 engineering 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 the 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 transformers behave in practical settings under varying load conditions.

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

This project aims to design and construct such a trainer, incorporating measurement instruments, safety features, and accessible terminals. The trainer will be housed in a durable casing with clearly labeled components, allowing for multiple experiments and visual demonstration of transformer principles. This practical approach enhances student engagement and deepens understanding of key transformer characteristics, 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 trainer which is an essential educational tool used in electrical engineering laboratories to demonstrate the principles of transformer operation, including voltage tran

sformation, turns ratio, efficiency, and losses. Also, the project supports engineering education by enabling effective and safe transformer experimentation in the laboratory, 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 trainer 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, voltage transformation, and efficiency.
- To provide a hands-on learning tool for students.
- To analyze transformer performance on open circuit and short circuit test
- 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 settings hinders students' understanding of transformer principles and operation, leading to a gap between theoretical knowledge and real-world application. Some of the 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. There is therefore a critical need for an affordable, customizable, and safe single-phase transformer trainer that enables students to conduct meaningful experiments, measure performance characteristics accurately, and develop practical skills in transformer operation and analysis. Such a solution would bridge the current educational 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 experience of students by providing hands-on experience with single-phase transformers, equipping them with practical skills, and bridging the gap between theoretical concepts a

and real-world applications, ultimately leading to improved student outcomes and better 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 transformer trainer intended for educational use in electrical engineering laboratories. The trainer covers basic transformer operations such as step-up and step-down voltage transformation, open-circuit and short-circuit testing, efficiency analysis, and load variation demonstrations. It is designed to operate at standard laboratory voltage levels (e.g., 230V/24V, 50Hz) with moderate current ratings suitable for academic experiments. However, the trainer does not support high-power industrial applications, three-phase transformer systems, or advanced digital data acquisition features. Additionally, the design prioritizes safety and simplicity over precision measurement, so it may not be suitable for highly accurate or specialized testing. Despite these limitations, the trainer serves as a robust educational tool for illustrating fundamental transformer principles in a controlled and safe environment.

CHAPTER TWO LITERATURE REVIEW

LITERATURE REVIEW

1.1 INTRODUCTION

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

1.1.1 Transformer

It is a static electrical device which transforms the electrical energy from one electrical circuit to another without any change of frequency through the process of electromagnetic induction. It is interesting to note that the transfer of energy from one circuit to another takes place with the help of mutual induction that is flux induced in the primary winding gets linked with the secondary winding (Engineering World, 2019).

2.1.2 Single Phase Transformer

A single-phase transformer is a power transformer that operates on single phase alternating current. It consists of a primary winding connected to the source of supply 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 convert the alternating voltage from one circuit to another without any direct electrical connection between the two circuits. A typical single-phase transformer uses single-phase AC, meaning it operates with a voltage cycle that moves in sync over time. This type of transformer works based on Faraday's law of electromagnetic induction, which states that

that 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 circuit when there is a change in the magnetic flux through the circuit. This electromagnetic induction effect is the basis for the working of single-phase transformers. When an alternating current flows through the primary winding, it produces an alternating magnetic flux around the core. According to Faraday's law, this changing flux induces an EMF 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, and its losses are very low because there isn't any mechanical friction involved in its operation. Transformers are used in almost all electrical systems, from low voltage up to the highest voltage.

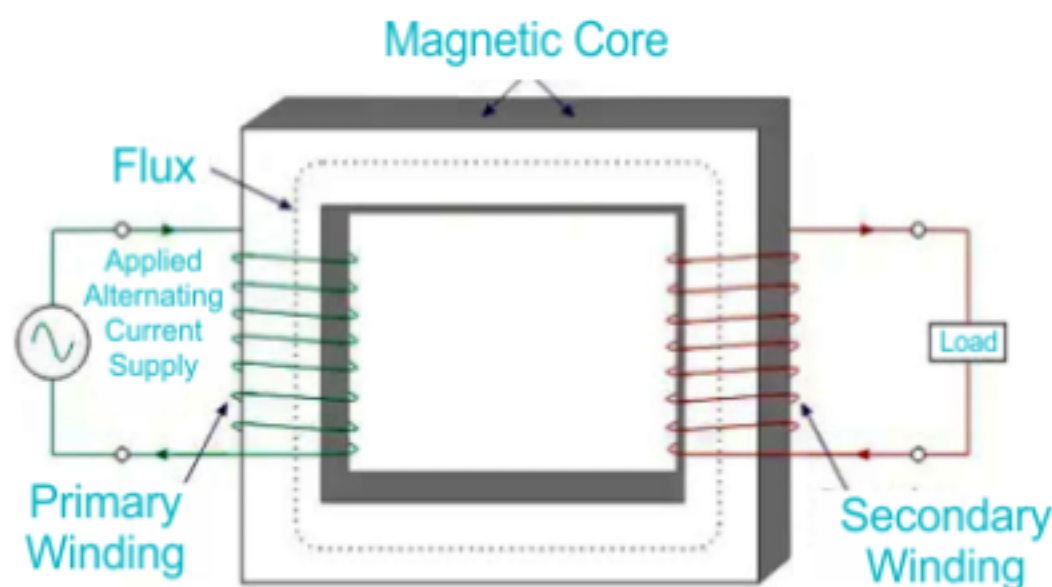


Figure 2.1: Single Phase Transformer Core

The primary coil of the transformer receives the voltage which is alternating in nature.

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 primary because some alternating flux gets linked. As the flux is changing continuously it induces an EMF in the secondary coil according to Faraday's law of electromagnetic induction. 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. Depending on the fact that the transformer is either a step up or step-down transformer the winding construction changes accordingly.

2.1.6 Secondary Winding

This is the winding in which the flux produced by the primary winding get linked. In this case also depending on the fact that the transformer is either a step up or step-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 secondary side of the transformer. This is achieved by having a greater number of turns in the secondary 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 the 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 their low power consumption, ease of interfacing, and clear visibility.

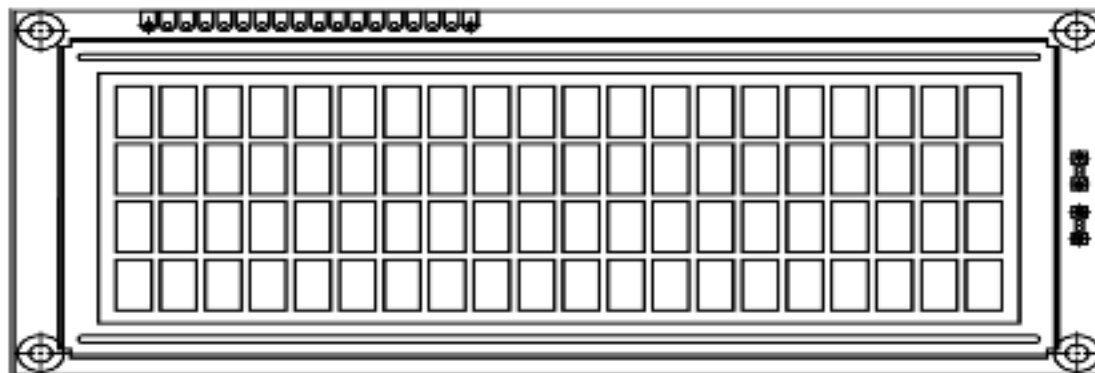


Figure 2.2: Arduino LED
Source: Raj, 2015