

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Access to reliable electricity is a fundamental pillar of modern society, enabling everything from basic household functions to sophisticated industrial operations. It powers lights, appliances, communication systems, and critical infrastructure such as hospitals and schools. Yet, for millions of people around the world, particularly in developing nations like Nigeria, this essential resource remains inconsistent or entirely unavailable. The national power grid in Nigeria, for example, struggles with a host of systemic issues: insufficient generation capacity, outdated infrastructure, inadequate maintenance, and disruptions caused by natural events or human interference. These challenges result in frequent power outages, unpredictable voltage fluctuations, and prolonged periods without electricity, severely impacting quality of life and economic productivity.

In Nigeria, the electricity supply primarily relies on hydroelectric and gas-fired power plants. Hydroelectric systems, while renewable, are heavily influenced by seasonal rainfall patterns, leading to reduced output during dry periods. Gas-fired plants, on the other hand, face challenges such as inconsistent fuel supply, pipeline vandalism, and logistical bottlenecks. Compounding these generation issues is an overburdened transmission and distribution network, which suffers from significant energy losses—sometimes as high as 30%—before electricity even reaches consumers. The World Bank reports that Nigeria experiences an average of 32.8 power outages per month, with each outage lasting several hours. This chronic unreliability costs the nation approximately \$29 billion annually in lost economic output, as businesses and households are forced to turn to costly and environmentally harmful alternatives like diesel generators.

The consequences of this energy crisis are particularly pronounced for sensitive electronic equipment, which requires a stable and high-quality power supply to operate effectively. Devices such as computers, medical imaging systems, and telecommunications infrastructure are highly susceptible to damage from voltage spikes or drops. Even brief interruptions can lead to data loss, equipment failure, or disrupted services. In critical settings like hospitals, where power is needed for ventilators, surgical tools, and refrigeration of vaccines, outages can have life-or-death implications. For instance, a sudden power cut during a surgical procedure could jeopardize patient safety if backup systems are unavailable or insufficient.

[1,2]. To address these pervasive issues, alternative power solutions have gained traction, with inverters emerging as a practical and versatile option. Inverters convert direct current (DC) from batteries into alternating current (AC), the form of electricity used by most household and industrial appliances. This capability allows them to provide uninterrupted power during outages by drawing on stored energy, making them invaluable in regions with unstable grids. However, traditional inverters depend on batteries charged by the grid or external generators, which poses a limitation in areas where power outages are frequent or prolonged, or where grid access is nonexistent.

This is where solar-powered inverters offer a groundbreaking advancement. By integrating solar photovoltaic (PV) panels, these systems use sunlight—a free, abundant, and renewable resource—to charge their batteries, creating a self-sustaining power solution. Nigeria, located near the equator, enjoys an average of 6.25 hours of sunlight daily, translating to a solar energy potential of over 427,000 megawatts (MW), according to the International Renewable Energy Agency (IRENA). Despite this vast potential, only a small fraction is currently harnessed, presenting a significant opportunity for solar-based technologies to bridge the energy gap. Solar-powered inverters reduce reliance on fossil fuels, lower long-term electricity costs, and contribute to environmental sustainability by cutting carbon emissions—a critical consideration as the world grapples with climate change.

The focus of this project is the design, construction, and installation of a 2KVA solar-powered inverter system, a solution tailored to meet the energy needs of small households or businesses. A 2KVA (kilovolt-ampere) inverter can deliver up to 2,000 volt-amperes of power, sufficient to support essential appliances such as lights, fans, televisions, laptops, and small refrigeration units. When paired with appropriately sized solar panels and batteries, this system can provide a reliable power supply even in off-grid locations or during extended grid failures. Beyond its immediate utility, the project emphasizes the use of locally sourced materials and expertise, fostering economic growth, job creation, and technological independence.

Designing such a system, however, involves navigating several technical challenges. The inverter must produce a pure sine wave output, which is essential for powering sensitive electronics without causing noise, inefficiency, or damage. Unlike modified sine wave inverters, which are cheaper but less compatible with modern devices, pure sine wave inverters replicate the smooth, consistent waveform of grid electricity. Additionally, the system requires careful selection and integration of components—solar panels, batteries, charge controllers, and the inverter itself—to optimize performance and durability. For

example, the solar panels must be sized to generate enough energy to charge the batteries fully, even on cloudy days, while the batteries must store sufficient power to meet demand during nighttime or prolonged outages.

1.2 Electrical Signal Waves

Electrical sine waves depict electrical signals represented by a sinusoidal graph. The wave shows all the properties of a wave like amplitude, frequency, wavelength, and can exhibit wave-like properties of reflection, refraction, diffraction, and polarization [3]. Moreover, when an electrical signal wave is said to be pure, it means the wave depiction is devoid of harmonics, as shown in Figure 1.1. Furthermore, when the wave output of the oscillation unit of an inverter is free of harmonics, the power inverter is termed a ‘pure sine wave power inverter’.

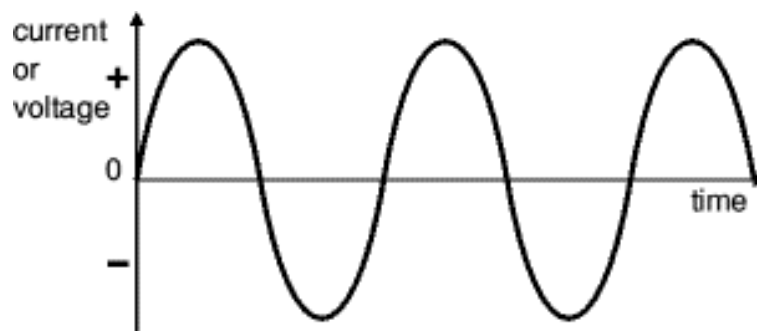


Figure 1.1: AC, DC and Electrical Signal.

Advantages of pure sine wave inverters over modified sine wave inverters:

- a) Output voltage waveform is pure sine wave with very low harmonic distortion and clean power like utility-supplied electricity.
- b) Inductive loads like microwave ovens and motors run faster, quieter, and cooler.

1.3. Problem Statement

This project work aims to address the challenges of poor power supply delivery to electrical loads by designing, constructing, and installing a 2KVA solar-powered inverter, harnessing the abundant solar energy available.

1.4 Aim of the Project

The aim of the study is to locally design, construct, and install a 2KVA solar-powered inverter for domestic electric power supply.

1.5 Objectives of the Project

1. To design and construct a reliable pure sine wave power inverter.
2. To construct an inverter system using high-quality components and efficient circuitry.

3. To test the performance and reliability of the inverter system.
4. To analyze the efficiency, voltage regulation, and waveform quality of the inverter output.

1.6 SCOPE OF THE PROJECT

The scope of the project encompasses the design, construction, installation, and testing phases of the 2KVA solar-powered inverter system. This includes selecting appropriate components such as solar panels, charge controllers, batteries, inverters, and control circuits, as well as designing the system layout and installation procedures.

1.7 SIGNIFICANCE OF THE PROJECT

The significance of the project lies in its contribution to promoting renewable energy solutions and reducing dependence on fossil fuels. By designing and installing a 2KVA solar-powered inverter, this project aims to provide a sustainable and eco-friendly power source for domestic applications.