THE DESIGN AND CONSTRUCTION OF AN EXTENSION BOX WITH AN UNINTERRUPTIBLE USB PORTS

BY

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CERTIFICATION

This is to certify that this project work was carried out by **ND/23/EEE/FT/0144,** the department of Electrical and Electronic Engineering is accepted, having conform with the requirement for the award of National Diploma (ND) in the department of Electrical and Electronic Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin

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DEDICATION

This project is dedicated to Almighty Allah the beginning and the end, the supremacy and the creation of all mankind. Who gave me the grace and support to complete this program.

Also, I dedicate this project to my beloved parent for their physical, spiritual, moral and financial support till the end of these program, I pray that almighty Allah should lift them up above there enemy.

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The most grace and honour goes Almighty God the most beneficent, the most merciful, the source of my inspiration, for His unquantifiable mercies and grace bestowed on us and most importantly for sparing our life in the course of this project work.

My sincere gratitude goes to my parents and my siblings for the financial, moral and spiritual support from the beginning up to where we are today.

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I also express my gratitude to all my colleagues who are there with me in good and bad time, who give me courage and support toward this program, I pray that Almighty should be with them all (Amin)

THANK YOU ALL.

ABSTRACT

This research explores the design and construction of a multi-socket device integrated with USB ports, featuring six 13-amp outlets, two USB ports, and a voltage display section. The device is connected in a ring formation, enhancing its functional efficiency when plugged into a main power source. A 200mAh lithium battery is included, which charges while the device is connected to the main power supply. This allows the USB ports to provide up to 5 hours of power during outages, ensuring continuous charging capabilities for multiple devices. The innovative design emphasizes user convenience and reliability, making it a valuable addition to both home and office environments. The functionality and practicality of this multi-socket device demonstrate its potential to meet the growing demands for versatile and resilient power solutions.

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CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND OF STUDY

An extension box is a multiple electrical socket system connected in parallel and housed within a shockproof enclosure. It plays a vital role in ensuring safety and convenience when using electricity in homes, offices, schools, and other public and private establishments. These boxes serve as intermediary devices that facilitate the simultaneous use of multiple electrical appliances from a single power source. Extension sockets simplify energy distribution and minimize the inconvenience of limited wall sockets. Typically, electricity enters a building through a main socket outlet rated at 220–240 volts and 50 Hz, which is the standard voltage supply in most countries, including Nigeria (Eze & Ogbuagu, 2020). However, these outlets often offer just one, two, or three plug points. When more devices need to be connected than available sockets, users often turn to extension boxes.

The global surge in electronic devices has increased the demand for flexible, safe, and multi-functional power distribution units. The extension box meets these demands by allowing users to connect four or more devices to a single source of electricity. As homes and workspaces grow increasingly digitized, more people rely on gadgets like laptops, smartphones, smart TVs, electric fans, and other appliances, all of which require constant power. An extension box is a practical solution that helps manage multiple load requirements while maintaining energy safety standards (Usman & Adewuyi, 2021). Its functionality is not just limited to providing more plug outlets; modern extension boxes are now designed to meet a variety of user needs, including surge protection, power regulation, and USB charging.

Technological advancement has significantly transformed the nature and complexity of power distribution systems. Extension boxes today are no longer passive devices; they are now designed as smart systems with built-in safety and convenience features. The integration of USB charging ports into extension sockets is one such innovation that allows for direct charging of mobile phones and other portable digital devices. This feature eliminates the need for multiple power adapters, streamlining energy access and promoting energy efficiency (Olatunji & Adepoju, 2022). Additionally, the growing need for portability and flexibility in power usage has led to the development of multi-purpose extension boxes equipped with switches, fuses, circuit breakers, and even wireless control capabilities.

The internal wiring of an extension box generally includes a live wire that passes through the fuse and switch before reaching the outlet sockets, while the neutral wire directly links to the corresponding terminals. The earth wire is connected to ensure grounding for user protection against electrical shock. In troubleshooting faults, tools such as multimeters and electrical testers are often used. For instance, if a tester lights up upon contact with the earth terminal, it could indicate a short circuit between the earth and live wires. Using a continuity checker or buzzer feature on a multimeter can help detect and isolate faults in the wiring system (Idris & Lawal, 2019). Such diagnostic procedures emphasize the importance of building safe and reliable power distribution systems, particularly when more advanced features like USB charging are included.

USB (Universal Serial Bus) technology has revolutionized data and power communication. Originally introduced in 1996, the USB was designed to standardize the connection of peripheral devices to computers. Over time, it has become the universal interface for charging and data exchange across a wide range of devices, including smartphones, cameras, printers, flash drives, and game consoles (USB Implementers Forum, 2020). The ability of USB ports to deliver DC power efficiently makes them ideal for integration into extension boxes. This integration offers users the flexibility of charging devices without relying on bulky power adapters.

Though initially limited to computers, USB ports are now embedded in various electronic appliances, including TVs, AC power adapters, solar power banks, and car chargers. The popularity of USB power delivery is partly due to its compact size, user-friendliness, and universality. It supports both charging and data transfer in a standardized manner, thus eliminating the complexity of using multiple cables or plugs (Smith & Chang, 2018). The adoption of USB-enabled extension boxes responds to the growing user preference for simplicity, mobility, and uninterrupted device functionality.

In countries where electrical power is unreliable, the concept of an uninterruptible USB port becomes even more valuable. An uninterruptible USB power system integrates a backup battery or rechargeable circuit that maintains power delivery to USB ports even during grid outages. This system ensures that devices like smartphones, routers, and small LED lamps remain operational, improving resilience during power interruptions. It is particularly beneficial in critical applications such as telemedicine, remote learning, and emergency communication systems (Chukwuma & Bello, 2021).

Nigeria, like many developing nations, faces challenges with electricity supply characterized by inconsistent grid power, frequent outages, and low voltage. These issues affect homes, businesses, and educational institutions. In such contexts, the development of an extension box with an uninterruptible USB system can offer a modest yet impactful solution to energy challenges. The design will not only cater to routine energy needs but also ensure the continuity of essential digital services during blackouts. By merging conventional extension socket designs with backup USB systems, users gain a hybrid device suited for modern digital lifestyles (Adewuyi & Hassan, 2023).

Moreover, from an educational standpoint, constructing such a device serves as an excellent learning experience for students in electrical and electronic engineering. It provides them with hands-on exposure to practical circuit design, component selection, fault diagnosis, and safety compliance. Students learn how theoretical knowledge in areas such as parallel circuits, power distribution, and continuity testing is applied in real-world situations. Building an extension box with added USB functionality allows students to experiment with fuses, switches, resistors, and voltage regulators, while understanding the interplay of alternating and direct current systems (Ahmed & Oladipo, 2022).

Beyond academics, the design and production of intelligent extension boxes offer entrepreneurial opportunities. With increasing consumer demand for smart, portable, and multi-functional power solutions, small and medium-scale enterprises (SMEs) can leverage this technology to produce market-ready solutions. Local manufacturing of these devices could reduce import dependency and stimulate job creation. Encouraging innovation in electrical accessory design supports sustainable development goals related to energy access and economic empowerment (World Bank, 2020).

Additionally, safety remains a major concern in extension box usage. Poorly constructed or overloaded extension sockets have been associated with electrical fires, appliance damage, and fatal accidents. Therefore, the design and construction process must comply with established safety standards and best practices. Features such as surge protection, grounding, circuit breakers, and fuse protection are essential components in mitigating risks. Testing for short circuits and verifying wire continuity with digital multimeters are part of quality control procedures that ensure safety and reliability (NECA, 2021).

From a sustainability perspective, energy-efficient designs are also critical. Incorporating LED indicators, automatic switches, and low-power standby modes helps reduce energy waste. The use of recyclable materials for casing and components aligns with environmental standards and reduces the carbon footprint of these products. Moreover, solar-compatible versions of these devices are also gaining traction, offering off-grid users access to clean, renewable energy sources for powering mobile devices (Ibrahim et al., 2023).

In summary, the design and construction of an extension box with an uninterruptible USB power system is a response to the evolving energy needs of modern users. It offers a solution that merges convenience, safety, affordability, and reliability. The project reflects both technological progress and socio-economic relevance, particularly in environments where power supply remains inconsistent. It supports academic learning, entrepreneurship, and sustainable development in equal measure.

1.1 PROBLEM STATEMENT

In contemporary environments, users often face challenges when attempting to connect multiple devices to a single power source, especially when the wall socket is distant or insufficient. Additionally, with the frequent occurrence of power outages in many regions, maintaining continuous power for critical USB-powered devices (such as smartphones or medical monitoring devices) becomes a necessity. This project aims to address the problem of power accessibility, convenience, and device continuity by designing and constructing an advanced extension box integrated with an uninterruptible USB power system.

1.2 AIM

The aim of this project is to design and construct a multi-socket extension box equipped with an uninterruptible Universal Serial Bus (USB) power supply system to ensure convenient and continuous usage of multiple electronic devices.

1.3 OBJECTIVES OF THE STUDY

The specific objectives of the study are:

i. To design a long-range extension box circuit with multiple parallel outlets.

ii. To develop a backup powered USB circuit capable of delivering uninterrupted power to USB devices.

iii. To enhance students' understanding of electronic circuit design and construction.

iv. To demonstrate the practical functionality of various electronic components in real-life applications.

1.4 SCOPE OF THE STUDY

This study focuses on the design and construction of an advanced extension box with USB charging capability and backup power support. It covers both qualitative and quantitative analysis of the electrical and electronic components involved in its construction. The scope includes circuit design, selection of suitable components, testing for continuity and safety, and performance evaluation under varying loads. The project also explores the educational benefits of such constructions, particularly in equipping students with hands-on experience in electronics.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents a comprehensive literature review on the development, functionality, and historical evolution of socket outlets, particularly extension boxes with USB outlets. It also explores the significance of the components employed in constructing such systems. As the demand for multipurpose power outlets increases, particularly in emerging markets where power supply inconsistencies persist, understanding the evolution and current advancements in socket design and integration becomes necessary.

2.2 HISTORY OF SOCKET OUTLETS

The development of socket outlets for portable appliances dates back to the 1880s. Initially, electricity was introduced primarily for lighting purposes. In those early years, appliances like vacuum cleaners and electric fans were often powered through light bulb sockets using lamp holder plugs (Thompson, 2015). These connections were both unsafe and inconvenient, necessitating the invention of safer alternatives.

In Britain, plug and socket systems started appearing in the mid-1880s. T.T. Smith was one of the pioneers in this field. He was granted British Patent 4162 in 1882 for a design that enabled flexible and safe electrical connections. A similar patent was registered in the United States in 1885 (Smith, 1885). These inventions marked a turning point in the accessibility and safety of electrical systems.

By 1903, Harvey Hubbell had introduced the first American designs for two-pin plugs and sockets. His inventions emphasized retention features that helped prevent accidental disconnections (Hubbell, 1903). Hubbell's design evolved further in 1912 with the introduction of parallel flat pins, which remain in use today in the NEMA 1-15 configuration. This form factor eventually became a de facto standard across the United States.

Between 1900 and 1920, several inventors and companies contributed to the proliferation of plug and socket designs. For example, Gustav Binswanger patented a coaxial plug and socket in 1895 under General Electric. These designs evolved based on user needs for convenience, safety, and compatibility (Mellanby, 1921).

In the early 20th century, earthed plug and socket systems began to emerge. George P. Knapp, working for the Harvey Hubbell Company, patented an earthed socket in 1915, with an extended grounding pin for enhanced safety (Knapp, 1915). Other inventors, like Philip F. Labre in 1928, further developed grounded systems that contributed to today's safer and more reliable socket outlets (Labre, 1928).

The international community began standardizing plugs and sockets in the mid-20th century. The British Standard BS 546 introduced a three-pin configuration in the 1950s, which became widespread in many Commonwealth countries (IEC, 1986). The Schuko plug, introduced in Germany around 1925 by Albert Büttner, also became a popular standard in European countries for its robustness and grounding feature (VDE, 1993).

To facilitate global trade and travel, the International Electrotechnical Commission (IEC) formed Technical Committee TC 23 to promote harmonization. While the IEC 60884-1 standard provides general guidelines, individual countries still adopt their unique plug and socket configurations (IEC, 2002). For instance, the CEE 7/7 plug is compatible with several European sockets and has become a semi-universal solution in that region.

Recent years have seen an increase in the integration of USB ports in socket outlets. USB technology, first standardized in 1996, has become indispensable in modern devices such as mobile phones, tablets, and portable storage devices. The demand for USB-enabled extension boxes has increased significantly due to the convenience of charging without the need for adapters (USB Implementers Forum, 2020).

2.3 COMPONENTS USED FOR THE PROJECT

To achieve a functional extension box with an uninterruptible USB outlet, several electronic components are required. Each component plays a critical role in power regulation, safety, and overall system functionality. Some of these components includes;

- Capacitor
- Transistor
- Metal Oxide Semiconductor Field Effect Transistor (MOSFET)
- Transformer
- Switch
- Fuse

- Light emitting diode (LED)
- 13A sockets
- Rectifier
- Micro-controller

2.3.1 CAPACITORS

Capacitors are passive electrical components that store energy electrostatically in an electric field. They are vital in filtering, voltage regulation, and transient suppression. The two major types used in this project are ceramic and electrolytic capacitors (Horowitz & Hill, 2015).

2.3.2 CERAMIC CAPACITORS

Ceramic capacitors are non-polarized and constructed from ceramic dielectric material. They offer high stability and reliability at low cost, making them ideal for general-purpose applications (Mohan et al., 2018). Ceramic capacitors are the common types of capacitors used in most of the electrical instruments, as they are more reliable and cheaper manufacture.

2.3.3 ELECTROLYTIC CAPACITOR

These capacitors use an electrolyte to achieve higher capacitance values. They are polarized, meaning their terminals must be connected correctly. They are primarily used in power supply filtering (Millman & Halkias, 2011). An electrolyte is a liquid or gel containing a high concentration. Almost all-electrolytic capacitor are polarized, which means that the voltage on the positive terminal must always be greater than the voltage on the negative terminal.

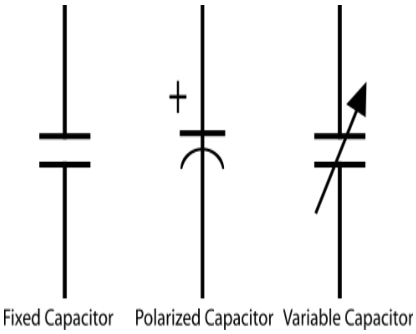

Fig.2.1 symbols of a capacitor

2.3.4 REGULATORS

A LM79805 regulator is a three terminal positive regulator with 5V fixed output voltage. The fixed regulator provides a local regulation, internal current limiting, thermal shut-down control, and safe area protection. Atypical diagram of a Regulator is shown in Fig. 2.3.

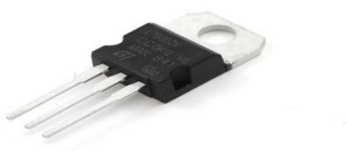

Fig. 2.2 A Regulator

2.3.5 RESISTORS

Resistors are passive elements used to oppose the flow of electricity in a circuit. The resistance of a resistor is measured in ohms. They are used to limit the current in the circuit and as a potential divider to achieve a specific value of voltage across a terminal. Resistors are either fixed or variable. A typical symbol of a resistor is shown in Fig. 2.3.

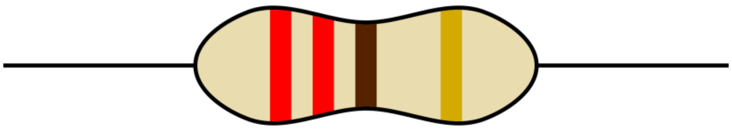

Fig. 2.3 Resistor

2.3.6 CRYSTAL OSCILLATOR

A crystal oscillator is an electronic circuit that uses the mechanical resonance vibrating crystal of piezoelectric material to create an electric signal with a precise frequency. This is often used to stabilize frequencies for radio transmitters and receivers. A typical diagram of crystal oscillator is shown in Fig. 2.4

Fig. 2.4 Crystal Oscillator

2.3.7 TRANSFORMER

A current is a passive component that transfers electrical energy from one electrical circuit to another circuit, or multiple circuit. A varying current in any one coil of the transformer produces a varying magnetic flux in the transformer's core, which induces a varying electromotive force across any other coils wound around the same core.

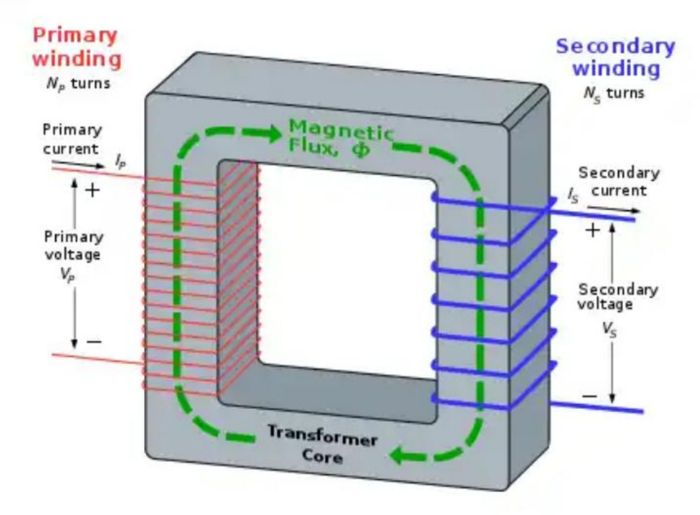

Fig. 2.5 Transformer winding

2.3.8 13A SOCKET

This is a standard socket in Nigeria and other countries that use BS 1363. It allows connection of appliances up to 3000W. It includes live, neutral, and earth pins for safety and functionality (BSI, 2019). It accommodates different electrical devices and aid their connection to the electricity before they can function properly. It helps in the connection of appliances rated between 700W and 3000W e.g dishwasher, microwave, kettle, toaster machine, Iron e.t.c

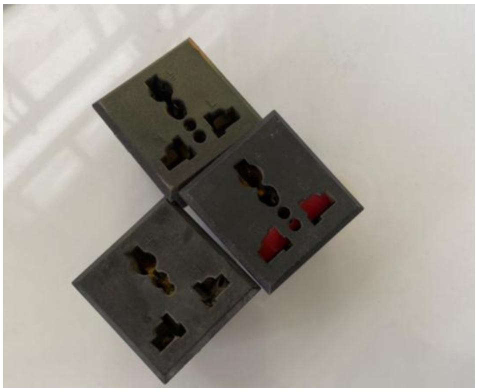

Fig. 2.6 13A Sockets

2.3.9 LIGHT EMITTING DIODE (LED)

This is a two lead semiconductor light source. It is a p-n junction diode that emits light when activated. When a suitable current is applied to the leads, electrons are able to recombine with electrons holes within the device, releasing energy in the form of photons. A typical diagram of a Led is shown in Fig 2.7

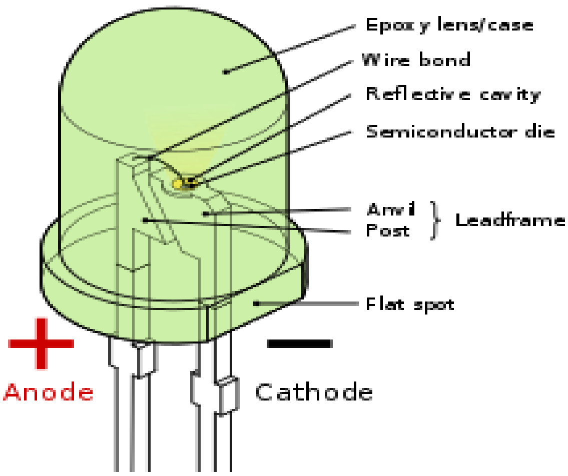

Fig. 2.7   light emitting diode (LED)

3.3.10 RELAY

Relays are electromechanical switches controlled by an electric signal. They enable the control of high-power devices with low-power logic circuits (Theraja & Theraja, 2010). it is an electromechanical switch composed of an electromagnet, an armature, a spring and a set of electrical constants. The electromagnetic switch is operated by a small electrical current that turns a larger current on or off by either releasing or retracting the armature constant, thereby cutting or completing the circuit.

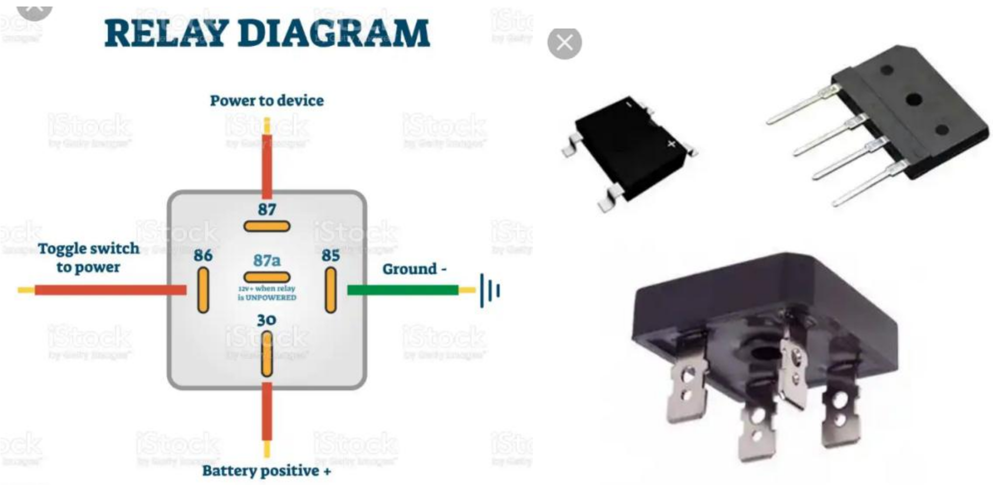

Fig. 2.8 Relay

3.3.11 TRANSISTOR

Transistors amplify and switch electronic signals. As the building blocks of integrated circuits, they are central to all electronic systems (Sedra & Smith, 2016). Transistor are active component of integrated circuits, or ‘microchips,’ which often contain billions of these minuscule devices etched into their shiny surfaces. Deeply embedded in almost everything electronic, transistors have become the nerve cells of the information Age.

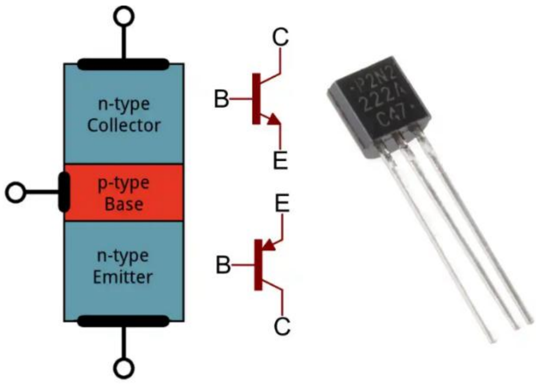

Fig. 2.9 Transistor

2.3.12 RECTIFIER

Rectifiers convert AC to DC. In this project, they ensure that USB outlets and control circuits receive DC power regardless of input type (Boylestad & Nashelsky, 2017). DC power is more expensive to produce. Therefore, a method of changing ac to dc is needed as an inexpensive dc source. AC power can be converted to DC power using rectifiers When ac power is converted to dc power using rectifiers, dc output contains un wanted alternating current components known as ripple. Many rectifier applications need that the ripple do not exceed a specified value. If the ripple exceeds the specified value, different unwanted effects appear in the system. Some of the unwanted effects are stray heating and audible noise. The ripple can be reduced using an output filter.

Fig. 2.10 Rectifier

2.3.13 THE MICRO-CONTROLLER

A microcontroller integrates a CPU, memory, and input/output peripherals. It acts as the brain of the system, executing programmed instructions to control switching, monitoring, and power management (Mazidi et al., 2014). A microcontroller is available in different word lengths like microprocessors (4bit,8bit,16bit,32bit,64bit and 128 bit microcontrollers are available today).

Fig. 2.11 The Micro-Controller Chip

CHAPTER THREE

DESIGN METHODOLOGY

3.1 INTRODUCTION

This chapter provides an in-depth explanation of the methodology employed in the design and construction of a multi-socket extension box with an uninterruptible USB power supply. The methodology discusses the materials, tools, theoretical calculations, and practical processes used to implement the system. The step-by-step procedures span from the marking of layouts to the final testing of the fully functional unit. Each stage is explained alongside relevant scientific principles and supported with appropriate illustrations and references.

3.2 DESIGN METHODOLOGY

To construct a reliable and efficient extension socket system with USB and backup functionality, several tools and electronic components were used. These include pencils, markers, rulers, scribers, cutters, screwdrivers, pliers, soldering irons, solder, printed circuit boards (PCBs), resistors, rectifiers, 13A sockets, relays, transistors, microcontrollers, crystal oscillators, USB ports, lithium batteries, and LCDs. The design methodology can be broadly classified into the following stages:

3.2.1 MARKING AND CUTTING

The initial step involved the measurement and marking of required shapes and placements for components such as 13A sockets, LCD screens, and USB ports. Pencils and rulers were used to define accurate outlines. Cutters and pliers were subsequently used to cut and shape the casing to accommodate these components. This phase is critical to ensuring proper component placement and aesthetics.

3.2.2 COMPONENT ARRANGEMENT AND SOLDERING

All electronic components were mounted and arranged on a printed circuit board (PCB). The soldering process was conducted using a soldering iron and lead solder. This step ensured firm and conductive connections among components, which is essential for efficient power transfer and signal integrity (Horowitz & Hill, 2015). Figure 3.1 illustrates the completed PCB with all components properly soldered.

3.2.3 LCD DISPLAY INTEGRATION

An LCD screen was included to display the AC input voltage, thereby enabling real-time voltage monitoring. The LCD was configured to draw power from the main AC supply and linked to the microcontroller, which processed the voltage readings. This display unit adds user value by improving usability and operational transparency (Mazidi et al., 2014). Figure 3.2 shows the installed LCD screen.

3.2.4 SOCKET WIRING

The 13A sockets were wired in a ring (parallel) configuration using high-quality copper connector cables (typically brown for live and blue for neutral). This configuration ensures that if one socket fails, the others remain operational. The parallel configuration allows uniform voltage distribution across all outlets while supporting varying loads simultaneously (Alexander & Sadiku, 2013). Figure 3.3 depicts the socket wiring arrangement.

3.2.5 BATTERY AND TRANSFORMER

A 240/12V step-down transformer was used to charge a 200mAh lithium-ion battery. The transformer steps down the voltage to a level suitable for charging the battery, and a rectifier converts AC to DC. This battery powers the USB ports during power outages. The system efficiency depends largely on battery capacity and health (Mohan et al., 2018). Figures 3.4 and 3.5 illustrate the transformer and lithium battery.

3.2.6 TRANSFORMER CALCULATIONS

The transformer design follows the standard relation:

$$\frac{Vp}{Vs} = \frac{Np}{Ns} \quad \text{(Equation 1)}$$

Where Vp = 240V (primary), Vs = output voltage, Np = 3000 turns (primary winding), and Ns = 150 turns (secondary winding).

Using:

$$Vs = \left(\frac{Vp}{Np} * Ns\right) \quad \text{(Equation 2)}$$

$$Vs = \left(\frac{240}{3000} * 150\right) = 12V \quad \text{(Equation 3)}$$

This output is suitable for USB charging and battery recharging purposes.

3.3 PARALLEL WIRING CONNECTION

In the design, a parallel connection was used for socket and circuit integration. This connection ensures consistent voltage across all sockets and allows the total current to be shared among different appliances:

$V = V1 = V2 = V3 = ... = Vn$ (Equation 4)

The equivalent resistance (RT) in parallel circuits is given by:

$1/RT = 1/R1 + 1/R2 + ... + 1/Rn$ (Equation 5)

Similarly, for inductors:

$1/LT = 1/L1 + 1/L2 + ... + 1/Ln$ (Equation 6)

For capacitors in parallel:

$CT = C1 + C2 + ... + Cn$ (Equation 7)

3.4 RESISTIVITY AND CONDUCTIVITY

Resistivity (ρ) of the connecting cables was considered. Resistance (R) of a wire is given by:

$R \alpha l/A$ (Equation 8)

$R = \rho l/A$ (Equation 9)

Where:

R = resistance in ohms (Ω)

l = length (m)

A = cross-sectional area (m^2)

ρ = resistivity (Ωm)

Conductivity (σ) is the reciprocal of resistivity:

$\sigma = 1/\rho$ (Equation 10)

3.5 OHM'S LAW AND CURRENT FLOW

Ohm's law explains the relationship between voltage (V), current (I), and resistance (R):

$I = \frac{V}{R}$ (Equation 11)

Additionally:

$I = E / (R + r)$ (Equation 12)

Where:

E = electromotive force (V)

r = internal resistance (Ω)

The total charge (Q) and electrical work (W) are given by:

Q = I * t (Equation 13)

$W = IVt$ (Equation 14)

And power (P) can be expressed as:

$P = I^2R$ (Equation 15)

$P = V^2 / R$ (Equation 16)

3.6 OPERATIONAL SUMMARY

A summary of the stepwise procedure is presented in Table 3.1 below:

S/N	OPERATION	EQUIPMENT USED	DESCRIPTION
	Measurement and marking out	Pencil, Ruler	Makout shapes for 13A sockets
	cutting	Cutters, Pliers	Cut shapes neatly
	Assembly	Soldering led, bolts and nuts	Solder and bolts for the Adaptable box
	Connection od components	Soldring iron, cables	Internal wiring and USB integration
	Testing	Plug-in gadgets	Functional verification of the sockets and USB

3.7 FUNCTIONAL TESTING

Testing involved powering different household and office appliances. During grid supply, devices such as laptops, electric fans, and other gadgets were powered successfully. During a blackout, mobile phones continued charging through the USB ports powered by the lithium battery, confirming the uninterruptible feature.

3.8 MAJOR COMPONENTS USED IN THE PROJECT

i. The Printed Circuit Board (PCB)

This image shows the neatly arranged and soldered electronic components mounted on a printed circuit board. The PCB serves as the backbone of the electronic system, providing both mechanical support and electrical connectivity for the components. Proper soldering ensures reliable current flow and reduces the risk of short circuits.

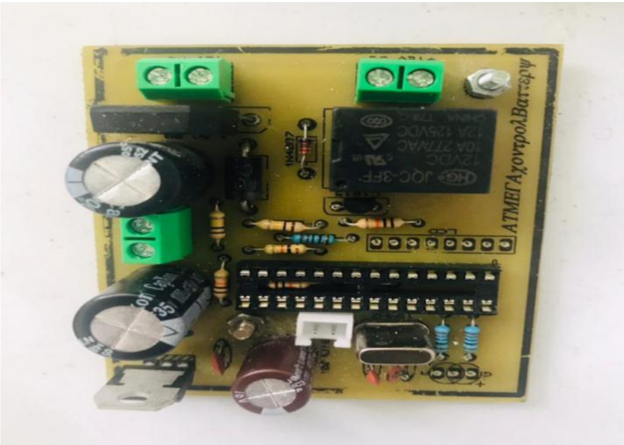

Figure 3.1: The Printed Circuit Board (PCB)

ii. The Liquid Crystal Display (LCD)

The LCD screen is responsible for displaying the real-time AC input voltage. This helps users monitor the power entering the device, enhancing usability and safety. The LCD is interfaced with the microcontroller, which processes and presents voltage readings.

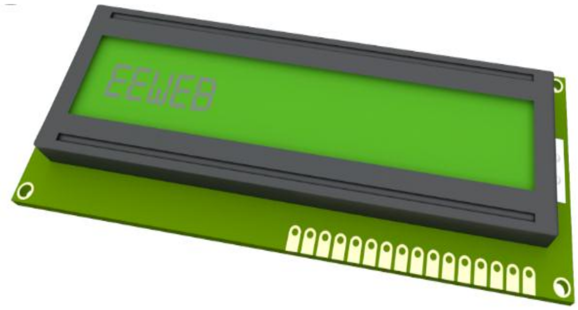

Figure 3.2: The Liquid Crystal Display (LCD)

iii. 13A Sockets

These sockets represent the output outlets of the extension box. Wired in a parallel configuration, they allow multiple devices to be connected and used simultaneously. Each 13A socket can support high-power appliances such as electric irons, microwaves, or heaters.

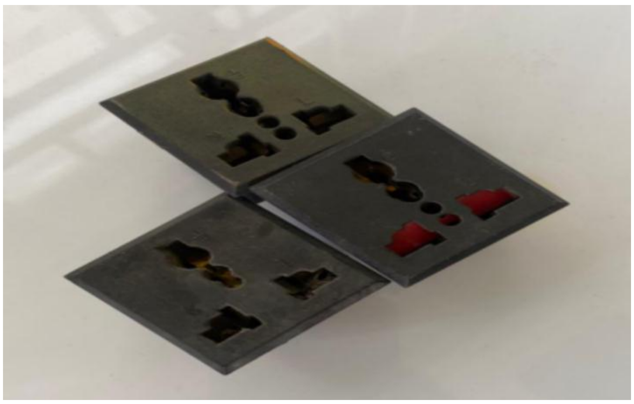

Figure 3.3: 13A Sockets

iv. 240V/12V Step-Down Transformer

This image shows the transformer used to reduce the 240V AC mains voltage to 12V AC. This reduced voltage is necessary for charging the lithium battery and powering the USB ports. The transformer also isolates the high voltage from the user-accessible components, improving safety.

Figure 3.4: 240V/12V Step-Down Transformer

v. The Lithium Battery

Depicted here is the 200mAh lithium-ion battery used as the backup power source for the USB ports. When there is a power outage, this battery supplies uninterrupted power to charge mobile devices, maintaining essential functionality even in the absence of grid electricity.

Figure 3.5: The Lithium Battery

CHAPTER FOUR

TESTING ,RESULTSAND DISCUSSION

4.1 RESULTS AND DISCUSSION

Upon completing the design and construction of the extension box with uninterruptible USB ports, a series of performance tests were carried out to evaluate the effectiveness, efficiency, and reliability of the system. This chapter presents the detailed results obtained from those tests and offers a comprehensive discussion of the system's response under various load conditions. The focus was on how the system performs, especially when powered solely by the backup lithium battery during a power outage.

The central aspect of the evaluation involved subjecting the extension box to varying electrical loads to observe how long the lithium battery could sustain USB charging functionality under these load conditions. The system was configured to charge devices with different wattages, simulating real-life usage patterns in homes and offices. The results recorded in Table 4.1 provide insight into how power consumption affects the operational duration of the system.

Table4.1 Results Obtained from the Charging Time of Different Loads

S/N	LOADS (WATTAGE)	TIME (HOURS)
1	400	5.09
2	500	4.06
3	600	3.82
4	700	3.42
5	800	2.29
6	900	2.05
7	1000	1.45

From the table, it is evident that as the load increases, the available operating time decreases. This inverse relationship between load wattage and time duration can be attributed to the fact that higher loads draw more current, depleting the battery at a faster rate. The maximum endurance of 5.09 hours was observed at 400W, while the system could only sustain 1.45 hours of operation at a 1000W load.

This test validates the theoretical basis that the battery's energy content (in watt-hours) is finite and any increase in the power consumption (wattage) of connected devices will proportionally reduce the duration for which the backup system can operate. The discharge rate aligns with Ohm's and Watt's Laws, where:

$P = V \times I$

And

$E = P \times t$

Where:

* P is the power (in watts)

* V is the voltage

* I is the current

* E is the energy capacity (in watt-hours)

* t is the time (in hours)

4.2 SYSTEM BEHAVIOR UNDER TEST CONDITIONS

The system was tested in real-life conditions involving a power outage. During the blackout, various devices were connected to the sockets and USB ports. Observations showed that:

a. The 13A socket outlets maintained steady voltage across all terminals.

b. The USB ports provided uninterrupted 5V DC, suitable for mobile phone and small gadget charging.

c. The LCD voltage display remained active, continuously showing the real-time status of AC input, and displayed a blackout notification when the input was zero.

These observations confirmed that the system design was effective in providing seamless switching from grid to battery power. The microcontroller efficiently managed power routing, and the lithium battery backup system ensured continuous operation of critical USB-powered devices.

4.3 GRAPHICAL REPRESENTATION OF RESULTS

The graphical plot of power consumed (in watts) against time (in hours) is shown in Figure 4.1. The curve shows a non-linear downward trend, confirming the rapid drop in available usage time with increasing load demand.

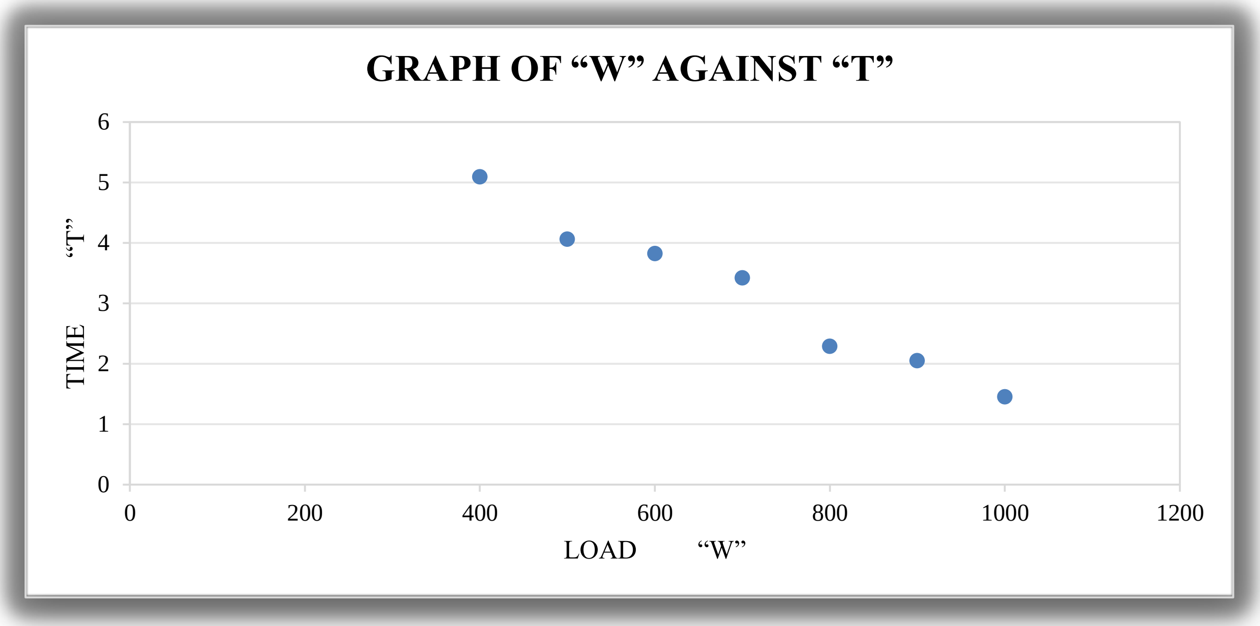

Figure 4.1. The graph of “W” against “T”

It was observed from the results, that the more the loads added at a particular period of time, the reduction in the time of use.

4.4 DISCUSSION OF RESULTS

The successful operation of the extension box during power failure reveals several practical advantages:

1. Reliability: The extension box performed reliably under various load conditions. This indicates that the components used, including the battery, rectifier, transformer, and USB interface, were effectively integrated.

2. Scalability: While the system performed well under 1000W, it is advisable to consider using higher-capacity lithium batteries in future designs to extend the operation time or accommodate heavier loads.

3. Efficiency: The power conversion and regulation circuitry ensured minimal losses, maintaining efficiency in USB charging. The 5V DC USB output remained stable even as the battery level decreased.

4. Safety: No overheating, short circuits, or voltage irregularities were observed during the test period, indicating robust circuit protection.

4.5 LIMITATIONS OBSERVED

Despite the successful implementation, the project exhibited certain limitations:

a) The 200mAh lithium battery had limited endurance under higher loads, lasting less than 2 hours for 900W and above.

b) The recharge time for the battery was relatively long, especially after full depletion.

c) The system does not yet include solar charging, which could improve off-grid resilience.

4.6 IMPLICATIONS OF FINDINGS

The findings demonstrate that such a system can be an effective solution for managing multiple electronic devices in areas with unstable power supply. The USB backup functionality can be particularly useful in emergency scenarios or in rural regions with limited electricity access. Furthermore, the concept can be adapted and scaled for SMEs, schools, and medical facilities where continuous access to mobile devices is critical.

These results also suggest that combining traditional socket functionality with battery-powered USB ports creates a hybrid solution capable of bridging the gap between convenience and necessity in power usage.

4.7 PICTORIAL DIAGRAM OF THE EXTENSION SOCKETS

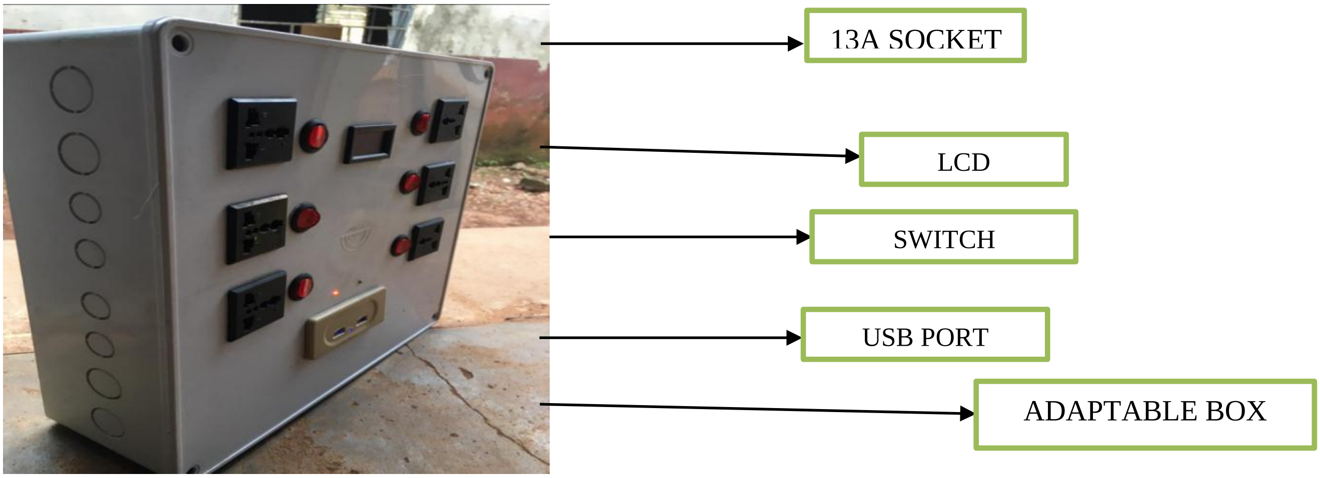

Figure 4.2. The final interface of the project.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This project has successfully demonstrated the design, construction, and performance of a multi-socket extension box integrated with uninterruptible USB power functionality. By combining traditional 13A sockets with modern USB power ports and backup lithium battery support, the system addressed a key challenge in power accessibility ensuring continuous device charging during outages.

The design methodology involved practical implementation of standard electronic components, including a step-down transformer, voltage regulator, rectifier, and microcontroller, integrated with a 200mAh lithium-ion battery to ensure reliability. The parallel wiring configuration guaranteed uniform voltage distribution across the sockets, and the use of a microcontroller facilitated efficient switching and monitoring through an LCD display.

Through testing, the system proved capable of sustaining USB power supply for multiple hours during power failure, depending on the connected load. Lower wattage devices experienced longer uninterrupted operation, while higher wattage devices shortened the available backup duration. The USB ports provided a stable 5V output throughout the testing phase, and no malfunction or safety issues were recorded.

5.2 RECOMMENDATIONS

In light of the testing outcomes and operational insights gained during this project, the following recommendations are proposed for future development, enhancement, and deployment:

1. Increase the battery capacity to 1000mAh or more to prolong operational time.
2. Integrate solar panels as an alternative charging source.
3. Add smart load detection to optimize energy usage and shut down unused sockets.
4. Incorporate fast-charging USB technology for enhanced performance.
5. Provide a mobile app interface to monitor battery levels and socket usage remotely.

BILL OF ENGINEERING MEASUREMENT AND EVALUATION

S/N	LIST OF ITEM	DESCRIPTION	QTY	PRICE	AMOUNT
1.	BATTERY	3.7V/2000AH	1	2000	2,000.00
2.	LED	5AH	15	100	1500.00
3.	RESISTOR	4.7K	3	20	60.00
4.	13A SOCKET		6	1000	6000.00
5.	12V TRANSFORMER		1	10,000	10,000.00
6.	RECTIFIER		2	100	200.00
7.	REGULATOR		4	500	2000.00
8.	USB PORTS		2	2000	4000.00
9.	MICRO CONTROLLER		1	2000	2000.00
10.	CONNECTOR		8	200	1600.00
11.	CASING			3000	3000.00
12.	BOLTS AND NUTS		8	100	800.00
13.	PRINTED CIRCUIT BOARD + DESIGN		1	2000	2000.00
14.	COVER OF PCB		1	200	200.00
15.	DRILLING BIT		1	150	150.00
16.	SOLDERING IRON		1	1500	350.00
17.	MISCELLANEOUS				
18.	SOLDERING LED		1		1000.00
	FIELD EFFECT TRANSISTOR		6	100	600.00
				TOTAL	37,460.00

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