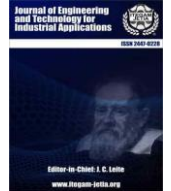




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RESEARCH ARTICLE

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## DEVELOPMENT AND TESTING OF A HYBRID DISTRIBUTION BOARD

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### ABSTRACT

The intermittent power supply in the country has given rise to the use of direct current (DC) source as a substitute, however, most devices such as LED lamps, refrigerators, television, and radios are available in DC nowadays and cannot be connected to the conventional mains supply without the help of other devices like AC to DC converters. This prompts the need for a hybrid distribution board capable of supplying AC and DC concurrently to a final sub-circuit of an electrical installation of a building where DC and AC devices are required. Major components used are an isolator, miniature circuit breakers, and a rectifying module that convert a section of the AC source to the correct voltage level to power the DC load. The design was implemented and tested on a demonstration board having two separate circuitry loads installed on it. The circuitry loads are DC and AC, the DC load is comprised of a 5W DC bulb controlled with a gang switch, while the second circuitry is comprised of a 13A single socket outlet and a 10W LED lamp controlled with a gang switch. The result shows that both the DC and AC output works perfectly which when encourage will minimise power consumption and make provision for the connection of DC appliances without the use of external converter and step-down transformers.



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### I. INTRODUCTION

The intermittent power supply in the country and the need for low rating equipment with higher efficiency have given rise to the use of DC Equipment and fittings such as LED fittings, fans, television sets, refrigerators, and sound systems that require less energy [1, 2]. In most electrical installations where many circuits are to be wired, the distribution fuse board becomes a necessity. Consequently, to develop equipment that can supply both AC and DC load concurrently to the final sub-circuit, a hybrid distribution board is proposed, which will take in and supply AC/DC load concurrently and also gives room for future expansion [3].

A distribution board is a piece of equipment or an assemblage of parts that includes the main switchboard, fuses, or circuit breakers suitably arranged for the distribution of electrical power to the final sub-circuit in an electrical installation [4, 5]. However, there are several types of distribution boards which include: main breaker panel, main lug panel, sub-panel, and

transfer switch and are available in 4-way, 6-way, 8-way, and 12-way configurations [6, 7]. The distribution board protects devices by allowing individual circuits to draw power from correctly rated breakers [8].

It is worthy of note that the rise of photovoltaic panels production increases the usage of DC electricity. DC distribution has more advantages such as stability, controlled emergency support, and no contribution to the short circuit level, and also used today in long-distance high-voltage cables, such as transmission cables on the floors of oceans [9]. However, there is a need for a step-down transformer or the usage of a converter before the DC load can be used in an AC supply board, but with the introduction of the hybrid distribution board, it is possible to use all these gadgets with ease with the use of an AC/DC module of adequate current rating that is capable of supplying AC and DC concurrently to a final sub-circuit in an electrical installation where DC and AC devices are required.

Hybrid is the combination of two or more things, while a hybrid distribution board refers to an electrical board that supplies alternating and direct current to the final sub-circuit. For effective energy efficiency management culture, the process of observing, controlling, and conserving electricity usage must be employed in residential and commercial installations [10], this will help more people to have access to electricity and also reduces the burden on the available power stations [11].

Several works on literature related to the study have been reviewed and [12] proposed a Smart Distribution Board that is optimized for the implementation of EMS for measuring the electricity usage on each circuit with the installation of a sensor that will enhance energy efficiency management. [13] opined that the applied AC and DC hybrid power distribution system has greater efficiency when deployed in renewable energy and also helps to

boost energy regeneration in the building. Similarly, [14] proposed a system that can work in centralized as well as in autonomous modes which makes the grid smarter.

## II. MATERIALS AND METHODS

The design is based on both DC and AC output supply, The AC load is connected to the AC output supply and the DC load is connected to the DC output supply. The board is expected to handle a total current of about 100Amps for the AC and DC module demand while the total current on the DC module shall not exceed 20A (DC).

The block diagram of the Hybrid Distribution Board is shown in Figure 1.

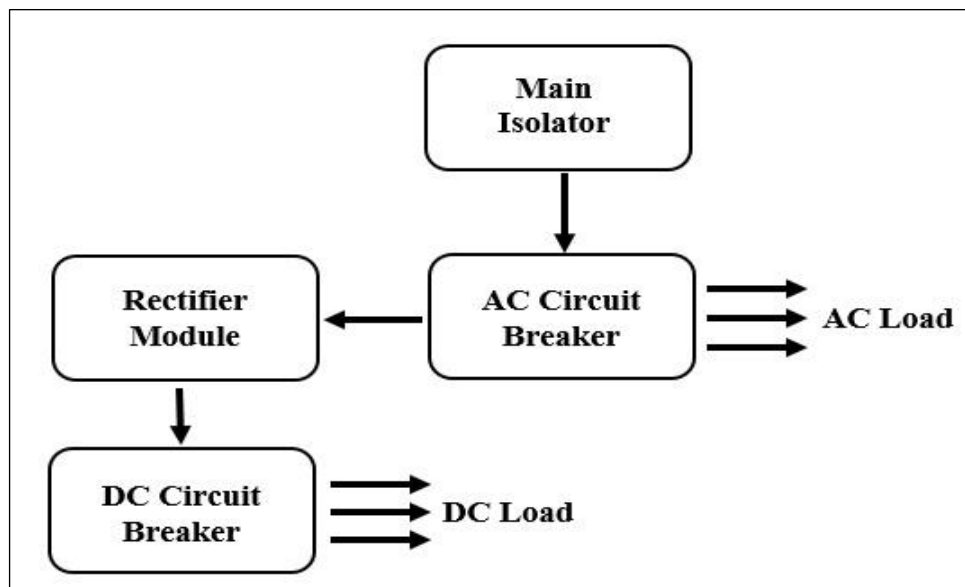


Figure 1: Block Diagram of Hybrid Distribution Board.  
Source: Authors, (2021).

The construction is based on both DC and AC output supply. A 100A double pole AC isolator was fixed on a rack with the aid of the isolator clip. The rack was mounted in an enclosure with screws. This 100A isolator helps in controlling the incoming source voltage. The output from the isolator was connected to one side of the AC circuit breakers with a 10mm single core cable and the neutral from the isolator was connected to the neutral bar.

The S-240-12Vdc Switch Power Supply Module was screwed onto the enclosure with a rubber insulator under it; the rubber insulator prevents the module from having direct contact with the metallic enclosure thus preventing electric shock. The supply voltage to the DC module was connected from one of the outputs of the 20A circuit breakers. This circuit breaker serves as a protection device for the incoming supply of the module and the neutral was terminated on the neutral connector. The module does the work of conversion i.e. the converting 220V AC to 12V DC thus supplying DC voltage. The entire board has two output supplies which are AC output and DC output. AC load is connected to the AC output supply and DC load is connected to the DC output supply.

### II.1 DEVELOPMENT PROCEDURE

The following materials are selected for the implementation of the design.

- 100A 240V Main Isolator Switch
- 20A 240 V AC – 12 V DC Switched Power Supply Module

- AC Miniature Circuit Breakers 10A, 25A, 25A and 30A
- DC Circuit Breakers

1) *100A 240V Main Isolator Switch*: It is a manually operated mechanical switch that separates a part of the electrical power, it is used to open a circuit under no-load conditions. Its main purpose is to isolate one portion of the circuit from the other and is not intended to be opened while current is flowing in the line. Main isolators are generally used on both ends of the breaker so that repair or replacement of the circuit breaker can be done without any danger.

2) *ModuleS-240V-12Vdc Switch Power Supply*: It is a switching device that converts 240V AC to 12V DC, AC input range selectable by auto-sensing, protecting short circuit/overload and overvoltage. The ModuleS-240V-12VDC Switch Power Supply circuit diagram is shown in figure1; it supplies electrical power to DC load, the primary function is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters.

3) *AC Circuit Breaker*: It is a circuit breaker that is also known as an overcurrent protection device (OCPD) designed to protect equipment or device from damage by shutting the power

when there is overload or malfunctioning in the circuit [15]. It is available in different ratings like 10A, 15A, 20A, 25A, 30A respectively. It can be reset after an overload has been cleared in a circuit.

4) *DC Circuit Breaker*: It is a circuit breaker that automatically shut off the power whenever the circuit is overloaded or experience short circuit conditions. The breaker detects a fault and immediately interrupts the continuity in the electrical flow. The main difference between direct current and alternating current is that in DC the voltage output is constant, while in AC it cycles several times per second [16].

### III. RESULTS AND DISCUSSIONS

The construction was tested with a wooden board having two separate circuitry loads installed on it. The circuitry loads are DC and AC. The DC load is comprised of a 5W DC bulb controlled with a gang switch. The second circuitry comprised of a 13A single socket and a 10W LED lamp controlled with a gang switch. The input of the hybrid distribution board was connected to a 220V AC supply and the main isolator and all other circuit breakers were turned ON. Voltages were supplied to the two circuits and the entire devices connected to the circuit were all working.



Figure 2: Internal Connection when all cables are connected.  
Source: Authors, (2021).



Figure 3: Constructed Hybrid Distribution Board Unpowered.  
Source: Authors, (2021).



Figure 4: Constructed Hybrid Distribution Board Powered.  
Source: Authors, (2021).



Figure 5: Hybrid Load on Wooden Board when Not Powered.  
Source: Authors, (2021).



Figure 6: Hybrid Load on Wooden Board when Powered.  
Source: Authors, (2021).

Figure 3. Shows the complete hybrid distribution construction when the board is not powered, and Figure 4. Shows the complete hybrid distribution construction when the board is powered, it was observed that the DC voltage displayed 12.6V while the AC voltage displayed 200V as shown in Figure 4. Similarly, Figure 5 and 6 displayed the extended load which comprises of both the AC and DC load when not powered and powered respectively. It was observed that energy efficiency can be achieved by hybrid distribution systems in a building. In addition to this when connecting DC load on the distribution board the polarity of the device to be connected needs to be done correctly i.e. positive connections to be made on the positive terminal and negative to the negative terminal. The testing of the project was done and the output result was achieved. The 5W LED DC bulb illuminated brightly at the output. Also, the 13A socket outlet and the 10W LED AC bulb worked perfectly fine.

#### IV. CONCLUSIONS

It is imperative to note that Hybrid Distribution Board implementation will minimize power consumption and make provision for the connection of DC appliances without the use of external converter and step-down transformers. The result shows that both the DC and AC output works perfectly, which when encouraged will reduce the cost of installing an inverter. It is concluded that in general, DC systems can improve energy efficiencies by simplifying system structures and improving conversion efficiencies of various converters.

#### V. AUTHOR'S CONTRIBUTION

**Conceptualization:** Najeem O. Adelakun, Banji A. Olanipekun and Samuel A. Omolola.

**Methodology:** Najeem O. Adelakun and Banji A. Olanipekun.

**Investigation:** Najeem O. Adelakun and Banji A. Olanipekun.

**Discussion of results:** Najeem O. Adelakun, Banji A. Olanipekun and Samuel A. Omolola.

**Writing – Original Draft:** Najeem O. Adelakun.

**Writing – Review and Editing:** Najeem O. Adelakun and Samuel A. Omolola.

**Resources:** Najeem O. Adelakun.

**Supervision:** Najeem O. Adelakun and Samuel A. Omolola.

**Approval of the final text:** Najeem O. Adelakun, Banji A. Olanipekun and Samuel A. Omolola.

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