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ASIAN JOURNAL OF ELECTRICAL AND ELECTRONIC ENGINEERING
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Design and Modelling of PV-Diesel Hybrid Energy System with Fuzzy Logic Controller

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Abstract— Renewable energy, such as wind and photovoltaic arrays, has become the core energy in micro-grids used for supplying remote areas and areas suffering from electricity outages. Many limitations, such as weather fluctuations and low efficiency, lead to designing and developing a hybrid energy system. The integration of photovoltaic arrays and diesel gensets has become one of the most common approaches to generating electricity for remote communities. Although the integration of photovoltaic arrays and diesel gensets has the potential to reduce the cost of electricity production by harnessing free energy from the sun to reduce the power generated by diesel engines, it tends to complicate the control of the entire system due to the intermittent nature of the renewable energy sources and changing load demand. This paper proposes a fuzzy logic controller of PV-Diesel hybrid energy system, which is used as an effective tool in facilitating optimum power-sharing between the PV power source, charging, and discharging batteries and diesel generator as a backup based on the dynamics of the available PV energy at any time. Optimizing power control in the PV-Diesel hybrid energy system is key to minimizing the cost of power generation and maximizing the overall efficiency of the PV-Diesel hybrid energy system. The MATLAB-Simulink is used to design the fuzzy logic controller of the PV-Diesel hybrid energy system and to validate its performance. Five scenarios during the day have been tested to show the performance of the fuzzy logic controller. The results showed the accurate controlling of the power flow in the PV-Diesel hybrid system and the power saved about 2%.

Keywords: *Fuzzy logic controller, Hybrid Energy System, Solar Power, Diesel Engine*

1. INTRODUCTION

Energy is very important to improve the quality of economic and social life. Thus, securing stable energy sources in remote areas (off-grid) and areas that suffer from large energy shortages due to wars and poverty is essential (Garcia, 2016). These areas usually rely on a diesel generator to overcome energy problems. Still, the continued rise in petrol prices and its delivery to these areas is difficult and expensive as well, led them to use other energy sources like renewable energy sources. In recent years, these areas have begun to depend on renewable energy especially solar energy, due to the low cost of photovoltaic panels (PV) and their efficiency (Ani, 2016).

Solar energy is still insufficient because the weather is volatile, as the sun rays on rainy and cloudy days are very weak, thus reducing the efficiency of the PV solar system and could not meet the power demand. So, using Hybrid Power Systems (HPS), which combines two or more different types of renewable and low carbon generators, is the most efficient for these areas (Kumar, 2014). The main object of combining a diesel generator with any of these renewable sources is to ensure meet power demands without interruption, minimize diesel fuel consumption and pollution emissions, thus reducing the costs of saving energy and preserving the environment. PV-Diesel hybrid systems are the best optimal solution for these areas where these systems are reliable and cost-effective and can achieve lifetime fuel saving (Ani, 2016). However, improper energy flow control between the PV solar and diesel generator and incorrect battery charge/discharge algorithms causes low output power efficiency and rapid system equipment damage (Serban, 2016). The low efficiencies of traditional monitoring and control techniques have led researchers to evolve artificial intelligence-based optimizations. Suitable utilization of intelligent technologies leads to sound systems with improved performance or other characteristics that traditional technologies cannot achieve. Artificial intelligence, especially fuzzy logic controllers, has been used widely in controlling a hybrid energy system. Using the fuzzy logic controller has shown a noticeable improvement in hybrid energy efficiency.

The fuzzy controller is used to share the contribution of each source and focus on the PV solar source to exploit energy from it as can as possible. In addition, the controller is used to protect the storage battery and improve diesel performance. The inputs of the fuzzy controller are an error (e) and change of error (Δe). The error is the difference between the load power and the output power from PV. The outputs of the fuzzy controller are three control signals: battery charging, battery discharging, and diesel switch commands. The results showed the fuzzy controller could deal with three cases (morning, daylight, night) according to the load profile and three sources to decrease fuel consumption and protect the storage battery for a long time of operation. A novel fuzzy logic controller has developed of PV-diesel hybrid energy system, and compared against existed control strategy, named load following and cycle charge. This fuzzy control strategy can extend generator shutdown time, thereby reducing consumers' electricity cost (COE). System performance is evaluated using MATLAB / Simulink. Results show that COE achieved through a control strategy based on a fuzzy basis is lower than the load following and cycle charging strategy. Also, lowering COE and CO2 emissions compared to the independent generator system is 12.7% and 25%, respectively (Chok, 2019). The fuzzy logical control unit has also demonstrated the ability to eliminate the need for sophisticated and dull mathematical models as required in conventional control methods. Thus, the system was the easiest to develop. Control of energy flow in the hybrid power system is still an advanced search. Several energy control solutions have been proposed. However, many of them lack validation. Validation of a proposed design is vital to ensure the viability of a system to be implemented (Nnadozie, 2018). This work has done the validation of a fuzzy logic controller designed for PV-Wind hybrid energy systems. The control unit has been verified by adapting it to a hybrid renewable energy system and simulating test case scenarios to verify claims of control functions. The simulation results showed that the monitoring and control of supply power, load demand, and charging and discharging of the battery delivered desirable results. For each test case, the controller is confirmed to simulate expert decisions. Hence fuzzy logic controller was validated, and the authors' claims were verified (Chibuikem, 2018).

This paper will design and develop a PV-Diesel Hybrid system, in addition, to design a fuzzy logic controller which used to control between PV solar system and Diesel generator to ensure when the power from PV solar system (include batteries) will be not enough to provide the load demand, the diesel generator will cover the power lack, that ensures stable power source without interruption, reduce the fuel consumption and pollution emissions as well

2. PV-DIESEL HYBRID ENERGY SYSTEM DESIGN AND MODELLING

In this section, PV-Diesel Hybris Energy System will be designed and modelled.

2.1 Photovoltaic Panel System Modelling

To model the photovoltaic panel, we have to model the PV cell firstly. Figure 1 shows the equivalent circuit of the photovoltaic cell. The PV cell circuit involves a photocurrent, diode, parallel resistor, or shunt resistor R_{sh} (leakage current) and a series resistor R_s. This model is recognized as a single diode solar cell model (Roy Chowdhury, 2010).

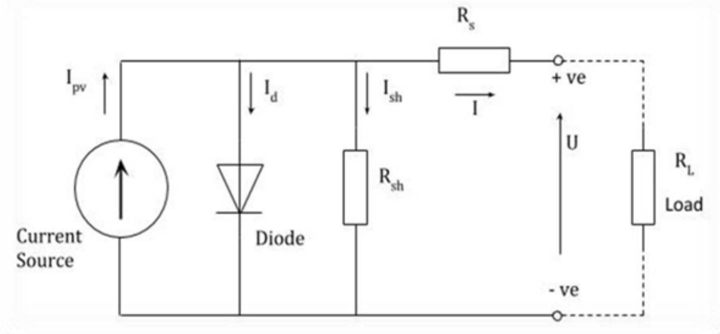

Fig.1. Equivalent Circuit of PV Cell.

Based on both Kirchhoff's circuit laws and the PV cell circuit shown in figure 1, the PV current can be stated as follows:

$$I_{pv} = I_{ph} - I_D - I_{sh} \quad (1)$$

$$I_{pv} = I_{ph} - 10\left[exp\left(\frac{(V+I_oR_s)q}{nKTNs}\right) - 1\right] - I_{sh} \quad (2)$$

Where:

I_{pv} shows the photovoltaic current (A)

I_{ph} shows photogenerated current (A); (this current will be calculated in the following equation)

V shows the solar cell voltage (V)

I_o shows the saturation current; (this current will be calculated in the following equation)

R_s shows series resistance (Ω)

q = Elementary charge constant $(C) = 1.60217646 \times 10^{-19} C$

n represents diode ideality factor

K = Boltzmann constant $(J/K) = 1.3806503 \times 10\text{^}(-23)\, J/K$

T is solar cell temperature (K)

N_s represents the series-connected cells

I_{sh} represents the shunt current (A) (this current will be calculated in the following equation)

Equation (1) is the general equation of solar cells. Whereby, the PV current depends on another three currents, which are photogenerated current I_{ph}, saturation current I_o and shunt current. These currents are calculated as follows:

- The photogenerated current I_{ph} primarily based on the temperature of cell and solar irradiation, which is represented as:

$$I_{ph} = \frac{[K_i(T-298) + I_{sc}]G}{1000} \quad (3)$$

Where, K_i is the temperature coefficient of the cell's short current of the cell panel, T is the cell's reference temperature, I_{sc} is the short circuit current and G is the solar radiation (kW/$m2$).

- The PV saturation current I_o varies with the cell temperature, which is described as:

$$I_o = I_{rs}\left(\frac{T_c}{T_r}\right)^3 exp\left[\frac{qEg}{nK}\left(\frac{1}{T_r} - \frac{1}{T_c}\right)\right] \quad (4)$$

Where I_{rs} is reverse saturation current of the cell panel, and it can be represented as:

$$I_{rs} = \frac{I_{sc}}{exp^{\left(\frac{qv_{OC}}{nN_sKT_C}\right)-1}} \quad (5)$$

Where q is the band-gap energy of the cell, and V_{oc} is the cell's open-circuit voltage.

- The shunt current is represented by the following equation.

$$I_{sh} = \frac{V+IR_s}{R_{sh}} \tag{6}$$

Where, R_{sh} represents the shunt resistance (Ω).

2.2 Battery System Model

In this work, the batteries will be used as an energy storage system. This subsystem relies on the general battery block provided by the Simscape power system in the Simulink environment [15]. There are four types of batteries supplied to use: Lid-Acid, Lithium-Ion, Nickel-Cadmium, and Nickel-Metal-Hydride. The type of battery that will be chosen for this system is a Lid-Acid battery. The battery will be connected with the system using a bi-directional DC-DC converter, which will be controlled using the fuzzy logic controller to charge and discharge the battery. For the lead-acid battery type, the model uses these equations (Tremblay, 2009):

- Discharge Mode (i<0)

$$V_{batt} = E_0 - R \cdot i - K\frac{Q}{Q-it} \cdot (it + i^*) + Exp(t) \tag{7}$$

- Charge mode (i>0)

$$V_{batt} = E_0 - R \cdot i - K\frac{Q}{it-0.1 \cdot Q} \cdot i^* - K\frac{Q}{Q-it} \cdot it + Exp(t) \tag{8}$$

Table 1: The Parameter of Lid-Acid Battery

Parameter	Values
Nominal voltage (V)	12
Rated capacity (AH)	5.4
Initial state-of-charge (%)	20
Battery response time (s)	1e-4

Figure 2 shows the battery and bidirectional converter was modelled using MATLAB-SIMULINK.

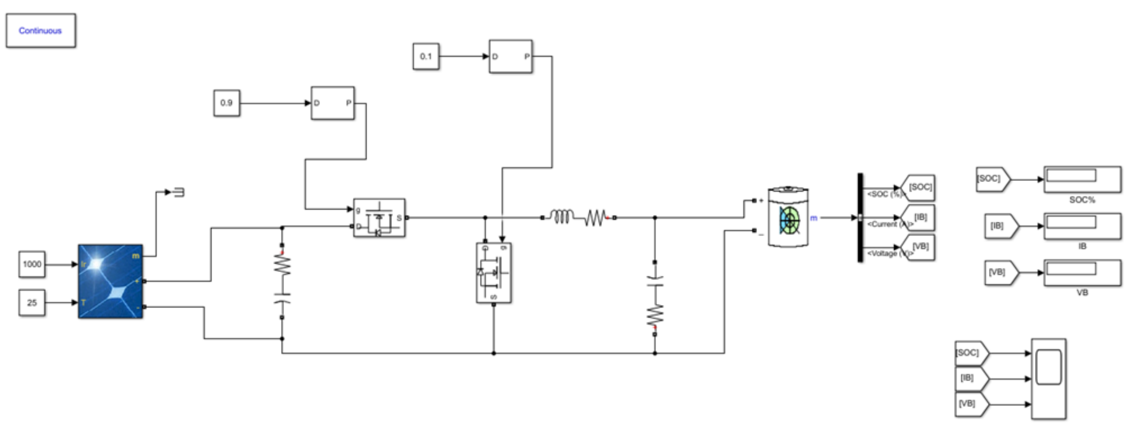

Fig. 2. Battery Connected with PV Panel using Bidirectional Converter.

2.3 Diesel Generator Model

In this work, the diesel generator will be a backup system to cover the night mood. "Here, the relationship between diesel input fuel and the resulting electric power is assumed to be linear. Idle fuel consumption is around 25 to 30 per cent of the consumption at nominal rated power. Diesel stations have a separator between diesel engines and generators. To be able to handle the beginnings and engines of a diesel engine, the clutch must also be designed." (Rebhi, 2019).

$$\frac{dw_d}{dt} = (\frac{[k_v(k_c m_f - p_o) - D_d w_d - T_{dgn})}{J_d} \tag{9}$$

$$\frac{dm_f}{dt} = \frac{w_d - w_{ref} - \frac{m_f}{\delta}}{T_d} \tag{10}$$

Where:

w_d is the speed of engine speed
w_{ref} is the speed of governor reference
δ is the gain constant of governor gain
T_d is the time constant in the governor
m_f is the fuel consumption in diesel
k_c is the combustion constant describing the efficiency
p_o is the pressure of the motor chamber when running idle
k_v is the volume of stroke
T_p is the produced torque
T_f is the friction torque
T_{den} is the load torque from generator and clutch
D_d is the constant describing the frictional losses
J_d is the total moment of inertia of the engine, clutch, and generator.

Figure 3 shows the subsystem of the diesel generator connected to the ON-OFF switch.

The diesel generator has been designed based on equations 9 and 10. A fuzzy logic controller will control the ON-OFF switch. When the solar power is too low and the battery is low, the switch will be ON.

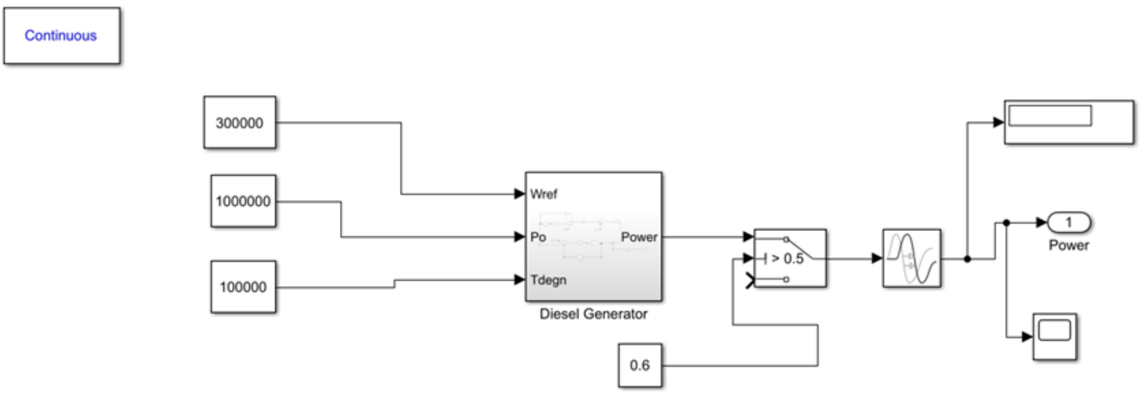

Fig. 3. The Subsystem of Diesel Generator.Fuzzy Logic Controller Model

2.4 The proposed Fuzzy Logic Controller

A fuzzy logic controller has been widely used over the last years due to its simplicity and flexibility. It is also used with nonlinear imprecise inputs [19]. Therefore, the FLC is suitable to control the PV-diesel hybrid energy system since the inputs from the PV panel and the diesel generator are not linear. In addition, the fuzzy logic controller is implemented to control the PV-diesel hybrid energy system is faster than the other traditional controllers. The intelligent power management system optimally selects the power supplies based on the availability of solar energy and battery state of charge. The proposed fuzzy logic controller has two inputs and three outputs. The two inputs of FLC are the error "e" and the state of the charge of the battery (SOC%).

$$e = P_{pv} - P_{load} \quad (11)$$

The input variable "e" is the power error in the system and the state of charge of the battery (SOC%). The outputs are three control signals. The first and second control signals are duty cycle signals "D" converted to PWM signal and sent to bidirectional charger to control charge and discharge the battery. The last signal is the duty cycle signal which will be sent to the ON-OFF switch to control start/ stop the diesel generator. Basically, fuzzy logical control has three stages: fuzzification, inference and defuzzification. These elements and the global structure of FLC are shown in Figure 4. Each input/output variable of fuzzy logic control must be stated in fuzzy set notations using linguistic forms. Therefore, fuzzification is the process of converting input/output variables to linguistic forms. The second stage of fuzzy logic is the inference in which the fuzzy processor uses linguistic rules to define the control procedure that must occur in response to a specific set of input values. The rule evaluation result is a fuzzy outcome for each type of consequence action. The last stage of fuzzy logic is defuzzification, in which the fuzzy quantity is converted into crisp quantity. In fact, there are many methods for the defuzzification process the most common one and used in this project is the centroid method or centre of gravity.

With refer to figure 4, once the inputs "e" and "SOC%" are measured, the controller converts them into linguistic variables using the membership functions. The two input membership functions are divided into five fuzzy levels which are: very positive (PP), small positive (P), middle (Z), small negative (N) and very negative (NN). The three outputs also will be converted into linguistic variables by means of the membership functions which are battery charge (BC), battery discharge (BD) and diesel generator (DG). The battery charge "BC" and battery discharge "BD" outputs are divided into five levels of membership functions the same as the inputs. The last output is "DG", which will be divided into two levels which are start (ON) and stop (OFF).

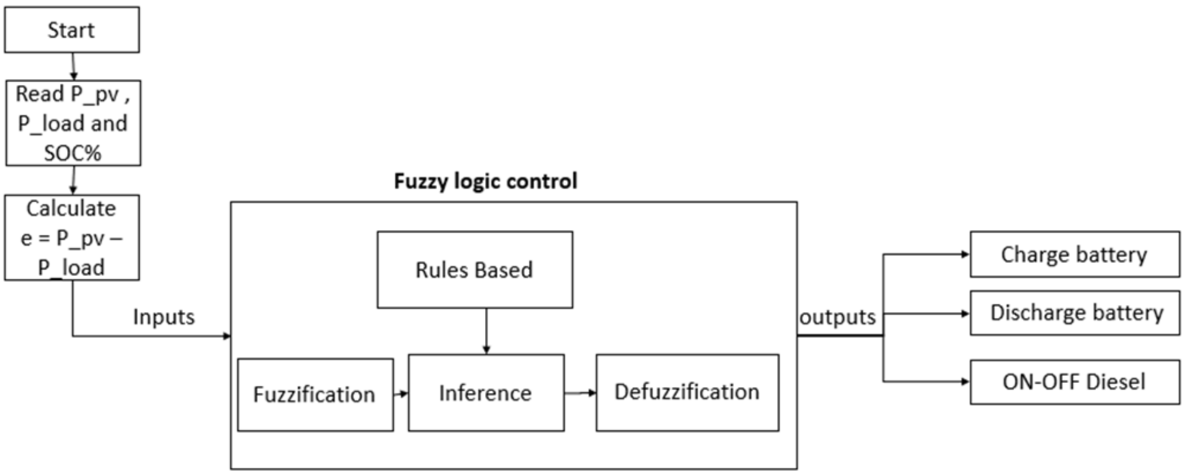

Fig. 4. The Proposed Fuzzy Logic Controller Components.

2.5 Fuzzy Logic Controller System Design

The fuzzy logic control system was designed using MATLAB software. The rule-base proposed by Mamdani was employed. The Fuzzy Logic Toolbox and its Graphics User Interface (GUI) were used to define the inputs and outputs, define the linguistic variables and values, construct the membership functions, and specify the fuzzy set operators and implication, aggregation, and defuzzification methods. In addition, surface plots for the controller were generated using MATLAB software.

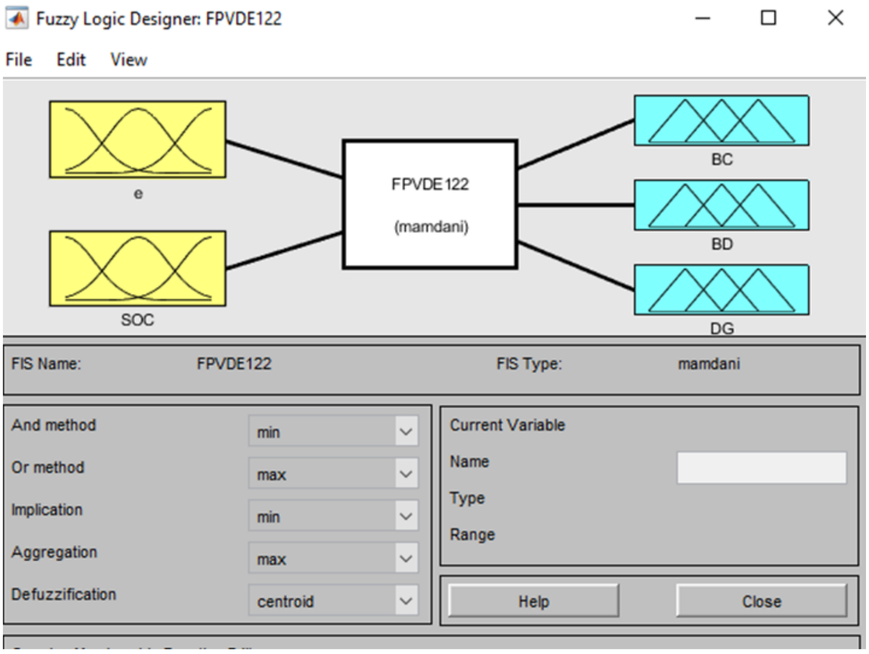

Fig. 5. Fuzzy Logic Controller Diagram.

Figures 6, 7, 8,9 and 10 show the membership function variables for both inputs and outputs.

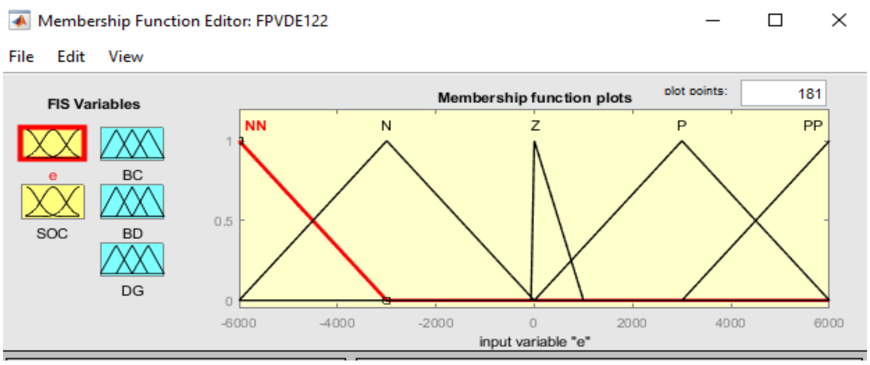

Fig.6. The Membership Function of the “e” Variable.

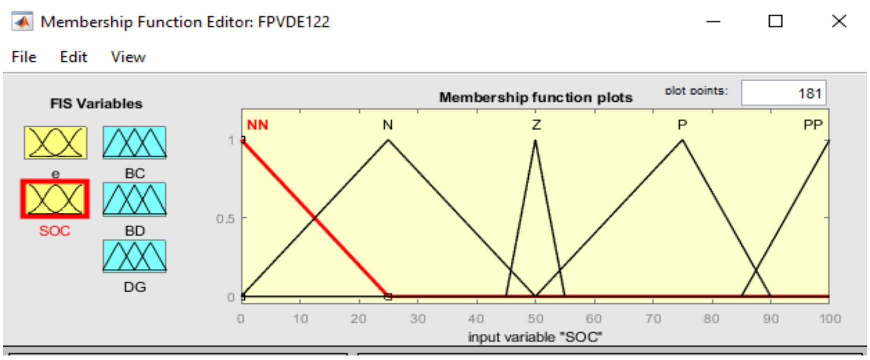

Fig. 7. The Membership Function of the “SOC” Variable.

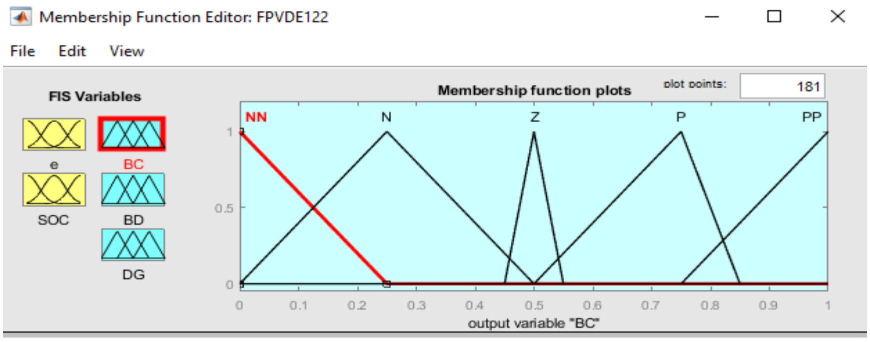

Fig. 8. The Membership Function of the "BC" Variable.

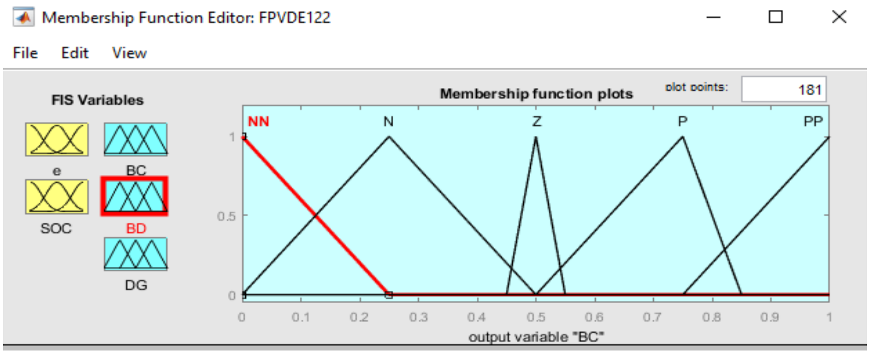

Fig. 9. The Membership Function of the "BD" Variable.

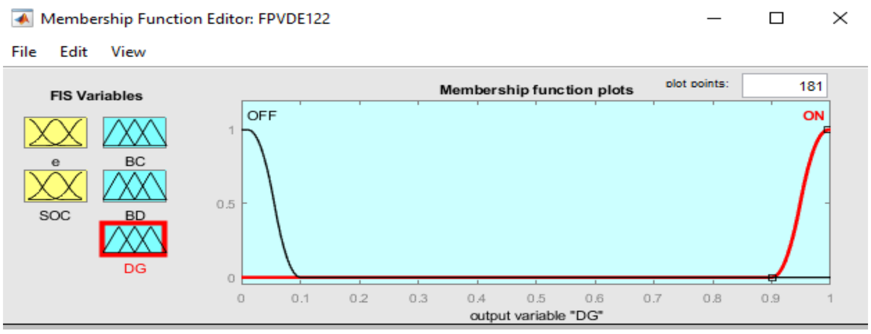

Fig. 10. The Membership Function of the "DG" Variable.

Table 2: Rules Table

SOC, e	PP	P	Z	N	NN
PP	N	Z	P	PP	PP
P	N	Z	P	PP	PP
Z	NN	NN	NN	NN	NN
N	NN	NN	NN	NN	NN
NN	NN	NN	NN	NN	NN

3. RESULTS

Applying a fuzzy logic controller in a PV-Diesel hybrid energy system is very important to manage the energy flow in the system and choose the most suitable source to supply the load based on sun availability. In this project, the fuzzy logic controller was developed and tested using MATLAB-Simulink and the online simulation results showed the performance of the fuzzy controller in the PV-diesel hybrid energy system. Four scenarios during the day have been tested to show the performance of the fuzzy logic controller.

3.1 Case 1

In this scenario, the noontime, the solar irradiance is at the highest level with 1000 W/m^2 and the battery state of charge (SOC%) is 10%. So, in this case, the P_PV = 10KW and P_LOAD = 5KW, the error will be very positive that is mean the PV solar panel can supply the load and charge the battery.

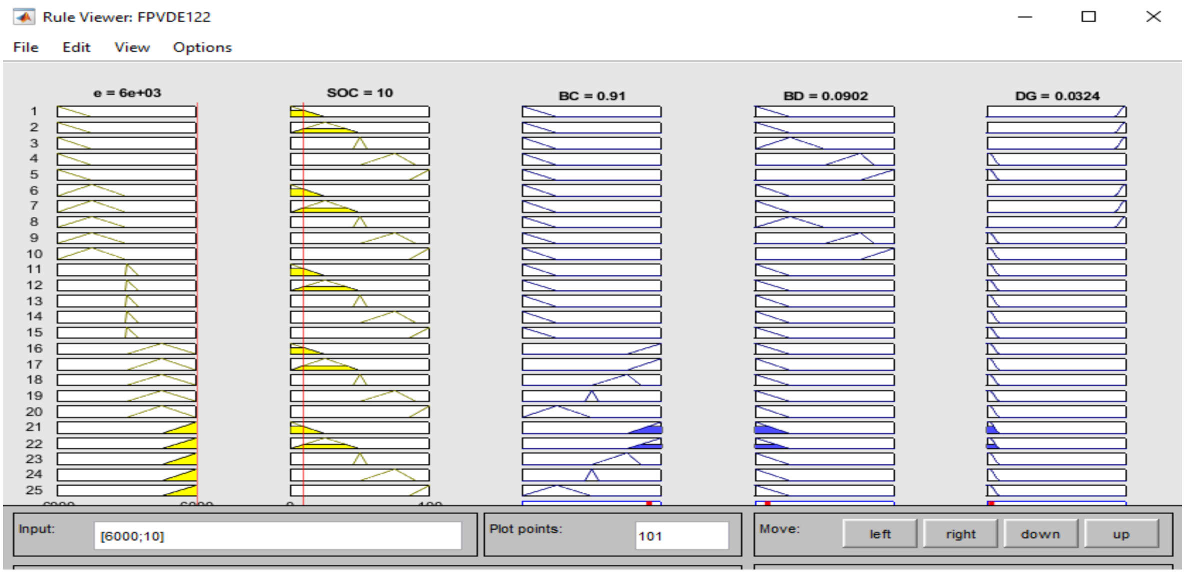

Fig. 11. Result of Rules for Case 1.

As we can see from figure 11, when the error is very positive and the SOC very negative, the output battery charge "BC" is 0.91 means the battery is charging speedily. On the other hand, the diesel generator "DG" is 0.0324 means OFF.

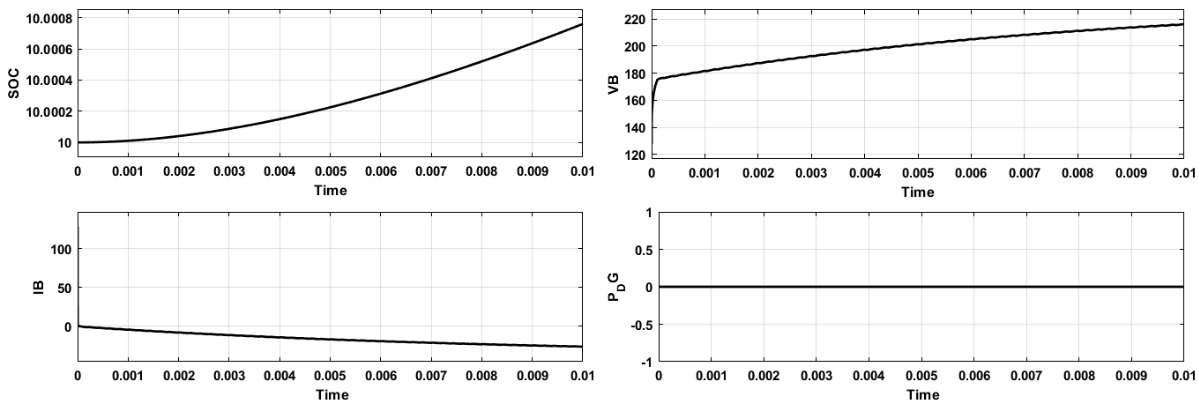

Fig.12. Results of the Implementation of Case 1.

As we can notice from figure 12, the battery is charging at the highest charging mode since the battery current charging is around 25A. The diesel generator is off since there is no power output.

3.2 Case 2

In this scenario in the late morning and early evening, the solar irradiance is at the middle level with 500 W/m^2, and the battery state of charge (SOC%) is 10%. So, in this case, the P_PV = 5KW and P_LOAD = 5KW, the error will be zero that is mean the PV solar panel can only supply the load.

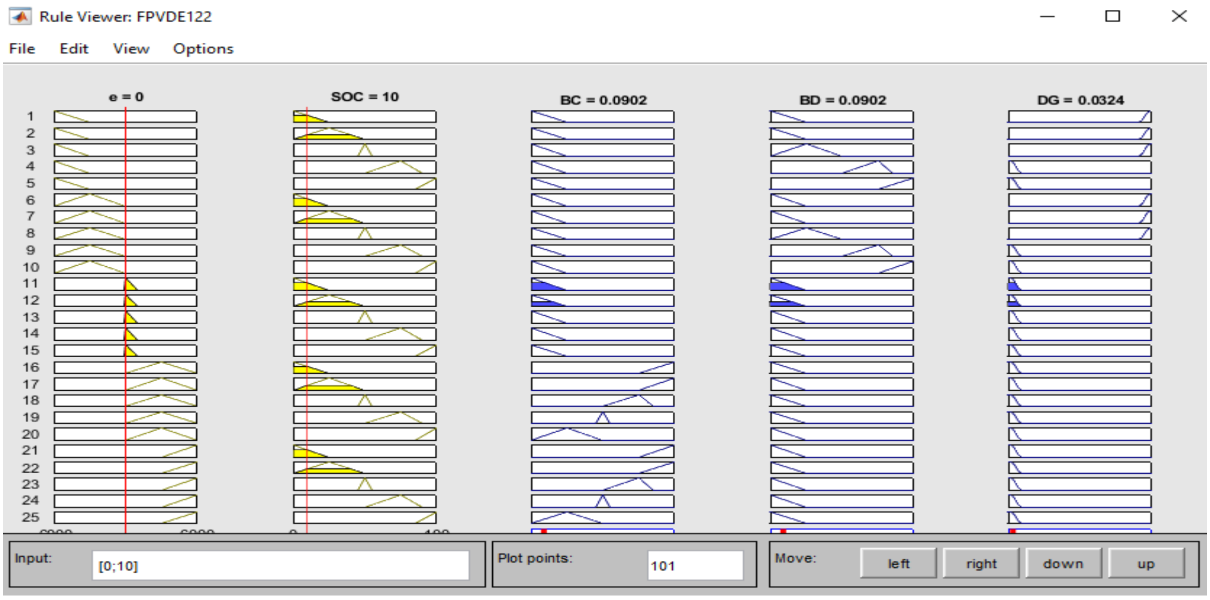

Fig. 13. Result of Rules for Case 2.

As we can see from figure 13, when the error is zero and the SOC is very negative, the output battery charge "BC" is 0.0902 means the battery is almost not charging. The diesel generator "DG" is 0.0324 means OFF.

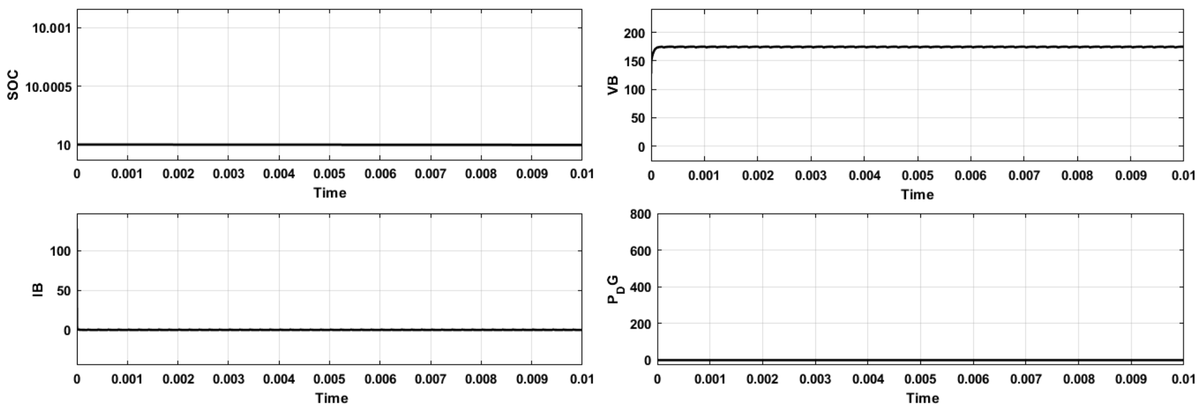

Fig. 14. Results of the Implementation of Case 2.

As we can see from figure 14, the battery is no change at the state of charge of the battery, which means the battery is not charging or discharging. The diesel generator is still off.

3.3 Case 3

In this scenario at night, the solar irradiance is at the lowest level with 0 W/m^2 and the battery state of charge (SOC%) is 95%. In this case, the P_PV = 0 W and P_LOAD = 5KW, the error will be very negative that is mean the PV solar panel can't supply the load so, the battery will be discharged to supply the load.

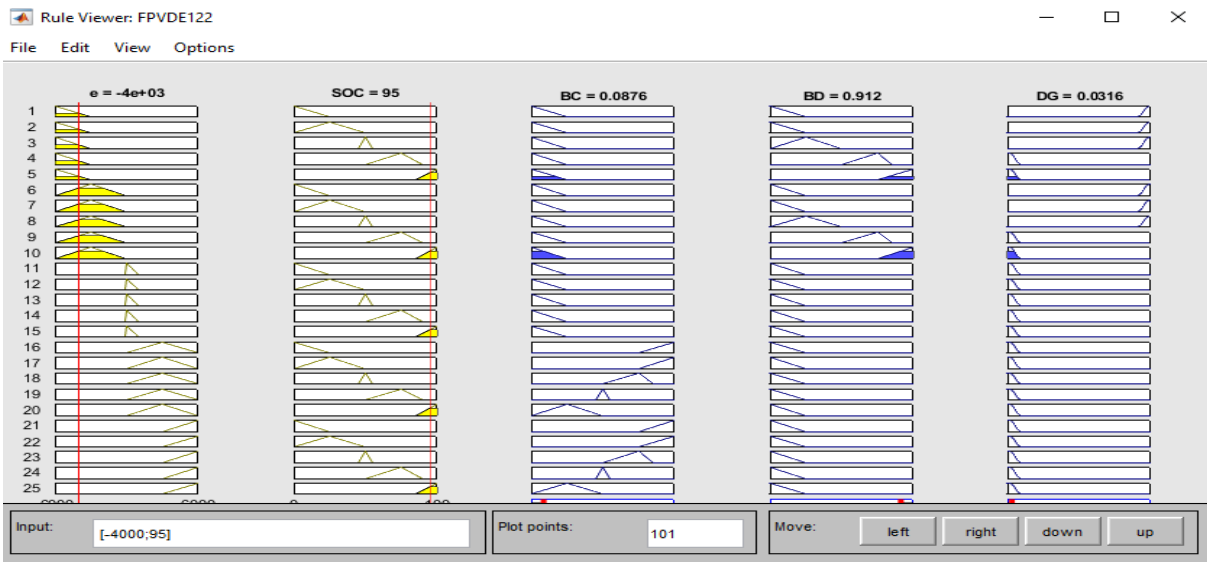

Fig. 15. Result of Rules for Case 3.

As we can see from figure 15, when the error is very negative and the SOC is very positive, the output battery discharge "BD" is 0.912 means the battery is discharging speedily to supply the load.
The diesel generator "DG" is 0.0324 means OFF.

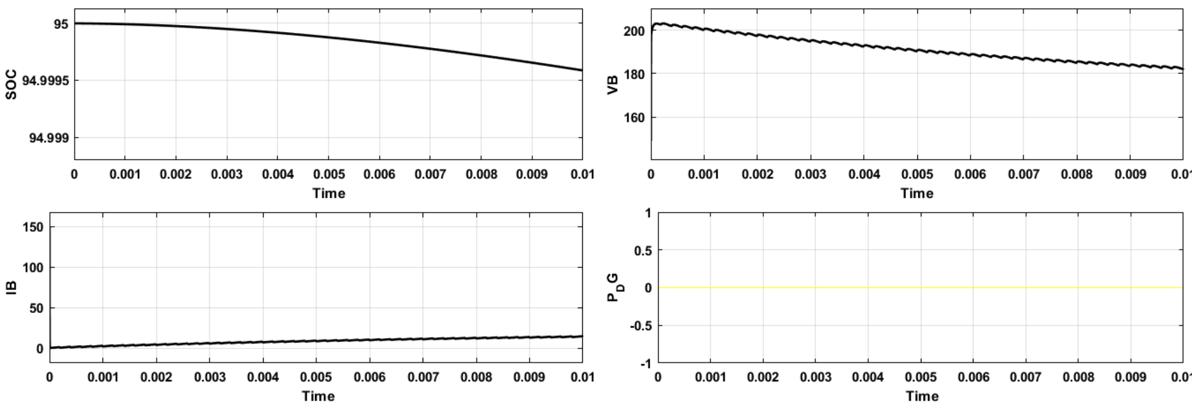

Fig. 16. Results of the Implementation of Case 3.

3.4 Case 4

In this scenario at night, the solar irradiance is at the lowest level with 0 W/m^2 and the battery state of charge (SOC%) is 10%. So, in this case, the P_PV = 0 W and P_LOAD = 5KW, the error will be very negative that means the PV solar panel can't supply, but the battery can't, so the backup diesel engine will be ON to supply the load.

Fig. 17. Result of Rules for Case 4.

As we can see from figure 17, when the error is very negative and the SOC very negative, the output battery charge and discharge “BC&BD” are 0.0902 means the battery is almost not changed. The diesel generator “DG” is 0.969 means ON to supply the load.

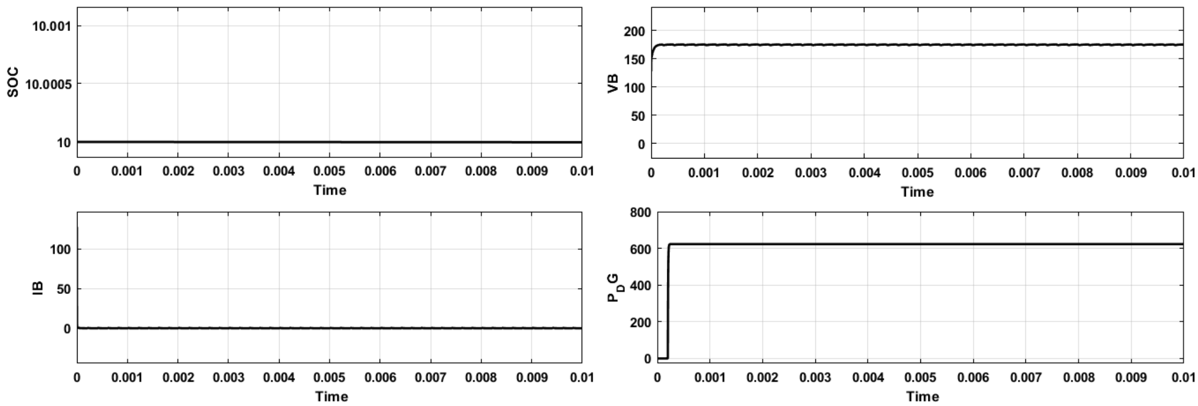

Fig. 18. Results of the Implementation of Case 4.

As we can see from figure 18, the state of the battery charge is stable. The diesel generator is working.

4. CONCLUSION

In conclusion, this paper has studied the PV-diesel hybrid energy system as a standalone energy system to solve the energy problems in areas far from electricity nets. The PV-diesel hybrid energy system is the best solution for these areas but still needs an efficient control method to control the energy flow inside the system and increase overall system efficiency. In this research, the fuzzy logic controller was proposed to control the energy flow in the PV-diesel hybrid energy system. Fuzzy logic controllers have taken place in high-performance power monitoring and control. One of the advantages of the fuzzy logic controller is saved the stress of tedious mathematical modelling of the system to be developed, thus making the controller easier to develop. The fuzzy logic controller is used to control the power flow in the PV-diesel hybrid energy system to incase the depending on the solar energy to supply the load as it is renewable energy. The fuzzy logic controller is also used to control charge and discharge the battery system and control the diesel generator as a backup source when the solar energy is not available, and the battery is empty. The fuzzy logic controller and the PV-diesel hybrid energy system have been designed using MATLAB-Simulink. The simulation of the fuzzy controller performance in the hybrid system showed the accurate controlling of the power flow in the PV-diesel hybrid energy system and the saved power about 2%.

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IoT-Based Lab System for Teaching Methods in Times of Crisis

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Abstract— The revolution of communication technology has enabled people to communicate easily with others and perform many tasks from a distance. The Internet plays an important role in communication and helps to perform tasks and make people's lives easier. It led to the introduction of the Internet of Things (IoT) technology, where physical objects are connected to the Internet to perform a specific task. So that IoT can be a valuable tool in times of crisis, most modern industries can produce their products automatically and remote monitor and control the system. The same technique can be applied to overcome face-to-face teaching in science and engineering education during times of crisis. This research proposes the design and development of an IoT-based hands-on laboratory system that can be operated remotely. The methodology has been implemented and worked based on the concept of virtual reality. The research has been carried out for two simple electrical laboratory experiments: the basic logic gate and Ohm's Law experiment. The experimental results show that the system can be implemented since the results obtained are satisfy their theoretical results. Furthermore, an improvement can be made so that the system can be integrated with the Internet and the system can function efficiently.

Keywords: *Internet of Things, IR4.0, hands-on laboratory, hardware-based language, Arduino*

1. INTRODUCTION

With the improvement of Internet connection such as Wi-Fi implementation and the enhancement of 5G mobile networks, even common electrical appliances can be linked to the Internet using IoT networks to perform as smart devices [1,2]. The example of IoT applications is the intelligent home system, intelligent health care system, smart traffic light system, smart voice recognition system, and many more. Besides, the IoT applications can also bring benefits in education, targeting specific groups of individuals, such as undergraduate students [3,4]. This technology has the potential to be used in various applications, such as implementing a sustainable IoT-based hands-on lab system for engineering and science teaching methods during a time of crisis. This research is under the UNESCO world Sustainable Development Goal number 4 (SDG-4), quality education [5].

Students and lecturers can use this application during a time of crisis, such as Covid-19. Students can have their hands-on lab sessions without going to the actual lab, and the lecturers can have their lab syllabus covered throughout the semester. This application can be made by using a simple Arduino microcontroller and software, as it is easily available to purchase online and is plentiful in the local market. It is a positive environment in which students can adapt to self-learning. Figure 1 shows a basic concept of how IoT technology can be used to connect and control different devices.

The IoT is a fundamental concept of integrating smart devices as part of a vast system. It also provides the ability to the object to perform a particular task through the Internet connection. The idea of IoT is to improve daily life's quality according to the current trend of modern life. In the end, everything around us would be automated and control by using IoT technology [6]. There are three basic IoT components which are the hardware, middleware, and presentation. The hardware component consists of field sensors and actuators, embedded controllers and communication systems. The middleware is used to perform cloud storage to store data.

On the other hand, the presentation component is an easily accessible tool designed for various types of applications. These components can be further divided into five (5) layers: perception, network, middleware, application, and business layers [7]. Figure 2 shows the usages of the different layers of the IoT structure.

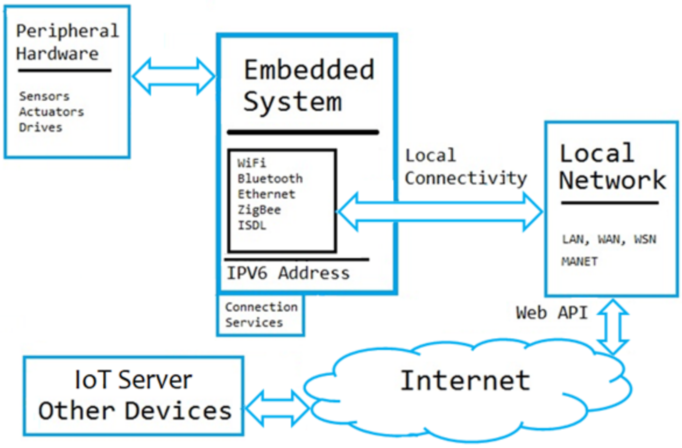

Fig. 1. A basic concept of IoT technology

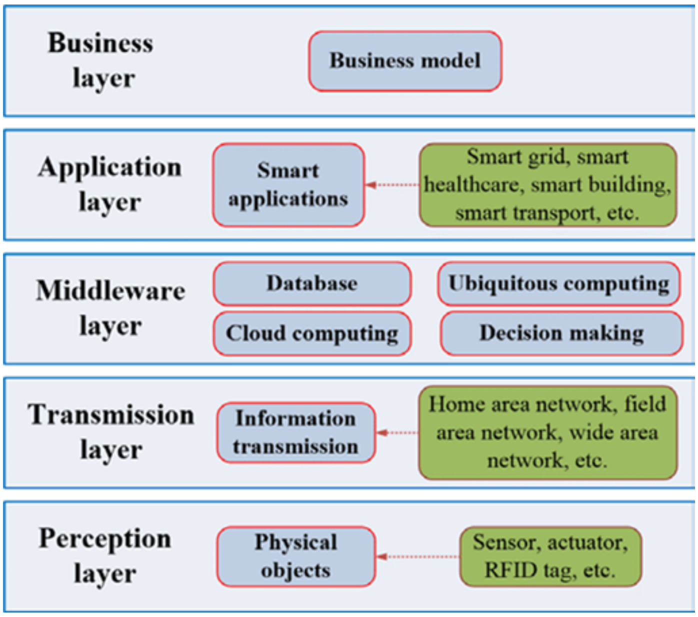

Fig. 2. Usages for different layers of IoT structure

The popularity of IoT has created the implementation of online laboratory systems that can be accessed for educational purposes. Most students need to do some practical work, although they are not physically inside the laboratory besides engineering and science students, to strengthen their understanding of certain theories [8,9]. The term accessible means it can be opened and used with the available gadgets such as PC (personal computers), tablets and smart mobile phones. Some of the developed examples are a low-cost type, which uses readily available hardware and software. An example of the most popular hardware used is the Arduino microcontroller. The Arduino RISC processor is an open-source platform that can be easily available and downloadable online. The Arduino based embedded system also is low-cost compared with the other platform, making it affordable. The working principle of Arduino is that it can send and receive information from various devices, including electronic devices [10]. It consists of hardware, Arduino UNO or Arduino MEGA circuit board and a software program that uses simplified C/C++. The program is transferred to the Arduino hardware using a USB cable from the PC to the hardware. An Arduino can help to obtain information from the input devices such as sensors and potentiometer and send information to the output devices such as LED, speakers, LCD screen, DC motor, and many more.

2. PROPOSED DESIGN

The proposed system includes the communication between the devices used, such as laptops or PC and mobile phones and the Arduino processor connected to the Internet using the ESP8266 Wi-Fi module. There are many ways to use the ESP8266 module for communication. The common ways to use it is to send and receive data online or regularly upload data. In addition, the Wi-Fi module serves as Access Point (AP Mode), providing access to the Wi-Fi network to other devices (stations) and connecting them further to a wired network. In other ways, the ESP8266 module acts as an interpreter between the devices and the Arduino microcontroller.

The ESP8266 module is connected to the nearby Internet or Wi-Fi hotspot to access the Internet and send data to the IoT server and authentication code. The authentication code is then sent to the device with the same authentication code and then, the device receives the data to create a secure connection between the device and the ESP8266 module.

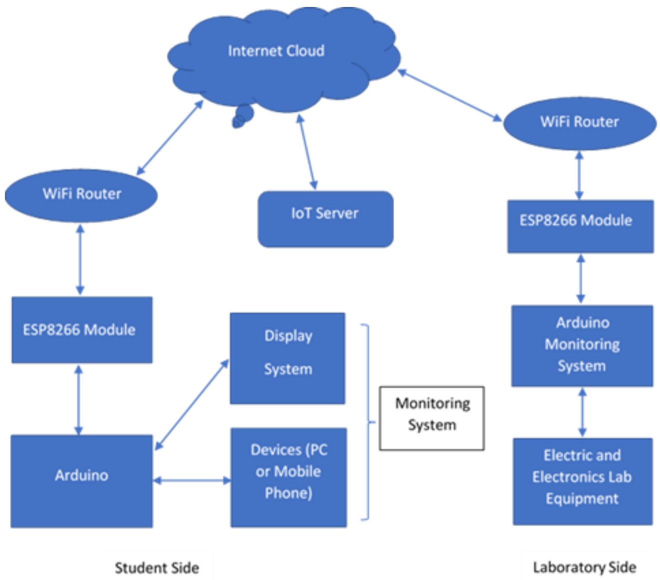

Fig. 3. Total flow diagram of the proposed hands-on laboratory systems

Figure 3 shows the flow mechanism of the hands-on laboratory system. The system is divided into two parts: the user and laboratory parts connected by the IoT server. The user uses their device, which includes the display system as the monitoring system sends the instructions to the laboratory devices—the instruction sends to the Arduino microcontroller connected to the ESP8266 Wi-Fi module. The IoT server sends the instructions to the Arduino monitoring system and then to the electrical and electronics laboratory equipment such as a potentiometer for them to operate. The equipment then sends the data back to the user through the IoT server as the system connection works in two ways.

3. RESULTS

The current work focuses on two simple experiments that are familiar to the electrical and electronics lab work. They are Ohm's law and logic gate simulation, respectively. For the Ohm's Law experiment, a circuit is constructed to investigate the effect of the different resistor values on the rotation angle of the servo motor. This is to show the effect of resistance value on the voltage and current. The types of equipment used are Arduino UNO, USB cable, SG90 Micro Servo Motor and jumper wires. The actual circuit constructed is shown in Figure 4.

A code was developed by using C language and Arduino IDE for the circuit to work. As the potentiometer was adjusted, the rotation of the servo motor was also changed accordingly. A protractor was used to measure the angle of the servo motor. Table 1 shows the rotation angle of the potentiometer and servo motor.

For the logic gate simulation, the simulation is done to demonstrate the mechanism of 3 basic logic gates, which are AND, OR and NOT gates. The simulation is done using the Arduino UNO and its peripherals. The types of equipment used are Arduino UNO, USB cable, 2 tactile switches, 1kΩ and 10kΩ ohm resistors, 3 LEDs and jumper wires. The schematic diagram for the logic gate circuit is shown in Figure 5.

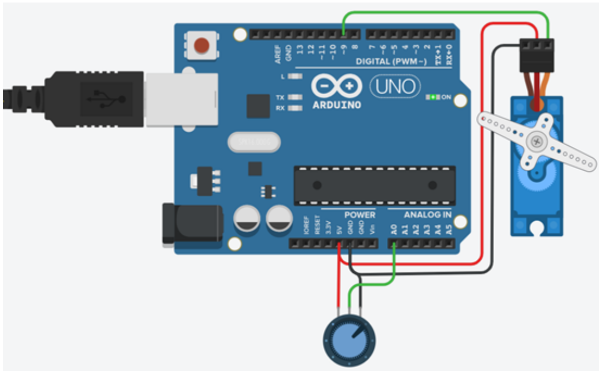

Fig. 4. Construction of actual circuit for Ohm's law experiment

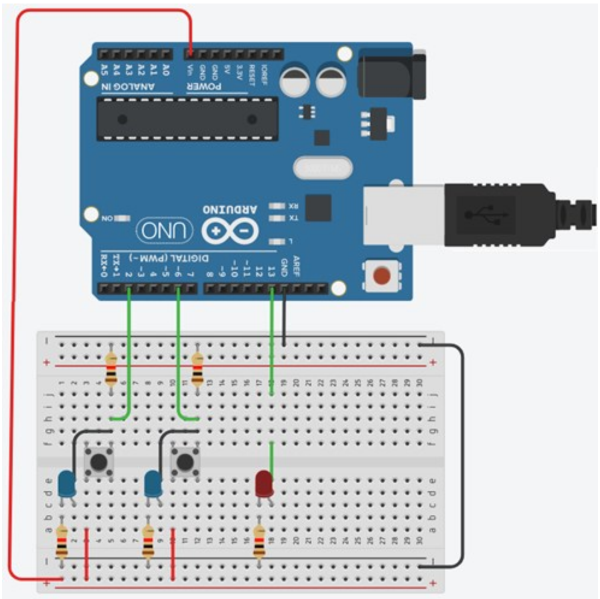

Fig. 5. Construction of actual circuit for logic gate experiment

Table 1: Rotation angle of potentiometer and servo motor

Angle in Degrees			
Potentiometer	*Servo Motor*	*Potentiometer*	*Servo Motor*
0	*0*	*0*	*0*
30	*30*	*-30*	*-30*
60	*60*	*-60*	*-60*
90	*90*	*-90*	*-90*
120	*120*	*-120*	*-120*
150	*150*	*-150*	*-150*
180	*180*	*-180*	*-180*

The circuit consists of 2 tactile push switches as the input, which are named switch SA and SB, respectively. Two LEDs are used as the input indicator, which is a green colour for switches A and B, respectively. A red LED is used as the output, which is named Z. For the circuit to work, a code was developed by using C language and Arduino IDE. When the LED is turned on, it is noted by the binary number '1' and when the LED is off, it is noted by the binary number '0'. The output LED will turn on based on the operation of different logic gates: AND, OR, NAND and NOR gates. The results for each logic gate are shown in Table 2 to Table 4.

Table 2: Results for AND gate

Logic Input		*Logic Output Z*	
SA	*SB*	*Theoretical*	*Experimental*
0	*0*	*0*	*0*
0	*1*	*0*	*0*
1	*0*	*0*	*0*
1	*1*	*1*	*1*

Table 3: Results for NOT gate

Logic Input	*Logic Output Z*	
SA	*Theoretical*	*Experimental*
0	*1*	
1	*0*	

Table 4: Results for OR gate

Logic Input		*Logic Output Z*	
SA	*SB*	*Theoretical*	*Experimental*
0	*0*	*0*	*0*
0	*1*	*1*	*1*
1	*0*	*1*	*1*
1	*1*	*1*	*1*

In Ohm's law, it is shown that the value of resistance can be changed from a far distance and thus can change the value of voltage and the current of the circuit. In the logic circuit simulation, the input LED A and B determines whether the output LED, Z turns on when the switch button turns on. The output Z turns on or off according to the truth table of the basic logic gates, which are AND, OR and NOT gates. These circuits are the basic circuit and would be expanded to perform complex tasks that are beneficial for the students for their lab activities. This is an important element for this research that enables students to perform their lab activities from a far distance. An improvement can be done so that the system can be integrated with the Internet and the system can function efficiently.

4. CONCLUSION

In conclusion, a system that enables students to perform their lab activities from a far distance can be developed by using the Arduino UNO microprocessor and its peripherals. Until now, the system development is focused on two simple lab experiments that are commonly practised by students, which are Ohm's law and the basic logic gate circuit experiments, respectively. The preliminary results were obtained satisfactory then still some improvements can be made for the system to improve the function efficiently. The Internet is the essential part of this research so that it can be used from a far distance.

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Multiprocessor Arbitration for AMBA Interface in ASIC

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Abstract— This paper addresses the multiprocessor arbitration for any System on Chip or ASIC. Any system, be it simple controller or very supplicated system, it needs processor to operate. There are series of processors offered by Intel, AMD or processor companies. Previously single processor used for any chop to access different targets. But technology advances, industry felt the need of multiprocessor access for higher performance. In order to allow multiprocessor to access it targets, system needs an efficient interface with very sophisticated arbitration system. This paper carried out the research to come up with an improved algorithm of hardware to allow multiprocessor access to the system. In order to design the hardware, modern HDL based design methodology has been used. There are two industry standard HDL by IEEE – VHDL and Verilog. Here Verilog is used. In HDL based d=hardware development, simulation is most important part to very verify design's functionality and make sure its 100% correct. Otherwise if any design problem goes forward undetected, that'll cost so much money and time in order to go back and fix, in some cases full respin. For hardware implementation Xilinx FPGA Device has been targeted on this research. AMBA bus protocol used in this research is the industry-standard protocol for processor access and very efficient and straightforward to use with any off the shelf macro available for the high tech industry.

Keywords: *Multiprocessor Arbitration, AMBA Bus Protocol, Processor Interface, FPGA, ASIC*

1. INTRODUCTION

In the past, a vacuum tube is an electronic device used in many older model radios, television sets, and amplifiers to control electric current flow. The transistor became cheaper in the 1960s and was much smaller, worked on lower voltages, and used less power. At this time, most radios, television sets, and amplifiers began using transistors instead. In an integrated circuit or IC, the components and interconnections are formed on the same substrate, typically a semiconductor such as doped silicon. An integrated circuit or monolithic integrated circuit (also referred to as an IC, a chip, or a microchip) is a set of electronic circuits on one small flat piece (or "chip") of semiconductor material, usually silicon.

Since the 1990s, chip technology has evolved to perform a complex operation as per the current industry's needs. To keep up with this advancement, a single need to integrate so many gates, ten million, is very common nowadays to deliver all the sophisticated controlling systems. In addition to size, speed and power dissipation became critical factors too. A single processor which was previously used is not capable enough to comply with this need. So current SoC or ASIC go for multiprocessor access. This multiprocessor needs an advanced arbitration system to have efficient access by the processor.

This research considers all these important factors and develops an improved version of the arbitration system for the multiprocessor interface. The arbitration controller is developed for AMBA AHB access by multiprocessors and performs all sorts of operations to access different targets under memory mapping. Verilog Hardware Description Language (HDL) was used to model the efficient arbiter for AMBA interface, verification was done Verilog simulator and hardware implementation was done using Xilinx Pegasus FPGA device.

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2. AMBA PROTOCOL AND ARBITRATION

AMBA (Advanced Microcontroller Bus Architecture) is a high-performance backbone bus AHB that holds Processor, DMA controller, on-chip memory to access slave targets like register, RAM, FIFO, UART. etc. Multiprocessor access operation requires an arbitration inside its interface to allow any selected bus master to control the bus. The arbitration scheme inside the interface resolves the bus master access scheme based on the priority shown in Fig 1.

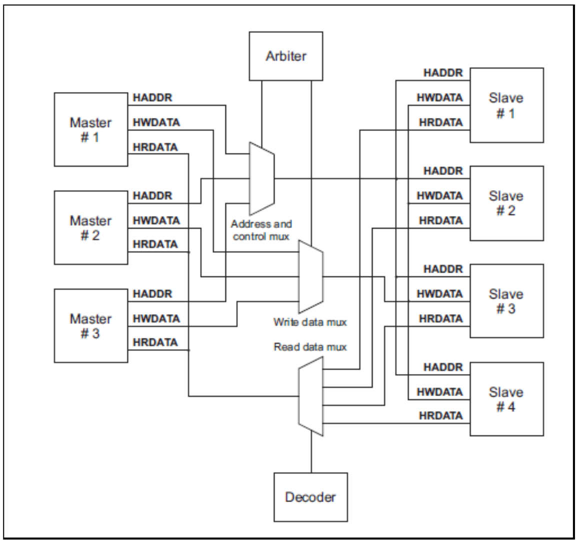


Fig. 1. AMBA Multiprocessor Interconnection [1].

In the arbitration scheme, only one out of multiple bus masters can access the bus to perform the access operation. Multiple processors assert a bus access request. Based on its arbitration algorithm, the arbiter in this research decides which master gets the priority and asserts the grant signal accordingly to give that master control of the bus [1]. In order to figure out how long a bus would be granted access, the arbiter looks at the value HTRANx[1:0] signal of that master and keeps asserting the grant signal as long as NOQ and NONSEQ transfers have occurred Signal description [1].

The signals involved in the AMBA Multiprocessor bus arbitration scheme have been discussed below [2]:

2.1 HCLK (Host bus clock):

AHB system clock HCLK is connected to all the flip flops in the address path, data path and control signals path to provide sequential access. The external system clock generator generates the system clock and drives all the signals in the system. As per AMBA AHB bus protocol, all signal timings are positive edge-triggered by HCLK.

2.2 HRESETn (Bus reset control signal):

The system reset signals comes from the reset controllers for AHB masters. It's active-low, i.e. it resets all flip flops inside the system and put those in a known value at the output, which is 0 in this research. Anytime a low (0) value at HRESETn signal will reset any sequential block in the system and put all state machines in a known state, address bus, data bus and control signals in known value. Both synchronous and asynchronous reset can be used. In this research work, synchronous rest has been used.

2.3 HBUSREQx (Bus request):

Whenever any AMBA processor needs to use the bus for access, it asserts it request a signal, HBUSREQx indicating its execution of the operation. Arbiter records that request and understands that that processor needs the grant to access the bus.

2.4 HTRANSx[1:0] (Bus transfer type):

2-bit signal HTRANSx comes from a particular master x and indicates its current transfer type of the master. It allows 4 types of bus access: IDLE, BUSY, SEQUENTIAL or NONSEQUENTIAL. Each of these transfer types is represented by a unique value or a bit combination of the HTRANSx signal.

2.5 HGRANTx (Bus grant):

A signal HGRANTx indicates that any bus master is allowed to get on the AHB bus. The central arbitration system generated this signal based on the arbitration scheme. It takes into account locked and SPLIT transfers to specify which master amongst the ones attempting bus access would get the highest priority. A locked transfer allows a master with bus access to complete a transfer by denying access to other masters requesting access to the bus. Similarly, a SPLIT response issued by a SPLIT-capable slave prevents new bus access unless it signals to the arbiter that it is ready to complete the transfer [1].

2.6 HMASTERx[3:0] (Master number):

A 4-bit signal, HMASTERx, where x denotes the master number, is generated by the arbiter. It indicates which master has been granted access to the bus and is currently performing a data transfer.

3. AHB BUS PROTOCOL IN AMBA BUS ARBITRATION

AMBA address decoder uses the processor address to create a select target signal for access operation [3-4].

3.1 Granting Bus ACCESS

The arbiter block resolves which processor would get bus access by using its arbitration controller and generates its grant signal and assigns the bus master number in HMASTER[3:0]. Fig 2 shows how arbiter issues GRANT signal to allow bus master as per its request and value of HTRANS as described in Fig 2.

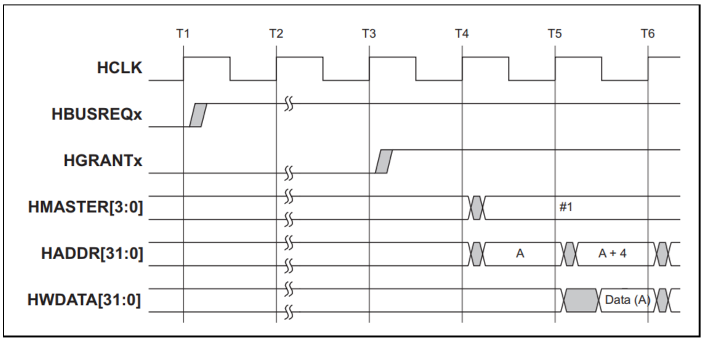


Fig. 2. AMBA BUS Request and Grant Protocol [1, 3].

3.2 Handover Bus Between Processors:

In a multiprocessor arbitration, the arbiter changes the current processor's HGRANT signal before the last address sampled and generates the GRANT signal for the next processor according to priority as it sends a request signal and according to the arbitration scheme, which is shown in Fig. 3.

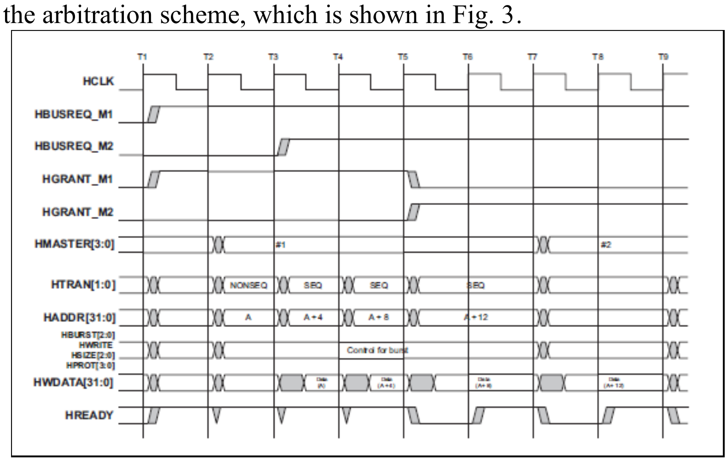


Fig. 3. Bus ownership for AMBA Multiprocessor [5].

3.3 Bus Master Grant Signal

Arbitration controller asserts HGRANTx as per the arbitration scheme that allows the corresponding processor to control the bus and initiate operation using its address, read/write data bus, and control bus.

4. HARDWARE DESIGN OF AMBA ARBITRATION SCHEME

Several types of schemes can be followed to implement an Arbitration system: fixed priority, daisy chain or round-robin. As in Fig. 4, fixed priority is implanted in this research using an efficient algorithm for faster arbitration targeting and low-sized faster grant signal generation logic [5 -6].

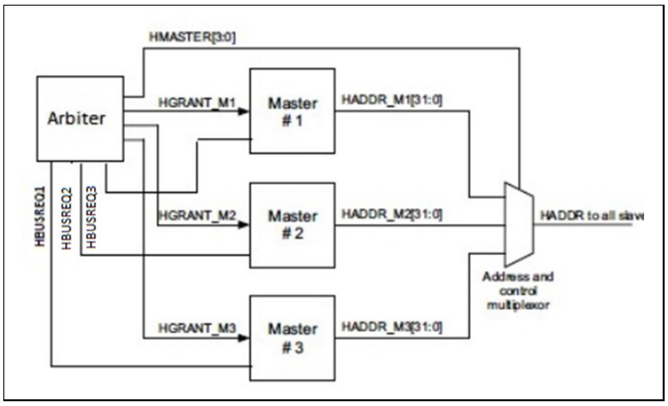


Fig. 4. AMBA bus arbitration scheme.

Three AMBA processors have been used on this multiprocessor arbitration system. AHB bus clock signal and the associated bus transfers have been timed

For bus master operation, AMBA processors use HBUSREQ1, HBUSREQ2 and HBUSREQ3. REQUEST SAMPLER module samples those request signals in HCLK and generates hbusreq1_a, hbusreq2_a and hbusreq3_a. The arbitration controller receives the sampled request and, as per the priority by the arbitration scheme, generates a pre-grant signal to allow the granted bus to do access operation. The grant receiver block samples the pre-GRANT signal to send the AHB grant signal to the processor. It allows the processor as long as it issues the NONSEQ cycle and keeps issuing the SEQ cycle. Additionally, the arbiter also sets the value of HMASTER. This 4-bit signal denotes which master has been granted access to the bus and is currently performing a data transfer to allow address, data, and control signals master to forward to the bus.

5. TOP-LEVEL BLOCK

The top block of the hierarchy, as shown in Fig. 5. It receives the AHB clock, reset, bus request signals from all the bus masters and as per the property of the arbitration scheme. In addition, the data transfer length creates a grant signal to allow a specific corresponding processor to control the AMBA bus. It also sends the write data and reserves read data.

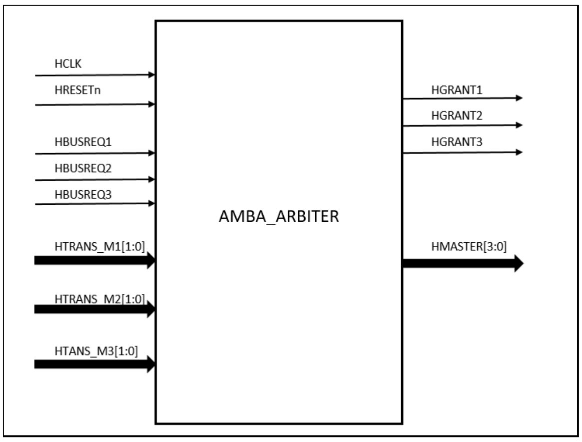


Fig. 5. Top Level Block of AMBA BUS Arbiter [7].

6. BLOCK DIAGRAM

The arbiter's top block consists of three sub-blocks, as in Fig. 6: Request Receiver, Arbitration Controller and Synchronous Grant Signal Generator for a processor. The AHB clock HCLOCK clocks all the data and control and the system is reset by AHB reset signal HRESET.

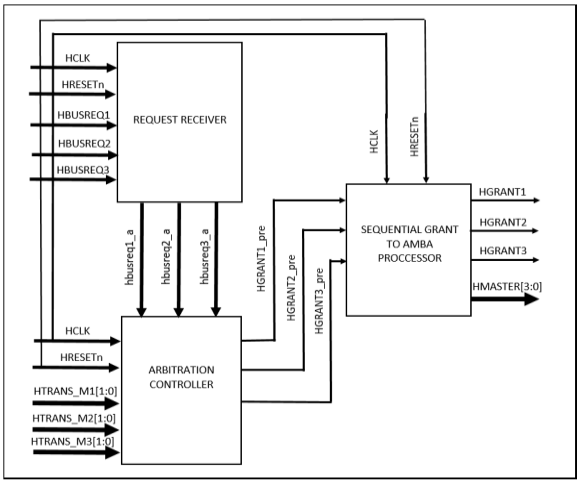


Fig. 6. Block Diagram of AMBA BUS Arbiter [7].

6.1 Request Receiver

Request receiver in Fig. 6 accepts bus requests signals from processors with the AHB clock HCLOCK after the request is asserted and then forward it to the arbitration controller.

6.2 Arbitration Controller

The main module of this multiprocessor access arbiter system is the arbitration controller in Fig. 6. is the major block of the arbiter. It uses a state machine to move the priority arbitration as requested by the bus request signals HBUSREQx and then, based on the transfer type of the bus masters, keep granting the HGRANTx signals to the allowed bus for its read-write access. Finally, it sets the value of HMSTER, which is used to figure out which address, HREAD, HWRITE and control signal will get control of the bus [5].

6.3 Synchronous Grant to AMBA Processor

The primary purpose of the block is to sample all the grant signs signals with the HCLK signal and send those grants to requesting processor. This sampling is done to ensure no setup and hold time violation occurs in static timing analysis after hardware implementation.

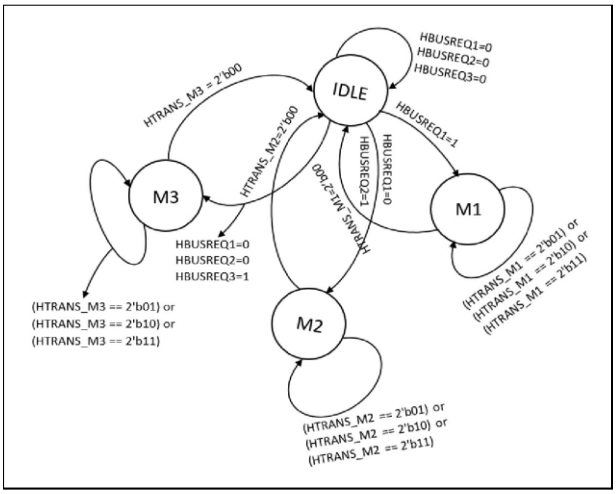


Fig. 7. Proposed Smart Arbitration State Machine Diagram [7].

6.4 State Machine

The state machine shown in Fig. 7 is a mail controlling part of the designed interface since it controls the priority, arbitration scheme and length of processor access. Three bus master M1, M2 and M3 are used in the design and the state machine is responsible for allowing access to them as per priority and avoid bus starvation. Two of the most significant categories of signals associated with the state machine are the bus request and transfer type signals generated by the processors. These signals' values give rise to certain transition conditions that cause transitions between the IDLE and either of the three data transfer states or transitions from one state to other.

6.5 State Diagram

The state diagram shows the state transitions of the state machine based on the current state and input, decides the next state and output. State transitions must consider processors priority scheme and any processors access length for the burst access. Based on the current priority, only a specific processor is granted access to the bus at a given time. These state transitions are shown in the state diagram in Fig. 7 and described below:

a) IDLE State (2'b00)

This state indicates there is no bus request from the processor.

b) M1 State (2'b00)

Processor M1 issues the BUSREQ1 signal and gets the bus control right away by the HGRANT1 signal as it has the highest priority. State machines stay in this state as long as master transfer data by issuing one NONSEQ and several SEQ transfers using the HTRANS_M1 signal.

c) M2 State (2'b01):

This state indicates that processor 1 doesn't have the request signal and processor 2 sends the request signal. It asserts HGRANT2 and keeps it high as long as processors issues one NONSEQ and several SEQ transfers using the HTRANS_M2 signal.

d) M3 State

This state indicates that processor 1 and processor 2 don't have the request signals and processor 3 sends the request signal. It asserts HGRANT3 and keeps it high as long as the processor issue one NONSEQ and several SEQ transfers using the HTRANS_M3 signal.

7. SIMULATION AND RESULT

Fig. 8, Fig. 9 and Fig. 10 simulation results of the arbitration system are shown. The simulation shows all the bus masters tried to access the bus by corresponding bus request signal created in the test bench, and the arbitration state machine provided grants as per the priority scheme.

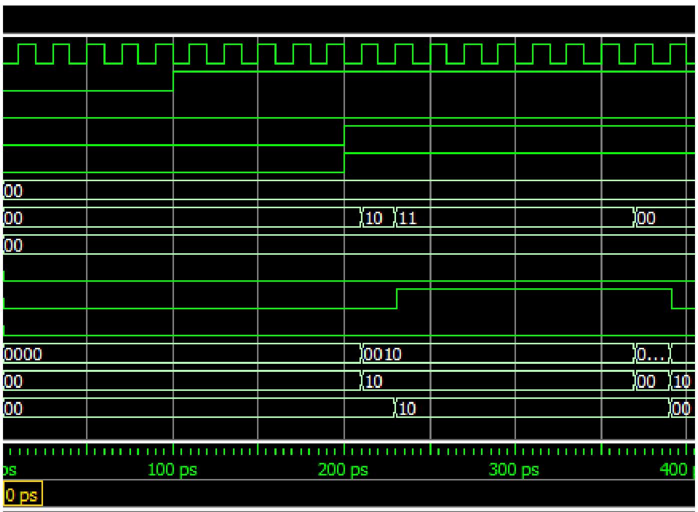


Fig. 8. Processor M1 and M2 send request, processor 2 gets grants as per priority.

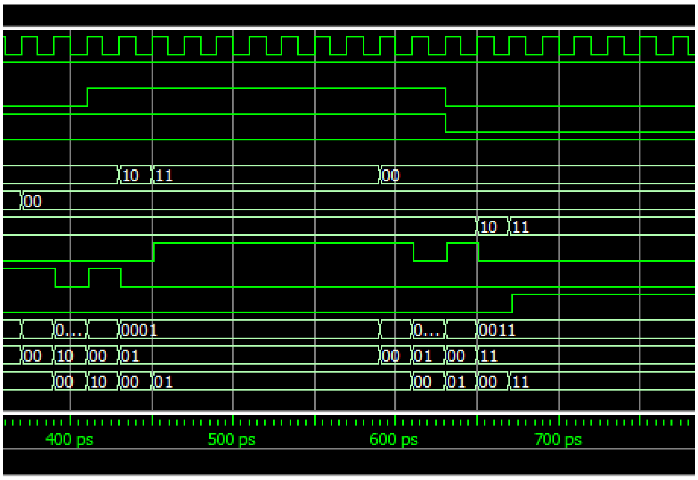


Fig. 9. All three processor send request, but highest priority Processor M1 gets the access.

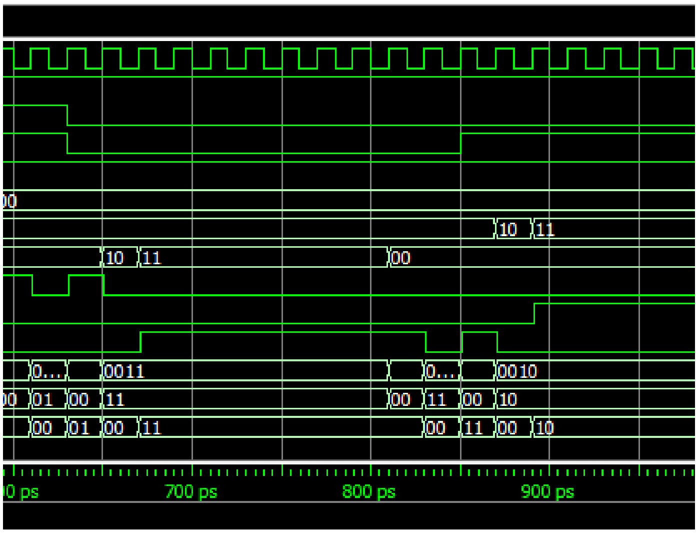


Fig. 10. No request from Processor M1 and M2, only processor 2 sends the request and automatically gets access as lowest property access.

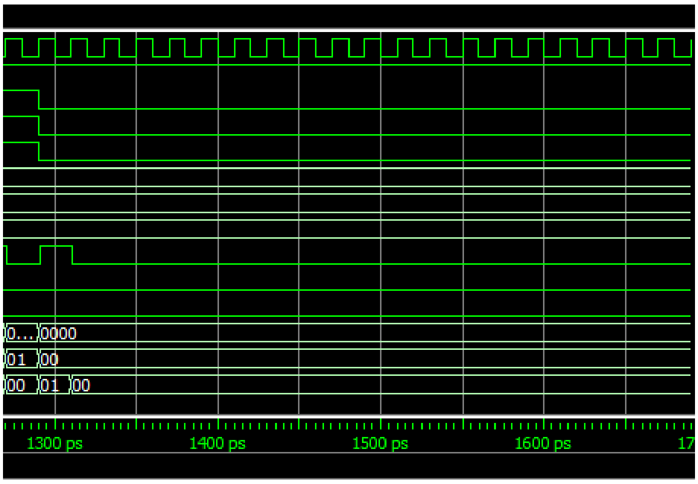
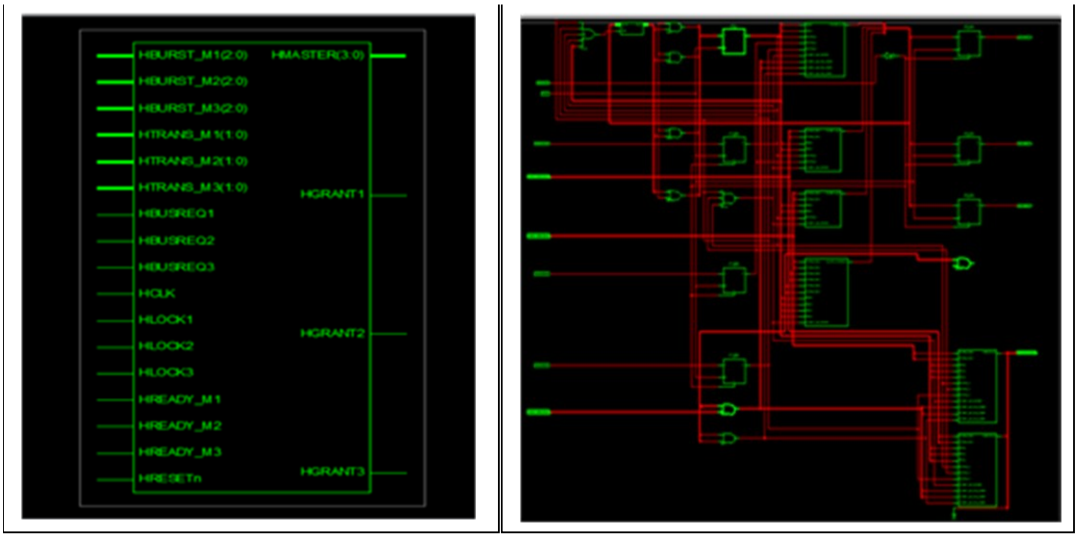


Fig. 11. No request from any processor, so bus activity and arbitration control state machine is in idle state.

8. SYNTHESIS RESULT

Fig. 11 shows the top-level block after synthesis. Fig. 11(b) shows the detailed schematic of the Arbitration Block after synthesis.



(a) Top Block (b) Schematic Diagram

Fig. 11. Top-Level Block after Synthesis.

9. CONCLUSION

Any SoC for all the high-tech application requires processor (external or internal) to run the hardware. Single processor is not enough to coop current need of complex and concurrent operations. This research targeted to use multi preprocessor three to access the ASIC. AMBA bus interface protocol is industry standard protocol for processor access. This research addressed the multiprocessor access by implementing an efficient arbitration process to allow processor to access the ASIC using its interface. Fictional design has been carried out by Verilog HDL and simulated using Cadence/ Modelsim Simulator. Finally, it was synthesized and implemented synthesized in Xilinx Pegasus FPGA device.

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Cryptocurrency Integration Challenges in Blockchain for Financial Institution

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Abstract— Cryptocurrency is the latest adventure of currencies that works by using the new edge technology called the blockchain. It has gained the notable attention of the people for the last several years across the world. Cryptocurrency is also globally known as digital currency or virtual currency, and it is a form of payment that can be used online for goods and services. Blockchain has captured the application of many in the financial industry, including those vigorous in the transaction, clearing, and settlement, with its promise of greater efficiency and higher resiliency. The Cryptocurrency has been adopted by using blockchain technology that raised eye-catching attention in the financial sector, government, stakeholders, and individuals as well. It can be anticipated that Cryptocurrency will be the future currency that will replace fiat money worldwide. Though it has been attracted the users' attention, the money of them worried about its future useability, drawbacks, and challenges. Still, the research on cryptocurrencies is far behind and in the initial stage to integrate these currencies in financial institutes. This lack of trust situation in the financial sector aggravates further when it comes to cryptocurrency management challenges that are still not critically analyzed. The originality of this paper is the concept of currencies including cryptocurrencies, the concept of the blockchain ecosystem, and the cryptocurrency integration challenges of the existing blockchain in the financial institution. This paper will help the new researchers to work on cryptocurrencies and their integration challenges in the financial system.

Keywords: *Cryptocurrency, Blockchain, Hash, consensus, immutability*

1. INTRODUCTION

The use of Cryptocurrency put forward valuable opportunities for financial institutes, where people are looking for modern version technological solutions to rebuild trust and confidence across the globe. A good number of technologists believe that financial transactions can be made more efficient and faster between senders and receivers by using cryptocurrencies. The first Cryptocurrency is called "Bitcoin" was introduced in 2009, was using the pseudonym Satoshi Nakamoto published a paper and suggested a peer-to-peer network (P-to-P) solution for online fund transfer from one party to another without intermediatory help [1].

Global Financial turmoil was the time where people lost their confidence in the financial system, and at the same time, they were looking for the best alternative for investment that could ensure security and accountability. Cryptocurrency is a type of digital currency which is mined by Blockchain technology. The distributed ledger is used for cryptocurrency transactions which is an immutable ledger for transferring the ownership, keeping transactions records in different nodes, tracing assets, ensure transparency, trust, and security [2]. Moreover, financial institutes always try to prevent security incidents and financial losses. Cryptocurrency is one of the latest innovations of the 21st century which creates a wave from financial industries to manufacturing companies [3]. A substantial positive change in the financial institutes is possible by using Cryptocurrency as well as other sectors like supply chain, medical treatment, insurance, and other industries [4]. Recently, a significant number of investors have become more interested in investing their money in Cryptocurrency for making more profit which is increasing day by day to other customers as well. In this paper, some of the majors' cryptocurrency challenges in financial institutes are discussed like scalability, regulatory policy, AML policy, and so on.

The remaining of this paper has been arranged in the following sections. A brief history of the currencies, including cryptocurrencies, is described in section 2. The concept of the blockchain ecosystem is in section 3. Then the integration challenges of cryptocurrencies in financial sectors in section 4. Finally, the paper is concluded with a discussion in section 5.

2. HISTORY OF CURRENCY

Before beginning history, the concept for the creation of money was taken place as one of the forms of (i) medium of exchange value, (ii) A unit of account, and (iii) a store of value. There are few steps for the development of money in history.

2.1 Barter System

The barter system is an old method to exchange goods and services. This system was used for centuries before inventing money. From the beginning of using money, people used the Barter System. A barter system has been used for centuries and before money was invented. The payment methods were created lots of problems and repercussions among the payees and receivers in the society in terms of an unequal measurement system [5].

2.2 Commodity Money

When people did not agree upon with the measurement and valuation of goods in the barter system, there was another system called the commodity money approached was introduced. Commodity money means a physical good that has an intrinsic value that was used as money. For examples include salts, copper, gold, silvers, cocoa beans, etc. As per the specification of this money, it has four characteristics, i.e., durability, divisible, easily exchangeable, and rare. Commodity money was used as the medium of exchange the money and as for payment. But it is not convenient and easy to carry the goods elsewhere [6].

2.3 Metallic Money

Metallic money is also a type of money that was issued by the central bank of the respective countries in the form of metal, and it was the legal tender money in the economy. It was made of gold and silver and people have used this money as a medium of exchange [7]. Metallic money was continued for a long period and the following steps were involved.

i) Initially, People used this metallic(gold and silver) money as a medium of exchange for several purposes, but there was no specification of this coin, and the value was measured based on the weight.
ii) After a long period, there was a proper coin system was invented against gold and silver, and the face value of these coins was measured by using the real value of gold and silver.
iii) However, the metallic money system was used for a longer period, where bimetallic coin systems were adopted, and both the coins were used simultaneously.
iv) The major challenges were raised to store the gold and silver coins from theft. Therefore, people found a new way to solve this problem and they stored these gold and silver coins to the jewelry dealers for safeguarding the same. On the other hand, the jewelry was started to keep the coins and gave the receipts against these coins, and the system became popular where the people started to exchange the receipts themselves instead of real coins.
v) The acceptability of these receipts for making the payment of goods and services among the people gave a new popular concept of community-backed. Banks capitalized on this new concept and started to issue the receipts in the form of that were ensured by gold.

2.4 Fiat money

In 1971, the president of the United States, Nixson raised the issues to the economic forum and gave the instruction to issue a series of temporary economic measures, He also instructed to cancel the direct convertibility of US dollars into gold and the convertibility process from fiat money to gold was stopped [8]. Therefore, the gold-backed money was replaced by non-convertible fiat money. Central banks legalized the paper money and started printing the different denominations, and they also circulated legal tender laws that people were bounded to accept the non-convertible fiat money.

2.5 Cryptocurrency

Nowadays, Cryptocurrency or digital money has become popular after blockchain and distributed ledger technology were added to the payment network. The system depends on the blockchain payment network where the technological infrastructure setup is essential to manage the payment gateway that may help to avoid multiple payments.

On the other hand, by using Cryptocurrency, individuals can do one-to-one or peer-to-peer transactions freely, allowing society to control the value of the Cryptocurrency. To maintain the Cryptocurrency, a distributed database system is required to maintain the distributed ledger into the network by using highly encrypted technology, which helps to manipulate or change the original data or information in the blockchain network. The Cryptocurrency has been developed through using blockchain applications that may provide a secure and immutable platform, and at the same time, all the transactions are recorded into every node or computer as a digital medium called Cryptocurrency.

The word crypto means encryption, and the Cryptocurrency or instrument is maintained by a distributed ledger through though using the blockchain application platform. The currency is here as a medium of exchange. It is also called virtual currency. The first Cryptocurrency is “Bitcoin” which was introduced by the pseudonym Satoshi Nakamoto in 2008, and this currency is maintained by users through a crypto wallet.

2.5.1 Bitcoin

A person or group of people in 2008, was using the pseudonym Satoshi Nakamoto published a paper and introduced a new cryptocurrency is called “bitcoin” and suggested a peer-to-peer network (P-to-P) solution for online fund transfer from one party to another without any third or trusted party [1].

Bitcoin is a virtual currency and there is no central authority of issuing the same, and it does not have any physical form to store. As per the design of Bitcoin, 21 million bitcoins generation is possible by solving complex mathematical algorithms, and the bitcoins will store cryptographically into the distributed ledger.

Characteristics of Bitcoin:

- Decentralize: Does not have any central authority to control or mining it, so it is completely out of control of Government authority.
- Faster payment process: Payment can be made digitally by using Cryptocurrency or bitcoin platform at any time, i.e., 24/7.
- Account or currency holders anonymous: All transactions of bitcoins are happening publicly, but still, it is anonymous and does not have any physical cash.

3. THE CONCEPT OF BLOCKCHAIN ECOSYSTEM

3.1 Blockchain

Blockchain is a technology that represents the data as a chain of blocks, allows transactions to be gathered into blocks, it is an immutable time-stamped series record of data that is distributed, and formed the chain blocks cryptographically in chronological order and permits the resulting ledger to be accessed by different servers [9]. It is not only a single technique, and it has some other important features like cryptography, complex mathematical game theory, algorithms, peer-to-peer networks, and distributed consensus algorithms that may solve the complex synchronization problem [10], [11]. Blockchain and Digital Ledger Technology (DLT) are used for the same purpose. Blockchain is a type of DLT [12]. A distributed database structure is used for blockchain technology to store all identical copies of auditable, latest, and decentralized transaction or data. The key features of Blockchain Technology are below.

i) Decentralized

Blockchain does not depend on the centralized database system, all data are stored in different notes or computers in distributed. Decentralization of database is a new concept; it is referred to as the transfer process of control and decision-making system from centralized to distributed system in blockchain through which greater and fairer services can be achieved [13].

ii) Distributed Ledger

Distributed Ledger Technology (DLT) refers to the digital system where all the records are connected or related to assets, and all the transactions or records are simultaneously located in different numerical locations [16]. Presently, in most cases, cryptocurrencies are used for the DLT system, where decentralized distributed ledger technology verify the transactions into the blockchain network. At least one or more copies of the ledger are maintained in the nodes. When the data is added to the ledger, all nodes receive identical copies of the updated ledger. DL is a very resilient system to prevent the single point failure of any node or compromise any single node by cyber-security threats, and it has an exceptional track record for assets and values across the industries [14].

iii) Immutability

Immutability is the ability of the blockchain technology to keep the data or records unchanged in the blockchain, which cannot alter, and each block of the transaction details proceed with a cryptographic hashing algorithm [15]. On the other hand, it can only change if someone or a group of people can take 51% control over the nodes at the same time [16].

iv) Enhanced Security

One of the key features of blockchain technology is a highly secured platform and all the transactions are recorded in the block by using the private and public key by a cryptographic hashing algorithm. No one can simply change the data into the block, which is ensured by encryption mechanism, and the cryptography layer is another type of protection of the data for users.

v) Consensus

For synchronization of distributed ledger, there is a mechanism for using a different number of protocols for communication between participants or nodes and for providing consensus among nodes for the current state of the ledger and historical ledgers as well. It is the fault-tolerance mechanism that is used for the blockchain network to achieve the necessary agreement to use a single data of the network among distributed systems.

vi) Faster Settlement

Direct payment method is used in blockchain network between buyer and seller where third-party involvement is not required. Presently, most of the banks are using third-party SWIFT for settlement the transactions which are less secured as well as time-consuming. On the other hand, Participants on a blockchain network can make the transaction which is visible and settle between parties in minutes or even seconds rather than days [17].

3.2 Blockchain Structure

Decentralization, accountability, and security is the core characteristic of blockchain technology. The structure of blockchain and its components and interaction, namely peer-to-peer network, properties of block and genesis block, transaction in ledger, validation process, consensus mechanism, and proof-of-work. Generally, blocks contain the data, previous block hash, current block hash, timestamp, and other information [18]. Figure 1 shows the structure of blockchain.

i) Data

Block is the form to store the data. It is very useful when we know the number of data elements and how large the data element will be [19]. It depends on the purpose of the use of a blockchain network. For example, the transaction record for clearing and settlement in the bank, IOT data, etc.

ii) Hash

When a transaction occurs in the blockchain network, it should be hashed with code and broadcast the message to all nodes in the participants' network. It is capable of holding and maintaining thousands of transactional records in a single block, and the Merkle function is used to generate the hash value in the blockchain application, which is called the Merkle tree root. The cryptographic hash function is used for security purposes, and it generates a fixed-length character string from random input data records in blockchain [20]. Finally, the hash value is recorded in the blockhead of the current block through the Merkle tree function, and the computer resources will be reduced significantly.

iii) Timestamp

The timestamp is generated into the block of the blockchain network. It creates a breakthrough in blockchain notarization and its fellow works like digital signature, authentication, etc. where any data is timestamped [21].

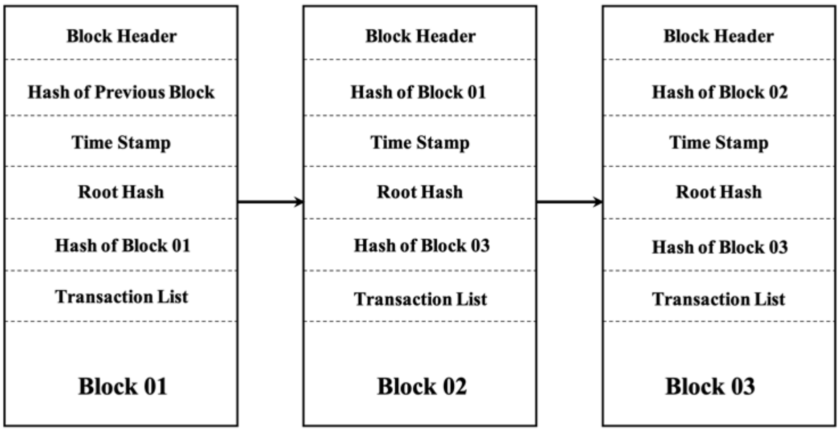

Fig 1. Blockchain Structure.

3.3 Comparison between Fiat money and Cryptocurrency Transaction

Fiat Money Transaction process:

Figure 2 showing the traditional banking transactions process with comparison to Cryptocurrency (digital currency) based transactions in the banking system. The process will start to send the money from user A (sender of the transaction) to user B (Receiver of the transaction). The system uses the traditional centralized banking

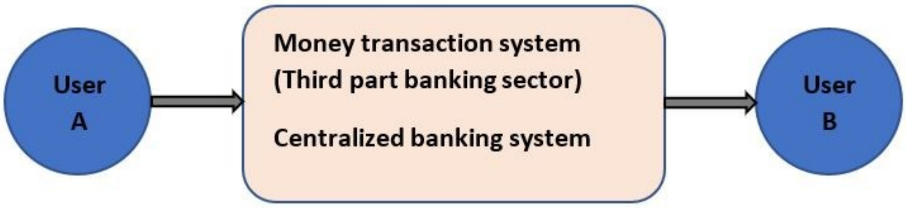

Fig. 2. Fiat Money Transaction process.

the system is controlled by the bank itself, and the major concern is security that is also controlled or maintained by the bank. In most cases, the central bank has the right to issues coins and banknotes, which is called fiat money, and the currency-produced policy depends on the monetary policy. The exchange rate is also controlled by the central bank of the specific country.

Cryptocurrency Transaction Process

Figure 3: showing the cryptocurrency transaction procedure. User A (Sender) can transfer the money to user B (Receiver).

The transaction should be bound into the blockchain network among the users. The node in the blockchain network keeps the transactions record with date and time, the previous block has value, text, and the next hash for the next blockchain. For making the transactions, blockchain technology uses the distributed ledger and all the transactions are validated by the users or node, and the same will be done through using private and public keys mechanisms. No doubt, Cryptocurrency is easier to use than fiat money and the fund transfer process is done within few seconds between the sender and receiver. For doing the transactions, the third part requirement is not required, and the currency values are maintained by digital application software.

3.4 Proof of Work (PoW)

Proof of Work (PoW) is one of the vital consensus mechanisms that is widely used in the blockchain which was popularized by Bitcoin [22]. It is like a piece of data and very hard to produce the proof of work but easy to verify for others and fulfil the requirements. The main consensus algorithm is PoW that is used to confirm the transaction and generate the new blocks in the chain, and miners compete with each other to complete the transaction in the network for rewarding [23]. Senders and receivers are required to the digital tokens among themselves where the transactions are stored in the blocks. The proof of work consensus algorithm solves the complex mathematical puzzle to create the new blocks into the Bitcoin blockchain network; the process is called mining and the computers that engage in mining are called miners [24].

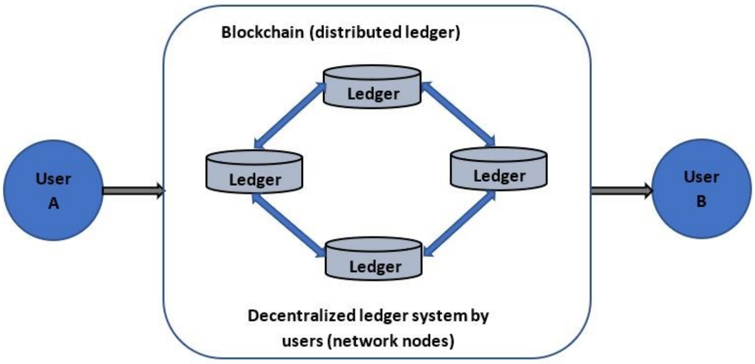

Fig. 3. Cryptocurrency Transaction Process.

3.5 Proof of Stake (PoS)

Proof of Stake express that a user can mine or validate transaction in the blockchain network according to his or her holding of coins, and it is created as an alternative of PoW. Proof of Work always consumes huge electric power. On the other hand, less computing power is required for proof of stake. The important features of Proof of Stake are as follows [25].

- Energy savings – less computing power is used for mining blocks.
- Reduced hardware requirements – comparatively low hardware configuration is needed to generate the blocks.
- Strong immunity – insist cryptocurrency Integration Challenges in Financial Institute.

4. CRYPTOCURRENCY INTEGRATION CHALLENGES

A few years before, when moved from many ledgers systems to a single ledger (i.e., all the transactions associated with reconciliation, central clearing parties, auditing, etc.) system in financial sectors, the huge challenges we faced to do the same. But now whole banking industries in the world are using the same or unique system. To design any Core Banking System (CBS) of today, we need to keep in mind the security concern, robustness, confidentiality, integrity, and availability as well. But the flexibilities are not enough in how they communicate with other technologies.

In the last couple of years, there has been a significant amount of hype behind the potential use of Cryptocurrency for financial institutes. The reason for this hype is a cryptocurrency that allows us to redesign the financial system. Currently, five major cryptocurrency integration challenges for the financial system are discussing below.

4.1. Cryptocurrency Governance

Cryptocurrency governance is one of the main policy-making governing body and they can also form and implement the Information Governance Framework(IGF) in the financial institutes. It brings apparent benefits such as reducing the transactional cost, minimize legal issues, and improved network performance. The metamorphosis of the financial sector is to expedite the use of ICT-enabled services for clients. Today, it is quite impossible to think about financial services without IT-enabled applications. Cryptocurrency, blockchain, and distributed ledger are the latest technology that may use for the financial system. It will also help to increase accountability, data privacy, trust between the users, and improve the transparency that will help to build the ITC functions. It has also the ability to support building the strategic planning for the financial institutes and delivery the value. The following guidelines need to be addressed before the integration of Cryptocurrency in financial institutes.

- Strategic Policy Alignment: The strategic policy guidelines will ensure the alignment as well as the involvement of the stakeholders with financial institutes that will align the business goal as well ensure the appropriate use of the technology.
- Value Delivery: It will ensure and certify that the Cryptocurrency system in blockchain for the financial system will deliver the products as per customers' needs.
- Performance Delivery: Business may obtain value from Cryptocurrency that need be quantified for the investment.
- Risk Management: A separate cryptocurrency governance model can be implemented to evaluate the risk management system which is one of the most important pillars of IT governance.

4.2. Non-Scalability

Cryptocurrency is moned and used by blockchain applications where the Blockchain is application is used the distributed ledger system to maintain participants' transactional history in each node of the computer network. For comparison purposes, VISA processes 1,700 transactions per second whereas the blockchain can process around 4.6 transactions per second on average. So, the adoption of Cryptocurrency in the financial will be a global challenge [26].

Nowadays, the popularity of Cryptocurrency has been increased tremendously along with other IT-enabled services in the financial sector, the scalability problem has become more apparent especially in the financial system. Although there are significant methods that have been suggested, still the limitations exist with each of them. The most notable challenge is known as "Sharing Database". However, for mining and using Cryptocurrency, the use of blockchain applications is essential. To develop the blockchain application, database sharing is required to share and store the transactional data into the nodes where the storage system keeps the records across the Peer-to-Peer (P2P) network.

The major challenge of sharing the database is the prime concern of security issues in the blockchain payment network system which provides additional complexity for the blockchain application developers who may need to add extra level communication protocol.

4.3 Regulatory Policy

All the financial institutions all over the world running under the supervision of their respective Central Bank. But there is a major lacking especially for the Cryptocurrency or digital currency transactions that no central authority is available to make the transaction i.e., no central bank policy available for the same. Until a proper regulatory framework is established, it is not possible to use digital currency to make the payment through a banking channel.

4.4 Anti Money Laundering policy formulation

Money Laundering (ML) is one of the major threats for the financial institute by affecting the economical stability of the nations. No financial institute is immune from money laundering risks. Most of the financial institutes in the world are using Anti Money Laundering (AML) software but still money launderers applying different mechanisms to send illegal money. Till there is no central authority to control the Cryptocurrency and it is mined by a few people of group and the total controlling power on their hand that will provide a huge opportunity to the money launderers to send and receive the illegal money. There is no AML system is using for Cryptocurrency (Bitcoin, Litecoin, Ethereum, etc.) transactions. Financial institutes should be integrated with their core financial system before making cryptocurrency transactions and the AML system should be capable to detect suspicious transaction reporting, cash transaction reporting, identification of PEP, usual transaction reporting, etc.

4.5 Cybersecurity threats

Nowadays, the financial industry is facing various types of cyber threats which intend to exploit the vulnerabilities of the system, interrupt the system, and finally steal the fund and data. Cyber-attacks are being frequently changed in the sense of sophistication and their occurrence is gaining momentum. In recent years, a significant number of high-profile cyber-attacks compromised the banking system and ultimately customers lost their funds and data. Some of the cyber-attacks frequently faced in the banking industry are as follows:

- Distributed Denial of Service (DDoS) attacks.
- Man-in-the-middle attacks.
- Ransomware attacks.
- Malware attacks.
- On process attacks.

5. CONCLUSION

In recent years, Cryptocurrency has become one of the greatest adventures in the field of currency due to its physical cashless nature. All financial institutions can play a key role in international cross-border payment by using Cryptocurrency or digital currency through the blockchain network. It will save the cost, settlement time, and avoid double-spending and third-party involvement. However, Cryptocurrency is the latest technology-based digital currency that can use for financial systems, but still, it has some integration challenges with the financial system which have been highlighted in the article.

We hope that soon we can see the use of Cryptocurrency, especially in the financial sectors through blockchain applications with a safe and supportive environment. On the other hand, for years and years, we have seen that there is a gap among the Government bodies, regulators, enterprises, and people that is one of the main challenges for cryptocurrency integration in the financial industry. The utilization of Cryptocurrency in the Finance system acts as part of difficulties as well as it investigates various chances. This Cryptocurrency can give a lift to new systems as it is straightforward, open, and simple to utilize. Though some significant achievements have already been adopted by using Cryptocurrency in the blockchain system, still, the regulators, government bodies, and financial institutes need to be addressed before the integration of Cryptocurrency in the financial system.

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Effects of Passive Components on Designing a Three-Phase DC-DC Converter

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Abstract—This paper presents the impact of the inductor and exchanging recurrence of a three-stage DC-DC converter for potential application in an electric vehicle. The proposed DC-DC converter comprises the essential and auxiliary stages. The essential phase of the converter is made from total scaffold converter go about as information port which associated in equal, while at the auxiliary stage which goes about as yield port contained full extension rectifier associated in series. At the auxiliary stage, the channel capacitor, an inductor associated in corresponding to sift through the waves from the information voltage and produce a DC yield voltage that prompts better execution. Various phases of the DC-DC converter have been reenacted through PSpice and execution were assessed.

Keywords: *DC-DC, converter, three-phase, six inverters*

1. INTRODUCTION

The three-phase converter is suitable for low voltage and high current applications. [1]. A high step-up ratio converter is required to enable efficient energy exchanges between DC-DC of different voltages. Higher operating frequency leads to better transformer utilization and increases in power density [2].

The high isolated DC-DC converter is often used in a high gain application for protecting devices [3]. The converter is commonly used to convert the energy system in high voltage and high-power applications. Thus, the converter compatible with high voltage and high-power applications [4].

To overcome the problem across the switching of the converter, different clamping techniques were used, such as active clamping and naturally clamping. The proposed converters provide modular power conversion with modular high-frequency transformers and utilize high-frequency low-power transformers. This converter is suitable for high power and high voltage applications [5].

Three-phase converter proposing a high-frequency three-phase transformer, compared to single phase, the losses are well distributed. It is three times higher in the cutting frequency than the switching frequency, and the filter reduced its required size. The output current ripple is sufficiently reduced ripple frequency increases. Hence, the output filter can be much smaller [6].

In this paper, a three-phase DC-DC converter with six inverter performance was evaluated with the variation of the filter capacitor, an inductor with a different load. The effects of switching frequencies were also explored.

2. METHODOLOGY

The DC-DC converter that comprised of three phase converter. This three-phase converter consists of three full-bridge converters connected parallel at the input side and three full-bridge rectifiers connected in series at the output side. The function of the rectifiers is to convert the alternating current (AC) into direct current (DC). The series output connection is suitable for generating a high output voltage with relatively low PWM, which reduces the voltage stress of rectifier diodes, has high efficiency, and is suitable for low power applications.

Figure 1 shows a block diagram of the DC-DC converter that can be divided into two stages. At the first stage, it is comprised of three full-bridge converters and act as an inverter to generate AC output voltage from DC. Meanwhile, at the second stage, a rectifier is used to convert AC voltage into DC output voltage. Therefore, three full-bridge diode rectifier is used to generate desired DC output voltage from AC. The advantages of the full-bridge rectifier are that it does not need a center tapped transformer, thus will reduce the size and its cost. The output voltage of the rectifier at the first stage acts as an input voltage rectifier for the second stage.

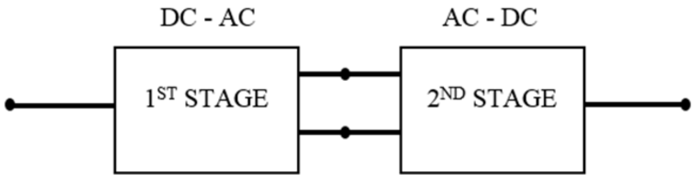

Fig. 1. System block diagram.

2.1 DC-DC Converter

Single-phase converter topology employs parallel one phase input and series output structure. Figure 2 shows the schematic diagram of a single-phase DC-DC converter. In this schematic, at the first stage of the converter, which is the primary side has one part of the full-bridge converter consists of an IRF150 rectifier connected to a voltage source. The second stage of the converter has a series output connection of a full-bridge diode rectifier. There have four diodes arranged in series labelled D1, D2, D3 and D4. During half cycle, only two diodes conducting current. During the positive half cycle, D1 and D3 conduct in a series while D2 and D4 conduct in reverse biased. The second stage converter is also comprised of the filter capacitor, filter inductor and load resistance. This single-phase converter works well, but for high power, the converter could suffer from current stresses.

They were adding one more part to the single-phase to obtain a two-phase DC-DC converter. As a result, the two-phase converter has a better improvement of the output voltage performances compared to the single-phase converter. Meanwhile, a three-phase converter is comprised of a single-phase and two-phase converter. A three-phase converter has low input/output ripple and low output voltage compared to a single-phase and two-phase. Therefore, three phases have better performance. The result of the various operating operations is illustrated in the simulation result.

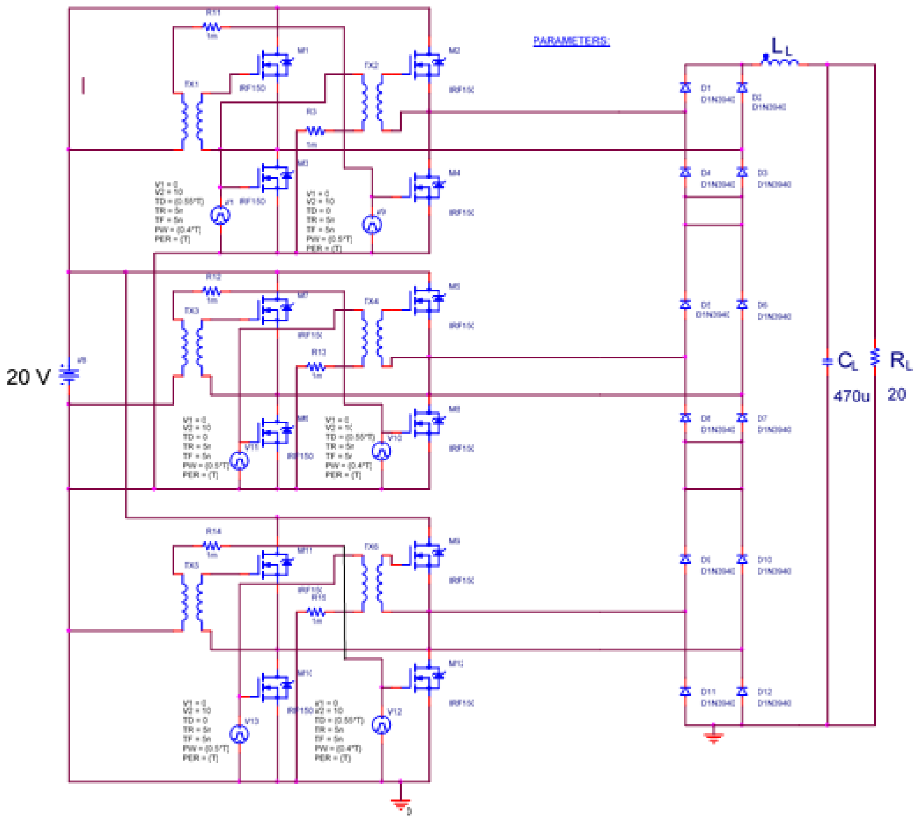

Fig. 2. Three-phase DC-DC converter.

3. RESULTS AND DISCUSSION

3.1 Effect of the Inductor on the converter

The analysis has been carried out to evaluate the converter operation. Simulations have been executed to see the effect of the inductor on the simulation result of single-phase, two phases and three-phase DC-DC converter. The frequency varies in range, from 100 kHz, 10 kHz and 1 kHz. Different frequencies result in the different output waveforms of the simulations. On the other hand, a different value of the inductor that varies from 100µH, 200µH, 400µH and 640µH also gives a significant impact on the results. The input and output voltage is constant. Results are shown respectively in Figure 3.

From the simulation results, when the inductor is at 100 µH with frequencies 10 kHz and 100 kHz, the output voltage ripples are relatively constant. The overshoot value is significantly lower, with a higher switching frequency at 100 kHz. For single-phase, as shown in Figure 3(a), based on the observation, the converter has a peak voltage around 21V and a short settling time with ripple at a frequency 1 kHz. The circuit settled around 2.4ms at the output voltage.

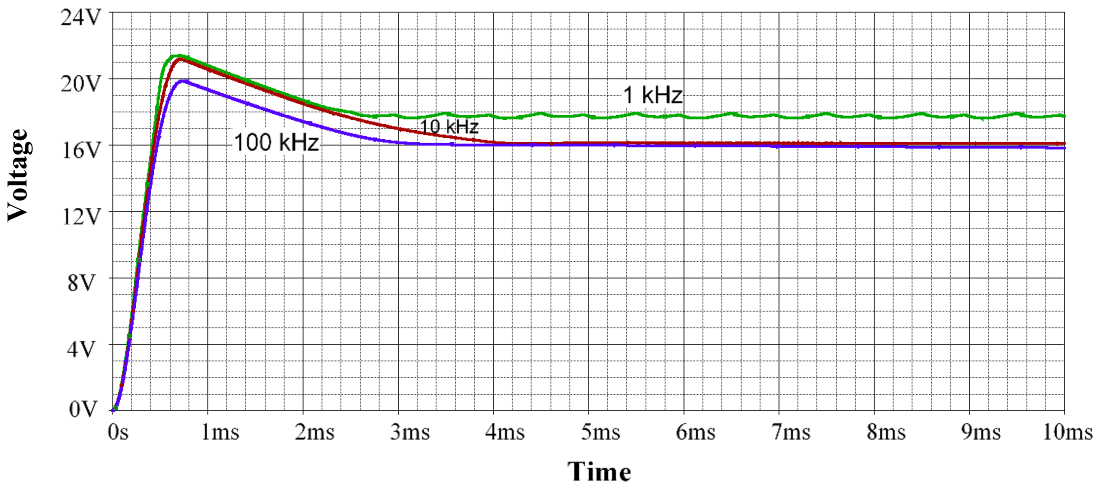

Fig. 3(a). Variation of the output voltage with frequency for single-phase converter with inductor L_f =100 µH.

For the two-phase converter shown in Figure 3(b), the peak voltage of the converter has slightly increased to 26V and have a longer settling time of around 3ms.

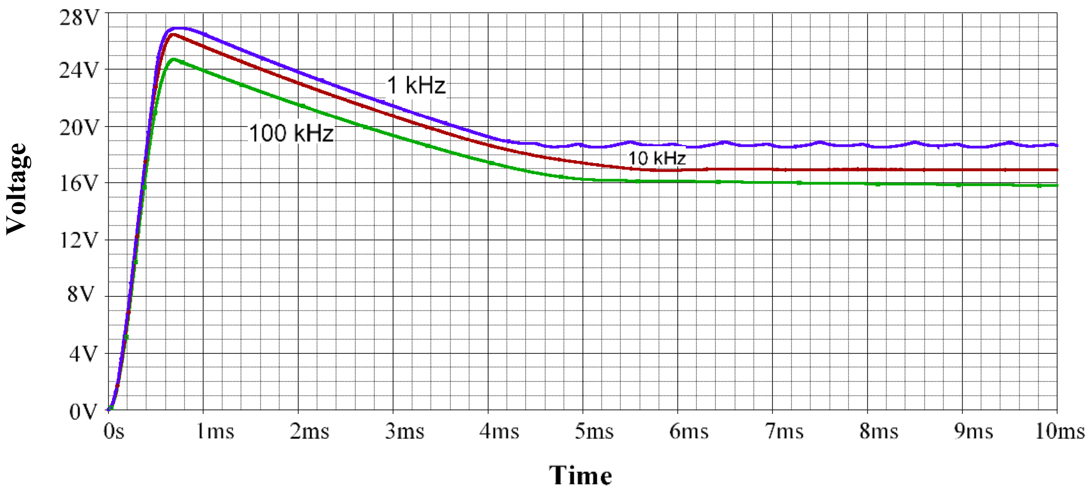

Figure 3(b): Variation of the output voltage with frequency for a two-phase converter with inductor L_f = 100 µH.

Meanwhile, in Figure 3(c), the three-phase converter shows peak voltage is sufficiently reduced compared with that in single-phase and two-phase converter, which is 12V.

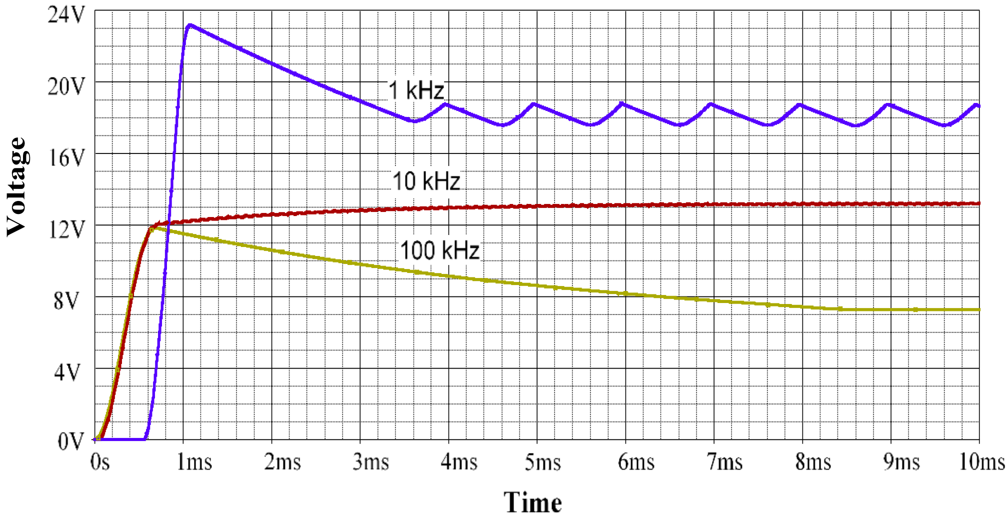

Fig. 3(c). Variation of the output voltage with frequency for a three-phase converter with inductor L_f =100 µH.

3.2 *Effect of the Frequency on the converter*

Simulations are carried out to see the effect of frequency, as shown in Fig. 4. The overshoot value is significantly lower, with a higher switching frequency at 100 kHz and inductor value at 100µH. The simulations result in single-phase represented in figure 4 (a) shows the output voltage ripples are low and the settling time settled around 4ms. Meanwhile, the value of voltage peak overshoots at 20V.

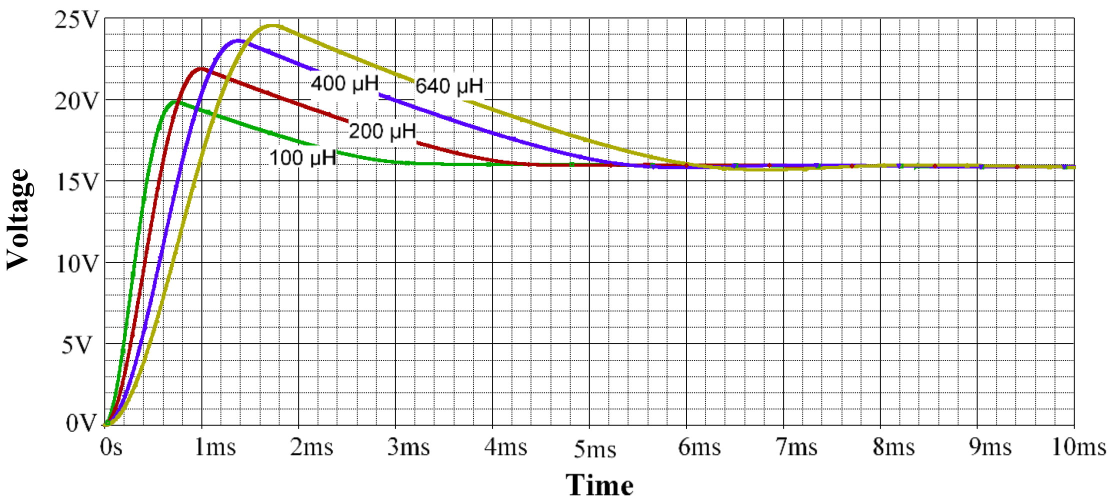

Fig. 4(a). Variation of the output voltage with an indicator for a single-phase converter with switching frequency fs=100 kHz.

The two-phase converter simulation result is illustrated in Fig. 4(b). The overshoot point is slightly increased. The output voltage shows at 25V and has a longer settling time, around 5ms.

The three-phase converter is shown in Fig. 4(c) as the most efficient because it lowers the output voltage. In conclusion, the higher the switching frequency value, the better performance of the simulation waveform will be achieved. On the other hand, it leads to better performance and increases the power density of the converter.

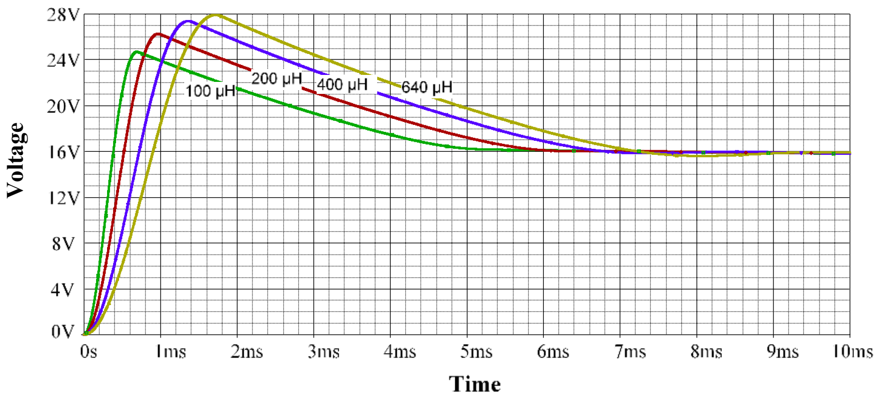

Fig. 4(b). Variation of the output voltage with an indicator for a two-phase converter with switching frequency fs=100 kHz.

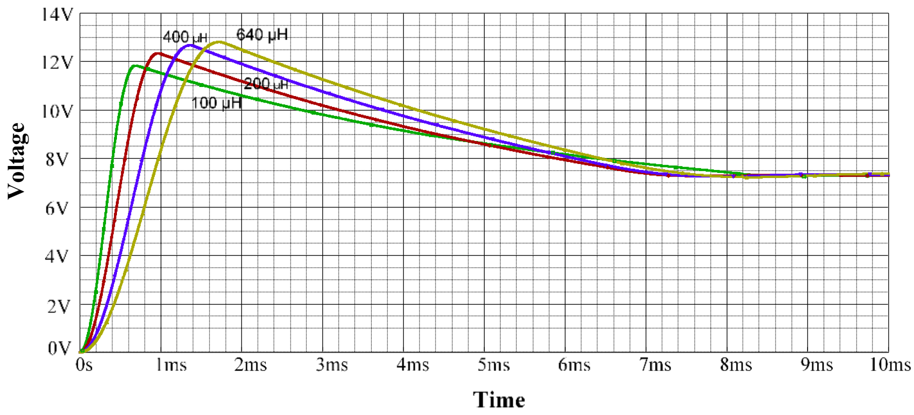

Fig. 4(c). Variation of the output voltage with an inductor for a three-phase converter with switching frequency fs=100 kHz.

3.3 Effect of the Frequency to Three Phase Converter

Figure 5 shows the effect of frequency to the simulation results. The value of inductor is 100uH, 200uH 400uH and 640uH and the frequency is varying from 100 kHz, 10 kHz and 1 kHz as shown in Figure 5(a-c). Based on the observation, frequency 100 kHz as shown in Figure 5(a) has better performance compared to frequency 10 kHz and 1 kHz. The overshoot point is significantly lower with the higher switching frequency. However, high frequency producing longer settling time.

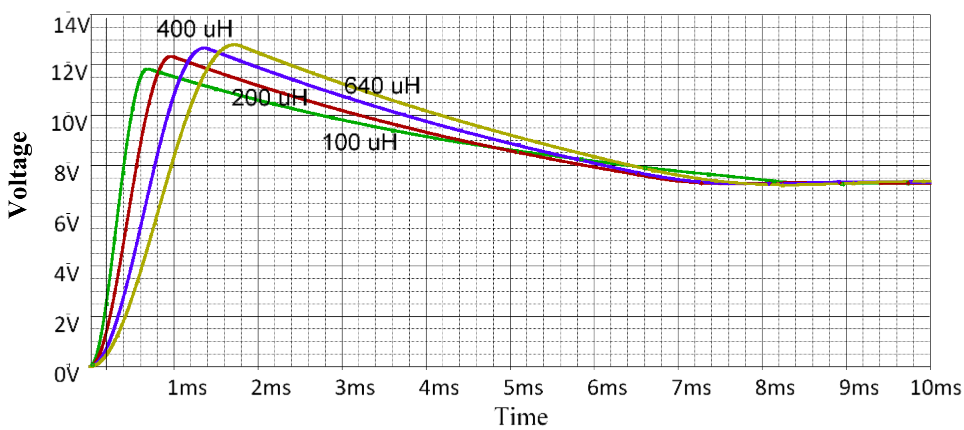

Fig. 5(a). Effect of the frequency to three phase converter for various inductors at 100 kHz.

Figure 5(c) when frequency is 1 kHz shows very undesirable output waveform with so many ripples. As can be seen from the output waveform, the overshoot point started a little bit late which at 0.6 ms instead of start form 0. Clearly the overshoot point is higher than the frequency of 10 kHz and 100 kHz. However, it has shorter settling time. On the other hand, the overshoot value is significantly lower with the higher switching frequency. The benefit of high frequency is lower ripple waveform.

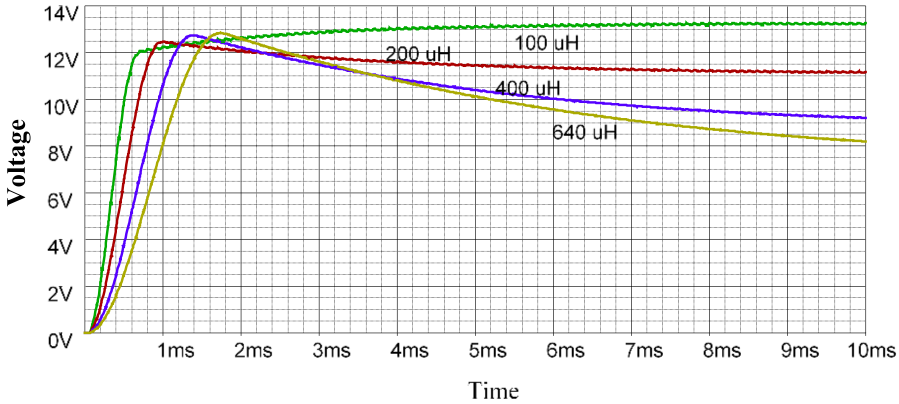

Fig. 5(b). Effect of the frequency to three phase converter for various inductors at 10 kHz.

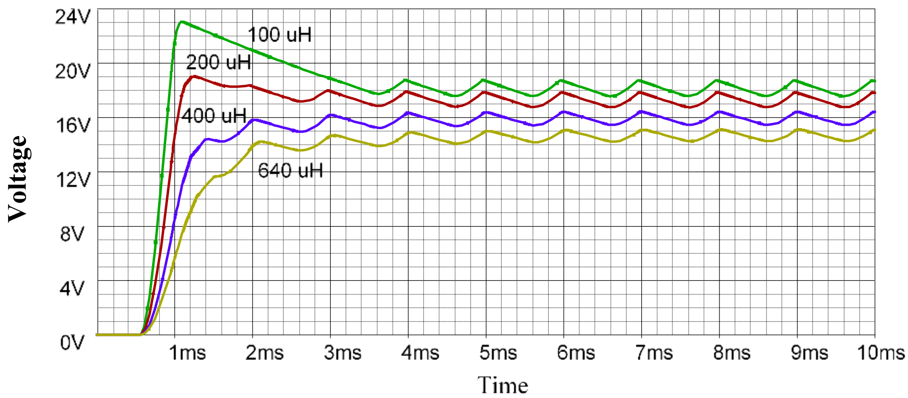

Fig. 5(c). Effect of the frequency to three phase converter for various inductors at 1 kHz.

3.4 Effect of the Load Resistance the converter

Figure 6 shows the effect of the load resistance on the simulation. We also need to consider the effect of load resistance. The load resistance varies from 20, 40, 60 and 100 Ωs, the value of the inductor of 640µH and frequency is at 100 kHz. From the observation, the converter needs to have minimal load resistance to handle the DC output voltage.

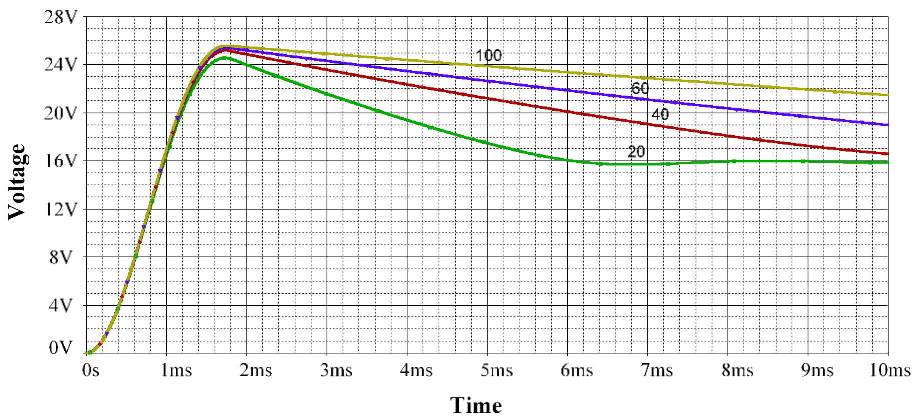

Fig. 6. Effect of the load resistance of the output stage.

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3.5 *Effect of the Capacitor on the converter*

Figure 7 shows the output capacitance affect the stability of the converter. The capacitance can significantly influence the converter, which defines the stability of the converter operation. The filter capacitor is to convert the rippled output of the rectifiers into a smooth DC output voltage. The parameter has to be in a certain range to assure the stability of the system. As the capacitance value of 100uH, the voltage peak is at 26V and settled at 2ms with small oscillation. Increase the value of the capacitor to 470µF; we can see the peak value is around 24V and have the smooth output waveform. Hence, it is crucial to consider the value of the capacitance, which will determine the number of ripples at the output waveform. If the capacitance value is too low, it will have little effect on the output waveform.

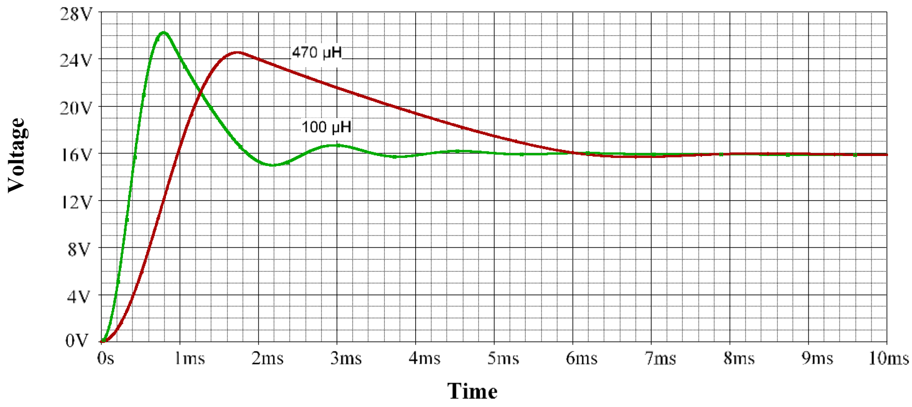

Fig. 7. Effect of the filter capacitor in the output stage.

3.6 *Output voltage after rectification*

Figure 8 shows the output voltage after rectification and before filter and after the filter. The output voltage after rectification is displayed in figure 8 shows the simulation result before filter when current is not passing through the inductor.

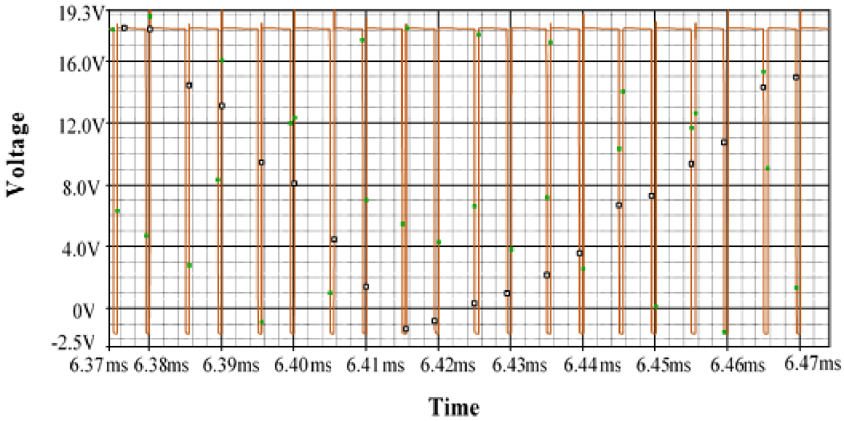

Fig. 8. Output voltage without a filter.

Meanwhile, as can be seen in Fig. 8, it shows the simulation result after filter when the current passing through the inductor. The output of the after rectification has less ripple and produced a smooth output waveform.

3.7 *Load current*

Figure 9 shows the load current in the inductor. The ripples are not only determined by the smoothing capacitor but load current is also important to determine the ripples of the output waveform. We have to consider the parameter of the load current to obtain a smooth output waveform of the simulation. Figure 10 shows the inductor current peak value is at 11.2A.

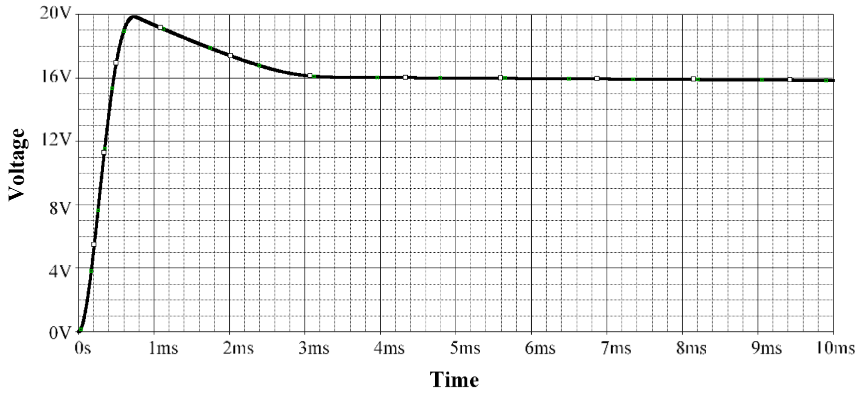

Fig. 9. Output voltage after the filter.

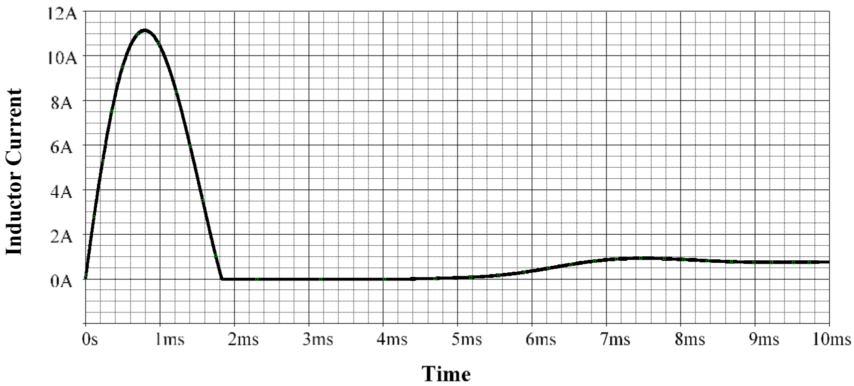

Fig. 10. Load current before the inductor

The inductor current is pulled down, as shown in Fig. 11, after the load current passing the inductor. It shows that the load current reaches the minimum value and inductor current becomes zero after a short period of time.

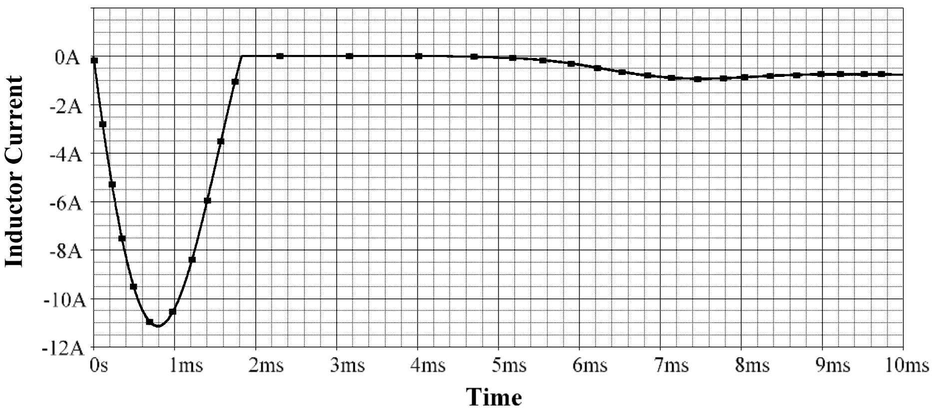

Fig. 11. Load current after the inductor

4. CONCLUSION

The simulation of the DC-DC converter has been done for designing various phases. The DC-DC converter can be operated at different phases, first is a single-phase, then two phases and lastly, three phases. The performance of the converter is simulated using PSPICE simulation software, and the performance is evaluated accordingly based on the switching frequency (f_s), which varies from 1 kHz, 10 kHz and 100 kHz, inductor (L_f), which varies from 100uH, 200uH, 400uH and 640uH, filter capacitor (C_f) selected as 470uH, load resistance and load current. The input voltage (U_{in}) used for this converter is 20V and the output voltage varies from 20V up to 100V. This converter simulation result shows better performance compared to the proposed converter from the previous study. Features such as high switching frequency and high capacitance value make this converter better in performance.

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