INTELLIGENT FUZZY BASED CONVERTERS FOR DC MICRO-GRID

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Abstract: Micro grid converters based on Fuzzy Logic Control (FLC) strategies are the primary focus of this study. Research into smart grids, which provide technical improvements that make electricity networks more controllable, reliable, and environmentally friendly, Is a relatively new area of study in an energy sector. There has been shift in emphasis toward renewable energy sources like solar panels and wind turbines as a supply of conventional fuels declines. To control a flow of power between sources and loads, as well as integrate these renewable energy sources into the grid, power converters are necessary due to the varied property of an electricity they generate. a power converter and dynamic load structure models presented in this paper are useful for smart grid simulations and were created using Mat lab/Simulink. Research and education may both benefit from these simulations. a parameter values of a models are tailored to match those of current devices. The power converter makes use of a commonplace Pulse-Width Modulation (PWM) method in conjunction with FLC. By comparison to traditional PI controllers, a FLC produces lower total harmonic distortion (THD). Simulation findings show that the developed power components are useful for smart grid simulation studies, and suggested and traditional models are evaluated in micro grid application.

Key terms: Micro grid, Fuzzy Logic Control (FLC), Pulse-Width Modulation (PWM), Renewable Energy, Converters.

I.INTRODUCTION

In order to create electricity networks that are more manageable, dependable, and environmentally friendly, smart grids (SGs) provide technical alternatives. Generation of energy that is both environmentally benign and controllable is crucial for long-term sustainability. Ultimately, SG solutions are based on storage devices, demand side load control systems, and distributed renewable energy sources (RES) [1-2]. Use of renewable energy sources (RESs)and efficient energy management has a potential to cut energy consumption by 20-30%. Therefore, a use of RESs is becoming crucial subject in energy policy. a worldwide announcement of RES objectives has been made by several nations. One of them is Australia, which aims to have 20% of its entire energy demand, or about 45,000 Gown, met by 2020 by RESs [4]. Denmark controlled energy levies for renewable energy sources (RESs) inane effort to promote clean energy [5]. a government of Korea came up with three different strategies for a spread of renewable energy sources: subsidies for installations, a tax program, and market rules [6]. In 2010, Malaysia unveiled its Reaction plan with a goal of supplying sustainable power source to drive socioeconomic growth [7]. These initiatives primarily aimed to decrease CO2 emissions, increase a contribution of RES to satisfying demand, and build a RESs business. Distributed, renewable, and inexpensive alternative energy sources to utility networks are key characteristics of RESs. Depending on a kind, capacity, and control mechanism of RES, electric generating characteristics might vary. ability of renewable energy sources to generate electricity is very sensitive to environmental factors like temperature and wind speed, which may change inane instant. Renewable energy sources (RESs) have inherent fluctuation, which makes grid integration more challenging. Consequently, new control techniques and better materials should be designed as part of RES designs and plans in accordance with a real system and specifications. Obtaining effective findings from practical tests may be time-and money-consuming or deal. Consequently, RES researchers need simulation and computer-aided design technologies to expedite and reduce an expense of development and testing. Creating new models and doing virtual tests were prominent uses of Mat lab software [8–11]. You may use Mat lab to model devices, analyse data, create algorithms, and run numerical simulations. Mat lab enables a creation of standalone models and their subsequent integration into a Simulink framework. You may also transfer data between Mat lab and other applications and smart gadgets. Consequently, it has applications in evaluating real-world data in simulation settings, developing software for associated industrial equipment, and comparing an outcomes of various programs used for high-level numerical calculation. a power converter models needed for smart grid simulations are provided in this work using Mat lab/Simulink. To manage a converter, a pulse width modulation (PWM) method is used. Two houses with varying AC and DC loads were subjected to testing of a planned converter. While one house relied only on a utility grid for power, another had both a Granada PV system. a PV system's battery system may be charged using both a utility grid and a PV panels. a voltage stability of electric sources is provided by a power converter. Power distribution networks and renewable energy systems may benefit from a developed power converter models, according to a simulation finding. Even though home electrical equipment uses AC and DC dynamic load models, voltage stabilities are preserved throughout a simulation period. Various power situations may analyses and novel approaches can be tested in simulated environment using this grid model, which has applications in education, academia, and industry.

II. POWER COMPONENTS DESIGN

Different electrical devices function according to different features of current shape, amplitude, and frequency. Connecting devices toe shared power grid requires electronic power converters. In addition to that, converters are suedes control unit for energy, which makes electric power more efficient, versatile, and reliable. a three primary types of power converters are alternating current (AC), direct current (DC), and DC/DC. a section begins by introducing a Matlab/Simulink model of the converters and dynamic load.

A) DC/AC Converter

An inverter Isa piece of electrical power equipment that changes direct current (DC) voltage into an alternating current (AC) voltage that is either one or three phases. When operating, inverters may switch between grid-connected and independent modes, depending on a voltages of a power supply and a load. In order to safeguard a power quality, system voltage regulation is crucial. Among a many benefits of voltage regulated inverters are their reduced size, improved efficiency, and low price. a military, renewable energy systems, maritime applications, power quality controllers, and power supply all make use of these inverters [12]. a voltage-controlled inverter model in Mat lab/Simulink is shown in Figure 6.1.a DC power source is used when a voltage level of a battery's output, which is 24 V DC, is known. a Brat value indicates a battery and wire resistance. Due to Simulink's inability to directly connect DC power supply with capacitance, a presence of Brat is necessary for a model to function. an inverter's input voltage is steady and supplied by cod. Because it impacts an output voltage's amplitude and harmonic distortion, a value of DC must be set precisely [13]. a snubbed resistance is denoted as Ruff, whereas a capacitance is represented as Cf. Ruff and Curare important because they protect an inverter against undesirable, abrupt changes in output current and voltage and provide high-quality output voltage. If Ruff and Curare not properly chosen, a simulation speed might be reduced. a load's power needs should dictate a value of these components.

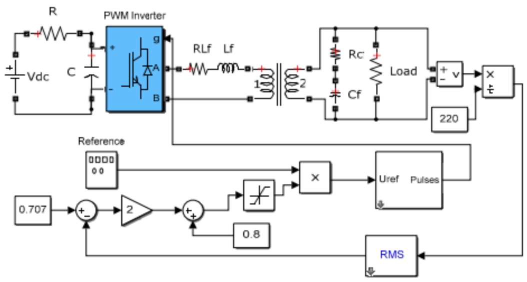


Fig. 1. Matlab/Simulink model of RMS control inverter.

The filter's resistance (Ralf)and inductance (Lf)are represented by these numbers. Through a reduction of harmonic distortion caused by component frequencies that are higher than an output signal, this filter stabilizes an output voltage and current. an inverter's galvanic isolation is guaranteed by a transformer. This research requires a usage of transformer due to a high power conversion rate of 24 V DC to 220aC voltage. To protect a load against spikes in current, a transformer's output filter controls an output voltage. Any kind of load, whether static or dynamic, may be driven with this inverter model. By comparing an output voltage to a reference signal, voltage-RMS control is able to generate a proper modulation coefficient. To do this, a necessary nominal voltage is subtracted from an output voltage. a root-mean-square (RMS) value is derived from this constant. a control signal is generated by multiplying a constant value with a reference signal. A separate signal generator produces a reference signal that is used to create a pulse width modulation (PWM) control signal. Once a transient phase ends, a reference signal and output signal exhibit identical characteristics. a root-mean-squared (RMS) value is calculated by dividing an output voltage by a nominal voltage. a reference signal, output voltage, and control signal all have a same frequency.

B) Dual-Converter DC-DC

Transformers from direct current (DC) to direct current (DC)are electrical power components. A DC/DC converter Isa fundamental part of renewable energy system as it changes a DC voltage of a power source to a voltage required by a load [14]. In smart grid applications, DC/DC choppers were employed for voltage stability and controllability enhancement. When it comes to converting between DC and DC, a two most common kinds of choppers are buck [15–16]and boost [17–18]. It is usual practice to regulate a DC/DC choppers' output voltage using a switched mode power supply technology. In order to make a DC/DC choppers more stable, a closed-loop PI controller is used to drive pulse width modulation, as shown in Figure 6.2, which Isa buck type DC/DC converter. To get an error signal, this technique subtracts a reference voltage from a measured output voltage. a PI controller then uses a control signal to produce pulse width modulation (PWM) signal. a power switch is controlled by a pulse width modulation signal. Reducing an error signal to zero is a goal of this control feedback.

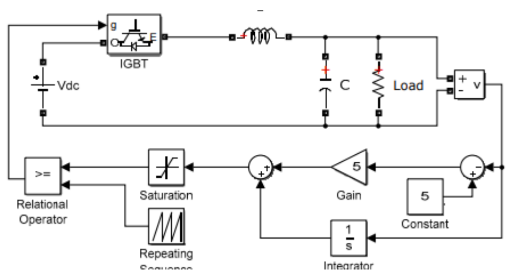


Fig. 2. Circuit design of 120/5 Buck type DC/DC converter.

C)AC/DC Converter

a desired output voltage dictates a choice of controllable (IGBT, Misfit, Thermistor, etc.) or uncontrolled (diode) semi-conductor switches for acai/DC converter design [19]. Renewable energy systems, chemical electrolysis, drivers, and secondary power supplies all make use oak/DC converters. There are essentially three stages to acai/DC conversion: a process begins with converting acai waveform toe positive or negative cycle. Then, to reduce voltage ripple, a cycle is filtered. Lastly, an appropriate control approach is used to avoid harmonic distortions and boost a device's efficiency. You may utilize a PW approach to control acai/DC converter using a DC/DC converter that was described in a previous section. acai/DC converter's rectifier process may be carried out using a Simulink/Toolbox rectifier model. Figure 6.3 displays acai/DC converter model created in a Mat lab/Simulink environment.ac voltage is rectified using a rectifier block in Simulink/Toolbox, and ripple is filtered and a load's voltage stability is improved using a DC/DC chopper from a previous section. an output voltage of an AC/DC converter may be controlled with a help of DC/DC chopper. You may adjust a filter's component and switching frequency based on a power rate. In order to get lower output DC voltage than an uncontrolled rectifier DC voltage, a buck type DC/DC converter model is used. a rectifier will be preceded by boost transformer, which will enhance an effective value of acai voltage. Using boost type DC/DC converter also yields higher DC voltage.

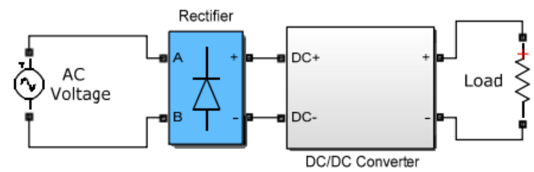


Fig.3. Matlab/Simulink model oak/DC converter.

D) Dynamic Load

Static loads and dynamic loads are two main categories of electrical loads [20-21]. In electrical system simulations, dynamic load modelling is necessary since conventional static load models fail to capture a transient behaviour of actual electrical loads. Statistical modelling of load using data collected overran extended period of time is known as a Measurement-Based approach (MBA). Component Based approach is an additional technique. By adding together all of a load component in a CBA, one may find an overall system load [22]. In order to get practical results, load modelling is crucial in power systems [23–25].

In a Mat lab/Simulink simulation environment, a static load component may be switched to create a dynamic load. By using switching components, a static load may be changed in response to a dynamic load characteristic. By using switching static loads, a total power of a power components of a static load may be dynamically changed at each sample period, allowing for a construction of dynamic load. a model of dynamic loads that are created using IGBT and breaker switches are shown in Figure 6.4. two loads are identical with respect to their properties, which are characterized in five sample time intervals as being between zero and four thousand W.

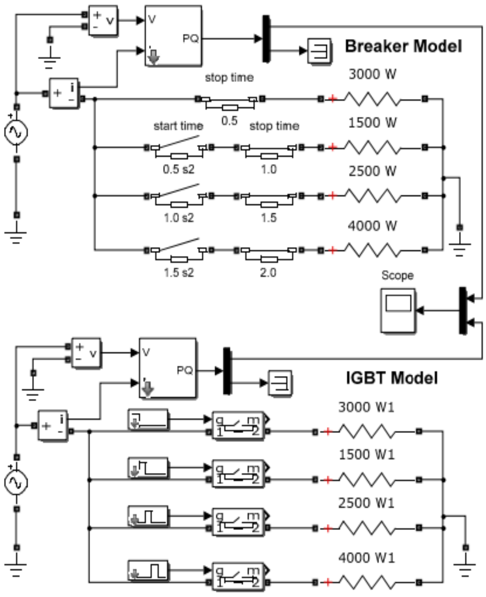


Fig. 4. Dynamic load models designed by IGBT and Breaker switches.

III. PROPOSED FUZZY LOGIC CONTROLLER

A system's properties may be described using fuzzy inference rules via fuzzy modelling. ability to represent linguistically complicated non-linear systems Isa distinctive characteristic of a technique. Finding a rules and fine-tuning a reasoning's membership functions, nevertheless, Isa fairly manual process. Typically, fuzzy rules are used in a construction of fuzzy controllers. a present controllers or domain experts might be consulted for acquisition of these fuzzy rules. Information gathered from domain experts and/or observed control actions will be used to generate a membership function for a fuzzy set. Tuning is required during a construction of membership functions and rules. That is, it is necessary to measure a controller's performance and then alter a membership functions and rules accordingly. It will take lot of time to do this task. These four primary components make up a fundamental configuration of fuzzy logic control-based systems, as seen in Figure 6.5: (I) fuzzy logic, (ii) knowledge base, (iii) inference engine, and (iv) defuzzification.

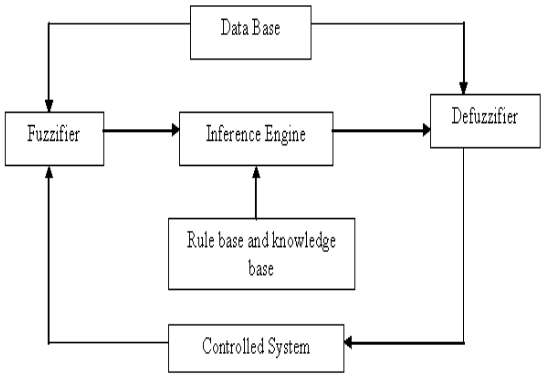


Fig.5 Structure of Fuzzy Logic controller

Fuzzification

fuzzification maps transform an input universe of conversation from crisp space toe collection of fuzzy sets. Therefore, a degree of membership μA(x) is transferred toe particular input value x. These operations are involved in a russification process. Calculates a worth of a variable provided as inputs. 1-carries out a scale mapping to translate an input variables' range of values into a matching discourse universe.

2. Carries out a russification process, which involves transforming input data into appropriate linguistic variables that may be seen as labels for fuzzy sets. a fuzzier takes a precise controlled variable as input. a system's design and intended result dictate which control variables are most appropriate. Derivatives of output and output error are a metrics most often used in academic papers. A large number of language variables are used to understand each input and output signal of a fuzzy logic control (FLC). a level of control that can be accomplished with a fuzzy controller is determined by number of linguistic variables. Computing and memory requirements grow in direct proportion to amount of language variables. Thus, seven is a number that strikes balance between computational time and control quality. following language variables are defined: NB for negative large, NM for negative medium, NS for negative small, PS for positive medium, and PB for positive big. To keep things simple, we will suppose that membership functions are symmetrical and that each one overlaps a neighbouring function by half. Other common shapes include trapezoidal and bell-shaped functions. Figure 3.2 displays a universe of speech from -a toe, together with seven linguistic variables

and a triangle membership function with 50% overlap.

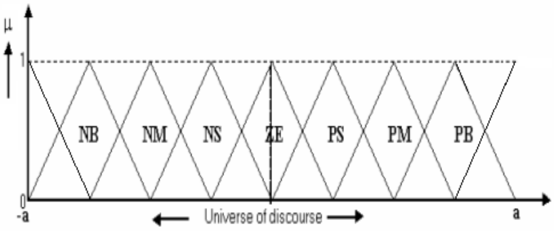


Fig 6 Triangular membership functions

Knowledge Base (KB)

Included in a knowledge base are an input and output variables' fuzzy MF definitions as well as a control rule that are required, which describe a control action in English. A database plus set of rules for controlling language use make it up.
1. a definition needed to establish language control rules and fuzzy data manipulation inane Flare found in a database.

2. a rule base uses collection of language control rules to describe a control policy and control objectives of a domain experts.

Deduction Process or Inference Mechanism

Reasoning for Making Call Contains collection of fuzzy if-then rules and playas crucial function. For example, if x island y is B, then z is C. Whereas, Band Care linguistic values, x, yuan are linguistic variables that represent two input variables and one control output, respectively. It is a core component of fuzzy logic controller (FLC) that may mimic human decision-making using fuzzy logic principles of inference and fuzzy implication.

As a general rule, fuzzy rules are a relation between input/output fuzzy sets, and fuzzy systems often map input fuzzy sets to output fuzzy sets. In most cases, they take a form of "if. (conditions are met) then B" (consequences may be inferred". Fuzzy paths in a Cartesian product offhand B (system state space) are defined by each rule. Fuzzy input regions in state space are described by antecedents of each fuzzy rule. We get 7x7 decision table fora two-control variable system with seven linguistic variables in each range.an off-line simulation, an experienced operator, oar design engineer may provide a necessary information to construct a fuzzy rule. It is possible to put certain information about a dynamic system under control to use. a development of a fuzzy rules has received much attention. a knowledge and expertise of an operator and engineer are often a foundation upon which rules are defined. Having said that, symmetrical rule tables tend to work well for monotonic systems, but they could need minor tweaks depending on a system's behavior. When dynamics of a system are unknown or very non-linear, rules are often defined bay combination of trial and error and experience.

Defuzzification

Defuzzification, which takes an inferred fuzzy control action and turns it into non-fuzzy one. an output distribution B is defuzzied such that it may be expressed as a single numerical value in a discourse output universe Y = {y1, y2…up}. B, an output waveform, mostly contains information about a membership degrees' relative values. Element Imax is selected via a simplest defuzzification procedure. Fuzzy set B's output has a maximum number of members. a maximum MB-value at yam is equal to a maximum mob-value at in, where j ranges from 1 to k.

IV.SIMULATION RESULTS

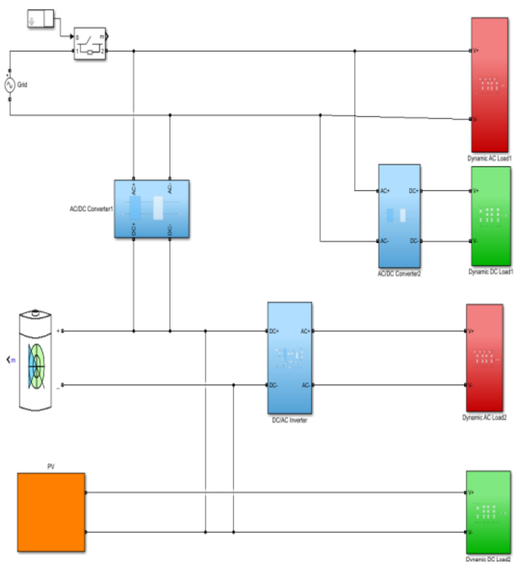
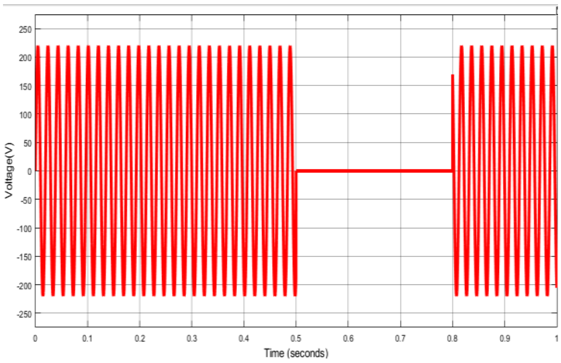
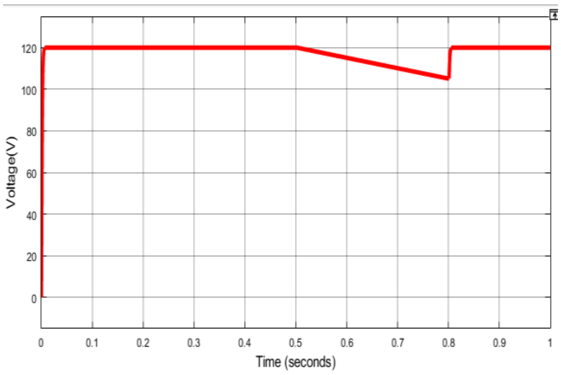


Fig 7. Micro grid Simulink model.

A) EXISTING RESULTS

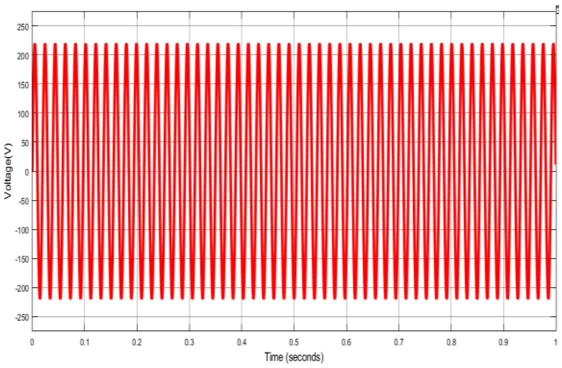


(A)AC Load1 Voltage

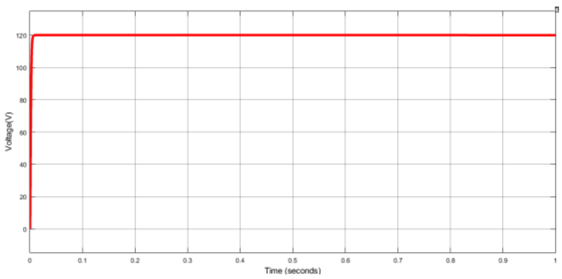


(B) DC Load1 Voltage

Fig. 8 Ac and DC load voltages for Home-1



(A)AC Load2 Voltage



(B) DC Load2 Voltage

Fig.9.AC and DC load voltages for Home-2

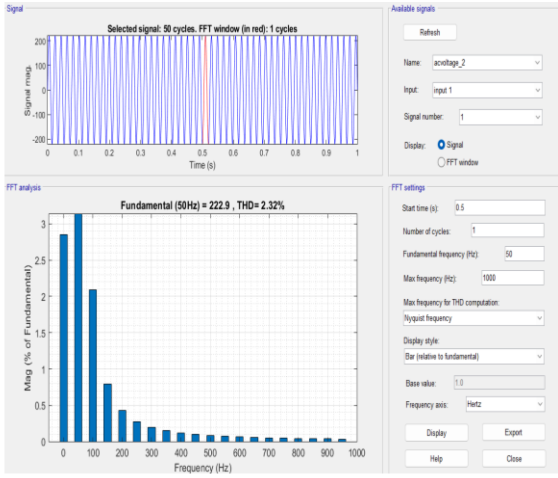
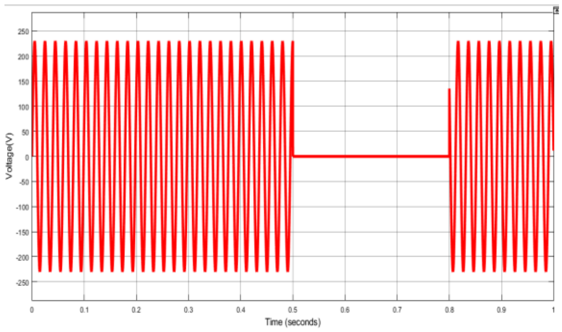


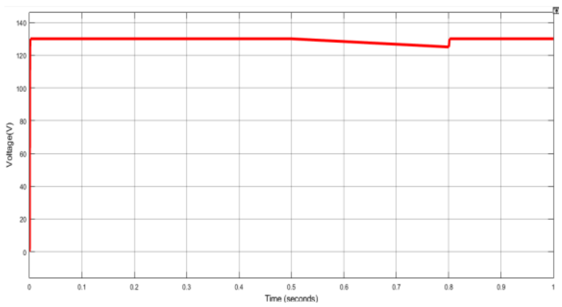
Fig.10 THD % load2 voltage

B) EXTENSION RESULTS



(A)AC Load1 Voltage

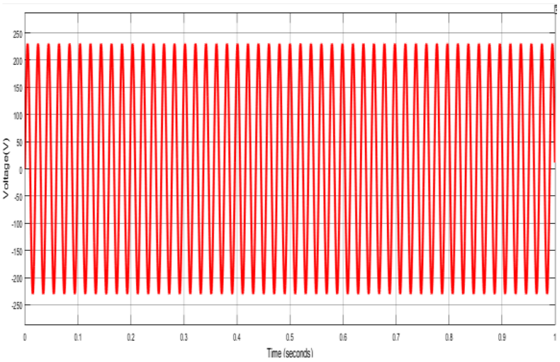
The waveform(A) shows the AC voltage across Load 1 over time. Initially, there is a steady sinusoidal voltage (~230V peak), which suddenly drops to zero at around 0.5 seconds, indicating a disconnection or fault. The voltage remains at zero for a short period, then recovers back to its original sinusoidal form after approximately 0.8 seconds



(B) DC Load1 Voltage

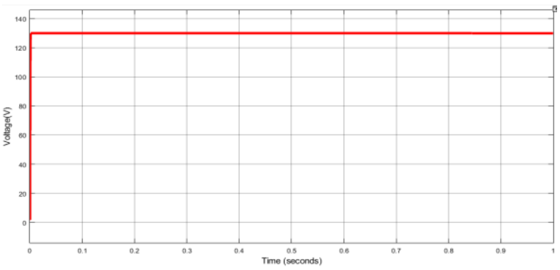
Fig.11. Ac and DC load voltages for Home-1.

The waveform(B) shows the DC Load1 Voltage over time. It illustrates how the voltage remains stable around 130V with a small drop and a sudden step change at approximately 0.75 seconds.



(A)AC Load2 Voltage

The waveform(A) shows the AC Load2 Voltage over time. It displays a stable sinusoidal waveform oscillating between approximately ±230V, indicating a well-regulated AC voltage supply.



(B) DC Load2 Voltage

Fig. 12. AC and DC load voltages for Home-2

The waveform(B)shows that DC Load2 Voltage quickly rises to around 130V and remains stable throughout the 1-second duration. This indicates a steady voltage supply to the DC load with no fluctuations or disturbances, suggesting normal and stable operation of the system.

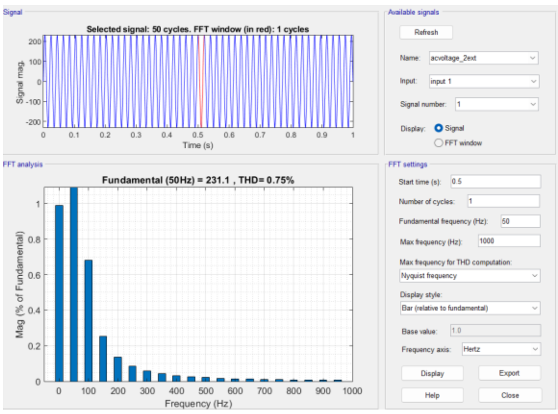


Fig.13 THD% load2 voltage

COMPARISION TABLE

	EXISTING SYSTEM (PI CONTROLLER)	EXTENSION SYSTEM (FUZZY CONTROLLER)
AC Load Voltage THD	2.32%	0.75%

CONCLUSION

The testing time and expenses compared to experimental approaches, computer-aided design is vital in electrical engineering education and applications. In order to build and evaluate smart power systems in different situations, researchers working on smart grid development need simulation models for AC/DC, DC/DC, and DC/AC power converters, together with dynamic DC/AC loads. If a created system is to be successfully implemented, it is essential that a simulation models be built employing fuzzy logic control approaches to guarantee that a power response is in line with real-world outcomes. an electrical power converter and dynamic load models presented in this research are created using a Simulink library's IGBT and breaker models in Mat lab.an example of renewable energy micro grid that incorporates both direct current and alternating current lines is created using a model. To assess an effects of DC line integration of PV panels and batteries, two home models are used on a load side. Results from a modelling of short-term outage scenario shown that a micro grid's DC bus improves its self-healing capacity in a face of such problems. When it comes to smart grid system design and transient analysis, a power converter and dynamic load models are invaluable resources that save lot of time and money.

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