ACTIVE POWER SHARING TECHNIQUE USING ARTIFICIAL INTELLIGENCE BY VOLTAGE CONTROL IN A HYBRID DC/AC MICROGRID USING IOT

P.Selvam[1], R.Devarajan[2], G. Rama Krishna Prabu[3] and C. Ravi Kumar[4]

[1]Head of the Department, Electrical and Electronics Engineering, Vinayaka Mission's Kirupananda Variyar Engineering College, Vinayaka Mission's Research Foundation (Deemed To Be University), Salem-636308, Tamil Nadu, India, hodeee@vmkvec.edu.in.

[2]Professor,Department of Electrical and Electronics Engineering, Vinayaka Mission's Kirupananda Variyar Engineering College, Vinayaka Mission's Research Foundation (Deemed To Be University), Salem-636308, Tamil Nadu, India, devarajan@vmkvec.edu.in.

[3]Associate Professor,Department of Electrical and Electronics Engineering, Vinayaka Mission's Kirupananda Variyar Engineering College, Vinayaka Mission's Research Foundation (Deemed To Be University), Salem-636308, Tamil Nadu, India, krishprabugovind@gmail.com.

[4]M.E – Power System Engineering, Department of Electrical and Electronics Engineering, Vinayaka Mission's Kirupananda Variyar Engineering College, Vinayaka Mission's Research Foundation (Deemed To Be University), Salem-636308, Tamil Nadu, India, sarathyforever2012@gmail.com

ABSTRACT:

The objective is to optimize the power flow while considering grid cost, predictions, data, grid power constraints, and storage capabilities into consideration. The variable factors IOT (Internet of Thing) and their effects on the micro grid operating problem via the limiting concentration points. The hybrid system is a combination of the several types of energy sources generated with different conversion methods. The energy is generated with either wind or solar with a voltage control-based genetic algorithm in the existing method. The existing method output voltage is constant, but noise appears in between the output waveform, so the output cannot give the constant voltage source in Micro gird. In the proposed method implementation of artificial intelligence by voltage control based hybrid system. Both solar and wind are the input source and converting the getting source voltage. The solar is the DC (Direct current) input source with battery energy management. A micro grid is a small scale while protecting the output load without any fluctuation. In this technique, the whole mechanism has to connect with the DC bus for a hybrid management system based on a combination of two different sources. The controller algorithm technique is the Artificial Intelligence gives the pulse width modulation for getting the better output voltage source. The result will get the better-balanced output and the voltage with the constant backup of Battery energy management from the unbalanced voltage input source. The experiment through both the hardware based on load voltage and software while using the Mat lab technique

Keywords: Micro Grid, Neural Network, Power Sharing Technique, Battery Energy Storage System, IOT (Internet of Thing).

1. INTRODUCTION

The dispersed energy waste assets are higher dependence on administration, better nature of power supply, and more leading productivity of energy waste consumption using accessible waste heat from the power age system. Moreover, using sustainable energy with almost no contamination is gradually attracted to environmental insurance thinking and gradually draws significant interest. Electric utilities can profit by reducing the clog on the rotation age matrix, reducing the need for new age and bandwidth, and

offering supportive administration. The advantages of dispersed energy waste assets are high dependence on administration, better nature of power supply, and significant productivity of energy waste consumption using accessible waste heat from the power age system [1].

Extensive concerns about natural issues and the growing ubiquity of ideas such as neighborhood age and self-use have shown widespread interest in alternatives to consumer utility nets such as micro grids and Smart Systems (SG). Despite its advantages, the disadvantages and endurance issues Related to MG are taken into account by its appearance, especially in improving the quality of force, urging the interests of the critical examination. [2]. For in-depth nonlinear and complex AC / DC MGs, control schemes based on Neural Network (NN) and transformative calculations gain inevitable interest. Regulators have expressed hope that they can accommodate vulnerabilities and use them when the system model is not appropriate to control. Learning-capable NNs are generally applied to the control of complex force structures [3].

For continuous assessment of wind speed in back propagation. An epic discrete-time NN regulator is planned to control the DC circulation structure. The specific proposed in writing. Based strategies can be ordered, by preparation calculation, into two classifications: disconnected and prepared. When the controlled structure is too complex, it is more sufficient to use a prepared line-ready NN that responds sequentially to system vulnerabilities caused by nonlinearities, changing boundaries, and external difficulties [4].The miniature matrix structure is a force supply structure consisting of load and rotation energy resources, for example, environmentally friendly power source, integrated warmth and force age, energy component and energy stocking structure. Neural organization calculations are used for micro matrix voltage control. This can cause low and high voltage problems at the terminals of the light load when the throat request is necessarily changed. The DC miniature structure maintains the DC transport, taking care of the DC loads associated with it. The AC miniature matrix maintains AC transport, which takes care of the AC loads associated [5].

II. Previous Method

Infiltration of Conventional Diesel Generators, Approved Energy Storage Systems (ESS), and become the appealing force supply response significantly reduce the pressure of natural protection and improve the uninterrupted quality of power supply [6]. The widespread concern about natural issues and the growing ubiquity of ideas such as near age and self-use have fueled widespread interest in alternatives to regular utility systems such as Micro Grids (MG) and the Nano grid (NG). Despite its advantages, the disadvantages and stability issues related to MG are taken into account by its appearance, especially in the improvement in force quality [7].

Urging the interests of the critical examination. As a promising response to the expansion of Distributed Energy Resources (DER), large space Micro Grid (MGs) will be associated with vehicle infrastructure. Intelligent Energy Router (ER), which can interface the Medium Voltage (MV) utility system and Low Voltage (LV) AC and highly acceptable and proficient matrix associated combination, can provide power and secondary administration to the board for both utility mesh [8], [9].

In the combination, AC / DC miniature mesh, the transport converter structure, including a high-frequency DC transformer, assumes an essential part for sending power to the DC and AC sub-networks. Nevertheless, the numerous control assignments of the bilateral DC / AC converter to the intentional regulatory scheme and the force move mode exchange difficulties [10]. The Interlinking Converter (IC) activity in the High Micro grid (HMG) shaped by AC and DC sub grids is based on the regular transport boundaries of AC and DC sub grids. This system introduces the simulation of AC and DC sub grids using power electronic converters to consider the activity of IC. Networks are formed by integrating different Distributed Energy Generators (DEGs) and neighborhood loads [11], [12].

The development of current conveyed DC fuel sources such as sun-oriented PV energy units. In addition, the development of a Low Voltage DC system has encouraged the adjustment of DC micro grids [13]. The efficient and operational parts of the micro grid and the model regulators that compensate for voltage imbalances have exploited converters to keep the normal voltage imbalance of the organization within the qualitative qualities to change the negative grouped voltage of their transport. The progress of High Voltage Direct Current (HVDC) transmission and changes in load structure and properties, the transient voltage issue undermines the safety and stable activity of a really strong system [14] [15].

A rapid transient voltage safety assessment technique for obtaining the final power system for AC / DC is suggested in this method with a view to in-depth education. Considering the effect of multi-inflated DC and dynamic loads, this method achieves a convoluted neural organization, which uses the corresponding state power flux and imperfection highlights as data sources and the transient voltage dependence of the space around the op-edged edge [16]. The transmission and the change in load synthesis and symptoms, the transient voltage issue compromises the protection and static activity of the force and structures.

A momentary voltage stability assessment technique based on intensive learning neural organization to obtain AC / DC to assemble the rapid assessment model. The preparation test set is used to prepare the transient voltage stability rapid assessment model [17]. The dependable and adaptable gained notoriety as a mode of transport to all destinations across the globe. High-Voltage Direct Current (HVDC) has gradually become familiar with the Jolt system [18]. However, the fusion of the AC and DC system will continue for some time, as the AC rail route system is still in its prime. A strong miniature system requires constant and rapid improvement [19]. This system proposes a new idea of an ideal reproductive model of the entire organization is set and settled by biography graphical-based progression calculation [20].

III. Factors and Defects of Hybrid DC/AC Micro grid.

Conventional networks a cross-race miniature network, when AC transport is directly associated with the utility matrix, the size of the DC transport voltage can be directed by the same inverter and miniature sources and stockless located in the DC part. Moreover, despite the durable properties of the extent and repetition are attractive, they are generally not reliable without energy-saving stocking gadgets.

Use of energy stocking units in the power system. In the general scheme, PI regulators control the DC transport voltage as the flow of dynamic and receptive force. Nevertheless, Forward Error Cracking (FEC) works powerfully over a wide range of MG activity for unpredictable Renewable Energy Sources (RES) power age and time-fluctuating load request. For this reason, Maximum PowerPoint Tracking (MPPT) calculation-based regulators are used in the received scheme to improve the unique performance and respond favorably to fluctuations instead of direct Proportional-Integral (PI) regulators.However, this fuel source is directly subject to climate; for example, in the PV system; Radiation of daylight and temperature changes. A DC to DC converter is a classification of a force converter. It is an electric circuit that varies on a charge of Direct Current (DC) starting from a voltage level then later, by placing the information energy radiation for a short time and then yielding that energy at alternating voltage.

A stalled inverter is an electronic gadget that is equipped to exchange voltage levels on output using various low-level DC voltages as information. A two-level inverter is commonly used to generate AC voltage from DC voltage. Driver circuit allows sun-based boards to work at their most adept point for conditions, and force means the most productive point for charging a battery. A pulse width adjustment is an extraordinary technique for controlling the measurement of the force delivered to a neck without scattering any irregular force. Hence the drive entryway is used to control the flow measurement for the drive throat.
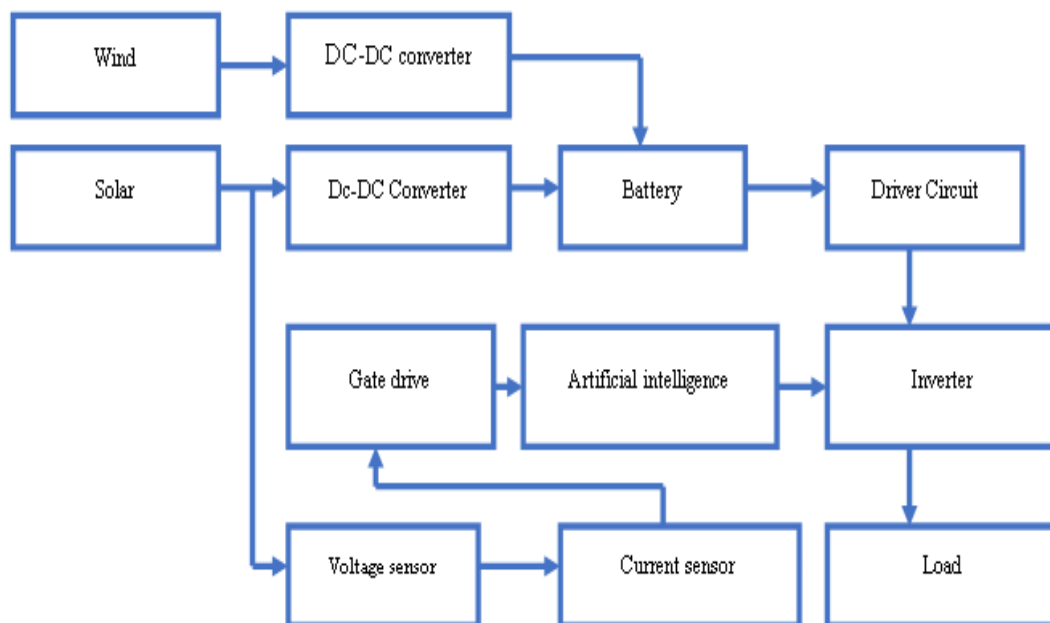

Figure 1: Proposed Block Diagram

The proposed crossover network may operate inbound or disconnected mode. Energy can be associated with the Stocking System DC or AC Connect. Information on improvement devices is needed. The some operating points, the PV array is nonlinear,

and the PV array generates maximum power. The perturbation and observation technique evaluates the momentary working area by monitoring voltage and current. The reference voltage is increased or reduced in line with that area, bringing the system close to maximum tracking. Because the perturbation and observation technique merely raises or decreases reference voltage, it is straightforward to implement. This technique, on the other hand, is unable to follow any quick and rapid changes in the surroundings. One option is to apply the incremental conductance technique, which can properly measure MPP by comparing incremental conductance.

The system is the auspicious sun-oriented energy of the power of our structure. Solar energy radiation is sent to a DC converter using a solar-oriented board. Solar energy is a DC source of power DC to DC converter is a classification of a force converter. It is an electric circuit that varies on a charge of Direct Current (DC) starting from a voltage level then later, by placing the information energy radiation for a short time and then yielding that energy at alternating voltage. The voltage and current sensors used for voltage and current testing can pass through the circuit from sunlight-based boards. After the data is collected, the drive entryway is used to investigate the information sent to the neural organization. The artificial intelligence is the progression of calculations carried out by an inverter circuit to understand the basic connections in a set of stream data up to the stack power inverter, or inverter, is a force electronic gadget or hardware that converts Direct Current (DC) to Automatic Current (AC). The data voltage, yield voltage and repetition, and generally speaking force, depending on the specific gadget or hardware plan.

A. SOLAR

The solar energy is correctly caught by the supplied solar panels and procured by the DC-DC system, which preserves and stores the net solar energy in a lithium battery for the autonomous grid system. This building's quiet habitation is used to convert rotational energy to electrical energy. The tiny fan blades that were given may be used to acquire it. The electrical energy that has been converted is correctly directed to the storage cells. As a DC-AC converter, the loading point of the storage cells is fixed. The provide AC power to household devices via the attached inverter.

B. WIND

Wind The surface of the world is created by the sun at conflicting temperatures. The wind turbine converts the kinetic energy of the wind into clean into dust. Then when the wind wave leads to the sharp edge of the wind length, the rotor captures the kinetic energy of the wind and turns it into a curved development to run the generator. This frame's passive habitation is used to convert rotational energy to electrical energy. The blades or generating device that were given may be used to acquire it. The electrical energy that has been converted is correctly directed to the storage cells. As a DC-AC converter, the loading point of the storage cells is fixed. The primary goal of this item is to provide AC power to household gadgets via the attached inverter.

The small wind design may be associated with the electric organization by your power provider or it may be very well limited (outside the barbecue). This small wind electric system is stationary at the right choice for provincial districts that are not systematically

associated with electric grids. A couple of wind turbines delivered today are level turn, upwind machines that have little edge. These front lines are usually made of composite materials, for example, fiberglass. The packaging of the turbine is a development with which the rotor, generator and tail are attached. The measure of energy of a turbine can basically be settled by the width of its rotor. The size of the rotor shows its "cleared territory" or the amount of wind caught by the turbine. The tail looks for the turbine in the wind wave.

C.   DC TO DC CONVERTER

DC-DC converters are high-frequency power change circuits used to convert high-frequency switches and clamps to indicators, transformers and capacitors at controlled DC voltages. When changing the voltage and output current of the data, the shut-off criticism circles keep a constant voltage yield in any event. DC-DC converters give one or the other advance the ability to undertake or venture below a fixed DC voltage source. Although converters cannot be used exclusively in gadgets such as autos and power supplies, they can be used to do things, for example, extend battery life for a long time. Changed DC to DC converters provides a strategy to amplify the voltage in part by lowering the battery voltage resulting in saving space instead of using multiple batteries to achieve the same thing. Most DC-to-DC converter circuits additionally manage the output voltage.

D.   BATTERY

A battery is a gadget that stores artificial energy and converts it into electrical energy. Artificial reactions in batteries involve the progression of electrons from one material (cathode) to another through an external circuit. It is used in circuits to control various sections. The battery delivers direct flow (DC) (power that streams one way and does not switch and from). The battery consists of a mixture of materials such as zinc (anode), manganese (cathode) and potassium. This material is all the elements of the earth.

E.   ACTIVE BRIDGE

The active bridge is a Double Dynamic Extension is a bi-DC-DC converter with integral essential and optional side full-connectors, a high-frequency transformer, energy-saving move indicator and DC-interface capacitor. The control adheres to the ultimate goal between the two DC transports that the main scaffolding delivers during the slacking period.

F.   IOT(Internet of Thing)

The dependability to offer continuous load supply and monitoring it using IOT interface in the suggested system. A wind turbine, PV solar, charge controller IOT system for monitoring electrical characteristics of the system comprise the system. Energy technologies are sufficiently promising to be included for growing power generating capabilities in the system.

In hardware, a driver is a circuit or segment used to control another circuit or segment, such as a powerful semiconductor, a fluid gemstone show and many others. In general, the driver stage (s) of a circuit requires different characteristics in other circuit stages.

They are usually used to manage the current flowing through the circuit or control various factors in the circuit, such as different parts or a few gadgets. The term is frequently used, for example, for specialized incorporated circuits that control high-power switches in an exchanged mode power converter.

G.   VOLTAGE SENSOR

A voltage sensor is a sensor used to detect and test a measure of voltage in an article. The voltage sensor can determine the AC voltage or DC voltage level. The contribution of this sensor is the voltage, however the output switches, simple voltage signal, current signal or sensor signal. A voltage sensor is a specific minimum cost sensor for estimating voltage. It is based on the guideline of the resistive voltage divider scheme. That red terminal connector can make the input voltage many times more modest.

H.   CURRENT SENSOR

A flow sensor is a gadget that detects the electric flow in a wire and makes a mark corresponding to the current. The generated sine can then be used to show the intentional current in the ammeter, placed in the data retrieval structure for additional investigation, or used with the ultimate goal of control. At that point, the sensor receives a specific voltage or current that can be converted into a current measure through the meter conductor associated with the sensor.
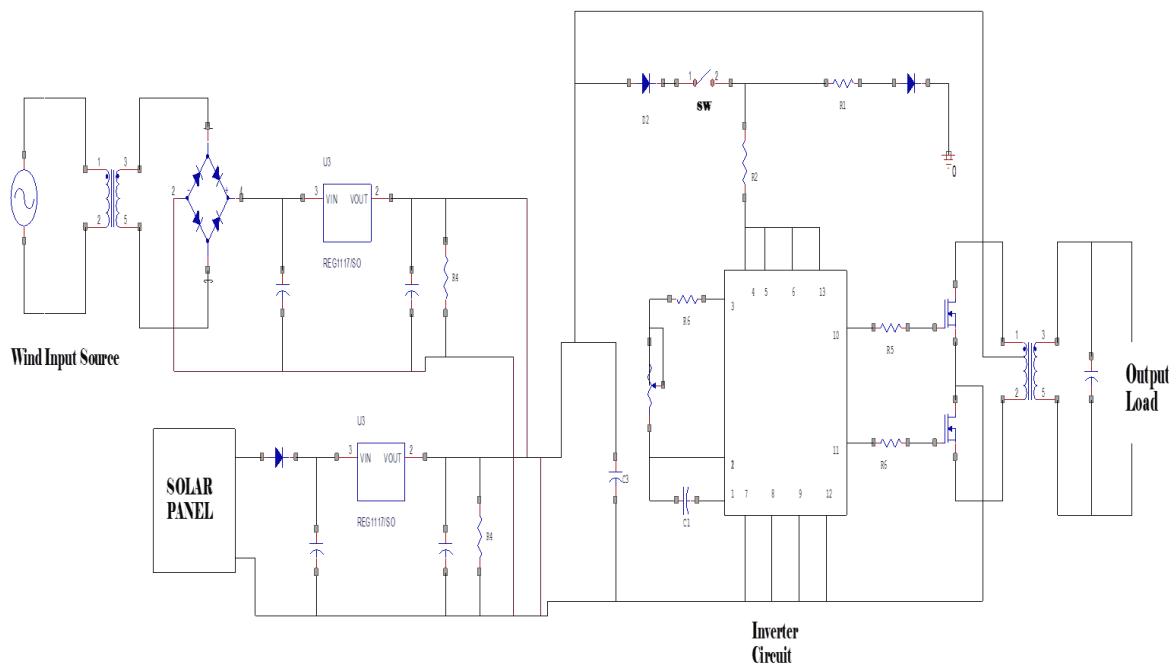
IV.   RESULTS AND DISCUSSION.

Figure 2: Circuit Diagram

The BES (Battery Energy Storage) system is connected to the Lift Buck-Boost Converter, while the PV Array 2 is connected to the DC Connect via the boost Converter. The DC transport bar is connected to AC MG2 by two identical bilateral

converters, 1.1 and 1.2, which can act as rectifiers or inverters for dynamic and receptive force trade through two transformers. In a one-line profile, the same bidirectional converter is set instead of two unique converters.

There is also the condition of the transformer 1-2, which replaces the two transformers. This rearrangement of one-line profiles is designed for straightforwardness. Finally, this AC / DC HMG. It also includes a diesel generator and the main grid with comparable direct and nonlinear loads. In this segment, the mat tests pre-owned AI controllers that shine in Mat Lab / Simulink. The magnitude and repetition of the AC transport voltage are somewhat similar to the utility network and consequently consistent. Battery Energy Storage (BES) System 1 contains BES1 and PV array.
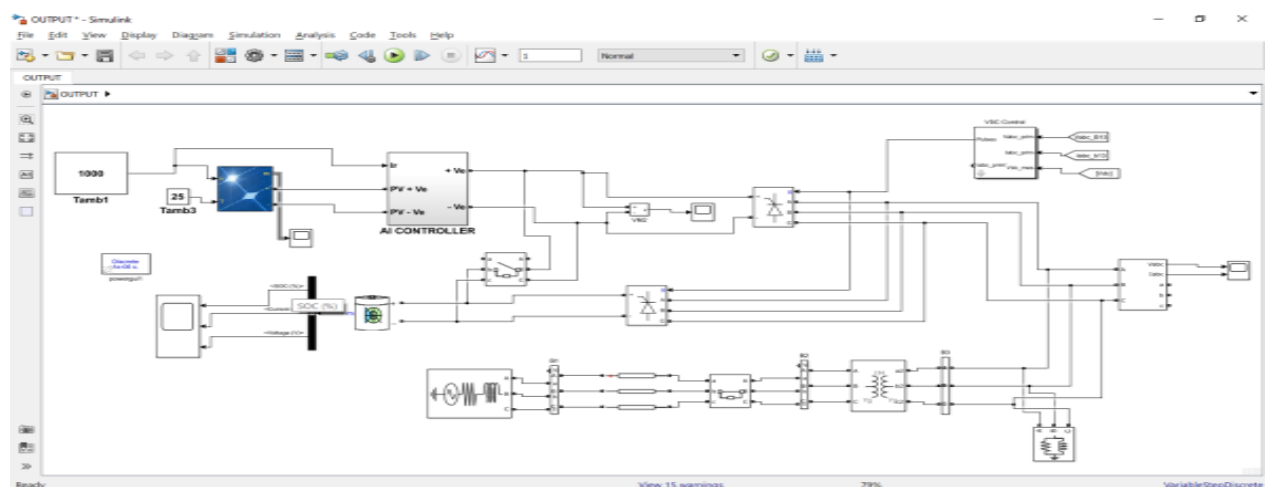

Figure 3 : Matalb Simulation Output

In this part, detailed results are examined, and similarly, the measurement of force quality and productivity factors will also be arranged. To evaluate the characteristic criteria of the base case taking into account the prospects and salary, two conditions of the examination are characteristic. The daily request curve of the proposed MG appears, which is received as the sum of the hourly requests of each Active Power neck of the model with excessive parts of the modern and commercial load. Constant throats were shown with constant obstruction, and, therefore, a slight contradiction between the external force of the AP throat and the actual force coming into use could be resolved. This is due to the voltage drops in the system. This difference between the two situations allows up to an acceptable power return for the actual future investigation. The limitations and area of re-interest payment gadgets should be addressed by considering the state of base interest. To be honest, the voltage profile of the system can reach the overvoltage level from the responsible impulse of the remuneration gadgets.
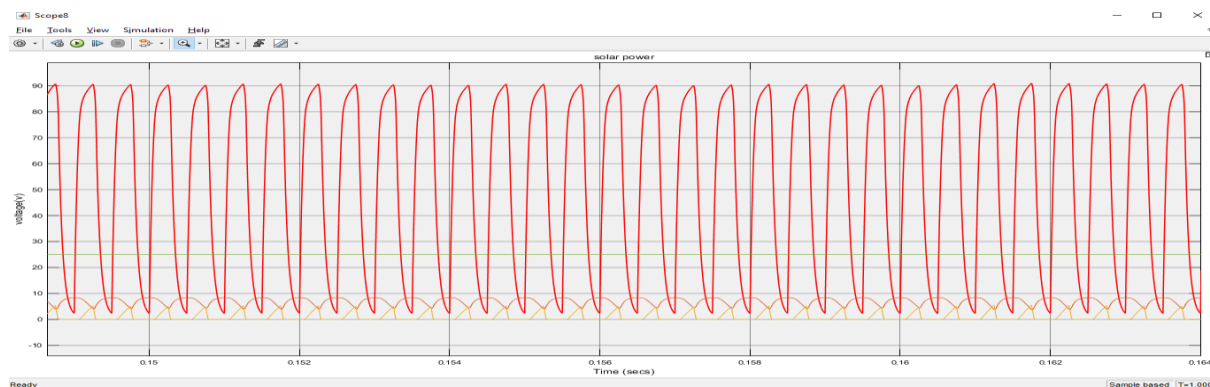
Figure 4 Simulation Output Waveform

The sun-powered photovoltaic innovation is one of MG's conveyed enduring power assets. Shows the limitations of the principle used by Mat lab / Simulink Climate to illustrate the implementation of sunlight-based cell boards. The two clusters work well in solar-dependent cells of G = 1000 Watts (W) / m2 and at a temperature of 25 cm. Display 1 has ten modules that accelerate the conductive power of 10.5 Kilowatts (kW) while Cluster 2 has 1750 modules, which excite. An unexplained force of 725 kW for DC bus. Both DC wells have DC converter wells with a force converter interface. Cluster 1 works with a DC-DC voltage-controlled lift converter. It has a 6000 μF connect capacitor operating at 300 V DC. The Pulse Width Modulation (PWM) shut circle control method uses the repetition of 5 Kilo Hertz (kHz). Display 2 works with an open-circle sinusoidal PWM inverter. Its M file is set to 1.0, and the venture is at 250 V AC below 480 V DC.
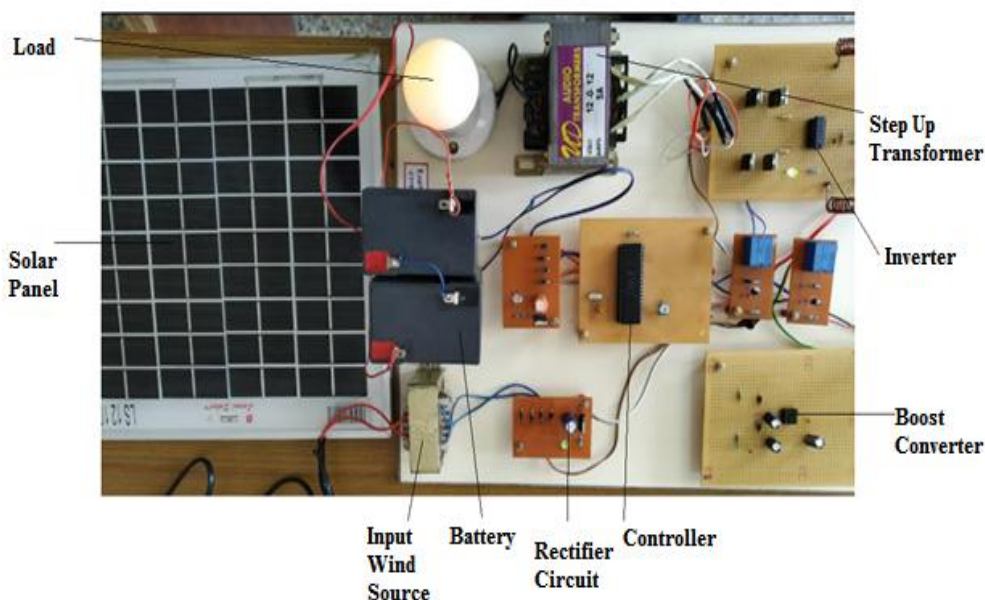

Figure 5: Experimental Kit

This segment presents an accurate description of the proposed three-phase model. It was rebuilt using the relevant Sims Cap Library in the Mat Lab / Simulink R 2017B environment. The point is to give established researchers a device and a better understanding of MG elements and their parts, as well as their general performance in different working conditions. It may be that the 3-phase voltage response of the DC network under various unstable influences appears in Figs. Time 10 s, DC load extends from 16 kW to 32 kW. Then, at that time, 15 s, the illuminated surface of the PV board is reduced to 200 W / m2. Time 20 s, this surface is expanded to the previous position. Finally, the time is 25 s, reducing the DC load from 32 kW to 16 kW. Also, the surface of light and wind speeds was strictly expected, as shown individually in Figs. It can be seen very well that the regulators plan to give a stable DC matrix voltage and quickly restore the voltage; it is well motivated.

Tabulation 1: Hardware Specification

Hardware	Specification	Input Ranges	Output Ranges
Power generation	Solar Power	-	12V
Transformer	Step down	230v	110V
Battery	Input power	12V	7.2A
Microcontroller	Input power	5V DC	5V DC
Inverter	Output Power	10V DC	10V-AC
Transformer	Step up	10V DC	230V AC
Load Output	Load (Incandescent Lamp)	230V	O.58 A- 72 watts

When the structure in case 1 is on Maximum Power Point Tracking (MPPT) mode, the DC transport voltage is kept constant by the buck-boost converter and the AC transport voltage is supplied by the default converter. Average static current / releasing voltage trademark curve for lithium-particle batteries. Shows the relative curvature for a nickel-metal-hydride battery. To turn two, three areas are recognizable: the dramatic locale in pink, the obscure or rated district, the last release in addition to dark and pink. DC transport voltage, PV yield force and battery are charged separately while DC load decreases from 20 kW to 10 kW to 0.2 C while the continuous sun-based light level is 1000 W / m2. The battery releasing current is kept constant at 65A. The DC transport voltage change is adjusted to 400 V after a neck change from 0.05 C. The PV power yield falls below the great value after 0.2 s, indicating that the operating conditions have changed from MPPT mode. PV yield power varies from 35 kW to 25 kW after 0.2 seconds.

A. ADVANTAGES

➢ Cost: Adjusting the mesh-related sub-format for a remote area is really expensive. It involves heavy hardware costs to install sub-stations, including transformers, to install humble solar DC miniature matrix boards well.

➢ In micro grid networks, the transmission is more unfortunate for the AC format.

➢ The reckless quality of the DC micro grid is undeniably more solid than the reliance on a unified design.

B. APPLICATION

➢ Renewable energy.

➢ Powered for remote locations.

➢ To harvest solar energy, the most common way is to use a solar panel.

➢ Space warming and cooling by sunlight based design.

➢ Potable water by purification.

V. CONCLUSION.

A micro grid is envisioned as a voltage balance and drop control system. Different difficulties are experienced in the intensive control of the crossover miniature structure. This structure voltage source the converting two different control techniques DC bus mechanism. The controller technique with artificial intelligence with AC / DC miniature matrix is examined. The (IOT) Internet of Thing output has better with composite load with sate of art both PV module. The simulation output waveform has without any noise and low voltage. The converting output voltage gives the source voltage to the inverter, which is AC (Alternating current) in the load of the experimental kit without any noise and fluctuation. There active force of the single-stage PV inverter is changed by repaying responsive force of the single-stage load, which influences antagonistically responsive force dividing among single-stage furthermore, three-stage inverters. In the subsequent stage, the responsive force dividing among Micro gird

REFERENCES

1. X. Li, Z. Li, L. Guo, J. Zhu, Y. Wang and C. Wang, "Enhanced Dynamic Stability Control for Low-Inertia Hybrid AC/DC Micro grid With Distributed Energy Storage Systems," in IEEE Access, vol. 7, pp. 91234-91242, 2019, doi: 10.1109/ACCESS.2019.2926814.
2. Navarro-Rodríguez, P. García, R. Georgious and J. García, "Adaptive Active Power Sharing Techniques for DC and AC Voltage Control in a Hybrid DC/AC Micro grid," in IEEE Transactions on Industry Applications, vol. 55, no. 2, pp. 1106-1116, March-April 2019, doi: 10.1109/TIA.2018.2873543.
3. Zhou, Y. Xu, H. Sun and K. Wang, "Flexible Control Strategy of Energy Router for Integration of Local Area Energy Networks with Diverse Services Provision Capability," 2020 IEEE Power & Energy Society General Meeting (PESGM), Montreal, QC, Canada, 2020, pp. 1-5, doi: 10.1109/PESGM41954.2020.9282082**.**
4. Huang, X. Zhang, A. Zhang and P. Wang, "Comprehensive Coordinated Frequency Control of Symmetrical CLLC-DC Transformer in Hybrid AC/DC Micro grids," in IEEE

Transactions on Power Electronics, vol. 35, no. 10, pp. 10374-10384, Oct. 2020, doi: 10.1109/TPEL.2020.2981544.

5.   R. V. S. E. Shravan and C. Vyjayanthi, "Emulation of AC and DC sub grids using Power Converters for Islanded Hybrid Micro grid Applications," TENCON 2019 - 2019 IEEE Region 10 Conference (TENCON), Kochi, India, 2019, pp. 2587-2592, doi: 10.1109/TENCON.2019.8929641.

6.   D. Forte de Oliveira Luna, P. Renato da Costa Mendes and J. E. Normey-Rico, "A Convex Optimal Voltage Unbalance Compensator for Hybrid AC/DC Micro grids," 2019 IEEE PES Innovative Smart Grid Technologies Conference - Latin America (ISGT Latin America), Gramado, Brazil, 2019, pp. 1-6, doi: 10.1109/ISGT-LA.2019.8895461.

7.   W. Yang, Y. Zhu and Y. Liu, "Fast Assessment of Short-Term Voltage Stability of AC/DC Power Grid Based on CNN," 2019 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC), Macao, China, 2019, pp. 1-4, doi: 10.1109/APPEEC45492.2019.8994504.

8.   Li et al., "Short-term Voltage Stability Assessment of AC/DC Power Grid based on SDAE and ADAM Algorithms," 2020 IEEE/IAS Industrial and Commercial Power System Asia (I&CPS Asia), Weihai, China, 2020, pp. 774-778, doi: 10.1109/ICPSAsia48933.2020.9208541.

9.   Q. Liu, T. Liang and V. Dinavahi, "Real-Time Hierarchical Neural Network Based Fault Detection and Isolation for High-Speed Railway System Under Hybrid AC/DC Grid," in IEEE Transactions on Power Delivery, vol. 35, no. 6, pp. 2853-2864, Dec. 2020, doi: 10.1109/TPWRD.2020.3022750.

10.   K. Zhang, W. Hou, A. Chen and T. Liu, "Grey Start Strategy for Hybrid AC/DC Microgrid in Semi-Black State," 2020 IEEE 9th International Power Electronics and Motion Control Conference (IPEMC2020-ECCE Asia), Nanjing, China, 2020, pp. 1181-1188, doi: 10.1109/IPEMC-ECCEAsia48364.2020.9368033.

11.   Almakhles, D. J., Ali, J. S. M., Padmanaban, S., Bhaskar, M. S., Subramaniam, U., & Sakthivel, R. (2020). An Original Hybrid Multilevel DC-AC Converter Using Single-Double Source Unit for Medium Voltage Applications: Hardware Implementation and Investigation. IEEE Access, 8, 71291–71301. doi:10.1109/access.2020.2986932

12.   T. Ajaykumar and N. R. Patne, "Hybrid Multi-Cell Single-Stage Reduced Switch Multilevel Inverter," 2020 IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy (PESGRE2020), 2020, pp. 1-5, doi: 10.1109/PESGRE45664.2020.9070332

13.   Rouhani and G. J. Kish, "Multiport DC–DC–AC Modular Multilevel Converters For Hybrid AC/DC Power Systems," in IEEE Transactions on Power Delivery, vol. 35, no. 1, pp. 408-419, Feb. 2020, doi: 10.1109/TPWRD.2019.2927324

14.   H. Gao, M. Maghenem and R. G. Sanfelice, "Hybrid Predictive Control for Tracking in a Single-Phase DC/AC Inverter with an Unknown Load" 2020 American Control Conference (ACC), 2020, pp. 1037-1042, doi: 10.23919/ACC45564.2020.9147521

15.   Z. Tang, Y. Yang, M. Su, H. Han and F. Blaabjerg, "An Improved Boost-Type Hybrid Converter with Multiple Outputs," 2020 IEEE 9th International Power Electronics and Motion Control Conference (IPEMC2020-ECCE Asia), 2020, pp. 3113-3118, doi: 10.1109/IPEMC-ECCEAsia48364.2020.9367813

16.   F. Roozitalab, M. A. Jarrahi, M. M. Arefi, M. S. Javadi, A. Anvari-Moghadam and J. P. S. Catalão, "Development of A Hybrid Method to Control the Grid-Connected PV Converter," 2020 IEEE International Conference on Environment and Electrical Engineering and 2020 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), 2020, pp. 1-6. doi:10.1109/EEEIC/ICPSEurope49358.2020.916066.

17.   S. S. Lee, C. S. Lim, Y. P. Siwakoti and K. -B. Lee, "Hybrid 7-Level Boost Active-Neutral-Point- Clamped (H-7L-BANPC) Inverter," in IEEE Transactions on Circuits and Systems II: Express Briefs, vol. 67, no. 10, pp. 2044-2048, Oct. 2020, doi: 10.1109/TCSII.2019.2946860.

18.   Floricau, "New hybrid multilevel inverters for high-Current applications," 2013 8TH International Symposium on Advanced Topics in Electrical Engineering (ATEE), 2013, pp. 1-6, doi: 10.1109/ATEE.2013.6563486.

19.   R. Rahmani, A. Fakharian and J. M. Guerrero, "An optimal power management system for automatic connection of DC and AC resources of hybrid-microgrid systems," 2017 IEEE Second International Conference on DC Microgrids (ICDCM), 2017, pp. 181-187, doi: 10.1109/ICDCM.2017.8001041.

20.   Rujas, V. M. Lopez, I. Villar, T. Nieva and I. Larzabal, "SiC-hybrid based railway inverter for metro application with 3.3kV low inductance power modules," 2019 IEEE Energy Conversion Congress and Exposition (ECCE), 2019, pp. 1992-1997, doi: 10.1109/ECCE.2019.8912684.

21.   Dipak Bhattacharjee, Priyadarshi Chakraborty, "Design of Transmission Lines and Tower Structure at Different High Voltages to Transmit Power with Minimum Losses", International Journal of Science and Research (IJSR), Volume 6 Issue 8, August 2017, 805 – 813.