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AI Based Control Strategy for A PV Wind Based Standalone AC Grid PWM Assisted DC Micro-grid with Hybrid Energy Storage System

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Abstract: This paper presents a control strategy for an independent DC micro-grid based on photovoltaic and wind power with a hybrid energy storage system. An energy management control algorithm was developed to improve the use of renewable sources. The proposed system helps in reducing DC bus voltage swing and current draw on the battery due to interruptions in solar and wind power. Photovoltaic and wind systems operating on the MPPT are connected to the DC load via boost converters. During low power mode, the control algorithm uses a drop control strategy to keep the bus voltage constant in the event of standby power. Battery controllers and super-capacitors designed using frequency domain analysis are also presented. The system is tested during sudden load changes, renewable energy and low-power modes, as well as load shedding, using the MATLAB Simulink platform. The effectiveness of the proposed strategy is validated by the results of the simulation.

Keywords: solar system, wind system, booster converter, Arduino, battery, switch, super capacitor bank, MATLAB etc.

I. INTRODUCTION

Energy is the quantitative property of physics that needs to be applied to an object for work on or heating the object. The Energy Conservation Law states that energy may be transformed into form but not produced or destroyed. Energy is a conserved quantification. The ability of a physical system to perform work is established. However, it's important to remember that it doesn't inherently imply that it is available to carry out work only because energy exists. In the general quest for energy efficiency, transport can be very relevant. Innovations such as more fuel efficient vehicles and the growth of alternative energy sources for our transport system will contribute greatly to energy saving. Energy saving efforts can be made globally if the uses are taken into account and dealt with one by one. Instead of trying to find solutions as a whole, if we concentrate on them as individual applications, we will make far larger conservation measures.

Electrical energy is a type of electrical charging energy. The ability to act or use energy to transfer an entity is energy. In the case of electrical energy, energy is electric attraction or repulsion from loaded particles. Electrical energy can either be energy potential or kinetic, but it typically comes as energy potential stored because of the relative locations of loaded particles or electrical fields. The movement by wire or other medium of charged particles is referred to as current or electricity. The imbalance or isolation of positive and negative charges in an object also produces static electricity. The power potential is static electricity. When there is a proper charge, electricity can form a spark (or even a light) of electric kinetic force.

By convention the direction of an electric field is always implicit in the movement of the positive particle. It is important to note that the most common electron carrier is an electron which travels in the opposite direction to the proton when interacting with electrical energy.

In the 1820s, British scholar Michael Faraday found a way of generating electricity. He crossed between the poles of a magnet a conductive metal band or a disc. The basic idea is that copper-wired electrons are free to pass through. Each electron has a negative electrical charge. It shifted by appeals between electron and positive charges and abject forces between electrics and equivalents (like protons and positive ions) (such as other electrons and negatively charged ions). In other words, the electrical field surrounding a charged particle (in this case, an electron) exerts its power on other charged particles and thus moves and operates. Two charged particles have to be forcibly moved away.

Any charged particle, including electrons, protons, atomic core, cations (positive ions), anions, post-antimatter equivalents, and so forth, may be involved in electrical processing.

1. Advancement in Electrical Energy

There has been much advancement in the field of electrical energy which has led to a great impact on human life. Some of this innovation in technologies is:

a. High Efficiency Photovoltaic Cells

Although photovoltaic technology is not cost-resistant, it is one of the most persistent issues in current electrical engineering. Photovoltaic cells have recently been the focus of major research institutions, although many engineering approaches have been applied to boost collection and distribution performance.

b. Green Energy Electrical Power Converter

When energy is stored, it is an important next step to convert to use in the electrical system. A new converter in electricity at Arkansas University will now make shifting excess energy to the electricity grid simpler for users of renewable energy. This will simplify solar roof projects and stimulate homeowners more to adopt energy efficient technologies.

c. Smart Electrical Grids

As energy networks get more complicated and energy sources become more diverse, smart grids are becoming increasingly important around the world. Smart Grids use a variety of cutting-edge electrical technology to enhance flow control, detect problems, and automate service delivery. By linking power plants, distribution centers, and the end user's electric point of presence all at once, we can improve efficiency and cut costs.

Micro-grid and its working

Micro-grid [21],[23],[26]is a collection of interconnected distributed energy resources and loads (sink) within specified electrical boundaries that act as a single entity with respect to the grid(as shown in Fig. 1.3).

Before going to know to how a microgrid works, we have to first understand what his gird and how it works. Grid connects businesses, homes, and other buildings to central power sources through which we use electrical and electronics appliances/devices such as Air condition, Television, Heater, Motor and Bulbs etc. i.e this interconnectedness means, if the grid needs to be repaired, everything shall effect. Amicrogrid generally operates while connected to the grid, but it is very important that it can break off and operate on its own using local energy generation in times of crisis like power outages or storms, or for other reasons.Amicrogrid can be powered by distributed generators, batteries, traditional energy resources and/or renewable resources like solar panels, wind turbines etc.

II. PROPOSED WORK

1. Design & development of a simply advanced, modified architecture Solar - PV powered DC Microgrid system using Hybrid Technique(s).
2. Development of modified bus structure comprising optional DC & AC bus, with facility of Grid Interfacing for Backup or Grid Feeding.
3. Adoption of an Universal Bus Architecture or Topology to operate DC Microgrid in Islanding /Standalone as well as Grid Fed / Grid Tied mode.
4. Enhancement of Energy Storage using Amalgamation of Energy Storage Techniques such as Next Generation Batteries, Super Capacitors, Fuel Cell or Pumped Storage.
5. Use of Artificial Intelligence to switch between Operating Profiles, change parameters of DC – DC Converters & Energy Storage Devices to Derive Maximum Power from the Renewable Sources.
6. Development of Prototype Hardware with Embedded 'C' Logic Using Low Cost 8-bit Micro controller to Facilitate Mass Production.
7. Use of Fuzzy Logic for Control of Load and Prioritization of Load Devices or Implementation of Scheduling of Load Devices Connection on Micro Grid so as to Maximize Energy Efficiency & Storage Capacity.

III. ARDIUNO INTRODUCTION

Arduino is a hardware and software company. They make the Arduino Uno board, an open source platform that is used as a digital device to control the operation of any device. Arduino board is basically a single board microcontroller which contains microprocessor and I/O points. They connect to another device, such as Bluetooth, during deployment.Arduino development began in 2005 with the intention of providing students with cheap and affordable digital tools to work on digital projects, as the cost of microcontrollers on the market at the time was high.Arduino licenses are available as the General Public License (GPL) or the Lesser General Public License (LGPL), allowing many people to design their own boards and redistribute the licenses. This product is available as a kit and as a ready-to-use product.

IV. MATLAB INTRODUCTION

MATLAB may be a programing language made by MathWorks. It began as a structure programing language wherever direct factor primarily based science composing PC programs was basic. It OK is similarly run each underneath canny meetings and as a bunch work. This informative exercise offers you compellingly a fragile presentation of MATLAB programing language. It's expected to allow understudies shared characteristic with MATLAB programing language. Issue essentially based MATLAB perspectives are given in central and basic manner to manage make your jumping on quickly and persuading.

MATLAB (framework assessment office) may be a fourth-age uncommon state programing language and smart condition for numerical tally, depiction and programming.

It grants system controls; plotting of limits and information; use of figuring's; creation of UIs; interfacing with comes written in various dialects, together with C, C++, Java, and FORTRAN; separate data; produce estimations; and assembling models and applications. It has different worked in headings and science works that help you in coherent counts, creating plots, and acting numerical techniques.

V. ARTIFICIAL NEURAL NETWORK

An efficient computer system, that main idea of which is based on the artificial neural network (ANN). ANN is also referred to as 'artificial nervous system' or the 'distributed parallel computer system' or the 'connectionist system.' ANN accumulates a huge number of interconnected blocks according to some models in order to allow communication between blocks. These blocks are sometimes known as nodes or neurons. They are easy parallel processors. Every power connection is connected to a load containing input signal information. This information is most beneficial for neurons in solving a certain difficulty because weight frequently transmits or interrupts the signal. The activation signal for each neuron is an internal state. Later, with the input signal and other devices, the outputs join the transmission trigger line.

VI. EXPERIMENTAL SETUP

Figure show hardware setup of proposed work. In this I propose a micro DC grid from small load. Two metallic plates show DC bus, which connected with inputs and outputs of micro grid. DC bus has three input one from solar power & another one from wind power, mains supply. DC bus has 2 bidirectional connections one from super capacitor and second from battery supply. Bidirectional supply is used to charging and discharging of super capacitor and battery according to load requirement. 100 watt bulb is used as solar source power generated by solar panel feed to boost converter and boost converter feed to DC bus. Forwind power generation step down transformer of 220V/12V convert 220 volt into 12 volt and rectifier convert in DC its feed to DC motor DC motor shaft connected to dynamo which generate wind power and feed to DC bus through wind boost converter. 8*10000uf capacitor used as capacitor bank its connected with bidirectional converter to DC bus when load is normal it's in charging condition and load is high than its feed boosted voltage to bus. Battery is connected to DC bus by a relay when load is high than it automatically connected & disconnected according to bus load requirement. Arduino used to read solar, wind, super capacitor, battery, mains voltage & PWM measurements and feed data to MATLAB & send signals to converter instructed by MATLAB & ANN. Two small 10MM leds& two led strips used as load.

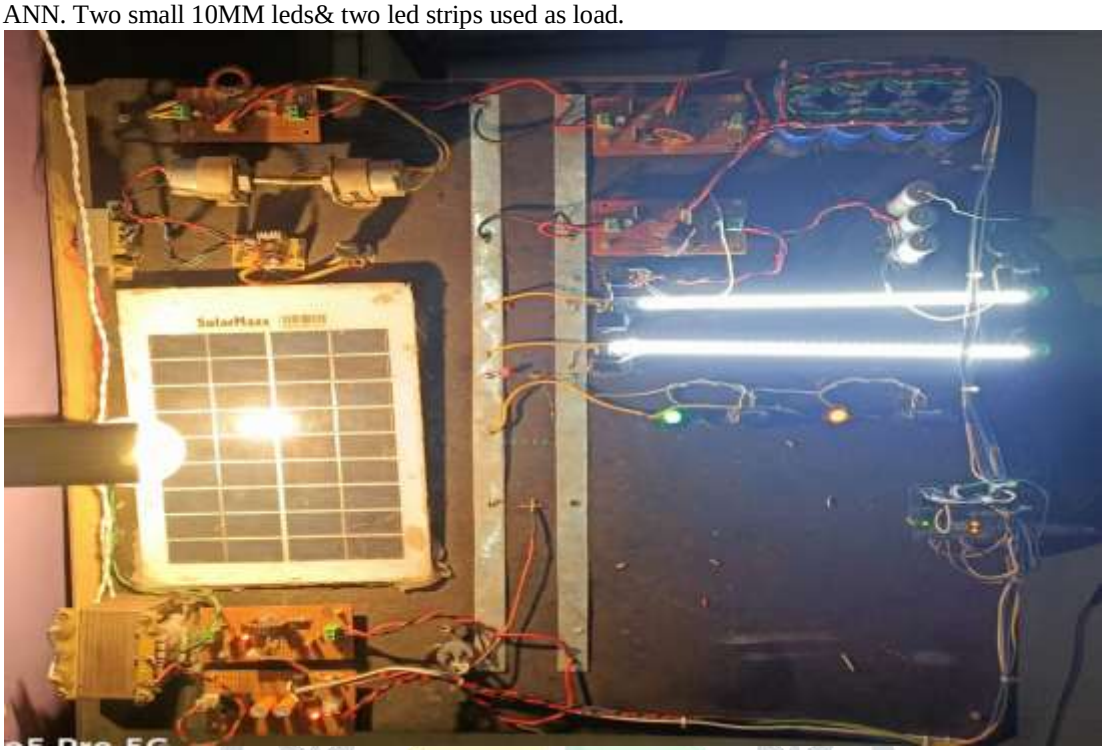

Fig.1: Hardware setup of proposed work

VII. METHODOLOGY

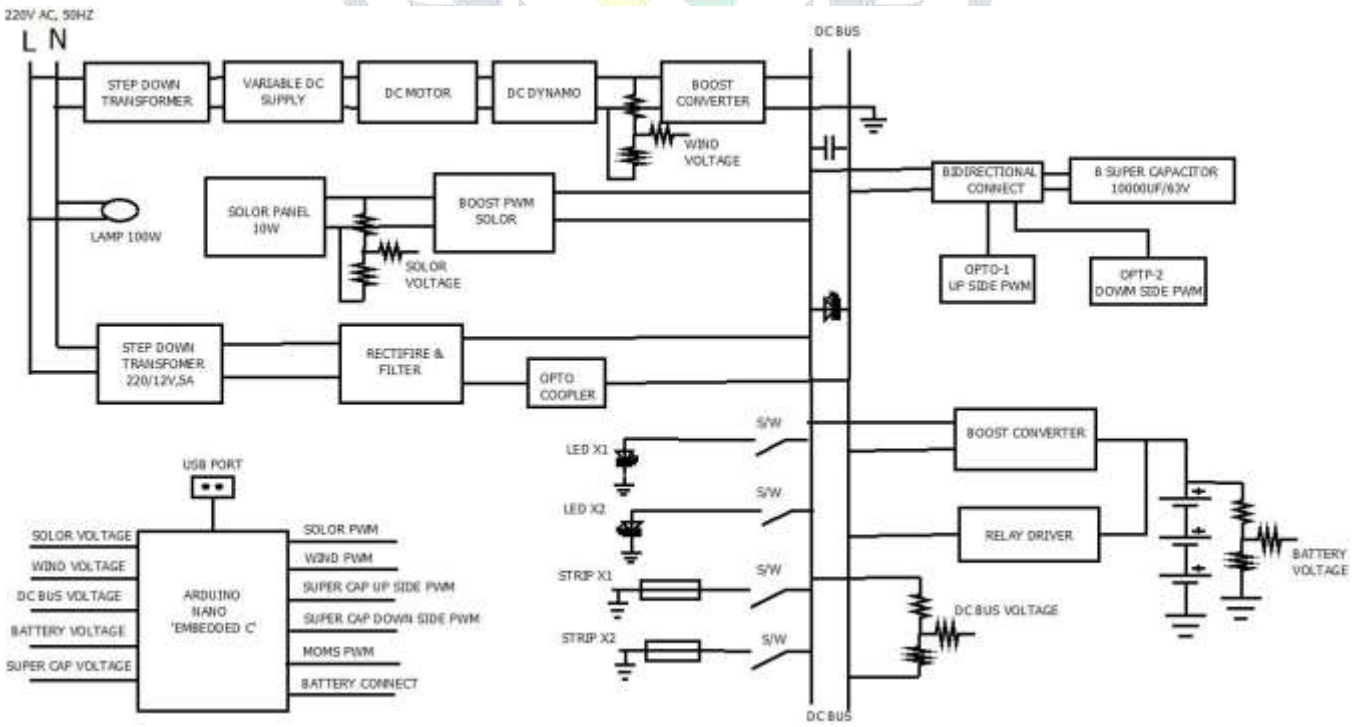

Fig.2: Functional block diagram

In this figure I show a dc micro grid which connected with wind power, solar power, mains supply, super capacitor and battery bank. Also connected load supply led x1, led x2, strip x1 & strip x2with switch. In experimental setup for generating wind power we used step down transformer which convert 220AC to 12 volt, 12 volt supply feed to DC motor is connected with dynamo.

Voltage generated by wind calculated by microcontroller and feed to boost converter. Solar setup using one light source generated the voltage and feed to solar boost converter. In next step mains connected with step down transformer & feed to DC micro grid.

This work do in the base paper in difference we also add super capacitor bank of 8*10000uf using bi-directional converter. In bi-directional converter 2 type of mode one is up side and another one down side. In upside operation mode capacitor performs charging and discharging. In down side mode capacitors not perform charging operation. Also we include battery bank which is in charging condition when load is normal and discharging when load is increase. Battery charging is connected through a boost converter and discharging on DC grid without a converter.

Arduinouno and MATLABis used for software update, read data from circuit like voltage & current of wind, solar, DC bus, super capacitor bank, battery and mains. MATLAB send signal according to load and power generated by different sources to change PWM of boost converter. Boosted voltage feed to DC micro grid.

The training block diagram of ANN for wind & solar PWM control according to voltage generated by wind & solar panels. ANN according to this data automatically control the PWM wind & solar boost convert & boost converter boost the voltage on ANN's instruction.

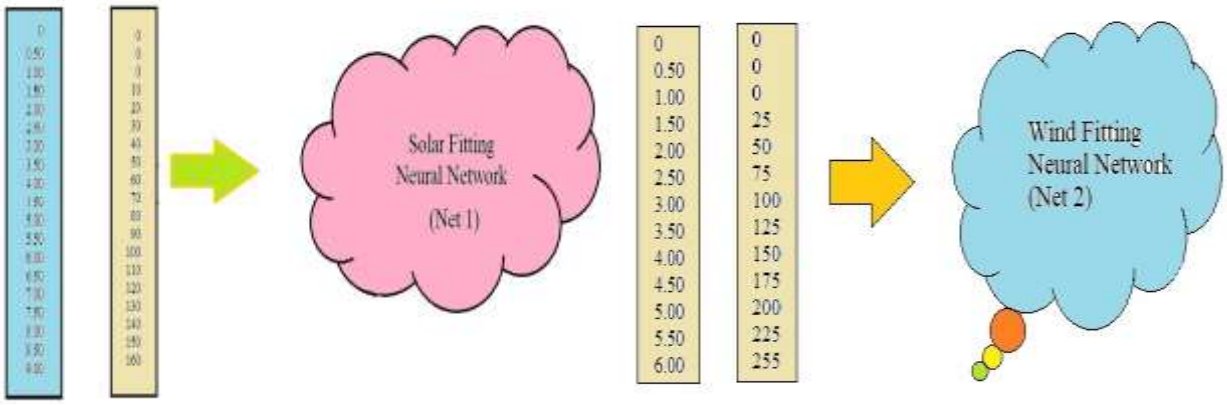

Fig.3: Neural fitting network

V. RESULTS AND DISCUSSION

In result analysis MATLAB draw different graphs. First graph draw between bus voltage vs time. Second graph show battery voltage vs time. Third graph show super capacitor voltage or upside PWM or down side PWM vs time graph.Fourth graph show wind voltage or wind booster PWM vs time graph.Fifth graph show solar voltage or booster PWM vs time. Sixth graph show mains PWM and battery connection status.Booster PWM range is 0 to 255 which is divided by 25 for scaling in graph. In these graphs red line indicate the voltage, blue line indicate the PWM and green line indicate down side PWM in super capacitor case. I perform different operation and take results. Some results attached in this section.

STEP 1

Solar – ON; Wind – OFF;Load – OFF; Time – 0 sec;

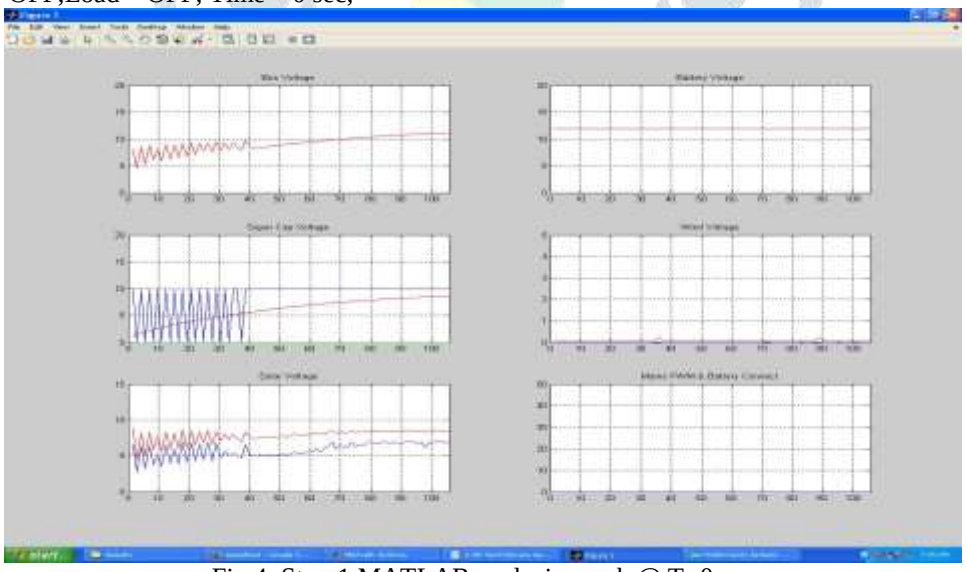

Fig 4: Step-1 MATLAB analysis graph @ T- 0 sec

In step first solar in ON condition, wind and load is OFF. Solar generate maximum 8 volt and boost convert boost the voltage and feed to DC bus. In graph show the bus voltage is 11volt and super capacitor is charging & its voltage is 8volt approx. blue line in graphs show the solar, super capacitor PWM. Its value is 150 for solar and 250 for super capacitor.

STEP 2

Solar – ON; Wind – OFF; Load – Load lED x1 ON; Time – 140 sec

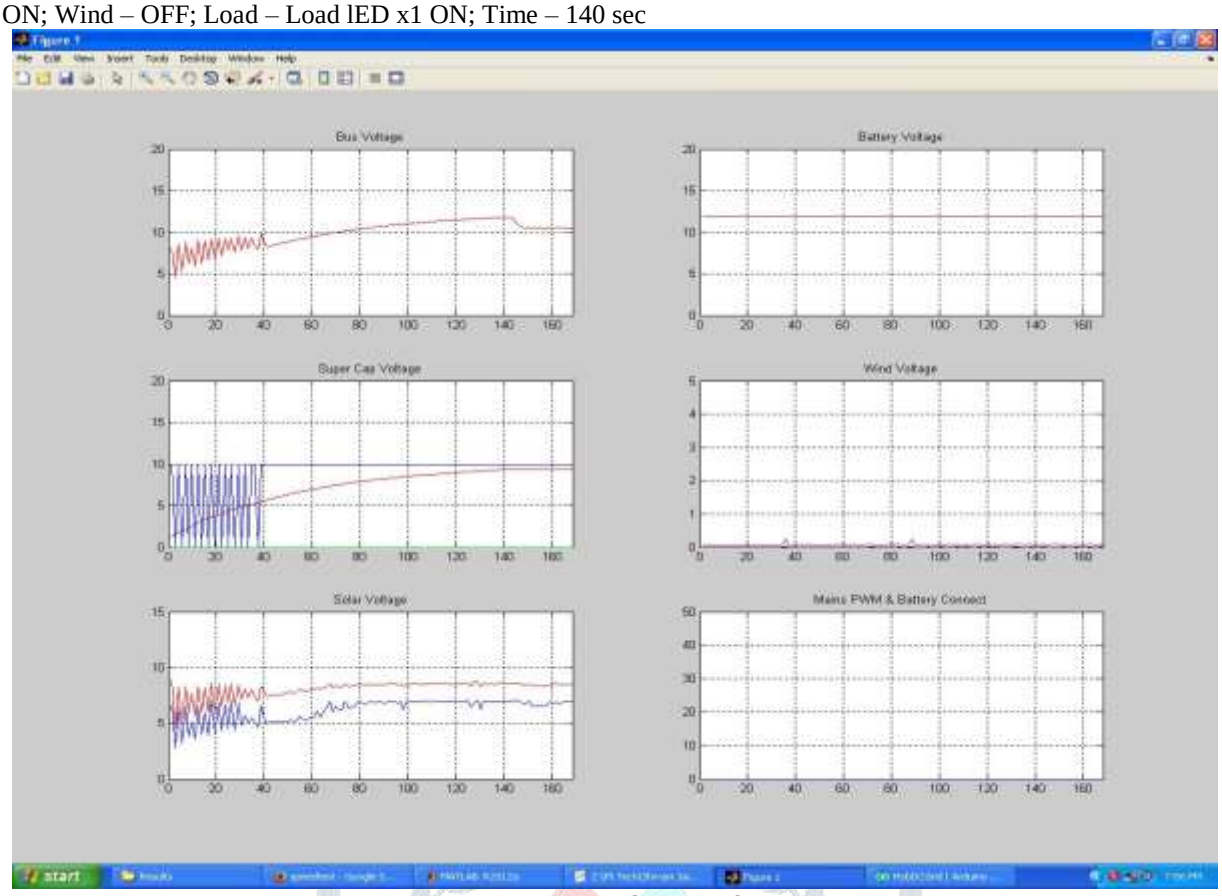

Fig 5: Step-2 MATLAB analysis graph @ T- 140 sec

In second step solar is ON condition and wind is OFF or Load LED x1 ON. Solar generate the maximum 8 voltage and boost convert boost the voltage and feed to DC bus. When led x1 is ON than bus voltage down 11V to 10V that's show in graph. Super capacitor is charging & its voltage is 10volt approx. Graphs show the solar, super capacitor PWM have no any change.

STEP 3

Solar – ON; Wind – OFF; Load – load strip x1 ON; Time – 250 sec

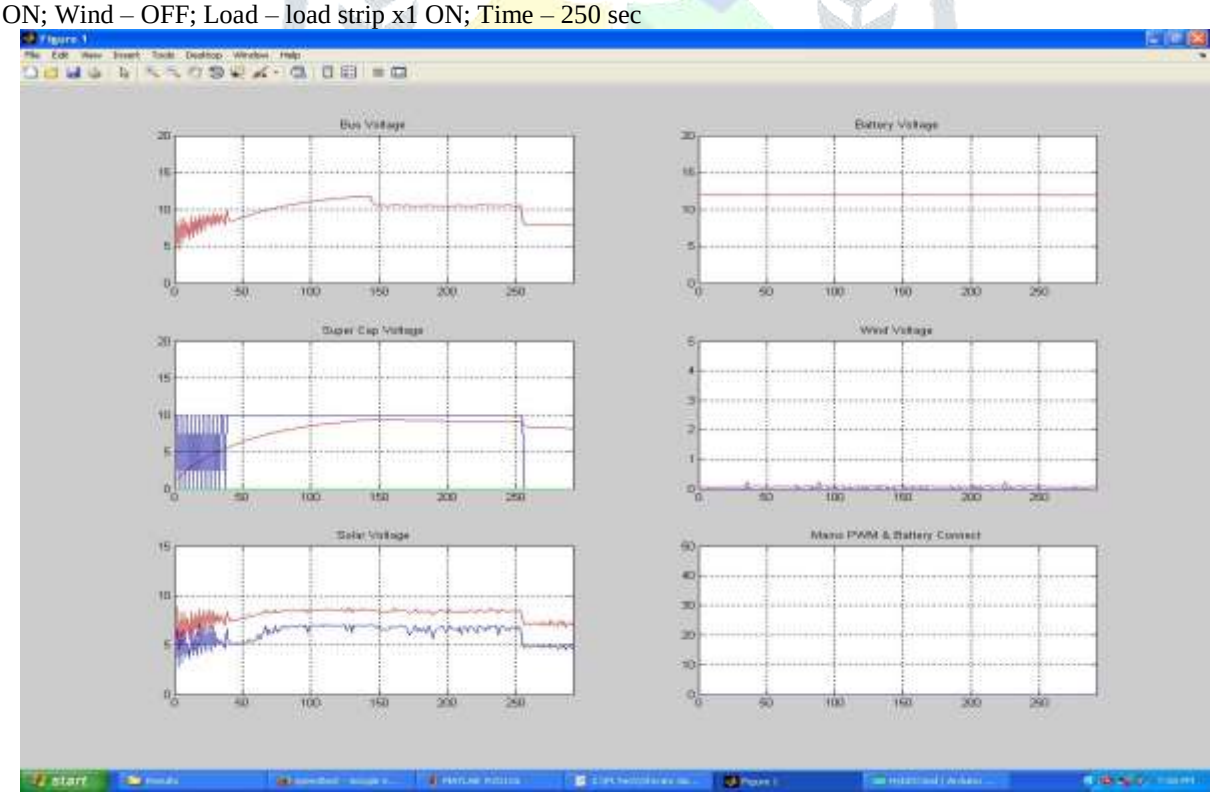

Fig 6: Step-3 MATLAB analysis graph @ T- 250 sec

In step third solar is ON condition and wind is OFF or Load strip x1 ON. When load strip x1 is on than Solar drop the voltage 8volt to 7 volt and bus voltage drop 10V to 8V that's show in graph. Super capacitor charging is off& its voltage is 8volt approx. when load high super capacitor PWM is off & solar boost converter PWM down 200 to 150& battery voltage also constant.

STEP 4

Solar – ON; Wind – ON; Load – Load LED x1 ON; Time – 300 sec

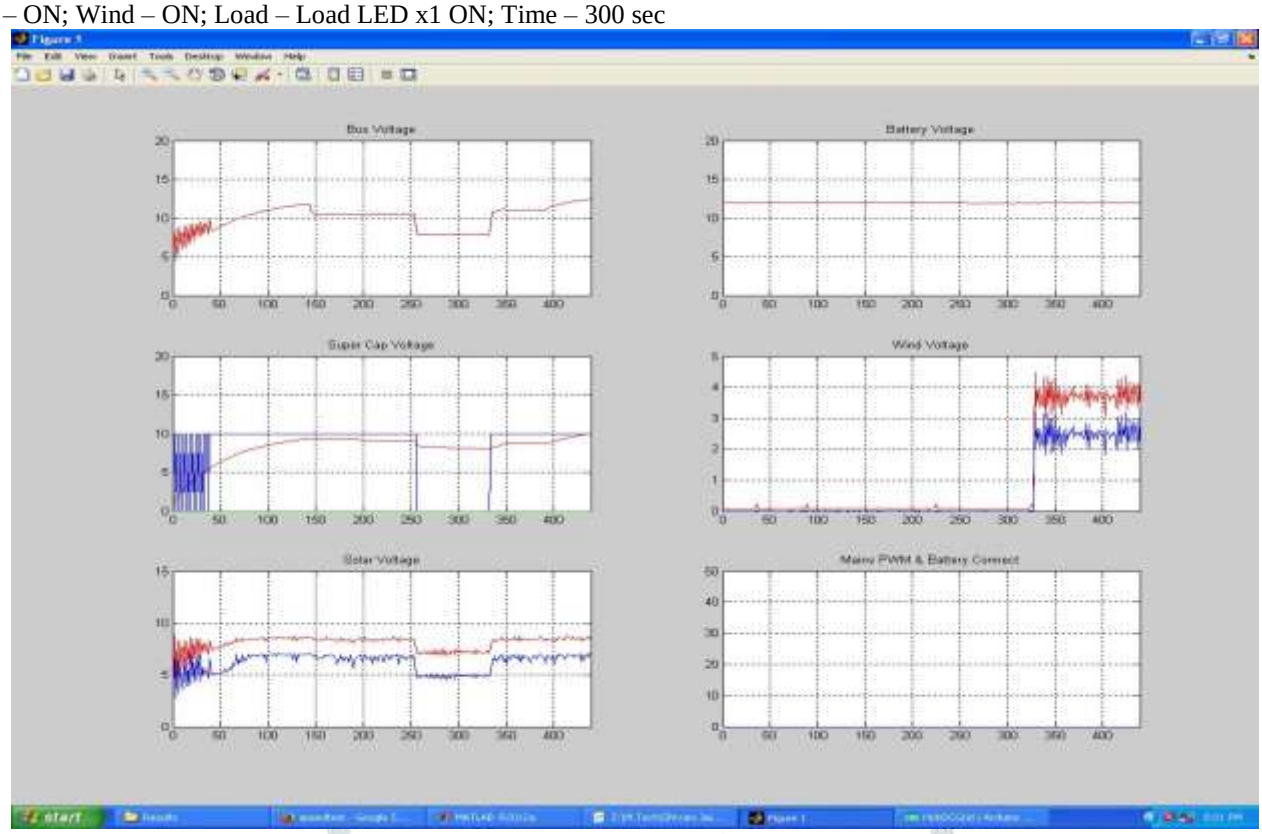

Fig 7: Step-4 MATLAB analysis graph @ T- 300 sec

In step-4 solar is ON condition and wind is ON & Load LED x1 ON. Solar voltage starts increasing 7volt to 8 volt.When wind & solar both are in ON condition than bus voltage start increasing 8V to 11V that's show in the graph. Super capacitor PWM is on & start the charging& its voltage is start rising 10volt approx. when wind started then wind booster PWM is 100 & solar PWM start increasing 125 to 150. Battery voltage is same.

STEP 5

Solar – ON; Wind – ON; Load – OFF; Time – 450 sec

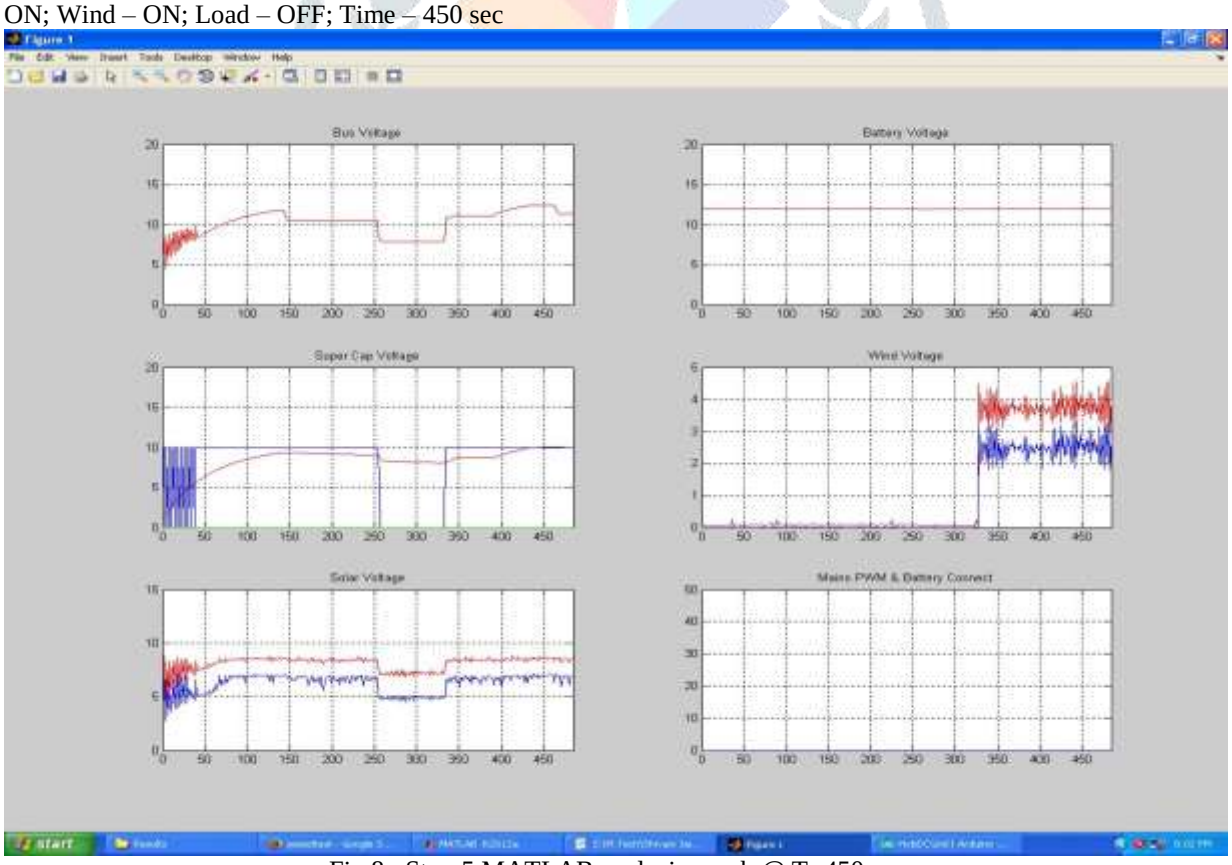

Fig 8: Step-5 MATLAB analysis graph @ T- 450 sec

In step-5 solar is ON condition and wind is ON & Load OFF than no change in solar voltage & wind voltage also same. Super capacitor on charging mode & its PWM is 200. Bus voltage is nearly same & no change in battery voltage.

STEP 6

Solar – ON; Wind – ON; Load – load LED x1 ON; Time – 450 sec

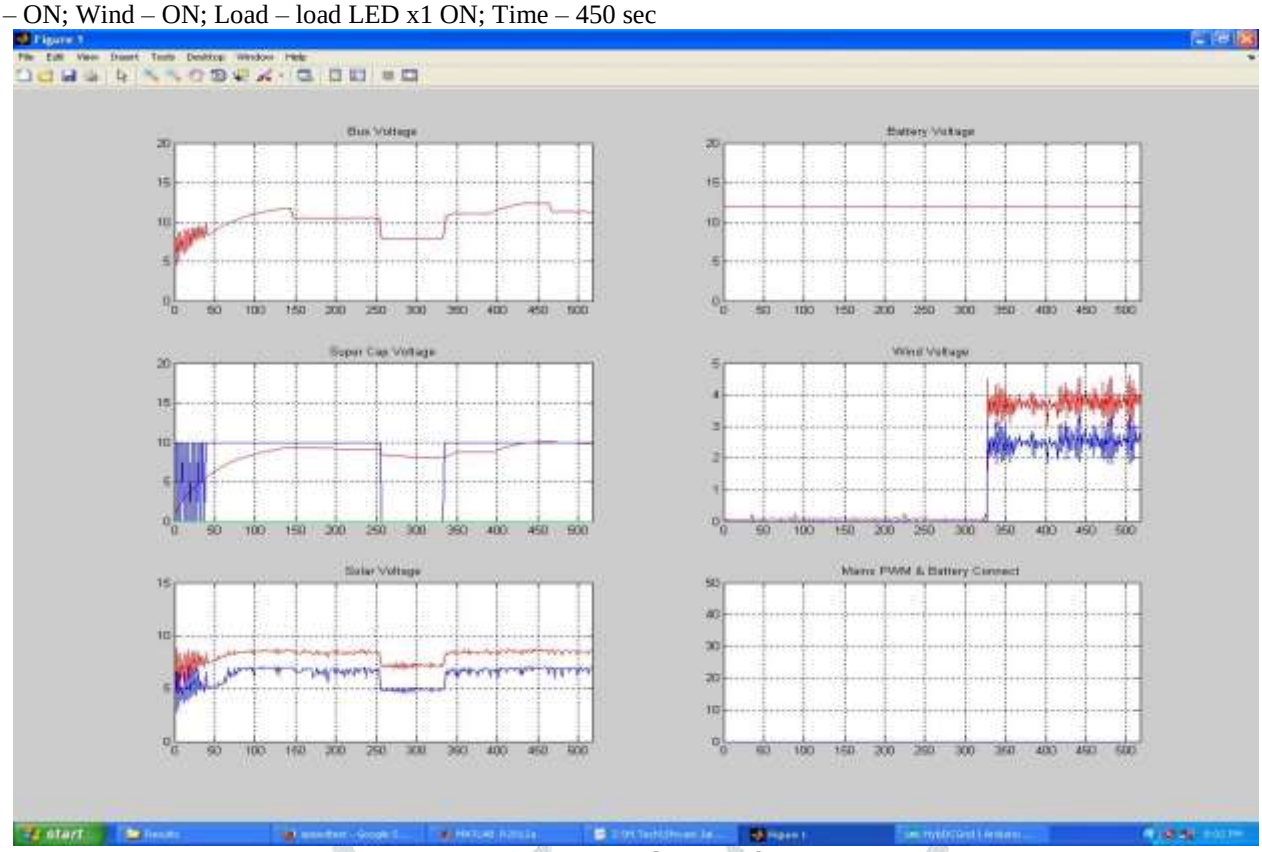

Fig 9: Step-6 MATLAB analysis graph @ T- 450 sec

In step-6 solar is ON condition and wind is ON and Load LED x1 ON. In this condition we don't have any change in power supply. Its mean when solar, wind is on & load is minimum then no effects on bus voltage and no effect on solar & wind voltage.

STEP 7

Solar – ON; Wind – ON; Load – load LED x2 ON; Time - 600 sec

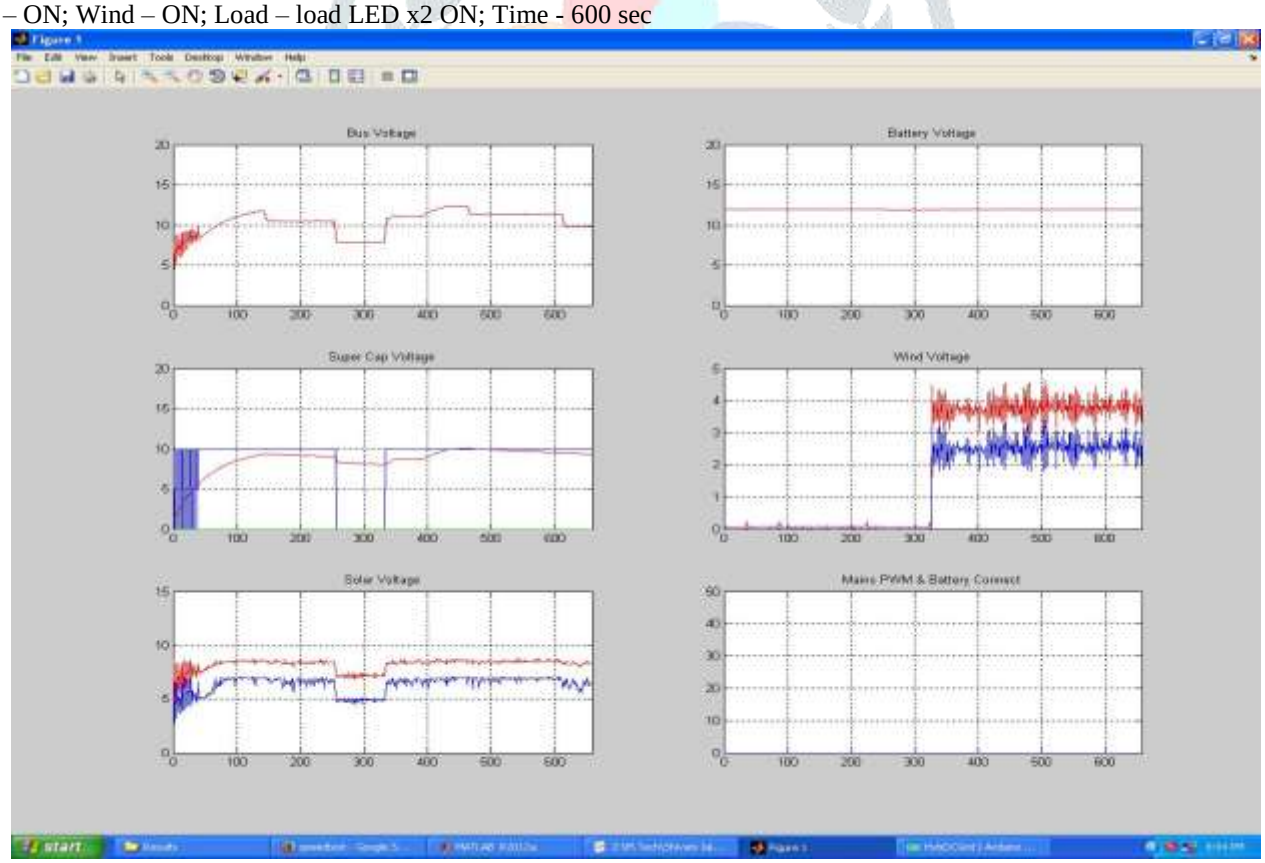

Fig 10: Step-7 MATLAB analysis graph @ T- 600 sec

In step-7 solar is ON condition and wind is ON & Load LED x2 ON then solar & wind voltage have minor change in PWM & voltage. Bus voltage has small change but super capacitor in charging condition & no change in its PWM. It's no effect on battery voltage.

STEP 8

Solar – ON; Wind – ON; Load – load strip x1; Time – 700 sec

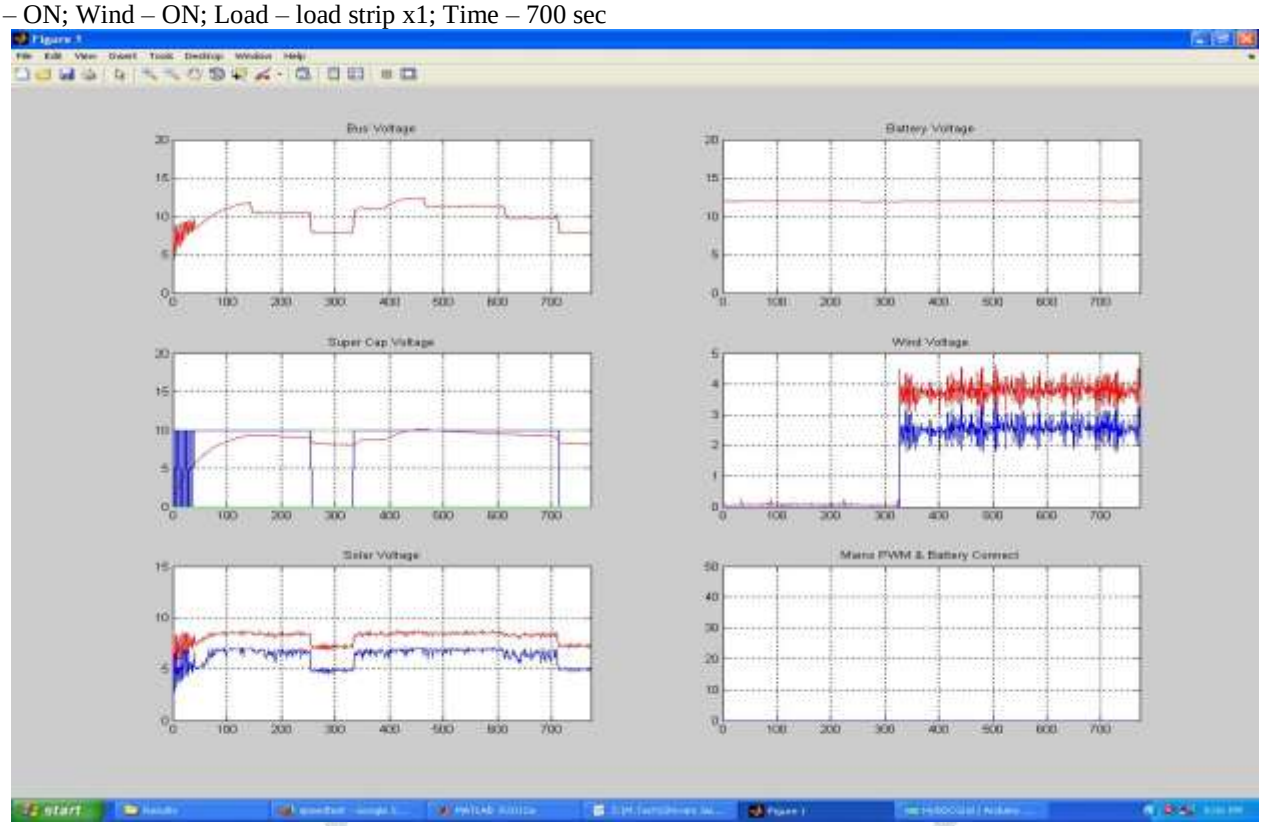

Fig 11: Step-8 MATLAB analysis graph @ T- 700 sec

In step-8 solar is ON condition and wind is ON & Load strip x1 ON.Solar and wind voltage decreased when suddenly load is increased & boosters PWM also decreased. Bus voltage is also decreased10Volt to 8Volt. Super capacitor stop charging because PWM of upside is low. Battery voltage still remains same.

STEP 9

Solar – ON; Wind – ON; Load – OFF; Time – 800 sec

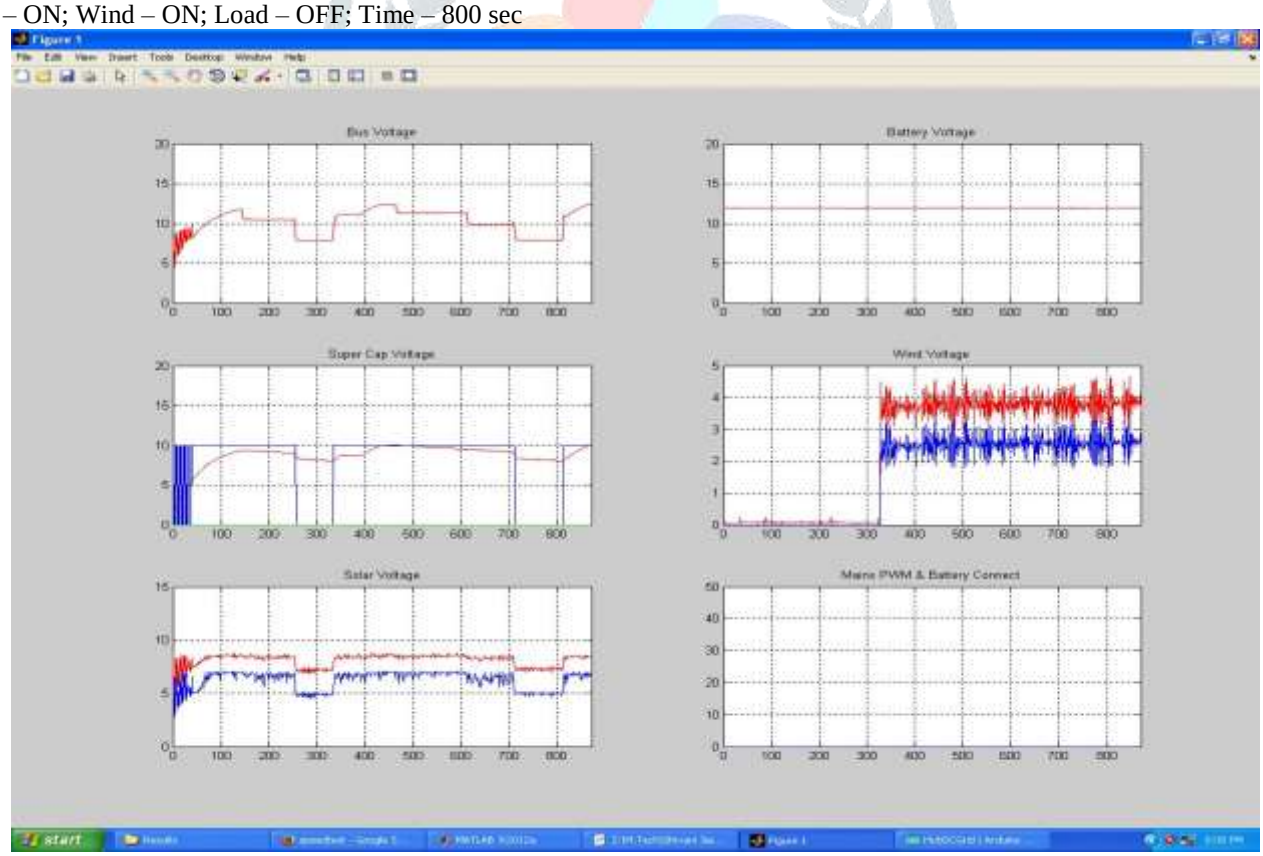

Fig 12: Step-9 MATLAB analysis graph @ T- 800 sec

In step-9 solar is ON condition and wind is ON & Load OFF. When load is off than solar and wind PWM increase and boosted voltage feed to DC bus. Graph show bus voltage increases from 8 volt to 12 volt. Super capacitor up side PWM is on so super capacitor start charging.

STEP 10

Solar – OFF; Wind – OFF; Load – OFF; Time – 900 sec

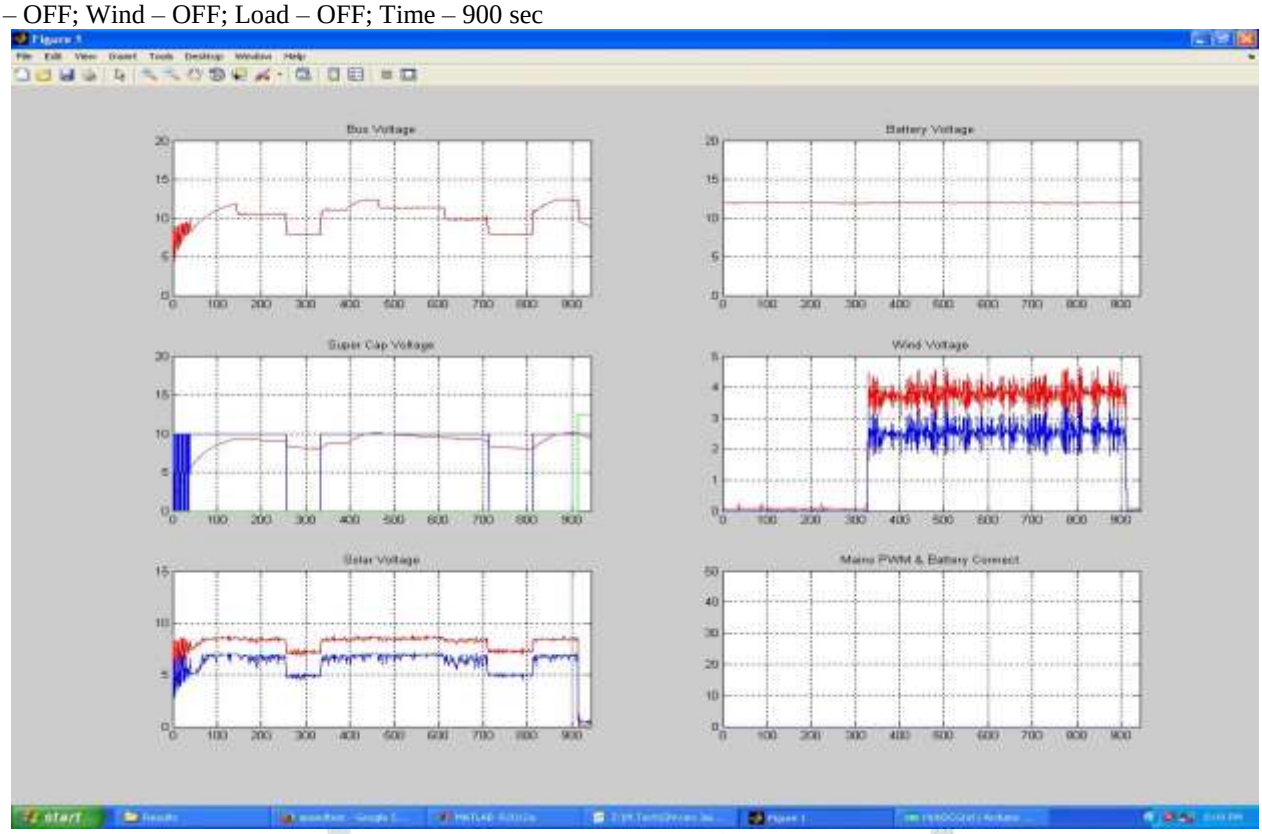

Fig 13: Step-10 MATLAB analysis graph @ T- 900 sec

In step-10 solar is OFF condition and wind is OFF & Load OFF. When renewable power sources is disconnected or unable to supply power and no load on bus then super capacitor start feed power to DC bus. Green PWM of super capacitor show the supply voltage to bus is boosted voltage.

STEP 11

Solar – OFF; Wind – OFF; Load – load LED x1 ON; Time -1000 sec

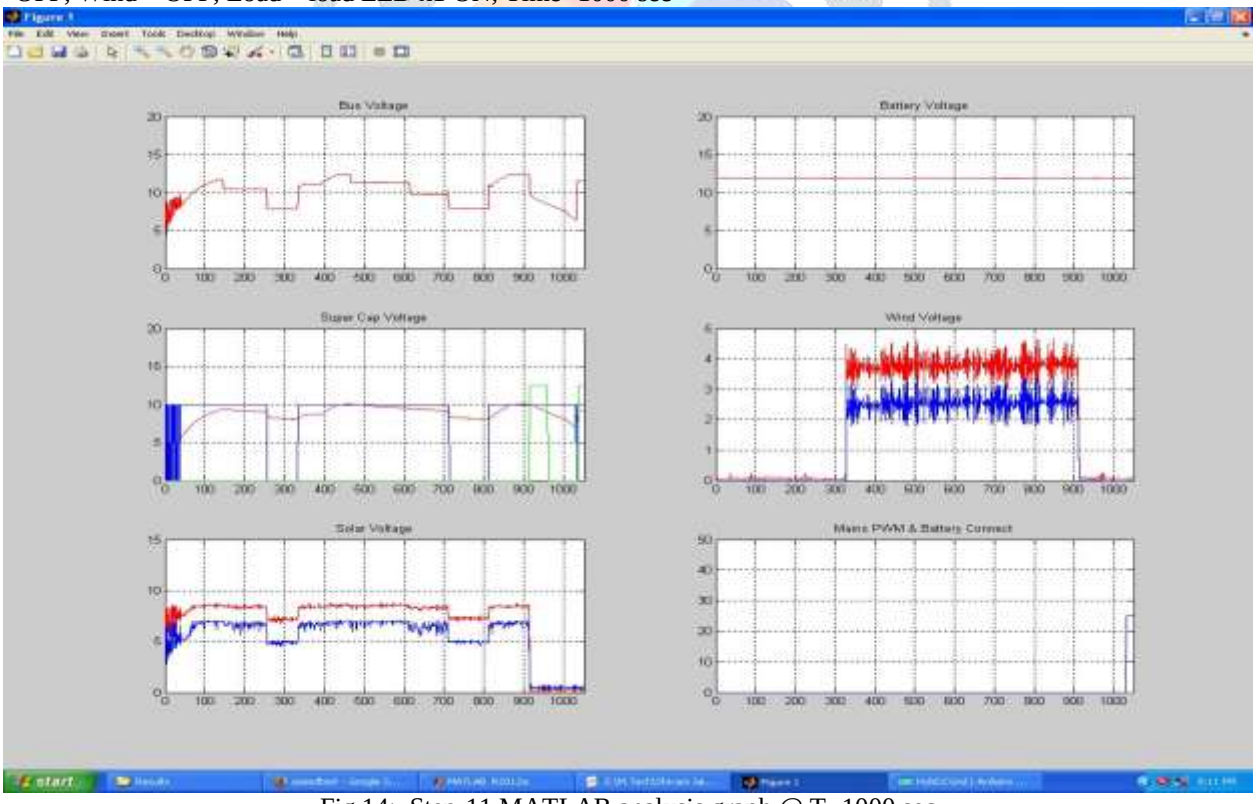

Fig 14: Step-11 MATLAB analysis graph @ T- 1000 sec

In step-11 solar is OFF condition and wind is OFF & Load LED x1 ON. When solar & wind is off super capacitor feed voltage to DC bus in super mode. When super capacitor voltage start decreasing and reach value at 8 volt then green PWM is off and blue PWM is ON, its mean super capacitor behavior is change super mode to normal mode. Also when super capacitor voltage is 8 volt and load is on than battery is automatically connected to DC grid show in graph.

STEP 12

Solar – ON; Wind – ON; Load – OFF; Time – 1200 sec

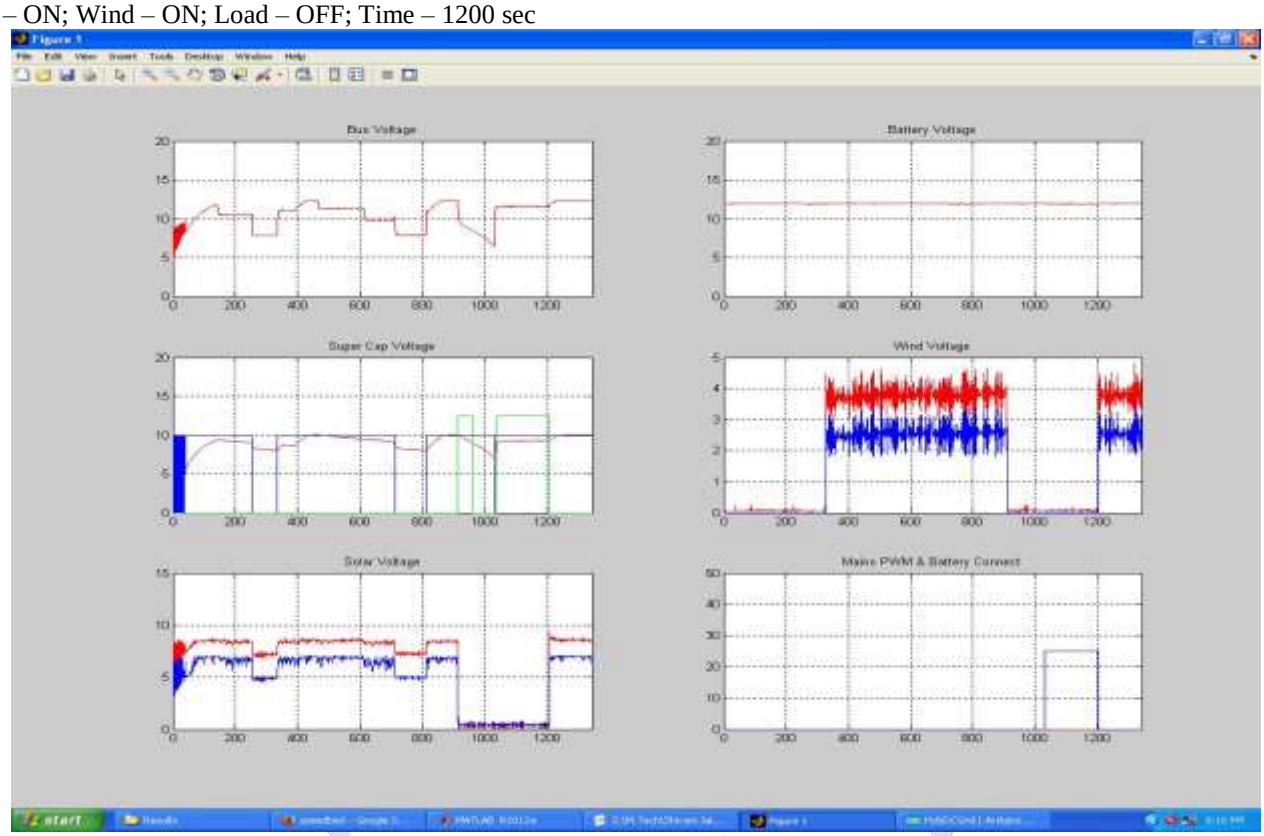

Fig 15: Step-12 MATLAB analysis graph @ T-120 0 sec

In step-12 solar is ON condition and wind is ON & Load OFF. Now solar & wind turn ON super capacitor start charging in normal mode & battery automatically disconnected show in graph. Bus voltage is 12 volt approx.

STEP 13

Solar – ON; Wind – OFF; Load – OFF; Time -1400 sec

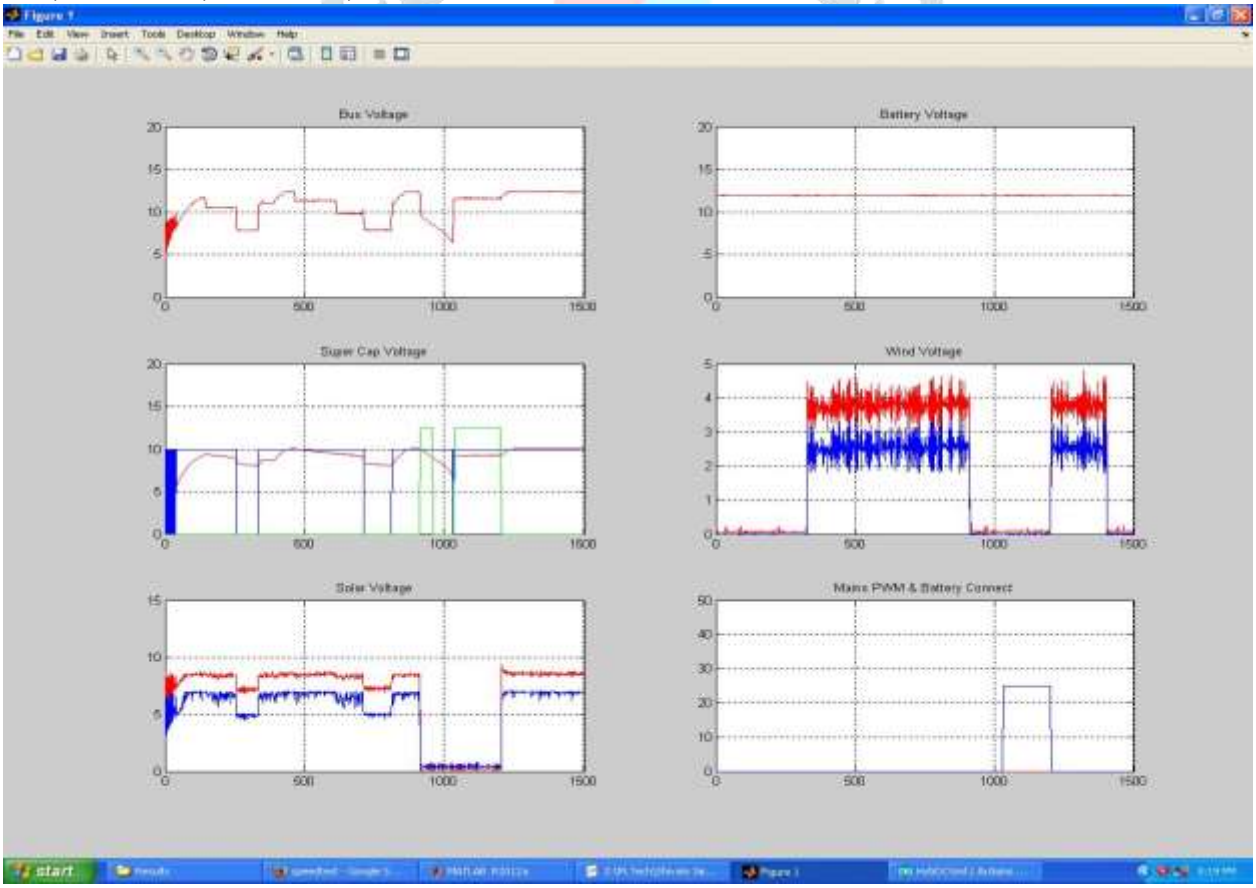

Fig 16: Step-13 MATLAB analysis graph @ T- 1400 sec

In step-13 solar is ON condition and wind is OFF or Load OFF. When load is off, wind off and solar is only on than bus voltage is maintain 12volt approx. Super capacitor in charging mode & battery is disconnected.

STEP 14

Solar – OFF; Wind – OFF; Load – load strip x1 ON; Time - 1600 sec

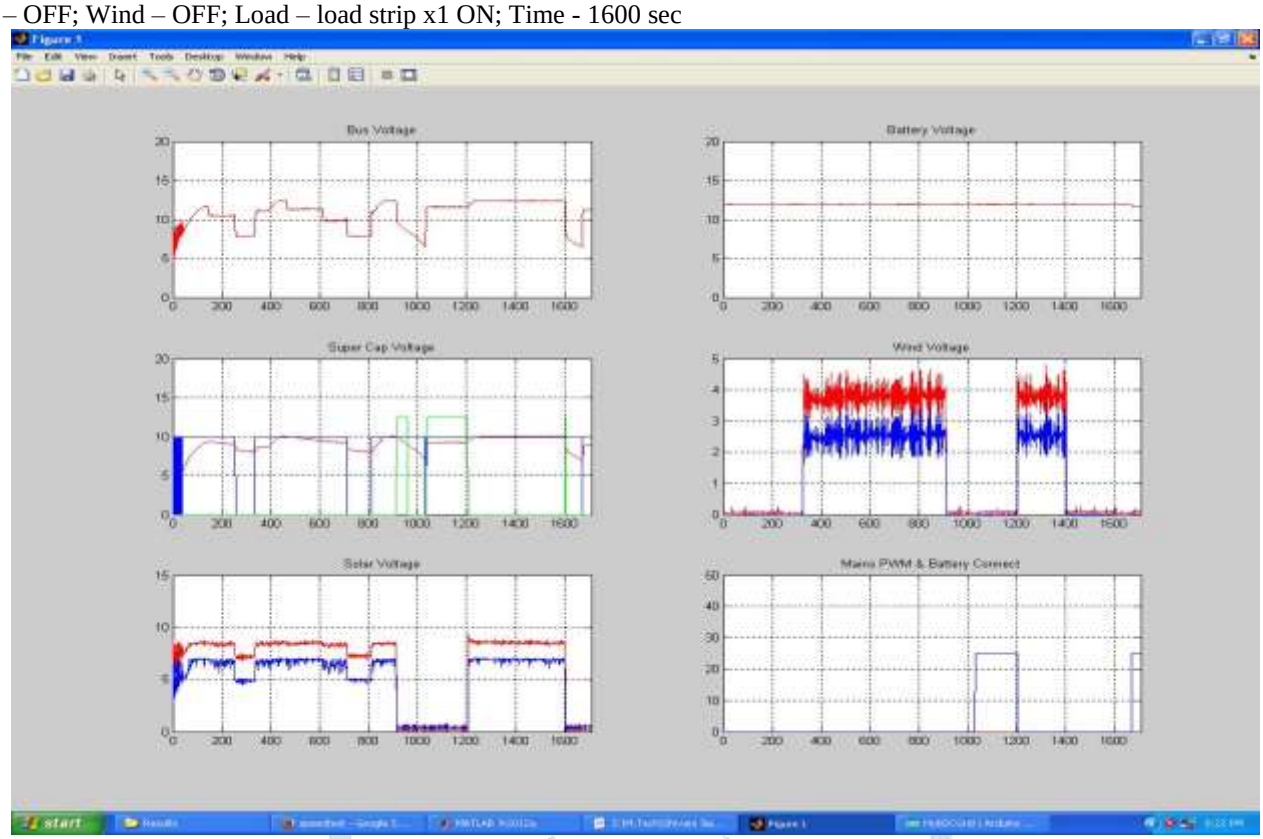

Fig 17: Step-14 MATLAB analysis graph @ T- 1600 sec

In step-14 solar is OFF condition and wind is OFF or Load strip x1 ON. In this condition super capacitor start supply voltage to bus in super mode when super capacitor voltage down to 8 voltages, super capacitor comes in normal mode & battery is connected to bus.

STEP 15

Solar – ON; Wind – OFF; Load – load strip x1 ON; Time – 1800 sec

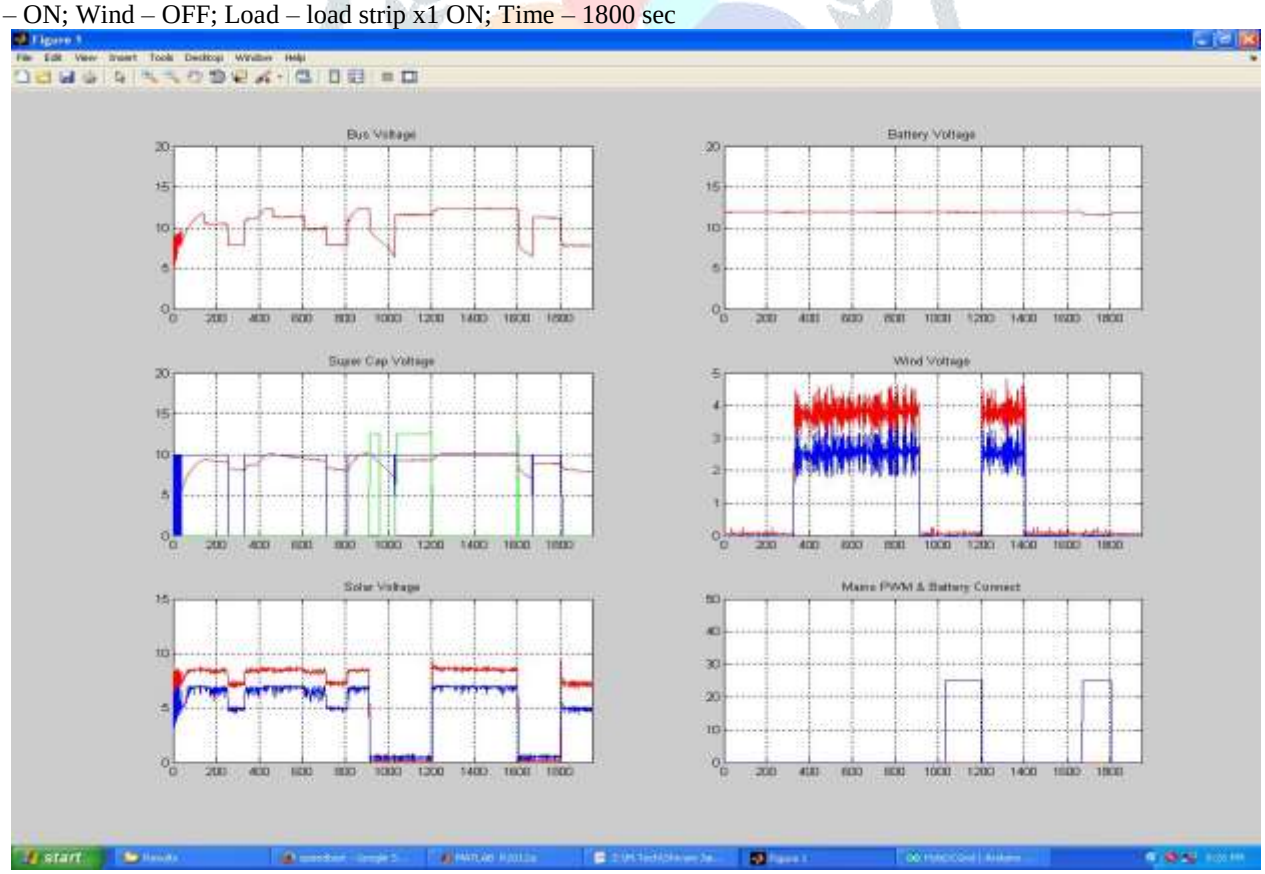

Fig 18: Step-15 MATLAB analysis graph @ T- 1800 sec

In step-15 solar is ON condition and wind is OFF or Load strip x1 ON. When only solar is ON than battery is disconnected automatically. The super capacitor & solar supply voltage to dc bus and maintain the load requirement.

STEP 16

Solar – ON; Wind – OFF; Load – OFF; Time – 2000 sec

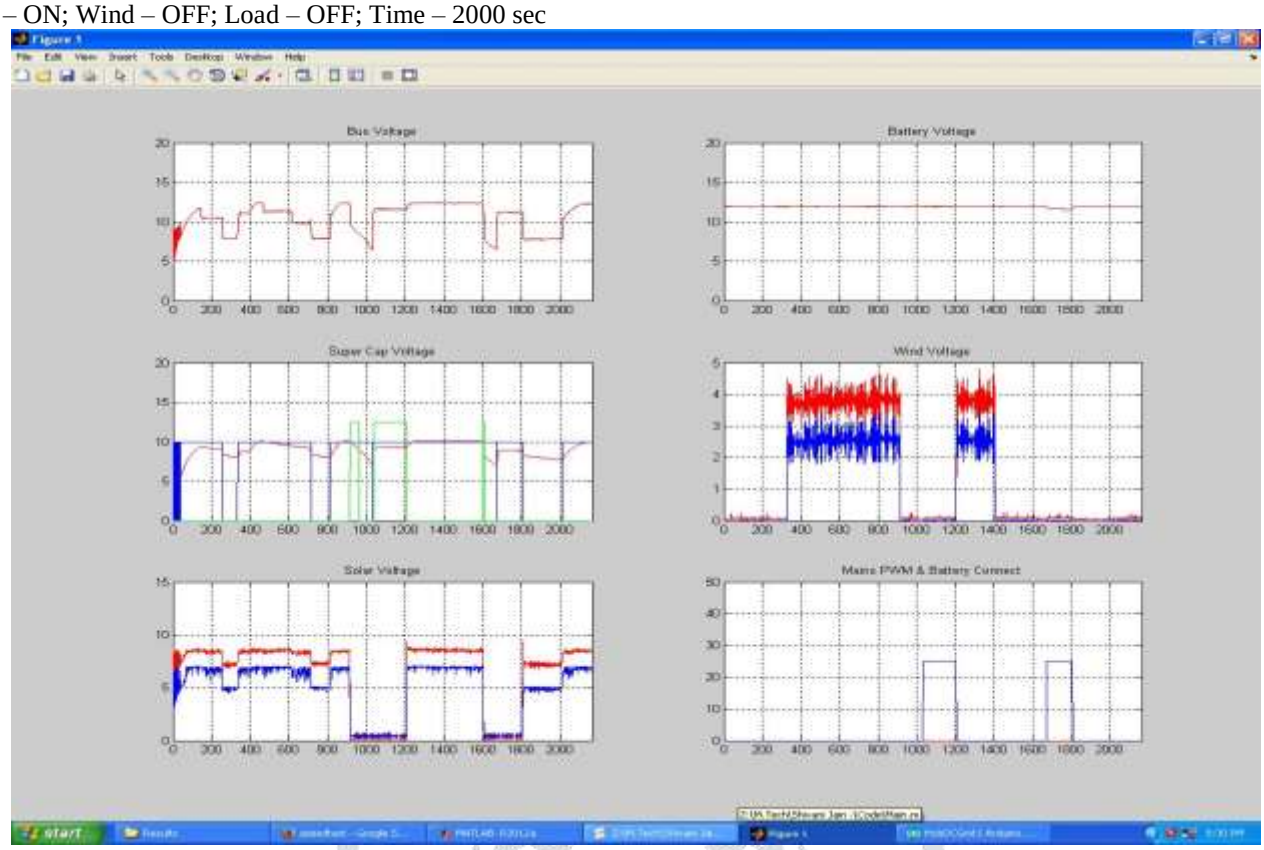

Fig 19: Step-16 MATLAB analysis graph @ T- 2000 sec

In step-16 solar is ON condition and wind is OFF or Load OFF. When load is off solar booster PWM increase and super capacitor and bus is charging. Now bus and capacitor bank voltage is increasing.

STEP 17

Solar – OFF; Wind – OFF; Load – load LED x2 & strip x2 ON; Time - 2200 sec

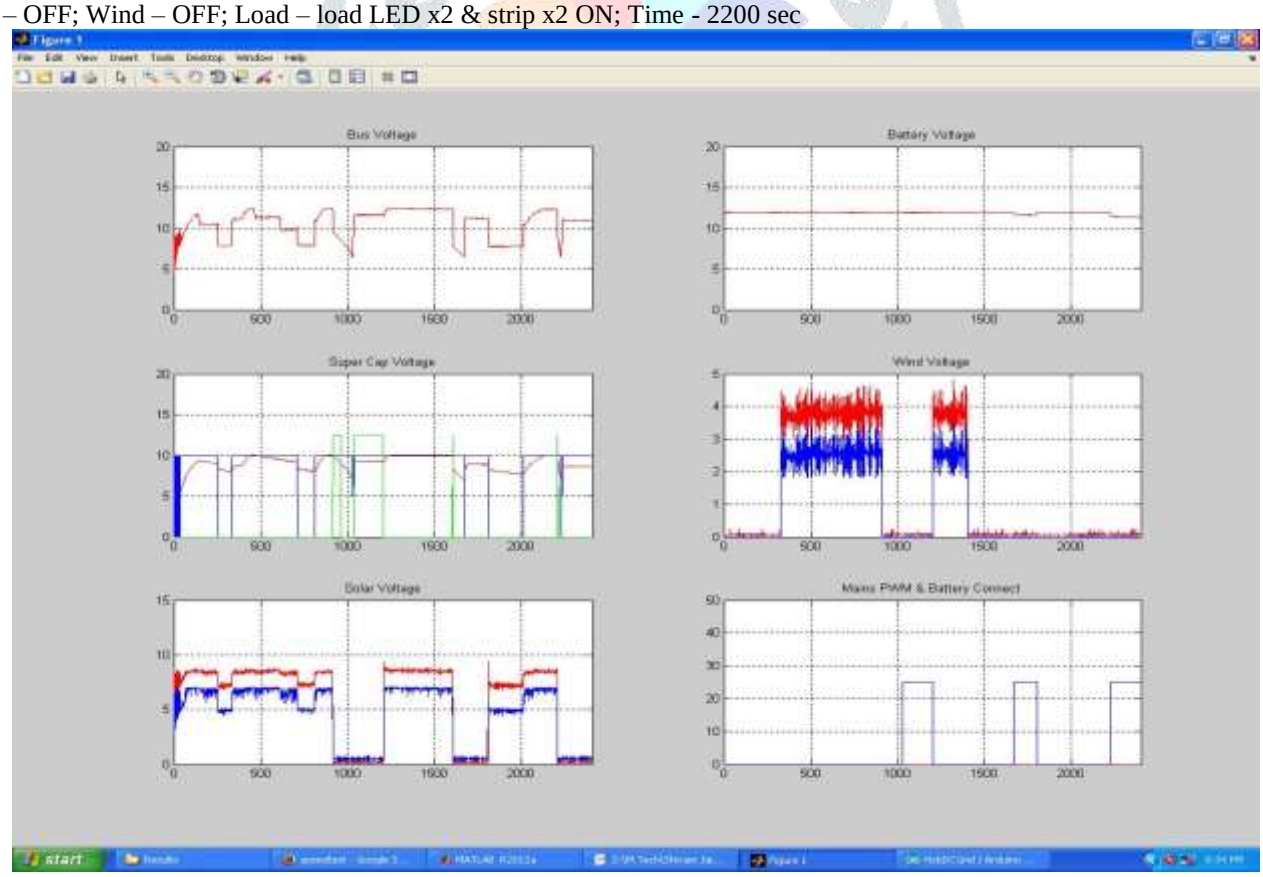

Fig 20: Step-17 MATLAB analysis graph @ T- 2200 sec

In step-17 solar is OFF condition and wind is OFF or Load LED x2 and strip x2 ON. When solar off, wind off and both loads are ON, bus voltage is suddenly down then super capacitor supply voltage to bus in super mode and battery is connected to bus. Battery voltage starts to decreasing show in graph.

STEP 18

Manual battery low

Solar – ON; Wind – OFF; Load – OFF; Time – 2500 sec

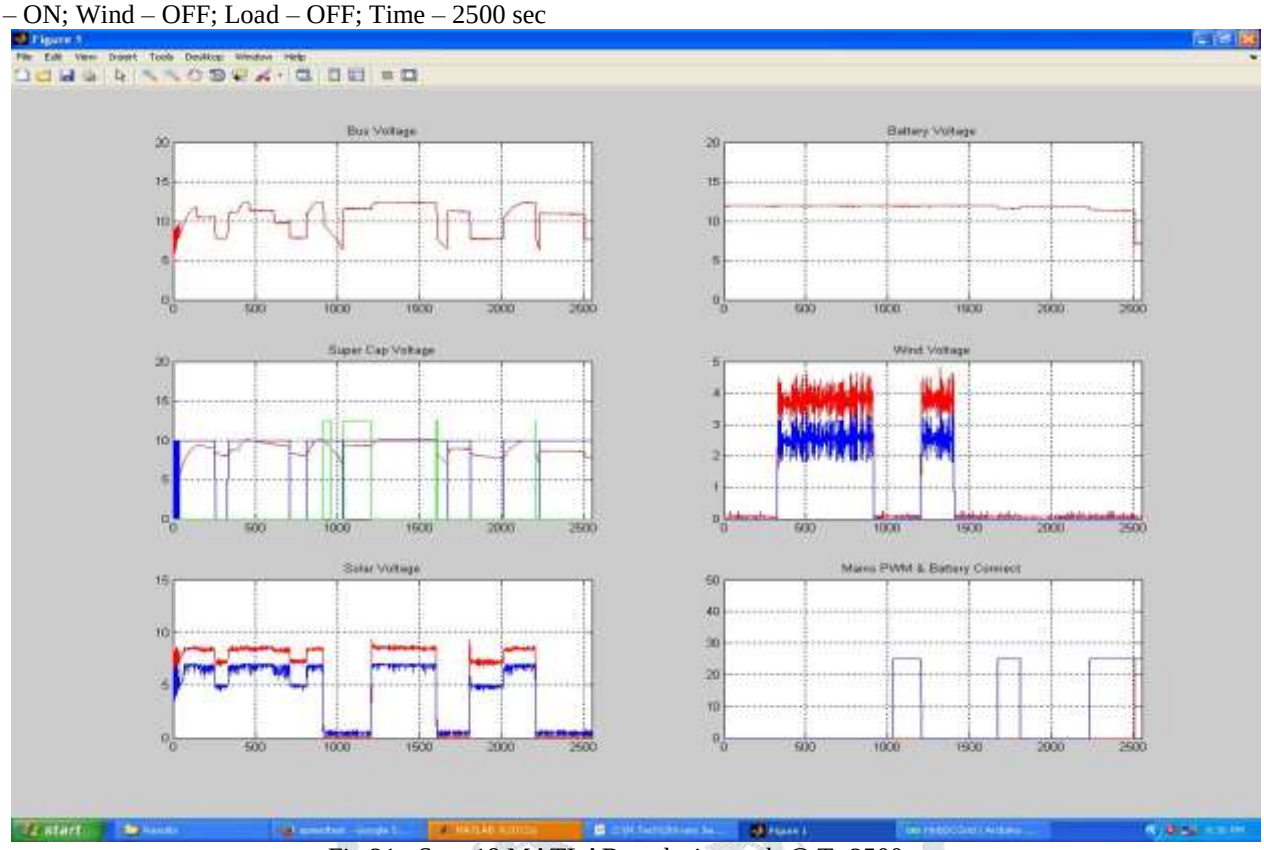

Fig 21: Step-18 MATLAB analysis graph @ T- 2500 sec

In step-18 solar is ON condition and wind is OFF or Load OFF. In this step I manually low the battery power. When solar, wind off and battery power is low than mains start supply to dc bus show in graph

STEP 19

Battery reconnected

Solar – ON; Wind – OFF; Load – OFF; Time – 2600 sec

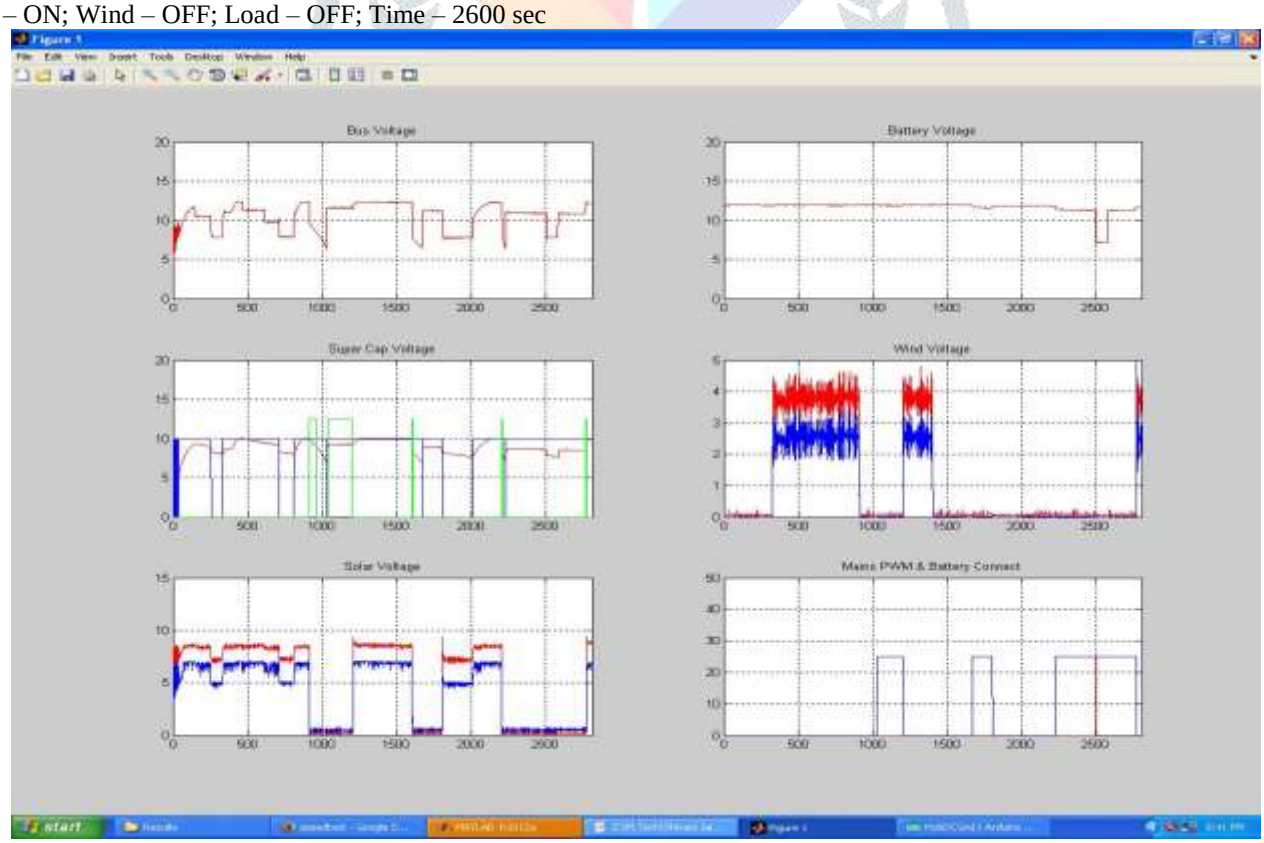

Fig 22: Step-19 MATLAB analysis graph @ T- 2600 sec

In step-19 solar is ON condition and wind is OFF or Load OFF. When solar is ON & wind is off and battery is reconnected than mains supply is off. Now bus and super capacitor start charging.

STEP 20

Solar – ON; Wind – ON; Load – OFF; Time – 2750 sec

Fig 23: Step-20 MATLAB analysis graph @ T- 2750 sec

In step-20 solar is ON condition and wind is OFF or Load OFF. When load off, wind & solar is ON then battery automatically disconnected. Now bus, super capacitor & battery is start charging.

VIII. CONCLUSION & FUTURE SCOPE

This work had 7 objectives to improve the work and all objective successfully performed. In this proposed work mainly I focused on renewable power to use with priority. In case of renewable power is not sufficient to operate the load than second it will be used super capacitor and battery power to circuit. I had successfully performed the operations using MATLAB & artificial neural network. Results show the different steps of performance of proposed work. In this work we used MATLAB, Arduino, artificial neural network, function fitting neural network for achieve high accuracy.. The main conclusion from experimental data is that high-accuracy & good feature automatically tuned to the operating task according to load demand, due to its greater accuracy and a considerably lower demand for computation, the artificial neural network is a more suitable.

Table 1 comparison table of base paper and proposed work

S.No.	Paramerers	Base Paper	Proposed Work
1	Title	Control strategy for a PV wind based standalone DC microgrid with hybrid energy storage system	AI based Control strategy for a PV wind based standalone AC grid PWM assisted DC microgrid with hybrid energy storage system
2	Technique Used	1.Power management control algorithm for utilization of renewable sources; 2.MPPT based boost converter for PV/Wind; 3.battery & super capacitor controller based upon frequency domain analysis; 4.drop control strategy to keep bus voltage under control under express power condition	1.Renewable periodization controller and DC bus using real time feedback assisted fuzzy logic controller; 2.AI based boost converter for PV/Wind; 3.battery & super capacitor controller based upon complex fuzzy controller , conserving SOC, renewable energy state & grid availability; 4. Grid subsidization using PWM to Maintain bus voltage never excess bad conditions.
3	Topology	DC bus with PV/WIND	AC grid PWM assisted DC bus with PV/wind

		connected via MPPT boost converter battery & super capacitor via bidirectional controller	connected AI boost converter super capacitor connected via bidirectional converter, battery connected via boost converter & relay forward reverse logic.
4	Boost converter control logic	MPPT	Real time feedback assisted Levenberg-Marquardt Neural Natwork
5	Power management control	Preparatory power management control algorithm	Complex fuzzy logic with consideration of SOC, renewable energy availability, load ETC.
6	AC mains/ Grid backup	NA	Yes, using PWM based Opto-isolated logic
7	Demonstration/ Simulation	MATLAB Simulink simulation	Real time hardware based with embedded 'c' controlled Ardiuno feed MATLAB Simulink simulation.

Future Scope

In future work, we will refine the efficiency and overall working of the proposed work. In this, we will also try for the real time implementation of the proposed work.

REFERENCES

[1] Faisal Mumtaz*, Islam SafakBayram, "Planning, Operation, and Protection of Microgrids: An Overview" 3rd International Conference on Energy and Environment Research, ICEER 2016, 7-11 September 2016, Barcelona, Spain.

[2] Dinesh Kumar1 , (Member, Ieee), Firuz Zare2 , (Senior Member, Ieee), And Arindam Ghosh3 , "DC Microgrid Technology: System Architectures, AC Grid Interfaces, Grounding Schemes, Power Quality, Communication Networks, Applications, and Standardizations Aspects" special section on power quality and harmonics issues of future and smart grids IEEE ACCESS volume 5, 2017.

[3] Marchand, S.; Monsalve, C.; Reimann, T.; Heckmann, W.; Ungerland, J.; Lauer, H.; Ruhe, S.; Krauß, C. Microgrid Systems: Towards a Technical Performance Assessment Frame. Energies 2021, 14, 2161.

[4] Abhishek Kumar, Muhammad ZafarUllah Khan, D. M. Akbar Hussain, "Microgrids Technology: A Review Paper" Gyancity Journal of Electronics and Computer Science Vol.3, No.1, pp. 11-20, March 2018.

[5] Nikos Hatziargyrioua, Hiroshi Asanob, Reza Iravanic, and Chris Marnayd, "Microgrids: An Overview of Ongoing Research, Development, and Demonstration Projects" 78 IEEE power & energy magazine july/august 2007.

[6] Dr.K.Ravichandrudu1, M.Manasa2, Mr.P.Yohan Babu3,G.V.P.Anjaneyulu4, "Design of Micro-grid System Based on Renewable Power Generation Units" International Journal of Scientific and Research Publications, Volume 3, Issue 8, August 2013 ISSN 2250-3153.

[7] RamazanBayindir, EklasHossain, ErsanKabalci, Ronald Perez, "A Comprehensive Study on Microgrid Technology" international journal of renewable energy research,Vol. 4, No. 4, 2014.

[8] M. Anjalakshi, S. Pavithra, M. Moovendan, P.Srinivasan, "A Research on Microgrid Technology by Non-Conventional and Renewable Sources" International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Volume-8 Issue-2S8, August 2019.

[9] Qi Wang, Bin Wang, WanwanXu, JiapanXu, "Research on STATCOM for Reactive Power Flow Control and Voltage Stability in Microgrid", 13th IEEE Conference on Industrial Electronics and Applications (ICIEA) 2018.

[10] MdRazibul Islam, Hossam A. Gabbar, "Study of Micro Grid Safety & Protection Strategies with Control System Infrastructures" Smart Grid and Renewable Energy, 3, 1-9, February 2012.

[11] R. H. Lasseter and P. Paigi, "Microgrid: A conceptual solution," in Proc. IEEEPESC'04, pp. 4285-4290, 2004.

[12] F. Katiraei and M. R. Iravani, "Power Management Strategies for a Microgrid with Multiple Distributed Generation Units," IEEE trans. Power System, vol. 21, no. 4, Nov. 2006.

[13] P. Piagi and R. H. Lasseter, "Autonomous control of microgrids," in Proc. IEEE-PES'06, 2006, IEEE, 2006.

[14] M. Barnes, J. Kondoh, H. Asano, and J. Oyarzabal, "Real-World microgrids- an Overview," in IEEE Int. Conf. Systems of Systems Engineering, pp.1-8, 2007.

[15] Chi Jin, Poh Chiang Loh, Peng Wang, Yang Mi, and FredeBlaabjerg, "Autonomous Operation of Hybrid AC-DC Microgrids," in IEEE Int. Conf. Sustainable Energy Technologies, pp. 1-7, 2010.