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Modeling and Simulink Analysis of Energy Management with Help of ANN Controller

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ABSTRACT

This project demonstrate functionality of a modeling and simulink analysis of energy management with help of ANN(ARTIFICIAL NEURAL NETWORK) controller. This is nothing but the energy management system (EMS). The EMS includes batteries and a digitally controlled single phase voltage source inverter (VSI), which can be controlled as a current source or voltage source depending on the status of the AC grid and the users preference. The EMS guarantees that the critical loads are powered when AC grid fails. In which case, the VSI is controlled as voltage source. It also accomplishes peak power control by supplying battery power to the local loads, while they are powered by AC grid if loads gets large. The DC power from the solar pannel can be transferred to the ANN controller. It converts pulsating signal to the constant signal and later it transfers to the H-bridge inverter. Then power from inverter is utilised by the AC loads, and then it transfers to AC grid. The electricity cost savings accomplished by peak savings are estimated. The Modeling and simulink analysis of energy management with the help of ANN controller is demonstrated by experimental management on MATLAB. The control architecture and logic embedded in modeling and simulink analysis of energy management with the help of ANN controller are discussed in detail.

KEYWORDS: *Renewable Energy resource, energy management system, ANN controller*

I. INTRODUCTION

Energy savings and energy efficiency have become top priorities all around the world, stimulated by the Kyoto protocol and other pressing needs to reduce fossil fuel consumption. Additionally, energy security is a necessity for many installations such as military bases and health care facilities where reducing energy consumption must be accomplished while keeping critical electrical loads serviced at all times. In this project, a power-electronics-based energy management system (EMS) is presented to accomplish peak power control in a single-phase power system while guaranteeing continuous service to critical loads at the same time. The EMS proposed in this project includes energy storage in the form of batteries in order to accomplish three main goals:

1) Make electric power available to critical loads at all times with or without main grid service available,
2) Reduce peak power consumption to lower electricity costs
3) Store energy produced by DG units or during the time in which electricity from the grid is least expensive. Recently researchers have used power converters to implement power management or EMS for ac and dc microgrids
4) The purpose of my work is to implement the Energy Management System for critical loads by using sources as Grid and Solar (Battery).
5) The simulation is done in MATLAB R2009a VERSION.

Furthermore, this project presents simpler control systems and different topologies than those reported in [19] through [24]. Another innovative feature of the EMS presented in this project is the use of a single off-the-shelf three-leg integrated power module to accomplish all the required tasks including battery charging, peak shaving, and fault tolerance. The trends toward a future Smart Grid implementation and the ever increase of numerous nonlinear industrial, commercial and residential type of loads that are generating pollution which led to 100% of total current harmonic distortions into the grids have drastically created a concern on power quality metrics for future power systems.

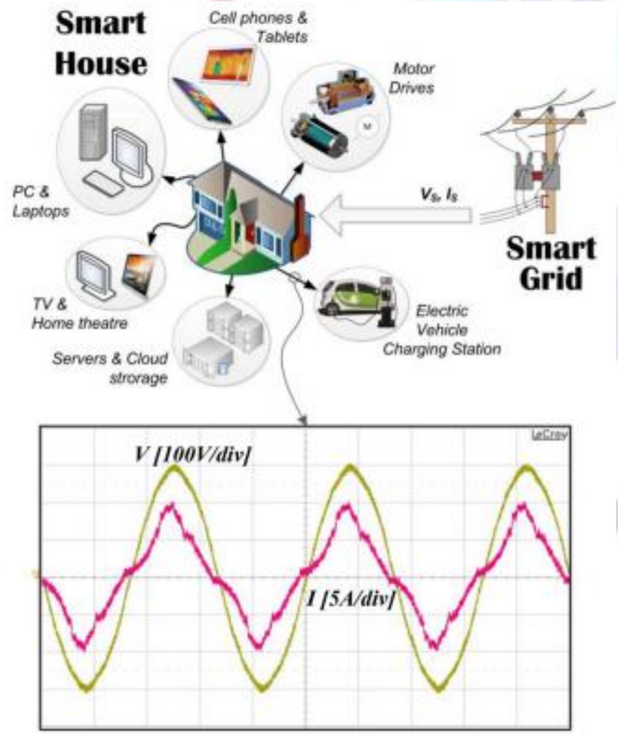


Fig. 1. Typical modern residential consumer with non-linear electronic loads and a Nissan LEAF measured voltage and current waveforms plugged to a level-2 charging station.

Objectives of my Work:

1) Power must available to the critical loads at all time with or without grid connections.
2) At Islanding or standalone mode of operation, the EMS manage power to the loads through batteries.
3) Reducing peak power absorbed by the microgrids by using battery power and by load shedding of non critical loads.
4) Battery charging mode through Solar cells as well as grid.
5) Maximizing the state of charge of the battery.
6) Make power available to the non critical loads too.

Explanation of My Work:

To overcome this draw back I have used photovoltaic cells for battery charging purpose and here battery is charged through ac grid also. I have used grid and photovoltaic cells for EMS to accomplish continuous supply to critical loads with or without grid. I have replaced IGBT's (Insulated Gate Bipolar Transistor) by MOSFET's (Metal Oxide Semiconductor Field Effect Transistor) to work under lower voltages with higher communication speed and greater efficiency.

II. SOLAR POWER GENERATION

A sun fuelled cell or photovoltaic cell is a device that adherent's daylight based imperativeness into control by the photovoltaic effect. A portion of the time the term sun fuelled cell is held for devices anticipated that especially would get essentialness from sunlight, while the term photovoltaic cell is used when the source is unspecified. Social affairs of cells are used to make sun situated board, daylight based modules, or photovoltaic shows. Photovoltaic is the field of development and research related to the utilization of sun fuelled cells for sun based essentialness. Sun situated cell efficiencies vary from 6% for vague silicon-based sun arranged cells to 40.7% with various crossing point research lab cells and 42.8% with different kicks the pail amassed into a cream package. Sun situated cell imperativeness change efficiencies for fiscally available multicrystalline Si sun arranged cells are around 14-19%. Sun based cells can in like manner be associated with various devices to make it poise plausible in the sun. There are daylight based cell phone chargers, sun arranged bike light and sun controlled outside lights that people can grasp for consistently use.

1) Equivalent circuit of a solar cell

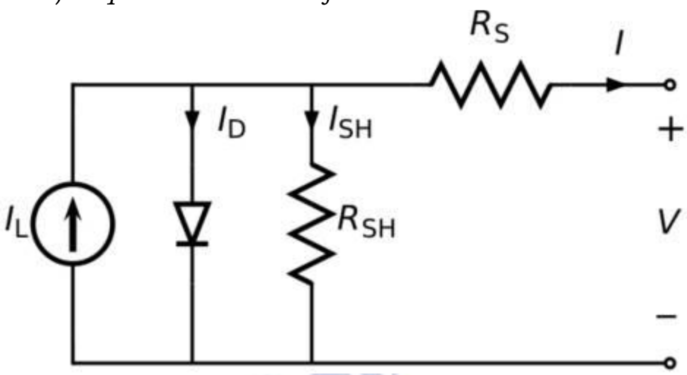


Fig2 equivalent circuit of solar cell

SOLAR PANEL

Fig 3 solar panel

Working:

Sun based power frameworks utilize photovoltaic cells to change over the brilliant vitality of daylight straightforwardly into electrical vitality. Photovoltaic sun based cells are semiconductor gadgets which convert daylight into power. Sun powered cells which use crystalline semiconductors, for example, silicon, offer the upsides of superior and unwavering quality. Photovoltaic cells are silicon-base precious stone wafers which create a voltage between inverse surfaces when light strikes one of the surfaces, which surface has a present gathering matrix consequently. The photons of the light are consumed by photovoltaic cells and yield their vitality to the valence electrons of the semiconductor and tear them from the securities that keep up them joined to the centers of the molecules, elevating them to a predominant vivacious state called conduction band in which they can move effectively through the semiconductor. Commonly, a majority of sun powered cells are collected and interconnected in order to frame a physically-incorporated module, and after that various such modules are amassed together to shape a sun oriented board. A few sunlight based boards might be associated together to shape a bigger cluster. The individual photovoltaic cells in a module might be associated in arrangement or parallel, normally by an interior wiring game plan and likewise at least two modules in a board might be associated in arrangement or parallel, contingent on the voltage yield wanted. Sunlight based cells are normally interconnected into arrangement strips by electrically interconnecting an authority cushion on the matrix to the contrary surface of the contiguous cell in the strip. Photovoltaic cells are fabricated in an assortment of arrangements, yet by and large involve a layered structure on a substrate. There are a wide range of kinds of meeting sun based cell modules in which daylight is met by methods for a focal point framework with the goal that the aggregate zone of costly sun based cells can be decreased so as to diminish the expense of electric power producing frameworks utilizing these sun based cells. **Hypothesis:**

A sunlight based vitality battery is not quite the same as the customary battery. The sun based battery module is built by having a variety of sunlight based battery components carried on a supporting base plate. At the point when the daylight encroaches on the individual sun powered battery components, the vitality of the light which makes no commitment to the photoelectric transformation is gathered as warmth to lift the temperature of the sun oriented battery components and lower the productivity of photoelectric change. A sun based cell having a photoelectric change layer in which no less than one PIN intersection is shaped utilizing an undefined or microcrystalline silicon film is used.

Applications:

Sunlight based cells can likewise be connected to different hardware gadgets to make it self-control reasonable in the sun. There are sun powered PDA chargers, sun oriented bicycle light and sunlight based outdoors lamps that individuals can receive for every day utilize. Sun oriented power plants can confront high establishment costs, in spite of the fact that this has been diminishing because of the expectation to learn and adapt. Creating nations have begun to assemble sun oriented power plants, supplanting different wellsprings of vitality age. In 2008, sun based power provided 0.02% of the world's aggregate vitality supply. Utilize has been multiplying each two, or less, years. In the event that it proceeded at that rate, sunlight based power would turn into the prevailing vitality source inside a couple of decades.

III. DC-DC CONVERTERS

3.1 Introduction:

A DC--DC Converter with a high step-up voltage gain is utilized for several applications such as high-intensity discharge light ballasts for Automobile headlamps, Fuel Cell Energy Conversion systems, Solar Cell Energy Conversion systems as well as Battery back-up systems for Uninterruptible Power Supplies. In theory, a DC--DC Boost Converter could accomplish a high step-up voltage gain with a very high obligation proportion. Nonetheless, in method, the step-up voltage gain is restricted as a result of the result of power buttons, rectifier diodes as well as the equal collection resistance of inductors and also capacitors.

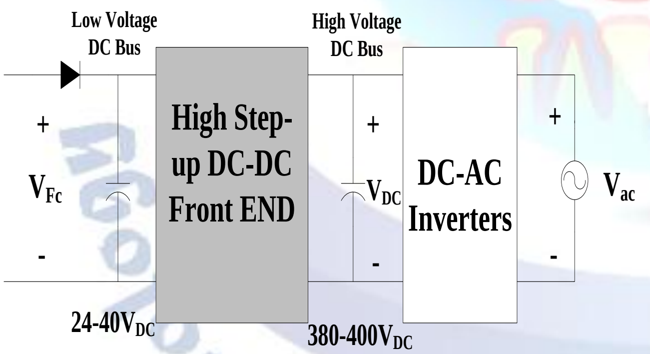


Figure 4: General Power generation system with a high step-up converter

Boost Converter:

A Boost Converter i.e. Step-up Converter is a DC-to-DC power converter with an output voltage greater than the enter voltage. It is a category of switched mode electricity supply containing at least semiconductor switches i.e., a diode and a transistor and as a minimum one strength storage element i.e., a capacitor, inductor or the two in mixture. Filters manufactured from capacitors every so often in mixture with inductors are normally introduced to the output of the converter to lessen output voltage ripple. It shows in Figure 5

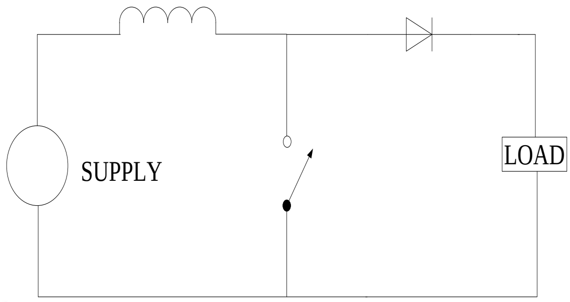


Figure 5: Basic schematic of a Boost Converter

The basic principle of a Boost Converter consists of distinct states:

- In the On-state, the transfer S is closed, resulting in an increase within the inductor contemporary.
- In the Off-country, the transfer S is open and the only route provided to inductor current is through the fly returned diode D, the capacitor C and the weight R. This brings about shifting the strength collected all through the On-state into the capacitor.

The input cutting-edge is similar to the inductor cutting-edge as can be seen in determine 3.Four.So it is not discontinuous as inside the greenback converter and the requirements on the input clear out are comfy compared to a buck converter.

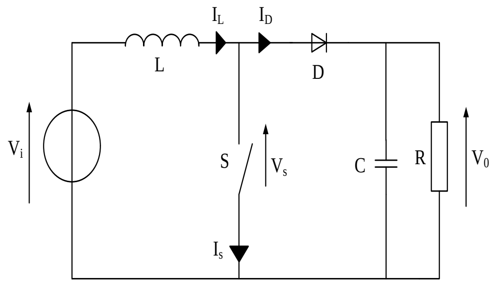
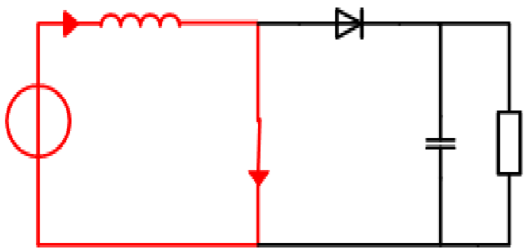


Figure 6: Overall diagram of Boost Converter



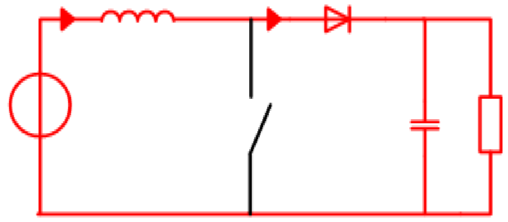


Figure 7: The two configurations of boost converter, depending on the state of the switch S

If the ripple amplitude of the current is too high, the inductor may be completely discharged before the end of a whole commutation cycle. This commonly occurs under light loads. In this case, the current through the inductor falls to zero during part of the period as shown in figure 3.7. Although slight, the difference has a strong effect on the output voltage equation.

It can be calculated as follows:

As the inductor current at the beginning of the cycle is zero, its maximum value I_{LMax} at t=DT is given by

$$I_{LMax} = \frac{V_i DT}{L} \text{------------------------------} (3.5)$$

During the off-period, I_L falls to zero after δT:

$$I_{LMax} + \frac{(V_i - V_0)\delta T}{L} = 0 \text{--------------------} (3.6)$$

Using the two previous equations, δ is:

$$\delta = \frac{V_i D}{V_0 - V_i} \text{-----------------------------} (3.7)$$

The heap current Io is equivalent to the normal diode current ID From figure 3.4, the diode current is equivalent to the inductor current amid the off-state. In this manner the yield current can be composed. Contrasted with the declaration of the yield voltage for the ceaseless mode, this articulation is substantially more convoluted. Moreover, in irregular activity, the yield voltage gain relies upon the obligation cycle, as well as on the inductor esteem, the information voltage, the exchanging recurrence and the yield current.

IV. PROPOSED SYSTEM

Note that a 300-V battery pack would eliminate the need for the buck/boost stage of the EMS, thus forming the dc bus for the H-bridge inverter. Critical loads are connected directly to the ac voltage created by the EMS, which is labeled *vac* in Fig. 8. Critical loads are those loads that must be powered at all times because they are critical to the mission. Noncritical loads are connected in parallel to *vac* , however, they can be shed when necessary using a Thyristor switch. This increases the control of the power that can be directed to the critical loads when necessary. The ac grid can also be disconnected from *vac* if needed to island the operation of the EMS. Typically islanding mode occurs when the ac grid fails. In this mode of operation, power to critical loads is guaranteed by drawing energy from the battery pack. The EMS functionality demonstrated in this project by experimental validation with a laboratory prototype. The following scenarios are discussed:

1) Peak shaving by tapping the energy storage system during high power demand;
2) Islanding or stand alone mode of operation when the main ac grid is no longer available;
3) Battery charging mode. By accomplishing these goals, the EMS can be very useful in grid-connected systems, where there is a limit on the user's power consumption. The EMS control algorithm was developed with the following goals, listed here in order of priority:
1) Power must be available to the critical loads at all times;
2) Reduce the peak power absorbed by the Microgrid by using
Battery power and by noncritical load shedding;
3) maximize the state of charge of the battery;
4) Make power available to noncritical loads.

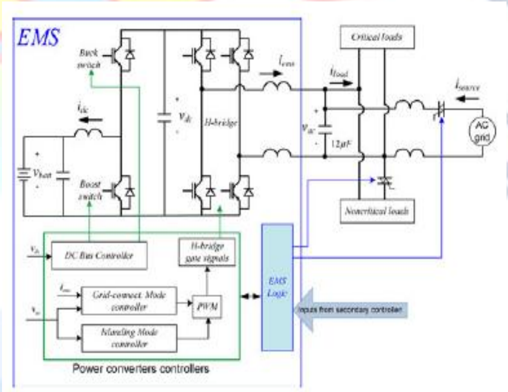


Fig .8 Proposed model

V. SIMULATION RESULTS

Decrease isolation condition:

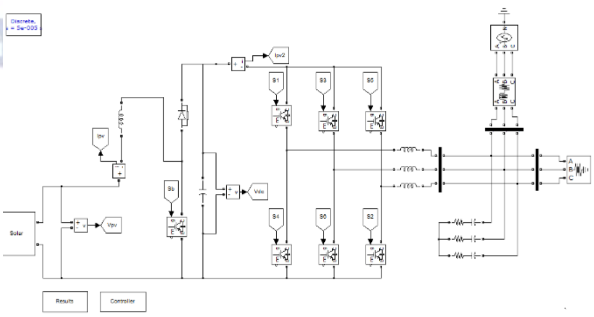


Fig.9. Proposed model in simulink.

Fig 9 represents the circuit diagram for the decreasing condition. In the above circuit diagram fig 6.1 we are converting the solar energy (DC) to the AC by using the inverter topology method and then the ac power supply given to the loads.

The power used by the ac loads and the remaining power is stored at the AC grid. And later the power stored at the AC grids is used by the AC loads. And there is a circuit breaker. The use of circuit breaker is when the loads are suddenly removed the extra power goes to the circuit breaker then the circuit breaker is closed and it acts as the switch.

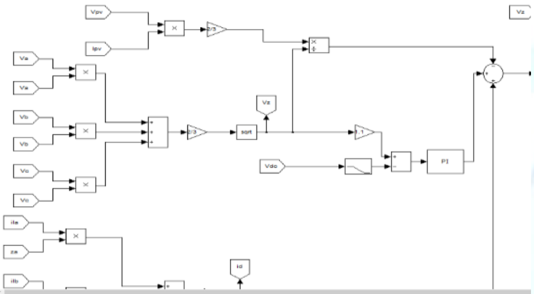


Fig.10. Controller circuit.

Fig 10 Represent the controller circuit which has been used in the circuit fig 6.1. The controller used in the above fig 10 is proportional integral (PI).The P.I controller is a feedback control loop that calculates an error signal by taking the difference between the output of a system.

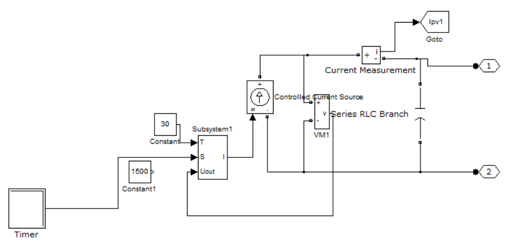


Fig .11. Solar PV system.

Fig 11 represent solar photovoltaic (PV) system. A PV system is a system composed of one or more solar panels combined with an inverter and other electrical and mechanical that use energy from the sun to generate electricity.

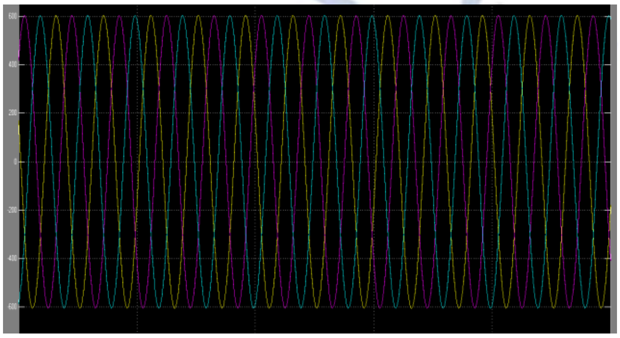


Fig.12. Three phase voltage across the OUTPUT.

Fig.12 represent the wave forms of the Three phase voltage across the OUTPUT. The results are shown out by using the MATLAB software. In the above result the peak voltage is 600v by using the PI controller.

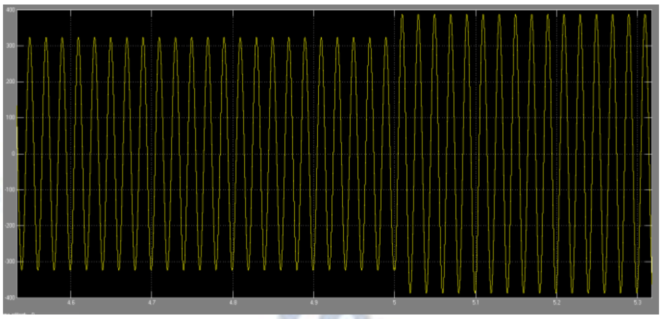


Fig.13. Output current at decrease insolation condition.

Output voltage at load increase condition. When we suddenly increase the load then the voltage also increases as shown in the fig 13, at the load increase condition the voltage increases from 320v to 380v as shown in the above figure 13.

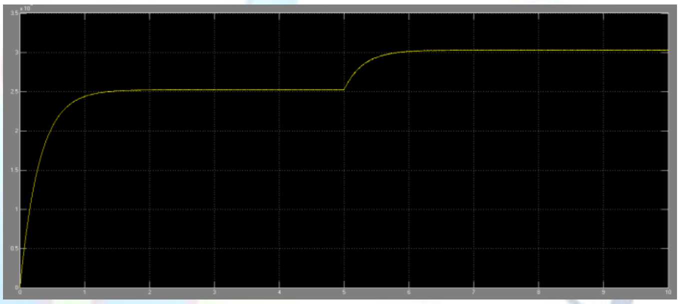


Fig.14. Voltage across the VDC.

Fig.14. Represent Voltage across the VDC. It means the voltage across the battery pack. In this the voltage is firstly increase (0 to 1) and then constant at the time period (1 to 5). and then again increases and maintain constant from (6 to 10) time period.

6.2. Increase insolation condition:

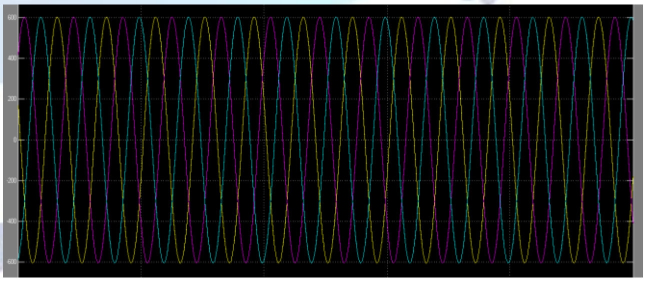


Fig.15. Output voltage with three phase.

Output voltage with three phase in the increasing condition. The wave forms are shown in the fig 15 with the help of the PI controller. While using PI controller the results depends on the Kp ,Ki values.

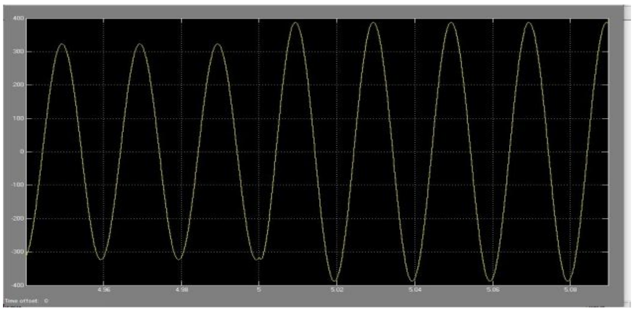


Fig.16. Output current in single phase.

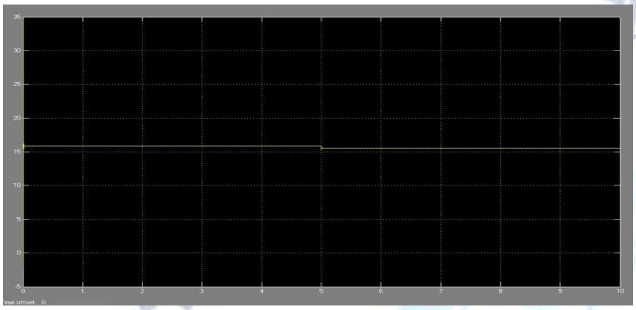


Fig.17. Output of PV system.

The above fig 17 represent the output of the photovoltaic system. In the photovoltaic system the current maintains constant .The constant current is 15.5A. The PV system waveforms shows the current value.

Simulation Results with ANN:

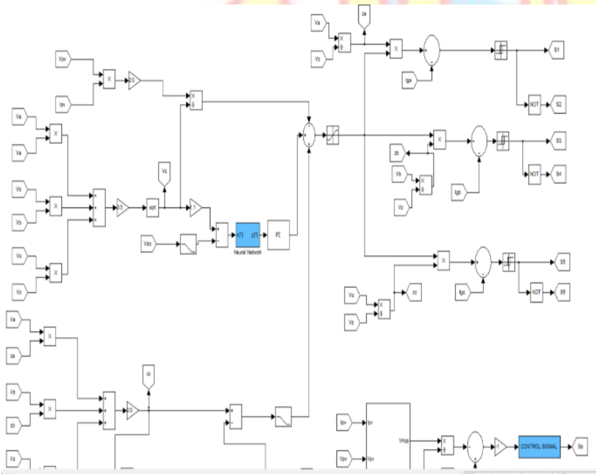


Fig.18. Controller circuit with ANN.

The above figure 18. Represent the Controller circuit with ANN (Artificial neural network). We are taking Va, Vb, Vc voltages as the feedback voltages, because we are using the closed loop system. For every closed loop system feedback is present. And we are taking 'Vz' as the reference voltage. The output from the ANN controller is given to the PI controller. The ANN controller used in this circuit is. Three layer (ANN) controller. The ANN controller gives the output in low running time than the PI controller. The accuracy of ANN controller is more than the PI controller (i.e 0.7%.).

DECREASE INSOLATION CONDITION (ANN):

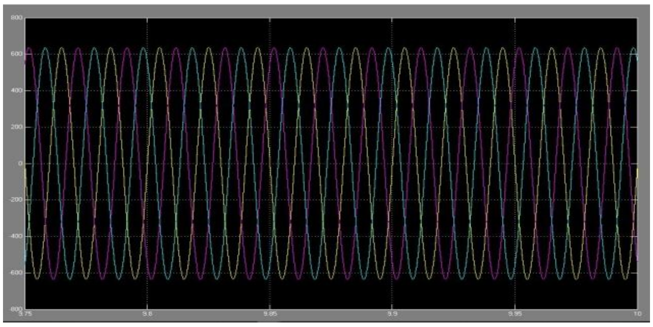


Fig.19. Three phase voltage across output.

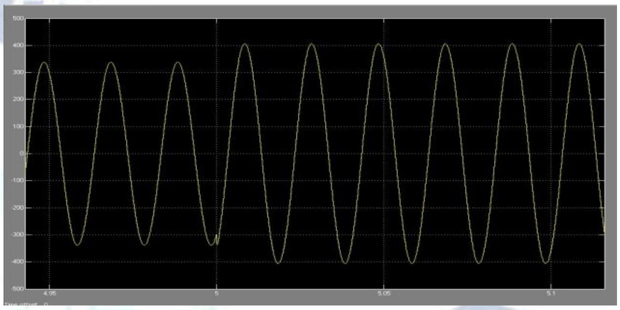


Fig.20. Output current in single phase.

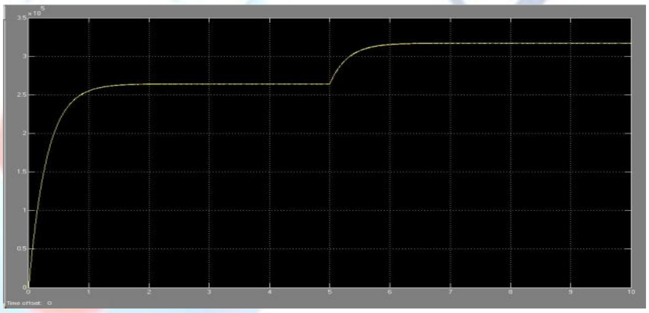


Fig.21.Output across the VDC

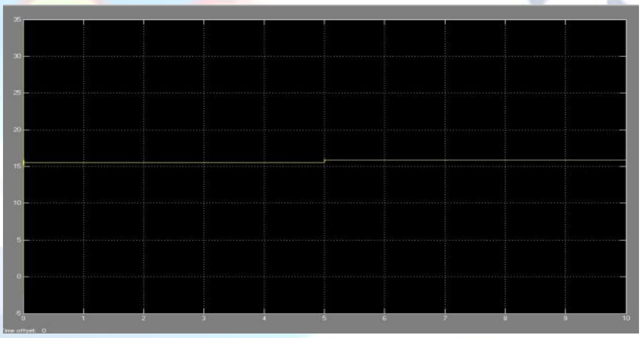


Fig 22. Output across IPV

ADVANTAGES

The proposed system having following advantages

1. In the diode clamped multilevel inverter the capacitors can be pre-charged as a group.
2. Efficiency is high for fundamental frequency switching and when the number of levels is high enough, harmonic content will be low enough to avoid the need for filters.
3. Peak shaving and store energy for house as well business purpose.
4. Reducing demand charges for the consumers.

5. EMS for military based works.
6. Hospitals never face problems when grid fails.

VI. CONCLUSION

In this project, the functionality of a power-electronics-based EMS is demonstrated with a laboratory prototype. The control system designed to perform the experimental implementation of typical scenarios is presented in detail. Experimental data are shown to demonstrate how the EMS supports critical loads when the ac grid becomes unavailable and how the connection to the ac grid is restored by the EMS when the ac grid becomes available again. Additionally, the EMS can accomplish other advantageous tasks such as peak shaving. Experimental measurements with linear and nonlinear loads demonstrate how the EMS, controlled in current mode, provides some of the power to the loads to accomplish peak shaving, thus reducing the cost of electricity. A simple economic analysis is provided in support of this statement.

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