GRID CONNECTED & STAND-ALONE MODE OPERATION OF SOLAR PV CHARGING STATION WITH BEMS

P. Manmadhareddy[1], Dr.Kurakula Vimala Kumar [2], D.Adinarayana[3]
[1&3]Assistant Professor, Dept.of.E.E.E, JNTUK University College of Engineering
Narasaraopet, Narasaraopet Palnadu Dist
Andhra Pradesh India 522601

[2]Assistant Professor, Dept.of.E.E.E, JNTUK University College of Engineering
Narasaraopet, Narasaraopet Palnadu Dist
Andhra Pradesh India 522601

Abstract

At present in the earth's atmosphere there are numerous number of gases. The gases released from automobiles combine with the atmospheric gases thereby causing "Green House Effect". As to minimize this effect the usage of automobiles should be decreased. This can be done only with the concept of Electric Vehicle. Electric Vehicles are far better than automobiles because they do not produce any type of pollution. The constrain in Electric vehicle is the run time of battery. The run time depends upon the size of the battery. This causes to increase in the size of a battery which is the most stupid idea for any manufacture company. So, implementation of solar charging stations at every possible area can lead to increase the usage of electrical vehicles, thereby causing a discrete reduction in pollution production.
In this project the design of grid connected and stand-alone mode operation of solar PV charging station with a BEMS is done. The EV can be charged by integrating three sources of power i.e., Solar power, Grid power and an External BEMS. This charging station extracts maximum power from solar energy with the help of MPPT controller. This power is used to charge the EV, it can be used to charge the battery and also can supply power to the grid using a Grid Connected Full Bridge Inverter. The simulated results are kept in this paper, so that one can understand how the charging station works.

Keywords: PV: Photo Voltaic, IGBT: Insulated-Gate Bipolar Transistor, BEMS: Battery Energy Management, PLL: Phase Locked Loop, EV: Electric Vehicle, PWM: Pulse Width Modulation, MPPT: Maximum Power Point Tracking

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1. Introduction

Since there is a tremendous amount of solar energy is getting wasted daily. If we can make use of that energy, we can decrease the usage of fossil fuels and the dependency on fuels gets decreased. Nowadays electrical vehicles are mostly using as public transport system. The major advantages of using an electric vehicle for public transport are listed as a) the efficiency of electric vehicle is higher than the automobiles which use fossil fuels as their fuel b) the electricity consumption cost that electric vehicle takes to cover particular distance is lesser than the cost of a normal fuel vehicles.
The best idea of this charging station it can integrate or it can combine the different modes of power supply to charge an electric vehicle. If we can integrate these sources (solar power, battery backup and grid power) then the burden on the grid can be reduced and it can be mostly effective during peak load condition.
The charging of an Electric vehicle is done in 3 ways:

1. Direct supply from PV array to the DC loads i.e., stand-Alone mode.
2. From the battery if the absence of illumination i.e., BEMS.
3. From grid in absence of PV energy and BEMS i.e., Grid connected operation.

PV array uses a special amount method named MPPT as to generate maximum amount of voltage at every level of illumination. Incremental conductance is the technique involved in the MPPT controller. As to increase the amount of voltage we generally use a transformer but in this charging station a Boost converter is used to increase the value of voltage because the transformer is efficient for stepping up the voltage but the cost of a transformer is high as compared to boost converter and both have nearly same performance in stepping up the voltage. The charging and discharging of battery can be done by using a TWO-WAY DC-DC converter. As the name two-way converter indicates that the converter can operate in both directions i.e., charging & discharging of the battery. A 2 arm 4 pulse grid tie inverter is used to synchronize the grid voltage and PV voltage and keeps them in phase.

2. Block Diagram for Proposed Charging Station

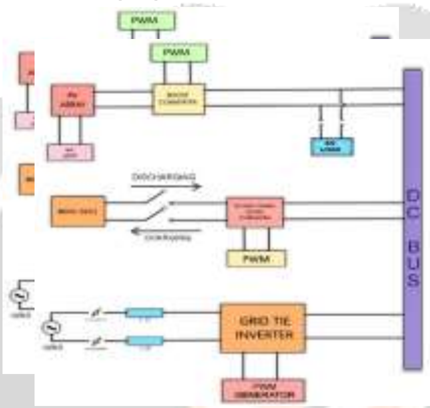


Fig1: Block Diagram for Proposed Charging Station

The block diagram shows the connections between the equipment and the way of operation briefly. The design contains solar array/ photo voltaic array, boost converter, two-way DC-DC converter, Grid tie inverter, Battery, DC-bus and an Incremental MPPT algorithm is also included. During stand-alone mode of grid tie inverter, the power from PV array is fed to EV load and Battery (BEMS). Since, PV array is controlled by Increment MPPT algorithm. If the excess of power is produced then the charging station operation grid connection mode to supply power to grid. Grid tie inverter is operated or controlled by using PWM generator output in form of input gate pulses. During grid connection mode the power from grid is fed to charge EV and BEMS.

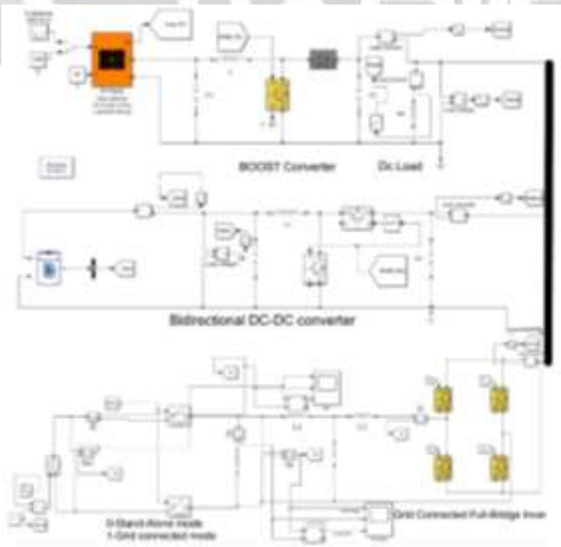


Fig2: Simulation Diagram of Charging Station

3. Interpretation of Components

3.1. PV Array

Photovoltaic system converts solar energy directly into electricity. The operation process is silent and does not emit any emissions such as gases like CO2, NO2. In a PV array the only visible pairs are mostly solar array. Solar array consists of small size cells called solar cells which is mostly mode from si are connecting in series and parallel to form an array. The voltage from solar array depends on the number of series and parallel connections of PV cells.

3.2. Incremental MPPT Controller

The incremental conductance algorithm detects the slope of PV curve and it finds a point, where it reaches the peak point of PV curve having the peak value. Since, the steady state accuracy of incremental conductance is higher than any MPPT technique.

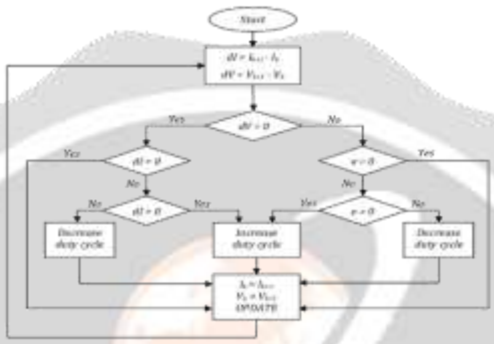


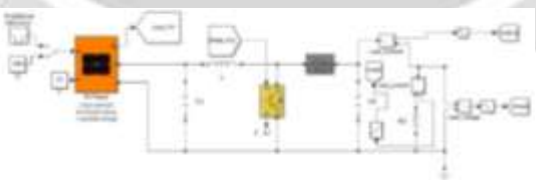
Fig3: Incremental MPPT Controller

Hence, Incremental MPPT is most efficient at rapidly changing conditions. PD controller is used because to achieve the higher steady state accuracy in MPPT.

3.3 DC-DC Boost Converter

The final value of MPPT is given to PWM generator so that the gate pulse of an IGBT high gain boost converter is controlled. Example, As the gate pulse various the voltage boosted varies. The DC-DC Boost converter consists the switching capacitors and inductors. The dc-dc boost converter is having switching capacitors and inductors cells so that the boosting does not drop to the previous produced value. As the (dc-dc converter allows the switching operation at higher frequency so that the size of inductor and capacitor can be decreased with higher boosted voltage

Fig4: DC-DC Boost Converter



3.4 Two-Way Chopper

Two-Way Chopper can perform the operation of energy flow in two directions This bi directional dc-dc converter plays a crucial part of work in the stable operation of the chopper and also in the distribution of power. As there is battery connected to the dc bus the electrical components such as voltage, current may vary irrespectively while feeding to battery So a two-way chopper is used to provide the stability in feeding the power and can guarantee, good working conditions Since the two-way chopper is the control core for the dc micro grid.

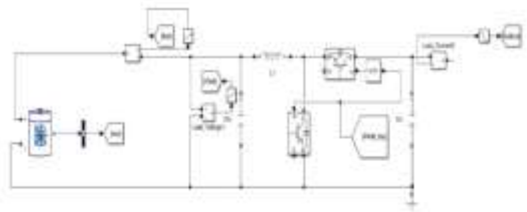


Fig5: Two-Way Chopper

3.5. DC GRID

Since the presence of locally established dc grid in the system can work without any problems like stability in frequency, reactive power regulation, losses in ac conditions. The dc micro grid can connect directly with the loads such as EV'S, BEMS, and other public requirements.

3.6. 2-Arm 4-Pulse Grid Tie Inverter

The 2 arm-4-pulse grid tie inverter operates in two modes; Islanded mode and Grid corded mode. During grid corded mode the inverter converts DC power from DC micro grid to AC power. The generated AC voltage value is slightly higher than the value of grid voltage and the phase angles are same (i.e.; in phase). IGBTs are used in these inverter as they can be handled very large power and can withstand to higher voltages and even having higher switching frequencies. A filter and a decoupling inductor is used between utility grid and inverter. This filter can perform two operations a) filtering the signals b) maintaining the constant voltage. The IGBTs of this inverter are controlled by the gate pulses of PWM generator as to produce the power efficiently. Generally, 10kHz-50kHz switching frequency is used for switching.

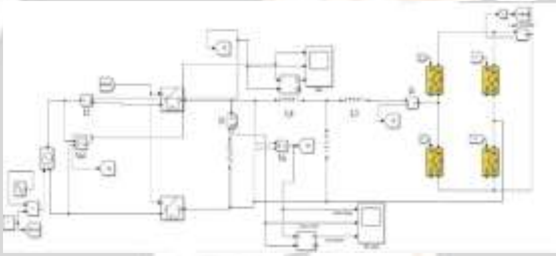


Fig6: 2-Arm 4-Pulse Grid Tie Inverter

4. Simulation Statistics

As to provide a clear information on this equipment the specifications of DC-DC Boost converter and grid corded inverter are shown.

4.1. Specifications of DC-DC Boost Converter

Parameters	**Values**
Input Voltage	38-40v
Output Voltage	278-400v DC
Internal Resistance (IGBT)	1e-3
PWM Generator (switching frequency)	10KHZ
Clamping Capacitance(C)	4.8250e-05F
Inductance(L)	0.1164H
Power Output	1.5-2KW

4.2. Specifications of Grid Tie Inverter

Parameters	**Specifications**
Input Voltage	278-400v DC (DC microgrid)
IGBT Internal Resistance	0.001 ohm
PWM Generator (carrier frequency)	10 KHZ
PLL	Low Pass Filter, Time Constant=0.0500 Frequency=20Hz
Grid Tie Inverter Model	2 arm bridge type

5. Necessary Conditions for BEMS

In our charging station the charging of battery from the grid can be performed in two ways:

1) For every ‘EV charging’ period the battery is recharged spontaneously

2) The charging of battery is done during off peak condition (ie; 7pm till morning)

Under these two circumstances power is taken from grid to charge battery

1) OMD (observational Metrological Data)

2) Load Variations

1) The estimated value of solar energy generated can be calculated from the below equation

$$E = A \times R \times H \times PR$$

The equation can be modified as

$$E = \eta A \int (1 - N) G(D, T)$$

Where η = pv conversion efficiency

A = area(m^2)

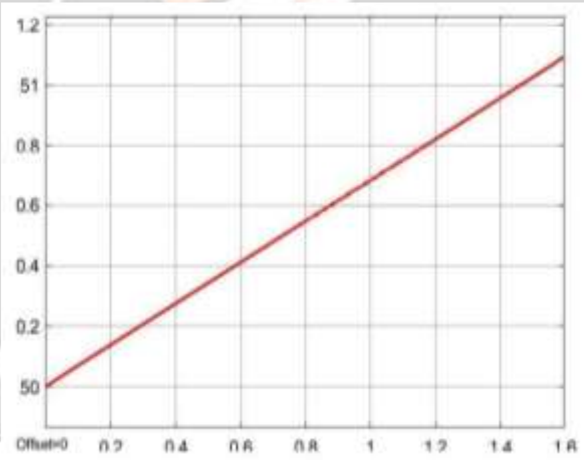
N = cloud covered portion

G(D,T) = solar insolation on PV array on a particular day on a clean sky

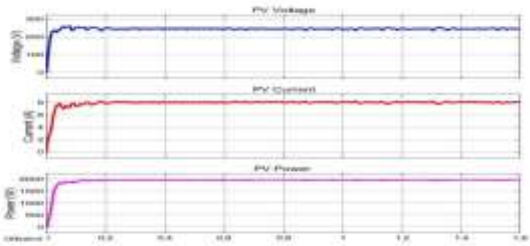
2) Load Variations such as off peak, on peak are to be estimated properly and maximization of efficiency should be done carefully.

6. Results

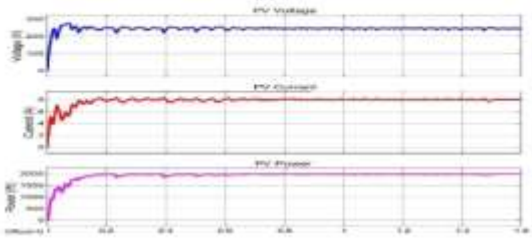
The simulation of our designed charging station is carried out under different circumstances such as constant irradiance, variable irradiance, grid connected mode, islanded mode. Generally, the irradiance is not constant. If the irradiance is assumed constant then the simulation graph of PV array is shown in fig7., PV measurement with irradiance graph. The Simulation Graphs Under Standalone Condition and Grid Connected Case for constant irradiance are also shown in fig7.



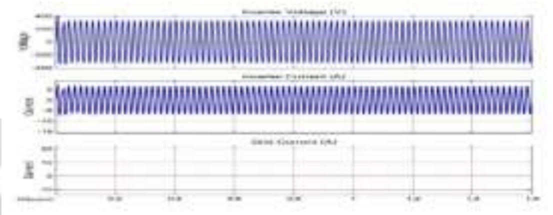
Fig(7.a): PV Measurement Graph



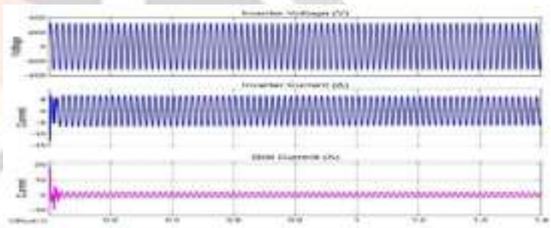
Fig(7.b): Islanded PV measurement graph



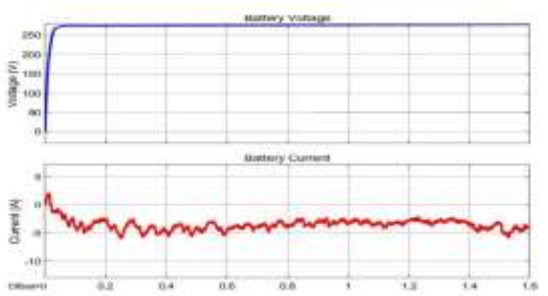
Fig(8.a): Inverter and Grid



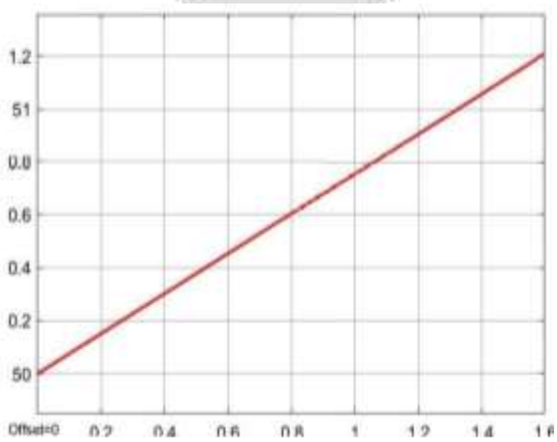
Fig(8.b): Islanded Inverter and Grid



Fig(9.a): Battery Measurement



Fig(10.b): Battery Measurement (islanded)
Fig(11.a): Battery SOC



7. In Summary

In this paper the design and development of grid connected &Stand-Alone charging station is done successfully. This charging station is electrified by integrating three sources of energy i.e., solar power, grid power and BEMS. The charging station works in an efficient way to supply power to vehicles. Here charging station is kept under various circumstances as to check the working conditions under those circumstances. This design and development can be implemented in real life as to change EVs in an efficient way.

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