Dynamic Modeling and Energy Storage Management of a Wind-Photovoltaic Integrated Charging Station connected with Three Phase Grid

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Abstract
An electrical appliance charging power supply is called a hybrid charging station. The goal of this project is to create a model of a portable electrical vehicle powered by solar and wind energy that can be used to charge laptops, mobile phones, and electric cars (EVs). By 2030, EVs are predicted to be the primary form of mobility on the road. EVs' great efficiency and zero carbon emissions are its main selling points. EVs are only sustainable, though, if the electricity used to charge them originates from renewable sources rather than fossil fuel-based power plants. This is where the solar charging of EV has gained interest in recent times, as it provides a clean and sustainable method to charge EVs. The goal of this project is to "Develop a highly efficient, robotic hybrid charging station which enables smart charging system for mobiles, laptops and electric vehicles at workplaces, that is powered by solar and wind energy".

Key words: Hybrid Electric Vehicles (HEV), Electric Vehicle (EV), Photovoltaic Cell , Wind Turbine,

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1.INTRODUCTION

The growth of Electric Vehicles (EVs) is causing a profound transformation in the automotive industry. The differences in the manufacturing process, additional safety concerns, different requirements for the materials involved, and so on have changed the way the car industry operates. These changes are also reflected in different disciplines, such as energy conversion, because power electronics has a fundamental role in both EV traction and battery recharging processes. Several studies on traction have been con- ducted in order to provide lighter and smaller converters, smoother dynamic response, improve the efficiency and reliability of the equipment, which are not excessively distant from the conventional requirements in most motor drive applications. The fast-charging process of the batteries, however, implies fundamental changes with conventional high- power applications because, aside from the vehicle, this process also involves the utility grid. In addition, the low-voltage levels of the battery packs increase the complexity, as typically these applications require medium voltage (MV) levels, hence impose a trade-off between the current stress of the switching devices and the step-down effort of the battery charger. This project is of designing a solar powered robotic electric vehicle charging station that utilizes solar power as an energy source is meant to address a number of issues that standard internal combustion engine vehicles do not. An electric vehicle with a solar charger will be easier to use. It will eliminate those unnecessary trips to the gas station for fill-ups. Just plug the vehicle into the charging station when not in use and it will be charged and ready for your next move. By contrast, conductive charging has already been adopted by the EV industry, including mainstream EV manufacturers. Both, EVs and PHEVs have emerged as the most likely successor to conventional internal combustion engine vehicles. Nevertheless, the shortcomings of these vehicles must be solved before they can become a real alternative to transportation. The long refueling process of their batteries, limited mileage capacity, lack of public fast-charging infrastructure are the main barriers to the widespread usage of EVs. No real threat to the utility grid exists at present, because the automotive industry is still mainly sourced by the gasoline supply chain; however, a gradual shift to larger

electricity consumption for transportation purposes will occur, and if this issue is not addressed properly, the electric system will be negatively affected (e.g., demand and energy price increase, voltage stability decreased, power quality issues, and so on) [8, 9].In order to address the effects of the large-scale adoption of these vehicles on utility systems, several studies have been conducted [10–14], most of them based on the conventional slow charging process of batteries. However, fast charging methods remain essential to the large- scale adoption of EVs, given that they will provide more flexibility to the drivers, particularly in terms of occasional longer trips, thereby addressing range anxiety [15–18]. An alternative that enables fast charging is in the form of fast robotic charging stations (RCS), which are similar to conventional gas filling stations. The concept of RCS refers to high-power fast chargers that are installed off-board. The structure of these charging stations can either be with an AC-bus, where each charging unit is fed by its independent AC-DC stage, or each unit connected to a common DC bus enabled by a single AC-DC stage with higher power ratings [19, 20]. Currently, fast charging is only enabled by standalone units, each of which has its independent rectifier stage using the AC-bus concept. However, considering the DC nature of the loads, the common DC bus con- figuration appears as the viable solution for utility scale adoption and also presents advantages in terms of cost, efficiency and size, as fewer conversion stages are needed [19, 21, 22]. Moreover, this structure facilitates the integration of distributed generation or energy storage systems [19, 21].The central converter AC-DC stage plays a fundamental role in this charging architecture, and is desirable to provide several features as low distortion operation, high power capability, and fully adjustable power factor. It can also simultaneously reduce the size of the input filters and the number in both active and passive components..

II Objective of the project

The project aims to produce a machine which would relieve people from a regular task of charging electricvehicles. An electrical vehicle charging station is a charging power supply for electrical vehicles. This paper proposes design of a model for a Photovoltaic (PV) based electrical vehicle that forecasts total power output under particular conditions. The connection to MV AC grids of EV RCS it is not a straightforward task because of the particularities involved. Unlike conventional multilevel converter applications, the loads in the system are volatile and present a stochastic behavior, therefore, the control scheme and the balancing techniques need careful designing. To develop a robotic charging station using PV through common bipolar dc bus fast charging architecture that allows the grid integration of several high- power fast charging units. To provide simulation results those verify the proposed architecture and control schemes. To complete the validation of the topics, the implementation of a low-voltage prototype of PV based RCS will for the experimental validation.

III Existing Technology

Nevertheless, the fast-charging process implies challenges not only to the vehicle itself but also to the utility system. To start with, the power rating involved in the fast-charging process, which is expected to be higher than 50 kW, makes it unlikely to be adopted as an on-board solution because of the requirement for larger, heavier and costly additional equipment [3-8]. Furthermore, studies show that conventional overnight charging (AC level) are expected to remain as the preferred charging method [9]; thus, installing an additional high-power charger on-board is not needed.On the other hand, quick charging is not suitable in residential applications for several reasons. First, dedicated equipment must be installed in the homes, as a result of the increase in the power consumed by the charger in order to reduce the charging time of the battery. In addition, this power consumption exceeds the typical power ratings of the conventional appliances. Moreover, a three-phase power connection is required because of the power levels involved. Furthermore, the electric system

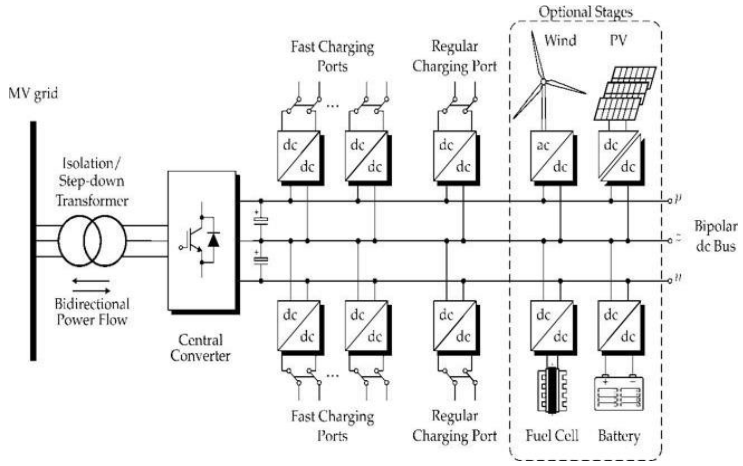


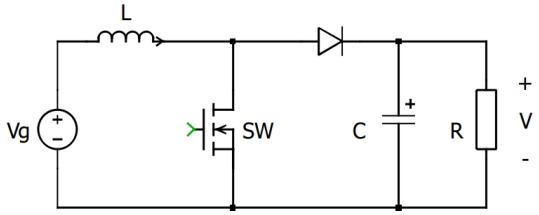
Figure 3.1 Conventional Charging station deploying Distributed Generation units through bi-polar DC bus

VI DC-DC Boost converter

Numerous devices, including PV and wind energy-based power systems, require the utilization of DC-to-DC converters. Buck converters, boost converters and buck- boost converters are three major types of non-isolated DC-DC converters [16]. Buck converters step-down the input voltage in order to generate a lower output voltage [16]. Conversely, boost converters step-up the input voltage leading to a higher output voltage [16]. Buck-boost converters are capable of both stepping-up and stepping-down voltages, which means that the magnitude of output voltage is either greater than or less than that of input voltage [16]. The boost converter is one of the most important components used in the design of this hybrid power system.

Figure 6.1 Ideal DC-DC boost converter

As previously mentioned, one DC-DC boost converter each was connected to the PV and wind energy sub-topologies of the system. The output voltage from both the boost converters is required to be 500V for the systems to operate as desired. Figure3.9a depicts the configuration of an ideal DC-DC boost converter. An ideal converter does not take losses into consideration and additional resistances are added to simulate losses, as shown in figure 3.9b. Voltage conversion ratio (M) of any dc-dc converter is the ratio of output to input voltage and is given by equation 3.16 [17]. $M = V = 1$ equation 3.16, that output voltage is equal to input voltage when duty cycle is zero. The output voltage tends to infinity as the duty cycle approaches one, meaning that theoretically an ideal boost converter can produce any value of output voltage greater than input voltage [17]. But practically, the maximum output voltage of a boost converter is constrained by the loss elements such as semiconductor on-resistances, inductor winding resistance



VII PID CONTROLLER

It is vital to reduce the steady state error and overshoot in output voltage of boost converters. One method to achieve zero steady state error and minimum overshoot is to employ a PID compensator. A PID compensator consists of a combination of three control systems – proportional, integral and derivative systems. Proportional control systems feed the error forward to the plant, integral control systems feed the integral of the error to plant, and derivative control systems feed the derivative of the error to plant [18]. The steady state error can be minimized or reduced to zero by implementing an ideal integral compensator. An ideal integral compensator also requires the error to be fed forward and therefore, is also referred to as proportional- integral (PI) compensator. Transient response which includes percent overshoot and settling time can be improved by implementing an ideal derivative compensator, which is commonly referred to as proportional-derivative (PD) compensator because using it requires feeding the error as well as the derivative of error forward to the plant. In order to improve both steady-state error and transient response, a PD(5)

Vgg $1-D$ controller followed by a PI controller must be designed [18]. The result of this combination Where, V is the output voltage; Vg is the input voltage; D is the duty cycle. It can be noted from of PD and PI controllers is called the PID compensator.

IX PRAPOSED NETWORK

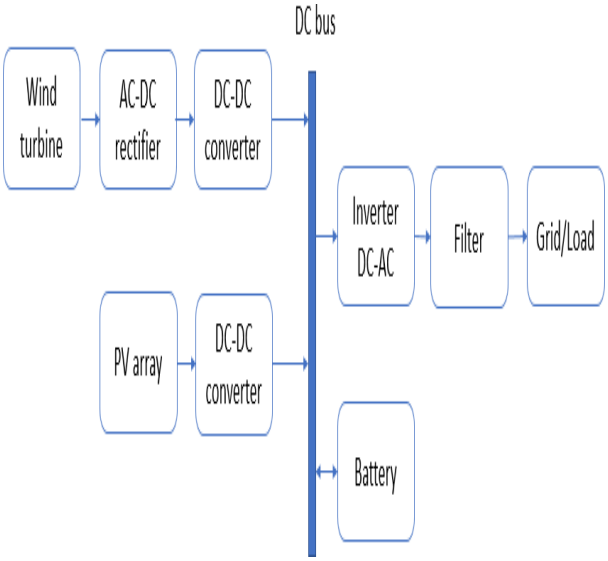


Figure 8.1. Block diagram of proposed model

The proposed hybrid system consists of a 12kW wind turbine, and a PV array comprising of six series modules and ten parallel strings which can generate a maximum power of 12.8kW. The wind turbine connects to a DC-DC boost converter through a rectifier. This boost converter converts the input voltage from the wind turbine to 500V output. Similarly, the PV array is connected to its own DC-DC boost converter giving an output of 500V. Both these output branches are joined and fed into an inverter which is connected to the grid through an L-filter. The model was built and analyzed using MATLAB/Simulink. Although it was possible to obtain an output power close to the required value of 12.8 kW without implementing PI controller, large ripple was observed, and the steady- state error could still be reduced in order to get a more stable output. Figure 2.17depicts the final PV model with boost converter, MPPT and PI controller which was implemented in the proposed hybrid system. As shown in figure 2.18b, the output power from the boost converter, which is further fed to dc bus, was 12.8 kW with low ripples and close to zero steady-state error. The resulting power output at various irradiance levels is depicted in figures 3.19a and 3.19b with the figures showing output power from the PV array and from boost converter with MPPT and PI controller installed respectively

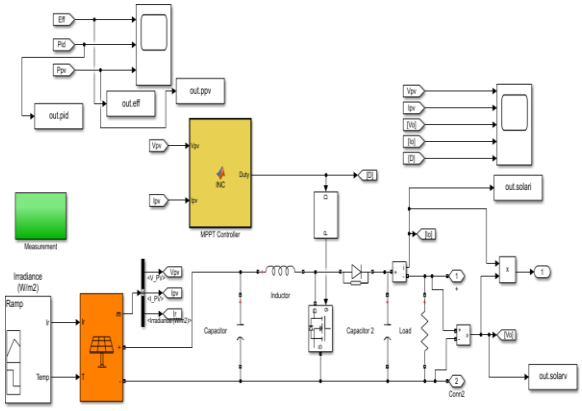


Figure 8.2 Simulink model of MPPT

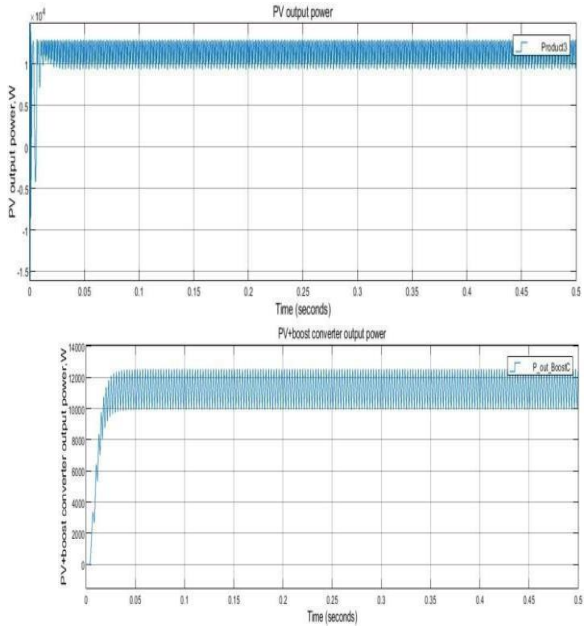


Figure 8.3a. Power output from PV array with Figure 8.3b. Power output from boost converter with INC MPPT without PI controller P&O MPPT without PI controller

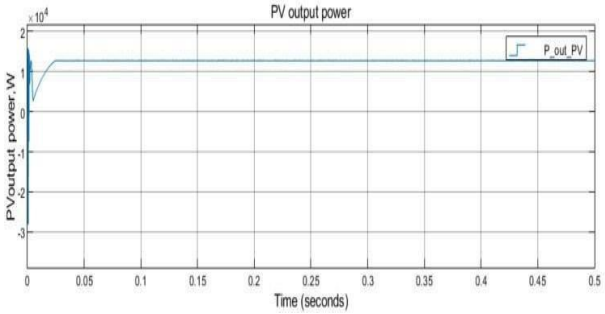
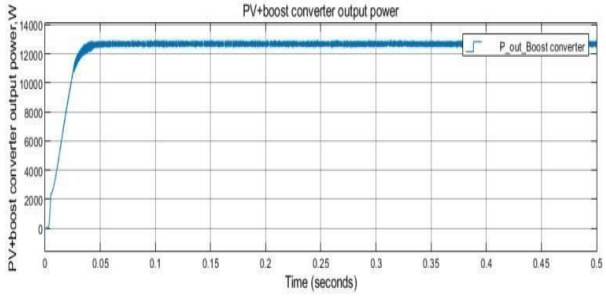


Figure 8.4a. Power output from PV array with Figure 8.4b. Power output PV+ boost converter INC MPPT + PI controller



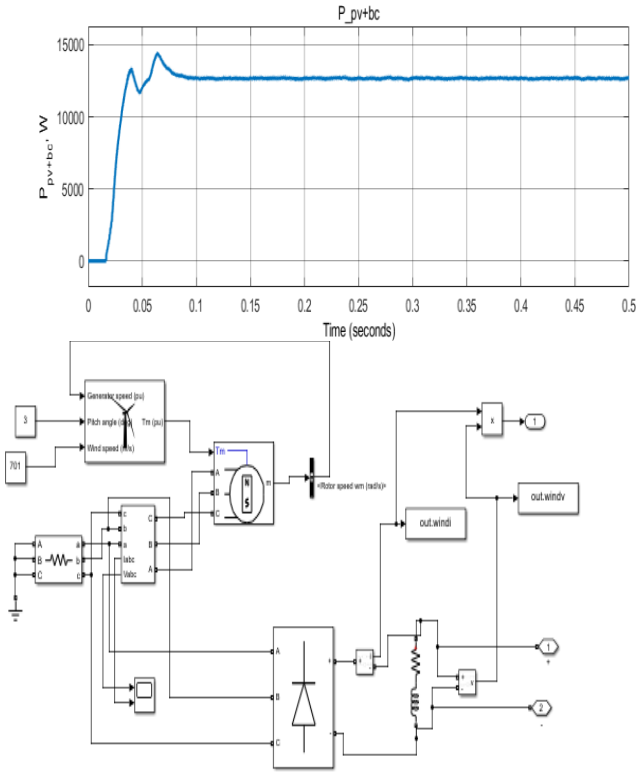
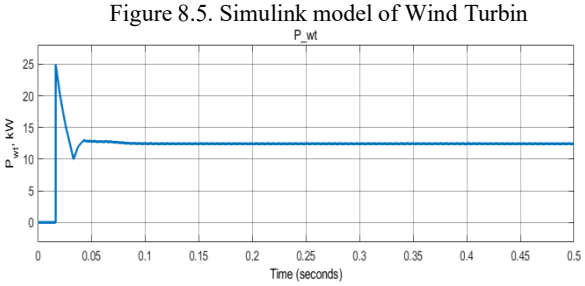
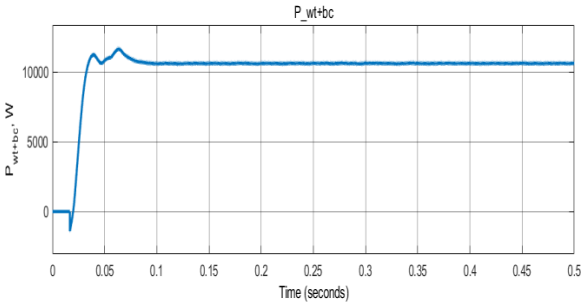


Figure 8.5. Simulink model of Wind Turbin





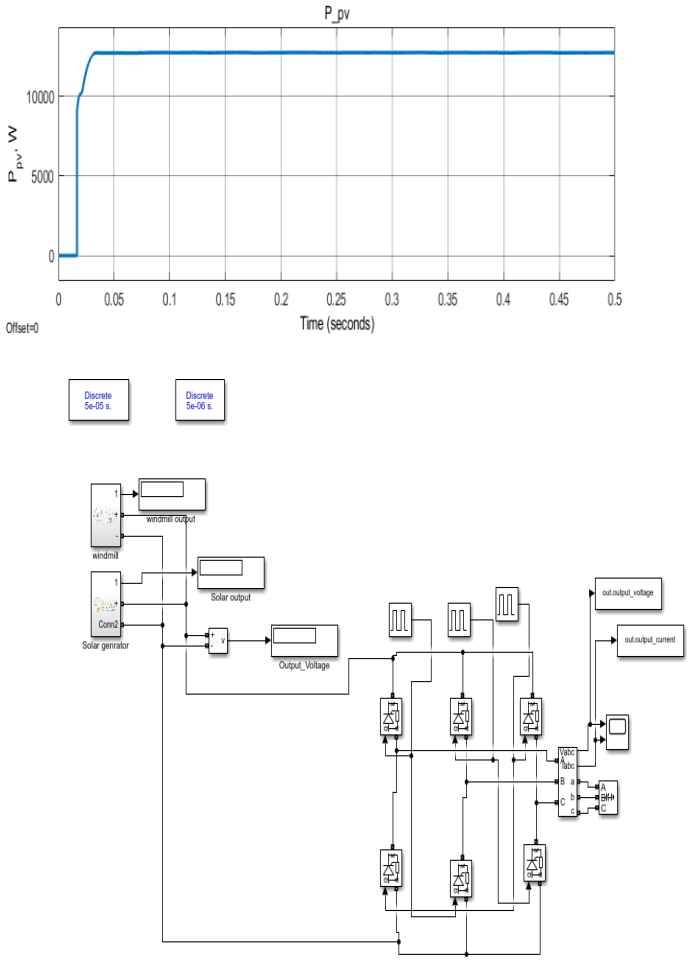
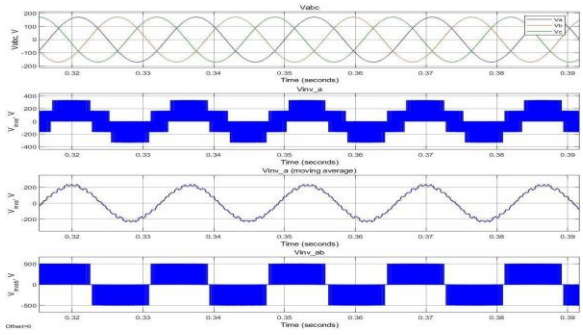


Figure 8.10 Simulink Diagram for PV power Generation



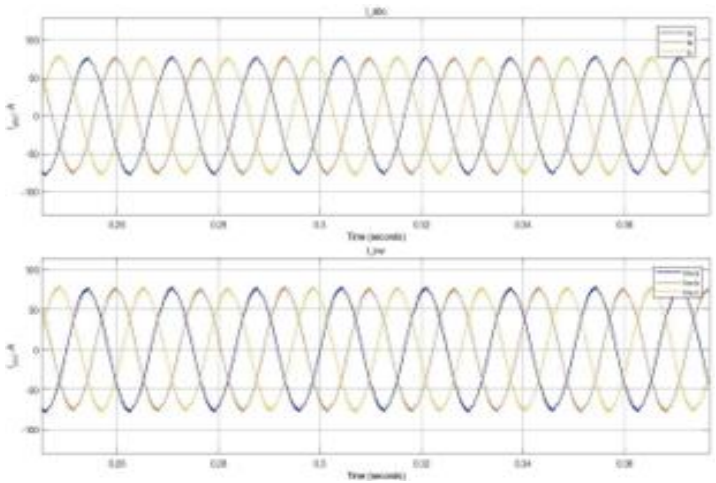


Figure 8.11. Voltage waveforms

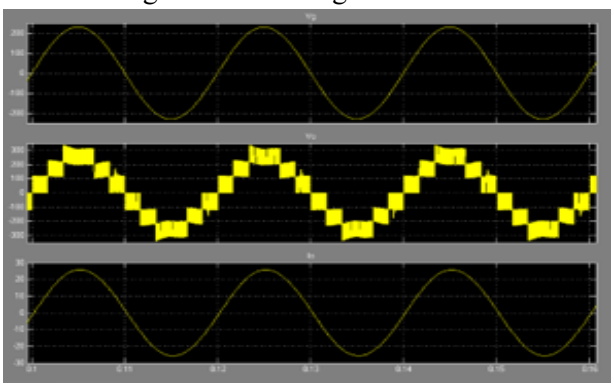
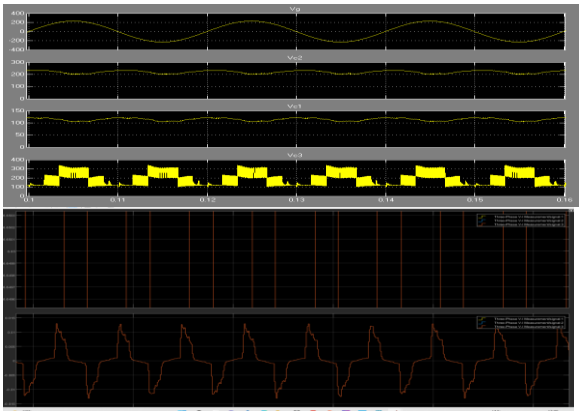
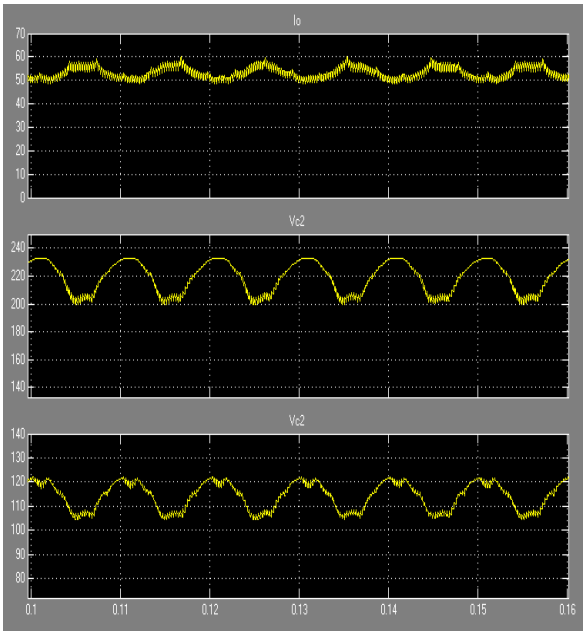


Figure 8.12. Current waveforms

Figure 3.36 shows the inverter voltage waveforms, which clearly depict that the uni polar switching sequence was obtained. This is in line with the theory that three-phase system generally generate unipolar switching. Unipolar switching sequence is said to have formed when the output is switched from high to zero or from low to zero. The first graph in figure 2.36 shows the three-phase voltage of the grid which is a sinusoidal waveform with desired magnitude of 208V. The second and third graphs show the phase-a inverter voltage and its moving average respectively, and the fourth graph depicts the line-to-line voltage between phase-a and phase-b. Current waveforms are presented in figure 2.37, with the first graph showing the sinusoidal grid current and the second one shows the sinusoidal current waveform measured out of inverter before the implantation of L-filter





6.CONCLUSION

As a consequence of finite petroleum original resources, renewable energy sources became indispensable for our daily life energy demand. In this perspective this project is intended to give an efficient, applicable and cost effective model of PV based EV charging station. This study shows that it is possible to implement and market Solar PV based EV charging station without grid connection in Mode-1. In accordance available irradiance and temperature values, it can produce sufficient energy while battery used as abackup. Instead of using the grid power as backup source, energy storage system (ESS) batteries are chosen so that whenever solar power is inadequate to supply power for charging of EV, ESS takes the control and injects the necessary energy to the charging system. The presented model of solar power energy can be a good initiative for the future appliances and implementation to be carried out in this area.

7.Future scope

There are several applications for smart charging like charging from renewables, reducing charging costs or delaying distribution network upgrade. The focus of existing research in this domain is to find better and efficient algorithms for each of these applications considering them as separate optimization problems. Reduction in the net cost of EV charging from PV using charging algorithms that combine solar forecast, energy prices, regulation services are recommended as extension of the work carried in this thesis.

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