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An Electric Scooter (G2V/V2H/V2G) With Renewable Energy Harvesting Functions

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ABSTRACT

Smart grids are advancing the management efficiency and security of power grids with the integration of energy storage, distributed controllers, and advanced meters. In particular, with the increasing prevalence of residential automation devices and distributed renewable energy generation, residential energy management is now drawing more attention. Meanwhile, the increasing adoption of electric vehicle (EV) brings more challenges and opportunities for smart residential energy management. This project analyzes the impact of photovoltaic (PV) systems on storage and electric vehicles in micro-grids. As these kinds of systems are becoming increasingly popular in the residential sector, the development of a new generation of equipment, such as more efficient batteries or solar panels, makes further study necessary. These systems are especially interesting in commercial or office buildings, since they have a more repetitive daily pattern of electricity consumption, which usually occurs within the maximum solar radiation hours. This project proposes an electric scooter with grid-to vehicle/ vehicle-to-home (V2H)/vehicle-to-grid (V2G) and energy harvesting functions.

Keywords : Bidirectional EV charger; grid able electric vehicles (GEVs); vehicle to grid (V2G); vehicle to home (V2H); grid to vehicle (G2V).

I. INTRODUCTION

Smart grid using distributed renewable generation, advanced meters, energy storage, communication and computation tools can cope with these challenges. Energy management is a core issue for the smart grid and can be beneficial for both the customers and utility companies. Recently, with the development of home based energy storage and controllers, energy management for the residential sector has attracted more and more attention. However, energy management for residential homes is a difficult problem. The main challenges come from uncertainties on both the power-supply and power-demand sides. Moreover, we usually only have limited historical data for residential houses which makes energy management an even more difficult task.

With the advancement of technology and increasing attention to environment protection, more and more electricity-driven products are introduced into people's daily life. Electric vehicles (EVs) are more efficient than traditional internal combustion engine vehicles and they are adopted by more and more customers. However, the introduction of EVs brings a high power consumption burden on the power system and may even jeopardize the infrastructure of power grids if there is no proper energy management.

The use of renewable energy in industrial frameworks has been investigated in recent years. Pollution and the depletion of fossil resources has motivated the development of new techniques to satisfy the increasing global demand for energy. Among the renewable energy resources, solar and wind energy are becoming more popular. These resources have traditionally been exploited by large public or private companies due to the need for high investments in expensive infrastructures. However, numerous individual heat and electricity consumers are now interested in playing an important role not only in the use of renewable energies, but also in their production. These kinds of consumers, also referred to as prosumers, are often motivated by the awareness of sustainability and the environment. This trend relies on the production of electricity in both residential and commercial buildings, generally by means of PV energy in micro-grids. Thus, by installing household rooftop solar panels, it is possible to produce electricity that is directly consumed and sold in cases of excess of production.

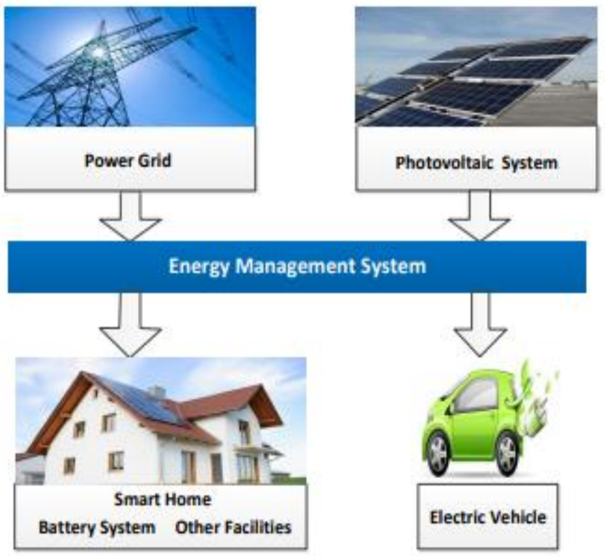


Figure.1. block diagram of EMS

More and more electronic appliances are introduced in people's daily life. The power consumption of the smart home is mainly divided into two groups: EV charging power consumption and base load power consumption. We consider the base load power consumption including all other power consumption in the home except the EV charging, namely power consumption for home appliances, cooling, heating, fans, interior lights, etc. For base load power consumptions, there is a morning peak after inhabitants wake up and an evening peak when they arrive home.

EV charging has become one of the major power demand for the residential sector with the fast increase of EV adoption. Here, we consider that each residential home is integrated with one EV and the EV is only charged at home. Home based renewable energy generation including solar and wind power generation are becoming an important power source for more and more homes. In this paper, we assume that the homes are equipped with solar panels which enable solar power generation. However, the output of solar power can be quite intermittent and varies according to different kinds of weather conditions. Home energy storage is an important component for smart homes. In this paper, we assume that a home based battery system is installed. The battery system can be used to save the energy when there is power surplus for later use and mitigate the volatility of renewable energy generation. We assume that home battery can be charged and discharged with continuous rate which means any power rate ranging from zero to the maximal allowed charging rate.

II. EXISTING METHOD

Recently, the permanent-magnet synchronous motors (PMSMs) have been gradually used to replace the brush dc motor as the actuators for electric scooters. In the established scooter drive, the motor is powered from the battery via a bidirectional dc–dc buck–boost converter. The smooth and satisfactory driving and regenerative braking performances are preserved through the properly designed schematic and control schemes.

DISADVANTAGE

- Complex structure
- Poor torque generating capabilities.

III. PROPOSED SYSTEM

This project develops an electric scooter dc motor drive with regenerative braking capability. In an idle case, it can be arranged to possess G2V/V2H/V2G and PV energy harvesting functions. The on-board battery can be charged from the mains with satisfactory line drawn power quality. Conversely, the ac 230 V/50 Hz with good waveforms by the proposed controls can be generated from the battery to power the home appliances or to provide emergency power use. Moreover, the V2G operation is also conductible. In addition, a synchronous rectifier-based buck dc/dc converter is designed to establish a 5-V dc USB source for charging use achieving G2X operation. In addition, the PV or possible dc sources can be harvested to make the battery auxiliary charging.

BLOCK DIAGRAM:

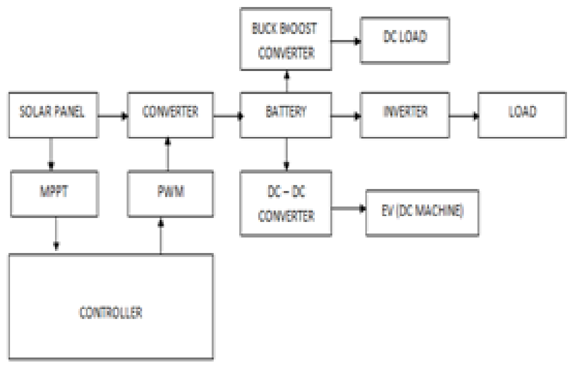


Figure.2. block diagram

SOLAR

A photovoltaic system, also solar PV power system, or PV system, is a power system designed to supply usable solar power by means of photovoltaic. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to change the electric current from DC to AC, as well as mounting, cabling and other electrical accessories to set up a working system. It may also use a solar tracking system to improve the system's overall performance and include an integrated battery solution, as prices for storage devices are expected to decline. Strictly speaking, a solar array only encompasses the ensemble of solar panels, the visible part of the PV system, and does not include all the other hardware, often summarized as balance of system (BOS). Moreover, PV systems convert light directly into electricity and shouldn't be confused with other technologies, such as power or solar thermal, used for heating and cooling.

MPPT

Maximum power point tracking (**MPPT**) is a technique that charge controllers use for wind turbines and PV solar systems to employ and maximize power output. PV solar comes in different configurations. The most basic version is one where power goes from collector panels to the inverter (often via a controller) and from there directly onto the grid. A second version might split the power at the inverter. This is called a hybrid inverter. The apportionment of how much power goes to each at any given moment varies continuously. Part of the power goes to the grid and part of it to a battery bank. The third version is not connected at all to the grid but still employs a dedicated PV inverter that features MPPT. In this configuration power goes from the solar panels to the inverter and from there to a battery bank. A variation on these configurations is that instead of only one single inverter, micro inverters are deployed, one for each PV panel. This allegedly increases PV solar efficiency by up to 20%. For the sake of completeness it should be mentioned that there are now MPPT equipped specialty inverters (mostly from China) that are designed to serve three functions. They grid-connect wind power as well as PV solar power and branch off power for battery charging.

IV. SEPIC CONVERTER

The single-ended primary-inductor converter (SEPIC) is a type of converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input. The output of the SEPIC is controlled by the duty cycle of the control transistor.

A SEPIC is essentially a boost converter followed by a buck-boost converter, therefore it is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output (and thus can respond more gracefully to a short-circuit output), and being capable of true shutdown: when the switch is turned off, its output drops to 0 V, following a fairly hefty transient dump of charge.

SEPICs are useful in applications in which a battery voltage can be above and below that of the regulator's intended output. For example, a single lithium ion battery typically discharges from 4.2 volts to 3 volts; if other components require 3.3 volts, then the SEPIC would be effective.

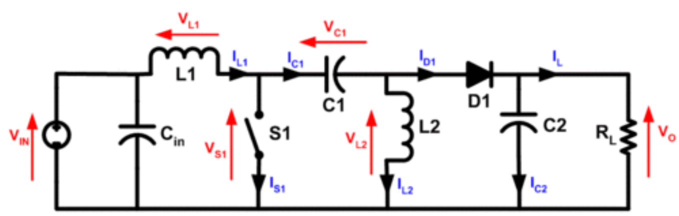


Figure 3. Circuit operation

The schematic diagram for a basic SEPIC is shown in Figure 1. As with other switched mode power supplies (specifically DC-to-DC converters), the SEPIC exchanges energy between the capacitors and inductors inorder to convert from one voltage to another. The amount of energy exchanged is controlled by switch S1, which is typically a transistor such as a MOSFET. MOSFETs offer much higher input impedance and lower voltage drop than bipolar junction transistors (BJTs), and do not require biasing resistors as MOSFET switching is controlled by differences in voltage rather than a current, as with BJTs).

V. Proportional- Integral (PI) Control

A **PI Controller** (proportional-integral controller) is a special case of the PID controller in which the derivative (D) of the error is not used.

The combination of proportional and integral terms is important to increase the speed of the response and also to eliminate the steady state error.

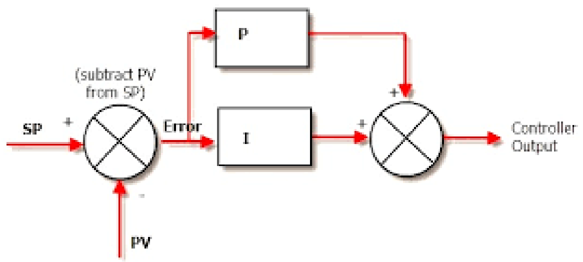


Figure 4 : Proportional Integral (PI) Controller block diagram

The proportional and integral terms is given by:

$$u(t) = K_p e(t) + K_i \int e(t)dt$$

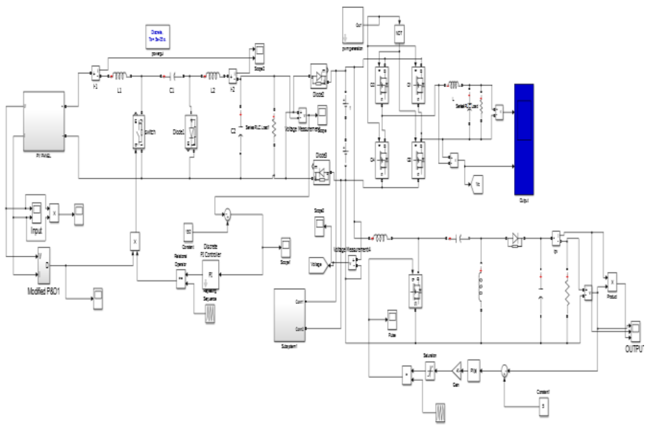
K_p and K_i are the tuning knobs, are adjusted to obtain the desired output. The following speed control example is used to demonstrate the effect of increase/decrease the gain, K_p and K_i

PI-controlled system is less responsive to real (non-noise) and relatively fast alterations in state and so the system will be slower to reach set point and slower to respond to perturbations.
Proportional action: responds quickly to changes in error deviation.
Integral action: is slower but removes offsets between the plants output and the reference.

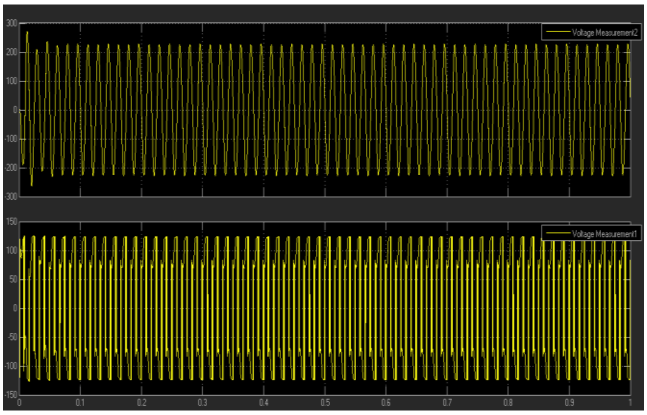
Tuning PI Controllers General approach to tuning:

1. Initially have no integral gain (TI large)
2. Increase KP until get satisfactory response
3. Start to add in integral (decreasing TI) until the steady state error is removed in satisfactory time (may need to reduce KP if the combination becomes oscillatory)

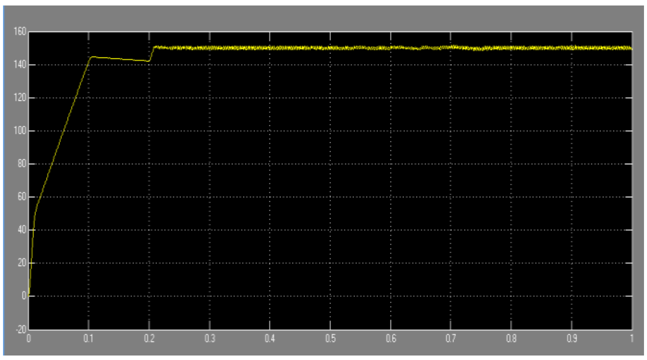
VI. SIMULATION RESULTS



AC OUTPUT: (INVERTER OUTPUT)



CONVERTER OUTPUT:



VII. CONCLUSION

This paper analyses thoroughly the operations of a bi-directional EV charger for grid connected electric vehicle applications. The framework of the paper is vehicle to grid (V2G), vehicle to home (V2H) and grid to vehicle (G2V) and modes of operations. The great challenges behind the three modes of operations is discussed clearly. Experimental results for both simulation and hardware implementations are obtained with improved efficiency.

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