AN IMPROVED ENERGY MANAGEMENT STRATEGY FOR A DC MICROGRID INCLUDING ELECTRIC VEHICLE FAST CHARGING STATIONS

BHUKYA ARUNA[1], V.PRASHANTH[2]

[1]M.Tech Student, Department Electrical and Electronics Engineering, Vinuthna Institute of Technology & Science, Hasanparthy (Mdl), Warangal, Dist, Hasanparthy, Telangana 506371
[2]Assistant professor, Department Electrical and Electronics Engineering, Vinuthna Institute of Technology & Science, Hasanparthy (Mdl), Warangal, Dist, Hasanparthy, Telangana 506371

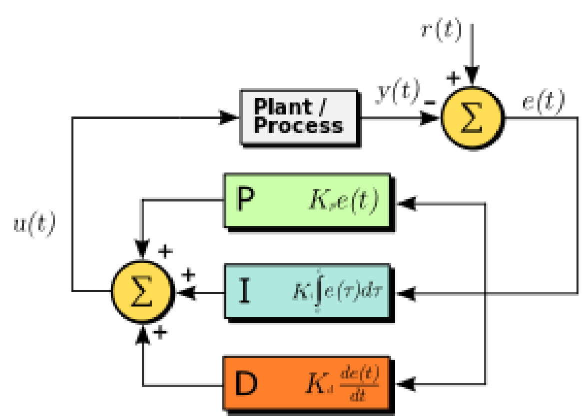
Abstract *The number of electric vehicles (EVs) on the road is expected to continue to increase during the next decades due to various factors such as the rapid progress in EV technology and decreasing battery prices. The prolonged battery charging process, which is one of the main problems that affects the increased EV penetration, makes the fast-charging units more attractive and efficient option for the charging stations.*

In this study, a control strategy for a DC microgrid including electric vehicle fast charging station (EVFCS) and distributed generation units is presented to examine the impacts of EVFCS on the grid as well as their potential contributions to the system operation in the case of considering the vehicle-to-grid (V2G) technology.

It is especially aimed to mitigate the voltage sag and swell problems by using the EV battery as a DC source of a distribution static compensator (D-STATCOM) device. Simulation studies in MATLAB Simulink/Sim Power systems show that considerable improvements can be achieved from the perspective of distribution system operation such as improved voltage quality and from the perspective of end users such as decreased charging durations.

I INTRODUCTION

P-I controller is mainly used to eliminate the steady state error resulting from P controller. However, in terms of the speed of the response and overall stability of the system, it has a negative impact. This controller is mostly used in areas where speed of the system is not an issue. Since P-I controller has no ability to predict the future errors of the system it cannot decrease the rise time and eliminate the oscillations. If applied, any amount of I guarantees set point overshoot.



PID controller

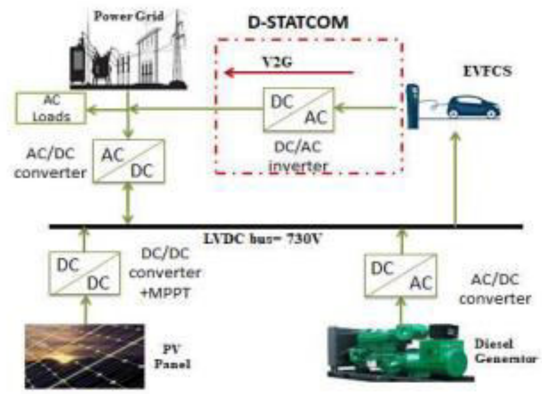
II SYSTEM DESCRIPTION

A DC microgrid is considered in the study due to its advantages for EVFCSs compared to AC microgrid on especially improving the peak performance of the public grid without increasing the grid capacity. Besides, PV arrays are deployed as distributed generation units in the proposed structure since the installation of wind turbines necessitates the availability of adequate locations and large premises, which is a major challenge in urban areas.

Also, the prospects of using PV power for charging applications are very diverse as the power production from PV arrays offers greater flexibility for the integration with the EVFCSs while the unstable nature of wind speed makes it less granulated for charging applications as compared to PV systems.

In addition, a diesel generator connected to the PV source is used to provide the necessary means of support to the PV system at various time intervals. The coordinated operation of the PV-diesel generator offers a reasonable way to eliminate the need for energy storage device in terms of the system economics.

In this study, a low-voltage DC microgrid including EVFCS and distributed generation units is considered as shown in Fig. 1. The proposed system uses a solar PV array with standard conditions (1000W/m2 irradiance, 25oC temperature), a diesel generator set and grid energy to charge the EVs connected to EVFCS. The proposed system parameters are given in Table I.



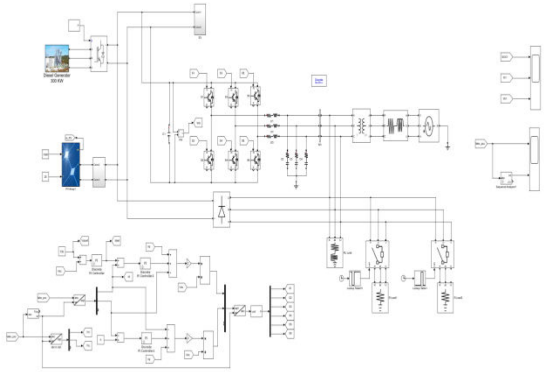
Schematic diagram of the proposed system

Parameter	Values	Parameter	Values
P_{PV}	170 kW	X/R ratio	7
P_{diesel}	300 kW	P_{EV}	103.8 kW
V_{bat}	480 V	Battery capacity	100 Ah
V_{grid}	400 V	Battery initial *SOC*	60%
f_{grid}	50 Hz	Battery response time	1e-3 Sec

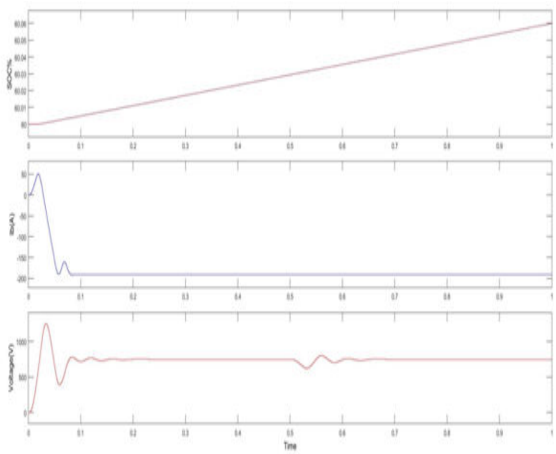
The detailed model of PV arrays and diesel generator can be found in [19], [20]. In the proposed model structure, the PV string is connected to the DC link through a DC/DC converter and the EVFCS is linked to the DC bus through bidirectional DC/DC charger. The electrical grid, diesel generator and other loads are connected to the DC link through individually controlled AC/DC inverters. The inverters' control are modulated in this system through the pulse width modulation (PWM) signals generated by the inner current and voltage loop PI controller based on the design introduced in [21].

It is noted that a PWM-PI controller is used in the proposed model structure since it is one of the most widely used methods in the control of inverter-based microgrids; however, any improved method such as model predictive control can be easily implemented for different objectives.

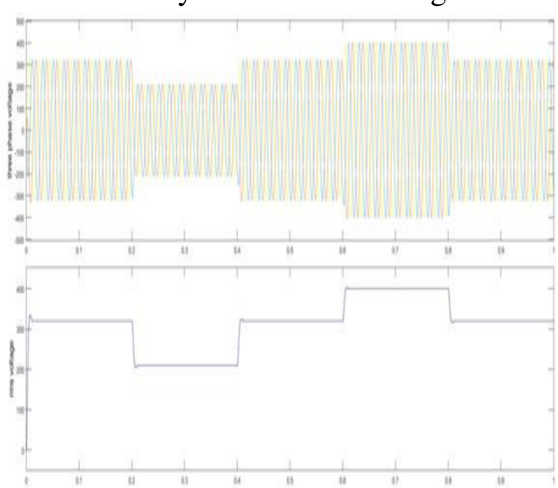
III SIMULATION RESULTS



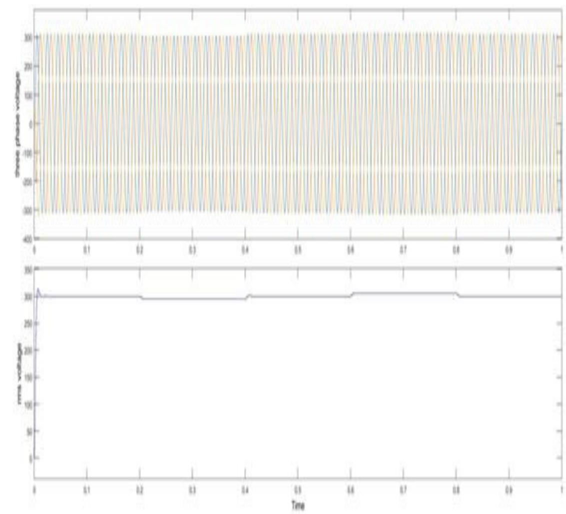
Simulation model



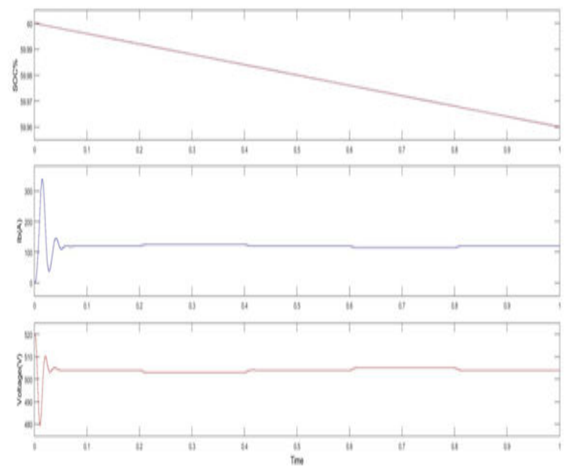
Battery charge conditionds1.state of charge 2.battery currents and voltages



Phase voltage and 2.RMS voltage



Three phase voltages and RMS voltages



1. state of charge 2. Battery currents and

3.voltage.

IV CONCLUSIONS

This study presents the idea of using a simplified model of decentralized PI control with renewable energy for fast charging modes in order to reduce grid reliance and make the system less polluted. The PI controllers are used to control the converters of two system components independently to achieve a coordinated operation. Besides, the idea of using an EV battery as a DC source for a D-STATCOM device to mitigate voltage sag/swell is considered in this paper. The D- STATCOM is built by integrating the PI control system and the implementation of the model in MATLAB/Simulink and SimPower Systems is described in detail. The results of the simulation studies conducted show that the proposed V2G system can be utilized to effectively overcome the power quality problems by reducing voltage sag and swell problems. As a future direction, the effectiveness of the proposed strategy is planned to be validated in a larger power grid including a higher number of components.

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