Available online at: http://www.ijmtst.com/vol6issue03.html
International Journal for Modern Trends in Science and Technology
ISSN: 2455-3778 :: Volume: 06, Issue No: 03, March 2020

ANN Controller Based Electrical Vehicle Charging Station

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To Cite this Article
N Venkateswara Reddy, Y Srikanth, K Sai Kumar and Syed Abdul Mujeer, "ANN Controller Based Electrical Vehicle Charging Station", *International Journal for Modern Trends in Science and Technology*, Vol. 06, Issue 03, March 2020, pp.:230-235.

Article Info
Received on 26-February-2020, Revised on 05-March-2020, Accepted on 11-March-2020, Published on 23-March-2020.

ABSTRACT

This paper proposes an electric vehicle (EV) charge-discharge management framework for the effective utilization of photovoltaic (PV) and Wind power output through coordination based on information exchange between home energy management system (HEMS) and grid energy management system (GEMS). In our proposed framework, the HEMS determines an EV charge discharge plan for reducing the residential operation cost and PV With wind curtailment without disturbing EV usage for driving, on the basis of voltage constraint information in the grid provided by the GEMS and forecasted power profiles. Then, the HEMS controls the EV charge-discharge according to the determined plan and real-time monitored data, which is utilized for mitigating the negative effect caused by forecast errors of power profiles. The proposed framework was evaluated on the basis of the Japanese distribution system simulation model. The simulation results show the effectiveness of our proposed framework from the viewpoint of reduction of the residential operation cost and PV curtailment.

KEYWORDS: *Electric vehicle, charging management, grid management system, ANN Controller.*

I. INTRODUCTION

Reduction of CO_2 emissions to prevent global warming is a worldwide challenge. Electricity will account for almost a quarter of the final energy consumption by 2040 [1]; the power sector is needed to lead the way toward a decarbonized energy system. In Japan, in addition to CO2 emissions,primary energy self-sufficiency is a large issue. Energy self sufficiency has stayed at only 6% after the Great East Japan earthquake and the Fukushima Daiichi accident in 2011. In order to break down this emergency, the government is aiming to increase it to approximately 25% by 2030 [2]. On the other hand, the amount of CO2 emissions was 201 million only in the household sector in 2013, and the aim is to reduce this volume by 39.3% by 2030.

II. OVER VIEW

SMES is initially conceived as load leveling devices that is it is used to store energy in bulk and also to smoothening the utility's daily peak demand. In SMES, the electricity is stored by circulating a current in a superconducting coil. Because of no conversion of energy to other forms is involved, its efficiency is very high. SMES can respond very rapidly to absorb or receive power from the grid/load. Because of its fast response, SMES can provide benefit to a utility not just as a load-leveling device, but also for enhancing transmission line stability and power quality. So SMES can be viewed as a Flexible Transmission system (FACTs) SMES applications in Transmission Substation are: Transmission Stability, Voltage/VAR Support. Load Leveling. SMES applications in Generation System are: Frequency Control, Spinning Reserve, Dynamic Response The basic principle of SMES is to store energy in the magnetic field generated by a dc current flowing through the coiled wire. Magnetic field produces heat when normal wire is used for wounding the coil. The coil is a DC device, the charge and discharge are usually done through an AC utility grid, so a power conditioning system (PCS) is required as the interface. PCS can use a standard solid state DC/AC converter for transferring the power back and forth between the superconducting coil and load/grid. The PCS interfaces the superconducting magnet (DC) with the utility grid (AC).The DC/AC conversion is done using through inverter/rectifier composed of SCR and GTO arrangement with a specified duty cycle.

GRID:

The microgrid concept, that is defined as a low-voltage system having a cluster of loads and generators capable of providing the stable electricity to the localised area, is regarded as an effective system formation to enhance the renewable power penetrations [3]. Due to the variable nature of renewable, the generated power profile may not be able to match the load requirement. Accordingly, much attention has been focused on the development of energy storage technologies to compensate the power disturbances and maintain the system stability [6]. The battery storage system (BSS) which has a relatively high level of maturity was reported to be used in the microgrid by many previous works.

III. BATTERY ENERGY STORAGE SYSTEM (BESS)

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smart phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode[2]. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit. It is the movement of those ions within the battery which allows current to flow out of the battery to perform work. Historically the term "battery" specifically referred to a device composed of multiple cells,however the usage has evolved to additionally include devices composed of a single cell.

Principle of Operation

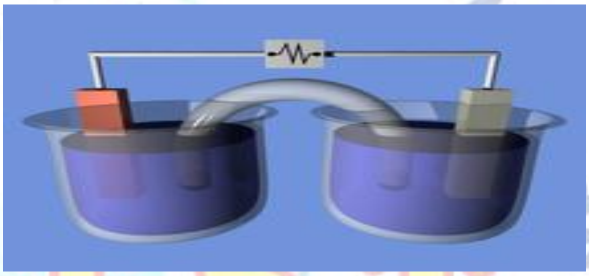

Fig 2.14A voltaic cell for demonstration purposes. In this example the two half-cells are linked by a salt bridge separator that permits the transfer of ions.

Batteries convert chemical energy directly to electrical energy. A battery consists of some number of voltaic cells. Each cell consists of two half-cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the negative electrode, the electrode to which anions (negatively charged ions) migrate; the other half-cell includes electrolyte and the positive electrode to which cations (positively charged ions) migrate. Redox reactions power the battery.

Battery Storage Plant:

A battery storage power plant is a form of storage power plant, which uses batteries on an electrochemical basis for energy storage. Unlike common storage power plants, such as the pumped storage power plants with capacities up to 1000 MW, the benefits of battery storage power plants move in the range of a few kW up to the low MW range - the largest installed systems reach capacities of up to 36 MWh. Battery storage power plants, like all storage power plants, primarily serve to cover peak load and in networks with insufficient control power and the grid stabilization[4].Small battery storage called solar batteries with few kWh storage capacity, are mostly in the private sector operated in conjunction with similarly sized photovoltaic systems to daytime bring revenue surpluses in yield poorer or unproductive hours in the evening or at night, and to strengthen their own consumption. Sometimes battery storage power stations are built with flywheel storage power systems in order to conserve battery power. Flywheels can handle rapid fluctuations better.

Construction

Fig2.15 A rechargeable battery bank used in a data center.

VSC (VOLTAGESOURCE CONVERTER)

Because thyristors can only be turned on (not off) by control action and rely on the external AC system toeffect the turn-off process, the control system only has one degree of freedom – when to turn on the thyristor. This limits the usefulness of HVDC in some circumstances because it means that the AC system to which the HVDC converter is connected must always contain synchronous machines in order to provide the commutating voltage – the HVDC converter cannot feed power into a passive system.

DC-DC CONVERTERS

A DC–DC Converter with a high step-up voltage gain is used for many applications such as high-intensity discharge lamp ballasts for Automobile headlamps, Fuel Cell Energy Conversion systems, Solar Cell Energy Conversion systems and Battery backup systems for Uninterruptible Power Supplies. Theoretically, a DC–DC Boost Converter can achieve a high step-up voltage gain with an extremely high duty ratio. However, in practice, the step-up voltage gain is limited due to the effect of power switches, rectifier diodes and the equivalent series resistance of inductors and capacitors.

IV. PROPOSED SYSTEM

We consider two energy management systems (EMSs), i.e., HEMS, which is composed of a rooftop PV, an EV, and a HEMS controller, and GEMS, which is composed of an on-load tap changer (OLTC) and a GEMS controller. Each EMS controller has automated control of its components, i.e., the EMS controllers can change the parameters of components at pre-set times. In general, these two EMSs is independently operated to meet their own requirements. Minimizing the residential operation cost while securing the EV usage for driving is an important requirement for the HEMS. To minimize the residential operation cost, the HEMS controller will charge the EV when the PV is not generating and discharge it to cover the residential electricity consumption when the PV is generating, selling as much surplus PV output as possible. However, such operations increase the reverse power flow which causes overvoltage in the DS, so that the PV inverter tend to curtail the PV output and expected power sales profit could not be obtained; the residential operation cost will increase. Meanwhile, maintaining the power quality in the power grid is a task for the GEMS. Note that increase of available PV output leads to cost reduction for the GEMS because the power source with high fuel cost will be replaced by PV. Therefore, the reduction of PV curtailment is a common profit for the GEMS and HEMS, and there is potential to expand the mutual profit by coordinating the two EMSs.The following control intends to mitigate the deficiency and excess of charge-discharge amount caused by the difference between the forecasted and actual profiles so as to avoid unnecessary electricity purchase and opportunity loss of surplus PV selling. The rest of this section explains the detailed procedures after the HEMS finishes forecasting the day-ahead power profiles.

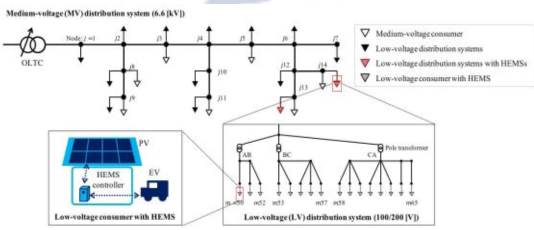

Fig.5.1. Proposed system.

Artificial Neural Network controller:

Artificial neural networks (ANN) or connectionist systems are computing systems that are inspired by, but not identical to, biological neural networks that constitute animal brains. Such systems "learn" to perform tasks by considering examples, generally without programmed with task-specific rules. For example, in image recognition, they might learn to identify images that contain cats by analyzing example images that have been manually labeled as "cat" or "no cat" and using the results to identify cats in other images. They do this without any prior knowledge of cats, for example, that they have fur, tails, whiskers and cat-like faces. Instead, they automatically generate identifying characteristics from the examples that they process.

V. SIMULATION RESULT

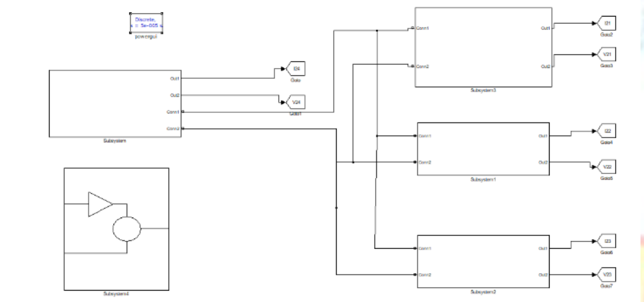

Fig.8.1. Simulation Circuit.

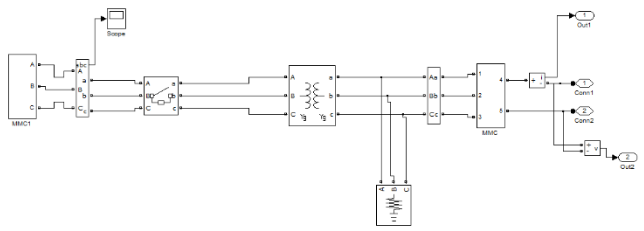

Fig.8.2. Generating station Simulation circuit.

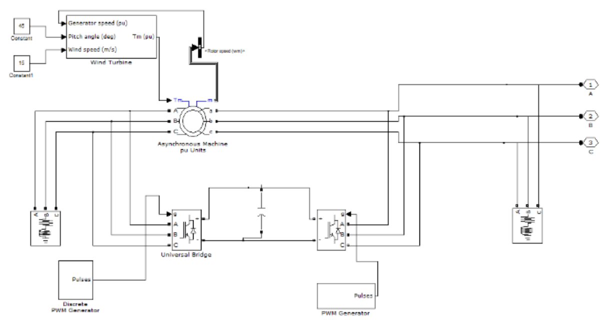

Fig.8.3. Wind power generation circuit.

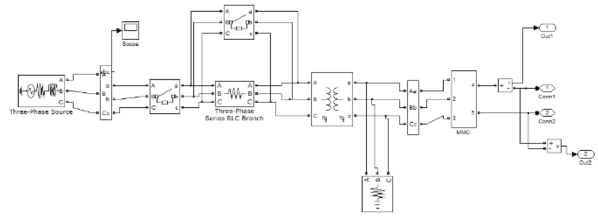

Fig.8.4. Subsystem circuit with phase voltage circuit.

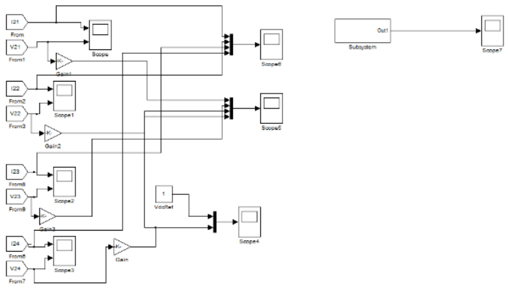

Fig.8.5. Simulation Results with outputs.

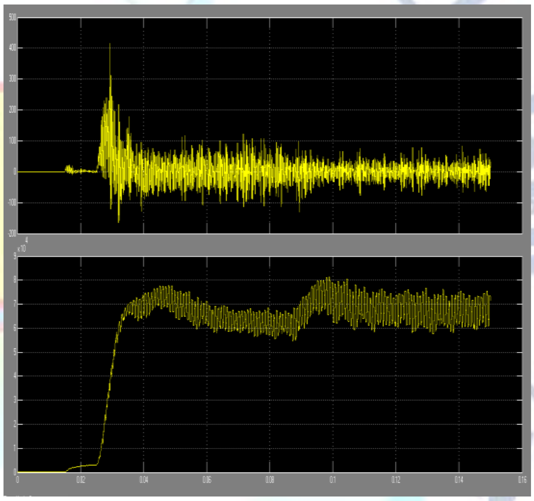

Fig.8.6. Voltage and current across the Subsystem.

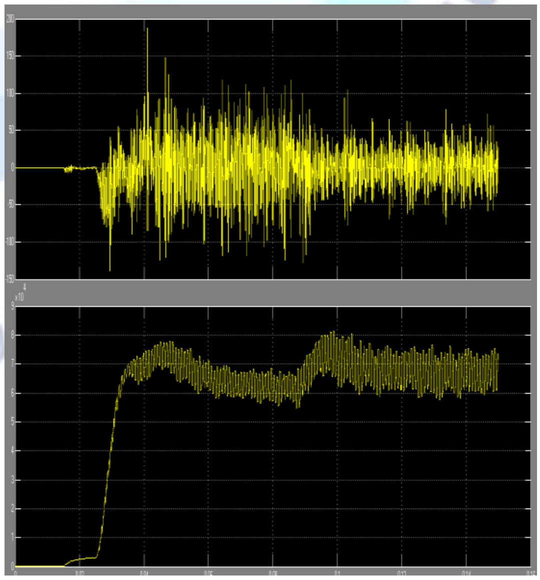

Fig.8.7. Output voltage across the subsystem 2.

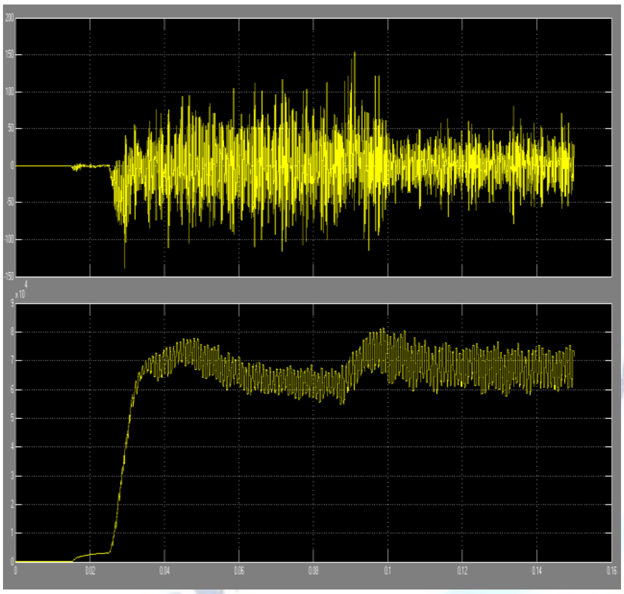

Fig.8.8. Output voltage across the subsystem 3.

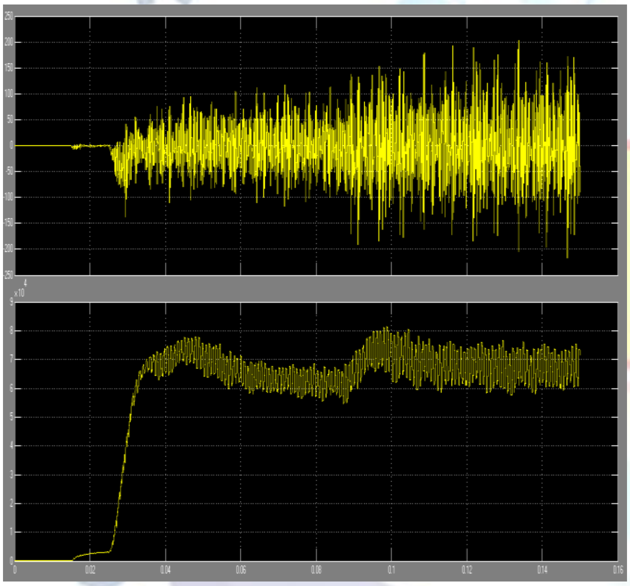

Fig.8.9. OUTPUT ACROSS THE GENERATION STATION.

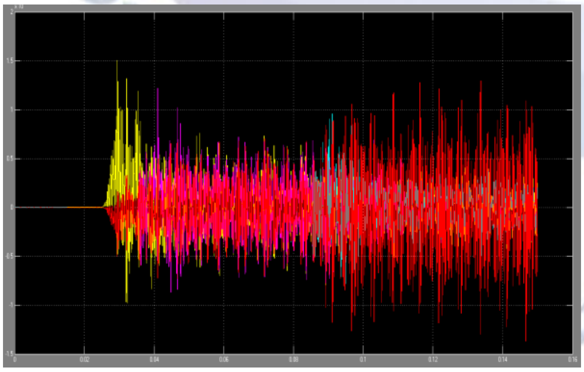

Fig.8.10. Output voltage across the three subsystems.

Extension circuit with ANN controller:

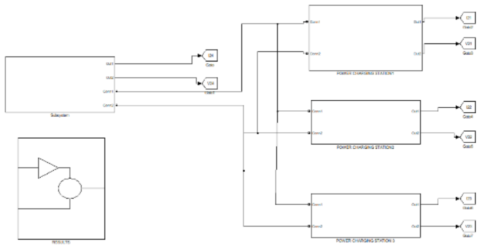

Fig.8.11. Simulation circuit.

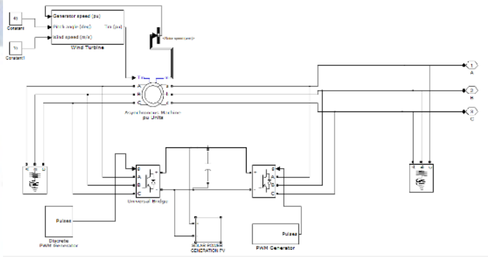

Fig.8.12. Generation system with PV system.

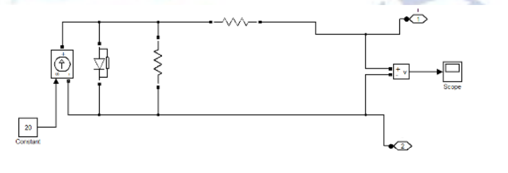

Fig.8.13. PV system circuit.

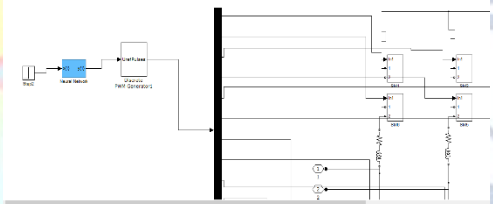

Fig.8.14. ANN controller circuit

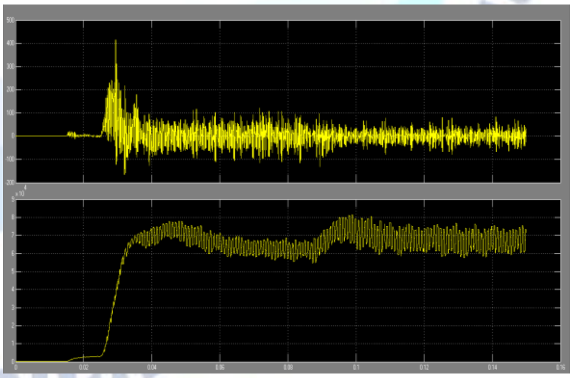

Fig.8.14. Voltage and current across the generation station1

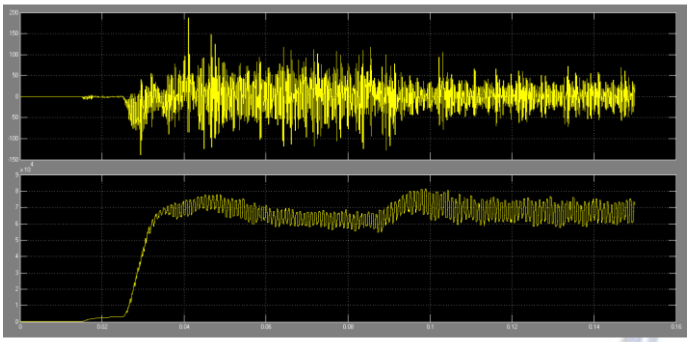

Fig.8.15. Voltage and current across the generation station2

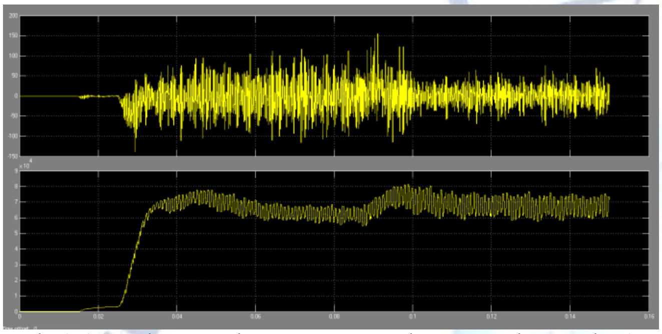

Fig.8.16. Voltage and current across the generation station3

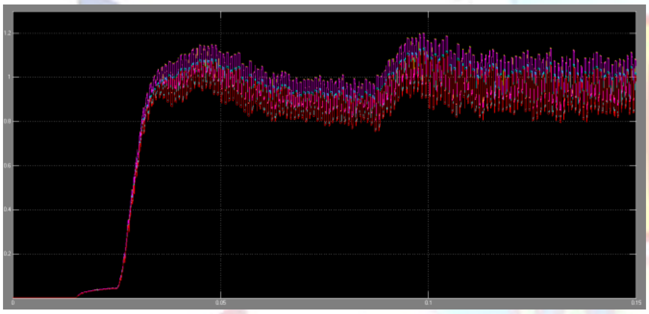

Fig.8.17. Output results.

VI. CONCLUSION

We proposed a coordinated EV charge discharge management framework. The coordination is based on the information exchange between the HEMS and GEMS. The proposed framework determines a daily EV charge-discharge plan on the basis of the exchanged information and day-ahead forecasted power profiles to ensure the adequate free capacity for charging the curtailed PV during the daytime and the charged capacity for the scheduled EV drive. We also proposed a following control scheme. The scheme controls the EV charge-discharge amount following to the realtime monitored data for mitigation of the deficiency and excess of charge-discharge amount caused by the forecast errors. The effectiveness of the proposed framework was evaluated using a DS simulation model from the viewpoint of the residential operation cost and the amount of PV curtailment. The simulation results implied that the proposed framework achieves to reduce the residential operation cost and the PV curtailment by the information exchange and the following control.

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