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An ANN Based SMES Implanted Smart Grid for EV Charging Station

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ABSTRACT

The battery lifetime of an electric vehicle (EV) has significant impact on the development of EV. In this paper a method with Superconducting Magnetic Energy Storage (SMES) is used to improve the battery lifetime of EV. The SMES is stabilizing the EV charging system voltage to improve battery life and charge efficiency on a smart grid. To verify the influence of the controlled SMES improves the system transient stability, situations under load fluctuation and fault, and the SMES capacity for system compensation have been investigated. The results obtained from the analysis indicate the compensating instantaneous voltage dip in the grid and improving the power system quality. So SMES increasing the power quality and stability of the EV system. In extension we are using ANN controller to generate the triggering pulses. The ANN circuit will be control the input and outputs.

KEYWORDS: *Electric Vehicle, SMES, Energy storage systems, ANN, Smart Grid*

I. Introduction

The concept of Smart grid has offered consumers with increased reliability and reduction in total energy losses, and has become a promising alternative for traditional power distribution system. One area of study for the connection of a Smart grid to the distribution grid is the impact of power quality (PQ) problems on the overall power system performance. These PQ problems include voltage and frequency deviations in the grid voltage and harmonics in the grid voltage and load currents. To overcome the aforementioned PQ problems, several power-conditioning equipment's such as active filters, uninterruptible power supplies, dynamic voltage restorers, and unified PQ conditioners are usually employed by consumers to protect their loads and systems against PQ disturbances in the distribution network. However, these devices are usually installed at the consumer sides and the PQ problems that they are capable to handle are usually limited.

A. *RESEARCH BACKGROUND*

Electric vehicles are principal choice for green transportation .Electric vehicle (EV) technology is recognized by many countries as a key component to reduce harmful green-house gas emissions. The main component of greenhouse gas is carbon-di-oxide. Burning one gallon of gas creates 20 pounds of carbon dioxide, and the average car emits about six tons of carbon dioxide every year.

So zero-emission battery-powered electric vehicles (EVs) are making the road transport system to green transportation system. So the demand of EV increases. The EV development will result in more and more EV- charging-stations being built in the near future.

B. OVER VIEW

SMES is initially conceived as load leveling devices that are 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.

C. SMART GRID:

The micro grid concept, that is defined as a low-voltage system having a cluster of loads and generators capable of providing the stable electricity to the localized 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 micro grid by many previous works

II. LITERATURE SURVEY

A. SMES MODELING:

There are two classes of SMES model-Current Source Converter (CSC) and Voltage Source Converter (VSC) based on the different connection way of converter. Both converters used to control power exchange between the system and power into the system SMES by independently adjusting its active and reactive. The main requirement of converter in the power transmission system is to control the active and reactive power flow to maintain its system voltage stability. It is achieved by the electronic converter and the electronic convert electrical energy from AC to DC. For VSC, the input voltage is kept constant and output voltage is independent of load.

B. 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.

Principle of Operation:

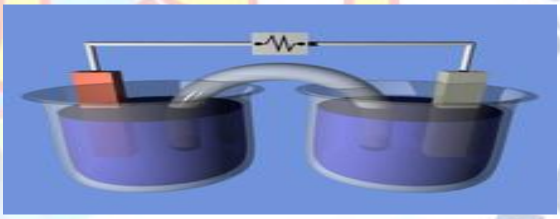

Figure 2.1. A voltaic cell for demonstration purposes. In this example the two half-cells are linked by a salt bridge separator that permits the transfer of ions.

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 cat ions. 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 cat ions (positively charged ions) migrate. Red ox reactions power the battery. Cat ions are reduced (electrons are added) at the cathode during charging, while anions are oxidized (electrons are removed) at the anode during charging. During discharge, the process is reversed. The electrodes do not touch each other, but are electrically connected by the electrolyte.

Some cells use different electrolytes for each half-cell. A separator allows ions to flow between half-cells, but prevents mixing of the electrolytes.

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:

Figure 2.2. A rechargeable battery bank used in a data center.

Installation:

Manufacturers provide detailed installation guidelines to ensure correct functioning, reliability and low maintenance costs. There are a range of different styles of generators for camping, RV's standby power, and portable commercial applications. When purchasing a generator online you must ensure that the product comes with installation guidelines and that ts stipulated within the product description. Guidelines cover such things as:

- Sizing and selection - typical loads of electrical devices, expected load for the application
- Electrical factors - Peak loads versus steady and allowing for certain applicances
- Cooling - Engine cooling during the power generation process
- Ventilation - Allowing air flow during the cooling process (design)
- Fuel storage - How long will the generator run for at a specific usage rate
- Noise - dB levels to be expected for specific models
- Exhaust – ppm (parts per million) levels of certain element, consider the environment and those around the generator
- Starting systems - key start, pull start, button start - lots of options.

RIPPLE FILTER:

A low-pass filter (LPF) is a filter that passes signals with a frequency lower than a selected cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency. The exact frequency response of the filter depends on the filter design. The filter is sometimes called a high-cut filter or treble-cut filter in audio applications. A low-pass filter is the complement of a high-pass filter.

C. *Electronic low-pass filters:First order* RC Filter:

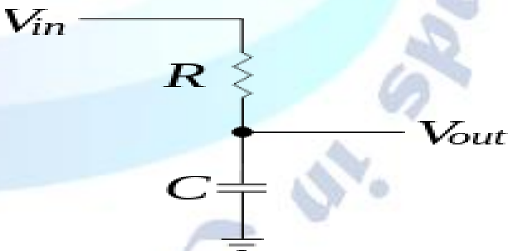

Figure 2.6. Passive, first order low-pass RC filter.

Parallel with the load. The capacitor exhibits reactance, and blocks low-frequency signals, forcing them through the load instead. At higher frequencies the reactance drops, and the capacitor effectively functions as a short circuit. The combination of resistance and capacitance gives the time One simple low-pass filter circuit consists of a resistor in series with a load, and a capacitor in constant of the filter (represented by the Greek letter tau). The break frequency, also called the turnover frequency or cutoff frequency (in hertz), is determined by the time constant or equivalently (in radians per second).

RL Filter:

A resistor–inductor circuit or RL filter is an electric circuit composed of resistors and inductors driven by a voltage or current source. A first order RL circuit is composed of one resistor and one inductor and is the simplest type of RL circuit. A first order RL circuit is one of the simplest analogueinfinite impulse responseelectronic filters. It consists of a resistor and an inductor, either in series driven by a voltage source or in parallel driven by a current source.

Second order: RLC filter:

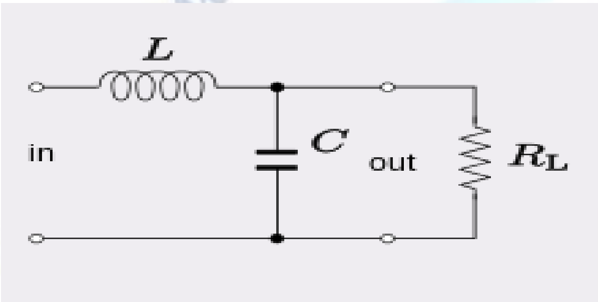

Figure 2.7. RLC circuit as a low-pass filter.

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.

Operating principle:

The key principle that drives the Boost Converter is the tendency of an inductor to resist changes in current. In a boost converter, the output voltage is always higher than the input voltage. A schematic of a boost power stage is shown in Figure 2.11. When the switch is closed, current flows through the inductor, which stores energy from the current in a magnetic field. During this time, the switch acts like a short circuit in parallel with the diode and the load, so no current flows to the right hand side of the circuit.

III. PROPOSED SYSTEM

The tremendous development in the entrance of electric vehicles (EVs), has laid the way to headways in the charging foundation. Availability between charging stations is a fundamental essential for future EV selection to lighten client's "range tension". The current charging stations neglect to embrace control arrangement, designation and planning administration. To enhance the current charging framework, information in view of constant data and accessibility of stores at charging stations could be transferred to the clients to enable them to find the closest charging station for an EV. The spotlights is on an intuitive client application created through stage to apportion the charging spaces in view of assessed battery parameters, which utilizes information correspondence with charging stations to get the opening accessibility data. The proposed server-based continuous gauge charging foundation abstains from holding up times and its planning administration productively keeps the EV from stopping out and about because of battery deplete out. The proposed show is actualized utilizing a minimal effort microcontroller and the framework decorum tried.

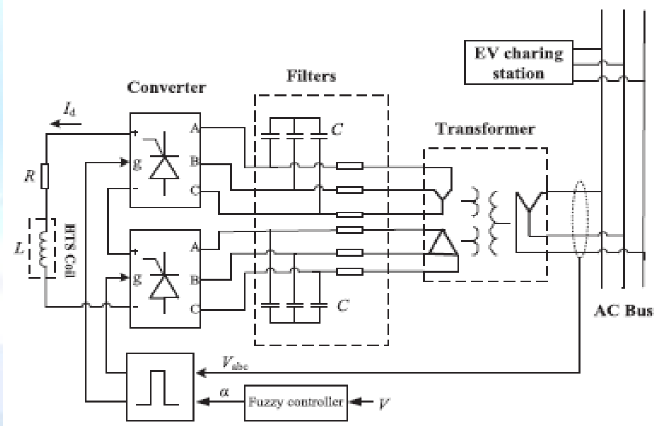

Figure 3.1. Proposed system Block diagram.

TABLE II
PARAMETERS OF SMES

Parameter	Value
HTS material	Bi 2223
HTS inductance (L)	2 H
Filter capacitance(C)	0.03 F
Snubber resistance (R_s)	1×10^5 Ω
Turn-on resistance (R_1)	1×10^{-3} Ω
Lossy resistance (R_L)	1×10^{-5} Ω
Load resistance (R)	2 Ω

The configuration of the proposed power system is a smart grid with EVs, which is shown in Figure 3.2. This system consists of a synchronous generator (SG), an EV aggregated grid, a CSC based SMES and an insensitive load. The CSC based SMES is connected to the EV aggregated grid to allow the power flow to be effectively regulated. The transient simulation analysis is carried out and the system dynamic performances are simulated under balanced fault (three-phase to ground fault) conditions. The dynamic equation of the SG can be expressed as follows

$$\frac{M}{\omega}\frac{d^2\delta}{dt^2} + \frac{D}{\omega}\frac{d\delta}{dt} = P_m - P_e,$$

Where M and D is the inertia constant and the damping coefficient, Pm and Pe are the mechanical power and electromagnetic power, and δ and ω are the load angle and rotor speed, respectively. When the fault occurs, Pm is greater than Pe .So the load angle δ will increase until the SMES starts to work.

IV. MATLAB/SIMULATION

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include-

- Math and computation
- Algorithm development
- Data acquisition
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization

Scientific and engineering graphicArtificial 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.

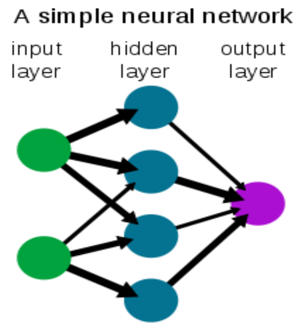

Figure 4.16 : A Simple Neural Network.

V. SIMULATION RESULT

5.1. BASE CIRCUIT:

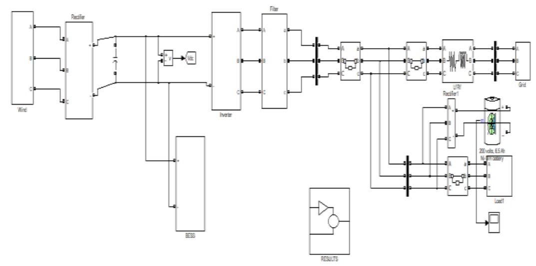

Figure 5.1. Simulation circuit.

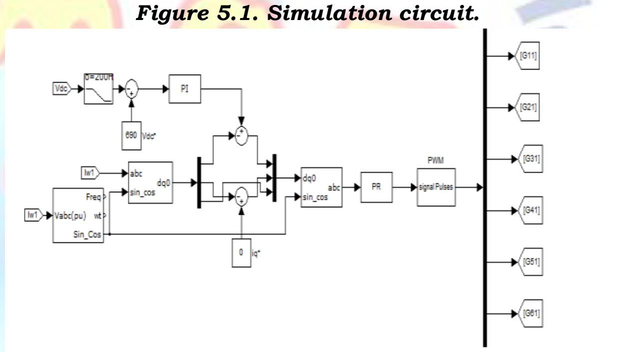

Figure 5.2. PI Controller circuit.

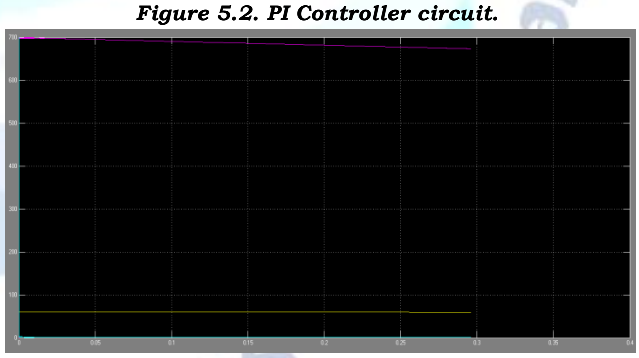

Figure 5.3. Battery output across the vehicle.

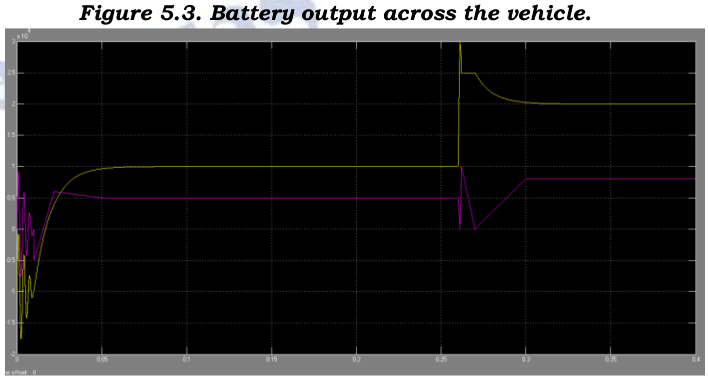

Figure 5.4. Power quality across the output of inverter.

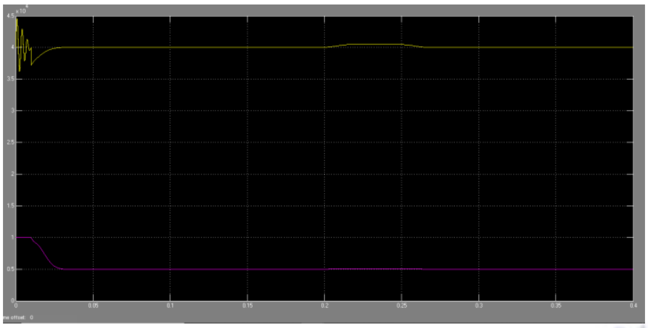

Figure 5.5. Power quality across the Grid.

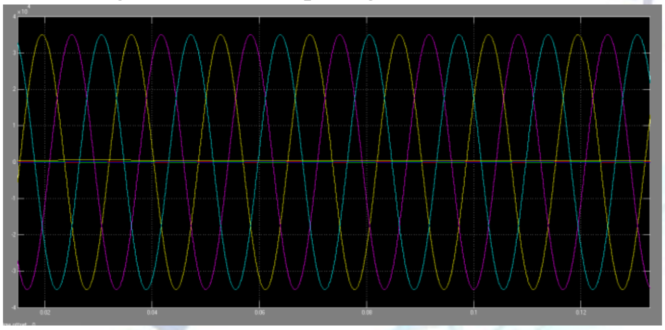

Figure 5.6. Voltage across the Grid.

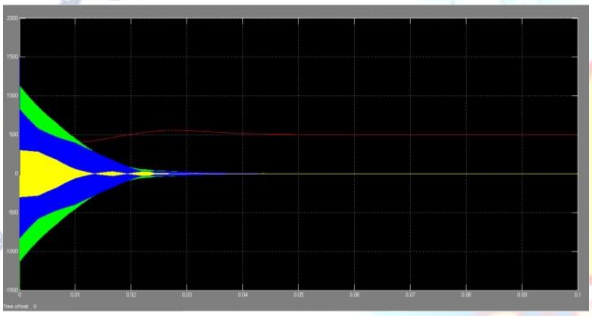

Figure 5.7 Disturbances in Current across the Load side

5.2. EXTENSION CIRCUIT:

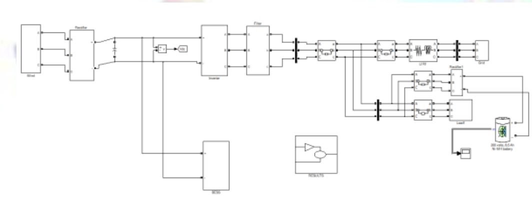

Figure 5.8. ANN circuit with main circuit.

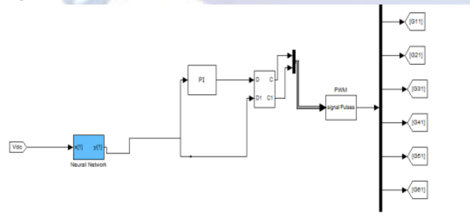

Figure 5.9. ANN controller circuit in control circuit side.

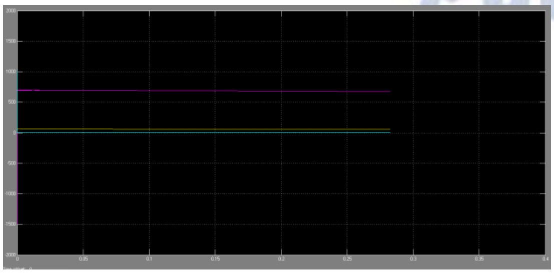

Figure 5.10. Battery voltage and current at output side.

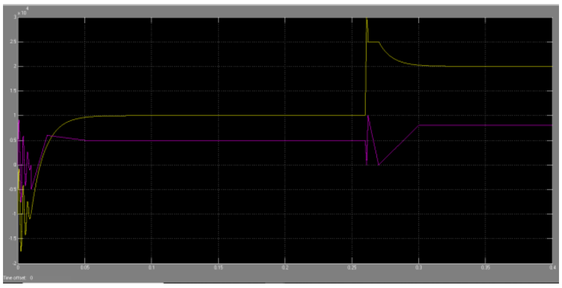

Figure 5.11. Active and reactive power across the inverter.

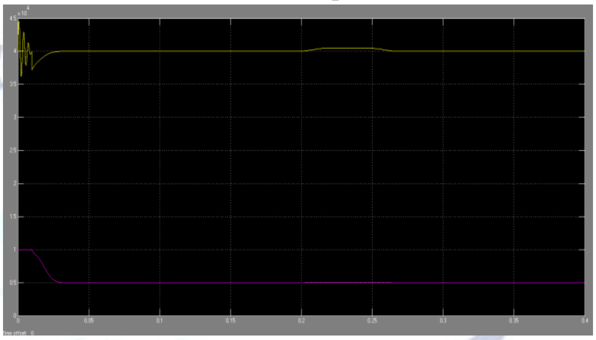

Figure 5.12. Power quality across the grid.

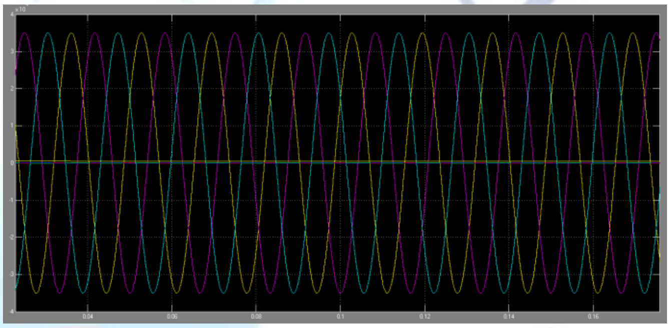

Figure 5.13. Output across the Grid.

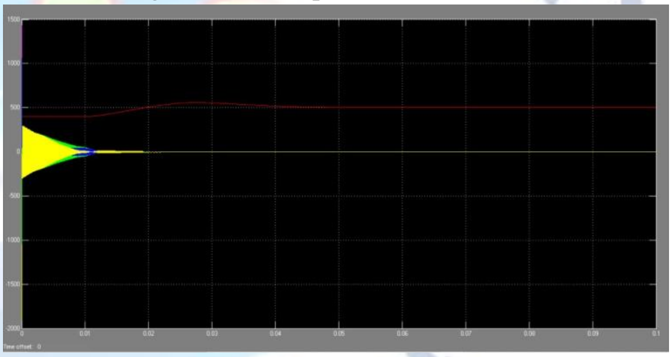

Figure 5.14 Disturbances in Current across the Load side.

VI. CONCLUSION

The effect of using a SMES unit to improve the stability of a power distribution smart grid with EVs has been analyzed. The results obtained show that the use of a SMES unit can smooth the voltage of the EV charging station right after the EVs are connected to the grid. If a fault occurs, the SMES unit is able to respond quickly to restore the load terminal voltage by compensating both active and reactive power of the system and improve system transient stability. The application of a SMES unit has also been confirmed to be able to effectively compensate the instantaneous voltage dip of the load terminal, stabilize power distribution networks with EVs, and improve their power quality.

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