Smart Battery Control for Improved Power System Stability

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BACKGROUND

Smart grids consist of various operational and energy measures such as smart meters, smart appliances, renewable energy resources such as solar panels, as well as energy efficiency resources like plug-in electric vehicles and rechargeable home batteries.

As more plug-in electric vehicles (PEV) and home batteries come into use, there are potential problems as well as promise for the efficient operation of the grid. For example, too many PEVs charging at the same location can overload the local grid. In addition, there will be a problem when PEV drivers come home from work, start charging their cars while turning on high-wattage electronic devices such as air conditioner or water heater. On the other hand, PEVs are mostly commuter vehicles that are idle for most of the day just like home batteries; they can both act as part of the grid, transferring energy to the grid when demand is high as well as absorbing excess electricity from the grid. There's a need to better regulate such bidirectional transfer of energy and maintain load balancing.

TECHNOLOGY DESCRIPTION

UC San Diego researchers are proposing an economical battery charger and inverter that improves stability and reduce system disturbances while controlling energy transfers between home batteries (HB) and plug-in electric vehicles (PEV) and the power grid.

The control mechanism is based on local frequency values, which are measured with a low-cost peripheral interface controller (PIC) that can also be used to regulate the power exchange rate. A decrease in frequency signals a power shortage, thus batteries are instructed to feed additional power to the grid, in essence acting as small generators.

By regulating the power output of the batteries the researchers showed that: 1) frequency and voltage fluctuations following a disturbance are reduced up to 80%; 2) the system takes up to 11 times less time to stabilize; the critical clearing time is extended by 40%; 3) steady-state stability is improved; the region of asymptotical stability expands; and the system becomes more robust overall. Furthermore, since the regulatory actions following large disturbances usually last only a few seconds, the effects of power regulation on the vehicle's energy reserves is minimal.

Another novel aspect of this control mechanism is that the algorithm is implemented locally and only relies on local frequency values; this is a significant departure from most current approaches in smart grid that rely on a centralized entity that to manage and control a series of devices.

In summary, by ways of smart local control of home batteries and plug-in electric vehicles, power grid stability can be improved using only local frequency values. The use of our control strategy results in improved steady-state stability, larger region of stability, reduced frequency and voltage fluctuations, faster stabilization and longer critical clearing times.

More technical details can be found at this draft publication.

http://arxiv.org/pdf/1506.07097.pdf

APPLICATIONS

This technology can potentially be used to enhance the efficiency and stability of smart grids.

STATE OF DEVELOPMENT

CONTACT

University of California, San Diego
Office of Innovation and Commercialization
innovation@ucsd.edu
tel: 858.534.5815.

OTHER INFORMATION

KEYWORDS

Keywords: energy, control systems, batteries, electric cars

CATEGORIZED AS

- **Energy**
  - Storage/Battery

RELATED CASES

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UC San Diego researchers propose a battery-to-grid (B2G) extended battery charger that consists of three main blocks: (1) a battery charger, (2) an inverter circuit and (3) a controller that adjust inverter power to the frequency deviation.

The controller block implementation may vary from a very simple frequency counter (such as ICM72161) combined with a custom finite state machine, up to a powerful smart general purpose computer, that offers a web configuration and control interface. The controller block will continuously measure the frequency deviation and switch on/off the charger (via G2B signal) or the inverter (via B2G signal). It will also regulate the inverter's output power based on the measured frequency deviation. Control is done locally with a bidirectional charger (G2B and B2G) using only local frequency values thus avoiding the need for a complex communication infrastructure and centralized control. This way the concerns about the network latency, data privacy and security will be minimal.

PATENT STATUS

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University of California, San Diego
Office of Innovation and Commercialization
9500 Gilman Drive, MC 0910, ,
La Jolla,CA 92093-0910

Tel: 858.534.5815
innovation@ucsd.edu
https://innovation.ucsd.edu
Fax: 858.534.7345