

# Power-Electronics-based Energy Management System with Storage

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**Abstract-**In Today's world energy management system is most important. Power electronics based energy management system used here The EMS includes batteries and a digitally controlled single-phase voltage source inverter (VSI), which can be controlled as a current source or a voltage source depending on the status of the ac grid and the user's preference. The EMS guarantees that the critical loads are powered when the ac grid fails; in which case, the VSI is controlled as a voltage source. It also accomplishes peak power control by supplying battery power to the local loads while they are powered by the ac grid if the loads get large. The electricity cost savings done by peak shaving are estimated.

**Keywords –** EMS, Peak power control, Cost saving, Peak shaving, islanding mode etc.

## I. INTRODUCTION

Energy savings and energy efficiency have become top priorities all around the world, stimulated by the Kyoto protocol and other pressing needs to reduce fossil fuel consumption [1]. Additionally, energy security is a necessity for many installations such as military bases and health care facilities where reducing energy consumption must be accomplished while keeping critical electrical loads serviced at all times. In this paper, A Power-electronics-based energy management system (EMS) is presented to accomplish peak power control in a single-phase power system while guaranteeing continuous service to critical loads at the same time. Peak power control, also known as peak shaving [2], is a method used to reduce the electricity charges for users with time of use (TOU) contracts and those who pay for the demand charges [1]. The power system does not need to be a micro-grid, meaning that distributed generation (DG) does not need to be part of the power system [4].

## II. OBJECTIVE

Objective of This system is

- 1) Peak shaving by tapping the energy storage system during high power demand.
- 2) Islanding or standalone mode of operation when the main AC grid is no longer available.
- 3) Battery charging mode.

## III. ARCHITECTURE OVERVIEW

Critical loads are those loads that must be powered at all times because they are critical to the mission [5]. Noncritical loads are connected in parallel to Vac, however, they can be shed when necessary using a thyristor switch. This increases the control of the power that can be directed to the critical loads when necessary. The ac grid can also be disconnected from if needed to island the operation of the EMS [2]. Typically islanding mode occurs when the ac grid fails. In this mode of operation, power to critical loads is guaranteed by drawing energy from the battery pack [5].

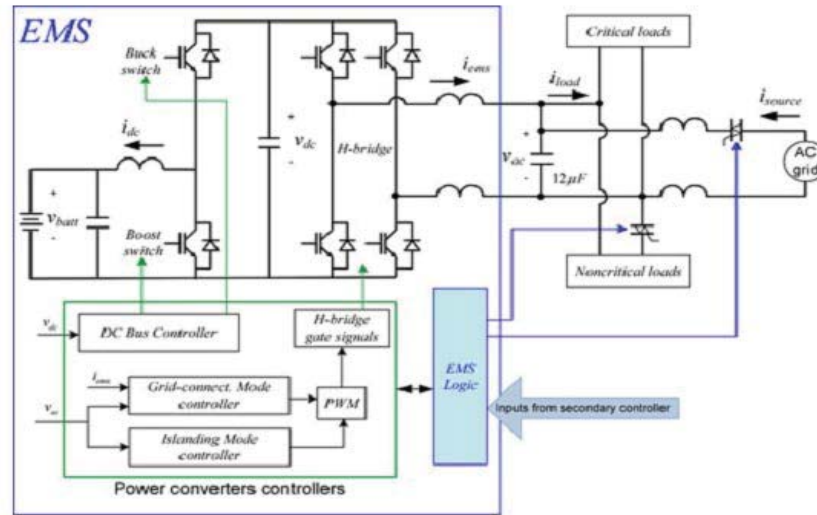


Fig 1 EMS Architecture [5]

The EMS functionality is demonstrated in this paper by experimental validation with a laboratory prototype. The following scenarios are discussed:

- 1) Peak shaving by tapping the energy storage system during high power demand
- 2) Islanding or stand-alone mode of operation when the main ac grid is no longer available;
- 3) Battery charging mode.

In power electronics based energy management system when ac grid is not available, at that time critical load are powered through battery charging.

#### IV. HARDWARE BLOCK DIAGRAM

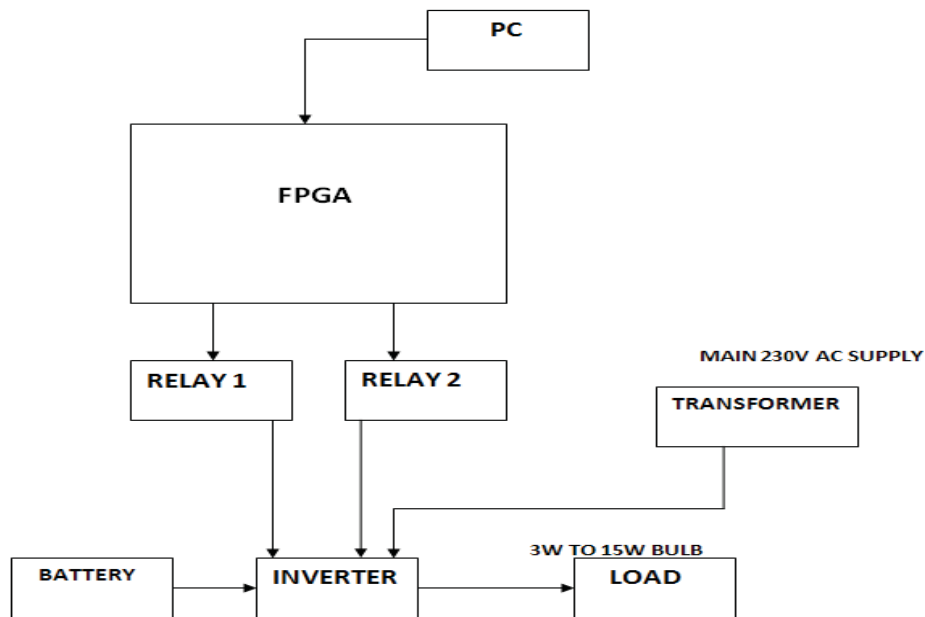


Fig.2 EMS Hardware

#### *4.1 Explanation:*

The FPGA can be used to implement any logic function. The Spartan 6 family of Field-Programmable Gate Arrays is specifically designed to meet the needs of high volume, cost-sensitive consumer electronic applications. The interfacing unit consists of FPGA kit, relays, battery, inverter, load, and transformer. For controlling the energy management PC is used as a controlling unit. From PC we send commands to switch relays, these relays are interfaced with a inverter through which load is operated. A battery is connected to the inverter in order to provide supply to load. Transformer is used to charge the battery. The inverter converts dc supply to ac supply.

#### *4.2 Inverter*

A power inverter, or inverter, is an electronic device circuitry that changes direct current (DC) to alternating current (AC). Power inverter device or circuit requires a relatively stable DC power source capable of supplying enough current for the intended power demands of the system. Here we used a fully transistorized inverter that can drive up to 60W loads.

#### *4.3 Relay:*

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first.

### V. SYSTEM FLOW CHART:

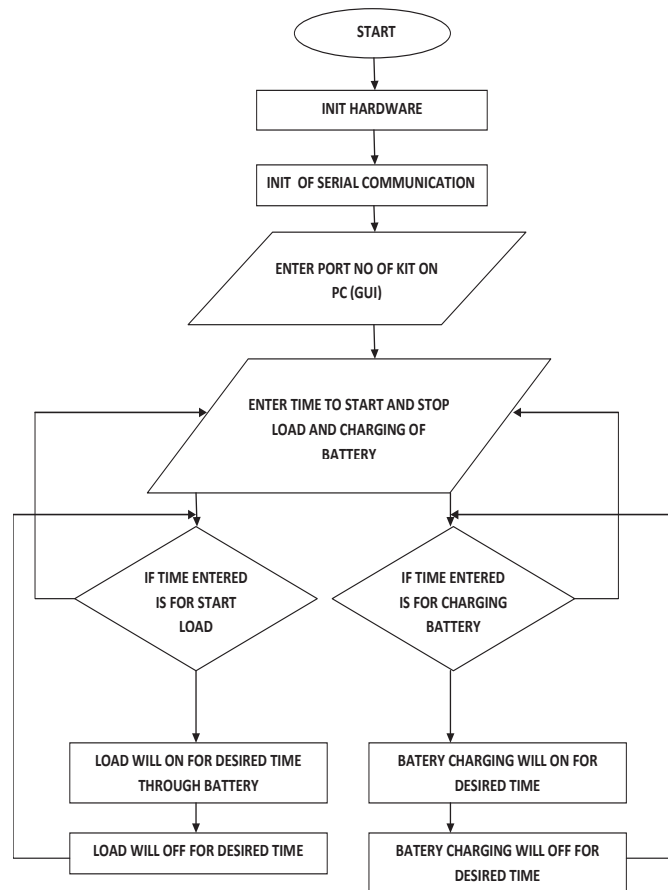


Fig.3 Flow Chart



Fig .4-Implementation Kit:

## VI. RESULT

### A. Peak Shaving and Battery Charging With the AC Grid Connected

Residential and commercial TOU electricity rates include different rates at different time of the day and also demand charges. These rates are devised by the power companies to encourage customer to shift their loads away from the peak demand times and in general reduce their peak power consumption. By reducing the peak power consumption results in significant cost savings [5]. Peak shaving is a known technique used to achieve this objective by use of stored energy. Electrical energy is stored during the times when electricity cost is lowest (typically at night) and used during the times when electricity cost is highest, in order to reduce the overall electricity charges [5].

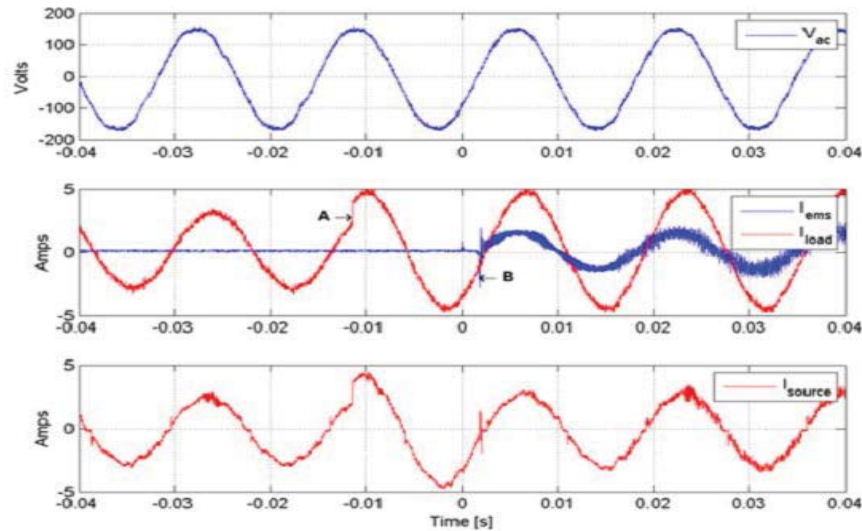


Fig.4 Peak shaving with the EMS providing some of the load current from the battery pack when the load increases [5].

Peak shaving is achieved by controlling the RMS current in the load, which is related to the source current. A threshold is set for the load current, such that when the load RMS current exceeds this threshold; the EMS supplies some of the load current. This keeps the peak current drawn from the ac grid below a set limit. In the laboratory experiments presented here, the threshold for the load current is such that the peak shaving feature turns ON when the load current is greater than 2.2 Arms and turns OFF when the load current is below 2.1 Arms[1].

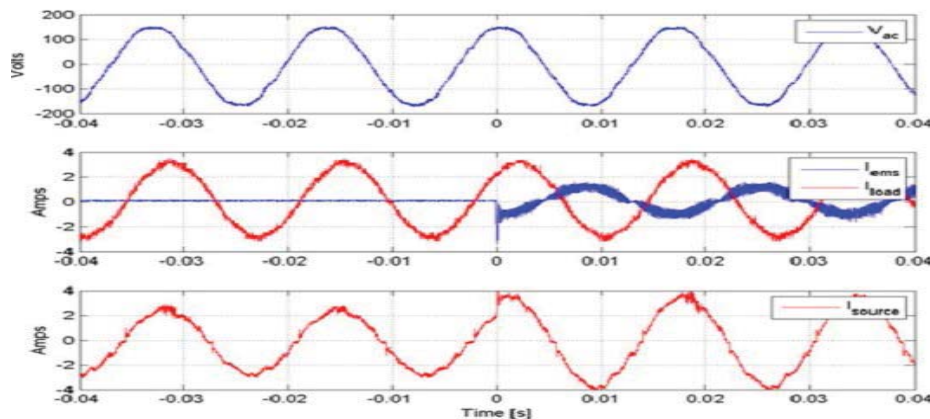


Fig.5 EMS turning ON at  $t=0$  to charge the battery pack [5].

The EMS turns ON to charge the battery at  $t=0$  as demonstrated by the EMS current  $I_{ems}$  being  $180^\circ$  out of phase with respect to the ac voltage. Only linear loads are used for this experiment, because the diode rectifier load is disabled. The battery charging mode of operation is allowed because the load is light, so the EMS does not need to provide an additional current for peak shaving.

#### B. EMS Powering Critical Loads When the AC Grid Fails—Islanding Mode of Operation

In order to provide power to critical loads when the ac grid fails, the EMS detects grid failure and acts as a voltage source for the critical loads. In this mode of operation,

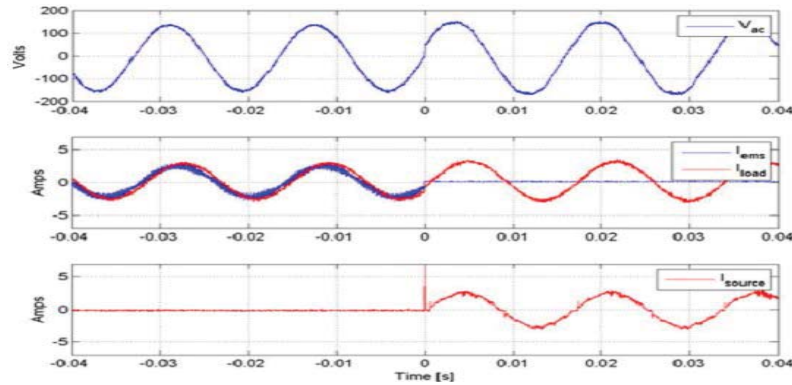


Fig.6 Experimental waveforms showing the ac grid being restored at  $t=0$ [5]

The disturbance in the voltage waveform is noticeable when the EMS reconnects the ac grid to the loads as shown in Fig.5. There is also an inrush current into the diode rectifier because the dc voltage of the rectifier had sagged some during islanding mode. Note that the ac voltage produced by the EMS during the islanding mode is slightly smaller (about 7%) than the ac grid voltage

## VII. OBSERVATIONS

Parameter	Peak shaving	Islanding mode
Battery operation	ON (Charging)	ON (discharging)
EMS current	OFF	ON
Load current	I <sub>source</sub>	I <sub>ems</sub>

Table 1. Experimental results

## VIII. CONCLUSION

By using this technique of energy management system critical load are powered even if AC grid fails. The control system designed to perform the experimental implementation of typical scenarios is presented in this .the EMS supports critical loads when the ac grid becomes unavailable and how the connection to the ac grid is restored by the EMS when the ac grid becomes available again. Additionally, the EMS can have other advantageous tasks such as peak shaving. Experimental measurements with linear and nonlinear loads demonstrate how the EMS, controlled in current mode, provides some of the power to the loads to accomplish peak shaving, thus reducing the cost of electricity.

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