SAND97-1160C

CONF-970953--1

SAND--97-1160C

AMP-HOUR COUNTING CHARGE CONTROL FOR PV HYBRID POWER SYSTEMS

Thomas D. Hund
Sandia National Labs, Albuq. NM

Bruce Thompson
Biri Systems, Ithaca, NY

An amp-hour (Ah) counting lead-acid battery charge control algorithm has been tested using the Digital Solar Technologies MPR-9400 microprocessor based PV hybrid charge controller. Extensive testing was conducted on flooded lead-antimony and valve regulated lead-acid (VRLA) batteries in hybrid system configurations that simulate home power and telecommunications systems. The test results after one-year have shown an improvement in PV charge utilization and charge control over conventional on/off or constant voltage regulated charge control.

This work is supported by the Photovoltaic Energy Technology Division, US Department of Energy, contract DE-AC04-94AL85000

Author of Correspondence
Thomas D. Hund
Sandia National Laboratories
PO Box 5800
Albuquerque, New Mexico 87185-0753
(505) 844-8627
FAX (505) 844-1504
Email: tdhund@sandia.gov

Category: 6. Terrestrial Systems and Applications
Subsection: A. Off-Grid Systems Design, Performance and Experience
The preferred presentation is oral.

Authors & affiliations:

Thomas D. Hund
Tom is a member of the technical staff at Sandia National Labs
Bruce Thompson
Bruce is President of Biri Systems and consultant to Digital Solar Technologies

Amp-Hour Counting Charge Control For PV Hybrid Power Systems

Thomas D. Hund
Sandia National Laboratories
PO Box 5800
Albuquerque, New Mexico 87185-0753

Bruce Thompson
Biri Systems
30 Sodom Rd.
Ithaca, NY 14850

Abstract
The performance of an amp-hour (Ah) counting battery charge control algorithm has been defined and tested using the Digital Solar Technologies MPR-9400 microprocessor based PV hybrid charge controller. This work included extensive field testing of the charge algorithm on flooded lead-antimony and valve regulated lead-acid (VRLA) batteries. The test results after one-year have demonstrated that PV charge utilization, battery charge control, and battery state of charge (SOC) has been significantly improved by providing maximum charge to the batteries while limiting battery overcharge to manufacturers specifications during variable solar resource and load periods.

Introduction
Batteries in stand-alone PV or wind systems are commonly subject to abusive conditions that are generally due to under charging in low resource periods and excessive charging in high resource periods. If in addition to the resource changes, the daily loads change also, then the amount of charge that the battery receives day to day can vary by an excessive amount. Voltage regulated charge control works well when a fixed time at regulation voltage is available for recharge. When the time at regulation voltage changes,

This work is supported by the Photovoltaic Energy Technology Division,
US Department of Energy, contract DE-AC04-94AL85000.

then the amount of charge that the battery sees changes accordingly. For VRLA batteries this charge needs to be very tightly controlled to achieve their rated cycle-life. Relatively small changes in recharge can have very detrimental effects on VRLA battery cycle-life. Based on energy calculations from the "RAPS Design Manual", published by the University of Cape Town South Africa, battery energy costs from PV or wind energy systems are estimated to be between 0.17 and $1.67 per kWh over the life of the system. As indicated above, any degradation in battery cycle-life can result in a significant cost increase. The potential cost benefit to stand-alone PV systems is substantial if batteries meet their rated cycle-life.

The Ah counting charge algorithm improves battery cycle-life by utilizing more of the PV array or wind energy when available and then shutting down the battery charging when the battery has reached a predetermined maximum overcharge based on Ah counting. This eliminates excessive overcharging and maximizes the use of available energy for battery charging in low resource periods, thus minimizing the costly use of a engine generator or thermoelectric generator to recharge the batteries.

Test Results

The new Digital Solar Technologies MPR-9400 Ah counting charge control algorithm requires the user to input several new parameters. These parameters include:

1) **%OVER** - Maximum overcharge above the daily Ah DOD (Input by user)
2) **BATAHINIT** - Estimated battery capacity (Input by user)
3) **AHVRESET** - Battery voltage when battery charging or high voltage disconnects (HVD's) are reactivated (Input by user)
4) **%ADD** - Deficit or excess battery Ah at initial battery regulation voltage (Input by user)

Figure 1 shows the battery Ah and voltage for a GNB 12-5000X absorbed glass mat (AGM) VRLA 250-Ah battery bank. The Ah counting charge control disables the high voltage disconnect (HVD 1 and 2) when the specified overcharge in Ah is reached. Percentage overcharge is defined as:

$$\% \text{ Overcharge} = ((\text{Ah charged} - \text{Ah discharged}) / \text{Ah discharged}) \times 100$$

The battery Ah in Figure 1 are calculated using the Campbell data logger with the same Ah counting charge control algorithm. The data for this test configuration indicates that the MPR-9400 is able to recharge the VRLA battery bank to within 1.5 Ah every day (253 to 254.5 Ah). After the required overcharge is reached, battery capacity is reset to its installed (BATAHINIT) value. If the required overcharge is not met, then the battery Ah are not reset to the installed value. In this test the daily overcharge based on depth of discharge is between 7.9 and 12%, which is within the battery manufacturer's recommended values.

This work is supported by the Photovoltaic Energy Technology Division,
US Department of Energy, contract DE-AC04-94AL85000.

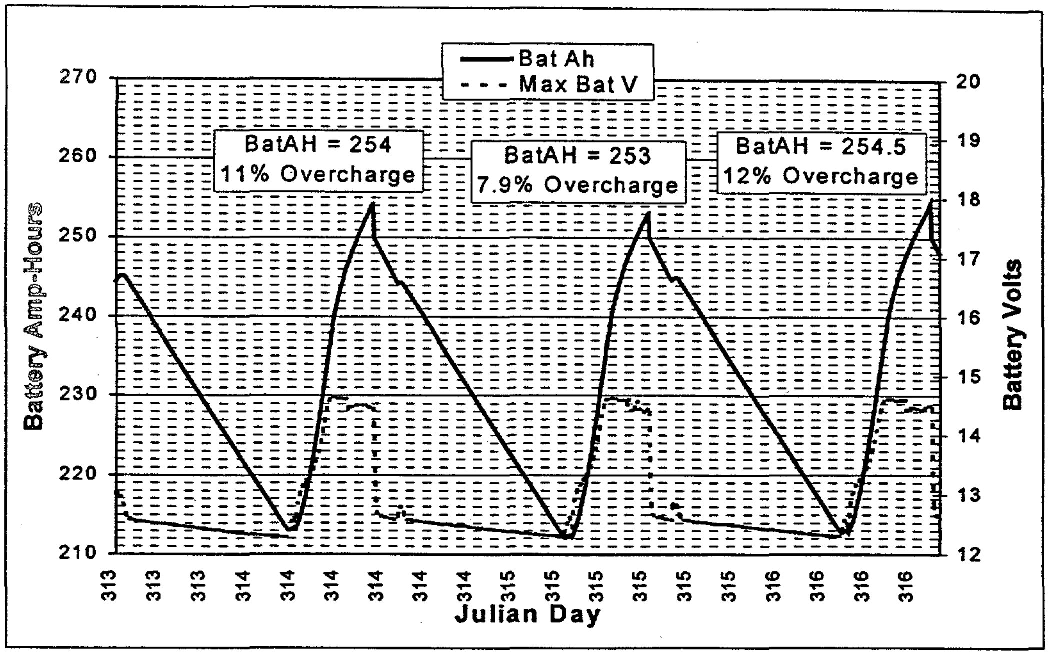

Figure 1. Ah Counting Charge Control on GNB 12-5000X VRLA Batteries. Battery Capacity Measured With Campbell Data Logger Using The Ah Counting Charge Control Algorithm. Battery Temperature is 13 to 15C With Temperature Comp. -30mV/C.

Field Setup

Field setup for the MPR-9400 and Ah counting charge control requires the user to conduct the following additional procedures:

1) Obtain the manufacturers battery capacity rating, and recommended % overcharge
2) Input manufacturers battery capacity and overcharge into BATAHINIT and %OVER
3) Based on DOD and loads identify appropriate battery charge reconnect voltage in AHVRESET
4) Boost charge or equalize the battery bank and set battery capacity in BATAHINIT
5) Operate battery charging system under normal operating conditions with loads and record the battery Ah reading from the MPR-9400 when the battery first reaches regulation voltage
6) Calculate %ADD by the following equation and input into MPR-9400

$$\%ADD = (1 - (\text{Battery Ah at Reg. Voltage}/ \text{BATAHINIT})) \times 100$$

Summary

Ah counting charge control has demonstrated in its initial performance testing that a significant advancement in PV hybrid battery management is possible with the aid of a microprocessor based charge controller and an advanced charge control algorithm. The added cost of the charge controller and added effort in configuring the control parameters can be justified by the potential cost savings resulting from longer battery cycle-life and more efficient utilization of the renewable energy power sources.

This work is supported by the Photovoltaic Energy Technology Division,
US Department of Energy, contract DE-AC04-94AL85000.