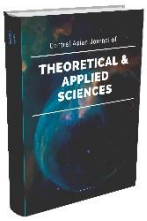

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Storage of Electricity Produced by Photovoltaic Systems

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Abstract: *In this article, we will write about energy storage batteries produced by photoelectric systems, their types and their charging process and stages. The charging are givenlevel of AGM and GEL batteries and their optimal charging algorithm .*

Keywords: *AGM, GEL, Start-Stop Vehicles, Charging, MPPT CHARGE.*

Introduction. The following types of lead-acid batteries are recommended for installation in photovoltaic systems:

- sealed (non-repairable VRLA GEL and VRLA AGM);
- open type (liquid, repairable).
- Other types of batteries such as NiCad or 36 V batteries can be used with TriStar controllers with appropriate computer programming of certain charging algorithms [1].
- Closed-type batteries are a class of lead-acid batteries that regulate the exhaust gases with a valve (VRLA - Valve Regulated Lead - Acid). The main characteristics of batteries of this category are the internal immobilization of the electrolyte and the recombination of oxygen [2]. When the battery is charged, the released oxygen is recombined within the cells to prevent water loss.

There are 2 types of sealed batteries used in solar systems: AGM and GEL batteries.

AGM (Absorber Glass Mat) batteries

In these batteries, the electrolyte is contained in fiberglass capsules between the lead plates. A charging voltage of 14.7 V is recommended for some new AGM batteries. The recommended charging voltage for these batteries is usually 14.4 - 14.5 V [3].

It is not recommended to equalize this type of battery, because the gas coming out through the valves is not filled [4]. In addition, at very high temperatures, the electrolyte can leak, and operating these batteries at temperatures above 33 °C can reduce their life by up to 50%.

For these types of batteries, their ability to recombine oxygen should not be exceeded [5]. The optimal operating temperature is from 5 to 35 ° C.

Absorbent Glass Mat (AGM) Technology: AGM or Absorbent Glass Mat is an advanced lead-acid battery that provides superior power to support the higher electrical demands of today's vehicles and start-stop applications [6]. AGM batteries are extremely resistant to vibration, are totally sealed, non-spillable and maintenance-free. AGM offers better cycling performance, minimal gassing and acid leakage when compared with conventional lead-acid batteries. The result of all the features of AGM technology is superior life performance [7].

AGM Battery Applications: Start-Stop Vehicles, Large Audio Systems, Heated Seats and Other Electronic Accessories. If you're looking to power a vehicle with numerous electronic features or plug-in accessories, you should consider a deep-cycle battery, or a battery made with advanced technology like AGM. AGM batteries are a great premium choice for high-end and advanced fuel-efficient vehicles with large power demands, and for people who seek greater reliability and longer life in auto batteries [8]. Electronic features such as DVD players, GPS, heated seats, and audio systems all add to the demands on a battery.

Start-Stop Vehicles: AGM batteries are also the preferred solution for start-stop vehicle technology, which rapidly gained popularity in Europe and entered the U.S. market in model-year 2013 vehicles [9]. Start-stop vehicle technology automatically shuts off the engine when your vehicle stops, such as at traffic light or in stop-and-go traffic and restarts it quickly and quietly when the clutch is engaged, or the brake pedal is released. When the engine is off, the battery is the sole source of power to all the car's electrical devices, such as air conditioning, the radio, and the navigation system [9]. And, in advanced start-stop systems with features like regenerative braking or passive boost, the battery is stressed even more. To power electrical loads during engine-off periods and to support a high number of starts per trip, these vehicles need a battery that is more robust than the typical lead-acid battery [10]. With superior cycling capability, charge acceptance and the ability to operate at a low state of charge, AGM is the technology of choice.

AGM Battery Construction: In AGM batteries, the positive and negative plates are separated by an absorbent glass mat that absorbs and holds the battery's acid and prevents it from flowing freely inside the battery. The plates are tightly compressed into each cell and held under pressure in the plastic case. The internal compression limits the shedding of plate material caused by cycling and allows for significantly longer life [11]. The element compression also lowers internal resistance and maximizes pulse power output. A rigid container maintains the necessary compression throughout the battery's life [16]. The basic design also includes relief venting to release pressure from minor gassing that occurs during charging. The valves open at low pressure and close automatically to prevent air from leaking into the battery [12].

AGM Battery Benefits:

- Up to 2x longer life than standard flooded batteries
- Designed for harsh climates and demanding conditions
- Handles high electrical loads
- Quickly recharges and extends cycle life
- Ideal for start-stop applications
- Vibration resistance
- Nonspillable and maintenance-free
- Greater mounting flexibility

Tomorrow's battery, available today. Our AGM batteries offer superior performance, with a glass mat separator that delivers up to twice the life of standard flooded batteries and unprecedented energy output even in the most demanding conditions [13].

Helium batteries

Helium batteries are generally similar to AGM. In helium batteries, special silicon-based additives are added to the electrolyte to reduce its fluidity [14]. It is important not to exceed the charging voltage for helium batteries. When installing the system, refer to the recommended charging parameters given in the instructions [15]. Typically, the charging voltage for helium batteries is 14.1 - 14.5 V. Helium batteries are sensitive to overcharging.

Discussion. An important operating condition for both types of batteries is 100% recombination of gases inside the battery. This prevents water loss. Equalization is not performed, but a short-term "shock" charge may occasionally be useful to balance the potentials between individual cells.

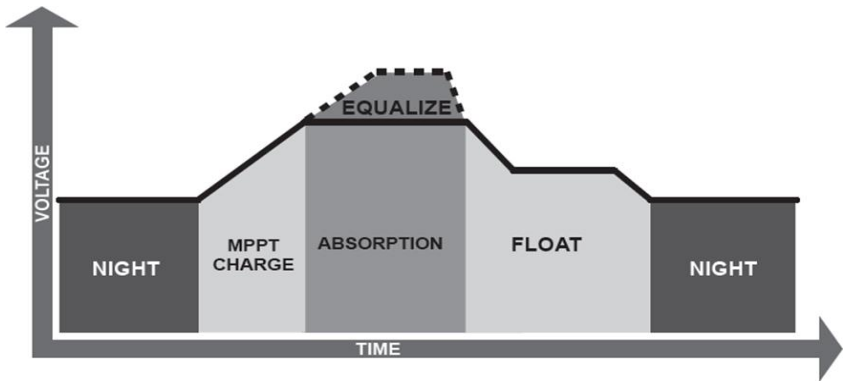

Figure 1. Optimal charging algorithm

MPPT CHARGE - In this phase, the battery receives all the charge from the solar panels.

ABSORPTION - when this stage is reached, the controller reduces the charge voltage and current to prevent heating and gassing. At this stage, the battery is close to full charge.

FLOAT - At this stage, the battery is in charging mode (also called rest mode).

EQUALIZE is used for this mode "shaking" an open-type battery with high voltage. The process prevents excessive sulfation of the plates and also equalizes the uneven charge between the individual capsules.

Battery charging points (at 25 °C)

Table 1

Stage	GEL	closed type	AGM	open type
Absorption	14.0 V	14.1 V	14.3 V	14.4 V
Charging	13.7 V	13.7 V	13.7 V	13.7 V
Charging time	3 hours	3 hours	3 hours	3 hours
Tension leveling	no	no	14.5 V	14.9 V
Equalization time	no	no	3 hours	3 hours

Periodless leveling	no	no	28 days	28 days
Maximum charge intensification	15V/30V	15V/30V	15V/30V	15V/30V
Get stronger	11.5V/11.0V	11.5V/11.0V	11.5V/11.0V	11.5V/11.0V
Rekindle _	12.6V/12.1V	12.6V/12.1V	12.6V/12.1V	12.6V/12.1V
[1] *Not compensated by temperature.* [2] *Set by switch, not temperature compensation.*				

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