# Enhancing 12-Volt Charging System Performance


*Among other functions, the Energy Monitor II helps to monitor battery voltage, current, and temperature, plus it has an auxiliary input for charge current, such as solar panels.*

Over the years frequent complaints have arisen about the inadequacies of the electrical systems in motorhomes. With the introduction of "all-electric" coaches, the problems have been magnified. This article discusses how we addressed our electrical problems.

Since beginning our motorhoming adventures, we have owned three coaches. The first was a small Class A that had one chassis battery and one coach battery. Both batteries were charged by the engine-driven alternator and a small convertor. This system functioned well, probably because of minimal 12 volt requirements.

The second coach had one chassis battery, two coach batteries, a 1,500-watt inverter, a 105-amp alternator, and a 35-amp convertor. It quickly became apparent that either the convertor was not able to recharge the batteries adequately or the batteries were not of sufficient capacity to power the inverter without sustaining deep discharge. When we were traveling, the inverter powered an ice-maker and an Instant Hot water system. Maintaining these batteries while dry camping overnight led to significant discharge. Even with the Instant Hot water system off, we continued to experience low charge conditions. Any additional demands, such as running a furnace, aggravated the problem.

In an attempt to rectify this situation, we added a third coach battery and a 50-amp convertor. This did not significantly improve the situation. Next we replaced the 105-amp alternator with a 130-amp version. In 30,000 miles, we experienced two alternator failures. We thought the alternators were defective. The manufacturer claimed that both alternators showed evidence of being extremely overworked. At the tune, we did not appreciate the problem, and in frustration we reinstalled the 105-amp alternator, which was still in operation when we sold the coach.

The 130 amp alternator was a small-frame version, the same size as the 105-amp model. We chose this size to make installation as easy as possible. Since that time, we have learned that 130-amp small-frame alternators have great difficulty with durability when they are run at maximum load for extended periods of time. Tremendous heat is generated, which further compromises the unit. In choosing an alternator, it often is better to obtain the largest capacity and size unit that will fit in the available space. It is important that the alternator be "hot rated." Cold ratings may sound impressive, but they are not achievable at normal operating temperatures. Nonetheless, with all of the changes, the performance of our 12-volt DC electrical system remained marginal.

Our third and current coach was delivered with 880 ampere-hours of coach batteries, divided into two banks of 440 ampere-hours each; a 1,500-watt inverter without a charger; a 130-amp 12-volt alternator; and a 75-amp 12-volt convertor with a ferroresonant charging circuit. In addition, it had a separate 24-volt system for the chassis and a single 12-volt battery for the generator. The chassis and generator batteries were group 31, *The NEXT Step Regulator provides charging similar to the four-stage charger available with inverter/chargers.*


## The authors outline the ways they have improved upon the electrical system in their motor coach.

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rated at 1,000 cold cranking amps (cca) each. The chassis batteries were charged by a 75-amp, 24-volt alternator. The generator had its own 12-volt alternator.

After using the coach on several trips, we noted inadequacies in the 12-volt coach system. Sound familiar? It should be emphasized that one readily available solution for these problems is to decrease electrical consumption, as was the case in our first coach. This was not a likely choice with our new coach, however. The convertor had insufficient charging capacity, so the batteries were constantly undercharged. Although deep-cycle batteries can tolerate 80 percent discharge on occasion, their life will be shortened significantly when repeatedly discharged in excess of 50 percent. It is important to understand that a 75-amp convertor never supplies anywhere near 75 amps of charge, except to deeply discharged batteries (voltage equal to approximately 11 volts).

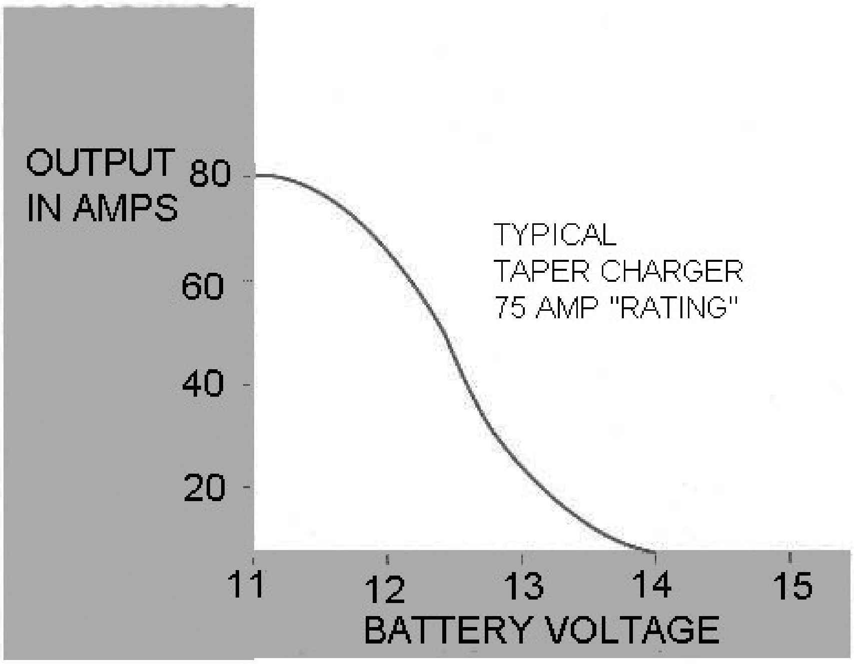
Note the charge characteristics of a typical taper charger as related to battery voltage in Figure 1. To confirm the charging capabilities of your convertor, place an ammeter in the circuit between the convertor and the batteries. By also measuring battery voltage, it will be possible to plot the output characteristics of your convertor relative to the battery voltage.

We opted to add a 2,000-watt inverter with a high-capacity (120 amps) charger. This performed better than the 75-amp convertor. This charger was a single-stage design that could he set to a maximum charge amperage and voltage. As the voltage rose to the maximum set level, the amperage was reduced, but there were no provisions for maintaining the batteries at a float voltage. As batteries age, they tend to gas at a lower voltage. The single-stage charger functioned well on new batteries, but the voltage set point had to be adjusted to accommodate older batteries. If the voltage set point was kept high enough to fully charge the batteries, they would gas. On the other hand, if the voltage set point was reduced to prevent gassing, the batteries would be only partially charged. The set point adjustments are made either with a screwdriver or with dip switches, depending on the manufacturer. The owner's manuals have easy-to-follow instructions.

Another modification we made was the addition of solar panels. Twenty-four amps of solar capacity proved to be totally inadequate, but an increase to 36 amps was satisfactory under ideal conditions of prolonged full sun. We recently upgraded to 60 amps.

In our application, the 6-volt lead-acid golf cart batteries have had a useful life of approximately three years. With that life span, they also appear to be the most cost-effective, although there is some maintenance associated with these batteries. This can he significantly reduced by the use of an electrolyte level monitor ("Battery Electrolyte level Monitor, FMC, October 1993). This device illuminates a red LED when the electrolyte level is low. Increasing water consumption indicates either aging batteries or an overcharging condition. Both overcharging and under-charging will shorten battery life. One way to reduce the problems of overcharging and undercharging is to replace the

FIGURE 1




single-stage charger with one of a four-stage design. Three of the stages are automatic, and the fourth is manual.

The three automatic stages are discussed below:

1. **Bulk.** Amperage is constant at a preset level (e.g., 120 amps) until volt age rises to a preset level, a point just below gassing (e.g., 14.5 volts). Once this voltage is achieved, the charger switches to the absorption stage.

2. **Absorption**. Amperage is reduced to hold voltage constant (just below gassing). This stage is terminated either by time (60 to 120 minutes) or when amperage is reduced to a preset point (e.g., 20 amps). Once the absorption stage is completed, the charger switches to the float stage.

3. **Float**. The charger delivers only enough amperage to hold the battery at a predetermined voltage (e.g., 13.6 volts). If the battery voltage is reduced to a predetermined level (e.g., 12.8 volts), the charger returns to bulk stage.

It is important to remember that the numerical presets mentioned above will depend upon the type of batteries used, the total capacity of the battery bank, and recommendations of the battery and charger manufacturers. Furthermore, a few sophisticated chargers and regulators have provisions for monitoring the temperature of the batteries and altering the set points according to variations in temperature. In our opinion, this is a very valuable feature. On our trip to Puyallup, Washington, we were amazed to routinely see battery temperature variations of 35 degrees in a single day.

Using these three automatic stages allows the batteries to be charged to their maximum capacity without overcharging and to be maintained at that level for a significant period of time. Many experts feel that a battery cannot be charged to its full potential without the use of an absorptive cycle.

Occasionally the electrolyte concentrations in the individual cells of a battery may vary from one to another or stratify from top to bottom in individual cells. When this occurs, it is possible to use the fourth stage, a manually initiated “equalizing charge,” to correct these conditions. Most manufacturers of gel batteries recommend that this stage not be used with their batteries. Equalization consists of an intentional gassing by overcharging with 16.2 volts for a controlled period of time. It is important to disconnect any voltage-sensitive equipment when utilizing this procedure. One manufacturer recommends that this be done every few months.

The use of this new charger minimized the possibility of either overcharging or undercharging as long as the coach was attached to shore power. However, when we spent extensive time on the road, we noted that the batteries began to require more water. It seemed that the alternator was now overcharging the batteries.

We contacted David Smead of Ample Technology Inc. because we had heard that he had a regulator that could be used with the 12-volt alternator to provide charging similar to the four-stage charger available with the inverters. Smead patiently discussed charging systems and recommended that we try his NEXT Step Regulator. He provided excellent technical advice and explained how to modify our existing 21 SI Delco alternator to make it compatible with the new regulator. Darryl Schmedding of Delco Remy kindly sent the required “I” Terminal Retrofit Kit to modify the alternator. It was also necessary to disable the internal regulator of the 21 SI alternator. This was accomplished at the same time the retrofit kit was installed. Alternators that have external regulators are compatible with the NEXT Step Regulator, and Ample Technology Inc. also has high-output, hot-rated alternators available. Installing the regulator was a straightforward procedure. It is important to carefully follow the installation instructions in the detailed 18-page manual to wire the unit correctly.

After installation, it is necessary to set the absorption voltage and absorption lime to desired limits, and to confirm the accuracy of the temperature sensor. The regulator is equipped with an LED that will identify the stages of charging and a fault LED that indicates six possible faults. The fault circuit also has a remote feature and an audible alarm so that the driver is aware of any fault that might occur while he or she is driving.

This regulator functions similarly to the three-stage automatic charger described earlier. In addition, it is possible to manually lock in either the bulk voltage or the float voltage. Because halogen headlights are voltage sensitive, provisions are available to have the float voltage locked in whenever the headlights are turned on. In our particular application, this feature was not used, because our headlights operate on the 24-volt system. This would he a very desirable feature on coaches that utilize only a 12-volt system. There is also a parallel output that allows the charging of another bank of batteries, either chassis batteries or, in our case, a 110-volt-AC generator battery.

With the installation of the NEXT Regulator, we had now completed the upgrading of the charging system, regardless of the source of charge. We thought the project was complete. Then we became fascinated by the description of the Energy Monitor II and, after further discussion with David Smead, decided that we wanted to evaluate the unit.

The Energy Monitor II (EMON II) performs the following functions:

1. Using high-resolution circuitry, measures voltage, current, and temperatures for a single battery bank (a version for two battery banks is available).

2. Measures voltage for a second starter battery bank.

3. Has an auxiliary input for charge current, such as solar panels.

4. Computes the following parameters: time remaining; ampere hours consumed (trip and lifetime); ampere-hours remaining; percent of charge; and state of charge.

5. Provides alarms for high and low voltage on the main and starter bank; main bank high temperature; main bank full charge; and main bank 50 percent and 80 percent discharge.

6. Provides voltage and current references to the following interfaces: NEXT Step controller interface; solar control relay interface; state-of-charge controller interface; and generator start/stop interface.

7. Contains a PC interface allowing full screen display and ability to log data to disk drive.

The Energy Monitor II-H1 is supplied with a 400-amp shunt, a temperature sensor, and an installation and operation manual. Optional accessories include a 200-amp shunt for measuring auxiliary current, a remote alarm, solar panel or load disconnect relays, and PC software. This single unit replaced two voltmeters, and a 400-0-400 ammeter. It provided the benefits of an alarm system, various interfaces, and, with the addition of a $39 shunt, a high-output solar panel regulator. The retail price of the standard package is $499.99. Initially, we thought this was expensive, but after using the EMON II we began to appreciate all the functions and benefits and now consider the price a bargain.

The 40-page installation and operation manual that comes with the unit is extremely detailed, and do-it-yourself motorhomers should have no difficulty in performing their own installation. The programming instructions are also quite detailed. Anyone with limited experience in computers or electronics may find the procedure tedious, but the benefits make it well worth exercising the patience to complete the task. After initialization, the EMON II can enhance any electrical system, even if it is used only as a passive integrator of all of the 12-volt charging components.

The data from the EMON II can be used to evaluate the performance of various electrical system components. Batteries can be purchased because of ampere-hour performance rather than advertising hype. Solar panel sizing can be based on daily ampere-hour usage. After installing the EMON II, we discovered that we were using 300 to 350 ampere-hours of power per day, which justified our increasing our solar panel array to 60 amps. The determination of Solar panel requirements is based on ampere-hour usage and is affected by environmental and geographic variables. A conservative formula is half of the solar panel capacity for eight hours of sunlight will approximate the daily ampere-hour output: C/2 X 8 is approximately equal to daily ampere-hours.

The more we use the Energy Monitor II, the more we are impressed. While our coach is not “all electric,’ this unit has become an invaluable tool, and would probably be of even more benefit to those who own “all electric” coaches.

Since we began this project, David Smead has reorganized his business. Instead of being both a manufacturer and a retailer under the name Ample Power, he is manufacturing as Ample Technology Inc. A new company. PowerTap Inc., has been formed to be the master dealer for retail sales.

For further information about the NEXT Step Regulator and the EMON II, contact:

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