



## Hand-held Devices: Recharging Batteries in the Field

Ted Etter, Project Leader

Field crews working away from their offices or work centers for several days occasionally need to recharge the batteries in devices such as global positioning system (GPS) receivers, personal digital assistants (PDAs), cameras, cell phones, and other battery-powered portable devices. The Missoula Technology and Development Center (MTDC) identified portable power sources, voltage converters, batteries, and battery chargers that may keep portable electronic devices running for many days. Solar power was the main source considered, but a car battery could have been substituted in most applications.

Products cited in this tech tip may not be the only ones available and should not be considered as an endorsement. The information will help managers select the best method for ensuring consistent communication with field crews.

### Highlights...

- Forest Service employees working in the field sometimes need to recharge batteries for hand-held devices.
- Chargers and converters are used to alter power from one voltage source to another voltage.
- Chargers are similar to converters, but include monitoring and control circuits to check charging progress and adjust applied voltage and current as needed.
- Matching a charger to a battery is important because overcharging a battery can result in serious mechanical and electrical failures.

### Converters versus Chargers

Many electronic devices, such as cell phones, have rechargeable batteries that are charged through internal circuits. These devices require a specific input voltage that matches the device's internal charge controller. Converters simply alter power from one voltage source to another voltage. One example is a cell phone booster power converter that takes 12 volts (V) from a vehicle's cigarette lighter receptacle and delivers 6 V to the booster.

Chargers (figure 1) are similar to converters, but include monitoring and control circuits to check charging progress and adjust applied voltage and current to the batteries as needed. Different battery chemistries require different charging procedures. One charger can't be shared for multiple battery chemistries at the same voltage unless the charger is programmable and is designed to handle specific battery chemistries.



Figure 1—Assorted chargers with 12 V and 120 V power source options.

## What Can Be Recharged in the Field

Recharging is straight forward if a device requires 12 V or less and uses replaceable batteries. Exchanging depleted batteries for recharged batteries will revive battery packs for hand-held radios, such as BK radios, PDAs, and cameras that accept AA cells. Nickel-metal hydride (NiMH) batteries typically are used. Some devices with Universal Serial Bus (USB) data ports can be recharged through those ports. The 5 V power and connector required to charge through a USB port is available from many sources, such as 120 volts alternating current (VAC) wall adapters and 12 V converters with 5 V outputs.

Some portable devices, such as cell phones, have an optional power converter that includes a plug for the cigarette lighter receptacle in a vehicle. These converters can handle input voltages in the 12 to 14 V range. As an example, a converter could be used to charge small batteries from a car battery. Protection against excessive voltage is required when a solar panel provides the energy. You should assume that additional hardware is required unless a charge controller specifically is advertised for use with a direct connection to a solar panel.

Most laptop computer batteries operate above 12 V. Converters are available to boost the voltage from the cigarette lighter receptacle in a vehicle or a 12 V battery to the voltage required by a computer. However, these converters draw 5 to 7 amperes (amps) when the computer is operating. Evaluating devices that harvest and store this amount of energy is beyond the scope of this project.

Charging requirements differ for nickel-cadmium (NiCad), NiMH, and lithium ion (Li-Ion) batteries. Matching a charger to a battery is important because overcharging a battery can result in serious mechanical and electrical failures.

## Plug-and-Play Solutions Using Solar Panels to Charge Batteries

A few battery chargers are designed to accept the voltage range from solar panels. The Solo 3.4 battery charger from the Brunton Outdoor Group contains an internal rechargeable battery that can be charged by a solar panel; its output is 5 V on a USB port. The internal battery stores energy during daylight hours and delivers energy to other devices at night. We have not yet tested the Solo 3.4.

The MH-C204GT battery charger from the Maha Energy Corp. works with NiMH rechargeable batteries. It can be powered directly from a solar panel and charges four AA or AAA batteries in about 4 hours. A storage battery is needed if the NiMH batteries must be charged when no sunlight is available. We have not yet tested the MH-C204GT.

A charge controller and storage battery (figure 2) are needed to operate many power adapters and battery chargers from a solar panel. These devices prevent damage to the chargers and adapters. While many solar panels rated at 12 V generate that voltage when their maximum power is delivered, they can generate close to 20 V when the loads are drawing small currents. Many devices with input specified at 12 V can be damaged by significantly higher voltages. The combination of a charge controller and a storage battery permit the energy from the panel to charge the storage battery safely. The storage battery, in turn, can power battery chargers and adapters that are rated for 12 V inputs.



Figure 2—A solar charge controller with large and small storage batteries.

Other battery chargers become viable options once a 12 V storage battery is added to the equipment assembly. The storage battery can have as small of a capacity as 2 amp-hours (Ah) if other batteries will be charged during daylight hours. A capacity of 7 to 12 Ah may be required if the storage battery must store energy for nighttime charging. The size of the storage battery and solar panel will depend on the number of devices that will be drawing energy from the storage battery. For example, a 12 Ah battery is recommended if a dozen AA NiMH batteries need to be charged overnight.

## **Tested Products**

The products tested by MTDC represent a partial list of what is available at this time.

### ***Power Sources***

We selected folding solar panels because they are compact, relatively easy to transport, and available from several manufacturers. We tested three models manufactured by Silicon Solar, Inc. from 10 to 30 watts (W) output. At the end of our testing, we learned that the panels were being discontinued.

Similar folding models up to 60 W are available from Brunton. We did not evaluate the Brunton panels during this exercise, but models that have been used successfully on other Forest Service projects are:

- Brunton Solaris 26 foldable solar panel—26 W
- Brunton Solaris 12 foldable solar panel—12 W

Several companies offer solar panels that can be rolled up instead of folded. The rollup model may be difficult to get into a backpack or box.

### ***Charge Controllers***

Many suppliers, such as Morningstar Corp., High Quality products for Reasonable Price (HQRP), and Brunton, offer charge controllers that prevent battery damage from voltages generated by solar panels. Batteries are required to maintain the output voltage between current pulses because the output from charge controllers is a pulsating current. The storage battery can be relatively small if you intend to recharge AA batteries during daylight hours, but still is required for the charge controller to work.

The charge controllers reviewed in this study were:

- Morningstar—SunSaver SS-10
- Morningstar—SunGuard
- HQRP—EPHC10-ST
- Brunton—F-SOLRCON

All of these charge controllers turn the current flow from the panel to the battery on and off (pulse-width modulation, also called PWM) to limit the power dissipated in the controller. This means that not all energy available from the solar panel will transfer to the battery, but the battery will be charged to the proper voltage over time.

### ***12 V Storage Batteries***

Many brands of sealed lead-acid (SLA) storage batteries are available, including Panasonic, Yuasa, Werker, and PowerSonic, to name a few. 12 V batteries with capacities below 14 Ah typically have quick connection spade terminals that are 0.187 of an inch wide, such as FASTON terminals manufactured by Tyco Electronics Corp. A 2.5 Ah battery, such as the PowerSonic PS-1220, would be suitable for daylight charging applications. To store energy for nighttime charging, a 7 Ah battery, such as the PowerSonic PS-1270, would store sufficient energy to charge multiple small devices. The PS-1270 weighs nearly 6 pounds, so transporting it by backpack with other heavy components may be difficult.

Comparable batteries are available from many manufacturers and distributors.

### ***Battery Chargers***

We tested two battery chargers (for NiMH AA and AAA batteries) that require a 12 V source. One is manufactured by Maha Energy Corp. (PowerEx) and the other by Nuon (EcoSense):

- Powerex model MC-C9000
- EcoSense model NURECH1-4B for NiMH AA and AAA batteries

The Nuon charger comes with a warning indicating that batteries should not be left in the charger for more than 12 hours.

## Rechargeable Power Sources That Were Tested

### AA Batteries

We tested rechargeable NiMH AA batteries from Sanyo North America Corp. (Eneloop) and Nuon (EcoSense):

- Eneloop model HR-3UTG—2,000 milliampere-hours (mAh)
- EcoSense model NUREAA—2,500 mAh

Both batteries charged successfully in the chargers and delivered energy consistent with their rated capacity. Although alkaline AA batteries are available with a higher Ah rating, “end-of-life” for alkaline batteries is specified as 0.9 V. Even though a new alkaline battery may register 1.6 V out of the box, its output voltage typically is below the nominal 1.2 V output of an NiMH battery (figure 3) after 2,000 mAh of energy is drained from it. Our tests found when BK hand-held radios are powered with NiMH batteries, they typically operate for several hours longer than alkaline batteries could withstand.



Figure 3—Three AA NiMH batteries (left) and one AA alkaline battery (right).

### Lithium Batteries for USB Devices

One portable power source for USB devices is a small lithium battery, such as the iFresh. This type of product can be charged from a computer USB port and can deliver 5 V to charge other USB devices. The iFresh also can be charged through a 120 V wall adapter (figure 4) if a computer is not available. Several models of 12 V-to-USB converters, such as the car USB charger (figure 5) manufactured by Kensington Computer Products Group, can convert power from a 12 V source to the iFresh input.



Figure 4—An iFresh USB battery with alternating current (AC) USB power adapter.



Figure 5—A car USB charger.

### Battery Packs for GPS Receivers

An 11 V lithium polymer (LiP) battery pack, such as the 3D-1122B from 3-D Marketing, has a 4 Ah capacity and is suitable for recharging batteries in GPS receivers, such as Trimble products and other devices that accept its 11 V output. Because of battery chemistry, the polymer battery is relatively light in weight compared to an SLA battery with the same capacity. 3-D Marketing also sells a charge controller that allows the device to be recharged directly from a solar panel. The battery pack we tested comes with a 120 V wall adapter. The battery pack does not include charge control circuitry, so the external charging device must be designed to handle the charging needs of a lithium battery.

## Recommendations

Solar-powered charging system complexity depends on the number of devices requiring power and the respective voltages of each. The Brunton Solo 3.4 and a 12 W solar panel would be adequate if all the field devices required 5 V through USB cables. A 12 W solar panel connected directly to a AA battery charger would suffice if a handful of AA NiMH batteries can be charged during daylight hours. A 26 W solar panel with a charge controller and a 7 Ah SLA battery would be appropriate if multiple devices need to be powered. Several manufacturers offer USB 5 V adapters built into cigarette lighter plugs, so the 12 V battery could provide power for 5 V devices, battery chargers, and devices with 12 V adapters.

During this study, we realized that products in this arena can be transitory. Some products were pulled from the market during the study while others were discovered. Reliability didn't appear to be the issue for the discontinued products we evaluated.

Rechargeable batteries do not respond well to long periods of inactivity. A program should be established for periodically charging and discharging batteries that will be used during more than one field season. Otherwise, NiMH batteries left unattended for most of a year will have diminished capacity and may require replacement. Battery conditioners, such as the Powerex MH-C9000, can reverse some age-related damage, but the batteries won't regain their original storage capacity. "Exercising" batteries in a device several times a year will extend battery life to multiple seasons.

All rechargeable batteries should be recycled at the end of life. Many hardware stores and battery specialty stores accept rechargeable batteries. Alkaline batteries are considered suitable for landfill disposal.

## Battery Appendix

Rechargeable batteries containing nickel generally are available in the same sizes as alkaline batteries: C, AA, and AAA. Rechargeable lithium batteries are not. Non-rechargeable lithium AA batteries (with a 1.5 V output) are available as long-lived replacements for alkaline batteries, but rechargeable lithium batteries (with around a 3.6 V output) are not available in the C/AA/AAA packages. Lithium battery charging characteristics are different from NiMH

and NiCad batteries, so different charging devices—or programmable ones (figure 6)—are required to match the battery chemistries.



Figure 6—A programmable charger.

Some battery packs have different configurations for rechargeable and non-rechargeable batteries because NiMH and NiCad batteries generate a voltage about 15 percent lower than a fresh alkaline battery. The AA battery "clam shells" for BK radios hold 10 NiMH batteries or 9 alkaline batteries with a shorting bar in place of the tenth battery. This arrangement prevents damage to the radio that excessive voltage from 10 fresh alkaline batteries would produce.

NiCad batteries still are available, but their use is discouraged due to the toxicity of cadmium. Changing from NiCad to NiMH can extend the operating time of a device because NiMH batteries have energy densities slightly higher than NiCad batteries. NiMH batteries have less of a tendency to develop a partially-charged capacity "memory" than NiCads, but do tend to lose their charge more rapidly than NiCads.

## About the Authors

**Ted Etter** joined MTDC in 2002 as an electronics engineer and project leader. He has 20 years of experience designing test equipment, display devices, and medical instrumentation for private industry. For 6 years before joining MTDC, Etter taught courses in electronics at the University of Montana College of Technology, Missoula. His work at MTDC includes projects in wireless communications, alternative energy sources, instrumentation, and process control. Etter received a bachelor's degree in mathematics from the University of Oregon and a master's degree in teacher education from Eastern Oregon State University.

**Dave Plummer** joined MTDC in 2010 as an electronics technician after 6 years working for the University of Montana and Bee Alert Technology, Inc. in Missoula. His work at the center includes schematic interpretation; component layout; printed circuit board (PCB) design; and the assembly, housing, and cabling of circuitry. Plummer also has experience with radiofrequency (RF) communication systems; radiofrequency identification (RFID); light detection and ranging (LIDAR); and complex programmable logic device (CPLD) and microcontroller programming. He has an associate's degree in electronics and a bachelor's degree in geology, both from the University of Montana.



## Library Card

Etter, Ted; Plummer, Dave. 2011. Hand-held devices: Recharging batteries in the field. Tech Tip 1166–2314–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 6 p.

Forest Service employees working in the field sometimes need to recharge batteries for hand-held devices, such as cell phones or global positioning system receivers. Chargers are used to alter power from one voltage source to another voltage. A charger and battery must be compatible because overcharging a battery can result in serious mechanical and electrical failures. The Missoula Technology and Development Center identified portable power sources, voltage converters, batteries, and battery chargers that may keep portable electronic devices running for many days.

**Keywords:** cell phones, chargers, converters, GPS receivers, hand-held devices, rechargeable batteries, safety at work, solar power



**Electronic copies of MTDC's documents are available on the Internet at:**

<http://www.fs.fed.us/t-d>

Missoula, MT 59808–9361

Phone: 406-329-3980

Fax: 406–329–3719

Email: [tetter@fs.fed.us](mailto:tetter@fs.fed.us)

**For additional information about recharging batteries for hand-held devices in the field, contact Ted Etter at MTDC:**

USDA Forest Service

Missoula Technology and Development Center

5785 Hwy. 10 West

**Forest Service and Bureau of Land Management employees can search a more complete collection of MTDC's documents, CDs, DVDs, and videos on their internal computer networks at:**

<http://fsweb.mtdc.wo.fs.fed.us/search/>



The Forest Service, United States Department of Agriculture (USDA), has developed this information for the guidance of its employees, its contractors, and its cooperating Federal and State agencies and is not responsible for the interpretation or use of this information by anyone except its own employees. The use of trade, firm, or corporation names in this document is for the information and convenience of the reader and does not constitute an endorsement by the Department of any product or service to the exclusion of others that may be suitable.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.