Model Railroad Hobbyist |

DCC IMPULSES

column

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Wireless DCC, part 2, batteries

Last month (TINY URL , I discussed communicating the DCC packets from a hand-held cab by radio to a mobile receiver or decoder. This month, let's look at providing motive power by battery for a truly wireless (dead track) solution. Since I'm currently knee-deep in a garden project, a lot of this column will revolve around larger batteries and the trailing cars to carry them. A future column will deal with smaller scales and their battery needs.

1. About 12-volts and 1000 mAh of storage: ten AAA NiMh cells or three (shorter) lithium ion cells. *Bruce Petrarca photo*

Types of batteries

Most folks don't want to be replacing batteries every few hours of operation, so they want rechargeables [1]. Let's look at various rechargeable chemistry designs and focus on their advantages and disadvantages.

NiCd - Nickel Cadmium were the first small, light, rechargeable cells. They have low energy density: that is, they have rather short life compared to newer chemistries. They also suffer from memory effect: that is, if they are not completely discharged every time they are drawn down, they tend to remember the partially discharged state and head for it like a horse to the barn. As an example, if you discharge your NiCds to 80% of their capacity and the recharge them back up repeatedly, they will drop from 100% to 80% almost immediately upon being removed from the charger. I haven't used any NiCd cells in over a decade.

NiMH - Nickel Metal Hydride are the choice for AA and AAA rechargeable cells these days. They have about double the energy density of NiCd and little to no memory effect. However, they are not really up to the task to provide locomotive power for more than a few minutes of use in a reasonably sized package [1]. I use the AAA version in my NCE DCC throttles.

Pb - Lead (also known as lead-acid) batteries are available in liquid electrolyte versions (like your car battery) and gelled electrolyte (like those used in computer Uninterruptible Power Supplies). They excel in high current drain applications. Due the large amount of lead in them, they are heavy. They also represent an ecological challenge for disposal or recycling. The size and weight preclude their use in model railroading, short of 7-½ inch gauge (ride-on) locomotives.

Li - Lithium chemistry batteries come in several varieties. They are smaller and lighter for an equivalent energy density, compared to all the prior choices. But this comes at a cost: they are finicky to charge and relatively expensive. That said, lithium polymer and lithium ion cells are the cell of choice for model railroading. So, I'm going to focus on them in this column and just refer to them as "lithium" batteries. I use a "9-volt" lithium rechargeable battery in my Digitrax throttles.

There are also non-rechargeable lithium batteries, just to confuse the mix. Coin cells, such as are used in some command stations, are one example.

Make sure you are looking at rechargeable lithiums for locomotive power uses.

Cell vs. battery

The terms are frequently used incorrectly. For example, the use of the word batteries in the paragraph headed “Types of batteries,” above, probably could have been cells.

A “cell” is a single storage element. The AA or AAA “batteries” that we use in cabs are a single storage device, so they should be properly referred to as “cells”. The group of cells installed in a cab becomes a “battery.”

The term “battery,” in general, refers to a group of things working together. This originates from the military battery, meaning a collection of artillery pieces. So, an electrical battery is a group of cells. For example, a 12-volt car battery consists of six 2-volt cells. Each fill cap (remember those) is a different cell. Yes, for the anal-retentive folks in the group, the cells are really 2.3-volts, making the battery 13.8-volts. But we still call them 12-volt systems.

Rechargeable battery abbreviations

mAh is the energy capacity of the battery in milliAmp hours. A 350 mAh battery will supply 350 mA for an hour. Note that 350 mA is 0.35 amps, so 350 mAh would be the same as 0.35 Amp hours (Ah).

C refers to the battery capacity in mAh or Ah. For a 350 mAh battery, C = 350 mAh. This capacity is used to reference charge and discharge rates. 1C means that your are drawing out or putting in current at the same rate as the mAh rating of the battery. For example, this 350 mAh battery being discharged at a 2 C rate would be delivering 700 mA of current. If the same battery were being charged with 175 mA of current, that would be a ½ C charge.

S refers to the number of cells in series comprising the battery pack. Four lithium cells in a battery will be referred to as a 4S pack. Since lithium cells have a nominal 3.7-volt rating, this would be a 14.8-volt battery; but it would run from 16.8-volts at full charge to 12-volts at shutoff. This gets complicated with series / parallel packs; beyond the scope of this column.

Lithium battery quality

There are two general hobby uses for rechargeable lithium batteries. Yes, they are usually batteries, as very few hobby systems can run on the about 4-volts from a single rechargeable lithium cell.

Radio Controlled (RC - boat, car and, especially airplane) model usage focuses on high rate discharge, followed by as rapid a charge as possible. Frequently RC users discharge batteries above 20 amps. The RC operator wants their model back in service quickly, so looks for charge times of a few minutes. Batteries intended for this abusive environment probably will not have built in safety measures.

2. RC style battery pack. This is a 3S 350 mAh pack designed to be discharged as quickly as 130C. Note the two connectors, one for the model and one for the balancing charger. The (two-wire) model wires are very large gauge. The (four-wire) balancing charger wires are a bit smaller. Since this pack is rated at 130C discharge, it will supply over 40 amps for about 2 minutes. Not recommended for model railroading. *Pete Steinmetz photo*

Since RC batteries have their lifetime shortened by the abusive charge / discharge cycles, lower quality cells are used to keep the price down. This is the reason for "explosion proof" charging pouches being sold along with RC batteries. Also, because of the "fire-hose" charging, individual cells within the pack may develop varied amounts of charge. RC packs usually have a second connector, called a balancing connector. This connector [2] allows capable chargers of analyzing the charge level of each cell and adjusting the power being applied to it during the charge cycle to bring all cells up to 100% before shutting off.

RC-style batteries can be identified by the two connectors and the high C rating boasted about on the package. They are not the best choice for model railroading, even if they seem to be cost effective.

In model railroading, there is no need to abuse batteries in the manner that RC modelers do. We need a couple of amps of current and can charge them for a few hours. Being kinder to the batteries allows us to take advantage of electronic safeguards within the battery pack, such as over charge, over discharge, and short circuit protection. These are referred to as "protected" packs. Always use protected packs in model railroading. This kindness translates into longer life: many hundreds of power cycles, frequently about a thousand. The cells are of higher quality and the cost is higher. But the safety is worth the cost, in my opinion.

Using a trailing battery car or a quickly changeable battery will allow a modeler to have one battery for each simultaneous operator, with one, or a very few, standby spares. One need not have one battery (or more) per loco owned - too many batteries. I'll discuss the battery cars I built for the PCMRC garden layout later in next month's column.

Size your needs

I found that I was overestimating how much battery capacity would be needed. There are two basic methods of running model trains: around in circles at a relatively constant speed or the back and forth, start and stop of operations. My observation is that operations style movement takes about ⅓ of the energy that constant running needs. Said another way, if a battery lasts an hour in constant running, it will probably run about 3 hours in an operations scenario.

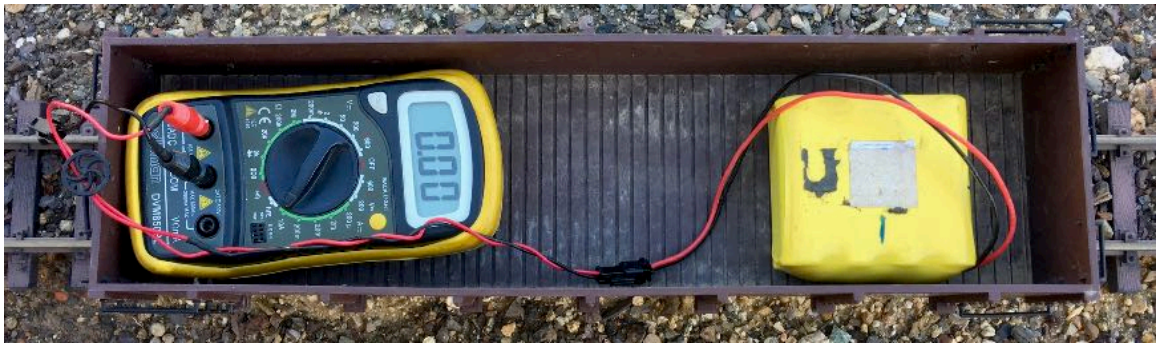
It is easy to calculate battery capacity for constant running. Measure the DC current being drawn from the battery when the loco is running as you desire (speed and load - number of cars).

Multiply the number of amps (A) or milliamps (mA) times the number of hours you want the loco to run. That number is the battery capacity needed. For example, if your loco draws 1-¼ amps and you want it to run for 3 hours, you need a battery with at least 3-¾ amp hour capacity (3.75 Ah = 3750 mAh).

Think of battery capacity just as you would fuel tank capacity. If your car burns 3 gallons per hour and you want to run for 3 hours, you need at least a 9 gallon tank. A larger tank will cost more to build and to fill and weigh

more when full, it will work just fine. Batteries are the same: higher capacity means higher cost and weight, but you will be able to run longer, too.

3. Battery pack and multimeter set for 10 amps running in trailing gondola to verify locomotive current draw. *Bruce Petrarca photo*



I built an adapter to do this testing. It has a connector on each end: one to mate with a battery and the other to mate with the loco. One lead has two banana plugs, allowing me to send the loco power through my digital multimeter, set to 10 A DC. I put the battery and my multimeter in a gondola car and ran it with each loco. I could read the running current while running around the layout [3].

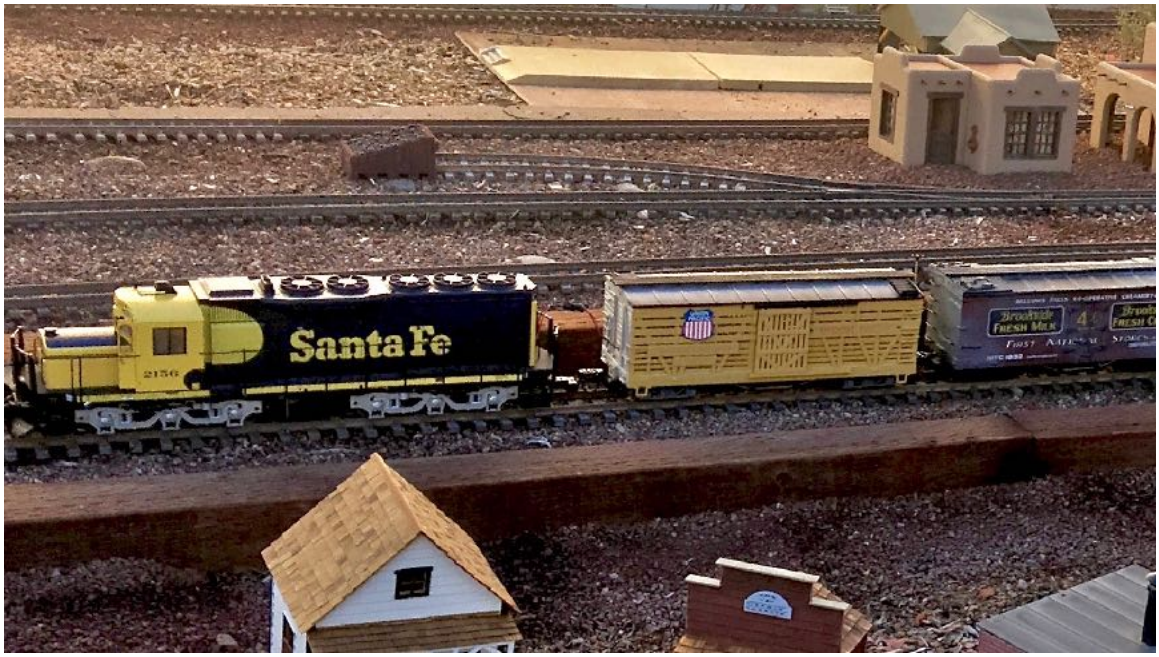
My club's garden layout [4] runs a few times a year around in circles for our open houses. For that we need two hours of reliable operation plus set up and check out time.

I was shooting for three running hours and I wanted to use the same battery size for every loco. Off hand, I thought the big LGB F7A & F7B pair would take about 3 amps (3000 mA). So that told me that I needed about 9000 mAh or larger batteries. When I looked at the price to buy three of these brutes, I decided to measure my needs and see what I really needed.

Guess what, none of our locos drew over 1.5 amps running. Most were under an amp. So, much less expensive and more available 6000 to 6800 mAh packs will give us over 4 hours continuous running on any of our locos.

The lesson to take away from this is don't guess. Measure and calculate.

4. PebbleCreek Model Railroad Club's (earlier) battery car (UP stock) and LGB loco preparing for the Thanksgiving open house in 2016.
Bruce Petrarca photo



Charging

Poor quality cells or improperly charged lithium batteries can lead to explosions and fires. Remember the 2016 debacle with the Galaxy Note7 smart phone that cost Samsung billions of dollars? If you don't want something like that to happen in your loco, pay attention.

I follow a few simple rules:

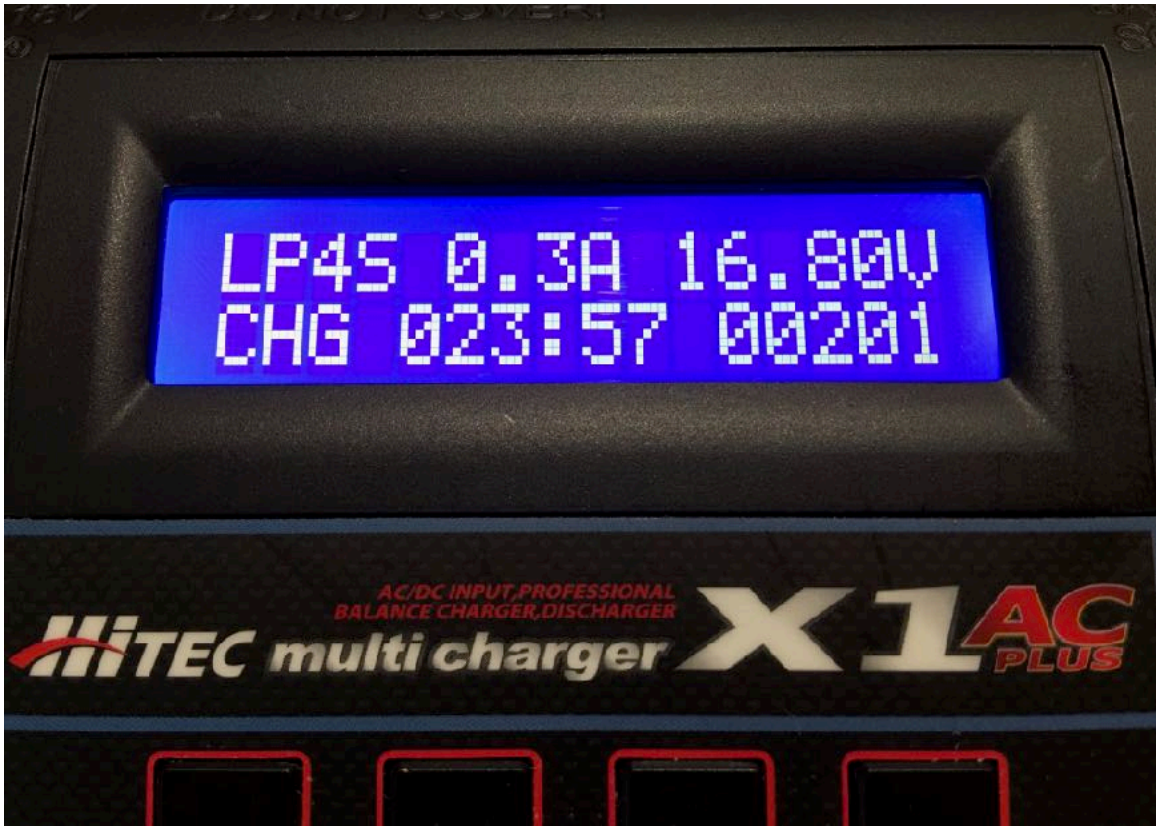
- Buy the best quality cells or batteries.
- Make sure they have built-in protection boards.
- Charge them with an appropriate charger designed for lithium batteries.
- Don't charge any faster than ½C - this will mean a few hours to fully charge a depleted pack.
- Charge the battery on a nonflammable [5] surface (old floor tile works).
- Don't leave the battery unattended during a charge cycle. Don't mow the lawn or go to the grocery store.

5. Charging a lithium pack on a nonflammable surface.
Bruce Petrarca photo

I found a charger that I like. It is not inexpensive, but you may only need one. My friend is the **HiTEC multi charger X1AC plus** [6]. Wow, what a mouthful. I bought mine from Amazon (**amazon.com/dp/B005LH3392**). It will run on AC power mains (100- to 240-volts) or DC (car battery) and charge almost any battery you can throw at it. It MUST be adjusted for battery chemistry and number of cells and maximum charging current. However, once it is set (in my case Lithium ion, 4S, 3 A for the 6800 mAh garden battery packs), it is plug and play. Connect the battery to the charger; plug the charger in; press and hold the start button; after the system verifies that its settings match the pack connected, press the start button again.

The X1, as I call it, not only charges things well, but does a great job of letting you know what it is doing along the way [6]. Many chargers expect you to understand what they are doing by a few LEDs that blink or change color depending upon what the charger is doing. The engineer in me likes data better than blinking lights.

6. HiTEC multi charger X1AC+ topping off the charge in a pack. This display shows: Lithium ion 4 cells (LP4S); charging at 0.3 A; with a battery voltage of 16.80 V; it has been charging (CHG) for 23 minutes and 57 seconds; 201 mAh have been added to the battery. *Bruce Petrarca photo*



Another good charger is the Imax B6AC charger. I understand that it is available on Amazon and eBay. The menu is exactly the same as the X1. While I cannot comment on this product from personal experience, I have a high recommendation for it.

Between garden railroading and smaller scales, there are differing needs. The garden folks would like charging capabilities up to 5 amps. For the smaller scales, 200 mA (0.2 amps) is a very convenient and safe level. Both the X1 and the B6AC are adjustable from 0.1 amps to 3 amps.

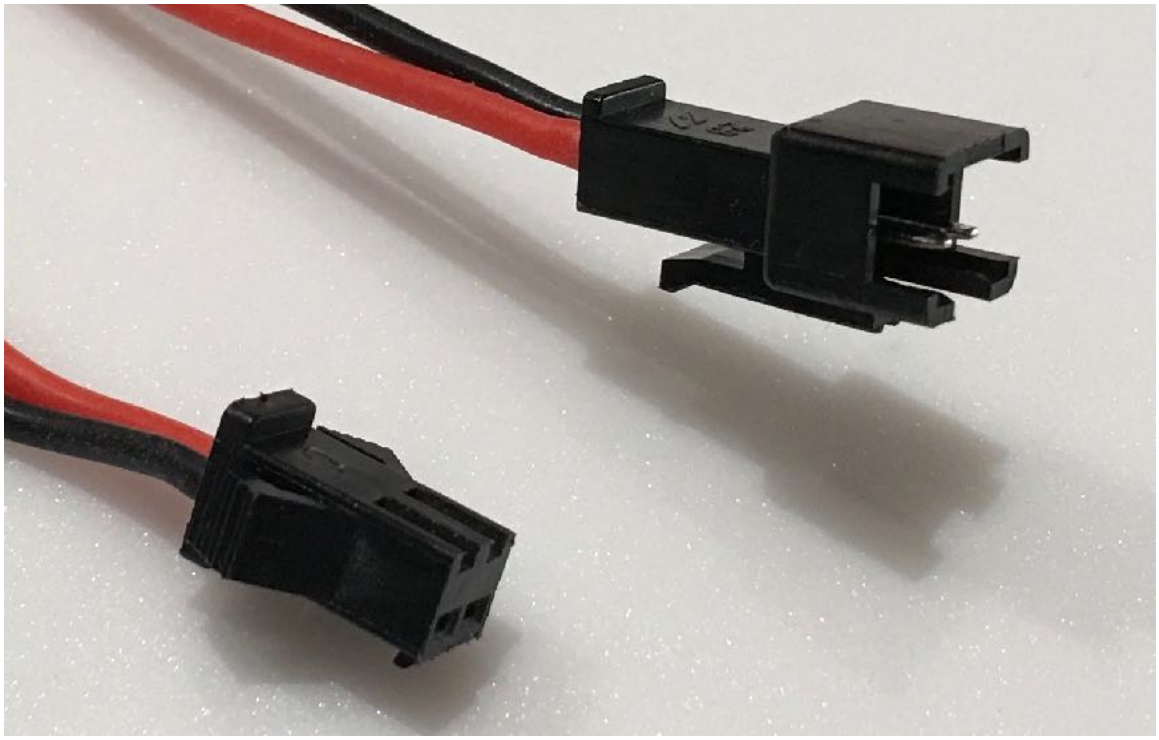
You may have a preferred charger. Perhaps you'll share your find with other readers by clicking on the reader comments buttons at the beginning and end of the column.

Polarity

One issue in the garden that doesn't raise its head so high other places is battery polarity. Most garden installations have trailing battery cars. Some with the DCC receiver in the car, some with it in the loco.

There is a semi-standard created by Aristo-Craft's early entry into battery powered garden locos. They equipped many of their models with a battery connector [7]. Many modelers use these connectors on all their battery powered locos, regardless of manufacturer.

7. Aristo-Craft connectors, both battery (left) and loco (right) side. *Bruce Petrarca photo*



Unfortunately, not all folks who are putting these connectors on their locos use the same side for positive and negative. I recommend you choose to follow the Aristo-Craft standard (red and black [7]) or the opposite and make all your locos the same. At the club, we started with the standard and will adjust future installations to comply.

Sources

Where to get the batteries you need? Here are some sources I've found. Feel free to share yours with readers by clicking on the Reader Feedback links at the beginning and end of the column.

For the garden, some folks want high speeds which translates into voltages around 20 volts. I haven't chased after these high values. They are available from garden railroad specialty retailers, such as RLD Hobbies (**rldhobbies.com**). Alas, we have no dedicated garden railroad retailers advertising in MRH.

However, I find that the 14.8 volt (4S) packs are just fine with any of the locos at our club or my layout. CVP sells, through their dealers (**cvpusa.com/airwire_dealer.php**) and directly on their web site, both 3400 mAh and 6800 mAh 14.8 volt packs. My only issue with this product is that it's polarity is reversed to the Aristo-Craft standard. However, with care, the pins can be slid out of the housing and reinserted in the opposite side. Be very careful not to short the two leads together in the process.

Quality packs in the smaller capacities are a bit harder to find.

Through the NMRA, I've come to know Pete Steinmetz. Pete was one of the co-founders of Dead Rail Society (**deadrailsociety.com**) and is currently the director of the San Diego division of the NMRA. He also has a business called Dead Rail Installs (**deadrailinstalls.com**), based in part on his prior career sourcing rechargeable batteries from around the world. A lot of what I've learned about present-day battery technology has come from Pete.

Pete has become my go-to guy for batteries (**deadrailinstalls.com/battery-sizes-and-capacities**). He stocks, or has available in a very few days, many sizes of the smaller batteries. Because of his prior work, he is fanatical about cell quality and protection. In addition, he is a dealer for CVP's AirWire, BlueRail Trains, SoundTraxx and Tam Valley Depot. Pete even makes kits for installations in what I call "mid-scale" locos, such as On30.

I realize this column is a snapshot of where I am in this process just now; aimed mostly at the garden. I'm planning some work in the smaller scales and hope to share that later this year.

Please share your experiences and ideas. Just click on the Reader Feedback icon at the beginning or the end of the column. While you are there, I encourage you to rate the column. "Awesome" is always appreciated. Thanks.

Until next month, I wish you green boards in all your endeavors. At that time, I'll discuss the battery cars I've been building for our PCMRC garden railroad with full time voltage metering.

