

# How to Install Battery/Sound/DCC

Steve Seidensticker (sseiden@att.net)

I have a small business installing such systems in O and G scale locomotives. In the last few years I have done 80+ such installations. I figure it is about time that I pass on some of the stuff I have learned.

Battery, sound, and control systems have been evolving for years, but for the last few years the organization and architecture of such systems have settled into the same arrangement and I think that will remain stable in the foreseeable future.

This current set up is much simpler and requires way less wiring and way less skill to install. In my business I have ripped out many old sound and control systems. With each one I marvel at their complexity and the ingenuity, patience, and skill of their installers.

The current generation of systems have smaller and fewer components. On G and O scale installs I can generally fit everything inside the loco (and tender) with maybe a bit of surgery that is not visible. On occasion I have mounted some components in the cab, where they are visible, but not obtrusive or obvious.

## **Battery Power Benefits**

I acknowledge that when discussing battery vs. track power the issues are as polarizing as politics or religion. But I am assuming that the readers of this are at least considering battery power. Let me list some reasons for heading in that direction.

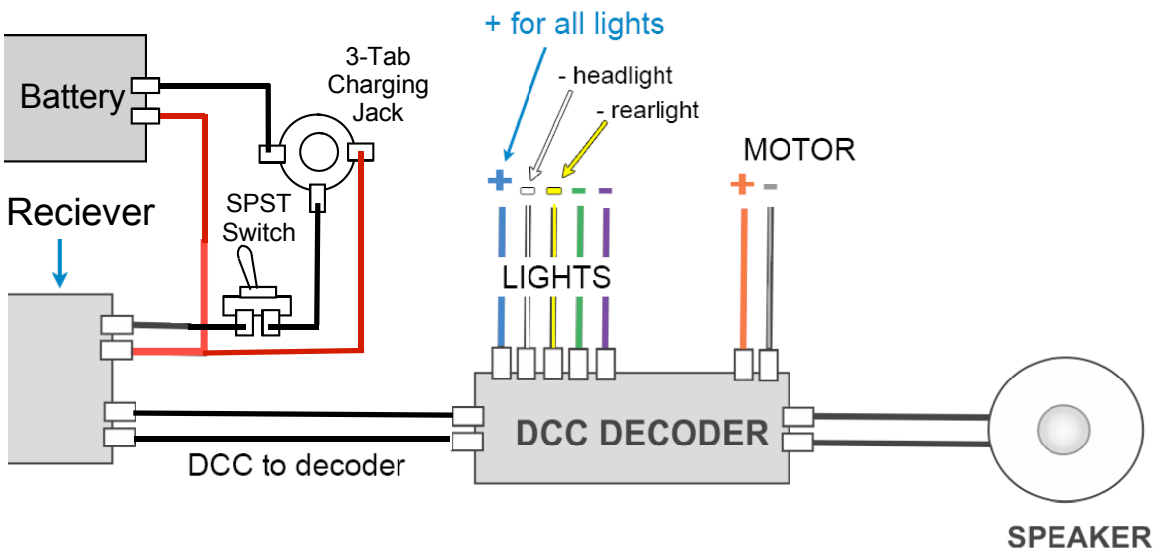
**Less wiring.** The main line of my outdoor Gopher Canyon Line started as an oval in 1992. I knew it would not stay that way. It now has about 800 feet of track and dozens of turnouts. I cannot even imagine trying to distribute and manage power to that much track. The larger the layout, the more complex power management becomes.

**Less Control Complexity.** No worries about what throttle is connected to what track. Reverse loops? Track shorts? Circuit breakers? Overloads from too many locos in the same block? All of these issues just go away with battery power.

**Less Maintenance.** Track connections loosening? Dirt? Corrosion? My only track cleaning tool is a broom.

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The following diagram illustrates how the various components fit together.



### Decoder

The heart of any sophisticated model loco control system is a DCC sound decoder. The architecture described here can use any NMRA compliant DCC decoder. However, I have settled on the two most popular in the U.S.: Soundtraxx and TCS (Train Control Systems).

The two outputs from the receivers are connected to the two power inputs to the decoder. Because they are DCC signals there is no correct polarity involved. That is, it does not make any difference which wire goes to which input. The decoder inputs are generally marked as "L" or "R" indicating that they are coming from the left or right rail. Sometimes they are labels as "B" or "R" indicating a black or red wire.

### Caution

A fundamental requirement when installing a decoder in any loco in any configuration is that the motor must be isolated from the track power pickups. On locos that have a label indicating "DCC ready" this is simplified. All one has to do is disconnect the wires from the track that go to a PC board. These are usually black and red and are labeled on the PC board.

However, on older models the wires from the power pickups go directly from the pickup to the motor and then may go on to power lights for a smoke unit. On G scale Bachmann Shays or Climaxes or diesels the situation is bit more tricky. On

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those the motors are in the trucks and the wires between the pickups and the motor are not accessible.

To be safe in all these situations I simply remove or disconnect the power pickups. Power pickups usually consist of a pair of spring loaded shoes that contact the rail and/or spring loaded plungers that push against the back of the driving wheels. Sometimes there are sneaky pickups. For example, G scale Bachmann Big Haulers also pick up power via the 4-wheel pilot truck.

**Soundtraxx Tsunami-2:** These are very popular. They come in small, medium, and large sizes: 1100, 2200, and 4400, to accommodate current of 1.1, 2.2, and 4.4 amps respectively. They are distinguished by the large variety of bells, whistles, horns, and prime mover sounds. They offer one decoder for steam locos and about a half dozen versions for diesel and electric locos. If you are installing a decoder into a model of an Alco loco you will need to pick a decoder that includes Alco sounds. In addition to a variety of sounds available these decoders have CV adjusts that allow one to change pitch, volume, echo effects, and a variety of other sound effects.

**TCS WOW:** They are comparable in price and capability to the Soundtraxx products. They come in two and five amp versions. They offer a single sound set for steam and a single set for all diesel. While the variety is less than that offered by Soundtraxx the number of prime mover sounds, horns, and bells is more than adequate for most modelers. TCS' claim to fame is a feature called Audio Assist that allows the user to quickly and easily change lights, sounds, motor operations via spoken menus emanating from the decoder.

I use the largest of the decoders offered by these companies for most installations. With small G and O scale locos where space is an issue I have used the smaller versions successfully.

**Other Decoder Offerings:** Many companies offer DCC decoders, each of which may offer advantages in the way of cost, features, power, fidelity of sound to the prototype, etc. Noteworthy among them are two European companies, ESU (Loksound) and Zimo. These companies seek to get the ultimate in prototype fidelity by selling sound "projects" based on detailed recording of specific locomotives. These projects must be loaded onto the decoder by either the dealer or the user.

### Note

I have very limited experience with these decoders but I am confident that any DCC decoder will work with the basic configuration defined in this article.

**RailPro from Ring Engineering:** This is a new control system that is based on direct two-way radio control with a hand held transmitter. Each loco is equipped with a proprietary module that combines the functions of the receiver and decoder. These modules come in G and HO scale sizes. It is not DCC. I have no experience with RailPro but I am confident that locos equipped with this system can also be battery

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powered using the info described here. Just consider the receiver and decoder as a one component.

### Receivers

Receivers capture the over-the-air signals from a hand held transmitter and converts them into DCC signals and sends them to the decoder. There are two major companies offering receivers. Although they each perform the same basic functions there are significant issues to consider.

**Airwire.** This is the trade name for a very popular control system from CVP, a pioneer in model railroad control systems. It has been refined over the years to become a very reliable system. One of its more attractive features is a transmitter with a knob that the user twists to control speed and a series of buttons to activate various functions (horn, bell, lights, etc.).

Communication is one-way. The transmitter can send speed/direction commands to the loco and can also program Control Variables (CVs) in DCC decoders. However, there is no feedback mechanism and the system cannot read the contents of CVs.

CVP sells two types of receivers. The first, which I will only mention here, is a series of boards that combine the receiver functions with a non-sound DCC decoder. This is an older architecture that I have not used. It is less versatile and an evolutionary dead end.

CVP/Airwire also sells what they call the Convtr series of receivers. It fits the architecture described here. It simply “converts” the over-the-air signals from the transmitter to DCC signals for a decoder.

CVP offers these Convtrs in three sizes (15, 25. and 60) to handle 1.5, 2.5, and 6.0 amps of current. For G and O scale I mostly use the 60 series. Where the loco is smaller and space is a consideration I have often used the 25 series without problems.

The Airwire system can operate on 17 different selectable frequencies. It is possible for a single Airwire transmitter to control multiple locos, but it is not possible for multiple Airwire transmitters to operate on the same frequency in the same area. The transmitters will interfere with each other and the locos will not get the intended commands. The transmitters can easily change their frequencies and they can also change the receiver’s frequency by sending commands to change certain CV values. These CV commands also get passed on to the decoder. This can get tricky if those CVs are important to loco operation.

**Note:** CVP/Airwire requires correct polarity input. The positive connection (almost always a red wire from the battery) must be connected to the positive(+) terminal on the board. Incorrect input polarity will destroy the receiver. CVP goes to some length in their instructions to ensure this and provides a diode to use to determine which lead is positive if it is not obvious from color or source.

**Tam Valley Depot DRS Series:** This company makes, among many other model RR electronics devices, a receiver that is Airwire compatible. It comes in two sizes to handle either two or five amps.

It functions the same way as the Airwire receivers but differs in the way frequencies are selected. It can be “hard wired” to frequencies 1, 2, and 3 by setting jumpers on the board. It can also select a frequency dynamically. In this mode, when it is first turned on, it looks for a signal at the same frequency at which it last operated. If it detects a signal at that frequency it locks onto it. If it does not detect a signal at that frequency it scans the 17 frequencies until it finds a signal and locks onto the frequency of that signal.

This can also be tricky if multiple transmitters at different frequencies are in the area. Which signal and transmitter will a receiver lock onto? Matching the intended receiver with the intended transmitter can be done, but only with careful procedures.

The DRS receiver is less sensitive to input polarity. It has a built-in diode to protect the board if the polarity is wrong. If the leads are incorrect, no harm will be done. The board will not be damaged but it will not work until the leads are connected correctly.

## **BlueRailDCC**

This is the new kid on the block. Perhaps the feature that most distinguishes it is that it allows control of trains from a smart phone app instead of a dedicated transmitter. This is attractive to many users because it eliminates the cost of a dedicated transmitter. It also appeals to the average user because they are familiar with a device they use daily.

BlueRailDCC uses the Bluetooth Low Energy communications protocol. BLE is often confused with "classic" bluetooth (typically used in speakers and earbuds). BLE uses less power, supports many simultaneous connections, and transmits at ranges up to 300 ft. This allows two-way communication and multiple locos and multiple smartphones in the same area without worries about frequencies and interference. The Bluetooth communications protocol hides all that from the user. He or she just turns the loco on, sees it listed as available in the app, and starts controlling it.

The app itself is very powerful in that it permits control of multiple locos. They can be controlled singly or in consist (with speed matching). It facilitates programming of decoder CVs with a quick read/write function, by associating english descriptions of each CV, reading multiple CVs, and remembering the values of the CVs read.

BlueRailDCC receivers are manufactured by Tam Valley Depot in two sizes. The larger one can handle five amps and the smaller one two amps.

BlueRailDCC has one unique feature. By inserting a jumper on to the board it can become both a receiver and decoder. In this “basic” mode the user can control speed

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and direction of the loco and two lights (headlight and rear light). In this configuration the user gives up sound but avoids the cost of a separate decoder.

As an installer I offer the user the choice of Airwire or BlueRailDCC systems. Some like the features and familiarity of using a smart phone app. Others prefer the simplicity and tactile feel of a knob and buttons.

### **Battery**

Lithium-ion or Lithium-polymer batteries are now the industry standard for just about all applications. There is no reason to buy any other type. They are small and have enough power to run your trains for several hours on a single charge. For this reason my battery installations are permanent. In the old days when the batteries ran down quickly swapping a depleted battery with a freshly charged one was the way to go. Not anymore!

On my GCL op sessions I charge the five locos that I am going to use the day before the session and that is invariably enough for two three hour sessions.

**Voltage:** The higher the voltage the faster the top speed of the loco. I find that 14.8 volt batteries drive G and O scale locos at a very brisk pace. The traditional track power systems will generally put out 18-20 volts. That increases the top speed a bit but I have never had a complaint that one of my 14.8 volt installations was not fast enough.

If there is not enough space for a 14.8 volt battery I have installed 11.1 volt batteries. This is often the situation in small G scale 0-4-0s and in many O scale locos. The 11.1 volt top speed in those smaller locos seems to be just fine also.

I had one exception. A customer brought me a small G-scale 0-4-0. Space was tight and I put in an 11.1 volt battery. The loco went merrily down the track at a good speed. It certainly was a scale speed greater than the prototype could do. The customer was initially happy, but a couple months later he asked if I could make it go faster. I did some surgery and was able to squeeze in a 14.8 volt battery. Everybody was happy.

**Capacity:** This determines how long a loco will run on a charge. Capacity for small batteries is stated in Milliamp Hours (mAh). To determine how long a particular loco will run with a particular battery first determine how much electrical current the loco uses. This is stated in Amps (A) or milliamps (1/1000 amp) and is measured by an ammeter. Once the current is determined divide mAh of the battery by the mA of the loco. For example, a loco that uses 1000mA (or one amp) powered by a 3000mAh battery will run for about three hours on a fully charged battery.

But you really don't have to haul out an ammeter. After doing many amp measurements and reading about current draw of various locos let me offer some rules of thumb in the following table regarding typical current draw of typical locomotives. One thing that

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surprised me in both my experience and research is that O scale locos draw as much current as their larger G scale cousins.

Loco and Load	Amps
Medium Size Steamer/4-Axle Diesel Running Light	<1
Pulling Short Train on Level Track	1-2
Pulling Long Train on Level Track or Shorter Train up a Hill	1.5-2.5
Maximum Load (Drive Wheels Slipping)	2-3

**Protection:** Batteries come with or without protection circuits built in. These protect the battery from shorts, over charging, and something called the minimum voltage limit. Such batteries are more expensive, but well worth the investment. The batteries without the protection are sold mostly to model airplane flyers that need high charge and discharge currents. Suppliers to that market provide protection by selling “explosion proof” charging bags. Although I have never experienced a battery fire or explosion it has been known to happen. The model railroad community works with relatively low currents and can put the protection circuits to good use.

Lithium batteries do have one negative characteristic. If they are completely discharged they are ruined. The protection circuit shuts down the battery when the voltage drops to a predetermined minimum. So your train will stop abruptly when the battery is discharged to that point and it will not run again until the battery is charged.

One more consideration is self discharge. All batteries, including lithium, will discharge when not being used or in storage. If they discharge much below the minimum voltage level trip of the protection circuit they will not recharge with the simple easy-to-use chargers. They can sometimes be charged with more sophisticated chargers, But if they discharge too far nothing will charge them. So don't store them for extended periods without charging them, at least partially, every three to four months.

**Battery Offerings:** I like the 3400mAh 14.8 volt battery offered by CVP and CVP dealers. It is small enough to fit into most G scale locos and runs them for several hours on a charge. CVP also offers a larger 6800mAh version of the battery. It fits into many G scale diesels and some steam tenders, but I find it is overkill in most circumstances. I do use that battery in my own six-axle USA Trains SD40 and I did install it a G scale MTH F7 AA diesel that was configured in a master/slave lash-up where both units always ran together. That loco has eight powered axles and four motors.

Where room is too tight for the CVP 3400 battery I have successfully used two smaller 7.4 volt 2900mAh batteries and wired them in series. This is often the case with O

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scale and smaller G scale locos. I get them on line from All-Battery.com. They, and other battery houses, have a tremendous selection of small batteries.

For yet smaller installations, where I have dropped to 11.1 volts, I get such batteries from DeadRailInstalls.com. The largest capacity battery that they sell is 850mAh. I wish that someone would offer either 11.1 or 14.8 volt batteries in the 1500-2500mAh range, but I have not been able to find any such battery.

### Switch and Charging Jack

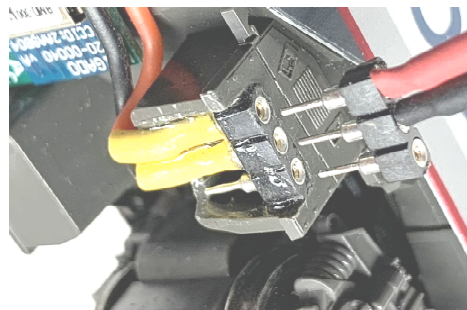


The switch is just a single pole, single throw (SPST) on/off toggle switch that is there to turn on the loco when you want to use it and off when you are done with it. I generally mount it to be easily accessible but not obtrusive.

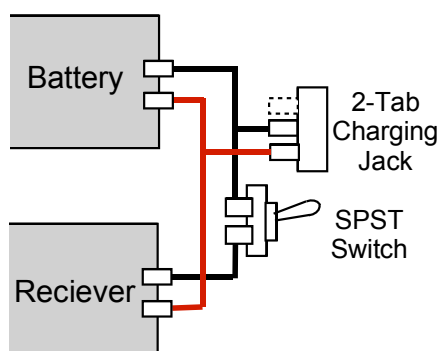
The charging jack is a receptacle into which we insert a plug connected to a charger. Although it is not universal installers like me have settled on a receptacle/plug combination that is technically referred to as a 2.5x5.5mm DC power connector. The receptacle and plug look like this.



The receptacle has three solder tabs on which to attach wires. It should be wired as indicated in the system wiring diagram. The three-tab receptacle is also a switch. When there is no plug inserted the two black wires are connected. When a plug is inserted that connection is broken and both leads of the battery are connected to the the charger. This prevents any power flowing to the receiver while the battery is charging, even if the user has forgotten to turn the toggle switch off.



For most O scale and all HO scale this charging jack is too large. It would work but is grossly out-of-scale. In such applications I use a very small plug connection that looks like this. These are made from common 0.1" pin connectors used in the electronics hobby.



These charging jacks show three connections but for a different reason than the three tab jack shown earlier. This smaller jack only has the two wires attached. The third hole and pin/tab have no wires connected and are only there to keep someone from inserting it incorrectly. When inserted correctly the



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two wired connections mate. If reversed only one connection is made and no harm is done. By convention the black wire from the battery and charger is connected to the center of the three pins.

The smaller jack does not cut power to the receiver as does the three-tab jack. It is up to the user to ensure that the power toggle is off when charging. No harm will be done if the switch remains on but the charger's current will go to both the battery and the receiver and that will slow the charging process. If the charger does not produce much current it may not charge the battery at all.

### **Charger**

There are two generally types of chargers; small, cheap, and easy-to-use; and expensive, capable of charging all kinds of batteries, with complex controls.

For my customers I supply and recommend the first type. They typically will charge only one type of battery and one battery voltage. They have no controls. The user simply plugs one cord into a 110 volt wall receptacle and the other cord into the charging jack. A red light indicates it is charging the battery and a green light indicated that the charge is complete. Typical cost is \$20-30.

Because I am constantly trying new battery configurations I invest in the more capable chargers. About 15 years ago I bought an Electrify Triton II. It cost \$160. I loved it. It did everything possible with charging, discharging, reviving "dead" batteries and could do it with all common battery types, voltages, and capacities. But a couple of years ago it died. The company that made it has gone out of business. The replacement high-end chargers are not nearly as capable.

### **Tips and Tricks**

**Bench Layout.** Before you start installing the components in the locomotive temporarily hook them up and put power to them on your work bench. This will give you the assurance that all the components are compatible and working.

**Test as You Go.** Before you start make sure the loco works well. A poor running loco will not run any better after you install a receiver, decoder, and battery. As you install and wire the components test your installation to that point. A key point is to test the wires to power the receiver before attaching them. Hook up a voltmeter to those leads and check the voltage, the polarity, and that the on/off switch works.

**Mounting Circuit Boards.** Use double sided foam tape to mount the board to a flat surface. Some of the larger boards have solder protrusions that may pierce a single layer of foam tape and may cause a short on the board if the board is mounted on a metal surface. In that situation just use two layers of foam tape.

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Use caution if you mount boards using a silicon adhesive. Silicon adhesive is conductive until it is fully cured. That may cause shorts or unwanted connections on the board. I do not use silicon adhesive for mounting boards and do not recommend it.

**Space Saving Mount.** Where space is tight I often attach the receiver and decoder to each other back-to-back. I do so by gluing small plastic spacers in the areas where there are no chips. Leave about an eighth to quarter inch spacing for air circulation. Then you can mount this sandwich vertically in a narrow space with foam tape along one edge.

**Multimeter.** In addition to the usual cutters, strippers, tweezers, etc. I recommend a multimeter. For one or two simple installs a basic one (less than \$20) is fine. All you need is continuity and voltage checks. For more complex installation or if you are going to do many installs, invest in a multimeter that can also show AC voltage and amperage.

**Power Supply.** When testing it is often handy to have a power source nearby. I often just used an extra battery that was lying around. Then I invested in a bench power supply. It became one of the handiest tools I have. I bought one on Amazon for about \$50 that lets me adjust voltage (0-30) and amperage (0-10).

**Third Hand.** Often when soldering it's nice to have something to hold the wires. Third hands are just small flexible or articulated arms with alligator clips on the ends that can be positioned as necessary. See the "Mogul" video described below to see one in action.

**Fuses.** Many older battery installations had a fuse in the circuit and some installation guides and videos still recommend them. However, if you use batteries with protection circuits built in, fuses are not needed. Receivers and decoders also contain current limiting circuitry.

**Current Surge.** Some decoders have capacitors built in to provide a "keep alive" function that keeps a loco running over dirty track. Of course, this is not needed with battery power, but it has bitten me on several installations. When battery power is switched on there is a surge of current to charge the capacitors. This surge can trip the over current protection in the battery. To prevent this put a 0.5-1 ohm 2-5 watt resistor in one line between the battery and the receiver.

## Videos

Here are some videos of recent installs that illustrate what I have been talking about.

**Porter:** Installation of an AirWire receiver, two batteries, a Soundtraxx decoder, an exciter (speaker) into a Bachman Fn3 0-4-0 Porter steam switcher. I normally install 14.8 volt lithium batteries, but due to space limitations I used two 7.4 volt batteries wired in series. There is a large weight in this loco that had to be cut up to make everything fit.

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<https://www.youtube.com/watch?v=ba5367CqUG4>

**Mogul:** Installation of a BlueRailDCC 5 amp receiver, a Soundtraxx decoder, and a CVP 14.8 volt battery into a 25+ year old LGB 2-6-0 Mogul. It had the original LGB sound system in it along with an old battery and control system. All that was removed but the speaker was retained.

<https://www.youtube.com/watch?v=mdY1LbTYYoE>

**Climax:** Installation of a BlueRailDCC 5 amp receiver and a CVP 14.8 volt battery into a new Bachmann Fn3 Climax that already has a factory installed Soundtraxx decoder. I was able to squeeze the BlueRail board into the fuel bunker next to the decoder.

<https://www.youtube.com/watch?v=c-E1oghXgsk>

**MTH F7:** Installation of a fairly large (6800mAh) CVP 14.8 volt battery and a Tam Valley DRS1 receiver (AirWire compatible) into a pair of 1:32 scale MTH F7A units. The factory installed DCC decoder and other electronics were retained. These units are permanently coupled back-to-back in a master/slave relationship. The battery and receiver are in one unit and the decoder and other electronics are in the other.

<https://www.youtube.com/watch?v=51xyXzDYdd4>

**GCL Rollin':** A fun video that my son and I made of a "sweeper" train on my Gopher Canyon Line. It picks up all the cars in a town at the end of an operating session and take them to the main yard.

<https://www.youtube.com/watch?v=o-ZJeS3U67Q>

Thanks for looking at this. I hope it is helpful. If you have any questions or comments send them to me at [sseiden@att.net](mailto:sseiden@att.net).