



Convert engines to --- BATTERY POWER



PART 1:

What to consider before you start

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PHOTOS BY THE AUTHOR UNLESS NOTED

Trying to write a detailed how-to article that applies to all battery conversions is impossible. Each locomotive is unique. Even two identical models from the same vendor have been known to be different once you get inside them. However, there are some constants that apply equally to all battery conversions, no matter the model, vendor, or type of locomotive. In this series I will stick to the generic things that need to be considered before starting a battery conversion.

The first thing necessary with a battery conversion is the understanding that new items will be added to the locomotive, the biggest probably being the battery. That means that space will have to be found for these new things. For diesels, finding space inside is usually easy. For a steam locomotive, that space is most often in the tender; for a tank engine, however, which has no tender, the problem becomes where to find the space in the boiler. If it's a flat-bed railtruck that is being converted, there is normally no naturally occurring empty space inside in which to place the necessary additions (**photo 1**). The only option here is to create a load to fit on the bed of the railtruck and hide the additional items inside that load.

What needs to be added?

There are three basic functions within a locomotive: something to make it move (the motor), something to make sound (whistle, horn, screeching brakes, etc.), and something to create visual effects (headlight, backup light, cab light, running lights, flicker in the firebox, smoke from the stack, etc). What needs to be added are circuit boards to power and control these

A smoking steam locomotive looks great when running on the railway but running a smoke generator consumes a lot of power and can easily cut the battery run time in half. The engine in this picture is running on Victor Thies' Too Much Fun Railroad. PHOTO BY VICTOR THIES

& RADIO CONTROL



1. This array of locomotives illustrates the potential problems in finding space for batteries and control gear. From back to front they are a USA Trains EMD GP-7, a Bachmann C-19 2-8-0, a Bachmann Heisler, and a Bachmann railtruck. Even though the GP-7 is a smaller scale, it has the most internal room for housing the electronics, speaker, and batteries. The tender on the C-19 carries its battery and

electronics. Speakers for the C-19 are in the smokebox. The Heisler, waiting for conversion, will have its battery and electronics in the bunker and speakers in the smokebox. The railtruck comes as a flat-bed truck. The battery pack, electronics, and speaker are mounted on the flat bed. To hide them, the owner mounted a box on the bed, making it a miniature boxcar.

three functions. These are usually called decoders because the commands that are sent to them are in the form of binary code that must first be decoded before the circuit board can act on the command.

In a basic, out-of-the-box track-powered locomotive, the movement function is provided by the motor, controlled by the power pack connected to track. Track-powered locomotives may also include some basic visual effects. (Not all track-powered engines come with factory-installed sound so this may be an item that must be added.)

Concerning the visual effects that come with track-powered locomotives, there are several options to choose from when doing a battery conversion. You can choose to keep all of the existing visuals; you can choose to remove some of these; or you can choose to add to or expand some of the existing effects.

Track power provides a virtually unlimited supply of power to the locomotive. However, the power from a battery is limited. The first thing to consider when doing a conversion is, "Are there any visual effects that draw an excessive amount of power but are not really needed and can be removed?" The most common item in this

category is a smoke generator. Smoke coming from the stack looks nice but it comes at a high price in power consumption. Running a smoke generator can easily cut the battery run time in half because it consumes so much power. The question then becomes, "Are you willing to significantly reduce your running time between battery-recharge cycles in order to keep the smoke generator?"

Another common visual effect is lighting. Here, too, the amount of power consumed can be reduced, not by removing lights, but by replacing incandescent lights with LEDs (**photo 2**). With unlimited track power, incandescent lights are okay. However, you will find that incandescent lights consume considerably more power than LEDs to generate the same amount of light. Switching as many incandescent lights to LEDs as possible is a great way to reduce power consumption. LEDs also have the advantage of long lifespans when compared to incandescent lights so you will likely not have to replace LEDs often.

With battery power, full, independent control of each electrical device is possible.

Basic track-power locomotive wiring

The basic wiring structure within a track-powered locomotive consists of a positive (+) and a negative (-) bus (**figure 1**). The positive bus is connected to one rail, while the negative bus is connected to the other. The connection to the locomotive is made

via the engine's wheels and, in some cases, also through the wheels of the tender. Some engines also have a "shoe" (**photo 3**) that slides on the rails to pick up power.

All electrical components in the locomotive draw their power from these two bus lines. Motor(s) are connected directly to the two bus lines. To reverse the direction of travel, the polarity in the rails is

reversed, which reverses the polarity of the bus lines. To change the speed of the locomotive, the voltage is varied—up for faster, down for slower, and off for stop. All other electrical components within the locomotive that are not direction-sensitive are connected directly to these same two bus lines. Components that *are* direction sensitive, such as the headlight and backup

light, are connected to the bus lines with a diode. The diode will only allow power to reach the electrical device for one polarity setting. When the opposite polarity exists, the diode blocks power from reaching the electrical device. This is how forward and reverse lights are made to operate for the appropriate direction.

One limitation of track-power-only locomotives is that the voltage on the rails must be set to zero to stop the locomotive. When this happens, there is no power available for the other electrical components on the locomotive so, when the engine is stopped, the lights go out and the sound goes away. Some manufacturers provide the option of a small, rechargeable battery that provides power to the lights and/or sound when the track power drops to zero, along with the ability to recharge these small batteries once track power is restored. These small batteries are intended to cover only the short periods of time when the locomotive is stopped and are not intended to provide power to motors. Thus, they do not replace track power.

With a conversion from track power to large batteries that will power the entire locomotive, there is a constant, if somewhat limited, source of power available, even when the locomotive is stopped. However, access to this power cannot be via the power-bus lines, as these must still go to zero in order to stop the locomotive. Accessing this battery power will require that the non-motor electrical devices no longer draw their power from the same bus lines that supply power to the motors. This, in turn, means that some rewiring will be required for these devices. With constant power available from the battery, the other electrical components need no longer be tied to the direction and/or speed of the locomotive. With battery power, full, independent control of each electrical device is possible.

Replacing incandescent lights with LEDs

The locomotive is not the only thing drawing power from the rails. Lighted passenger cars and marker lights on cabooses can also draw power from the rails. If the conversion to battery power occurs in all locomotives on your line and the final goal is to totally remove power from the rails, then a solution must be



2. From left to right are a grain-of-wheat light bulb, a white LED, a 470-ohm resistor, a red LED with resistor, and a green LED with resistor. At 12V, the grain-of-wheat bulb is moderately bright and draws 36ma. At the same 12 volts, the clear LED, combined with the 470-ohm resistor in series, is very bright and draws only 18ma. The red and green LEDs are mounted in correspondingly colored housings that include the recommended resistor. The LED and resistor as separate items allow for more flexibility in mounting, while the LED-with-resistor package creates a ready-to-go solution.

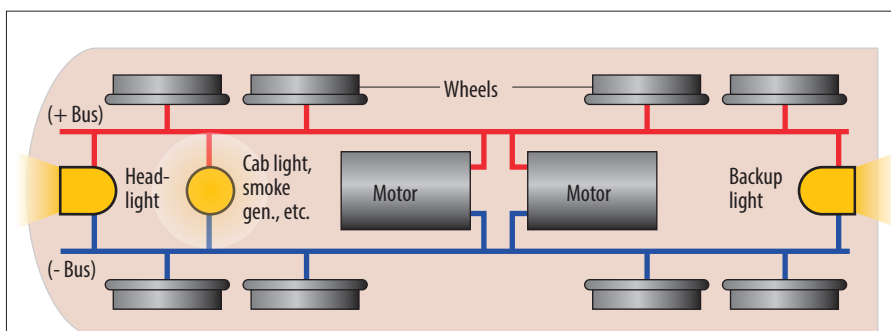


Figure 1—Basic track-power wiring

MARC HOROVITZ

found for these lighted cars, too. This solution may involve finding space in each car for batteries to power the car's lights. Another option is to place the batteries in a battery car, such as the baggage car, from which lighting power is fed to all of the other cars. This is a great place to reduce power and extend battery life by replacing incandescent car lights with LED strips.

What will be added to make it work?

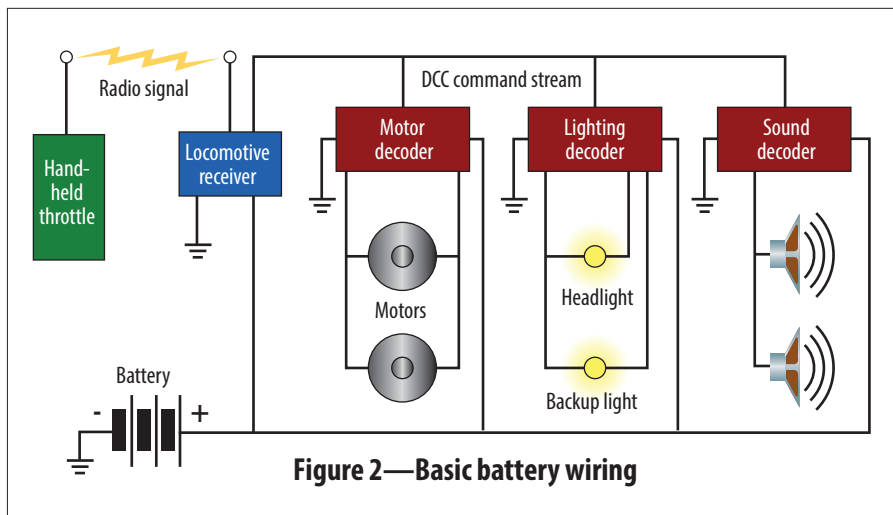
Now that a decision has been made concerning which items to remove, which to keep, and which to modify in order to lower the power consumption, it's time to identify what needs to be added. Each of the three basic areas of interest (motor, lights, and sound) will require a controller circuit (a.k.a. decoder).

In addition, something must be put in place to get commands to these controller circuits. This is generally done in one of two ways—either through the track or through the air via a radio signal. The



3. Locomotives running off rail power collect electricity either directly through the wheels or, as shown here, through separate shoes, or sliders, that contact the rails as the locomotive moves along.

through-the-track method for delivering command signals has a few advantages but it also has many of the same disadvantages associated with track power, the biggest of which is the need to keep the tracks clean. The primary advantage of sending signals through the track is range. Radio signals have a limited range and do not travel well through soil to reach a locomotive in a tunnel or behind a hill. Delivering command signals via the rails is not limited by range or location.




Combining various control circuits

With both radio-delivered and track-delivered commands, we need to set aside space for four different circuits in each locomotive (**figure 2**)—communications, motor control, lighting, and sound. Also, don't forget space for the speaker. Speakers come in different sizes and shapes. The available space may dictate the size and shape of the speaker.

Some manufacturers combine several functions on a single circuit board. The traditional AirWire solution combines communications, motor control, and lighting on a single board. QSI has a single board that combines sound, motor control, and lighting. Phoenix Sound Systems has a board that controls just sound, while Sierra Sound Systems (a.k.a. Soundtraxx) has a board that provides sound, motor control, and lighting. AirWire has recently announced a series of boards that handle only communications.

There are a number of manufacturers with products in each of these categories so it becomes a question of deciding how to mix and match the various circuit boards to achieve the desired goal. The single standing rule to follow here is to select circuit boards that are compatible. If they all comply with the DCC standard, you should be able to freely mix and match them. If any of them follow a proprietary standard, you may find that you will need to purchase all of your equipment from that vendor in order to maintain compatibility between circuit boards.

If the best motor and light control appears to be AirWire and the best sound control appears to be Soundtraxx, then the conversion will result in both circuit boards being capable of providing motor control. Only one of the two motor-control circuits will be used.

This gets us through the initial set of issues that need to be addressed before starting a battery conversion. In the next issue I will address the subject of battery selection—deciding which battery chemistry you should use. 



4. Two popular throttles, the AirWire T-5000 (left) and the Revolution throttle from Crest Electronics. The Revolution throttle uses all buttons: two for direction and two for speed. The AirWire throttle uses a knob for speed and a push/push switch on the knob for direction. Functionally, they are similar, both allowing you to select different locomotives.

In addition to keeping the rails clean, another limitation to track-delivered commands is reliability. With radio-delivered commands, each hand-held throttle (**photo 4**) contains a unique radio transmitter. If one of the throttles fails, that failure impacts only the locomotive it controls. With track-delivered commands, all of the commands from all of the throttles typically must go through a single, shared transmitter. Should this transmitter fail, it will impact *all* locomotives.

Some control systems maintain a two-way communication between the hand-held throttle and the locomotive. With these systems, the throttle display indicates if the throttle is in contact with the locomotive. Other systems are one-way only, meaning that the throttle sends commands but receives back no confirmation signal. With one-way systems, the operator cannot be sure the throttle commands

are actually reaching the locomotive.

Two-way systems maintain a relatively constant communication between the throttle and the locomotive. The locomotive can be configured to automatically come to a smooth stop, should this communication be broken. One-way systems send out a “heartbeat” signal at regular intervals. This may be as simple as, “Hi, I’m still here,” or it could be a full repeat of the current throttle settings. In either case, the receiver in the locomotive will have a timer that is reset each time the heartbeat signal is received. Between heartbeat signals, this timer counts the seconds since the last heartbeat signal was received. If the timer ever reaches a preset limit, the receiver will assume that it has lost contact with the throttle and bring the locomotive to a smooth stop.

In both cases (one-way and two-way communication), when the locomotive automatically stops due to loss of throttle contact, generally only the motion (motor) control will stop. Sound and lights will remain on. For the one-way system’s loss-of-heartbeat-signal timer, the limit is generally programmable to deal with cases where you might expect a momentary loss of signal, and that is okay.

A side note here would be that running locomotive consists (i.e. multiple locomotives in a train) may be a problem if you know there is a high risk of throttle-signal loss. If one locomotive shuts down due to throttle-signal loss, while the other continues to run, you will end up with a stopped locomotive and a locomotive that is pulling hard to overcome the resultant drag, which could damage the locomotive that is still running.

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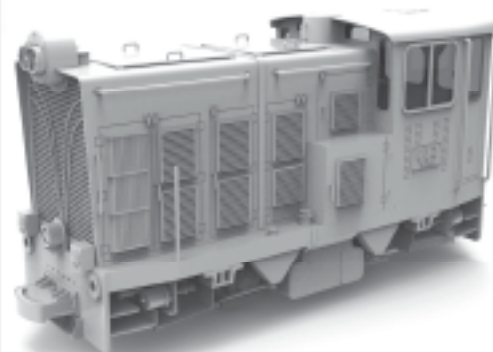


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