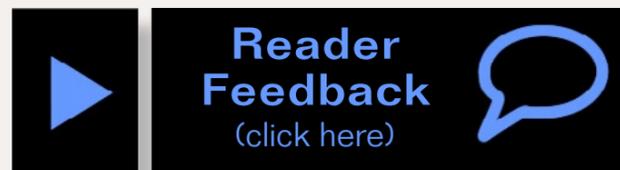


BATTERY-POWERED MODELS IN *HO scale*



KAOS comes to model railroading ...

– by **Dr. Geoff Bunza**
Photos by author



Many modelers have experienced DCC-controlled locos sputtering off and resetting over dirty track, and DC loco stalls necessitating five-finger encouragement. Some modelers have resorted to the use of “super cap” keep-alive supplemental circuits which can power the decoder and loco for a few seconds, but some keep-alive implementations do not meet clearance requirements on HO layouts.

What if a loco carried its own power on board? It would enter the realm of battery-powered model railroading. This article is an exploration of battery power for HO scale modeling, from relatively simple to more complex applications. Different approaches are presented with successful results and problems encountered along the way.

Battery-powered scale models exhaust all their power. Constantly replacing them can be both expensive and prone to damage in small scales. One then considers rechargeable

batteries, but recharging them has often resulted in special connections and more handling.

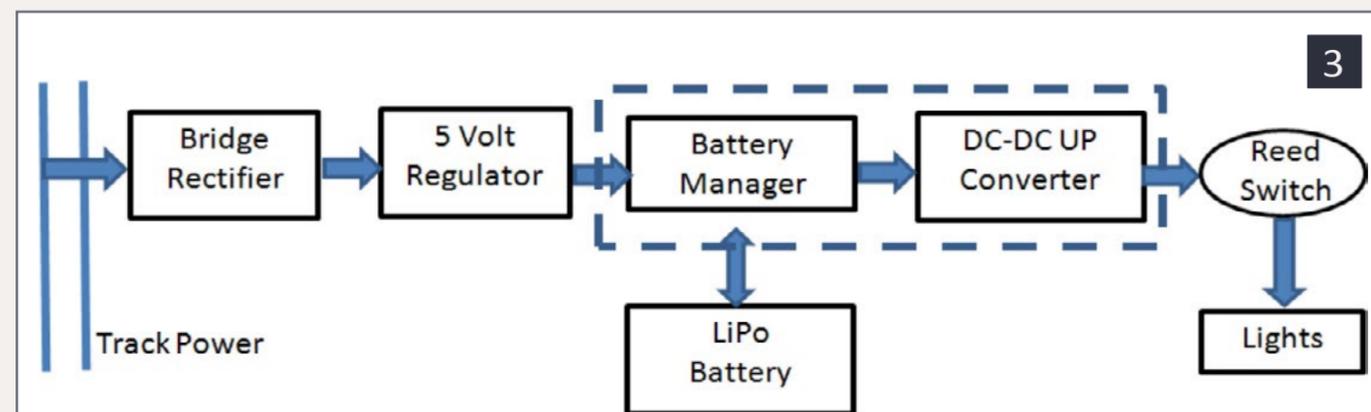
This leads to considering combinations of techniques and technologies, eventually resulting in “KAOS” -- Keep-Alive On Steroids. KAOS power uses high energy density, lithium polymer (LiPo) batteries, a low-cost, battery manager/converter board, and a simple scheme to charge the battery from whatever power is on the rails —DCC or DC power. Both work just fine. We will explore a number of alternatives and their issues. We’ll also consider a low-cost approach for remote control. This lays the groundwork for more modeling possibilities, and, of course, more fun!

Power, regulation, recharge, and conversion

This began as an experiment to see how the small but powerful LiPo batteries could be used for modeling. I have had some success using them with my small mobile cranes (See model-railroad-hobbyist.com/blog/geoff-bunza) and I wanted to put them on the rails. There are additional complications with charging and maintaining multi-cell LiPos used to get the higher voltages we are familiar with – like 12 volts.



2. 2600 farad keep-alive capacitor with clearance problem.



3. Basic power block diagram.

To keep things simple I elected to use a single 3.7 volt cell, recharged from the rails. LiPo batteries have a usable voltage range from about 3 to 4.2 volts, so part of the problem is converting battery power to a usable range for model railroading. Low cost and ease of construction were important constraints too. The other problem is one of control. If the model is independently powered, then how does one control it? It may be possible to open up a DCC decoder and re-wire it, but my ultimate goal was for autonomous animation applications. So, I didn’t pursue the DCC mod approach at all.

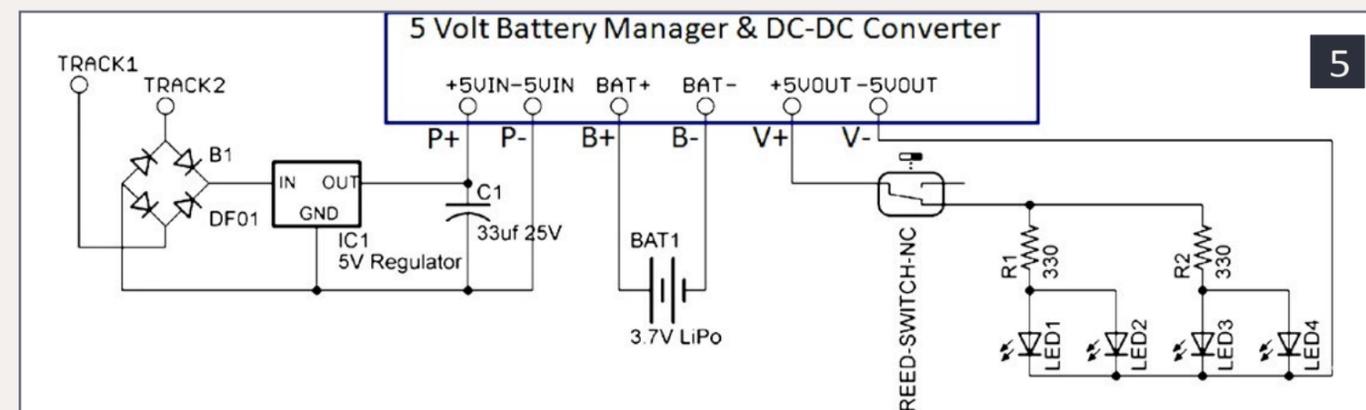
Before getting into the aspects of control, let’s look at the basic power source. The power block diagram is in [3]. Whatever power is on the rails is put through a small full-wave rectifier, regulated to 5 volts, and fed to the charging inputs of a commercial battery-manager/converter board. This board prevents overcharging the lithium polymer 240 milliamp-hour (MAH) battery. The module also controls the charging pattern and prevents over-discharge which can also damage the battery.

One version of the maintainer board contains a 5 volt DC-DC converter, which provides a stable, regulated 5 volt power source until the battery is turned off to prevent over-discharge. This combination of components provides a stable 5 volt, .45

amp mobile power source whose battery is recharged whenever it finds 6-25 volts on the rails, in any form, DC or DCC, even AC! It will recharge and protect the LiPo battery simultaneously. Later, we'll look at another variation.

Not everyone may be familiar with LiPo batteries, but they are actually quite common. They power many cell phones and tablets. They are light in weight compared to many other battery types. LiPo batteries have very high energy density. That is, they pack a great deal of electrochemical power in a very small volume. As such, if shorted out they can generate a great deal of heat in a short time, and can even explode and catch fire. Therefore, protection circuitry is essential for safe use. Damaged LiPo batteries should not be used, and should be disposed of properly and safely. When fully discharged for disposal they are not a toxic hazard. Over-charging and over-discharging damages a LiPo battery.

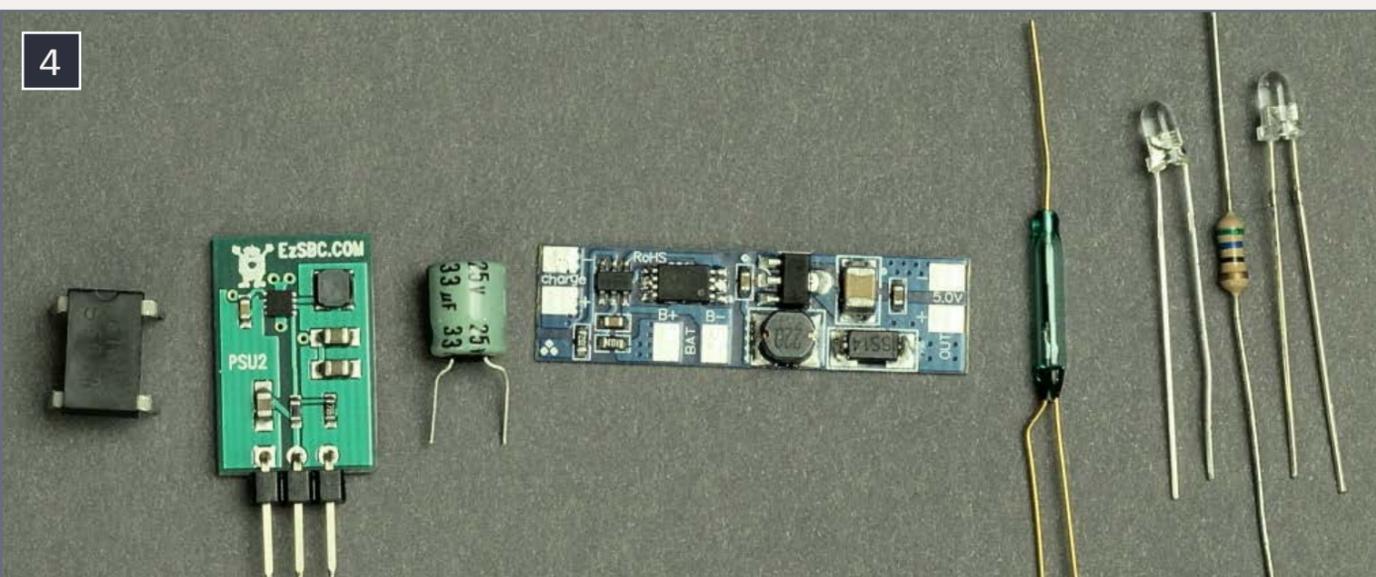
All these concerns for charging and use are handled by a small, low-cost (\$3.99) battery manager board. This board is available



5. Basic power block schematic.

via eBay ebay.com/itm/121003094575 as “Lithium battery charging 5V step up, protection all-in-one PCB.” I use a 240 MAH battery because it is small and fits many of my models, but larger single-cell LiPos will work too, if they meet the physical space requirements. You should note the rating pictured on each battery of 20C or 30C. This is the maximum charging rate specified for the specific battery. This would refer to 30 times 240 milliamps or 7.2 amps max charging rate. Or 20 times 250 milliamps or 5 amps max charging rate. These charging rates should never be exceeded, to prevent damage to the battery. Some LiPo batteries come with a small battery manager circuit board embedded in the battery package, but many, particularly the small LiPos, do not have them.

The first battery manager board I used expects 5 volts input to the board. We will use track power (DC or DCC) for board power. First, we convert track power to DC with a full wave bridge rectifier, and then regulate it to 5 volts. The bridge rectifier is a 1.5 amp DF01 bridge rectifier from goldmine-elec-products.com. The first attempt used a 5 volt, 1 amp LM2940CT-5.0/NOPB-ND from Digikey.com, similar to a common LM7805. But the peak current draw (charging a very low battery) was close to 900 milliamps, and the regulator ran quite



4. Basic power block components.

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6. LiPo batteries.

hot to the touch, even with a small heat sink attached. This was too hot for a closed plastic shell. A melt-down was coming.

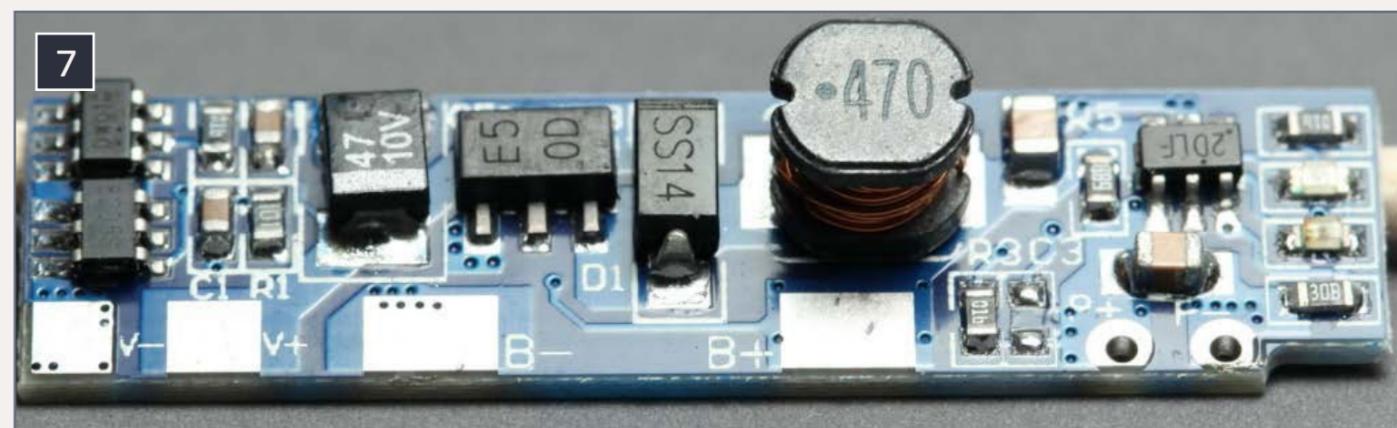
Fortunately, there is relatively new technology in the form of switching regulators to save the day. I had on hand a few 78ST105HC modules which come in a plastic frame with no heat sink. They provided the same regulation function and worked great, generating little heat if any. While the 78ST105HC is hard to get, their success prompted me to find the PSU2-5 from EzSBC.com, also available from their eBay store, an even smaller switching regulator in the same package outline as an LM7805. The heat problem was solved. A small capacitor was added across the output of the regulator — about 33uf at 25 volts. This capacitance value is not critical but use at least a 10 volt rating.

The last component in the basic power unit is a magnetic reed switch to turn the unit on and off. A plain single-pole

single-throw switch can also be used. LiPos are supposed to have a limited lifetime of charge/recharge cycles, as do most if not all rechargeable batteries. So when I'm done operating, I switch the unit off either with a tiny magnet attached to a figure [8], a small wand, or other device.

The reed switch is a single-pole double-throw switch, whose “normally on” side is used, such that when the switching magnet is taken away it assumes the “on” position. I was able to locate these easily on eBay ebay.com/itm/251461210780. A mechanical switch will also do well, but it requires more handling of the model to operate. Small reed switches like these are easily hidden, and can be activated by a small magnet without direct contact. This is a nice feature to build into a model. If the model is not used for a long time (say a week), it may be necessary to use the switch to disconnect the load, and recharge the battery back-up.

I have been able to operate the twin motors of one diesel (described later), for over an hour with no other power source. Current draw was about 180 ma. For lower-power LED lighting in cars, operation is much longer. While this will not provide



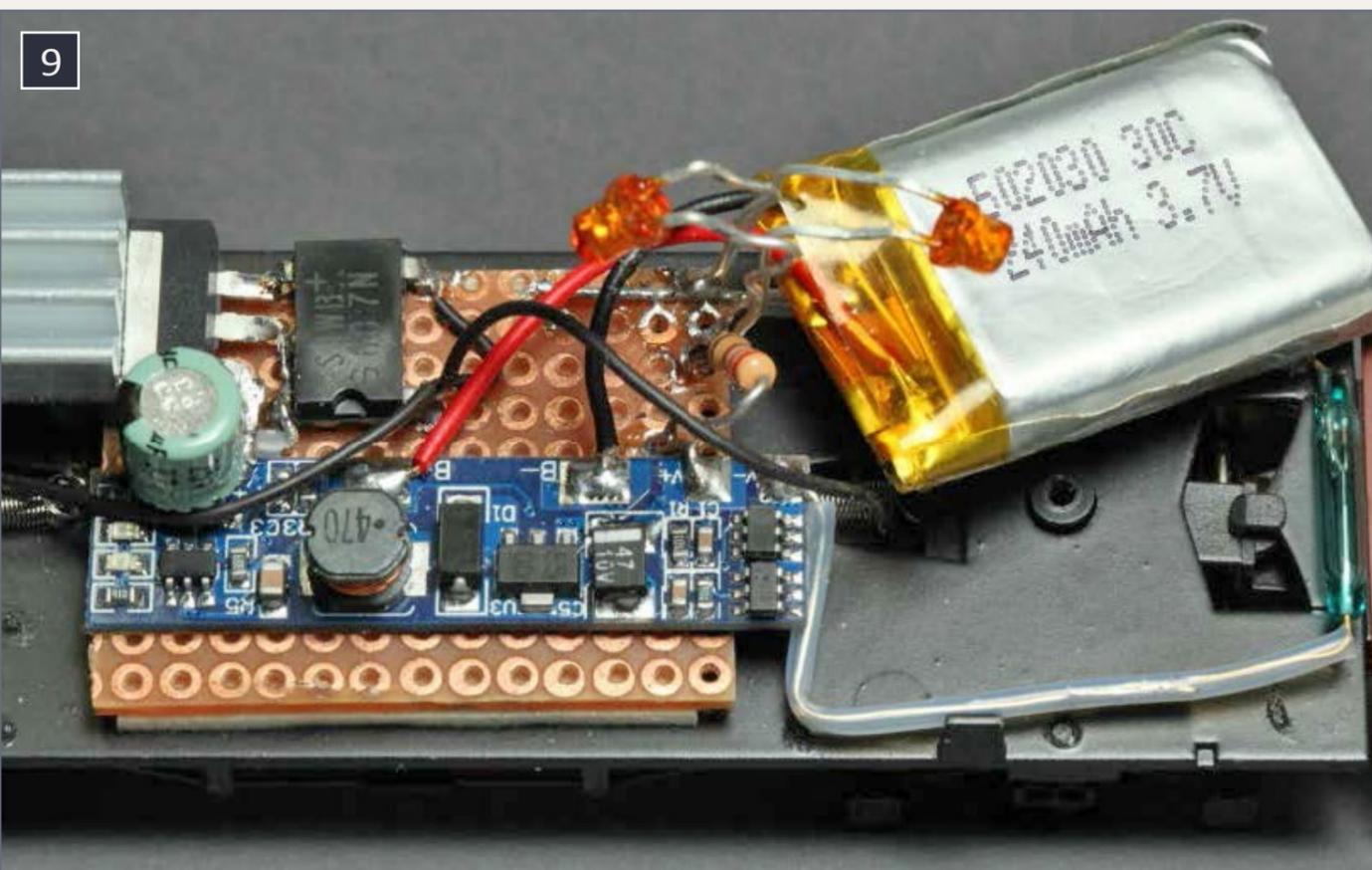
7. Battery manager board with built-in DC-DC 5V converter.

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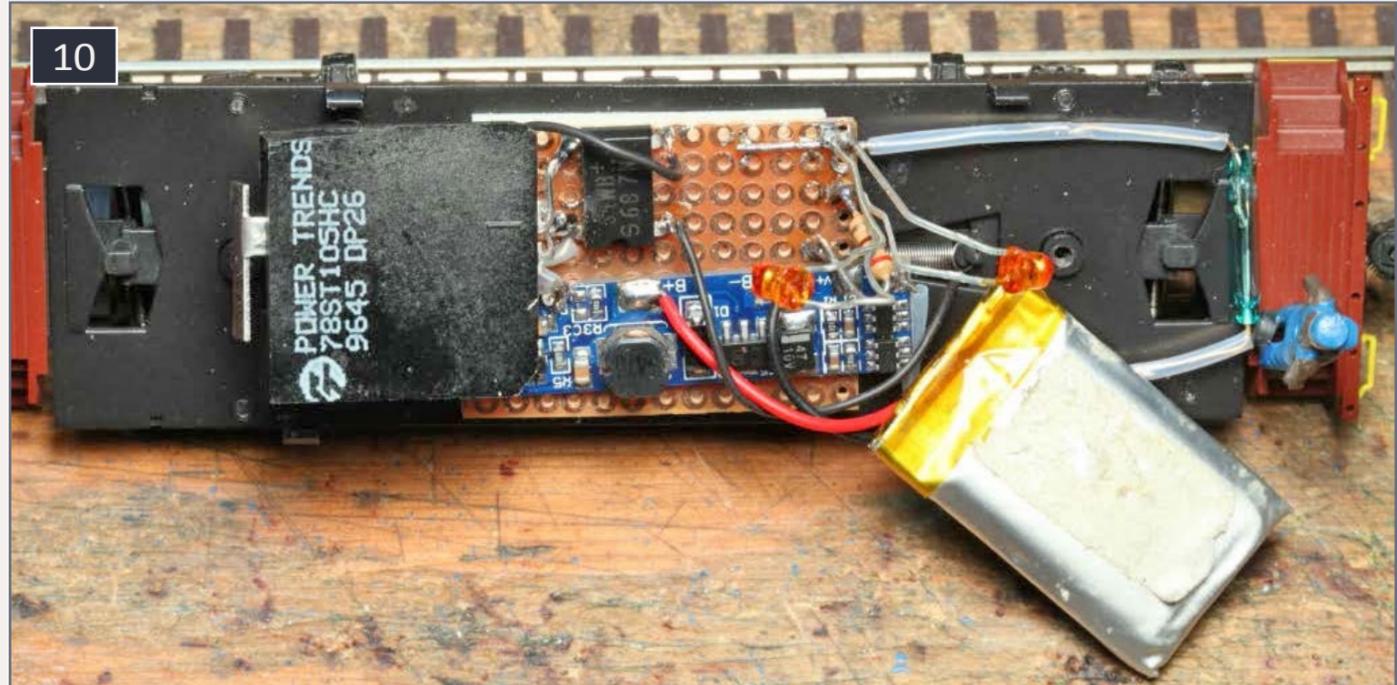
8. Caboose lights on.

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9. The basic power block installed in the caboose.

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10. Caboose using the upgraded basic power block.

power by itself for a multi-hour operating session, operation on powered track, even incredibly dirty power track, allows for recharging on the fly, and for smooth, continuous power. It's like a Keep-Alive module on steroids – hence, KAOS power.

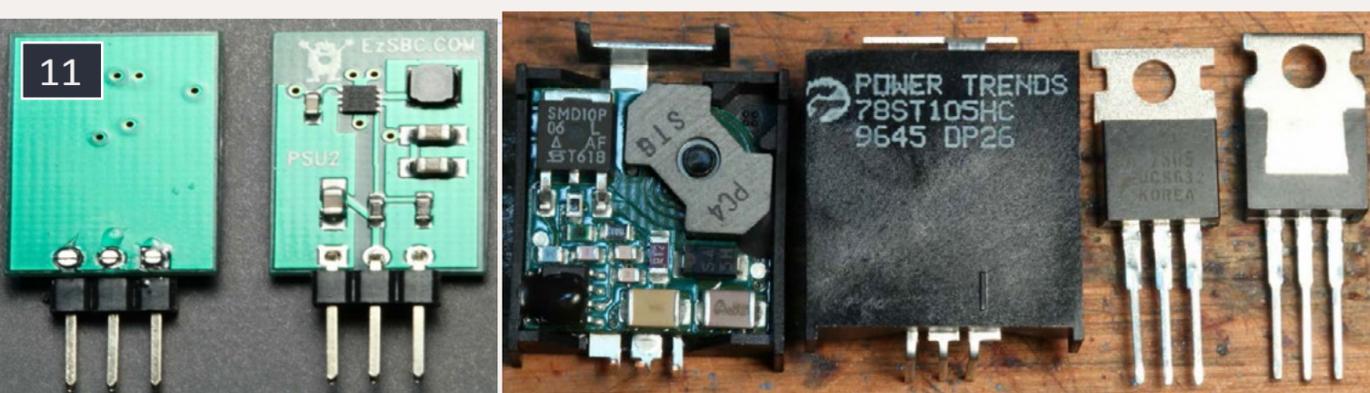
Caboose lighting details

Using the KAOS module just described provides an uninterruptable power source which can be used to light car interiors with no light flickering at all – unless you really want to make them flicker! The caboose pictured was my first test. It uses four LEDs, all lit with KAOS power. Figure [9] shows the basic power block installed in a caboose. Note the first use of the silver-finned, heatsinked regulator on the left. Figure [10] has the later version using the 78ST105HC to avoid a caboose meltdown.

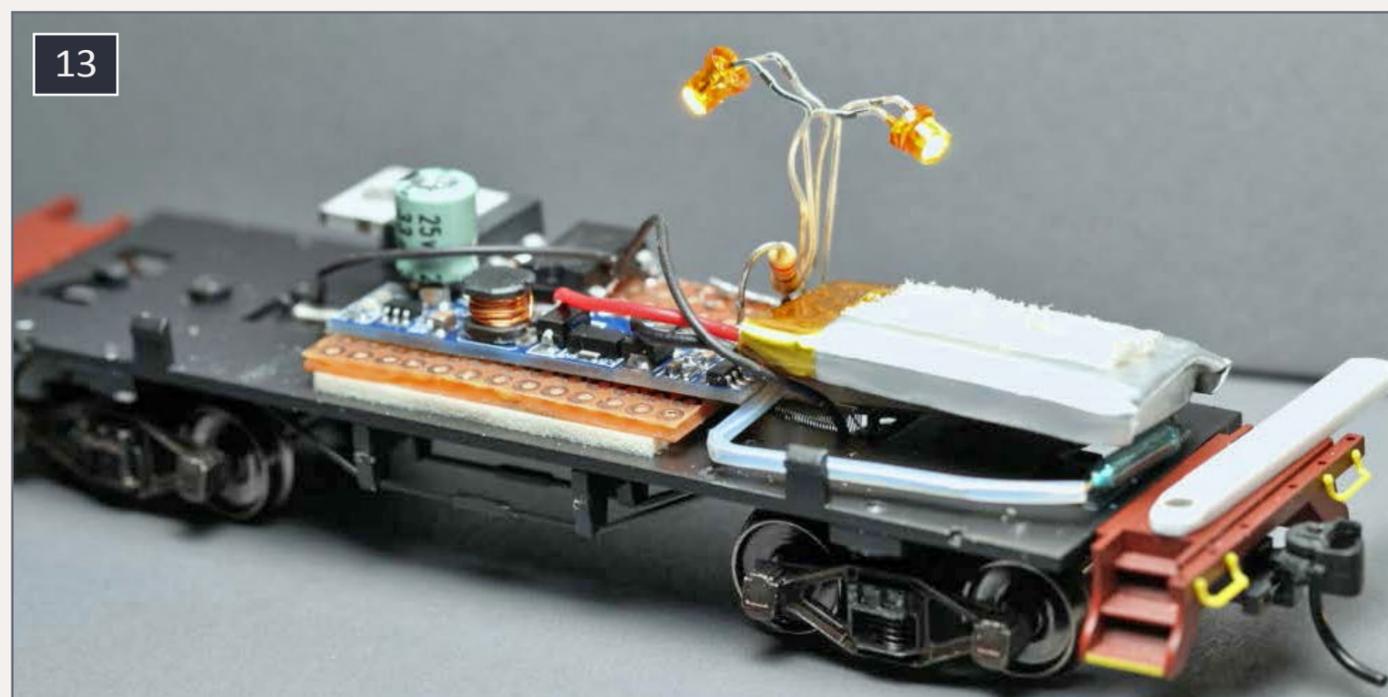
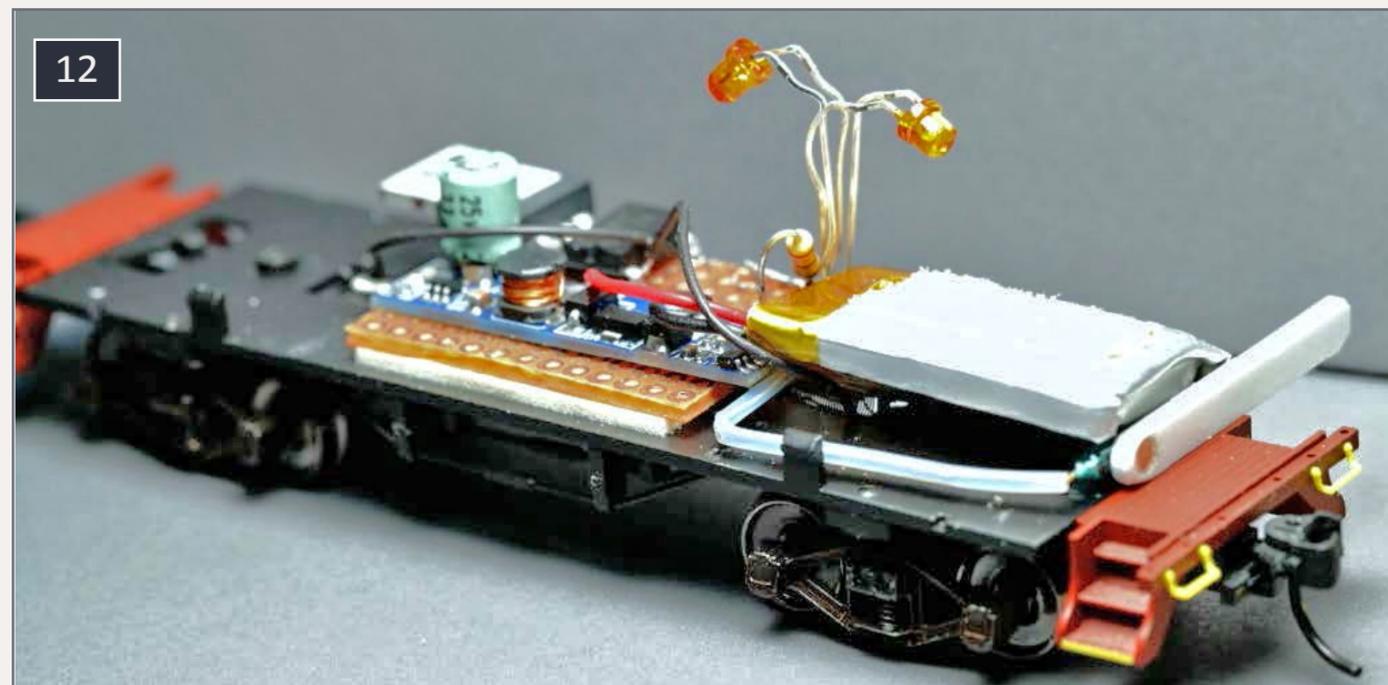
Two of the LEDs are powered through a 270 ohm 1/8 watt resistor. Dropping resistor values are lower than you might be used to, as the LED power is from 5 volts, not 12 volts. The

marker LEDs are powered similarly. This is very straightforward. The components are soldered to a scrap piece of perforated circuit board, mounted to the caboose floor with double-sided foam tape. No attempt was made to reduce the overall size. Many variations were tried. The components are such that all should fit with little effort, even in a four-wheel bobber caboose. I used Kadee trucks with Intermountain metal wheelsets, and added .08" phosphor bronze pickup wire pairs to each truck. Track power was fed with very flexible 30 gauge wire through the floor to the bridge rectifier. The regulator limits the track voltage to the battery manager to 5 volts, when power is available from the track.

The caboose marker lights are Utah Pacific marker housings painted black. The lenses are created with Micro Kristal Klear from Microscale. Once dry, they are colored with Tamiya clear paint. The markers are lighted with a 0603 surface mount (SMD) LED with 38 gauge wire leads. Working with such small LEDs was covered in the February 2012 MRH article "Points of Light" [mrh12-02-feb2012](#). Once you get used to it, it's easy and satisfying. When I don't want the lights on, I position magnetic Mike on the caboose deck near the hidden, internal



11. Regulator comparison (left to right): PSU2-5, 78ST105HC, LM7805.



12-13. Caboose power unit w/reed switching via magnet wand. 12 is off, 13 is on.

reed switch to shut things down. The battery will still charge if there is power on the rails, until it reaches the charge limit and stops. Simply remove Mike when you want the lights back on. I have left Mike on board with a charged battery and come

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14. Caboose wheel wipers.

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15. Lighted battery-powered caboose.

back a day or two later to find that power is still available for the lights. There is some current draw even when the lights are switched off, due to the built-in DC-DC converter. Eventually the battery will be drawn down. I haven't done any long-term tests on this scheme.

Powering a locomotive

Since I had found the great little battery manager with built-in converter, I thought of using it to power a locomotive, even

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16. Unlighted caboose with Mike as the switch.

though it only puts out 5 volts at .45 amps. I was going to modify a loco to use a lower voltage motor when I remembered the outstanding low voltage performance of the old Bachmann 44-ton GE switchers. But these units were also plagued with split gears. Besides, there was virtually no space inside the body for my experiments and trials.

Willing to accept the impossible as a challenge, I looked for the maximum size body I could put on top of the 44-tonner chassis. From the pile of misbegotten acquisitions, I found an old MDC/Roundhouse boxcab shell that fit nearly perfectly on the switcher frame! I opened an old early-run two-motor 44-ton switcher box, thinking that nothing could have affected the gears inside. To my chagrin, all four axle gears were starting to crack from the outside in, but none of the cracks had reached the gear teeth.

The weeping and gnashing of teeth over splitting gears, and the valiant efforts of expert machinists and tubing mashers, has been well recorded in the MRH forums. With neither the proper size tubing, nor the right stock on hand to machine,

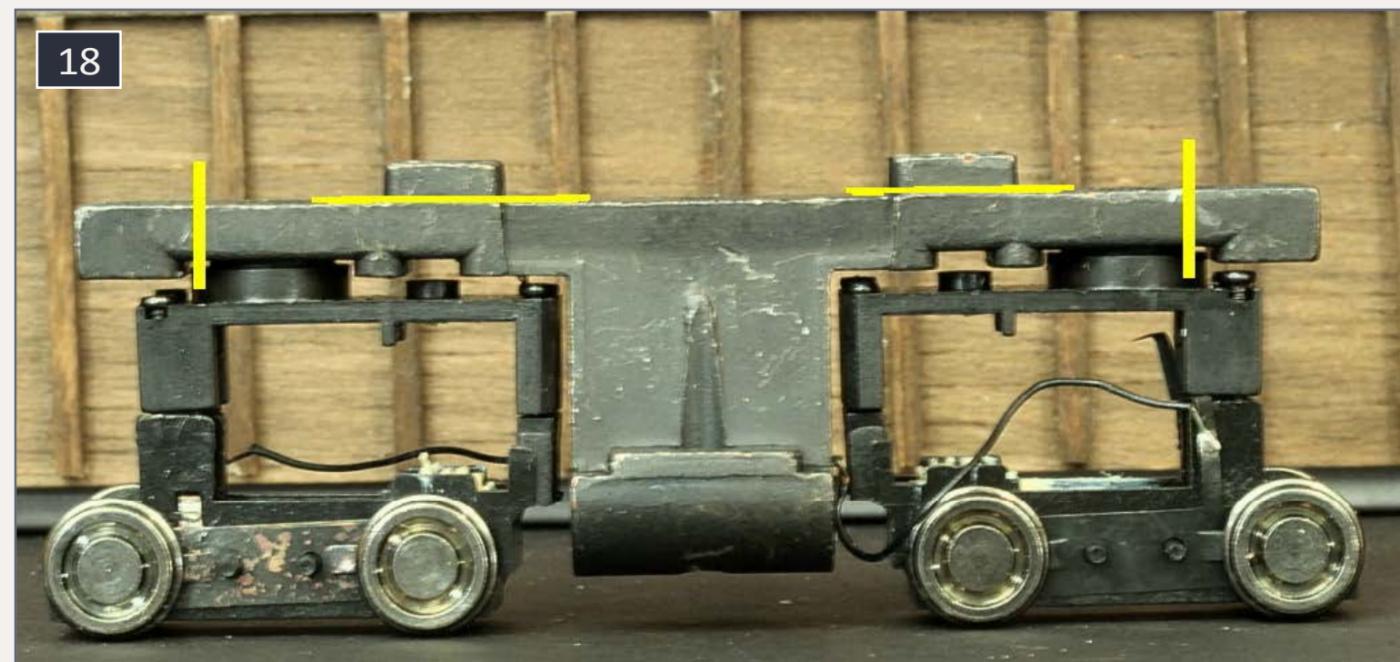
necessity and desperation inspired yet another approach. I had been working on a model waterfront pier, and realized that the piling reinforcement often found with hemp rope might work here. I had a spool of very fine, strong thread on hand, and decided that pilings and axle gears are close enough!

After removing and cleaning the gear, I verified that the crack had not progressed to the center of the gear. The axle gears are made of a slippery plastic, much like Delrin which typically does not glue well at all. I applied a thin coat of CA glue surrounding the end of each side of the gear and wound several turns of thread through the glue. It is imperative that you make this as thin and strong as possible, as clearances in the motor truck are tight. So far, the reassembled trucks have worked fine and the crack did not progress to the gears.

Considering that power might be at a premium in this loco, other variations were tried to reduce the current draw. First, the motor and truck gears were removed completely, leaving only the two freely turning axles in one truck. This obviously reduced the tractive force available, but also halved the total power. On another truck I removed the intermediary gears



17. Bachmann 44-ton switcher, in sections.



18. Bachmann 44-ton switcher, chassis cuts.

between the directly driven axle and the other axle. Again some power was saved at the expense of traction. I also used Northwest Short Line's (NWSL) geared replacement wheel sets as another alternative. All worked, but ultimately I found that two fully geared motored trucks could easily be driven by battery power.

The boxcab loco is built with the body of an old Roundhouse/MDC locomotive also available as a track cleaner, powered and non-powered. Its lower mounting "ears" are cut off. These bodies are no longer in production but are readily available in swap meets and on eBay.

As mentioned above, the chassis and drive motors are from an old dual motor Bachmann GE 44-ton switcher. The body is removed and cut down to the walkways [17]. The wiring board is removed and the top of the metal chassis is shortened as much as possible [18]. The top metal protrusions are removed. The metal chassis is used to support the power trucks and

the body. The motor trucks are disassembled. Cracked axles should be replaced or repaired. Solder two thin, very flexible wires to the side frame contacts directly (I replaced the ones that came with the unit), and carefully solder two more directly to the motor brush supports. Don't melt the housing or you may destroy the motor. This gives us independent pickups and isolated motor contacts for independent control. I covered the leveled top of the metal chassis with Kapton tape to prevent any possible electrical shorts.

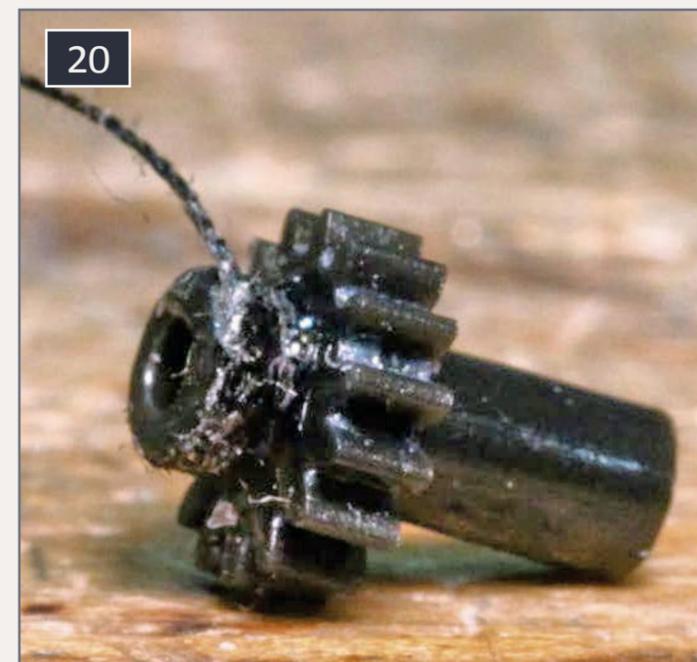
The block diagram outlines the power and control scheme. In the first model, everything is powered with 5 volts from the basic power block, exactly the same as the caboose lighting application. Even if you're used to working with electronics, battery power adds more constraints to design. I started using the same H-Bridge devices I had used before (like the SN754410 driver and the L298 device). But with only 5 volts



19. Original boxcab shell on right before bottom tabs are removed.

available they did not provide enough voltage swing out to the nominally 12-volt motors.

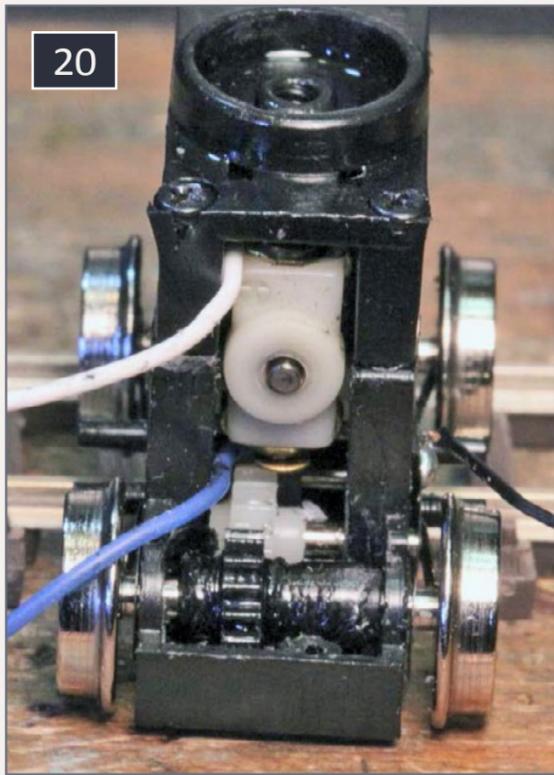
As an aside, I did consider re-motoring with 6-volt motors but found success before I had to resort to this. I am now considering using a 6-volt or even a 3-volt motor in the original Roundhouse Boxcab mechanism, even with its poor power transmission. The H-Bridge designs usually solve the problem of using a single voltage source to power a DC motor both forward and reverse. I even tried using a discrete FET H-Bridge with poor results. Success came via a throwback! I used an electromechanical relay as a double-pole double-throw switch, just like DC power packs typically use. The problem was the typical relay would constantly draw power in its activated state, decreasing battery life.



20. Repairing gears.



21. Wrapping the axle.

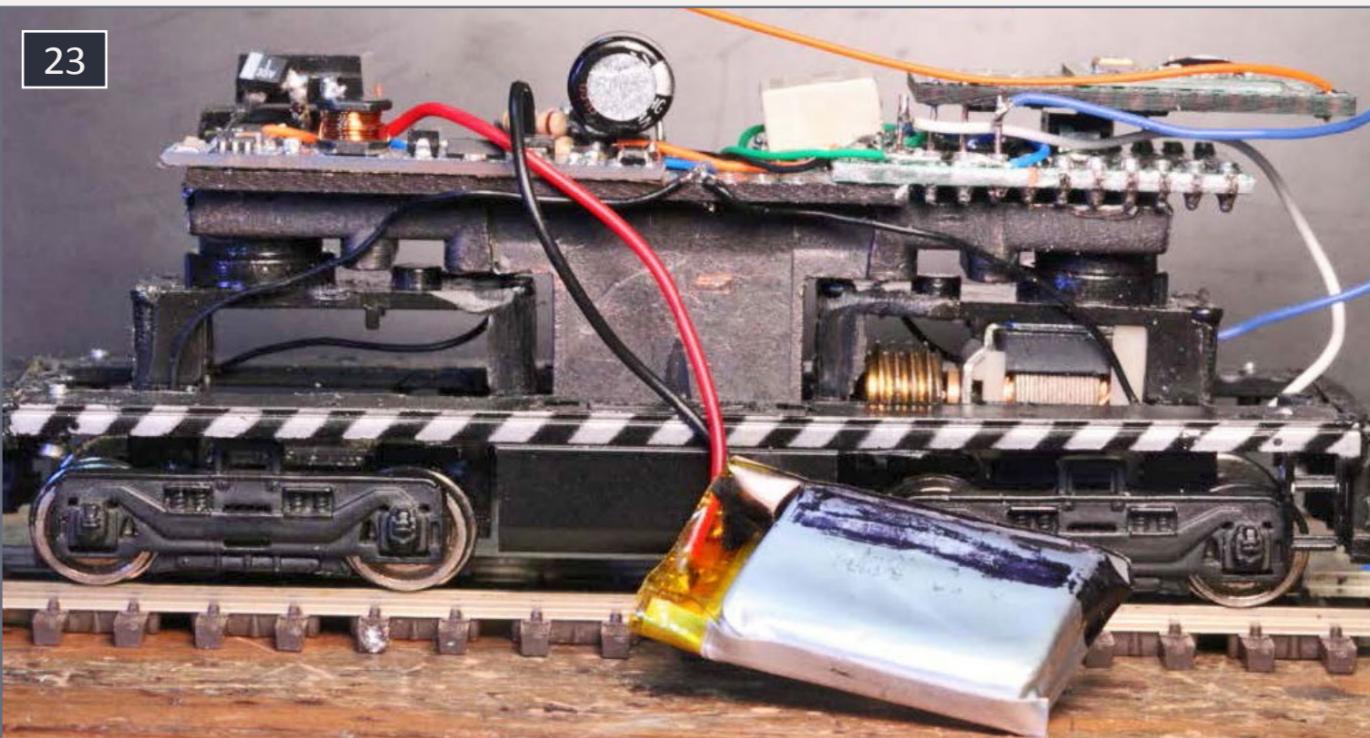


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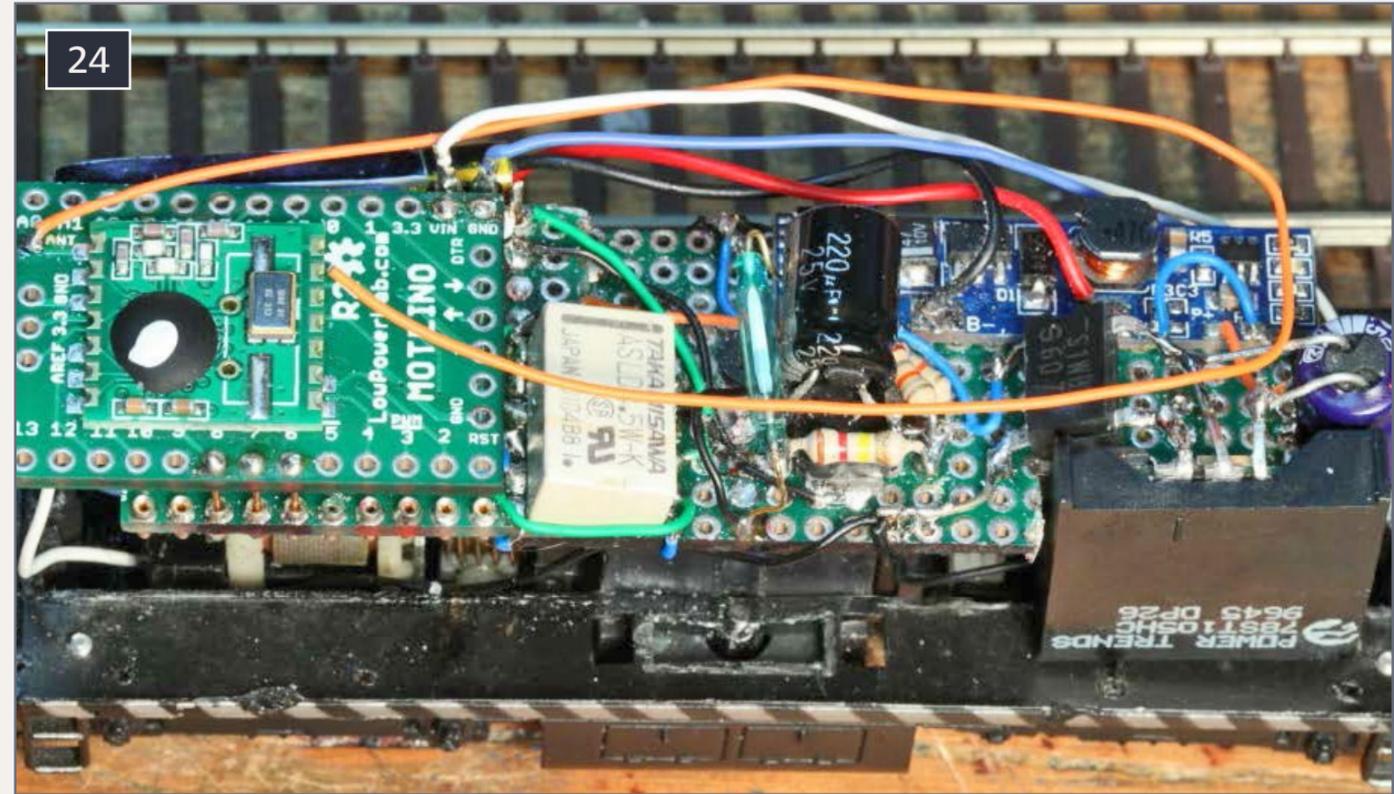
The solution was to use a tiny latching relay which only needed a short pulse to switch the contacts. Look for 4.5-volt dual coil latching relays at Digikey.com or Mouser.com. The relay holds its position until pulsed to the opposite position. To maximize the voltage swing to the motor, a single, logic level FET transistor was used to pulse (Pulse Width Modulation - PWM) the power

22. Repaired gears back in the power truck. Note the new motor wiring.

23. Loco1 boards mounted atop the 44-ton chassis. Note that the left power truck has had its motor removed.

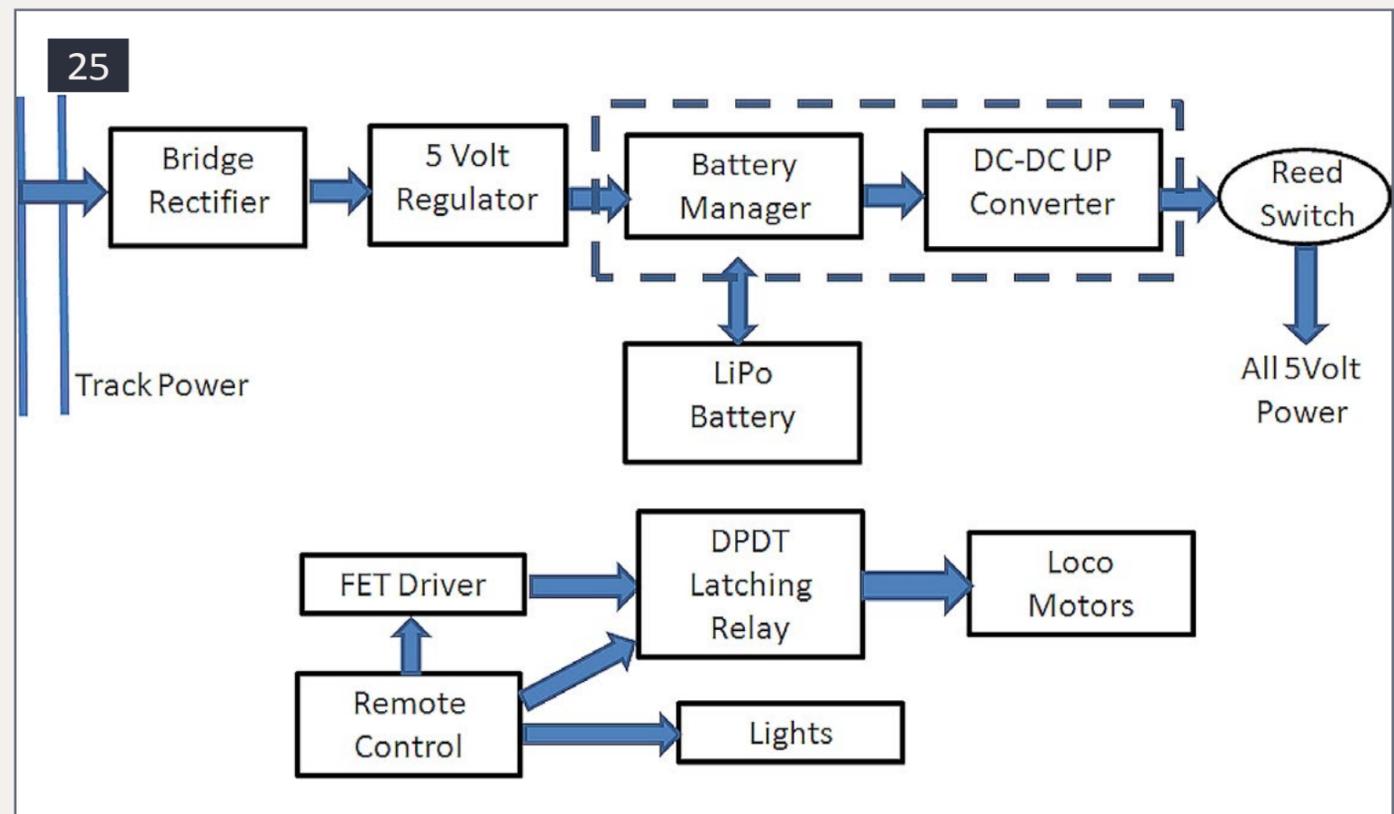


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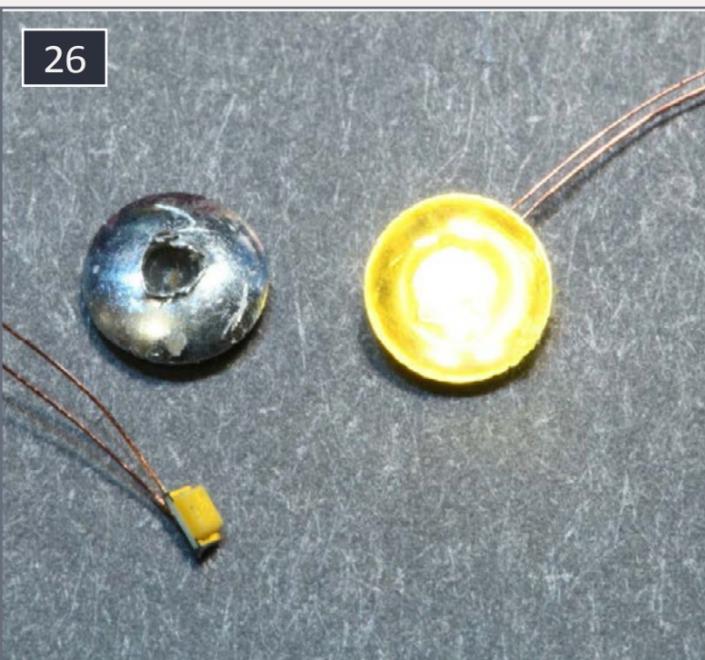


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24. Loco1 with 78ST105HC regulator mounted.



25. Locomotive battery power block diagram.



26. 0603 White LED & MV lens with rear hole.

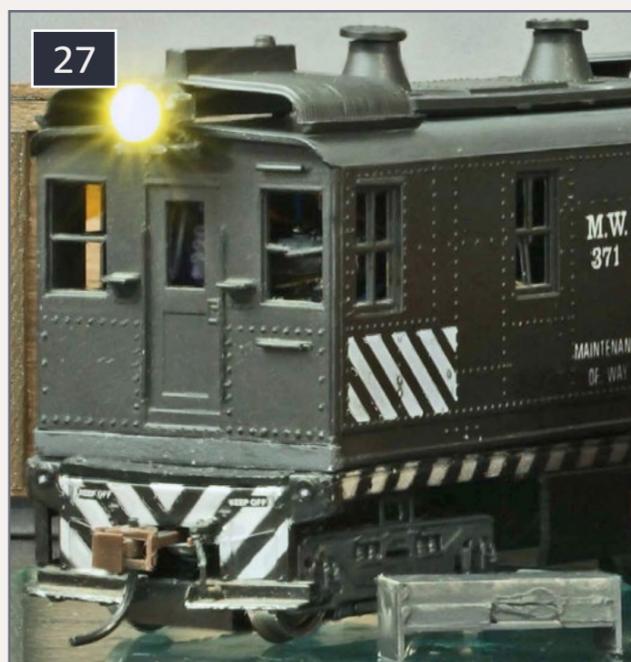
to the motor, similar to a DCC decoder's speed control.

If left idle for many days the battery will drain down. The battery manager board will isolate the battery from further discharge to protect it. The DC-DC converter needs to be isolated from its load to reset its operation. So a magnetic reed switch is used to remove the load when not in use, and limit battery drain.

Headlights

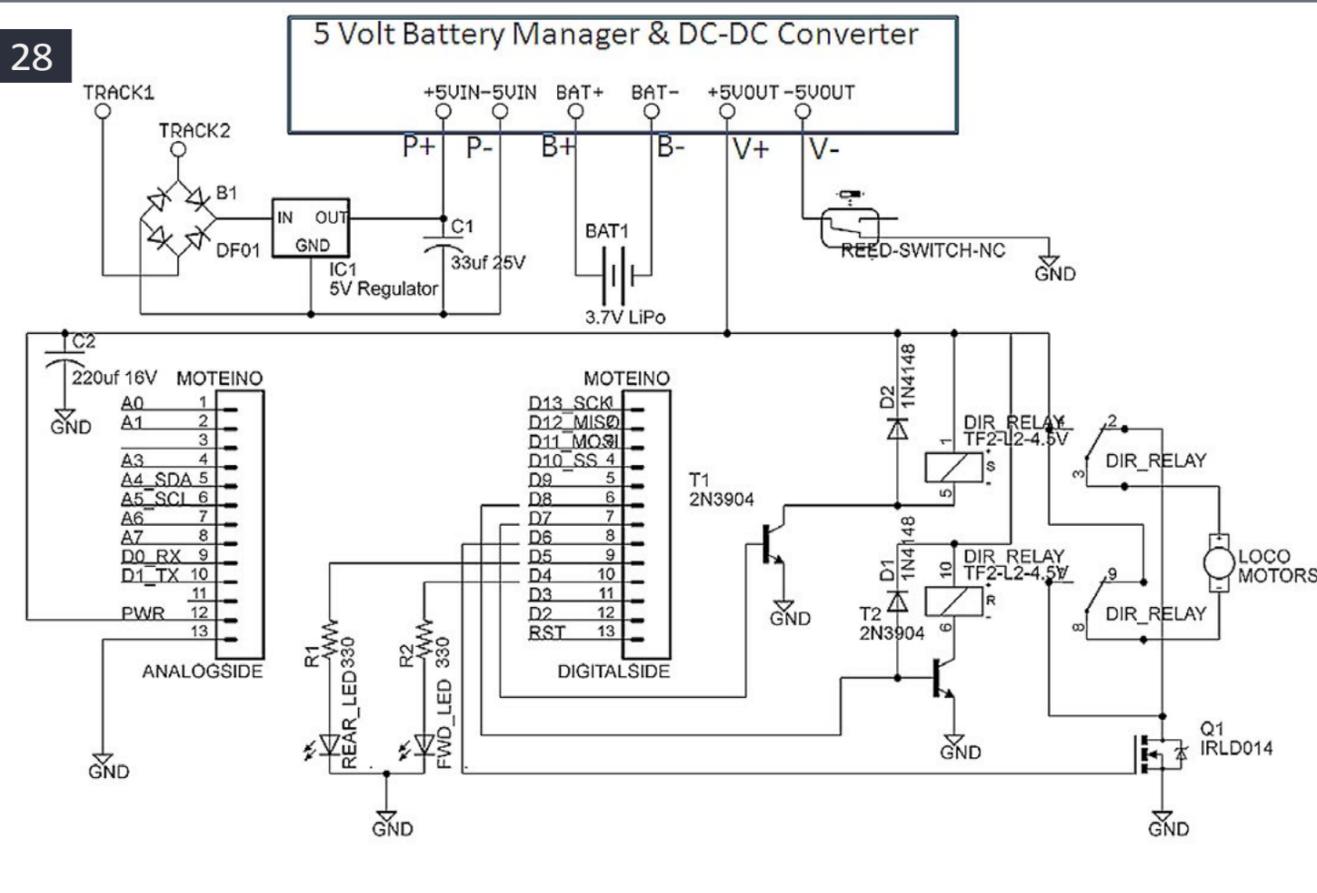
Working headlights are built by gluing sunny-white 0603 LEDs onto the back of an MV Lens, with a 1/16" shallow hole barely drilled into its center rear [24]. I use the pre-wired LEDs available from LedBaron stores.ebay.com/ledbaron quite a bit. For older models, I like the effect it gives, with a white LED with a yellowish tint. I used to simply glue the LED in the back of the headlight housing, and cover the front with a clear styrene disk punched out with a paper hole punch. But I think the MV Lens combination is an improvement. Add some clear glue

to cover where the wires attach to the LED back too, to insulate the wire contacts and strengthen the connections.



27. Loco with "magnet box."

28



28. Locomotive battery power block diagram.

to cover where the wires attach to the LED back too, to insulate the wire contacts and strengthen the connections.

All components are mounted on a piece of perf board running the length of the body shell and screwed to the top of the chassis. The reed switch is mounted at the highest point, in the middle and just under the roof. I use a small magnet glued into a box-like structure, painted the same color as the body, to make an unobtrusive on/off switch [25]. These reed switches have worked out so well that I have ordered more to use in future models.

Remote control

A model loco providing its own power will no longer respond to voltage changes on the rails (DC) or to power and signal on the rails (DCC). In fact, battery operation is by definition (at

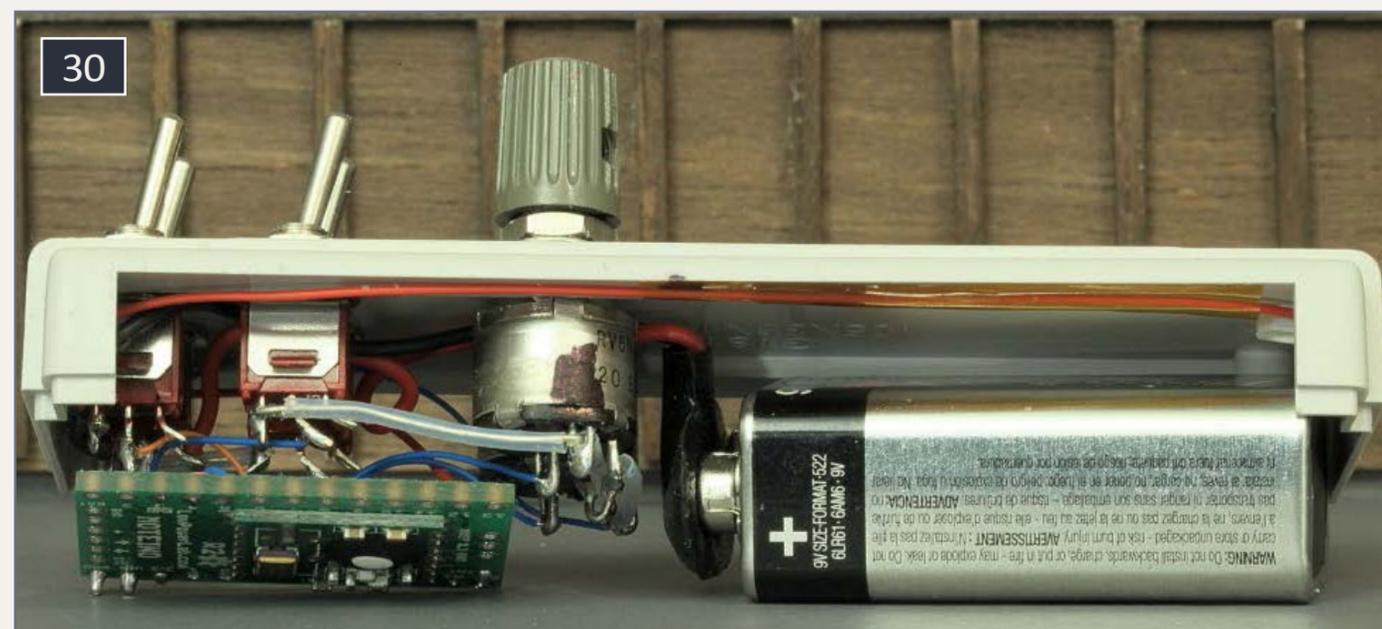
least in part) independent of the rails. My own interest is not in enabling KAOS power for DCC, but in rail-mounted animation.

The solution for loco control is a relatively simple, low-cost (\$3.60) radio link to the loco, using an RFM12B transceiver module (transmitter/receiver). This is not traditional RC control, even though traditional RC control could be used here at greater cost, and using more space in the loco. This scheme is more like a 2-way serial data link via radio. The RFM12B is controlled with a small Arduino.

The combination of the RFM12B mounted on the back of a small Arduino, nearly in the form factor of an Arduino Pro-Mini, is available as a Moteino from Low Power Lab lowpowerlab.com/moteino/. This saves even more space, and comes with its own program sketch library including working examples. As I recommend quite often, I copied a basic example and edited it for use in a small, 9-volt battery-operated remote control. The example library will support 255 channel IDs, allowing many different locos to be independently addressed.



29. Remote controller.



30. Remote controller internals.

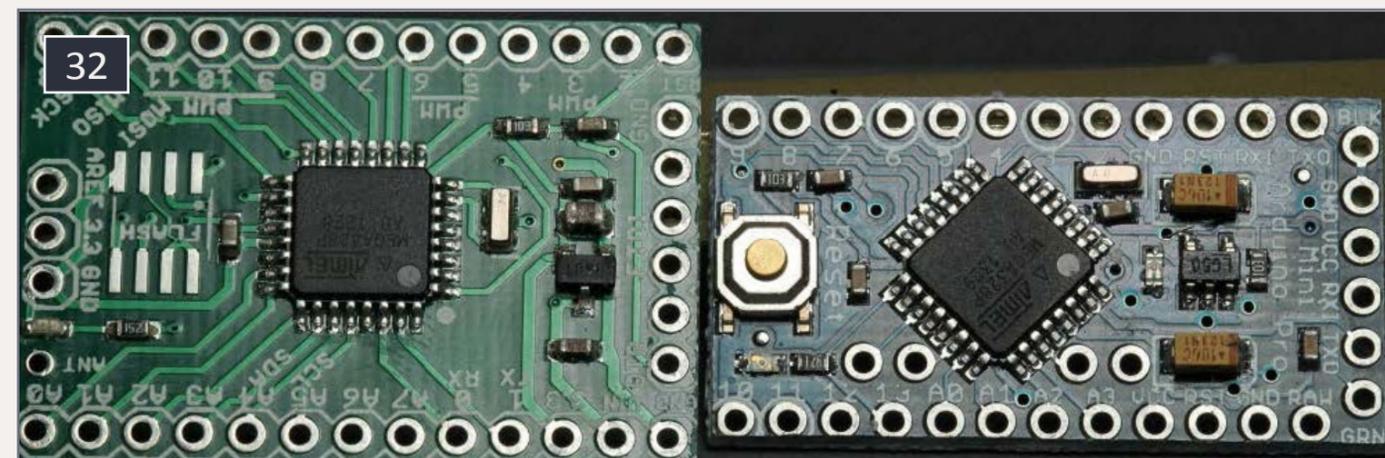
The remote has more knobs and switches than you need for this model, but I am anticipating expanded use later. There is a power switch, a direction switch, a lights switch, and a speed knob. Lights are directional when turned on. Two Moteino boards are used, one in the loco and the other in the controller. RFM12B's can be operated at 434 MHz (universal), 868 MHz (EU), and 915 MHz (US, Australia, etc.). There are several versions now available. I used the R2 version. Both programs are included in the additional materials with this article. There is more information on the Low Power Lab website.

They are set up very much like the cheap Arduino Pro Minis I use. (See the sidebar following this story). Besides power and ground, there are five other connections to the Moteino, and two are for the lights! The controller Moteino just connects to the switches and knobs. This version is very basic. The enterprising individual could add momentum effects, sound, classification lights, and more. This is enough for a start.

A more powerful locomotive

The 5-volt power set-up works quite well but if you really want to power stubborn 12-volt motors, one might want a bit more oomph! This next loco separates the DC to DC converter from the battery manager and allows for converting the varying (3-4.2 volt) battery voltage to anywhere from 6 to 14 volts tinyurl.com/lhvay2w. I adjusted mine to run at 10 volts. I thought it was a good tradeoff for higher motor power and reasonable battery drain. The converter will put out voltages up to 35 volts but you may destroy the electronics and motors! So please make adjustments before you connect it in your model loco! You'll need a voltmeter to make the adjustment. Pay close attention to all pins and connections.

This design uses a different battery manager board as well, the inexpensive protection circuit module at tinyurl.com/n9mrl75, and is wired into the circuit differently. Battery manager/protection boards must always be connected to the battery. In this circuit, the reed switch disconnects the load and the track power (lowered to 4.4 volts) to the battery manager. This



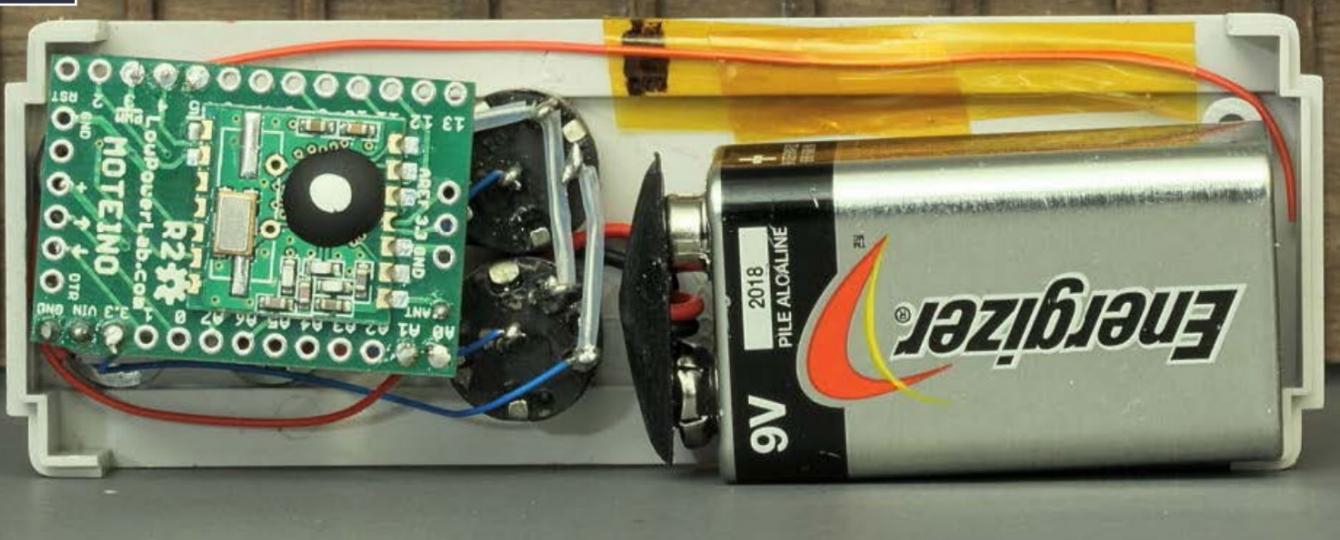
32. Controller comparison: Moteino (left) & ProMini.

allows the battery to hold its charge longer when not in use. The battery is charged in this design only when the reed switch is on (i.e. no magnet present).

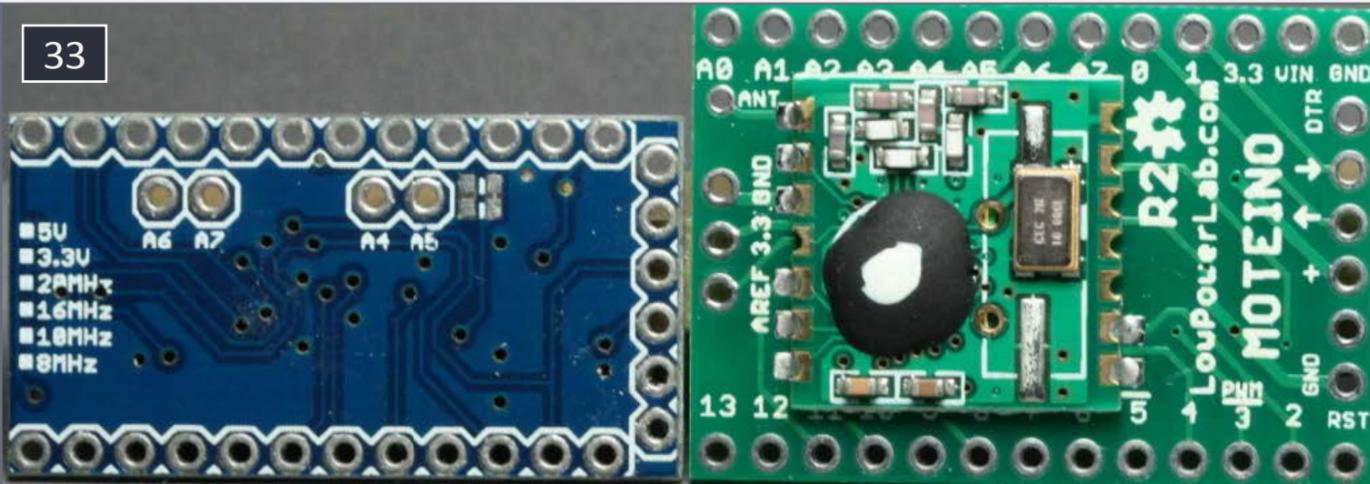
You will get noticeably more power delivered to the motors, but battery drain will occur more rapidly. Because the DC-DC converter accepts a wide range for input, and regulates the output, the voltage delivered will remain relatively constant whether powered from the rails, or from the battery directly throughout its 3-4.2-volt range. It's quite something to see the locomotive go over dirty track, switch frogs, and uneven rails without missing a beat. Take a look at all the models in operation:

Even though this version provides more power, I am not happy with it. The battery manager used here allows a very high charging current, only limited by the 5-volt switching regulator's current limit. Fast recharging in these models is not necessary. As such, this still performs within the limits of the LiPo battery specification. A better design would have used a special charging circuit specifically for LiPo batteries, rather than the 4.4-volt circuit. Moreover, to my thinking, the slow speed of the locomotive at 5 volts is a benefit, not a weakness. In my own modeling, I have more confidence in the previous design, and will prefer its use.

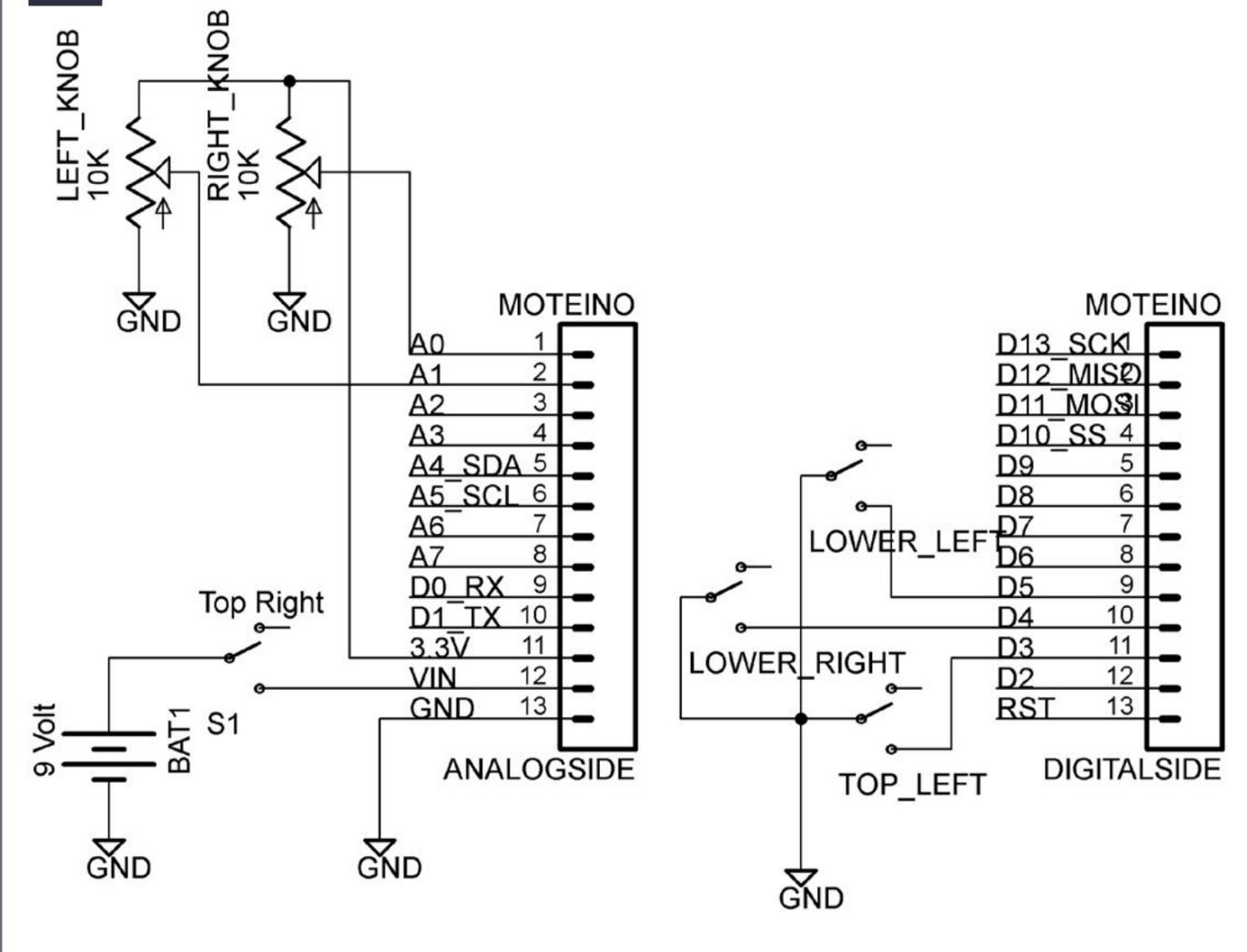
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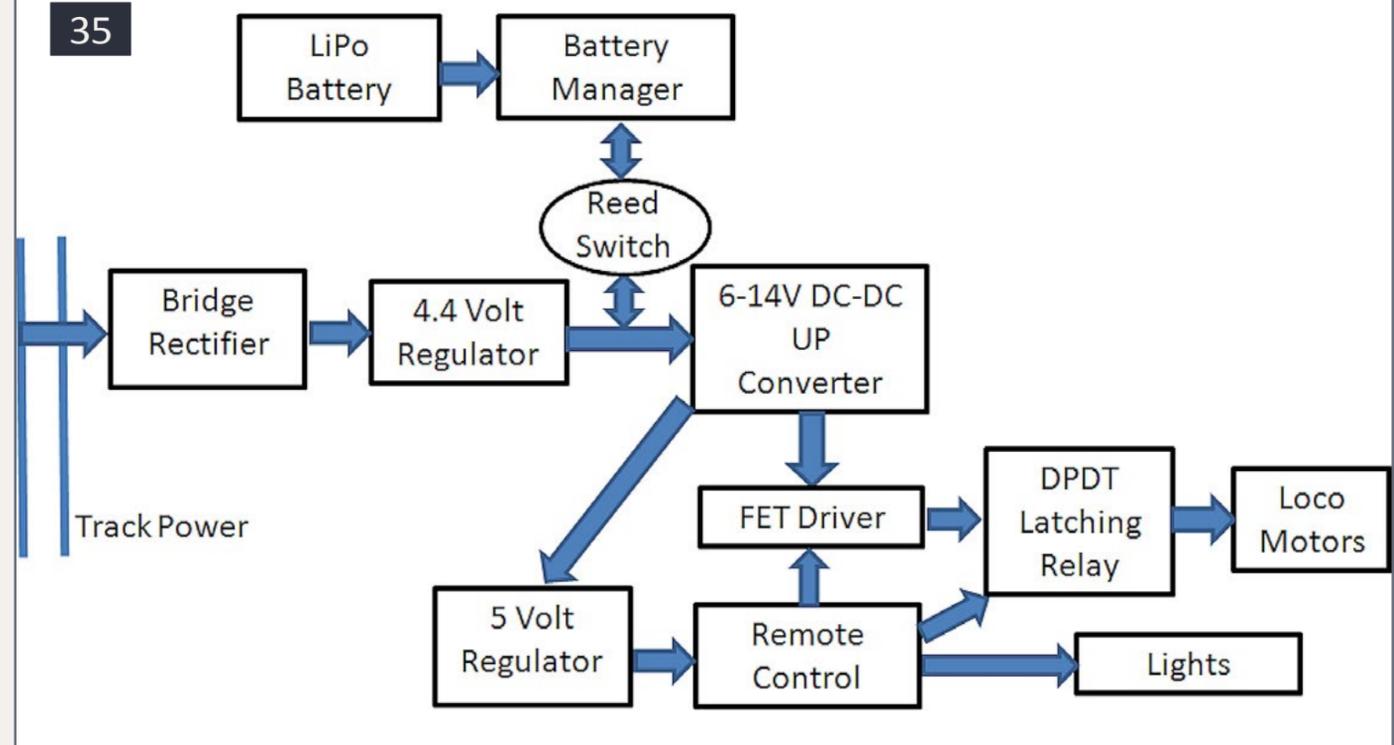
31. Another view of the remote controller internals.



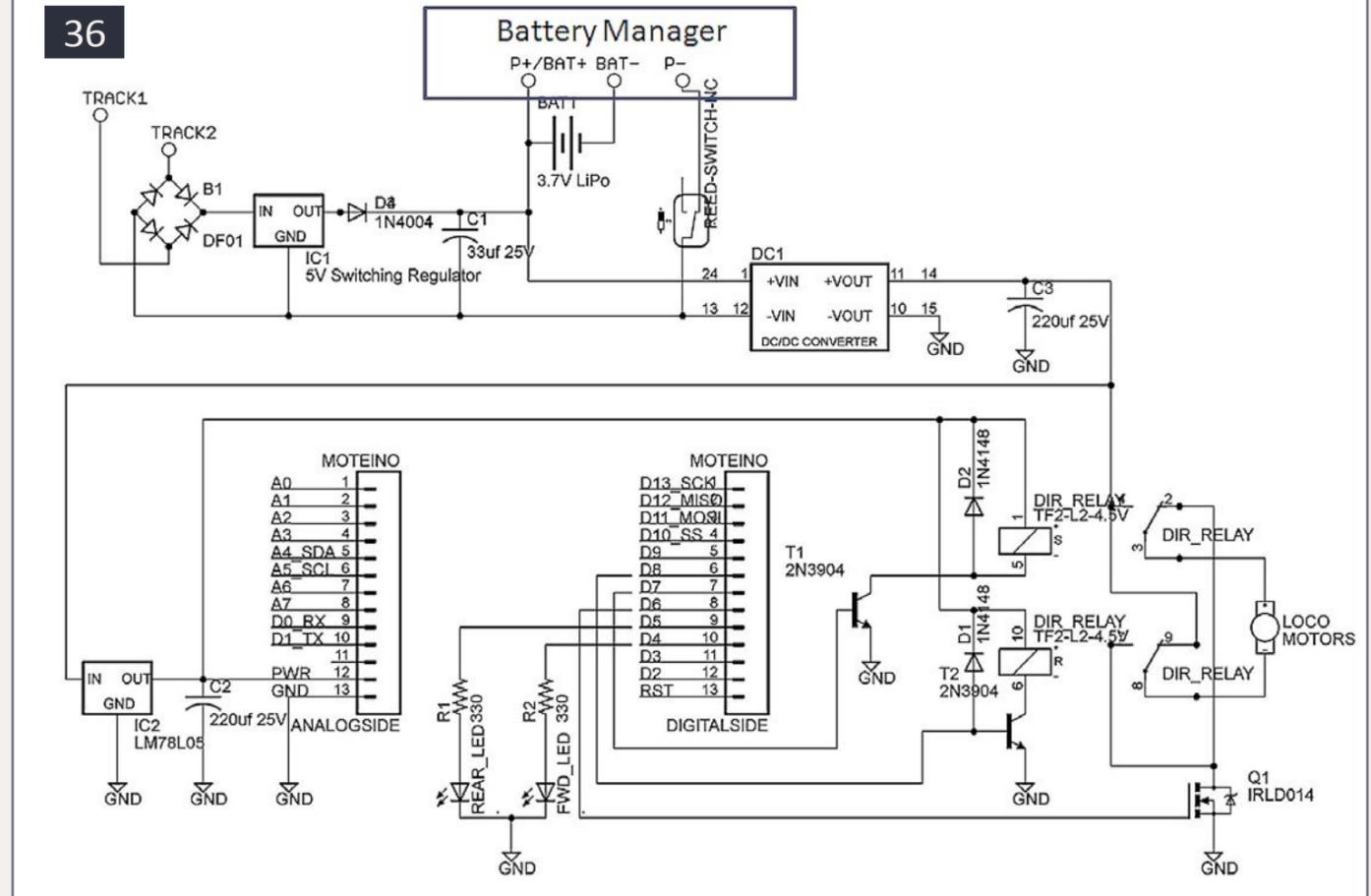
33. Bottom comparison: Moteino (right) & ProMini.



34. Loco controller schematic.



35. Locomotive higher power block diagram.

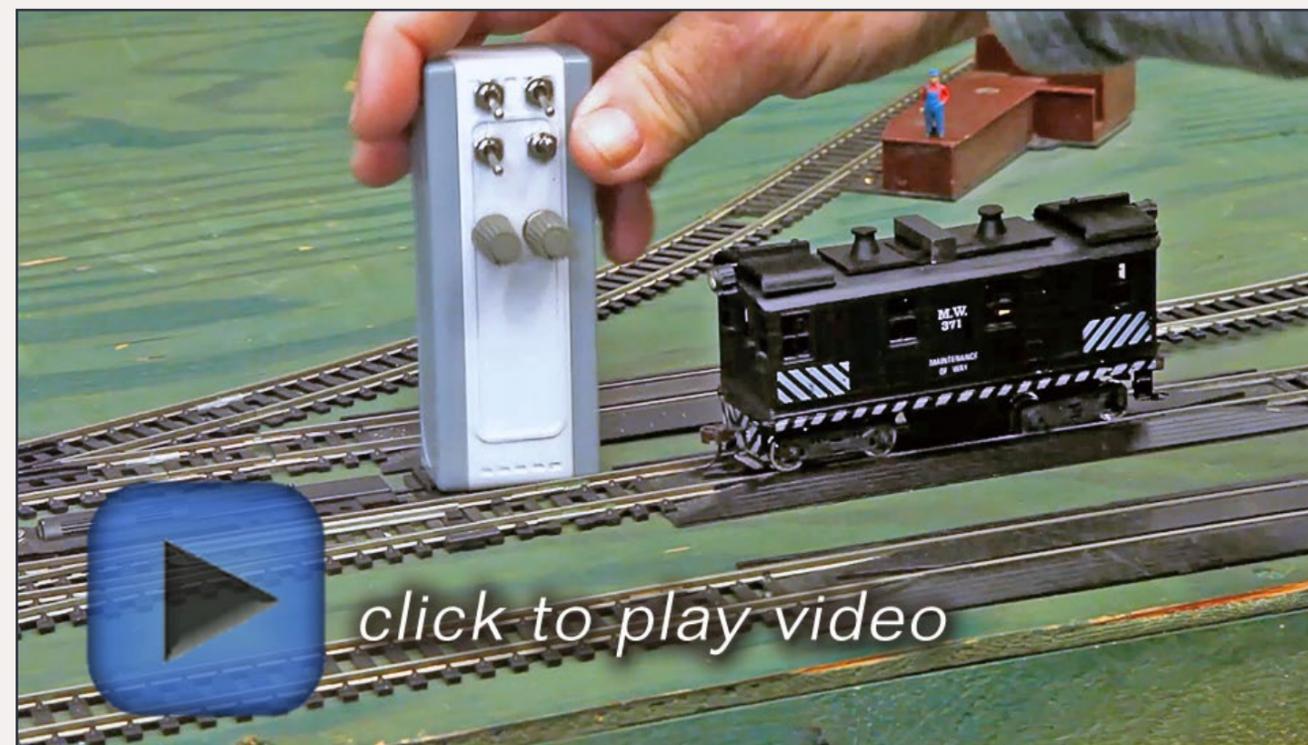


36. Locomotive higher power schematic.

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37. Battery manager (on left) and DC-DC converter.

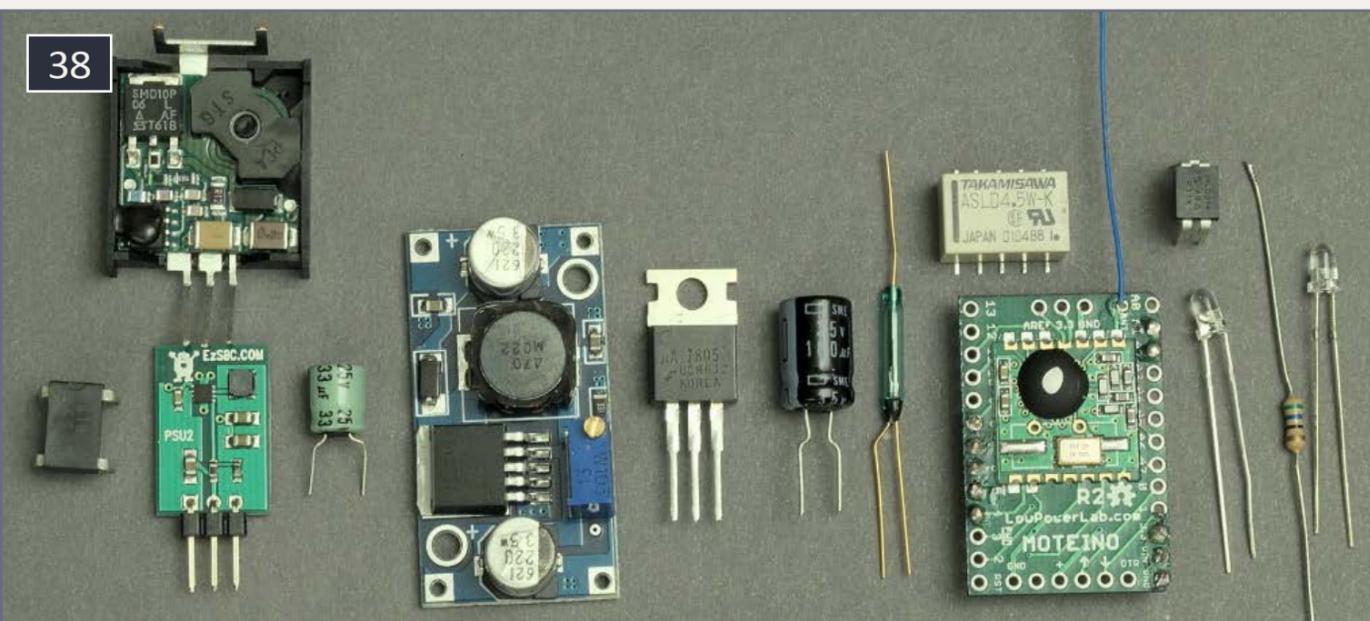


Playback problems? [Click to try a different version.](#)

These efforts were made to establish the viability of running motive power at reduced voltages with small, on-board batteries. The same power is used to provide remote control for these models.

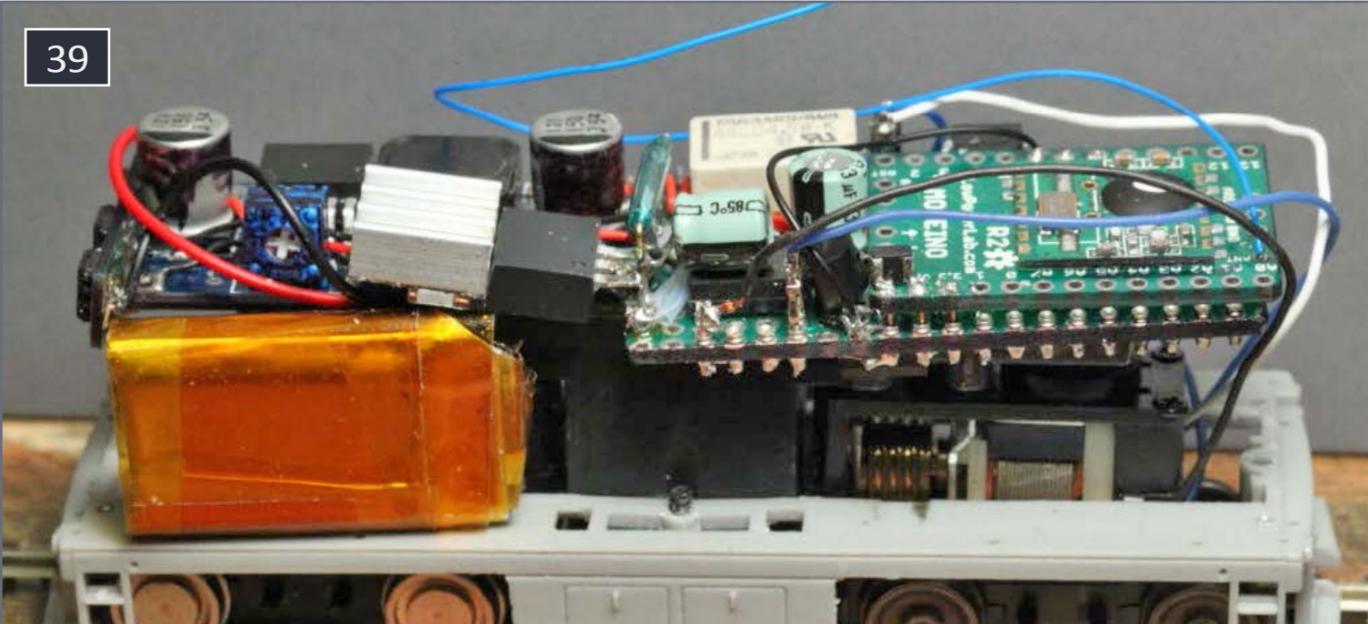
In the future, I hope to use the same platform to power roving inspection engines which mix with normal operator-controlled rail traffic. A small sound module would not be too hard to add, and I might try that first. I hope this provides you with some ideas and encouragement to try new ways to power and control your layout too!

38

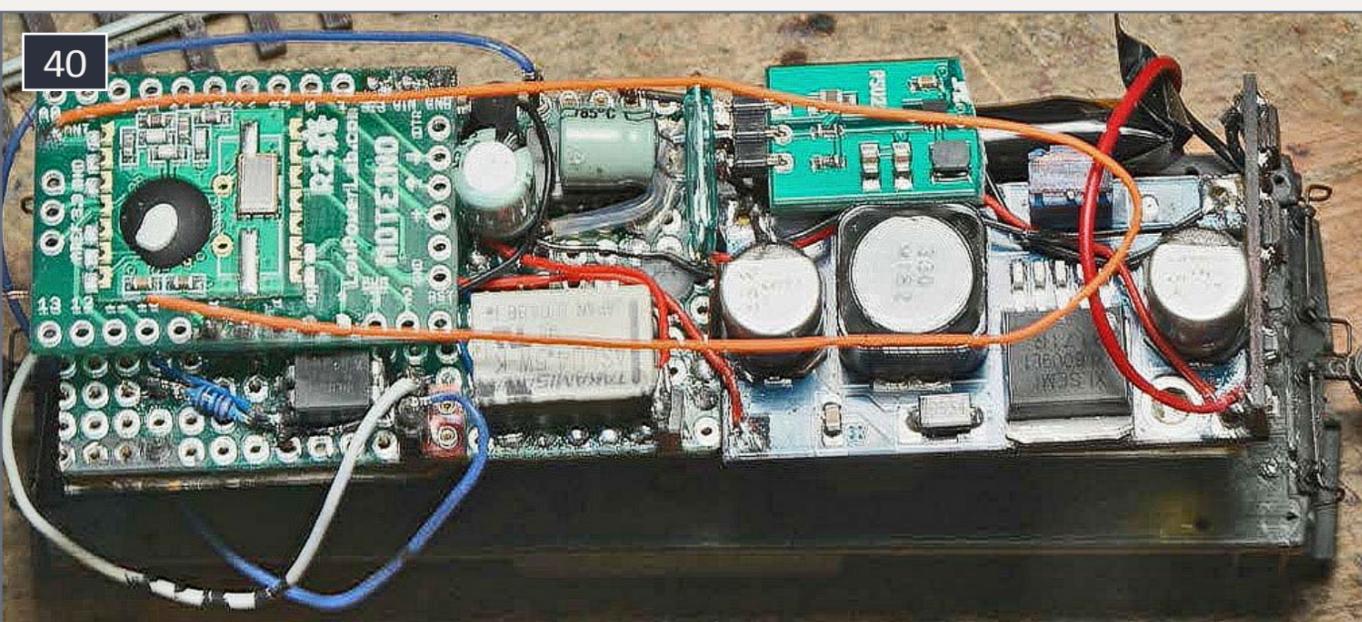


38. From left, bridge rectifiers, 5-volt switching regulators, capacitor, DC-DC up converter, 7805 5-volt regulator, capacitor, reed switch, latching relay (top), Moteino (bottom), FET transistor (top), LEDs and resistor.

As I mentioned before, this project was built to lay the groundwork for later animation-on-rails projects. I was somewhat surprised just how well these worked, using off-the-shelf parts and LiPo batteries with relatively simple controls at low cost.



39. High power version.



40. High power version with switching regulator.



Geoff Bunza started as a model railroader when he received a Mantua train set for Christmas, at age 6. Interest in the New York Central was cemented when riding on a NYC fan trip to Harmon in November, 1966 behind S-Motor 110. He fed his interests through college, becoming a member of the Tech Model Railroad Club (TMRC) at MIT while getting his doctorate and three other degrees in electrical engineering.

Geoff has lectured on various aspects of electronic system design in over 15 countries around the world. He is blessed with his wife, Lin, in marriage for 33 years, and their two terrific sons. He is a member of the New York Central System Historical Society.

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Starting from Scratch with an Arduino Pro Mini (or Moteino)

Many projects can use an Arduino Pro Mini Board US\$2.59 each with free shipping off eBay. See: tinyurl.com/oamynj5. Add a USB-to-TTL cable to set up the programs on the little board, now US\$7.24 off eBay see: tinyurl.com/lydcv99.

While you are waiting to get these download the Arduino IDE (Integrated Development Environment) free software off the net from: arduino.cc/en/Main/Software or arduino.googlecode.com/files/arduino-1.0.5-windows.zip (for Windows specifically) which has an editor, a library, and examples for you to use.

Note this IDE will run on Windows, MACs, and Linux machines, so pick the right one for your computer. When you unzip the package, write down the full path name to the folder, like: C:\arduino-1.0.5 or wherever you put it. This will be important later.

Now take a glance at the Getting Started info: arduino.cc/en/Guide/HomePage and the info at arduino.cc/en/Guide/ArduinoProMini. Just a quick read to give you some context. I had people get lost at this point, so I'll step you through the rest.

The accelerated learners among you can also glean more info from: arduino.cc/en/Tutorial/HomePage. There are a lot of topics there:

instructables.com/files/orig/F3J/MTJN/FVW22MXN/F3JMTJNFVW22MXN.pdf or richardvannoy.info/arduino.php or <http://arduino-info.wikispaces.com/TUTORIALS>.

These offer info at different learning levels so pick one you are comfortable with.

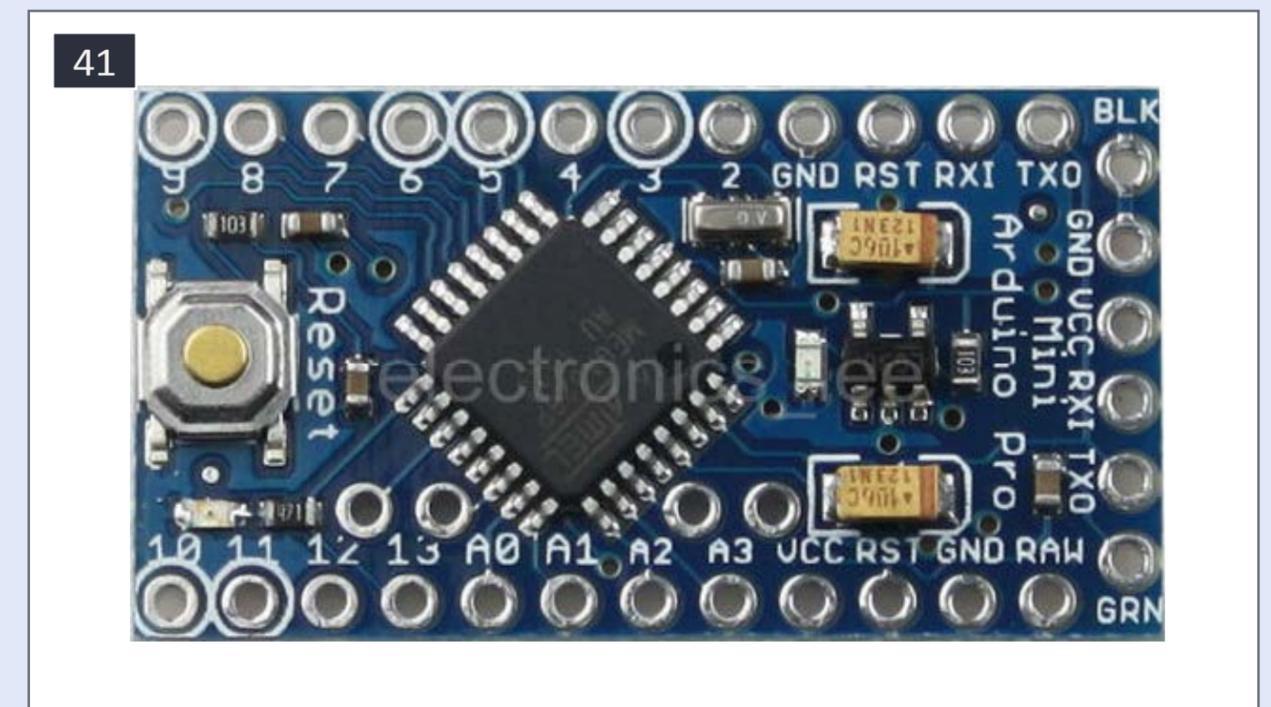
The Moteino used in the accompanying article is a repackaged Arduino combined with the RFM12B radio module. You can find additional information here: lowpowerlab.com/moteino and here w5vwp.com/moteino.shtml.

You can follow the steps below to use either a Pro Mini or a Moteino.

Now you should have at least one Pro Mini Board, a cable, and the IDE software loaded.

If you ordered the Pro Mini I referenced before, it came with a set of header pins. Cut off a six-pin group and solder it into the six holes on the end of the Pro Mini Board. Either side will do, I prefer the header to stick out the component side with the button on it.

In some model settings you may prefer not to solder the header on at all. I'll show you later how to deal with this. Notice that ends of the six holes are either labeled BLK and GRN, or GND and DTR.



41. Arduino Pro Mini.

Starting from Scratch with an Arduino Pro Mini (or Moteino) Continued ...

The black wire on the six-pin USB to TTL Serial cable will connect to the BLK/GND pin, and the other end of the cable connector will connect to the GRN/DTR pin. (If you didn't want to solder the 6 pin header to your board for some reason, insert the long end of the header pins into the 6 pin cable connector.

When you are ready to load a program onto the board, insert the connector with pins into the top of the board, observing the proper orientation I described above, and hold placing side pressure during the programming download.) Plug the USB side of the cable into your computer.

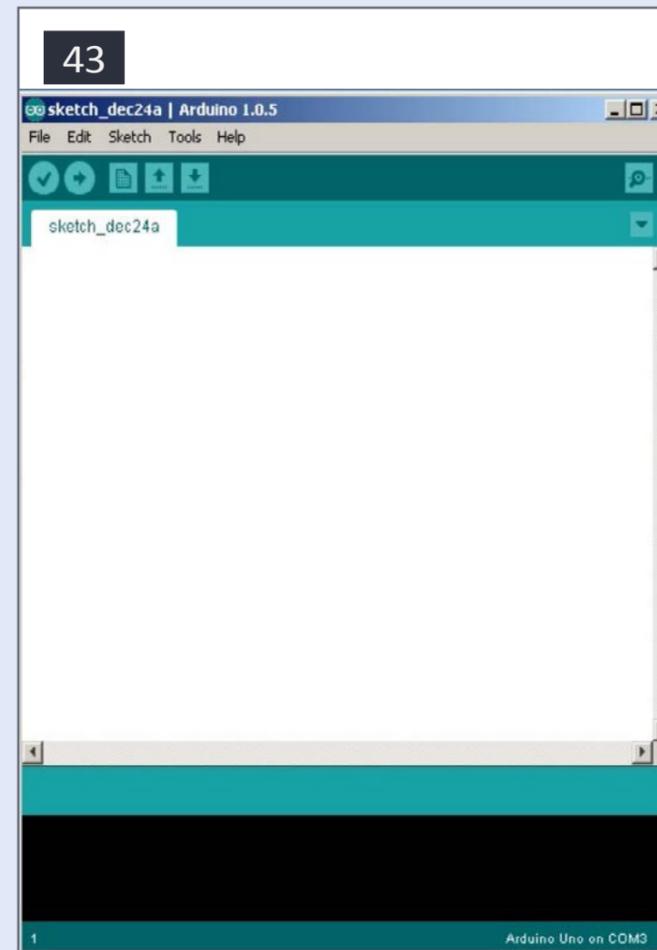
In all likelihood Windows will need to load a driver. For Windows XP, here: arduino.cc/en/Guide/UnoDriversWindowsXP is a good detailed, step-by-step. The drivers you want to install are in the Arduino folder (from my example above) C:\arduino-1.0.5\drivers\ You might also benefit from reading arduino.cc/en/Guide/Windows



42. USB to Serial TTL Programming Cable.

For other operating Systems go to arduino.cc/en/Guide/HomePage and poke around there.

Remember the serial port number for the serial cable installation. Now start up the Arduino IDE software you loaded, and you should get a window like [43]: (All my examples will be MS Windows based.)



43. Start-up window.

The Arduino Pro Mini is small, low power, cheap, fast, and comes with a large program memory. If you are setting up for a Moteino, then select Arduino Uno instead of the Pro Mini selection above.

Now go back to the top menu bar, mouse click on Tools, then Serial Port. Select the Serial Port corresponding to the USB cable you set up before. All that we've done so far only needs to be done *once*.

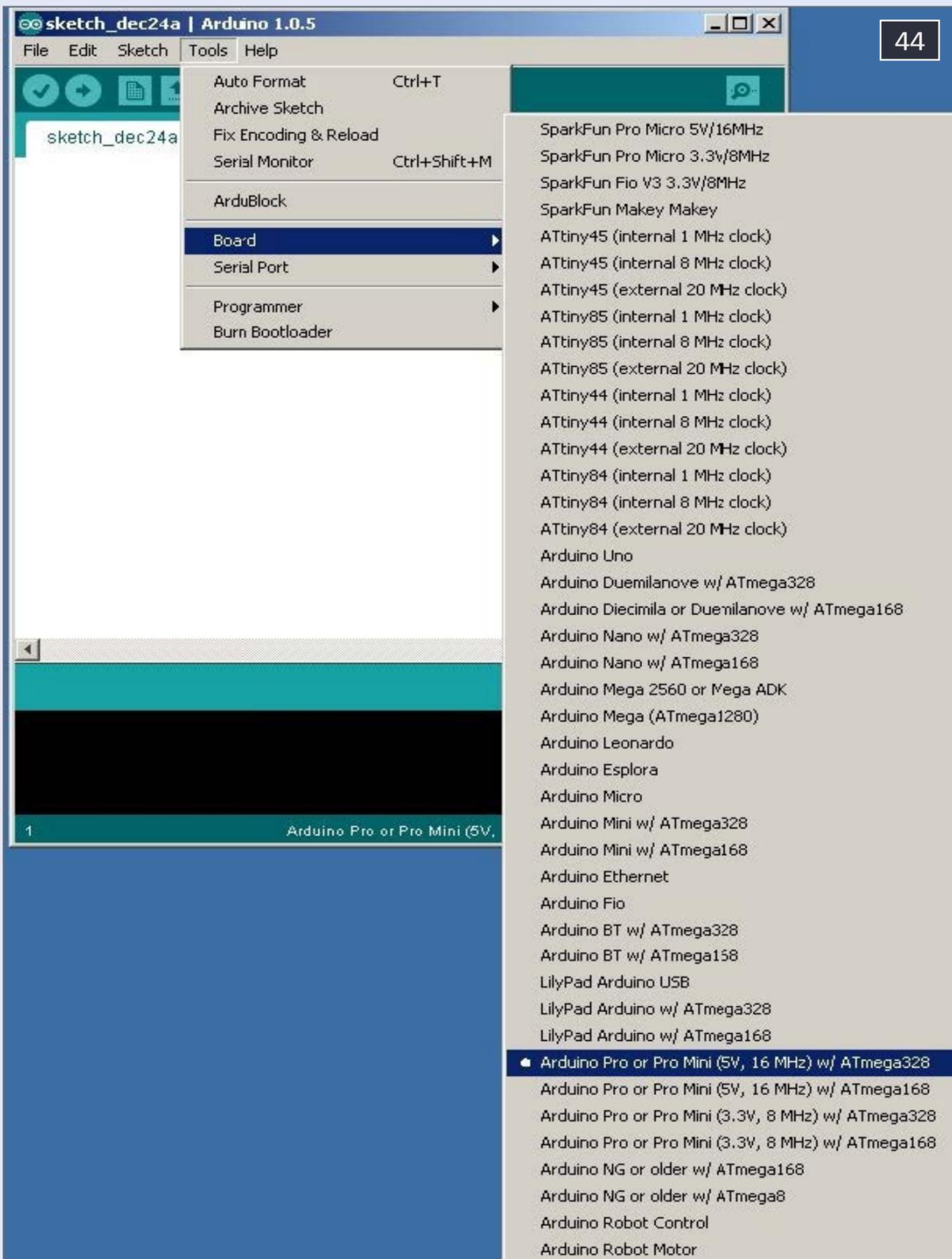
OK, now we are ready to do something with the Pro Mini. In the open window of the Arduino IDE, click on File, then Examples, then 01 Basics, then Blink:

And the window [46] should open.

This is the window for the Arduino Editor, where you can recall programs from libraries or create your own.

Go to the top menu bar, mouse click on Tools, then Board, then Arduino Pro Mini (5V, 16MHz) w/ Atmega328. This will place a black dot next to your selection, and corresponds to the Pro Mini Board I referenced before.

Note that there are many variations of Arduinos. They all can run the same exam-



44. Tools menu and board selection.

Starting from Scratch with an Arduino Pro Mini (or Moteino) *Continued ...*

This is the editor screen in which you can load, edit, save, and download your programs, called sketches, for the Arduino. The program shown is from the list of examples which are great starting points for you to learn just how much you can do. With NO modification, making sure your Pro Mini Board is connected and selected properly, click on the circled right arrow button below the edit menu pick, to the right of the circled checkmark. These two screens should appear in succession:

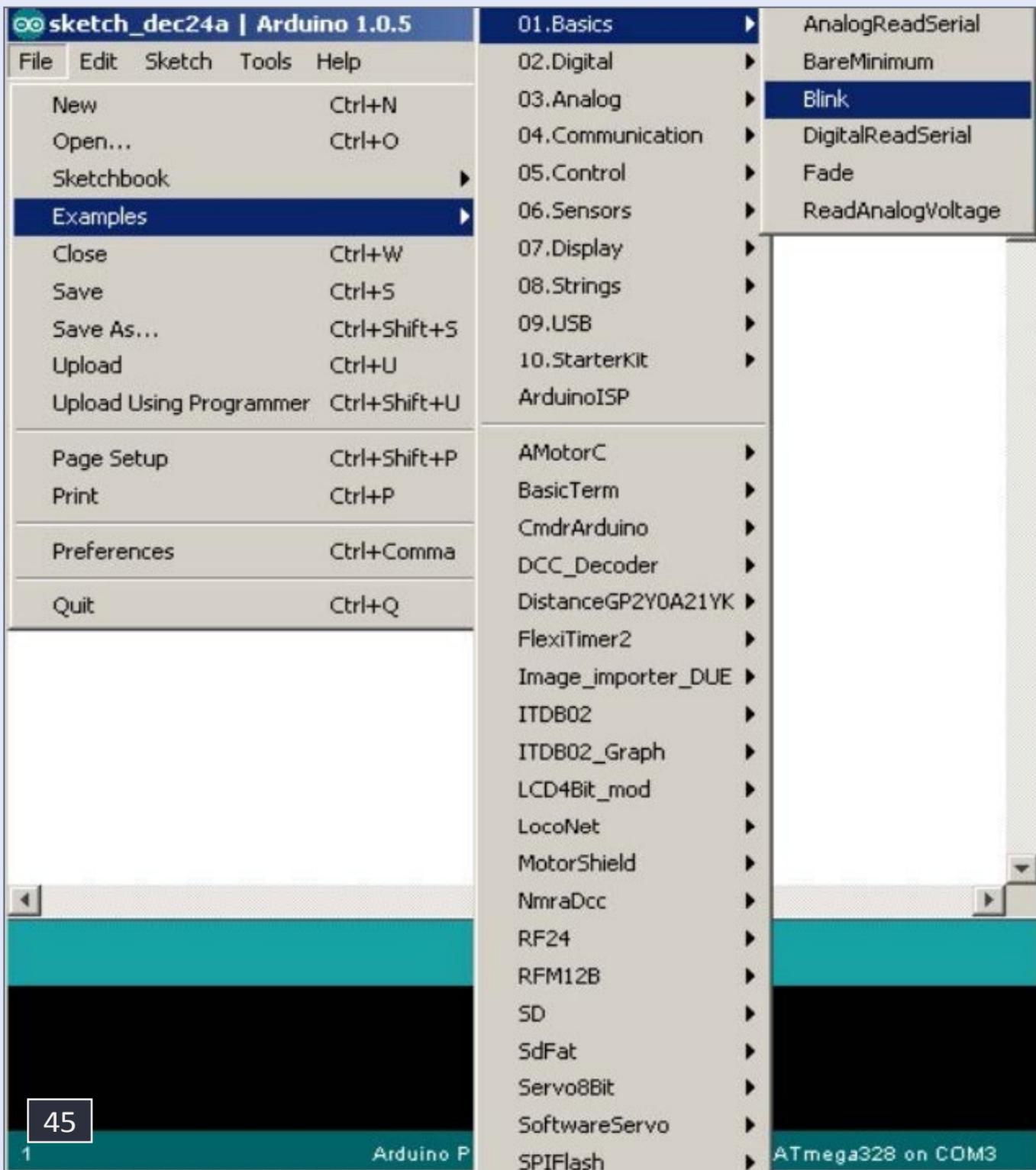
You will also see the LEDs on the Pro Mini Board blinking along. After a short time, a LED connected to Digital Pin13 will blink one second on, one second off. You have now successfully set up your Pro Mini Board! To prove a point, go back to your computer, and in the IDE window with the Blink program, highlight and change both of the delay(1000), lines to delay(90), need space, “and” that is change the 1000 to 90. Hit the right arrow to download the now-modified program and watch the change. Now the blink rate is 90 milliseconds (0.09 seconds) on and off. This is how simple it is to change the behavior of the Pro Mini.

Back to model railroading

While blinking a LED was instructive it is not particularly useful. So here are some small projects that might be of interest to modelers:

We do Windows!

One of the neatest animations I use is relatively simple to set up with a Pro Mini. This was built as an example for my animation clinics. This sketch (program) randomly turns on 16 LEDs



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45. Examples window.

used for room lights in my model structures. It can turn background buildings from lifeless shadows into hives of activity.

Here is the sketch:

```
#define numleds

16 byte ledpins [ ] =
{ 0,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17 } ;

void setup( ) {

for ( int i=1; i <= numleds; i++ ) {
    pinMode ( ledpins [ i ], OUTPUT) ;
    digitalWrite ( ledpins [ i ] , HIGH) ;
}

void loop ( ) {
    digitalWrite ( ledpins [ random ( 0, numleds+1 ) ], lightsw ( ) ) ;
    delay ( 900 ) ;
}

boolean lightsw ( ) {
    if ( random (0,100) > 40 ) return LOW ;
    else return HIGH ;
}
```

Copy, paste , and save it as a text file, but name it with a “.ino” suffix like “building.ino”

Then open the file with the Arduino IDE and load it into your Pro Mini. You can also copy and paste the text directly into the Arduino editor window. (See this issue’s subscriber downloads for the code.)

Now let’s set up the Pro Mini Board. Since this will be part of a freestanding model, we need to power the board independently. A cheap and easy alternative is a “wall wart” 5 Volt DC power adapter commonly available. I cut off the connector at the end. Strip the two wires exposing the bare wires, not allowing them to touch.

Blink

```
/*
Blink
Turns on an LED on for one second, then off for one second, repeatedly.

This example code is in the public domain.
*/

// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led = 13;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop() {
  digitalWrite(led, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000);             // wait for a second
  digitalWrite(led, LOW);  // turn the LED off by making the voltage LOW
  delay(1000);             // wait for a second
}
```

46

46. Simple LED blinking program

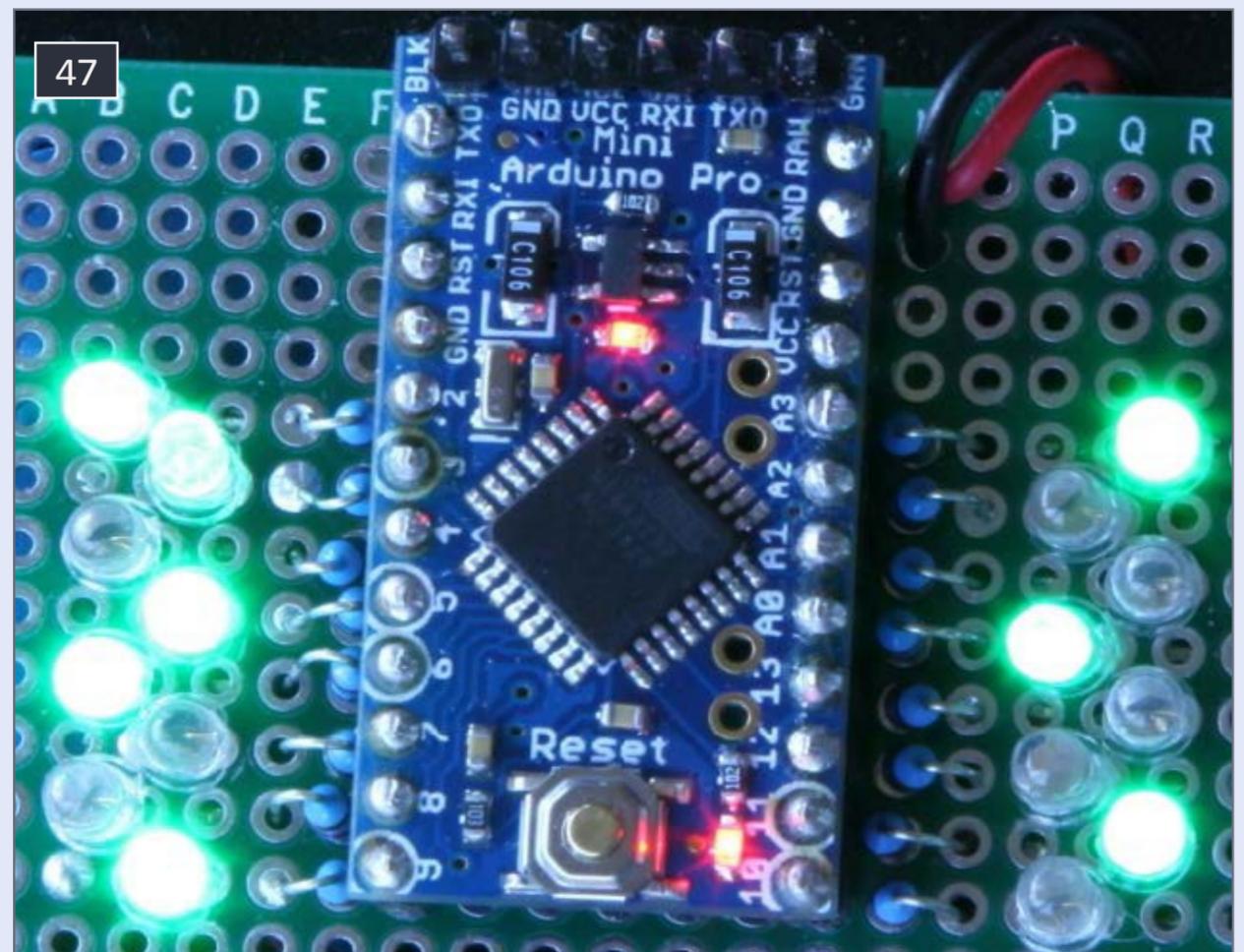
Connect a LED in series with a 1000 to 3000 ohm resistor. Typically the longer length LED wire is the positive side. Touch the resistor/LED combination to the exposed power adapter wires.

When the LED lights, you know which of the wires is positive and which is negative. Connect the Negative wire to GND on the pro Mini and the Positive wire to the hole on the Pro Mini marked VCC. Note this works for the Pro Mini mentioned before. There are other variations for which this will NOT work. Only use a 5 volt

DC adapter here, rated 400 milliamps or more. Place your LEDs in building rooms or where ever you want them, connecting all LED anodes (Plus or positive sides) together and to the positive side of your power source, in my case the 5 volt wall wart.

For each LED connect a 1/8-1/4 watt resistor of somewhere between 330 and 2000 ohms depending on your LED and the LED brightness you desire (experiment a little here) to the LED cathode (Negative side). The other side of the resistor connects to one of the Arduino pins labeled 2-13 and A0-A3 on the Pro Mini Board. These are referred to as Arduino Digital Pins 2-17.

The assembly pictured below is my demo of this very project. The LEDs will come on randomly, and, on the average, stay on for 60% of the time. On the next page is a video demoing the final result.



47. Building lighting demo board.