



North Raleigh Model Railroad Club

Installing Decoders in N Scale Locomotives Detailed Instructions

Arnold Alco S-2 Diesel Switcher

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Introduction

The Arnold S-2 is a nice looking, relatively heavy switcher in N-Scale with a few minor difficulties. Converting it to DCC is not easy, but can be done. Most DCC conversions require modification of the motor/chassis frame. Unfortunately, the cast metal body and locomotive assembly make it a bit difficult for this, and also didn't leave a lot of room for new wires. The answer is in the circuit board used to pick up rail power and route it to the motor. By modifying the board, we can not only convert this locomotive to DCC, but with a little extra work, add directional lighting to it as well. The idea of the lights came from the article: "N Scale Niche: Lights for the Arnold S-2", written by Max Magliaro in Railroad Model Craftsman back in February, 1992.

Two versions of the S-2 locomotive have been produced by Arnold — an analog version and a digital version equipped with a Lenz decoder. The printed circuit board in the locomotive is different for the digital version. The printed circuit board referred in this conversion description is the board in the analog version of the locomotive.

Prior to converting this locomotive over, there are a few items that usually help make the unit function smoother, and have been covered by several well-written articles:

Motor worm gear improvement and idler gear interference solution: "Locomotives: Improving S-2 Operations" by Ron Bearden. July/August 1991 issue of N-Scale Magazine.

Broken drive wheel gear solution: "S-2 Gearing Improvement" by Ron Bearden, November/December 2002 issue of N-Scale Magazine.

Both of the S-2's owned by the author had all of these problems and their operation was helped considerably by the improvements/solutions mentioned in these articles.

The most important factor to remember in performing an analog to digital conversion is to ensure both motor brushes and the decoder orange and gray wires are insulated from the frame. Any contact of the brushes and/or these wires with the frame may result in virtually instant destruction of the decoder.

The first step in the description which follows is to test the decoder for proper operation, following the instructions provided by the manufacturer. The purpose of this step is to ensure any non-operational or dead-on-arrival decoder can be repaired by the manufacturer under warranty. While all decoders carry a warranty for some period of time, usually one year, that warranty usually expires the minute you cut the wires, which, of course, you must do to install the decoder in a locomotive.

As you carry out the detailed instructions below, also refer also to the assembly diagram and parts list provided by Arnold/Rivarossi with the locomotive. They will help with laying out the parts and understanding the terminology used.

Tools Required

To install the decoder and modify the frame you will need the following tools:

Installing the Decoder

- Small Phillips-head and flat-head screwdrivers
- Wire cutter and stripper
- Soldering iron with fine tipped point, 20 watts maximum
- Fine resin core solder
- Tweezers (hook tipped work best)
- Long-nosed pliers, small
- Walther's Goo

Modifying the Frame

- Jeweler's files
- Safety glasses
- Motor Tool with diamond tip point cutting bits, plus 1/16" and 1/32" bits
- 600 Grit wet and dry sandpaper

Modifying the Frame

All of the DCC modifications can be done without modifying the metal body. If you wish to add the lighting, you can add it just in the cab with a minimum of effort. However, with just a little more work, you can add a light at the front of the locomotive and make them directional. The front light will require some minor modification of the metal body. We will also be disassembling and reassembling the locomotive after each modification to make sure if any problem crops up, it will be caught early and we know exactly which modification caused it.

Modifying the Printed Circuit Board

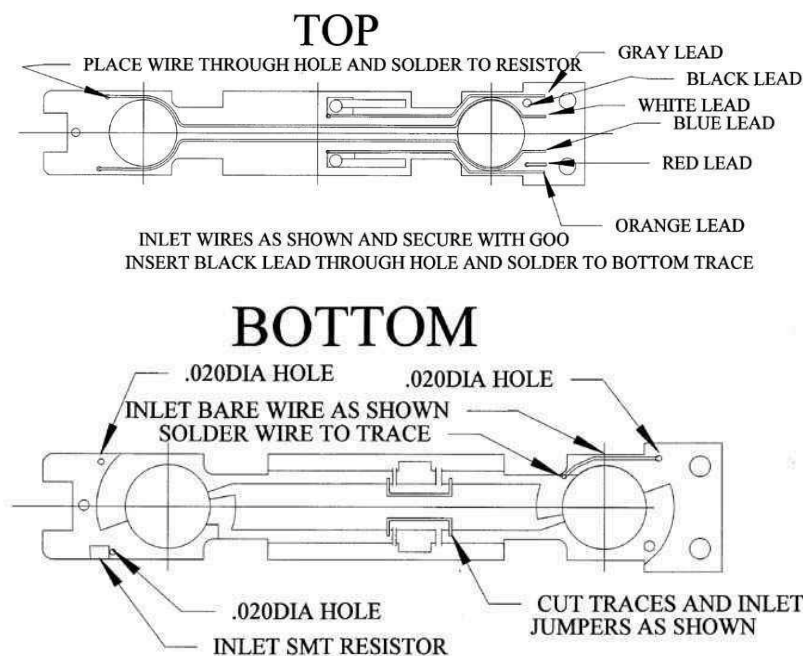
Experimentation on scrap circuit board led me to the method I ended up using, which was to cut small channels into the board and inlaying .010" diameter bare wire (scraps from Miniaturics bulb wire can be used) using Walther's Goo to hold the wires in

place. To successfully inlay the wires, I used a diamond tip point tool to cut a small channel in the circuit board where it needed to be. A length of wire (slightly longer than needed) was cut and set aside. Where applicable, the wires were tinned prior to placement for ease of later soldering. After cleaning all of the dust off the surface of the board, a small amount of Goo was placed in the channel, being careful that no Goo was placed where a solder joint was to be made. The length of wire was dropped in the channel and given a push with the back end of an X-Acto knife to fully seat the wire in the channel. If the channel wasn't exactly straight, the wire was formed to the channel using the back of the X-Acto knife and a small screwdriver. The excess Goo was cleaned off the surface of the board, and a strip of .080" square styrene was clamped over the wire to keep it place. Once the Goo had set, the styrene strip was carefully pulled off.

The inlaying can be checked by sighting down the edge of the circuit board. The wire should not stick above the surface of the board. If it is a tiny bit above the surface, sometimes burnishing the top of the wire with a round object will flatten the wire enough to make it level. Apply light pressure and make sure to fully support the underside of the board while burnishing it.

Care must be taken when cutting the depth of the channels as there will be areas where we will be cutting both sides of the circuit board, and you don't want to cut all the way through the board when cutting the opposing channel. Care must be exercised that none of this dust is inhaled as it could contain fiberglass. Practicing on a scrap piece of circuit board or perfboard is highly recommended as there are no replacement boards available. Proceed at your own risk.

These are the modifications we will be doing to the circuit board:



Detailed Installation Instruction Arnold/Rivarossi Also S-2 Switcher

Set your browser left and right margins to 0.25" (File Page Setup) and print out this document. As each step in the installation is completed place a "X" or a check-mark through the bullet. All references to the frame are based on the front being at the top or away from you.

Before beginning, test your decoder to insure it is functioning correctly. We will be trimming the shrink wrap cover of the decoder which negates the decoder warranty. A Digitrax DZ143 was used due to it's small size and high frequency PWM feature which is needed for the planned addition of a can style motor.

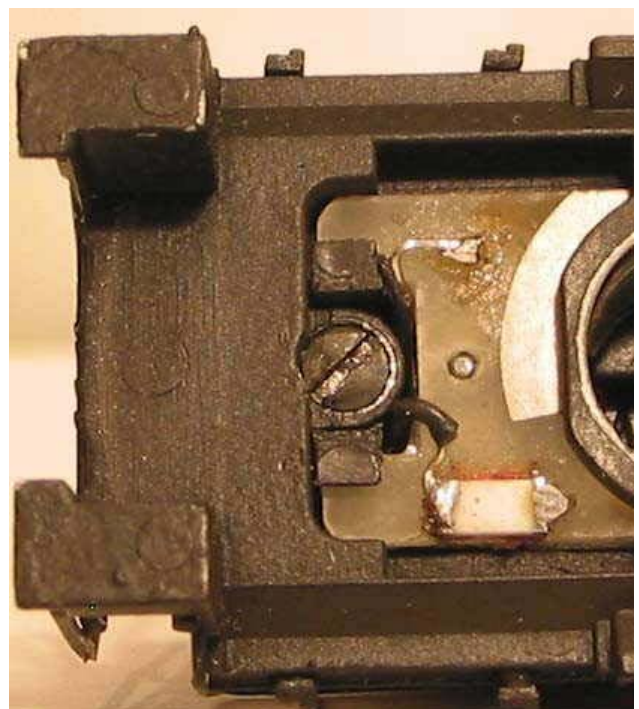
- ❑ Refer to the instructions that came with your S-2 to disassemble it. Place all of the components (except the circuit board) in a safe place away from the work area as there will be a lot of dust generated working on the board. For all of the following steps, refer to the pictures of the completed circuit board top and bottom as needed.
- ❑ Working on the bottom of the circuit board, cut the wire inlay channel from the left hand power pickup trace to the small hole at the rear of the circuit board (the other small hole is in the right hand power pickup trace). Cut the channel as far towards the edge of the board as possible (where the truck retention clips slide) to keep from interfering with the truck rotation or where the power wiper contacts the trace. You also don't want to go too deep as we will be making a channel in the opposite side of the board in this same area and don't want to severely weaken the board.
- ❑ Cut a wire slightly longer than necessary, and tin one end. Inlay the wire as described previously, with the tinned end in the trace, and the other end inserted through the small hole. Solder the wire to the trace and then file the solder joint to get it as close to the board surface as possible without filing the joint completely away (See picture below).



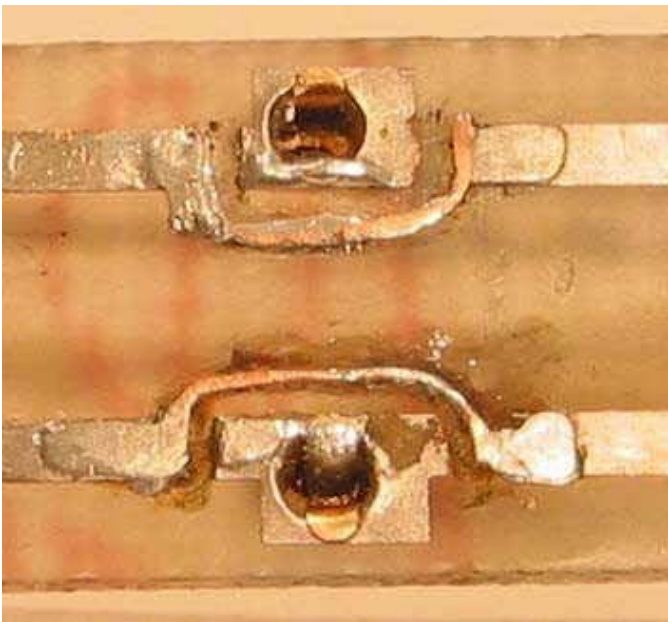
- ❑ Flip the circuit board over, and clip off the extra wire, leaving a short length (at least 1/8") to solder the decoder to. Tin this short end of the wire. (See picture below.) This extends the power pickup trace to a place where we can solder the decoder lead directly to it.



- ❑ At this time, reassemble the locomotive (except the cab) and check the functioning of the truck and truck retaining clips to make sure there is no interference from the new wire and solder joint. Once trouble free operation is confirmed, again remove the trucks and the retaining clips.
- ❑ If you are going to add directional lighting, temporarily place a 361 ohm Surface Mount Resistor (SMR) with a dab of Goo on the back to the bottom of the circuit board as shown in the picture below. A suitable resistor is a 1/8 Watt, 5% Thick Film Chip Resistor from Digikey (P/N P361ECT-ND). We'll come back to this resistor a little later



- ❑ Now we need to isolate the motor leaf springs from the rail power. Finish disassembling the locomotive back to the circuit board. Working on the bottom of the circuit board again, cut through the traces where the square pad juts out and the leaf springs are soldered to them. Cut each trace twice, once on each side of the square. Then take a diamond point tool and cut the inlay channel in the board to route the jumper wire around the square pad and tie the traces back together electrically. Since we will be cutting into the board on the other side to add lighting, go slowly and carefully. Cut the traces back far enough to make sure you don't accidentally solder the trace jumpers to the square pad when soldering them to the traces. There just isn't much room there.
- ❑ Clean the ends of the traces and tin the jumper wires. Inlay the wire as described previously. Solder the legs of the jumper wire to the cut traces and file the solder joint down so it will not interfere with the operation of the sliding truck clips. Clean up all excess Goo and test the traces for electrical continuity and to make sure they are now isolated from the motor leaf springs. See picture at right.
- ❑ Once the goo has set, reassemble the body, circuit board and walkway/chassis, then install the truck clips (without inserting the trucks). Slide the truck clips back and forth several times to make sure there is no interference from the new jumpers. Since there is only plastic against the traces, electrical tape over them is not needed. This completes the isolation of the motor leaf springs.
- ❑ To get power from the decoder to the motor, again take the locomotive apart down to the circuit board.



- ❑ Starting on the top side of the circuit board, right where the motor leaf spring is flat to the board (and goes through the board to the bottom trace), cut the inlay channel in the circuit board as shown in the picture below. Make sure you do not cut too deeply, or you may hit the jumper installed earlier on the other side, or cut through the board where you extended the trace earlier (also on the other side of the board). You also don't want it to interfere with the body's metal catch that catches the board near the back. Take it slow and remember you can always take more out, but can't put it back once it's gone. Cut a piece of wire slightly longer than the inlay channel and tin one end of it. Clean the leaf spring at the flat spot where you started the channel to insure a good solder joint. Lay the tinned end of the wire in the channel, and against the side of the leaf spring at the flat spot. Solder together with a minimum of solder. File the joint down to get it as close to the board as possible without filing away the entire joint. Inlay all but the last 3/8" of wire as described earlier. When you have about 3/8" to go before you run out of channel, tin the rest of the wire. Finish pushing it in the channel and cut off the excess wire, leaving about 1/8" of tinned wire free to be soldered to.

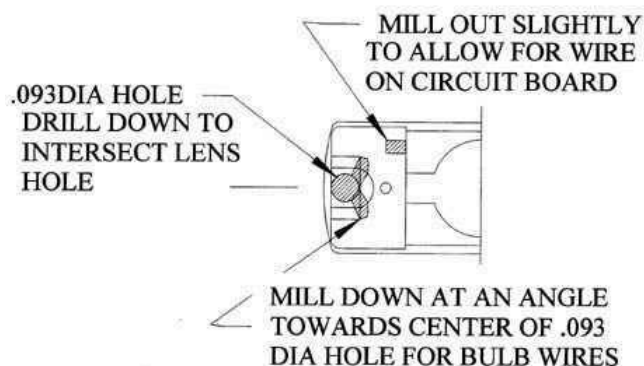


- ❑ Repeat the above to the second motor leaf spring.
- ❑ After completing this, electrically test ALL the circuits for shorts to make sure you didn't accidentally cut into something you didn't want to.
- ❑ Reassemble the unit leaving out the trucks (and cab if you wish), but putting in the truck retaining clips and check to make sure there is no interference as it goes together. Note that with the unit together, when you look at it from the top, without the cab installed, there should be 3 new wires looking at you, and the original hole that goes to one of the traces. This is what you will solder the decoder wires to.

The addition of 1.5V grain of rice bulbs (Miniatronics 30mA 1.5V) to this locomotive really improves the looks of an already good-looking locomotive. If you wish to forgo the lighting, skip the following sections and go directly to the section on cutting the decoder cover. For the cab light only, skip this next section regarding the front light.

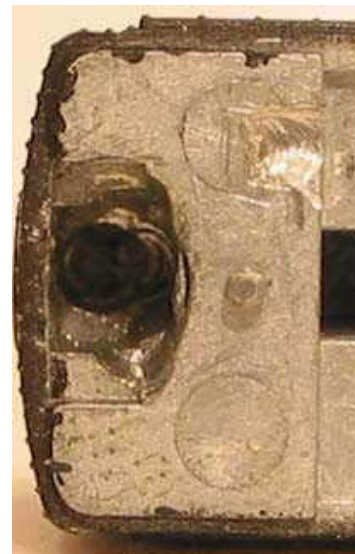
- ❑ For Directional Lights, we need to modify the locomotive's body casting, drill 2 new holes, inlet a Surface Mount Resistor (SMR), and add 2 new wires to the circuit board top. To locate the 2 new holes to be drilled, look at the bottom of the circuit board and note where the SMR is. Trace the outside of the SMR with an X-Acto knife and then

remove the SMR. At the edge of the tracing, drill a .020" DIA hole. Inlet the SMR so that about one-half of it's thickness extends above the surface of the circuit board. Goo the back of the SMR to the circuit board so the solder pads are pointed up. Refer to the drawing at the beginning of these instructions and to the picture below regarding the location of the new inlaid wire channels on the circuit board. One wire is soldered to the SMR, passes through the hole and goes to the rear of the board via its channel. The other wire passes through the other hole, and goes to the rear of the board via its channel. This second wire should have 1/8" of bare tinned wire available at the front of the circuit board. The front bulb wires will be soldered to these later.

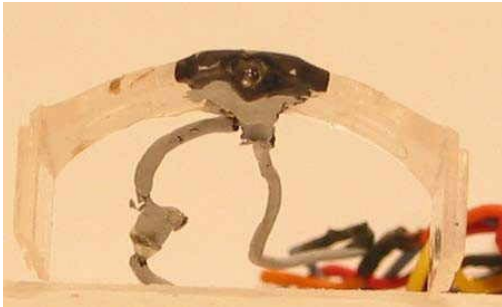
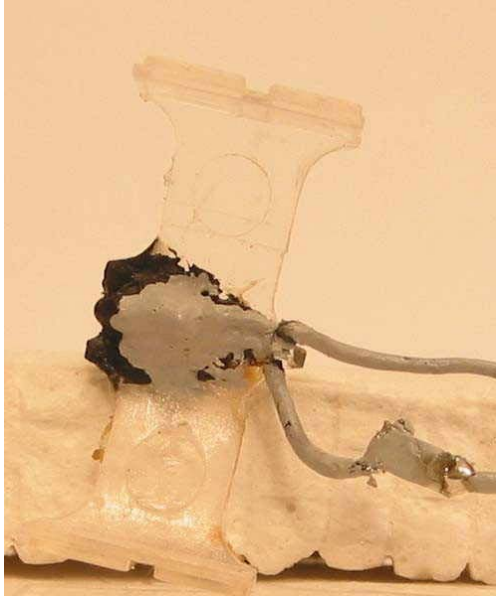


- ❑ Refer to the above drawing and picture at top right for the following modifications to the body casting. Remove the motor and the worm gear bushings from the body and place them in a safe area far from the metal grindings that are about to be made. Carefully grind the area shown to a depth of .010" – .020" for wire clearance. Remove the front plastic lens and use a 1/16" drill bit to go about 1/32" deeper. Looking at the bottom of the metal body, where the screw and retainer go in the front, use a 3/32" carbide drill to go straight down the center of this hole till you break through the first hole. Use a Dremel tool cutter to rout out an area for the wires to go around the retainer and screw. Thoroughly clean all the metal shavings from the casting. Trial fit a 1.2mm bulb by inserting the bulb into the hole in the bottom of the body casting. If all is well, the bulb can be seen from the hole where the lens used to be. Replace the circuit board and circuit board retainer. The wires should not interfere with installation of the retainer. If they do, a little more grinding is required. Once the wire cavity is correct, replace the worm gear bushings, motor and circuit board, and route the bulb wires to their contact points on the circuit board. See previous picture of assembled bottom to see

how the wires are routed. Cut the wires to length, tin the ends, and solder one wire to the SMR. Solder the other wire to the wire coming through the new hole in the circuit board. Remove the bulb/circuit board assembly, take a dab of Testor's glue (the thick stuff from the tube) and place it in the lens hole. The glue will dry clear, forming a lens. A better solution is to use one of the commercially available lenses.



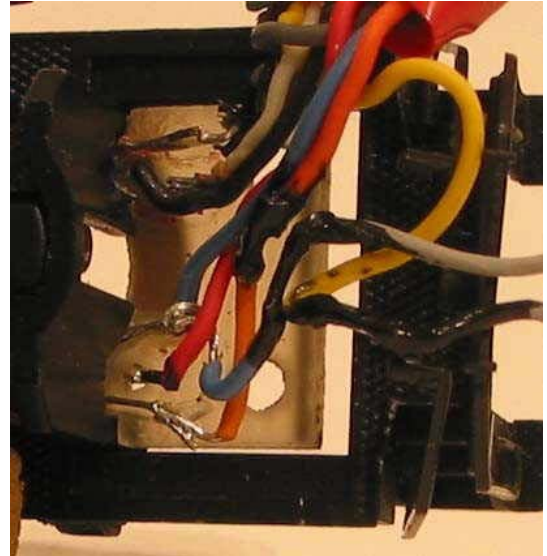
- ❑ To add Cab Lighting, take the cab and remove the one-piece clear side windows molding. Working on the center section, adjacent to the light lens in the cab, file a tapered slot in the center of the section. Temporarily adhering a Miniaturics 1.2mm bulb into the slot with Goo, reinserting the side windows molding, and energizing the bulb with a 1.5 volt battery helps in determining the correct angle and depth of the slot. After completing the slot, remove the bulb and clean all remnants of the adhesive from the molding. Paint the slot and the immediate area around it black. Take a 3/16" length of .047"ID tubing and cut it in half lengthways. Goo the bulb to the ID of the tube and paint the exterior of the tube black. After the paint cures, Goo the bulb/tube assembly to the slot in the molding. Trim one of the bulb wires to a length of 1/2". Remove 1/16" of insulation, tin the end and solder a 361 ohm SMR to it. Cut a 3/4" length of wire from the scrap bulb lead, trim 1/16" insulation and tin each end. Solder one end to the other side of the SMR. Paint the wires and the SMR gray to match the inside of the cab. Also paint all the areas previously painted black. For directional lights, the white decoder lead will be soldered to this wire. For a nondirectional light, both the white and yellow lead will be soldered to this wire. Cut the other bulb wire to a length of 1-1/4", trim 1/16" insulation and tin the end. The blue decoder lead will be soldered to this wire. Reassemble the cab window/bulb assembly to the cab and make the 2 solder connections to the decoder.



- Once the **Lighting Modifications are Complete** (if so chosen), carefully trim the cover of the decoder on the end opposite the wire harness back to the edge of the decoder circuit board. On the end with the harness, carefully trim the cover back approximately 3/32". Check by folding the wires under the decoder and inserting it into the cab so the decoder would be laying on it's side, lengthwise, in the cab. Once the decoder cover is correctly trimmed, lay the decoder to the side of the circuit board as shown in the photographs at right and below. Cut, tin and solder the decoder wires to the appropriate attachment points (see previous illustrations).



- Note the special blue wire trimming for directional light requirements. It is much easier to solder the leads closest to the decoder first, and work your way across the circuit board away from the decoder. Carefully fold the decoder back over the wires onto the top of the circuit board. To insulate the leads from the body, use liquid electrical tape at all points where the new wires might contact the body or each other. Note: this insulation is not shown in the photograph below.



- Reassemble the locomotive and program the decoder using an appropriate current limited program track. Test to be sure your locomotive operates as it should.

The conversion is complete and it's time to enjoy your new DCC Alco S-2 switcher.

