
ALL ABOARD!

Congratulations on the purchase of your SoundTraxx™ Digital Sound Decoder™ (DSD). Properly installed, the DSD will provide all the pleasures of high quality, digital onboard sound and the benefits of today's DCC (Digital Command Control) technology.

With the proper tools, basic modeling skills and common sense, equipping a locomotive with sound is not difficult. It may, however, be a new experience for you, and you will find that successive installations will go more quickly than the first. The Digital Sound Decoders have some unique features and capabilities that require some steps not found in regular decoder installations. We strongly encourage even the most skilled and experienced modeler to read this manual thoroughly as it contains instructions and information designed to provide optimum, trouble free performance from your DSD. We urge you to test the decoder first using the simple test procedure in Appendix B to verify that everything is working as it should. If you do not feel comfortable attempting the installation - don't! You may prefer to have your dealer perform the installation while you watch, until you gain some experience.

Please note that while each decoder is tested thoroughly before it is shipped, we cannot control the correctness or quality of the installation. It is imperative that you follow the directions and do not install the decoder before you have tested it. Never remove the protective heat shrink from the decoder; there are no adjustments or user serviceable parts and this will void your warranty. Do not shorten any of the decoder wires until you have verified that it is functioning properly using the Decoder Test.

This manual is divided into two parts for your convenience. Part I is the Owner's Manual, which covers the features of the Digital Sound Decoder, its installation and its operation. Part II is the Decoder Technical Reference. This is designed for the advanced user who wishes to have the technical data on the Digital Sound Decoder as a reference for advanced programming techniques. If this is your first decoder installation, Part I will provide you with all the information you need to get started.

DSD FEATURES AND SPECIFICATIONS

The Digital Sound Decoder is designed to be installed onboard a locomotive in conjunction with a miniature speaker to provide the ultimate in realism and control. The DSD integrates a full featured digital sound system, a Hyperlight™ and a DCC decoder into a single miniature electronic module. The modeler is thus freed of the expense and frustration of trying to fit multiple pieces of equipment into an often space limited locomotive. The Digital Sound Decoder is compatible with the latest NMRA DCC Standards and Recommended Practices.

The DSD is available with prototype-specific sound and lighting effects for a multitude of North American and foreign locomotives. Depending on the effect, the sounds are generated continuously, automatically in response to some other action, or as controlled by the user. Additionally, certain sounds can be modified using specific Configuration Variables (CVs).

Decoder Features

Compatible with the latest NMRA DCC Standards and Recommended Practices as defined by S-9.1, S-9.2, RP-9.1.1, RP-9.2.1, RP-9.2.2, RP-9.2.3 and RP-9.2.4.

Supports 7 bit address modes for compatibility with 'simple' systems.

Supports 14 bit address modes for addressing any locomotive number up to 9,999.

Supports 7 bit consist addressing.

Supports Function Mapping.

Supports paged, register, and direct mode CV programming.

Supports 'Operation Mode Programming', allowing many CVs to be changed on the mainline without using a special programming track.

Steam Sound Features

The Steam DSD provides high quality digital sounds specific to its prototype. Each Steam DSD includes:

- *Steam Exhaust Chuff*
- *Bell*
- *Dynamo*
- *Cylinder Blowdown (Hiss)*
- *Fireman Fred*
- *Adjustable Volume Control*
- *Auto-Exhaust™ allows chuff to be synchronized using an exhaust cam sensor or track voltage.*
- *Whistle*
- *Firebox Blower*
- *Airpump*
- *Boiler Pop Valve*
- *Coupler Clank*
- *1 Watt Audio Amplifier*
- *Dynamic Digital Exhaust™ modifies exhaust volume, cutoff and timbre as locomotive load changes.*

Throttle Features

- *Supports 14, 28 and 128 speed step modes.*
- *Programmable acceleration, deceleration and starting voltage, for prototypical starting and stopping.*
- *Use of standard and alternate speed tables; 14 built-in speed tables and 1 user programmable speed table.*
- *Thermal and overload protection.*
- *DSD-050 suitable for engines whose current draw (stalled) does not exceed 1/2 amp (3/4 amp peak). DSD-150 suitable for engines whose current draw (stalled) does not exceed 1-1/2 amp.*

Lighting Features

Each DSD also comes equipped with four auxiliary function outputs that can be programmed to accommodate a number of lighting features including four programmable Hyperlight effects:

- *Simple On/Off Lamp*
- *Firebox Flicker*
- *Mars Light*
- *Intelligent Firebox Flicker - synchronizes with sound of firebox door opening and closing.*
- *Supports "Rule 17" headlight and backup light operation or automatic direction control.*
- *100mA current sink capability.*

IMPORTANT STEPS FOR A SUCCESSFUL INSTALLATION

It will be a great temptation to begin connecting wires immediately. Before you install your DSD, there are some simple precautions you should take.

First, finish reading this Owner's Manual!

The DSDs should be handled carefully in a static-free environment. To discharge static electricity, touch a grounded water pipe or bare sheet metal surface before handling the DSD.

Work in a clean, well lit area on a nonconductive surface. Metal scraps and dirt can get onto the DSD's circuitry and cause shorts.

Never, ever remove the decoder's protective shrink tubing. First, it will void your warranty and secondly, you will compromise part of the decoder's built-in thermal management system.

Never, ever make connections to the decoder while it is powered. Doing so makes for an accident waiting to happen.

Make sure all electrical connections are insulated. Avoid using electrical tape if possible as it tends to unravel over time. We recommend using heat shrinkable tubing instead.

Never, ever allow the decoder leads to come in contact with any DCC track wiring except those specifically designed for that purpose.

Never allow speaker outputs to become shorted together.

Never allow the motor outputs to become shorted together.

Do not exceed the output ratings for which the decoder is designed.

Take your time and have fun!

DSD Functional Testing

Although each DSD has been fully tested prior to shipment and is ready for installation, we urge you to test your decoder before installing in your locomotive! We have developed a simple procedure (see Appendix B) that assures you that the DSD is functioning as it should before you do the installation. If this is your first sound or decoder installation, it will give you an added boost of confidence, knowing that as long as you follow the installation instructions...it *will* work!

In the event you do have a problem, please contact your dealer or Throttle Up! for technical assistance first. We will gladly refund payment or replace any decoder that does not pass the functional test free of charge provided that none of the decoder wires have been cut short.



Before you get started, we must reiterate - *do not shorten any decoder leads* until you have verified that the decoder is functioning properly. *Do not install any decoder that does not pass the Functional Test.*

INSTALLATION

10 Easy Steps to Steam Sound

Installing the DSD generally requires the following steps:

1. Select the Locomotive

Choose a locomotive appropriate to the decoder and your installation skills.

2. Plan the Installation

Determine the location of the DSD, speaker, cam, lamps and connectors.

3. Isolate the Motor

Disassemble the locomotive and disconnect all wires to the motor and lights.

4. Fit the Speaker

Trim the speaker frame and/or add baffles to get a sound-tight fit.

5. Modify the Tender Body and Floor

Modify the tender to accept the speaker and decoder.

6. Install the Lamps

Modify headlight castings to accept miniature lamps.

7. Install the Exhaust Cam

Install synchronizer disk and mount cam switch.

8. Install and Wire the Decoder

Mount the decoder and connect the lamps, motor, speaker, etc.

9. Test the Installation

10. Program the CVs

Program CVs to tune performance and sound effects.

Tools and Materials You Will Need

In addition to the common hand tools found on most modeler's workbenches, you should have at your disposal:

- Low wattage (under 25 watts!) soldering iron
- Rosin Core Solder
- X-acto knife
- Miniature screwdriver set
- Diagonal cutters
- High speed motor tool (such as a Dremel)
- Ohmmeter
- Double sided tape
- Silicone RTV

We also recommend the following items to ease your installation:

Micro-connectors to facilitate easy separation of items like speakers from the locomotive. Throttle Up! sells P.N. 810012 2-pin microconnector, P.N. 810063 3-pin microconnector, P.N. 810064 6-pin microconnector, P.N. 810065 8-pin microconnector and P.N. 810058, 10-pack of micro-mini connector pins.

We recommend you use insulative and shrink tubing, to insulate your connections. Throttle Up! sells P.N. 810037,

which contains an assortment of heat shrink tubing suitable for this purpose and P.N. 810036 which provides a length of Teflon tubing. Electrical tape will unravel with time and is not recommended!

If you intend to take advantage of the special lighting effects and wish to use 1.5 Volt microbulbs for this purpose, Throttle Up! offers two sizes; P.N. 810022 has a diameter of 1.3mm. P.N. 810024 has a diameter of 2.5mm for use in larger scales. You can also buy these lamps in economical six packs. See Appendix A.

Throttle Up! also offers a variety of 8 ohm speakers suitable for use with the DSD. Choose the largest speaker that can be fit in the locomotive. The larger the size, the better the sound quality and volume. See Appendix A for ordering information.

P.N.	SPEAKER SIZE	SUITABLE SCALES				
		N-Scale	HO-Scale	S-Scale	O-Scale	G-Scale
810053	3/4" Speaker	●	●			
810054	1" Speaker		●	●		
810055	1-1/2" Speaker		●	●	●	
810056	2" Speaker			●	●	
810057	3" Speaker				●	●

Step 1. Select your Locomotive

If this is the first time you have installed sound in a locomotive, then we suggest you choose your locomotive carefully. A few simple precautions will ensure that your first effort produces a great sounding locomotive instead of an intimidating ball of wires:

- *Do* pick a smooth running locomotive that runs well on straight DC power. A smooth running mechanism is vital for good throttle control and enhances the realism of the sound. Dirty, worn out or binding mechanisms not only overload the decoder, but will have trouble starting smoothly and will destroy the illusion created by the Auto-Exhaust feature if they barely lurch along at half throttle.
- *Do* pick a locomotive with a reasonably large, rectangular tender. The larger the tender, the more room you will have for installation of the decoder and speaker. It will also allow you to use a larger speaker, giving both better volume and sound fidelity. Reserve that favorite little shay for a future installation when you have some experience behind you.
- *Do* start with an engine that is 'sound-ready' if possible, such as an engine with predrilled speaker holes, for example. The simpler you can make your first installation, the better.
- *Don't* pick a noisy engine, or one which experiences some arcing or sparking when in operation. The best sound will come from locomotives powered with can motors. Older, open-frame motors may produce an offensive, interference sound.
- *Don't* pick a locomotive whose stall current draw exceeds the rating of the decoder. The following procedure can be used to determine a locomotive's stall current:
 1. Place the locomotive on a section of track powered with a conventional DC power pack set to 12 volts for N, HO, S, and O scales or 16 volts for G scale.
 2. Connect a DC ammeter in series with one of the track feeders as shown in Figure 1. If your power pack has built-in meters, they may be used for this purpose.
 3. While grasping the locomotive to prevent it from taking off, turn the power pack to full on.
 4. Stop the motor from turning by firmly pushing the locomotive down into the track or grabbing hold of the flywheel or driveshaft.
 5. To ensure the most accurate current measurement, be sure that the power pack voltage remains at 12 volts (16 volts for G scale) during this test.
 6. Measure the current the locomotive is drawing while the motor is stalled. This is the stall current and must be less that the decoder's rated capacity.

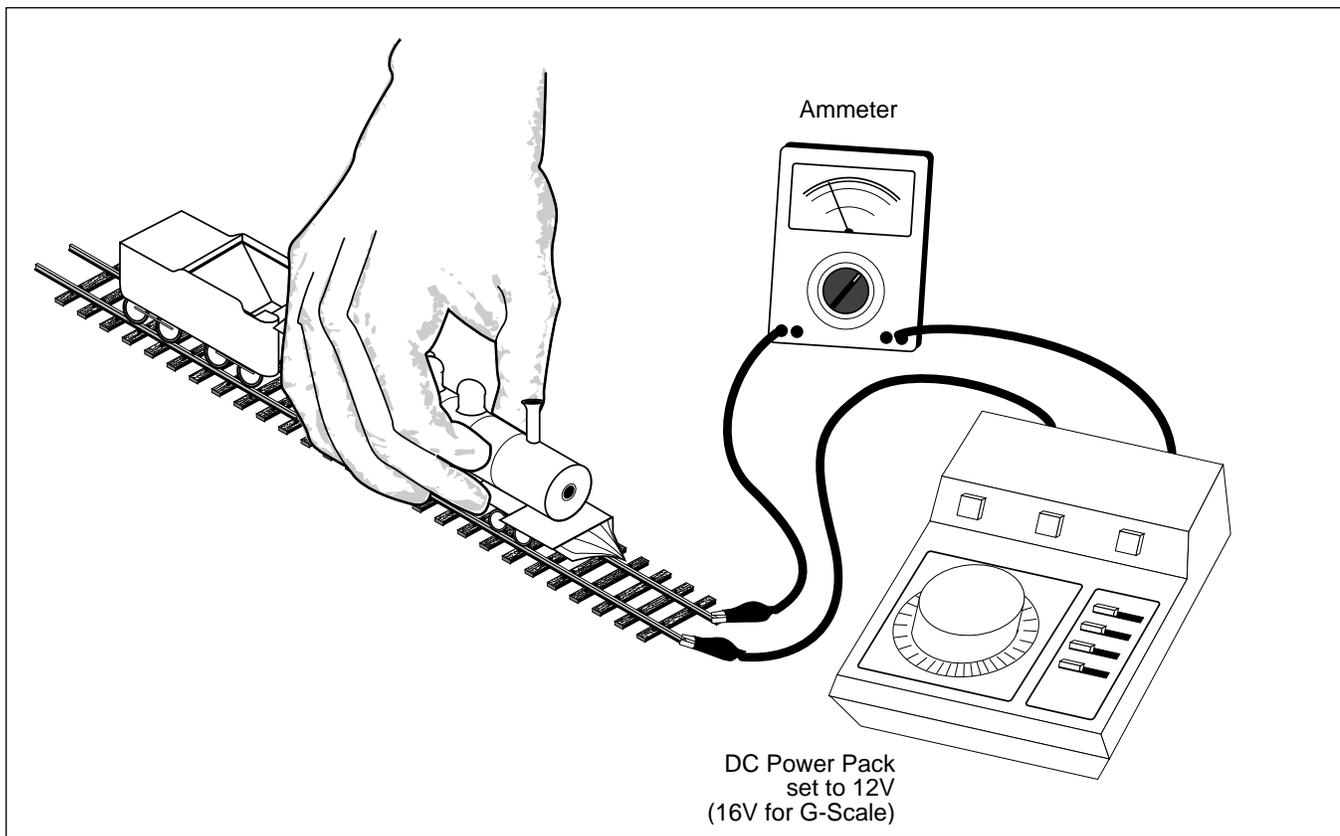


Figure 1 - Stall Current Test Setup

Step 2. Plan the Installation

You should give some thought to where the installation of the various DSD components will be within the locomotive before you get started. Figure 2 shows a typical installation.

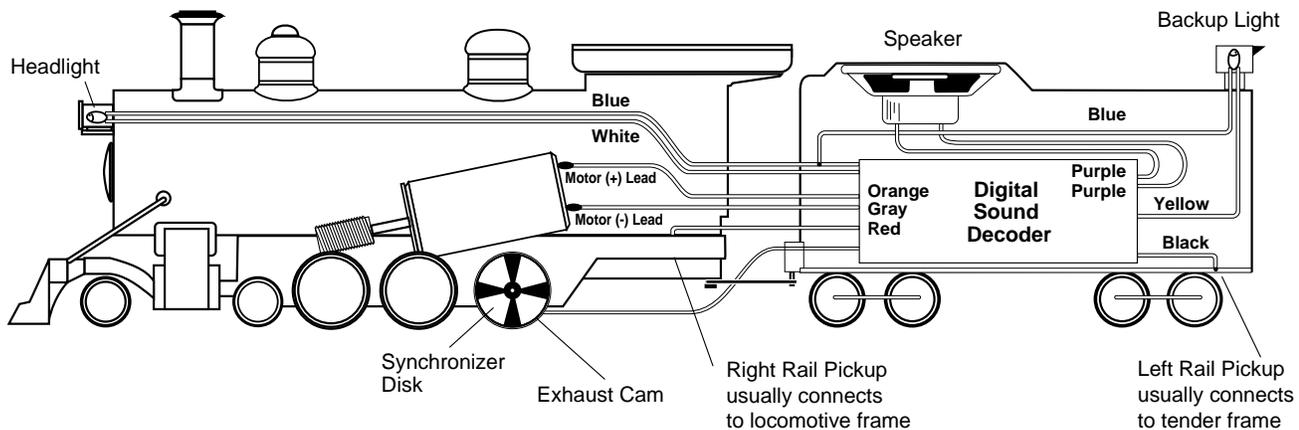


Figure 2 - Typical Sound Installation

The decision most critical to the success of your installation will be where to put the speaker. Obviously, the 'where' of speaker installation will depend on the size and type of the locomotive. But when considering the speaker's location, remember that the volume of the speaker will be greatly enhanced when the speaker is fitted into a small airtight enclosure with the front of the speaker open to surrounding air. The reason for this is simple: in order to generate any appreciable sound, the speaker must develop air pressure. Without an enclosure, any pressure devel-

oped by the front of the speaker is canceled by an opposite pressure behind the speaker. The enclosure isolates the front and back surfaces of the speaker, thereby increasing the sound pressure and hence, the volume.

Additionally, the enclosure must be sized proportionally to the speaker such that the volume of air enclosed is several times larger than the speaker diameter. If an enclosure is too small, it will interfere with the speaker operation and although it cannot be made too large, there is a point of diminishing return. As a rule of thumb, for small speakers, the minimum for the length, width and height should be equal to the speaker diameter. Thus the smallest enclosure for a 1" speaker would be 1" X 1" X 1", while 2" X 2" X 2" would be the smallest size enclosure for a 2" speaker. As this is only a general guideline, exceptions can and must be made in many circumstances.

 **HOWEVER, the use of a proper speaker enclosure cannot be over emphasized and failure to use one is almost always the cause for poor sound quality.**

Fortunately, most steam engines have a tender and with a little work, the tender itself becomes a great speaker enclosure. The speaker can face up through the coal bunker or down through the floor. Either way will produce equally good sound.

You will also want to use the largest speaker possible to get the best bass response. Larger diameter speakers can be trimmed down in width so they will fit within the tender shell. By building an internal baffle, they can also be mounted at an angle although this will compromise the available space for the DSD module in all but the largest of tenders.

In small tenders, the speaker should be mounted forward in the coal bunker area, where higher walls are available to cover the speaker magnet.

For other locomotives, the speaker enclosure need not be fancy and can be fabricated from sheet styrene, bass wood, and even cardboard in a pinch! A 35mm film canister usually produces excellent results, as does the cardboard tube center of a roll of paper towels.

The Digital Sound Decoder is best suited for installation in the tender, although it will fit in the boiler of larger locomotives. Boiler installation has the advantage of requiring considerably less wires that have to be routed between the engine and tender. It will usually come at the expense of some boiler weight and possible reduction in traction.

It is normal for the DSD to get warm after periods of extended operation and its built-in thermal overload protection will automatically shut down the throttle and audio amplifier if it gets too warm. Therefore, it is important to install the DSD in a location where it can dissipate the most heat. Avoid placing the DSD near heat sources such as the motor or lights.

You will also need to decide how you will synchronize the exhaust chuff. The DSD provides two means for synchronization. The first method is to use the mechanical cam which works by opening and closing a switch contact with the locomotive wheels or axle.

The exhaust cam switch is best mounted so it contacts the inside face of a driver wheel. This will give the most precise synchronization and even produce a wheel slip effect if the locomotive is accelerated too quickly! In a pinch, the exhaust cam can be used with a tender axle, although the synchronization effect will not be exact unless the tender wheel diameter is an exact multiple of the locomotive driver diameter.

The other method of exhaust synchronization is the DSD's Auto-Exhaust feature which produces chuffs in proportion to the throttle setting. This method is recommended for those locomotives where a mechanical cam would be difficult to install such as N scale and smaller HO locomotives. When used in conjunction with the programmable speed curves, it is difficult to tell the difference between the Auto Exhaust and the exhaust cam at all but the slowest speeds.

Next, you will need to consider which lighting effects you will use. The DSD provides four auxiliary function outputs which can be used for controlling miniature lamps or LEDs. Two of the outputs will usually be used for the headlight

and backup light. These outputs may be configured for automatic direction control such that the headlight is on when the locomotive is traveling in the forward direction and the backup light is on when the locomotive is reversed. The lights may also be setup for “Rule 17” operation where the engineer must manually turn each light on or off as appropriate.

The other two outputs are programmable Hyperlight effects and may be used in a variety of ways:

- As a conventional on/off output, they may drive additional bulbs for the cab light, marker lights, number boards, small relays or other electronic circuits.
- As a Mars light, they may be used to simulate the famous warning beacon found in front of the modern steam engines used by railroads such as the Southern Pacific, Union Pacific and Nickel Plate Roads.
- The outputs can also be set up to simulate the flickering glow from the firebox. This is best done by mounting an orange or red lamp underneath the locomotive’s firebox area.
- A second version of the firebox flicker effect is available that turns on only when the sound of the firebox door opening has been activated and turns off when the doors “close”. The lamp for this effect is best mounted in the cab behind a partially open firebox door detail.

Each Hyperlight output can be independently programmed so it is possible to use one bulb as a Mars light and the other bulb for the firebox.

The function outputs may also be used to control other electrical devices such as a smoke generator although you must be careful that such devices do not exceed the output’s current rating (100 mA) in which case you will need to add a relay or other low current switching device. A clamping diode may be required for inductive loads, such as a relay coil.

You must also be careful that the combined current draw of each lamp and the locomotive’s stall current does not exceed the decoder’s current rating.

Finally, you will need to decide whether or not to hardwire the electrical connections between the tender and the locomotive or use a pluggable connector. Using a connector will allow you to separate the engine and tender for storage as well as make painting and service easier but can be unsightly in smaller models and also opens the possibility of accidentally damaging the decoder by reversing the connector during reassembly. Hardwiring the decoder will prevent this possibility at the expense of making tender separation difficult.

Throttle Up! offers several microconnectors suitable for locomotive use. P.N. 810064, 6-pin connector and P.N. 810065, 8-pin connectors are best for HO and larger models and they can be wired so they are “damage proof”, i.e., no decoder damage will occur if they are accidentally plugged together backwards (see page 14, Step 8). The particular connector you will use will depend upon the number of lighting functions you are using. The 8-pin connector provides enough pins to wire the headlight and two auxiliary lighting functions. The 6-pin connector provides enough pins to wire only the headlight. Individual connector pins are also available which will allow you to disguise the connecting wires as air and water lines but requires great care when reconnecting them so as not to miswire the decoder.

After you have fully read the installation manual, we suggest reviewing Step 8 on wiring the decoder and draw yourself a schematic similar to Figure 8 showing all connections between the DSD and various sub-components. This will also help you determine which connector is best suited for your needs.

Step 3. Isolate the Motor

 Pay careful attention this step as it is the most important step in successfully converting any locomotive over to DCC operation.

The two motor brush connections must be electrically isolated so they are driven **exclusively** by the DSD motor outputs. We’re not kidding about this!



Failure to properly isolate the motor will damage your decoder and turn it into an effective, but short lived smoke generator!

Our warranty specifically excludes damage caused by improperly isolating the motor; however, in the event you do damage your decoder, simply return it to Throttle Up! along with the service fee (please call for current amount) and we will repair and return it promptly.

Begin motor isolation by removing the boiler and tender shell from the locomotive and tender frame.

Before you proceed further, it is important to carefully examine the locomotive wiring and determine where each wire goes and what it does. The manufacturer's assembly drawings may be useful here or you may elect to create your own wiring diagram. In particular, you will need to identify the connections to the left and right power pickups as well as the (+) and (-) motor connections. Note: for N, HO, S and O scale locos, the positive motor connection is the one connected to the right rail (engineer side) power pickup. On G scale locos, the positive motor lead is connected to the left rail pickup (fireman side).

Disconnect all wires leading to both motor terminals. Note that some motor brush connections are made using a spring contact to the chassis. In such cases, it will be necessary to remove or modify the spring contact as well. Be aware that some locomotives may make contact between the motor and frame only when the body is reinstalled.

Next, verify that each motor terminal is electrically isolated from the left and right rail pickups using an volt-ohmmeter or continuity tester. With your meter set to the ohms scale, touch both meter probes together and note that the meter indicates 0 ohms (short circuit). You don't want to see this indication again! Touch one of the probes to one of the motor brush terminals. Touch the other probe to the locomotive frame, then the left rail power pickup wire, and finally to the right rail power pickup wire. Move the first probe to the other motor brush terminal and repeat the tests. If all tests indicate an open circuit, the motor is properly isolated. Do not proceed further until this is done.

You will also need to disconnect the wires leading to any lights you wish to use. If you plan to use the Full-Wave method of lamp wiring (see page 15), you must disconnect and isolate both lamp wires. Using an ohmmeter, check that each lamp lead is electrically isolated from the frame as well as the left and right rail pickups.

If you choose to use the Half-Wave method of lamp wiring (see page 15), leave one lamp lead connected to the locomotive frame or tender chassis provided the frame or chassis is electrically connected to the proper power pickup. This will allow you to use existing lamp sockets if your engine is so equipped. See Step 8, page 15 "Lighting Outputs" for specific details.

Step 4. Fit the Speaker

If the speaker is wider than the tender, it will be necessary to reduce the speaker width to get a proper fit. Determine how much the speaker must be cut down and remove half of that amount from each side of the speaker.

Speakers with plastic frames may be trimmed down using a sharp flat file. File down the speaker sides - work slowly and alternate from side to side until the speaker just fits within the tender shell. Be careful to remove only the speaker frame and outer edge of the diaphragm. Avoid cutting into the diaphragm itself.

Speakers with metal frames can generally have a larger amount of frame and speaker cone removed and still maintain a satisfactory sound. On the back of the speaker frame, draw a line where the first cut will be made. Draw a second, parallel line

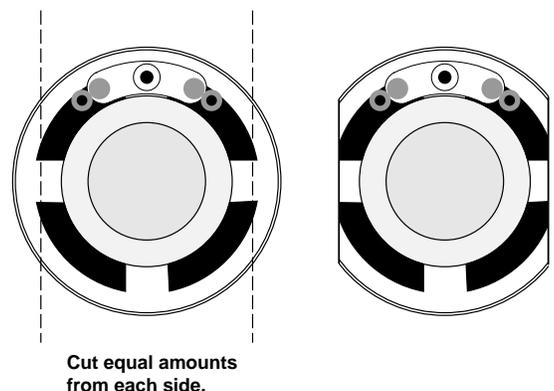


Figure 3 - Modifying the Speaker

marking the other cut. Be sure that neither line cuts into the speaker coil wire.

A Dremel or similar motor tool with an abrasive cutoff wheel will make the job of cutting the speaker go quickly. Be sure to wear your safety glasses! Hold the speaker face down and make shallow cuts along each line until the frame has been cut through. Trim the speaker cone with a sharp single edged razor blade or hobby knife.

Check the speaker's fit into the installation site and trim the speaker frame and cone as needed until the desired fit is attained. For best performance, the speaker should fit snugly within the tender so that the edges of the speaker cone are as close to the tender sides as possible without actually touching. Do not allow the speaker cone to rub the tender walls as this will produce a "scratchy" sound. Likewise, a large air gap will reduce the speaker's bass response but can be filled in with cardstock if needed.

Step 5. Modify the Tender Body and Floor

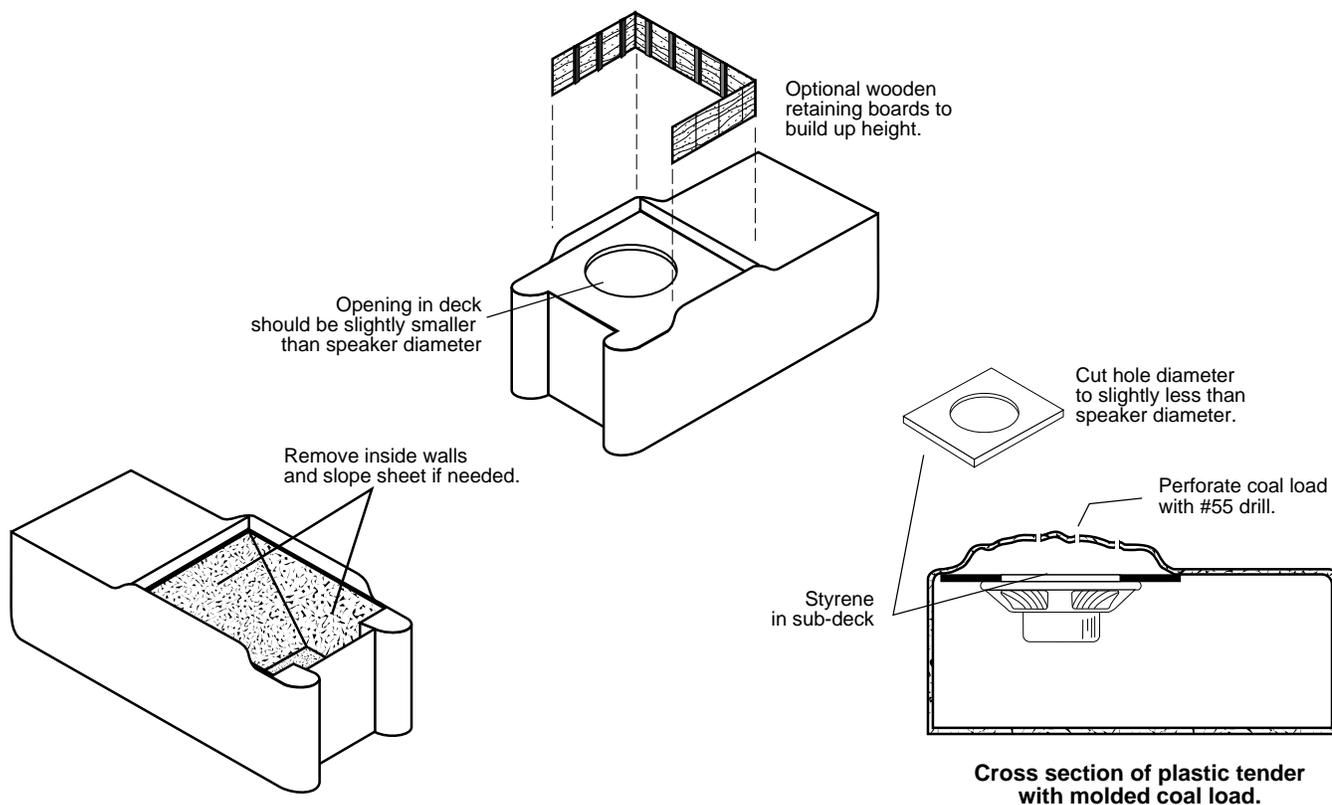
Depending upon your choice of tender, you will probably be mounting the speaker facing down on the tender floor or facing up in the coal bunker. In either case, a certain amount of "body work" is usually necessary to accommodate the speaker and decoder. This may include removing weights, mounting brackets, internal bracing and other structural features.

You will probably need to cut an opening in the tender shell or floor for the speaker. A series of small holes can be easily drilled and will work as well as one large hole provided the open area is at least one half the area of the speaker cone. In either case, there should be no openings outside or larger than the speaker cone itself.

Tender Body Modifications

On tenders with low side walls, the speaker is often best mounted facing up in the coal bunker so as to provide adequate clearance for the decoder which will be mounted against the tender floor. In some cases, it may even be necessary to add a wooden "retaining wall" to build up height.

Figure 4 - Tender Shell Modifications



The simplest tenders have a flat deck across the coal bunker and are the easiest to deal with. Simply mark or scribe

the speaker outline onto the tender deck and using a jeweler's saw, cut out a circular opening about 1/16" inside the outline marks. Remove all sharp edges and burrs. The speaker is then disguised by covering the opening with a acoustically transparent coal load. The coal load can be fabricated by contouring a piece of fine screen mesh or polyurethane foam to represent a coal load and then covering it with a thin layer of scale coal cemented in place with a thin wash of diluted white glue.

Plastic tenders often have a molded coal load already in place. Unfortunately, the inside surface of such tenders are contoured to match the coal load and do not provide a flat mounting surface for the speaker. In such cases, the modeler has two options. The first is to cut out and remove the coal load entirely and replace it with a flat sheet of 0.060" or thicker styrene and then proceed as described above for the flat decked tenders.

Alternatively, a sub-deck can be fabricated from 0.060" sheet styrene such that it fits below the coal load tightly against the tender sides. Cut a large circular opening appropriate for the speaker diameter into the styrene sheet and then glue the sub-deck to the inside of the tender shell. Perforate the coal load by drilling a series of small holes (use a #50-#60 drill) at random angles between the coal "nuggets". This way, the sound will be allowed to escape yet the speaker remains relatively invisible regardless of viewing angle.

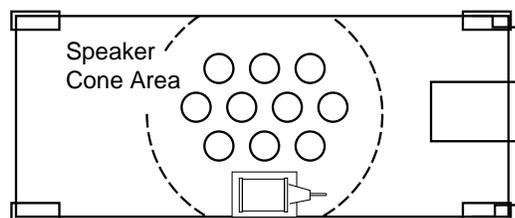
The more realistic tenders will have fuel bunkers that prototypically extend to the tender floor. For larger tenders with such a feature, the speaker is best mounted on the tender floor. For smaller tenders, the slope sheet and interior walls will not only interfere with the speaker, but the decoder as well and it will usually be necessary to remove and replace them with sheet brass or styrene to create a flat decked tender.

Tender Floor Modifications

If you are mounting the speaker to the tender floor, first determine the exact speaker location within the tender and verify that there is adequate clearance between the tender body and speaker magnet. Use a marker or scribe to note the location of the speaker on the tender floor and then drill three rows of holes (see Figure 5) in the pattern shown to provide an opening for the sound to escape. A drill approximately .250" is a good size. Space the holes as best you can, taking into consideration the tender underbody detail. Although the spacing is not critical, you should attempt to provide at least this much of an opening. If necessary, use more holes of a smaller diameter. Keep all the holes within the expected cone area of the speaker. Take care not to place holes at the outer edge of the speaker assembly itself.

Once you have drilled your holes, remove all burrs and uneven edges. Make sure there are no metal burrs or edges projecting up - the speaker floor should be smooth, with nothing to physically interfere with the speaker's ability to lay completely flat on the tender floor, such as solder joints, screw bosses, and mounting studs.

Figure 5 - Tender Floor Modifications



Secure the Speaker in Place

Once body work is complete and the speaker has been fitted in place, it must be secured tightly to the enclosure. For the best sound, an airtight seal is needed around the speaker edge and we have found the best way to hold the speaker in place is to use silicone RTV - it provides the airtight seal needed and unlike epoxy or other hard glues, allows the speaker to be readily removed in the future. Be careful that you don't get any RTV onto the speaker cone itself as this will severely distort the sound quality!

Step 6. Install the Lamps

Headlights, Backup Lights and Mars Lights

Drill out the headlight castings to accept any lights you intend to use, including the tender backup light. If you are using Throttle Up!'s 1.5V, 1.3mm microbulbs, P.N. 810022, a #53 twist drill makes a perfect hole. If you are using the

larger, 2.5mm microbulbs, P.N. 810024, a #41 twist drill works well.

Test fit the microbulb for adequate hole clearance and enlarge the hole if necessary. Next, paint the headlight castings' reflector surface with white or silver paint and allow to dry.

Install the light bulbs and secure in place using tape or a flexible glue that does not bond well to glass such as white glue, rubber cement or RTV. Epoxy or ACC glues will make bulb replacement very difficult and are not recommended.

As a final touch, install a lens using white glue to hold it in place. You may wish to use a commercially available lens such as those offered by MV Lenses or make your own. A lens can be easily fabricated from a sheet of clear styrene or alternatively, molded from a drop of clear epoxy that is allowed to flatten and harden on a non-stick surface.

Firebox Lights

The firebox lights should first be colored with a THIN coat of orange paint followed with a few streaks of red and yellow. Testors makes a variety of transparent candy enamels for automobile modelers that work well for this purpose. Alternatively, you can use red or orange LEDs in which case painting is unnecessary.

The firebox light should be mounted between the locomotive frame rails in the general vicinity of the ash pan. The idea is that the bulb is never directly visible but rather casts a gentle glow onto the ground below. The bulb may be held in place with tape or silicone RTV.

If you are using the Intelligent Firebox Flicker effect, you may wish to modify the locomotive's firebox door so it is slightly open and then mount the bulb directly behind it. In this manner, when Fireman Fred puts a few scoops of coal into the fire, the cab will fill with a soft orange glow.

Step 7. Install the Exhaust Cam (Optional)

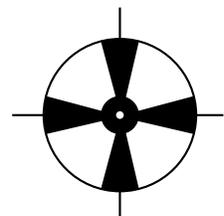
If you are intending to synchronize the steam exhaust chuff using a mechanical cam switch, you have a little more work to do! Otherwise, if you are planning to use the DSD's Auto-Exhaust feature, you may skip this step.

Throttle Up! offers its P.N. 810038 Exhaust Cam Kit as an easy to install alternative to traditional axle mounted sound cams. The Exhaust Cam set provides nine different synchronizer disks of varying diameters and configurations. Installation is straightforward and unlike the traditional sound cam, has the advantage that the drive wheel does not need to be removed from the axle.

Begin by selecting the synchronizer disk pattern appropriate for your engine:

2-Cylinder Steam Locomotives

In all conventional 2-cylinder steam engines, use a synchronizer disk with 4 foil segments. You can achieve the proper prototypical exhaust chuff timing by aligning the foil strips of the synchronizing disks to the crank pin on the driver wheel.



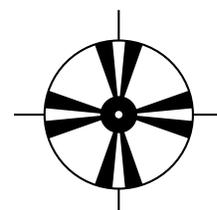
Articulated Steam Locomotives

Articulated engines come in two flavors, simple and compound. On simple articulated engines, the cylinders on the front and rear are the same size. On compound engines, one set of cylinders is considerably larger than the second set.

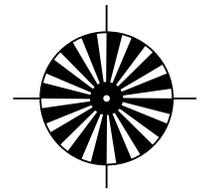
For compound articulated engines, 4 chuffs per driver revolution is correct. Install the same as for regular locomotives.

For simple articulated engines, a synchronizer disk is available that provides 8 chuffs per driver revolution.

Geared Locomotives



Geared engines require a larger number of chuffs due to multiple cylinders and gearing of the drive wheels. Due to the large number of contacts required for each wheel revolution, it is usually impractical to achieve the prototypically correct number of exhaust chuffs per revolution. The Shay disk (supplied with the Exhaust Cam set) will provide a reasonable compromise. Optionally, you may elect to use the Auto-Exhaust feature.



Install the Synchronizer Disk

Carefully measure the diameter of your locomotive's driver axle. Drill a hole of the same diameter in the center of the synchronizer disk you plan to use. *Note: the thin disk material will be easier to drill if you temporarily adhere it to a smooth wood block with a water soluble glue. The disk can be separated from the block by soaking in water after the drilling operation is complete.* Be sure to use a sharp drill to get a clean burr-free hole.

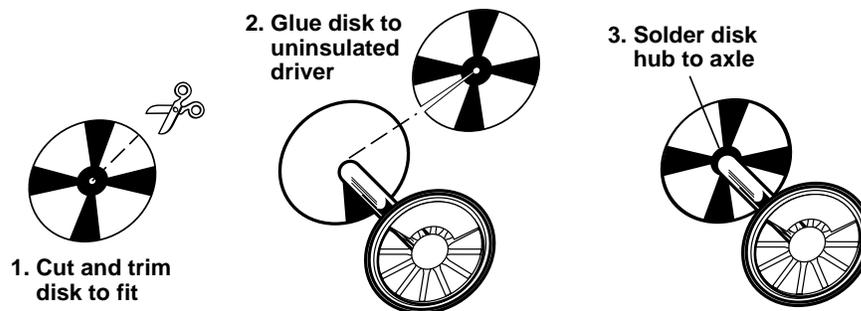
Once the hole is drilled, check that there is still enough foil at the 'hub' to connect all the spokes together. If not, you will need to use a synchronizer disk with a large hub.

Cut the disk out with a sharp pair of scissors, and trim the disk diameter to slightly less than the locomotive drive wheel diameter. This is important as clearance will be needed to clear turnout frogs, guard rails, and other trackwork features.

Using the scissors, make a single radial cut in the disk between the foil spokes from the outer edge to the center hole. Slip the disk over the drive axle with the insulated side facing against the drive wheel. Check for a correct fit and make any needed adjustments. The disk should fit flush against the drive wheel and there should be a close fit against the axle. Once you are satisfied with the fit, glue the disk against the *non-insulated* drive wheel with epoxy or contact cement.

You will need to electrically connect the synchronizer disk to the drive wheel axle. This is best done by soldering the axle to the foil hub. Alternatively, you may use conductive paint to make the connection.

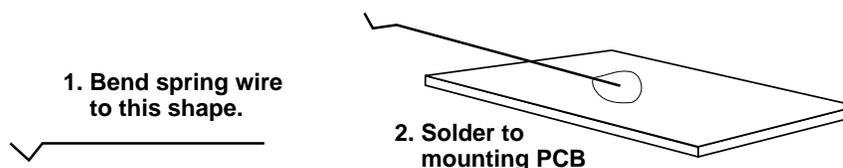
Figure 6 - Synchronizer Disk Installation



Install the Cam Wiper

Using the spring wire supplied with the Exhaust Cam set, fabricate a contact wiper. Bend the wire to match the pattern of Figure 7 using a pair of needle nose pliers.

Figure 7 - Cam Wiper Fabrication

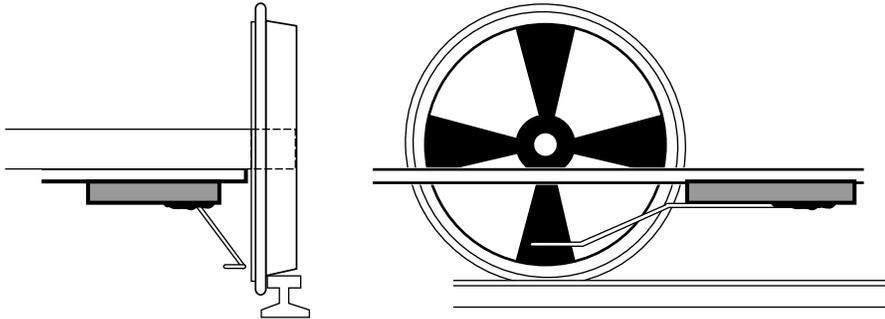


Solder the wiper to the small printed circuit board base as shown in Figure 7. Keep the spring wire as long as possible

to provide flexibility. If the wire is too short, it will rub against the synchronizer disk with excess force causing premature wear and possible binding.

Temporarily mount the insulated side of the wiper base to the locomotive frame such that the wiper end barely rubs against the synchronizer disk and does not touch any other part of the locomotive. Referring to Figure 8, adjust the spring wire so that the contact point is centered directly below the axle and its plane is parallel with the top of the rail. Once the wiper has been properly adjusted, move the wiper base until the spring wire is deflected by about 1/32" to 1/16" and secure the base in place with epoxy.

Figure 8 - Contact Wiper Alignment



Step 8. Install and Wire the Decoder

Begin by securing the decoder in place using double sided foam tape. Temporarily refit the body shell to ensure that adequate clearance still exists.

When wiring the decoder, trim all wires to reduce unnecessary lead length. This will not only give your installation a neater appearance but also prevent wires from interfering with the drive mechanism and getting pinched between the frame and body shell.

To ensure long-term reliability, solder all connections and insulate with heat shrinkable tubing. Throttle Up! has heat shrink tubing available for this purpose, Item no. 810036.

A separate connector should be used for the cam switch (if used) and wired to a P.N. 810058, single-pin connector.

It is also recommended that the female end of all connectors be wired to the decoder side of the harness. If the connector becomes unplugged, it is less likely for the female end to inadvertently come in contact with a potentially harmful electrical signal.

Motor and Power Connections

The DSD wires uses two wire harnesses color-coded per the NMRA Standard:

POWER, MOTOR AND LIGHTS (9-Pin Connector Pin-outs)

1	GREEN	F1 Power Sink
2	RED	Right Hand Rail Power Pickup
3	ORANGE	Motor (+) Terminal
4	BLUE	Function Common (+Raw)
5	WHITE	Headlight Power Sink
6	YELLOW	Backup Light Power Sink
7	GREY	Motor (-) Terminal
8	BLACK	Left Hand Rail Power Pickup
9	BROWN	F5 Power Sink

SPEAKER AND CAM (3-Pin Connector Pin-outs)

10	PURPLE	Speaker (-)
11	BROWN	Cam Input
12	PURPLE	Speaker (+)

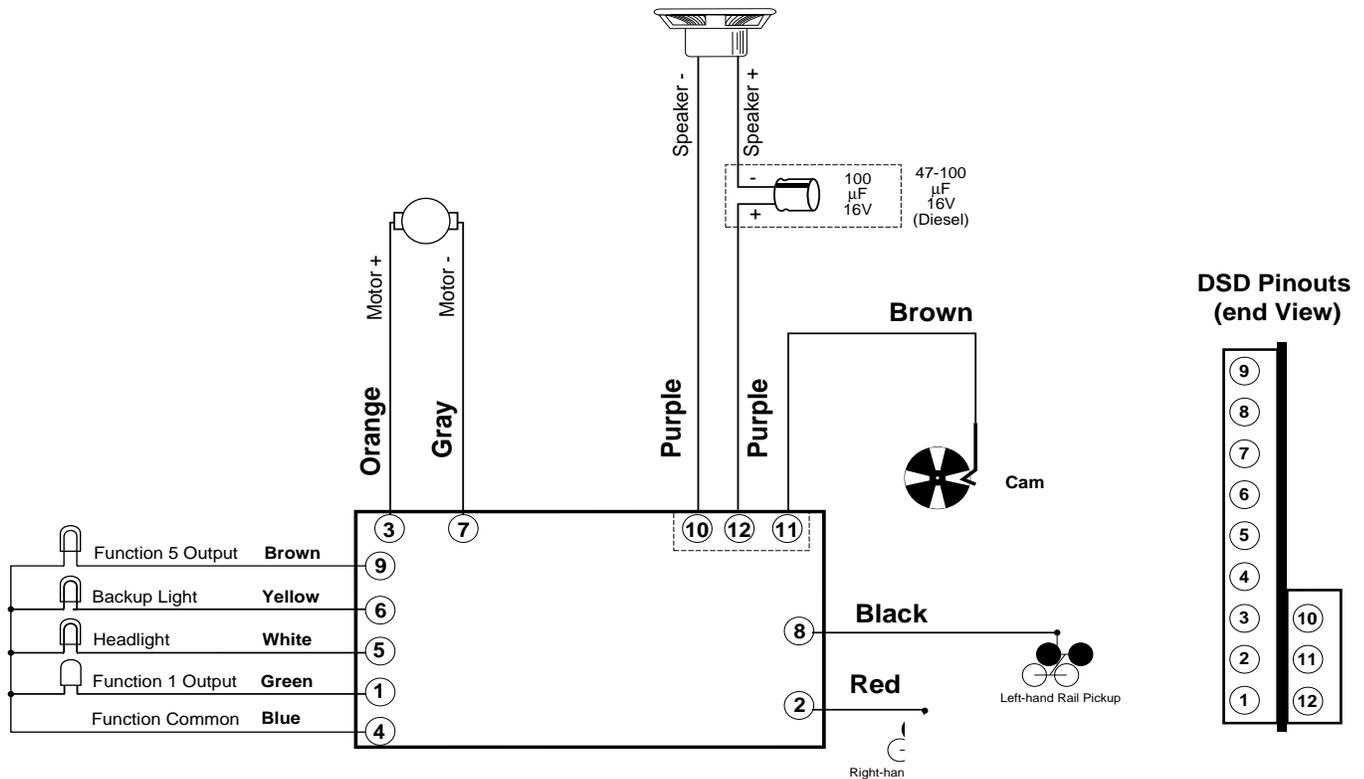


Figure 9 - Master Wiring Diagram

Referring to the master wiring diagram (Figure 9), begin with the power connection.

1. Connect the decoder's RED wire to the right hand rail power pickup (typically the locomotive frame).
2. Connect the decoder's BLACK wire to the left hand rail power pickup (typically the tender pickup)
3. Connect the decoder's orange wire to the motor's (+) brush terminal.
4. Connect the decoder's gray wire to the motor's (-) brush terminal.

BE ABSOLUTELY SURE THAT THE CONNECTIONS TO THE MOTOR ARE ISOLATED FROM EVERYTHING OTHER THAN THE DECODER CONNECTIONS DESCRIBED ABOVE, AND MAKE SURE THERE ARE NO SHORT CIRCUITS.

Speaker Connections

5. Connect the decoder's PURPLE wires to the plus and minus terminals on the speaker. If you have installed multiple speakers, make sure they are phased properly, i.e., positive lead to positive lead and minus lead to minus lead of each speaker.

A 100µf, 16V capacitor must be wired in series with the speaker (+) wire (pin 12) for steam DSDs. Use either a 47uF or 100uF, 16V capacitor for the diesel DSDs. The positive (+) lead of the capacitor should connect to the DSD wire. The negative (-) capacitor lead should connect to the speaker as shown in Figure 9.

Lighting Outputs

Each DSD is equipped with four function outputs that are intended to drive headlight, backup light and special effect lights. Each output is rated for 100mA.

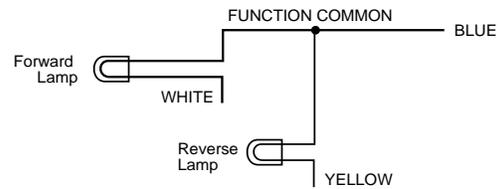
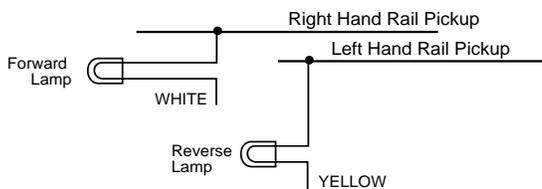
Do not exceed this rating! Be sure that the combined current of all lights as well as the motor stall current measured in Step 1 does not exceed the decoder rating.

The lamps may be wired for one of two modes of operation: full-wave and half-wave. Full-wave operation is the preferred wiring method and supplies power to each lamp via the common BLUE wire. The advantage of the full-wave wiring scheme is that the lamp brightness will be unaffected when the layout is operating another locomotive in analog mode.

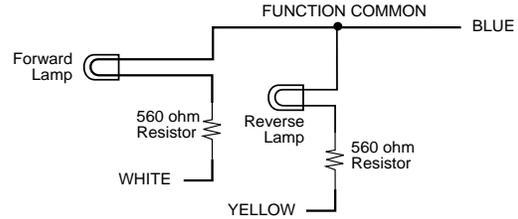
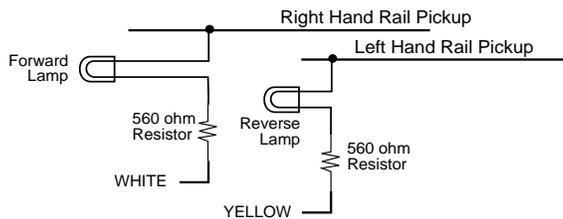
HALF-WAVE LAMP WIRING METHOD

FULL-WAVE LAMP WIRING METHOD

12-16V Lamps



1.5V Microbulbs



LEDs

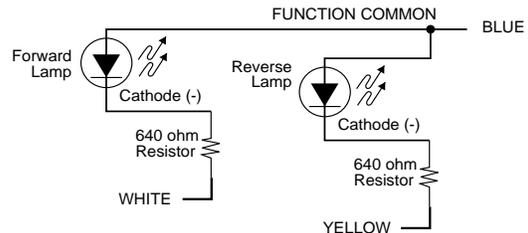
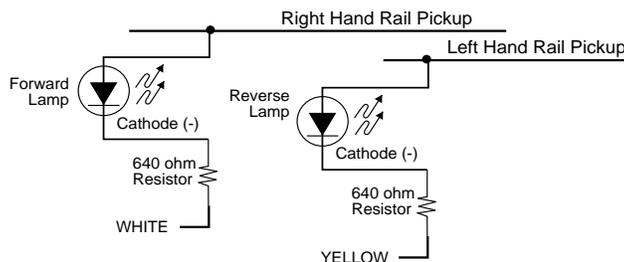


Figure 10 - Lamp Wiring Diagram

The half-wave wiring method has the advantage that the BLUE common wire is not used meaning there is one less wire connection to the decoder which may be an issue when installing the DSD into smaller locomotives. The primary drawback is that lamp brightness will change when operating another locomotive in the analog mode.

The DSD lighting outputs may be used with 12-16 volt incandescent lamps, 1.5 volt microbulbs or LEDs. If you are using the DSD to drive 12-16V lamps, each bulb can be directly wired to the function outputs as shown in Figure 10. If the lamps draw more than 50mA, wire a 22 ohm, 1/4W resistor in series with each lamp to prevent the lamp start-

up currents from overloading the decoder outputs.

If you are using the DSD to drive 1.5V microbulbs, it will be necessary to wire a small current-limiting resistor in series with each of the lamps to prevent them from burning out. A 560 ohm, 1/4W resistor is recommended for use with Throttle Up! P.N. 810022 or 810024 microbulbs, however, you may need to adjust this value to get the desired brightness depending on the output voltage of the command station. Lower resistances will increase the brightness of the lamp.

The DSD may also be used with LEDs, which also require a resistor, typically about 680 ohms, 1/4W. Note that LEDs are sensitive to polarity. The minus (cathode) end of the LED is connected to function output and the plus (anode) end is wired to the decoder's BLUE or common wire.

 *Note: LEDs are not recommended for use with the Mars Hyperlight effect.*

1. To wire the Headlight, connect one end of the bulb (or cathode of an LED) to the decoder's WHITE wire. Wire the other bulb lead to the decoder's BLUE wire for full-wave operation. For half-wave operation, the other bulb lead may be connected to either the left or right hand rail power pickup as convenient.
2. To wire the Backup light, connect one end of the bulb (or cathode of an LED) to the decoder's YELLOW wire. Wire the other bulb lead to the decoder's BLUE wire for full-wave operation. For half-wave operation, the other bulb lead may be connected to either the left or right hand rail power pickup as convenient.
3. To wire the Function 1 output, connect one end of the bulb (or cathode of an LED) to the decoder's GREEN wire. Wire the other bulb lead to the decoder's BLUE wire for full wave-operation. For half-wave operation, the other bulb lead may be connected to either the left or right hand rail power pickup as convenient.
4. To wire the Function 5 output, connect one end of the bulb (or cathode of an LED) to the decoder's BROWN wire. Wire the other bulb lead to the decoder's BLUE wire for full wave-operation. For half-wave operation, the other bulb lead may be connected to either the left or right hand rail power pickup as convenient.

Any outputs not used can be left disconnected, but you should cut off and insulate the ends of the wires so they do not come in contact with locomotive or locomotive wiring.

Cam Connections

1. Connect the decoder's BROWN wire from the 3-pin Speaker/Cam Connector (pin 11) to the cam wiper switch.

This completes your wiring! Double check all your wiring and verify that all joints are insulated and there are no short circuits. Be sure that BOTH motor brush connections are completely isolated from all connections other than to the decoder's Orange and Gray wires.

Reassemble the locomotive. Be sure that no wires are pinched between the assemblies and that there is no interference with moving parts that could causing chafing and short circuits in the future.

Step 9. Test the Installation

Now you are ready for the test track! We recommend your test track be fused with a fast-blo fuse appropriately rated for your decoder (i.e. 1 amp decoder, 1 amp fuse). Place the locomotive on the track, and turn on power to the system. Set your controller so commands are sent to locomotive address 03.

You should hear the firebox blower and the airpumps running and be able to run the engine in both directions as well as turn the lights on and off with the function keys. If the locomotive does not travel in the appropriate direction, you have reversed the polarity of the motor brush connection. Turn the power off, switch the ORANGE and GRAY motor leads and try again. If everything seems OK at this point, it is time to program the decoder's Configuration Variables to get the desired sound and lighting effects.

Step 10. Programming the CVs

The final installation step (At last!) is programming the DSD's Configuration Variables or CVs.

What is a CV?

CV stands for Configuration Variable which is the industry adopted term for a decoder's user-programmable memory locations. CVs allow you to customize individual decoder properties such as the address, momentum, throttle response, sound volume and much, more. Once a CV has been programmed, it will be permanently remembered even after the power has been turned off. A CV can be modified as often as necessary by simply reprogramming it with a new value.

The NMRA has defined over 70 standard CVs and their usage in RP-9.2.2. Most of these CVs have been uniformly implemented by the various DCC component manufacturers including SoundTraxx resulting in a high degree of interoperability, particularly with products designed after July, 1995 when the standards and recommendations were formally agreed upon. For example, the decoder's primary address is always stored in CV 1. Be aware that there are also a number of CVs which have been designated as "Reserved for Manufacturer Use" allowing the manufacturer to add a feature that is unique to their products. The SoundTraxx DSD has several such CVs used primarily for customizing the sound and lighting effects.

With the large number of CVs available, first inspection of the available options may cause confusion and perhaps even a brain-cramp! Take an aspirin and relax.

 ***The DSD has been shipped with all CVs pre-programmed so you can begin using your locomotive immediately without having to worry about what adjustments to make.***

Table A summarizes the DSD's default operating characteristics as shipped. Simply set your controller to address 03 and away you go! Be sure to also set your controller for 28 speed step mode or the headlights may not operate as expected.

Table A.
SoundTraxx DSD Default Operating Characteristics

Address = 03
Vstart = 7
Acceleration = 0
Braking = 0
Consist Addressing = Off
Speed Steps = 28
Speed Tables = Not used
Lighting Control = Automatic Direction Control
F1 Effect = On/Off
F5 Effect = On/Off

Audio Volume = 50%
Background Sounds = All on.
Exhaust Synchronization Source = Exhaust Cam

Function Mapping:

FL = headlight (forward) and Backup (reverse) Light On/Off
F1 = F1 Function Output
F2 = Whistle
F3 = Bell
F4 = Hiss
F5 = F5 Function Output
F6 = Dynamo Sound On/Off
F7 = Coupler Sound Trigger
F8 = Audio Mute

After awhile, you will probably want to make some changes such as selecting a new address or changing a sound effect. The following paragraphs break the DSD's CVs into various subsystems so it is only necessary to change a few CV's at a time. As you become comfortable with the DSD's operation, move onto a new section and begin exploring the options and capabilities found there. Detailed information on any CV can be found in the **DSD Technical Reference** located in Part II of this manual.

Bits and Bytes

One of the most confusing aspects of programming a CV is figuring out what the all the different bits, bytes and x's found on the various decoder manuals (including this one) mean. The problem is compounded further by differences in each command station manufacturer's user interface. For those users unfamiliar with such terms, a short math lesson (ugh!) is in order before proceeding:

Each decoder CV stores a numeric value that can be represented in one of three forms:

Decimal - This is the form we are all familiar with and use in our day-to-day lives. Numbers are represented as a sequence of digits composed of the numerals 0,1,2,3,4,5,6,7,8, and 9.

Hexadecimal - Also referred to as simply "hex", this is a more specialized number representation that, in addition to 0 through 9, also uses the characters A-F. It has the advantage that a given decimal number can be more compactly represented. For example, the decimal number 127 is simply 7F in hex (one less digit). This allows user interfaces with a limited number of digits to display a wider range of numbers.

Binary - Binary numbers get their name from the fact they use only two digits 0 and 1 called '*bits*' and is the fundamental number system used by all computers including the ones found inside a digital decoder. Because there are only two bit values, it takes more digits to represent a number using binary. The decimal number 127, for example, is written as 01111111 in binary notation. A '*byte*' is a binary number made up of eight bits. And a '*nibble*' is half a byte or four bits. Really! We didn't make that up.

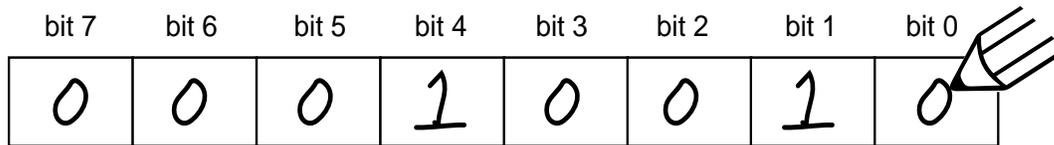
Coincidentally, each CV is made up from one byte or eight bits and can store any number between 0 and 255. Most of the CVs contain a single piece of data that can be easily represented in any of the three forms. i.e., CV 3, the acceleration rate, can be loaded with any value from 0 to 255 and it always affects the same thing - the acceleration rate.

On the other hand, some CVs use individual bits to represent different variables. This allows a CV to hold up to eight individual variables within a single byte and is done in order to conserve the numbers of CVs. As the bit variables can take on only one of two values 0 and 1 they are usually used for simple variables that are either On or Off, enabled or disabled or something similar. Unfortunately, bit variables are difficult to represent in any form other than binary and still preserve any meaning. Because most DCC system user interfaces don't use binary representation, these numbers are the most difficult to work with and require a tedious series of additions to convert to the decimal or hex form used by most systems.

Whenever possible, we have tried to use the decimal number system in this manual when describing the proper values to program into a given CV. For users of those systems that use hexadecimal numbers, we have shown the hex equivalent in parenthesis. Throughout this manual, a hex number can be distinguished from a decimal number by noting a **0x** prefix. Thus 0x10 is the hex version of sixteen and not ten as one might guess. Binary numbers are represented using a '**b**' suffix. 100b is thus the number four and not one hundred.

To further assist the math-impaired user, we have provided a handy-dandy conversion table in Appendix C that allows one to quickly convert between decimal, hex and binary.

When working with bit variables such as CV 29, we suggest the following procedure for determining the correct value to program. Referring to the CV description, write down from left to right, the value of each individual bit. Consider for example, the case of CV 29. We would like to set this CV so the speed tables are enabled and the 28 speed step mode is in effect. Referring to page 21 in the **DSD Technical Reference**, we see that bit 4 and bit 1 should be set to 1 and all other bits are cleared to 0. Starting with bit 7 and working to the right, we write down the individual bit values and get:



We then look up the value Binary value 00010010b in Appendix C and see that it corresponds to the decimal value 18 (0x12 in hex). This is the value to use when programming the CV.

Programming Procedure

There are six methods for programming the DSD which fall into one of two classifications:

Service Mode Programming - These programming modes usually require the locomotive to be placed on a special programming track or connected to a dedicated programmer. There are four types of service mode instructions:

Address Mode - Can change CV 1 (Primary Address) only.

Register Mode - Can change CVs 1,2,3,4,7,8 and 29 only.

Paged Mode - Uses a page register to indirectly modify any CV.

Direct Mode - Can directly change any CV.

Operations Mode Programming - Sometimes called 'Ops Mode' or 'Programming on the Main', these programming modes allow the CVs to be changed while the locomotive is operating on the layout even when other locomotives are present. The neat thing about these modes is that the CVs can be changed in the middle of operation allowing the engineer for example, to change the increase the momentum rate of a locomotive after it couples to a train. There are two forms of this programming mode:

Operations Mode Short Form - Uses an abbreviated packet format and allows only CV 23 and 24 (consist acceleration and braking) to be modified.

Operations Mode Long Form - Allows any CV to be modified.



Note: The DSD imposes the restriction that CV 1, CV 17 and CV 18 cannot be changed in this mode to prevent accidental modification of the locomotive's address during operation.

It is important to realize that not all programming modes will program all CVs. The **DSD Technical Reference** lists the programming modes that may be used for each CV.

The specific programming mode you use will depend upon the type of DCC system you are using. Some of the newer DCC systems can automatically select the proper programming mode so all you need to do is specify the CV number and its new value. On the other hand, some systems support only a few of the programming modes and may restrict which CVs you can program. If in doubt, refer to your DCC system's manual or contact the manufacturer to determine which methods they support.

If you have trouble reading or verifying CVs, the problem may be due to the design of your command station and not the DSD itself. The DSD and all other decoders communicate back to the command station using what's called an acknowledgement pulse, which is defined in NMRA RP-9.2.3 as "an increased load on the programming track of at least 60mA for at least 50ms." Like most decoders, the DSD generates the acknowledgement pulse by momentarily applying power to the motor. You can often visually verify that the DSD is properly responding to your programmer by observing a slight twitch in the motor shaft when a read or write command is given.

If your DSD is otherwise working properly (i.e., responds properly on the mainline to speed and direction commands) but your command station is having troubles reading CV data from the DSD, it may be due to incompatibilities between the electrical requirements of the DSD (which are different from conventional decoders due to the added

audio circuitry) and the electrical characteristics of your programming track. In such an event, we suggest you simply go ahead and program the data into the CVs anyway. Usually the DSD will accept the data and function properly when it's placed back on the main track. You can also try a different programming mode. If your system supports it, the best way to program the CVs is Operations Mode, as it allows you to immediately see or hear the results of your changes.

As each DCC system is different, the specific procedure for programming a CV will vary depending upon the system. We have summarized the basic programming steps for several of the most popular systems below. For more information, as well as programming procedures for all other systems, please consult your DCC system manual.

Digitrax Chief and Big Boy

1. Place the locomotive on the programming track.
2. Press the RUN/STOP and FUNC buttons together until the PROG light glows green.
3. Turn the left throttle knob until the left hand numbers on the LCD display correspond to the CV number you wish to change.
4. Turn the right throttle knob until the right hand numbers on the LCD correspond to the value you wish to program into the CV selected in step 3.
5. Press the SEL/SET button to store the new value into the CV.
6. Repeat steps 3-5 until you are finished programming the CVs you wish to change.
7. To exit the programming mode, press the RUN/STOP and FUNC buttons together until the PROG light turns off.

 *Note: The Digitrax Chief also supports Operations Mode Programming. See your owner's manual for more information.*

Wangrow System One

1. Place the locomotive on the programming track.
2. Press the PROG MODE key several times until the display shows USE PROGRAM TRK.
3. Press the Enter key. The display will show 1=STD 2=CV 3=REG.
4. Press the 2 key. The display will show ENTER CV NUM:
5. Enter the number of the CV you wish to change and press ENTER.
6. After a moment, the display will show the current value of the CV.
7. Enter the new value for the CV and press ENTER.
8. Repeat steps 5-7 until you are finished programming the CVs you wish to change.
9. Press the PROG MODE button to exit the programming mode and return to normal operation.

 *Note: The System One also supports Operations Mode Programming. See your owner's manual for more information.*

Lenz Digital Plus, Version 2.1

1. Place the locomotive on the programming track.
2. To activate the programming mode, press F, 8, and ENTER.
3. Press the ENTER key again and the display will show CV.
4. Press the ENTER key again and the display will show SEARCH and after several seconds should show the Manufacturer ID for Throttle Up! as MF 141.
5. Press any key seven times until the display shows C_.
6. Enter the number of the CV you wish to change and press ENTER twice.
7. After a moment, the display will show the current value of the selected CV.
8. Enter the new value for the CV and press ENTER.
9. Repeat steps 6-8 until you are finished programming the CVs you wish to change.
10. Press the ESC button to exit the programming mode and return to normal operation.

 *Note: When using the Lenz Digital Plus's binary display mode, remember that it shows binary numbers with bit 0 on the left and bit 7 on the right which is opposite to normal convention and as used in this manual. Lenz does not currently support Operations Mode Programming. See your owner's manual for more information.*

Configuring the Address

The first group of CVs you will want to change are those that set the DSD's address:

- CV 1, Primary Address
- CV 17:18, Extended Address
- CV 29, Configuration Data

The DSD may be set up to recognize either the primary address which provides a range of 1 to 127 or the extended address which has a range of 1 to 9999! Whether you use the primary or extended address will first depend on whether or not your DCC system uses long addresses (not all of them do- if in doubt, see your owner's manual.) Second, it will depend on your preferences and the numbering scheme you use for setting your decoder addresses. The extended address has the advantage that you can use all four digits of a locomotive's road number for the decoder address making it easy to remember.

 *Note: The primary and extended addresses can only be set in service mode.*

Primary Address

To use the primary address, simply set CV 1 to the desired address between 1 and 127 (0x01-0x7F).

Extended Address

The extended address is actually made up of two CVs, 17 and 18. Unless you are an experienced user, you should not try to program these CVs individually as a specific protocol is required in order for the DSD to accept the new data (See the **DSD Technical Reference** for details). Since most command stations that support extended addressing will automatically generate the correct protocol, simply follow their instructions for setting the extended address. Once the extended address is stored in CV 17 and 18, bit 5 of CV 29 must be set to 1 so the decoder will recognize the extended address format. Otherwise, the decoder will continue to respond only to its primary address. See the next section, Configuring the Decoder.

Configuring the Decoder

The next CV you will want to changed is CV 29, Decoder Configuration Byte. CV 29 is one of those complicated bit variables mentioned earlier and is used to set a multitude of decoder characteristics including:

Speed Step Mode - Sets the decoder to use 14, 28 or 128 speed steps (see "Configuring the Throttle", page 22).

Speed Table - Sets the decoder to use speed tables selected by CV 25 (see "Configuring the Throttle", page 22).

Primary or Extended Address - Sets the decoder to recognize its primary address in CV 1 or extended address in CV 17:18 (see "Configuring the Address", above).

Locomotive Direction - Sets whether the decoder will invert direction commands so that the locomotive runs in reverse when it receives a command to move forward and vice-versa. This operating mode has little use for steam locomotives but is useful for setting up diesel engines that ran with the long hood section forward.

To assist the novice user, we have created Table B that lists the correct value for CV 29 to get the desired operating modes. Simply find the row that has the modes you want and program CV 29 with the listed value. The advanced user should refer to the **DSD Technical Reference** for more details.

Table B.
Quick-Reference Table for CV29 Values

CV 29 Value	Speed Steps	Use Speed Tables?	Address Type	Locomotive Direction
00 (0x00)	14	No	Primary (CV1)	Normal
16 (0x10)	14	Yes	Primary (CV1)	Normal
32 (0x20)	14	No	Extended (CV17:18)	Normal
48 (0x30)	14	Yes	Extended (CV17:18)	Normal
02 (0x02)	28,128	No	Primary (CV1)	Normal
18 (0x12)	28,128	Yes	Primary (CV1)	Normal
34 (0x22)	28,128	No	Extended (CV17:18)	Normal
50 (0x32)	28,128	Yes	Extended (CV17:18)	Normal
01 (0x01)	14	No	Primary (CV1)	Reversed
17 (0x11)	14	Yes	Primary (CV1)	Reversed
33 (0x21)	14	No	Extended (CV17:18)	Reversed
49 (0x31)	14	Yes	Extended (CV17:18)	Reversed
03 (0x03)	28,128	No	Primary (CV1)	Reversed
19 (0x13)	28,128	Yes	Primary (CV1)	Reversed
35 (0x23)	28,128	No	Extended (CV17:18)	Reversed
51 (0x33)	28,128	Yes	Extended (CV17:18)	Reversed

Configuring the Throttle

There are eight CVs that characterize the DSD's throttle response and 28 more use to create a custom speed table:

- CV 2, VStart
- CV 3, Acceleration Rate
- CV 4, Braking Rate
- CV 9, Motor PWM period
- CV 25, Speed Table Select
- CV 29, Configuration Data
- CV 66, Forward Trim
- CV 95, Reverse Trim
- CV 67-94, Loadable Speed Table

This may sound like a lot of CVs but don't worry; it's not necessary to change all of them if you don't want to.

Speed Step Mode Selection

As it is a digital system, the DSD splits the throttle voltage over its minimum and maximum range into discrete *speed steps*. The DSD can be configured so there are 14, 28 or 128 individual speed steps. The largest number of steps will give the smoothest throttle response. Beware that not all DCC systems have the ability to control 28 or 128 speed steps and your choice will depend upon the capabilities of your command station. The DSD's speed step mode is selected by CV 29. Refer to the previous section **Configuring the Decoder** or the **DSD Technical Reference** to determine the correct value for CV 29.

Set the Start Voltage

The DSD provides CV 2, Vstart, to set a starting voltage that is applied to the motor at speed step 1 and is used to compensate for inefficiencies in the locomotive's motor and driveline. CV 2 may be programmed with any value between 0 and 255 (0xFF) with each step in value being about 0.5% of the maximum available motor voltage. To

calculate the value for CV 2, you can use the formula:

$$CV\ 2 = 255 \times \frac{\text{Desired Starting Voltage}}{\text{Maximum Motor Voltage}}$$

If your DCC system supports Operations Mode Programming, an alternative method for setting Vstart is to turn your throttle to the first speed step and then use the operations mode programming feature to increase the value in CV 2 until the locomotive just begins to move.

Set the Acceleration and Braking Rates

The DSD provides two CVs to simulate the momentum due to train weight. CV 3, Acceleration Rate, controls how fast the locomotive responds to increases in throttle settings and CV 4, Braking Rate, controls how fast the locomotive will respond to decreases in the throttle setting.

Both CVs can be programmed with any value between 0 and 255 (0xFF) with 255 corresponding to the *slowest* acceleration or braking rate. Lower settings yield a more responsive locomotive which is useful for switching. When both CVs are set to 0, the locomotive will respond nearly instantly to any throttle changes. A setting of 255, on the other hand, will require *3.8 minutes* for a locomotive to reach full speed from a standing stop!

The DSD's Dynamic Digital Exhaust feature (see page 28) will be more dramatic with larger CV values and we suggest setting CV 3 and CV 4 to a minimum value of 16 (0x10) or higher.

If you are using 14 or 28 Speed Step mode, setting CV 3 and CV 4 to any value greater than 0 will also improve the DSD's throttle response. While it is accelerating or braking, the DSD interpolates between speed steps so in effect, your locomotive will respond as if it were being controlled with 128 speed steps. No more sudden lurching from one speed step to another!

Select the Speed Table

The DSD provides 14 preset and one loadable speed tables which can be used for several purposes:

1. Matching the Auto Exhaust chuffing rate to locomotive speed.
2. Speed matching one locomotive to another.
3. Changing the feel of the throttle. For example, you could configure a switching locomotive so there are more speed steps available at lower speeds for switching and fewer steps at high speeds where the locomotive is seldom operated.
4. Compensating for an improperly designed driveline so the locomotive will operate within its prototypical speed range.

CV 25, Speed Table Select, is used to select which speed curve will be used by the DSD. CV 25 may be programmed with any value between 2 and 15 (0x02-0x0F) to select one of the preset speed curves shown in Table C, page 24. The exact throttle response for each curve is shown graphically in the **DSD Technical Reference** under CV 25.

To select the user loadable speed table, set CV 25 to 16 (0x10).

In order for the speed table selection in CV 25 to take effect, CV 29 must also be programmed so the DSD knows to use speed tables. Refer to the previous section "Configuring the Decoder" or the **DSD Technical Reference** to determine the correct value for CV 29.

Table C.
Speed Table Selection

CV 25	Speed Curve Type
2 (0x02)	Straight Line
3 (0x03)	Logarithmic Curve 1
4 (0x04)	Logarithmic Curve 2
5 (0x05)	Logarithmic Curve 3
6 (0x06)	Logarithmic Curve 4
7 (0x07)	Logarithmic Curve 5
8 (0x08)	Logarithmic Curve 6
9 (0x09)	Logarithmic Curve 7
10 (0x0A)	Exponential Curve 1
11 (0x0B)	Exponential Curve 2
12 (0x0C)	Exponential Curve 3
13 (0x0D)	Exponential Curve 4
14 (0x0E)	Exponential Curve 5
15 (0x0F)	Exponential Curve 6
16 (0x10)	User Loadable Speed Table

Set the User Loadable Speed Curve

If you set CV 25 to select the User Loadable Speed Table, you will also need to design and program the Loadable Speed Table. The Loadable Speed Table consists of 28 data points contained in CVs 67 through 94, each defining the *percentage* of motor voltage applied at a give speed step. Each data point can contain a value of 0 to 255 (0xFF) corresponding to 0 to 100% of available motor voltage.

In 28 speed step mode, each data point directly corresponds to a speed step. In 128 speed step mode, each data point corresponds to every four and a half speed steps. The motor voltage for intermediate steps are interpolated by the DSD to produce a smooth curve. In 14 speed step mode, alternate (odd numbered) data points correspond to speed steps 1-14. Important: all 28 data points must be programmed *even for 14 speed step mode* or an unpredictable throttle response may occur while accelerating or braking.

To create a speed curve, begin by assuming the DSD will be operated in 28 speed step mode. Don't worry if you are using another mode - the DSD will automatically take care of the translation between modes.

1. Start by making a table containing 28 entries - one entry for each speed step.
2. For each entry, record the desired throttle response as a percentage of full speed. i.e., 0 to 100%
3. Compute and record the CV value for each step using the following formula:

$$\text{CV Value} = 255 \times \frac{\text{Percentage of Full Speed (from Step 2)}}{100}$$

4. Program CV 67 with the value computed in step 3 for the first data entry (Speed Step 1)
5. Program CV 68 with the value computed in step 3 for the second data entry (Speed Step 2)
6. Repeat step 5 for each of the remaining 26 CVs from CV 69 to CV 94 until they have been programmed with their respective values.

Table D may be followed as an example and lists the default CV values already programmed into the DSD.

Table D.
Calculating the User Loadable Speed Table

CV #	Speed Step	% Full Speed	CV Value
CV 67	1	0	0 (0x00)
CV 68	2	4	9 (0x09)
CV 69	3	7	18 (0x12)
CV 70	4	11	28 (0x1C)
CV 71	5	15	37 (0x25)
CV 72	6	18	47 (0x2F)
CV 73	7	22	56 (0x38)
CV 74	8	26	66 (0x42)
CV 75	9	30	75 (0x4B)
CV 76	10	33	85 (0x55)
CV 77	11	37	94 (0x5E)
CV 78	12	40	103 (0x67)
CV 79	13	44	113 (0x71)
CV 80	14	48	122 (0x7A)
CV 81	15	51	132 (0x84)
CV 82	16	55	141 (0x8D)
CV 83	17	59	151 (0x97)
CV 84	18	62	160 (0xA0)
CV 85	19	67	170 (0xAA)
CV 86	20	70	179 (0xB3)
CV 87	21	74	188 (0xBC)
CV 88	22	77	198 (0xC6)
CV 89	23	81	207 (0xCF)
CV 90	24	85	217 (0xD9)
CV 91	25	87	226 (0xE2)
CV 92	26	92	236 (0xEC)
CV 93	27	96	245 (0xF5)
CV 94	28	100	255 (0xFF)

Adjust the Forward and Reverse Trim

The DSD provides two CVs for adjusting or 'trimming' the forward and reverse speeds.

CV 66, Forward Trim

CV 95, Reverse Trim

These CVs multiply all data points in the speed tables by a factor of $n/128$ (n is the CV value) allowing the overall speed curve to be adjusted up or down without reloading all 28 data points again.

These CVs may contain any value between 0 and 255 (0xFF). Trim values between 129 (0x81) and 255 (0xFF) will increase speed curve values between 100% and 200% in 1% steps. Trim values between 1 and 127 (0x7F) will decrease speed curve values between 1% and 99%. A value of 128 (0x80) yields a scaling factor of 1.0 and has no effect on the speed curve.

Using different values for the forward and reverse trim will yield different forward and reverse speeds.

Adjust the Motor Drive Frequency

Virtually all DCC decoders, including the DSD, drive the locomotive motor using a technique called Pulse-Width-Modulation or PWM. PWM works by alternately switching the motor from full off to full on. If the motor is switched fast enough, the speed can be controlled by varying the ratio between the time the motor is on and the time the motor is off. One drawback to PWM is that it can cause the locomotive to buzz, sometimes quite loudly, at low speeds.

To mitigate some of this noise, the DSD provides CV 9, Motor PWM Period to control the frequency at which the motor is switched on and off. By adjusting this CV, one can usually find a drive frequency that is quieter than others. CV 9 can be programmed with any value between 0 and 230 (0xE6). The DSD Technical Reference (see CV 9) provides suggestions for selecting a proper value. A value between 170 and 190 works well for most locomotives.

Configuring the Lights and Function Outputs

The DSD has four function outputs used for controlling the locomotive lights. Two of these functions, headlight and backup light, are always used as on-off outputs.

Setting the Hyperlight Effects

The other two functions, F1 and F5 can be also setup for several special Hyperlight lighting effects using CV 49 as described under **Installation, Step 2**.

The table below lists the modes for each output and required CV setting:

Table E.
Setting the Hyperlight Effects

CV 49	F5 Output Type	F1 Output Type
0 (0x00)	On-off	On-off
1 (0x01)	On-off	Mars Light
2 (0x02)	On-off	Firebox Flicker
3 (0x03)	On-off	Sync. Firebox
4 (0x04)	Mars light	On-off
5 (0x05)	Mars Light	Mars Light
6 (0x06)	Mars Light	Firebox Flicker
7 (0x07)	Mars Light	Sync. Firebox
8 (0x08)	Firebox Flicker	On-off
9 (0x09)	Firebox Flicker	Mars Light
10 (0x0A)	Firebox Flicker	Firebox Flicker
11 (0x0B)	Firebox Flicker	Sync. Firebox
12 (0x0C)	Sync. Firebox	On-off
13 (0x0D)	Sync. Firebox	Mars Light
14 (0x0E)	Sync. Firebox	Firebox Flicker
15 (0x0F)	Sync. Firebox	Sync. Firebox

Configure Lighting Control

The DSD supports two modes of headlight operation:

Automatic Direction Control

Both the headlight and backup lights are turned on and off using the FL function. The DSD automatically switches the proper light on depending upon locomotive direction.

“Rule 17” Headlight Operation

This is the more prototypical form of operation and requires the engineer to manually switch each lights on or off individually. Thus, it is possible for both lights to be on at the same time.

The DSD uses Function Mapping (see **Remapping the Functions**, below) to determine which mode is used. For automatic direction control, the headlight is mapped to FL(fwd) by setting CV 33 to 1 (0x01), and the backup light is mapped to FL(rev) setting CV 34 to 2 (0x02).

For Rule 17 Operation the headlight is mapped to both FL(fwd and FL(rev) by setting both CV 33 and 34 to 1 (0x01). The backup light is remapped to a different function by setting the corresponding function map CV to 2 (0x02). For this example, let's use F1. If CV 35 is programmed to 2, your controller's FL key would now control the headlight (in both directions) and the F1 key controls the backup light.

Configuring the Sound Effects

The DSD provides five CVs for customizing the sound effects:

- CV 50, Volume Control
- CV 51, Background Sound Configuration
- CV 52, Foreground Sound Configuration
- CV 54, Auto Exhaust Rate
- CV 55, Exhaust Tone
- CV 56, Exhaust Volume

Setting the Volume

CV 50 may be programmed with any value between 0 and 15 (0x0F) to control the overall volume of the locomotive's sound. A setting of 0 will turn the sound off and a setting of 15 will provide maximum volume.

Setting the Exhaust

CV 54 is used to set the automatic synchronization rate or cutoff rate if cam synchronization is used.

For Auto-Exhaust synchronization, the chuff rate will be generated in proportion to the throttle setting. To select Auto-Exhaust mode, CV 54 is loaded with any value between 0 and 255 (0xFF). Higher values will yield higher chuff rates for a given throttle setting. The correct synchronization rate may be computed as:

$$\text{CV Value} = 115.9 \times \frac{\text{SPD}}{\text{DIA}} \times \text{Gear Ratio}$$

Where SPD is the locomotive's top speed in scale miles-per-hour at full throttle and DIA is the locomotive's driver wheel diameter in scale inches, and Gear Ratio is the gear ratio for shays and other geared engines. For conventional steam engines, use gear ratio =1. The driver diameter can be easily measured with a scale ruler but remember to convert the measurement to scale inches.

If you don't know your locomotive's top speed, you can figure it out by using a stop watch to measure the time (in seconds) it takes for the engine to travel over a 1/4 scale mile of track and using the formula:

$$\text{MPH} = \frac{900}{\text{Time}}$$

- Note: A 1/4 mile in N = 8' 3"
A 1/4 mile in HO = 15' 2"
A 1/4 mile in O = 27' 5"

For HO, a 1/4 mile is 15 feet, 2". If an engine take 20 seconds to traverse this distance, its speed is 45 MPH. You can also estimate your locomotive's top speed and still get pretty good results. A good rule of thumb is to use 45 MPH for freight locomotives and 70 MPH for passenger engines.

If you are using the exhaust cam, use the same formula as above for setting the cutoff rate.

CV 55 is used to set the exhaust tone and may be programmed with any value between 0 and 63 (0x3F). Higher values will produce a steamier exhaust chuff.

CV 56 is used to adjust exhaust volume when the DDE processor is disabled and may be programmed to any value between 0 and 255 (0xFF). Higher values will produce a louder exhaust.

Setting the Background Sound Effects

CV 51 is used to select which background sound effects are active as some may not be suitable for your particular model (an oil burner for example will not have a fireman shoveling coal).

CV 51 can be programmed with any value between 0 and 255 (0xFF). However, each bit in CV 51 controls a different effect and there are over 255 combinations! You will need to use the technique described under **Bits and Bytes** and refer to the **DSD Technical Reference** to determine the proper value for CV 51. Alternatively, you can calculate the value for CV 51 with a series of additions as follows:

1. Start with CV 51 set to 0.
2. The intervals at which the background sounds occur are spaced randomly by a 'clock' inside the DSD. This clock can work in scale time so that sounds occur every few minutes or in real time so sounds occur every few hours! To select real time intervals, add one to the value in CV 51. Otherwise, skip to step 3.
3. One of the DSD background sound effect is the sound of Airpumps building up pressure in the train line. If you want to enable this sound, add 2 to the value in CV 51. Otherwise, skip to step 4.
4. A second DSD background sound effect is the sound of Fireman Fred building up a good draft in the firebox with the blower. If you want to enable this sound, add 4 to the value in CV 51. Otherwise, skip to step 5.
5. Another DSD background sound effect is the sound of Fireman Fred scooping coal into the firebox. He'll do this whenever the loco is brought to a stop and again at random intervals. If you want to enable this sound, add 8 to the value in CV 51. Otherwise, skip to step 6.
6. Another DSD background sound effect is the sound of Fireman Fred lubricating the side rods with his pneumatic grease gun from time to time. If you want to enable this sound, add 16 to the value in CV 51. Otherwise, skip to step 7.
7. Another DSD background sound effect is the boiler pop-valve blow off. This is a loud effect that runs for about 10 seconds at random intervals. If you want to enable the pop valve sound, add 32 to the value in CV 51. Otherwise, skip to step 8.
8. The DSD's Cylinder Blow Down effect can be operated as function key or automatically whenever the locomotive comes to a stop. This frees up a function key to use for something else. If you want to use the Automatic feature, add 64 to the value in CV 51. If you want to use the function key instead, skip to step 9.
9. The DSD background sounds selected in steps 2-8 will run whenever the locomotive is stopped. You can also silence them without changing individual settings for when the engine is the roundhouse for example. If you want the background sounds on, add 128 to value in CV 51 otherwise skip to step 10.
10. Program CV 51 with the new value calculated in steps 2-9.

Setting the Foreground Sound Effects

CV 52 is used to modify certain foreground sound effects. CV 52 can be programmed with any value between 0 and 255 (0xFF). However, each bit in CV 52 controls a different effect as with the Background Sound Effects, there are over 255 combinations! You will need to use the technique described under **Bits and Bytes**, page 18, and refer to the **DSD Technical Reference** to determine the proper value for CV 52. Alternatively, you can calculate the value for CV 52 with a series of additions as follows:

1. Start with CV 52 set to 0.
2. If you are using the Auto-Exhaust feature with a simple articulated locomotive (both sets of cylinders the same size) add one to the value in CV 52. This will produce a slightly uneven exhaust cadence effect. For all other types of engines, skip to step 3.
3. The DSD features a Dynamic Digital Exhaust (DDE) processor that modifies the exhaust sound as the engine load changes. To activate the DDE processor, add 2 to the value in CV 52. Otherwise, skip to step 4.
4. If you are using the exhaust cam to trigger the exhaust chuffs, add 4 to the value in CV 52. Otherwise, skip to step 5.
5. If your locomotive has dual airpumps, add 8 to the value in CV 52 to activate the sound of another pump. If the engine has only one airpump, skip to step 6.
6. You can also adjust how fast the bell rings over seven steps by adding 0, 16, 32, 48, 64, 80, 96, or 112 to the value in CV 52. Do not add any other number as this may affect the settings made in steps 2-4! 0 will produce the fastest ring rate and 112 will produce the slowest ring rate.
7. Program CV 52 with the new value calculated in steps 2-6.

Configuring for Consist Operation

The DSD supports consist operations and has three related CVs:

- CV 19, Consist Address
- CV 21, Consist Function Active
- CV 22, Consist FL Function Active

The consist CVs allow the DSD to recognize a new address assigned to the consist without changing the primary or extended addresses. Additionally, they allow each locomotive in the consist to be run as a single unit but with different function properties.

These CVs are useful when building up a triple header for example. Each locomotive in the triple header is assigned the same consist address by programming CV 19 with the consist address between 0 and 127 (0x7F). If a locomotive is facing backwards in the consist (unlikely for steam operations but we mention it anyway), it should be programmed with the same consist address plus 128 (0x80). If the forward locomotives are set to address 60 for example, the backwards engine must be set to $60+128 = 188$. Failure to do this will turn the consist into an angry pushme-pullyou as all locomotives will try to move forward from the perspective of their own cab and a few pulled couplers might result!

With three engines in the consist, you'll probably want the headlight function to activate only the lead engine's light. And you'll only want the backup light on the trailing engine to work. But you probably want the firebox flicker on for all three engines. CV 21 and 22 allow you to define how each engine responds to function commands sent to the consist address. CV 21 controls which of functions 1-8 are active when the consist address is enabled and CV 21 controls the FL function for forward and reverse. As each bit in both CVs enable a different function, you'll need to refer to the section on **Bits and Bytes**, page 18, and the **DSD Technical Reference** to determine the proper value for each CV.

Note that when the consist address is set, the locomotive will continue to respond to instructions sent to its primary or extended address except for speed and direction data.

To deactivate the consist address and restore normal operation, CV 19 must be reprogrammed to 0.

Remapping the Functions

Function Mapping Explained

Function mapping allows the DSD's sound effects and function outputs to be reconfigured to respond to a different function key input. This especially useful for users who have throttles with less than eight function keys as now they can pick and choose what effects they can control instead of being restricted to an arbitrary assignment.

There are 10 function mapping CVs - eight CVs, 35-42 are used to assign output control to function keys 1 through 8 respectively.

The other two CVs, 33 and 34 are both for the FL function. CV 33 controls which outputs are on when FL is on *and* the locomotive is moving forward. CV 34 controls which outputs are on when FL is on *and* the locomotive is moving in reverse. If the same output is selected in both CV 33 and CV 34, that function will turn on when the FL function is on regardless of locomotive direction.

As the DSD has more function outputs (for the purpose of discussion, we'll consider sound effects to be outputs) than there are function keys, not all keys can control all outputs. The table on page 24 in the **DSD Technical Reference** shows which functions can be mapped to which outputs. Note that a function key can be set up to control more than one output and also an output can be controlled by more than one function key. In the second case, the outputs are logically or'ed to the function keys so that if an output is mapped to two function keys, either key will turn that output on, however, the output will not turn off until both function keys have been turned off.

Function mapping is tricky and if the user is not careful, 'interesting' things can happen. As each bit in the function mapping CVs enables a different output, you'll need to refer to the section on **Bits and Bytes** and the **DSD Technical Reference** to determine the proper value for each CV.

Function Mapping Example

There are a several throttles on the market that have only five function buttons. The following example describes one way to reconfigure the DSD for such a throttle and still maintain access to most of the DSD's functionality.

We'll use the FL (F0 on some units) key for turning on the headlight and backup light and use automatic direction control to select which light is on. Since lights require electricity, we'll also set the dynamo to come on automatically when the lights are turned on.

We'll use the F1 key to turn on both auxiliary function outputs F1 and F5. This makes particular sense if both outputs have been setup as a firebox flicker effect

The F2 and F3 keys will be used for the whistle and bell respectively. The F4 key will control the coupler clank sound.

The two functions that had to be given up are the cylinder blow down effect and the audio mute function. The cylinder blowdown effect can still be used by enabling the automatic blowdown effect (see **Configuring Background Sounds**) which will produce the effect whenever the locomotive is brought to a stop. The audio mute function can be implemented by setting CV 50, volume control, to zero when sound is not desired. Not too bad a sacrifice!

Using the **DSD Technical Reference**, we look up the proper bits to set for each CV and after a bit of head scratching, come up with the following list of values:

CV 33 = 129 (0x81), FL(fwd) = headlight and dynamo
CV 34 = 130 (0x82), FL(rev) = backup light and dynamo
CV 35 = 68 (0x44), F1 = F1 and F5 outputs
CV 36 = 8 (0x08), F2 = Whistle
CV 37 = 2 (0x02), F3 = Bell
CV 38 = 32 (0x20), F4 = Coupler
CV 39-42 = 0, Functions not used.

Once these are programmed into the proper CVs, the DSD will exhibit the functionality described above. To enable the Auto-blowdown effect, set CV 51 to 255 (0xFF).

OPERATING THE SOUNDTRAXX DSD

Whew! Now that we've installed the DSD and have all the CVs set up, it's time to run trains! This section is intended to give you a general feel for how the DSD is used in operation. We had to make a few assumptions on how the DSD is set up and for the most part, will assume you've left most CVs at their default settings, particularly the function key assignments. If you've made a lot of CV changes then your DSD may respond somewhat differently.

At the Roundhouse

Press the F1 and F5 keys on your controller to turn on the firebox flicker. When the engine is first fired up, you'll hear the boiler gently simmering away and the airpumps pounding out a steady cadence as the airline builds up pressure. Once pressure has been built, the pumps will slow down and eventually come to a stop.

Press the F6 key on your controller to turn on the dynamo. What a racket! But unfortunately it's needed to power the loco's lights. Speaking of which, press the F0 key to turn the headlight on.

Our engine's been sitting around awhile and there's bound to be some condensation buildup in the cylinders. Press the F4 key to open up the cylinder cocks and blow out the moisture. Press the F4 key again to close the cocks.

It's time to couple up the train. Press the F2 key and let off three short blasts of the whistle to let everyone know you're backin' up. What? You don't remember your whistle signals? Get out of the cab and don't come back until you've memorized Table F by heart. As the locomotive's coupler hooks into the train, press the F7 button to activate the coupler sound. The airpumps are pounding away again as the train line fills with air.

After a few minutes, we're ready to head out onto the mainline. Now it's time to try out the DSD's Dynamic Digital Exhaust (DDE) processor. If your DCC system uses operations mode program, this is a good time to set in a little inertia. Set CV 3 and 4 to something around 20-30.

On the Mainline

Press the F2 key and let off two short whistle blasts. Push the throttle forward. As the locomotive grunts out a couple long exhaust chuffs, train begins to move forward. Push the throttle forward some more (what the heck, turn it all the way up!) and notice that the train inertia keeps the engine from taking off but the exhaust chuff becomes louder and more drawn out as the engine struggles with the train weight. As the train builds up speed, back the throttle down to the desired setting and you'll notice the exhaust chuff quiets down a bit as the train has stopped accelerating. Back the throttle down to zero and the exhaust chuff will really get quiet now that the train is just coasting along.

This is the DDE processor in action! The DDE senses the difference between the actual locomotive speed and the throttle setting, using the information to adjust the volume, cutoff and timbre of the exhaust chuff. If you slowly accelerate or brake the train the exhaust chuff will remain relatively constant. If you turn the throttle substantially up or down, you will hear a dramatic change in the exhaust sound until the train speed has reached the new throttle setting. The DDE works best when there is a reasonable amount of inertia programmed into CVs 3 and 4. With substantial amounts of inertia, you can even use the throttle as an exhaust volume control. Note also that a rapid decrease in the throttle will be processed as a hard brake application and the airpumps will pickup again to restore 'pressure' in the airline.

Into the Station

We've had some fun on the mainline but now we're nearing the station. Let off a few long and loud whistle blasts to let everyone know we're here. As the train slows, press the F3 key to ring the bell and clear the tracks. Bring the train to a stop and press the F3 again to stop the bell.

After a moment, Fireman Fred will open the firebox doors and shovel a few scoops of coal onto the flames to keep the boiler ready for the next trip out. Clink! The doors close and it's time for Fred to take a nap. But he knows better than to snooze for too long and if you hang around long enough, you'll hear him get up and grease the valve gear and draft the firebox. If he lets the boiler get too hot, you'll even the pop-valves go off. What a noise!

Hey! What's that other noise? Your spouse is yelling that they're trying to take a nap too? Uh-oh, press the F8 key to mute the sound until they're better rested...

Table F.
Whistle Signals

Note: • = Short Blast, - = Long Blast

- - • -	Approaching Grade Crossing. (Hold final blast until crossing is reached.)
• -	Approaching a bridge or tunnel
•	Stop, set brakes
• •	Release brakes and proceed forward
• • •	Backup
• • • •	Request signal from Trainman

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Box 789, Chama, NM 87520
(505) 756-2151

The Durango & Silverton Railroad

Main Street, Durango, CO 81301
(970) 247-2733

The Georgetown Loop Railroad

P.O. Box 27, Georgetown, CO 80444
(303) 569-2403

The Leadville, Colorado & Southern

P.O. Box 916, Leadville, CO 80461
(719) 486-3936

The Nevada Northern Railway Museum

P.O. Box 150040, East Ely, NV 89315
(702) 289-2085

The Portola Railroad Museum

P.O. Box 608, Portola, CA 96122
(916)832-4131

TROUBLESHOOTING

If you should have any difficulties with the operation of your SoundTraxx Digital Sound Decoder, first check this section for hints on troubleshooting. If you cannot isolate and find a solution for the problem, we suggest that you write the factory a note describing the problem in as much detail as possible before returning the unit to the factory (see Service and Warranty Policy).

The locomotive runs for awhile and then stops.

The decoder may be overheating. Be sure the decoder is located where it can dissipate excess heat. You may also try lowering your command station's track voltage setting.

The sound works for awhile and then stops.

The decoder amplifier may be overheating. Be sure the decoder is located where it can dissipate excess heat. You can also try lower the volume using CV 50 or your command station's track voltage setting.

The locomotive doesn't move.

Be sure the locomotive address matches that of your controller. If the acceleration CVs are loaded with large values, the locomotive may be also be very slow to accelerate taking almost four minutes to reach full speed.

The decoder and lights work OK but there is no sound.

Check that the CV 50, volume control is not set to zero or that the mute function (F8) isn't on.

The locomotive buzzes when moving at slow speeds.

This is a normal characteristic of virtually all DCC decoders and is an unavoidable side effect of using PWM (Pulse Width Modulation) to drive the motor. The buzzing can be minimized by adjusting the drive frequency via CV 9 and lubricating the motor brushes with a conductive lubricant such as Aero Car Technology's "Conducta".

The lights won't turn on and off.

This is caused when the decoder is set up for 14 speed step operation and the throttle or command station is sending 28 or 128 speed step packets. Reprogram the decoder and/or command station so the speed step modes match. For more information, see CV 29.

An alternate cause may be that the decoder functions have been improperly mapped to another function key. See CVs 33 to 42 for more information.

The headlights flicker on and off as the throttle increases.

This occurs when the decoder is set up for 14 speed step operation and the throttle or command station is sending speed and direction commands for 28 speed step mode. Reprogram the decoder and/or command station so the speed step modes match. For more information, see CV 29.

The Hiss function does not work.

If the auto blowdown feature is enabled, the hiss function cannot be manually controlled. See CV 51 for more information.

The Exhaust Chuff does not work.

If you are using the exhaust cam, be sure the wiper is making contact with the synchronizer disk and there is no buildup of dirt or grease. If you are using the Auto-Exhaust feature, be sure bit 2 in CV 52 is set to 0. See CV 52 for more information. If the DDE is disabled (CV 52, bit = 0), be sure exhaust volume (CV 56) is not 0.

The Locomotive Just Sits and Flashes Both Headlights

This indicates that the CV data has become corrupted and all CVs have been reset to their default values. The DSD will return to normal operation after about 30 seconds, or if power is turned off and back on. You will need to reprogram any CVs you previously modified.

SERVICE AND WARRANTY POLICY

LIMITED NINETY DAY WARRANTY

The Digital Sound Decoder is warranted by Throttle Up! to be operative and free of defects in materials and workmanship for a period of ninety (90) days after original purchase date. Defective Digital Sound Decoders which are received by Throttle Up! during the warranty period will be repaired or replaced free of charge at the option of Throttle Up!

Exclusions

This warranty does not cover damage resulting from negligent installation, improper operation, over voltage or over current damage, failure to follow instructions, misuse, unauthorized repairs or modifications, accidents, damage while in transit to service location, fire, floods, and other acts of God.

Removing the protective shrink tubing from the decoder automatically voids your warranty.

Due to their fragile nature, onboard locomotive speakers are not covered by this warranty. Throttle Up! certifies the speakers to be operational at time of sale. In the event a speaker is damaged, we will replace them free of charge if the defective speaker is returned to the factory within five (5) days of purchase. Prevailing retail and shipping charges will apply after the five day period.

Warranty Procedure

The product must be returned, postage prepaid and insured to the factory for repair. It is advisable to write or phone the factory for advice before returning the product for service. Include name, street address (We cannot ship to P.O. Boxes!), daytime phone number, and description of problem. After repairing product we will ship it to your home at no cost to you.

Important!: Return only the Digital Sound Decoder. Under no circumstances should you send your locomotive (or other model) to us as we cannot assume any liability for their safe return.

Limits of Liability

The foregoing shall constitute the sole and exclusive remedy of any owner of this product for breach of warranty including the implied warranties of merchantability and fitness. IN NO EVENT SHALL THROTTLE UP! BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES OR FOR THE REPRESENTATIONS OF RETAIL SELLERS.

Non-Warranty Repairs

Digital Sound Decoders needing repairs after exceeding the warranty period or damaged during installation, will be repaired at modest cost for parts and labor. Customer will be advised in writing or by telephone of any service charges before work is begun. The product will be returned to the address specified with a C.O.D. charge for service, shipping and handling.

For Prompt Factory Service, mail to:

Throttle Up!/SoundTraxx
210 Rock Point Drive
Durango, CO 81301
Telephone (970) 259-0690
FAX (970) 259-0691

FCC STATEMENT

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio interference energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and back on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment to an outlet or on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

You may also find helpful the following booklet, prepared by the FCC: "How to identify and Resolve Radio-TV Interference Problems." This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402.

Changes and modifications not expressly approved by the manufacturer or registrant of this equipment can void your authority to operate this equipment under Federal Communications Commissions rules.

Throttle Up! Corp.
210 Rock Point Drive
Durango, CO 81301
Telephone (970) 259-0690
FAX (970) 259-0691

APPENDIX B - DSD FUNCTIONAL TEST

Although each DSD has been fully tested prior to shipment and is ready for installation, we urge you to test your decoder before installing in your locomotive! We have developed a simple procedure that assures you that the DSD is functioning as it should before you do the installation. If this is your first sound or decoder installation, it will give you an added boost of confidence, knowing that as long as you follow the installation instructions...it *will* work!

In the event you do have a problem, please contact your dealer or Throttle Up! for technical assistance first. We will gladly refund payment or replace any decoder that does not pass the functional test free of charge provided that none of the decoder wires have been cut short.

Before you get started, we must reiterate - *do not shorten any decoder leads* until you have verified that the decoder is functioning properly. *Do not install any decoder that does not pass the Functional Test.*

Items Needed for the Functional Test

To perform the Functional Test, you will need:

- A Decoder Test Kit
- An NMRA-compatible DCC system
- One 8 ohm speaker

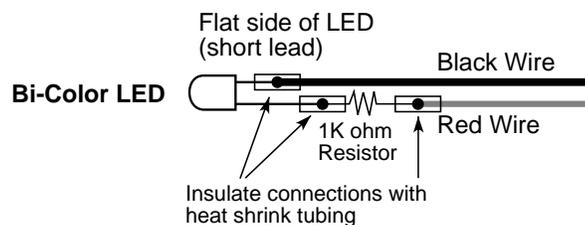
Creating a Test Kit

For your convenience, Throttle Up! offers a test kit, Item No. 829001 which includes all of the items needed for testing the DSD, including detailed instructions. If you prefer, you can make up your own kit with some simple parts purchased from your local electronics supplier. If you decide to create your own test kit, you will need:

Qty.	Description
1	Resistor, 22 ohm, 2 Watt
1	Resistor, 1K ohm, 1/4 Watt
1	Bicolor LED
1	Black Wire
1	Red Wire
	Length of small diameter shrink tubing

Preparing the Test Fixture

1. Connect the black wire to the short lead of the LED.
2. Connect one lead of the 1K ohm resistor to the long lead of the LED.
3. Connect the other lead of the 1K ohm resistor to the red wire.
4. Insulate the connections with heat shrink tubing.
5. Verify the LED is working properly by connecting the red lead to the positive (+) terminal of a fresh 9 volt battery and the black lead to the battery's negative terminal. The LED should glow red. Reverse the leads and note that the LED color changes to green.



Preparing the Decoder Test Kit

DSD Functional Test Procedure

Follow directions carefully, working on a *non-metallic surface*.

Any NMRA-compatible DCC system will work for the test. Consult your system manual for appropriate operating instructions.

It isn't necessary to solder any wires together during the test. Simply twisting the wires together will suffice.

We recommend insulating the ends of the decoder leads with electrical tape to prevent accidental shorts during the testing.

General Hookup

1. Turn the power to the DCC system off.
2. Select the lowest possible output voltage setting, usually the N-scale setting.
3. Connect the decoder's purple (pin 10) lead to the negative (-) terminal of the speaker.
4. Connect the other purple lead (pin 12) to the positive (+) speaker terminal. A 100 μ F, 16V capacitor must be wired in series as shown in Figure 2.
5. Connect the red lead of the test LED to the decoder's orange lead.
6. Connect the black lead of the test LED to the decoder's gray lead.
7. Connect the 22 ohm resistor to one of your DCC system's track outputs.
8. Connect the free end of the resistor to the Decoder's red wire.
9. Connect the Decoder's black wire to your DCC system's other track output.

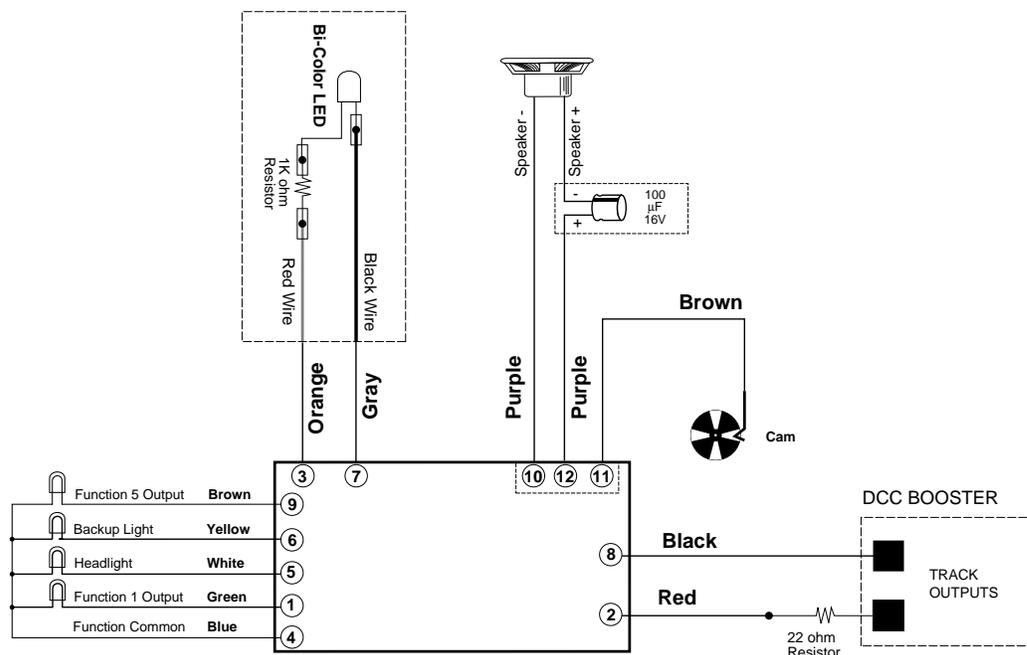


Figure 2 - General Hookup Procedure

Speaker Test

The objective of the Speaker Test is to ensure that the DSD is generating sound.

1. Make sure no other decoder leads are shorted to any other leads. The best way to do this is to simply tape the other leads out of harm's way while you are performing the test. Tape them to the non-metallic surface you are working on until they are needed.
2. Turn on power to the system.
3. Configure your DCC system to send commands to locomotive address 03 using 28 speed step mode.
4. After a moment, you should hear the sound of airpumps and blowers running in the background. If you do not, turn off power to the system and recheck your connections.
5. Activate Auxiliary Function 2. The Whistle should blow. Activate Auxiliary Function 3 and the bell should begin to ring.

If the bell and whistle functions do not work, verify that your DCC system is indeed set to address 03. If your system has dedicated bell and whistle keys, check that they are properly mapped to control Auxiliary Functions 2 and 3.

Note: If the sound becomes erratic or cuts out when the whistle or bell sounds are activated, you may need to change the command station's track voltage setting to a higher level. If this is not practical or does not solve the problem, you may try wiring the decoder's red wire directly to the DCC system's track output and bypass the 22 ohm resistor. However, you must be extra careful performing the rest of the test as the resistor serves to protect the decoder from accidental short circuits.

If the DSD still does not produce any sound it is possible that the CV settings may have been altered. You may skip ahead to the Programming Test section and program the following CV to reset all CVs to their default settings:

CV 30 = 02

If this does not work, contact SoundTraxx for a replacement.

Motor Operation Test

The purpose of this test is to verify that the decoder correctly interprets the speed and direction commands that are received from the command station.

1. Make sure no other decoder leads are shorted to any other leads.
2. Turn on power to the system.
3. Configure your DCC system to send commands to locomotive address 03.
4. After a moment, you should hear the sound of airpumps and blowers running in the background.
5. Select the forward direction and slowly increase the throttle speed. The Bipolar LED will begin to glow red.
6. Now select the reverse direction and slowly increase the throttle. The Bipolar LED should now begin to glow green. If the LED does not light or change color, first check that the DCC system is set to address 03. Next, verify the LED is working properly as outlined under **Preparing the Test Fixture**, page A-4.

If the LED still does not light or change color, contact SoundTraxx for a replacement.

Exhaust Cam Test

The purpose of this test is to verify proper operation of the DSD's cam sensor.

1. Turn on power to the system.
2. After a moment, you should hear the sound of airpumps and blowers running in the background.
3. Locate the brown cam wire (pin 11 of the 3-pin Speaker/Cam connector. *Do not confuse with the brown wire of the 9-pin connector!*). Tap this wire against either rail. As the cam wire makes contact, you should hear a chuff sound.

If you do not hear a chuff, it is possible that the CV settings may have been altered in which case you should have noted a chuffing sound when performing the Motor Operations Test. If this is the case, you may skip ahead to the Programming Test section and program the following: CV 30 = 02, to reset the CVs.

Then repeat steps 1,2 and 3 above. If you still do not get a response, contact SoundTraxx For a replacement.

Auxiliary Function Output Test

The purpose of this test is to verify that the decoder correctly interprets the commands for the four auxiliary output functions.

1. Turn power to the system OFF.
2. Disconnect the test LED from the gray and orange leads of the decoder. Insulate the ends of the gray and orange wires with electrical tape.
3. Attach the black lead of the test LED to the decoder's blue lead.
4. Connect the red lead of the test LED to the decoder's white lead (head light). Make sure no other decoder leads are shorted to any other leads.
5. Turn on power to the system.
6. Using your DCC controller, turn on Function 0 and set the throttle direction to forward. The Bipolar LED should light. Turn Function 0 off and the LED should turn off.

-
7. Turn power to the system OFF. Disconnect the decoder's white wire from the red lead of the test LED. Now connect the red lead to the yellow decoder wire (reverse light).
 8. Turn on power to the system. Using your DCC controller, turn on Function 0 and set the throttle direction to reverse. The Bipolar LED should light. Turn Function 0 off and the LED should turn off
 9. Turn power to the system OFF.
 10. Disconnect the yellow lead of the decoder from the red wire of the test LED. Connect the red lead of the test LED to the decoder's green lead (F1 output). Make sure no other decoder leads are shorted to any other leads.
 11. Turn on power to the system. Using your DCC controller, turn on Function 1. The Bipolar LED should light. Turn Function 1 off and the LED should turn off.
 12. Turn power to the system OFF.
 13. Disconnect the green lead of the decoder from the red wire of the test LED. Connect the red lead of the test LED to the decoder's brown lead (F5 output). Make sure no other decoder leads are shorted to any other leads.
 14. Turn on power to the system. Using your DCC controller, turn on Function 5. The Bipolar LED should light. Turn Function 5 off and the LED should turn off.

Programming Test

The purpose of this test is to verify that the decoder correctly accepts programming commands.

1. Turn power to the system OFF.
2. Connect the red lead of the test LED to the decoder's orange lead.
3. Connect the black lead of the test LED to the decoder's gray lead. Make sure no other decoder leads are shorted to any other leads.
4. If your DCC system requires the use of a programming track, disconnect the red and the black lead of the decoder and reconnect to your system's programming track outputs.
5. Turn on power to the system.
6. The DSD supports register, paged, and direct CV access modes. The mode you use will be entirely dependent upon the DCC system you are using and you should refer to your owner's manual for further information. Using your system controller, reprogram CV1, decoder address, to an address other than 03 that is within the range of your system's capability. Write down the address that you select.
7. Turn off power to the system.
8. Reconnect the DSD's red and black leads to your DCC system's track outputs.
9. Turn on power to the system and reconfigure it to send commands to the address you programmed in step 5.
10. Now slowly increase the throttle. The Bipolar LED should now begin to glow. This indicates that the decoder has accepted the address change. If the LED does not light, verify that the locomotive address is programmed to the address you selected. If it still does not light, contact Throttle Up! For a replacement.

The Functional Decoder Test is complete. You have verified that your decoder is operating as it should and you can now proceed to locomotive installation!

BINARY/HEX CONVERSION CHART - APPENDIX C

DECIMAL	HEX	BINARY (76543210)									
0	00	00000000	64	40	01000000	128	80	10000000	192	C0	11000000
1	01	00000001	65	41	01000001	129	81	10000001	193	C1	11000001
2	02	00000010	66	42	01000010	130	82	10000010	194	C2	11000010
3	03	00000011	67	43	01000011	131	83	10000011	195	C3	11000011
4	04	00000100	68	44	01000100	132	84	10000100	196	C4	11000100
5	05	00000101	69	45	01000101	133	85	10000101	197	C5	11000101
6	06	00000110	70	46	01000110	134	86	10000110	198	C6	11000110
7	07	00000111	71	47	01000111	135	87	10000111	199	C7	11000111
8	08	00001000	72	48	01001000	136	88	10001000	200	C8	11001000
9	09	00001001	73	49	01001001	137	89	10001001	201	C9	11001001
10	0A	00001010	74	4A	01001010	138	8A	10001010	202	CA	11001010
11	0B	00001011	75	4B	01001011	139	8B	10001011	203	CB	11001011
12	0C	00001100	76	4C	01001100	140	8C	10001100	204	CC	11001100
13	0D	00001101	77	4D	01001101	141	8D	10001101	205	CD	11001101
14	0E	00001110	78	4E	01001110	142	8E	10001110	206	CE	11001110
15	0F	00001111	79	4F	01001111	143	8F	10001111	207	CF	11001111
16	10	00010000	80	50	01010000	144	90	10010000	208	D0	11010000
17	11	00010001	81	51	01010001	145	91	10010001	209	D1	11010001
18	12	00010010	82	52	01010010	146	92	10010010	210	D2	11010010
19	13	00010011	83	53	01010011	147	93	10010011	211	D3	11010011
20	14	00010100	84	54	01010100	148	94	10010100	212	D4	11010100
21	15	00010101	85	55	01010101	149	95	10010101	213	D5	11010101
22	16	00010110	86	56	01010110	150	96	10010110	214	D6	11010110
23	17	00010111	87	57	01010111	151	97	10010111	215	D7	11010111
24	18	00011000	88	58	01011000	152	98	10011000	216	D8	11011000
25	19	00011001	89	59	01011001	153	99	10011001	217	D9	11011001
26	1A	00011010	90	5A	01011010	154	9A	10011010	218	DA	11011010
27	1B	00011011	91	5B	01011011	155	9B	10011011	219	DB	11011011
28	1C	00011100	92	5C	01011100	156	9C	10011100	220	DC	11011100
29	1D	00011101	93	5D	01011101	157	9D	10011101	221	DD	11011101
30	1E	00011110	94	5E	01011110	158	9E	10011110	222	DE	11011110
31	1F	00011111	95	5F	01011111	159	9F	10011111	223	DF	11011111
32	20	00100000	96	60	01100000	160	A0	10100000	224	E0	11100000
33	21	00100001	97	61	01100001	161	A1	10100001	225	E1	11100001
34	22	00100010	98	62	01100010	162	A2	10100010	226	E2	11100010
35	23	00100011	99	63	01100011	163	A3	10100011	227	E3	11100011
36	24	00100100	100	64	01100100	164	A4	10100100	228	E4	11100100
37	25	00100101	101	65	01100101	165	A5	10100101	229	E5	11100101
38	26	00100110	102	66	01100110	166	A6	10100110	230	E6	11100110
39	27	00100111	103	67	01100111	167	A7	10100111	231	E7	11100111
40	28	00101000	104	68	01101000	168	A8	10101000	232	E8	11101000
41	29	00101001	105	69	01101001	169	A9	10101001	233	E9	11101001
42	2A	00101010	106	6A	01101010	170	AA	10101010	234	EA	11101010
43	2B	00101011	107	6B	01101011	171	AB	10101011	235	EB	11101011
44	2C	00101100	108	6C	01101100	172	AC	10101100	236	EC	11101100
45	2D	00101101	109	6D	01101101	173	AD	10101101	237	ED	11101101
46	2E	00101110	110	6E	01101110	174	AE	10101110	238	EE	11101110
47	2F	00101111	111	6F	01101111	175	AF	10101111	239	EF	11101111
48	30	00110000	112	70	01110000	176	B0	10110000	240	F0	11110000
49	31	00110001	113	71	01110001	177	B1	10110001	241	F1	11110001
50	32	00110010	114	72	01110010	178	B2	10110010	242	F2	11110010
51	33	00110011	115	73	01110011	179	B3	10110011	243	F3	11110011
52	34	00110100	116	74	01110100	180	B4	10110100	244	F4	11110100
53	35	00110101	117	75	01110101	181	B5	10110101	245	F5	11110101
54	36	00110110	118	76	01110110	182	B6	10110110	246	F6	11110110
55	37	00110111	119	77	01110111	183	B7	10110111	247	F7	11110111
56	38	00111000	120	78	01111000	184	B8	10111000	248	F8	11111000
57	39	00111001	121	79	01111001	185	B9	10111001	249	F9	11111001
58	3A	00111010	122	7A	01111010	186	BA	10111010	250	FA	11111010
59	3B	00111011	123	7B	01111011	187	BB	10111011	251	FB	11111011
60	3C	00111100	124	7C	01111100	188	BC	10111100	252	FC	11111100
61	3D	00111101	125	7D	01111101	189	BD	10111101	253	FD	11111101
62	3E	00111110	126	7E	01111110	190	BE	10111110	254	FE	11111110
63	3F	00111111	127	7F	01111111	191	BF	10111111	255	FF	11111111