Model Railroad Engineer Electrical

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NMRA Model Railroad Engineer Electrical AP
Ernest H. Little
NMRA Member #129108

INTRODUCTION

The Norfolk Southern Connector is a free lanced model railroad that I have constructed. I will use the electrical components of this model railroad to satisfy the requirements of the NMRA Model Railroad Engineer- Electrical AP requirements. The document I have prepared is intended to provide a summary of how the AP requirements are met on my model railroad.

Requirement #1: Construct and demonstrate the satisfactory operation of an electrical control system.

The Norfolk Southern Connector is an HO scale model train layout which utilizes a Digitrax© digital command and control electrical system for provision of electrical power and control of the trains operating on the layout. The layout was designed as a single track mainline for continuous operation. One *mainline passing siding* was provided along the layout in the area designated as Furnace Mountain which provides the ability for one train to be able to pass another at this point regardless of the direction of travel of each train.

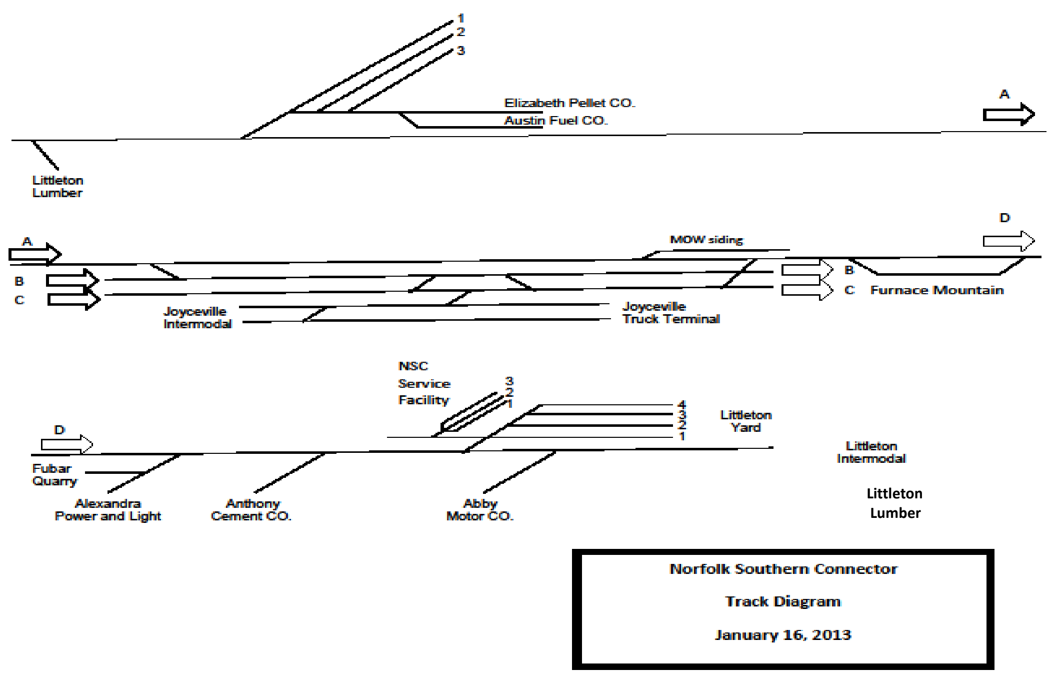


Figure 1
NSC Track Diagram

DC Power

The NSC is a command- control digital command and control layout with no DC wiring used for track power. Power to some blocks is independently controlled with wiring to enable locomotives to be stored in yards at the NSC shops.

DCC Power

This section will be used to provide an explanation of how the NSC digital command and control system is wired with sufficient narrative provided to indicate the location of components.

Layout power control

The NSC is a one level layout with one power source utilized to provide power to the layout. Track power is provided by a home built eight amp power supply that utilizes a transformer to convert 110 volt AC input power down to a track voltage of 18 volts on its output side. Power then goes from the 18 volt output side of this transformer to input of an eight amp circuit breaker that provides overcurrent protection to the track power circuit in the event of an over current event. From this point the output of the circuit breaker is wired to the input of a Digitrax© DCS100 Digital command station to provide track power. The power output from the command station is connected to the input of a Tony's Train Exchange RRamp© meter which in turn allow power to be monitored by utilization of the RRamp© meter to provide a digital read out of the track voltage provided to the layout and the amperage demand by the locomotives operating on the layout. This is achieved due to the RRamp© meter's output being connected to the mainline track, by use of wire conductors soldered directly to each of the rails, in the area of Elizabeth's Pellet Company. The main line track is used as the conductors to distribute track power to remainder of the layout.

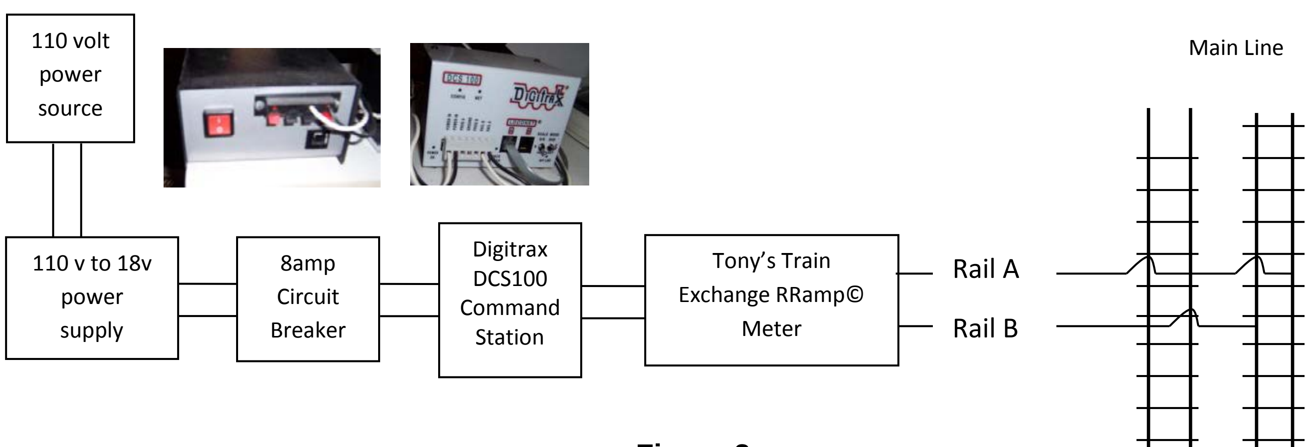


Figure 2

NSC Power Control

The following sequence of operations is performed to power-up the layout.

1. Turn on the 110 volt power strip utilizing the power strip power switch.
2. Turn on the Power supply utilizing the on/off power switch. Observe that the power indicator light comes on.
3. Listen to the DCS 100 for to provide audible indication (beeps) that it is on.
4. Turn on the track power using one of the provided DCC throttles by pressing the power switch.

Power to the layout is now on and selection of that appropriate locomotive(s) using the DCC throttle through acquiring and selecting them will permit their operation.

To power down the layout the sequence of operations is as follows.

1. Deselect the locomotive(s) being run on the layout and dispatch their addresses.
2. Turn off the track power using one of the provided DCC throttles by pressing the power switch.
3. Turn off the power supply utilizing the on/off power switch.
4. Turn off the 110 volt power strip utilizing the power strip power switch.

Power gaps

Double gapping of the track is used as a means of electrical isolation at several points on the NSC layout and is provided as indicated below going from west to east on the layout starting at Elizabeth’s Pellet Company.

- The east and west ends of the bridge at Furnace Mountain. This gapping is used as a safety provision to cutoff track power in the event the bridge is raised. This provides protection to locomotives travelling this portion of the layout from running off of the track when the bridge is open.

- Just west of the Littleton Yard spur near the lumber company. This gaping provides electrical isolation of the Littleton Yard from the main line and allows the phase of the Littleton Yard to be manually changed, through use of a DPDT switch, so the yard power will match where entry to the section of main line, in the area, desired.

- On the three engine service facility tracks from the main spur to the engine maintenance facility are single gapped to permit shut down of power of one or more of the engine facility tracks at a time and allows storage of unused motive units as necessary.

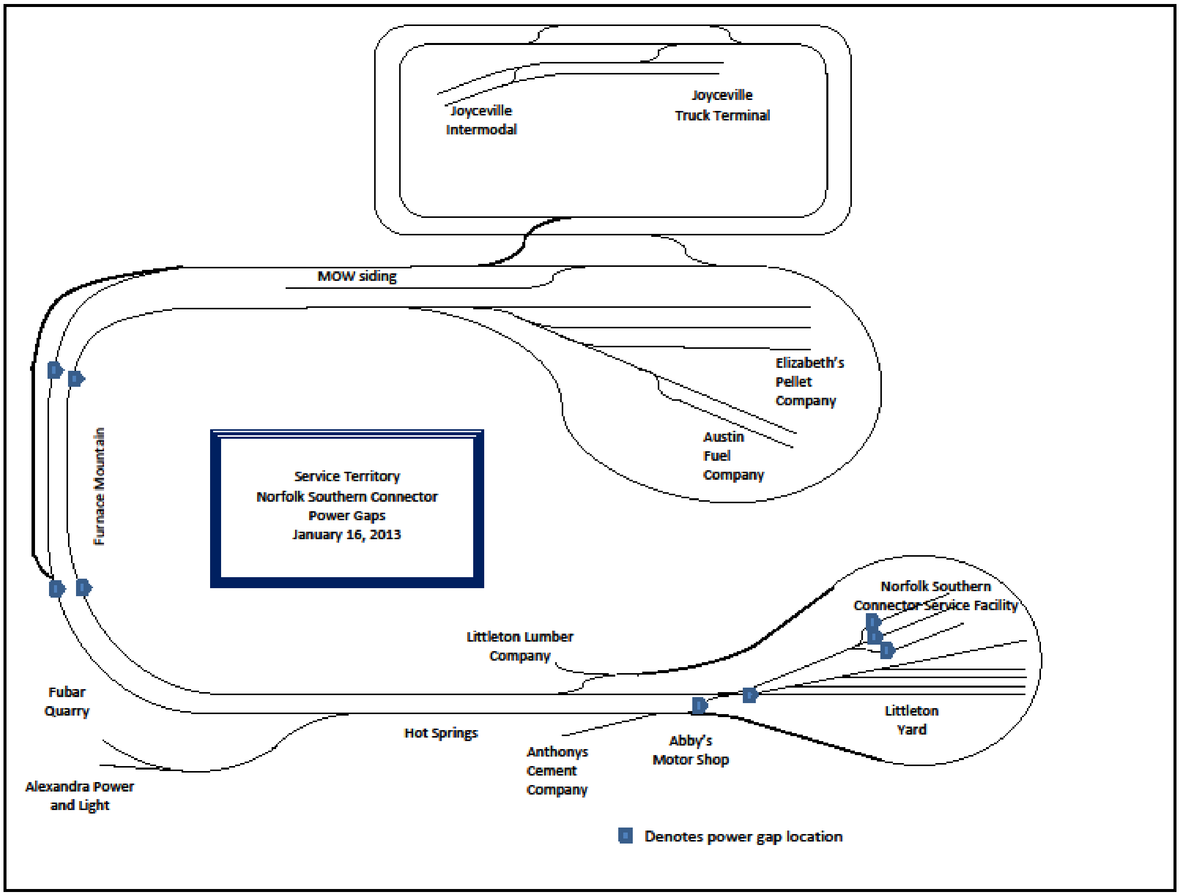


Figure 3
NSC Service Territory Track diagram showing power gaps

Loconet

The layout features a LocoNet that originates at the DCS100 command station and extends throughout the layout providing additional control points located such that tethered operation is possible. There are three Loconet control points for the layout which are located at the DCS100 control station, utilization of a Digitrax© UP5 on the layout near the MOW siding and a Digitrax© UR91near the Elizabeth's Pellet Company. By the control point near the Elizabeth's Pellet Company utilizing a Digitrax© UR91 control of the layout can be done by both tethered and radio cab controls of the command and control system.

Digitrax© DCS100

Digitrax© UP5

Digitrax© UR91

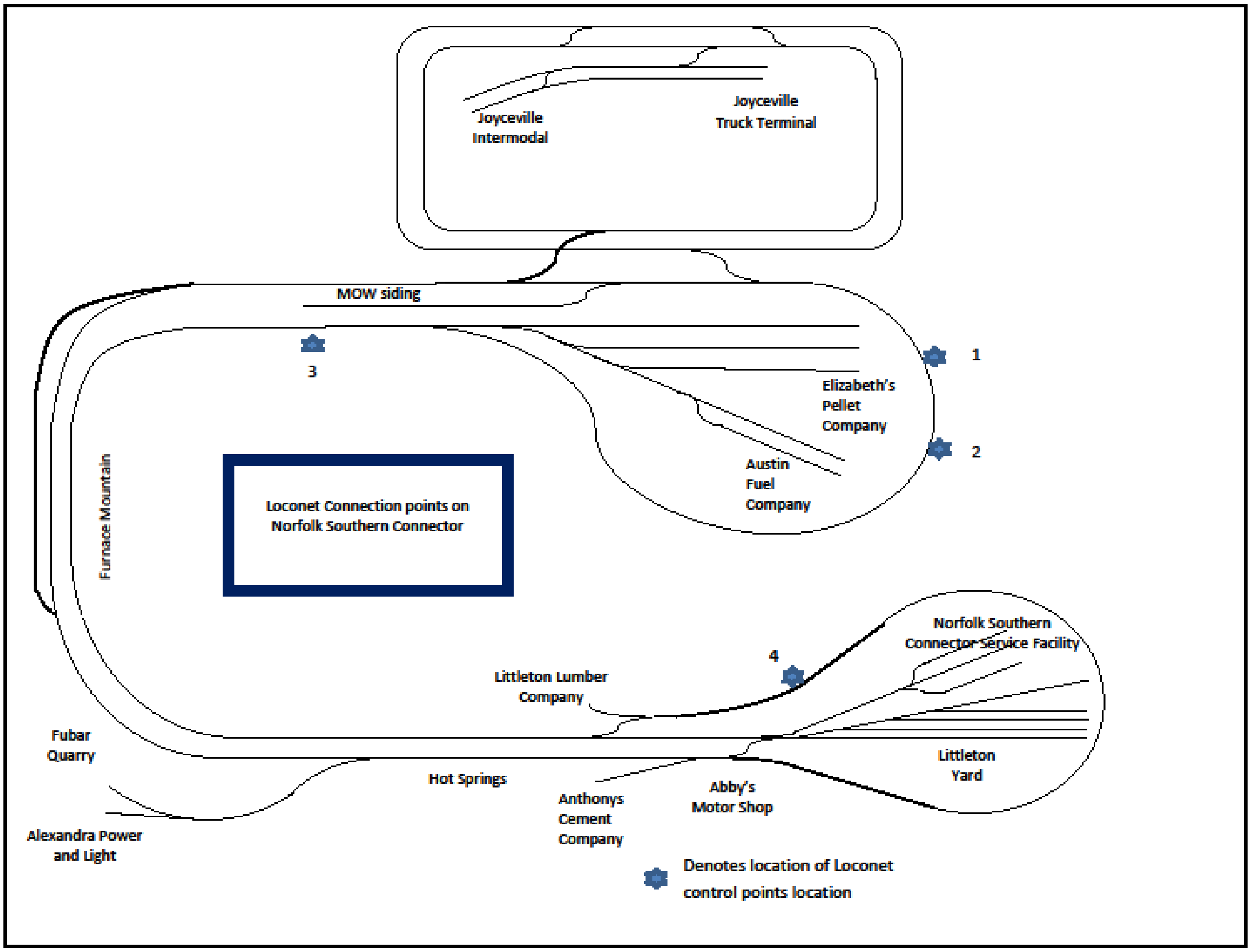


Figure 4
Loconet Connection point diagram

Cab Controls

The NSC utilizes Digitrax© cab throttles to control a locomotive's speed, direction, light functions, and sound (when equipped). The cab throttle(s) used on the NSC are either a Digitrax© DT300R, DT400R, or UT4R, DCC cab throttle and are capable of being connected to the LocoNet on the layout. Locomotives that run on the NSC are equipped with DCC decoders manufactured by Digitrax©, Soundtraxx©, or TCS which are addressed to the locomotive's number board designation to permit each locomotive to have a unique address on the DCC system. Some of the locomotives also have the ability have their lights, speed, and direction controlled but also produce sound utilizing either Digitrax© or Soundtraxx© or QSI sound decoders. Typical function assignments are F0 for running lights, F1 for the locomotive bell, and F2 for the locomotive horn.

The DCC cab throttle, a Digitrax© DT400R is pictured here, sends digital commands to the command station via tethered or by radio connection to the LocoNet. The commands are sent by the selection of the appropriate function or control button on the DCC cab throttle to select the desired function, speed, direction, or other control.

After being received by the command station, the commands are interpreted, and then sent out to the locomotives operating on the layout embedded in the track power from the command station. Each of the locomotives have DCC decoders installed in them that have unique addresses allowing each of them to be controlled individually or as part of a multi-unit power unit. The locomotives carry out commands that are addressed to them by the throttle cab. The DCC cab throttle can also control track power to the entire layout by use of the power on, power off, or emergency power shutdown buttons.

To demonstrate the use of a **passing siding** I will use the siding at Furnace Mountain. As stated before, power gaps were provided at the east and west sides of the Furnace Mountain passing siding. Polarity is maintained by use of a DCC friendly #6 switch at each end of the siding. The power gaps are utilized to sense an open bridge that, if open, will shut power down and not permit a locomotive to enter the power sector.

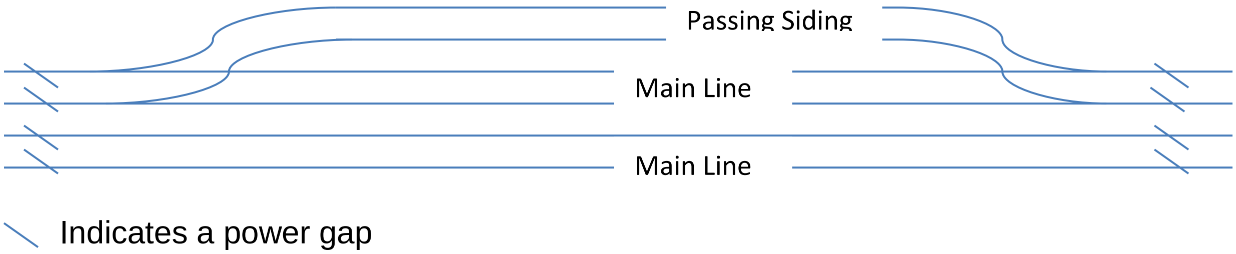


Figure 5
Furnace Mountain Passing Siding showing power gaps for power control.

To demonstrate the use of a **wye** and the provision of a **yard with a minimum of three tracks** and a **switching lead independent of the mainline**, I will use the main lead into the NSC engine facility where the lead transitions to three tracks to go into the service facility yard and building.

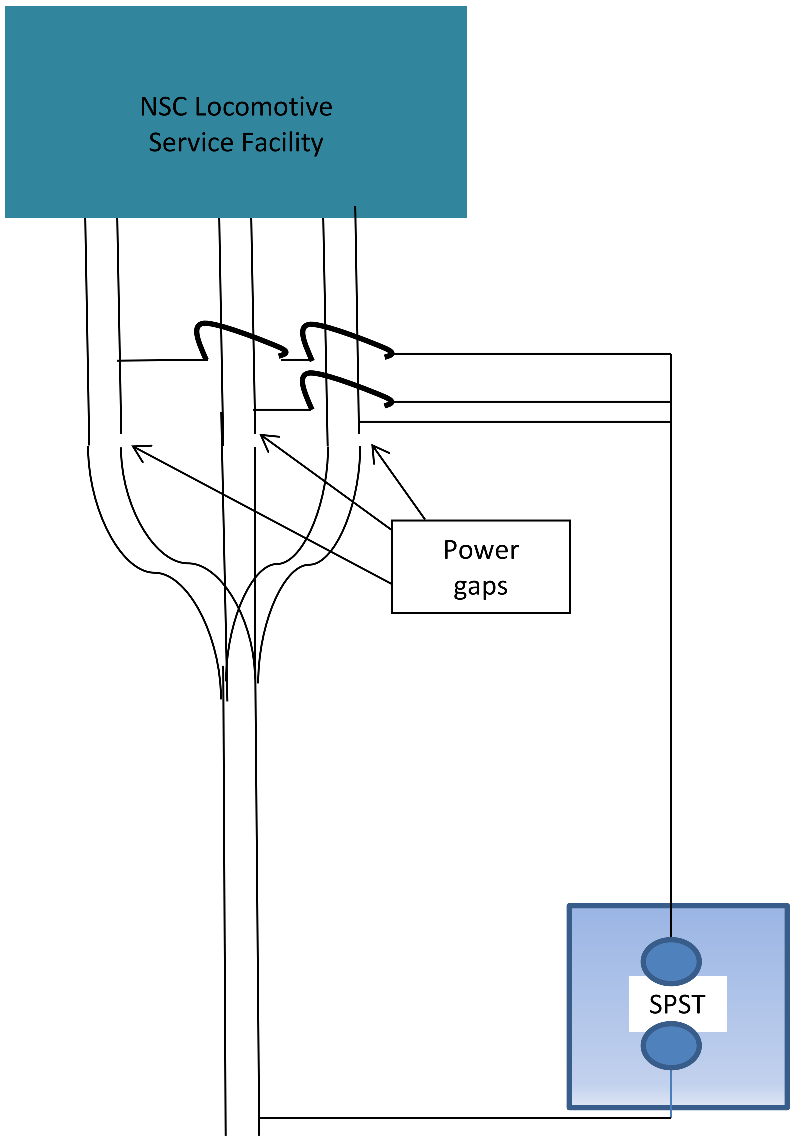


Figure 6
Switch Control of power to
Triple Track Wye lead to NSC Locomotive Servicing Facility

A single SPST switch controls the power for the track to theNSC Locomotive Servicing Facility. Polarity is maintained by use of a DCC friendly three way wye switch. This permits the locomotive yard to be unpowered to conserve power for the mainline when locomotives are idle at the shop. Mainline operations are not affected by operation of the shop yard. This meets the requirement of provision of facilities for the **storage of at least two unused motive power units**.

The requirement for **one power supply with protective devices** (short indicator or circuit breaker) to ensure safe operation was described earlier in the section describing how the power was provided to the layout.

Requirement number 2. Wire and demonstrate the electrical operation of at least three electrical items:

1. **Turnout**
2. **Crossing**
3. **Crossover**
4. Double Crossover
5. Slip Switch - *(single or double)*
6. Gauge Separation Turnout
7. Double Junction Turnout
8. **Three Way Turnout**
9. Gauntlet Turnout
10. Spring Switch
11. Operating Switch in Overhead Wire

To meet this requirement I will use the turnouts, a crossover, a crossing, and a three way turnout that are located on the layout which are manufactured by either Atlas, Peco, or Shiniahara. On the NSC layout the turnouts are controlled through the use of either Tortoise motors or manual throws. At least 10 of the turnouts controlled through Tortoise motors, 6 by Atlas snap switches, and 4 by manual ground throws made by Caboose Industries. The Tortoise motors have their power supplied by a Radio Shack 120 volt to 14 volts DC transformer (Figure 6). A 14 volt DC power bus originates at this transformer and provides power to all of the powered Tortoise equipped turnouts.

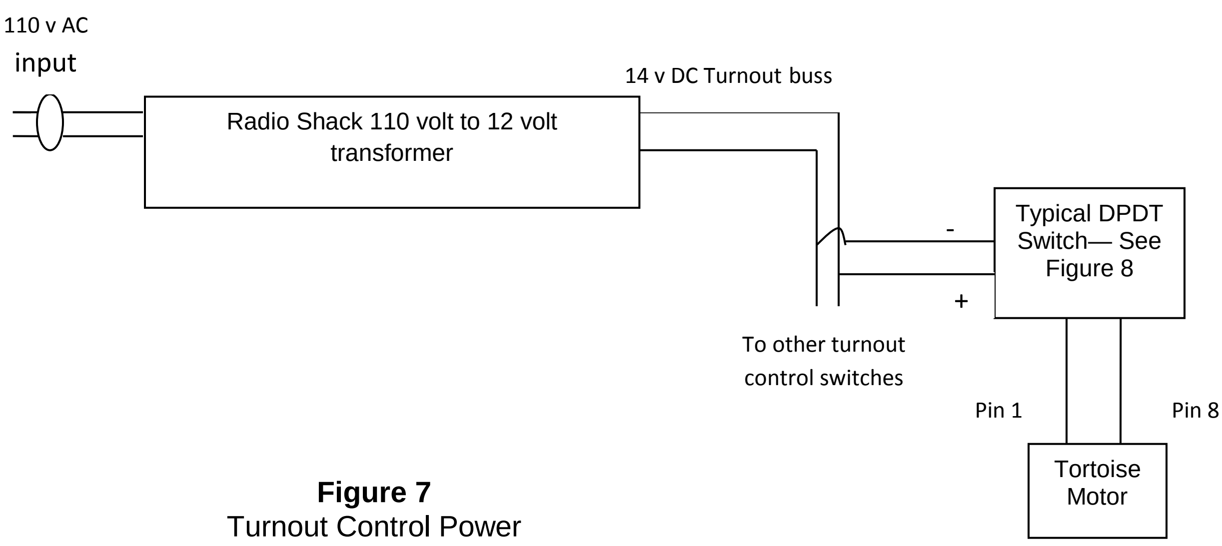


Figure 7
Turnout Control Power

DPDT switches are used to control the turnouts and change their status by changing the polarity of the power to the individual tortoise motor. The DPDT switch positions are labeled to indicate the position of the turnout. LED's are also wired into the turnouts to indicate their position.

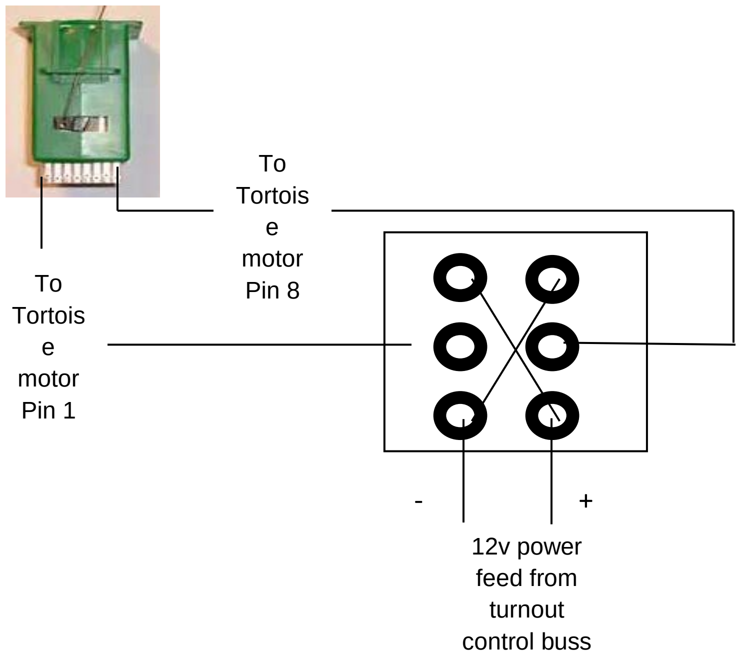


Figure 8

Typical DPDT switch wiring

Most of the turnouts are single in nature. However, there is one three way turnout located on the engine maintenance facility spur. This turnout allows, through use of a manual ground throw, the selection of one of the engine facility tracks to proceed from the spur to the facility track. The electrical wiring of this turnout was shown in Figure 6.

There are three cross over turnouts in the layout. (Joyceville Intermodal, on the mainline near the Littleton Lumber Company, and at the Littleton Yard). The crossover near the Littleton Lumber Company consists of two #6 turnouts and is controlled by two Tortoise motors (see figure 8) that are connected to a common DPDT switch thus allowing a locomotive to cross over to a parallel track with the use of one motion. The wiring for this DPDT switch is shown in Figure 9.

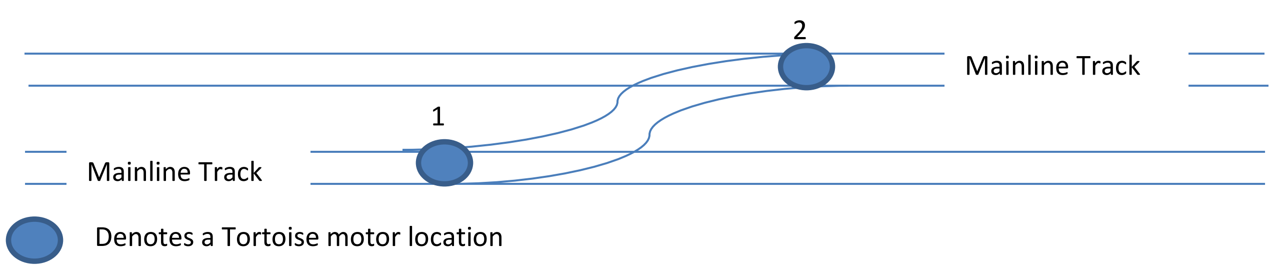


Figure 9
Littleton Lumber crossover

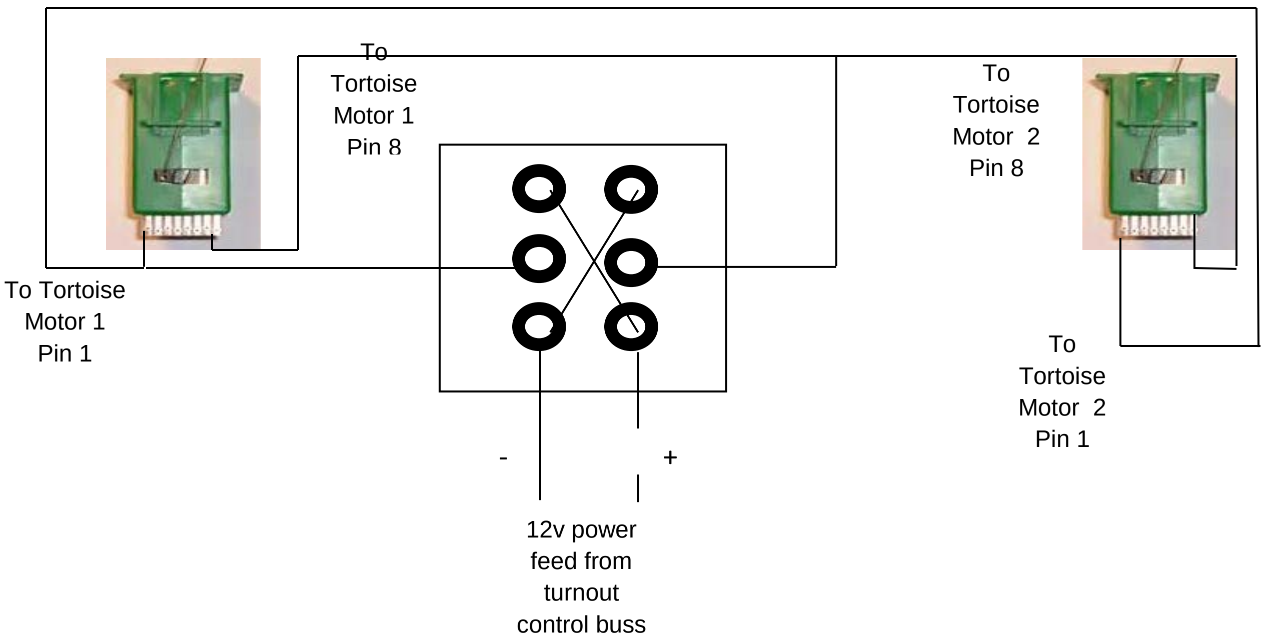


Figure 10
Littleton Crossover DPDT Switch electrical wiring

The layout also has a 30 degree crossing that permits the outer track of the Joyceville area to be crossed by a spur coming off of the main line East of the Furnace Mountain bridge. This picture to the left shows the 30 degree crossing which is made by Atlas and is a DCC friendly crossing. The frogs and rails of this crossing are isolated to protect the polarity of the DCC electrical system. Figure 11 depicts the electrical structure of this crossing.

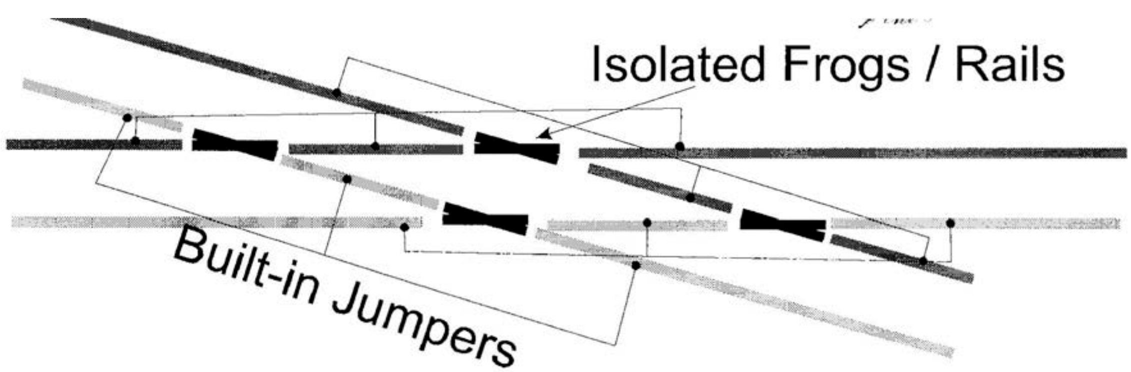


Figure 11
Structure of 30 degree crossing

Requirement #3 Wire and demonstrate the electrical operation of at least three of the following electrical items:

I have selected Electrical turnout position indication on a control panel or at trackside for a minimum of four turnouts, installation of a command control receiver which can be found in Appendix A, and installation of a Loconet (see Figure 13) as the three items I will provide schematics and wire.

Electrical turnout position

Diagram 12 shows how the wiring is done to use red and green LEDs in combination with a Tortoise motor to indicate the status of a switch on the layout. The LEDs are wired in series with the Tortoise motor which allows the LEDs to detect the direction of current flow thus allow the LED to indicate the direction a switch is thrown.

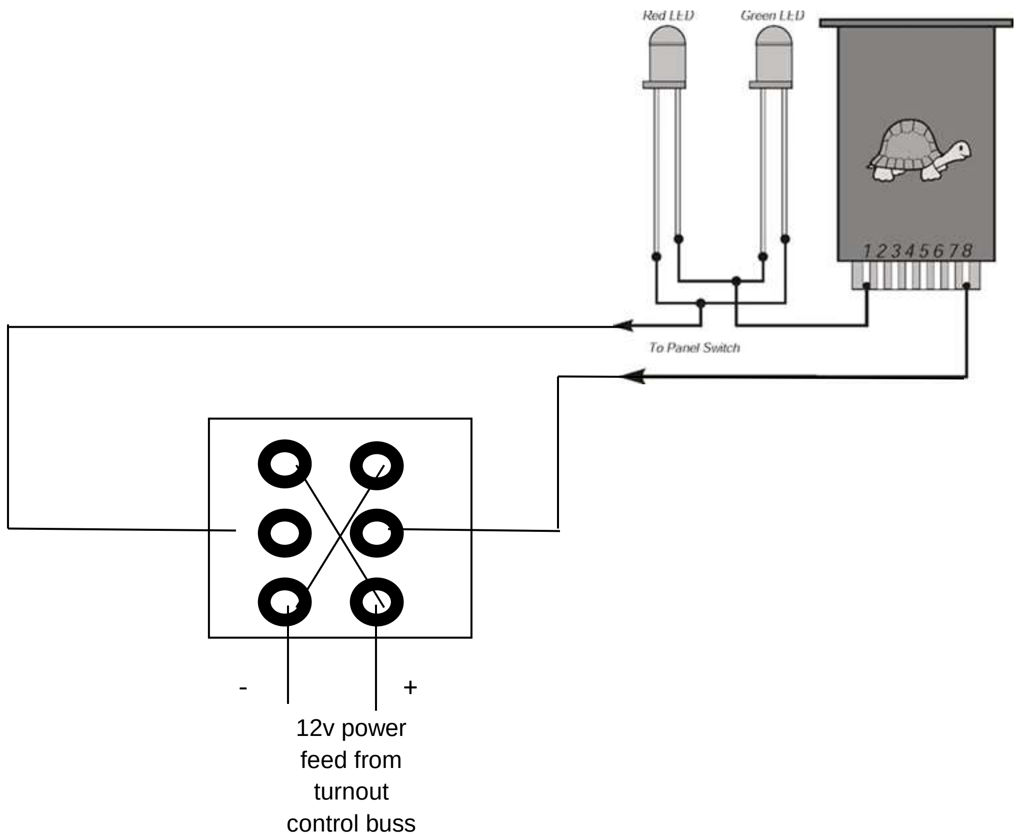


Figure 12

Typical DPDT switch wiring wired to Tortoise motor to indicate switch position

Requirement # 4- Prepare a schematic drawing of the propulsion circuitry of the model railroad in (A) showing the gaps, blocks, feeders, speed and direction control, electrical switches, and power supplies.

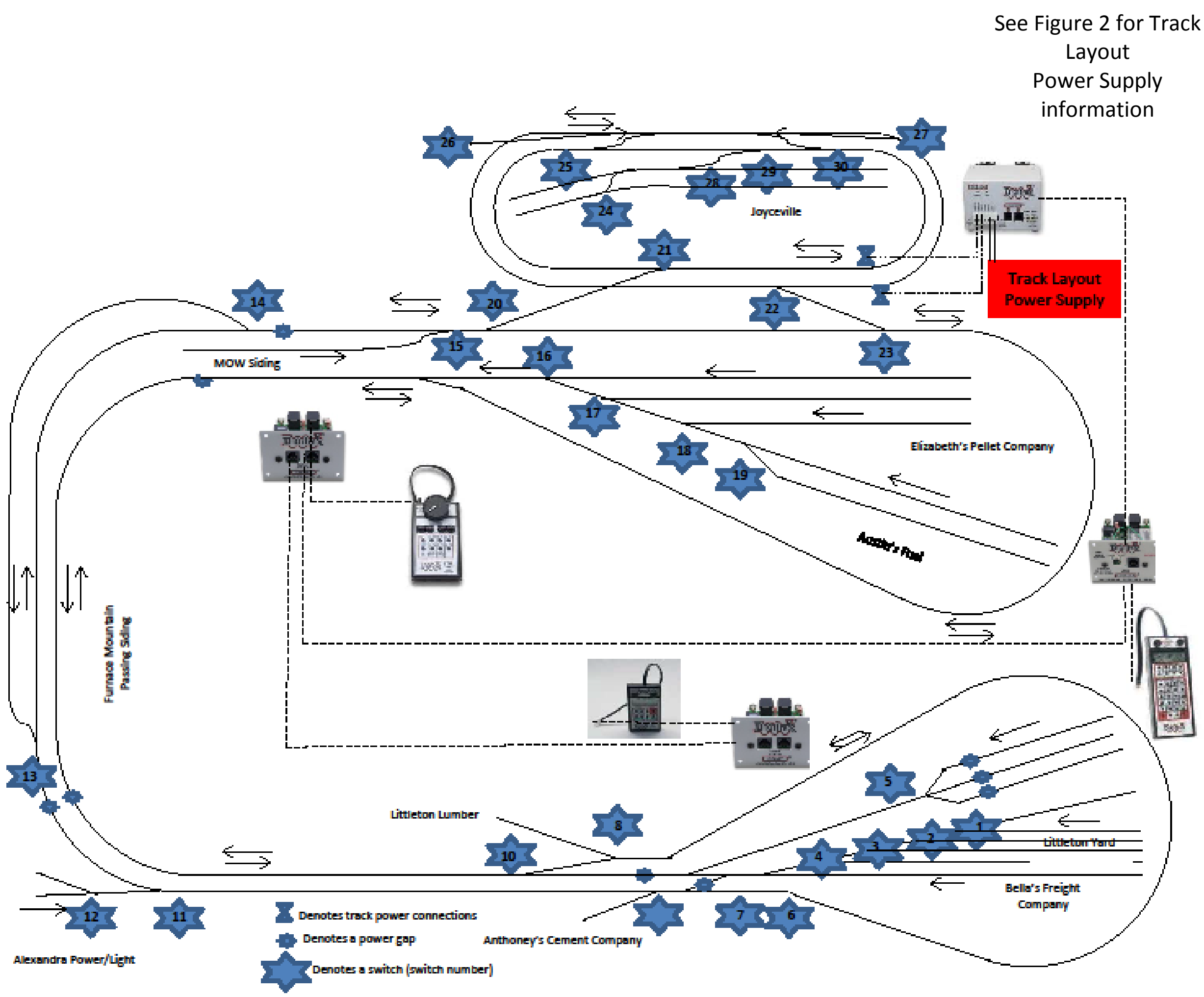


Figure 13

NSC Propulsion Schematic

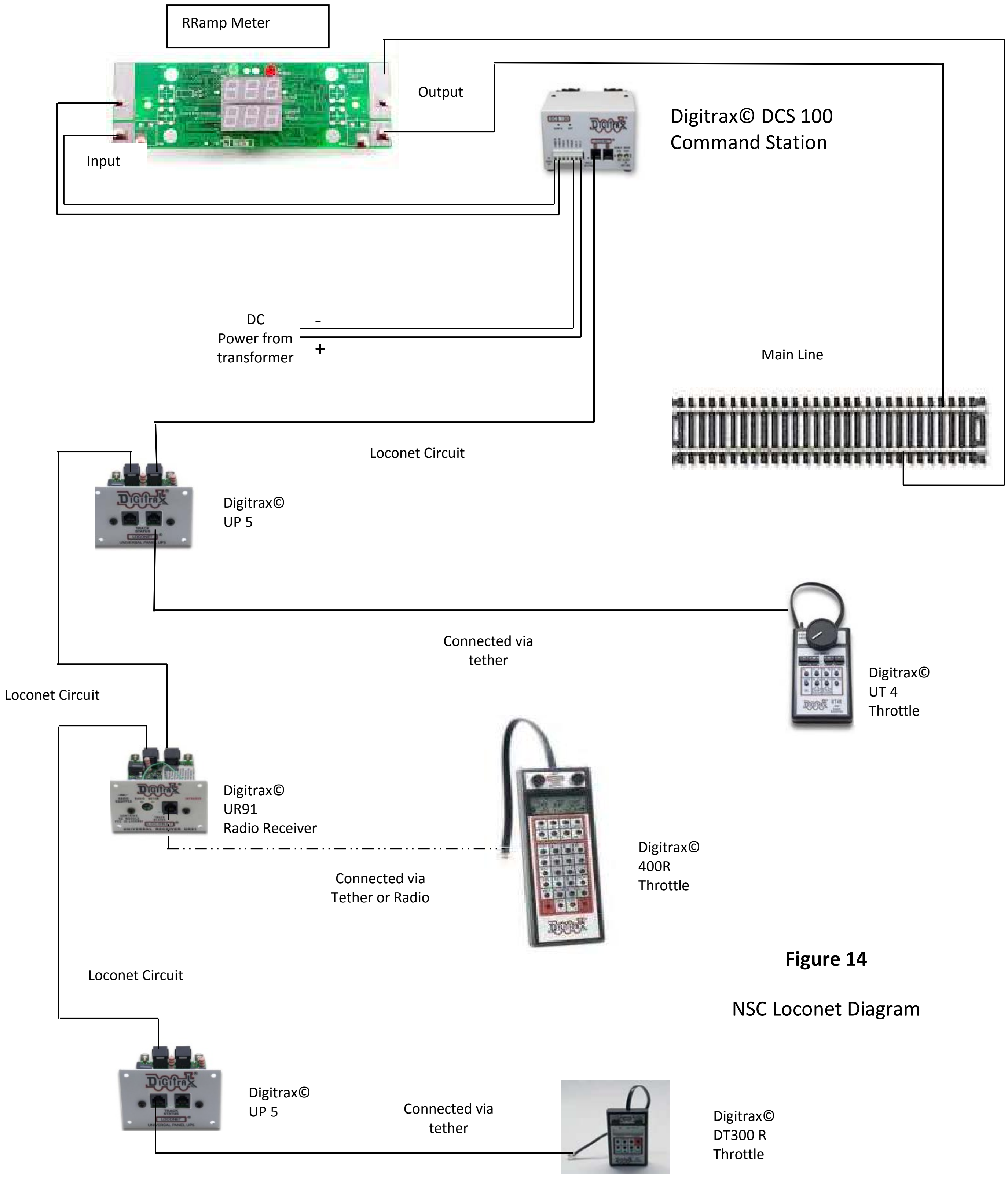


Figure 14

NSC Loconet Diagram

Layout Switch Power Schematic

The wiring to provide power for the controls of the layout switches was shown in Figure 7. The following schematic reflects how the layout switch circuit is done.

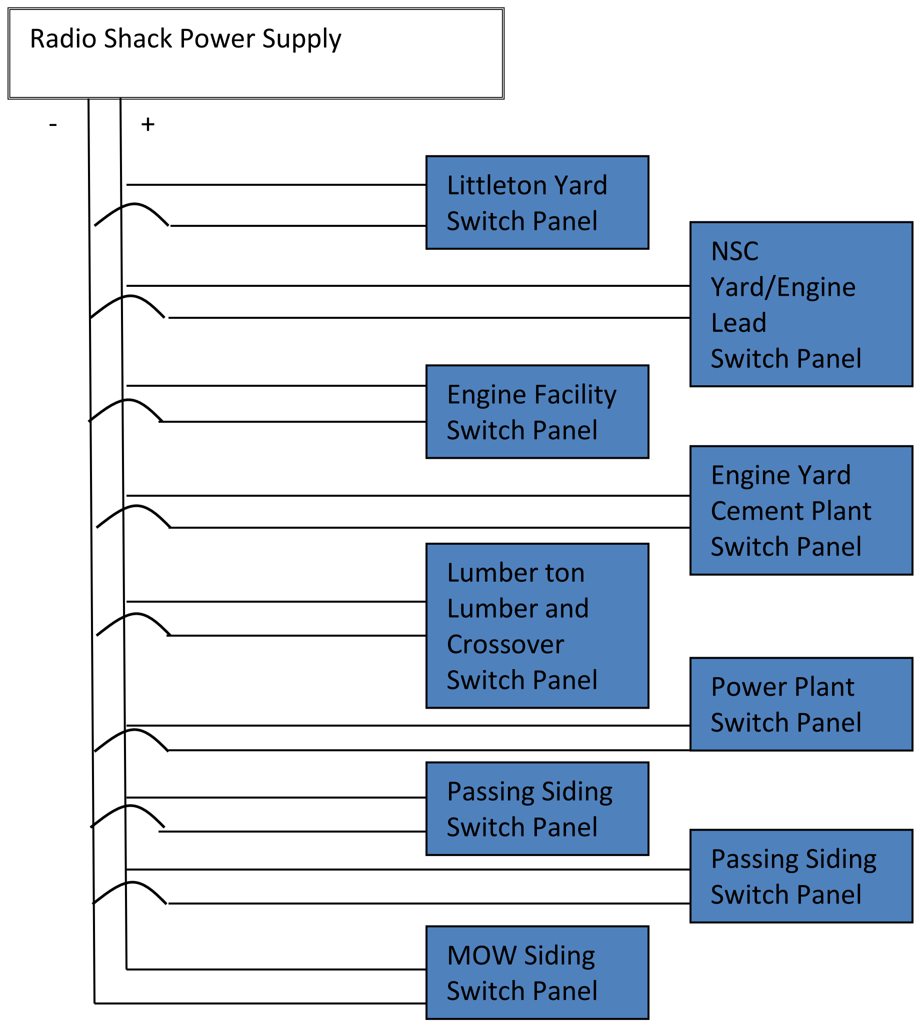


Figure 15
NSC Layout Switch Power Schematic

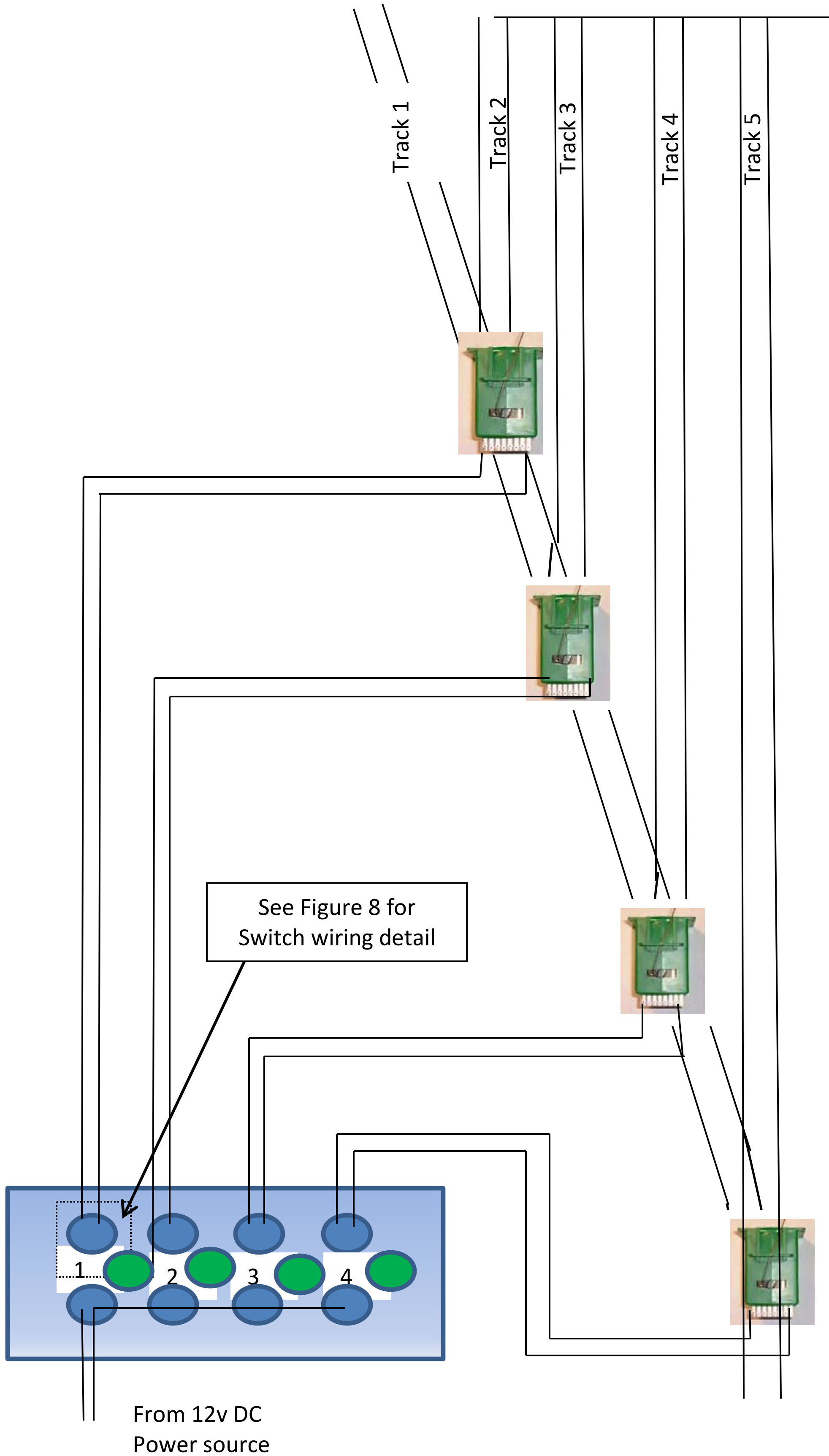
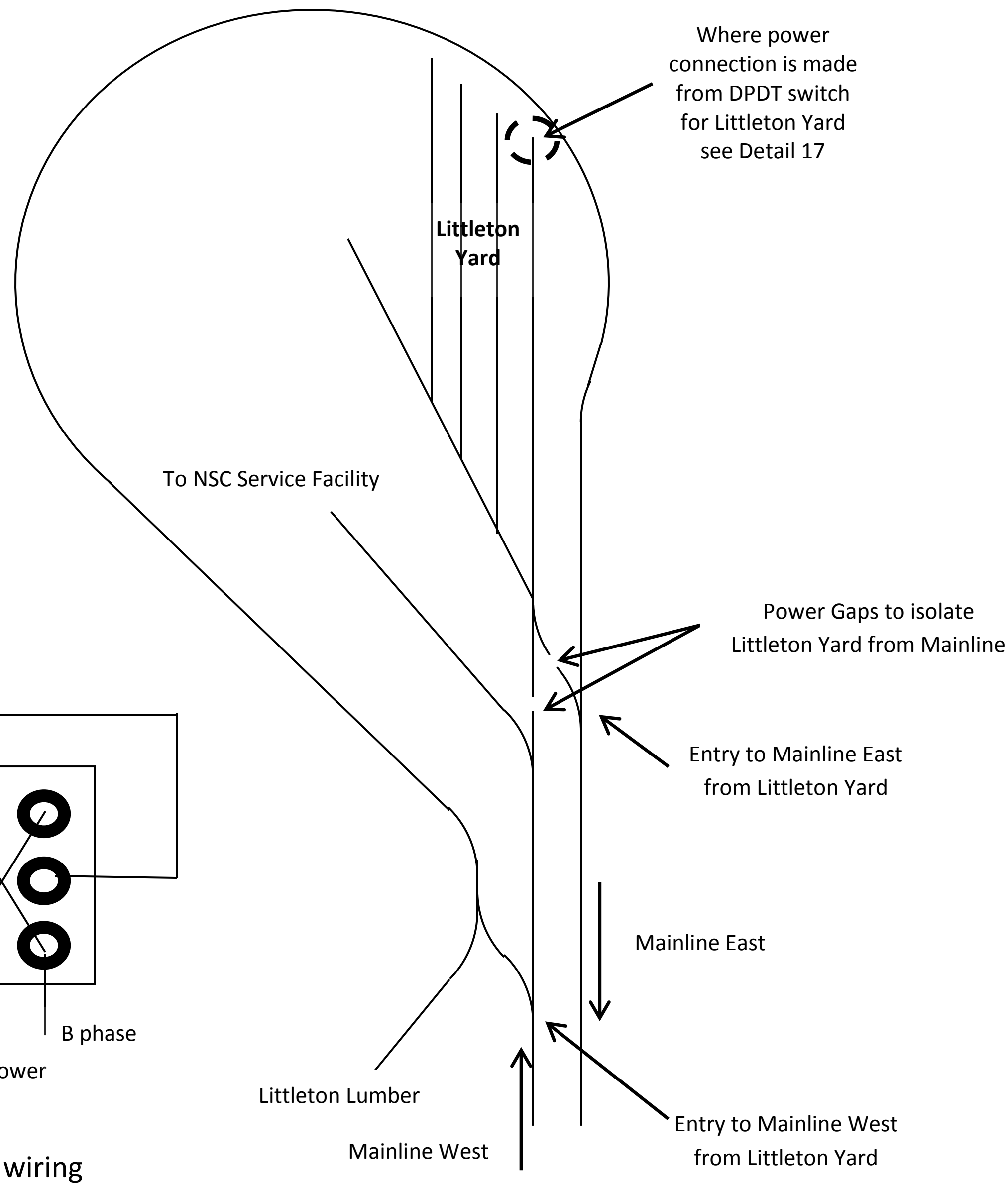


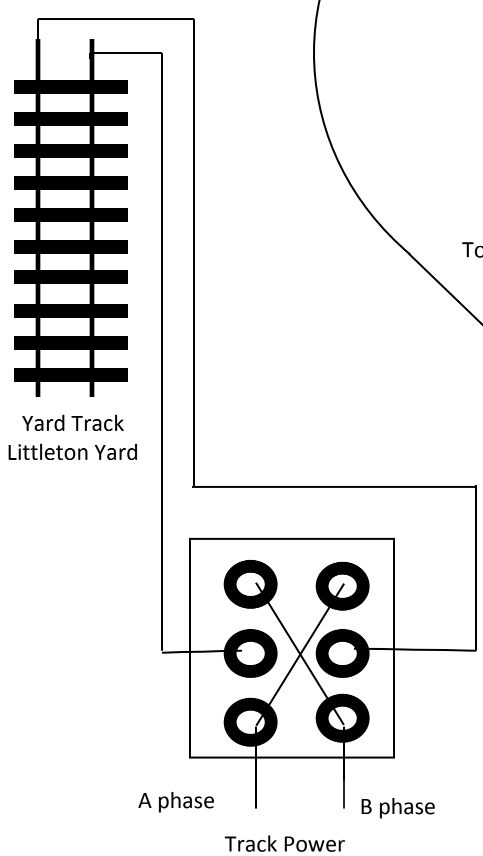
Figure 16
Littleton Yard
Switch Panel

Figure 17

Littleton Yard reversing

As stated under power gaps on Page 5 the Littleton Yard is isolated from the main line track Just west of the Littleton Yard spur near the lumber company. This gaping provides electrical isolation of the Littleton Yard from the main line and allows the phase of the Littleton Yard to be manually changed, through use of a DPDT switch, so the yard power will match where entry to the section of main line is desired. Locomotives can be turned by entering and leaving different entrances into the Littleton Yard. This functions as a reversal loop.





Detail 17
A DPDT Switch and wiring
for phase reversal in Littleton Yard

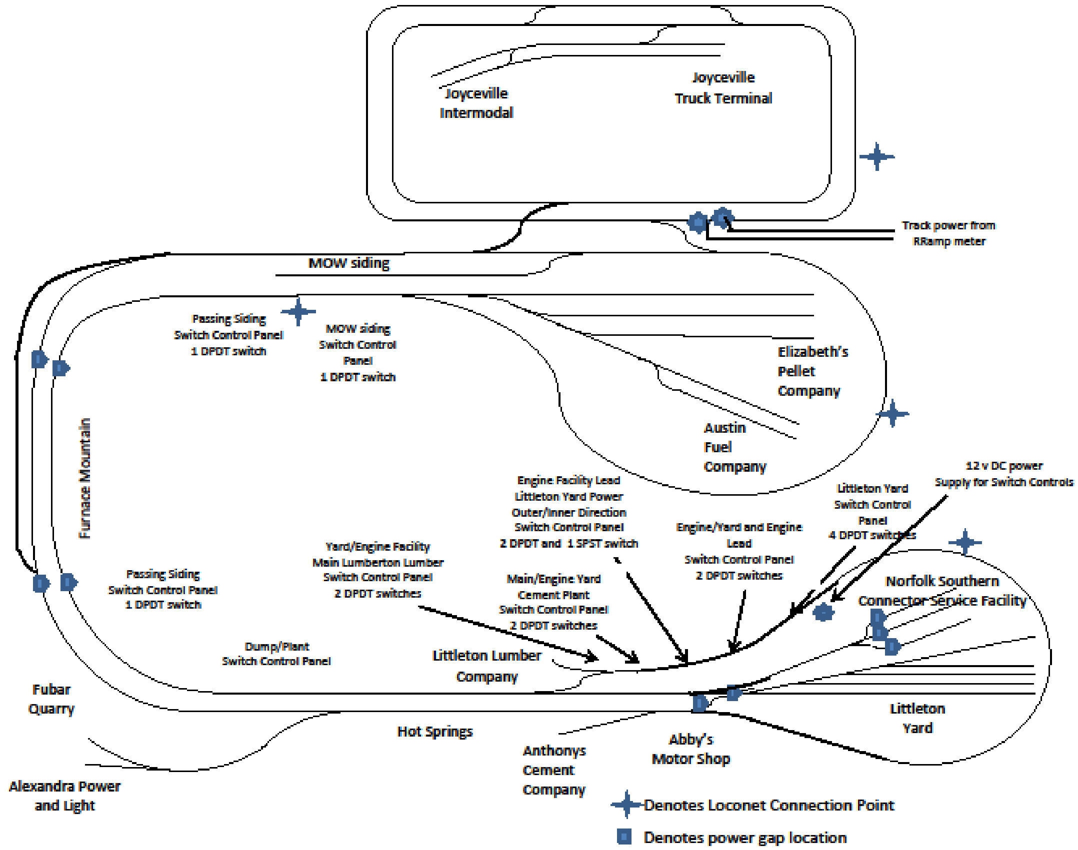


Figure 18

NSC Electrical Switch, Power Gaps, Feeders, and Power Supplies

Requirement #6 -Trackwork Features, Construction Methods, and Commercial Components

The NSC is currently a one tier train layout that is contained in one room. Plans are being developed to make it a two tier layout by creation of a second deck and utilization of a Digitrax© DB150 command station. A track plan for the NSC was provided in Figure 1.

For requirements 2 and 3, the track work features, methods of their construction, and a summary list of the commercial components are provided as follows:

Track work features-

All turnouts, crossings, crossovers, and the three-way turnout were commercial components. There are not any hand-laid tracks used on the NSC layout.

LH and RH #6 turnouts were installed throughout the layout.

A curved switch was used on the spur to the power plant to accommodate the switch in the space available.

A three-way turnout was used on the spur to the Engine Servicing facility to allow the use of all three bays of the facility from one track.

Rerailers were used in several locations in the layout to minimize the number of locomotives derailing when negotiating the layout.

Wiring and installation instructions provided by manufacturers of the commercial components used on the layout were followed to make them ready for operation.

Bumping posts were installed at the end of all sidings and staging tracks.

Commercial turnout motors were installed on many of the turnouts located on the layout and are controlled through the use of hand built switch panels that are equipped with visual indicators to provide the status of the switch at a glance. DPDT switches were utilized as the control for the turnout motor. Details on the wiring of the turnout controls is provided in Figures 8, 14, and 15.

The commercial turnout motors were installed underneath of the switches except in one instance where it was installed on the top of the layout and contained within a building.

There are ground turnout throws located on a few of the switches.

Programming of DCC locomotives is done with a programming track connected to a Digitrax DCS100 Command Station.

Schematic diagrams have been provided for the items I chose to demonstrate for requirements 2 and 3.

The entire layout is controlled by use of a Digitrax DCS 100 Command station, a loconet system, and Digitrax Cab throttles all of which are capable of tethered operation and some of which are capable of radio and Infra-red control.

No decoders are in use on turnout motors on the NSC layout.

Methods of Construction-

Several methods were used for the construction of the track which involved many techniques which I will summarize below:

Normal track construction practices were followed for laying track on the NSC including the installation of commercial turnouts, crossings, crossovers, and a three way turnout.

The layout support consists of L girder design topped with 5/8” plywood and ½” homosote on much of the layout.

Cork roadbed was installed on top of the homosote or plywood to provide support for the track.

Flex track was used on much of the layout and where flex track was not used single sections of curved and straight track were utilized. All connections between track sections were made with appropriate rail joiners. After using the rail joiners the track was soldered together to provide a strong method of continuity for electrical current. The only exception to using conductive rail joiners and soldering was where a section of track required isolation when a non-conductive rail joiner was used and feeders were wired to the affected track section.

None of the switches installed had feeders connected to them.

Track power from the RRamp meter to the main line track is provided by using #12 conductor wires. The power supply providing the track power has constructed from parts secured from a train dealership following the instructions provided with the kit. The kit provided the enclosure, SPST switch, step down transformer, 8 amp circuit breaker, and power cord.

The DC power buss providing power to the Tortoise motors consists of a two conductor #16 wires. A commercial power supply made by Radio Shack was used to provide the 12v DC power.

Red/green bipolar LED were installed to provide a visual indication of the alignment of the switches having Tortoise motors attached to them. As the motors have sufficient resistance the need for 470 ohm resisters was resolved and the LEDs will not burn out due to exposure to higher voltages.

All wiring associated with the Tortoise motors was soldered and connectors were used to provide connection between the wiring and the motors themselves.

Switch panels were constructed of 1/8" plexiglass with the appropriate holes drilled into them to accommodate the installation of DPDT or SPST switches and LEDs.

A strip electrical multi-plug was utilized to control power to the layout electrical components.

A programming track was installed using the appropriate power connections to the Digitrax DCS100.

A Digitrax UR-91 was installed at a midpoint to the layout to permit the use of radio Cab controls.

Commercial Components used on the layout-

The following list of commercial components was used for the construction of the layout:

Turnouts-

Atlas LH and RH #6

Peco triple turnout

Shihahara curved #6

Circuitron Tortoise motors

Atlas Snap Switch controllers

Caboose Industries manual ground throws

Atlas Code 100 Nickel silver flex track

Atlas Code 100 Nickel silver straight and 15” and 18” radius curves

Radio Shack multi-voltage power supply

Minatronics DPDT and SPST switches

Minatronics 3mm bi-polar LEDs

#12 stranded copper wire

#16 stranded copper wire

Multiwire #22 loconet cable with connectors. The Loconet cables were home made and installed on the layout.

Controls-

Digitrax DCS100 Command Station

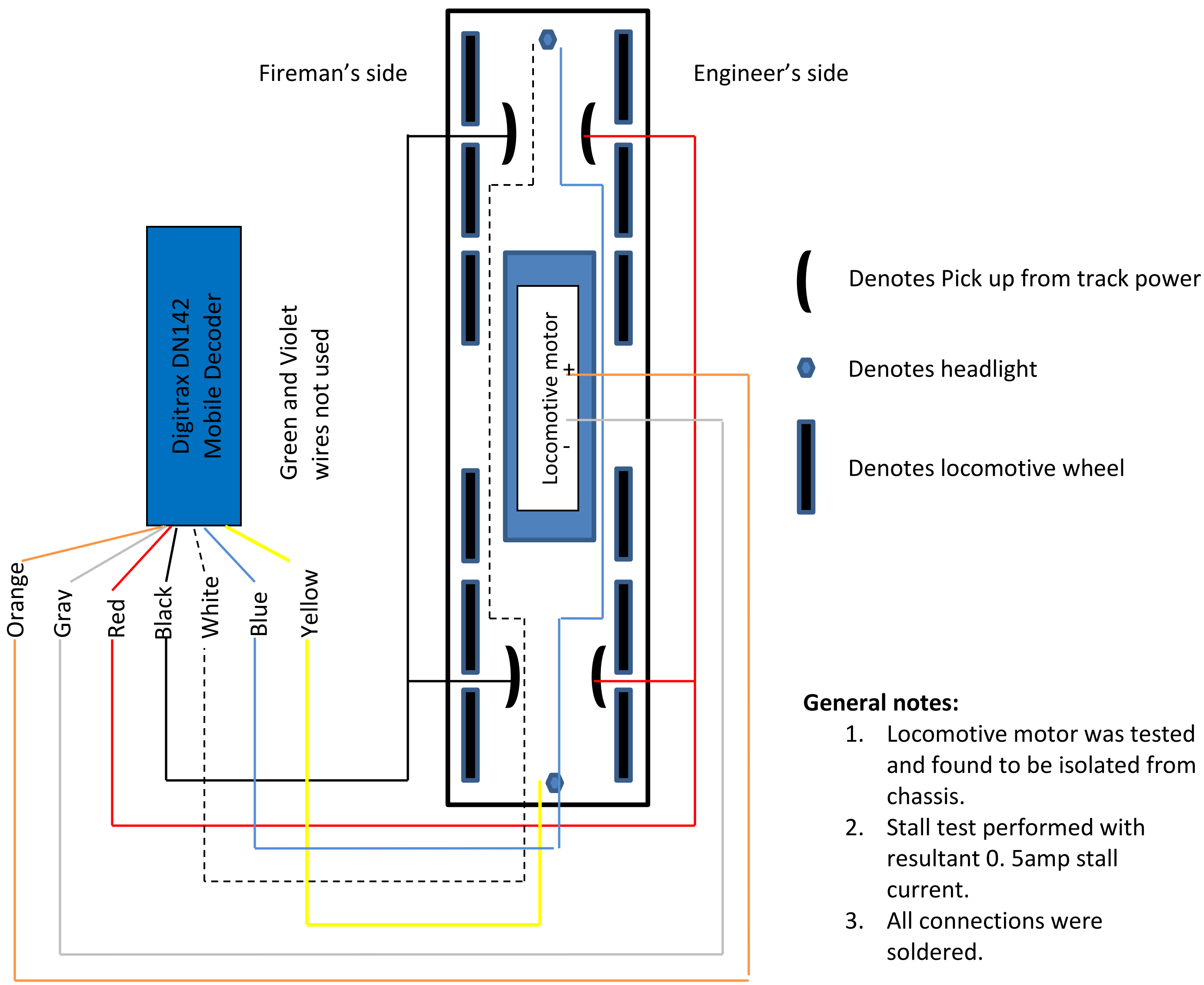
Digitrax UP-5, UR-91, and UP-5 Loconet interface panels

Digitrax DT400R, DR300R, and UT4 cab throttles

Springhaven Shops layout power transformer kit.

Appendix A

Installation of a Command Control Receiver



General notes:

1. Locomotive motor was tested and found to be isolated from chassis.
2. Stall test performed with resultant 0. 5amp stall current.
3. All connections were soldered.

Figure A1

Wiring Diagram

Digitrax DN142 mobile decoder installation in a Bachman Dash 8C HO locomotive

Step 1- Removal of the Locomotive's fuel tank

Picture 1

To remove the shell from the locomotive it was necessary to locate two screws on the fuel tank on the underbelly of the locomotive and remove them (Picture 1).

Picture 2

To remove the fuel tank from the shell I had to apply slight tension to the fuel tank and pull it away from the shell (Picture 2).

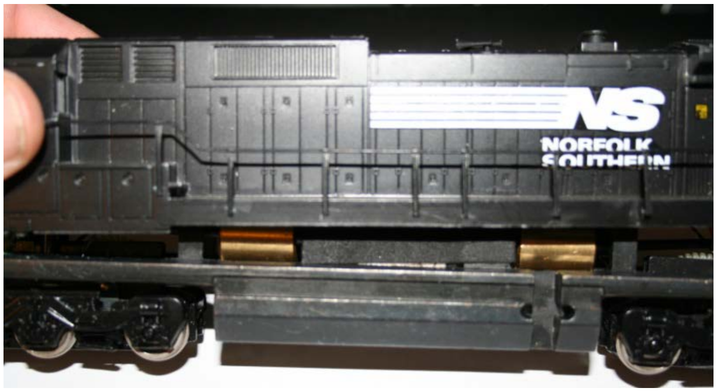
Step 2- Removal of the shell from the locomotive chassis

Picture 3

After removing the fuel tank from the shell access to the two additional screws holding the shell onto the locomotive chassis was gained (Pictures 3 and 4).

Picture 4

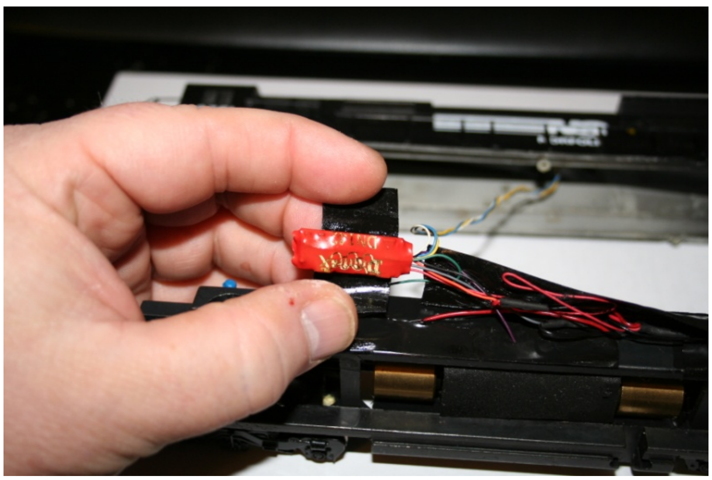
Using a Dremel wheel I burnished the contact points where the electrical contacts made contact with the chassis. With this particular Bachmann locomotive the chassis is a split chassis and each side is used as a conductor to transmit electricity to the motor assembly. By burnishing the contact points I was ensuring that the current picked up by the wheels would make good electrical contact with the chassis which had been painted. You can see the area I burnished above the second locomotive wheel (Picture 4).



After removal of both of the screws and associated screw retainers I was able to remove the shell from the chassis by applying gentle pressure to both of sides of the shell body and pulling away from the chassis (Picture 5).

Picture 5

Step -3 Installing the decoder



Picture 6

With the shell removed from the chassis, and taking care with the wiring to the front and rear headlights I was then able to access the wiring to the locomotive motor and electrical pickups. I had previously identified that from the factory this locomotive's motor was not isolated so I removed the motor by disassembling the chassis (four screws) , solder two wires to the motor, one to each of the power points, and placed two layers of electrical tape over the former electrical contact area. This isolated the motor from the chassis and then reinstalled the motor in the chassis. Following the wiring diagram I have provided in Figure A1 I proceeded to remove the factory locomotive control board and install the Digitrax DN142 decoder in its place soldering all electrical connections and then wrapping the connections in electrical tape or using shrink tubing (Picture 6).

Step 4- Securing the decoder and putting the shell back on the chassis

Prior to putting the shell back on the chassis the decoder and associated wiring to the chassis was secured using electrical tape to prevent interference with the operations of the locomotive. I then tested the light and motor functions (Picture 7).

Picture 7

After testing my installation II resecured the shell to the chassis and then the fuel tank assembly to the chassis. The decoder installation was successful. I then took the locomotive to the programming track and reconfigured the decoder address from the factory default of “03” to “8761” which is the road number of this locomotive.

Picture 8

Appendix B

Installation of a Command Control Clinic

Appendix B

Installation of a command control receiver clinic

The following is information I used to provide a clinic on the installation of decoders at a Boy Scout Show a couple of years ago---

Locomotives that operate on the NSC are equipped with decoders that enable them work on the Digitrax DCC system. Many of them were purchased with decoders already installed or were DCC ready and I installed a decoder in them. However, I have had to take locomotives that were not DCC ready and convert them to DCC (Athearn Locomotives). The installation of a digital command and control receiver, commonly known as a decoder, has several steps that must be followed to allow for a successful installation.

There are several things that should have been done prior to starting the installation. First is the selection of the decoder which is very important as installing or trying to install the wrong decoder will lead to a lot of frustration. One of the first steps in the selection process is what size of decoder you need. In this case we are not speaking of physical size, rather, we are looking at what current rating is needed to provide the electrical capacity large enough to supply the locomotive’s electric motor. A stall test needs to be performed to determine what the maximum draw, in terms of current, was required by the locomotive. This allows us to select a decoder that is rated for the amount of current which will be needed by the locomotive when it is first starting from a dead stop, when the maximum draw of electric current takes place.
Another step in the selection process is to determine what physical size decoder can be installed in the locomotive’s frame and shell. Although decoders are designed for N, HO, O, G and the other gauges of track, just because you have a particular scale decoder doesn’t mean that that decoder will fit in the locomotive itself. For example for a steam engine you may need to locate the decoder in the tender due to space limitations inside the body of the steam locomotive’s body. Another step in the selection process, just as important as the other two we have already mentioned, is selecting a decoder that is compatible with the wiring of the locomotive. Today’s decoders are of such design that they can be installed using at least three different methods in a locomotive.

- ❖ Direct replacement of a circuit board with a decoder circuit board,
- ❖ Removal of a dummy plug which allows the installation of a plug attached to a decoder that just plugs into the provided receptacle, or
- ❖ Rewiring of the locomotive to connect the decoder’s wires to the appropriate wires on the locomotive. This is the method you will have to use if your locomotive is not DCC ready.

The decoder that allows it to be installed, taking up the least amount of space and is compatible with the locomotive’s wiring system is the one you want to install. Remember rule number 1; Model railroading is supposed to be a fun and enjoyable activity.

Next you will have to determine how to remove the shell of the locomotive, and there isn’t only one way to do it. If you can find the literature that came with the locomotive you should be able to find a drawing of the locomotive that shows the how the parts are assembled. If you can’t find, or never did have such a thing, then you are into the next challenge of installation. Locomotives usually can have the shells removed by one of the following methods.

- Removal of screws that go through the frame into a retainer that is attached to the shell.
- Removal of the screws that retain the couplers and perhaps removal of the couplers also.
- Slight squeezing of the shell at two or more points to permit the retention devices to release.
- Slight spreading of the shell on each side of the frame to permit retention devices to release.

If none of the above work, or if you are not sure, you may want to get in touch with your hobby shop expert to seek their advice. You could also surf the Internet as there are web sites dealing with decoder installation that have step-by-step directions for some of the more popular brands of locomotives. (I.E. Digitrax.com or Digitrax@yahoogroups.com)

Now that you have gotten this far and have made the decision that you are going to get the decoder installed in your favorite locomotive, perhaps with a little help, and you have gotten the shell off of the frame without breaking it you are ready to move to the installation of the decoder itself.

Looking at the internal workings of the locomotive you need to determine if the locomotive's electric motor is ***isolated*** from the frame. For the decoder to work all paths that current can get to the motor from the rails must be intercepted by the decoder or it isn't going to work and probably short out and go up in smoke. Some locomotives use the frame as a method to carry current from one of the rail pickups to the motor. If you encounter this the wiring must be changed so this isn't the case. A simple test with a continuity light will tell you if this is true or not. If you find continuity between either of the two motor wires and the frame that indicates that the frame is being used for pickup and you will need to modify the wiring to make the pickup come through the decoder instead. This will involve connecting a new wire to the frame, possibly removing an internal connector between the motor and the frame, and installing a layer of insulated material (I.E. electrical tape) between the motor and the frame.

Once you assure that the locomotive's electric motor is isolated, you can now get to the nuts and bolts of decoder installation.

For non-DCC ready locomotives you will probably have to modify the wiring of your locomotive or attach wires to the solder terminals on the decoder board. I recommend that you solder them using an appropriate wattage solder iron or pencil. You should also use fine electronic solder and rosin soldering paste or fine electronic solder with rosin. The use of an appropriate weight of solder and type of flux is important as use of the wrong type may be corrosive the to electrical wire and connectors. Use enough heat but not too much as we don't want to melt the circuit boards or decoder chip.

Some soldering tips:

- Strip and tin the wire tip,
- Put a small quantity of paste on the tinned tip and board,
- Clean any excess rosin off immediately with alcohol.

The decoder should come with a set of directions showing the wire colors and their purposes.

The wiring of a DDC decoder has been simplified for you by the standards set out by the National Model Railroaders Association for colors of the wires relating to their purpose and the connector size and pin locations on the connectors.

The wires you see on the decoder are ***<u>coded</u>*** as follows:
BLACK wire- left rail pick up
RED wire- right rail pick up
Orange wire- electric motor negative
Gray wire- electric motor positive

Think of it like this gray is a light black and orange is a light red.

BLUE wire- a common for the functions
WHITE wire- the forward headlight (F0)
YELLOW wire- the reverse headlight (F0)
OTHER wires- related to other functions depending upon the decoder.

The headlight bulbs on the locomotive may need to be changed depending upon what voltage they are rated for. Many older locomotives used bulbs that were not rated for 12-14 volt operation. Unless you selected a decoder that has voltage control to the headlights you will have to install a resistor on the wires going to the headlights to drop the voltage for the 1.5-volt rated headlights. The size of the resistor will depend upon how much amperage the headlight uses. If you don't know what the draw is start with a 1,000 OHM, ½ watt resistor and work you way down until you get enough light. Headlights rated for over 12-14 volts will not present a problem.

You need to secure the decoder to the frame using something that is not electrically conductive, such as double sided adhesive, electrical, or scotch tape. Remember to dress up the wiring so it doesn't interfere with any of the moving parts of the locomotive. Give the decoder a little bit of room to breath, remember, it has current going through it and it will heat up, especially when you are trying to pull a large train with it..

Then put the shell back on the frame and secure it in place by using whatever retention system it uses. You are then ready to program the decoder if it requires such.

The brand of decoder you selected will dictate how you program it. One of the first things you probably will want to do is assign it an address so that you can control your locomotive. This will probably require you to program it to a new address different from the default. You will have to decide if you want a two digit or four-digit address. Your decoder may or may not be capable of four digit addressing. You will also want to look at programming the functions 1-6, if applicable to your decoder, the NDT (Normal Direction of Travel), and F0 (headlight function).

After successfully installing a DDC decoder you should run it on the layout and confirm that all of the functions are working properly.