Application for NMRA AP Engineer- Electrical

Introduction

I have included a detailed explanation of my application on the following pages. Because of the difference in numbering of the requirements between the Web page documentation and the older SOQ, I have tried to bring them together in a way that is understandable.

This is my second application for the AP EE, the other having fallen between the cracks of the system. One was back in the 1990s when I was AP chair of the Du Page division and the application was signed by the Super as I should not sign my own. That was a different layout in a different house.

Parts of the requirements contained in this set of documentations come from the early layout and were witnessed by Bon French, Keith McMillen, Chuck La Buda, Brian Wussow and Charlie Lewis, all still members of the NMRA. The new layout has been witnessed by Bon French, Charlie Lewis, Brian Wussow, Roger Blocks, and Keith Mc Millen. An additional layout installation in the Choo Choo Store of Three Lakes Wisconsin has been witnessed by Roger Blocks, Dale and Janel Wolke, as well as the members of the Three Lakes Model Railroad Club (Wisconsin's only 100% NMRA Club) and was visited by Mark and Marvin Preussler while on their fishing trip last summer.

My layout undergoes changes and upgrades and is anything but static. While there is no scenery as yet changes to the structure continue and replacement of track in some yards continues as I try to balance the use of code 83 track from different suppliers. Rhinelander yard was originally on pink foam but due to noise it is being replaced with furniture grade plywood. A passing siding and two opposite facing sidings provide operation at the temporary tracks in Rhinelander.

As stated above I have included material from layouts that have been retired and witnessed in the past by other members

Thanks,

Paul A. Wussow

Section Descriptions based on NMRA Web Site

Section 1.A

1) Construct and demonstrate on your own or a club layout, the satisfactory operation of an electrical control system on a model railroad capable of simultaneous and independent control of two mainline trains in either direction, and containing at least gaps, switches to maintain polarity and phase if needed, and troubleshooting.

2) This layout should contain at least one mainline passing siding.

3) This layout should contain One reverse loop

4) This layout should contain one yard with a minimum of three tracks and a switching lead independent of the main line.

5) This layout should contain facilities for storing at least 2 unused motive power units.

6) This layout should have at least One Power supply with protective devices to ensure safe operation.

Section 1.B

1) DC layout with at least 5 electrical blocks that can be controlled independently.

2) This layout should contain at least one mainline passing siding.

3) This layout should contain One reverse loop

4) This layout should contain one yard with a minimum of three tracks and a switching lead independent of the main line.

5) This layout should contain facilities for storing at least 2 unused motive power units.

6) This layout should have at least One Power supply with protective devices to ensure safe operation.

Section 2

Wire and demonstrate the electrical operation of at least three of the items listed

Selected Items:

2-1) Turnout

2-2) Crossing

2-3) Crossover

2-4) Double Crossover

Section 3

Wire and demonstrate the electrical operation of at least three of the items listed

Selected Items:

3-1) Electrical Turnout Position indication on a control panel for a minimum of four turnouts

3-3) Cab control

3-5) Two turnout junctions with electrical interlocking and protecting trackside signals.

3-7) Electronic Throttle with Inertia and braking

3-8) Grade crossing with electrically actuated warning indication.

3-14) Installation of a Command control receiver modifications to locomotive

3-15) Installation of a Command control buss line around the layout handling two throttles at 3 or more locations. Added Radio control throttles.

3-16) Construction of a sound system using commercial parts from different suppliers to complete an on board sound system.

3-22) DCC with JMRI RS232 serial Interface for locomotive ID and programming

3-23A) Other: Flashing warning device

3-23B) Other: Fast Time Clock

3-23C) Other: Lighting FX for a locomotive

3-23D) Other: DC operated normal and oscillating headlight and power regulation.

Section 4

1A) Attached is the track diagrams of the DCC layout with the blocks color coded. Also attached is the documentation of the DCC system having a control station and two 5 Amp. Booster and a total of ten breaker districts including 2 auto reverse section breakers. Each Booster and breaker contains LED indications of their function and breaker status.

Feeder wires are shown on photos #12 wire is used to reach the breaker districts from the control point and #18 or #22 wire is used to feed the track in each district. Examples of track feeders and gaps are shown in photos.

1B) Contains documentation of the DC layout built before the DCC layout using DC power supplies and throttles to connect to blocks controlled by DPDT switches. Yard control allowed for the operation of a yard locomotive and one mainline locomotive. Storage tracks used SPST switches to turn off power when not in use.

Section 5

Schematic drawings are supplied with numbers referring to the item based on sections 2 and 3

SOQ Section 4

Section 1A Documentation for DCC layout

The first set of drawings is of my Perch Lake and Superior layout in Glen Ellyn IL. The layout operates on NCE DCC Command Control with 2 Boosters and 10 breaker districts providing sufficient gaps and controls to maintain polarity, phase and trouble shooting. I have included 4 drawings of the layout, a full drawing and one for each level described below. Color coded lines in the drawing denote the blocks or breaker districts. Also at the end of this section is a typical drawing for a breaker district.

There are 3 levels to the layout:

> The Lower level (LL) contains a portion of the main Line, 2 staging yards, a reverse loop and a holding area.
> This LL level is considered hidden however one may use LED light to see into the operating space.
>
> > The main line is rendered in Black
> > The North Staging yard is rendered in Green
> > The South Staging yard is in rendered a Pink
> > The reverse loop is rendered in Purple
>
> The Mid Level is visible and contains the main line and Bradley Junction with industrial sidings.
>
> > The main line is rendered in Red
> > The Junction and industries are rendered in Light Blue
>
> The Upper Level has the main line Rheinlander Yard and a reverse loop.
>
> > The main line is rendered in Blue
> > Rhinelander is rendered in Tan
> > The upper reverse loop is rendered in Yellow

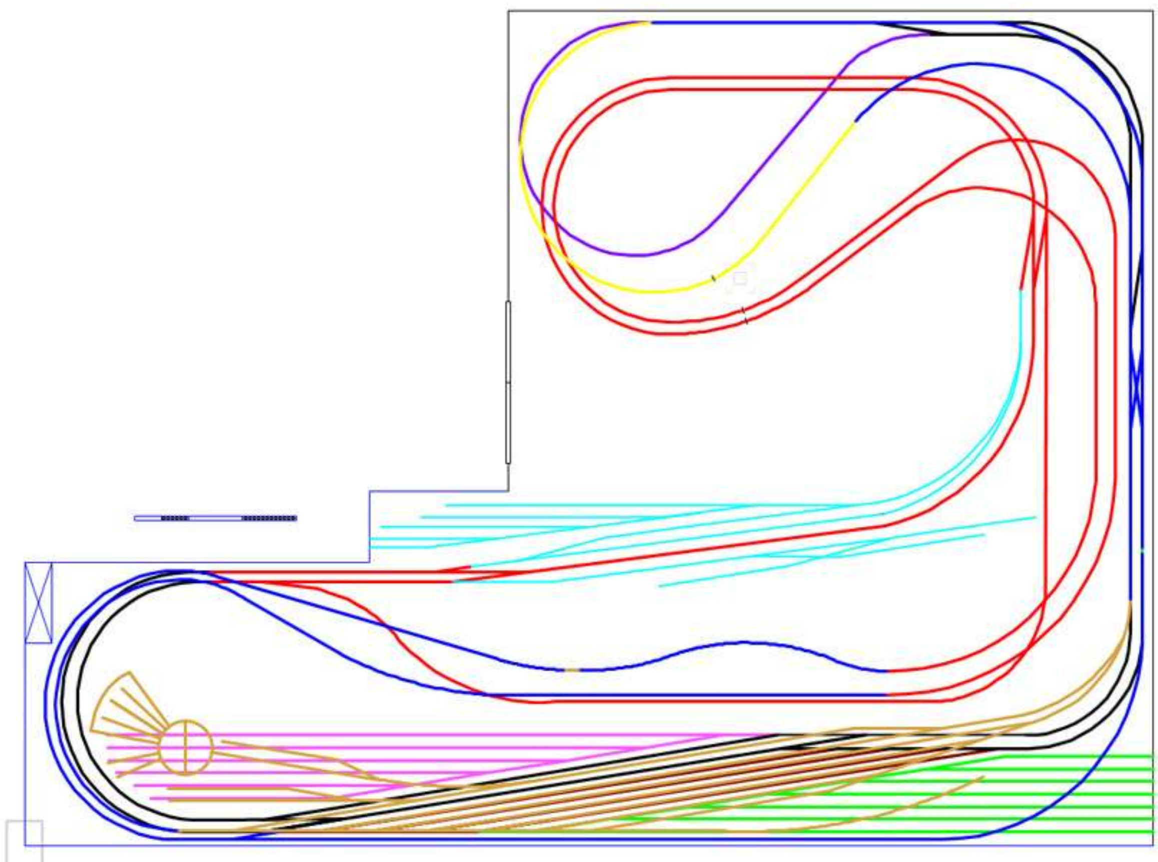
Each of these colors represents a different breaker zone on the layout. I divide the layout by Booster divisions and each booster into sub-divisions or breaker divisions. I use DCC Specialties PSX series intelligent solid state circuit breakers with integrated block detection and feedback.

Eight of these boards along with two PSX-AR auto reversers protect the layout. Parallel gaps are cut in the track and grounding is connected between the boosters. The system contains a NCE Power Pro System with an internal 5 amp booster and a PB105 5 amp booster. These units are connected to the circuit breakers and then to layout feeders using #12 wires. The track connections are # 18 or #22 short wires connecting the rails to the #12 feeders. Wire drops are used liberally to ensure proper voltage and current to all parts of the layout.

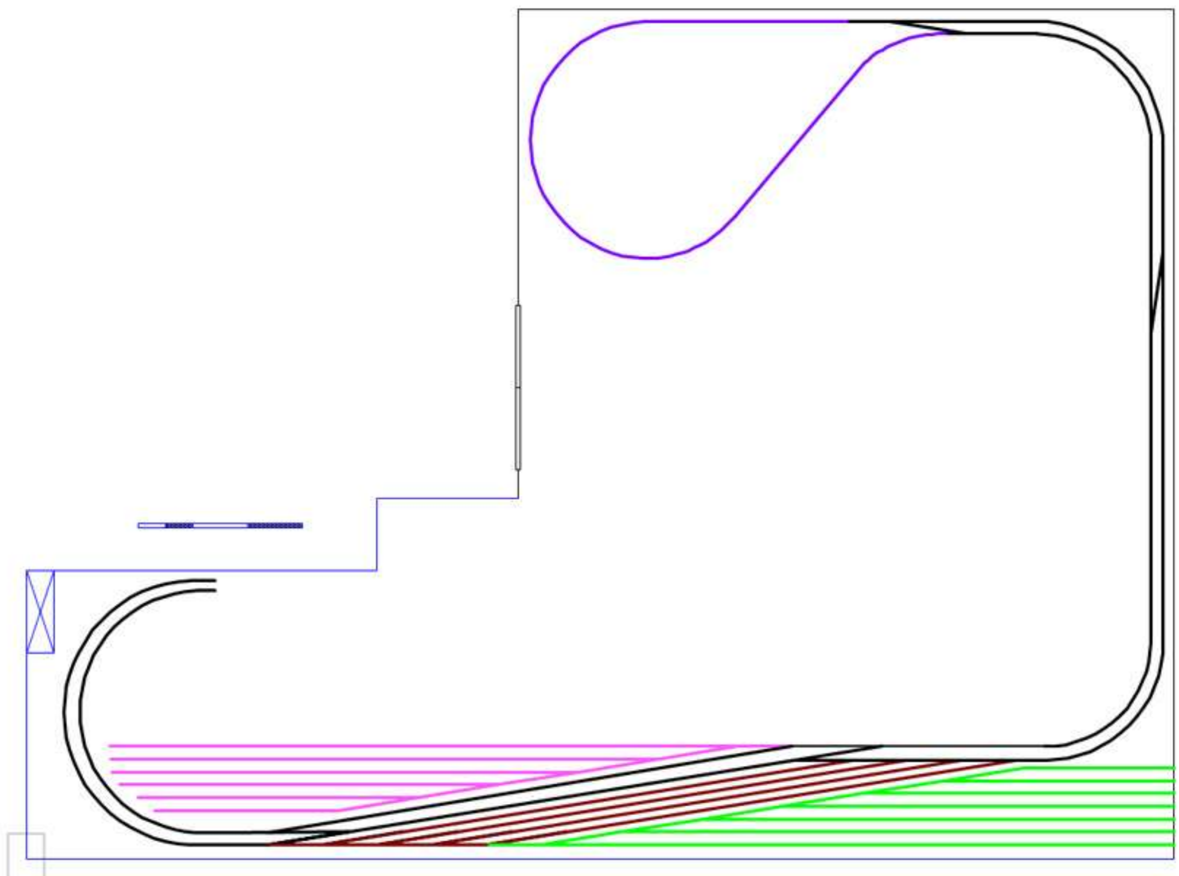
The Power Pro command station is connected to the Cab Buss which provides connections around the layout for wired hand held walk-around throttles. A RB102 radio receiver is also installed for use with the wireless throttles. I do not need repeaters due to the size of the room and the layout.

Power is supplied by 2 individual DCC Specialties Magna Force model MF615 Class 2 Safe (Separated) extra-low voltage (SELV) Transformers. These power supplies have 3 prong grounded plugs and are protected with circuit breakers and surge protection connected to a wall outlet that is connected to the house power. When the layout is not in use the house power is shut off to the power outlets in the Railroad room by a wall switch, different than the room lighting switches.

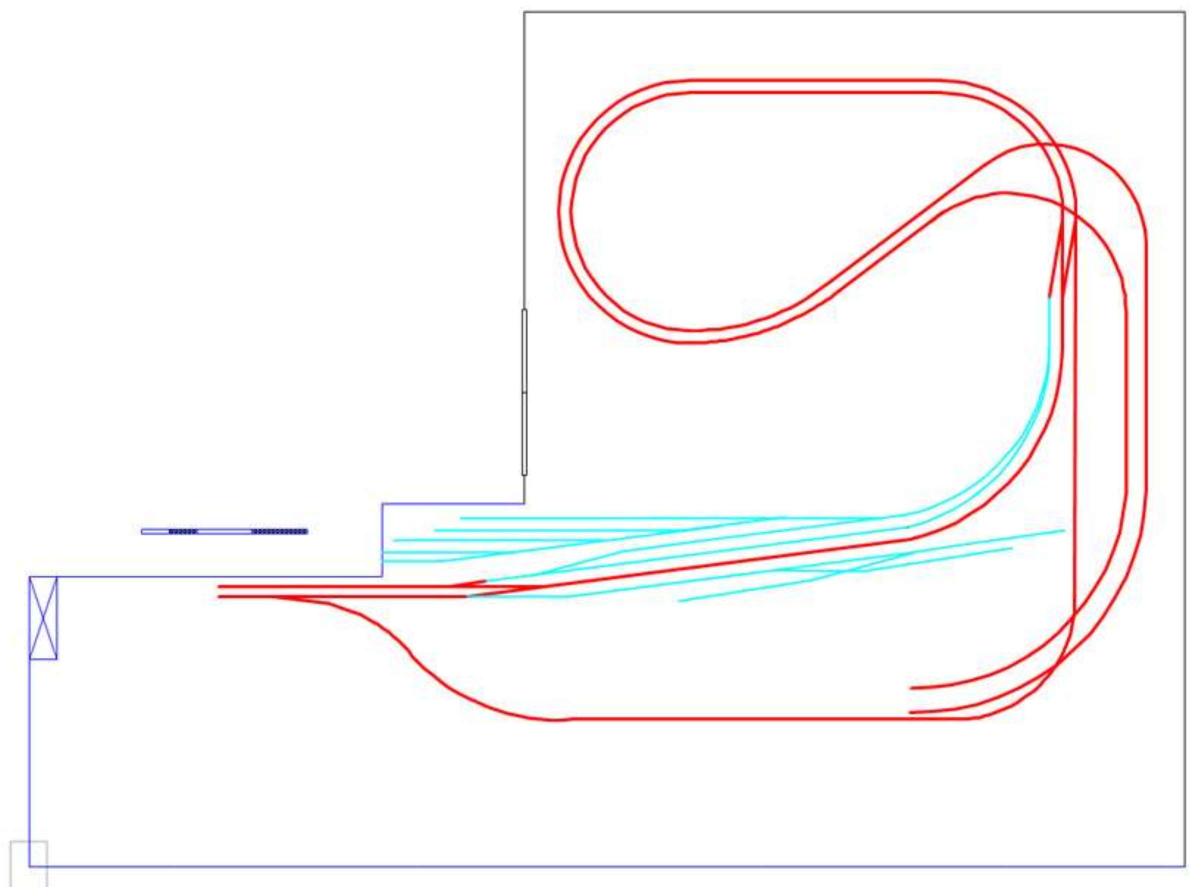
Perch Lake and Superior Railroad
Total overview of all layers



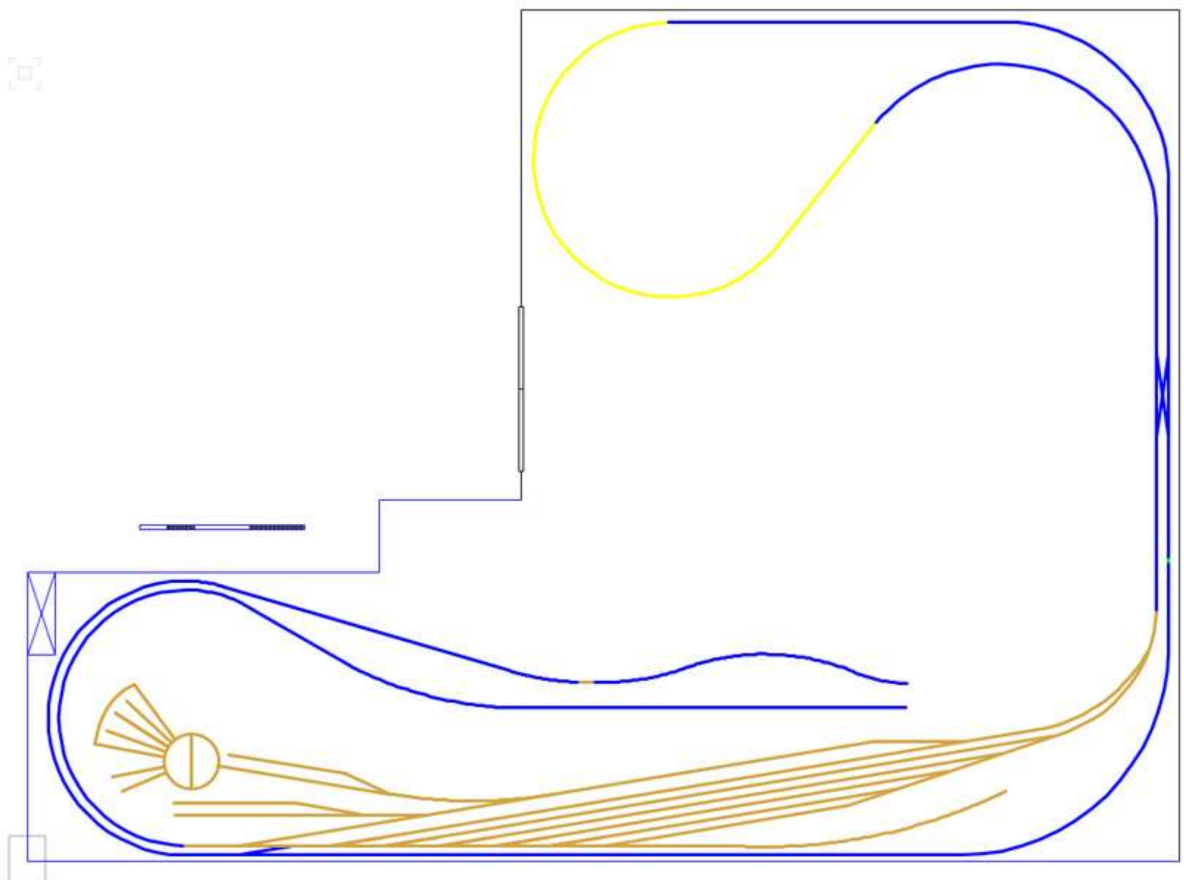
Lower level



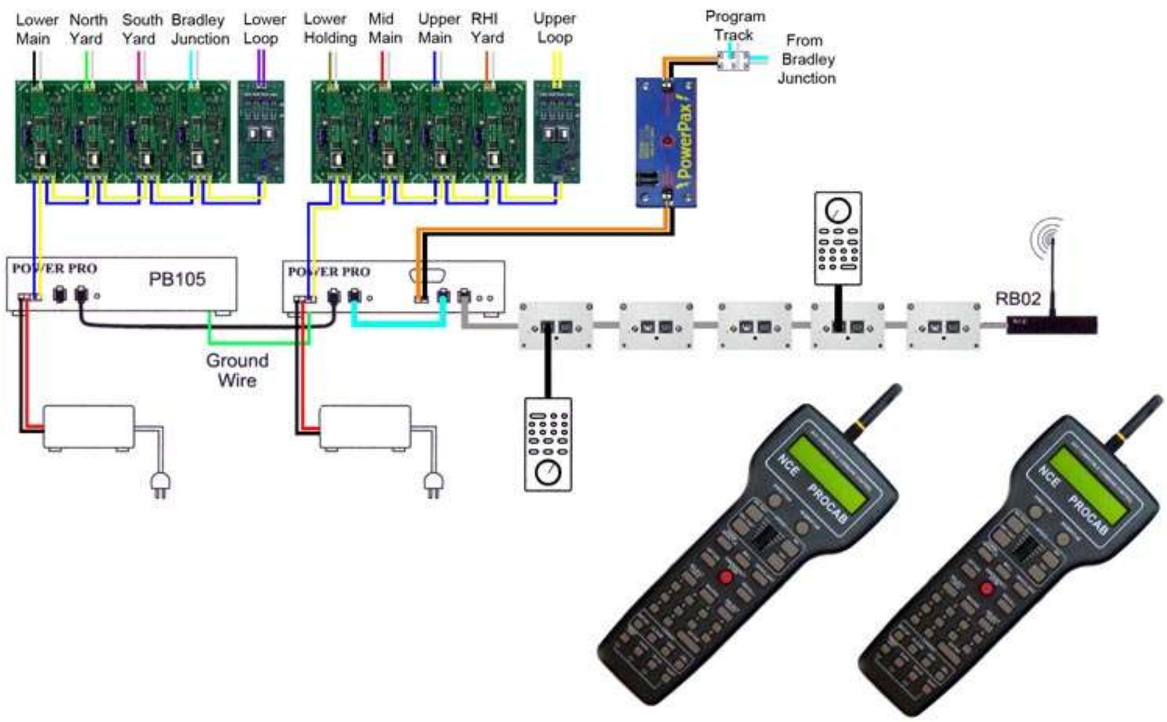
Mid Level



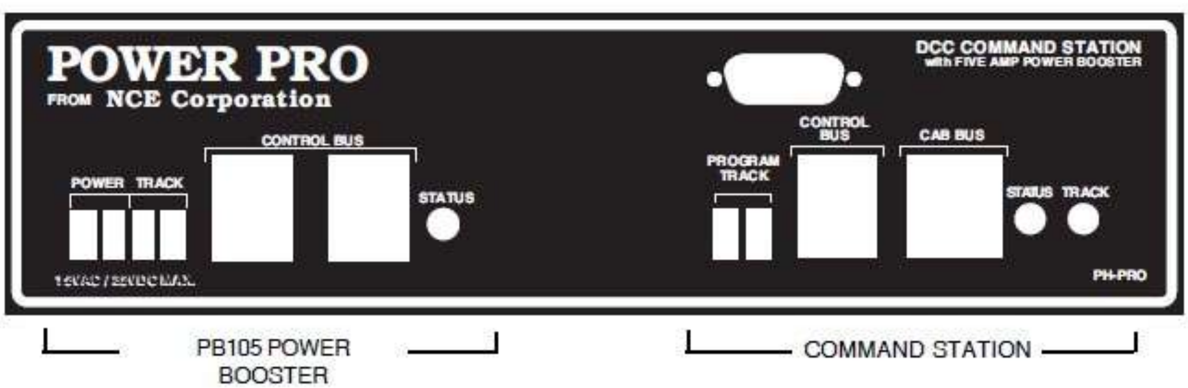
Upper Level



Command Station, Boosters, Protection circuits, Auto Reverse Loop control, and Power for Programming track with selection switch

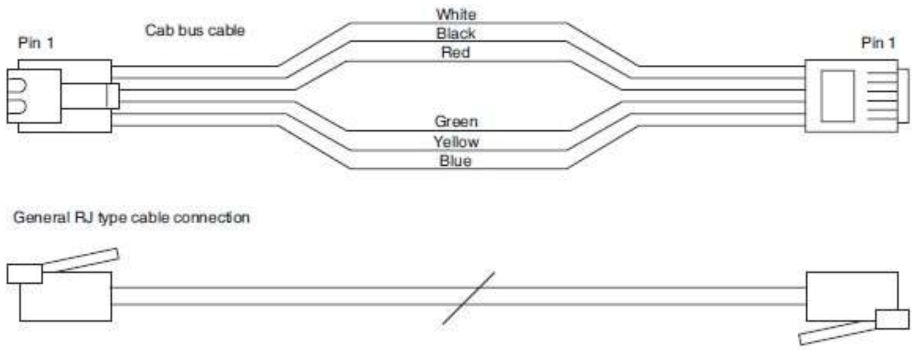


In the power distribution drawing we see the NCE PH Pro



This is the main control unit for the NCE DCC and includes a 5 Amp Booster and shown here.

In the distribution drawing, above, you will see the gray buss wire goes to the Cab Bus which connects to the UTP cab bus connectors placed around the layout by way of the bus wire shown below.



6 WIRE CAB BUS CABLE WITH RJ-12 CONNECTORS

Pin #	Color	Description
Pin 1	White	No Connection, reserved
Pin 2	Black	Ground
Pin 3	Red	- RS-485
Pin 4	Green	+ RS-485
Pin 5	Yellow	+12 volts
Pin 6	Blue	No Connection, reserved

UTP Panel

The Radio Cabs communicate via the Radio Base (RB02) that is connected to the end of the cab bus.

The control bus connects with a Light Blue connection from the Command Station control Bus socket to the Power booster control buss socket. There are two Control Bus sockets allowing daisy chaining boosters, as is shown with the black wire to the PB105.

Each booster has power supply wires shown as red and black that connect to their power supplies.

Each Booster also has a track output which goes to a set of PSX cards to form breaker districts. These wires on the drawing are blue and yellow.

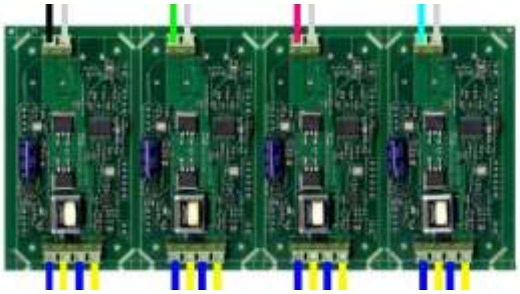
In addition to these connections the Command Station portion of the PH Pro has an output for a programming track. I use a PowerPax to increase the current in the Programming track for programming locomotives with sound systems. The PowerPax has input from the command station, output to the programming track and a power supply for a wall transformer, not shown.

A DPDT switch selects power from the PowerPax or the PSX card for the Programming track allowing it to be used on the layout and well as for programming.

The command station also has a RS232 serial port for communication with a computer. I use this port to aid in the configuration of my locomotive fleet using the Java Model Railroad Interface (JMRI) Decoder Pro (this wire is not shown).

The green wire connecting the PH Pro and the PB 105 is a protective ground that will carry current between the boosters if the is an issue on the layout that causes the need for current to flow between districts. Without this wire it is possible to send current via the control bus and blow out the systems.

The PSX cards provide circuit breaker protection to the breaker districts to prevent over loads and the shutting down of the booster and all trains operating on that booster.



The PSX 4 cards have 4 breakers on each card.

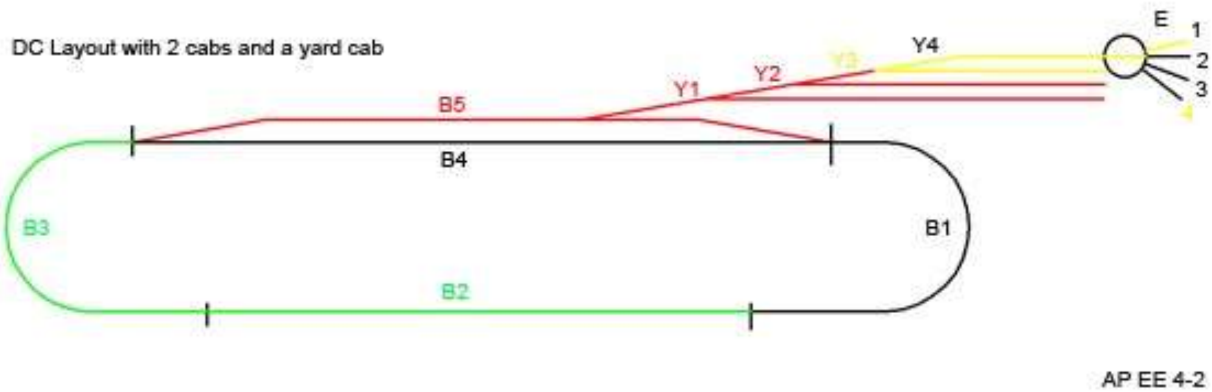
The PSX AR cards control reverce loops.

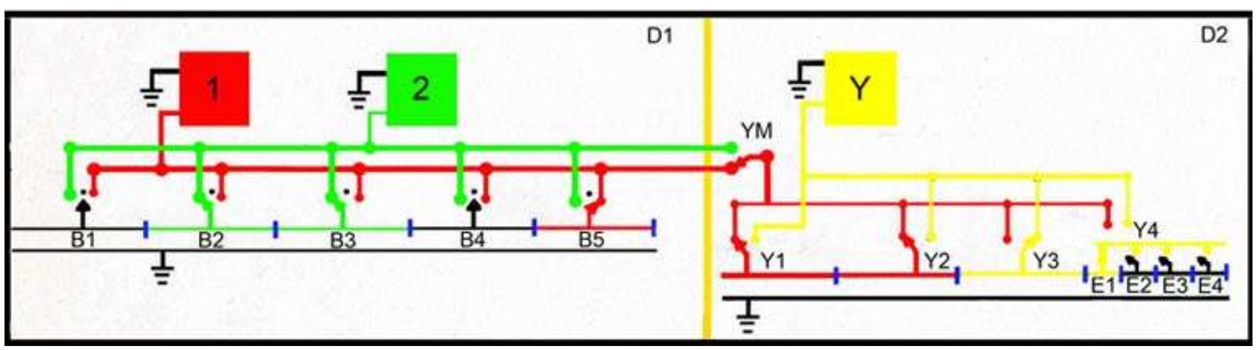
ON the layout each breaker district is connected to a PSX card for protection while the reverce loops have the PSX AR cards to allow for auto reverce function.

Please note some illistrations are from the NCE Power Pro instruction manual others are photos from the layout or drawings.

Section 1B Perch Lake & Superior DC layout (622 High Road Glen Ellyn)

DC layout section Built and operated in prior years





In these drawings I am showing the layout section of my former layout which was DC and had been reviewed and witnessed for EE in 1992. (SOQ copy enclosed) The layout was also witnessed by Bon French.

The power is supplied by 3 Throttle packs or cabs (1, 2, Y) that are connected to single pole double throw (SPDT) switches allowing selection of the cab controlling the block. I used DPDT Center off on my layout to be able to have extra contacts and to cut power to any block. This layout has common north rail and all power packs are grounded to the common rail feed.

The yard operations have its own cab and the yardmaster may select from the main line cabs with an SPDT switch to allow the operation in the yard. Each track in the yard is connected to either the Yard cab or the selected main line cab using SPDT switches.

The engine terminal is part of the yard and is controlled by a SPDT to select the cab operating and simple Single Pole Single Throw (SPST) switches for storing unused motive power.

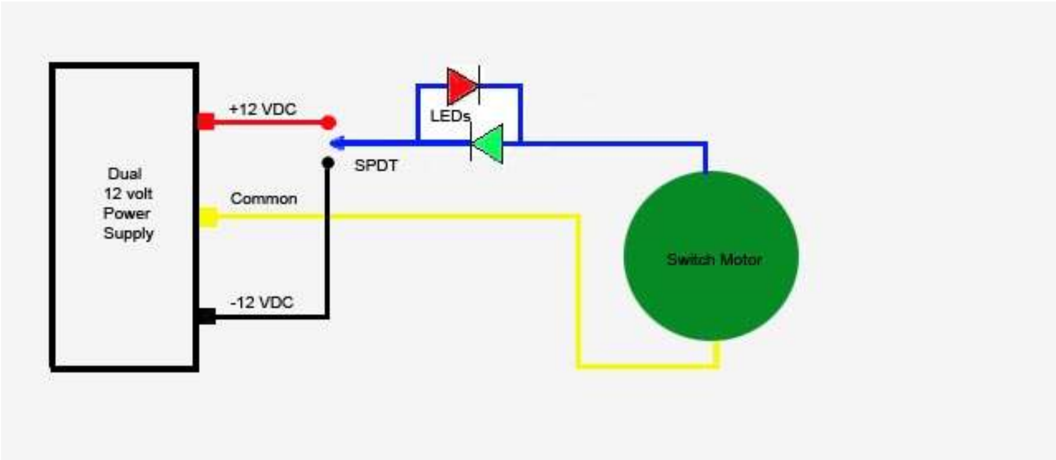
In the drawings we see cab 1 is connected to the passing siding and 2 yard leads while cab 2 is operating on the main in blocks B2 and B3. The Yard cab is being used to move motive power from E1 on to Y4. B1 and B4 are not assigned and E2, 3, 4 are shut off.

SOQ SECTION 5

Drawings for requirements in: Section 2

Turnout 2-1

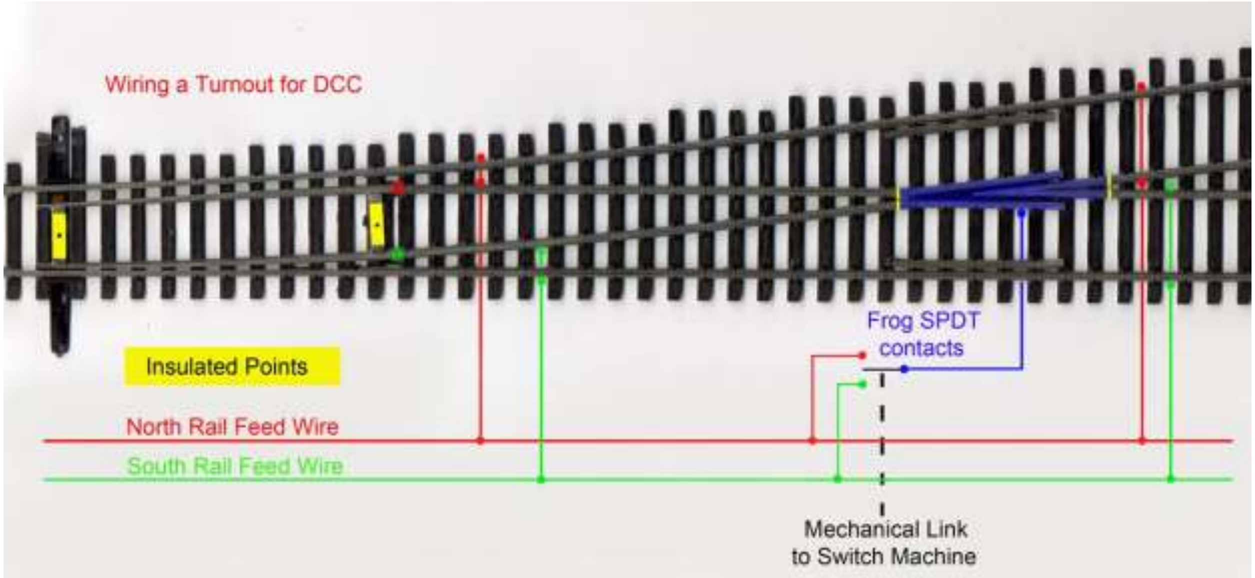
The current layout contains more than 40 turnouts controlled by panels with position indications.



Using slow-motion switch motors I use a Dual DC power supply with Ground, +12 and -12 volts direct current VDC. On the control panels using one half of a double pole double throw (DPDT) electrical switches +12 VDC is connected to the top pole and -12VDC is connected to the bottom pole of the switch. The center contact is connected to a bi color LED which passes the current to one contact of the switch motor the other power to the switch motor contact is connected to the ground or neutral terminal. The polarity of the current passing from the DPDT will set the direction of the motor and the color of the LED.

Additional LEDs may be used for signaling around the turnout or the second set of contacts on the DPDT at the panel or the contacts on the switch machine may control signals. Additional contacts on the switch motor a SPDT is connected to rails and powers the frog.

Additional information on the crossover each turnout is gapped at the frog and for DCC operations the points should be insulated and powered the same as the rails they contact to prevent shorts.

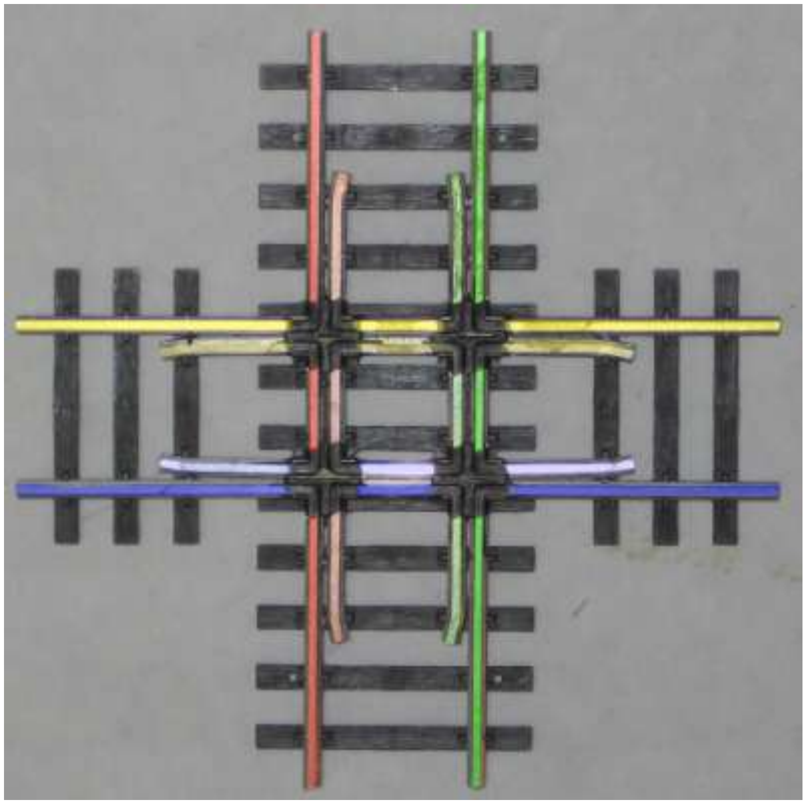


To be DCC friendly the points are insulated and powered from the closure rails to avoid shorts.

There are 2 sets of SPDT contacts on the switch machines which may be used for frog power, controlling signals or as in the section 3 Interlocking track power with junction turnouts.

Crossing 2-2

I have a crossing on the service tracks near Bradley and there was a hand built Crossing on the DC layout.



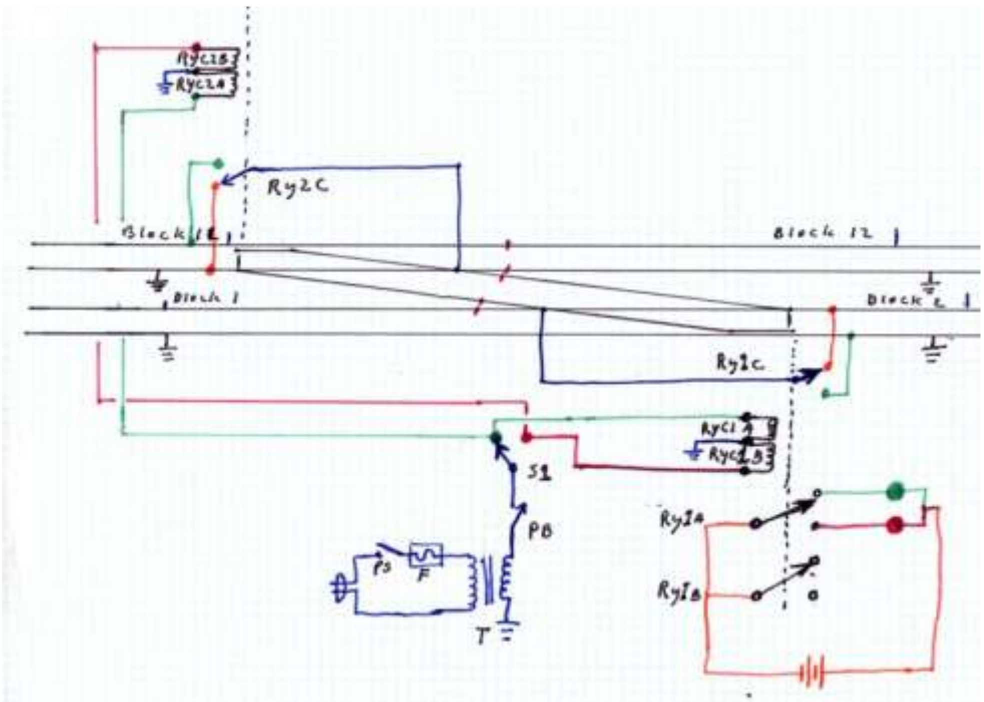
In this example of a crossing I have used colors to represent the connections (wires) of the power to the rails. The Blue and Yellow are for the left to right track and the Red and Green are for the vertical track. Insulation, in Black, prevents shorts in the operation of the crossing. Guard rails associated with the adjoining track may or may not have power (they are shown in light color above) and are normally insulated in a commercial crossing. In this commercial crossing the wiring is contained in the plastic molding of the crossing and is consented as shown by the dark colors. When part of a double crossover the tracks are powered by the crossover turnouts just having a crossing in between.

In building a hand laid crossing I cut gaps in the rails inside the crossing and control the power with a switch on the control panel while insulating the crossing from all other track with gaps. Signals for the crossing may be controlled by the switch on the panel.

Crossover 2-3

I have a number of crossovers that are operational on the current layout as well as The CHOo ChoO Store Layout.

This covers Turnouts, Crossovers, and Electrical turnout position indication in section 2 and drawings for section 5 of the SOQ

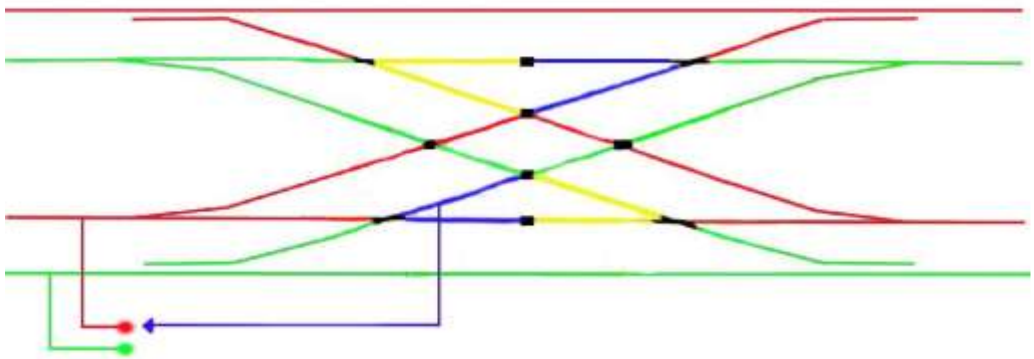


This drawing uses twin coil switch machines with relay contacts attached. The control is powered by an AC power supply with a plug, switch, fuse and a step-down transformer. (120 VAC to 12 VAC)
This power is sent to the control panel which allows the dispatcher to set the turnout controls (S1) and then press a “take” push button (PB) that supplies power to make the turnouts change to the positions set on the panel. In the above drawing you see that the crossover is wired to S1 that selects the position of the points. The coils on the switch machines acting as solenoids will move a bell crank to move the points of the turnout. At the same time contacts on the switch machine, 3 sets of single pole double throw contact (SPDT), control the power to the frogs and with support of DC power will change the color of signal lamps. RY1C and RY2C select the power from the rails that connect to the turnouts and power the frogs with the correct polarity. A second set of SPDT contacts RY1A selects between red and green lamps powered by a battery in this case.

Double Crossover 2-4

A double crossover is operational on the current layout with remote control and panel indication. This Double crossover is from Walthers and has insulated frog points the diagram below shows how the power is distributed to the rails. The Walthers Double crossover has the connections built into the track.

The double crossover seen here is on my Glen Ellyn layout it contains 4 turnouts which act a 2 pairs of crossovers with a crossing at the connection. All 4 switch machines are controlled by one control panel switch and have indications on the panel as well as a pot signal on the layout.



Red and Green are the right and left rails the frogs (blue and yellow) are controlled by the position of the points and the SPDT terminals on each switch machine. There are 4 Switch machines on one control switch with indication of crossover or straight. Refer to turnout control for additional information.

All of the above items are operated by slow motion switch machines and have panel indications. The Turnout Junctions, in section 3, use the normal connections of power to the switch machines from the control panel but also use 2 pair of SPDT contacts, one to control the signals and the other to control power to the right rails as interlocking.

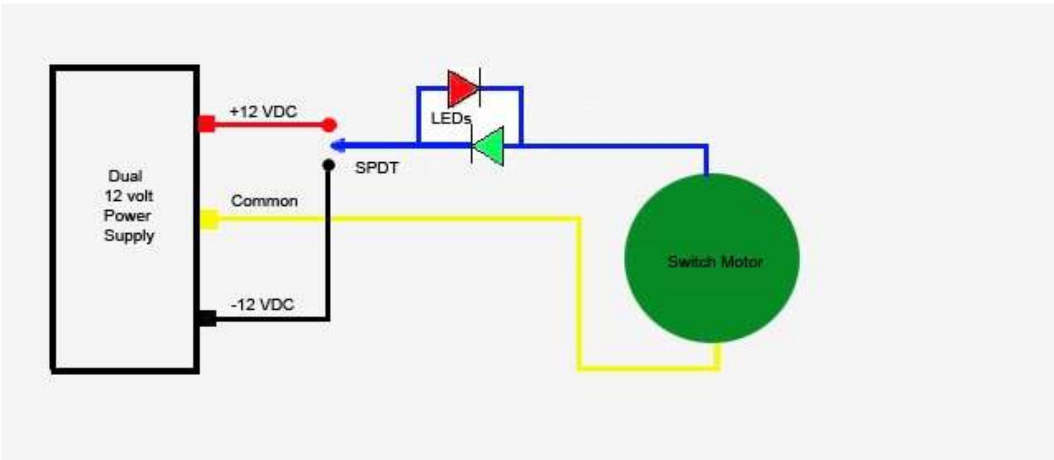
SOQ SECTION 5

Drawings for requirements in: Section 3

Wire and demonstrate the satisfactory electrical operation of at least three of the following features:

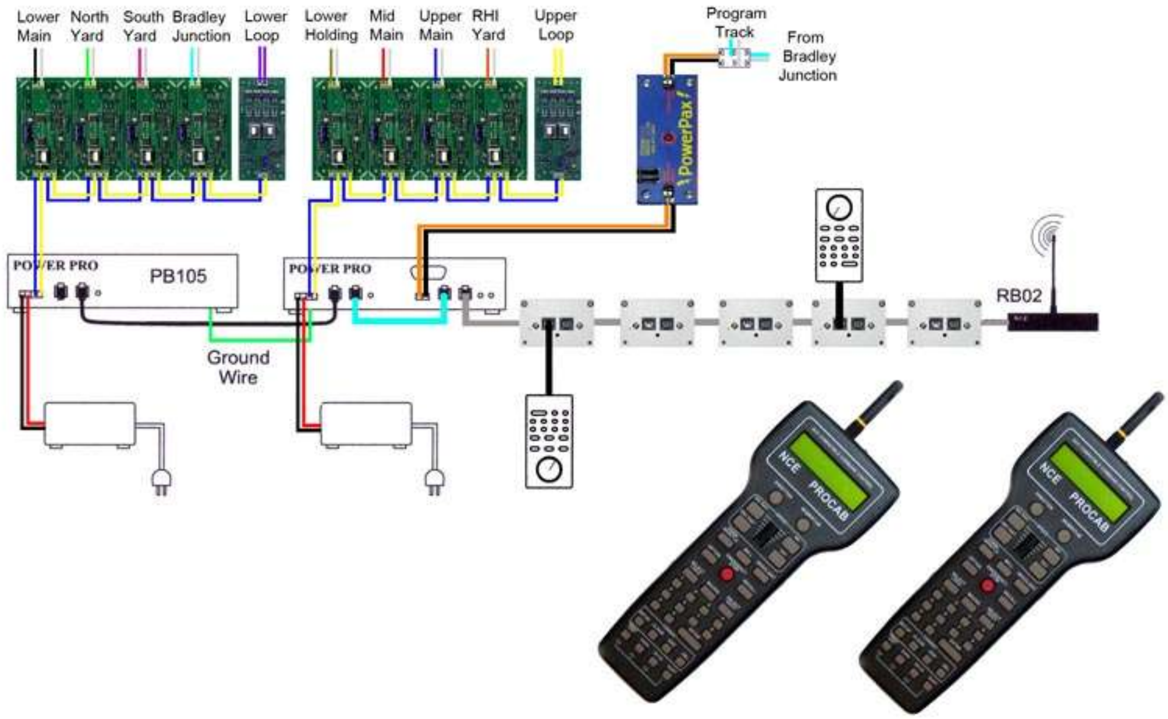
Electrical turnout position 3-1

Electrical turnout position indication is located on different control panels or at trackside for all my remote control turnouts.



Cab Control 3-3 DCC

In DCC I have at least 5 Cabs operating on the layout, 2 via radio.

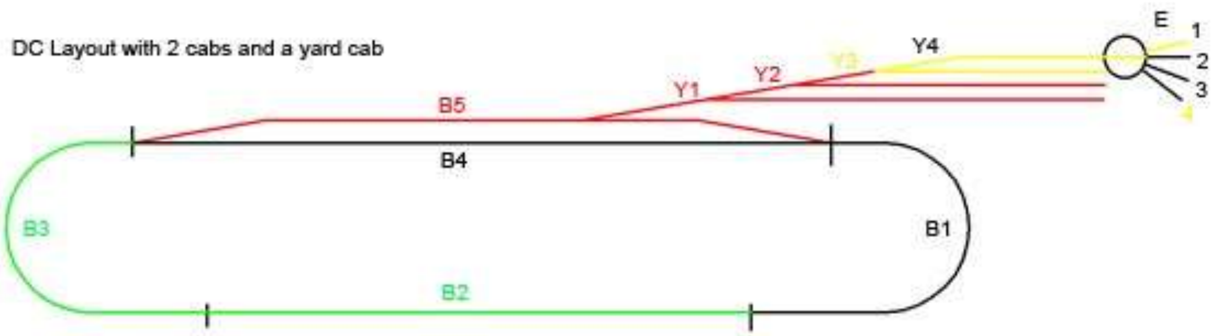


Full DCC details are in the above documentation on propulsion.

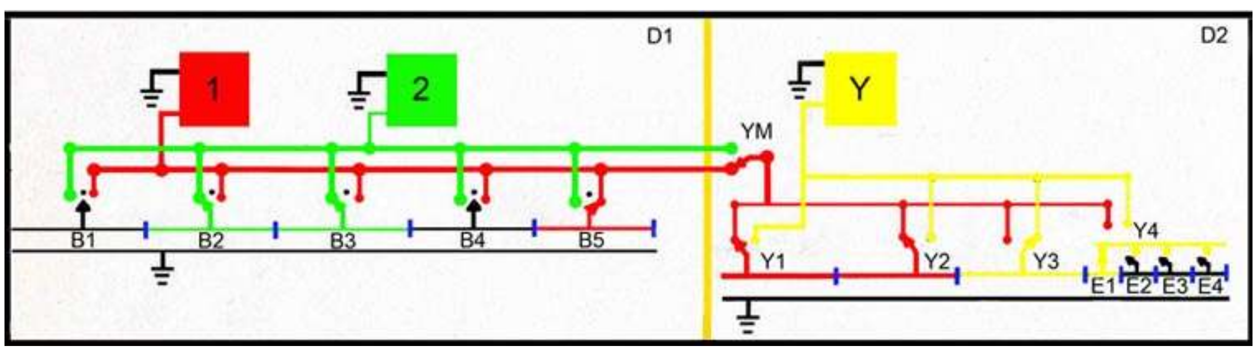
DC Cab Controls 3-3 DC

This has been done on my previous DC layout at 622 High Road Glen Ellyn with notes and witnesses from Du Page Division.

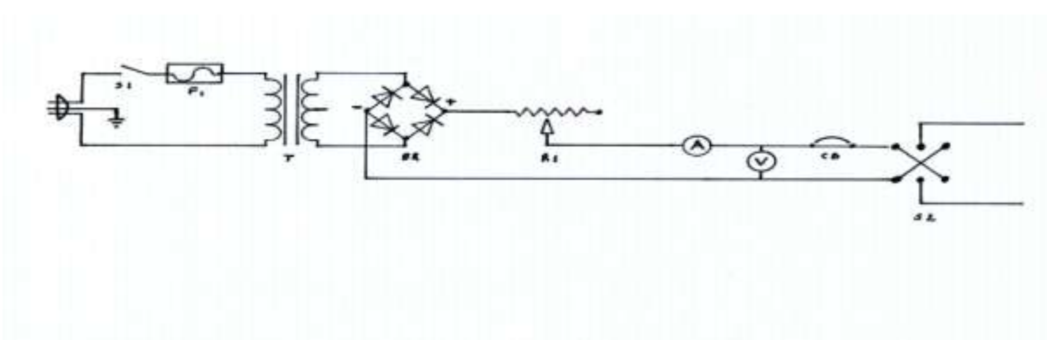
This is also been done on the Late, Bill Bieler's Layout in Glendale Heights also witnessed by members of the DU Page Division.,



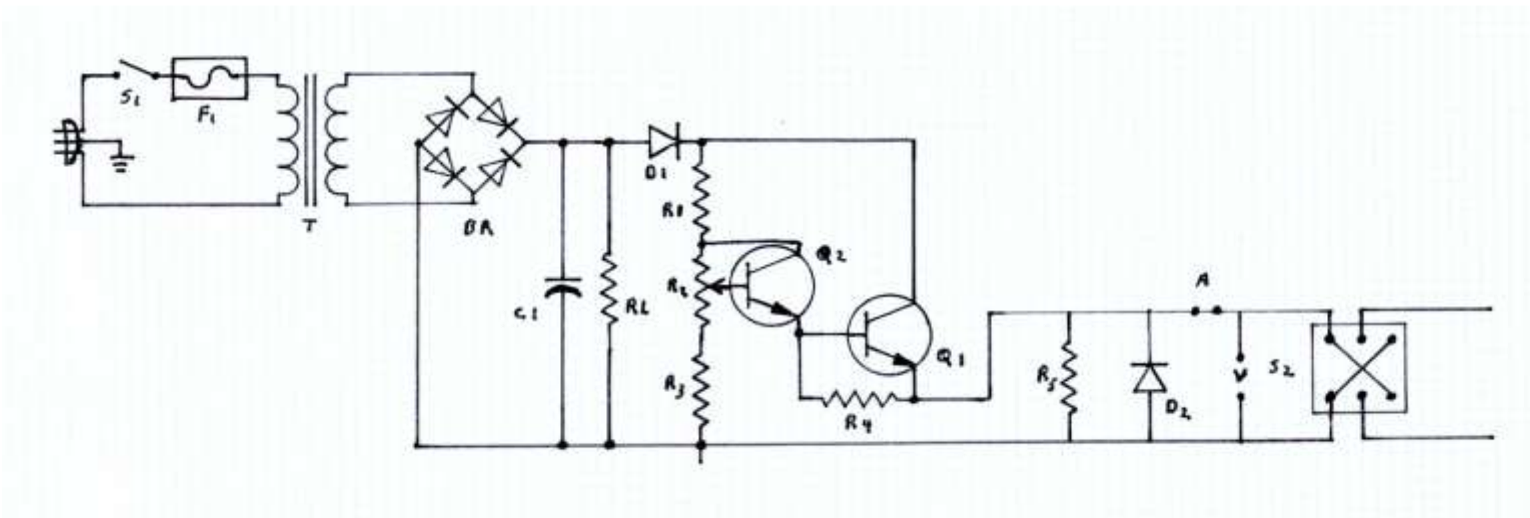
AP EE 4-2



I these diagrams each block is marked with a title (B1, Y1, ..) the gaps between the blocks are denoted by color change and, or color change. Colors in the top diagram match the lower diagram to aid in understanding. Power supply 1, 2, and Y are shown below.



This DC power supply contains a grounded AC plug, a power switch (S1) a fuse on the AC side at (F1) before the primary of a step down transformer (T). A simple bridge rectifier (BR) takes the AC power from the secondary of the transformer and supplies direct current (DC) with ripples due to the lack of filtering, which is unnecessary and beyond the scope of the AP EE. A variable resistor (R1) is a wire wound rheostat that controls the voltage on the positive side of the circuit. Meters (A) an ampere meter is in series with the circuit and displays the current used while the meter (V) a volt meter is across the + and – leads to measure the output voltage. A Circuit breaker (CB) protects the power supply from short circuits on the output to the layout or overloading of the system. The switch (S2) is a reversing switch that will change the polarity out of the power supply going to the track or block control circuit. Below is a transistor version of a DC power supply. The photo on the next page shows the hand held version that does not contain the transformer or rectifier but does have an extra reverse switch for control of a reverse loop.

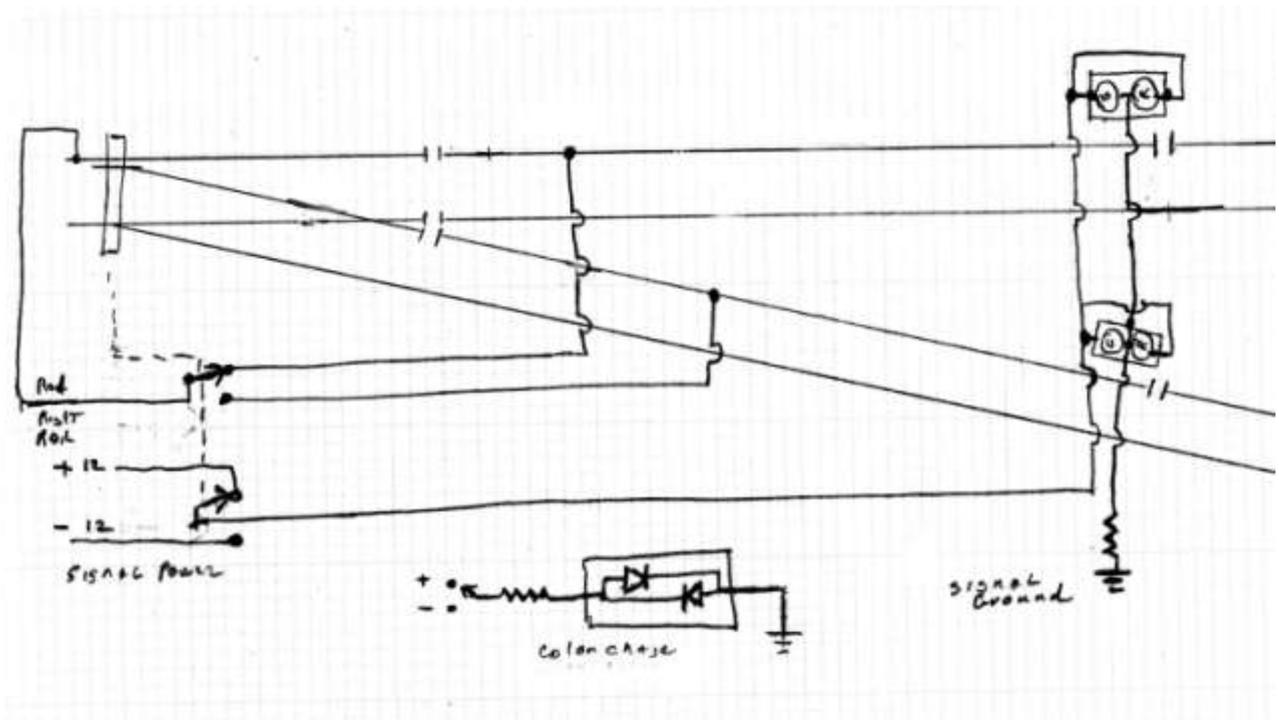


This is a handheld transistor throttle I built for operation on an HO layout using DC power. You will note the 3 controls (2 switches and one variable resistor (the knob)) The Knob controls the voltage output thus the speed of the train while the 2 switches are for direction control. One switch moves up and down and the other side to side. These switches control the direction of the train's movement by controlling the polarity of the output current. One switch is used to control the direction of the train on the layout with exception of the reverse loop, wye or turntable; the other switch controls the polarity, thus the train's direction in the reverse loop or on a wye or turntable. A simple circuit bridging the gap of one rail at each entrance to the reverse loop, wye or turntable would light a red signal lamp indicating the polarity was reversed and the train must have the polarity reversed. In the diagram you would add a second reverse switch in parallel with the first.

Two Turnout Junctions 3-5

I have 2 Junctions turnouts one at the each end of a passing track that protect trains from going across a switch set against them even if they pass the signals that indicate the position of the turnout is set against the train.



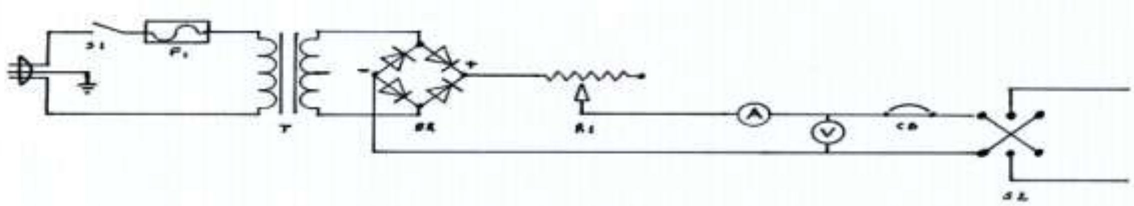
In the above drawing we see a turnout with the SPDT contacts of the switch machine connected to the right rail (Red in the location on my layout) and locking out of the approaching track current by removing the power to the right rail of the track that is not selected. The signals use the second contact to switch polarity of the current going to the signal heads selecting the correct color red or green weather there is a single LED or a pair. The layout had one of each type

High Frequency Lighting 3-6

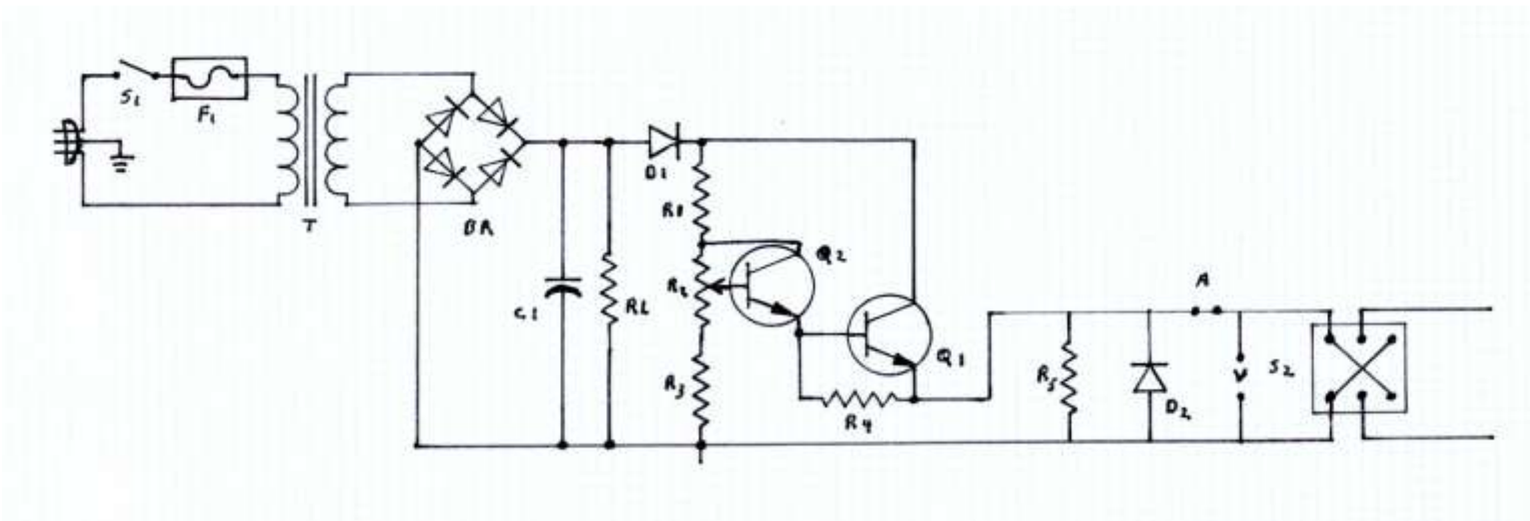
DCC provides the equivalent of HF lighting on locomotives and in cars if equipped with lighting systems. Locomotive lighting and safety lighting operate on my layout under DCC control. An example is the beacons on switchers and CNW SD40-2 that I have wired for operation under DCC control which are not connected as delivered but must be wired and programmed. Another example is the use of the AC power on the DCC track for operating lighting in cars and cabooses including marker lights.

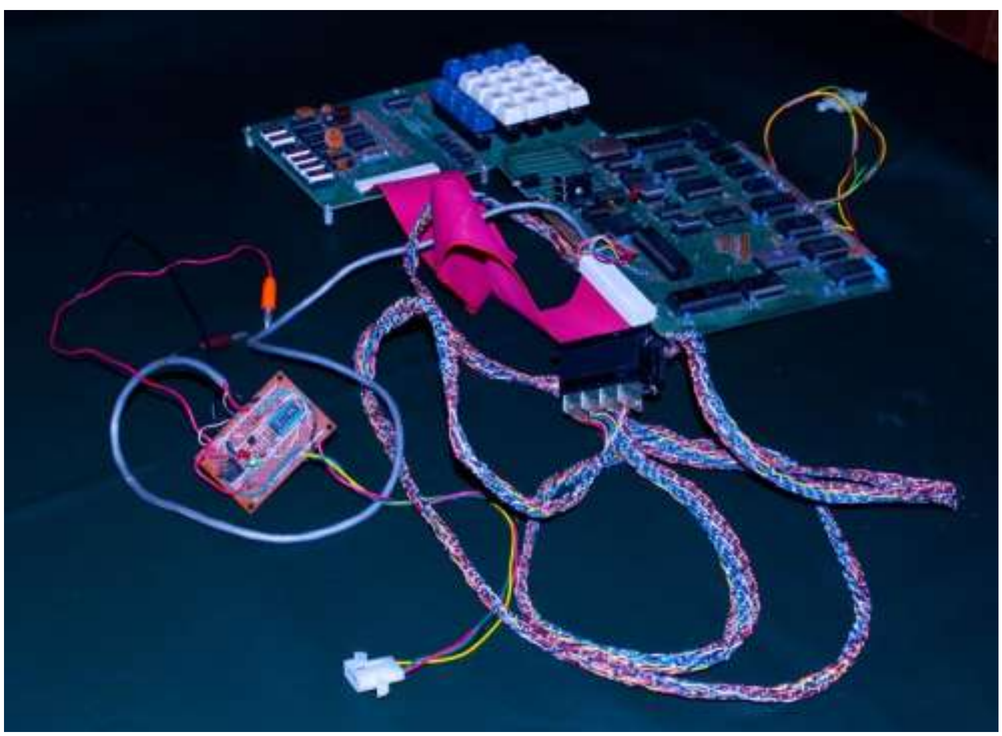
Electronic Throttle 3-7

DCC, DC, AC and computer controlled throttles, as well as DCS and TMCC, have been used on the layouts described in this document from simple full wave rectification of an AC transformer to a programmed Motorola M6800 computer on a DC layout before DCC.



This DC power supply contains a grounded AC plug, a power switch (S1) a fuse on the AC side at (F1) before the primary of a step down transformer (T). A simple bridge rectifier (BR) takes the AC power from the secondary of the transformer and supplies direct current (DC) with ripples due to the lack of filtering, which is unnecessary and beyond the scope of the AP EE. A variable resistor (R1) is a wire wound rheostat that controls the voltage on the positive side of the circuit. Meters (A) an ampere meter is in series with the circuit and displays the current used while the meter (V) a volt meter is across the + and – leads to measure the output voltage. A Circuit breaker (CB) protects the power supply from short circuits on the output to the layout or overloading of the system. The switch (S2) is a reversing switch that will change the polarity out of the power supply going to the track or block control circuit. Below is a transistor version of a DC power supply. The photo on the next page shows the hand held version that does not contain the transformer or rectifier but does have an extra reverse switch for control of a reverse loop.

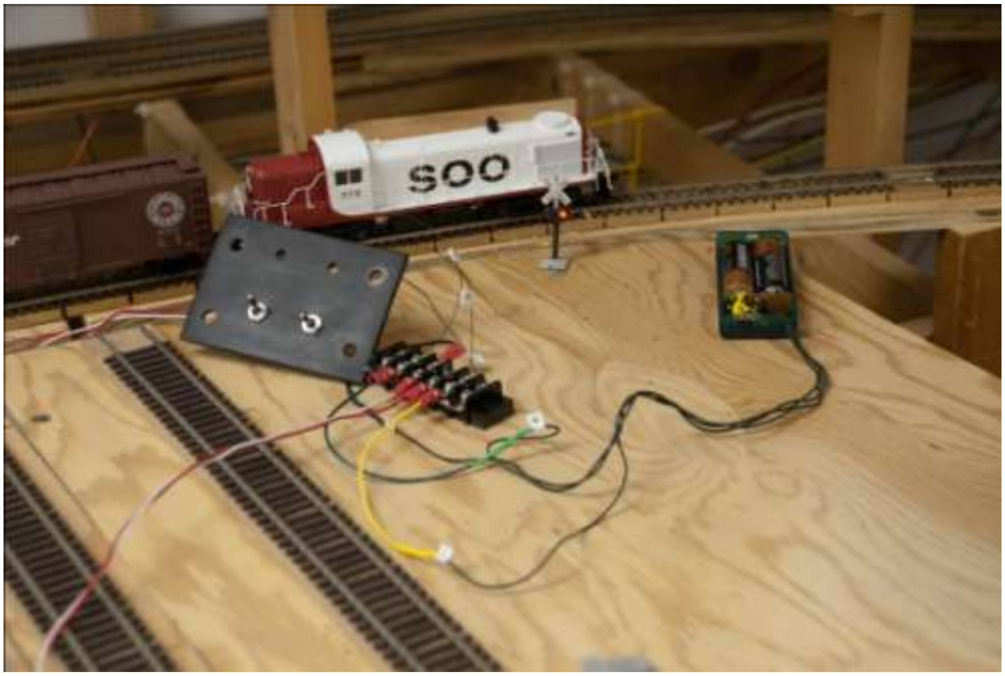


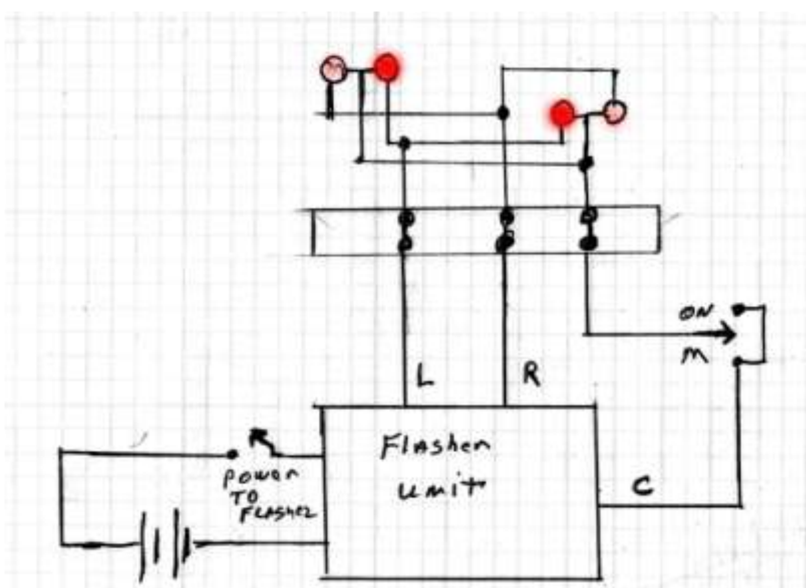


Computer controlled with momentum and brake

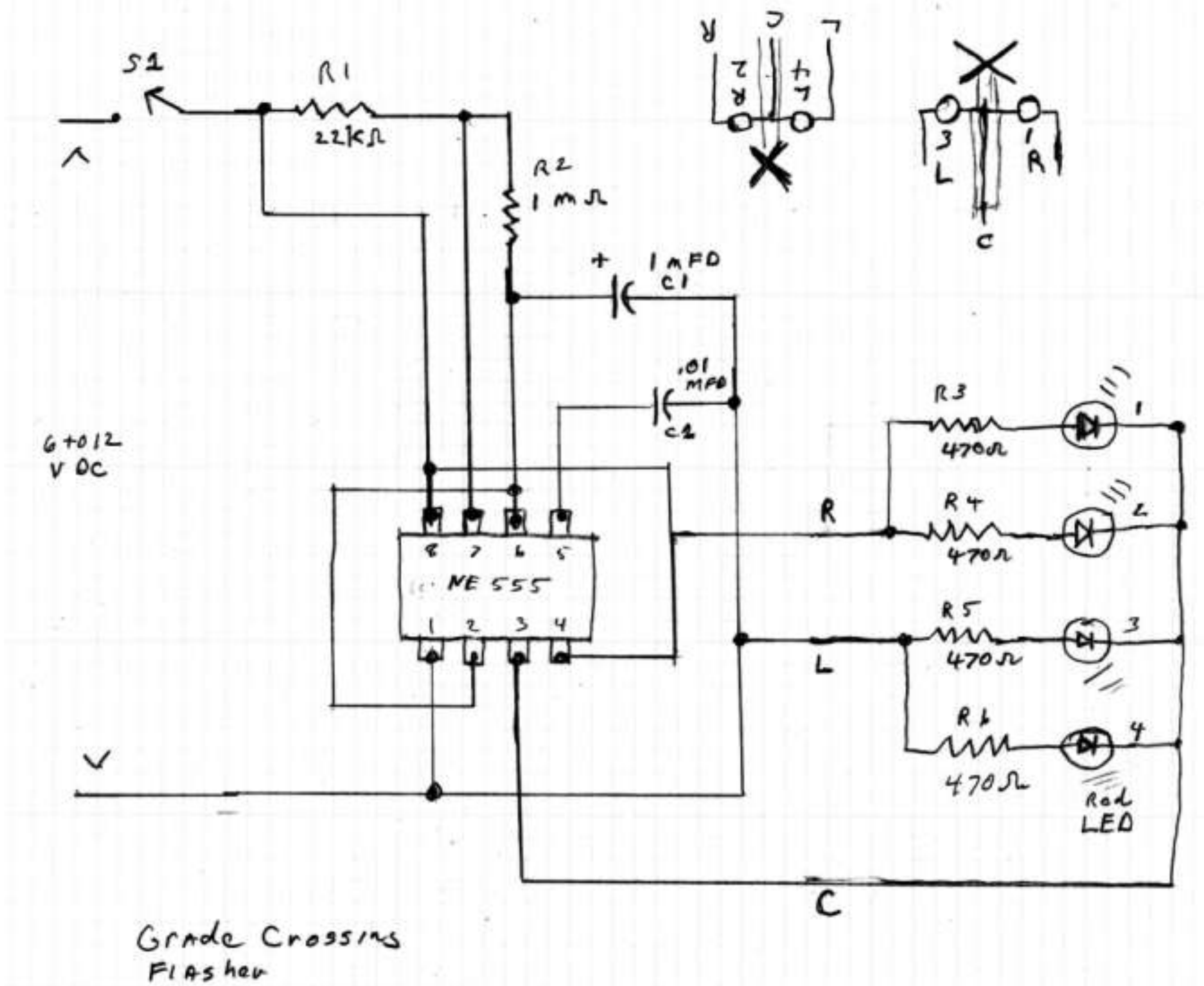
Grade crossing 3-8

I have provided an example of a grade crossing using a flasher and push button activation, in the case of my layout, they are controlled by one half of a DPDT switch (on the left) with momentary contact in one direction (down) and on in the other direction with a center off.





Advanced flasher circuit



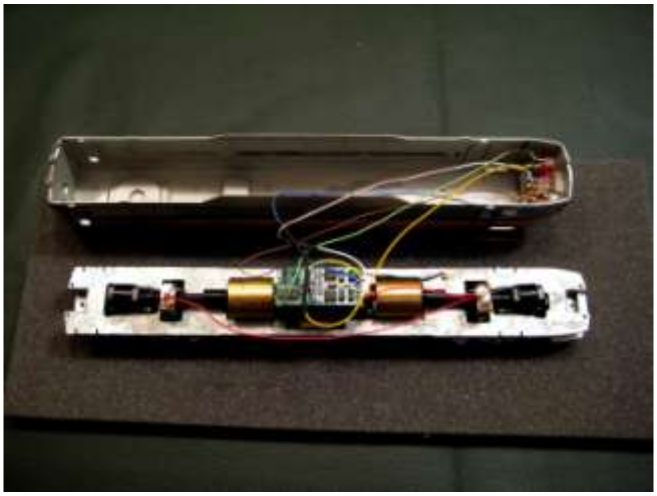
This is a circuit for the flasher unit that uses a NE555 timer to provide a even duty cycle pulses that when sent to the L and R LED circuits with current limiting resisters will flash the LEDs alternately on 2 cross bucks. I used the 555 because I can control the duty cycle, or time the lights are on by adjusting the resisters and capacitors that set the time of each pulse.

Command Control Receiver 3-14

> I have installed countless DCC receivers for myself and others. I also have given clinics on the installation of DCC receivers into both DCC ready and DC locomotives not "DCC Ready" an example is the Amtrak diesel in the documentation.

This covers the installation of a DCC decoder in an Athearn non plug and play locomotive (#14) and then the addition of effects lighting (#23).

During installation of a Digital Command Control (DCC) decoder, in a blue box Athearn locomotive that is not a plug and play, it is necessary to define two locations to pick-up the track power. The red wire connects to the rail on the Engineer's side of locomotive. The black wire connects to the rail on the fireman's side. On these Athearn locomotives the right (red) wheels connect to the tabs that connect to the top of the motor by way of a metal strip that connects to the tabs on the trucks. I removed the metal strip and soldered red wires to the truck's tabs.

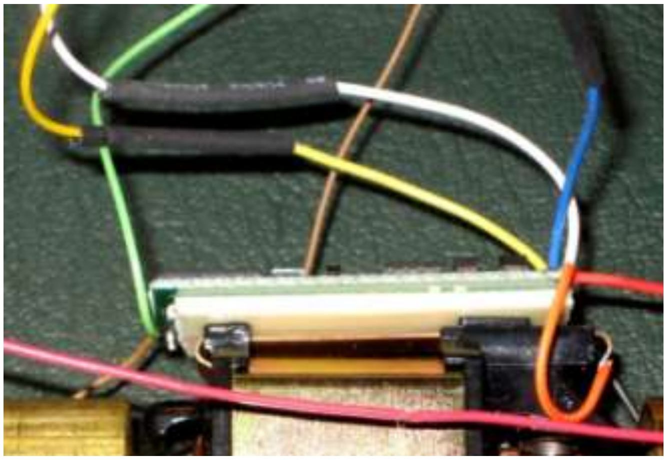


For the left side pickup, which is connected via the trucks to the frame, I install a brass bolt. The bolt should be installed into frame in an area that is accessible but does not interfere with the operation of the locomotive. I drilled and taped a hole for a 0 -80 bolt and install the black wire to the bolt and tighten it down.

I next removed the motor and the brass clip, that holds the spring and brush which transfers the current to the commentator, on the bottom of the can motor, being careful not to lose the spring and brush. Next I removed the two tabs that are punched out of the brass that make contact with the frame. This can be done by cutting the tabs off and filling the clip smooth or you may press the tabs back into the clip but make sure it is smooth and flat. Connect a gray wire to this clip at the top front. To insure there is no possible short to the frame I installed a small piece of insulation before reinstalling the motor.

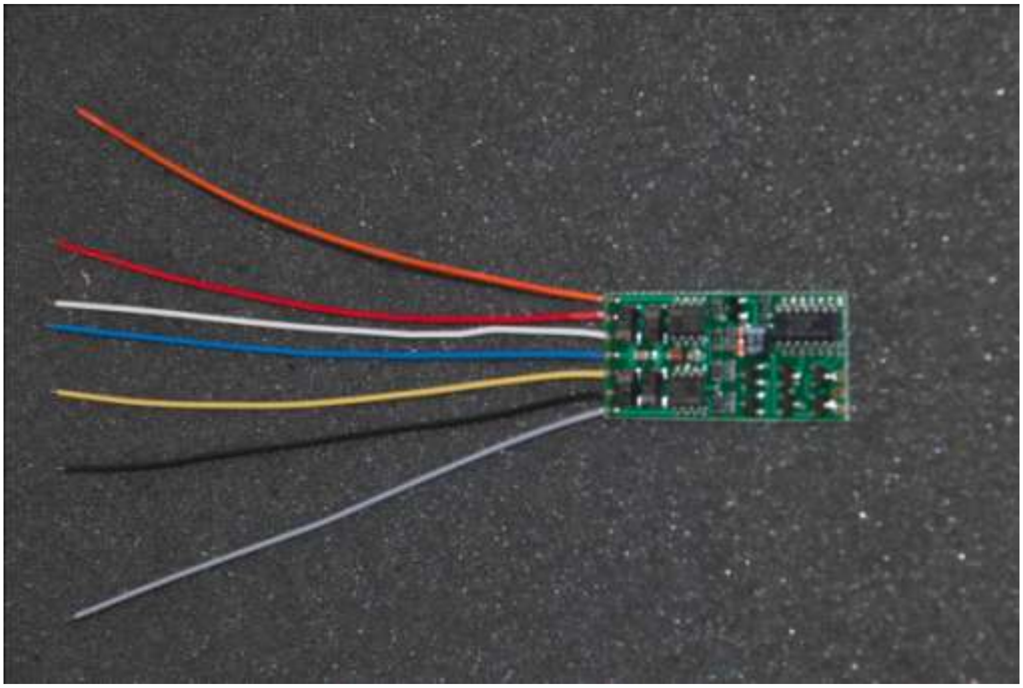
With these wires connected, red to the right rail, black to the left rail, gray to the bottom, I then added the orange wire to the top of the motor brass clip. At this point the locomotive may be tested on the program track for shorts.

I attach the decoder to the top of the motor with two sided foam tape.



The next step is to connect the headlights. In most of my early conversions I installed 14.5 volt grain of wheat lamps in a brass tube behind the plastic lenses. The white wire is connected to the front headlight and the yellow to the rear headlight. The blue wire is common to all functions. Remember the output is at track voltage; do not blow out low voltage lighting or LEDs. Note the heat shrink tubing over the soldering joints to prevent shorts.

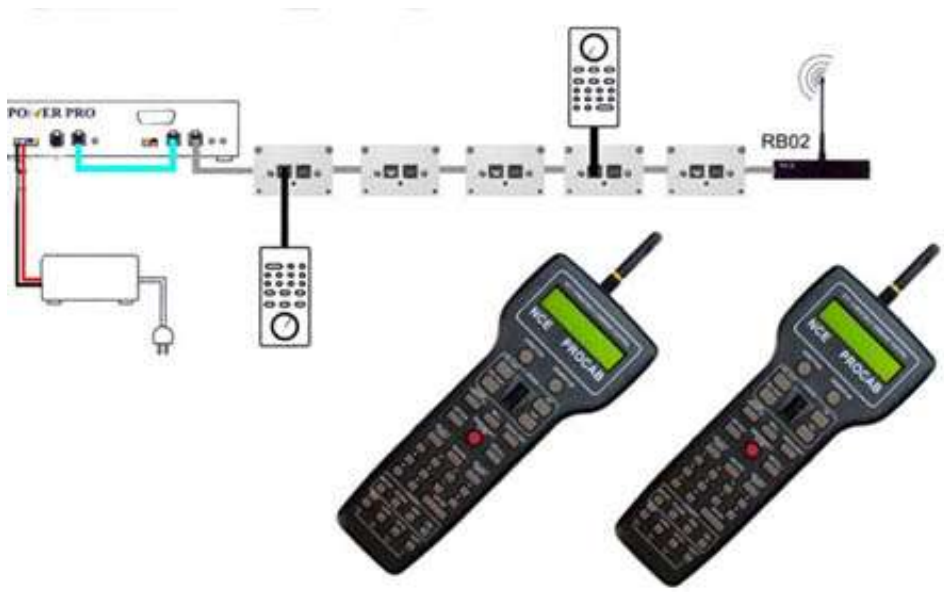
With the lights connected a normal installation may be tested and then the locomotive is ready for programming. Program the Locomotives number into the long address and set the start voltage. Then set the acceleration and deceleration value. I use 10 for acceleration and 5 for deceleration. Programming is part of the installation and if you are able to bump the start or have EMF feedback it is important to program these as well.



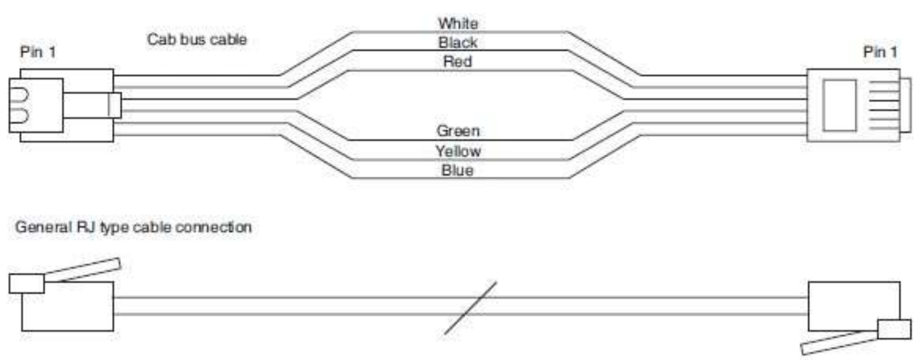
Here we see a basic decoder the Orange and Gray wires are connected with the Orange being + and the Gray being connected to the – terminal to the motor. The red goes to the pick up from the Right Rail pickup and black to the left rail pickup.   The White (forward) and the Yellow (reverse) are headlight connections with the Blue being common for the lighting circuit and providing the + side of the lighting circuit. It is important that you note that these are at track voltage so the use of 14.5 volt lamps is required unless you insert resistors for low voltage lamps or LEDs

Command Control Throttle Buss Line 3-15

My layout contains a control buss that connects throttle connections around the layout as well as radio control of the DCC system as shown below.



In the distribution drawing, above, you will see the gray buss wire goes to the Cab Bus which connects to the UTP cab bus connectors placed around the layout by way of the bus wire shown below.



6 WIRE CAB BUS CABLE WITH RJ-12 CONNECTORS

Pin #	Color	Description
Pin 1	White	No Connection, reserved
Pin 2	Black	Ground
Pin 3	Red	- RS-485
Pin 4	Green	+ RS-485
Pin 5	Yellow	+12 volts
Pin 6	Blue	No Connection, reserved

The 6 wire bus cable enters one side of the UTP and provides 2 ports for plugging in cabs. There is also a second port on the back to extend the bus by using another 6 wire cable with an RJ-12 connector.

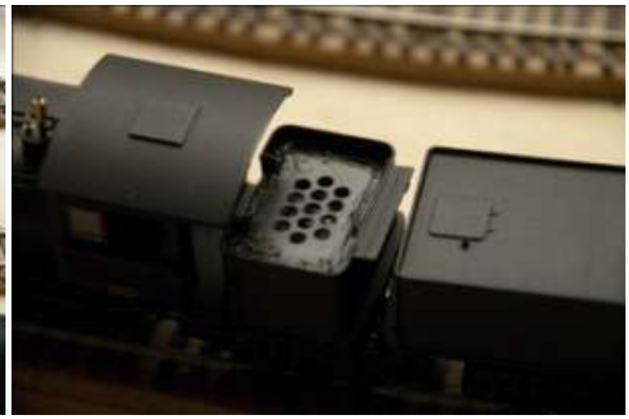
The radio receiver provides a termination at the end of the bus and does not have a second connector.

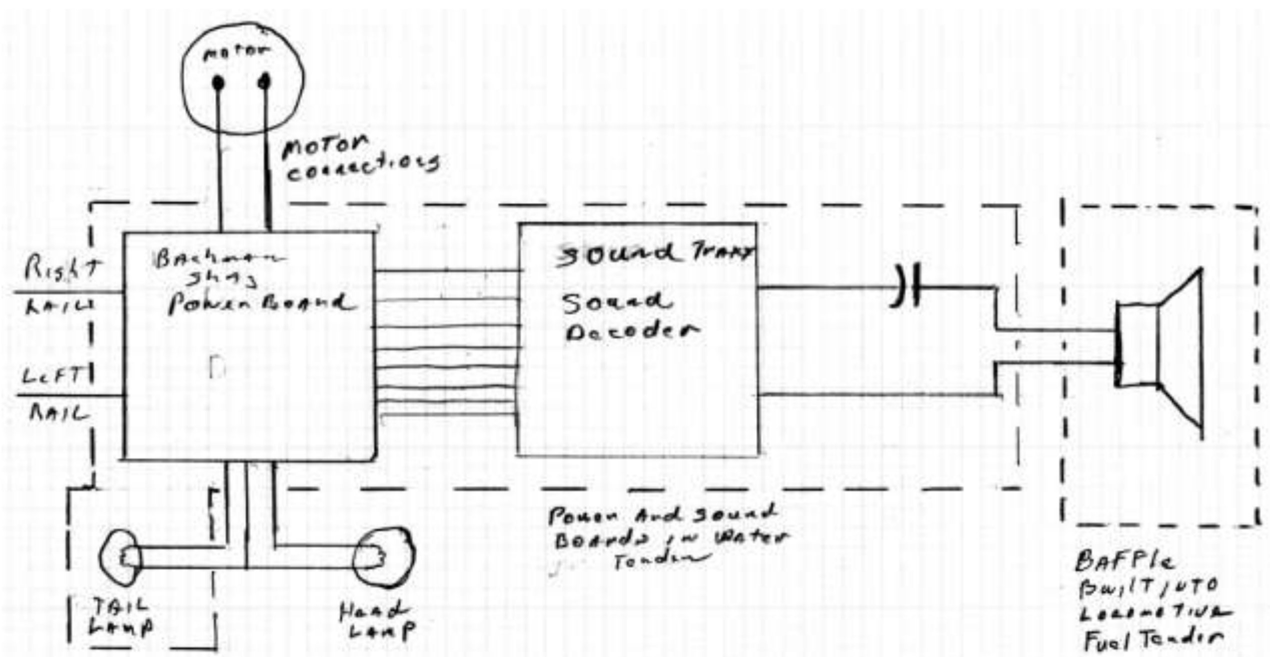
UTP Panel

The Radio Cabs communicate via the Radio Base (RB02) that is connected to the end of the cab bus.

Sound system 3-16

As stated in the instructions for AP EE I assembled a sound system out of commercial parts from multiple manufactures to install a sound system in an early non DCC Shay. This included decoder sound system board and creating a speaker space and baffle to fit in the Shay. In the past I have a PFM sound system long since removed from service which worked with the DC system and used the track to transmit and receive information and sound between the unit and locomotives.





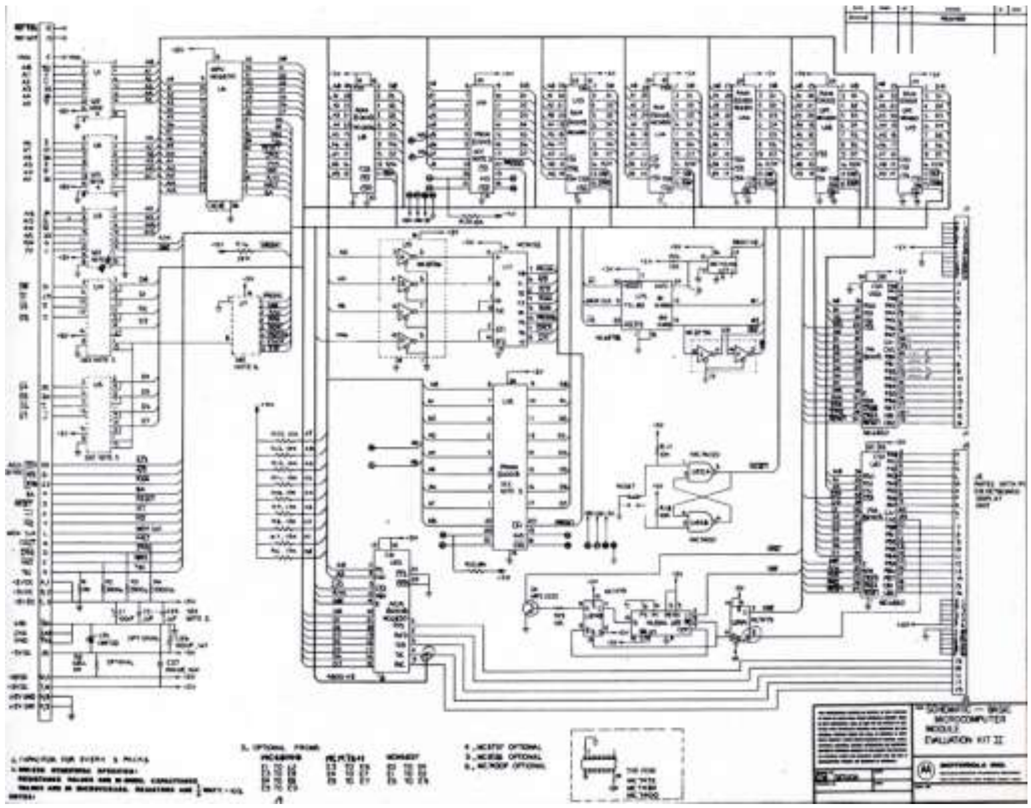
Computer to railroad interface on DC 3-7

Before DCC I built a DC throttle that used the Motorola M6800 single board computer and software I developed to act as a DC throttle on my DC layout replacing one of the MRC throttles. The Motorola M6800 train control interfaced a new “advanced” technology, the microchip computer, with the layout to control the movement of trains.

The Computer system is a standard 6800 single board computer with additional I/O support to operate a model railroad. The software is in 6800 assembler. I have attached the control variables and I/O. This system was used and witnessed by members of Du Page division when we were running DC. The table below lists the variables used to control the output of the cap and thud the train assigned.

```
RR1.doc

CAB DATA AND CONTROL

     DIRECTION       (1)        EAST / WEST
     SPEED TO TRACK  (7)        DUTY CYCLE COUNT
     ACCELERATION    (7)        DIFFERENCE BETWEEN NOTCH
                                     AND SPEED
     BRAKE           (7)        AMOUNT OF DECELERATION
     START           (7)        DUTY CYCLE TO START LOCOMOTIVE
     MAX             (7)        DUTY CYCLE FOR MAX SPEED
     LOAD            (7)        FACTOR FOR MOMENTUM
     FUEL            (8)        LEVEL
     WATER           (8)        LEVEL
     AIR             (8)        PRESSURE
     SAND            (8)        TRACTION
     BLOCK           (8)        CURRENT BLOCK #
     NEXT BLOCK      (8)        NEXT BLOCK #
     SIGNAL          (2)        CAB SIGNAL (R,Y,G)


               INPUT

     DIRECTION
     THROTTLE               ACCELERATION
     BRAKE
     SAND
     BLOCK
     E BRAKE                E BRAKE/DIRECTION
     SIGNAL                 DIRECTION LED

               OUTPUT

     COMPUTER DATA                   DISPLAY

     DUTY CYCLE                 SPEED
     DIRECTION                  DIRECTION LED
     BLOCK                      AIR
                                FUEL
                                WATER
```

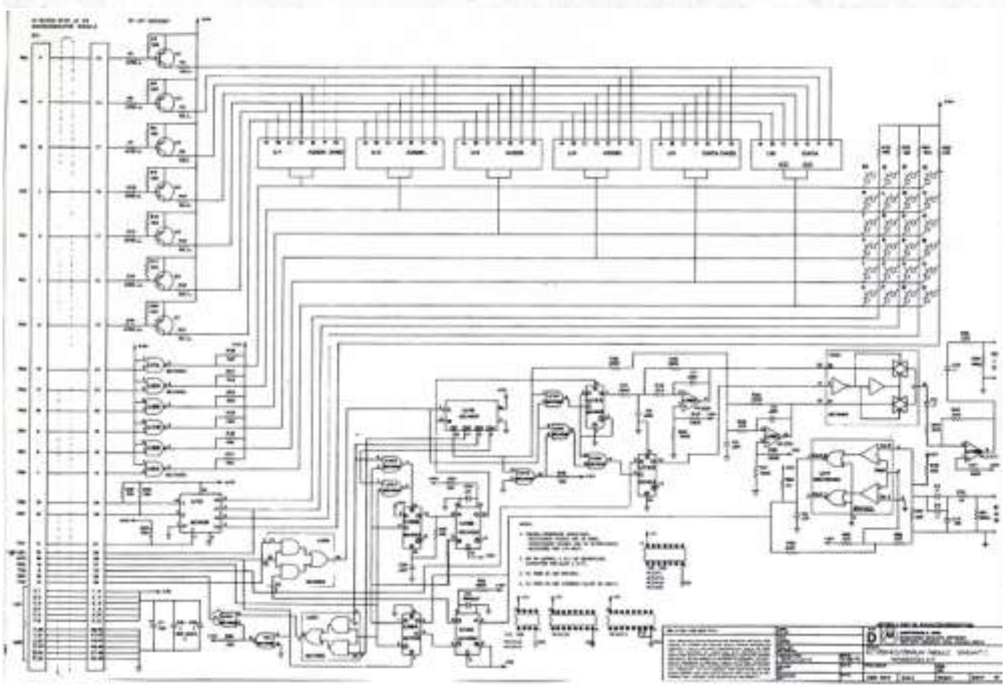
Motorola M6800



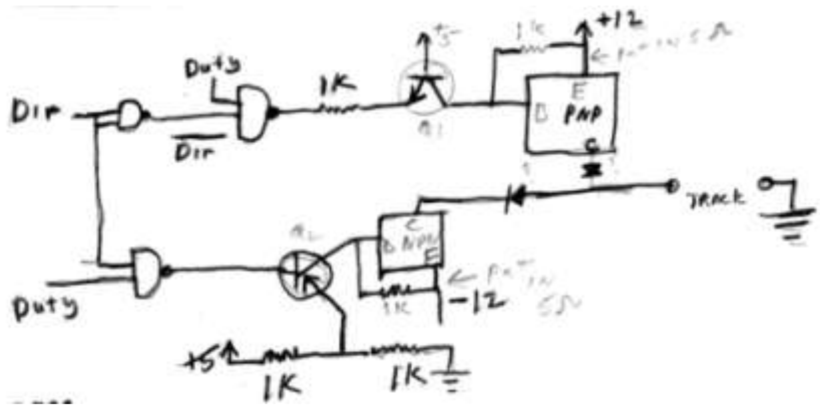
With the Motorola M6800 single board computer and its contorl keyboard a user may program the microcomputer in HEX code or use an assembler to generate code. This code is burned into an Erasasable Programmable Read Only Memroy (EPROM) that is then placed into the mother board and becomes the program to operate the micro computer. The System Layout sheet shows the use of Input/ Output (I/O) devices on the mother board. It is into and out of these I/O devices that I have the ability to control a DC locomotive on any selected block. The varaibles listed above contorl the parameters of the operations. If up run out of fule you coast to a stop. The momentium of the train in acceleration and braking is set by entering information into the program via the Hex keypad.

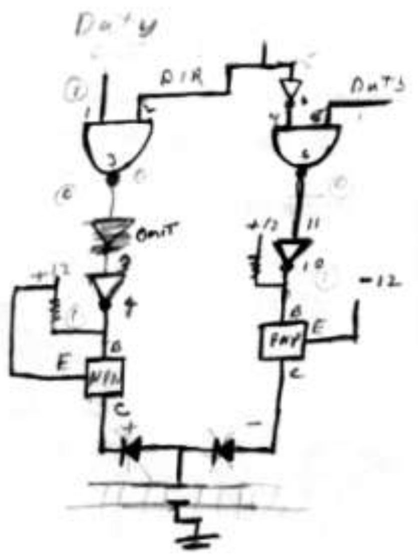
SYSTEM LAYOUT WORK SHEET

	MPU ADDRESS LINES (A0–A15)																ADDRESS	
DEVICE	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	FROM	TO
* PIA 1	CS1	$\overline{CS2}$												CS0	RS1	RSØ	8004	8007
PIA 2	CS1	$\overline{CS2}$										CS0			RS1	RSØ	8010	8013
* PIA 3	CS1	$\overline{CS2}$									CS0				RS1	RS0	8020	8023
PIA 4	CS1	$\overline{CS2}$								CS0					RS1	RS0	8040	8093
PIA 5	CS1	$\overline{CS2}$							CS0						RS1	RS0	8080	8083
*ACIA 1	CS1	$\overline{CS2}$											CS0			RS	8008	8009
*RAM 1	$\overline{CS}$	$\overline{CS}$						$\overline{CS}$	$\overline{CS}$	X	X	X	X	X	X	X	0000	007F
*RAM 2	$\overline{CS}$	$\overline{CS}$						$\overline{CS}$	CS	X	X	X	X	X	X	X	0080	00FF
*RAM 3	CS		CS					$\overline{CS}$	$\overline{CS}$	X	X	X	X	X	X	X	A000	A07F
*ROM 1	1	0	1	1			X	X	X	X	X	X	X	X	X	X	6000	63FF
*ROM 2	1	1	0	0			X	X	X	X	X	X	X	X	X	X	C000	C3FF
*ROM 3	1	1	1	0			X	X	X	X	X	X	X	X	X	X	E000	E3FF



I/O contorl panel for the M6800 board

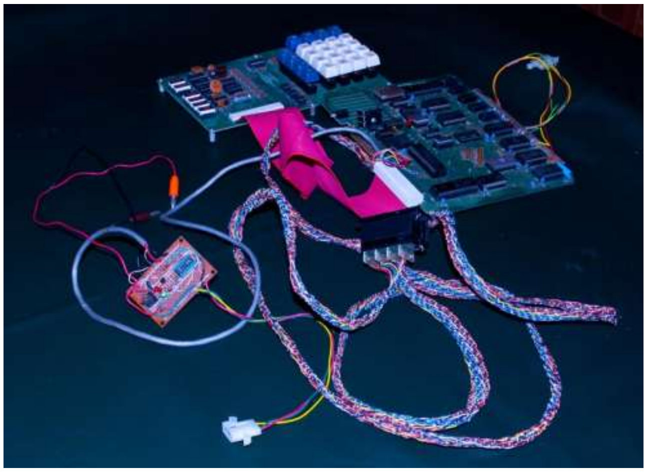




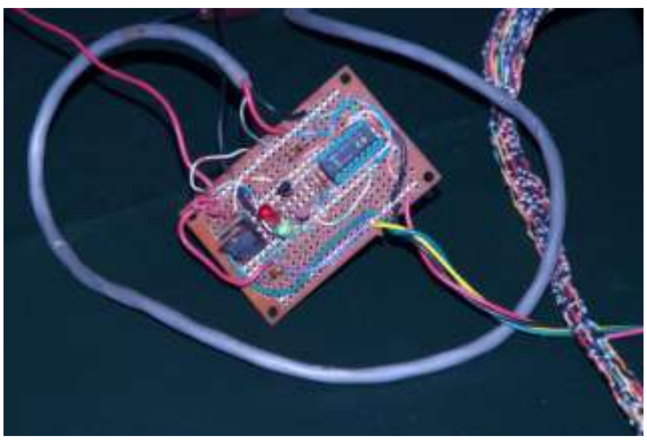
Two different circuits for connection of the track to the computer output.

In order to drive the current needed and control the direction the output from the logic circuits needed to drive power transistors between the computer system and the track block. Duty cycle (time on) and direction are combined to provide the length of time the power is on and the polarity of the current, thus providing speed and direction of the train out of the computer. If each block on the railroad was provided with one of these boards and a given an address the computer could send speed and direction to the blocks allocated to each locomotive.

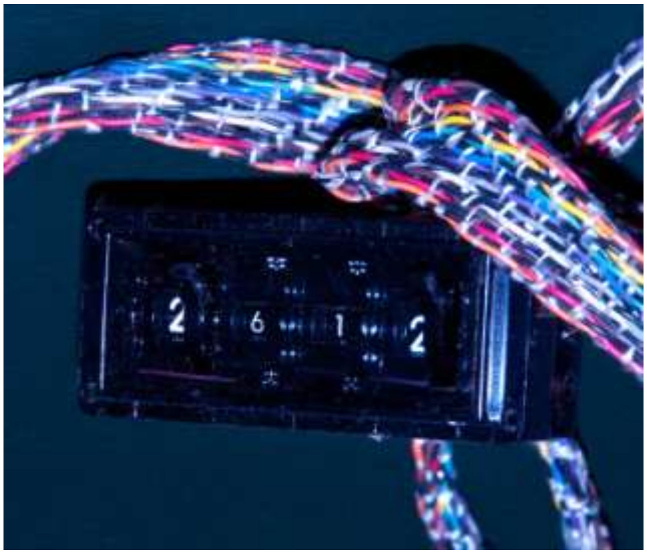
Computer Controlled Throttle



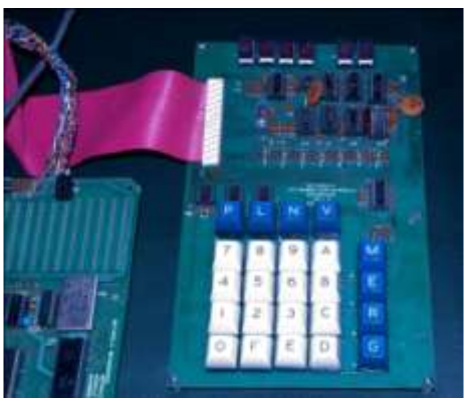
This Motorola 6800 system with connections to a keyboard, hand held control, track interface and power supplies makes up what today we find in a DCC decoder that we mount in a locomotive.



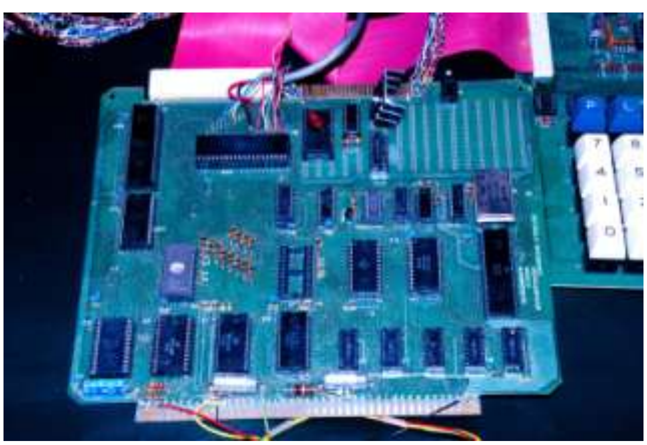
This is the track interface board that took in digital level signals and put out pulsed DC to the track. Direction and speed information was sent to this board and the DC power (today known as Booster power) was controlled.



I used a small set of switches to control the notch and direction on a long tether to allow me to move about the layout. Two extra settings in the center were used for testing loading and braking.



Data could be entered via this Hex pad with function keys around the outside. This was connected to the CPU board shown below. The system used +and -12 Volts and +5 Volts for the computer and an additional 12 Volt supply for the track power connected to the track interface.



Computer to railroad interface on DCC 3-22

DCC with JMRI RS232 serial Interface for locomotive ID and Control of NCE system

This image shows the IBM Think Pad X60 on a Media slice using a serial RS232 connection on Com 1 to connect to the NCE command station. The JMRI Java programs on the laptop interface with the NCE system to allow for setting the programming of locomotives as well as setting up the NCE system.

In this image the real time/ fast clock is being set for time and ratio. The results of these inputs appear on the handheld throttles as layout clock time.

I use the X60 because it still has a serial port on the media slice located under the laptop. This avoids the use of a USB to RS232 Serial adapter.

The JMRI programs have updates that keep the system current with new decoders and allow programming on the program track or the main.

In the table below we see the 9 pin serial connections. JMRI to NCE uses pin 3 to transmit data to the DCC and pin 2 to receive data from the DCC system, Pin 5 is signal ground. The cable is not a flip or a null modem but a direct one to one connection. The selected data rate is 9600 baud with 8 bits of data, No parity and one stop bit. The NCE DCC powerhouse Pro does not echo characters.

Computer connection is via a direct DB9 RS232 cable

In the table below I describe the wires and their use.

Computer	RS 232 Interface	Command Station
RS232	Direct Connection	RS232
DB9-S	Socket to Plug DB9	DB9-P
Pin number	Use	Pin number
1	Data Carrier Detect	1
2	Receive data	2
3	Transmit data	3
4	Data Terminal Ready	4
5	Signal Ground	5
6	Data Set Ready	6
7	Request to send	7
8	Clear to send	8
9	Ring Indicator	9

The Binary Command Set uses a format of <command number> <data> <data>

The range is from 0x80 to 0xBF in hexadecimal.

This is equal to 128 base 10 or 10000000 binary to 191 base 10 or 10111111 binary

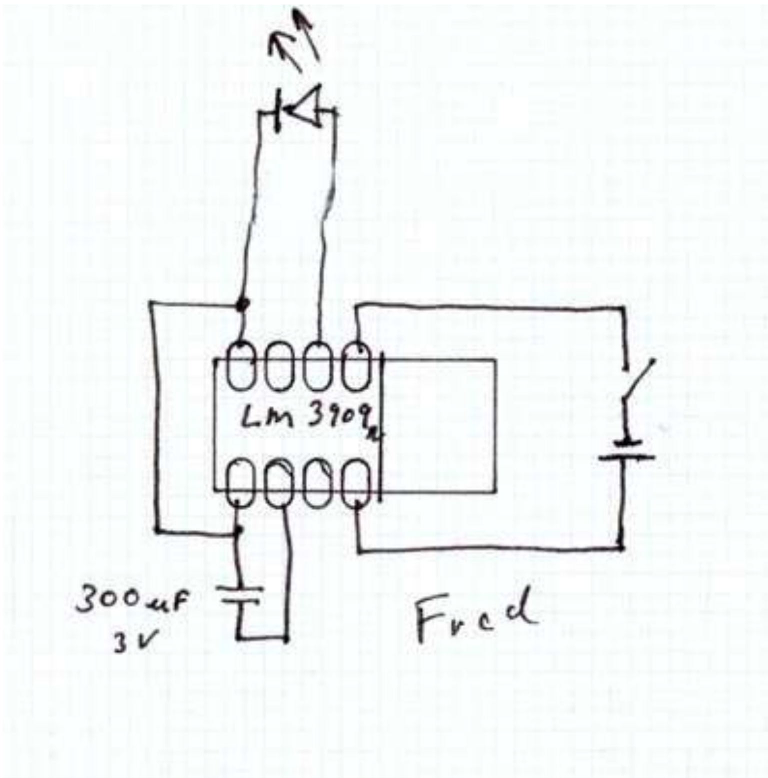
As an example to assign a cab to a locomotive the command would be 0x81 xx xx cc where xxxx is equal to the loco number in Hex and cc is equal to the cab in Hex.

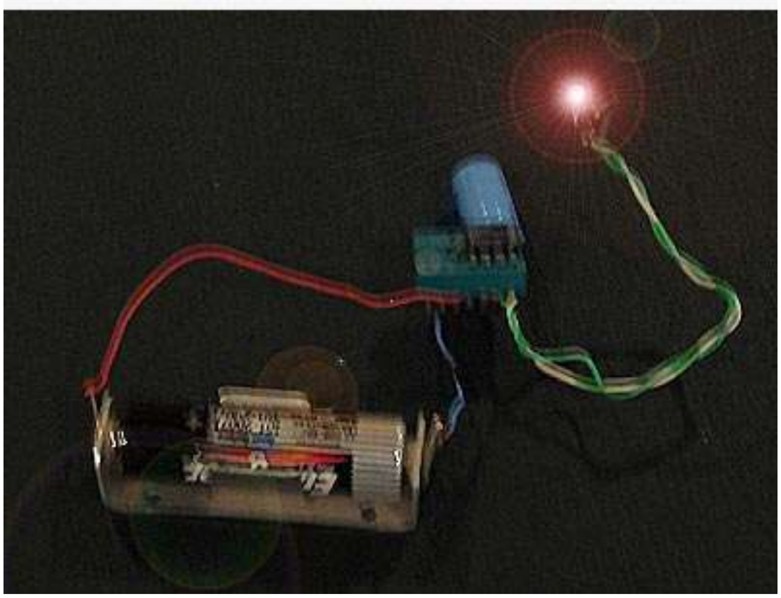
Sending speed to a loco is done with the 0xA2 command set for a short address loco #3 to speed 64 forward would be: 0xA2 <0x00> <0x03> <04> <40>. The NCE system would return a “!” for command completed successfully or a “1” meaning loco address out of range.

The JMRI software removes the need to know all of these commands and the base 10 to base 16 conversions. It is a user friendly interface program for computer to command station operation.

Other 3-23A   Flashing Marker

Part 5 now Other, This is part of the old EE under FRED





This is a very simple circuit using an LM3909, a 300mf capacitor and LED and shown with a 1.5 volt battery. A switch is added to save power. It is shown here outside of the caboose that was used on a DC layout for a training video.

Fast Time clock (retired) 3-23B

This has been replaced by the system in NCE DCC

Category 6

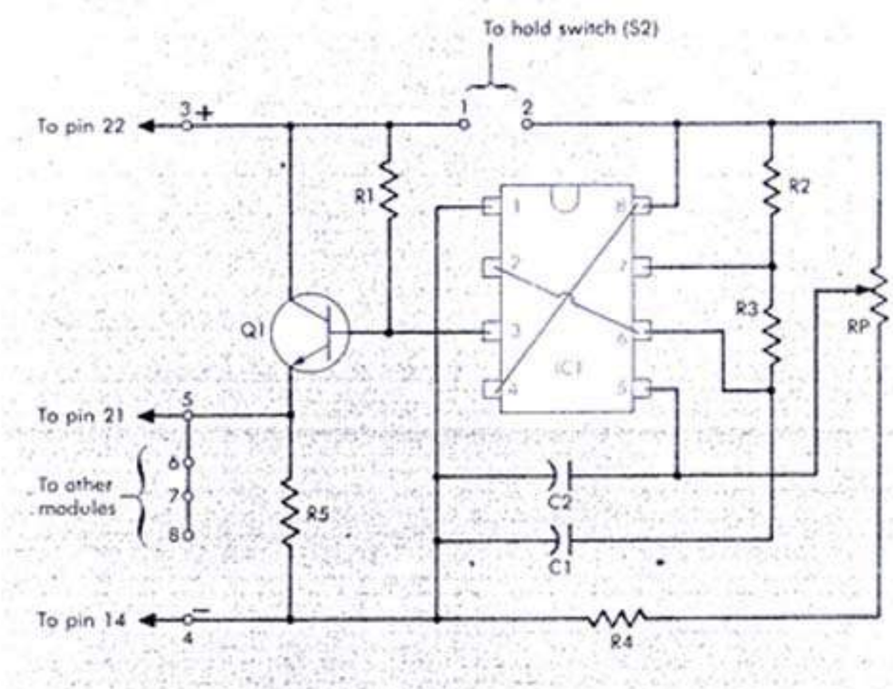
Requirement C22-2

Fast Time Clock

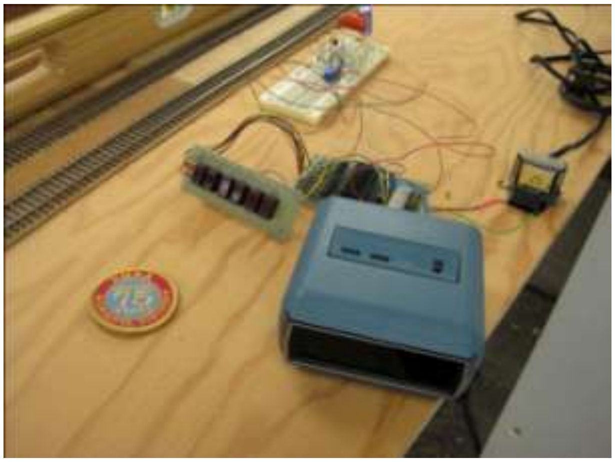
Drawing C22-2 shows the modifications to a Radio Shack four digit clock module (273-1001) which provides a new and variable time base.

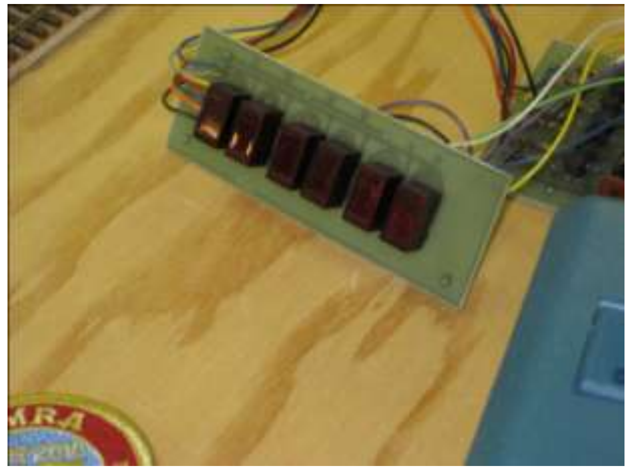
Electronic clocks of this type use the line frequency of 60 Hz to divide down and count seconds. Replacing the frequency input to the clock module with a signal from a home made time base allows the designer to determine the length of a second. This control allows for a choose of clock ratios.

Parts list	
R1	1,000 ohm resistor
R2	22,000 ohm resistor
R3	15,000 ohm resistor
R4, R5	510 ohm resistor
R6	5,000 ohm resistor
C1, C2	.068 mfd disk capacitor
Q1	NPN transistor
IC1	NE 555 timer IC
S1, S2	SPST switch
PB1, PB2	SPST NO push-button



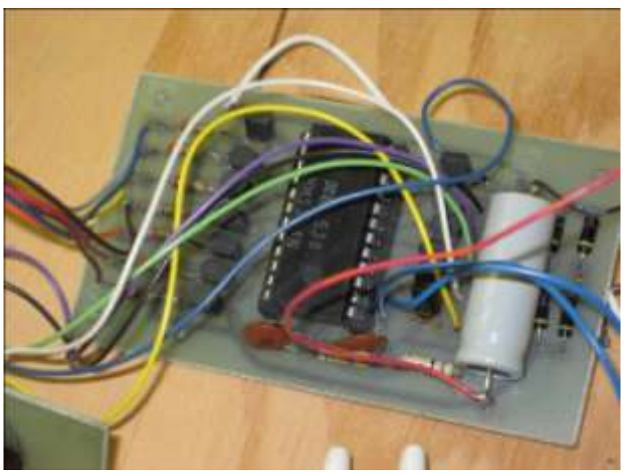
This fast time clock was built with a set of parts for a normal digital clock from Radio Shack and was modified with a new time base shown in the drawing above. This allows the changing of the ratio of model operating time to real time for use in operating sessions. I have added the photos of the clock and its case. For detail and demonstration of the operation I have setup a breadboard with the Fast Clock time base on it.

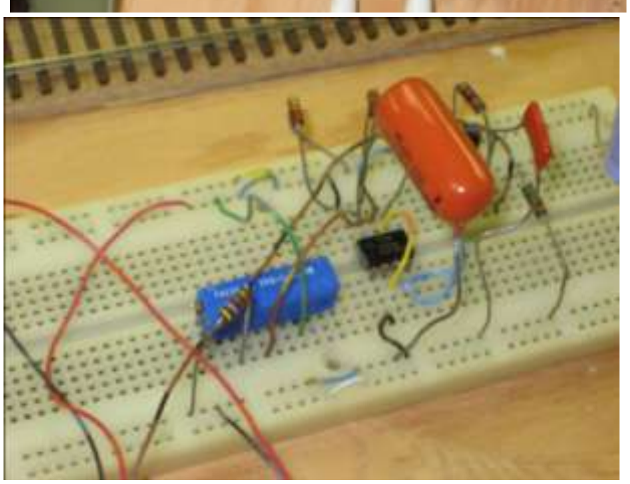




This is the clock case and parts.

This is the clock display Hours, Minutes, seconds





This is the logic board for the normal clock.

This is the circuit for a fast time base breadboard.

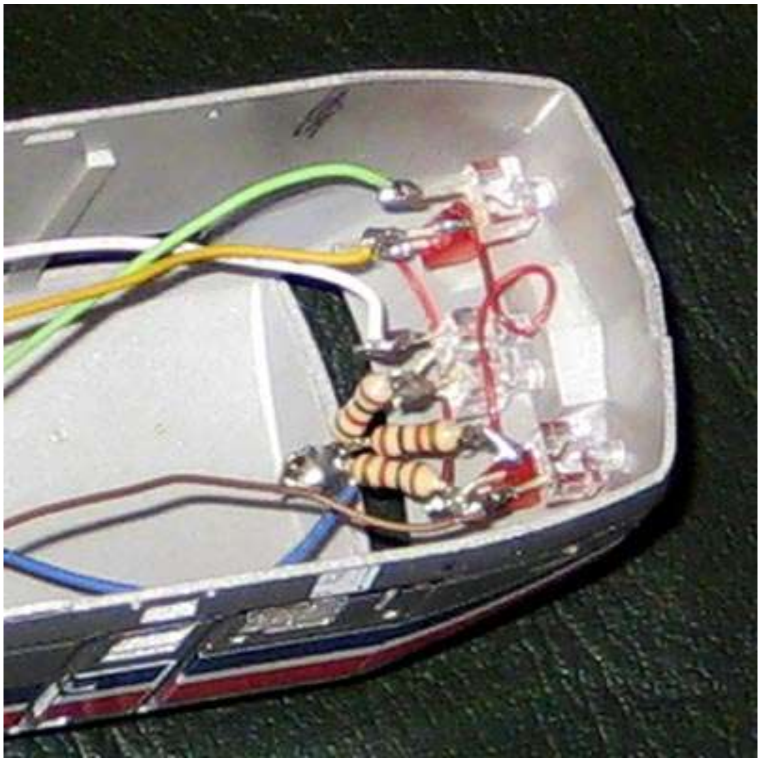
The blue part is a multi turn pot to adjust the time.

The clock system was retired because of the use of the NCE DCC throttles that have fast clocks connected to the main control system. The time ratio is controlled by the resistance set by fixed resistors in conjunction with the 10 turn pot.

3-23C Special installation of dual headlights, operating ditch lights and marker lights that show red when in the push of push/pull operations

I installed sub-miniature LEDs for headlights, red marker lights, and white ditch lights. Four lines, white, yellow, green, and brown, official color is purple but it came out brown in the photos, are used. Mapping the functions and the effects (FX) to the correct connections and then restricting the current for the LEDs is necessary for the operation to work. The LEDs used in this HO locomotive were made with small 3 mm lenses and have a rectangular base. In the case of the headlights and the marker lights these were wired in parallel. The ditch lights each have a dedicated wire and a common return to their resistor.

In this photo we see the white lead is connected to the 2 main headlights, the yellow wire is connected to the marker/ classification lights and the green and brown wires are connected to the ditch lights. All LEDs are then connected to their current limiting 1K resistors and then to the common blue wire.



The programming includes selecting the FX configuration for each output and assigning the appropriate value to the associated Configuration Variable (CV) for function mapping.

CV 33 is for Function (F) 0 Fwd (Headlight White wire) is assigned a value of 1
CV 34 is for F0 Rev (rear Headlight Yellow wire) is assigned the value of 2
CV 36 controls the Ditch lights and has outputs 3 and 4 assigned with a value of 12

Next program the FX CVs for outputs 1 thru 4
CV 120 for F0 Fwd (Headlight White wire) is assigned a value of 1, for forward, plus 128 for an LED =129
CV 121 for F0 Rev (used for the marker lights) is assigned the value of 2, for reverse, plus 128 for an LED =130
CV 122 and CV 123 control the Ditch lights these get set for forward 1 +60 for ditch lights +128 for LEDs

This programs the FX so that the headlights and the ditch lights operate in the forward direction and the marker lights are available for backing in push / pull operations.

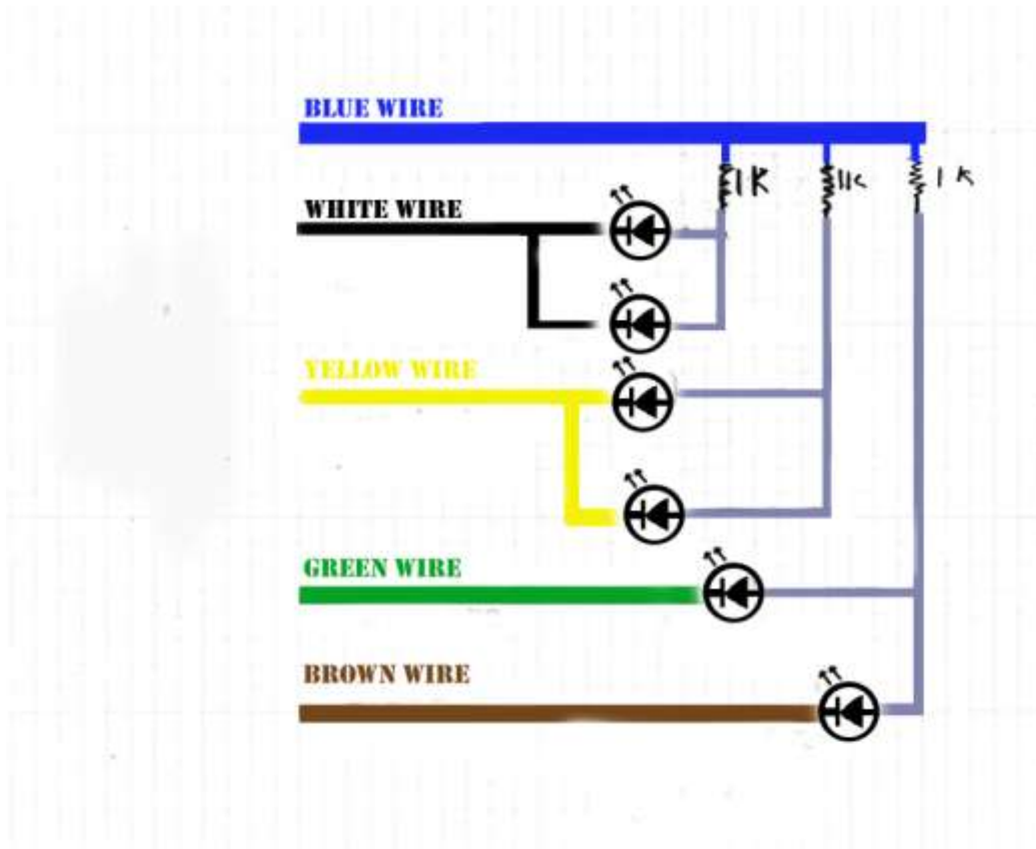
With these Athearn blue box locomotives you can also add Rotary Beacons on the roof using 1.5 volt lamps or LEDs with resistors to limit the current flow. The beacon program value is 12. It is common is to use the green wire (Function 3 which is CV 122) and add 128 if you use an LED.

You will also find that in the DCC ready locomotives the beacon is connected to the headlight and does not flash. This may be rewired for Function 3 control by rewiring the lamp. (Remember the resistor or you will get one flash)



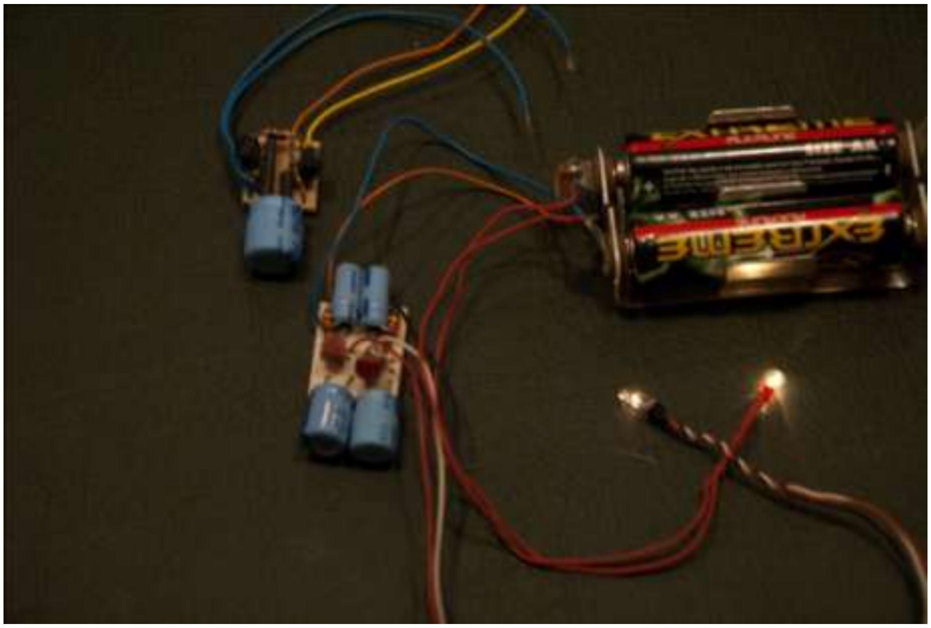
Amtrak

Amtrak



This is the drawing of the wires used from the NCE decoder to the LED lighting on the locomotive.

3-23D Normal and oscillating headlight and power regulation for DC



Hand drawing of the block circuit for an oscillating headlight circuit using a twin transistor multi-vibrator.