# MODEL RAILROAD ELECTRONICS

FROM DC TO DCC

# PURPOSE OF ELECTRONICS:

- Allow more prototypical trains operations on the layout
- Allow more prototypical track logistics: switch machines, signals
- Allow operations of accessories: building lights, animated parts, etc.

# DC OPERATIONS

- Provides simple analog control of locomotives
- Consisted locomotives all get same track voltage
- To control multiple trains, layout needs blocks wired to control panels
- Throttle are switched (DPDT toggle switch or rotary switch if more than 2 throttles) to connect to the block with the desired train.
- Functions like simulated momentum and braking can be included in throttle
- Reverse loops controlled by toggle switches

# DC PANEL

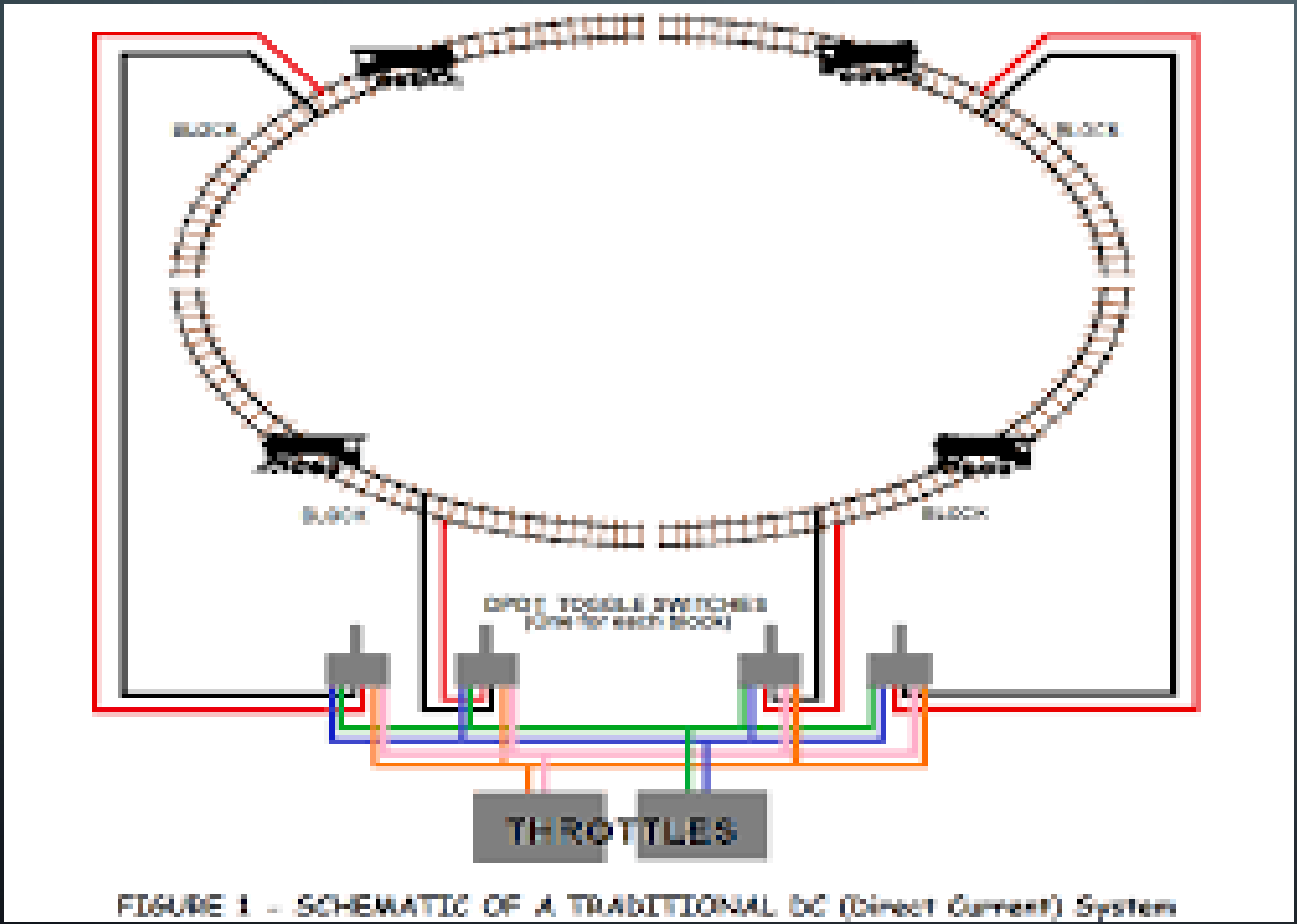
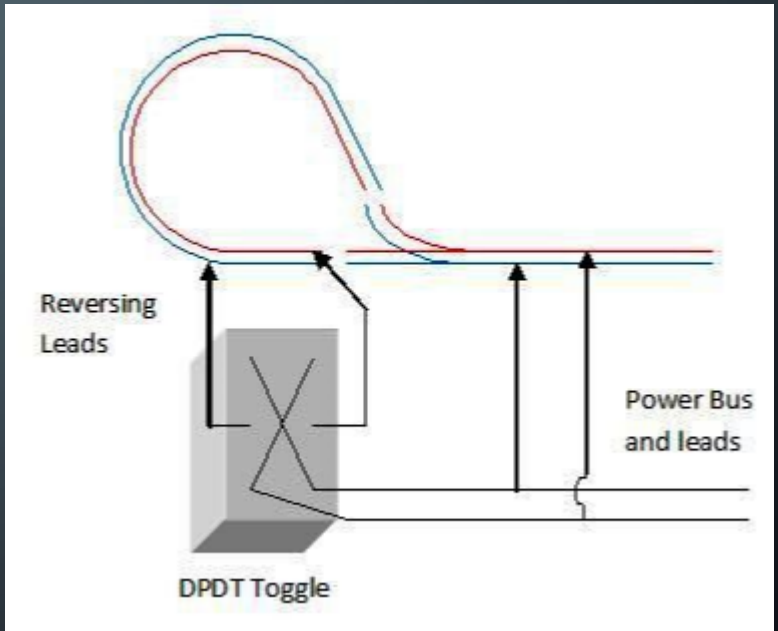



FIGURE 1 – SCHEMATIC OF A TRADITIONAL DC (Direct Current) System



# WHY GO DIGITAL ?

- Easy individual loco control
- Operation more typical of the prototype
- No block controls and no more “Who's got my train”
- Easier wiring
- Better motor performance by tuning your locos
- Walk around capability
- Sound in your existing locos.
- Light effects that can be selected off/dim/on at a constant intensity!

  Can also be on when the loco is stationary.
- **Do you want to operate trains and not your layout?**

# COMMAND CONTROL

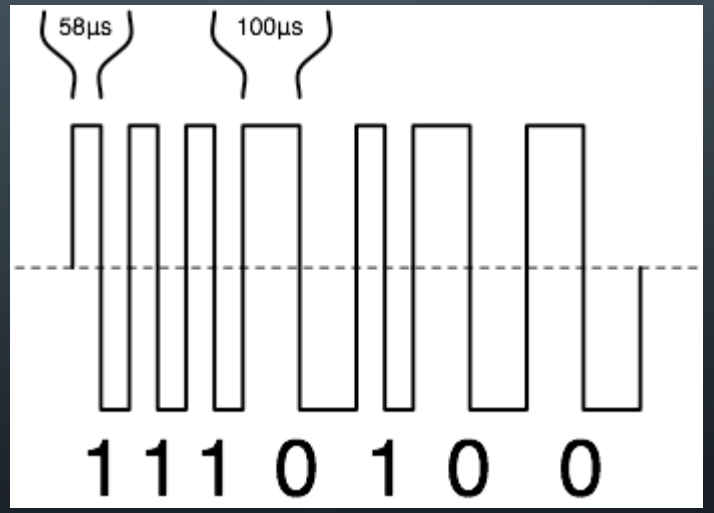
- Early Command Control systems were a Hybrid of analog and digital and not interoperable
- Vendors developed proprietary command control systems, wild west of digital days
- Early Systems included: **Märklin Digital, Selectrix, Trainmaster Command Control, Hornby Zero 1, Airfix Multiple Control System, DYNATROL, Digitrack 1600, Rail-Command 816, CTC-16, PROTRAC, SALOTA 5300, PMP-112, RFPT, KATO Digital**
- Poor technical support
- High Prices
- Large decoders
- Limited availability
- Limited acceptance

# EARLY DCC

- NMRA created a Digital Command Control working group
- NMRA desired interoperability
- In 1992 Stan Ames, who later chaired the NMRA/DCC Working Group, investigated the Märklin/Lenz system as possible candidate for the NMRA/DCC standards.
- NMRA developed a standard and a set of recommended practices based on the Lenz system

# NMRA STANDARDS

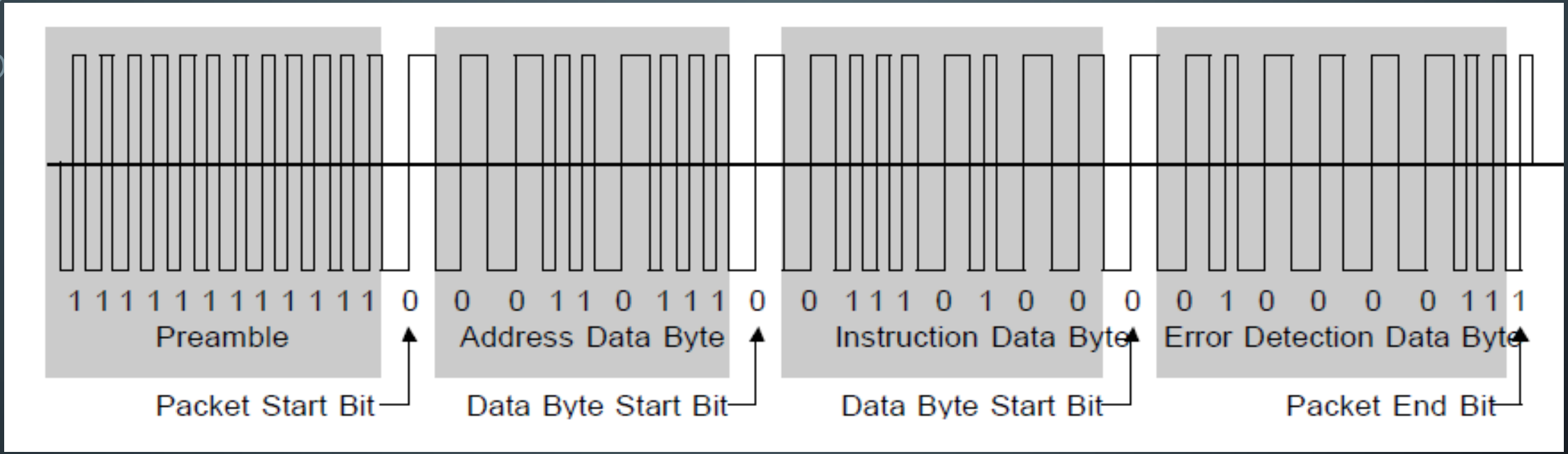
- Defined the signal to the rails (voltage, digital pulses, etc.)
- Did not define some aspects to allow vendor development (cab wiring, CV assignments, etc)
- Allowed interoperability meaning a throttle/command station of a manufacture could control decoders of any manufacture



# DCC SIGNAL

- The DCC data packet consists of a preamble, the address and instruction, followed by the post amble.
- The most common packets are four-word bundles.
- Preamble — Tells all decoders a data packet is about to start.
- Address — This sequence of bits contains the address of the decoder the packet it meant for.
- Instruction — The command that is being sent to the addressed decoder.
- Error Detection — This allows the decoder to check that the packet is valid, and if it is corrupted, the decoder will just ignore the packet and wait for the next preamble
- 200 data packets are sent each second

# DCC Packet Construction

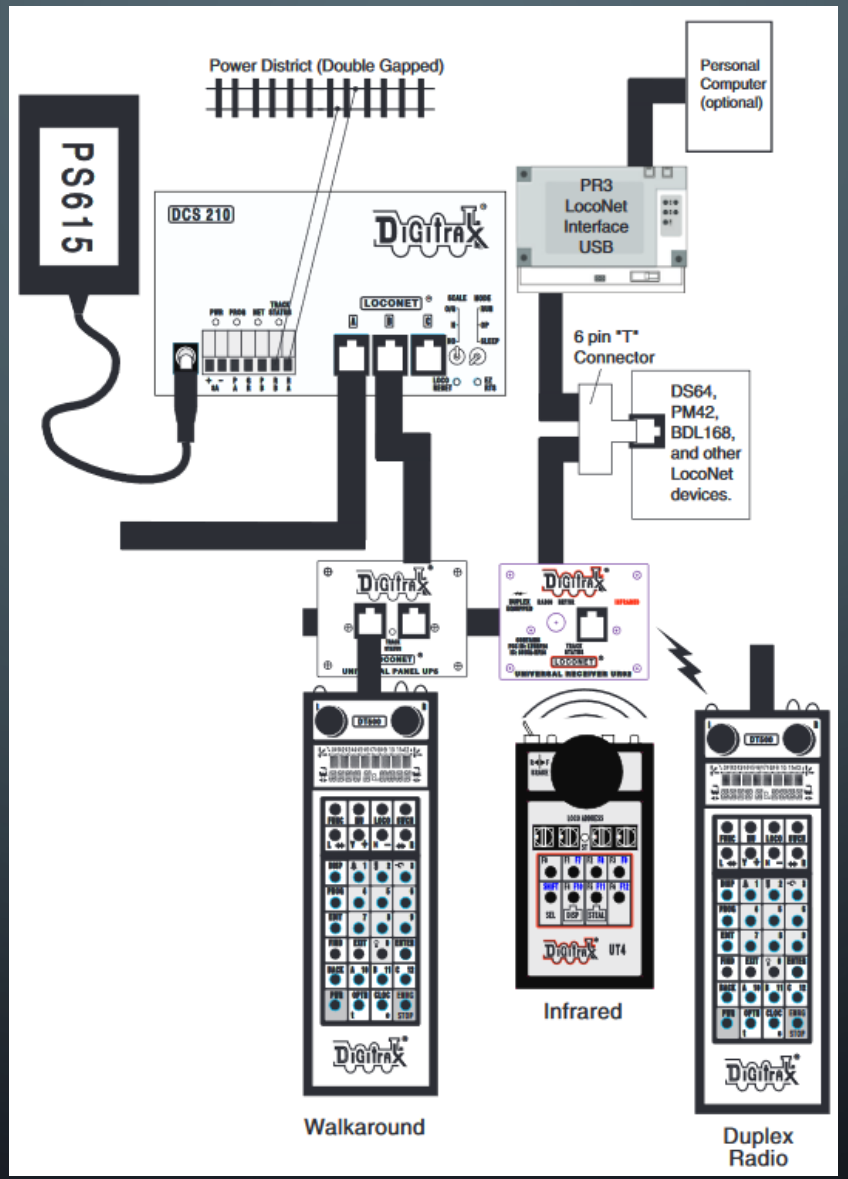



| Preamble | Packet Start Bit | Address Data Byte | Packet Start Bit | Instruction Data Byte | Packet Start Bit | Error Detection Data Byte | Trailing Bit |
|---|---|---|---|---|---|---|---|
| 111111111111 | 0 | AAAAAAA0 | 0 | 1DUSSSS0 | 0 | EEEEEEEE | 1 |
| | | A= Address<br>0 = Headlight | | D=Direction<br>U=Undefined<br>S=Speed | | XORed address and data bytes | |

# PINE RIDGE CLUB USES DIGITRAX SYSTEM

- Each layout has a command station and boosters
- Each layout has tethered throttles which connect into UP5 loconet jacks
- Duplex radio jacks (UR92) on both layouts allow untethered walk around
- Each layout has multiple power districts
- Each power district has an independent circuit breaker
- Reversing loops controlled by Autoreversers

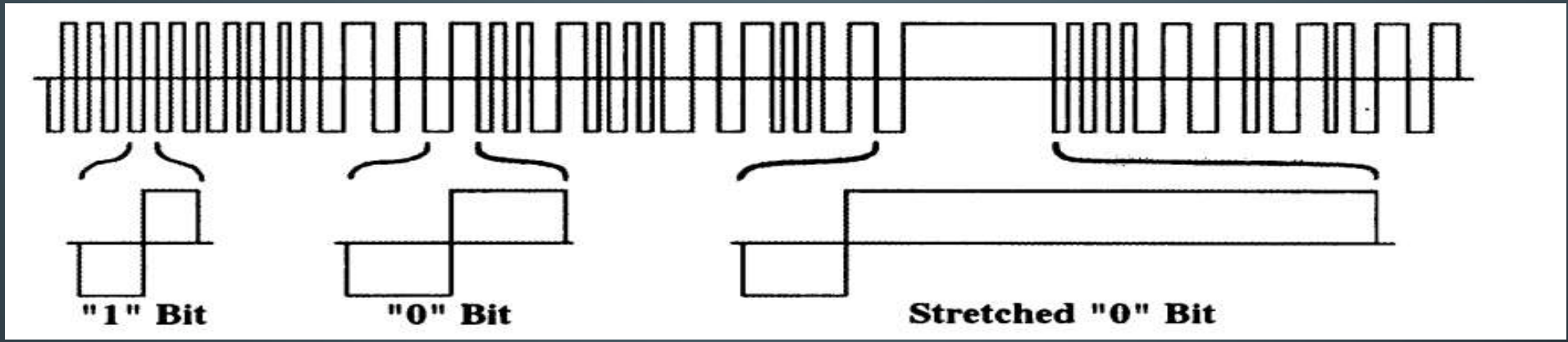
# PINE RIDGE CLUB USES DIGITRAX SYSTEM



# DIGITRAX COMMAND STATIONS

- Brains of the DCC system – generates the information decoders use to operate your locomotive
- Each system needs just one command station no matter the size of the layout
- Is a microcontroller based system
- Provides track power for several districts with digital based signal
- Loconet connects command station to boosters, throttle panels, stationary decoders
- Has configurable parameters to alter operating characteristics (OpSw)
- Has memory slots assigned for each mobile decoders (locomotives) – Default is 22 slots but can support 120 or 400. (altered by OpSw 44)
- Has output for a programming track
- Allows control of one DC loco using Zero Stretching

# DC CONTROL USING ZERO STRETCHING




- This feature was created to make DCC appealing during the early days. It enabled migration while minimizing fears relating to the cost and installation work required to upgrade to DCC. Zero Stretching is not part of the NMRA DCC specification and as such, not all manufacturers support Zero Stretching.
- As locomotive speed increases, more bandwidth will be demanded of address 0, which can have an impact on response times when more than 5 DCC equipped locomotives are also in operation. This technique is a bandwidth hog due to the need to constantly send packets addressed to 0.
- Creates motor buzzing when stopped, many reports of overheating motors and motor damage (I've lost one Atlas motor this way)

Note: Some manufacturers do not recommend operating a non-DCC decoder equipped locomotive on a DCC system. Refer to the instructions before trying your new locomotive on a DCC powered track.

- Digitrax Recommendation:
  "It is highly recommended that you remove any analog locomotives being run on DCC from the track when they are not actively running. DO NOT LEAVE AN ANALOG LOCO SITTING ON A DCC TRACK AT 0 SPEED!!! This can cause heat damage to your locomotive."

# DIGITRAX COMMAND STATIONS (CONT)

## 7.16 DCS210 Audible Sounds

The DCS210 uses several beeps and clicks that can be used as diagnostic tools that help you debug a number of conditions. Some Audible sounds mean different things depending on the DCS210's current mode.

| Sound | Meaning |
|---|---|
| Continuous short beeps | In Voltage Trim Mode, selection is in range. |
| 1 Short Beep | Diagnostic Beep when OpSw41 = c, LocoNet commands incoming. In EZ routes mode indicates a switch has been saved. During operation, DCS210 has recovered from a fault |
| 2 Short Beeps | Initial DCS210 Power on or DCS210 had purged a loco address |
| 3 Short Beeps | Entered quick routes mode |
| 4 short Beeps | Booster short circuit shutdown. |
| 5 Short Beeps | Route Error, looping route |
| 8 Short Beeps | Route Error, Maximum switch commands issued. |
| 1 Long Beeps | In EZ routes, initial Route ID saved |
| 2 Long Beeps | In EZ routes, route saved and exit EZ Routes |
| 3 Long Beeps | When pressing the Loco Reset Button, all loco addresses purged from the system. |
| 4 Long Beeps | Input Voltage is out of the range 13.8V to 24V DC |
| 10 Long Beeps | DCS210 has detected another Command Station on LocoNet and has turned off track power. |

***DCS210 AUDIBLE SOUNDS***

# DIGITRAX COMMAND STATIONS (CONT)

**DCS Option Switch Tables**

| Option Switch # | Effect on System operation when "closed" | Factory Default |
|---|---|---|
| OpSw 01 | Do Not Change | t |
| OpSw 02 | Do Not Change ("c" setting makes DCS100 a booster) | t |
| OpSw 03 | DCS100's booster is auto reversing | t |
| OpSw 04 | Do Not Change | t |
| OpSw 05 | Command station master mode<br>(We recommend this be changed to c) | t |
| OpSw 06 | Do Not Change | t |
| OpSw 07 | Do Not Change | t |
| OpSw 08 | Do Not Change | t |
| OpSw 09 | Do Not Change | t |
| OpSw 10 | Do Not Change | t |
| OpSw 11 | Do Not Change | t |
| OpSw 12 | Do Not Change | t |
| OpSw 13 | Loco address purge time extended from 200 seconds to 600 seconds | t |
| OpSw 14 | Loco address purging disabled | t |
| OpSw 15 | Purging will force a loco to 0 speed | t |
| OpSw 16 | Do Not Change | t |
| OpSw 17 | Automatic advanced decoder assisted [FX] consists are disabled | t |
| OpSw 18 | Extend DCS100 booster short circuit shutdown time from 1/8th to 1/2 second | t |
| OpSw 19 | Do Not Change | t |
| OpSw 20 | Disable address 00 or analog stretching for conventional locos. | t |
| OpSw 21 | OpSw 21-23 set the global system default type for "NEW" loco selections. SW21/22/23 set as follows:<br>t-t-t = 128 step mode<br>t-t-c = 128 step FX mode<br>c-t-t = 14 step mode<br>c-c-t = 28 step | t |
| OpSw 22 | | t |
| OpSw 23 | | t |
| OpSw 24 | Do Not Change | t |
| OpSw 25 | Disable aliasing | t |
| OpSw 26 | Enable routes | t |
| OpSw 27 | Disable normal switch commands, a.k.a. the "Bushby bit." Allows attached PC to handle switch control logic | t |
| OpSw 28 | Disable DS54 interrogate commands at power on | t |
| OpSw 29 | Do Not Change | t |
| OpSw 30 | Do Not Change | t |
| OpSw 31 | Meter route/switch output rate when not trinary | t |
| OpSw 32 | Do Not Change | t |
| OpSw 33 | Allow track power to restore to prior state at power on | t |
| OpSw 34 | Allow track to power up to run state, if set to run prior to power on | t |
| OpSw 35 | Do Not Change | t |
| OpSw 36* | Clears all mobile decoder info & consists | t |
| OpSw 37* | Clears all routes | t |
| OpSw 38* | Clears the loco roster | t |
| OpSw 39* | Clears all internal memory states, including OpSw 36, 37 & 38 | t |
| OpSw 40 | Do Not Change | t |
| OpSw 41 | Diagnostic click when valid LocoNet commands incoming & routes being output | t |
| OpSw 42 | Disable 3 beeps when loco address purged | t |

* See special instructions in *Section 9.1* for setting OpSw 36-39..

# DIGITRAX COMMAND STATIONS (CONT)

| Option Switch # | Effect on System operation when "closed" | Factory Default |
|---|---|---|
| OpSw 43 | Disable LocoNet update of command station's track status | t |
| OpSw 44 | Expand slot refresh area from 22 (Big Boy compatible) to 120 | t |
| OpSw 45 | Disable reply for switch state request | t |
| OpSw 46 | Do Not Change | t |
| OpSw 47 | Program track is brake generator when not program-ming. Braking is DCC set to speed 0 (not Emergency stop) for address 0, light ON, broadcast to all addresses | t |

*DCS100/200 Option Switches (Continued)*

# DIGITRAX COMMAND STATIONS (CONT)

**9.1 Changing DCS100/200 Option Switches**

1. See the Option Switch Table below to decide which option switches you want to change.
2. Move the MODE toggle switch on the front of the DCS100 into the "OP" position. The LocoNet Railsync will go inactive and all other boosters plugged in to LocoNet, including the one that is built into the DCS100, will shut down.
3. Disconnect LocoNet from the DCS100 you are configuring.
4. Connect your DT402 throttle directly to either DCS100 LocoNet Jack A or Jack B.
5. Press the **SWCH** key on the DT402 to enter Sw (Switch) mode. Since the DCS100's MODE toggle switch is set to "OP", switch commands from your throttle will now control DCS100 internal option switch settings instead of the accessory decoders (usually turnouts) on the layout!


6. Key in the number of the OpSw. In the example above, we have keyed in 5 for the switch. As you browse through the OpSws, the right side of the text area will show the current setting for each OpSw , either "**c**" or "**t**".
7. Use the **CLOC / c** key to set the OpSw to **c** (closed) or the **OPTN / t** key to set the OpSw to **t** (thrown). In the example above we have changed OpSw 5 from its factory setting of **t** to **c** (recommended setting).
8. Exit DCS100 Option Switch Mode by moving the MODE toggle switch on the DCS100 to "RUN." Remember to reconnect LocoNet to the DCS100. Track power will be off so you will need to use your DT402 to turn it on again before you can run trains.

**Note: Do not adjust any Op Switches marked "Do Not Change"** These option switches are reserved and changing them may give unpredictable operations. Do not change any option switches not listed in the table below.

**Special Instructions for DCS100 Op Switches 36, 37, 38, and 39**

For Op Switch #36-#39 to work properly,

1. Set the OpSw to "**c**" by pressing the **CLOC / c** key.
2. Set the DCS100's MODE Switch to "SLEEP" mode.
3. Set the DCS100's MODE Switch back to "RUN" mode.
4. The operation will occur (data will be cleared) and the option switch will reset to "**t**".
5. Your DT402 display will still show "**c**" even though the reset has occurred.
6. The display will update the next time you access the OpSw.

# DIGITRAX BOOSTERS

- Amplifies the digital signal from loconet to the rails
- Built into the command station most often as well as standalone units
- Some provide short circuit protection, voltage regulation, and auto-reversing capabilities
- Loconet connects booster to the command station, throttle panels, stationary decoders
- Has configurable parameters to alter operating characteristics

# DIGITRAX THROTTLES

- Tethered, wireless, and built-in to the command station (Zepher)
- Multiple throttles per system for multi-operator ease
- Utility throttles (UT4) allow single loco control, speed, direction, lighting and functions
- Advance throttles (DT400 series & DT500 series) have basic features plus allow dual throttles programming capability, switch control, accessory control, build consists
- Both throttle types available in tethered, IR and Duplex Radio varieties
- Both throttle types have different methods to dispatch locomotives (frees the limited slots)
- The DT400 series of throttle support configuration of up to 255 CVs
- The DT402 & DT500 series of throttles support configuration of up to 1024 CVs

# DIGITRAX THROTTLES (CONTINUED)


# SLOT MANAGEMENT AFFECTS PERFORMANCE

| Slot # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Engine # | 3088 | 2017 | 1520 | 28 | 128 | 5128 | 181 | 818 | 8181 | 57 | 1520 | 2002 | 681 | 6881 | 287 | 6887 | 3210 | 7229 | 6337 | 7112 | 3084 | 7337 | 2000 |
| User | Dave A | Roger E | Steve | Mark | Mark | Mark | Mark | Mark | Mark | Dan | Brian | Mark | Dave M | Dave M | Ryan | Sean | Shaun | Keldon | Michael | Roger | Chuck | Eric | Adam |

22 Slots in use, roughly 1/5 second to transmit data for all 22 locos
(Adam shows up at 7:30 and gets "Slot Max" and can't run mainly because of Mark)

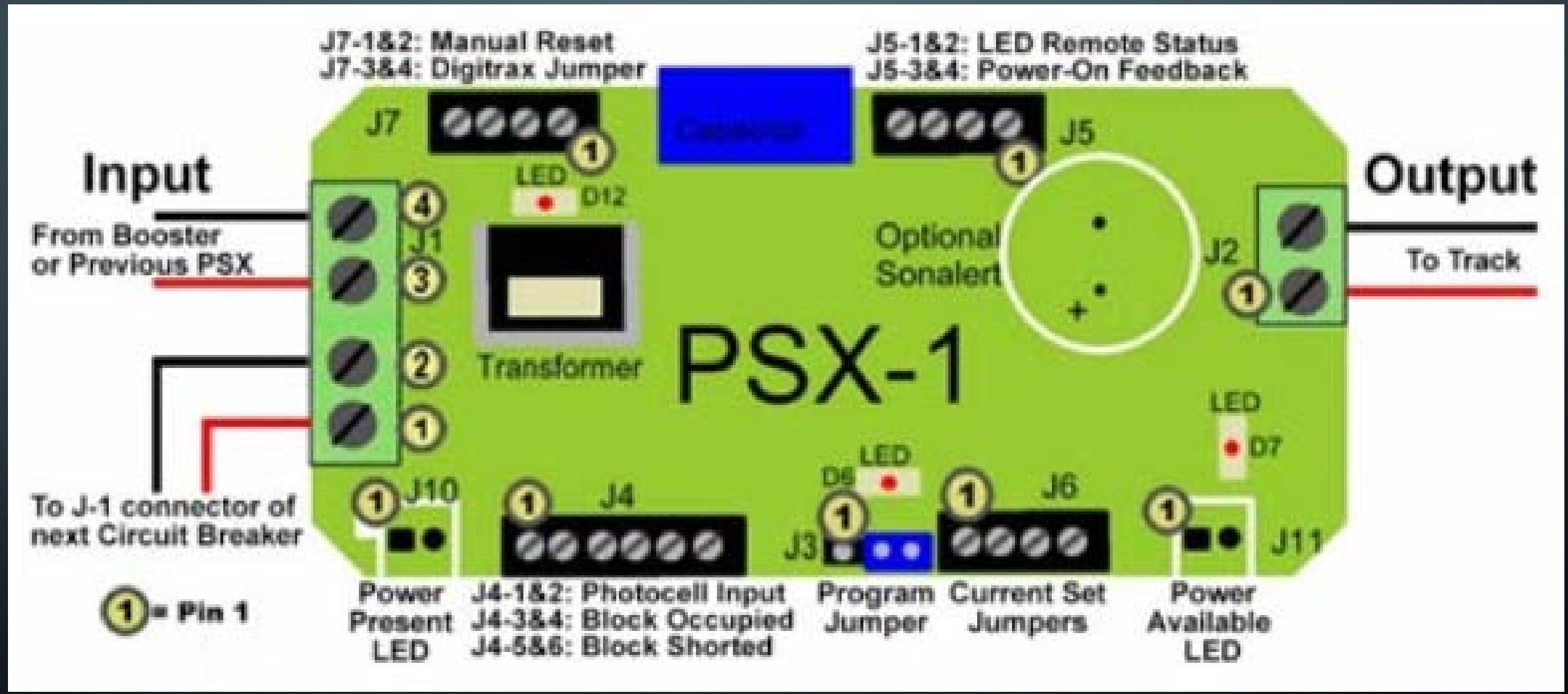
| Slot # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Engine # | 3088 | 2017 | 5120 | 128 | 5128 | 0 | 57 | 1520 | 2002 | 681 | 6881 | 287 | 6887 | 3210 | 3 | 7229 | 6337 | 7112 | 3084 | 7337 | 8181 | 2000 | |
| User | Dave A | Roger E | Steve | Mark | Mark | Mark | Dan | Brian | Mark | Dave M | Dave M | Ryan | Sean | Shaun | Mark | Keldon | Michael | Roger | Chuck | Eric | Mark | Adam | |

22 Slots in use, roughly 1-2 seconds to transmit data for all 22 loco if DC loco is slow then faster transmission, if DC loco running fast then very slow data transmission
(Everyone get slow response because of Mark)

# CIRCUIT BREAKERS

- Each power district has an independent circuit breaker
- Both permanent and portable layouts use PSX circuit breakers by DCC Specialties
- Each breaker has configurable parameters (jumper and/or OpSw)
- Configurable trip current level, trip delay

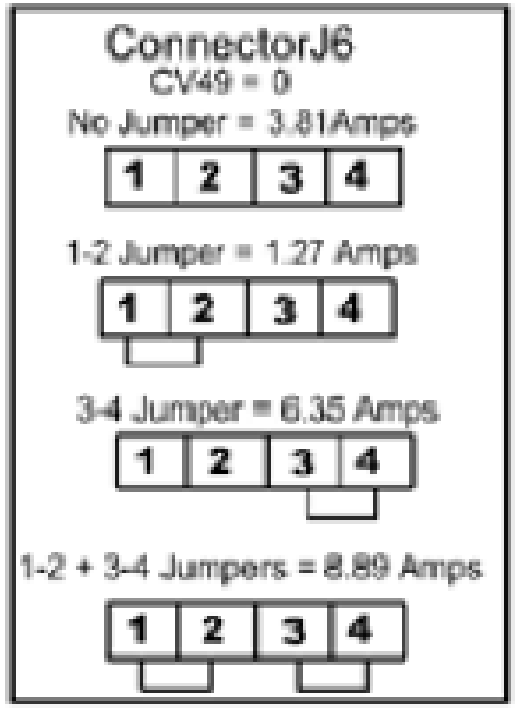
# CIRCUIT BREAKERS (CONT.)




PSX circuit breakers by DCC Specialties

# CIRCUIT BREAKERS (CONT.)

**CV49** – sets the current trip value. If CV49=0, then the Trip Current jumpers on J6 are enabled. **Remember to use either the Jumpers or the CV settings, NOT BOTH!** The following trip currents can be set by programming:




| CV49 | Trip Current [Amps] | Continued | |
|---|---|---|---|
| 00 | 3.81 or Per Jumper Chart | CV | Trip Current |
| 01 | 1.27 | 08 | 10.2 |
| 02 | 2.54 | 09 | 11.4* |
| 03 | 3.81 | 10 | 12.7* |
| 04 | 5.08 | 11 | 14.0* |
| 05 | 6.35 | 12 | 15.2* |
| 06 | 7.62 | 13 | 16.5* |
| 07 | 8.89 | 14 | 17.8* |
| | | 15 | 19.1* |

*Caution: continuous operations at a value higher than CV49=08, [10.2 amps] without the addition of heat sinks to the output transistors may overheat or damage the PSX. Heat sinks are available from DCC Specialties. PSX's can also be ordered with heat sinks installed by DCC Specialties.

# CIRCUIT BREAKERS (CONT.)

**CV55** determines the time between the occurrence of an over current condition [e.g. short circuit] and the removal of power from the PSX J2 Power Output Terminal.

- CV55=0. The PSX trip time is equivalent to a fast blow fuse. The output will turn off in less than 1ms after the over current condition occurs.
- CV55=1 The PSX will insert a delay between the time the over current condition occurs and the output turns off. If the current drops below the trip current set point [CV49] during the delay time, the output will not turn off. This is equivalent to the behavior of a slow blow fuse.
- If CV55=1, the length of the delay is determined by CV65.
- The CV55 default is 0 [see CV65 for default delay].

**CV65** controls the length of delay enabled by CV55.

- Valid CV65 values are 1 to 255.
- The delay in milliseconds is the CV65 value divided by 8 [e.g. a value of 80 = 10ms delay].
- The ideal value for CV65 is the smallest value that still results in reliable layout operation.
- If you are experiencing nuisance trips, try increasing CV65 by 8 until the nuisance trips stop.
- A value of CV65=128 should work for almost all layout problems. Remember, the PSX is supposed to turn off when it sees too much current. A "nuisance" trip is still an over current condition. Make sure the "nuisance" condition is acceptable before you increase the trip delay of the PSX and hide a real layout issue.
- The CV65 default is 24 which will be a delay of approximately 3ms. It is selected as the minimum delay to use in conjunction with a PSX-AR, although your layout may require more delay.

# CIRCUIT BREAKERS (CONT.)

## J. Special Programming Instructions

**Specific DCC Systems need to follow specific programming sequences to reliably program a PSX. See Section K for specific system instruction**

**All systems:** Program CV's using POM. Do not use Program track or accessory programming.

**Digitrax: Install the Digitrax Configuration Jumper wire from Terminal J7.3 to J7.4**

By installing the Digitrax Configuration jumper connection, all aspects of the PSX series are optimized to operate with Digitrax equipment. This includes the DCS50, DCS51, DCS100, DCS200, DCS210, DCS240 and the associated booster only units. As a result of these changes, it is recommended that any layout using Digitrax equipment should install this jumper. Note that the configuration jumper does NOT affect the trip current setting. You will still need to select the trip current you want to use.

At power up, Digitrax systems place several commands on the track bus intended for use by other Digitrax accessories. These signals appear to the PSX as an accessory address. In order to prevent these addresses from incorrectly programming the PSX, a PSX will not accept a command to program an accessory address above 999 when the Digitrax Configuration Jumper is installed.

With the Digitrax Configuration Jumper installed, the PSX uses a different turn on algorithm that enhances the ability of the Digitrax equipment to turn on multiple sound decoders without difficulty.

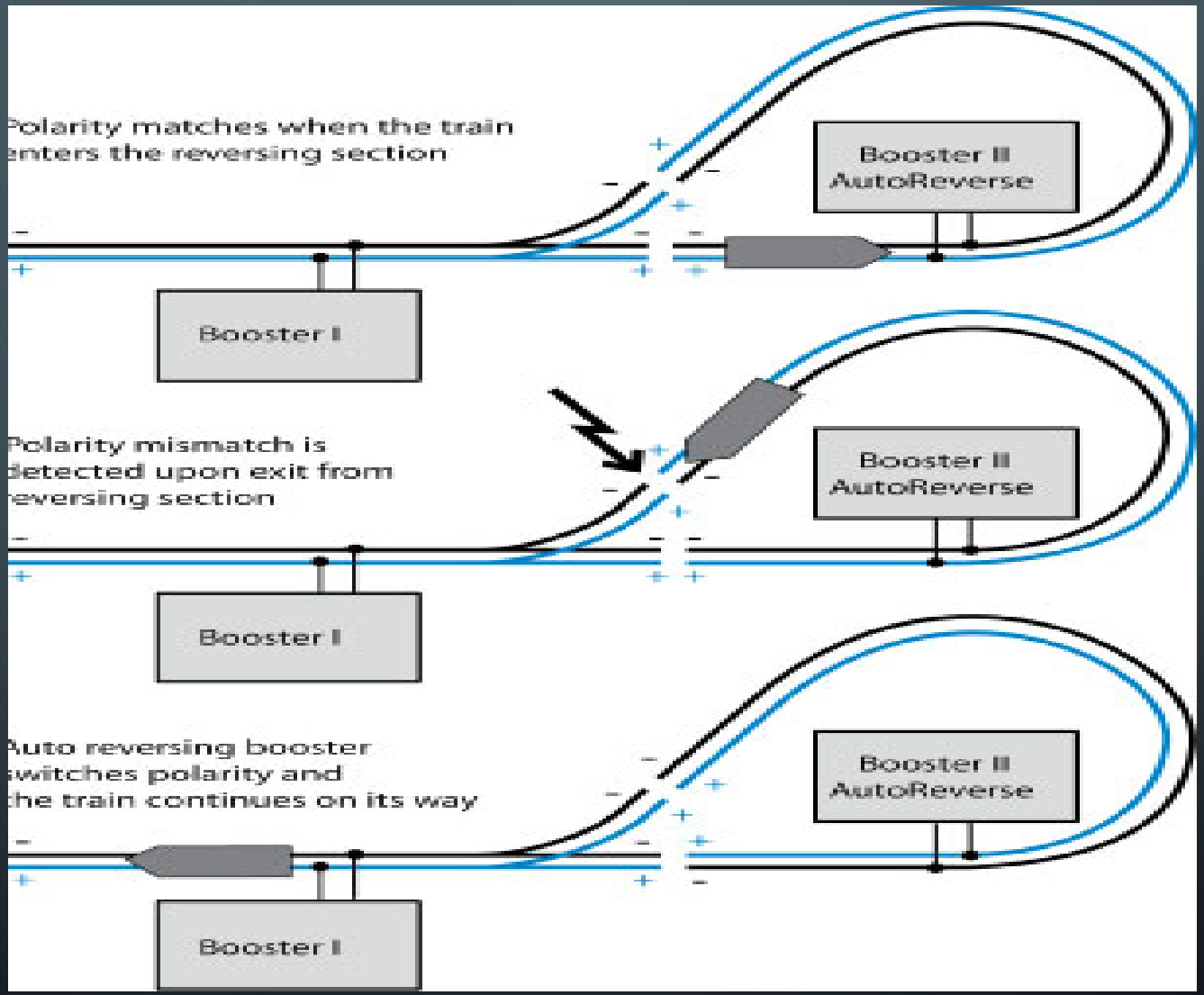
# AUTO REVERSERS

- Virtually all automatic reversing will fall into 3 categories with the wiring principles for all being the same:

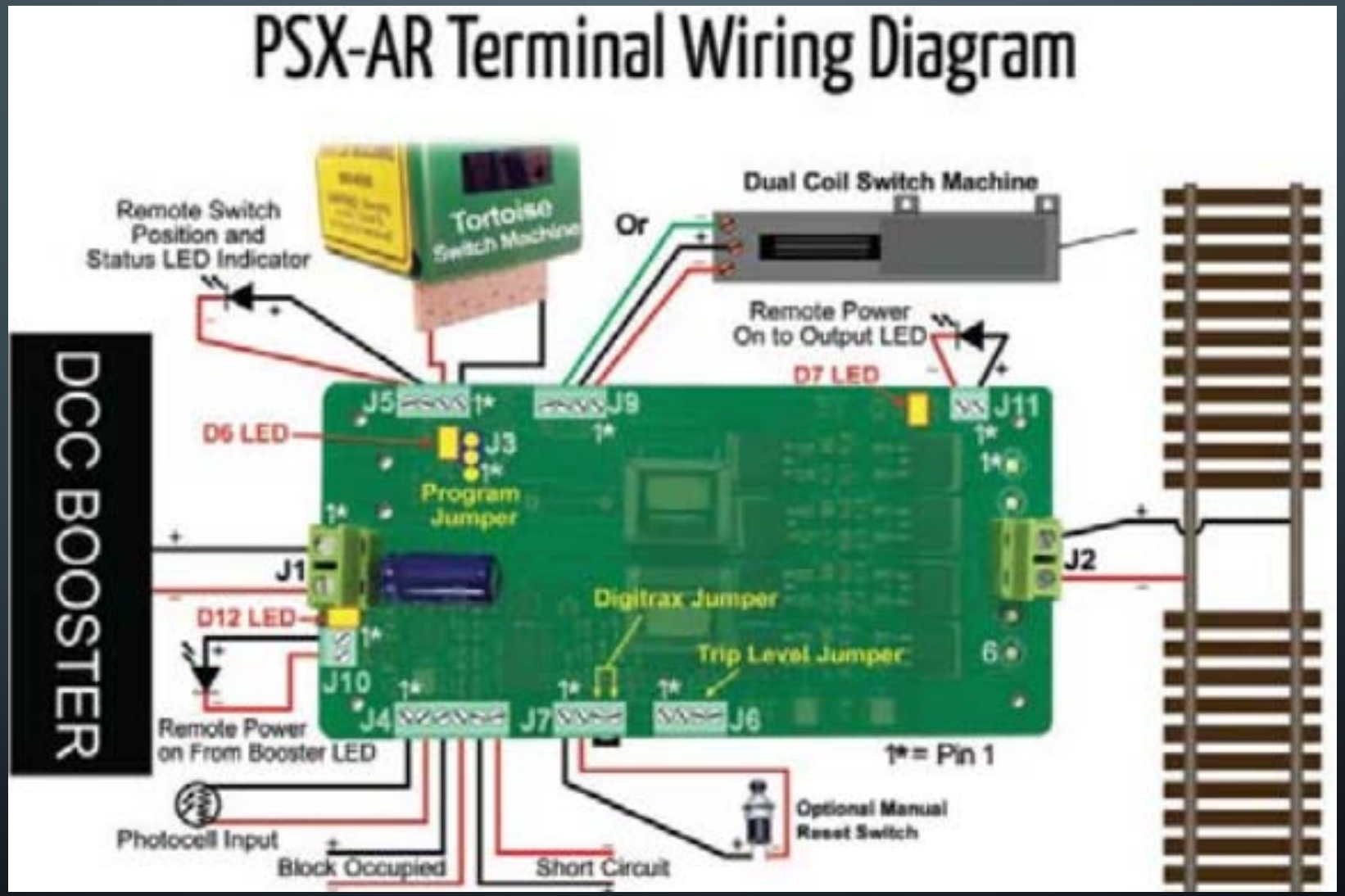
  1. Reverse Loops  2. Wyes  3. Turntables

- Available from several manufactures, several models per manufacture
- HO uses PSX-AR by DCC Specialties for the Y leading into CP yard and reverse loop on upper deck by the farm
- N uses the Booster in Autoreverse mode for turntable
- Trip current / switching time controlled by jumpers and/or OpSw settings

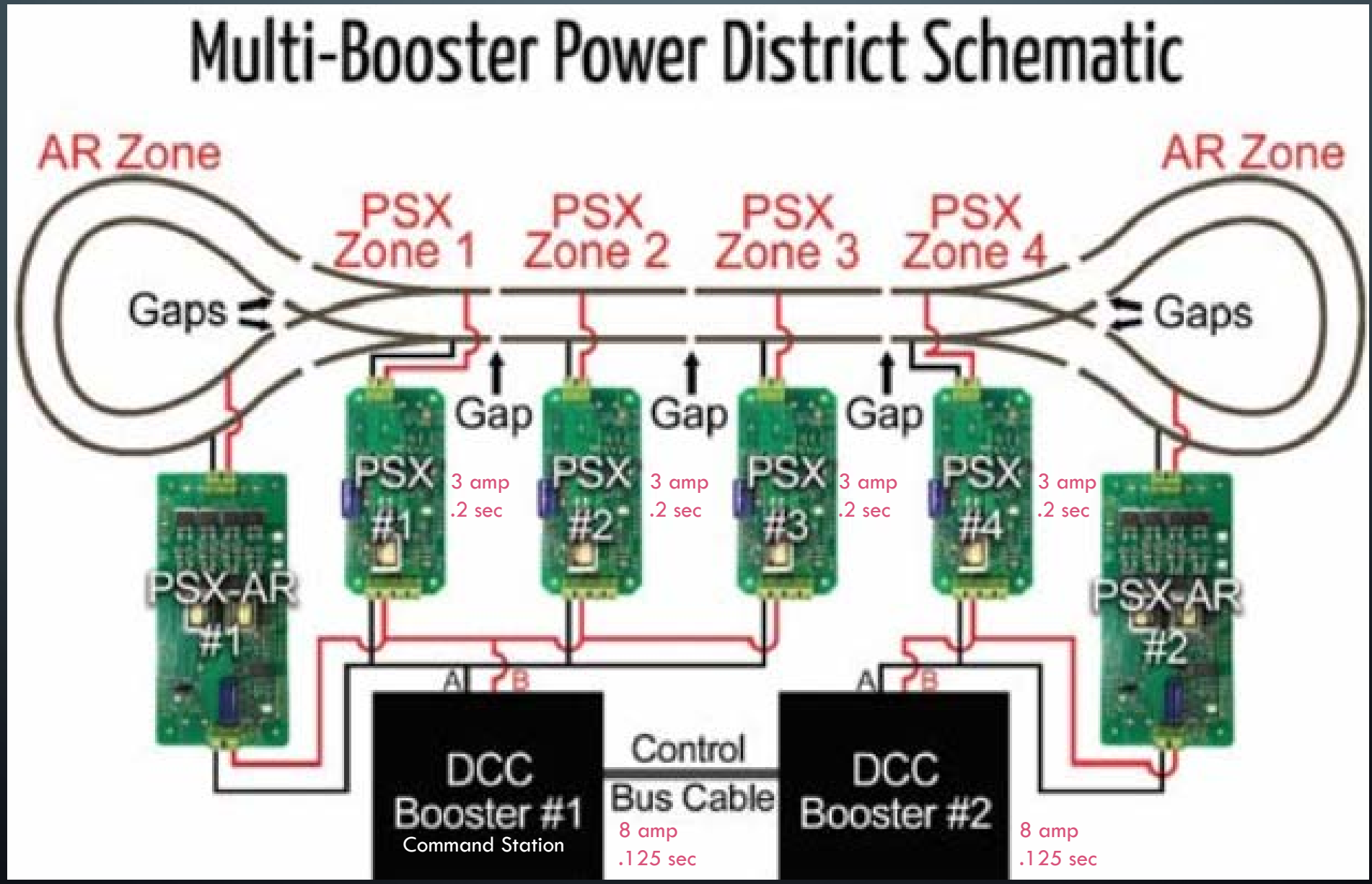
# AUTO REVERSERS (CONTINUED)



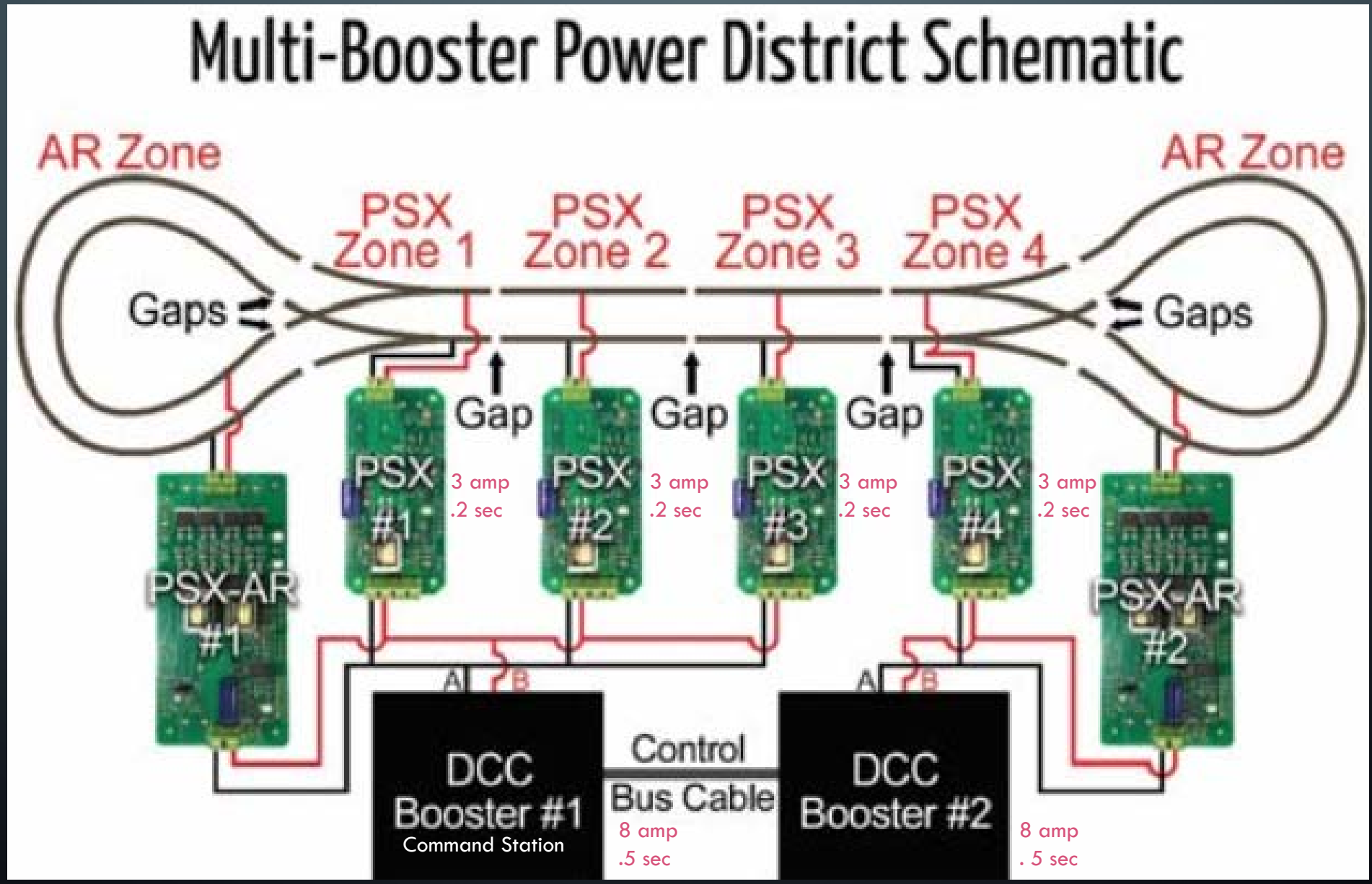
# AUTO REVERSERS (CONTINUED)



# TYPICAL MULTI DISTRICT



# TYPICAL MULTI DISTRICT (CORRECTED TRIP TIMING)



# DISTRICT POWER WIRING

| Length | Current in AMPS | |
|---|---|---|
| | • 0 - 5 amps | • 5 - 8 amps |
| • 0’ – 30’ | • 18awg | • 16 awg |
| • 30’ – 50’ | • 14awg | • 12 awg |
| • 50’ – 100’ | • 12 awg | • 12 awg |

# MOBILE DECODERS

- The brains for the locomotives
- Connects between the locomotive motor and the rails
- Receives the digital signal from the command station and translates (decodes) the signal into visual or audible effects from the locomotive uses a unique address to identify it amongst multiple locomotives – user assigned – usually the cab number
- Non-Sound: $10 - $40  Sound: $100 - $140  Speakers: $10 - $15

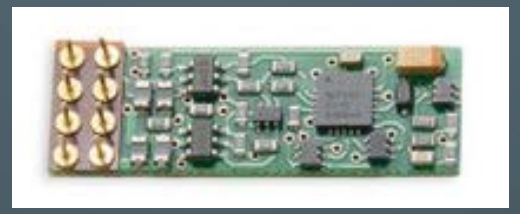
# MOBILE DECODERS
## Terminology

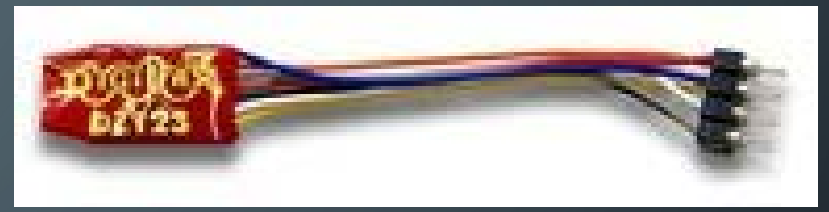
- Lots of jargon and acronyms
- DCC Ready vs. DCC Equipped
- DCC Ready means the locomotive is “ready” for a decoder. Its motor is isolated from the track through a circuit board. The circuit board may have a plug (8-pin or 9-pin) for easy decoder installation. Others require replacing the factory circuit board with a similarly shaped and sized DCC decoder.
- DCC Equipped means the locomotive is “equipped” from the factory with a DCC decoder. Place on a DCC layout and have fun. Some factory installed decoders are pre-programmed to the last 2 digits of the cab number. Others are default to address 3. Decoder equipped locomotives can be operated on analog DC.
- Sound Equipped locomotives are automatically DCC Equipped!

# MOBILE DECODERS

## Types

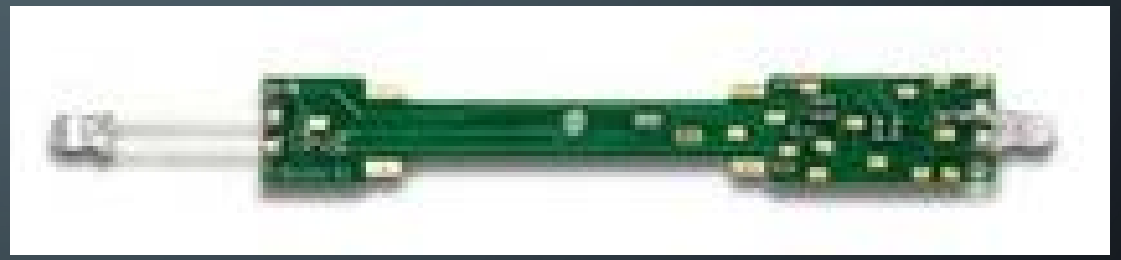
- Pin Connected



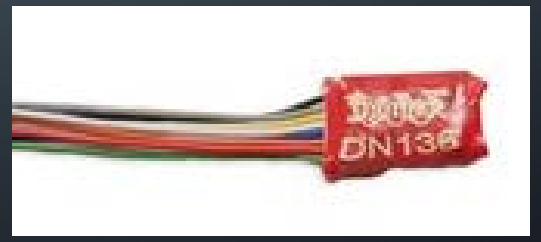


- Drop in light

Board replacement



- Hard wired



# CONFIGURATION VARIABLES

- Configuration Variables (CVs) are used to make changes to parameters within decoders
- NMRA Standard CVs
- Manufacturer specific CVs
- Numerous CVs available for use – not all are used
- Some CVs have multiple ‘levels’ and control many different parameters – Indexing

# CHANGING CVS

- There are two methods for changing CV settings:
- Service Mode Programming – Program track
- Operations (Ops) Mode Programming - Main Operating Track

# SERVICE MODE PROGRAMMING

- Uses a separate track called the ‘program track’
- Requires an isolated section of track – can be a dead end siding with a Run / Program toggle switch  (N layout has programming track on upper deck front track behind engine house)
- Can read CVs back with most systems
- Do not need to know the locomotive address
- Cannot test settings changes in Service Mode
- Program track booster required for some sound decoders
- Some systems may have difficulty reading or programming other brands of decoders

# OPERATIONS (OPS) MODE PROGRAMMING

- Also known as “Programming on the Main (POM)”
- Reliable
- No need for a separate track or to shut down the layout
- No need for programing boosters for sound decoders
- Can test settings changes immediately
- Cannot read CVs
- Must know the locomotive address
- Each locomotive on the main needs to have a different address OR locos programmed individually
- Multiple locomotives can get programmed accidentally

# IMPORTANT CVS

- Decoder Reset CV
- Most decoders CV 8 to 8 resets the decoder
- Some decoders use other methods
- SoundTraxx uses CV 30 to 2 (CV 8 to 8 also)

(Must interrupt track power – 16 headlight flashes confirms reset)

- Lenz uses register 8 to 33

# DECODER FUNCTION OUTPUTS

- Functions are outputs for controlling bulbs, LEDs, relays, etc.
- Color coding for easy wiring – NMRA standard
- Pin 1 – orange motor +
- Pin 2 – yellow reverse light (F0r)
- Pin 3 – green wire (typically not used)
- Pin 4 – black left rail track pickup
- Pin 5 – grey motor
- Pin 6 – white forward light (F0f)
- Pin 7 – blue + common for lights
- Pin 8 – red right rail track pickup
- White, Yellow, Green (Purple) are function output wires (-)
- Some decoders have 4, 5, or 6 function outputs for more lights
- Blue wire is ALL lights common (+) and about 12 volts
- 1k ohm ¼ watt resistors required in most cases for LEDs (Some decoders have resistors built-in)

# DECODER FUNCTION OUTPUTS (CONTINUED)

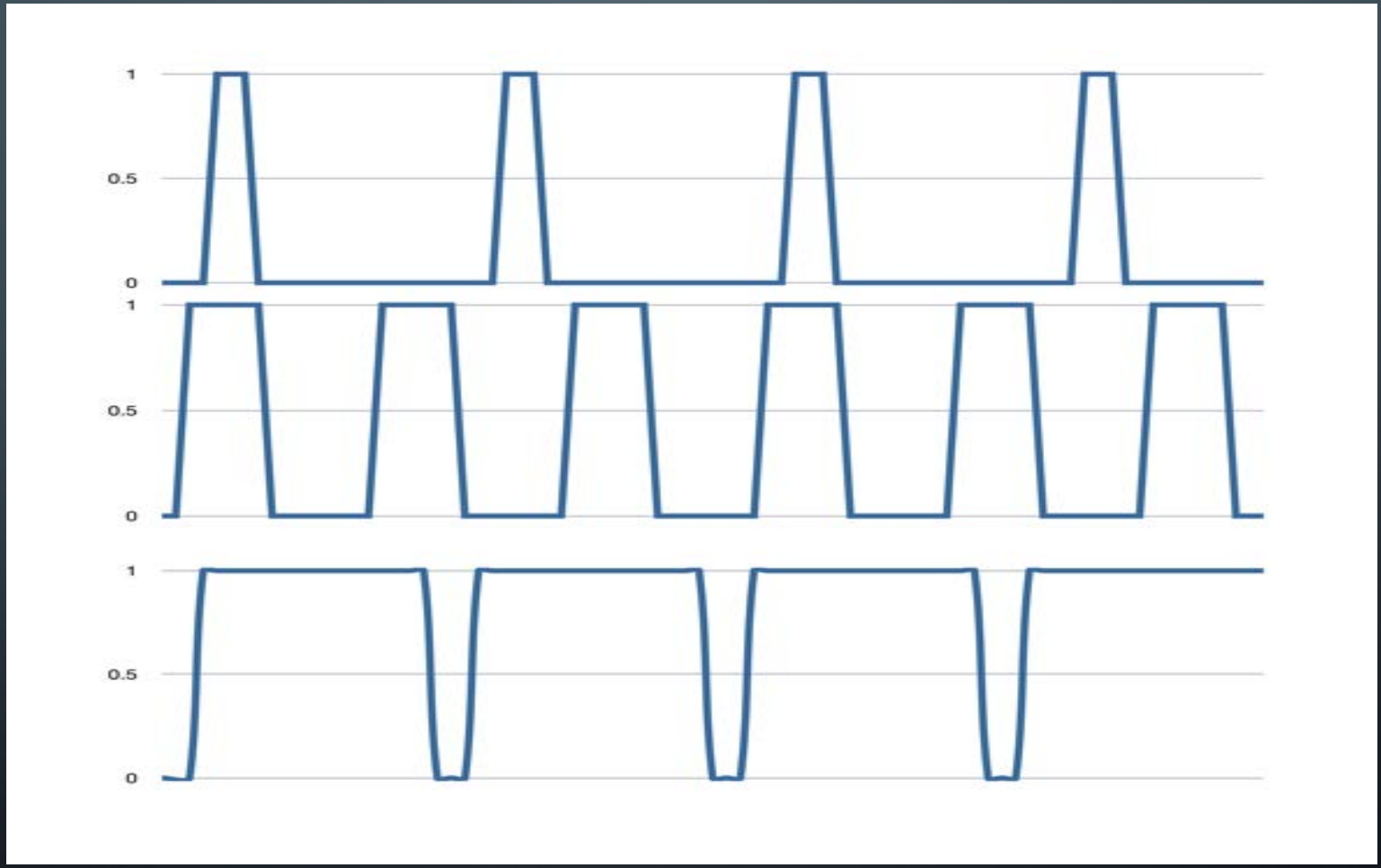
- Lighting effects available on some decoders – Gyralite, MARS light, beacons, strobe lights, firebox flicker, FRED, dimming, ditch lights, etc.
- Sound decoders use functions to control sound effects – some sound effects can be tied to lighting effects (alternate flashing ditch lights when horn is sounded)
- Represented on cabs / throttles by F0 to F12 – most systems and some decoders follow the newer NMRA standard 28 function control

# MOTOR CONTROL

## PWM – Pulse Width Modulation

- All decoders use PWM to control motor speed and direction
- The motor is switched on and off between zero and full power
- Speed is controlled by varying the ratio of OFF and ON time
- Example half speed is full power 50% of the time

# SIGNAL FROM DECODER TO MOTOR



# SPEED STEPS

- Decoder splits minimum and maximum throttle range into speed steps
- Speed steps are set via the throttle per locomotive
- More speed steps means finer control of the locomotive
- 14 and 28 speed steps are NMRA standard
- 128 speed steps is also supported
- For a maximum voltage of 14 volts DC, each speed step on a straight line speed curve will equal:

- 14 Speed Steps - 1 volt per Speed Step increment
- 28 Speed Steps 0.5 volt per Speed Step increment
- 128 Speed Steps 0.11 volts per Speed Step increment

# BACK EMF MOTOR CONTROL

- Motors generate electricity when they turn and it can be measured
- Also called cruise control
- Uses motor back-EMF to sense motor speed
- Helps maintain constant speed up and down grades
- Improves low speed performance and control

# STALL CURRENT

- The amount of current drawn by a motor at full voltage with armature locked up
- Must be matched to decoder specifications
- Most HO decoders are rated for 1.1A continuous with up to 2A peak
- A locomotive that draws more current than the decoder is rated for can turn a decoder into a smoke unit!

# STATIONARY DECODERS

- Similar to mobile decoders except that these are stationary around the layout
- Used for controlling line side items such as track switches, signals, turntables, lighting, or anything you wish to animate

# STATIONARY DECODERS (CONT.)

*Figure 2: Hook up for solenoid type turnout machines.*

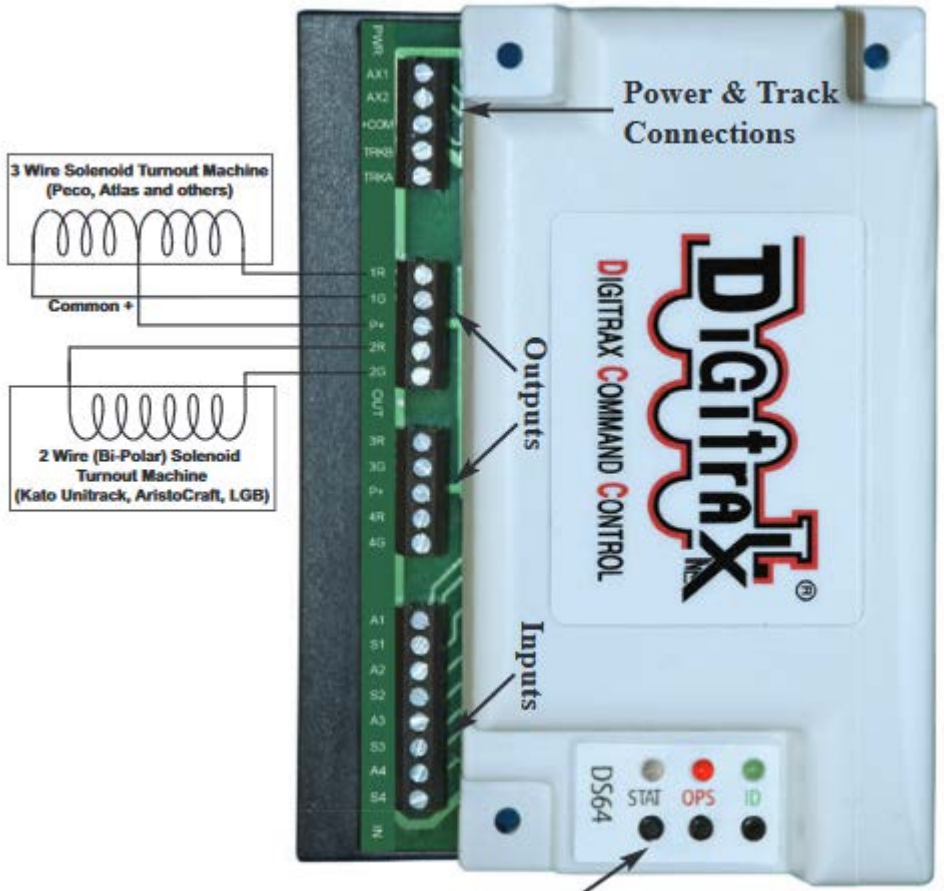
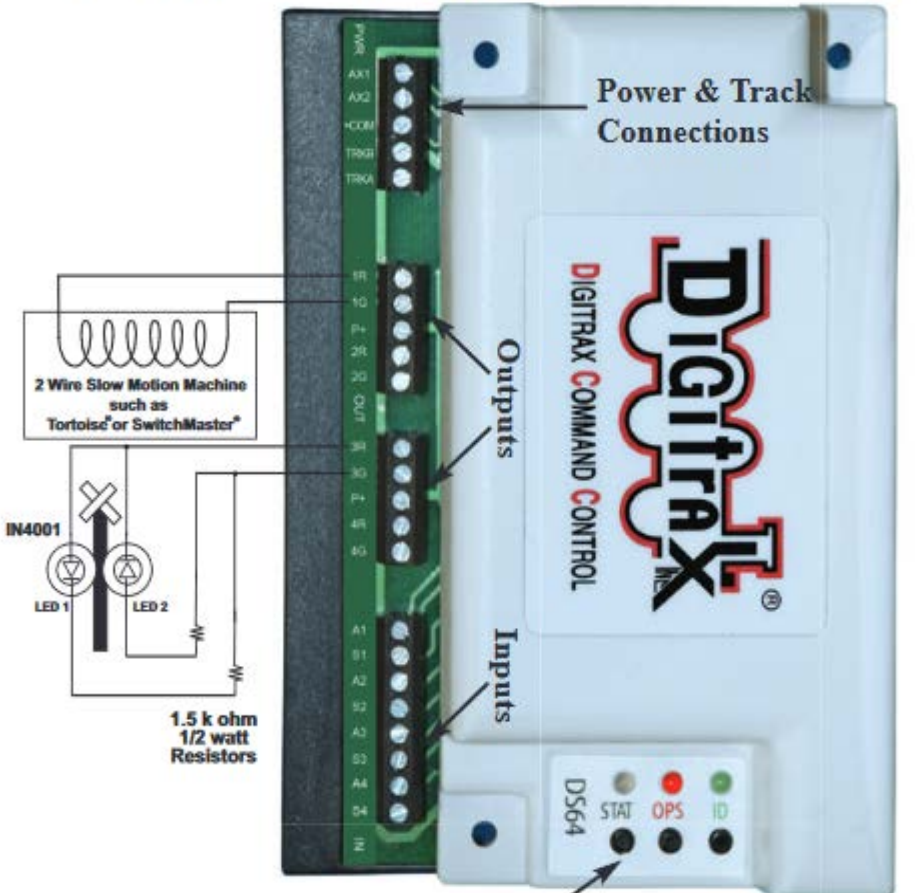



*Figure 3: Hook up for slow motion type turnout machines & crossing gates.*



# STATIONARY DECODERS (CONT.)

**DS64 Address Programming**

Your DS64 has 4 Outputs labeled 1R & 1G, 2R & 2G, 3R & 3G, and 4R & 4G, which are shipped from the factory programmed as Switch Addresses 01, 02, 03, and 04 respectively. You can set the Switch Address of each of these four Outputs to any value from 01 - 2048.

Note: To change a single Switch Address, you must program all four Switch Addresses on a particular DS64. If you make a mistake while programming, you'll need to complete the programming cycle and then go back and start again. The DS64 does not timeout during programming so, you must program 4 switch addresses each time you enter the ID mode.

1. On the DS64's control panel, press and hold the ID button down for 3 seconds until the green LED slowly blinks on and off. This indicates that the DS64 is ready to accept address programming for the Outputs.
2. Using your DCC throttle in Switch mode, select the Switch Address you want to program for Output 1 and issue either a Closed OR Thrown command. The LEDs will start to blink faster indicating that your Output 1 is programmed to the Switch Address you selected.
3. Repeat step 2 to program the Switch Address for Output 2. The LEDs will blink faster indicating that Output 2 is programmed to the address you selected.
4. Repeat this process for Output 3 and Output 4. After Output 4 is programmed, the alternating lights will stop and you will see a single green 'heart beat' this is visual confirmation that all 4 Outputs have successfully been programmed to the Switch Addresses you selected.

# STATIONARY DECODERS (CONT.)

**How to change the settings of your DS64's Option Switches (OpSw)**

1. Begin with your DS64 powered up and connected to the track. Turnouts can be either connected or not.
2. On the DS64 press and hold the OPS button down for about 3 seconds until the red OPS LED and green ID LED begin to blink alternately. This indicates that the DS64 is ready to change the option switches
3. Using your DCC throttle, select the **Switch Address that corresponds to the OpSw number** and send the **Closed or Thrown** command corresponding to the setting you have chosen. Refer to your DCC throttle's operating guide for specific instructions for selecting switch addresses and sending switch commands.
4. Exit the set up mode by again pressing and holding the OPS button on the DS64 until the red LED stops blinking.

**The following table shows the factory default settings (Thrown) for the DS64.**

| OpSw Table Settings for the DS64 | | |
|---|---|---|
| **OpSw** | **Description Thrown State (Factory Default)** | **Description Closed State** |
| 01 | Pulse Enabled for Solenoid Devices | Static Output for Slow Motion Devices |
| 02 | Disabled | Pulse Timeout 200ms |
| 03 | Disabled | Pulse Timeout 400ms |
| 04 | Disabled | Pulse Timeout 800ms |
| 05 | Disabled | Pulse Timeout 1600ms |
| 06 | Output Auto Power Up | Disabled |
| 07 | N/A | |
| 08 | Regular Startup Delay 65ms x Output #1 Address | Startup Delay Doubled |
| 09 | Timeout disabled | 16 second timeout for static output |
| 10 | Throttle and computer commands accepted | computer commands only accepted |
| 11 | Route commands from throttle or computer only | Enable rout commands from local Inputs |
| 12 | The "A" input is set for Sensor only<br>The "S" input toggles the Output | The "A" input if High, forces the Output to Thrown,<br>The "S" input if High, forces the Output to Closed |
| 13 | Allow commands form LocoNet and Track | All Inputs are Set for Sensors & also control Outputs per OpSw 12 setting |
| 14 | Allow commands from LocoNet and Track | Allow Commands from Track Only |
| 15 | Function not yet implemented | |
| 16 | Enable operation of routes | Disable operation of routes |
| 17 | Disabled | Enable Crossing Gate Function for Output '1' |
| 18 | Disabled | Enable Crossing Gate Function for Output '2' |
| 19 | Disabled | Enable Crossing Gate Function for Output '3' |
| 20 | Disabled | Enable Crossing Gate Function for Output '4' |
| 21 | Generate LocoNet General Sensor Messages | Generate LocoNet Turnout State messages |

# STATIONARY DECODERS (CONT.)

- Smails are Tortoise Stall motor switch machines with built in decoder

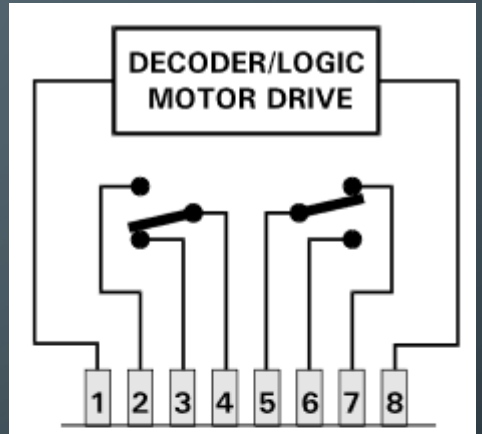




FIGURE 3

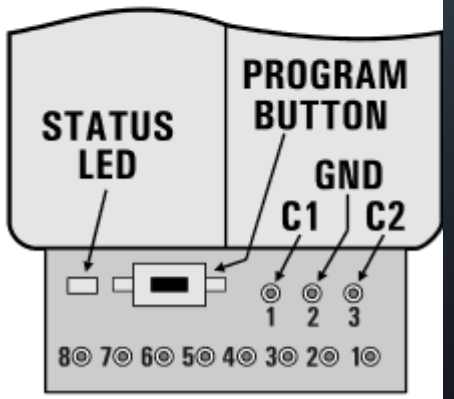



FIGURE 4. Rear View

# STATIONARY DECODERS (CONT.)

## PROGRAMMABLE FEATURES (CVs) OF THE SMAIL™

The SMAIL™ factory default NMRA *ACCESSORY* address is **1**.

The SMAIL™ factory default NMRA *SIGNAL* address is **1**.

**CV546: Reset the SMAIL to factory defaults**
Program 85 into CV546 and the SMAIL will restore all CVs to original factory settings. ***You must remove the power after reset*** for the SMAIL to return to normal operation.

**CV547: Make CV556 non-volatile ("Sticky")**
When CV547 = 1 it will make CV556 non-volatile (SMAIL will remember the settings of CV556 during power off (or power loss). If CV547 = 0 the value programmed into CV556 will be lost the next time power to the SMAIL is removed.

**CV548: "Toggle" the outputs using only 1 pushbutton**
Setting CV 548 to a value of 1 uses C1 to "toggle" the switch machine output. Each press of C1 will alternate the switch position. C2 is disabled when toggle mode is enabled Set CV548 = 1 to enable the toggle option or 0 to disable it.

**CV549: Report SMAIL software version**
Setting CV 549 to any value will cause the SMAIL to flash its LED in a two digit code indicating the software version. It will flash the version four times, then return to normal operations.

**CV582: Aspect for bottom semaphore position:**
CV582 holds the NMRA signal aspect value that will move the SMAIL™ to the "bottom" (Normal) semaphore position. The factory value is 0 (absolute stop).

**CV584: Polarity reversal for turnout or semaphore position:**
Setting CV584 to 1 will reverse the direction of operation for the SMAIL™ when a DCC command is received. Set CV584 to 0 to return the SMAIL to normal direction of operation.

**CV586: DC mode polarity enable:**
Setting CV586 to 0 enables traditional Tortoise like response to DC polarity on pins 1 and 8 of the SMAIL™. Values other than 0 (1-255) disable polarity sensitive operation of the SMAIL™.

**CV556: Pushbutton lockout**
On some layouts it may be desirable to disable operation of the local control pushbuttons. Setting CV556 to a value of 1 prevents operation of the decoder by the buttons. Setting CV556 to 0 enables operation of these buttons. You can disable or enable ALL decoders on the layout at the same time by using the accessory decoder broadcast address of 2044 when programming CV556.

**CV558: Signal Mode:**
You can set the SMAIL to operate 3 position semaphore signals under DCC control. Set CV558 to 1 to enable NMRA signal mode, 2 for Digitrax signal mode. Can also be used for crossing gates. To disable semaphore mode, set CV558 to 0.

**CV580: Aspect for top semaphore position:**
CV580 holds the NMRA signal aspect value that will move the SMAIL to the "top" (Reverse) semaphore position. The factory value is 2.

**CV581: Aspect for middle semaphore position:**
CV581 holds the NMRA signal aspect value that will move the SMAIL to the "middle" semaphore position. The factory value is 1.

**FACTORY DEFAULT SETTINGS**

| CV NUMBER | DESCRIPTION | DEFAULT VALUE |
|---|---|---|
| 546 | Reset CV | 0 |
| 547 | Make CV556 "sticky" | 0 (Disabled) |
| 548 | Toggle Using C1 | 0 (Disabled) |
| 556 | Control Terminal Lockout | 0 (Disabled) |
| 558 | DCC Signal Mode | 0 (Disabled) |
| 580 | Top Position Aspect | 2 (Green/Clear) |
| 581 | Middle Position Aspect | 1 (Yellow/Approach) |
| 582 | Bottom Position Aspect | 0 (Red/Stop) |
| 584 | Direction of Travel | 0 (Normal) |
| 586 | DC polarity Enable | 1 (Disabled) |

**ALWAYS RESTORE THE SMAIL™ TO FACTORY DEFAULTS USING CV546 BEFORE CHANGING FROM DCC TO DC POWER.**

*Download **AN-6200-02** from our website for more information.*

# STATIONARY DECODERS (CONT.)

- SWITCH MACHINE CONNECTED TO DECODERS CAN BE CONTROLLED FROM ADVANCED THROTTLE

- PRESS [SWCH]

- ENTER ADDRESS

- PRESS OPTN “T” OR CLOC “C”

- PRESS EXIT

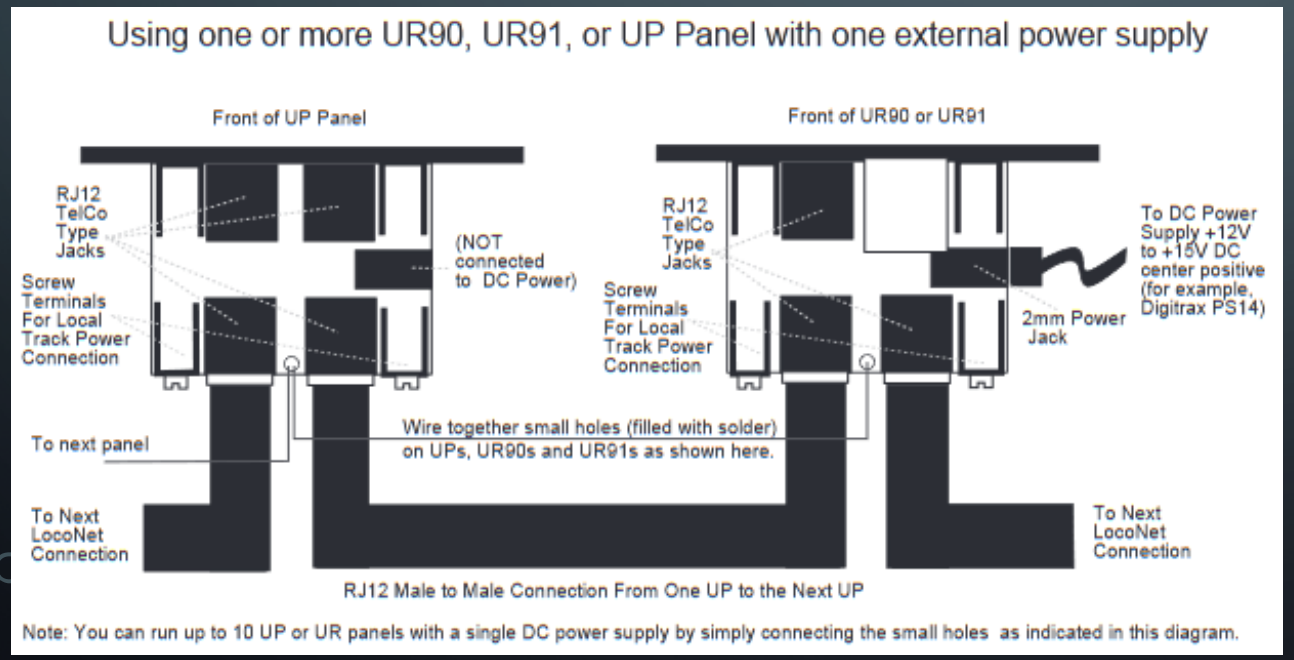
# DIGITRAX THROTTLE PANELS

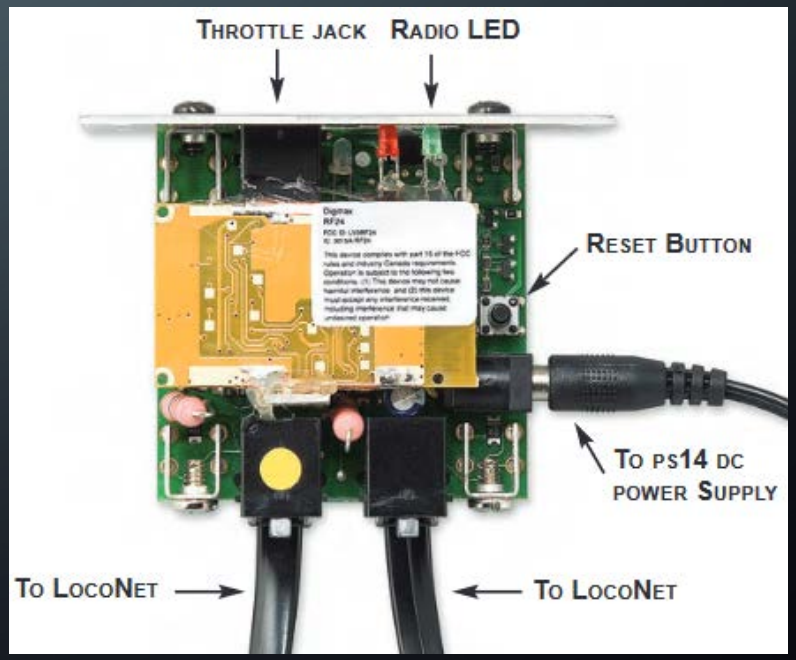
- Dual wired panels (UP5)
- Single wired panel with IR capability (UR90)
- Single wired panel with IR & Simplex radio (UR91) (discontinued)
- Single wired panel with IR & Duplex radio (UR92)

(not backward compatible with simplex radio throttles)

# DIGITRAX THROTTLE LOCONET PANELS



# DIGITRAX WIFI INTERFACE

- LNWI installed on N layout
- Allows up to 8 users to control up to 2 trains from a smart phone or tablet
- Allows control of switch machines connected to stationary decoders

# DIGITRAX COMPUTER INTERFACE

- PR3 and PR4 (smaller version)
- USB to Loconet adapter
- Has programming track capability (handy when not connected to a command station)

# COMPUTER CONTROL

- Used to program decoders, upload sounds, control trains
- Freeware JMRI allows decoder programing, digital control panels
- JMRI can be run on PCs or small cheap Linux computers like Raspberry Pi's