

DCC Decoders: Hardware

By Mark Gurries

NMRA San Jose National Convention

August 2000

Copies of this presentation can be found at:

<http://www.falken.net/dave/svl/dcc.html>

Revision History

- V1.0 NMRA Convention. Based on:
Decoder Parts 1& 2 V1.0 PCR Mini Convention 4/30/00

Acknowledgment & Scope

- Acknowledgment / DCC Book

Some material in this presentation was taken directly from the DIGITAL COMMAND CONTROL book published by “Allt om Hobby” in cooperation with the NMRA. Written by Stan Ames, Rutger Friberg & Ed Loizeaux

- Scope

This presentation limits it’s discussion to the most popular North American DCC Systems. However, most material is generic in nature and can be applied to other systems.

Decoders Basics

- **Function:**

Gives each locomotive a unique number or Address.

- Address can be 2 digit or optional 4 digit. --> Set to Loco #.
- Detect DCC command and implement it when “Addressed”.
 - Motor Speed, Function output, MU, etc.

Drives motor

- Provides basic “Pulse Power” to motor.
- Implements optional Momentum, Speed Table, and “Back EMF”

Drives function outputs.

- Function output is a “switched outlet” to power things.
- Drives: Headlights, Special FX lights, Sound, Coupler, etc.

- **Packaging:** Size a function of power and number of functions.

Some have NMRA plug for “Plug and Play” installation!

- **Cost:** Basic \$16 (qty discount) on up to \$180 for sound.

Decoder Basics

- There are 2 types of decoders

1) Locomotive Decoders

- Basic types provide Address, Motor Speed & simple Headlights
- Advanced types provide additional controls and features
 - Speed Tables, Back EMF, Silent Drive
 - More lights, Light effects (FX, Hyperlight)
 - Sound

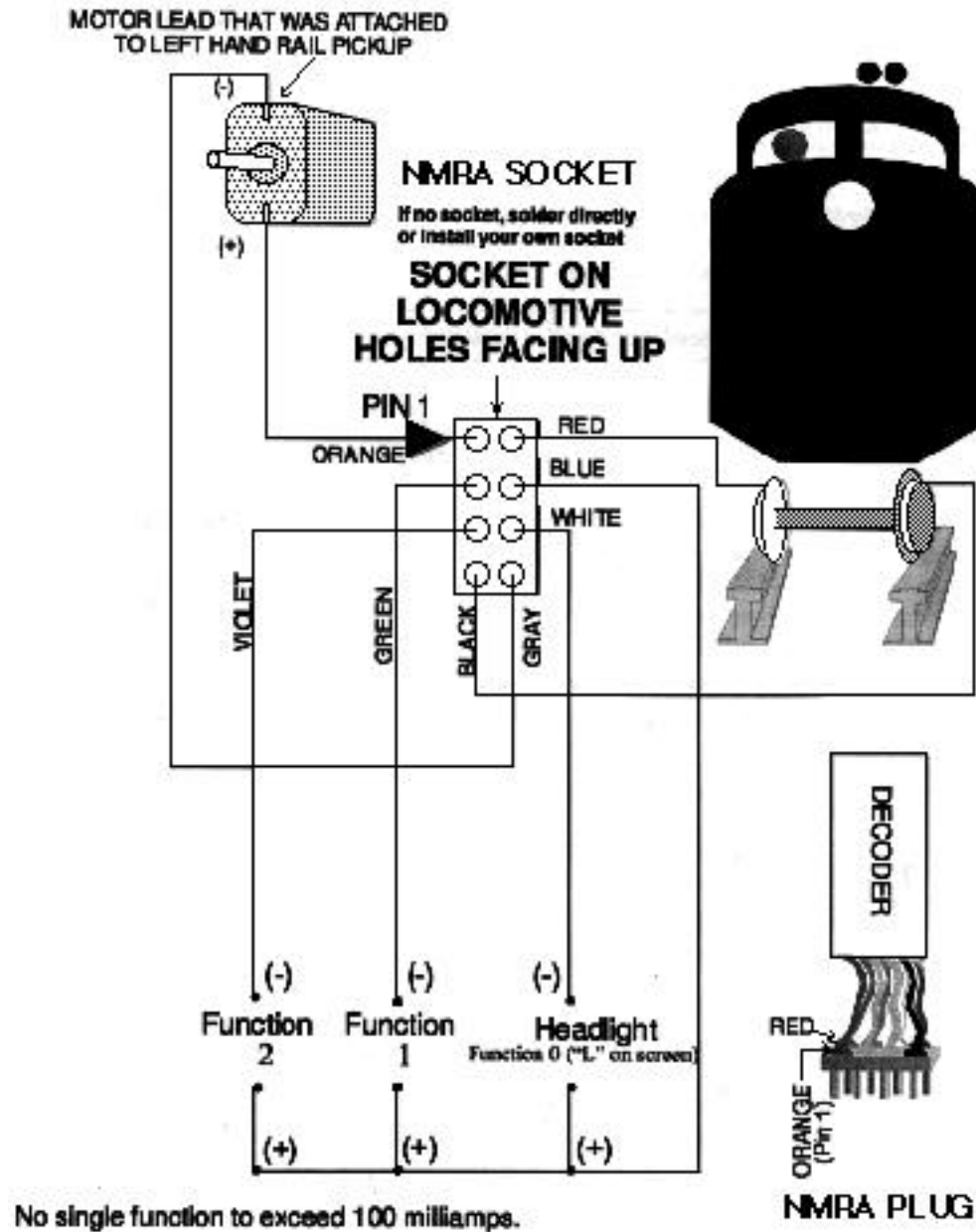
2) Stationary Accessory Decoders

- Basic types provide address and one toggling output.
 - Simple switch machine control or light control.
- Advanced types provide
 - more outputs, direct switch machine drive
 - » Stall motor and/or Twin Coil
 - multiple inputs for block detection and/or control panel input.

Decoder Wire Standards

- NMRA & Industry have assigned connection colors.
- Track Pickup
 - Red = Right Hand Rail (DC + when fwd)
 - Blk = Left Hand Rail (DC - when fwd)
 - Important for Decoder operation under DC power.
- Motor: Org = “+” Motor & Gry = “-” Motor
- Functions
 - Current DCC standard call for 8 Maximum.
 - Blue is “+” common SUPPLY for all functions.
 - Headlights: Wht (F0 Fwd), Yel (F0 Rev and optional)
 - Grn (F1), Vio (F2), Brn (F3)

Typical Decoder Wiring



Selecting a Decoder

- Decoders have 2 current ratings.
 - Continuos current.
 - Peak current.
- Motors have 2 corresponding current parameters
 - Maximum run current. (Maximum load & not stalled)
 - Stall current. (Locked rotor)
- Relationship
 - Decoder continuous current \geq Motor max run current
 - Decoder peak current \geq Motor stall current.
- **WHY? Prevent Decoder thermal (heat) overload.**
 - Using a decoder beyond it's rating can destroy the decoder.
 - Avoid installing decoder near engine motor. (Motor heat)

Selecting a Decoder (Cont.)

- MOTOR TEST

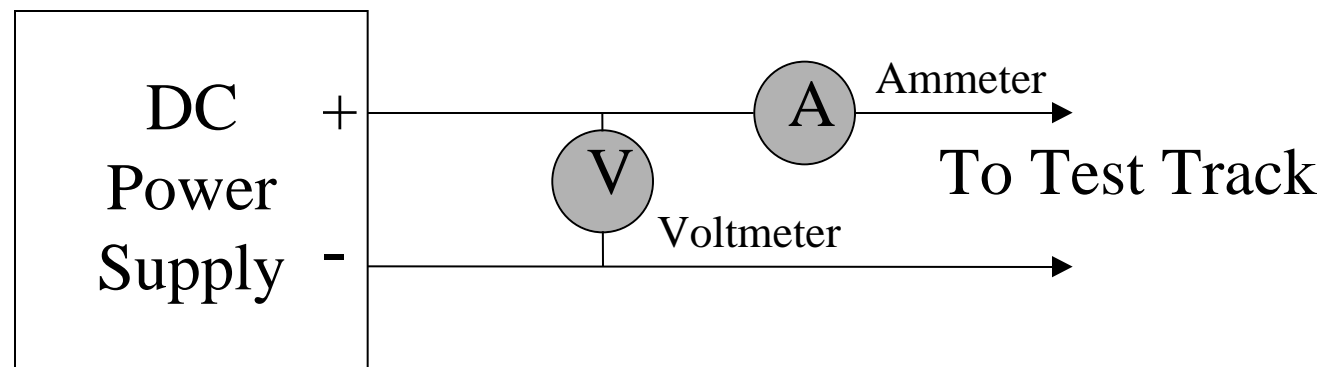
Equipment needed.

- DC Voltmeter
- DC Ammeter with a 3 amp current capability.
- DC power source set to 12V with a current rating of:
 - > 1.5 A for N, >3A for HO & S, >8A for O, >6A for G.

Example: MRC 9000 DC power pack for N/HO

- Built in Volt and Amp meters.

Setup



Selecting a Decoder (Cont.)

- Maximum Run Current Test Procedure

Place Loco on Track.

Hold loco to prevent movement down the track by

- Holding rear coupler for loco.

-or-

- Holding body without applying any downward or upward force.
- YOU MUST ALLOW THE WHEELS TO SPIN.

Turn on DC power supply power supply

- Engine wheels should be slipping.

Verify proper voltage.

- Adjust supply as required.

Measure current on Ammeter.

- This is your max run current.

Selecting a Decoder (Cont.)

- Stall Motor Current Test Procedure

Remove Loco Shell to gain access to motor

Place Loco on Track.

Prevent motor from turning by grabbing shaft or flywheel.

- Do not push down on shell to stop motor. Risk damaging mechanism.

Turn on DC power supply

- Motor should be trying to turn. Hold On!

Verify proper voltage.

- Adjust supply as required.

Measure current on Ammeter. This is your Stall current.

- **DO NOT DO THIS TEST TO LONG!**
 - Motor will get hot quickly and you may damage motor.
 - Recommend 5 Seconds max.

Decoder Analog Operation

- Allows a decoder to work with traditional DC
Option set when programming decoder.
- **IF ON:**
Slow performance varies with decoder and DC power pack used.
 - Will not start to move until DC Voltage $> 5V$ or so.
 - Some may experience delay in DC throttle response.Some may maintain directional lighting operation.
IF decoder is installed backwards, engine will run in reverse.
 - Direction bit works.
 - Watch you track wiring polarity to get direction right.Some reported problems with mixed DC and DCC operations.
 - Decoders can get confused.**Loco can “take off” if DC is present.**
 - **Watch out for DCC to DC transitions in track blocks.**

Decoder Analog Operation (Cont.)

- IF OFF:

Decoder will come to a stop when it senses DC.

Lights will remain on.

Stop response varies with decoder.

- Some use momentum setting to control stop rate.

No Decoder: DC Loco On DCC Track

- Engine does not move.

Motor will audibly buzz and lights will light up full.

Not all motors will work OK.

- Many locomotive manufactures do not recommend it!!
 - The smaller the motor, the higher the risk.
 - Do not use Coreless Motors in this mode.
- Some DCC systems can run a DC loco on track.
Penalizes normal DCC operation.
 - Slows down user response to all operating DCC engines.

Intended to be a transition tool.

DC Support by manufactures varies

- Easy: Digitrax, EasyDCC, Lenz?
- Hard: System 1, NCE

Decoder Plugs: NMRA

- 3 NMRA Sizes.

Small Plug

- 6 pin in-line type
- N-scale 0.75A
- 1 function
- Limited to European full body Loco. Not popular.

Figure 2: Top View
Medium Interface

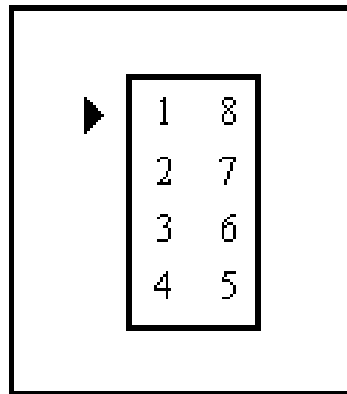
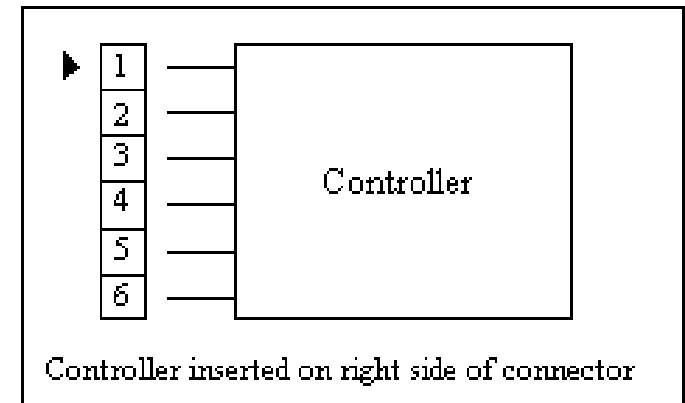


Figure 3: Top View Small Interface



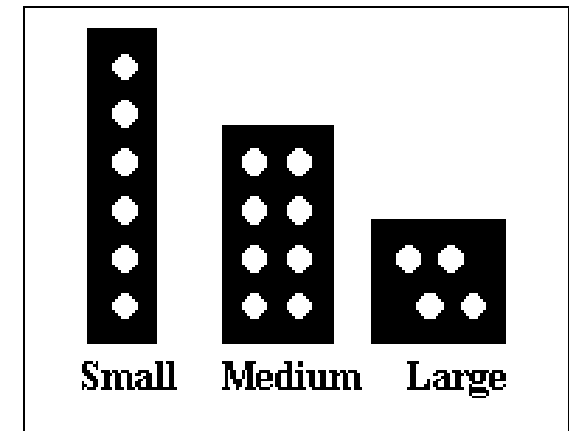
Medium plug

- 8 pin in a 2 x 4 rectangular shape
- HO scale. 1.5A Large industry acceptance.
- 3 functions

Large

- 4 large pin in a 2 x 2 offset square shape.
- G & O scale. 3A. Popular with LGB Loco's
- No functions. Functions on "Flying Leads"

Figure 1: Pictograms



Decoder Plugs: NMRA (Cont.)

- NMRA HO 8 pin plug

True Electrical Plug and Play!

Plugging it in backwards does not damage decoder!!

- Goof Proof.
- Lights will not work.

Has Track Power, Motor, & up to 3 Functions

- F0_Fwd, F0_Rev, F1 -or-
 - F0_Fwd, F1, F2
- Most New HO Loco made today offer receptacle.

Look for “DCC ready” wording.

Athearn Genesis, Bachmann Spectrum, Proto 2K & 1K, Kato, Atlas, & Stewart

- Decoder with NMRA plug adds cost. Around \$5.

Decoder Plugs: 9 Pin Inline

- Primarily a decoder to cable plug.

As opposed to an engine plug like the NMRA 8 pin.

Allows easy movement of decoder from engine to engine.

- Harness stays with engine
- Potentially save \$ by sharing decoder among engines.
 - But why risk shell damage to Loco? Decoders cost <\$20.

Allows custom harnesses to be used to ease installation.

- Not a NMRA standard Yet. But will be soon.

Follows NMRA wire color standard.

- Allows up to 4 functions.

Typ are: Wht(F0_Fwd), Yel(F0_Rev), Grn(F1), Vio(F2).

- Manufactures

Digitrax, Lenz, NCE, System One, Zimo

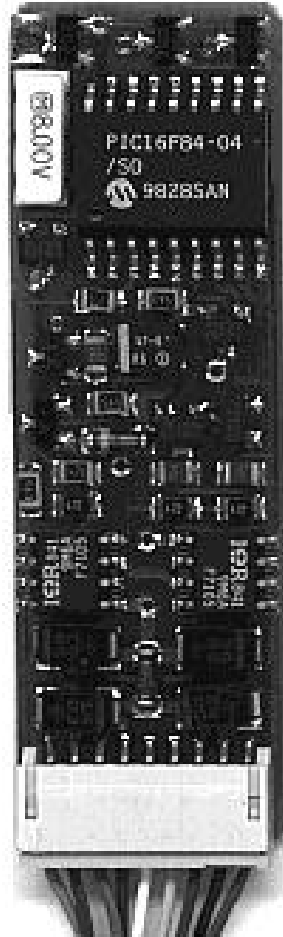
Decoder Plugs: 9 Pin Inline (Cont.)

DOUBLE SIDE PCB



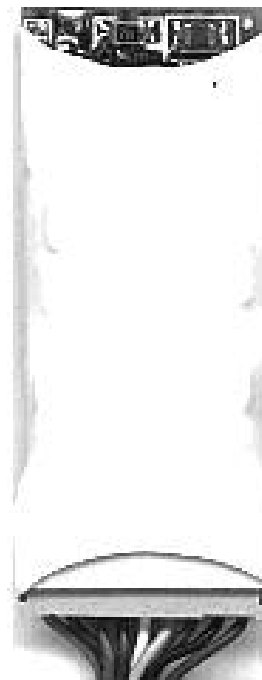
LENZ LE130

SINGLE SIDE PCB



NCE D104

DOUBLE SIDE PCB



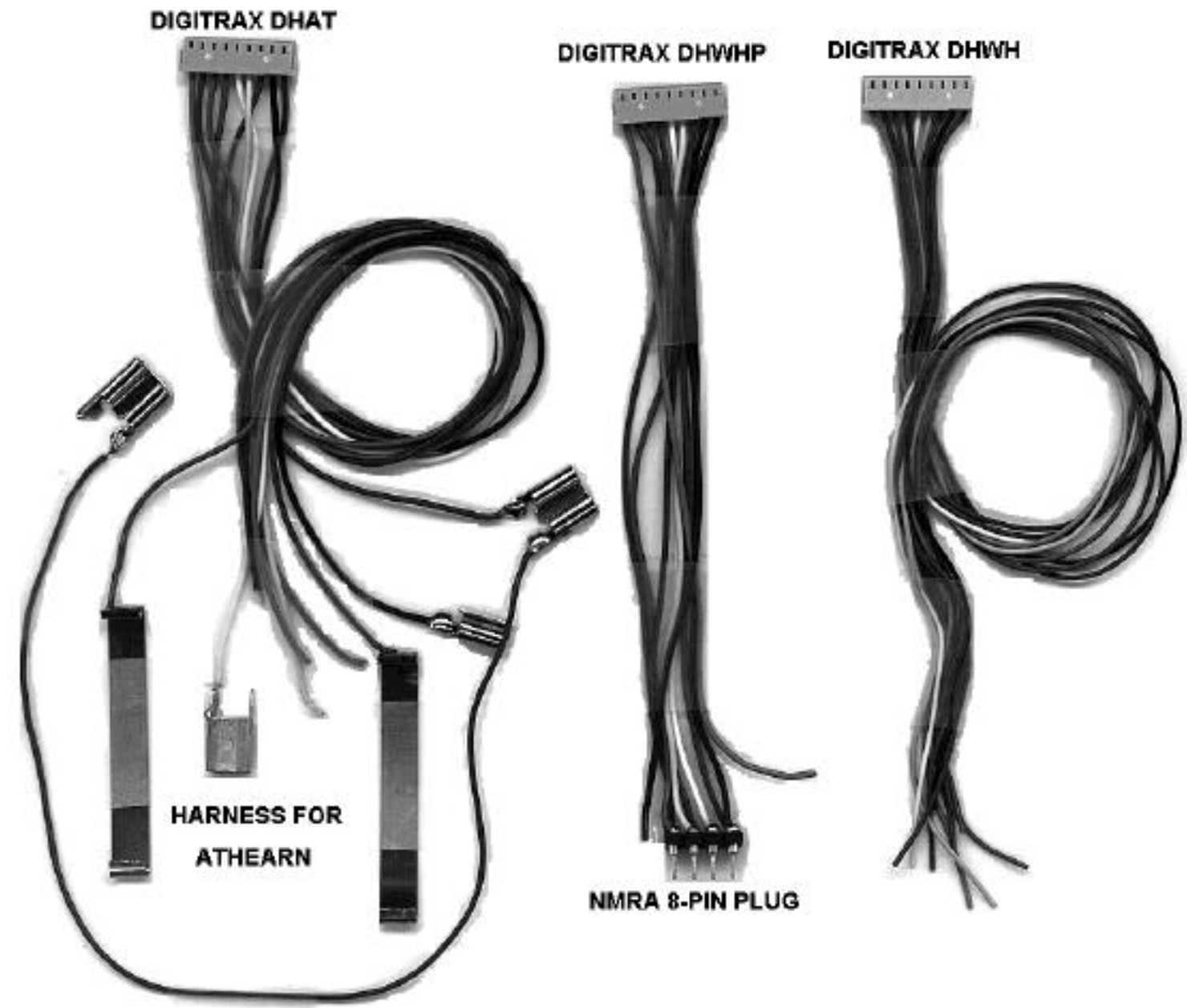
SYS 1 DH-155

DOUBLE SIDE PCB



DIGITRAX DH121

Decoder Plugs: 9 Pin Wire Harness

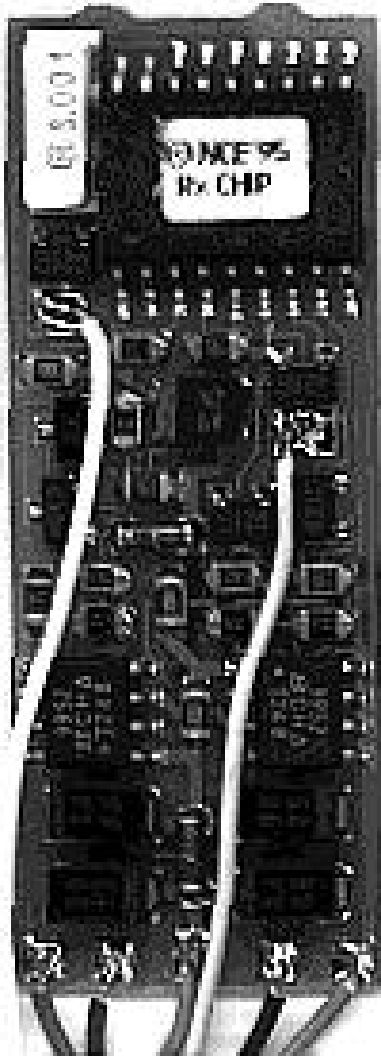


Low Cost Decoders

- Sometimes called Fleet Decoders
- Prices have dropped to a street price of \$16 (TTX\$ Qty1)
- Advanced functions.
 - 4 Digit, 128 step, Speed Table, Advance Consist, few FX lights.
- Connections: Direct wire or 9 pin formats.
- Shapes: Long and thin or short and thick.
- Manufactures: Digitrax, Lenz, NCE, MRC
- **RECOMEND YOU DO NOT BUY MRC DECODERS**
 - MRC does not support Advance Consisting.
 - Most systems **REQUIRE** this feature for good MU operation.

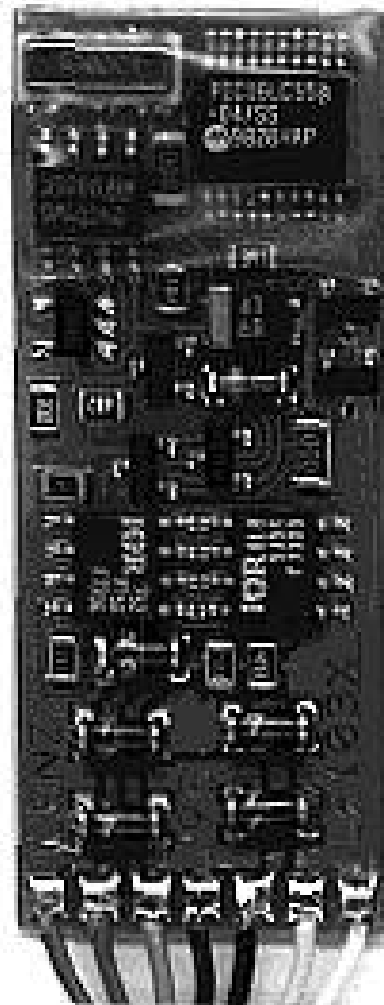
Low Cost Decoders (Cont.)

SINGLE SIDE PCB



NCE D102 EU/US

SINGLE SIDE PCB



LENZ 103XF

DOUBLE SIDE PCB



DIGITRAX DH121

Plug & Play Decoders

- Physical “Drop In” power board replacements.

Uses all existing wires or connections

- Some are solderless installs. Use existing push on plastic plugs

Some reproduce existing special light effects.

- Some improved or add light effects.

- Some solve physical installations problems

- Some are good for Pre-DCC loco’s.

Offer good mechanical mounting.

Minimize wiring changes to loco.

Some wiring and soldering required

- Motor and Lamps

- Manufactures: Digitrax, Lenz, NCE, System One

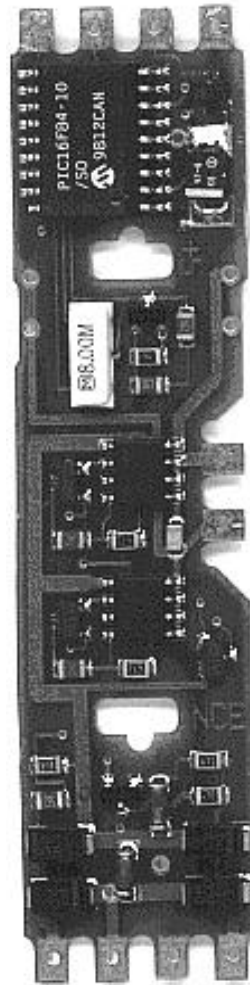
Plug & Play Decoders (Cont.)

Lenz LE103ADUS for Atlas not shown.

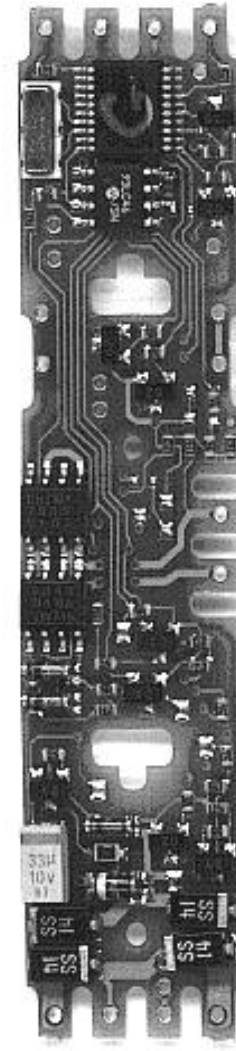
NCE offers a “Flipped” D104KRS to fit in new LLP2K GP7 and GP30. Called: D104P2K

Tony Train Exchange (TTX) offers both versions under it’s own name. TTX/RS-2 and TTX/GP7/30

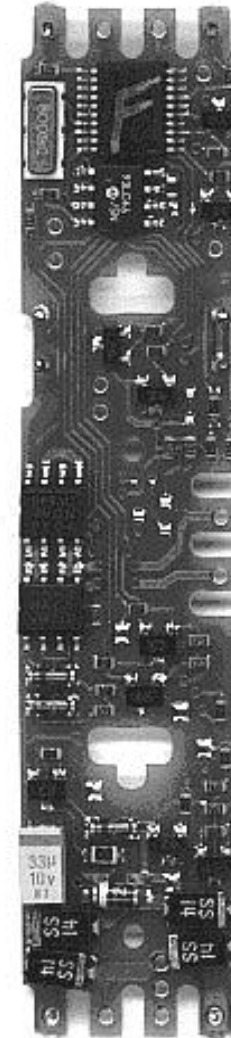
LEFT 3 BOARDS SHOWN UPSIDED DOWN COMPONENT SIDE
THIS END IS FRONT



NCE DA102

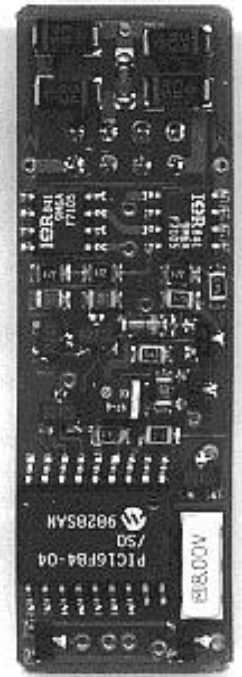


DIGITRAX DH150A



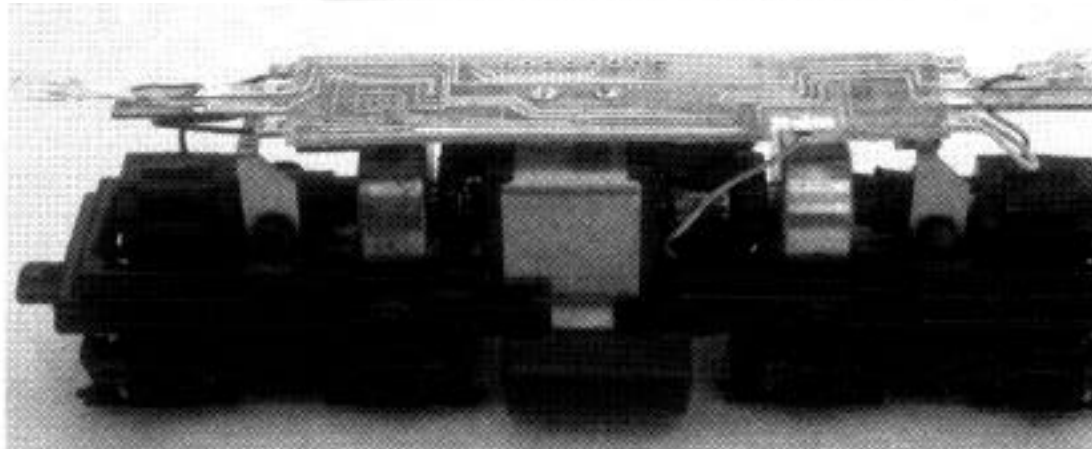
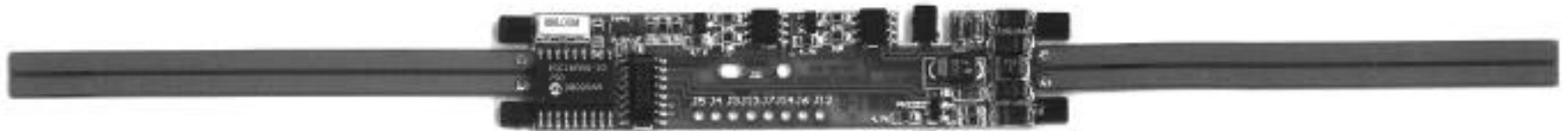
DIGITRAX DH150K
DH150A WITH WIRE STUBS

NMRA PLUG ON PCB!
NO WIRES!



NCE D104KRS

Plug & Play Decoders (Cont.)

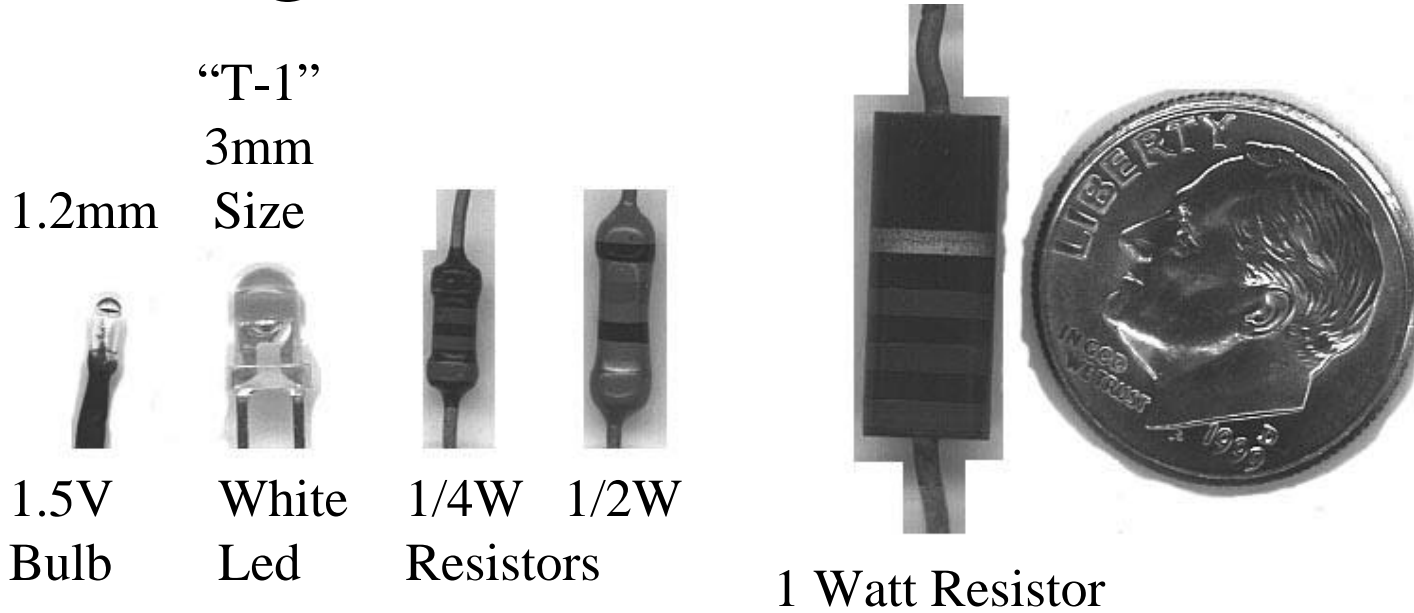


System One
DH-157A For
Athearn



System One DH-103S for Atlas S1/S4 Switchers

Lights: Parts often Used



- Clear LED's: You cannot tell the color of the LED.
- The 1/2 Watt resistors and 12V bulbs will get hot.
Avoid direct or loose contact with plastics. Heat Sink!
- Constant lighting: DCC does not need "diode circuits" often used with DC power.
Remove these circuits before installing decoders.

Lights: Low Voltage Resistor values

DCC Track voltage	1.5V @ 15mA	1.5V @ 30mA	1.5V@40mA	3V @ 5mA	3V @ 15mA
12	620	300	220	1500	510
14	750	390	300	2000	680
16	910	430	330	2400	820
18	1000	510	390	2700	910

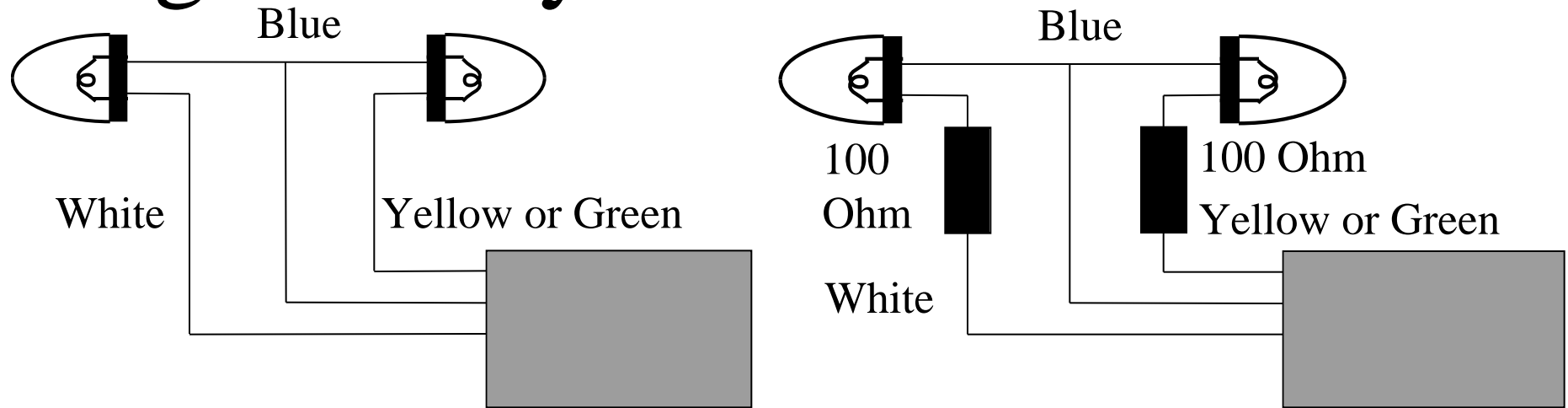
- Resistors are 1/4W, Light shaded=1/2W, Dark shaded = 1W
- Table uses a 1.4V drop in decoder “blue wire” voltage.
- White LED’s are approximately 3V.
 - Led gets to bright above 5mA. Do not exceed 25mA.
- Different circuit may require other resistor values.
 - Use a 3V @ 15mA resistor value for two 1.5V 15mA bulbs in series.
 - Use a 1.5V @ 30mA resistor value for two 1.5V 15mA bulbs in parallel.
- Resistor(s) will get hot! Keep away from plastic.
 - Spread heat around: Use 2 small resistors in series for a single big resistor.
 - Ex: Two 180 ohm 1/4W + 150 ohm 1/4W = One 330 Ohm 1/2W resistor.
 - Make both resistor as close to each in value as possible.

Lights: High Voltage Resistor Values

DCC Track voltage	12V @ 15mA	12V @ 30mA	14V @ 30mA	14V @ 80mA	16V @ 30mA
12	100	100	100	100	100
14	100	100	100	100	100
16	180	100	100	100	100
18	330	150	100	100	100

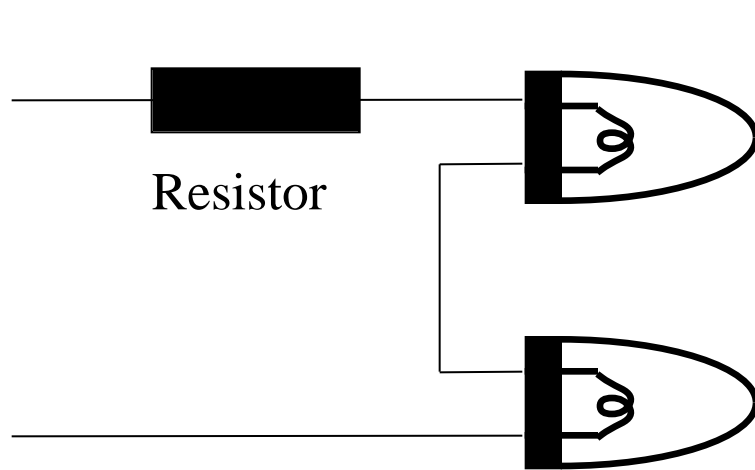
- Resistors are 1/4W, Light Shaded = 1/2W, Dark = 1W
- Table uses a 1.4V drop in decoder “blue wire” voltage.
- 100 Ohms is recommended minimum value for all lamps.
Purpose is to protect decoder function output from high current surge of a cold filament bulb.
- You can extend bulb life by running it below it rated voltage.

Lights: Why 100 Ohm minimum?

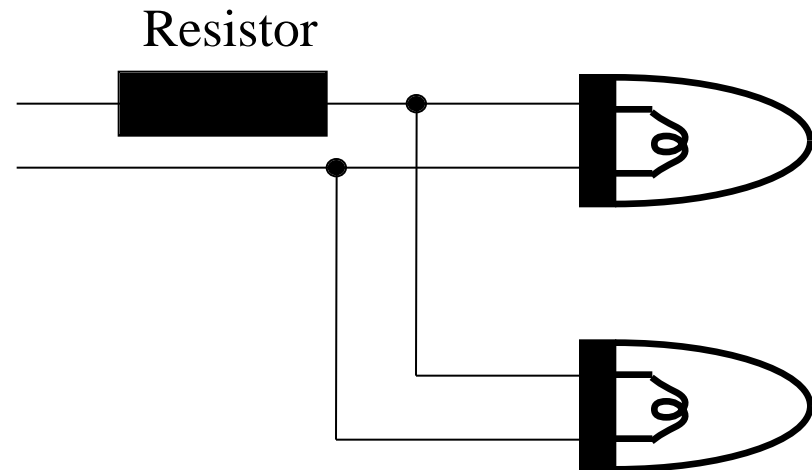


- Circuit on the left is normal wiring for HV lamps.
- BUT, bulbs have a unique problem.
 - Bulbs have very little resistance when filament is cold (off).
Creates a big surge of current at turn on!
 - However, resistance increases as filament heats up (glows).
- Circuit on the right is better.
 - Resistor limits the high current that occurs when bulb is cold.
 - Bulb and decoder function output will last longer.

Lights: Series and Parallel Circuits



Series Circuit



Parallel Circuit

- Sometimes it can be beneficial to wire lights in a common circuit.
- There are two types of circuits. Series and Parallel.
Each has benefits and problems.
- However strongly recommend you wire each bulb by itself!

Avoid electrical issues in the future.

Lights: Series Circuits

- Bulbs must have same current ratings.

You can mix bulb voltages.

Must calculate resistor value and power for mixed voltages.

- Up Side:

Bulbs in series use power more efficiently. Less heat.

Physical Resistor size (wattage) will be smaller.

Can reduce wiring.

- Down side:

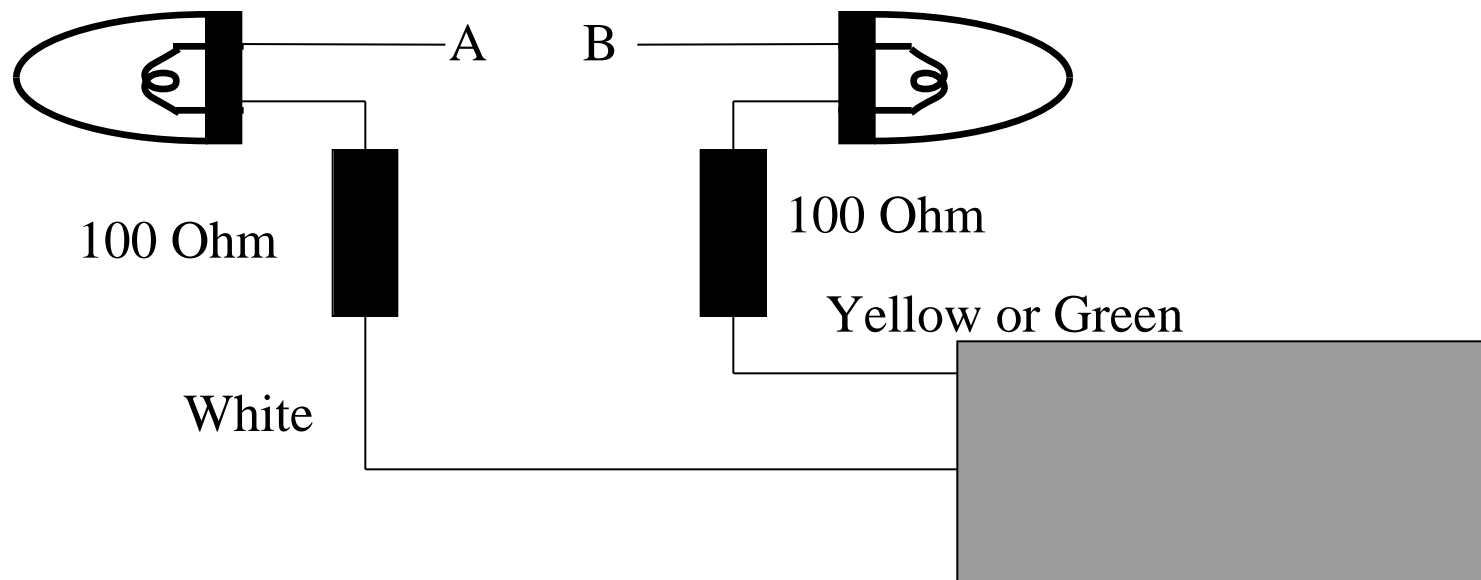
When one bulb burns out, the other bulb will go out too.

- Like Christmas tree lights....But the other bulb is still good!
- Recommend replace both bulbs if same type anyway since the other good bulb will die soon too. (Both have same bulb life)

Lights: Parallel Circuits

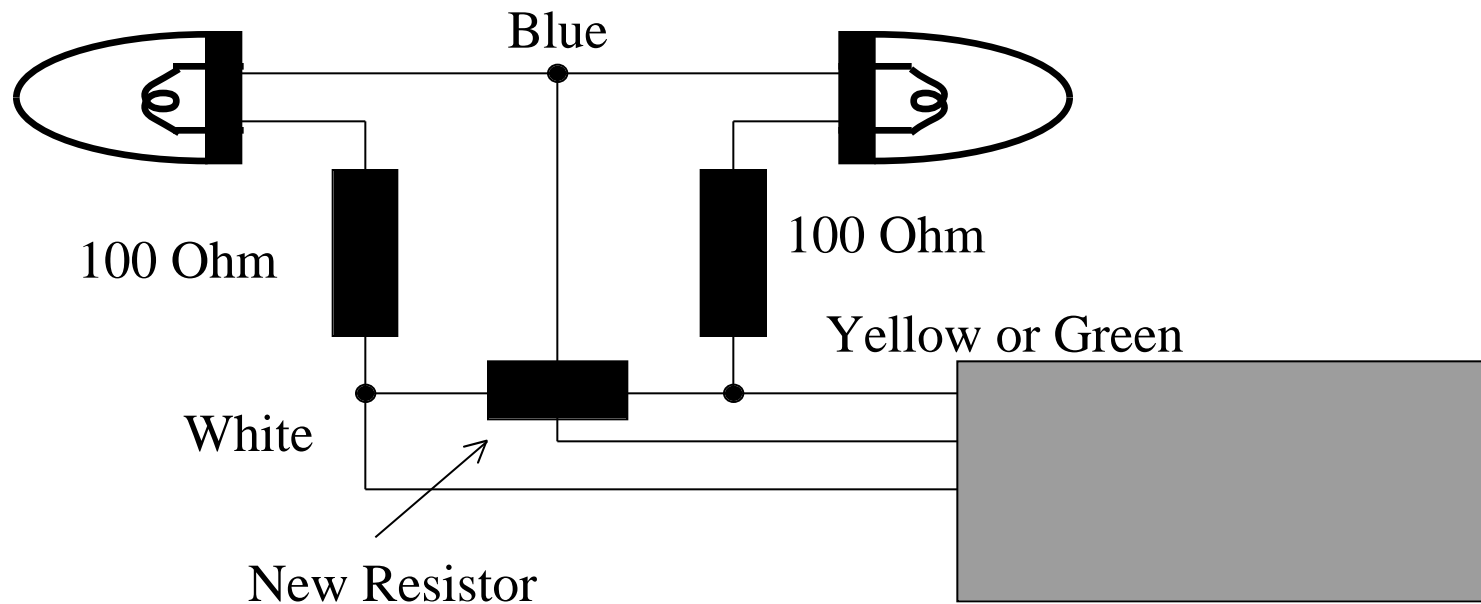
- Bulbs must have same voltage ratings.
 - You can mix different bulb currents.
 - Must calculate resistor value and power for mixed currents.
- Up side:
 - Simpler to wire.
 - If using high voltage bulb and one bulb burns out, the others will remain lit.
- Down side:
 - Uses power least efficiently. More heat in resistors.
 - If you are using low voltage bulbs and one bulb burns out, the other bulb will become overloaded and burn out too!
- Recommend this circuit only for high voltage bulbs.

Lights: Using track power (No blue wire)



- Connection “A” or “B” can be connected to any track connection. (Same as decoder Black or Red wire.)
- Common use: Steam locomotives with headlight that connects to the “live frame”. Hard to wire up light.
- Bulb brightness will be less than normal.

Lights: Simple “Rule 17” light trick.



- Rule 17: The light NOT turned on will be dim.
- Simple resistor put between forward and reverse light.
Between white (F0fwd) and Yellow (F0rev) or Green (F1).
- Resistor value should be set to run lamp at 1/2 full current or less. Adjust value to your taste.

Appendix A

Additional Decoder Installation Info

Selecting a Decoder

- Popular N-Scale Motor Current Data.

Data from DCC Handbook.	Stall	Max Run
N Scale Locomotives	@12 volts DC	@12 Volts DC
Arnold 2018	0.5 Amps	0.3 Amps
Atlas GP7	0.8 Amps	0.3 Amps
Bachmann F7	0.6 Amps	0.2 Amps
Con-Cor PA	0.4 Amps	0.2 Amps
MiniTrix 4-6-2 Pacific	0.7 Amps	0.4 Amps
Kato E8	1.2 Amps	0.4 Amps
Kato SD45	0.7 Amps	0.3 Amps
Life Like SD7	0.4 Amps	0.3 Amps
Arnold GG-1	0.9 Amps	0.3 Amps
Atlas (Rivarossi) 4-6-2 Pacific	0.8 Amps	0.4 Amps
Roco DB AG 101	0.7 Amps	0.3 Amps

Selecting a Decoder

- Popular HO-Scale Motor Current Data.

Data from DCC Handbook.	Stall	Max Run
AHM RS1	3.0 Amps	0.8 Amps
Athearn New Generation	1.0 Amps	0.8Amps
Athearn Older (unlubed) PA1	2.3Amps	1.3Amps
Athearn Older Lubed	1.4Amps	0.5Amps
Atlas S2	1.3Amps	0.8Amps
Bachmann Doodlebug	0.6Amps	0.2Amps
Bachmann Plus SD45	0.7Amps	0.6Amps
Con-Cor E7A	1.5Amps	0.5Amps
Fratesch FA1	1.5Amps	0.8Amps
Life Like Proto 2000 E7	1.7Amps	0.7Amps
Life Like Proto 2000 GP18	1.0Amps	0.5Amps
Life Like BL2	1.0Amps	0.6Amps
Rivarossi 2-8-8-2	1.8Amps	1.4Amps
ROCO Class Re4/4 Electric	1.6Amps	0.7Amps
Walthers EMD SW1	0.9Amps	0.6Amps