DCC and Beyond

DCC explained
at Piedmont Division of SER, NMRA

Ovidiu Trifanescu
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What We Will Discuss

- DCC principles, standards
- DCC system components: power supply, command station, throttle bus, throttle, layout wiring, booster, power districts, mobile decoder, stationary decoder
- DCC systems general features
- How to choose a DCC system: scale, size, expansion, support, radio
- DCC Decoder basics
- CVs explained
- How to choose a decoder: motor size, available space, features
- Basics of decoder installations: normal & sound, light bulb & LED
- Wiring for DCC, DCC friendly turnouts
- Do's and Don'ts
- DCC systems extra features: feedback, signaling, computer interfaces, computer SW
- Probable future of DCC
- DCC manufacturers
- Resources: books, websites manufacturers and others, web groups

DCC Principles, Standards

- DCC stands for "**D**igital **C**ommand **C**ontrol"

- Since 1990's there were different attempts to command and control multiple trains independently on same track. Most of them employed analog solutions.

- In the same time Lenz Company in Germany developed a digital system and after judging different systems was selected by NMRA DCC committee. Eventually Lenz offered the patent free of royalties to NMRA. In this way DCC become an NMRA standard.

- The principle of DCC is sending commands through the rails in a digital format (0s and 1s) coded in such way that it makes transmission very reliable and stable.

- Thanks to NMRA standard and the system reliability we can use any decoder with any digital system

DCC Principles, Standards

- DCC standards are covered in NMRA S-9.1 and S-9.2 and a number of Recommended Practice documents, easy to find on NMRA website. Similar standards and documents are listed on MOROP website (European equivalent of NMRA).

- The standard specify how the signal is encoded on the rails to form the "0s" and "1s". Basically it will flip-flop the DC voltage (about 8000 times per second), the duration of the flip and flop giving the "0" or "1".

DCC Principles, Standards

- That's how the famous "DCC square wave AC" appears:
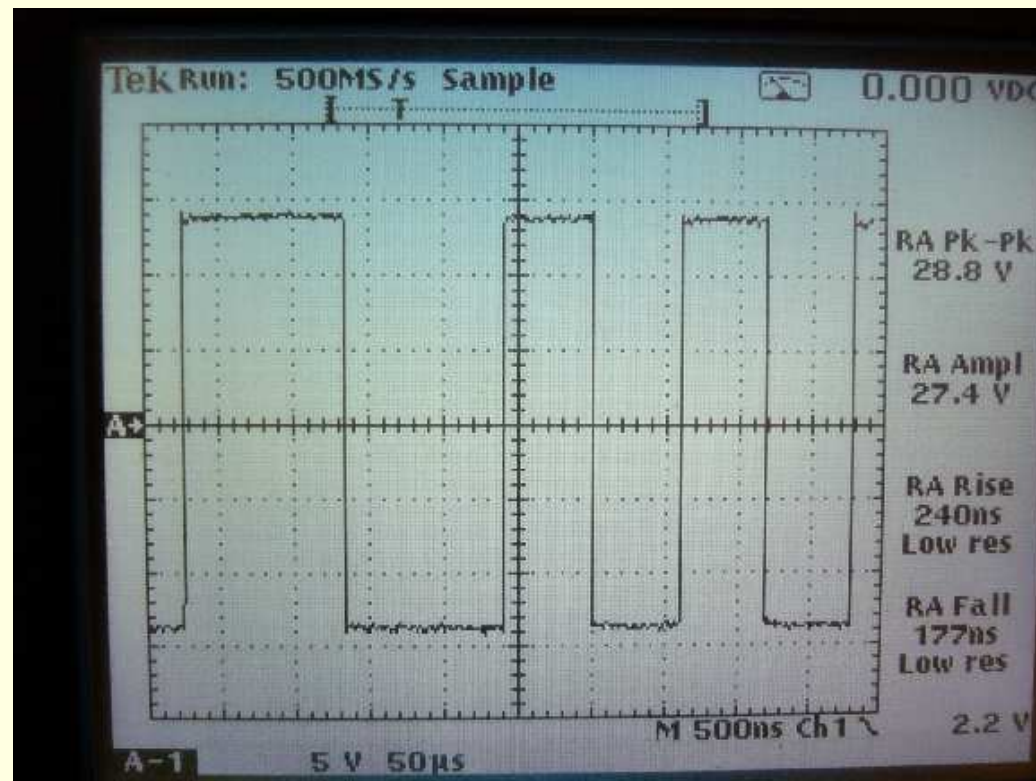
From http://www.wiringfordcc.com/wirefordcc_toc.htm website

DCC System Components

- **Command Station –** The heart or brains of DCC. The Command Station is a dedicated computer that communicates with all other parts of the DCC system. Selecting the brand and model of Command Station is key to selecting the type of Throttle controls as well as feature expandability of the system. Important: It can be only one!

- **Throttle** or **Cab –** The man-machine interface between You, the engineer, and the Command Station controlling the train. Various Throttle equipment styles exist. Some systems use a plug-in, walk-around Throttle, with the possibility that more than one can be used at the same time. Some systems have Throttles built into the Command Station. Each brand of DCC system requires their own brand of Throttle or Engineer's Cab, and their specific type of Throttle to Command Station wiring interface. You cannot easily intermix brands here.

- **Loco Decoder –** An electronic receiver inside the loco out on the track. The Decoder receives communications from the Command Station and controls the loco motor and lighting effects. Some Decoders also add locomotive sounds to operation. Every DCC controlled locomotive must have its own decoder. But any brand of Loco decoder should work with any brand of DCC Command Station / Throttle equipment.

DCC System Components

- **Power Supply** – An AC transformer or DC power source for the Command Station and track power Booster. The Power Supply is not included with many DCC equipment systems and must be purchased separately. An additional Power Supply is usually required with each additional Booster.

- **Rail Bus** – The wiring that goes around the layout to supply power to your trains. It basically doubles the electrical circuit of you rails and makes trains go smoother

- **Booster** – A power amplifier of the communication signals from the Command Station into power applied to the track. Some starter systems combine a Command Station and Booster into one box. Almost all Boosters require an external Power Supply. The ampere rating of the Booster and Power Supply will limit how many locos you can run at the same time. Some Boosters are in a separately available box and may be controllable from a Command Stations of a different brand.

- **DCC bus** – The wiring that caries the DCC signals from the command station to the boosters around the layout and often carries information from the layout back to the command station

- **Throttle Bus** – The wiring that connects all the throttles between themselves and command station. If the throttles are radio, then that the wire between the radio receiver and command station (sometimes combined with DCC bus)

- **Stationary decoder** – Decoders that based on DCC commands will activate your turnouts, signals, lights and any animation that you like to

DCC Systems General Features

- What to look for in a DCC system:
  - How many engines can you store/run in the system
  - 2 or 4 digits mobile decoders addressing
  - Possibility of controlling accessory decoders
  - What type of throttle bus (LocoNet, XpressNet, CAN, s88)
  - Programming capabilities: same or separate output
  - Throttles options: simple, complicated, infrared, radio
  - Possibility of using feedback (LocoNet, RS bus, CAN, s88)
  - Accessories and modules available from manufacturer or other companies
  - Expansion possibilities, computer interface

How to Choose a DCC System

- Points to consider when choosing a system:
    - How many engines it can run: 5 Amps can run 2 O scale engines, 5 HO scale or 10 N scale engines. Adding lighted passenger cars decrease the number of engine you can run
    - PRICE! Choose the best you can afford. Expanding it will be cheaper in the future.
    - Programming capabilities. Some systems have only one output and can program only the basic CVs. Others (more developed and expensive) have separated outputs and can program all CVs on both mobile and stationary decoders
    - What throttles do you feel comfortable options: simple, complicated, IR, radio. Try to play with a few different models and select the one that you feel the best for you
    - Expansion capabilities: if you plan a medium layout or bigger then consider if you can add boosters, more throttles, radio, signaling, feedback or computer control
    - What your friends have: operate on your friends layouts and talk with them how happy they are with their system. Or find out the dislikes
    - How good the documentation is, manufacturer support. Check the available documentation, manufacturer's website and how friendly and helpful is the technical support. You might call them more than once
    - Warranty: very important as shows manufacturer commitment to quality, product durability and user support. Some systems have 10 years warranty.
    - Check if other companies produce accessories or devices that run with your system, expanding beyond what's offered by the manufacturer

Mobile Decoder Basics

- The decoder is a smart electronic module (microcontroller) that is able to interpret and act upon DCC commands received through the rails.
- The mobile DCC decoders can be categorized in different ways:
  - Type: regular, sound only, sound upgradeable, sound decoders
  - Applicable Scale and power:
    - Big scale (O,1,G) decoders (3-5A)
    - HO & S decoders (1-2A)
    - N, TT, Z scale decoders (less than 1A)

	Continuous	Peak
O scale engine	2 - 3 A	5 A
HO scale engine	0.7 - 1 A	2 A
N scale engine	0.2 - 0.5 A	0.7 - 1 A

  - Construction type:
    - Small board double sided - usually shrink wrapped
    - Drop in decoders – usually they have the form of the board they replace
  - Connection type
    - Wires only – wires are soldered to decoder and ends are free
    - Wires and 8 pin NMRA plug – wires are soldered to decoder and have 8 pin NMRA plug
    - 9 pin JST connector, (you can add different types of wire harnesses)
    - Integrated 8 pin NMRA plug, the plug is part of the decoder or 6 pin for small scale decoders
    - New: integrated 21-pin interface to become a standard
  - Features
    - Number of output functions: 1, 2, 4, 6 or more on big scale decoders
    - Back EMF capabilities (cruise control),
    - For sound decoders: Number of effects generated, sound quality, upgradeable or not
    - Transponding, Railcom, USP

CVs Explained

- CV is short for Configuration Variable, the basic of decoder concept
- These are the decoder's adjustable parameters that are used to determine how the decoder behaves and how the decoder's outputs (motor, lights etc) perform.
- Once a CV is adjusted it is remembered even when power is removed. All decoders have the basic operating CVs and other CVs that may be unique to that decoder. Refer to decoder's instruction manual for all associated Configuration Variables.
- Adjusting the CVs is what the DCC manufacturers call "programming" and is usually done by giving a decimal value between 0 and 255 for most CVs. Different manufacturers use different ranges for their own CVs
- The manufacturers enter default values for each CV that enables the decoder to run a loco without any adjustment (programming) out of the box. To address this decoder you must select "3" the default value for CV 1, the short address. The decoder can be reset to default values.
- For independent running of locos, all locos decoders must have a different address.
- Changing CV values can be in 2 ways: On programming track (read-write possibility) or main track (only write. On programming track we can use these modes: registers (history), page (still in use) or direct CV (preferred today), while on main is only one mode. Depending on DCC system or decoder, not all CVs can be changed on main (notable CV1 – short address)

CVs Explained

- Once a CV is adjusted it is remembered even when power is removed.
- A few examples of basic operating CVs:
    - CV1: Decoder (engine) short address, also known as 2 digit address 1-99 (1-127 on some systems)
    - CV 2 that is used to set the first (start) speed step
    - CV 3 sets how fast the engine accelerates (acceleration momentum)
    - CV 4 sets how fast the engine stops (brake momentum)
    - CV 5 sets the maximum speed that the engine will have
    - CV 17 & 18: Decoder long address and.
    - CV 29 very important as it sets how the decoder interprets the DCC address & commands
- Other CVs that may be unique to that decoder.
    - CVs that set the different types of lighting effects for different light outputs
    - CVs that set how the decoder controls the motor
    - CV that set how a sound decoder behaves and how sounds are related to moving
- A CV contains 8 bits numbered 0-7 or 1-8. A bit can be 0 or 1. Hence the description of the value of a CV as binary "00000100" or as decimal 3, or hexadecimal x03 or h03. A value of 100 is binary "01100100" (1x64+1x32+1x4) or as hexadecimal 0x64 (6x16=96 + 4 = 100)

Bit	7	6	5	4	3	2	1	0	
Binary	0	1	1	0	0	1	0	0	
Multiplier	128	64	32	16	8	4	2	1	
Decimal	0	64	32	0	0	4	0	0	100

Hexadecimal	6	4	
Multiplier	16	1	
Decimal	96	4	100

Stationary Decoders

- Generally they are a bigger format, can be just the board with terminals or can be enclosed in a nicer box
- Their main functions are according to DCC commands to throw your turnouts, activate your signals, turn on-off lights on the layout, drive any animation that you might have (e.g. crossing gates or turntable)
- Usually the stationary decoders are programmed only once during initial installation, but is possible to program them again later on if their functions are changing (like assigned turnout numbers or lights sequence)
- Stationary decoders will have usually these terminals:
    - Power input from rail or a separate AC or DC plug
    - DCC command input, can be through the rails or through the throttle bus
    - Outputs for the functions are from 2 to 8 and can be momentary or continuous
    - The outputs have power ratings, try not to exceed them ☺
- Some of the accessory decoders will also have feedback to the command station through the throttle bus (Digitrax LocoNet) or separate (Lenz RS bus)
- Other designs will also have inputs for "local commands" like: push buttons, switches, contacts, Reed relays

How to Choose a Mobile Decoder

- Points to consider when choosing a decoder for your engine
  - Amperage (power) needed for your engine. This is most important to avoid burning up the decoder. There are methods to determine the maximum current draw for an engine (stall current) but here are the guidelines. In general newer engines have about 30-40% less current draw then older engines
  - Available space in the engine: find the proper space where you can fit the decoder so nothing will crimp it, punch, rub against it or overheat it.
  - Check if the engine is "DCC ready" meaning that already has a DCC socket (newer engines) or you need to "hardwire" the decoder in the engine (older ones)
  - Also check if there exist a "replacement board" or "drop-in" type decoder for your engine. This makes installation much easier, especially in HO switchers and N scale engines
  - Depending on how many functions and features you want on your engine chose the right decoder:
    - Functions: front lights, back-up lights, ditch lights, marker lights, class lights, beacons, cab, remote uncoupling, smoke generator, etc.
    - Features: back-EMF, transponding, light effects, consisting features
  - Decoders that you used previously. If you had good results with a certain brand, it's easier to continue to use it as you become familiar to their features, programming and troubleshooting. Don't be afraid to try new ones!

How to Install a Regular Decoder

- If you chose the decoder correctly at previous step, here is how you install it.

1. Dismantle the engine according to instructions (or experience), taking care not to pull or break any wires.

2. If the engine is "DCC ready" plug-in the decoder and fit it in available space.

3. If not, trace wires and make notes where each wire goes into the engine. Mostly you have these: from wheel pickups to the board, board to motor, board to the lights.

4. If the engine has a non-DCC board or only wires, then is the case to hard-wire the decoder. Based on previous notes connect (solder) the engine wires to decoder wires according to the color code

Color	Use	Pin Number
Violet or Brown	Output 4	1
Black	Track – Left Rail	2
Gray	Motor (-)	3
Yellow	Output 2 (Rear Headlight)	4
White	Output 1 (Front Headlight)	5
Blue	+V	6
Orange	Motor (+)	7
Red	Track – Right Rail	8
Green	Output 3	9
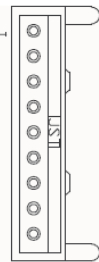
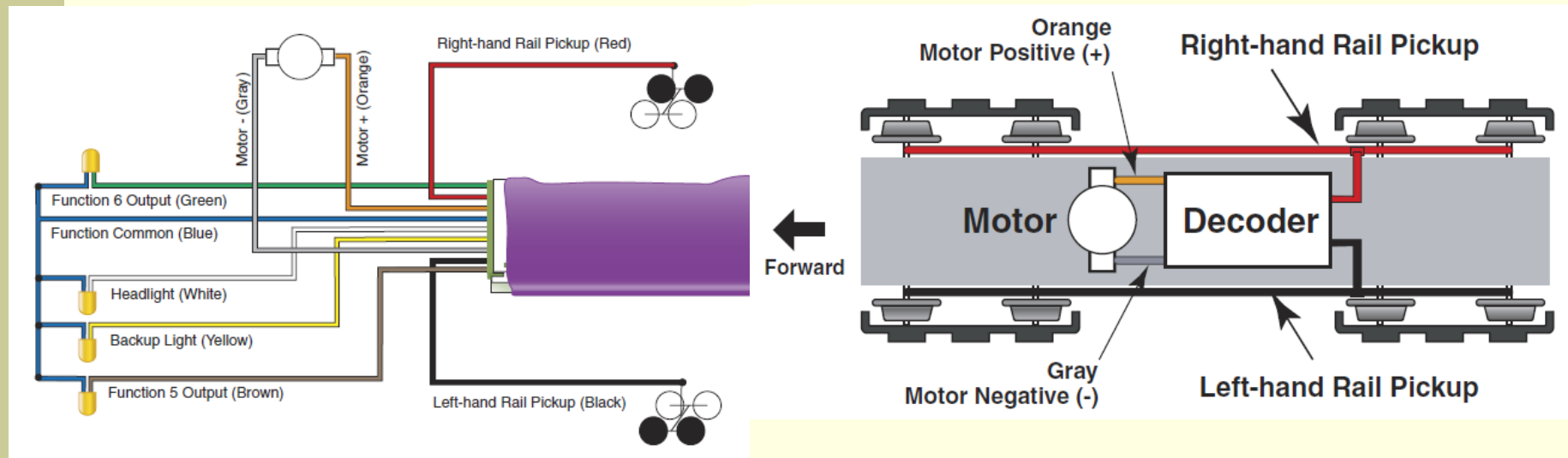| Pin No.	Small		Medium	
	Color	Use	Color	Use
1	Orange	Motor Right	Orange	Motor Right
2	Gray	Motor Left	Yellow	Rear Headlight
3	Red	Right Rail	(1)	(1)
4	Black	Left Rail	Black	Left Rail
5	White	Front Headlight	Gray	Motor Left
6	Yellow	Rear Headlight	White	Front Headlight
7			Blue	Common (V+)
8			Red	Right Rail
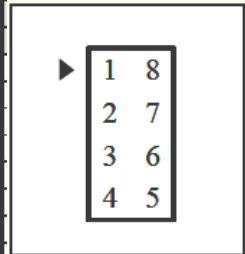
Both tables from NMRA DCC RP-9.1.1

5. Make sure you have the space to run the wires to the pick-ups, motor and lights so they will not be pinched, will not rub against something and will not impede movement of other parts

6. Install back the engine shell and test it first on programming track (low power) and then test it on regular track (full power)

How to Install a Regular Decoder

Left diagram labels:
- Motor - (Gray)
- Motor + (Orange)
- Right-hand Rail Pickup (Red)
- Function 6 Output (Green)
- Function Common (Blue)
- Headlight (White)
- Backup Light (Yellow)
- Function 5 Output (Brown)
- Left-hand Rail Pickup (Black)
- Forward

Right diagram labels:
- Orange Motor Positive (+)
- Right-hand Rail Pickup
- Motor
- Decoder
- Gray Motor Negative (-)
- Left-hand Rail Pickup

From Soundtraxx "Tsunami installation" manuals

- ■ That's how a typical decoder will be connected inside an engine.
- ■ Variations will exist in case of steam engines and/or in case of sound decoder installations.
- ■ For sound is important were do you want (have space) to install the decoder and speaker.
- ■ In case of steam you need to decide how many wires you want to run between the engine and the tender, where is the most space.

How to Install a Sound Decoder
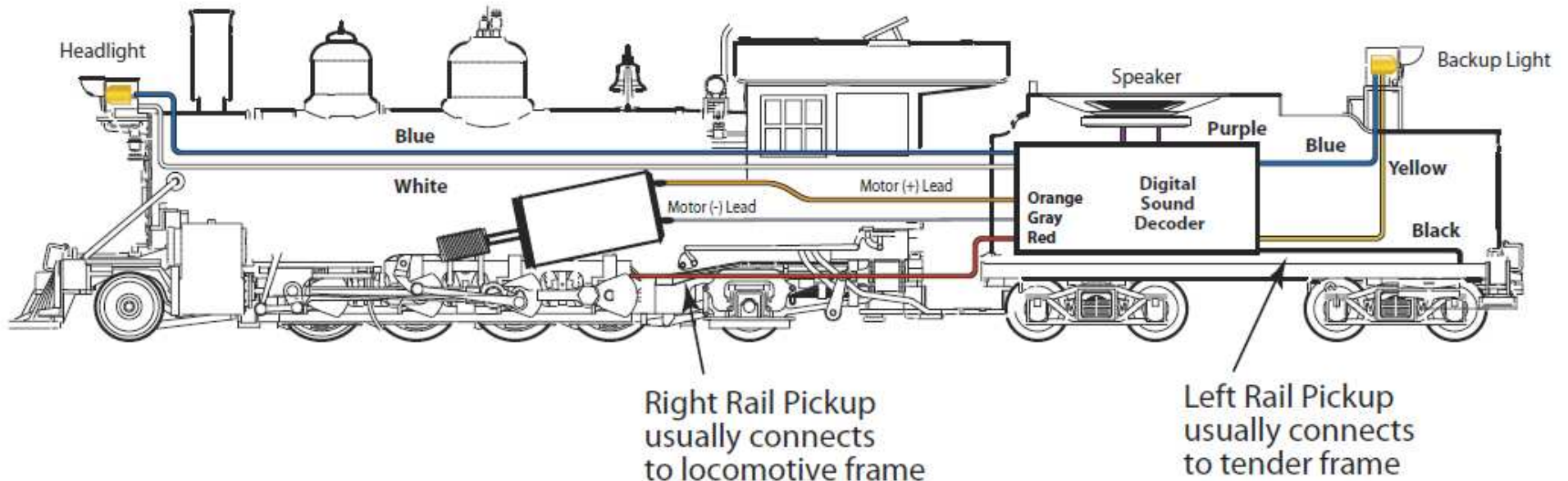
From Soundtraxx "Tsunami installation" manuals

- Soundtraxx decoder manuals have the above schematics for steam decoder installations with clear explanations for testing and installing their decoders and for the matter any sound decoder.

- Same kind of schematic can be found in all manufacturers installation manuals for decoders

How to Install a Sound Decoder

JUMPER WIRE BETWEEN TRUCKS

Headlight
Blue
White
Red
Orange Motor (+) Lead
Blue
Gray (Motor (-) Lead)
Red
Black
Digital Sound Decoder
Backup L
Yellow
Purple
Left Rail Pickup

Speaker in fuel tank or under fan grills

From Soundtraxx "Tsunami installation" manuals

- Soundtraxx decoder manuals have the above schematics for Diesel decoder installations with clear explanations for testing and installing their decoders and for the matter any sound decoder.
- Same kind of schematic can be found in all manufacturers installation manuals for decoders
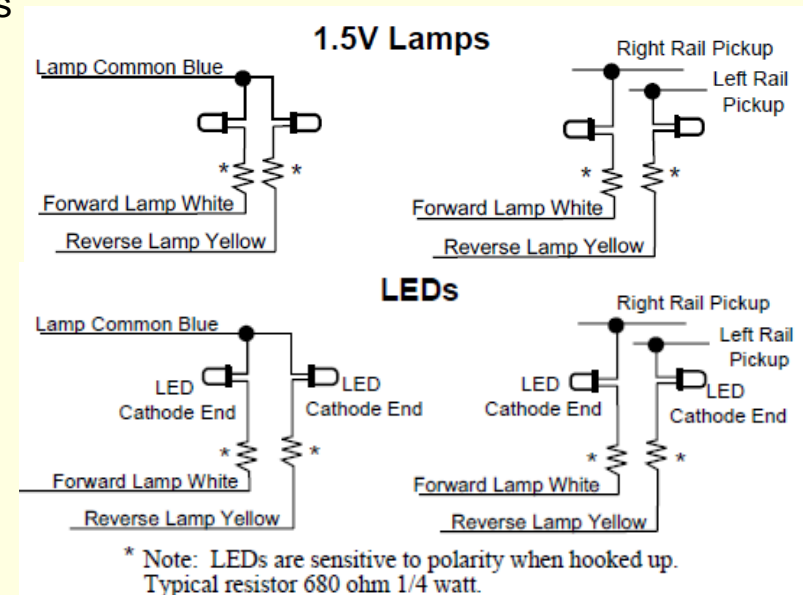
How to Install a Decoder - Lights

- Depending on what was already installed in the engine as lights, you might keep them or need to change them. For some engines the instructions specify that you need to change bulbs if you install DCC.

- If you chose to change them, personal recommendations in order are: Sunny white or Golden white LEDs (2.8V @ 15mA) and micro bulbs 1.5V @ 15 mA (great for small places).

- If you can, avoid 12V, 14V or 16V @ 30mA, 40mA or 50 mA bulbs as they <u>will</u> get hot and melt the plastic around them. Also they can damage the output.

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 Wattage: no shade 1/4W, Light shaded 1/2W, Dark shaded 1W

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

From Mark Gurries – DCC Decoder Hardware presentation

1.5V Lamps

Lamp Common Blue
Forward Lamp White
Reverse Lamp Yellow

Right Rail Pickup
Left Rail Pickup
Forward Lamp White
Reverse Lamp Yellow

LEDs

Lamp Common Blue
LED Cathode End
LED Cathode End
Forward Lamp White
Reverse Lamp Yellow

Right Rail Pickup
Left Rail Pickup
LED Cathode End
LED Cathode End
Forward Lamp White
Reverse Lamp Yellow

* Note: LEDs are sensitive to polarity when hooked up. Typical resistor 680 ohm 1/4 watt.

12V to 16V Lamps

Lamp Common Blue
Forward Lamp White
Reverse Lamp Yellow

Right Rail Pickup
Left Rail Pickup
Forward Lamp White
Reverse Lamp Yellow

All above schematics from Digitrax Decoder Manual

Wiring for DCC

- **The DCC legend**, half truth, half myth: you need only 2 wires to connect to the layout
  - The truth: yes it can be done if you have a small layout and run only a couple of engines
  - The myth: in practice you need a bit more complicated wiring to assure good operation, safety and reliability
- **First fact about DCC** systems: except for basics systems, they put out more power (5A @ 14V = 70W) than your traditional throttles (1.5A @ 12V = 18W). This can produce serious damage in case of mishaps
- **Second fact about DCC**: due to higher amperage, you need the extra bus wires and do not rely only on railroad track conductivity
- **Third fact about DCC**: usually the short-circuit protection is extremely fast and sensitive, which will bring to attention problems not seen on regular DC engines or layouts

Wiring for DCC

- The bus wires are basically wires that double your track schematics, but under the layout. From point to point (in practice every 2-3 feet) you attach "feeder" wires to connect the bus to the track.

- Here are some recommendations for bus and feeder wires sizes:

Scale	Suggested Wire Sizes	
	Smallest	Largest
Z	24 (.511)	22 (.645)
N	24 (.511)	22 (.645)
HO	24 (.511)	20 (.813)
S,O	22 (.645)	16 (1.290)
G	20 (.813)	14 (1.628)

Scale	Suggested Wire Sizes	
	Smallest	Largest
Z	16 (1.290)	14 (1.628)
N	16 (1.290)	14 (1.628)
HO	16 (1.290)	12 (2.052)
S,O	14 (1.628)	10 (2.588)
G	14 (1.628)	10 (2.588)

Both tables from Alan Gartners' "Wiring for DCC" website

- What happens if you have a big layout and you run multiple Diesel lash-ups and lighted cars? You need more power.
  - **Solution:** more power districts, each one powered by a booster. In this way each booster will drive only a couple of trains and all will obey the single command station.

- What happens if something (or somebody) produces a short-circuit? Your whole layout (or booster district) goes down due built-in protection.
  - **Solution:** use the power modules to give you power sections. One booster will power a few sections and if there is a short-circuit in a power section only that section will go down. The rest of the crew con continue to play with trains

- The "Quarter test": go around the layout and short each piece of rail with a quarter. If short-circuits protection activates you have good wiring. If not, there could be problems: too small bus wires, too few feeders, not well made solder joints or connections.

Wiring for DCC

- Then we have some "special" pieces of track

- **Reverse loops:** on DCC to power the reverse loops you can use a "DCC reversing module" instead of the traditional DPDT switch. This module will sense the momentary short-circuit when and engine enters or leaves the loop and will flip very fast the DCC rails "polarity". This is done faster then the short-circuit protections so they will not activate. The wyes wiring works the same.

- **DCC "friendly" turnouts:** as mentioned, the short circuit protections on DCC are very fast. When the wheels or tracks are not perfectly matching in the turnout, a momentary contact can appear between parts with opposite polarities and this will shut down the protection. The DCC friendly turnouts are built so that parts that can short circuit are insulated and the rails close to each other have similar polarities.

- **Programming track:** this is where you do programming of your decoders. Usually this is a stub end track connected to layout with a DPDT switch. One position is "Run" the other "Program". Make sure you follow system specific instructions! Or better yet make this a separate piece of track totally disconnected from layout.

- **Storage tracks:** this is where you keep your engines when not in use. Even if they don't move, the decoders are alive using voltage from rails; especially sound decoders (certain brands) can draw a lot of current at start-up and trigger the short-circuit protections. Recommendation: if you can, install a kill switch.

DO's and DON'Ts

DCC and beyond

- **DO:**
  - Maintain clean track and wheels: dirty track can get decoders to act strange.
  - Install DCC decoders in good running DC engines. A bad running engine on DC will be even worse on DCC
  - Use only decoders specifically designed to work with coreless motors (on high end locos)
  - Break your layout in power districts if it's bigger than a 4'x8' or if you have more then one operator.
  - Perform the "quarter test" to make sure that the DCC system will protect your layout, rolling stock and house
  - When everything else fail, DO read the manuals or ask your friends

- **DO NOT:**
  - Run a regular DC engine without decoder on a DCC system (address 00) for too long (more than 1-2 minutes) or you could damage the motor
  - Let a regular DC engine without decoder on a DCC system sitting and buzzing – it will damage the motor and lights
  - Use DCC power through an overhead wire system. The poor contact and sparks could confuse or even kill the decoder
  - Use too much cheap decoders, if you want enjoyment from your DCC trains. Cheap decoder could fail faster or have poor drive characteristics

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DCC Systems Extra Features

- There are a number of extra features, less used:
- **Feedback:** this is the DCC system capability to collect information back from the layout. Can be in the same bus like the system bus (e.g. Digitrax's LocoNet) or a separate bus (Lenz's RS bus).
- **Transponding:** capability of the decoders to send their own information to the command station according to their location (e.g. Digitrax Trainsponding or Lenz Railcom) Different manufacturers can use one of the above or even make their own (no standard yet)
- **Computer interface:** many of the traditional DCC systems manufacturers are offering a module that acts as interface between the DCC system and a computer. In this way you can use the computer's "superior intelligence" to control your trains. (Digitrax PR3, Lenz LI-USB, RR-CirKits LocoBuffer USB, ESU LokProgrammer, QSI Quantum programmer)
- **Computer software:** usually these are programs offered by DCC manufacturers or other companies or groups that enable you to control much better, easier and with superior logic what's happening on your layout. With the aid of the interfaces the computer is part of the play and you can achieve high automatization and operating realism. Most known: JMRI suite, Freiwald's Railroad & Co suite, KAM's suite

Current, Near and Probable Future

- **Non-sound decoders are becoming smarter with more features:**
    - voltage regulators for all outputs (already in)
    - Real time feedback to the command station and throttles, on the main
    - All programming will be on the main with read-back
    - more realistic lighting effects, easier to program
    - Internal power supply to get over dead track up to 10 inches (the Power module from Lenz USP)
    - counters for coal, water, crew time, diesel fuel that if you forget to check will stop you in the middle of the track (optional ☺)
    - Regular decoders can easily be upgraded to sound decoders (the SoundBug from Digitrax)
    - DCC ready engines will require no wiring due to new 21 pins connector starting to be the new standard. This contains all possible current connections and connections for future applications
    - Capability of multiple decoders in an engine to communicate between themselves and self adjust for operation and programming
- **Sound decoders are becoming more realistic**
    - Higher quality recordings (16 bit sound), more simultaneous channels,
    - Better and realistic synchronization between sound and movement
    - More options to customize sounds, easier to optimize to your specific loco. Already ESU, Digitrax and QSI let you create and upload your own sound files updates and uploads thorough computer interfaces)
    - On the internet, growing number of sound libraries for different decoders and locomotives

DCC Manufacturers

- There are many manufacturers of complete DCC systems or components for DCC systems, or Software
  - Digitrax - complete systems, components, decoders (simple & sound)
  - Lenz - complete systems, components, decoders (simple & sound)
  - North Coast Engineering (NCE) - complete systems, components, decoders
  - CVP products (Easy DCC) – complete products, radio cabs and receivers
  - Model Rectifier Co (MRC) - complete systems, components, decoders (simple & sound)
  - Soundtraxx – sound decoders and systems
  - Elektronik Solutions Ulm (ESU) - complete systems, components, decoders (simple & sound)
  - Zimo - complete systems, components, decoders (simple & sound)
  - QSI Solutions – sound decoders
  - Train Control Systems (TCS) – decoders
  - Software: Railroad & Co, JMRI, Rocomotion, WinDigital, KAM
  - Many others… at different quality, prices and features

Resources

- http://www.nmra.org/standards/DCC/index.html - standards
- http://www.digitrax.com/ - Digitrax
- http://www.ncedcc.com/ - NCE
- http://www.soundtraxx.com/ - Soundtraxx
- http://www.lenz.com/ - Lenz Elektronik
- http://www.loksound.com/ - ESU Loksound
- http://www.tcsdcc.com/ - TCS
- http://www.modelrec.com/train-controls/dcc.asp - MRC
- http://www.qsisolutions.com/ - QSI
- http://www.zimo.at/web2007/index2E.htm - Zimo
- http://www.wiringfordcc.com/wirefordcc_toc.htm - **Fantastic site!**
- http://www.loystoys.com/MiscHTML/dcc-topics.html - info
- http://www.tonystrains.com/news.htm - reviews
- http://jmri.sourceforge.net/ - JMRI suite
- http://www.freiwald.com/ - RailRoad & Co

More Questions?

■ Contact the on-hand resource:

Ovidiu Trifanescu

Cell: (678) 230-3184

Email: piko7403@yahoo.com