DCC 103

Getting started in DCC
Power Districts
Finding Short Circuits
Introduction

• In this clinic we will cover:
  • The Origins of DCC
  • What is DCC?
  • Converting from DC to DCC
  • DCC Starter Systems • DCC Manufacturers
  • Bus Wiring & Wire Sizes • Stranded vs Solid Wire
  • Power Districts • Circuit Breakers • Boosters
  • Short Circuits
  • Turnouts • Frog Juicers
Origins of DCC

- Digital Command Control (DCC) is a system patented by Bernd Lenz in the early 1990s.
- Patents assigned to the NMRA, who then created a set of Standards and Recommended Practices for DCC.
- Standards describe the track interface: voltages, pulses, data and waveforms. Recommended Practices related to CV (configuration variable) values, communication, Manufacturer ID, etc.
- All DCC manufacturers accept the Standards, and most the Recommended Practices.
- Refer: www.nmra.org/standards/DCC/Index.html
What is DCC?

- **DCC is an alternative method of running Trains**
  - Using DC the Loco receives its instructions on how fast to run from the amount of DC volts applied to the rails.
  - Using DCC a signal is sent – via the rails - to a decoder installed in the Loco instructing it on, not just how fast to run, but also on which lights to turn on and if sound equipped what noises (bell, horn, etc) to make.
  - Because the power to the rails is always “on” DCC can provide additional functions such as constant passenger car lighting.
Why convert from DC to DCC?

- The ability to control individual locomotives without any complicated control panels, block switching and wiring.
- In the DC environment, no matter how much you grow your power availability, all you ever control is the track.
- With DCC, you control the Locos — i.e. you drive the train!
- Speed matching — all your Locos running at the same speed.
- Advanced Consisting — running two or more Locos together.
- Wireless Radio Control
- Computer Control
- Greater realism.
Which Manufacturer to chose?

**Considerations:**

- What systems are your friends using? Having the same system means:
  - You have someone to talk to if you experience a problem
  - Your throttle will work on your friends system when you operate
- Is local Sales support important to you? Only available in Sydney, Melbourne and Brisbane.
- Is local Service support important to you? Only available in Sydney at this time . . .
- However Sydney is closer than the United States . . . But.
- How Technical are you?
- Do you want a user friendly system?
DCC Manufacturers

• The four top players are:
  • NCE
  • Digitrax
  • EasyDCC
  • MRC

• However most people choose either Digitrax or NCE
Digitrax

- Digitrax are a major player in the DCC systems market with a full range of options.
- Digitrax is considered to be the best system from a technical perspective . . . But it helps if you are technical as well.
- It is however let down by the design of it’s throttles.
- Digitrax also market a large range of DCC decoders and DCC accessories.
- They have only have 7 dealers in Australia and all repairs are made in the USA.
- Furthermore there is limited stocks held in Australia
NCE

- NCE currently appears to be the most popular DCC system in both Australia and the USA.
- They have a solid range of Systems which cover every requirement, as well as a good range of accessories.
- The most important factor is that their systems and their throttles are considered to be “user friendly.”
- NCE have a "Nothing Wasted" Growth Path in that all major components purchased while growing an NCE system can be reused in one form or another.
- NCE systems purchased in Australia can be serviced by their Australian service agent in Blacktown, NSW. But they charge an additional $100 surcharge to support USA purchased systems.
- However NCE in the USA will repair any of their systems.
DCC System Components

- Command Station
- Power Supply
- Throttle
- Power Panel – if using Walkaround throttles
- Booster
- Circuit Breakers
- Wireless Radio Control
DCC Systems

- Basic 2 Amp systems **without** Booster (eg. NCE PowerCab, MRC Prodigy Explorer).
- Basic 3 Amp fixed position throttle with Booster (eg. NCE Twin, Digitrax Zephyr Xtra).
- Intermediate 5 Amp system with Booster (eg. NCE PowerCab combined with NCE SB5 Booster).
- Advanced 5 Amp system (eg. NCE Power Pro, Digitrax EVO, EasyDCC CVP2)
- Wireless Radio system
- 10 Amp system for “O” scale and above

Refer: [http://denversrailroads.com/DCC-Systems.htm](http://denversrailroads.com/DCC-Systems.htm)
Basic DCC System

NCE PowerCab

Small (approx. 8’x4’/2400mmx1200mm) layouts running one or two Locos at once. Single Throttle Cost = A$275

Command Station & Throttle (Cab)
Power Supply
Power Panel
Intermediate DCC System
NCE PowerCab combined with NCE SB5 Booster
Medium sized (approx. 6mx3m single car garage) layouts running up to 4 Locos at once. Single Throttle Cost = A$630

Command Station
Throttle (Cab)
Power Supply
Power Panel
+ Booster
Additional Cabs
Advanced DCC System

NCE Power Pro with optional additional Boosters and/or Radio Control (ProCab R)

Large (two car garage or greater) layouts running up to 50 Locos at once. Single Throttle Cost = A$859 (A$1,072 for radio)

Command Station
Throttle (Cab)
Power Supply
Power Panels
Multiple Boosters
Additional Cabs
Circuit Breakers
Radio Control
Additional NCE Throttles

- NCE Cab06 throttles cost an A$148 each.
Bus Wiring

• The idea is to run two “Bus” wires around your layout — something like this:

• And then run smaller feeder wires from the track to the Bus wires.
Wire Sizes

- **This is a very confusing area.**
  - Most of the books and articles on DCC are American and so quote wire sizes in AWG (American Wire Gauge) sizes.
  - Not only is this unhelpful but metric sizes are quite different.
  - They are quoted for example as 1.5mm² (AWG 15½)
Recommended Wire Sizes

- Based on a chart published by Model Railway Hobbyist of BUS lengths I have complied the following table:

<table>
<thead>
<tr>
<th>Length</th>
<th>Metric</th>
<th>AWG Size</th>
<th>Metric Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>50’</td>
<td>15.24m</td>
<td>12</td>
<td>3.31mm²</td>
</tr>
<tr>
<td>31.45’</td>
<td>9.58m</td>
<td>14</td>
<td>2.08mm²</td>
</tr>
<tr>
<td>19.77’</td>
<td>6.02m</td>
<td>16</td>
<td>1.31mm²</td>
</tr>
<tr>
<td>12.44’</td>
<td>3.79m</td>
<td>18</td>
<td>0.823mm²</td>
</tr>
<tr>
<td>7.82’</td>
<td>2.38m</td>
<td>20</td>
<td>0.518mm²</td>
</tr>
<tr>
<td>4.92’</td>
<td>1.50m</td>
<td>22</td>
<td>0.326mm²</td>
</tr>
<tr>
<td>3.09’</td>
<td>0.94m</td>
<td>24</td>
<td>0.205mm²</td>
</tr>
</tbody>
</table>
Wire Size in Reality

• Size AWG 12 (3.31mm²) wire is larger than that used for 240 volt house cabling.

• I have an N scale layout which is 37 feet long and I use a Bunnings stranded wire which is 1.5mm² (AWG 15½) between each of my modules.
BUS and Feeder Wire Sizes

- I then use a solid 1mm² (AWG 17) wire as a “BUS” wire from the module connection to my feeder wires.
- My feeder wires are generally size AWG 21.
- Both are available from Bunnings:
Stranded vs Solid Wire

- The books all say use stranded wire and some books indicate that it will carry the DCC signal further.
- It is also true that if some strands are broken the current will still get through on the unbroken wires.
- And solid wire does tend to be more brittle and break more often.
- But solid wire is so much easier to work with and to solder — so it gets my vote!
Converting from DC

- **Myth:**
  - DCC wiring is easier than DC

- **Reality:**
  - DCC requires a feeder wire every 600 – 900mm
  - DCC Turnout wiring is more complicated than DC
  - What is easier is that DCC does not require block switches on a control panel in order to operate . . .
  - Once the feeders are attached to the BUS wiring trains should run.
  - However . . .
DCC positive and negative rails

- DC power always has a + (positive) and — (negative) side.
- DCC power uses a bipolar DC signal.
  - This results in a form of alternating current, but the DCC signal does not follow a sine wave. Instead, the command station quickly switches the direction of the DC voltage, resulting in a modulated pulse wave.
- To quote from Model Railway Hobbyist magazine:
  - “DCC puts a voltage across the rails that is a collection of computer data pulses. Assume a 15 volt track voltage; at any given time, the voltage on one rail will be 15 volts higher than the other. They take turns being the higher voltage and they switch at the same time. The time span between when they switch varies based on the data being sent between the DCC system and the decoders.”
The reality of Positive & Negative rails

- With DC you always know which track is which.
- With DCC you have no idea, unless you use a multimeter across two rail blocks see video to follow later.
- A simple solution for mainline track is to colour code a freight car and push it around the track to indicate which side is “red” and which side is “white” (the most common wire colours). For example:
And then label the rails on the layout
DCC Wiring Challenges

• Where it gets more difficult is in yards and significantly more difficult with reversing loops.
• But the biggest challenge can come when trying to convert existing DC wiring to DCC.
• You would think that all you had to do was to link up all of the DC blocks into one big block like this:
Linking DC blocks together
The problem

• If just one connection is reversed . . .
  • eg a red (or green in the example) rail is connected to a white rail
  • you may have a short, or at the very least a Loco will stall.
• Then you have the problem of finding just one bad connection amongst many.
The Solution

- Wire a block – or two at the most – and then test:
  - First with a multi-meter and
  - Then with a locomotive
- If all is ok go on to the next block or two
  - Then test again
- And so on.
- Easy really — but time consuming!
Testing Video 1
Testing Video 2
DCC equipment brands

• A note here to explain that DCC Accessory devices:
  • ie. Circuit Breakers, Decoders, Frog Juicers, Reversing Units, Boosters, etc.
  • But **Not** Throttles
• that you add to your DCC System can be of any brand and do not have to be the same brand as your DCC Command Station.
Power Districts

• **Why divide your layout?** After all isn't one of the big selling points of DCC that you don’t need to divide your layout into individual electrical blocks for independent train control?

• Well yes, but . . . In addition to minimizing operating disruptions, power districts are also the key to good DCC power management.

• If you’re running a lot of trains, you’ll need to make sure your DCC system can supply all your power needs efficiently and safely.

• Adding power districts to your layout will help you do that. By separating your layout into power districts, you divide the total track power available into smaller, more manageable units.
A Large DCC Layout
Short Circuits

- **In addition short circuits happen . . . A LOT!**
- With DCC a short has the potential to disrupt all operations. That’s because when one train causes a short, it trips the master circuit breaker, interrupting power to all trains on the layout.
- Once you clear the short, the circuit breaker resets itself and your trains are back in operation. But these breaks in activity aren’t realistic or fun.
- Fortunately, you can minimize this type of disruption by dividing your layout into smaller power districts – electrically isolated sections that have their own protective Boosters or Circuit Breakers.

Causes of Short Circuits

- Whatever you last did or whatever you recently did but have not tested.
- Broken wires or a metal object touching the track or across control panel wires.
- A Non-DCC friendly turnout or driving into a live frog turnout set against you.
- A reversing loop or any other arrangement that allows a train to end up going back the way it came.
- Bad track wiring - eg, un-insulated feeder wires coming into contact or feeder wire connected to the wrong BUS wire.
- A derailment shorting opposite polarity rails.
- A locomotive crossing between unmatched power districts.
- **Dirty track.**
Circuit Breakers

- The goal of the DCC circuit breaker is to protect the Command Station or Booster by isolating the short locally within the circuit breakers power district so the booster can remain powering the other power districts to keep the other parts of the layout running.

- For the DCC circuit breaker to act, a short circuit has to meet specific criteria:
  - a) The short circuit current must be above the trip point of the DCC circuit breaker.
  - b) The short circuit current must last for a period of time.

Source: NCE Information Sheet
Why use a Circuit Breaker

• **A Circuit Breaker protects the Booster.**
• A Circuit Breaker is wired between the DCC system’s booster and the track BUS.
• **It does NOT protect the Decoder in the Loco.**
• The reason you would add protection of some sort – the Circuit Breaker is not the only choice – is that you don’t want your entire railroad to shut down just because you have a short circuit that only effects one part of your layout.
Circuit Breaker Options  (US$ Prices)

• **From the cheapest to the best:**
  - An 1156 automotive 12 volt 32 candle power (27 watt) brake lamp bulb. About $2.00.
  - NCE CP6, 6 Zone DCC circuit protector. $34.95 for 6.
  - Voltscooter Engineering Automatic Fuse for DCC. $5.95 each.
  - NCE EB1 Circuit Breaker. $29.95.
  - DCC Specialties PSX1 Circuit Breaker. $37.95.
1156 Automotive Bulb

- To quote Alan Jones, writing on the cs.trains.com web site:
  - “I use a 1156 car light bulb to limit the current for my NCE Powercab to under 1.5 amps. It works well for me.
  - The theory is that a cold filament in a light globe has a low resistance, so long as the current thru the globe stays at that low level there is very little voltage drop in the globe, but once the current reaches the point that warms the filament sufficiently, the resistance increases and prevents the current form getting so high it causes damage elsewhere in the circuit.
  - If you have a large layout it is best to use several globes, each one feeding a separate part of the layout.
  - Two big advantages are you get visual indication of a short and it resets automatically once the short is removed.”
NCE CP6, 6 Zone DCC circuit protector

- The CP6 is a current limiting device that provides circuit protection for up to 6 sections of your railroad and operates with any DCC system.
- It can power 6 - 1 amp power districts with current limiting. Bulbs are in series with load. It allows 1 amp to pass thru while the rest of the load (up to 12 amps) burns off as heat/light. Multiple sections of CP6 can be used in parallel to create larger limits.
A note on the NCE Power Cab

- The CP6 is recommended for the NCE Power Cab because it provides basic current limiting protection of 1 amp per section for 6 areas.

- **The CP6 will not make the Power Cab reboot.**

- The Power Cab is rated around 1.7–2 amps. I recently used a Power Cab on a temporary basis and had it hooked to an NCE EB1 Circuit Breaker. The lowest setting of an EB1 is 2.5 amps and consequently although the EB1 identifies the short circuit the Power Cab does keep rebooting itself, which is not good for the device!

- And NCE Power Cabs supplied with Australian power supplies have been known to melt!
Voltscooter Engineering
Automatic Fuse for DCC

- This product provides a low cost means of electrically isolating blocks of your layout so that a short circuit in one area does not shut down the entire layout.

- These fuses can be used to replace much more costly DCC electronic circuit breakers. The trip level is settable for 3.8, 2.3, 1.5 or 0.8 Amperes.

- **I am still in the process of assessing this product, which could provide much better protection to a NCE PowerCab than a light bulb.**

 Available from:
http://voltscooter.com/?page_id=134
NCE EB1 Circuit Breaker

- I have 9 of these devices on my layout protecting 9 of my 12 power districts. Of the other 3 power districts, 2 are protected by reversing units and 1 by a DCC Specialties PSX1 Circuit Breaker.

- I use the EB1 instead of the PSX1 because it is cheaper.
NCE EB1 Circuit Breaker Stats

“The EB1 Circuit Breaker provides short circuit protection for one power district and can be used with most DCC systems. Threshold, Duration, type of reset can all be configured.

The EB1:
- Provides short circuit protection for one power district.
- Is trip current adjustable for 2.5 to 8 Amps.
- Is easy to hookup using screw terminals, no soldering.
- It has a status indication LED and additional output for remote LED.
- Optional manual reset.
- Adjustable short circuit response time.
- Adjustable power-up response time to accommodate sound decoder equipped locomotives.”
DCC Specialties PSX1 Circuit Breaker

- The PSX1 Circuit Breaker includes Network Feedback, Shorted and Occupancy Status to Digitrax LocoNet, Lenz ExpressNet and NCE Cab Bus.

- The PSX-1’s trip current is set at 3.81 amps. You can adjust it from 1.27 amps to 17.8 amps easily via programming or jumper connections on the board.
To quote Bruce Petrarca of MRH Magazine:

- “I personally use and most highly recommend the PSx series. They were designed after sound decoders and stay alive capacitors became the norm.
- Thus, they can handle restarting close to 20 locos with sound decoders in a single district . . .
- It was designed for DCC Specialties (a company started by Tony Parisi of Tony's Trains) and is contract manufactured for them by NCE.
- They can accommodate any system from the NCE PowerCab (one of the lowest powered units on the market, but has a very quick shut down) to the BRUTE FORCE short circuit current (60 amps) from the NCE PowerHouse Pro. Every other system I know about falls between these extremes.
- They even have a "weak booster" mode to ease the load onto Digitrax boosters to keep them from shutting down with several sound locos in the same district.”
DCC Boosters

- Boosters are responsible for the following tasks:
  - Converting the incoming AC or DC power into a local internal DC power source suitable to drive the track.
  - Providing short circuit protection, so any short circuits will trigger the circuit breaker to cut power to the track before something is damaged.
  - Provide an automatic resetting "Circuit Breaker" function.
  - Convert the command station's digital level signals into a DCC track waveforms with suitable voltage and current to run locomotives.
  - Optionally provide a regulated voltage for the track.

http://www.dccwiki.com/
Adding Boosters

- To add additional boosters, you will need to electrically divide your track into power districts, and connect a new booster to that section of track.
- The booster may need a separate power supply, and must be connected to your DCC system's booster bus.
- By connecting the booster to the booster bus, all boosters on the layout will send out the same commands to all sections of the track. This allows trains to receive commands, even if they are crossing between power districts controlled by different boosters.
- **Be sure to double gap the tracks to fully isolate the boosters.** That is, both rails need to be cut at the same spot. Otherwise you can create a short if one booster on the section goes out of sync with the others.

http://www.dccwiki.com/
How many Boosters do you need

• **At least one!**

• If you have bought a DCC Starter System that does not include a 5 amp booster (eg. NCE Power Cab) and you grow your system you will need to buy a Booster sooner or later.

• Such as a **NCE SB5 5 Amp Smart Booster** for a NCE Power Cab.

• But you will only require additional Boosters if your system gets **really really big** or you decide to use Boosters instead of Circuit Breakers or you use an Accessory Booster.
Tam Valley Depot Booster

- This DCC Booster was designed to solve two issues that putting a lot of DCC accessory decoders on your layout brings up:
  - 1) They are a drain on your precious loco amps and
  - 2) When a loco causes a short all the accessories lose power.

- To solve this problem Tam Valley have made a DCC booster that can provide about 5 Amps of power to run the DCC accessories independent of the track power from your command station.

- During a short on the layout, when the DCC signal dies, the booster continues to deliver full power. This is a so-called "dumb" booster in that it does not need a cab bus - it connects directly to the track output of your existing command station.
Powered circuit breaker

- You can also use the booster as a "powered circuit breaker".
- It fills all the functions of a circuit breaker but provides its own power. Each of your power districts puts no load on the command station as it is fully buffered.
- Auto-shutdown – the unit shuts down after 5 minutes of no DCC signal (accessory mode) or immediately (power district mode). When the DCC signal returns it wakes up immediately. Just plug the booster in and forget about it.
- The booster has protection against shorts and overheating.
Boosters instead of Circuit Breakers

- Used with the 16V 4.5A 72W 110/240v switching power supply (available from Tam Valley) you get about 14.5 Volts on the track to power a layout with just a single NCE PowerCab.
- The diagram of the right is of Bruce Petrarca of MRH Magazine’s own layout.
Booster as an Accessory Booster

- I use the Tam Valley supplied 12V 5A 60W switching power supply with the Tam Valley Booster on my layout for all of my accessories.
- It powers 50 or more frog juicers and works like a dream.
- The Power supply is a Laptop type and comes with a US 110V plug.
- But by swapping the power cord (available from OfficeWorks) it can be used with 240V~50/60Hz power.
Turnouts

• Turnouts and DCC can be a really big challenge as short circuits are caused by the metal wheels touching both rails.

• However installing a “DCC friendly” turnout like the Peco Insulfrog should not cause a problem.

• Installing a live frog turnout, like Peco Electrofrog, requires that you either make an adjustment to the turnout as described on the following web sites:
  • See Allan Gartner's site at http://www.wiringfordcc.com/switches.htm and at Brian Lambert’s site at http://www.brian-lambert.co.uk/DCC.html#On_1
  • Or you install a Tam Valley Frog Juicer, wired to the frog.
Tam Valley Frog Juicers

- Frogs need to be powered to prevent interruptions in power to your locomotives and short circuits as they pass over a turnout.

- The issue with powering a frog is that you have to switch the power to the same polarity as the points when the turnout is thrown.

- **The frog juicer automatically switches the power on a frog.**

- A wire from the frog juicer is used to power the frog - if the frog is of the wrong polarity the frog juicer detects the current surge and nearly instantaneously switches the power before the locomotive decoder or the command station can notice.
Turnouts with Accessory Contacts

• Another alternative is to use an accessory switch added to a Peco point motor, or the built-in DPDT contacts on the SEEP and Tortoise point motors you can power the frog rail in the direction of travel.
Summary

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  - Bus Wiring & Wire Sizes • Stranded vs Solid Wire
  - Power Districts • Circuit Breakers • Boosters
  - Short Circuits
  - Turnouts • Frog Juicers