DCC Power and Wiring - Part 1

The importance of the best possible power supply

(followed in part 2 by wiring the DCC layout for best performance and what is needed to wire various special trackwork types).

~~~~~~

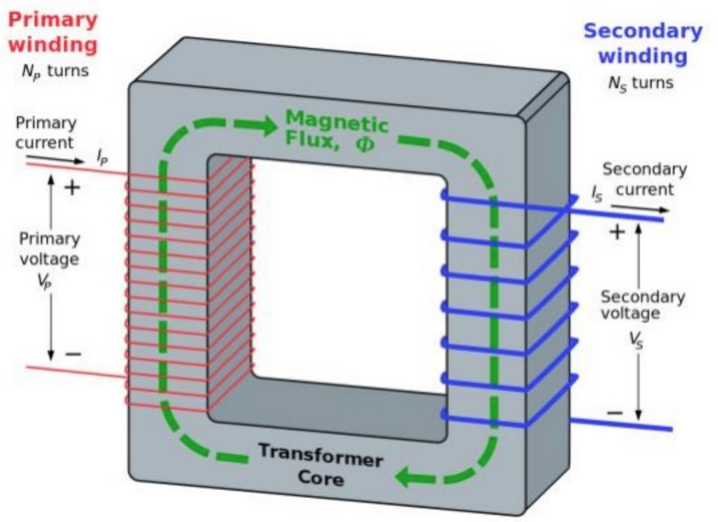
We have no hesitation in saying that QUALITY WIRING on your layout and QUALITY ELECTRICAL PICKUP on your locos and stock are the single most important keys to success in model railway operation… Wiring and power collection can't be skimped if the best result is wanted, as it is totally essential for reliable operation of DC or DCC layouts of all sizes.

Of course there is more than **one** aspect to good electrical performance. Before we even get to the detail part where power goes into the control system and via correctly structured wiring, on to the track… or gets from rail to the wheels to the loco or lights, we need to be sure that the power source is good… so first a few words about that.

The DCC System Power Supply

A quality power supply is important. That means a properly regulated power supply that will deliver stable coltage at all times, and one that will not pass on variances in mains supply or allow destructive voltage spikes to get from mains wiring to your precious trains.

That can only mean a top quality regulated DC power supply, not the low cost AC transformer many choose - and that some DCC makers also recommend in order to make their "whole system" price look good… Use regulated DC supplies. No other approach will give the best possible result!



(There are some very good reasons to recommend a proper regulated DC power supply - see below)

An AC transformer is totally unregulated:

It is really just a couple of wire coils arranged around an iron core so that they transfer a portion of the input voltage from the input coil to the output coil. It has no regulation or protection at all, and will simply pass through spikes, surges and similar things. If the input (mains voltage) varies, so will the output voltage - in direct proportion.

A standard train controller is just as "uncontrolled":

It uses a mixture of unregulated AC outputs (usually marked 15V uncontrolled, but actually 17-18V with no load) and it will have rectified but unregulated DC available too - like an AC device, it just passes through whatever is put into its mains transformer. To confuse modellers even further, its DC outputs will claim 12V, but they will really be about 16V DC, only actually dropping to 12V when the transformer's recommended current rating is reached - usually around 1 Amp.

A regulated DC power supply is the ideal DCC system choice for good reasons:

It will have an AC transformer or similar, but following that is a circuit board that will include rectification from AC to DC, parts that set and keep the voltage to exactly what it should be, irrespective of mains input variance or load.
~~~~~~

DCC Power and Wiring - Part 1

This is followed by filtering circuits that ensure a clean and stable voltage is provided at the outputs. Because of the greater sophistication of a regulated supply, it will also give a degree of protection from spikes and voltage surges that might otherwise damage your DCC system or even pass through to the track, harming decoders and other things!

So we've shown WHY a regulated DC supply is a better power supply… but why are other sorts OK for DC layouts, and why do brands often say that an AC supply is OK for DCC? Can the maker be wrong?

Fair questions! Here is our answer…

Why are basic power supplies OK for DC users?

Unregulated AC & DC are OK for analog control because the coarse pulse of AC and the spikiness of unfiltered DC will not usually harm basic iron-core model train motors - in fact DC controllers can often take advantage of this to "goose" stiffer motors into life and start them moving (that is the half-wave switch on some controllers).

None of this is good for DCC systems or decoders though - they are mini computers really, and they already have far more sophisticated digital abilities built in - and they really **do** *prefer smooth DC power!*

Why do DCC makers sometimes recommend AC power supplies?

DCC brands all try to compete, and they know that overall price matters because modellers are like anyone: They tend to save money if they can. The brands therefore try to keep the "whole system price" to a pre-set limit. On the other hand, they **do** *know that their DCC systems are fundamentally computer devices that like clean, stable power. Therefore all those that recommend AC do of course put some form of rectification with minimal filtering inside the "black boxes. Its never much though, and rarely ever properly regulated, so while it makes AC into DC, it does* ***not*** *add any real level of voltage stability or spike protection.*

There is now a good positive manufacturer trend happening…

DCC brands are at last realising that a proper regulated DC supply will let them make the system cheaper because they can let a power supply fo all the voltage stability, rectifying and filtering - ***so they're moving towards what we've been saying for years! Use a quality regulated DC supply!***

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Understood - but what DC voltage should I use for my DCC system?

First,, so what we say makes sense, a wee bit of tech-talk to help with the understanding of what happens when we rectify voltage from AC to DC. AC, for the record, is a sinusoidal wave form alternating from positive to negative (I'll skim over the details, but if you want to know more, Google "voltage change when rectifying AC" for lots of tech talk)

Basically - when measuring AC "voltage", what your meter reports is the RMS (root mean square) value of the AV waveform. It is a sine wave, so the RMS value is 1/√2 x peak amplitude. A basic bridge rectifier essentially flips the negative-going half of each sine wave to become positive, which moves the RMS value much closer to the peak. The rectifier diodes don't really introduce a big voltage drop (perhaps 1.4V total) and the result is a theoretical approximate AC x 1.4 = the resulting DC voltage. So if we rectify 15V AC, we get about 21V DC.

Additionally - if the DCC system already has some rectifier parts inside it, as many do, when it is fed by a regulated DC power supply, these diodes have **no** added work to do. However, their voltage drop ability will still exist - so when fed with DC, the voltage that gets inside your DCC system will be equivalent to the output of the regulated DC supply less about 1.4V.

Now we are armed with some facts, we can take a look at some examples!
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

DCC Power and Wiring - Part 1

Let's look at the specs in a couple of manuals and give some specific answers.

Get this sorted OK and you'll be able to safely make a "what voltage to use" decision for any system!

LENZ: Lenz make quite a good DCC system with most of its design pretty rock-solid… but its input power rectification is not great. It tends to allow any hash generated during the boot (including that added by a poorly filtered power supply) get to the track. Lenz owners can often see this manifest itself as random locomotive runaways during the "power up" sequence. They often end up adding a switch between the system and the track to stop it, but using a better power supply reduces the problem!

Lenz recommend an AC power supply. They claim their TR100 delivers 16 volts but it is designed for use on European 220V mains power - in many other places around the world, mains power can very often be as high as 255 volts, so because its just a linear device it will then end up delivering 18.5 volts! (guess why many EU designed consumer electronics items fail prematurely :-))

We are going to use a DC supply, so lets just ignore the above and look at their manual.

The Lenz LZV100 manual says (P18) "You will need a transformer that delivers between 14 and 16 volts"
Let's work it out… We already know too that Lenz track voltage is above NMRA spec for OO/HO of 14.5V, so we will work this into the calculation too We'll start with 15 volts AC: multiply by 1.4 then remove 1.4 volts. Result is 15x1.4-1.4 = 19.6 volts. Now - we know the direct equivalent DC voltage LIMIT is say 19V. But… Electronics should NOT be run at its limit and so lets add a safety margin of say 10% (A good idea as we know from experience Lenz has internal protection. If it is pushed to its limits, the Lenz LZV100 will shut down because it gets hot)

Be safe - The nearest round-down value becomes 18 volts. Use an 18 volt DC regulated power supply.

We can be quicker with the next one, having explored many issues with the Lenz.

NCE: Like Lenz, the NCE systems are really well made. The internal power supply is also not properly regulated though, so it too will really benefit from a really smooth regulated DC power supply.

NCE also initially recommended AC supplies (They now pack regulated DC supplies with some models)

They are very clear that their limit for input voltage is 18V AC. Doing the same calculations as above all at once, we work it out as 18x1.4-1.4… and then we deduct 10%. That results in a quite high 21 volts. From experience, I **know** that is a safe voltage as I have tested is - **but** it also results in a track voltage that is too high. Rather than adjusting the system to "waste" the excess, lets be more conservative and once again just go down to the 18V we decided on with Lenz.

You will see a trend here: 18V = a good voltage level for a reasonable track voltage for N or OO/HO & O

DCCconcepts Alpha Power. A rock solid 18V 5-amp regulated power supply perfect for all high power DCC systems.

Summarising:

All the above is based on facts.. and real world tests.

Our overall recommendation for 18V regulated DC is because it will be safe for most DCC systems, will be high enough to give track speeds not too far below DC power pack levels and it will be safe for any scale from N to O. Want more or less? you can if needed go <u>down to 15V</u> for N and <u>up to 21V</u> for O scale.

DCC Power and Wiring - Part 1

If budget is an issue, then please use a laptop-type computer power supply, not a gnarly old trainset transformer that never had enough grunt even when it was new… ...that should be dumped!

Some last thoughts of the choice of power supply.

Modellers often have no trouble spending lots of money on lots of locomotives, but will often skimp on wiring or a power supply. How silly is that - spend a fortune on nice quality locos so they'll run well and look great, then deny the layout the right power sources to let them perform at their best!

Of course - you aren't one of those foolish modellers, are you?

Don't skimp on the one thing that provides a source of power for your whole layout - please!

~~~~~~

Some more thoughts on the use of alternative power supplies:

Power supplies for small "starter sets". Generally, starter sets have lower quality, lower output power supplies. Many modellers think that they can just change the power supply to a big one to run more trains, but this isn't the case. The power handling of the internal parts of the "starter DCC system" is the real limit and because they are smaller sets, they often have less active internal protection, so if you just add a **big** power supply, **you will very likely cook it the first time there is a big track short!**

Rules of thumb we follow in this area are as follows. So far they've not let us down, but be aware we do know what's inside the DCC systems when we do it. Please be conservative if you try it:

If you DO have to increase the system power supply, then please always add electronic circuit protection such as the DCC Specialities PSX breaker. Experiment, but initially adjust its trip current to no more than say 15% above the system power handling as printed inside the DCC system manual.

At the very most, double the current rating of the original if you're changing the power supply. For example, swap a 1 Amp supply for a 2 Amp supply, no more! Stay conservative here please!

Sometimes, when systems ship from country of manufacture to another place, the power supply gets changed to one with a local plug. Sometimes the replacement supply ends up with a lower voltage output than the system was designed for (NCE PowerCab often has this problem if sold in the UK). The systems work but trains run slowly. Some sound decoders don't work well at low voltages.

If your system needs it, then you CAN improve the power supply a bit, but please be sensible.

Some guidelines that work for us...

For a system that is designed for say 13.5V~14V DC (many starter sets) it's usually OK to replace it with a good quality 15~18V regulated DC power supply.

It MUST NOT be significantly higher in power (power in amps) than the original power supply.

Do check for / observe the correct connection polarity if swapping power supplies.

The polarity of the NEW power supply must match the polarity of the OLD supply.

Don't try to push it too far. Keep it reasonable. All experimentation is at your own risk!
~~~~~~

DCC Power and Wiring - Part 1

Power Supply Choices

Calculating power need and achieving the best results without guessing at it!

Power for the DCC system.

We have shown you excellent examples already and we have also shown you why a good supply is needed. The final choice is up to you, but make sure it matches the capabilities of your system current draw.

DCC systems are rated at the current level they are able to safely **handle** internally and **deliver** to the track. Adding a power supply that has significantly higher power handling than the DCC system will **not** do anything to increase the ability of the DCC system to deliver power, but it **may** allow excess of current to cause damage.

If you really must use AC, then as a rule of thumb, look for a 15V to 18V AC supply equal or preferably up to 20% higher in current rating than the DCC system. Make sure it really **is** rated at your local mains supply voltage, too (so it doesn't start dropping voltage as it reaches its limit).

Better still, as already explained, use a properly regulated DC supply that matches the system power properly. Either choice will give you a good stability at maximum current draw (but the regulated DC supply will always give the best stability under load).

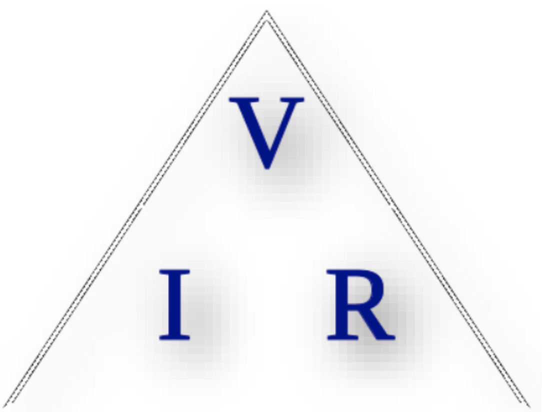
Power supply for solenoid type turnout or point motors.

Manufacturers vary rarely provide good guidance here, but one thing is certain - there is no way the average trainset controller power pack will give you enough power for reliable operation of low impedance solenoids such as Hornby, Peco, Seep, Atlas or similar types. The best way to work out the ideal power supply for your own brand of solenoid motors is to use **Ohm's Law**.

This is theoretically expressed as E=I/R when used to calculate current need. However, I will translate it to more commonly understood terms as (E = amps/current, I = voltage, R = resistance). So needed current (amps) is equal to the voltage you use divided by the resistance of the item being powered.

I am keeping it simple, so by all means Google "Ohm's Law" if you want more tech-talk.

Academic terms are not so familiar, so I've added some plain English here to clarify it a little.



Ohm's Law defines the relationships between (P) watts or power, (E) voltage, (I) amps or current and (R) resistance. One Ohm is the resistance value through which one volt will maintain a current of one Ampere.

(I) <u>Current</u> *is what flows on a wire or conductor (like water flowing down a river). Current flows from negative to positive on the surface of a conductor. Current (I) is measured in Amperes (shortened to Amps).*

(E) <u>Voltage</u> *is the difference in electrical potential between two points in a circuit. It's the push or pressure (like speed of the water in the river) behind current flow through a circuit. Electrical pressure (E) is measured in Volts.*

(R) <u>Resistance</u> *determines how much current will flow through a component. As an equivalent, imagine something that restricts flow - such as a narrow point on a river, rapids. Resistance (R) is measured in Ohms.*

(P) <u>Power</u> *is the amount of current times the voltage level at a given point. Power (P) is measured in Watts. (The "water equivalent" is the total weight or volume of water flowing past a certain point in the river per second).*

DCC Power and Wiring - Part 1

For a solenoid motor:

Firstly, you will need to know the coil impedance. To measure it, set your multimeter to “Ohms”, put one probe on the centre or common terminal, the other on the left or right coil terminal. Example you can try: let’s say you have a Peco PL-10 point motor which will measure at about 4 Ohms for each coil. If your power supply is 15V, it will need to deliver 15V divided by 4Ω (Ohms) which is 3.75 Amps!

Allowing a little for voltage drop over wire length and through solder joints, you will need a power supply campable of delivering a peak of 4 Amps to reliably throw this point motor! Because volatage drop will be at its maximum at the very moment it draws maximum current, **do** think about using big wire and a bigger supply to keep voltage drop minimal. Lowered voltage really compromises efficiency, so look for 15 to 20 Volts at 5 Amps for a really solid throw!

I promised you I’d try to keep costs down, so there is a low cost option here: it’s a laptop power supply that delivers 4 to 5 Amps at 18 Volts DC.

However, there is another way. Add a CDU or “Capacitor Discharge Unit”. This takes the supply voltage and stores it in a capacitor, releasing it instantly when needed to deliver a solid “kick” of power to change the solenoid. The usual way is to get a 15 to 20 Volt power supply and connect it to a CDU which is a small electronic circuit, then connect that to the solenoids via momentary switches.

A better choice here is to use a DCCconcepts CDU-2. This unit is a very effective mains-powered device with dual CDUs. It is very easy to wire and use. Because we have made an optimum match between power supply and CDU, we have been able to make its charge time (the time between changes) very short **and** incorporate not one but **two** super-power CDUs into it. Each output has been tested with up to 12 Peco PL10 or Seep motors at one time, so it will always change your solenoids properly **every** time.

Digital technology gives both DC and DCC users another choice now - it saves ££ and makes wiring easier.

If you use the DCCconcepts ADS-2sx (2-output) (shown here) or the ADS-4sx (4 output) accessory decoder, you can power a whole crossover from each output, so it’s very economical and efficient. It can be powered by connecting it to a laptop or similar power supply at 15 - 18 Volts DC (for DC modellers) or directly to the DCC power or accessory bus (for DCC modellers). These accessory decoders work with either momentary switches or digital control, and have the added benefit that they will also switch frog polarity and provide outputs for LEDs or I/O controls.

DCC Power and Wiring - Part 1

For a stall-type motor:

The process is very similar really, although the current needs will be much, much lower - measure the impedance of the motor (across the two power connection terminals).

For standard analog motors such as Cobalt Ω Omega, this will give you the "R" part of your Ohms law calculation and it will be between 20 and 30mA, depending on the voltage you use for the power supply (recommended voltages are 6~18V for Cobalt Ω Omega).

For Cobalt iP series motors (Analog or Digital) the power use changes during operation. However, you can safely use 5mA (0.005 amps) for calculations as this will be the maximum current draw between changes.

(By the way, of course this method is also handy for calculating current draw for DCC decoders - measure across the DC motor terminals with nothing else connected to them. it will give you the "stall current")

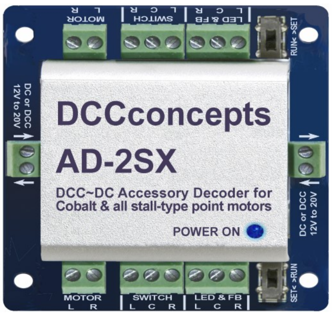
For example, if the stall type turnout motor is very high in impedance, it will need very low current to operate it at its rated voltage. Pure DC is good for a stall type motor - lower voltage giving higher current… the advantage being slower changes which are still strong and reliable but have lower operating noise too!

Remember though that "stall" motors are always on and drawing power - so you should multiply the static current draw by the total quantity, ie 12@ 30mA will be 360mA.

Economical power supply for these *- a regulated DC “wall” type, where the supply plugs directly into the mains socket. These are low-cost and easy to find from many sources.*

Best DC power supply for Analog Cobalt-type motors is the DCCconcepts SPS12. The SPS12 will also let you simplify wiring as it is a split rail (+12V) (0V) (-12V) type regulated DC power supply that needs only SPDT switches and two wires to work!

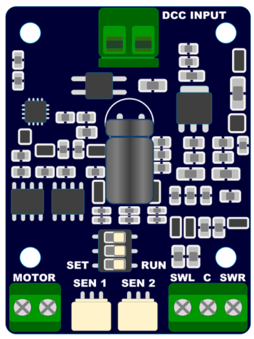
Alternatively, both DC and DCC users can use the versatile high-power “AD” Accessory Decoders for stall motors.



These make wiring easy and give fantastic versatility in control - they also provide added on-board switching **and** feedback or computer I/O ability. Connect to the track or accessory power bus - or for DC users, use a 12-15V regulated DC wall plug supply to power them.

For a turnout motor with “end of throw” off switches:

Measure the motor as in the above example. A good example of this is the “Fulgarex” or “Lemaco” type. Please note that they have varied the motors they use over the years, however, those I have are about 40 Ohm across the motor terminals, which would make them draw approximately 300mA at maximum. This type draws power only when operating, so to choose a power supply for these, work out how many will ever be operating at once, then to be safe, add one more (you never know what might happen in the future).



Economical power supply for these: Again, it is probably regulated DC “wall” type, as the supply plugs directly into the mains socket - I would choose one that will let you choose the voltage, with a rating of approximately 1 to 1.5 Amps to give you a bit of leeway for later

DCC Power and Wiring - Part 1

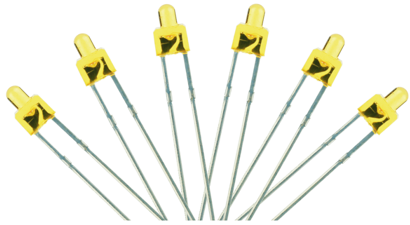
For signalling, panel lights or layout lighting:

Ohm’s Law works well here too - or we can use a simple “rule of thumb” for calculating the power supply need for lighting of signal lamps, panel lamps or layout lighting (each of which ideally has its own supply of course).

Simply use the figures below multiplied by the number which will be on at once, and you will have a good guide to how big the power supply you need will have to be.

Do thing about light control too - it’s nice to be able to tweak or tune lighting to realistic levels!

LEDs:



For normal low cost red, green or yellow LEDs, 5mA per LED.

For standard super-bright red green or red LEDs, 20mA per LED.

For white or blue standard type LEDs, 15mA per LED.

For super-bright white or blue, 30mA per LED.

The above does **not** necessarily cover the larger sizes of LED - only up to 5mm.

If you can, check the actual LED specification sheets if your LEDs are anything but “normal” types for model railway use.

Incandescent bulbs:

These vary quite a lot. However, the figures below are pretty safe. **Always** run incandescent bulbs off DC for a long life and try to supply them at no more than 75% of their rated voltage.

They will look better, run cooler and last a **lot** longer.

For normal grain of rice or wheat bulbs, allow 50mA.

For small threaded base bulbs sold by most brands, allow 75mA.

For any other lamp or light bulb, particularly automotive types, check before using - there will be a huge variety of ratings and they can draw up to several amps each!

Best power supply for these:

LEDs should be run on DC. Bulbs last much, much longer on DC than on AC. Additionally, whilst LEDs are protected by the resistor that you place in series with each of them, incandescent bulbs have no such protection - so for best life and to reduce the high heat output of any incandescent bulb of any size, run it at least 25% below its manufacturer’s ratings and it will last a very, very long time!

Yet again, the best power supply is probably a regulated DC “wall” type, where the supply plugs directly into the mains socket. I would personally chose one that will let you choose the voltage with a rating to suit, but probably of approximately 1 to 1.5 Amps to give you a bit of leeway for later changes in how many lamps may be used at any one time.

Time and money saving tip: distribute the power rather than running more or longer wires! “Wall” power supplies are low cost, and you may even have a few in the bottom drawer! **Do** consider using several of them, distributed around the layout. That way, you will have several “local circuits” with perhaps just a couple of wires to the control panel - that will help you to reduce the number of long wires you need to run and keep your layout tidy!

DCC Power and Wiring - Part 1

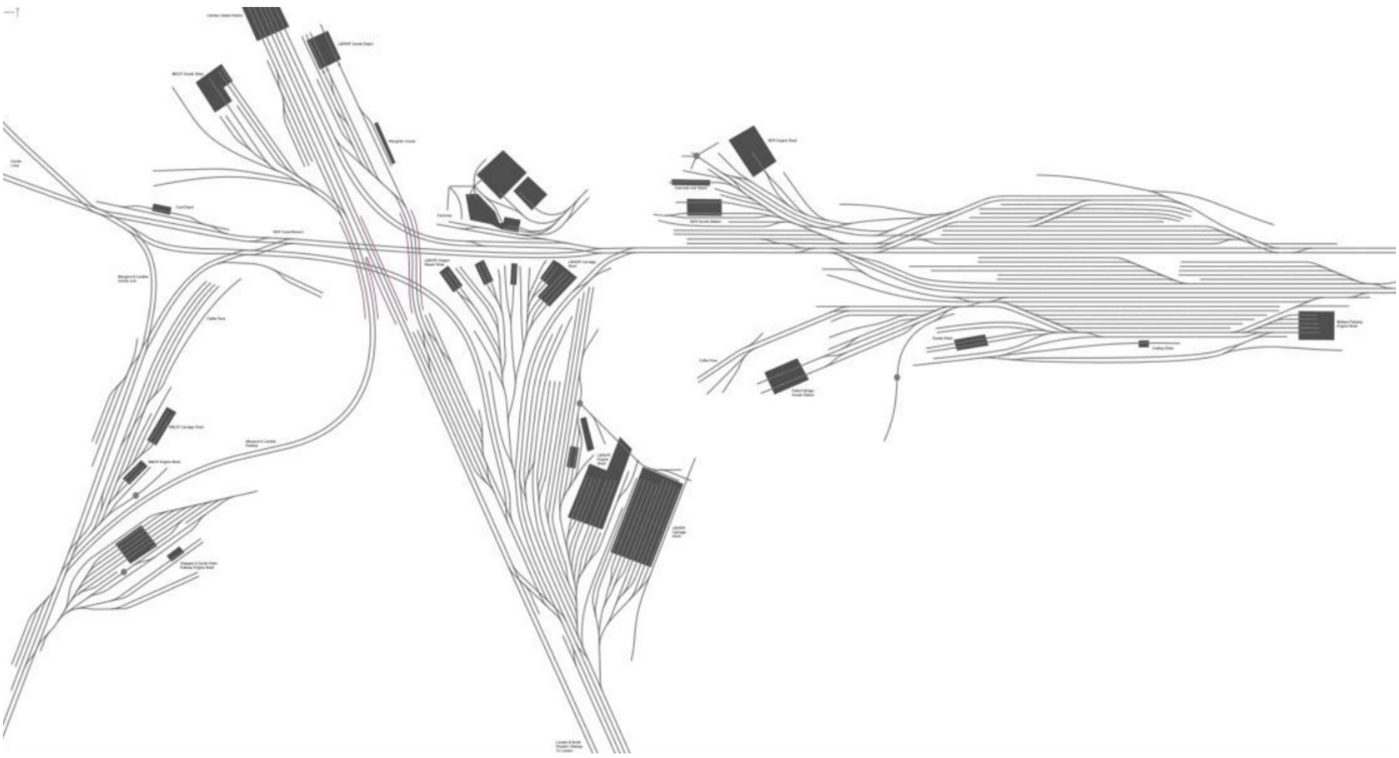
Layout Wiring & Power Structure - General Oversight Comment

From this point on, we will cover why each set of devices used on your layout should have its on discrete wiring circuitry. The pages that follow in "DCC Power and Wiring - Part 2" will also include wire charts and wire size recommendations as well as how to layout the bus, add filters, connect droppers and go about handling any complex trackwork or wiring issues you may come across.

It is the nature of layouts and modellers that all are different, so if you cannot answer your questions by reviewing these pages, please do feel free to emails us and we will do our very best to give you some "one-on-one" assistance with your questions. Alternatively, join our free forum at www.dccconceptsforum.com!

Not all layouts will be big and complete (this is the prototype of Carlisle here in the UK).

In reality though, it is **not** about complex or not: the wiring guidelines and rules will always stay the same no matter what size your layout is. Keep following "best practice" from the very beginning and your layout will work and perform well, bif **or** small! Read on to see how easy "doing it right" can be.



First, a few "Dos" and "Don'ts"

Do match your power supply and overall system power ability - and please be sure your system really is appropriate for the size of layout you're building. Example: An NCE PowerCab or basic low power start set is a great start set or system for testing the larger layout (even one as big as this) as you build it. **But - you should upgrade later** - especially if your layout will be more than 1/2 of an average standard bedroom in size, run more than 4~5 locos at a time or if it will be a heavy user of DCC accessory devices.

DCC Power and Wiring - Part 1

When you build larger layouts, think "more power districts with matching separate boosters", not "buy a larger power system". We often get asked for 10 Amp systems for HO / OO or N scale layouts, and some are surprised when we refuse to supply. Basically, there is so much energy in a 5 Amp system already, that increasing to 10 Amps is unwise - even a partial short will then be strong enough to literally **melt** an N scale loco or turn an HO / OO one into a Salvadore Dali artwork!

Where more power is needed, unless you run old large cale (Tinplate O or Gauge 1 etc) that is less efficient, stick with multiple 5 Amp boosters for all modern O, HO, OO, N or other small scales.

Don't share power supplies between boosters or main system and boosters. It can be done but wiring becomes critical - get it out of phase and voltage doubling is likely at power district boundaries - and that can harm things very quickly. "One power supply per power booster" should be the rule.

Don't share a power supply between track needs and accessories. This is **never** a good idea. When the load grows, one wins and one loses, and you need **both** to work at their best all the time.

If the layout will be larger or "electronically busy", always run a separate DCC accessory bus. Different DCC accessories act and react differently to trains on the track, and they should be separated if possible. Besides, if you have it all on **one** power bus, a short in anything, accessory or loco, will stop it all. A separate power booster may cost the same as a low cost loco, but **one** usually does it all!

Taking power from the system around the layout needs <u>real</u> wire. This is **no** different whether it's a DC or DCC layout. Stay away from light gauge wire for all power feeds. Use heavy wire for all main track "bus" or feeds and try to standardise on something solid enough to carry a reasonable current.

11 gauge or $3.5mm^2$

13 gauge or $2.5mm^2$

15 gauge or $1.5mm^2$

The images are three example of high quality power bus wire in the gauges we talk about.

We suggest even for a modest layout, no wire that carries power for more than 6 feet (2 metres) should be less than 16 gauge, and if the layout is mid sized or larger, any longer and 14 gauge would be great!

For several very good reasons (we will detail later) Power Bus wires need to be twisted together about 12 turns per metre/yard. Doing this lowers inductance and helps to reduce other potential problems. You **can** twist it yourself but it's a pain—so we have a full range of pre-twisted bus wire available from DCCconcepts.

DCC Power and Wiring - Part 1

Taking power from the main power bus wires to the rails. We can be a little lighter here, and droppers can be fairly fine if they are kept to 1ft / 300mm or less, but **do** use lots of droppers from rail to the main feed wires. DCCconcepts dropper wire is a great choice at 26 x 0.015 or 17~18 gauge.

The simple and sensible approach to droppers is - buy new wire - it’s cheap! Always use consistent colour codes and use the largest wire you can reliably solder **tidily and invisibly** to the rails.
Red for Right rail, Black for Left rail and Green for Frogs is a good way to start a colour code plan!

How many droppers? *Nominally about one per length of track is a common guide. Electrically, they could be further apart, but there are so many joiners, gaps in track and turnout breaks that the guide never survives reality. Put them where needed and do not skimp for the sake of small savings!*

One of the ***best*** *phrases to keep in mind here is “every bit of track should be soldered to something”. As we said, we suggest that as an ideal, every yard/metre of track should have droppers from rail to main feed wires for best results. Yes, it’s a lot of soldering, but do your best to follow that maxim.*

Basically, droppers must always be adequate, but can be smaller wire if they are short. For droppers where it’s hard to get to, or in difficult places, use droppers as small as 22 gauge if they are short (6” / 150mm or less). Standardise on 18 to 20 gauge for droppers in easier to get places. These can be as long as 24” / 600mm without much voltage drop.

Strip and solder bus wires and droppers, but use the right tools and wiring accessories, too! *We’re often asked about chocolate blocks, crimp connectors and the like but we simply cannot recommend them. There is* ***no*** *substitute for properly stripped and soldered wiring.*

DCC Power and Wiring - Part 1

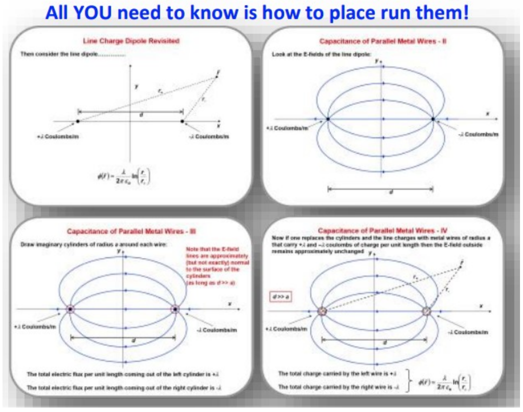
Planning The Power and Distribution

This does not need to be expensive or complex, just well thought out! As we said previously, to get the best from everything from layout lighting through point/turnout control and to ensure the best performance for DCC system and locomotives, it is important that you plan ahead and do not share a power supply between track needs and accessories.

So, why shouldn't you save time and money by wiring to common power sources or share things like track power if you have a high current DCC system? There are several reasons, all important:

1) **You should be careful to maintain the ability to separately trace and maintain wiring.** As the layout grows, even though DCC itself requires relatively simple wiring and the total quantity of wires needed for track will remain relatively small, you will soon add wires for point/turnout motors, signals, lighting around the layout and operating accessories etc. Even though a single light may need only 2 wires, ten of them will need 20. A turnout motor may need only 3, but ten of them will need 30… and it goes on. Before long, you have looms of wires of various colours and it becomes a blur. How hard will it be to separate and work on them logically and systematically after a few months?
2) **It is important to keep the ability to simply and logically troubleshoot problems.** It's clear from this that if they are all added to the one main supply, then not only will loading increase, it will become nearly impossible to troubleshoot. Imagine if a fault in a simple light that you may not notice has failed creates a short circuit that will shut down the whole layout would you ever find it? Therefore you should do **two** things. Create a logical set of "power districts" so you can turn off specific parts of the layout for troubleshooting and also make sure that accessories are powered by their own power supply, or via their own booster on a larger layout. Similarly, separate power for lights, signalling and detectors may be needed.
3) **You need to keep different operating systems apart to allow each wiring circuit to do the job it should, without unexpected interference or adding to current loading from other circuitry.** When different electrical devices share a common power source and wires, they will inevitably interact. This interaction is rarely without some form of negative effect on the performance of one or the other. At its simplest, it is one item draining current so there is no longer enough for the other to run reliably, but it can be much more complex, and even **how** and **where** the wires run relative to each other can make a difference… For example, power structures should not be close to data, and detection systems can be very sensitive to other wiring! So - if you don't keep them separate, you will never be able to manage them properly!

Part of the explanation of capacitance in wiring.
All YOU need to know is how to place run them!



Wires all have their own "electrical characteristics" such as resistance, capacitance, inductance etc… and when any two or more wires connect between a power source and any device, these things effect the result. This becomes **more** important when you are sending digital information, which is a waveform with variable frequency and amplitude as effects are magnified, so while you don't need to worry about the maths or theory, you **do** need to follow simple wiring rules to be sure that your layout and all of the things that go to make up its power and control can work the way you want them to!

DCC Power and Wiring - Part 1

Every wire is affected by the following:

1) **Resistance.** This is the same resistance that is used to rate the wire, for AC or DC use, however you cannot use those ratings as when a waveform other than a standard AC is used, the other factors take over and the wire reacts differently - with far more voltage drop.
2) **Capacitance.** Both the track and wires are long parallel power carrying things - they have a very real capacitance and when a waveform interacts with this, it adds to the circuit resistance.
3) **Inductance.** Similar to but not the same as resistance, it is affected and modified by the capacitance and will vary with the wire positions vs each other, waveform, power consumption (Amps) and voltage levels.

For example, a DCC system puts out a high frequency square wave with varying waveform characteristics and this is already also influenced by the layout of the wiring and the distance it travels.

If you now add other powered devices, every wire has its own related electromagnetic field so each will generate its own effect on the DCC signal even while static, and when it operates it may generate a huge amount of "hash" or interference, causing locos to stop or run away randomly, or prevent commands being received.
Good examples of this are solenoid point motors (instantaneous current draw and a huge back EMF pulse when triggered) any form of motor connected to an accessory (constant interference with waveform, back EMF fed into track bus with negative possible effects).
Even a simple light bulb can destroy control. I saw this recently where a bulb that had become intermittent really affected the smoothness of control from a DCC system, all because the tiny spring-like filament was intermittently losing contact as it vibrated.

Taken together, these three things all affect power and information along the power and other "bus" circuits on the layout. Even so, most of you can relax as in general the effects do vary with layout size.

To bring all this down to earth a little more gently:
If the layout is small, then the effects aren't significant. If your layout is medium (bedroom sized) then **they are there, but unlikely to create any issues** unless wiring is under-sized **or** has poor connections **or** if the use of DCC or computer or other digital control is very complex.

However - builders of larger layouts would be **very** wise to follow our recommendations as closely as possible because while your first steps will probably show no effects, the more you add, the greater the effects will become.
That's all for this first part. We have set the scene here - in the following sections, I'll explain the right way to go about layout wiring step-by-step, from materials to the layout and connections to the configuration of the wiring.

Next article? Look for DCC Power Wiring - Part 2