

ST LUKE'S RAILWAY MODELLERS

Introduction to Electricity for Model Trains

Note:

These notes are aimed at persons with no prior knowledge of electrical theory to help them avoid basic mistakes when operating model trains.

Those wanting more depth of information should refer to:

http://www.ndt-ed.org/EducationResources/HighSchool/Electricity/hs_elec_index.htm

Introduction

Commercial model trains have been operating from electricity since the 1920s. Early use of mains voltage was replaced quickly with lower (safer) voltages within a few years.

These days, mains voltage electricity is transformed to safe low voltage which is then passed through a control system to vary speed and direction.

Basic Principles

Model trains can be powered by (a) clockwork, (b) on-board batteries, (c) steam or (d) low-voltage electricity supplied via the rails. This paper describes only (d).

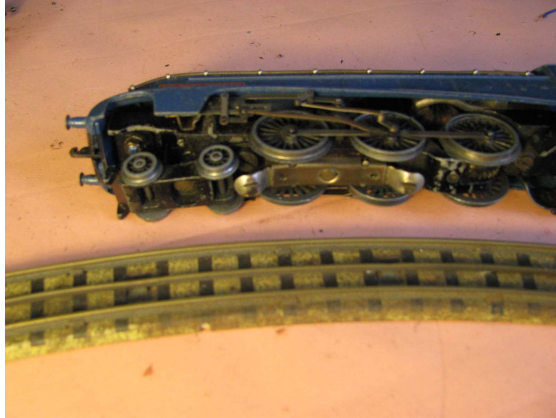
Operating systems

Electric model trains are powered by powerful low-voltage motors. These draw their electricity from the rails. Therefore, rails should be kept clean so that electricity can flow from the rail heads to the wheels and thence to the motor. Dirty rails and/or wheels will lead to erratic and unreliable operation which can be very disappointing. Regular cleaning will prevent this problem.



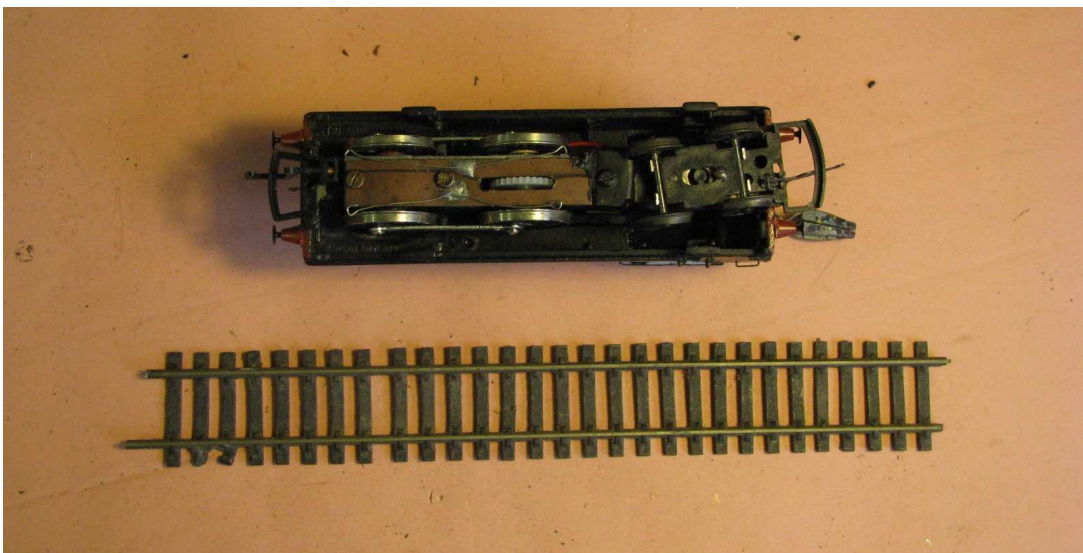
Simple Tri-ang model, showing wire bringing power to the motor from the pickups on the insulated wheels.

Historically, an insulated middle (third) rail supplied electricity to the motor via a “skate” under the locomotive which slid along the rail, and the electricity was returned to the transformer via the locomotive’s wheels. Pre-war Hornby and current Lionel 0-gauge electric trains use this system. A similar third-rail system was developed by Marklin for its H0 models before World War 2 and copied (in principle) by Hornby when they released their Dublo system in 1938. Marklin later improved the appearance of their tracks by replacing the third rail with “studs” which are still located between the main rails, appearing every 5mm or so. Hornby continued to use a third rail until they introduced a more modern 2-rail system in 1964.



Hornby Dublo 3-rail locomotive and track, showing central skate power pickup.

Most 00, H0, N and Z-scale systems now use a 2-rail system, where power is supplied to the motor via one rail and returned (earthed) via the other rail. This means that wheels on one side of every vehicle must be insulated from the wheels on the opposite side, so that a “short circuit” cannot occur.



2-rail model locomotive and track, showing pickup wipers to both sets of driving wheels.

Definition of short circuit :

A low-resistance connection established by accident or intention between two points in an electric circuit. The current tends to flow through the area of low resistance, bypassing the rest of the circuit.

Short circuits should always be avoided, as they can cause damage to power supplies (and, in some cases, fires). Most commercial model train controllers have safety cutouts built into them, but they can fail to operate correctly if overused. If a short circuit occurs when a light is

operating, then it will go out. The same sort of thing will occur if a short circuit occurs when a train is running, eg by a piece of metal falling onto the powered rails. (The train will suddenly stop.)

Marklin and older Hornby Dublo coaches and wagons have metal wheels that are not insulated. They cannot be used on 2-rail systems, as they will cause short circuits. (They can, of course, be re-wheeled with insulated wheels.)



3-rail wheels (on left) and 2-rail wheels (on right). The 2-rail wheels have tiny insulating bushes between the axles and wheels.

Control Systems

Whether “analogue” or “digital” systems are used, the train is still when no power is supplied to the motor. It moves slowly when low voltage is provided and faster when the voltage is raised. (Voltage is a measure of the “pressure” of the electricity.) For most models, equipped with DC motors, when the electricity is running in one direction, the train goes forwards. When the electricity goes the other way (ie its polarity is reversed), the train goes backwards.

Marklin H0 trains, which run on AC, have a simple on-board mechanical system to “change gear” from forward to reverse.

Power is supplied to the tracks from a transformer/controller system, which converts the 240 volt mains electricity to 12 or 15 volts – safe even for children. Please remember to correctly match the power supply to the trains it has to operate. If you try to use a small train set controller to operate a large locomotive pulling a heavy train, the controller may overheat and fail. Conversely, if you use a large power supply for a small model, you may harm the motor. If in doubt, seek advice from a more experienced modeller.

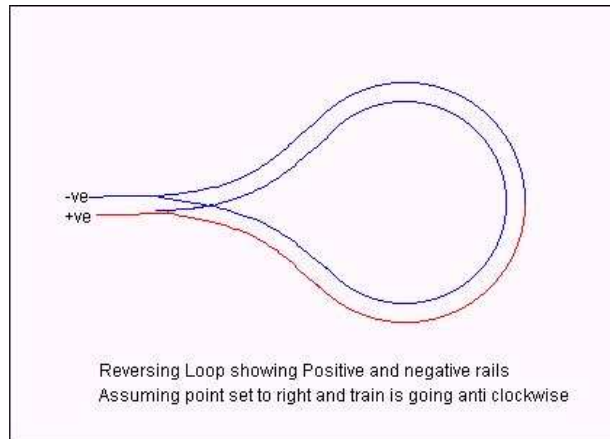


Please note that Z-gauge trains operate on only 9 volts DC and cannot use controllers designed for H0/00 or N scale models, as they will damage the motors.

Trackwork

All model train tracks should be installed so that no short circuits will occur, otherwise trains won't run!

Hence, for 2-rail systems, reverse loops should be avoided:



Some points have frogs that are permanently live, which can lead to some tricky short circuits, so care should be taken when designing your layout to manage such possibilities. Both live frogs and reverse loops can be managed by means of complex switches, isolating rail gaps, etc, but these may not suit all modellers.

DON'T STALL THE MOTOR!

Motors come in many shapes and sizes, but they have one thing in common: they should not stall when under load. All of them have at their heart a collection of windings (called an armature) which rotates rapidly when the power is turned on to them. As the armature begins to spin, it can get quite warm due to the high initial current (the amount of electricity passing through it to help it do its work), but cools once it settles down and the current reduces. It depends upon this cooling effect to avoid overheating, which will melt soldered connections and cause total failure of the motor. Hence, if the motor stalls, the current increases, cooling stops, but electricity continues to flow. Worse still, it draws even more power to try to move itself, and can quickly overheat and "burn out". Even if the motor windings continue to work, overheating will damage the magnets in the motor, weakening the motor. This also causes further high current draw during normal operation, which causes overheating and eventual total failure of the motor. Hence DON'T STALL THE MOTOR!