3.1 Introduction

As model trains are powered by electricity, there is the need for a system of electrical conductors and other equipment to get the electric power to the motors of the trains. All N-scale trains run on a safe low voltage of 12 V DC, which should be regulated to achieve speed and directional control. Much pioneering work in setting up electrical standards has been done by the NMRA in the USA, and the NMRA made the standards in such a way that they are applicable word-wide. The author thought that it was wise to follow these NMRA standards plus the additional recommendations for modular model railways.

3.2 Mains operated equipment

3.2.1 General

On the modules there should be no electrical equipment that is powered directly from the mains, just for safety reasons. Always use electrical equipment that is powered via a suitable transformer, that complies with local safety regulations. All transformers used (controller-transformers, transformers with a fixed low-voltage output etc.) should comply with local safety regulations. For Continental Europe it is best to use equipment that has a German VDE, GS or CE approval label. The German regulations are among the best used on the Continent and most other countries accept VDE, GS or CE approved equipment as 'safe'. Normal mains voltage on the Continent is 230V 50Hz AC, normal plugs are round-pin plugs. There are 2 different earth-connections around. Normally the German 'Schuko' edge-contact earth connection should be used. Under circumstances the French-style third-pin earth connection may be used. Under these circumstances adapter plugs for the German 'Schuko' plugs should be provided by the owner of the 3rd pin equipped equipment. The European NEM standard NEM 609 is applicable on this subject.

3.2.2 Mains powered equipment on differing mains voltages. (Japanese and American equipment)

Use of mains-powered equipment running on 100 V AC (Japanese) and 115 V AC (USA) is allowed when there is a suitable step-down transformer to convert the 230 V AC mains into the desired lower voltage. All power cords, distributor boxes and other mains-powered equipment for lower voltages **should be clearly labelled** with the voltage carried. Do not run 100 V Japanese and 115 V US equipment on the same step-down transformer. The step-down transformers should comply to the standards mentioned in paragraph 3.2.1. Outlets for 100 V and 115 V should be of a plug and socket type that is normally used within the country of origin (flat-pin type plugs and sockets, as usual in both Japan and the USA). Wiring and distributors boxes should be dimensioned to carry at least 10 Amps or more. Wiring of 1.5mm^2 or more is strongly recommended. **Step-down transformers are not to be overloaded! Risk of overheating!**

3.2.3 Connecting the layout to a power outlet

On exhibtions it wise to connect the layout's transformers and distributor outlets through a protective breaker (earth-leakage breaker). This is a protective device that trips when there is a difference between the current in the 'hot' wire and the 'neutral' return wire. Normally these breakers trip at a difference of 30mA. An overload protection device should also be included in the housing of the protective breaker, normally these are rated at 16 Amps. All wiring to and from the power outlets should be of a heavy gauge (2.5mm^2 or more recommended) and 16 Amp plugs should be fitted. Plugs that are moulded onto the cable are preferred.

3.3 Low-voltage electricity and wiring

All wiring and electrical appliances should confirm to the applicable standards, NMRA S-9 an R-9, and MOROP (European) NEM 609. These standards include important regulations on electrical safety and should be followed. Please use low-voltage wiring of sufficient rating, thin wires have a high resistance.

3.3.1 Power supplies and controllers

Commercially available power supplies are recommended, just because this is the easiest way to comply to the safety regulations mentioned in paragraph 3.2.1. In many cases a controller is built-in in the same case as the power supply, a so-called power pack. These power packs come in a variety of qualties. Japanese power packs are normally of a good quality, offering fine control at slow speeds. American power packs can be very good, such as MRC's Tech II and Tech 4 ranges. British power packs are of a varying quality, some are much better than others. Those with an electronic control and no feedback are best suited to our needs. European power packs are again of differing quality, but most have a too high starting voltage, which can not be adjusted and are therefore less suitable. You may use a separate transformer and controller, but remember that the transformer **must be mounted in a separate case** and comply to the safety regulations mentioned in paragraph 3.2.1. Mounting the **transformer** or other **mains powered** equipment (even wiring!) inside your control panel is **NOT** allowed, just for safety reasons. You may build a power supply yourself, but ask yourself first if can build one that complies with applicable safety regulations and build a power-supply only if this is not on the edge of or beyond your skills!

Choosing a controller

Any controller that ensures smooth slow running and a gradual start may be used, regarding that it complies to VDE, GS or CE regulations. The label on the unit should state this. An exception is made for Japanese and US mains controllers when run via a **suitable step-down transformer** (100 V for Japanese, 110 V for US units). The Japanese label for electrical safety is the inverted 'IR' label, for the USA the label is a circle with the letters 'UL'. Please check these labels before purchase of any equipment. There are many controllers which offer good performance, but the Tomix N-DU202-CL is worth special notice, it is a model of a real train cab and has a seperate accellerator and brake lever. Other suitable Tomix controllers are the N-1000-CL and the new N-1. Other good controllers can be found in the British KPC and Gaugemaster ranges, and I have the impression that Helmsman Electronics from Blackpool (UK) also offer quality equipment. Among the US-based manufacturers I can recommend MRC, their Tech II 2500 is one of the best controllers I know offering very slow running and smooth control. Unfortunately I can not recommend the small transformer-controllers supplied with the European starter sets, the starting voltage of these is usually too high, giving a jump start. Other European made controllers may be better, but I recommend to do some testing with a Japanese train model before purchase. Please do not use the old rheostat (variable resistance) controllers at all as these offer very poor control, a modern transistor-type controller is recommended. Suitable controllers are listed in the controller shortlist.

3.3.2 Running more trains at once

To achieve a prototypical dense traffic pattern, the layout should be divided into 'blocks'. Each block consists of a station module group and one or more neighbouring modules on either side, the whole setup will consist of a series of ' mini-layouts', linked by the joiner tracks. To achieve smooth transition between the control blocks, the voltage on the tracks should be about the same in neighbouring blocks. Some trial-and-error testing will be necessary to find the right adjustment of the speed control knobs! To divide the

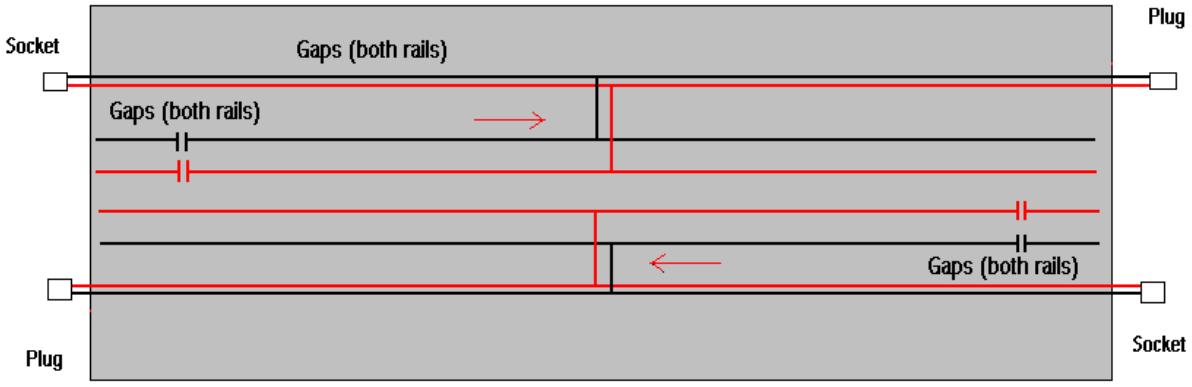
layout into electrical 'blocks' the cables that connect the modules electrically will just have to be left unconnected. Plugging these cable together will join two modules and amke them work as one. Both main lines are electrically seperate, and special precautions are to be made at stations and other croosover situations. More on this subject later in the wiring section.

3.4 Wiring

3.4.1 Introduction to module wiring

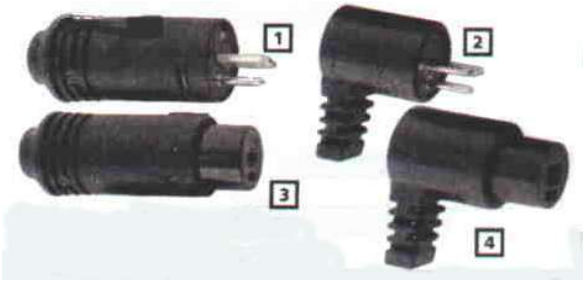
Wiring a modular model railway differs a little from wiring a fixed layout. Just as with the tracks, the wiring has to be devided into sections and connected with suitable connectors. To ensure interoperatibilty, the wiring is also subject to standards. I desiged the wiring to be as simple as possible. Any modeller with reasonable skill can wire a J-Module! In a J-Module set-up, groups of modules are connected into a 'control district', normally such a 'control district' consists of a station module group and one or two neighbouring modules on either side. 'Control districts' are insulated from each other, this is important as the controllers should not influence each other.

J-Module wiring scheme for a basic module, as seen from above, arrows indicate direction of travel



The image above shows how a 2-track module should be wired.

Under the module run 2 2-core cables, minimum size is 0.75 mm^2, 1.0 or 1.5 mm^2 is recommended. The ends of these cables are fitted with DIN loudspeaker plugs and matching sockets. The plug should be fitted at that side of the module where the train leaves the module running in normal direction (left track). The sockets are fitted to those ends where the train enters the module. The right-hand rail when seen from above in normal running direction should be connected to the round (top) pin of the DIN plug or socket, the left rail should be connected to the flat (bottom) tab of the plug or socket. Recommended wire is loudspeaker wire, a normal quality is good enough, expensive cable is meant to be used in high-quality audio systems and a waste of money when used on a model railway. This wire comes in several sizes, from 0.5 mm2 (square millimetres) to over 6.0 mm2. Practical sizes are 0.75 (minimum) and 1.0 mm2. Most wires are colour-coded or have a rib on the insulation of one core, to identify the cores. The feeder wires that connect the rails should 'tap in' on the wires running under the module. You can strip off a little of the insulation and the solder the feeder wires to the 'bus' wires. Another option is to use solderless connectors that cut through the insulation. These connectors - IDCs - are very common in the electrical system of your car.



The DIN loudspeaker plugs and sockets as used on J-Modules - the pictured ones come from the Conrad Electronic catalogue

IDCs are very easy to use. Lay the wires to be connected in the 'case', press in the metal part with pliers , then fold over the lid and you're ready.

3.4.2 Wiring of more complex modules

When you have put one or more points on your module, the module will become an 'operational module', a module that allows the train to change tracks or take a siding. This will seriously affect the wiring. I will describe a few typical situations together with a description of the wiring.

- **Siding**
- At a siding with only one point that diverges from the main line there's little to worry about. Make sure that the feeding point is at the toe (blade) end of the point. No further precautions needed.
- **Passing loop**
- At a passing loop, allowing trains to be overtaken by other trains, you have two points, one on each side of the loop. This situation is again simple to wire up. Just like the siding, make sure the feeding point is at the toe end of the point where trains normally enter the passing loop.
- **Crossover**
- This one is more complicated, as trains can be transferred form the 'up' to the 'down' main line and vice versa. Important is that both tracks are insulated form each other and are controlled with their own controller, or on the same controller with the use of a system of switches to assign power to different 'blocks'. Tomix points have a built-in insulation and a built-in bridge switch which can switch the insulated section on or off. At a crossover, you have to open one of the switches, the power to the inslulated section is controlled by the other point
- **Scissors crossover**
- A scissors crossover is in fact 2 crossovers in the same location. It consists of 4 points and a crossing, looking a bit like a pair of scissors. The Tomix scissors crossover has two sets of insulations: one lengthwise, seperating the left-hand and right-hand part of the crossover and one set of transverse insulations, seperating the 'up' and 'down' tracks. Tomix offers a special switch which 'crosses' the electrical feeders according to the position of the point blades. If you are not using this special switch you need to know a little more of how the crossover works.