# Electronics for Model Railways



## Chapter 23

### Using computers

By Davy Dick

# Electronics for Model Railways

**By Davy Dick**

In memory of Margaret

# Contents

# Computers & Model Railways

This chapter looks at how computers can benefit your layout, what is available, and how to use it.

Most people have access to computers, generally desktops and laptops. Along with mobile phones, they are mostly used for browsing, email and social networking.

However, computers can make a major contribution to model railways. Some shy away from computers in their modelling but there are many levels at which computers can contribute to your layout. These range from finding out how to do things (e.g. lay track or build trees) up to implementing full-blown automated layouts.

## Why use computers?

You don't have to install new software or change anything on your computer to get loads of extra benefits.

If your computer is connected to the Internet, you already have access to:
- Information
- Help
- Free goodies
- Most model railway and electronics retailers

If you are comfortable about purchasing/downloading software and installing it on your computer, you can have any (or all) of these:
- Train simulators.
- Track planners
- Stock inventory
- Layout control software
- Automation software

## Information

A Google search for *'model railway'* returned over 41 million results! There is certainly plenty to keep you searching and reading for a long, long time. Getting more specific, a search for *'model railway turntables'* returned 1,380,000 results and *'laying model railway track'* returned 4,770,000 results

There are whole websites dedicated to bringing together model railway news, views and product reviews. Examples of such sites are:

     www.modelrailforum.com
     www.mre-mag.com/
     http://mrr.trains.com

For free track layout suggestions, check out:

     www.freetrackplans.com/
     https://modelrailwayideas.com/
     www.track-plans.net/

# Help

Model railway enthusiasts are always happy to help newer members or members with specific problems.   There are websites that are dedicated to answering questions and each Forum is worth a visit.

Examples are:

www.modelrailwayforum.co.uk/
www.newrailwaymodellers.co.uk/Forums/
www.rmweb.co.uk/community/
www.mrlforum.co.uk/
www.modeltrainforum.com/

This is one of the sections from the modelrailwayforum.co.uk website.

| Model Railway Construction | | | |
|---|---|---|---|
| **Forum** | **Last Post** | **Threads** | **Posts** |
| **Baseboards** (4 Viewing)<br>All posts regarding baseboard construction | BASEBOARD - another way to...<br>by LostockGuy<br>Yesterday 12:17 PM | 107 | 1,141 |
| **Track Layout & Design** (18 Viewing)<br>Help with designing your track work | Hornby uncoupler units<br>by Bethony<br>Today 01:54 PM | 440 | 4,022 |
| **Scenery** (7 Viewing)<br>Help with layout scenics | Platforms - Metcalf? Cutting...<br>by Walkingthedog<br>Today 06:55 PM | 217 | 1,790 |
| **Wiring & Electronics** (19 Viewing)<br>DCC (530/4278)<br>Analogue (177/1356)<br>Other (100/883) | Defying the laws of physics?<br>by Steve M<br>Today 06:25 PM | 965 | 8,021 |
| **Kit Building** (4 Viewing)<br>Help with scenic kits | Card kit pub?<br>by Wishmaster<br>19-04-2014 10:04 AM | 123 | 1,248 |
| **The Gallery**<br>Post your model railway pictures here for others to see. | - | - | - |
| **Members layouts** (10 Viewing)<br>Dedicated area to show the community your model railway projects | DCC Automated N-Gauge Loft...<br>by RogerB<br>Today 08:08 PM | 127 | 3,973 |
| **Location location location** (2 Viewing)<br>Where can I keep my model railway? | loft or shed<br>by andy757<br>15-04-2014 07:58 AM | 15 | 164 |
| **Allan Downes - Model Buildings** (2 Viewing)<br>Here Allan will show his detailed buildings and give construction techniques to help others make their scratch built buildings. | Scratchbuilt buildings<br>by allan downes<br>19-04-2014 09:22 PM | 1 | 325 |

Other sections cover specific gauges, sales and wants, etc.

Examples of more specific Forums are:

www.hornby.com/forums/
www.009society.com/forum/
www.merg.org.uk

# Freebies and savings

Constructing buildings from pre-printed card is very popular, although some kits are now quite expensive. To the purchase, you have to add the cost of postage, unless you buy them at an exhibition.

If you have Internet access, you can download the images and print them off yourself. This is cheaper than paying postage and has the advantage that the buildings' images can be printed again and again. One purchase can create multiple buildings.

Even better, a number of websites provide free downloads of building kits.

If you prefer constructing your own buildings and use brick paper, tile paper, etc., then you can also download these textures, including free versions.

The image shows a building that was constructed from a free download from:

  www.modelrailwaybuildings.com/

Other sites worth a look are:

  www.wordsworthmodelrailway.co.uk/index.html  (accepts PayPal donations)

  www.scenerybuilder.com/modelbuildingkits.html   (accepts PayPal donations)

  www.railwayscenics.com/free-downloads-c-30_309.html  (also sells commercial card kits)

This website mainly sell kits but offers free samples.

  www.smartmodels.co.uk/

# Mail order suppliers

In the past, you ordered from a limited number of catalogues and, if the items you wanted were not available locally, you had to send off cheques to the companies along with your order form. That facility is still available, although you can now place telephone orders using your credit/debit card.

With the expansion of the Internet, even small local model railway shops and electronic suppliers are within your reach.

www.ukmodelshops.co.uk/ provides a list of many local model railway shops.

### eBay

If you subscribe to eBay you can access sellers from all around the world, which is ideal for tracking spcecialist items, or for making significant savings.

You can order from UK sellers, or worldwide sellers, although be prepared to wait up to five weeks for deliveries from Hong Kong, China, etc.

A search for *'OO'* resulted in 20574 items being sold, with *'HO loco'* displaying 3125 items for sale. Overall, 480626 items for sale were found in the *'model train'* category.

Some items are for immediate purchase, while others are on auction.

**The next two pages provide a list of resources and suppliers that you can find on the Internet. Please note that some smaller companies may come and go; its difficult to keep such a list current.**

# Sources of information, calculators

http://led.linear1.org/1led.wiz      - Calculates resistor need for LEDs

www.csgnetwork.com/resistcolcalc.html      - Identifies a resistor by its colour code

www.hobby-hour.com/electronics/resistorcalculator.php   ditto

www.circuitous.ca/CircuitIndex.html   -  Loads of electronic circuits for railways

www.wiringfordcc.com     - Loads of DCC-related how-to articles

www.opendcc.de/index_e.html      - Build your own DCC modules

www.nmra.org/beginner/wiring.html    -  NMRA's basics on layout wiring

www.stonysmith.com/railroad/speedcalc.asp   - Speed and scale calculators

www.electronics2000.co.uk/data/index.php    - Technical data archive

www.talkingelectronics.com/te_interactive_index.html   -  Loads of general electronic projects

www.discovercircuits.com   -  Loads of general electronic projects

www.electronics-lab.com   -  Loads of general electronic projects

www.epanorama.net

www.microchip.com   - Loads of  PIC specifications, suggestions

www4.tpg.com.au/users/talking/index_of_chapters.html   - Course on PICs

http://elecfree3.rssing.com/chan-7124476/all_p1.html

www.bnoack.com/index.html  - Information on a wide range of electronic devices

https://electronicsclub.info/   - The Electronics Club

www.eleccircuit.com/

www.electroschematics.com/

www.discovercircuits.com/list.htm

The MERG Launchpad has a wealth of information for modellers new to electronics.

# General component suppliers

www.rapidonline.com

http://www.bitsbox.co.uk

http://uk.farnell.com/

www.cricklewoodelectronics.com

www.expotools.com/

www.futurlec.com

www.mindsetsonline.co.uk

www.partridgeelectronics.co.uk

www.richmondcontrols.com

www.greenweld.co.uk

www.bowood-electronics.co.uk

www.toby.co.uk    -  Mainly cables and connectors

www.toolstation.com

www.allcomponentsltd.co.uk

www.brimal.co.uk

www.conrad.com

www.petersspares.com

https://hobby.uk.com

https://hobbycomponents.com/

www.squirestools.com

# Specialist component suppliers

www.active-robots.com     - Robotics & electronics technology

www.avitresearch.co.uk –  Suppliers of specialist adaptors and cables

www.jperkins.com  - Mainly aircraft but have a range of useful materials

www.keene.co.uk   - Mainly Audio/Video but selection of cables, etc.

www.ultraleds.co.uk   - Large range of LEDs

www.mecanique.co.uk   - PIC-related

www.fored.co.uk   - PIC-related

www.millhillsupplies.co.uk   -  Tools

www.skpang.co.uk   - Mainly PICs but a selection of electronic components

http://robosavvy.com   - Robotics, servos, etc.

https://slatersplastikard.com/

# Model railway software

The previous pages covered accessing a range of support, using just your computer and your web browser.   Now we will look at software that you have to install on your computer, to get the benefits of their features.   In most cases, the installation is easy and all you need is some time to get familiar with the application and all its options.

## Train simulators

Just a quick mention, since it is railway related software of a sort.    You don't even need a layout for this, as it mainly for fun.

Most packages have pre-determined routes that you follow as the train's driver. The image shows a screenshot from the RealRailway Train Simulator.

Those that allow you to alter the trackwork, can provide the feel of a layout before committing to a real track plan.
Examples are:

> ArcRail Train Simulation (http://arcrail-train-simulation.en.softonic.com/)
>
> RealRailway Train Simulator   (www.realrailway.com/en/)
>
> PC-Rail Simulations (https://pcrail.co.uk/index.php)

Although something to entertain you and the kids/grand-kids, it does not make a serious contribution to your layout.  The software that follows does.

## Track planners

When contemplating starting a new layout, modellers take many approaches.
Some have a plan of sorts in their heads and just start laying track.
Some draw a sketch on a postcard or a sheet of paper.   Some are more organised and use graph paper to judge lengths and the radius of each bend and point.

Clearly, making it up as you go along or working to a vague plan is a recipe for lots of mistakes.  In fact, even the more disciplined approach of using graph paper has it drawbacks.
Firstly, as you work through the planned layout, you will likely want to alter track positions, locations of points, the radius of a curve, etc.   To make the changes, you have to rub out some the existing plan and start over.    This can be a laborious and frustrating process, particularly when working with flexitrack.
Sometimes the difficulty is visualising how the layout will look when it is finished.

This is where track planning software becomes useful.   The time spent in installing the software and learning how it works makes planning a layout an interesting and enjoyable experience.   Even better, it need not cost too much – some programs are free.

## Features

Some packages have basic (although useful) facilities while others are rich in their features. The most useful facilities could include:

- Works for any gauge.
- Works with both set track and flexitrack.
- Pre-defined track libraries for different manufacturers.
- Handles transition curves (a curve of constantly changing radius).
- Can print out layout sheets.
- Can print out track templates.
- Option to display a 3D view of the layout.
- Option to add in lineside features, trees, etc.

This illustration shows a layout that has been designed using the *'Cadrail'* package.
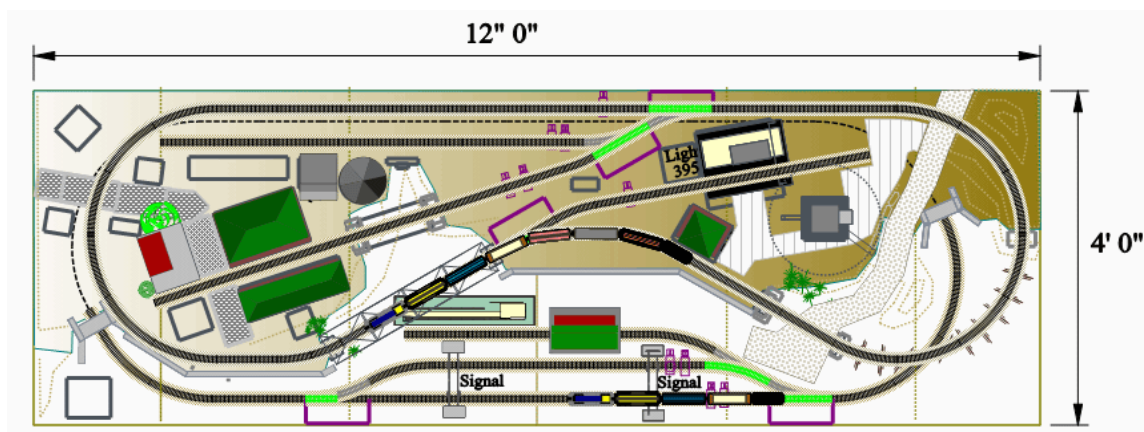


And this is the software displaying the same layout in 3D.
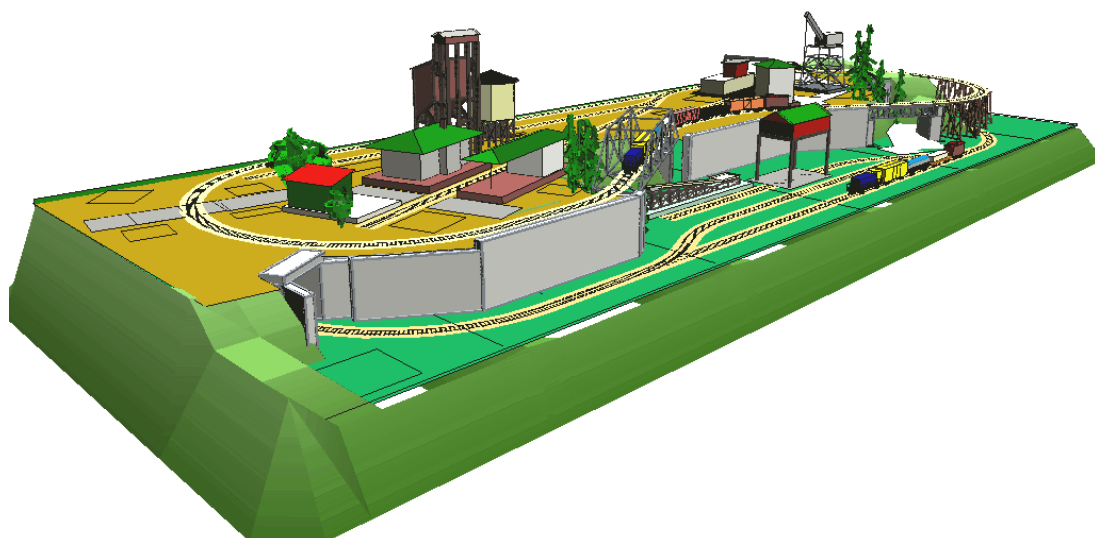
# Track planning packages

Here is a look at some of the packages that are available.   Some are completely free, some are commercial but allow free use on a limited basis and some are completely commercial.

## Cadrail

The images you saw on the last page were made using this package.
It is available for download from:
> www.sandiasoftware.com/

It is a commercial package but allows free use with a maximum of 60 objects.

## SCARM

This stands for '*Simple Computer Aided Railway Modeller'* and is a freeware package that is available from:
> www.scarm.info/index_en.html

Here is a screenshot of the package in operation.
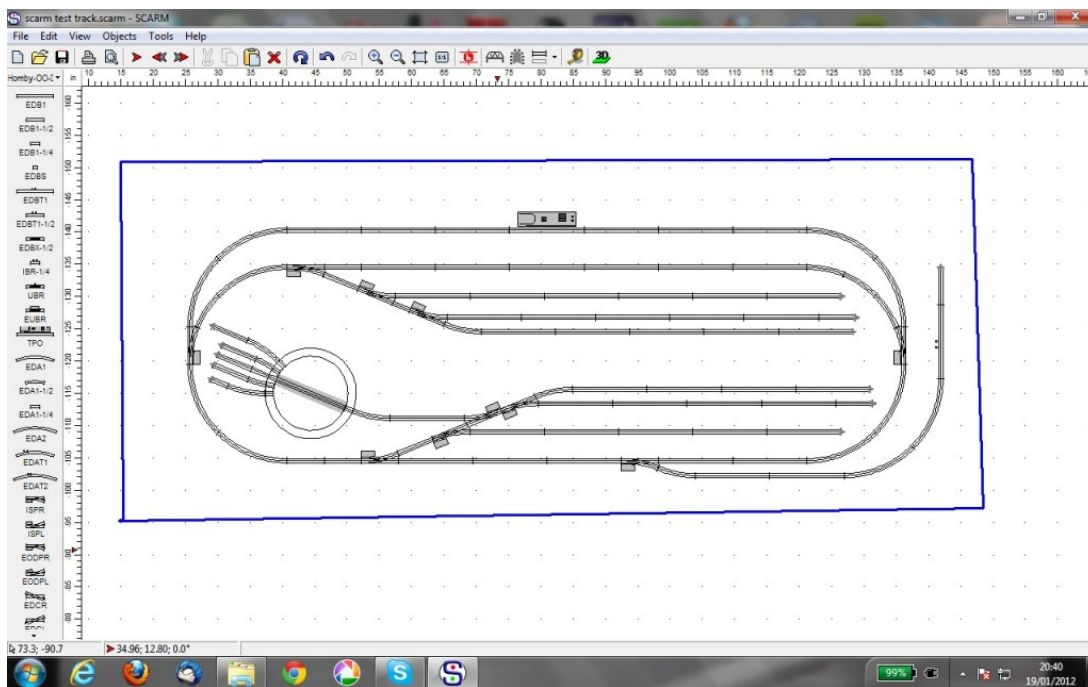


## AnyRail

This is another commercial package that allows free use, this time a maximum of 50 objects.
It can be downloaded from:
> www.anyrail.com

## Templot

Templot is intended primarily for modellers who wish to construct their own track.
It can handle slips, 3-way tandem turnouts, curved double-junctions and mixed-gauge formations.  It is free to download and use, with a request for donations.
It can be downloaded from:
> www.templot.com

It has its own user Forum.

## XTrkCad

This is a fairly comprehensive package with benchwork, on-screen ruler, elevations and even 'Post It' notes.

It is free and can be downloaded from:

www.xtrkcad.org

It has its own Yahoo Group with over 5,000 members.

## WinRail

A commercial product that can be downloaded from:

www.winrail.com

Has useful features such a tool to design 3-rail trackwork, for combining narrow-gauge and standard gauge track systems.

## 3rd PlanIt

A very well featured commercial package that can be downloaded from

www.trackplanning.com/3pi.htm

It has facilities for adding terrain including foliage and viewing in 3D.

A special feature is the ability to design your own locos and run them on the track, as shown in this screenshot.
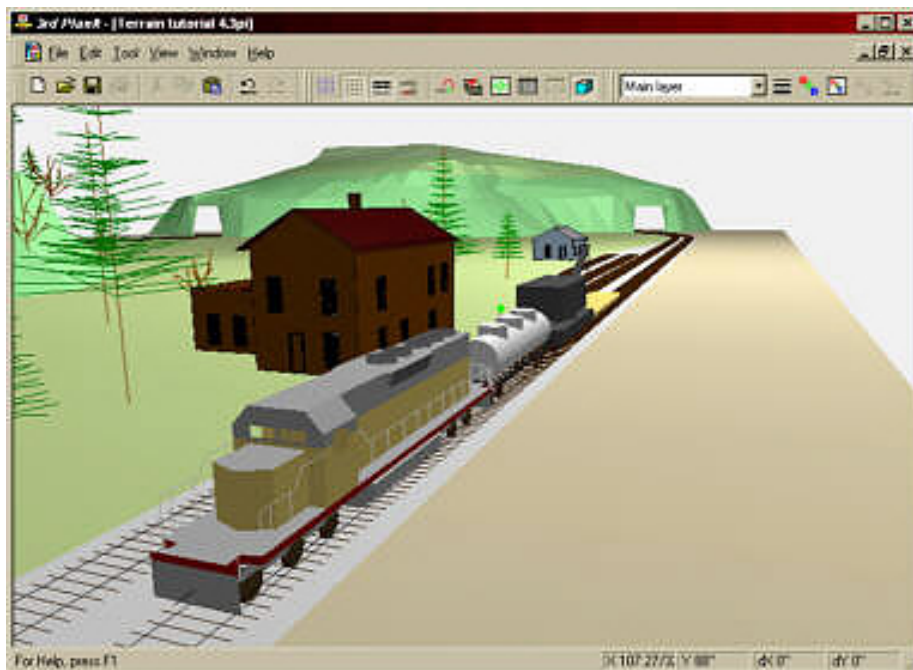


It allows you to use the software without payment, with a restriction of no more than 100 objects and no ability to save the layout.

## The Right Track

This is a freeware package that is available from:

http://the-right-track-r-software.software.informer.com/10.0/

This application provides templates not just for track but also bridges, turntables, buildings and electrical controls.

# Stock inventory

It is not uncommon for railway modellers to amass countless locos and pieces of rolling stock.   When the cost of the trackwork, buildings, controls, etc. are added, the entire collection can easily be a four or even a five figure sum.

That raises the question of how to protect these items in case of fire, flood, theft, damage in transit, accidental damage, etc.
Household insurance policies don't fully cover collections of items and most will not cover layouts in garages or sheds, or garden layouts.   In addition, layouts taken to exhibitions or stored in clubrooms are not included in  household insurance policies.

Luckily, a number of insurance companies offer special policies for model railways.
To maintain proper coverage, an accurate and up-to-date record of all your model railway items need to be recorded and lodged with the insurers.

A number of stock inventory systems are available for installation on your computer.   You enter the details of each item and they are stored in the application's database.   This can be a simple set of details, while the more advanced applications allow you to store additional information including photographs, scanned documents (e.g. receipts) and videos.

## CMS Stock

This is a fully-specified application that can be downloaded from:
http://www.gppsoftware.com/Pages/Vu/Downloads

It is a commercial product but you can download a free fully-functional one month trial version.

The program stores Locomotives, Carriages and Wagons separately with no limit on the number of records.   The program is also customisable, allowing you add your own extra categories to the database.

Apart from creating a list for insurance purposes, the database can store valuable information for day-to-day use, such as servicing or maintenance schedules, exhibition dates, which locos have DCC decoders, what type of coupling is used, etc.

## Track Those Trains

This program can be downloaded from
www.bacitsystems.com/index.php?p=1_8_Track-Those-Trains
It is *'shareware'*, which means that it can be freely distributed and used for evaluation purposes.   Buying a license allows you to add unlimited records and adds printing, exporting in PDF format, a backup function, and other features.
The program also allows you to attach multiple digital images, video clips and documents.

## AP Railventory
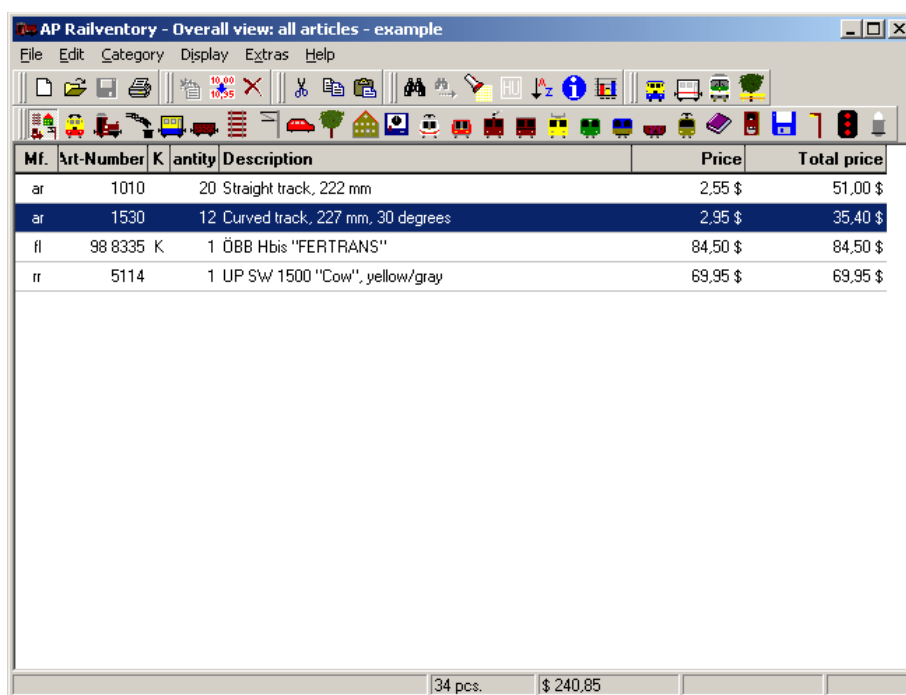
This is a commercial program although you can download a 30 day trial version that is limited to 50 items.
It is available for download only from
www.pothe.com

The database supports 26 categories including locomotives, rolling stock, track, buildings, electronics, software and literature.   There is no limit to the number of items.
You can include two images and unlimited text for each item.



| Mf. | Art-Number | K | antity | Description | Price | Total price |
|-----|-----------|---|--------|-------------|-------|-------------|
| ar | 1010 | | 20 | Straight track, 222 mm | 2,55 $ | 51,00 $ |
| ar | 1530 | | 12 | Curved track, 227 mm, 30 degrees | 2,95 $ | 35,40 $ |
| fl | 98 8335 | K | 1 | ÖBB Hbis "FERTRANS" | 84,50 $ | 84,50 $ |
| rr | 5114 | | 1 | UP SW 1500 "Cow", yellow/gray | 69,95 $ | 69,95 $ |

34 pcs.    $ 240,85

# Computer control

The previous pages looked at what you could achieve using only your computer, the Internet and maybe a printer.   These provide benefits that supported your model railway activities. This next section looks at using your computer to <u>control</u> what actually happens on your layout.

## What is a computer controlled layout?

Computer-assisted systems can provide different levels of operating support.
There are three main operating modes:
Fully manual

> The  operator is in complete charge of all loco, point and accessory operations, using a mouse or pad to interact with buttons and sliders on an on-screen control panel.   It is the responsibility of the operator to see where things are and what needs to happen next.

Partially automated

> The computer software is left to run locos on the layout's main lines, with no attention needed from the operator.   The operator is responsible for, and manually controls, locos in specific areas of the layout such as the shunting yard or fiddle yard.

Fully automated

> The operator sets up a sequence of operations and the computer handles all the layout activities, while the operator sit backs and watches.   To work, the layout needs to provide feedback to the computer, telling it when events have occurred (e.g. a train has arrived at a station).

Well-written software allows the operator to switch between these different modes, with fully automated running on some occasions (e.g. at an exhibition) and fully operator controlled at other times.   The operator can have both a normal physical control panel and also a screen-based control panel (sometimes called a 'glass panel').

Although it is possible to design automatic controls for DC systems, DCC systems have an advantage for computer control as they are already equipped with decoders in the locos.

## What do you need?

The computer has to interface to the layout's electronics, so that it can control activities (locos, points, accessories) on the layout.

For this, it needs both hardware and software.
- The hardware makes the physical link between the computer and the model railway electronics (usually a DCC command station or a DCC booster).
- The software provides the user with the ability to operate locos, points, etc. using the computer monitor and an input device such as a mouse or a touch screen.

# Hardware

There are two main ways that the computer can interface to your layout:

## Through your existing DCC command stations

If your command station has a built-in USB port, then it can connect directly to your computer's USB port.   Examples of this type are the ESU Navigator and the Hornby Elite.

The setup is as shown in this illustration.

The command station connects to power and to the track as normal.   A USB cable is used to connect the command station to the computer.
The control software (see examples of these later) is installed in the computer.
The monitor screen layout can be as simple as a replica of a handheld control, where you click on screen buttons instead of pressing physical buttons.
Most packages allow you to go much further and create a replica of your layout on the screen.
There are no physical alterations to the computer; nothing needs to be added or tweaked; the case does not need to be opened.   The only additional tasks are those of setting up and configuring the software.
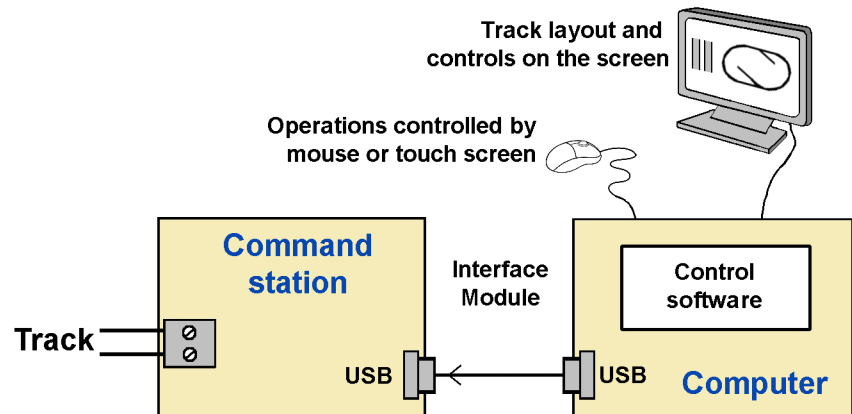
### Proprietary interfaces

For their own reasons, manufactures often use their own interface methods.
To make these command stations work with a computer, you have to place an external module between the command station and the computer.
This module's purpose is to translate the signals on the computer's USB port into signals that are understood by the manufacturer's own particular interface.
Examples are Digitrax using a PR3 unit in MS100 mode or a LocoBuffer-USB unit, NCE using the NCE USB interface module, and Lenz or Atlas Commander using the Lenz LI-USB interface module.
The interface modules connect between the two ports and are usually powered from the computer's USB port.
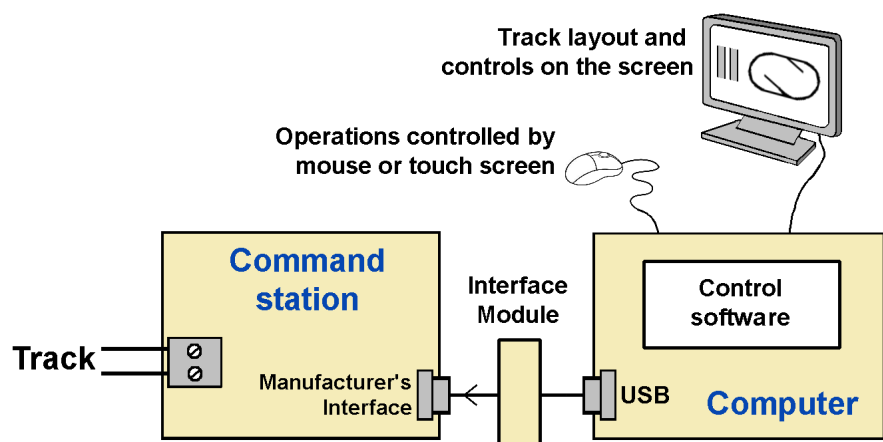
# Through an independent interface unit

The systems above use a command station that can be operated with or without connection to a computer, allowing you to switch between these uses.

Another approach uses units that *only* work when controlled by a computer. They do not have external knobs, buttons or sliders that you can touch and manipulate.   They rely solely on the instructions they receive from your computer.
Their main advantage is their relatively cheap price compared to standard command stations.

## Hornby's *'eLink'*

This unit combines a USB connection to a computer and a DCC booster.   It has outputs for the main layout track and for a separate programming track
It is supplied with a 1A transformer, which is sufficient for many smaller layouts, but can be replaced with a 4A transformer if required.



## SPROG modules

The first SPROG model was intended as a programmer for DCC decoders.    The SPROG 2 is a combined USB interface and 1A DCC booster. When it was recognised that it could also be used for controlling layouts, a more powerful  SPROG 3 version also became available.   The SPROG3 looks similar to the one in the picture but includes a 2.5A DCC booster.
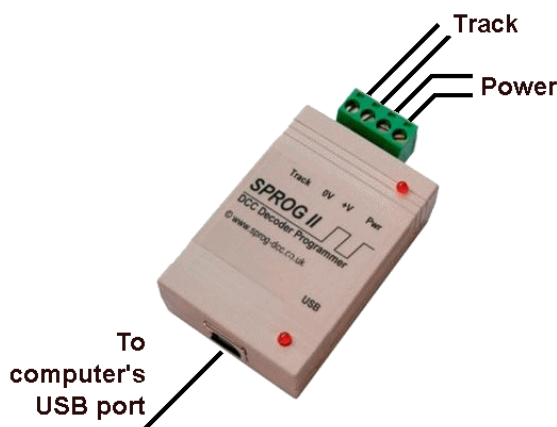


If you own a DCC booster but no command station, SPROG have introduced the *'s-Nano'* which interfaces a computer's USB port to any any DCC booster.

## MERG Command Station

Like the others, this module connects to both power and the track.
Unlike the others, it can be connected to a handset to convert it into a conventional DCC command station.
Its interface uses a variation of the CANBUS system (CBUS), so has to use a CBUS-to-USB interface.
The CBUS system is explained in a separate chapter.
It is supplied as a kit and its ability to work from a handset or from a computer makes this unit very versatile.
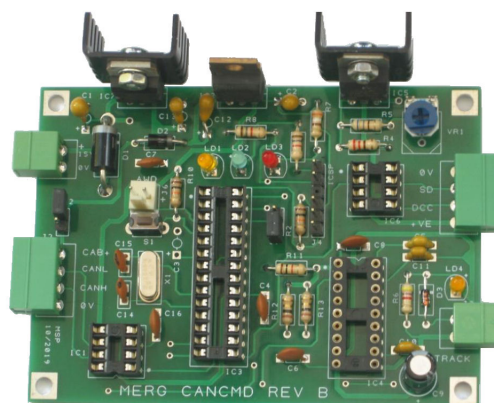
# Control Software

Controlling layouts from a computer can be as simple or as complicated as you want. This chapter cannot provide tutorials on all the software applications out there. You need to choose the one that best suits your needs (and pocket) and be prepared to learn how to use it and get the most from its facilities.

At its simplest, the computer screen can look just like a handheld DCC controller, as shown in this illustration.

Once the program is running, you select which loco you want from the drop-down list near the bottom of the screen, click on the 'Forward' or 'Reverse' button and move the slider up and down to adjust the loco speed.

This *'Throttle'* facility is included as part of *'Decoder Pro'* .
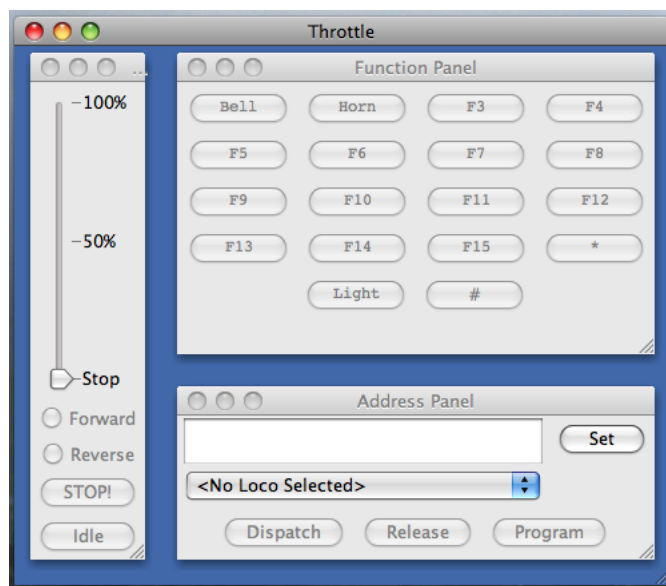
The software is provided by the JMRI (Java Model Railroad Interface) Project group.   This is an informal open-source software group who describe their project as:

> *"a jumping-off point for hobbyists who want to control their layouts from a computer without having to create an entire system from scratch."*

The software is constantly being developed by this large group of enthusiasts who co-operate to provide free access to their two main programs.
Their website explains that

> *"JMRI can be used to automate parts of your layout, from simply controlling a crossing gate to running trains in the background".*

The Decoder Pro program is mainly used to make programming DCC decoders an easy task and this is described in the chapter on DCC.  The *'Throttle'* facility is a useful addition for those who do not want to go down the road of automation.

JMRI's other application is called *'PanelPro'* and it is used for handling automated or semi-automated layouts, using two methods.  You can choose to use either method, or even both together.
The *'Layout Editor'* lets you draw your layout on your screen, as shown in this simple example.
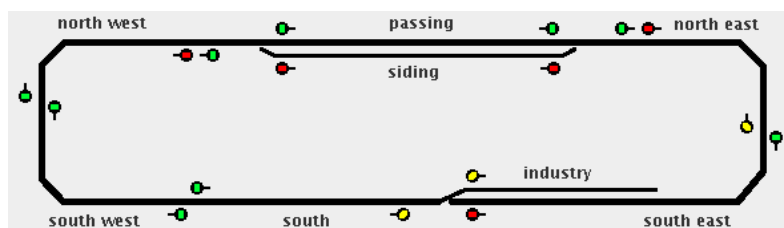
Once set up, the operator can control the layout's points and signals.

The *'Panel Editor'* lets you create an on-screen representation of a normal control panel like the one shown here.
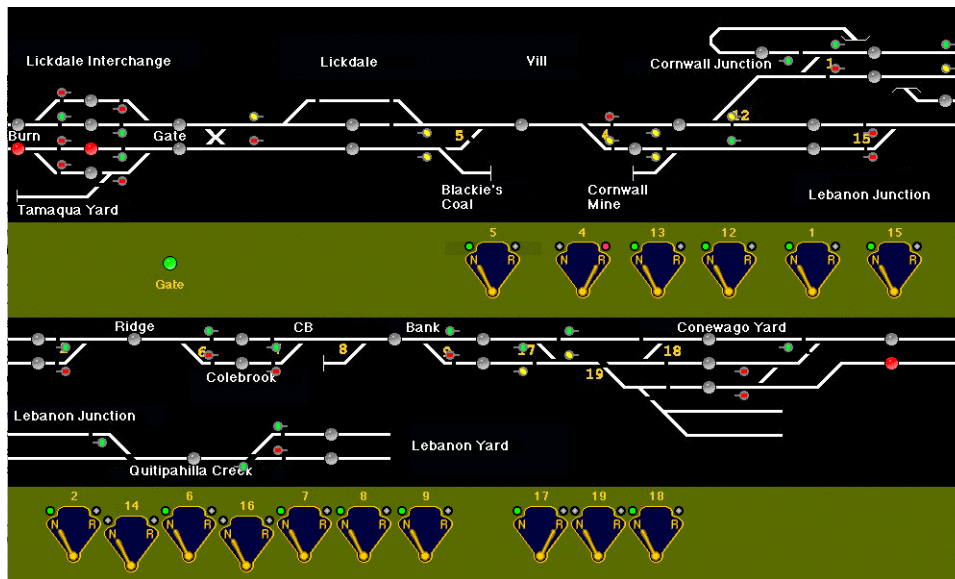


It is an alternative approach to control locos, points, etc. from the screen – or have them run automatically.

For automatic running you need feedback to the computer from sensors that tell the software when events have completed (e.g. a train has arrived at a station).   See the chapter on track occupancy detectors for information on this.

JMRI software includes the ability to use iPhones, iPods and Android phones as handheld remote throttles.

More information is available at:

  www.jmri.org

The website provides a list of all the command stations and hardware that it is compatible with.

## Rocrail

This another open source project that is free to download and use.   It is also being continually developed by enthusiasts.

It provides options for you to run the layout manually from your on-screen layout, or to configure it to run automatically or semi-automatically.

As for JMRI, automatic running in Rocrail relies on feedback to the computer from sensors that tell the software when events have completed (e.g. a train has arrived at a station).   See the chapter on track occupancy detectors for information on this.

More information is available at:

  http://wiki.rocrail.net/doku.php

The website provides a list of all the command stations and other hardware that it is able to work with.

Rocrail also has its own Forum where help and advice is available.

  http://forum.rocrail.net/viewforum.php?f=95

Here is an example:
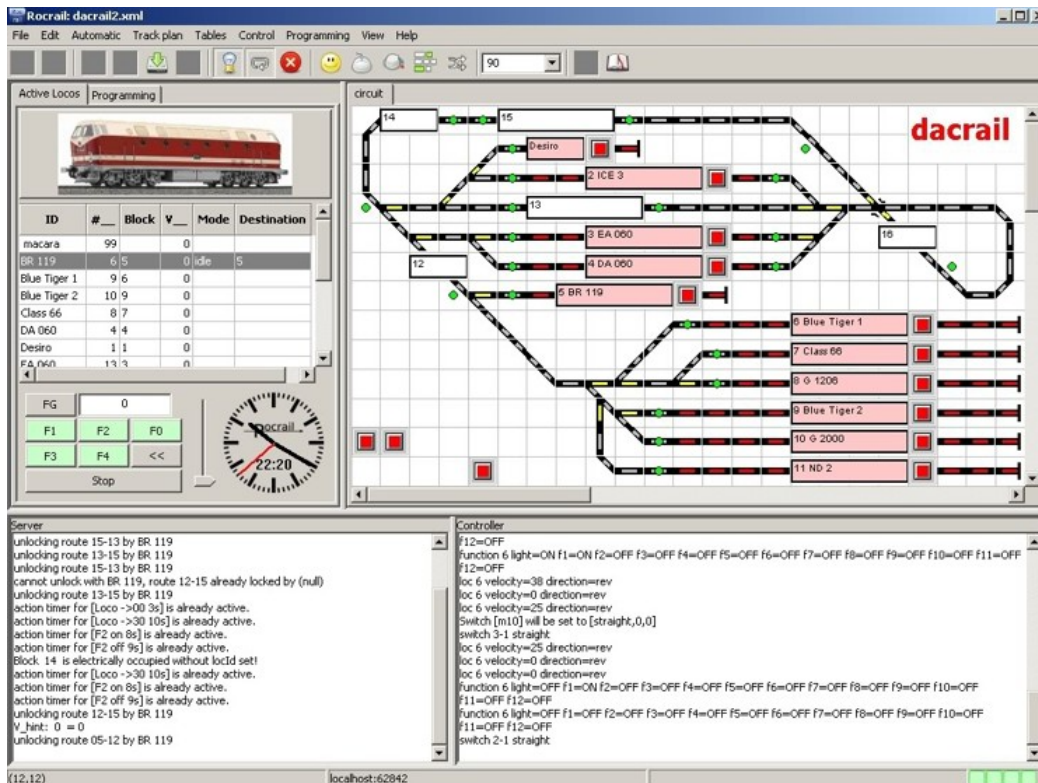


## Hornby RailMaster

Hornby's RailMaster software works with the Hornby Elite DCC controller or the e-Link DCC booster.

It can be purchased on its own or bundled with e-Link.

As the image shows, it uses the same approaches of drawing the layout on the screen and providing on-screen control of locos if required..   The movement of locos, points, uncouplers, etc. can be controlled either by your mouse or by using a computer with a touch screen.

The points and accessories are controlled via DCC accessory decoders.

Automation can be achieved in two ways.



The software provides a programming option where you enter a list of activities such as starting or stopping locos, operating points and setting signals.  These events are entered in the order that you want them to occur and you have to enter the times at which each event will happen.   This may be a bit of a suck-it-and-see operation where you amend the timings after running the program.
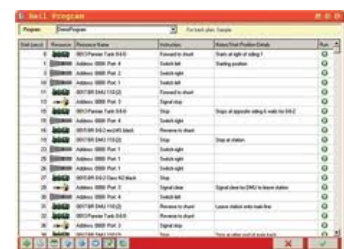
The alternative is to use the software's 'recording' option, where the software creates the list of activities and includes the actual times you took to run the locos, etc.

While Hornby's timed list approach is simple to create, it has the serious drawback that it cannot cope with unexpected events such as stalling or derailments.   The program relentlessly progresses though its list of events, since it has no knowledge that a previous event failed.

JMRI and Rocrail cope with mishaps by using feedback from track detectors.   That way, it knows that a loco failed to arrive at its intended destination and won't carry on until the situation is rectified.

Hornby are aware of this shortcoming and they are likely to introduce a range of their own detector modules, possibly including RFID.  At the time of writing they are awaiting patents before bringing them to the market.

Like the JMRI and Rocrail, RailMaster allows remote control of your layout using and iPhone, iPad tablet,  and Apple and Android devices.   The device communicates via Wi-Fi with your computer and you have to purchase their app.
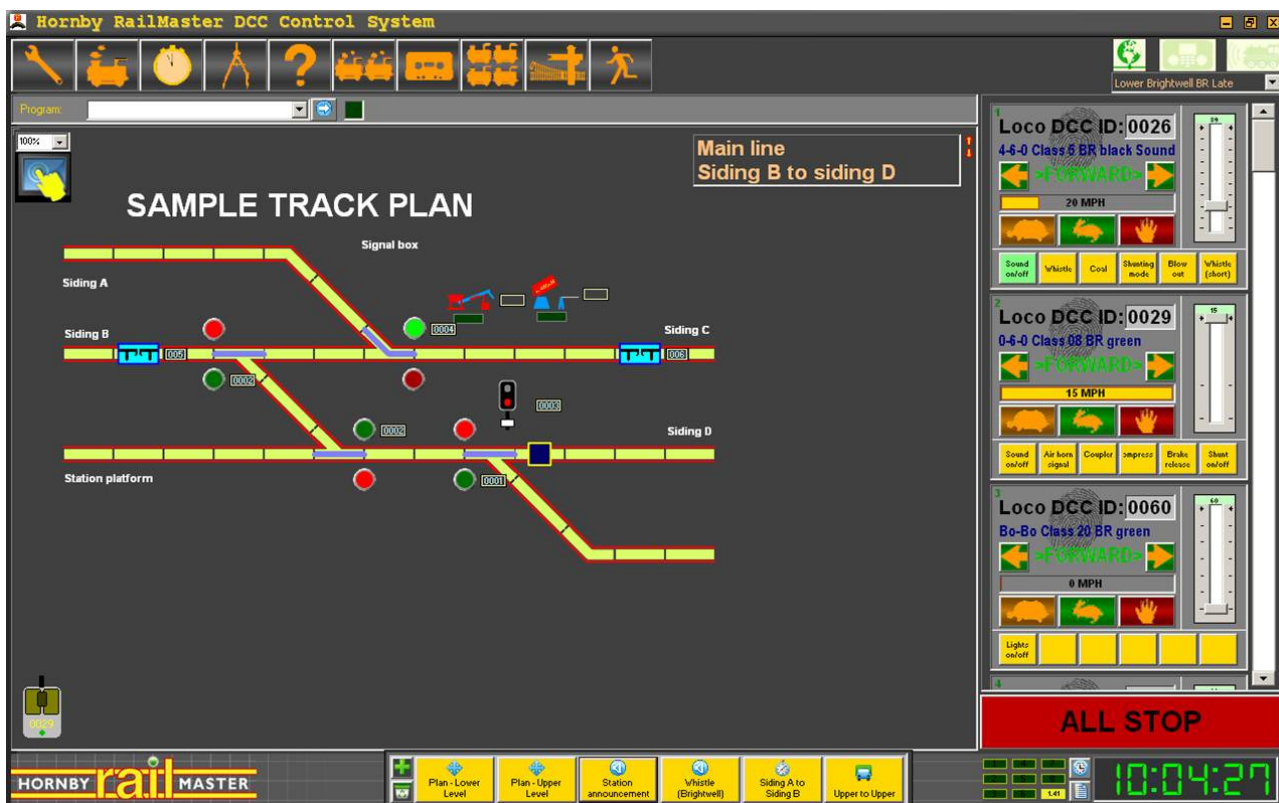


## TrainController

This is another commercial product, created by Railroad & Co.
It is available in three versions, Bronze, Silver and Gold, with differing amounts of facilities and prices ranging from around £100 to around £500.
A comparison chart for the three versions can be read at:
        www.freiwald.com/pages/traincontroller_bronze.htm

It claims to support the train detection systems of all leading manufacturers.

The program has several thousand users and has its own Forum.

They offer a free trial download with no restrictions for the first 30 days.
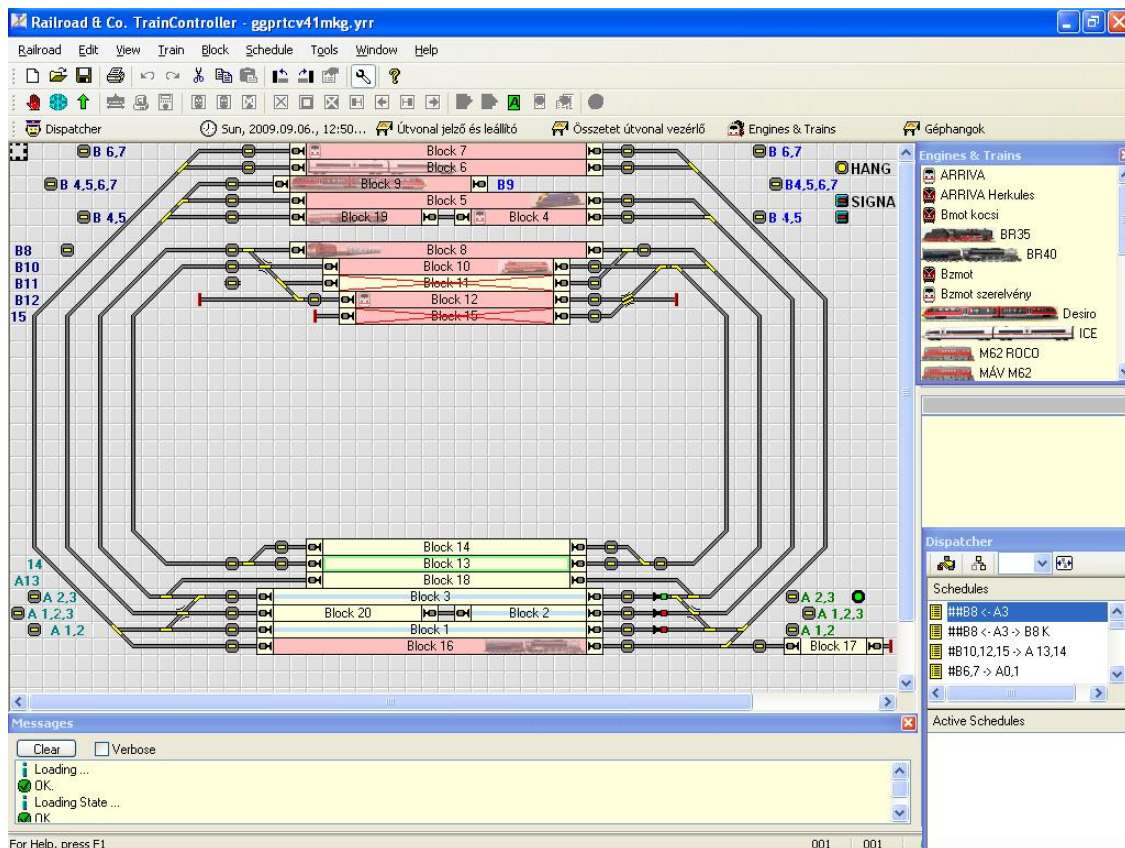
## SSI

SSI stands for Solid State Interlocking, since it provides full control of points and signalling and these can be interlocked. The software provides prototypical operation and control. Routes can be defined so that a series of points and signals can be set in one operation. A range of drivers is provided, allowing it work with various pieces of hardware (e.g. the MERG RPC, MERG CBUS, Lenz ExpressNet, Hornby Elite, and NCE DCC).
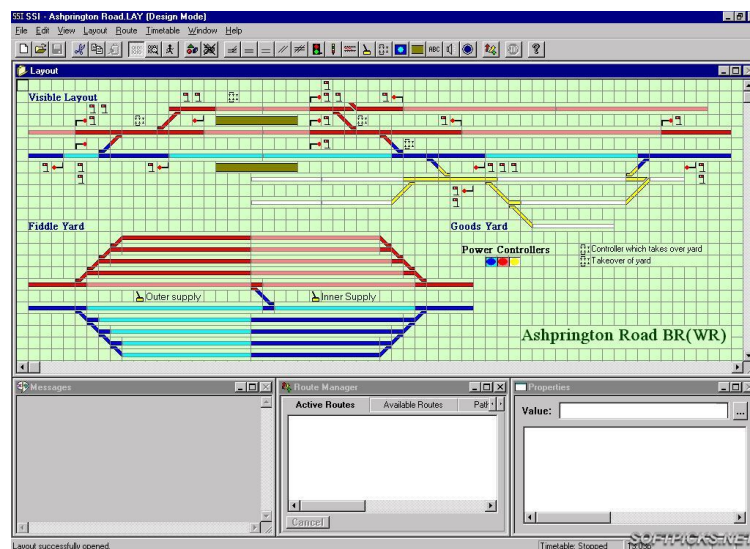


The software can be purchased from:
http://www.gppsoftware.com/Pages/Vu/Downloads

You can also download a fully functional 30 day trial.

## TCC

TCC (Train Control Centre) can drive three types of hardware interface module: CTI modules, RPC modules and QTU modules available from QtuTrains.

It connects to your computer's serial port, or to your USB port using a serial-to-USB adaptor.

More information is available at:

www.qtutrains.com/SoftPane.html

In its most complex form it could be used to control signals and points with full interlocking, entry/exit route selection, automatic timetable running or fully automatic operation. To do these more complex things you have to write a configuration script.
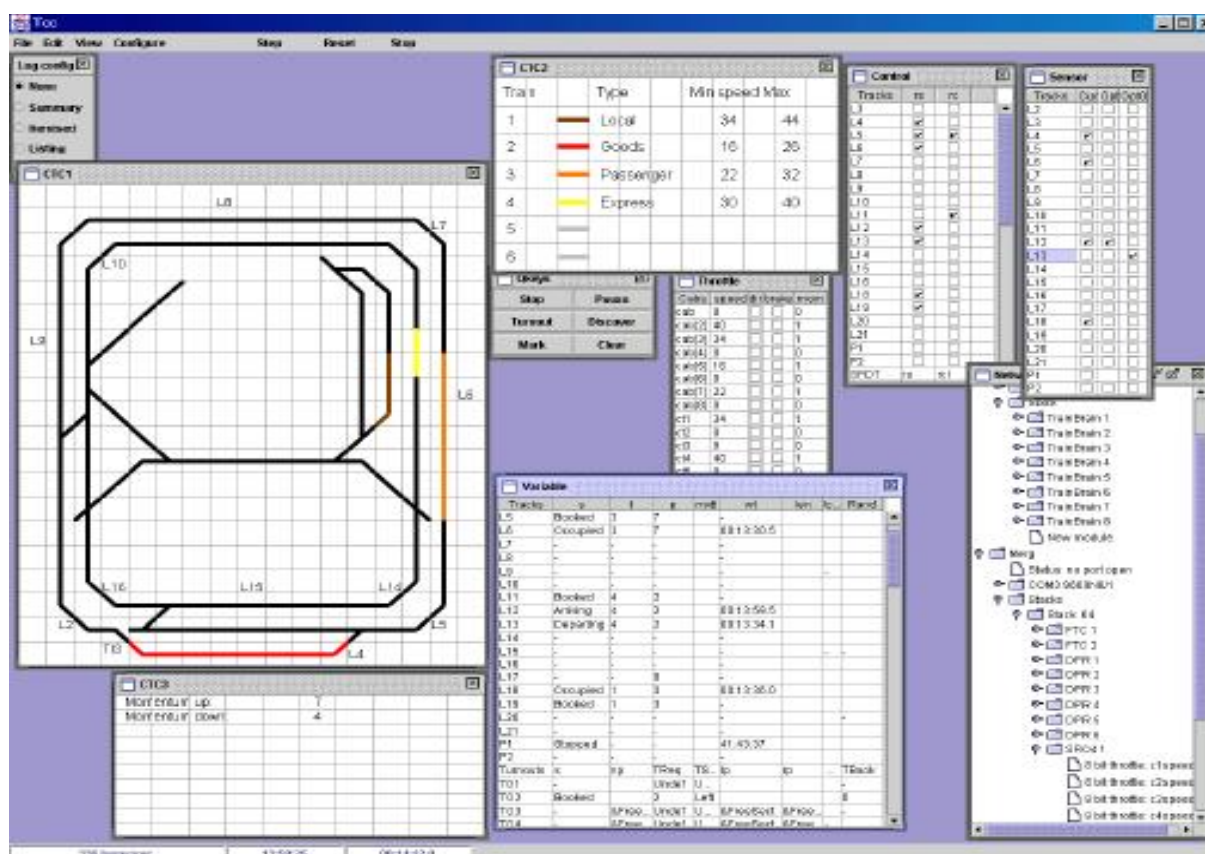


### Note

Although these programs can reduce a lot of the workload, the user will only get the best from these systems by tweaking them to their own needs. This is achieved through writing 'scripts', small sections of computer instructions.

So, although of great help, computer-assisted layout operations still need you to learn a little about programming.

Here is a line of JMRI code, expressed in their Jython language:

turnout.commandedState = CLOSED

which hopefully is self-explanatory.

You may wish to dip your toe into this challenging and rewarding area of model railway control. Many of the software programs are free and the only investment is some time. But when you click on a button and move the slider and watch a loco slowly move off …....

# Interfaces – technical notes

## First the good news

You do not need to know a lot about how computers work in order to use railway control software.   You only need to know how to install and run a computer program and connect some cables/wires.    In most cases, the software installs automatically or leads you through the steps.   Similarly, the hardware you buy will have installation notes.
How it all works can remain invisible to you if you want.

These next pages explain how serial and USB interfaces work.
It is included for two reasons:

- To satisfy the curiosity of those who like to know how things work and want to learn more.
- To help those who may be having problems with their setup.

   The approach should be - read what you need – skip what you know.

## What is digital?

Almost all computer activities involve data communication of some sort.  Communications can take two forms: '*Analogue*' or '*Digital*'.   This describes how the signal level changes with time (usually the voltage level changes across two wires or between two points).

### Analogue

   Data transmitted in analogue form has infinite potential variations.  Examples include sounds recorded on a cassette tape and AM radio transmissions.  In the model railway world, turning the knob on the DC controller results in voltages that can vary from zero to 12 volts or more – and every voltage level in between.

### Digital

   Digital signals can be in one of only a set number of possible states for each item of data.  For example, computer data consists purely of ones and zeroes, with nothing in between.  Either the wire carries the full voltage or no voltage.  It is either high or low, ON or OFF, 1 or 0.  There are no intermediate levels.  The ON, or HI, voltage level depends on the system.   It is 5 volts for many electronic devices and systems (e.g. USB, PICs, many digital logic chips, CBUS) and 12 volts and above for others (e.g. RS232 ports, DCC).  Examples of digital devices include printer cables, broadband connections, and DCC and CBUS in the model railway world.

## What are bits and bytes?

Most data is stored in multiples of a 'byte' – a byte being a collection of eight data bits.  At any point in time, all bits could be at zero voltage, or all at high voltage, or any combination of Highs and Lows.   This provides 256 possible different combinations and explains why a GIF image offers only 256 colours (one byte representing a screen pixel of a particular colour) or why early sound cards only produced 256 sound levels.
Its also why some decoders offer a range of 256 CVs.

A byte can also be used to store alphanumeric characters or numbers between 0 and 255.
For larger numbers, bytes are grouped into multiples and handled in multiples.

Hence, we have 32-bit, 64-bit, 128-bit or even 256-bit graphics cards and Windows 7 and Windows 10 handling data in 64-bit chunks at a time.   CBUS uses events that are 32 bits. And not forgetting CV 2-byte long addresses.

All storage and speed measurements are stated in bytes, with a typical hard disk being 1TB or a typical broadband modem speed being 10Mbps.  The upper case B denotes the value is in bytes, while the lower-case denotes bits.  So, in the examples, the 1TB hard drive stores 1,099,511,627,776 bytes while the modem receives at ten million bits per second.

### Note
When measuring weights, distances, transmission speeds, etc., kilo is a magnitude of 1,000.  However, in computing memory and data storage, a kilo is 1024; this is due to the binary system used in computing ( 1 kilo = 2x2x2x2x2x2x2x2x2x2 = 1024). Similarly, Mega is 1024x1024 not 1000x1000.

### How is data moved around?

There are two ways in which data can be transmitted: *'Parallel' or 'Serial'.*
The parallel method uses multiple data lines, to transfer multiple data bits in parallel with each other.   The values on all the data lines are moved around at the same time.
Within a computer, most data is moved round in parallel format on the various internal buses between the CPU and other chips.   Older computers had parallel ports that were used to connect external peripherals such as a printer.

# Serial

This type of communication uses a single data line, with only one data bit being transferred at a time, as shown in the diagram.  On a basic level, the serial device waits for a group of eight incoming bits to arrive and assembles them into a byte for use.  Similarly, a string of data from the device to the PC is built up into byte-size chunks before being used by the PC programs.
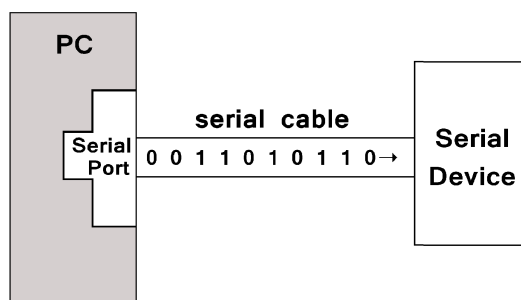


Modern computers pass data between computers and peripherals using one of a number of different serial types of connection.  Serial systems are used for keyboards, mice, memory sticks, scanners, digital cameras, broadband routers and modems, local area networks, etc. Example interfaces are the serial port. USB, Firewire, external SATA ports, Bluetooth, IrDA, etc.   In model railway systems, DCC, CBUS and EzyBus use serial techniques.

### What is a serial port?

The serial port is situated at the rear of older PCs.  They are generally 9-pin D-type connectors, although the specification allows for 25-pin connectors.  9-pin to 25-pin adapter or cables are available.   The connector at the rear of the PC is male (i.e. has pins) while the cable end is female (i.e. has sockets).
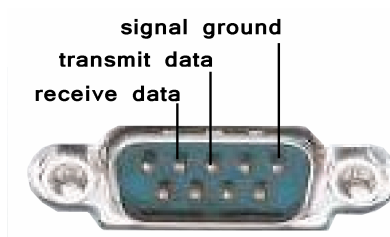


As the illustration shows, one of the pins ('signal ground') is used as a common return for all connections on the port.   The data signals are measured with respect to this pin.    One pin is used for transmitting data down the serial cable, while

another is used to receive data that has been sent to the computer. The other pins are used for various signalling purposes.

The RS232 standard was designed to minimise interference on the wires carrying the data signals.
To aid this, the voltages carried are higher than the normal range for digital signals carried inside the PC. The logic states inside the PC carry voltages typically no more than 5 volts. With RS232, binary 0 is represented by a voltage of +3 to +15 volts and binary 1 is represented by a voltage of -3 to -15 volts. Ideally, the signals would be +15v and -15v but by specifying a positive and a negative range, allowance is made for signal losses along the line.
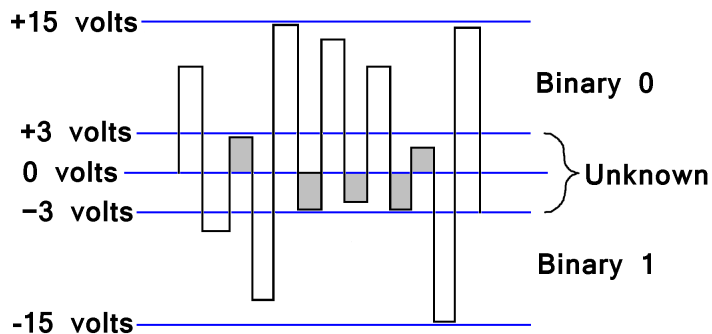


Voltages between +3 volts and -3 volts cannot be converted to known values. These indeterminate values may be caused by interference spikes or may be the result of losses of signal on the line. They are shown shaded in the diagram.

Note:
The RS232 serial port uses values that swing both positive and negative of the common ground wire. Other serial systems only use data that swings positive with respect to the common ground (e.g. CBUS and USB).

## Transmission Speeds

The speed of data transfer is measured in bits per second (bps). So, for example, if a device had an output running at only 1bps, you could monitor the output every second and find either a high or a low value. Of course, data is moved round at much faster rates than that. The very early modem connections ran at just 110bps, later dial-up modems run at 56kbps, while the latest USB3.1 offers a transfer rate of up to 10Gbps.
The maximum data rates for different interfaces are given in the table below.

| Interface | Speed |
|---|---|
| CBUS | 125kbps |
| EzyBus | 100kbps |
| Serial RS232 | 115kbps |
| USB1 | 12Mbps |
| USB 2 | 480Mbps |
| USB 3 | 4.8Gbps |
| USB 3.1 | 10Gbps |

When you connect two devices that operate at different speeds, the data can only be transferred at the lowest data rate, as the slowest one will not be able to keep up with and understand the fastest one. For example, if you use a USB-to-serial adaptor, the USB port will be able to operate at many Mbps or even Gbps but the serial end of the adaptor can only transfer data at at a maximum rate of 115kbps.

The MERG series of CBUS modules operate at 125kbps. So, the modules communicate with each other at a data rate of 125kbps. However, if you use their CAN-to-serial adaptor (the CAN_RS) the communication between the computer and the modules is limited to 115kbps. This should not cause any problems unless a layout has a huge amount of traffic on the CBUS which could potentially result in loss of some data. This possible limitation can be overcome if a CAN_USB computer interface is used, as this will communicate with the computer at the full CBUS speed of 125kbps.

## Using the serial port with a serial device

There are two steps to connecting a serial device to a computer's serial port.
- The first step is simple. Take a serial cable and plug one end into the computer and the other end into the device! In our realm, this might be a serial SPROG, a CAN_RS module, a Servo4 module, or a Lenz LI101F Computer Interface. Of course, the device will need to have its own power supply connected.
- The second step is to ensure that the necessary application software to control the device is installed on the computer. This may be Decoder Pro, MERG's CAN_RS software, Servo setting programs (Servoset or AltServo), etc.

### Allocating a COM port

In most cases, when the software is run, it asks which serial port is to be used with the application, with some offering an enumerated list to choose from. The computer supports a number of different serial ports, often numbered 1 to 4 but could go higher.
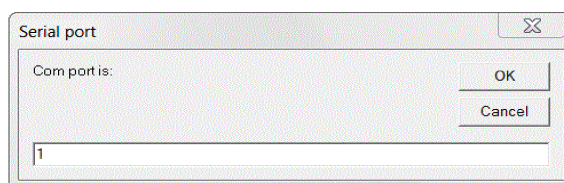
The user can simply try selecting each port number in turn until the application works. In well-written applications, entering the wrong port number simply results in an 'Invalid port number' error message. The experienced user might wish to use Window's Device Manager to examine which COM ports may already be in use.

One benefit of using a genuine serial port, compared to USB ports (or USB to serial adapters) is its robustness. If the device temporarily loses power or the cable disconnects, the system will begin working again as soon as the power/connection is restored. Such glitches in USB-connected systems could prove more of a problem.

# USB

All new computers have USB ports, with up to six external ports being common. USB (Universal Serial Bus) is designed to connect external peripherals such as mice, keyboards, scanners, digital cameras, printers, memory sticks, hard disks, networking components, etc. to computers.

It has become the standard external connection method for Windows, Macs and Linux. USB and RS232 ports both send and receive data in serial format – but the format of each is different (in terms of speed, data format, etc.)
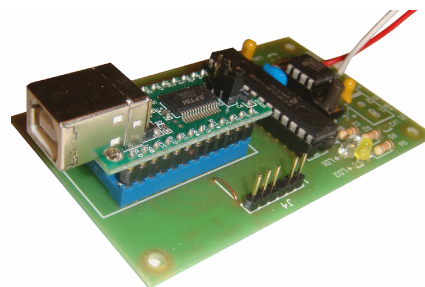
## What does USB offer?

The advantages for model railway systems include:

- Can handle full CBUS data rates, unlike RS232.
- Never run out of interface ports, even with many devices attached.
- Overcomes lack of serial ports on many modern computers, despite some devices still using serial interfaces (e.g. Servo4, serial SPROG).   Solved with USB to serial adapters.
- Good noise immunity (see later)
- USB ports can supply some power to externally connected devices.
- Like RS232, you don't have to open the computer case to add extra devices.
- USB devices can be *'hot swapped'* - fitted and removed without rebooting or reconfiguring the computer.  If a new device is plugged in while the computer is switched on, it may be configured with no need to throw DIP switches, add/remove jumpers or determine IRQ settings or I/O addresses.

## USB Speeds

The table shows the maximum data rates for different USB versions, measured in millions of bits per second. The actual data rate is usually lower, due to protocol overhead.

| USB Standard | Description | Max Data Rate |
|---|---|---|
| USB 1.1 | Low Speed | 1.5Mbps |
| USB 1.1 | Full Speed | 12Mbps |
| USB 2 | Hi Speed | 480Mbps |
| USB 3 | SuperSpeed | 4.8Gbps |
| USB 3.1 | Superspeed+ | 10Gbps |

The early USB standard, USB 1.1, is only found in the very earliest computers with USB. Most computers have either USB 2.0 or USB 3.

The lower rate of 1.5Mbps was intended for slow devices such as keyboards and mice, while Hi Speed USB, SuperSpeed and SuperSpeed+ are designed for for quick data transfers on external drives, quick copying, and for playing video.

For our purposes, even the slowest implementation of USB has a faster maximum data rate than CBUS.  So, all computers with USB ports, even old computers, can run happily CBUS.

## USB Cables

Unlike the multi-wiring of 9/25 pin serial ports, USB 1.1 and USB 2 cables are light and flexible containing only four wires.   They have two wires for power (+5 volts and ground) and a pair of wires to carry the data.   There may be a fifth connection at the computer end, wired to a protective shield around the USB cable.   USB 1.1 and USB 2 use a twisted pair for the data wires, to reduce noise and crosstalk.   To achieve its higher data rates, USB 3.0 cables use two pairs of shielded data wires.

The maximum length of a standard USB 1.1 and 2 cable is 5.0 metres (16.4 ft).

The USB 3 standard only requires that the cable meet its electrical specification, although a cable that uses AWG26 copper wires is limited to 3m (9.8 ft).

With most electronics, the voltage readings are taken with respect to ground (e.g. 5v higher than ground).   USB uses *'differential signalling'* instead.   The receiving device reads the difference between the two signals wires D- and D+ and ignores the wires' voltages with respect to ground.  This increases the system's noise immunity and minimises problems of unwanted electrical interference.

## Can the 5m length be increased?

While some enthusiasts have a computer dedicated to their model railway operations, others may have their computers installed some distance from their layouts.

USB cables of 5m in length are readily available but care should be taken with *'USB Extension Cables'.* Extension cables have a plug on one end and a socket on the other and one or more can be used to increase the cable length between the computer and the controlled device. Consequently, these cables can be used to exceed the cable length restrictions for USB. However, the length restriction exists for a good reason – it encompasses the permissible round-trip time delay of USB signals. If the computer's commands are not answered by the connected USB device within the allotted time, the computer treats the command as being lost. A safe way to increase distance is to use hubs.

# USB Connections

A variety of plug types are used on the end of USB cables, as shown here.



Type A    Type B    Type A Mini    Type B Mini
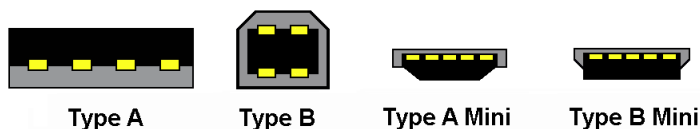
The USB specification describes two main categories:



Type A Micro    Type B Micro    Type B USB3 Micro    Type C

**Upstream**

These plugs and sockets are called Type-A (sometimes just *'USB-A'*) and are always used at the controlling *'host'* end– usually the computer.

**Downstream**

These plugs and sockets (Type-B or USB-B) are always used at an attached device.

USB cables have a Type-A plug at one end and a variety of plug types at the other end.

The ones most likely to be used with model railway electronics are shown in this illustration.



Type-A    Type-B    USB 3
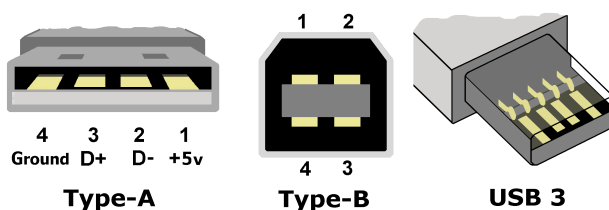
| Pin | Purpose | Colour | |
|-----|---------|--------|---|
| 1 | +5V | Red | |
| 2 | D- | White | |
| 3 | D+ | Green | |
| 4 | Ground | Black | |

The table shows the wiring for each pin in USB 1 and USB2 connectors. The illustration shows the connections on the plugs. The wiring on the sockets are reversed, so that the +5v on the socket connects to the +5v on the plug, and so on.

As the illustrations show, the connectors have power pads that are longer than the data pads. This ensures that the device is powered up before data signals are applied.

USB 3 connectors have the same four connection pads as earlier versions but have additional contacts recessed into them.

These additional contacts provide the extra data lines for the SuperSpeed signals.

### Smaller connectors

Smaller USB connectors are available. These are known as Micro USB, Mini USB and Type C. Mini and Micro types are commonly used for connecting small devices such as PDAs, mobile phones and digital cameras. They are also commonly found on Arduinos. The Type C is commonly used to connect to mobile phones.

They are not very common on model railway devices.

## Are they all compatible?

All USB systems maintain backwards compatibility.    This means that older specification devices still work on newer ports.   So, a USB 2.0 device can be work with a USB 1.1 port, but only at USB 1.1 speed.  A USB 3 device will connect to either older port (USB1.1 or USB2) but will only perform at the data rate of that port.

Mechanically, they will all connect although, because of its extra connections, the USB 3 plugs and port sockets are deeper than earlier types.

## Power from USB?

The computer's USB ports can provide power to any low-power devices that connect to it., eliminating the need for the external device to have its own power supply.

Low-power devices (such as a mouse or a keyboard) can draw their power directly from the bus.  High-power devices (such as printers and scanners) have their own power supplies and draw minimal power from the bus.

USB 1.1 and USB 2 ports are capable of providing a <u>maximum</u> of 500mA at 5v, while USB 3 ports can provide up to 900mA.

Type C is designed to provide up to 3A charging.

These figures are for the <u>total</u> of all devices connecting to a USB port.   If the power requirements of  device, or a collection of devices, exceeds the port's limit,  the computer will  turn off the port.

So don't be tempted to use the USB port to power modules, relays, LEDs, desk fans, drinks warmer pads, etc.

## What are USB hubs?

USB uses a master/slave implementation.   The computer host is the master controlling all bus traffic.  This is achieved by having a host controller that handles a *'root hub'*.  All devices connect to the computer through a root hub.   Some computers now have two controller and two root hubs.   With all the functions (controlling power, enabling and disabling ports, etc.) being handled inside the computer, external slave I/O devices are simplified and cheaper to make.

Microsoft has a utility called USBView that can be downloaded from its website.  This provides information on the hubs in use on your computer.

In the example shown, the computer has two host controllers and two root hubs.  Two of the ports are used for connecting to memory cards readers built in to the computer, while the other root hub has two input devices (USB mouse and USB keyboard in this example) attached externally.
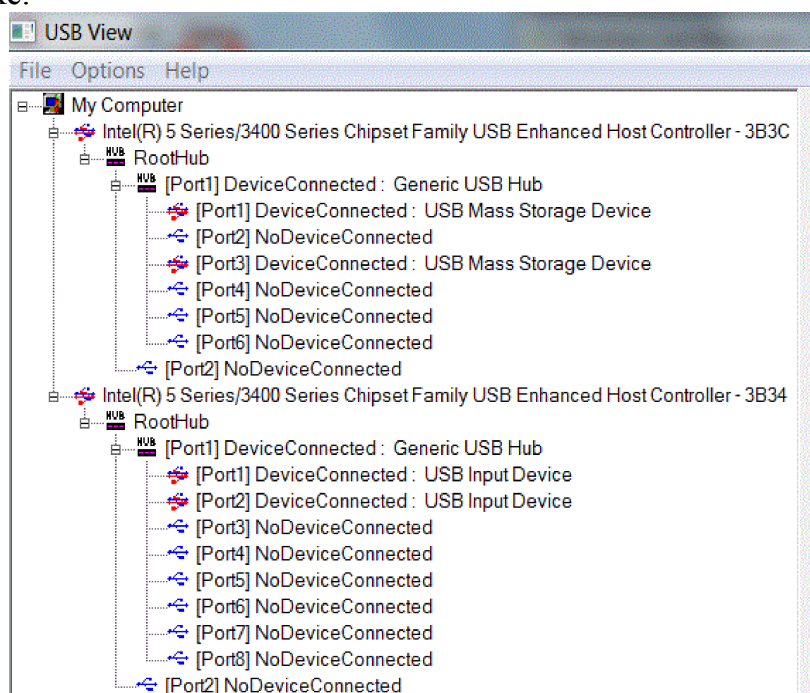
### External hubs

As computer users, we are more familiar with external hubs.
They come in a range of shapes but they all have multiple input
USB ports and a single lead to connect the hub unit to one of the
computer's USB ports.   A hub therefore connects a group of
devices to a single connection point.

So, for example, a laptop with only two USB ports can be expanded to allow the connection
of multiple USB devices (e.g. external mouse, keyboard, CAN_USB3 module and a
SPROG) all at the same time.

External hubs are of two types:

Bus-powered
  Bus-powered hubs use the power supplied from the computer's USB port to supply their internal
  electronics.   With a permitted maximum of 500mA, a hub often uses 100mA, leaving 100mA to
  each of its four downstream devices.

Self-powered
  Self-powered hubs have their own mains power supply and can supply 500mA to each of its
  downstream devices.   This allows further hubs to be connected downstream (see next).

Like USB ports, hubs are built to standard USB 1.1, 2.0 or 3 specifications.
Devices connected to a USB 1.1 hub will only operate at USB 1.1 rates.
On an USB 2.0 controller, standards can be mixed; a connected USB 1.1 device can operate
at USB1.1 speeds while a USB 2 device can operate simultaneously at USB 2 speed.
When purchasing a hub, make sure that you check their speed.
Cheaper hubs only operate at USB1.1 speeds.

## Using external hubs

External hubs are employed for two reasons:

### To connect multiple devices

If the handful of USB ports on a computer
are insufficient, hubs allow additional
devices to be connected.  In fact, up to 127
devices can connect to a single USB port if
hubs are used to expand the system.
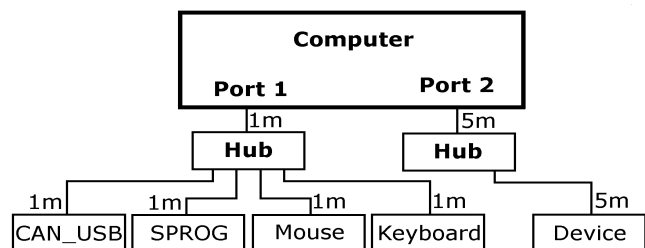
The diagram shows a PC with two USB ports.   Port 1 connects directly to a hub and this
has four outlets connected to typical USB devices.
If you have greater connections needs, you can replace one of the attached devices with
another hub.  This will provide further connection ports.   In this case, however, the original
hub will have to be a powered type, as an unpowered hub would be unable to handle the
anticipated extra power requirements.
In fact, USB supports a tiered network of hubs cascaded up to five levels, providing for a
maximum of 127 devices attached at any one time.   As expected, the port's bandwidth has
to be shared between all the devices connected to it.

### To overcome distance limitations

In the example, all the cables attaching devices to Port 1 are shown as short 1m lengths.
Due to timing restrictions, an individual USB cable cannot be longer than 5m.  In the
example, Port 2, connects to a hub over a 5m cable and the hub's connection to the device is

a further 5m in length.   The 10m coverage should be sufficient for most people's needs. However, the USB 2.0 specification allows up to five hubs to be connected in a long tiered daisy chain.   If 5m cables are used between each connection, the maximum distance can be extended to 30m (although why would you want to operate your layout from a computer sited almost 100ft away?).

**Note**

USB is marketed as being 'hot-swappable', with USB devices able be added and removed at any time.   This is not strictly true, otherwise Windows would not need to provide a *'Safely Remove Hardware'* facility!     The problem arises with the use of external storage devices. To prevent constant access to a hard drive, for example, software will not write data to it continually.  Instead it will store some data in its cache (a chunk of memory) and only send the data in chunks.   If the user removes a drive before all its data is successfully stored, the file on the drive can be corrupted.

This is not a problem for model railway electronics which do not handle such large blocks of data to requires caching, so for example MERG's CAN_USB module can be inserted/removed without any problems.

## What about Device Drivers?

There are many hardware devices that can connect to a computer and the computer has to be able to communicate with devices that have completely different methods of passing data. A device driver is a small piece of software that provides a properly functioning interface to a particular piece of computer equipment.  The equipment might be external such as a printer, plotter, digital camera or monitor – or it might be an internal such as a graphics card. Take, for example, connecting a printer to a computer.   There are a huge range of printers, past and present, of different types (inkjet, laser, plotters, etc.).   Even printers using the same basic technology may provide different facilities and employ different methods to achieve the same results. and offering different facilities.   Since it is not practical to write a separate version of a word-processing package to interface to each available model of printer, the solution lies in placing a piece of conversion software between the word-processing package and the computer's printer port.  This is called the 'device driver'. When the user prints a document, the material is processed by the driver software and sent to the printer in the specific format required by that particular printer model.

That explains why many products are packaged along with CDs containing their own device drivers.   Microsoft Windows includes many commonly-used drivers along with its operating system.   However, unusual devices, including those for model railways, are not included in Windows and have to be installed by the user.

The illustration shows a MERG CAN_USB3 module attached to a computer's USB port. A number of applications can communicate with this module, either working as a *'sniffer'* allowing the user to view messages coming in from the module (e.g. track occupancy information) or sending messages to the module to operate devices on the CAN bus.



FTDI, the company that manufacture the UM245R USB interface module used on the CAN_USB3 module, provide an appropriate royalty-free driver (VCOM or VCP- Virtual
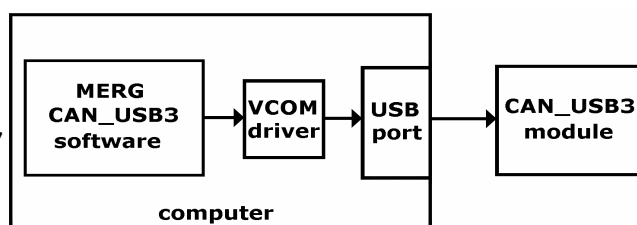
COM Port) from their website. It is packaged as the *'Combined Driver Model'.* This driver emulates a standard PC serial port, saving program writers from the many complications of handling USB communications.

When a user sends a message using the application software, the following things happen:

- The software writes a CAN bus message to the serial port.
- The VCOM driver intercepts this and translates it into a message for the USB port.
- The USB port sends the message to the CAN_USB3 module.
- The CAB_USB3 modules translates the message into a CAN bus message.
- The original CANbus message remains the same throughout the process; it is only the way the message is packaged that changes with each step.

Although it looks a bit over-complicated, it is the easiest way to do things, as many existing applications are written for serial ports. In addition, routines for reading/writing with serial ports are provided in a number of programming languages.

## Installing a device driver

There are a number of ways that a device driver can be installed

If Windows recognises the device, one of these happens:

- Windows automatically installs the specific associated driver from its own collection that was stored on the hard drive during the installation of the operating system.
- Windows automatically installs a generic driver (one that is common to many similar devices) from its collection.

In these cases, a message might pop up to inform the user that the device is successfully installed.

If Windows does not already have the driver, it gives the user three options:

- Windows will search the Internet for the driver, then install it.
- Windows will search the computer, or CD/DVD drive, looking for a folder that might have the driver stored there. If it finds it, Windows installs it.
- The user can tell Windows which folder to find the driver.

This may result the user being given the choice from a small menu of drivers and the user must select the one that exactly matches the device.

There are variations on this procedure. Some manufacturers specify that their driver should be installed prior to installing their device. Others place an auto-run, menu-driven installation routine on their CD. In some cases, the computer has to re-booted after installing a driver. Windows may prompt for a re-boot, or it may be stipulated in the device's manual.

### Note

Depending on the specific computer architecture, drivers can be 8-bit, 16-bit, 32-bit, or 64-bit. This corresponds directly to the architecture of the operating system for which those drivers were developed. For example, in 16-bit Windows 3.11, most drivers were 16-bit, while most drivers for 32-bit Windows XP are 32-bit. Modern 64-bit Linux and Windows versions have required hardware vendors to provide newer 64-bit drivers for their devices.

## Using a USB device with a USB port

Having read all the above, there is not much to say about this. Just plug the USB device into a USB port and, assuming that any necessary device driver is present, the device (and its controlling software) is ready to use. Examples here are memory sticks, Bluetooth and Wi-Fi dongles, mice and keyboards – not forgetting the CAN_USB3 module.

## Using a serial device with a USB port

At one time, all older computers had serial ports. While serial devices (e.g. the Servo4 and CAN_RS modules) are easily used with serial ports, they cannot be used with modern USB ports. This is solved with the use of a *'USB to serial adapter'*. It does what it says on the tin; it is a piece of hardware (often built into a cable) with one end plugging into the computer's USB socket and the other end plugging into a serial device. The adapter's hardware carries out the conversion between USB and serial formats.
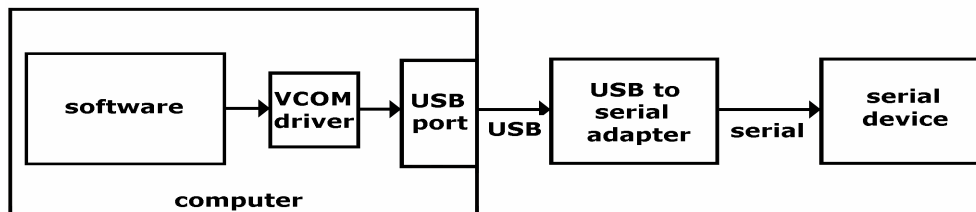


The illustration shows the steps involved in using a serial device (e.g. Servo4 module) on a modern computer that only has USB ports.

The module's control software writes to a serial port but, since the computer has no serial ports, the drivers and adapters are used to transport the data to USB and then back to serial before connecting to a serial device.
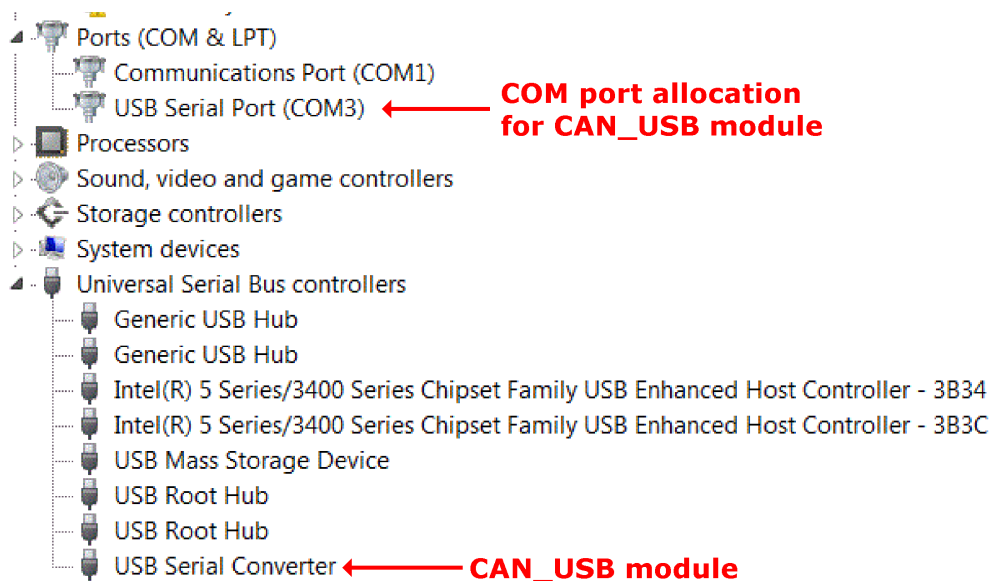
## COM ports

When software is run that accesses a serial (or in our case a virtual COM port), it asks which serial port is to be used with the application.

Although we are using a USB port for the external connection, the software still has to be allocated a serial port number to associate with the virtual driver.

Once a COM port is allocated, the process shown in the above illustration is established.

The illustration below shows the entries in Device Manager after connecting a CAN_BUS module.



In this example, COM3 has been automatically allocated to the module and this value is the one to enter into any application software when prompted for the COM port number.

Note

It cannot be assumed that the COM port allocated will be the same each time the device is plugged in. So, for example, if another device is already allocated to COM3, it will use the next available COM port. With a computer dedicated to layout control, such changes are less likely.
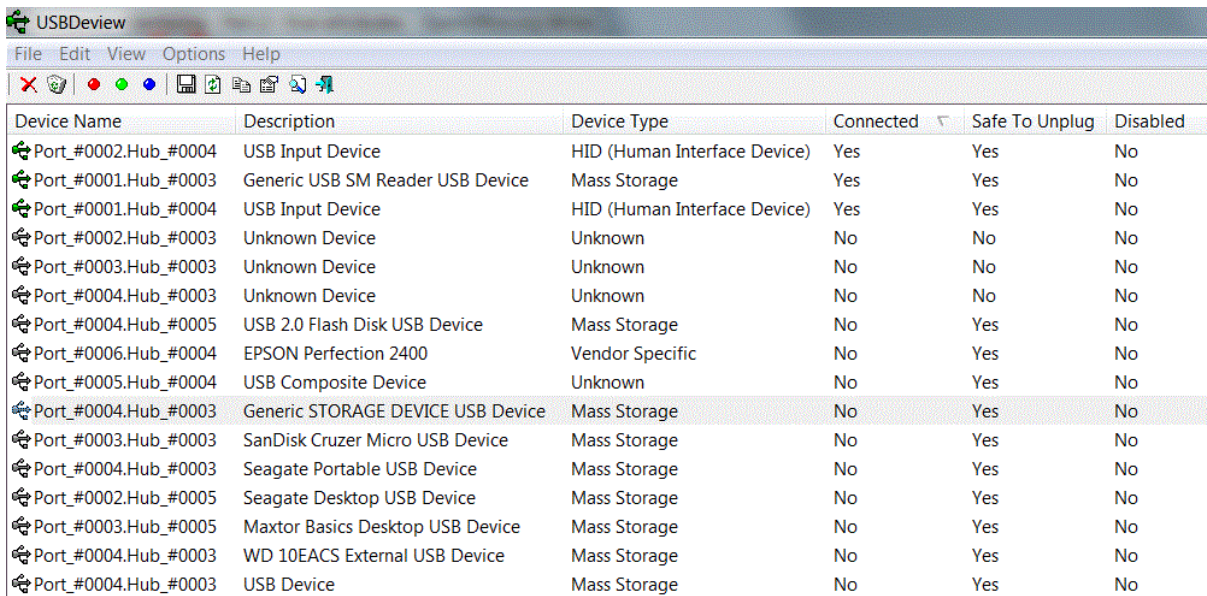
## USB Problems

As mentioned before. the serial port is a robust, if slow, communication mechanism. For example, if a serially-connected device temporarily lost power or had its serial cable temporarily disconnected, the port, the software and the modules would all work as normal as soon as the cable/power was restored. This without any additional action by the user. With USB, on the other hand, the loss of power or cable disconnection affects a USB connection badly. In both cases, the voltage from the device's pull-up resistors would be removed and the hub would detect this and disable the port. The usual remedy is to unplug and re-insert the USB cable, so that the device is detected and configured once again. As a consequence, the application software usually has to be restarted.

When a USB device is enabled, its driver software is located and loaded into memory. When that same device is unplugged, its port is freed and its driver is unloaded from memory.
However, the computer stills stores information about that device and its connection in the Windows Registry (use regedit to look under the 'Enum' key in the HKEY_LOCAL_MACHINE folder – but don't alter anything unless you know what you are doing).
The illustration shows a computer's USB enumerations, as viewed by USBDeview, a freeware utility that improves on Microsoft's USBview and on Device Manager. While Microsoft's USBview utility only allows viewing of port information, USBDeview has options to disable and/or uninstall device allocations (when run using Administrator rights).

| Device Name | Description | Device Type | Connected | Safe To Unplug | Disabled |
|---|---|---|---|---|---|
| Port_#0002.Hub_#0004 | USB Input Device | HID (Human Interface Device) | Yes | Yes | No |
| Port_#0001.Hub_#0003 | Generic USB SM Reader USB Device | Mass Storage | Yes | Yes | No |
| Port_#0001.Hub_#0004 | USB Input Device | HID (Human Interface Device) | Yes | Yes | No |
| Port_#0002.Hub_#0003 | Unknown Device | Unknown | No | No | No |
| Port_#0003.Hub_#0003 | Unknown Device | Unknown | No | No | No |
| Port_#0004.Hub_#0003 | Unknown Device | Unknown | No | No | No |
| Port_#0004.Hub_#0005 | USB 2.0 Flash Disk USB Device | Mass Storage | No | Yes | No |
| Port_#0006.Hub_#0004 | EPSON Perfection 2400 | Vendor Specific | No | Yes | No |
| Port_#0005.Hub_#0004 | USB Composite Device | Unknown | No | Yes | No |
| Port_#0004.Hub_#0003 | Generic STORAGE DEVICE USB Device | Mass Storage | No | Yes | No |
| Port_#0003.Hub_#0003 | SanDisk Cruzer Micro USB Device | Mass Storage | No | Yes | No |
| Port_#0004.Hub_#0003 | Seagate Portable USB Device | Mass Storage | No | Yes | No |
| Port_#0002.Hub_#0005 | Seagate Desktop USB Device | Mass Storage | No | Yes | No |
| Port_#0003.Hub_#0005 | Maxtor Basics Desktop USB Device | Mass Storage | No | Yes | No |
| Port_#0004.Hub_#0003 | WD 10EACS External USB Device | Mass Storage | No | Yes | No |
| Port_#0004.Hub_#0003 | USB Device | Mass Storage | No | Yes | No |

Note that only three devices are currently connected ( a mouse, keyboard and memory card reader). All other entries describe devices that were previously connected to various ports. Hub #003 is actually Hub 1, Hub #004 is actually Hub 2, while Hub #005 is an external hub.