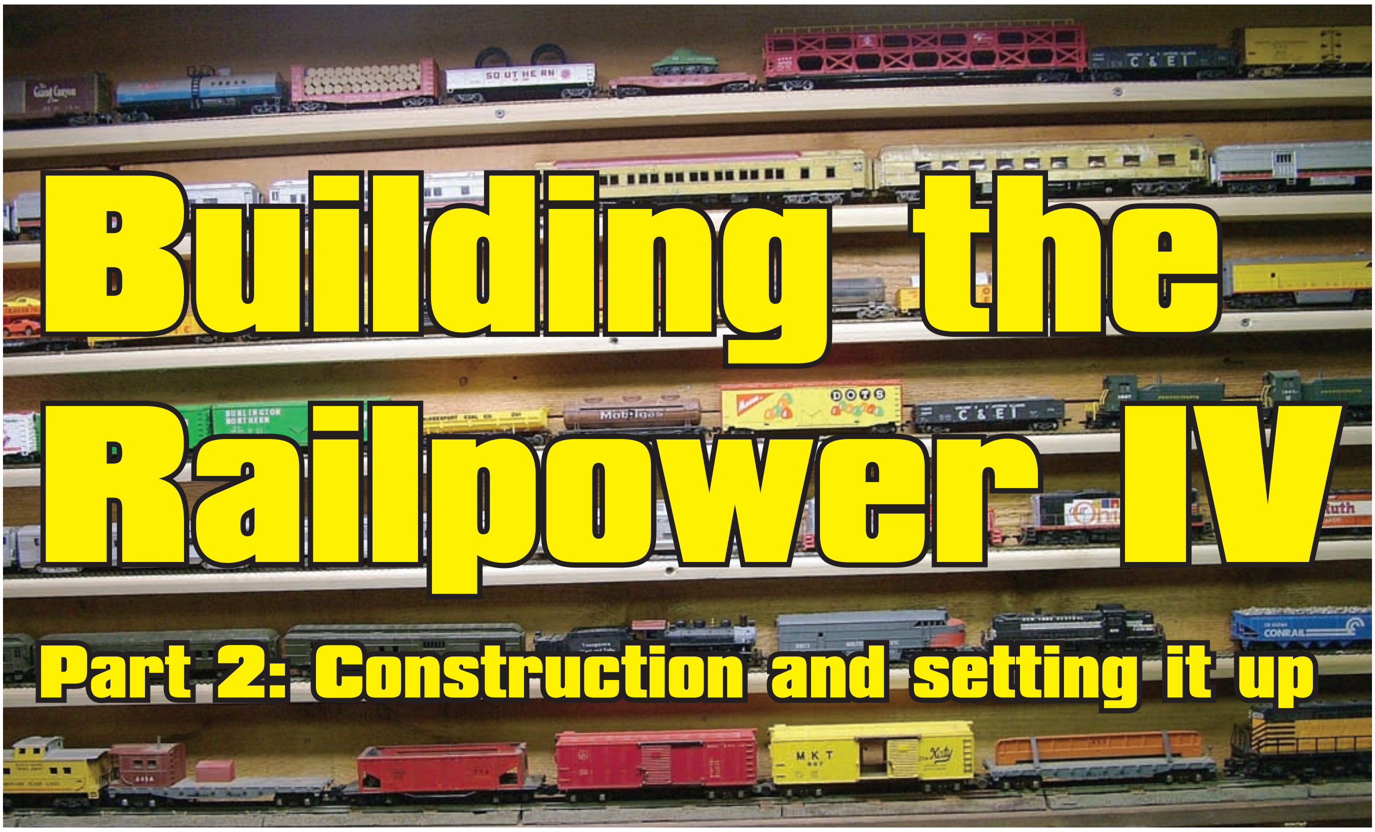


Building the Railpower IV

Part 2: Construction and setting it up

Last month, we presented the circuit, specifications and parts list for our new high-performance Railpower IV model train controller. Now it's time for the construction details – and we show you how to set it up for best performance.

Considering that the new Railpower IV has such a lot of features and gives great performance, its construction is relatively simple. This is mainly as a result of using the PIC16F88 microcontroller.

This latest design uses two PC boards. The main board accommodates the power transformer and most of the circuitry, including the microcontroller, while the vertically-mounted display board is for the LCD panel and four pushbutton switches.

The main control board measures 217mm × 102mm and is coded 773, while the display board is coded 774 and measures 141mm × 71mm. Both boards are available from the *EPE PCB Service*.

These PC boards are housed in a plastic instrument case measuring 260mm × 190mm × 80mm. The rear panel is made from aluminium sheet. It provides heatsinking for the four Darlington power transistors (Q1 to Q4) used in the H-bridge motor drive circuit.

You can begin construction by checking each of the PC boards for defects, such as shorts or breaks in the copper tracks and to see that all holes have been drilled correctly to suit the various components. The holes for the mounting screws, the LCD mounts and for REG1 need to be 3mm in diameter. The four holes to mount the transformer are 4mm in diameter.

Note that there are different mounting positions for the dual in-line (DIL) or the single in-line (SIL) type LCD modules; the board has been designed to accommodate either.

Main board assembly

The component layout diagram for the main control PC board is shown in Fig.3.

by JOHN CLARKE

Start construction by inserting the resistors in the main board, taking care to place each in its correct position. You can use the resistor colour code table (see last month's issue) as a guide to each value. You can also use a digital multimeter to check each resistor – this is a good idea because it is easy to misread colour codes.

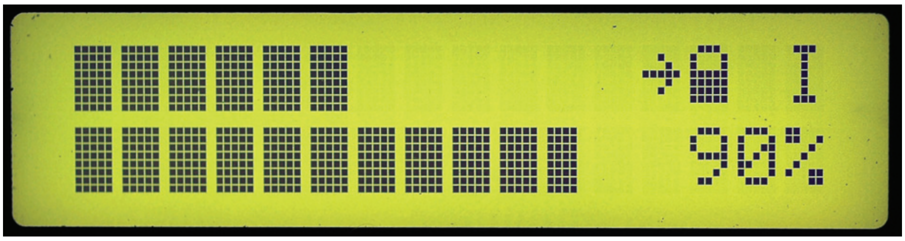
Next, install the wire links and the PC stakes for the motor outputs and the 'track' LED. A 3-way pin header is used for connecting speed potentiometer, VR1.

Install diodes D1 to D7, taking care with their orientation. Note that D1 to D4 are 1N5404 types, D5 and D6 are 1N4004 and D7 is a 1N4148. The socket for IC1 can now be mounted, taking care with its orientation (leave IC1 out of its socket for now). Then install IC2, again taking care with its orientation.

The capacitors can go in next. The five electrolytic types must be oriented with the polarity as shown – see Fig.3. The crystal can then be mounted, as well as the piezo siren.

The voltage regulator (REG1) is attached to the PC board together with a U-shaped finned heatsink. Bend the regulator leads at right angles to fit into the holes provided. First secure it with an M3 × 10mm screw and nut and then solder the three leads. Next, install trimpot VR2 (10kΩ), the 2-way screw terminal block (CON3) and the 10-way IDC vertical header (CON2), mounted with the orientation slot as shown.

The transistors can now be mounted on the board. All the small-signal transistors (Q5 to Q10) are BC337 types. Just push them in and solder the leads. The TO-220 transistors are BD650 (Q1 and Q2), while Q3 and Q4 are BD649s. Mount them with their full lead length and with about 1mm of lead below the PC board for soldering.



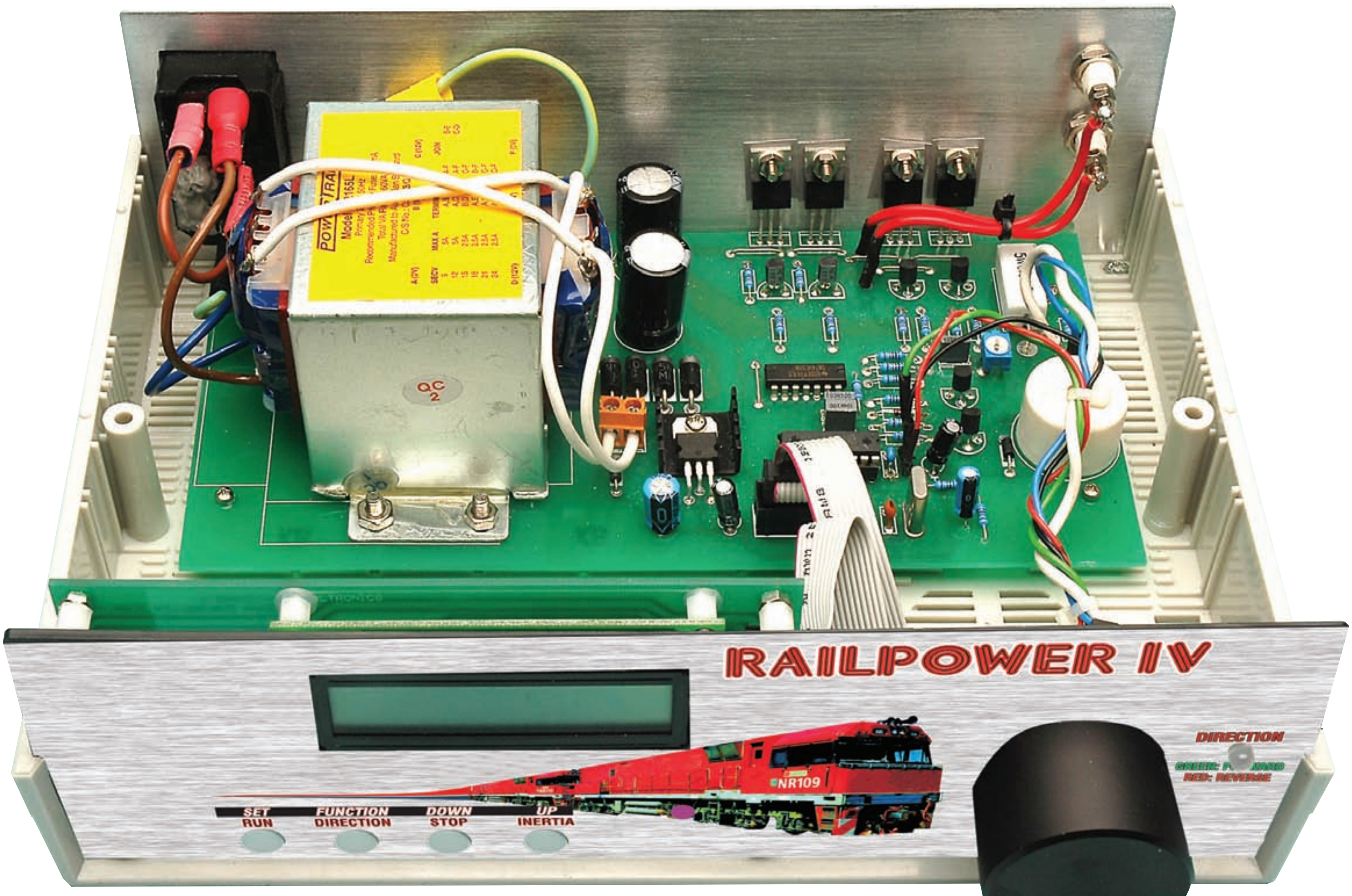
This is the two-line alphanumeric display (in this case the Jaycar model with backlight) which gives you all the information you need about your settings. Here it shows the train speed at about 56% of the maximum speed set (90%). Inertia is on (indicated by the 'I') and the lock is on (shown by the padlock being closed). As you enter other modes, the information on the display changes to reflect those modes.

Mains transfer

The power transformer (T1) is mounted on the PC board using four M4 screws and nuts. A 6.4mm spade terminal is attached to one corner, as shown, to earth the transformer body back to the rear panel – see Fig.6 and photos. You'll need to scrape off some of the varnish coating from around the hole. A star washer between the transformer mounting foot and the spade terminal then ensures a good contact.

To obtain the current rating required, two secondaries are wired in parallel, with *heavy-gauge* insulated hookup wire connecting the appropriate terminals, as shown in the photographs and in Fig.3.

Two wires, again *heavy duty* insulated hookup wire, are then run from the transformer secondary terminals to the adjacent 2-way screw terminal block (CON3). In fact, we used the same lengths of wire to connect the two terminals on the transformer and the terminal block.



Inside shot of the Railpower IV

Assembling the display board

Insert the five resistors and trimpot VR3 (10kΩ). The 100μF and 10μF 16V electrolytic capacitors must be laid on their sides before they are soldered into place.

The connections for the LCD modules are made with socket strip and with header terminal strips. You can use a 14-pin DIL (dual in-line) socket strip or a 14-pin SIL (single in-line) strip. This depends, of course, on which type of display module you will be using.

They can be made by cutting a 14-DIL IC socket to produce two 7-way strips. These can be placed side by side for the DIL or in-line for the SIL strip on the display PC board.

The header terminal strips are soldered to the LCD module. Install them with the longer pins sticking up through the LCD module PC board and then solder them in place on the topside of the module. The excess lead length on the topside is then cut short with side-cutters.

You can now plug the LCD into place on the display board. Secure the module using four tapped 6mm spacers plus nylon washers to increase height to about 7mm. These are secured in place with 8 M3 × 6mm screws.

The four pushbutton switches are mounted on the PC board, oriented with the flat side as shown in the component overlay diagram – see Fig.4. The infrared detector (IRD1) is mounted with its full lead length so it can be bent over at right angles. This means its lens lines up with the hole in the front panel. Finally, fit the 90-degree IDC connector (CON1).

You can make up the IDC lead with 10-way IDC cable, making sure that the red strip side is as shown on both the main board and display board sockets. The IDC cable can be compressed into its fittings by clamping up in a vice

Working on the case

Several holes need to be drilled in the front panel of the case for the pushbutton switches, the potentiometer and the IR detector (IRD1). A cut-out is also required for the LCD module – the size and location depend on whether the DIL type or the SIL LCD modules are used.

The larger holes can be initially drilled to 5mm to start with, and successively drilling larger holes. It can then be carefully reamed out to the required diameter. But why bother with all that? Why not use the correct size drill to make the holes in one go?

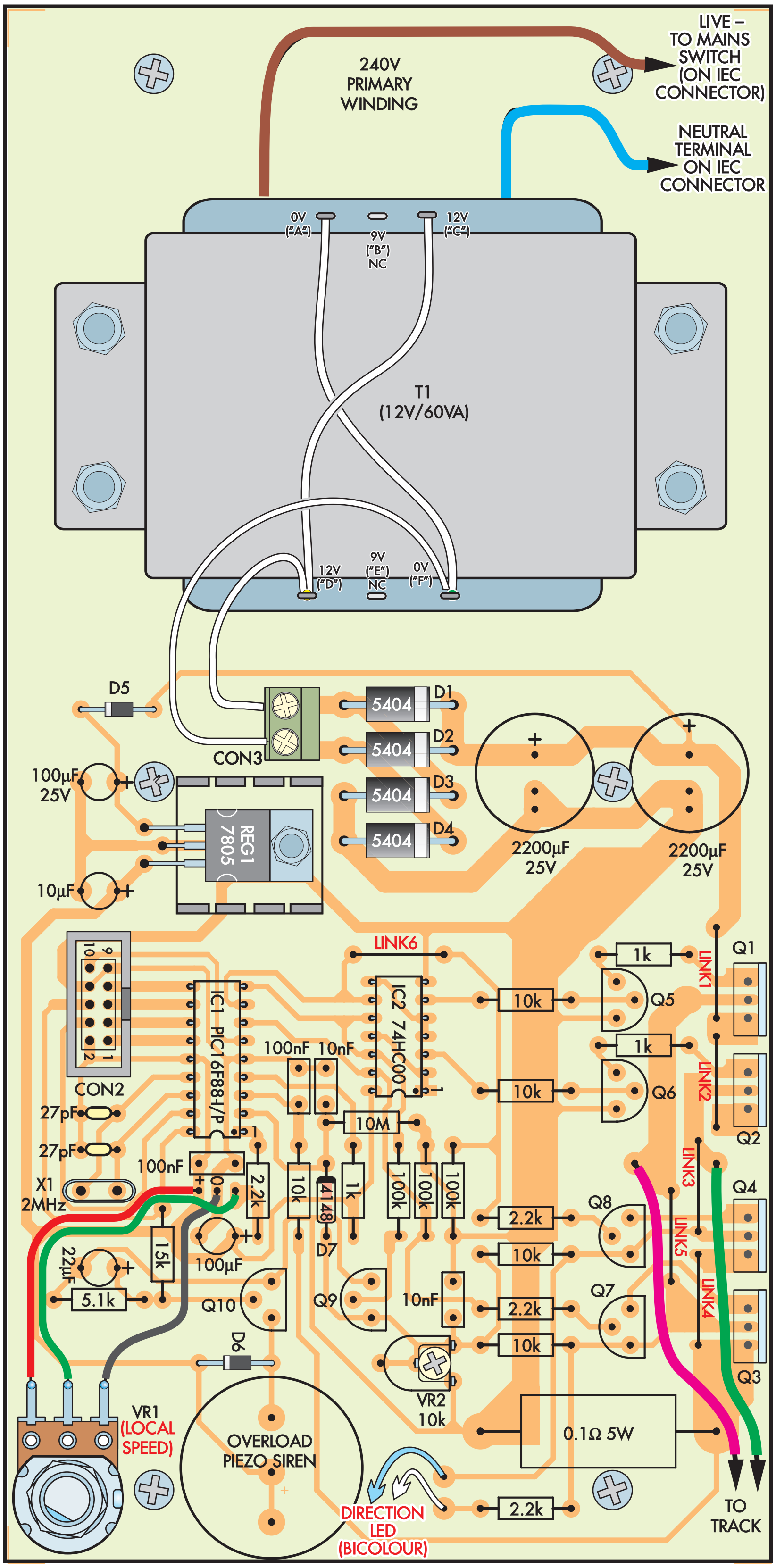
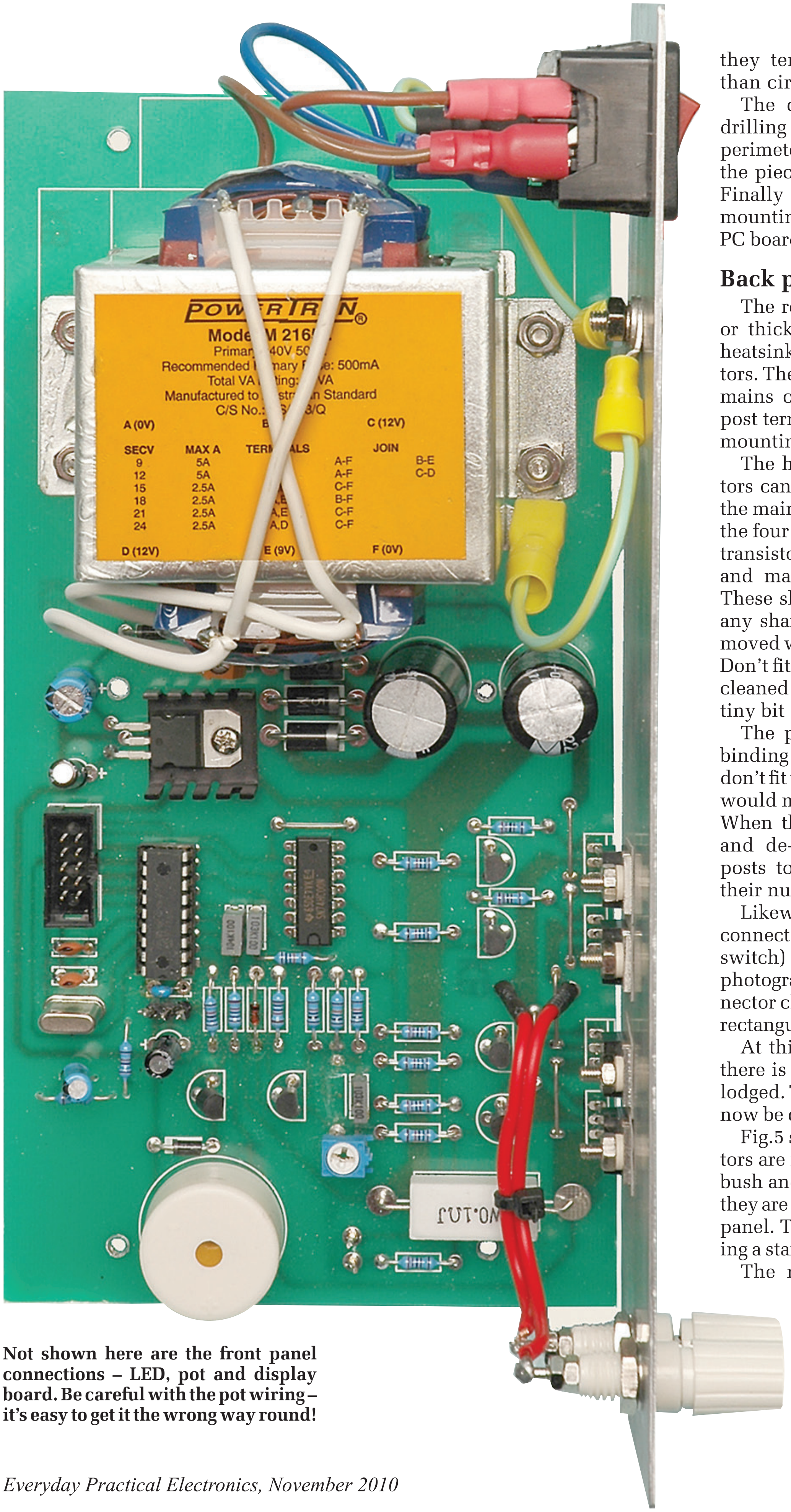


Fig.3: component overlay for the main PC board, with a similar-size photo at right for comparison. This has the back panel already fitted.

The reason is simply that it is almost impossible to drill large round holes in sheet material – usually



Not shown here are the front panel connections – LED, pot and display board. Be careful with the pot wiring – it's easy to get it the wrong way round!

they tend to be 'triangular' rather than circular.

The display cut-out is made by drilling a series of holes around the perimeter of the cut-out, knocking out the piece and then filing it to shape. Finally mark out and drill the four mounting positions for the display PC board.

Back panel

The rear panel is made from 1mm or thicker aluminium, to provide a heatsink for the four power transistors. The panel needs holes for the IEC mains connector, earth lug, binding post terminals and the four transistor mounting holes.

The hole positions for the transistors can be marked out by mounting the main PC board into the case using the four self-tapping screws. Push the transistors flat against the rear panel and mark out their hole positions. These should be drilled to 3mm and any sharp edges around the hole removed with a countersinking drill bit. Don't fit the transistors until you have cleaned up all the holes, just in case a tiny bit of swarf causes a short.

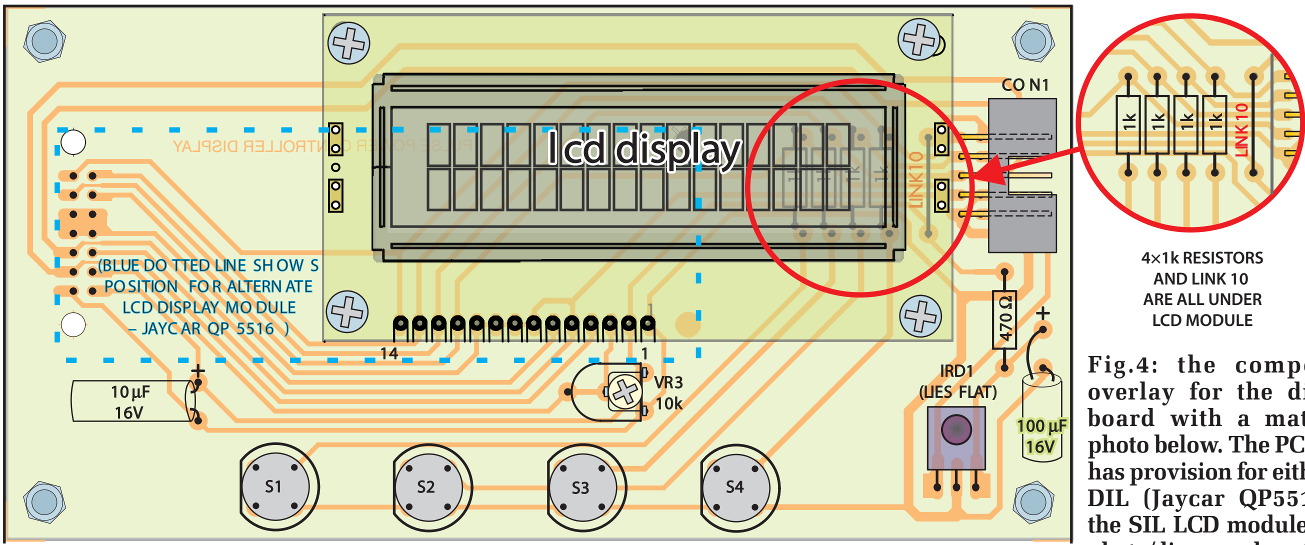
The position of the holes for the binding posts is not critical – just don't fit them too close together, which would make attaching wires difficult. When the holes are drilled, reamed and de-burred, attach the binding posts to the rear panel and tighten their nuts with a spanner.

Likewise, the position of the IEC connector (with its integral fuse and switch) is not too critical – use the photographs as a guide. The IEC connector clips into a 47 × 28mm vertical rectangular cutout.

At this size, it is a tight fit so that there is no likelihood of it being dislodged. The wiring inside the case can now be completed, as shown in Fig.6.

Fig.5 shows how the power transistors are mounted, using an insulating bush and washer as shown, to ensure they are insulated from the aluminium panel. The earth lugs are attached using a star washer between each eyelet.

The mains wiring is done with the brown and blue wires already connected to the specified transformer. Both are about 100mm longer than is required, so the offcut from the Live (brown) wire is used to make up the



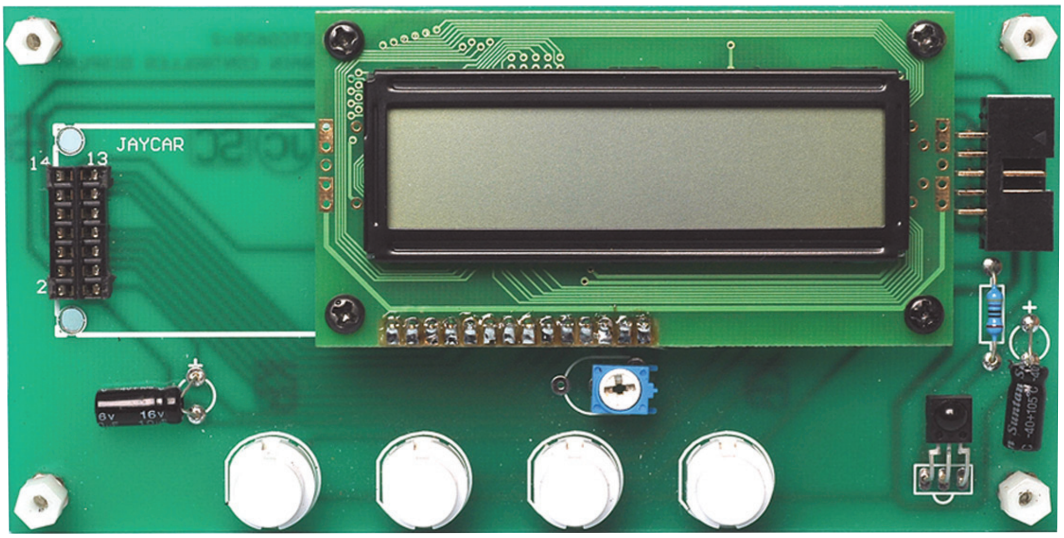


Fig.4: the component overlay for the display board with a matching photo below. The PC board has provision for either the DIL (Jaycar QP5516) or the SIL LCD modules, The photo/diagram show the SIL version, which connects to the PC board via a single row of 14 header sockets at the bottom of the display board. (The Jaycar version was shown in the photos last month. It connects via the dual row of sockets on the left side of the board). Note the inset above – four resistors and a link are actually under the SIL LCD module. Also note that for minimum height, the electrolytic capacitors and the infrared receiver (IRD1) are installed parallel with the PC board.

~50mm fuse-to-switch link on the back of the IEC connector.

Green/yellow-striped wire is used solely for the earth connections – one from the IEC socket earth pin to the rear panel, and one from the transformer to the same point on the rear panel. Together, these require only 150mm or so of wire. This coloured wire must not be used for any other wiring.

We used insulated 4.8mm crimped quick connectors for all wires going to the rear of the IEC connector, and insulated 6.4mm crimped quick connectors to the earth connections, as shown.

If for some reason you need to use any other wire for the mains wiring, ensure that is 250V AC-rated 7.5A wire, with brown used for Live and blue for Neutral.

For safety, all the mains wiring must be tied with cable ties so that they cannot come adrift. The exposed area at the rear of the IEC connector where the Live connects to the fuse should be covered with a liberal coating of neutral-cure silicone sealant.

The wiring to the transformer secondary and to the binding posts is made with heavy duty hookup wire. Note that the two 12V windings are connected in parallel. Connect the two 0V connections together and the two 12V connections together.

Before mounting and connecting the potentiometer, its shaft may need cutting to length to suit the knob to be used.

Power up

Note that the following tests and setup need the tracks connected and a 'loco' on them until indicated.

Check your wiring carefully, including the insulated covers over all the quick-connect terminals (these ensure that there are no dangerous voltages exposed with power connected, so that you can safely work on the project without it being sealed inside a case. There are no dangerous voltages on any tracks or pads on the PC board because the transformer is directly wired to the IEC connector).

Speaking of the IEC connector, make sure there is a 1A fuse inside its fuseholder. You open this by gently levering up the tab on the fuseholder

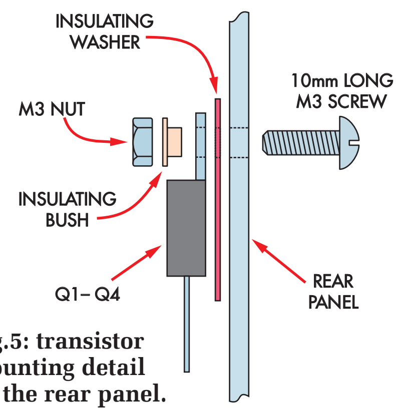


Fig.5: transistor mounting detail on the rear panel.

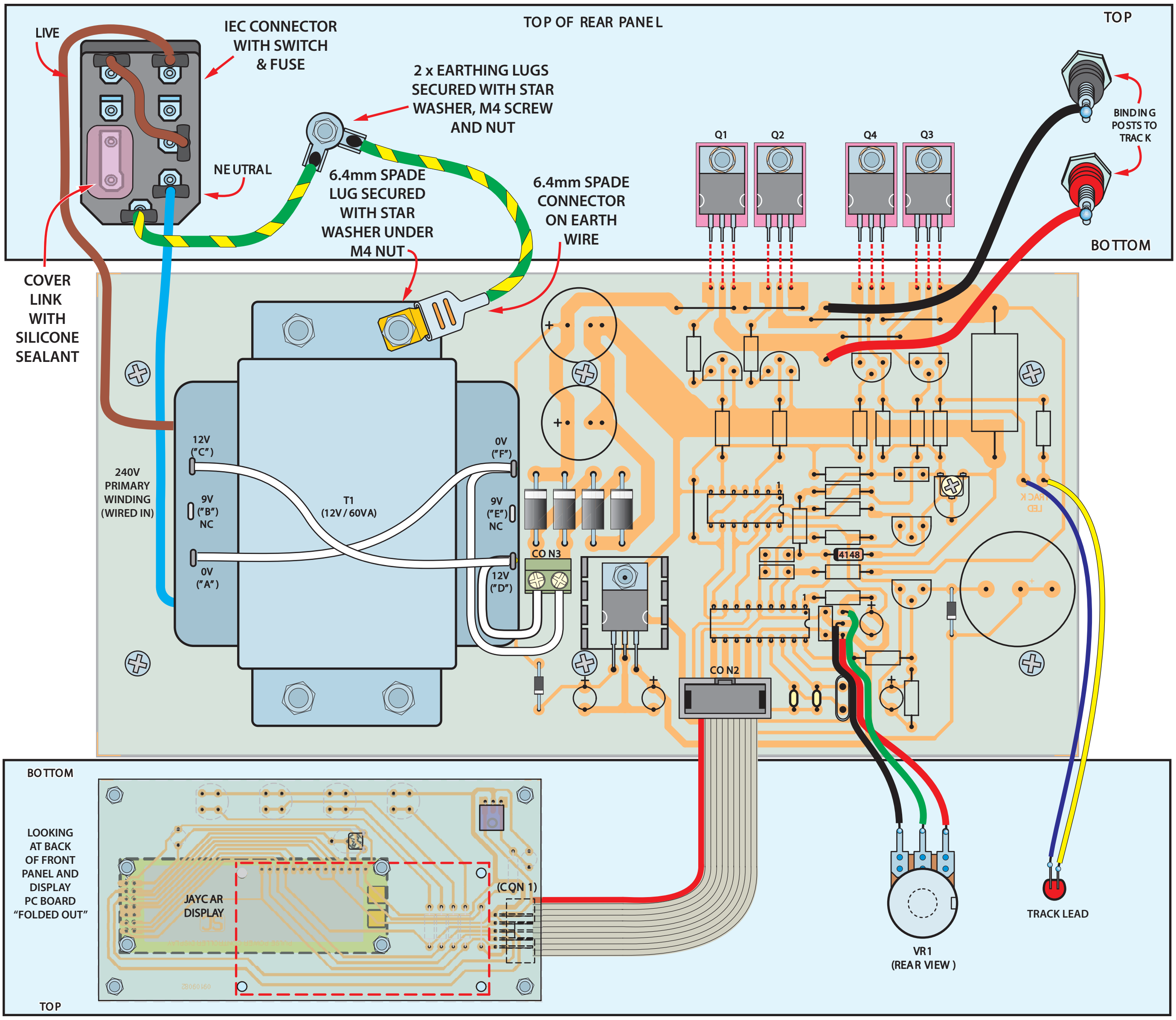


Fig.6: this 'opened out' view shows the wiring between the PC board and front/rear panels.

underside with a tiny flat screwdriver. And as mentioned earlier, IC1 should not yet be in its socket.

Apply power and check for 5V between pins 5 and 14 of IC1's socket. This may range between 4.9V and 5.1V. If the voltage is correct, switch off power and insert IC1 into its socket, taking care to install it the correct way around.

Reapply power and adjust trimpot VR3, so the LCD is easily viewed with good contrast. Note that you need to wait a few seconds after powering down before reapplying power. If you rapidly switch the power on and off, the LCD module may not reset correctly.

At this stage, the display should show a left arrow, an 'S' for stop and an 'I' for inertia on the top right of the display. The lower line of the display should show a bar graph and a percentage reading (0-100%) that varies depending on the setting of the Local Speed potentiometer (VR1).

The pushbutton switches below the display serve different functions depending on the Mode selected. At power up, the display is in RUN mode, where three of the switches control the Direction, Stop and Inertia.

If the Stop switch is pressed, then the 'S' should disappear and the top line will now begin to show a bargraph that increases slowly up to the speed setting value shown on the lower line. The Lockout (padlock) symbol will show as the speed increases beyond the first few bars on the top line. You should be able to switch the Inertia on and off with the Inertia switch and change the direction arrow when the speed is below the lockout speed. The direction will only change when the padlock lockout symbol is not showing.

If these tests are OK, then the display PC board can be attached to the front panel using 12mm tapped stand-offs and M3 screws. Countersunk screws are used on the panel for a flush finish.

Adjusting parameters

You are probably now ready to try out the controller on your model railway layout.

Connect the Railpower IV to the tracks by means of the terminals on the back panel and place a locomotive on them. Check that its speed can be controlled with the front panel knob.

At this stage, the maximum and minimum speed settings can be adjusted. To do this, press the Inertia

The Railpower IV rear panel, showing the positions of (from left) the track terminals, four transistor mounting bolts, earth bolt and the combination IEC mains input socket, fuse and power switch. Only the four transistor mounting bolt hole locations are critical – they need to line up with the transistors on the PC board. The IEC combo clips into a rectangular hole measuring 48 × 28mm – no screws are required.

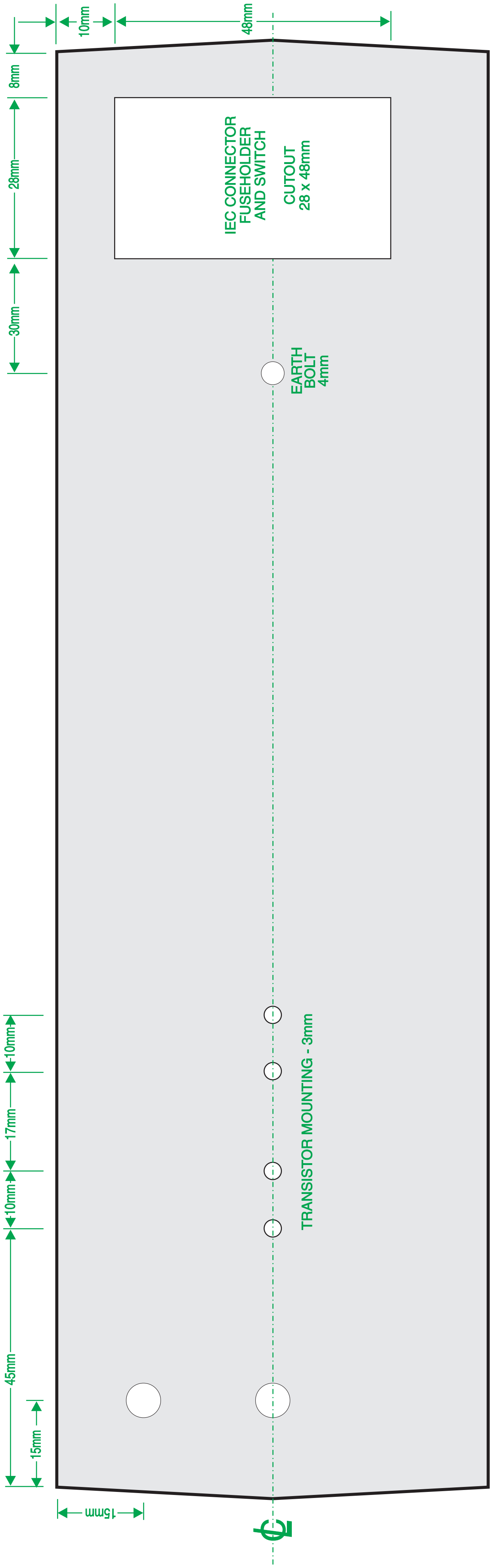
switch so that the 'I' is not displayed (inertia disabled). This will allow the locomotive to respond instantly to speed settings. Now press the RUN switch and the display will now show the SET mode in which the three right-most switches change their function to Function, Down and Up. Any changes made to the SET values are stored in memory unless they are changed again.

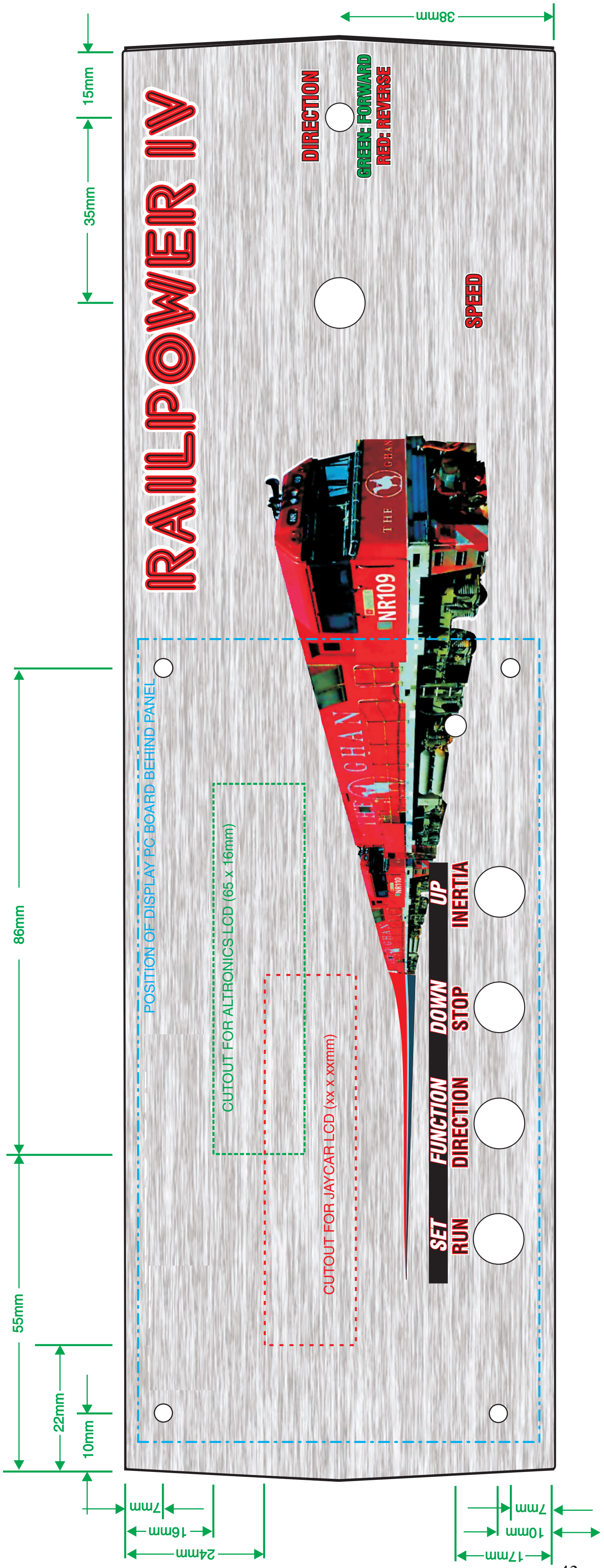
Each press of the Function switch selects the following:

MAXIMUM SPEED (self explanatory)
MINIMUM SPEED (self explanatory)
LOCKOUT SPEED (the maximum speed that reverse direction can invoke)
DEFAULT SPEED (the switch-on or default speed of the Railpower)
LOCAL/REMOTE (control is from front panel controls or infrared remote)
CODE TV (the code from your particular infrared remote – see the infrared remote instructions)
INERTIA (self explanatory)
STOP (self explanatory)
FEEDBACK (the degree to which back-EMF from the motor affects the Railpower)
SPEED RAMP (the rate at which the speed setting changes under remote control)
PULSE (the frequency of the interrupted DC going to the tracks)

Further details on what these mean and how to set them are shown in the programming panel on pages 44/45.

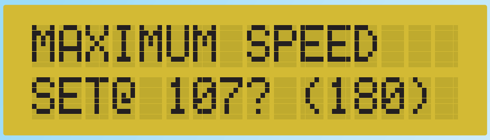
Opposite: Railpower IV front and rear panel drilling details, shown life size.


10mm
48mm
8mm
28mm
30mm
IEC CONNECTOR
FUSEHOLDER
AND SWITCH
CUTOUT
28 x 48mm
EARTH
BOLT
4mm
TRANSISTOR MOUNTING - 3mm
10mm
17mm
10mm
45mm
15mm
15mm


38mm
15mm
35mm
RAILPOWER IV
DIRECTION
GREEN: FORWARD
RED: REVERSE
SPEED
NR109
POSITION OF DISPLAY PC BOARD BEHIND PANEL
CUTOUT FOR ALTRONICS LCD (65 x 16mm)
CUTOUT FOR JAYCAR LCD (xx x xxmm)
UP
INERTIA
DOWN
STOP
FUNCTION
DIRECTION
SET
RUN
86mm
55mm
22mm
10mm
7mm
16mm
24mm
7mm
10mm
17mm

PROGRAMMING YOUR RAILPOWER IV

Maximum Speed



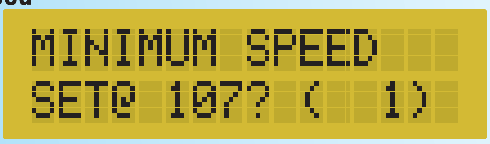
Press the Function switch until MAXIMUM SPEED is displayed on the top line of the display. The lower line shows SET@ 107? (180). The value 107 could be any number between 0 and 204 depending on the position of the Local Speed potentiometer. The number in brackets is the original default setting or your previous maximum speed setting.

Typically, you will want no more than 12V DC applied if you are running HO or OO-scale locomotives, and no more than 9V DC if you are running N gauge. If in doubt, check the manufacturer's recommendations. In fact, running an HO scale locomotive at its maximum of 12V will normally result in a scale speed of 180km/h, so for the sake of realism and safety, you might want to reduce it somewhat.

To set the maximum speed, wind up the Speed control until you get the desired DC voltage across the locomotive's motor, or you obtain the maximum speed you require. Depending on the different types of locomotive on your layout, the MAXIMUM SPEED setting may have to be a compromise.

Once you have obtained the desired value, press the Up or Down switch and the display will momentarily show LOADED. Thus, the new maximum speed setting will be loaded and shown in brackets. The motor will now run up to this new maximum speed setting.

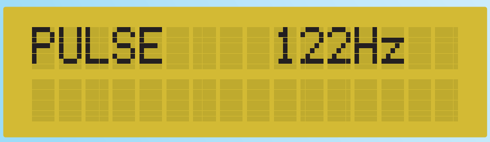
Minimum Speed



Now select MINIMUM SPEED and you go through the same process. In this case, the lower line shows SET@ 107? (1). Again, the 107 could be any number between 0 and 204 depending on the position of VR1, while the number in brackets is the actual minimum speed setting. Adjust the Speed control to a low setting that is just at the point where the motor stops (or is about to start) The SET@ reading will probably be around 1 to 5, or maybe higher with motors that require more voltage to start. Again, you can store this value by pressing the Up or Down switch and the word LOADED will appear briefly. The stored value will show in the bracketed section of the display.

Pulse

At this point you will probably become aware of the noise the locomotive makes at the low speed settings. If it is quite apparent, you may want to change the PULSE setting. Initially, it will be 122Hz and that is probably the optimum setting with most model locomotives, but give it a try at 488Hz or 1953Hz.



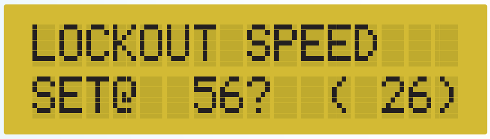
Once you have decided on the PULSE frequency setting, you may need to go back and reset the MINIMUM SPEED. You cannot have the minimum speed setting the same as or larger than the maximum speed setting. If you make a mistake here, you need to redo the adjustments. Generally speaking, you would need to initially select 204 for the maximum and 0 for the minimum values first before readjusting the minimum and maximum values again for your requirements.

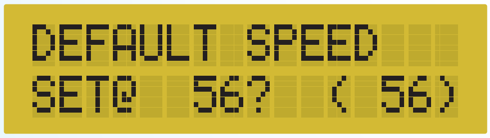
Note that while the displayed numbers range from 0 through to 204 in increments of 1, the actual control is over 816 values. So, depending on the resolution of the Speed control potentiometer, it is possible to obtain up to four speed settings between each value increment on the display. This extra resolution can be useful for the minimum speed setting. The stored values include this extra resolution.

Note also that if you are using a standard 16mm potentiometer for the Speed control, this fine resolution probably will not be possible.

Lockout and Default

LOCKOUT and DEFAULT speeds can now be adjusted.



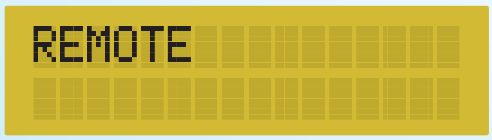


Lockout sets the speed above which forward and reverse changes are prevented, ie, 'locked out'. We suggest that you set it to a very low speed, similar to that used in shunting.

The Default setting is the speed that is applied each time you turn on the Railpower when the remote control is used. It does not apply when you are using the front panel Speed control (local).

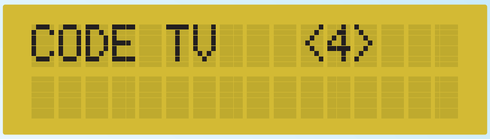
Initial default settings for Maximum, Minimum, Lockout and Default are 180, 1, 8 and 64, respectively.

Local/Remote



The Local/Remote setting selects whether speed is controlled via the front panel Speed control or the infrared remote control. You can toggle between either setting using the Up or Down switches.

Code

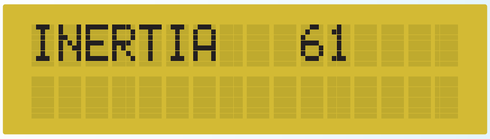


Next, you need to select the CODE for the infrared remote control. You can select between TV, SAT1 or SAT2 using the Down switch. Normally, TV would be selected (the default setting). SAT1 or SAT2 are used when you have more than one Railpower controller used on the same layout vicinity.

Note that there is a number in brackets (0 to 9) following the code selection. This sets the rate at which the Railpower decodes the infrared data, because some remote units are slow or fast compared with the correct data transmission rate of the RC5 code. The number can be changed using the Up switch. In practice, you select the number that works best with your remote unit.

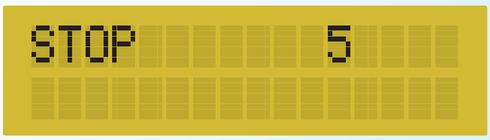
Note that if you press the RUN/SET switch, the display is returned to the RUN mode showing the speed settings. You can then test the remote unit for reliability. You can quickly toggle between the settings mode and the CODE selection using the Mode switch.

Inertia



INERTIA is the next selection. This selects the rate at which a locomotive changes its speed (accelerate or decelerate). The number is adjustable from 0 to 100, using the Up and Down switches. You will want to try several different values, depending on the size of your layout and the locomotives and length of the trains to be run. If you are using Inertia value of 60 or more, the locomotive will take several minutes to reach its set speed from a complete stop, or to go from the set speed to stop.

Stop



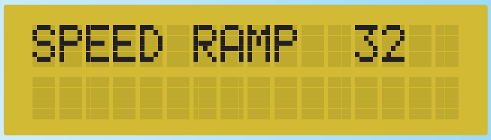
The Stop value is selected next, and is the rate at which the locomotive comes to a halt when the Stop button is pressed. It also can be adjusted from between 0 and 100, but typically you will not want to use very high values otherwise it is too difficult to judge just when and where the locomotive will come to a halt.

Feedback

The Feedback value can be set between 0 and 100 and corresponds to the degree that the motor back-EMF affects speed regulation. A low value will mean that the locomotive will tend to slow down more when pulling a train up an incline. Hence, the setting you use will be a compromise between ease of running trains around the layout versus reality, ie, a heavy train should slow down when going up a hill unless the throttle is advanced.

Trimpot VR2 also needs to be adjusted to provide optimum control. Generally, VR2 is set so the motor speed does not change much (when set to a slow speed) between feedback values from 0 to around 40 or 50. If in doubt, just set VR2 is to mid-point.

Speed Ramp



The Speed Ramp value, adjustable from 0 to 255, selects the rate at which the Speed Setting will change when under infrared remote control. If 0 is selected, the speed setting will change slowly under remote control.

In practice, a setting between 10 and 20 is fine. Any faster than that and you will find it tricky to make small changes in speed.

Universal remote controls

Further testing requires a universal or 'pre-programmed' remote control. In this case, one with very few controls is the way to go. If you are going to build only one Railpower for your layout we suggest the AR-1703 from Jaycar. It is small and only has the control buttons you need. However, it does have one drawback, and that is that it can only be used for the TV code.

If you intend to have more than one Railpower on your layout, you will need a remote control with the SAT1 and SAT2 codes available.

Programming the remote

The best approach to programming the remote control is to initially program it for a Philips brand TV (just follow the instructions supplied with the unit). In most cases, programming involves simultaneously pressing the 'Set' button and the button for the item that is to be operated. In other words, press the 'Set' and 'TV' buttons together and enter a number for a Philips TV set.

For the Jaycar AR-1703 remote use 11414. If you are using a different remote control, just select a number for a Philips TV set. If you later find that this doesn't work, try another number for a Philips TV.

Having programmed the remote, check that the Speed can be raised or lowered when the Volume Up and Down buttons are pressed. Check that the directions can be changed with the channel Up and Down buttons. Also check that the Mute button stops the loco and the Operate button switches Inertia on and off.