

## The DC Co-Pilot System

### MR Innovations Ltd DC Automation Installation and operating instructions.

The system is designed to automate a DC Model railway layout. It is suitable for O, OO, HO, TT120 and N gauges and Garden Railways. The usual DC rules apply such that locos move only when there is power applied to the track. Typically this means only one Loco moves at a time with sidings isolated or powered depending on the position of the points or 'turnouts'.

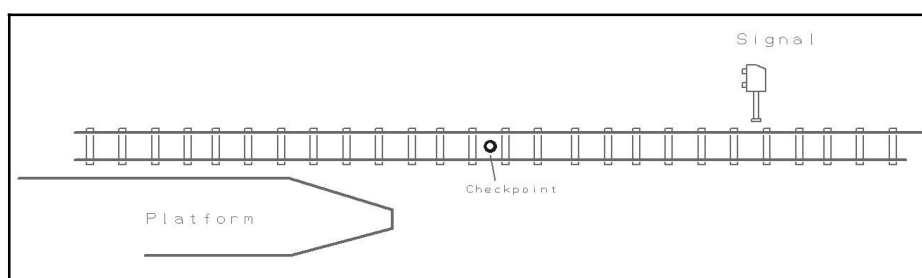
The system allows you to record and playback a train movement routine, thus creating storylines and making the layout come to life rather than just having the loco go round and round or shuttle at a fixed speed. Recorded routines include signals and points.

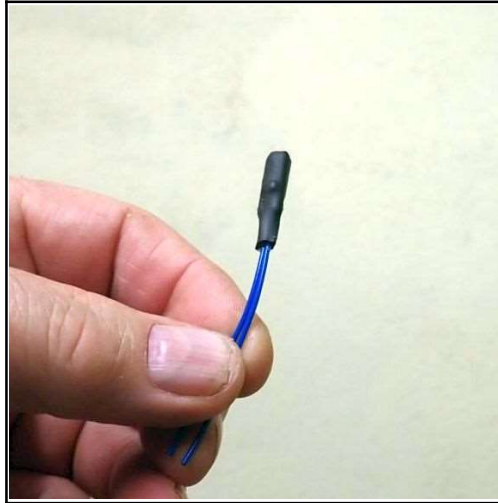
The recorded routine can be played back as many times as you wish and there is a repeat function that will automatically repeat the routine until you intervene.

The system relies on fitting Checkpoints between the rails at strategic places and fixing a small magnet to the underside of any loco. The more checkpoints fitted, the greater the positioning accuracy. Positioning accuracy is up to 2% of the distance between checkpoints, so if they are 1 metre apart then you will get a stopping accuracy of better than 20mm, the error is not accumulative eg its only between 2 checkpoints. We recommend a spacing of up to 1m in the countryside and 500mm around stations and sidings. The actual positions are not critical but you might want to fit them just before a station and say, 150mm into a siding. For a simple diorama you can get away with 1 checkpoint.

### Fitting Checkpoints.

An ideal place to fit a checkpoint is just outside a platform and before a signal as shown below.





These go end-on between the rails on the centre line and the top of the checkpoint should be level with the top of the sleepers.

The checkpoint in the photo needs a 5mm hole drilled. 4.5mm works too, but can be a bit tight. Black encapsulated checkpoints are 6mm. It should be easy to push the checkpoint up through the baseboard and glued in at a height level with the top of the sleepers.

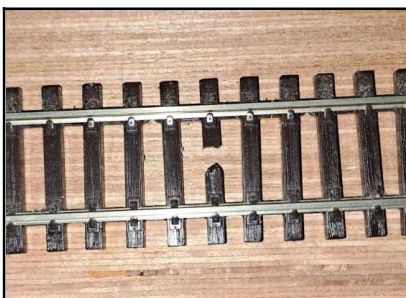
If, when fitting, you need to push the checkpoint down to enlarge the hole use a drill bit rather than a screwdriver.

The 2 wires from the checkpoint are not polarity sensitive, they can be connected either way round to the Sens terminals of the checkpoint connector.

For retrofitting you may choose to remove a sleeper or at least part of it with a scalpel, or fit a checkpoint between the sleepers if you prefer.

You can paint the top of the checkpoint or cover it with ballast, This will not affect the performance.

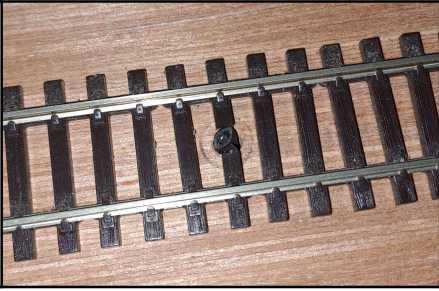
They might look like detonators but they are perfectly safe!! They are the key to the system working as well as it does.



Cut a piece from the centre of a sleeper

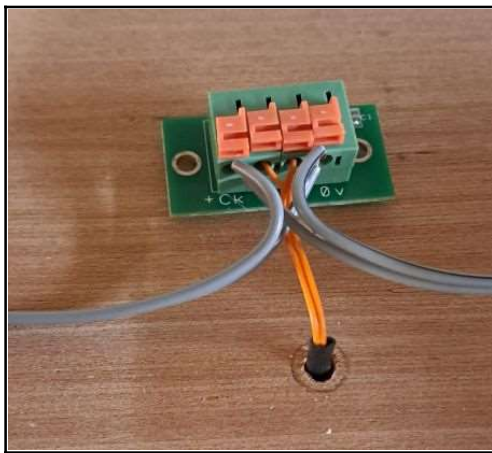
Drill a hole through the baseboard





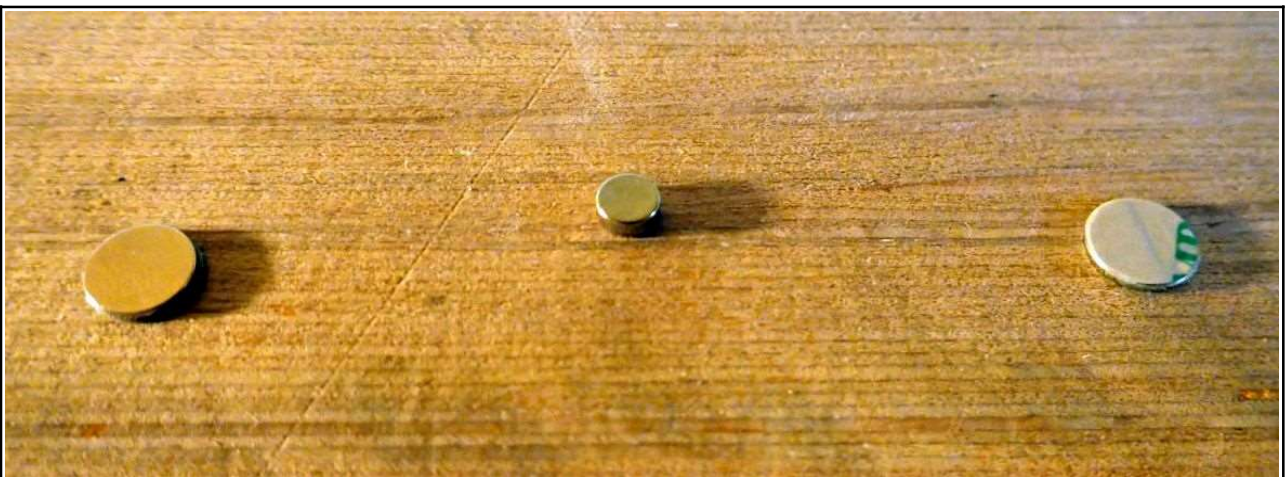
Checkpoint level with the top of the sleepers.

The checkpoint goes to the middle 2 connections, the polarity is not critical. Use ordinary Bell wire for the checkpoint string In and Out.



All checkpoints in a system are connected in parallel.

### Fitting the magnets.



Magnets are fitted to the underside of any loco, tender or indeed carriage. It makes sense to fit between the front bogeys. Superglue works well. The magnet on the right above has a self-adhesive back. The North / South polarity of the magnet is not important as the checkpoints respond to either. You should aim for a clearance between the magnet and the checkpoint of 2 to 4 mm. We can supply magnets either 8mmx2mm or 5mm x 2mm. For N-gauge then the 5mm diameter magnet is called for. See List

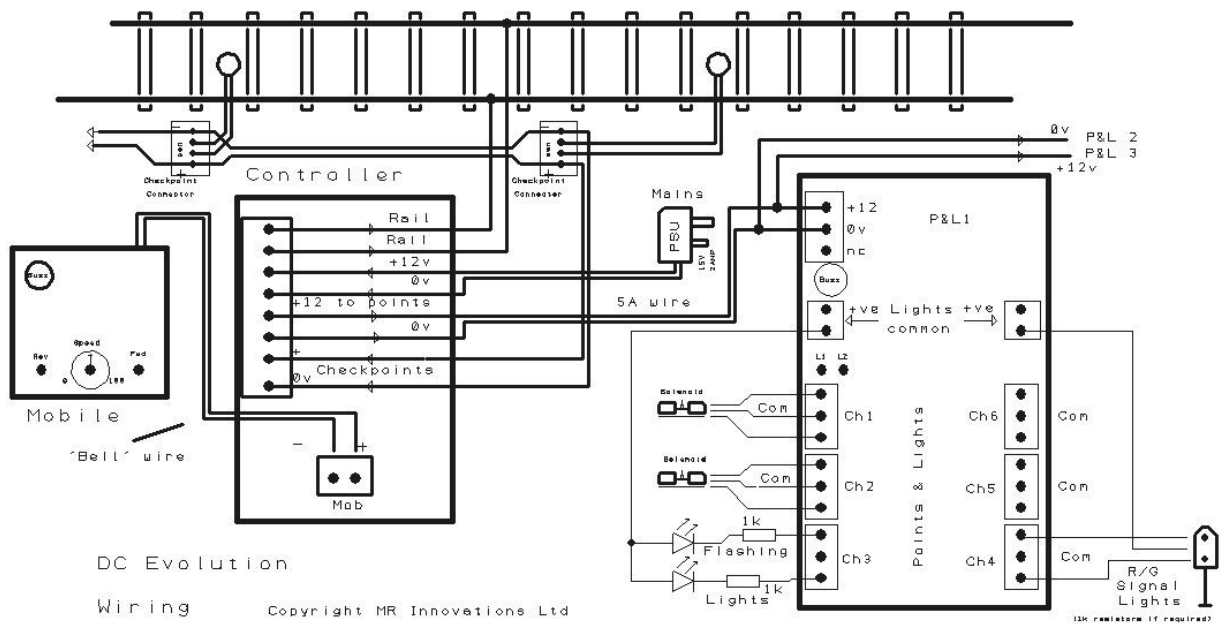
In record mode the handset beeps when a checkpoint is activated showing that the magnet has done its job.



### **The wiring**

This circuit is available on the [www.dc-co-pilot.co.uk](http://www.dc-co-pilot.co.uk) website as a PDF Download.





## The Power Supply

This must be 12v at 2A DC Short Circuit protected and Type approved

## Connecting the controller to the Rails

This is a 2-wire connection from the controller and the polarity is not important except that your layout will have a preference to which is Forward and which is Reverse. Swap the wires over to suit. The controller is short-circuit protected and will trip out if there's a short across the lines and resume when the short is removed.

## The 'Mobile' or Handheld unit

This connects to the main controller via a piece of bell wire, just 2 connections but you must observe the polarity.

## The Points and Signals board(s)

These connect to the controller with bell wire as shown, observe the polarity. Commands to and from the points and signals board and the mobile (Handheld) are superimposed upon the supply voltage to minimise the wiring.

There are 6 channels per board. These can be all points, all flashing signals or all fixed signals (Red/Green) or a combination of these 3 functions. The common wire from **Points** goes to the centre connector of its channel. The common wires from **Signals** go to any of the separate 4 lights common connectors as the voltage is different for LEDs. Wires to the P&S board from the point must be 1mm cross sectional area to avoid voltage drop and the point not working for up to 5m run.

Most manufactured signals have built in resistors in series with the LEDs, if you make your own you will need to fit a 1k 1/4W resistor in series with each LED.

## **Setting up**

To get familiar with the system **it is highly recommended that you start small before building up to more complex arrangements.** In fact you might like to assemble a small diorama set up to gain experience.

In your layout you need to allocate a permanent number to each set of points starting with 1 and each set of signals starting with 1, flashing signals first. You also need to decide on what is to be your main line, as the points will reset to mainline automatically before a recording and playback starts. This often involves swapping over the solenoid wires to connections 1 and 3 in its channel so that the solenoids set the points to the mainline. You won't necessarily know which is the right way round until you switch on and follow the set up instructions.

Always allocate channels in this order.

- 1st) Points
- 2nd) Flashing signals
- 3rd) Fixed signals (Red/Green)

Lets assume you have one P&S board to control 3 points, one pair of flashing lights and 2 signals.

In this case you should connect the points to Ch1, 2 and 3, the flashing lights to Ch4 and the signals to Ch5 and Ch6. The common wires for the signals connect to any of the 4 lights common terminals and not the centre channel common. You could daisy-chain the lights commons under the board and take one wire to a Lights common terminal if you wish. If you wire it up wrong then you'll get a continuous long tone from the beeper.

## **Setting up the Points & Signals (P&S) board.**

The controller needs to know how many points and how many flashing signals you have. Any spare channels default to fixed signals (Red/Green), This is done via the handheld or mobile unit.

Once you have told the controller how many points and signals you have then it will remember this information. You would only need to re-enter the information if you later add a new siding or signal.

When entering commands from the handheld unit press the numbers reasonably quickly so that a number such as 121 is sent in under 2 seconds ensuring you get 121 – beep - and not 1 – beep 21 beep. The beep indicates the number has been received.

The following commands set up the system

Using our example of 3 points, one flashing and 2 fixed signals you would do the following

121=start points address, 121 beep 1 (start at 1)  
122=start signals address, 122 beep 1 (start at 1)

123= number of points, 123 beep 3 (I have 3 sets of points)

124= number of flashing signals, 124 beep 1 (I have 1 set of flashing lights)

You don't need to tell the controller that you have 2 fixed signals as any remaining channels on a board are automatically set as Red/Green signals.

Test the points and signals are switching correctly by going to Manual Mode – C -

Press – D – this toggles the mode between points and signals where a long beep tells you that you are in Points mode, and a short beep tells you that you are in Signals mode.

In points mode, press 1 and points 1 should change state. A short beep means SET and a long beep means UNSET. Let UNSET be the mainline position. The same applies to signals. For signals make UNSET mean flashing signals OFF and Fixed signals RED.

Sending 127 from the handheld will reset the system to default as if you'd just switched on. This is handy if you've got in a bit of a mess with the points and lights and want to be sure its a clean sheet. The memory for the number of points and flashing signals is retained so you don't need to enter these again

128 clears the signals to default and clears any signals recordings. Enter this number and wait for the long beep.

Notes:

1) Only solenoid type points actuators are supported by the system.

2) Lights can be flashing such as warning lights on a level crossing as well as the Stop/Go Red and Green signal lights.

3) Up to 25 points channels are supported

4) Up to 25 lights channels are supported – combinations of flashing and signal.

5) There is no limit to the number of checkpoints in a system. Minimum is 1.

6) The points board has a capacitor discharge unit operating at 18v and takes up to 3 seconds to fully recover after a points operation.

## **Operating in Manual Mode**

When you switch on from cold the lights on the handheld unit will flash left-right green until its ready. The previously recorded routine will be retained.

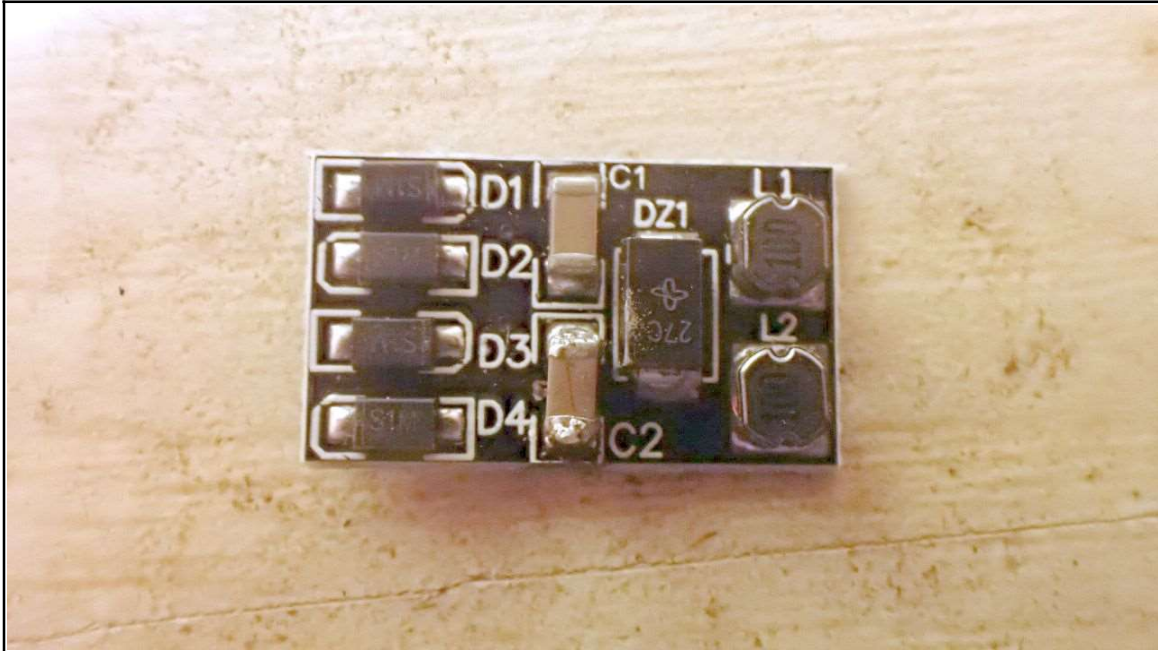
Press C for manual mode.

If the loco is stopped and the system is set to reverse then you will hear a beep – beep – beep. This is to remind you that if you turn up the speed control the loco will go backwards. As soon as the loco starts moving the beep will stop. Very handy feature! Press STAR (\*) to change to Forward. Notice there is a built-in acceleration and deceleration characteristic (adjustable). Emergency stop is the # button. Press # again to cancel Estop

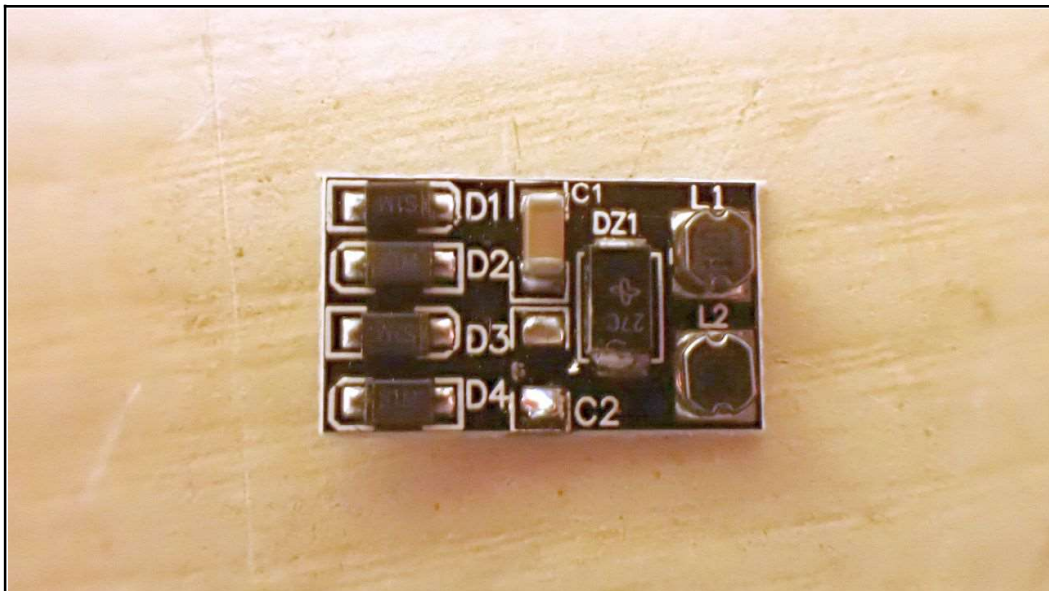
In manual mode button D toggles between Points and Lights. Long beep for points and short for lights. To change a point in manual mode press D until you hear a long beep. (points mode) Then press 1 to toggle points No1, press 2 for points No2 and 3 for points No3. You may need to do this a couple of times after playing back a routine.

## Locos with DCC Ready pcbs fitted

Some locos are supplied ready for DCC and have a dummy pcb fitted in them like the one below.



This one is in the Hornby TT120 Flying Scotsman and also the Mallard, in the tender. To use this with our system **you must remove C2** as shown below



Our system detects the presence of C2 and will emit a series of long beeps and shut down every few seconds until its removed.



## Recording a routine

Make sure the loco is at your preferred start position, probably waiting in a station. You should have a checkpoint just outside the station and perhaps a signal light just beyond that.

Press A the loco will proceed automatically and when it goes over the checkpoint a beep will sound this is the Datum checkpoint for this recording. The loco will stop unless you've turned up the speed control a little. Proceed with the routine, beeps will occur when you go over a checkpoint. During record the controller will be in points mode, we record signals afterwards. Operate the speed, waiting, reversing and points as you wish but remember to return to the original station at the end of the routine. This ensures that the first checkpoint encountered on playback is the same one as on record. Press C to end the recording and return to manual mode.

Check whether you are happy with the routine before adding the signals by pressing B and observe the miracle of automation!! At the end of playback a long beep will sound.

Routines can be up to 12 mins long which should be plenty.

*To repeat, finish a routine in the same zone between checkpoints that was used to start the recording. This ensures that the first checkpoint encountered on playback is the same one that it was on record. - This is a RULE!!*

If your routine involves more than one loco then at the end of the routine loco 2, or locos 2 and 3 MUST end up parked within 25mm of their ORIGINAL positions otherwise when you play back they may be too far away from the next checkpoint for the slippage correction to work. This doesn't apply to Loco 1 as it only needs to be in the original zone between checkpoints so that it sees the first checkpoint encountered as Datum on both Record and Playback.

## Adding Signals

If there are previous signals commands recorded 128 wipes them back to default

In manual mode press 130 to tell the recorder to record Signals..

The routine will automatically start, get ready to switch the signals on and off, in our example No1 is the set of flashing signals for a level crossing, No2 is the first set of signals and No3 is the second.

It takes a little bit of getting used to to get the lights timing correct you need to toggle them **earlier** than you think for best effect. At the end of the routine wait for the long beep and Press C to store the data.

Note: At the beginning, signals will not be recorded until the loco has reached the first 'Datum' Checkpoint as this marks the start of the recorded sequence and the run-up is not part of the recording.

## Commands from the Handheld unit.

Here is a list of the commands from the handheld unit. You will get a beep when a command is entered. When entering a 3 digit command be reasonably quick to avoid the timer interpreting 125 as 1 and ignoring the 2 and 5. A beep indicates the command has been received.

\* (Star) Toggles from forward to reverse. If set to reverse and the loco is stopped you get a series of beeps to remind you if you turn up the speed the loco will go backwards. We've all done that plenty of times in error!

# Emergency stop (toggle)

A = Record a routine

B = Play back a routine

C = Manual operation

D = In manual, this switches commands from points to signals. Long beep = points mode short beep = signals mode.

125 = repeat mode. Routine will repeat until you press C

126 = Turn on and off the fault mode 126,1 turns it on 126,2 turns it off.

127 = master reset. Same as switching on from cold. The previously recorded routine is retained.

The faults modes are:-

1) Comms failure – loss of comms from the handheld unit. Both the lights on the controller will go out.

2) No loco present – 3 beeps per second.

3) Checkpoint timing error – 2 beeps per second. This will occur if a checkpoint is encountered on playback which is not expected or if no checkpoint is seen when one is expected. This is usually due to a set of points failing to change over properly.

128 = wipe signal memory (use this if you want to re-do the signals during playback)

129 = wipe a single signal memory eg signal no2 would be wiped by 129 (beep) 2

130 = Record signals. The routine will automatically play and you add signals as required. Let the routine finish and wait for the long beep.

131 = set acceleration. The values are 1 to 20. – default is 10 this sets the rate at which the loco is allowed to accelerate and decelerate to give a realistic look to the motion of a train. Try different values in manual mode to see which you like best.

132 = set the record start-up speed. In manual set the speed you like after acceleration has finished and press 132 to write that speed in to the memory.

133 = Enter the max number of points fitted in your layout. If its 3 then 133 (beep) 3. This speeds up the reset to default procedure.

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## **Improving the overall reliability.**

When using automation reliability is particularly important as unexpected glitches can cause the system to misbehave. The system is as good as its weakest link.

- 1) Power supply. 12V 2A regulated power supply recommended by us on the Website. Must be short circuit protected and Type approved
- 2) Ensure your loco runs smoothly at low speed all round the track. Locos with 6 or preferably 8 wheel pick-ups are much more reliable.
- 3) Test all your checkpoints by driving the loco over them several times in record mode. You must get a beep every time. You are also checking the magnet on the loco by doing this.
- 4) Check the reliability of the points switching and continuity by switching them, say, 20 times. It helps to have a voltage indicator LED set as described below to see that the voltage gets switched reliably.
- 5) Ensure the track is clean and level.
- 6) Use 1mm CSA rating cable between the Points&Signals boards and the points as the initial current can be 10 Amps so the resistance of the cable can be significant and prevent the points working. If the distance between the P&S board and the points is over 4m then upgrade the wire to 1.75 sq mm cross section area.
- 7) If you get derailments at the points look for dirt and check they are level.
- 8) During Record avoid stopping and reversing the loco within 50mm of a checkpoint to avoid the possibility of slippage causing a missed checkpoint on playback.
- 9) Correct positioning of the magnet on the locos should mean a gap of not more than 4mm from the sleeper tops.
- 10) If more than one Point&Signals PCB is used then the power supply should be upgraded to 15v 3A
- 11) Make sure all connections are neat and no wire strands are sticking out risking a short.
- 12) It is best practise to solder the rails rather than rely on fishplates.
- 13) Always switch off before connecting wires to avoid possible damage.

## **Additional information**

1) The system on playback is looking for the checkpoints just as it does on record. If slippage occurs and its less than 50mm then the playback routine is adjusted to ensure the loco stopping points are as recorded. If however the error is more than about 50mm then the system assumes a checkpoint has been missed or perhaps a set of points has not worked as expected. If a gross error occurs the program will stop and the handheld unit

will produce 3 beeps per second. This is to prevent the loco from running into buffers, of if it does then not for very long. Reset by going back to Manual operation – C -.

2) If your loco loses contact with the rails then the controller detects this, the programme will stop and the handheld unit will beep twice a second. More likely to occur due to points in the wrong position or a bad points contact.

3) If communication is lost between the handheld and the controller the lights on the controller will go out.

4) The purpose of the checkpoints is to tell the controller that the loco has passed and to record the speed, direction, journey time and checkpoint number from Datum. During playback, *which must be started from the same zone between checkpoints as the recording*, the checkpoints are used to correct slippage and keep everything accurate. This is part of the patent.

5) The speed control is PWM (Pulse Width Modulation) and uses speed feedback compensation to give good slow speed performance and load compensation. As a result there may be a low level of high pitched noise from the loco. This can be minimised by fitting cork or foam available from model shops under the tracks as is common practise.

6) In future we are hoping for an APP to replace the handheld unit. This is intended to store different routines that may be recalled and played. We are also hoping to apply this record/playback technique for use with DCC as well as DC.

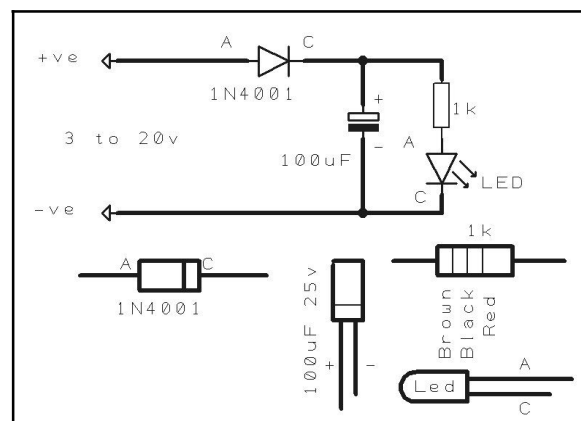
7) We have tested the system on OO Gauge and TT120, there is no reason why it should not work on N-Gauge or O or Gauge 1.

8) For surface mount points solenoids we recommend PECO, for underneath the Gauge-master are reliable but trickier to fit.

9) Loco motors are prone to failure. It is good policy to buy a spare motor from Hornby while they are still stocked as they have a rapid turn-over of models and spares are not usually kept for models discontinued for more than 12 months.

10) A Tester is more than useful, ideally a Digital Voltmeter but the circuit below is a simple way of checking for the presence of voltage including PWM (across the rails try both ways round as you cant be sure which is + and which -.

11)



Finally,

11) The tiny screws that are used in locos are easily lost. Its worth getting a pack of 2mm screws from Amazon.

### **Advanced train settings**

Speed feedback is used to significantly improve the low speed performance and load regulation of your loco.

The default values are set for mailine locos rather than tank engines

The parameters below adjust the amount of feedback applied.

204 , 1 = speed feedback on; 204 , 2 = feedback off

The default values will probably be fine but you can fine tune the slow speed performance

200 = Adjusts the amount of speed feedback applied above the threshold set in parameter in 202 below. Values 1 to 6, the default is 2 for big tender engines value of 1 suggested for small tank engines or switch the feedback off with 204 , 2.

201 = Adjusts the amount of speed feedback applied below the threshold set in parameter in 202 below values are 1 to 6 – default is 3 good for big tender engines. For smaller tank engines suggest 1 or off with 204 , 2

202 = Speed feedback threshold (1 to 6) default is 1 and equates to 5mph scale speed.

203 = Filter frequency cut-off. This adjusts the low frequency filter characteristic the default is 5 with range 1 to 20. The filter smooths out the speed feedback and affects the stability of the feedback loop.

If the values in 200 and 201 are set to high the loco will judder, the best value is just before juddering occurs.

Only one set of parameters is stored so if you adjust them for a tank engine and want to run two different locos with different spec then you might be best to leave the default values in.

### **Magnets Information**

Magnets should be super-glued to the underside of the loco.

For OO gauge measure the distance between the intended mounting surface and the top of the sleepers. If more than 7mm use 8mm x 2mm diameter button magnets, if not use 5mm x 3mm magnets

For TT120 if more than 5mm use 5 x 3mm magnets if less use 5 x 2mm or 4 x 3mm



For N gauge if more than 3mm use 4 x 3mm, if less 4 x 2mm

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Please feel free to send us pictures and feedback.

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