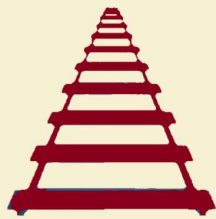


Model Railway



Automation

The DC Co-Pilot System Patented

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 start, stop waiting time and direction along with points and signals control. You create storylines making the layout come to life rather than just having the loco go round and round or shuttle at a fixed speed.

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.

Features

- No Computers or software required
- No decoders to be fitted to locos
- No cutting tracks or fitting diodes
- Minimal wiring, data rides on the 12v line
- 1mph scale speed
- Record and Playback
- No Soldering
- Easy to retrofit
- Points and signals control
- CDU Included
- Adjustable acceleration and deceleration
- Repeat Playback
- Speed feedback compensation
- Slippage compensation
- Recording saved on switch off
- Runs alongside DCC
- UK Design

No radio or batteries required

Short circuit protection

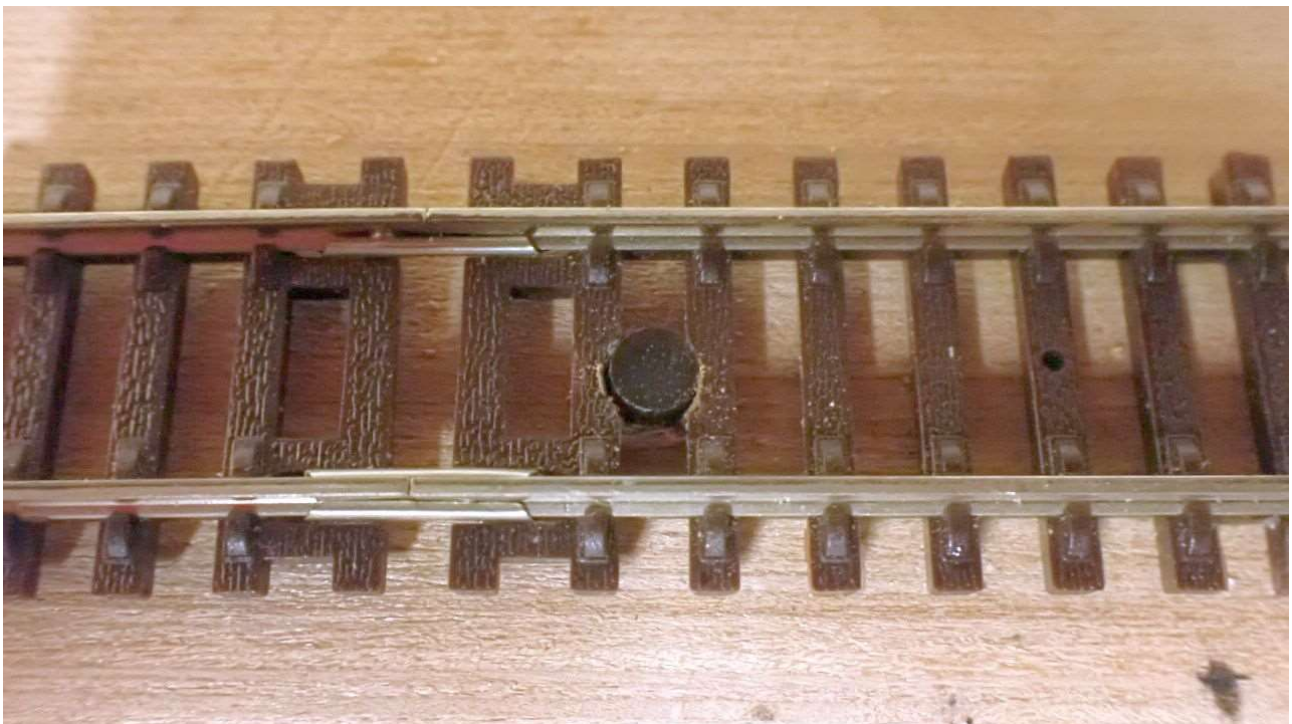
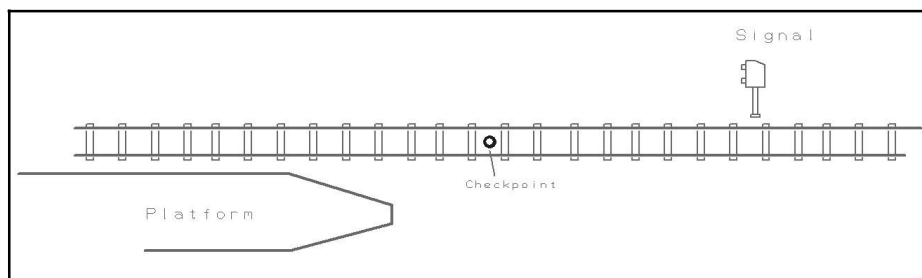
Total realism with better than 20mm stopping accuracy between record and playback

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, it is 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. For a simple diorama you can get away with 1 or 2 checkpoints.

Fitting Checkpoints.

An ideal place to fit a checkpoint is just outside a platform and before a signal as shown below. Also putting one on the main line before branch lines will cover a number of branch lines meaning you don't have to fit checkpoints in sidings.



The example above is on a TT120 gauge track.

Checkpoints are fitted 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 fits in a 4.5mm diameter hole. 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.

The 2 wires from the checkpoint are not polarity sensitive, they can be connected either way round, and all checkpoints are to be connected in parallel.

You can paint the top of the checkpoint or cover it with ballast, This will not affect the performance. The maximum cable length for checkpoints is 50m and twin cable is to be used between checkpoints to minimise noise pickup.

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.

The magnets provided have a peel-off self adhesive side. The North / South polarity of the magnet is not important as the checkpoints respond to either.

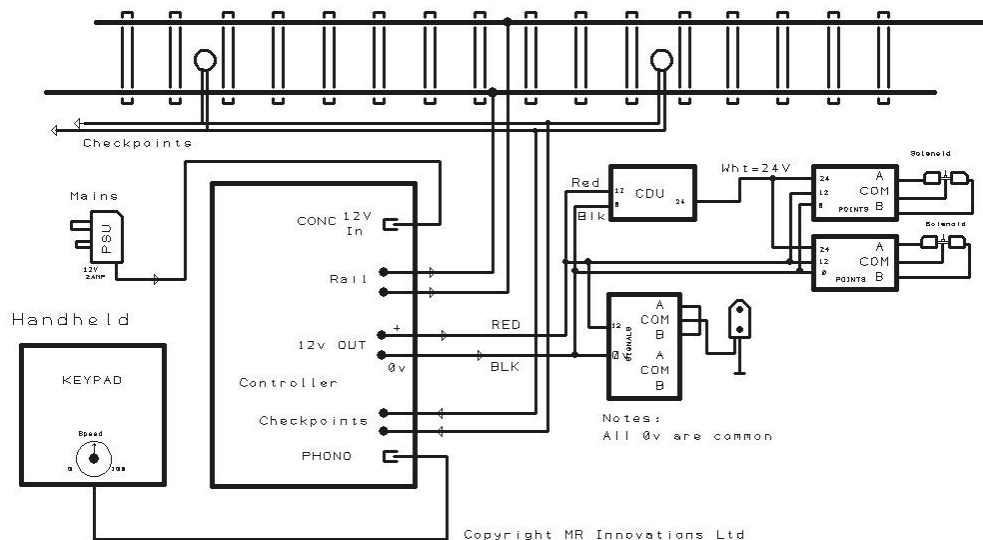
You should aim for a clearance between the magnet and the checkpoint of 2 to 4 mm. We can supply magnets either 8mm x1mm or 6mm x 1mm.

Magnets can be doubled up for extra strength. O-gauge not yet tested. For N-gauge then the 6mm diameter magnet is called for you may have to countersink the magnet to avoid hitting the rails that cross over points.

In record mode (A) the handset beeps when a checkpoint is activated showing that the magnet has done its job. If the beep sounds like a double beep this is normal and is not an issue.



The wiring



The 12v OUT from the controller is a 12v/0v bus that also carries data. It connects to the CDU IN and daisy-chains to every points and signals board. The +24v comes from the CDU OUT and daisy-chains only to the points boards.

The terminal strips on the boards are 'rising clamp' types. You need to fully undo the screws until they click before inserting the wires otherwise its easy to miss the opening. Once you've tightened down the screw, give the wires a good tug. The wires will come out if you've missed.

The Power Supply

Its important to use the one provided. 12V 2A. Indoor use only

The Electronic Control Unit – ECU



The ECU can be fitted anywhere convenient. There are LEDs on the ECU but they are not required for normal operation. There are 2 processors on the board, one for the main programme, record and playback, and the other controls the speed and performance of the loco. There are 2 5-way headers and supplied units are fitted with a 2-way jumper between pins 1 and 2. The programme is read protected and cannot be copied.

Connecting the controller to the Rails

The polarity is not important except that your layout will have a preference for which is Forward and which is Reverse. Swap the wires over to suit. Short-circuit protection will trip out if there's a short across the lines and resume when the short is removed. The beeper will sound continuously

Connecting the controller to the checkpoints, points and signals

Checkpoints are all in parallel and the polarity is not critical connect to CKP and CKP Use twin cable between checkpoints to minimise noise pickup. Max length 50m

The 12v/0v out daisy chains to the CDU, the Points and the Signals boards. Data to these boards is sent on the 12v wire to reduce the external wiring. Use Red for +12 and Black or Green for 0v. Be sure to observe the polarity. Use minimum 22swg wire and as short as possible.

The 'Mobile' or Handheld unit



This connects to the main controller via a phono lead.

When you first switch on (set speed to zero) the green leds in the handheld will flash Left – Right for about 8 seconds while it initiates everything and then sound beep beep. Whenever you hear 'beep beep' it means an operation has been completed. Note the white LEDs flash in sympathy with the sounder this is an aid for deaf people.

When entering numbers 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 single beep indicates the number has been received.

A full list of commands follows later but the important ones are.

C = Manual mode

* Star, this toggles between forward and reverse and can only be used when the loco is stopped. Long beep for reverse short for forward.

= Emergency stop (# again to cancel)

D = toggles between Points mode and Signals mode. Long beep = Points Short = Sigs

On switch-on the system does not know in which position the toggles were left for Direction, Points and Signals so you may need to press the commands twice for these channels so that they do what you expect them to do before you start.

Setting up

When screwing down any of the PCBs use as little force as possible so as not to risk bending the boards and having any components ping off. Fix only to insulated surfaces such as wood to avoid short circuits to the bottom of the boards.

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. The present system will support up to 15 points and 24 signals. (25 of each in the future)

In your layout you need to allocate a logical number to each set of points starting with 1 and each set of signals starting with 1.

You need to decide on what is to be your main line, as the points will reset to mainline automatically on start-up and before a recording and playback starts. This may involve swapping over the solenoid wires to connections A and B in its channel so that the solenoids automatically 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.

The CDU (Capacitor discharge Unit)



This takes 12v in and gives 24v out for operating the points. If the LED is on, 24v is being generated.

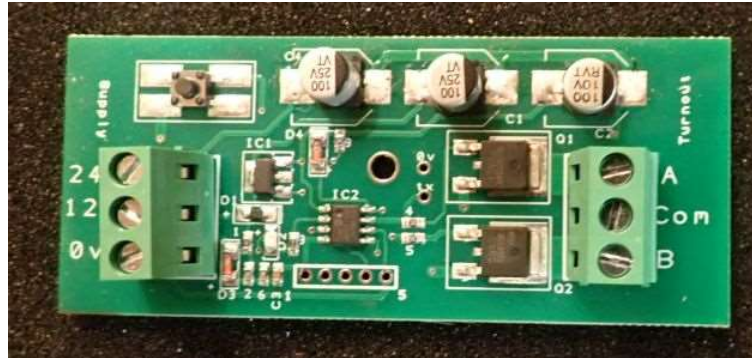
The 0v at the 24v Out end is electrically the same as the 0v IN, ie system 0V

The CDU provides a high current pulse for the points solenoids.

Fit the CDU as close as possible to where most points are located, it will support any number of points. On larger layouts run the 24v and 0v as a ring between the points boards rather than all on a spur to prevent voltage loss in the resistance of the wire. This will improve reliability. Max cable length for 12v to a CDU is 12m, Cable length from a CDU is 3m Max for a spur or 12m max for a ring circuit. 22 Swg minimum.

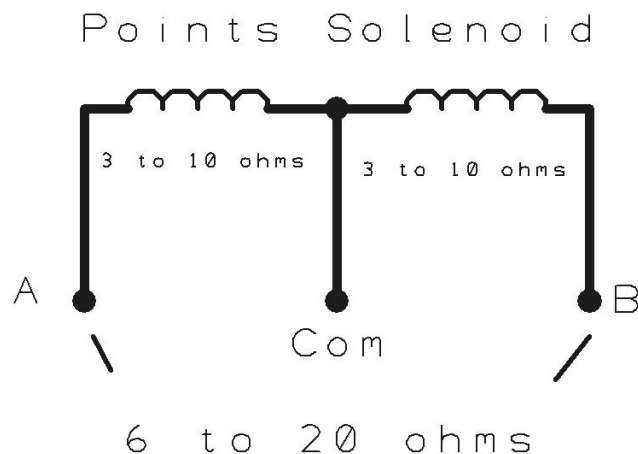
The CDU is short-circuit protected, the light will go out. Once the short circuit is removed, reset by pressing the reset button. The CDU light will wink off when points are operated and the 24v will recover in less than half a second.

The Points boards



Each set of points requires its own board. (Future designs will cater for 2 channels of points per board). Connect the 12v/0v bus with twin wire as shown, Black or Green is 0v, Red is +12v and we use White for +24v to the points boards. Command data to the points and signals board are superimposed upon the 12v supply to minimise the wiring.

Connecting the 3-wire points is simple, the centre terminal is the COMMON. You can identify the common with an Ohm Meter on 200 Ohm range each solenoid is about 3 to 10 Ohms so the 2 wires that show the higher resistance ie 6 to 20 Ohms are the solenoid ends and the 3rd wire is the common.



Only solenoid type points are supported by this system. 2-wire Kato points will work with the DCC Concepts 3 to 2 wire adapter

To set the number of the points board.

Each points board has to be allocated its address number starting with 1

1) Ensure the controller is in Points mode, press D so that you hear a long beep

- 2) Press the button on the points board until the LED comes on.
- 3) Press 121 followed by the address of the points board eg 121 beep 1; up to 15, (25 in future version)
- 4) The LED on the points board will go out
- 5) Confirm its working by pressing 1 on the handheld. It should toggle with a short beep for SET and a long beep for UNSET.

Repeat for all the other points boards eg 121 beep 5 for points number 5 then when in points mode pressing 5 will toggle points number 5 to Set and Unset.

Signals Boards



Connect the +12V and 0v to the input. The board has 2 output channels and these can be set up as flashing warning signals or fixed Stop/Go types. For one flashing and one fixed then the flashing will be on Channel 1.

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. The Common is +12v so the LED's Cathode is taken to 0v when the LED is to be lit. The arrangement is known as Open Drain.

Because the signals board supports 2 output channels then board 1 is for sigs 1 and 2, board 2 would be for sigs 3 and 4, board 3 for sigs 5 and 6 etc.

Setting up a Signals board.

Each signals board has to be allocated its address number starting with 1

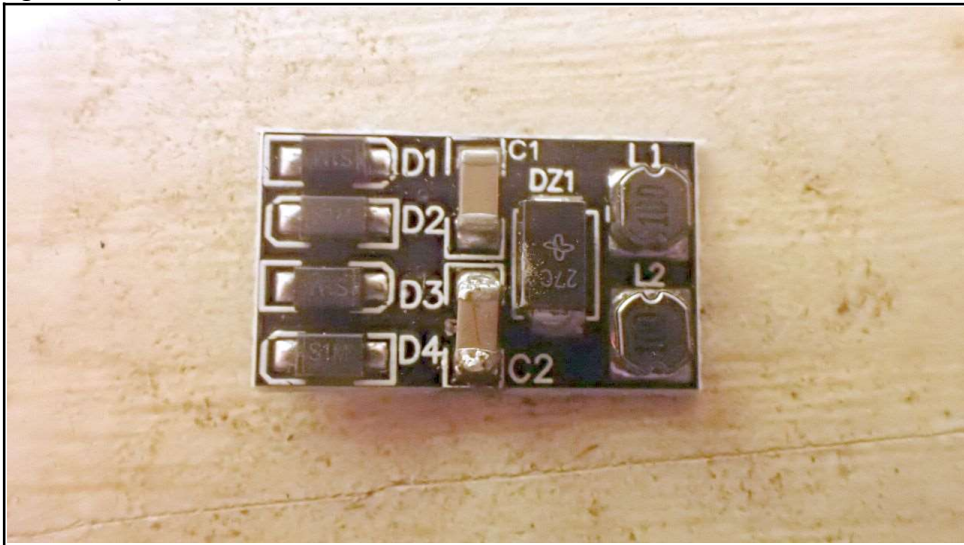
- 1) Ensure the controller is in Signals mode, press D until you hear the short beep.
- 2) Press the button on the signals board until the LED lights, might need 2 goes.
- 3) Send 121 followed by the address of the signals board in question eg 121 beep 1
- 4) LED will flash
- 5) Now send 122 followed by the number of flashing signal to be handled by this board.
0 = no flashing signals, 1 = 1 flashing signal and 1 fixed, 2 = both channels are flashing signals. The LED will go out.
- 6) Test the signals by pressing the signals number short beep for ON and Long for

OFF. In the case of fixed signals its short for Set and long for Unset
7) Repeat for any other board bearing in mind the second signals will be board number 2 (121 beep 2) and controls signals 3 and 4 up to board 12 ie 24 signals

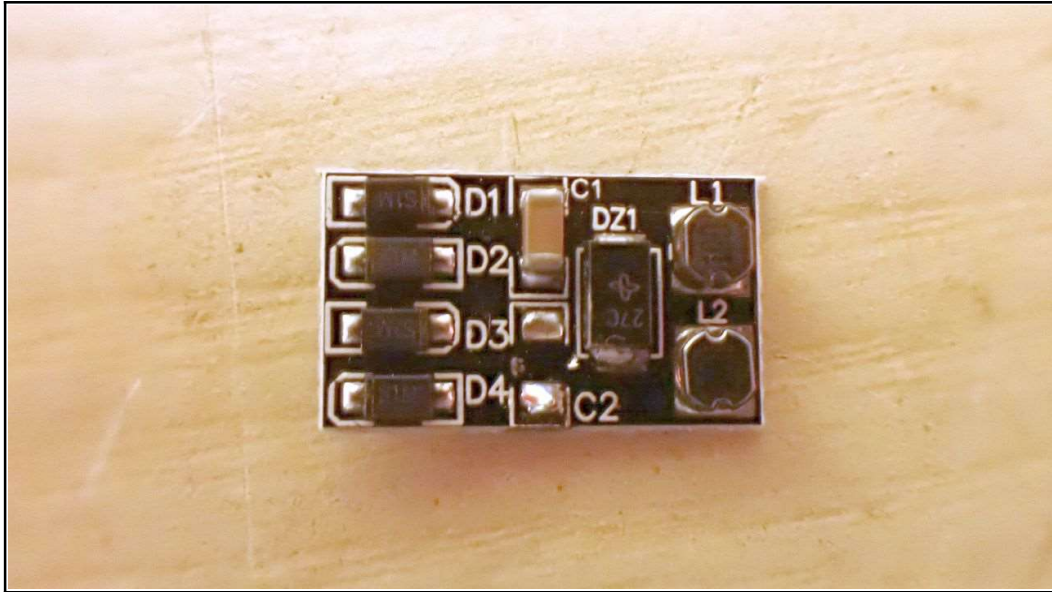
You should now be nicely set up in manual mode. Pressing C takes you to manual mode and pressing D toggles between Points mode (long beep) and signals mode (short beep)

Locos with DCC Ready pcbs fitted and others that beeeep!

If when you place the loco on the powered up track you get a continuous beep then the loco has a capacitor fitted across the motor which must be removed. This is because we use a PWM signal rather than basic DC. The controller has a capacitor detector circuit built in. The example below is from a Hornby loco of the TT120 range that has a dummy board fitted that gets replaced when used for DCC



To use such a loco with our system **you must remove C2** with a soldering iron as shown below



Recording a routine

Take plenty of time, the less hurried the routine the better the results will be.

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 and WAIT for the two beeps before moving off. The handheld will change to RED lights to tell you you are in Record mode.

Proceed with the routine, beeps will occur when you go over checkpoints, these beeps can sometimes sound like double beeps, don't worry this is not an issue. During record the controller will be in points mode, we add signals afterwards once you are happy with the routine. Operate the speed, waiting, reversing and points as you wish but remember to return to the original start position 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 followed by 2 beeps to say the operation is complete.

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

If you accidentally stop over a checkpoint the beeper will sound continuously. Drive on a little, it will not affect the recorded routine.

To repeat, finish a routine in the same position 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 all locos 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.

Recordings are kept in non volatile memory and will not be lost when you switch off.

Adding Signals

If there are previous signals commands recorded, 128 wipes them back to default
Press 128 and wait for the long beep.

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, be aware of the signals and their numbers.

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.

Playback

Press C to ensure you are in manual mode then press B to playback. The routine will play. You can interrupt the routine by pressing C
Emergency stop is # useful in a derailment. Press # again to cancel.

To repeat the routine over and over press 125 it will automatically start. Interrupt with C preferably at the original start position.

Commands from the Handheld unit.

* (Star) Toggles from forward to reverse. Short beep for forward, long for 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 if 111 is set to ON.

111 sets the beeper to sound if the loco is stopped and you are about to reverse. Most people find this useful as we've all turned up the speed only to find the loco goes backwards unintentionally. You can disable this feature with 110 but the white LEDs will still act as a reminder.

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.

110 = set reverse beeper reminder to off
111 = set the reverse beeper reminder to on
121 = in points mode set the points board number, 1 to 15
121 in signals mode set the signals board number, 1 to 12 (up to 24 different signals)
122 in signals setup enter the number of flashing signals 0,1 or 2
125 = repeat mode. Routine will repeat until you press C
128 = wipe signal memory (use this if you want to re-do the signals in 130)
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.
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.
134 = reset the signals to default.
200 = set the loco feedback from 1 to 20. default = 4 adjust for smooth low speed running. See below

Feedback information

The system has a complex algorithm for getting the best slow speed performance for any loco down to 1mph scale speed. Different locos will have different requirements but the amount of feedback is critical to get the best performance. The feedback multiplier is set with parameter 200. This value can be from 1 to 20 with the default as 4. Try different settings, the best setting is the highest number before jittering starts at low speed. For a small tank engine the default value of 4 is a good start. For larger locos you might find 12 or 16 gives excellent slow speed performance. To set press 200 (beep) number. If that number coincides with a points number then that set of points will operate. Ignore that and reset the points afterwards. It is well worth finding the best feedback value for your locos. You can impress your friends with how slow the locos can go!

Improving the overall reliability.

When using automation reliability is particularly important as unexpected glitches can cause the system to misbehave.

- 1) Power supply. 12V 2A regulated power supply provided
- 2) To 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) Ensure the track is clean and level.
- 5) For larger layouts the 24v and its 0v line should be installed as a ring main rather than all on a spur.

7) If you get derailments at the points look for dirt and check they are level, and check that the magnet under the train has not collected bits of metal. Magnets might possibly become detached and cause derailment too.

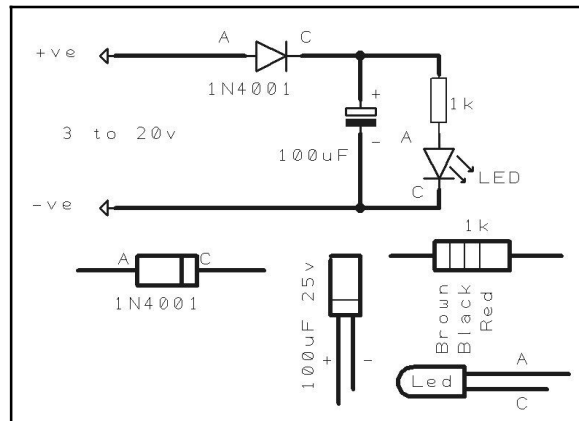
- 8) During Record avoid stopping and reversing the loco within 50mm of a checkpoint to avoid the possibility of slippage causing a missed checkpoint on playback.
- 9) Correct positioning of the magnet on the locos should mean a gap of not more than 4mm from the sleeper tops.
- 10) Make sure all connections are neat and no wire strands are sticking out risking a short.
- 11) It is best practise to solder the rails rather than rely on fishplates.
- 12) Always switch off before connecting wires to avoid possible damage.
- 13) Its always best to drive slowly over points but fast enough to avoid loss of contact with the rails.

Additional information

- 1) If your loco loses contact with the rails then the controller detects this, the programme will stop and the handheld unit will beep 3 times a second. More likely to occur due to points in the wrong position or a bad points contact.
- 2) If communication is lost between the handheld and the controller the lights on the controller will go out.
- 3) 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 original position as the recording ± 25 mm, the checkpoints are used to correct slippage and keep everything accurate.
- 4) 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. The noise is from a small voltage applied at all times this provides contact wetting and greatly improves the running reliability. The thicker the base board the less the noise will be.
- 5) In future we are planning for an APP to replace the handheld unit. This is intended to store different routines that may be recalled and played. We are also planning to apply this record/playback technique for use with DCC as well as DC.
- 6) We have tested the system on OO Gauge TT120 and N. Smaller gauges than N are not recommended. We have not tried it with the DCC Concepts gradient climb magnetic idea but it might be fine.
- 7) For surface mount points solenoids we recommend PECO, for underneath the Gauge-master are reliable but trickier to fit.

8) 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.

9) 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 -.



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

Safety

Use only the 12 volt 2amp power supply supplied with this product and ensure your premises are fitted with an RCD or use a plug-in one.

Use the power supply in open space and do not cover it

Switch off at the mains after use

Indoor use only, keep away from water.

Do not leave a person under the 16 years in charge of this product

If any part of this product become damage do not use and contact us for a replacement

Small parts such as the magnets, do not swallow, especially more than one.

Safety of your models

Digital Electronics can occasionally do the unexpected. Always fit buffers at the end off the line to prevent trains running off the end of the track.

Ensure your tracks are not too close to the edge where if the train comes off the rail it could fall and become damaged

When putting your engine on the track set the speed control to zero

Ensure when switching from record to playback to manual the speed control is set to zero

Specifications:

Record and playback time up to 15 Minutes

Maximum number of points 15 (expandable to 25)

Maximum number of signals 24 (12 boards)

Slow speed 1mph Scale

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Please feel free to send us pictures and feedback.

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