Model Electronic Railway Group

DCC District Cutout (DCO) Module (Kit 57)

Building Instructions — Issue 4a August 2023

These are the Building Instructions for the DCC District Cutout (DCO) Module Kit 57. The module is primarily used to allow DCC Power Districts to be divided into smaller 'sub-district' segments and provide localised short-circuit protection for them. It provides a facility for central monitoring of sub-district status and prevent a local short-circuit from disabling the entire layout. ***The firmware used in this module is now Railcom-compatible.*** *This design may be used with commercial DCC systems as well as the MERG DCC system. It is designed to be capable of protection at 1.5A and 3A thresholds and includes selectable delay, if required, to allow for DCC auto-reverse unit operation. Do take a few minutes to read right through these instructions before commencing assembly and begin by checking through the kit contents. If any items are missing please contact the Kit Sales Manager.*

'Static' caution. *While most modern Integrated Circuits (ICs) are reasonably protected from static electricity, today's centrally-heated houses, and man-made fibres as used in carpets (and underwear!) can cause significant static charge to build up as you move around. Before opening any kits, wear an earth strap or touch a nearby radiator, tap, or other earthed metal, and then try to stay seated while the kit is opened and assembly undertaken.* ***Leave all the Integrated Circuit components (ICs) in their protective packaging until ready to insert into their sockets.***

Kit Contents

Component Card		No.		**Component Bag**		No.
100R 0.25W	R1, R2, R3	3		3mm red LED	LD1	1
220R 0.25W	R7	1		3mm green LED	LD2	1
1K 0.25W	R4, R9, R10	3		STP55NF06L*** TO220 MOSFET	Q1, Q2	2
1K5 0.25W	R11	1		2 way 5mm terminal block	J1, J2	2
4K7 0.25W	R5, R13	2		3 way 3.5mm terminal block**	J3	2
10K 0.25W	R6, R8, R12	3		2 way 3.5mm terminal block	J4	1**
10K x 4 SIL	R14	1		12 way 2.54mm header	LK1, S0 - S3	1
UF4002 plastic diode	D1	1		2.5mm jumper plug	(LK1)	5
1N4148 glass diode	D2, D3	2		1000uF/25V electrolytic capacitor	C1	1
4.7uF/16v tantalum capacitor	C2	1		200:1 current transformer	L1	1
100nF 2.5mm ceramic capacitor	C3	1				
78L05 5V 100mA regulator	U1	1		**Loose**		
				12V Piezo Sounder	external	1
DIL Pack				DCO Printed Circuit Board		1
PIC16F630-I/P PIC microcontroller	U2	1		Building Instructions	6 sides A4	1
KB824 Dual opto-isolator*	U3, U4	2				
8 pin DIL skt	for U3, U4,	2		**J3 can be supplied as 3 x 2 way		
14 pin DIL skt	for U2	1		making a total of 4 x 2 way blocks		

*depending on availability from the supplier, there may be 4 x KB814 single channel opto-isolators provided. 2 each slot into the space for a KB824. See text below for detail. ** note that 6 way terminal block J3 can be supplied as 3 x 2 way blocks, see text.
***Earlier kits may have the STP36NF06L MOSFET

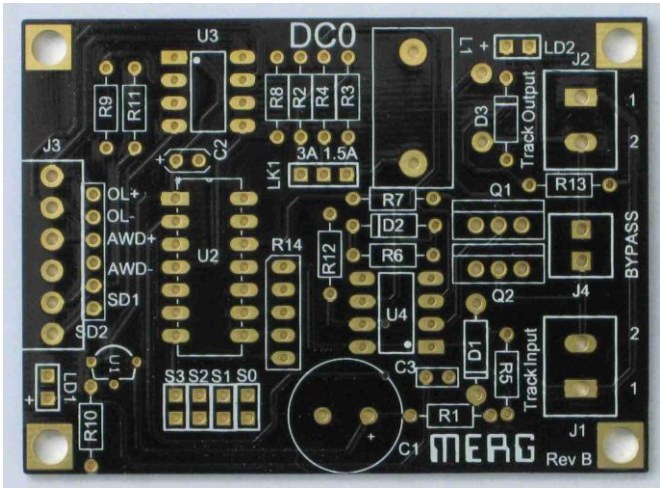


Fig.1 DCO Printed Circuit Board

Preparation

This kit contains all components necessary to build a barebones module without a case. If it is desired to fit inside a case of your choice then it can be either an ABS case or a metal case but, if the latter, then the case must be large enough to clear the metal tabs of the TO220 MOSFETS Q1 and Q2 which will be live in operation.

Check the type/value of each component ***before*** soldering. For each component, locate its correct position by examination of the pcb top legend and ensure that it is correctly oriented if required. Some components have a +ve and a –ve lead and must be inserted the right way round. All components in this kit are to be located on the top legend side of the pcb. Insert the component until it is flush with the pcb (unless instructed otherwise) and, if possible, slightly splay the leads on the underside to hold it flush when the pcb is turned over for soldering. Trim excess leads when soldered. Work through these instructions sequentially and carefully, ticking off each task as you go. You might find crossing through the components in the parts list on the rear of the schematic, as you proceed, helps you keep track of where you are. Remember, also, that if you take your time you will get more enjoyment from building your module and you are less likely to make a mistake.

Assembly

Low Power Components – Diodes and Resistors

Locate the diodes and resistors on the component card and work up from the smallest components to enable them to lie flat against the pcb when it is turned over for soldering.

1. Starting with the 2 small glass diodes D2 and D3 (1N4148), then the slightly larger plastic diode D1 (UF4002), ensuring correct orientation by fitting the end bands to the double white line on the pcb legend.

2. Next fit the 1/4W resistors in order from Component Card:-

R1, R2, R3 (100R brown-black-brown); R7 (220R red-red-brown); R4, R9, R10 (1K 1/4W, brown-black-red); R11 (1K5 brown-green-red); R5, R13 (4K7 yellow-violet-red); R6, R8, R12 (10K brown-black-orange)

3. Locate the 5 pin commoned 10K SIL resistor pack R14 next on the card (usually black with white numerals eg '5A103G' but might depend on source) and fit in the appropriate pcb location ensuring that the marked dot, which denotes the common connection, is adjacent the right hand side of the legend closest to 'R14' or the angled corner on the pcb legend.

Small Capacitors

4. Detach the miniature 100nF ceramic capacitor (marked '104'). Fit it in position C3. It is ***not*** polarised and may be fitted either way round.

5. Detach the brown polarised 4.7uF/16V Tantalum Bead Capacitor from the card which is C2. It is marked with its value and a dot or '+' sign against the longer +ve lead. It must be inserted in the pcb with the longer +ve lead in the hole marked as being the positive. ***Check that you have this the right way round before soldering.*** Component availability may mean that a 5mm version is supplied in the kit against the 2.5mm version in the parts list but the leads may be gently straightened with miniature long-nosed pliers before sliding into the pcb holes.

DIL Sockets

6. Fit the 3 DIL IC sockets from the DIL pack, for U3, U4 (8-pin); and U2 (14 pin). ***The 'bite' on the sockets for U2 and U3 are facing the top of the pcb layout. That for U4 faces the bottom (dots and square pads denote pin1).*** For each socket, insert into the pcb and bend over 2 diagonal corner pins to hold it in position. Right the pcb to check you have it inserted correctly and solder the other 2 diagonal corner pins ***not*** bent over (it's a lot easier to extract a socket that way, if you get it wrong). If satisfied, solder the remaining pins. For any IC or DIL socket it is good practice to solder diagonally opposite pins to spread the heat effect on the component. Do not insert the DIL ICs at this stage

Links and Terminal Blocks from the Component Bag

7. The 6-way 3.5mm terminal block J3 may be supplied as 2 x 3-way blocks or 3 x 2-way blocks depending on availability. Locate these terminal blocks which you will slot together to make 1 x 6-way block for J3. They have small ribs and grooves on the mating edges which must be properly engaged to enable the resultant block to sit correctly on the pcb. Insert in the pcb ***ensuring that the cable entry holes face the pcb edge.*** Solder one pin at each end and right the pcb to check you have it the right way round. Solder the remaining pins.

8. The remaining 2-way 3.5mm terminal block is now fitted into position J4 (BYPASS) with the cable entry holes facing the pcb edge

9. Locate the 12 pin 2.54mm pcb header plug which you must gently cut into 4 x 2 pin headers for S0, S1, S2 and S3, plus 1 x 3 pin header for LK1 with a small pair of cutters or a sharp pair of nail scissors. This will leave one spare pin for the spares box. These headers shatter easily if not careful. Insert into position on the pcb with the longer pins upright, when looking at the pcb top, and solder in position one at a time. Try to ensure that the header is firm against the pcb or else it will look crooked when viewed from the top. It is useful to place a jumper link over the longer component side pins and solder one pin to secure the header. Turn the board over to check it is fully home and upright. If not, reheat the pin gently whilst pushing it home. Solder remaining pins.

10. Fit the 2 larger 5mm terminal blocks (J1 and J2) with the cable entry holes facing the pcb edge.

Small Semiconductors

11. Detach the final component from the card which should be the 78L05 5V regulator U1. Insert it in the PCB such that its outline matches the legend. Solder in place taking care not to bake the pins.

12. From the component bag select the red 3mm LED, LD1. Insert in the PCB with the longer +ve lead in the hole marked '+'. Solder in place. Repeat for the green LED, LD2.

Current Transformer

13. This is the large, dark-grey 2 pin semicircular component with a hole through it, marked 56200C or CS1200L. Insert it into the PCB at L1 ensuring that it is fully home, solder the 2 underside pins. If there is an arrow marked on it then have it point to nearby J2 although this is not essential. That establishes its secondary winding connection to the circuit.

14. It is now necessary to establish the transformer's primary winding connection which is achieved with a simple piece of approx 70 - 75mm 16/0.2 (0.5mm^2) stranded insulated wire such as that from a light piece of lamp flex. The winding must consist of one turn through the centre of the current transformer, the ends of which are soldered in place between the transformer and diode D3. See the photograph here. This can be quite fiddly so take your time.

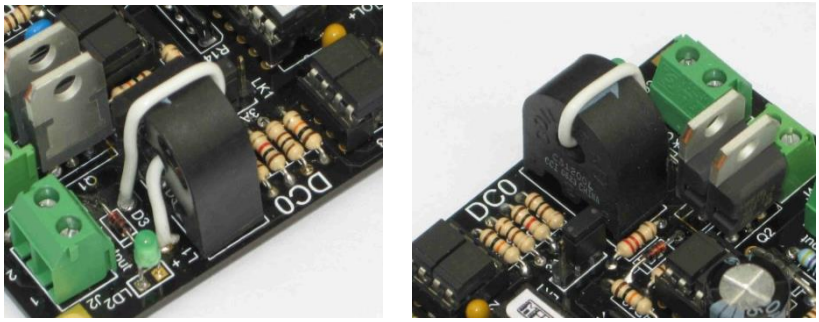


Figure 2 Current Transformer showing Primary Winding.

Major Components

15. Locate the two TO220 MOSFETS Q1 and Q2 (eg STP36NF06L or STP55NF06L) in the component bag. Insert them in the PCB and slightly splay 2 legs to hold them in position. Ensure that the metal tabs match the PCB legend and face towards D3. Solder in place.

16. Finally insert the large 1000uF/25V electrolytic capacitor into the PCB ensuring its longer +ve lead goes in the hole marked '+' (the grey stripe should be adjacent to jumper S0). Slightly splay the leads to hold it in position. Right the pcb to check you have it the right way round before soldering as this component is polarized and will make a mess if it is powered up the wrong way round. Solder in place when satisfied.

This completes the module assembly which is now ready for testing.

Inspection and Preliminary Electrical Test

17. At this point, with the small components and DIL IC holders installed, it is useful to check the electrical integrity of the board to remove any problems with short circuits or bad joints prior to applying serious power. Use a 12Vdc 1A PSU if possible. You should not have fitted any of the jumper plugs at this stage.

18. Carefully check the PCB trackside for any unsoldered or bridged joints and rectify any faults found.

19. Connect a 12 - 15Vdc power supply to the PCB, ***+ve to input terminal J1/1 and –ve to terminal J3/AWD-.*** Diode D1 will protect against reversed connection provided you have installed it the right way round (see 1. above). Power up and wait for 30 seconds. The LEDs should remain dark. This applies power to the regulator enabling you to check for solid joints and/or short circuits in the 5V circuits. Carefully check that the 5v regulator U1 remains cold. If it does not, switch off immediately and check the whole pcb for solder bridges/shorts on tracks and pads under the pcb and that all polarised components are installed correctly.

20. When satisfied, reapply power and, using a standard multimeter set to its Vdc range, check for the following voltages on the pin receptacles of the empty DIL sockets, ensuring that you get the probes on the right points:-

a. that there is 5v at U2 pin 1 with respect to (wrt) both pins 5 and 14.

b. that there is near to 5v at U2 pins 7, 8, 9, 10 and 13* wrt both pins 5 and 14. (*might be only 3.5V)

b. that there is near to 5v on U3 pin 1 wrt pin 5.

c. that there is 5v on U4 pin 8 wrt pins 4 and 5. (don't forget that U4 is upside down to the other ICs)

If these preliminary checks are successful then ***depower, disconnect the DC power supply which may now be discarded*** and proceed to the installation of the remaining active components. If not then the PCB component pads must be checked for sound joints before proceeding. ***If you do not then there is a risk of unexpected electrical behaviour and possibly overheating when full power is applied.*** Please note that both U3 and U4 may be fitted with 2 each KB814 ICs which slot into the DIL sockets side by side and perform the same function.

Tip Some people struggle to fit ICs but, as with a lot of electronics, there is a knack to it which one gains with experience. If you are experiencing difficulties then try the following. ***Observing all static precautions*** hold the IC lengthways between the index finger and thumb of both hands, the pins facing horizontally away from you, index fingers on the ends, thumbs on the top.
Lay the legs of the IC on a flat surface and gently bend the pins **SLIGHTLY** inward. Turn the IC over and do the other side. This should angle the pins closer to each other so that they slot into the holder more easily....***but don't overdo it.***

21. Locate the two 8-pin DIL KB824 opto-isolators from the DIL pack (*or 4 x 4 pin KB814s) which are to be inserted into the DIL sockets in positions U3 and U4. It is vital to install these correctly oriented and the chamfered side denotes pins 1-4. Therefore when looking at the PCB the chamfer on U3 must be left-facing when fitted and that on U4 right facing (see photo here).

22. Fit the DCOR PIC16F630 in position for U2.

23. Insert a jumper plug in the 1.5A or 3A position of LK1.

24. Check the completed board resembles the photograph here bearing in mind that component availability might mean not all items are exactly the same shape or colour.

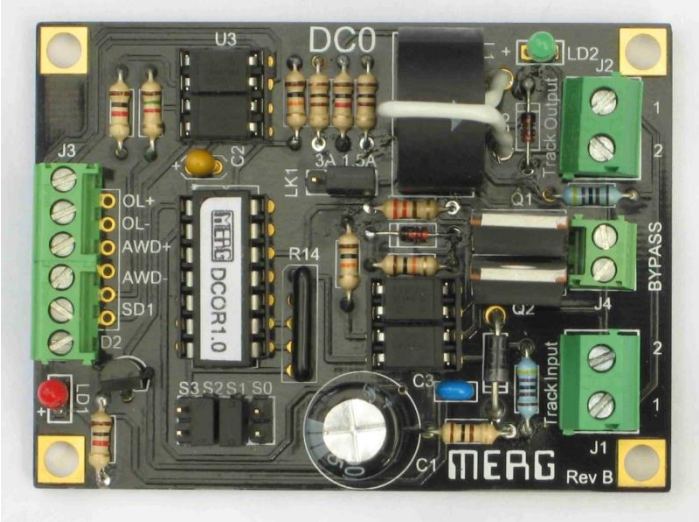


Figure 3 Completed DCO Module

Final Electrical Testing

25. To test your DCO module, which is normally powered from the applied DCC input, you will need the following:

a. A source of DCC input signal from a 3 – 5A Booster system connected to the terminal block marked 'Track Input'.

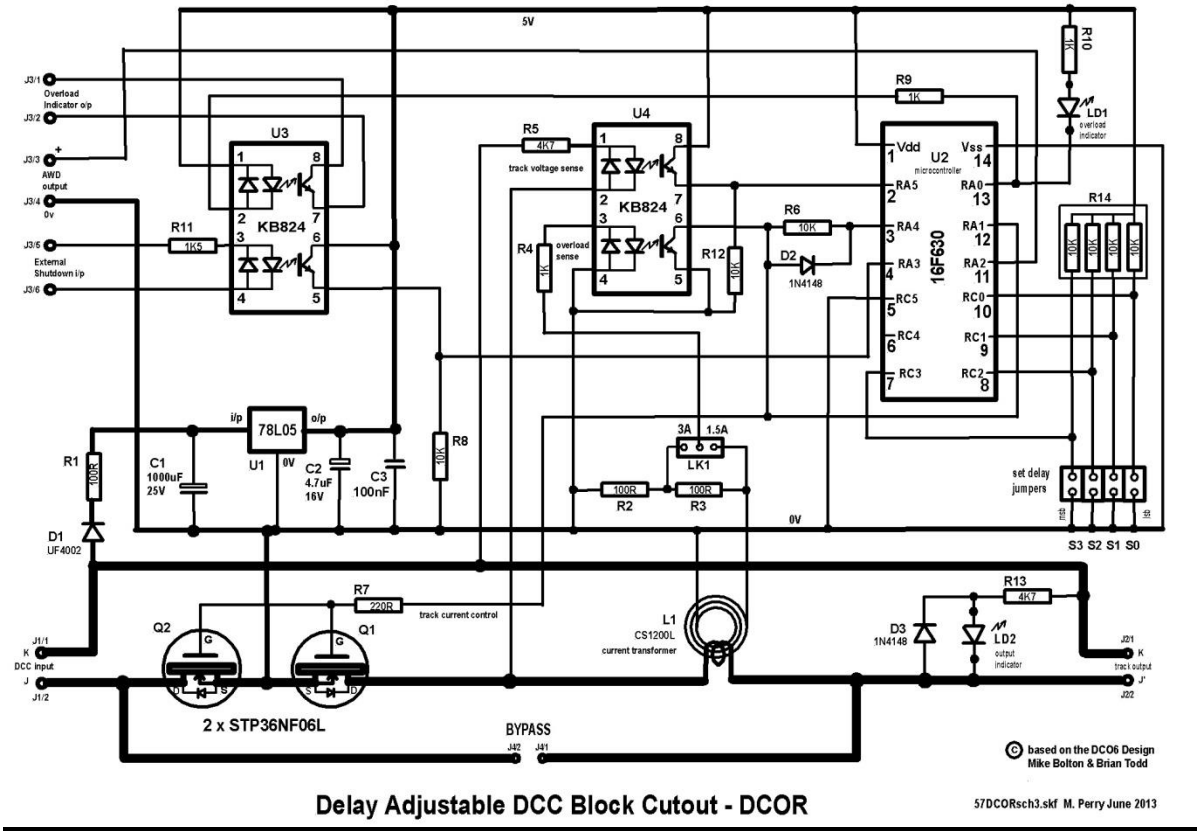
b. The supplied Audible Warning Device (AWD) is connected to J3/3 (+ve) and J3/4 (-ve). ***Polarity must be correct***.

26. Apply the DCC input signal and the green track output LED should illuminate. If not then your assembly must be depowered and checked again for short circuits.

At this point, the red TRIP LED should be dark. Wait 30 seconds and then repeat the preliminary electrical tests specified in paragraph 20. above remembering that, now the IC sockets are populated, it is vital not to short adjacent IC pins with your meter probes.

27. To test short circuit protection apply a short circuit across the track output terminal block J2. The track output LED should go dark and red LED illuminate. The AWD will emit a continuous tone. The DCO should enter shutdown mode and commence retrying every few seconds. This will be evident from the AWD and TRK/TRIP LEDs alternating.

Your DCO module is now ready to be connected to the track for running trains. Set link LK1 to the trip current you require. Please pay particular attention to the following notes on operation, cabling and correct connection .



Notes on Cabling, Connection and Operation – MERG DCC District Cutout Kit 57

The DCC District Cutout (DCO) is specifically designed to enable Power Districts to be subdivided and locally protected from track short-circuits which would otherwise shut down an entire layout. It can be set for shutdown at either 1.5A or 3A by selection of jumper position at LK1. Like all DCC systems correct operation depends on appropriate cabling and builders are therefore advised to pay particular attention to this.

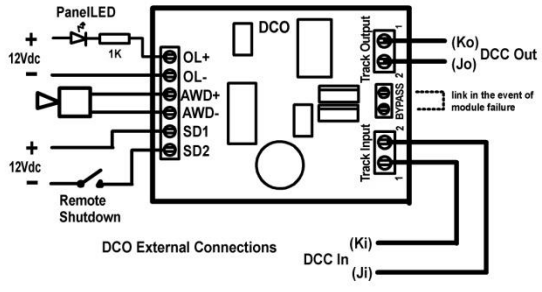
Cabling

A basic function of any power supply system is adequate protection in the event of short circuits occurring and this can be a frequent occurrence on a model railway layout. In this event the DCO module must be tripped to shut down and remove power until the situation is resolved and it does this by monitoring the current supplied to the track. If it exceeds a set amount, shutdown is tripped automatically.

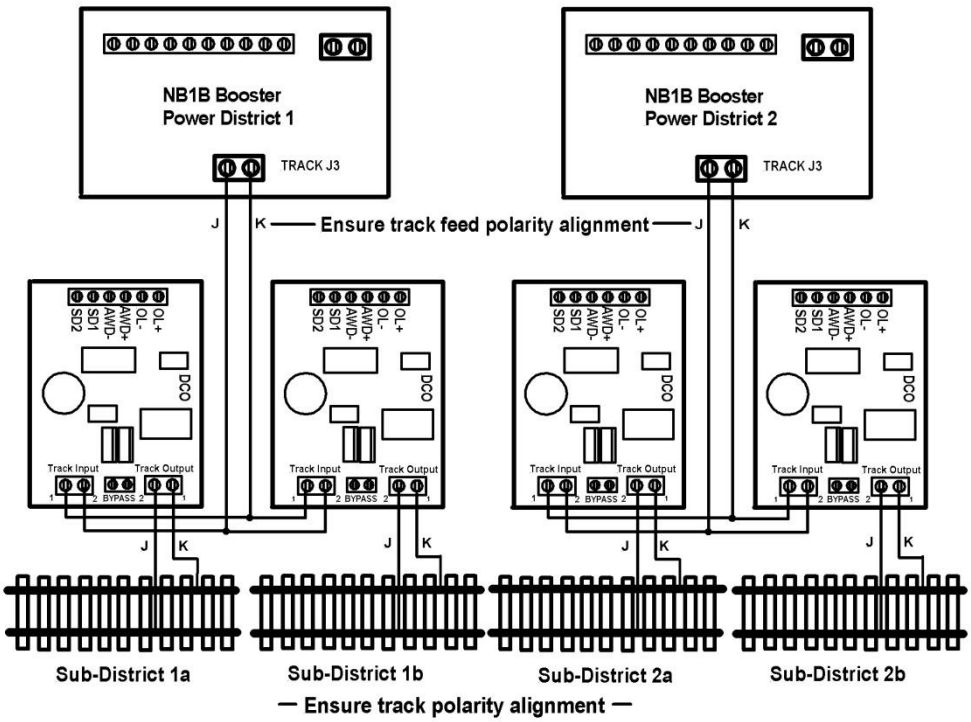
Therefore it is inadvisable to use cabling with cores of cross-section area lighter than 1.5sqmm or 16AWG and preferably much more substantial than that in order to render the lowest possible loop resistance. In any case the DCO short-circuit protection must operate at any and every point in its sub-district and it is advisable that this is tested before every operating session.

Connections

The local connections for the DCO are shown in the diagram to the right here. External facilities are provided on J3 to connect a switch for remote sub-district shutdown, the Audible Warning Device and a shutdown LED indicator (which may be panel mounted). There is also provision for a bypass link to be inserted at J4 should the DCO fail. This latter would be absent in normal operation.



The DCO may be used singly, or in parallel multiples to feed separate sub-districts. The track inputs must be paralleled, in phase, from the DCC Booster(s) and the track outputs must be connected to ensure polarity alignment across the layout. If any sub-district contains a track arrangement which presents polarity reversal across sub-district boundaries then that sub-district must contain an auto-reverse section, or other satisfactory switching arrangement, to correct that. Failure to implement this properly may result in DCO disconnect and/or damage to track and models. If in any doubt contact MERG Technical Support with descriptive track plans to explain requirements. See the diagram overleaf.



System Connections for the DCO

Operation

1. In both configurations (1.5A or 3A) the DCO module will automatically disconnect supply under the following conditions:-

a. Short-circuit in bus cabling or on the track resulting in current draw greater than that set by LK1, typically in the event of a derailment. The DCO automatically tries to re-establish every few seconds. Prolonged short-circuits could cause overheating in the track and models so must be avoided.

b. Application of the remote shutdown signal from an operator-controlled panel switch

S3	S2	S1	S0	Delay ms
				0
			X	6
		X		12
		X	X	18
	X			24
	X		X	30
	X	X		36
	X	X	X	42
X				48
X			X	54
X		X		60
X		X	X	66
X	X			72
X	X		X	78
X	X	X		84
X	X	X	X	90

2. The delay from detection of short-circuit to shutdown can be selected by jumper links S0 – S3. If no jumper links are present shutdown occurs within micoseconds and should occur before Booster shutdown in all but the very fastest commercial systems. At the time of writing the DCO has been tested successfully in this respect with every known commercial system.

3. For some layouts, particularly where a sub-district incorporates a DCC auto-reverse unit, the DCO, in its fastest state, may disconnect too quickly to allow proper operation of the auto-reverse unit. Additionally it is known that transient short-circuits can be experienced on trackage employing some varieties of insulated frog turnouts (eg Peco). This can be caused by locomotives with coarse wheel profiles bridging rails of opposite polarity momentarily and will result in annoying interruptions to running whilst the DCO disconnects and reconnects.

4. In these cases it will be necessary to invoke some delay in DCO disconnect and this is achieved by setting jumper links in S0 – S3 which form a binary delay multiplier to the PIC microcontroller operation. Builders may need to experiment therefore with the most appropriate delay setting to allow the DCO to tolerate layout transients or auto-reversers and still disconnect before the Booster shuts down. The table here shows the approximate delay settings for jumpers S0 – S3.

Acknowledgements

Original DCO designs - Mike Bolton M786 and Brian Todd M2670
Production Engineering - Trevor Stockill M2433 and Martin Perry M1481
PCB layout - Trevor Stockill M2433
Kit Crafting and Documentation – Martin Perry M1481