

An electronic overload cutout for DCC systems (BCO1)

DCC systems require a rapid acting overload or short circuit cutout mechanism which is also capable of carrying the relatively high currents available to a DCC track in normal operation.

DCC power boosters have their own overload protection which always uses a cutout and retry mechanism. Simple current limiting is not satisfactory as the full current will still flow which may be 5 amps or more. When a DCC booster detects an overload it will completely cut off the current and then reconnect after a preset time, usually about 0.5 seconds. If the short remains, it will repeat the process so, apart from the brief 'retry' periods, there is no current flowing and power is minimal. One critical factor is the retry time or delay before the current is cut off. If this is made too short, any current surge when the circuit is restored will cause it to trip again. This is particularly apparent in decoders with a significant capacitance such as some sound decoders. If the delay is too long, a high current will flow for a significant time and may cause damage to the track, wiring or the booster itself.

For larger layouts it is an advantage to split the track into blocks and have each block protected by its own cutout. This prevents a short in one section shutting down the whole layout. The requirement for such block cutouts is they act faster than the main booster. This can present a problem with the adequacy of the delay time for current surges. The block cutout (BCO) must act faster than the booster but not so fast that it trips on current surges or short transients. Also, as the BCO is in series with the track feed, there must be negligible voltage drop during normal operation.

BCO1 is a relatively simple design which fulfils the requirements above. It features user selectable current trip levels of 2, 3 or 4 amps so covering low power boosters as well as being adequate for larger blocks with several locos per block. It also has a user adjustable delay so it can be optimised for different boosters and decoders with a high capacitance.

Circuit description (see BCO1_sch.pdf)

The electronic switch consists of two 'back to back' power MOSFETs (Q3 and Q5). In normal operation, both of these are fully conducting. The prototype used Fairchild FDP6035AL devices which are low cost but also have a low 'on' resistance. They are rated at 48 amps continuous current (not likely to blow up!) and a maximum resistance of 12 milliohms. As there are two in series, the worst case resistance is 24 milliohms which gives a voltage drop of 120millivolts at 5 amps. Heat dissipation is 0.6 watts shared between two devices. As a continuous current of 5 amps is most unlikely, no heatsink has been found necessary but could be added if required for even higher currents. However, with the present circuit values, the maximum trip current is set to 4 amps.

Current sensing is via a 'current transformer' – the same type as used in other MERG kits and designs. This gives a secondary output of 1 volt per amp in the primary. Only one primary turn is used. As the primary is just a short length of thick wire, there is no voltage drop here.

All the logic is performed using an 8 pin, low cost PIC microcontroller type PIC 12F675. This contains both an A to D converter and an analogue comparator. The comparator compares the current transformer output voltage with one of three DC voltages set by the resistor chain R2 to R5. There is a jumper to select one of these voltages which gives current trip levels of approximately 2, 3 and 4 amps.

VR1 gives a user adjustable voltage on the A to D input. This is read internally by the PIC and used to set the delay value from 200 microsecs minimum to 65 milliseconds maximum.

A value between 20 and 30 milliseconds is recommended but it must be less than the main booster delay.

The overload state can be monitored by either a LED, an audible warning device or both as well as transmitted to other indicators via an opto-isolator. As the BCO1 is powered off the DCC booster, the output must not be connected directly to any other circuit other than by the opto. A terminal block is available for connecting the AWD and the opto output.

The PIC program gives immunity to short spikes or false triggering and the overload condition has to be maintained for the full delay period. It has been tested with sound equipped locos using SoundTraxx Tsunami decoders at a delay of 25 millisecs. Other types of decoder may require a longer delay but many boosters have their own delay of less than 50 millisecs so a compromise might be required.

Note: As a current transformer is used which has limited low frequency response, the operation of this circuit cannot be guaranteed when running a DC loco on address 00 where the zero bits are stretched to the maximum. It will not work at all on non-DCC layouts.

The circuit, built on a small PCB, protects a single block. This enables it to be placed close to the block itself, unlike cutouts which have multiple block capability.

A schematic, a full sized PCB layout and the PIC program is available on the website.

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