New DCC booster design. (see schematic NB1A_sch.pdf)

I have had requests for a basic DCC booster that can be used with a separate command station and / or for additional boosters with existing systems like Lenz or the MERG BC1A.

My original booster design (Boost5 on the MERG website) had auto reverse and was fairly complex. It also used a MOSFET driver IC which is quite difficult to get and moderately expensive. This new design (NB1 – New Booster 1) uses the same principles as Boost5 but is simpler and the driver ICs are cheaper and easier to obtain (for now at least).

Target specification

1. Output current dependent on choice of MOSFETs and power supply, not set by the design itself. NB1 can be rated up to 10 amps with low cost devices but there is no real limit and 100 amps plus is feasible!
2. DCC voltage range is flexible and set by the power supply.
3. Overload protection is by cutout and retry method.
4. Low cost, small size, suitable for surface mount if wanted.
5. Output cutout for use with RP 9.3.1 bi-directional communication.
6. Use of common components. No programmable devices.

The use of MOSFET driver ICs rather than transistors or logic devices has many advantages. These create a high side gate voltage which is above the supply +ve voltage. This allows the use of N channel MOSFETs for all four in the H bridge. N channel devices are generally cheaper and have a lower on resistance (Rds on) as well as there being a much greater choice. The driver ICs have a high gate charge current capability so will switch the MOSFETs quickly and allow a wide range of MOSFETs to be used, even those with a large gate capacity – the very high current types.

The output stage of NB1A uses two ‘half bridge’ drivers (L6384) as this was cheaper than a single full bridge device as used in Boost5. The L6384 is £1.25 in small quantities. They have a switching delay (anti shoot-through) settable by a resistor (R15) and a turn off capability by a low voltage (< 0.5v) on pin 3. Also these devices have an inbuilt zener diode (about 15v) for the supply so they can be powered off the main DC feed by suitable choice of R14 and R18. (They are rated at 600v DC maximum!)

Overload sensing is conventional and uses the voltage developed across R17. However, to avoid voltage drops and high power in R17, this is made a very low value (0.022 ohms) and the voltage is sensed with a comparator U6/2 which is part of a dual LM393. The threshold is set by R10 and R11 to 100mV but this could easily be made adjustable. With R17 at 0.022 ohms the trip is 4.5 amps. There is plenty of scope for reducing the value of R17 even further so higher output currents would not lead to more voltage drop or more heat.

DCC boosters require a delay between a short on the track and the cutout being activated to allow block cutouts to operate first. R8 and C5 provide this delay and also remove very short overloads. R16 and C8 prevent switching spikes in the H bridge from getting to the comparator. On the prototype, R8 and C5 were adjusted to give a delay of 30 milliseconds. Provided the overload exceeds 30 milliseconds, the monostable in U4/2 is triggered and causes a shut down of the H bridge through U5/1 and U6/1. The open collector of the comparator is needed to pull the voltage on pins 3 of U7 and U8 to zero to give the shut off while allowing R16 to set the switching delay in the bridge in normal operation. The 74HC123 monostable (U4) is retriggerable and has Schmidt trigger inputs which makes it ideal for the slow rise of the R8 / C5 filter. The monostable is set to about 0.5 seconds during which time the output on pin 12 is logic low. This forces pin 3 of U5 high and turns on the comparator U6/1, so causing a shut down. At the end of the monostable time, the H bridge is enabled again and the ‘retry’ takes place. The cycle repeats as long as the overload persists with an on time of 30 millisecs (set by R8 / C5) and an off time set by U4/2 of 0.5 seconds (or whatever the mono. is set to)

The other half of the monostable U4/1is used to detect the presence of a DCC input on pin 1. This is constantly retriggered while there is a DCC signal so keeping pin 13 high. If DCC is lost, pin 3 of U5/1 is forced high and the H bridge is shut off. This prevents the full DC voltage being applied to the track with possibly serious consequences, especially if there is a DC loco on the track. The time period of U4/1 is 10 milliseconds to allow for a maximum 'stretched zero' condition in the DCC signal.

The 74HC123 monostable also has a 'reset' input which overrides the outputs if it is logic low. This is utilised in NB1 for shutting off the H bridge from an external logic signal, either as a safety measure from the command station or for creating the 'cutout' in the power needed for the bi-directional communications facility in RP 9.3.1. In the shut off state, all 4 of the MOSFETs are 'off' so the output impedance is very high.

U5/3 and U5/4 create the anti phase DCC signals for the two MOSFET drivers. U5/2 is spare.

The inputs are opto-isolated and so is the overload output. Opto-isolation is an advantage if other boosters are being used. The input on connector J1 pins 3 and 4 may be driven with a DCC signal from the output of another booster or a lower power bipolar or logic level signal. A positive voltage of between 5 and 12v on pins J1, 5 and 6 (6 is positive) will cause a shutdown of the output stage.

Overload is indicated by a 5v DC sounder connected between J1 pins 8 and 9 and a LED between pin 7 and 9. U3 is an opto-isolator for remote indication of an overload if required.

NB1 deliberately does not have a DC power supply built in. This allows the output current and voltage to be determined depending on its use. However, any supply used must be current limited or at least capable of withstanding a short for 30milliseconds. High power switch mode supplies with mains inputs are recommended. A voltage of 13 to 15V DC is suitable for HO /OO.

Construction

All the components used are available in surface mount packages and conventional through hole types. The use of all SM components with D-PAK MOSFETs like the FQD20N06 (Fairchild) would give a very compact and low cost design with up to 10 amp rating. The PCB copper acts as a heatsink with each MOSFET requiring about 500 sq.mm of area (1 inch square or less).

There is a PCB layout for a 'through hole' version and a prototype had been tested. For currents greater than 5 amps, the tracks on this PCB which carry the high currents should be reinforced by soldering solid copper wire along the tracks. MOSFETs with a low Rds(on) must be used. The STP36NF06 is a low cost choice for up to 5 amps and the STP55NF06 for higher currents. (presently available from Rapid Electronics)

All (polite) comments and suggestions regarding this design – or any thoughts on boosters in general – will be welcome.

Note. Many manufacturers (but not all) have adopted a common nomenclature for power MOSFETs. This is a number, one or more letters and a number. Trailing letters denote the package and preceding letters the manufacturer. The first number is the continuous current, the letter will have a P or N depending on the channel polarity and sometimes a letter denoting the device structure and the final number is the voltage rating – in volts x 10. e.g the FQD 20N06 is a 20 amp, 60v, N channel device and the STP55NF06 is a 55 amp, 60 v device with a very low on resistance of 0.018 ohms.

Mike Bolton   12/02/09