The MERG Booster (Revised 22/6/99)

All DCC systems require a booster of some sort. However, the requirements will vary depending on the application. This design was an attempt to be as ‘universal’ as possible so it could be tailored to almost any situation.

It has the following characteristics:

The power output stage is independent of the driver electronics so can be tailored to suit. There is effectively no limit to the output current. The output voltage is limited to 80 which is well in excess of any likely DCC requirement.

It has an auto-reverse facility which can be switched off (or left out altogether).

There is an adjustable current trip of the ‘keep retrying’ variety.

There is an optional output voltage and output current meter facility.

The DCC input is opto-isolated to prevent ground loops.

Circuit description.

Refer to drawings boost5 revision G and boostpwr revision C

The circuit is based around the Harris HIP4082 full bridge MOSFET driver chip. This is an ideal device for DCC boosters as it will drive virtually any N channel MOSFETs with the minimum of extermal components. Shoot through is prevented and shut down is easy. Resistor R7 determines the delay for shoot through prevention. The actual value will depend on the MOSFETs used - slow MOSFETs need a larger value. However, too large a value will give a kink in the switching edges (non NMRA compliant) and too small a value will give a shoot through current pulse which is undesirable. The value of 10K seems a good compromise for medium current MOSFETs like RFP3055LE. (These are very cheap and good for upto 10 amps)

The chip generates the necessary gate voltage for the high side MOSFETs with a diode pump. The pump capacitors C7 and C8 (0.68uF) were chosen to give an acceptable ‘droop’ with stretched zero operation of upto 10 millisecs. Fast diodes like the UF4002 are necessary here (D4 and D5). Resistors R11 to R14 are series gate resistors for the MOSFETs. Again the value will depend on the MOSFETs used. They are used to limit the rise and fall times of the DCC track output. Without resistors, the rise / fall time can be very fast - a few 10s of nanoseconds - which may give rise to ‘ringing’ and RF interference. My prototype had no resistors and when connected to the track produced marked ringing at about 20 MHz. The track was acting like a tuned circuit! A value of 1K has been adopted as suitable for the RFP3055LE but could be increased until the switching time just met the NMRA spec. if RFI was a problem. Diodes D8 to D11 allow the MOSFETs to turn off quickly.

The DCC input is at logic level and drives a fast opto isolator (U2). The TLP2200 has a high voltage and symmetrical output so can drive the logic directly while preserving the DCC mark-space ratio. (ordinary optos may have different rise and fall times which can markedly affect the waveform and give a DC component as well.)

The opto output passes through two inverters U3c and U3f (CD40106) to the HIP4082. A bistable U6b and two analog switches (U4a and U4b) select the phase of the DCC for the auto reverse function. Two more analog switches (U4c and U4d) are wired in the HIP4082 shut down line. If either of these are open, the MOSFET drive is removed. Two more stages of the CD40106 inverter (U3a and U3b) act to detect the presence of a DCC signal. The output of the detector is linked to the shutdown switch and an indicator LED to show if DCC is present. No DCC, no output.

Track current is sensed by a resistor R17 in the ‘tail’ of the H bridge. This should be chosen to give about 1 volt at the maximum desired current. 0R22 suits a 5 amp booster. (NB 5.5 watts at full power continuous but a 5 watt resistor is OK). The voltage across this resistor is used in the current meter circuit as well. The voltage contains switching spikes so it is low pass filtered by R18 and C13 before passing to the current trip system. A LM393 comparator (U7b) senses if the current is above a preset threshold, set by VR1, and tries reversing the track phase first. If this cures the ‘short’ then no further action is taken. For a 5 amp limit, the voltage at U7 pin 6 should be set to 1.1v. If the short remains, the RC network (R22 and C14) charges up and an inverter U3d triggers the second half of the LM393 which is wired as a monostable. While this is running, the output is shut down and the ‘short’ LED (and AWD) comes on. When the monostable ‘times out’ the output is turned on and tries again. This process is repeated till there is no overload. As the on period is very much shorter than the off period, the mean current during an overload state is low.

The LED indicators and optional AWD have a common ground to simplify the wiring.

The HIP 4082 and all the logic is supplied with 12 v from an on board IC regulator (U1).

The power supply design will depend on the current output and voltage required. The present design aimed at 5 amps and an adjustable track voltage between 10 and 16 volts. An L200 (U8) adjustable regulator was boosted by a TIP3055 transistor to give 5 amps with a variable voltage. Also incorporated was a current limiter so that during the ‘retry’ pulses, the supply current was not dangerously high.

The MOSFET bridge can be fed with higher voltages for large gauges and a higher current supply can also be utilised. However, 5 amps should be sufficient for most applications and sections can be powered with separate boosters - essential for reverse loops anyway.

Printed circuit board and construction.

A PCB layout (single sided) has now been produced for a 5 amp booster. The board has been designed so that the power supply section can be separated for mounting elsewhere or dispensed with altogether if an alternative supply is available e.g. an ex-computer switch mode. It would also allow the basic booster board to be uprated with a higher current supply.

If the PSU section is left attached, the power section must be physically wired to the booster section using the terminal blocks or hard wiring. The booster PSU requires a 15v AC supply with adequate current rating. Although the booster as shown will deliver 5 amps continuous, a real layout will be most unlikely to take this all the time and the supply transformer can be of lower rating than the 100VA needed for 5 amps. 50VA should be satisfactory in most cases.

The power section of the PCB also includes the components for an isolated 5v supply for the command station and handsets. This needs a separate small mains transformer. If there is a 5v supply available elsewhere, this can be omitted.

All the power transistors and regulators are on one edge of the board and can be fastened to a common heatsink via insulated mountings. This could be the side of the case provided it was aluminium (not steel) and of sufficient thickness. (2mm or more). Running flat out, the heat to be dissipated is around 30 watts (25 from the TIP3055). The booster section alone will only contribute about 5 watts maximum.

If the booster is uprated for a higher current, R17 should also be mounted on the heatsink and the value changed to maintain about 1 volt drop at full current.

There is provision for adjusting the track voltage with VR2. This can be either a ‘trimpot’ on the board or an external 1K pot can be mounted on the case.

The circuitry for an optional voltage / current meter is not included on this PCB.

The PCB version has now been built and tested. It worked OK. Slight modifications have been made to the layout which is now revision C.

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