MERG DCC Command Station and Booster. (BC1A)

Introduction

The original booster design (Boost5) was intended for its flexibility and could use any command station input. Its advantages were almost any power rating (upto at least 10 amps) and a wide output voltage range depending on the power supply used. It used easily available N channel MOSFETs and had an auto-reverse capability. Its disadvantages were its relative complexity and the use of a specialised MOSFET driver chip (HIP4082) which was only available from one manufacturer and not always easy to obtain.

The Mk1 command station worked satisfactorily but was a separate unit and used a MAX1112 A to D converter which has proved difficult to obtain unless you can get free samples. (which was why I used it, apart from it being the best chip of its type)

Having built several complete systems for ‘customers’ I found that all were for smaller layouts where the need for high power was less relevant and 4 handsets was the maximum generally used.

I have now produced a design for a combined command station and booster suitable for HO/OO/N scales with a maximum current of 5 amps and a maximum track voltage of 16v. I have reduced the need for specialist ICs and combining everything on one PCB and in one box simplified construction.

The system allows for 4 handsets of the same design as the Mk1 command station to be plugged into the box (connectors on the PCB) but there is a connector for an extension panel for all 8 handsets. Also included in the PCB design is the facility for a fast serial bus (probably using the Lenz XpressNet V3 protocol) and a PC interface. I am waiting for the Lenz V3 specification before including the software for this. The core of the system is a PIC 16F874 microcontroller running at a clock of 16 MHz so there is plenty of scope for expansion. The PIC is integral to the booster and controls the MOSFET H bridge drive and handles the overload sensing.

The 16F874 has A/D conversion so the MAX1112 is not needed. Neither is the HIP4082 MOSFET driver. The only ‘down’ side is the use of P channel MOSFETs in the bridge. These are slightly harder to obtain than N channel.

In order to produce an ‘integrated’ unit, the PCB includes space for a toroidal mains transformer with links for 110/120 v or 220/240v mains. However, there is no reason why a separate transformer cannot be used.

As there is now a single supply for the command station and booster, the track is no longer ‘floating’ relative to the command station ‘ground’. A home ground terminal is provided if required. However, there is a DCC signal output for connecting to additional boosters.

Circuit description. (schematic BC1a Rev B)

The simple to use MERG handsets produce an analog voltage for speed control and a 17 bit serial data stream for address, function and consist data. Up to 8 handsets are scanned on a 'round robin' basis. The PIC has 8 A/D channels for the speed information and 8 digital inputs are used to select the serial data from each handset. A common serial clock drives the handsets through a clock driver chip U3. This allows longer leads and a high capacitive load. The wiring for 4 handsets is taken to four RJ12 (6 way) connectors on the main PCB but all handset and other connections are also available on a 26 way IDC plug (J11) on the PCB for remote connection. (You can't use the same 4 handsets on both the PCB and the remote extension at the same time as the connections are in parallel)

The 16F874 has a USART able to operate at 62.5KB (Lenz X-bus) or 9600 baud for a PC. The PCB contains a RS485 driver chip (U3) for a serial handset bus and simple connections for a COM port. A true RS232 driver is not used so the cable length to the PC will be limited. (The software for serial interfacing has not yet been developed).

The PIC handles the overload sensing for the booster as well as errors in the command station section (address clashes etc). The overload has a rapid (but software adjustable) trip time with a retry at about one second intervals. There is a common audible alarm but separate warning LEDs for the handset and booster faults. The alarm sound is different for the two conditions.

The booster output is a H bridge arrangement using two N channel MOSFETs for the low side and two P channel MOSFETs for the high side. The use of P channel devices avoids the need for a drive voltage above the main supply rail and greatly simplifies the system. (This arrangement is the same as used in DCC decoders).

The PIC provides the two phases of the H bridge drive with a switching delay. Transistors Q3 and Q4 are level translators to convert the 5v PIC output to the 10 to 16 v of the booster supply. A 4000 series hex inverter (U4) drives the MOSFETs. This allows a symmetrical signal on the gates (active pull up and pull down) and avoids needing logic level MOSFETs on the low side. Driving all the MOSFETs from the same chip gives the same switching characteristics for all and hence a clean waveform. The relatively low drive capability of the CD40106 is an advantage as it slows the switching of the MOSFETs to a rate where EMI and ringing due to track resonances are tolerable. (specialised MOSFET driver chips give a switching time which is too fast)

The PCB has space to fit EMI filtering (L1, L2 C20 and C21) if required but the best values remain to be determined. The track current is sensed across the resistor combination R17//R18. Two resistors here allowed the use of cheaper 2.5 watt devices and the ability to 'mix and match' for the overload current. Overload is sensed when the voltage is sufficient to turn on Q5. With two 0.33 ohm resistors in parallel, the trip current is about 4 amps. R15 and R16 allow for some adjustment here.

The booster power supply is derived from the transformer via the bridge rectifier BR1 and the 5 amp regulator U5. The LM338T is a low cost device but with current limiting and thermal shutdown. It also allows the voltage to be adjusted. However, it must be on a reasonable heatsink. With Vin at 20v, Vout at 14v and current at 4 amps, the power dissipated is 6v x 4A = 24 watts. The PCB is designed so that all the power devices can be mounted on the same heatsink. This can be the back of the box or a single sheet of thick (3mm) aluminium.

The 5v supply is provided by the regulator U7 (with small local heatsink) and U6 provides a 12v supply. The latter is only needed for the Lenz X-Bus which specifies a 12v supply and can be left out otherwise. The AWD and fault LEDs can be run from either 5v or 12v (if fitted) by a jumper on the board. Adjust the values of R6 and R7 for LED brightness.

The schematic and PCB layouts are downloadable as .PDF files from the MERG site. You can create a PCB mask directly by printing the .PDF file on clear film with a Laser printer. (Print at 100%, NOT 'print to fit')
The PIC source code is also available as is a parts list. The present code replicates that of the Mk1 command station. The 16F874 is a reprogrammable device so can be upgraded if or when the serial facility is written.

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