6.0A
H-Bridge Driver
for DC Motor

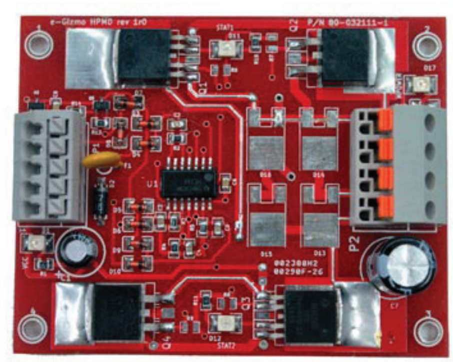
Technical Manual Rev 1r0

The 6A H-Bridge Driver 6HBD is a DC motor driver kit for control of small to medium size motors rated at 6A (or less). It features low loss MOSFET outputs with protected high-side drivers. Protected high side-drivers make the 6HBD tolerant to overload and over temperature conditions. It works with motor power source up to 24VDC.

The control input works with 5V logic level. The on-board logic prevents the MOSFET from entering states that may cause unwanted short circuiting. At the same time, it performs basic motor control functions such as forward and reverse run operation. Motor speed control can be implemented by applying a PWM input to a control input.

Specifications

Motor Supply:	5-24VDC
Output Current :	6A cont, 10A peak (500ms)
PWM Frequency:	<500Hz
Logic Supply :	5V @ 50mA typical
Board Dimensions:	62x78 mm



High quality solderless connectors are used for the controls and motor load terminals. The 6HBD does not even require a heatsink to handle 6A loads. Forced air cooling could extend the load capacity a bit more. See text for more details.

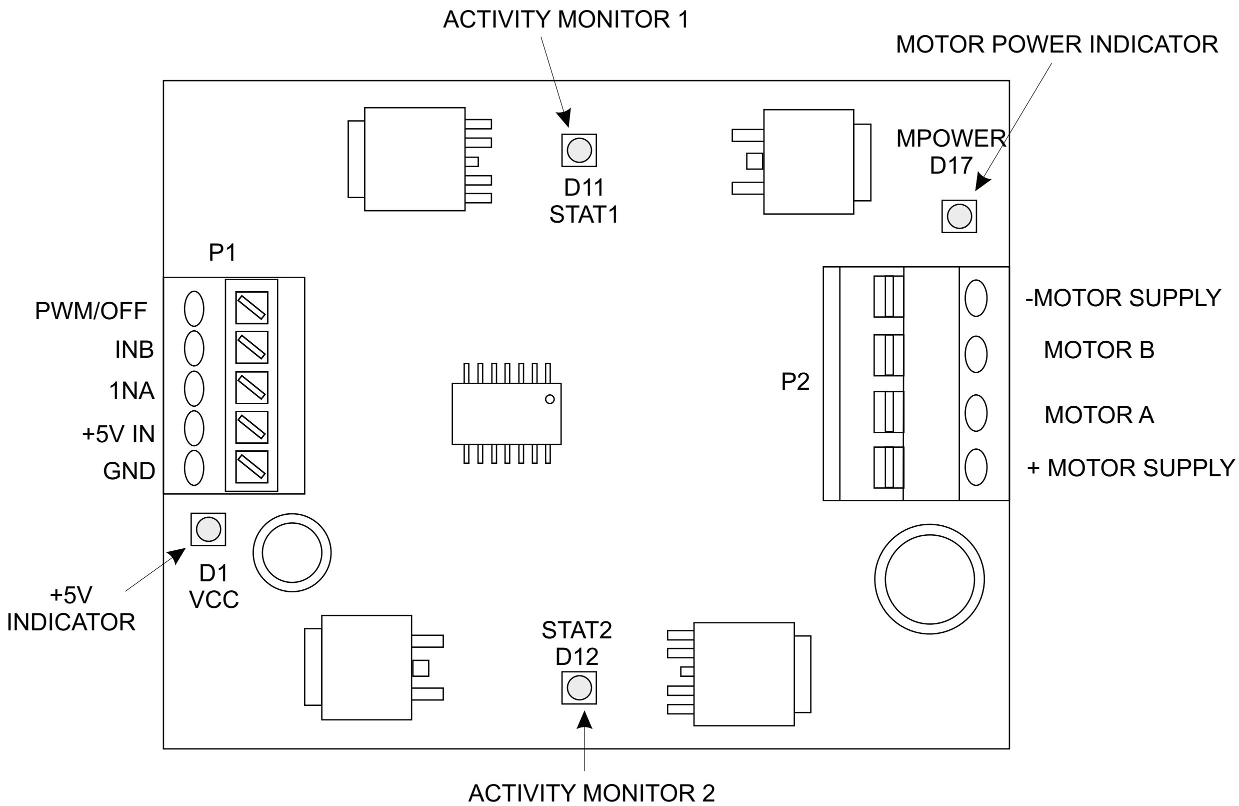


Figure 1. *6A H-Bridge Driver 6HBD terminals and LED indicators layout.*

Table 1. LED Indicators

LED	ID	Description	Remarks
D1	VCC	Logic power indicator (+5V)	
D11	STAT1	Q1 high-side switch fault indicator (note 1)	ON when INA=INB=logic 0
D12	STAT2	Q3 high-side switch fault indicator (note 1)	ON when INA=INB=logic 0
D17	MPOWER	Motor power indicator	

Note 1: STAT1 and STAT2 are fault indicator LEDs, but will lit even under normal conditions when both INA and INB are set to logic “0”. This is normal and does not indicate a fault. PWM operation will also turn the LEDs ON. Refer to the BUK-205Y device datasheet for more information.

Table 2. P1 Control Terminal

Pin No:	Pin ID	Description	Remarks
1	GND	Logic GND	Power Input
2	+5V	+5V Power Input	Power Input
3	INA	Run Forward (note 2)	0-5V Input, Active High
4	INB	Run Reverse (note 2)	0-5V Input, Active High
5	PWM/OFF	PWM input for speed control/ HBridge OFF	0-5V Input, Active Low

Note 2: Actual direction will depend on how the motor is used and connected at the motor driver output.

Table 3. P2 Motor Output Terminal

Pin No:	Pin ID	Description	Remarks
1	+Vmotor	Motor Power (+) input	
2	MOTOR A	Connect to DC Motor	
3	MOTOR B	Connect to DC Motor	
4	-Vmotor	Motor Power (-) input	Connected to GND

Table 4. Truth Table

INA	INB	PWM/ OFF	MOTOR A	MOTOR B	Remarks
L	L	H	+Vmotor	+Vmotor	Motor terminal is effectively shorted to +Vmotor causing a braking action
H	L	H	+Vmotor	-Vmotor	Forward Run
L	H	H	-Vmotor	+Vmotor	Reverse Run
H	H	H	-Vmotor	-Vmotor	Motor terminal is effectively shorted to -Vmotor causing a braking action
X	X	L	OFF	OFF	All output OFFs. Motor is powered down without braking action.

CIRCUIT DESCRIPTION

The complete schematic diagram of the 6HBD circuit is shown in figure 4. The circuit at first may appear complicated, but with a closer look, you will find it as just consisting of two identical MOS-FET driver circuit, both driving the motor to a certain polarity. Figure 2 shows one half of the circuit in simplified form.

As can be seen from the simplified block diagram, the circuit operation is quite simple and straightforward. The output stage consists of a P channel MOSFET, referred hereafter by its function as the high-side switch (since its main job is to connect the output to the +Vmotor rail when it is switched ON), and a N channel MOSFET, the low-side, switch responsible for connecting the output to the –Vmotor side.

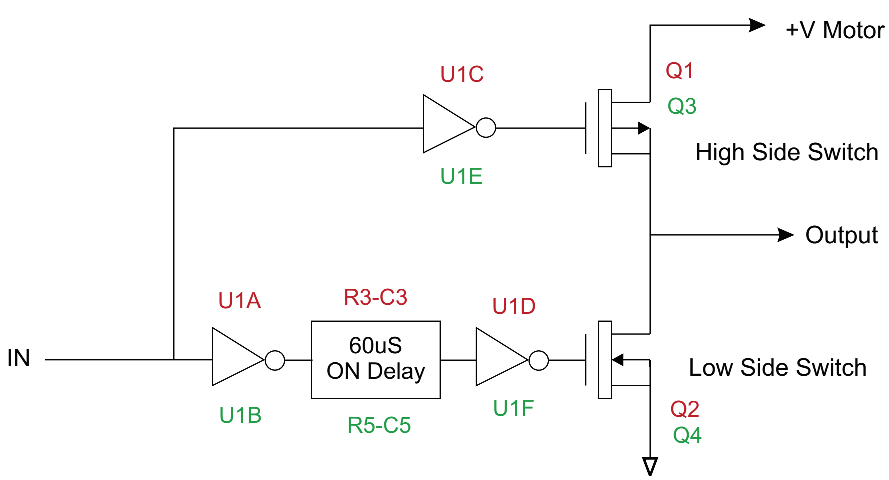


Figure 2. *Simplified block diagram of 1/2 6HBD driver. Components in red text comprises the upper half bridge illustrated in the complete schematic. The green text corresponds to components used in the lower half bridge.*

The MOSFET switches are 5V logic level compatible and can be turned ON by applying 5V at its input. During operation, you don't want to turn ON both switches at the same time. Doing so will cause a direct short between the +Vmotor and –Vmotor. Hence to prevent this, an inverter is inserted into one of the switch input. A logic "0" input will turn ON the high-side switch. The inverter, at about the same time, will respond by driving the low-side switch input to logic "1", hence turning OFF the low side switch as well. Feeding IN input with logic "1", on the other hand, will turn OFF the high-side switch and turn ON the low-side switch at about the same time.

At this point, you are probably wondering what that "60uS ON delay" block doing in the circuit. MOSFET switches, fast as they are supposed to be, still takes a finite amount of time to switch from one state to another. That's it, applying a logic high to the switch input will not switch it ON immediately. The switch needs a few more microseconds to respond. This transition period is what the datasheets refers to as the ON time t_{ON}. The same is true when you apply logic "0" to a switch to turn it off. The OFF transition period is called the OFF time t_{OFF}. If we do not take this into account, both switches can turn ON at the same time for a brief period during state transitions, producing an unwanted momentary shorts along the +Vmotor and –Vmotor rail.

MOSFETs, as it turns out, are easier (faster) to turn ON than to turn OFF. The IP06N03LA low-side switch we used in this circuit needs only 16nS to turn ON, but takes on 45nS to turn OFF. The BUK205-50Y high-side switch, on the other hand, is a slow switcher by comparison, exhibiting a 40uS ton and 50uS toff switching times.

With these switching times in mind, it should be easy to picture why the 60uS ON delay is needed. Imagine the circuit without the 60uS delay. During a logic "0" to "1" transition at the IN input, the fast low-side switch will turn ON in no time at all. But the high-side switch does not switch OFF as fast, in fact, it needs 50uS to do that. Hence, during this 50uS period, both high-side and low-side switches are ON, creating a momentary short!

The 60uS ON delay for the fast low-side switch will prevent this from happening. No delay circuit is needed for the high-side switch because it is slow enough to start with.

U2-Q5 forms a power ON reset circuit to prevent the switches from turning ON while the circuit is powering up.

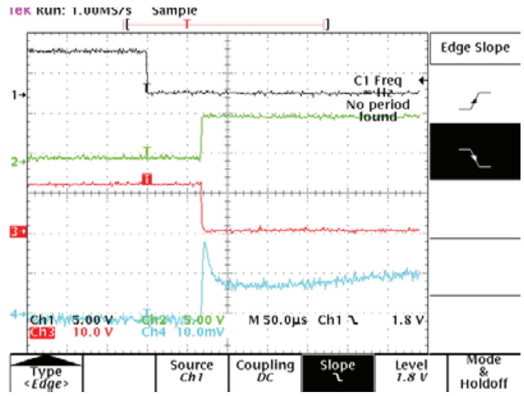


Figure 3a

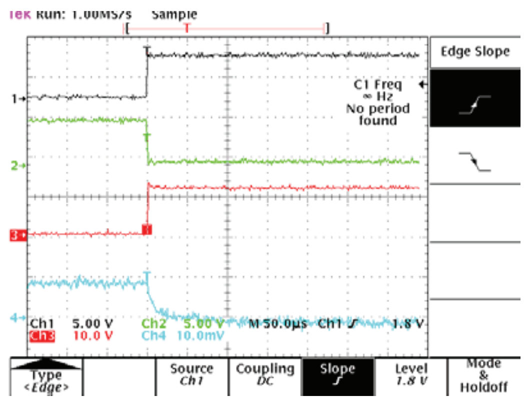


Figure 3b

Ch1 - Low-side switch gate drive
Ch2 - High-side switch gate drive
Ch3 - Output
Ch4 - Load current at 5A/div

Equipment Used:
Tektronix TDS784D Digital Oscilloscope
Tektronix A6302 current probe with AM503B Amplifier

Figure 3. *Actual oscilloscope patterns showing the gate drives timing relationship of the MOSFET switches, and the corresponding outputs. Figure 3a shows high-side OFF transition occuring with the low-side 60uS turn ON delay in action. The peak in current trace suggests that even after 60uS, the high-side switch still has not completed its OFF transition. Figure 3b, in contrast, shows a clean high-side ON transition without the need for any pulse delay.*

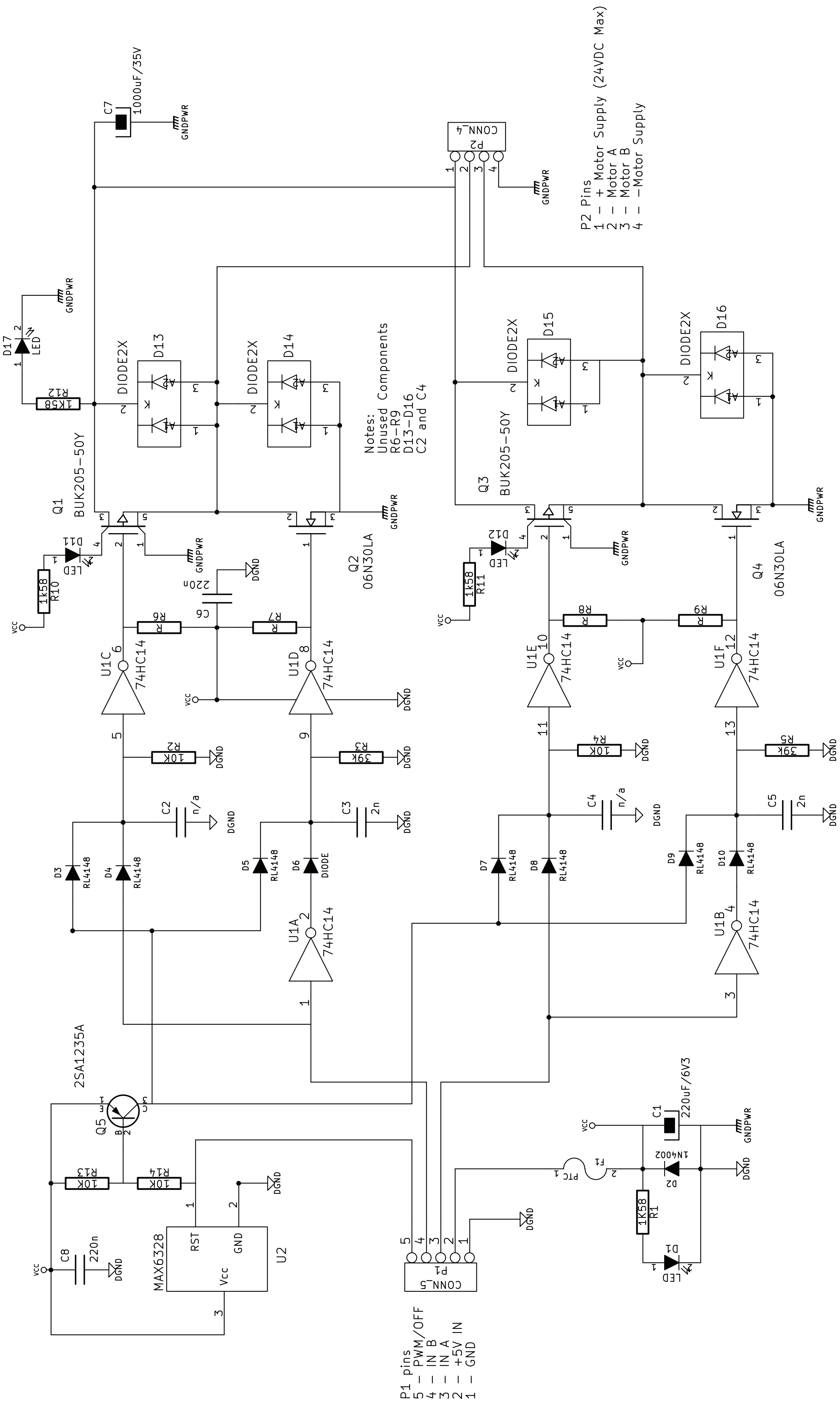


Figure 4. Complete schematic diagram of the 6A H-Bridge Driver (6HBD).

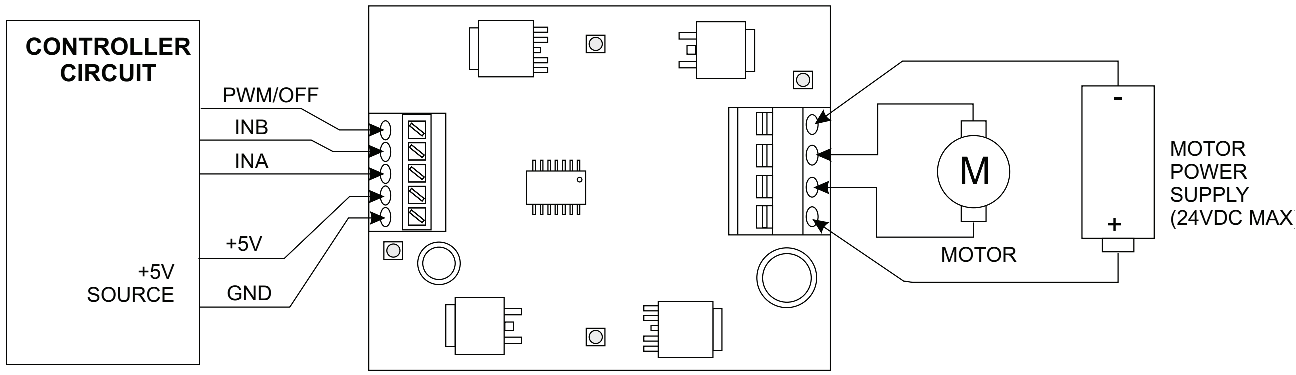


Figure 5. *6HBD typical wiring diagram. Use the PWM/OFF control input for PWM speed control. Using INA or INB for PWM speed control is inefficient and will unnecessarily draw more power from the motor supply and put more stress on the MOSFETs.*

APPLICATION HINTS

A typical 6HBD application wiring is shown in Figure 5. The output terminals connects to the DC motor and DC Motor supply. A controller circuit operates the 6HBD system by applying a 5V control logic input to INA, INB and OFF inputs. A quick function description of the control terminal pins is shown in Table 2.

Forward-Reverse Operation

To run the motor, apply a logic “1” input to INA or INB input. A steady logic “1” input will run the motor at full power. The direction of motion will depend on how you connect the motor. If logic”1” on INA causes the motor to run in clockwise direction, INB will run it counterclockwise. INB will always run the motor opposite the direction of INA.

PWM Speed Control

A speed control can easily be implemented by feeding PWM/OFF with a PWM signal, instead of a steady logic “1” or “0”. The motor will be driven with power roughly proportional to the duty cycle of the PWM input. A 50% duty cycle will cause the motor driven to just half the available power. 75% duty cycle will correspondingly increase the motor power to 75%, and so on. The 6HBD will work with PWM input frequencies of up to 500Hz, but will work best for PWM frequencies less than 200Hz.

Stopping the Motor

The motor can be stopped two ways: by applying logic “1” or “0” to both INA and INB, or by forcing the OFF pin to logic “0”. Each method stops the motor in a different manner. As shown in Table 4, driving both INA and INB to logic “1” or “0” will short both motor terminals to –Vmotor or +Vmotor respectively. This method, asides from removing power from the motor, effectively shorts the motor terminals together, causing a rapid motor stop (braking effect). A logic “0” in the “OFF” terminal, on the other hand, effectively disconnects the motor from the driver, causing the motor coast to a stop.

Load Considerations

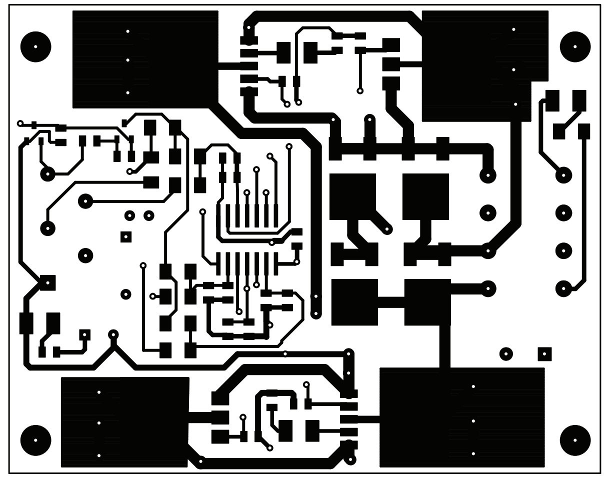
To keep the cost low, the 6HBD MOSFETS switch are not equipped with heat sinks. The high side switch has rather large ON resistance- 0.06 ohms. This essentially set the maximum load the 6HBD can take. By comparison, the low side switch has an ON resistance about 10 times lower -0.006 ohm. As a consequence, during operation, the high side switch will heat up necessarily faster and hotter that the low side switch. Under high load conditions, the high-side switch may already start overheating just when low-side switch starts to warm up.

Overloading the 6HBD will not cause any permanent damage. Once the high side switch overheats, it will simply shut down, and will work again once its temperature drops to a workable level..

Without the aid of heat sinks, the 6HBD can drive up to 6Amps load continuously for at least an hour. With PWM input of 50% duty cycle at 100Hz, actual tests showed the 6HBD could take about 7.5A peak for at least an hour without shutting down. Under this loading conditions, tab temperature of the high-side switch can exceed 100C.

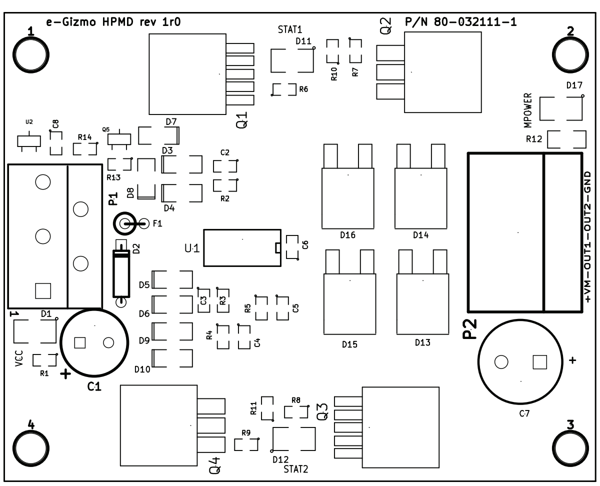
When used in applications where the motor load is turn ON only for a brief period (and is OFF most of the time), the 6HBD should be able to work loads of up to 7.5A.

You can extend the capacity of the 6HBD by adding means that will help the high-side switch draw away its heat. Adding a heatsink may not be the best option, unless you find an easy way to mount one. Forced-air cooling using a small box fan will make your 6HBD work with up to 7.5A load with continuous duty. •

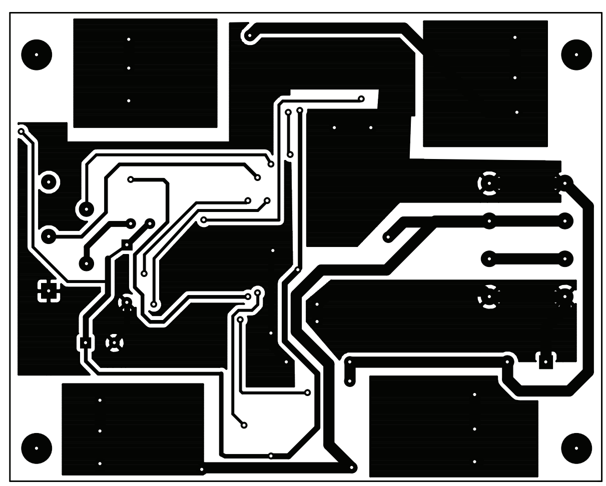


Component side pattern.

PCB ART GALLERY



Component side Silk Screen print



Copper side pattern (mirrored).