DeviceCraft

Revision #3 3/9/2010

H-Bridge DC Motor Driver / Speed Controller

(P/N 1005-20A-50V 50V 20amps)

(P/N 1005-20A-90V 90V 20amps)

(P/N 1005-10A-190V 190V 10amps)

Features:

- Analog Forward/Reverse input speed control (0 to 5Volt)
- High Side very fast Hall effect ~6usec over current protection
- MOSFET H-Bridge configuration
- Thick copper traces on both sides
- On board regulator with a +5v regulated output for powering circuitry
- Thermistor based over temperature protection
- Includes heat sink/mounting plate
- Quiet ~17Khz Pulse Width Modulation ~95% Duty cycle(depends on decay)
- On board power/stop/overheat LED indicators(also wired to output pins)
- Screw terminal inputs for Power and Motor
- Ramp up speed control for smooth acceleration, Coast, and Brake.
- On board pullup/pull-down resistors on digital input pins
- High side current sensing output (0 to 5volts)
- Internal diode in MOSFETS for generator/regeneration applications
- Conservative Current specifications
- Insensitive to noise on power line.

Specifications for (P/N 1005-20A-50V 50V 20amps)

Operating Voltage	10V to 50V
Current Limit Setting	30-50Amps
Over Current Response Time	~6us
Over Temperature On	80C
Over Temperature Off	70C
Startup Time	~1Sec
Ramp Rate (stop to full speed)	~0 to 4Sec (Can be changed to 0sec)
Duty Cycle	0 to ~95%(depends on decay type)
PWM switching rate	~17 Khz
Digital Input low	0 to 1V
Digital Input High	3.5 to 5V
Quiescent Current Note: Hall effect current sensor draws 10mA Green LED draws 3ma	~13mA
MOSFET On resistance	15milliohms(30 milliohms total for both high and low side)
Reversing Delay Time	(0 sec) depends on motor

Power Handling

+V voltage	Current	Power
10	20 amps	200 watts
12	20 amps	240 watts
20	20 amps	400 watts
24	20 amps	480 watts
36	20 amps	720 watts
40	20 amps	800 watts
50	20 amps	1000 watts

Specifications for (P/N 1005-20A-90V 90V 20amps)

Operating Voltage	20V to 90V
Current Limit Setting	~22-30Amps
Over Current Response Time	~6us
Over Temperature On	80C
Over Temperature Off	70C
Startup Time	~1Sec
Ramp Rate (stop to full speed)	~1Sec(Can be changed to 0sec)
Duty Cycle	0 to ~100%
PWM switching rate	~18 Khz
Digital Input low	0 to 1V
Digital Input High	3.5 to 5V
Quiescent Current Note: Hall effect current sensor draws 10mA Green LED draws 3ma	~13mA
MOSFET On resistance	20milliohms(40 milliohms total for both high and low side)
Reversing Delay Time	0sec depends on motor

Power Handling

+V voltage	Current	Power
20	20 amps	400 watts
40	20 amps	800 watts
60	20 amps	1200 watts
80	20 amps	1600 watts
90	20 amps	1800 watts

Specifications for (P/N 1005-10A-190V 190V 10amps)

Operating Voltage	30V to 190V
Current Limit Setting	15-20Amps
Over Current Response Time	~6us
Over Temperature On	80C
Over Temperature Off	70C
Startup Time	~1Sec
Ramp Rate (stop to full speed)	~1Sec(Can be changed to 0sec)
Duty Cycle	0 to ~97%
PWM switching rate	~18 KHz
Digital Input low	0 to 1V
Digital Input High	3.5 to 5V
Quiescent Current Note: Hall effect current sensor draws 10mA Green LED draws 3ma	~13mA
MOSFET On resistance	150milliohms(300 milliohms total for both high and low side)
Reversing Delay Time	0 sec

Power Handling

+V voltage	Current	Power
30	10 Amps	300 watts
50	10 Amps	500 watts
100	10 Amps	1000 watts
150	10 Amps	1500 watts
190	10 Amps	1900 watts

Input/Output Pins for Standard Model:

Note: Pins may have an alternate function for other models

Pin	Name	Function
1	Is	High Side Current sense output 1k resistor in series with output for protection 2.5v indicates 0amps drawn The hall effect device voltage goes positive with increasing current drawn, up to about 4volts. Less than 2.5v indicates current is being feed back into the power supply or battery. The exact voltage out depends on the over current tuning.
2	Ain	PWM duty cycle analog input 50k at input to ground for protection. 0 to 2.5v reverse (0v full reverse) 2.5v forward(5v full forward)
3	+5v	+5v DC output Only a small <10ma of current should be drawn from this pin for powering potentiometers and hall effect throttles.
4	Gnd	Ground
5	Gnd	Ground
6	Rs	Brake to stop (ground MOSFETs On) Brake when pulled low 20k resistor to 5v at input on board Caution: High side over current detection disabled during braking, use Ain or F/R coast to slow motor before braking.
7	Fs	Acceleration 0 volts min 5 volts max (~5 sec to full speed) 20k resistor to 5v at input on board
8	F/R	Coast to stop (all MOSFETs off) Coast when pulled low 20k resistor to 5v at input on board.
9	C0	Digital Output, portC0. Tied to Green LED Drive (Status ok when High)
10	C1	Digital Output, portC1. Tied to Red LED Drive (Fault condition when high or flashing)
	+V	DC power to unit
	Gnd	DC power Gnd to unit
	M+	Positive Motor Output
	M-	Negative Motor Output

Schematic

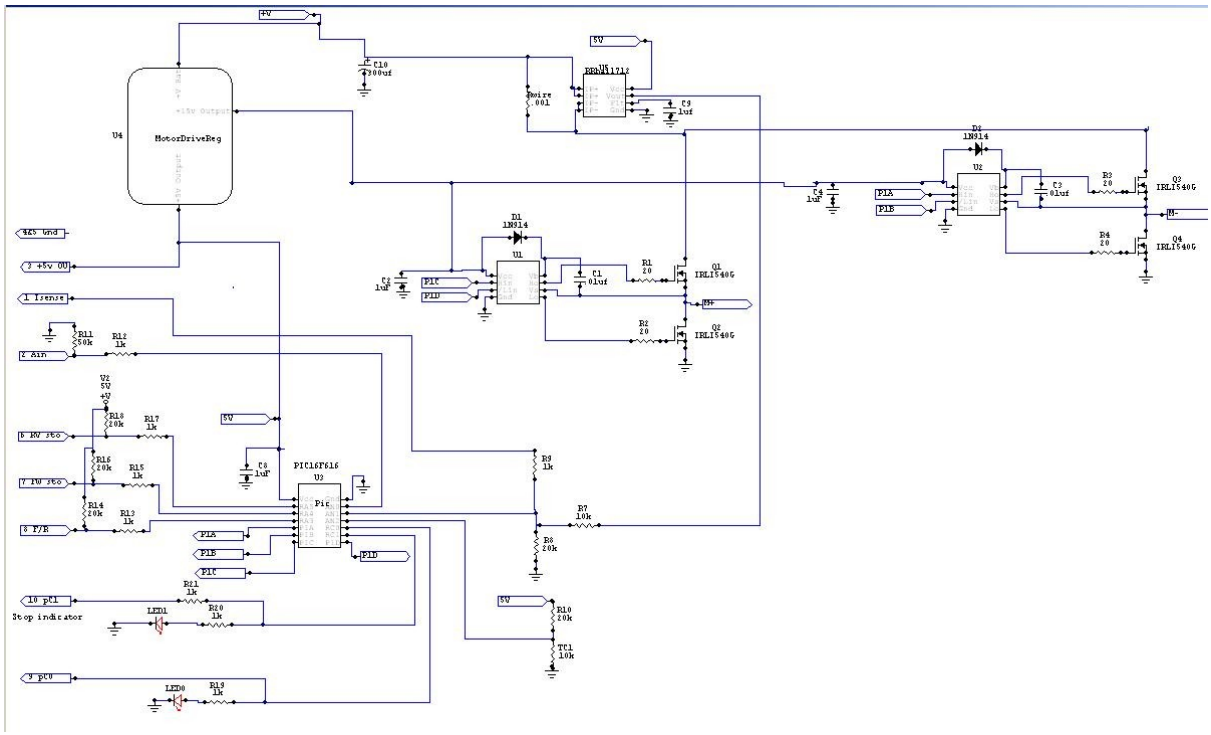
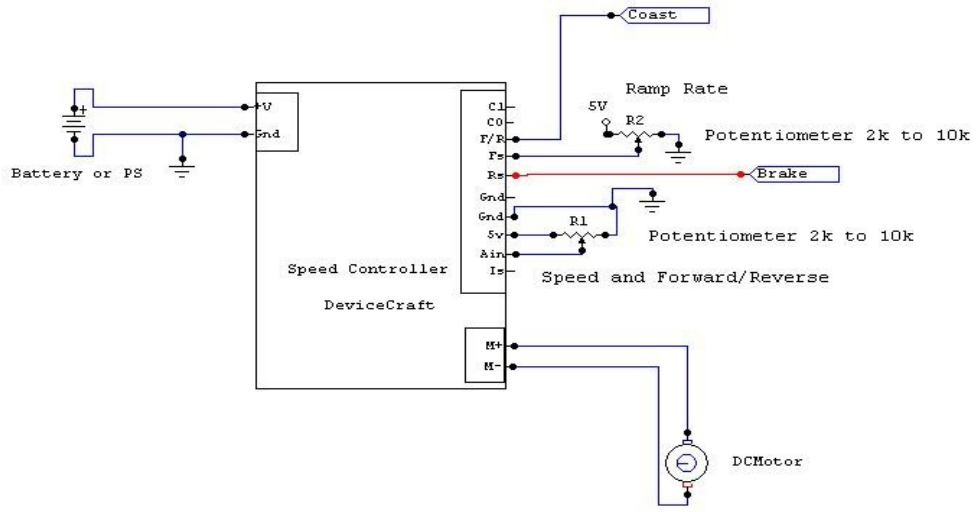


Figure 1: Schematic



Hookup Figure 2: Simple hookup diagram

Notes:

1) Be aware of the on board 50k resistor to ground at the Ain input pin. High resistance potentiometers can be more moisture/noise sensitive.

2) Do not place snubbing or other capacitors across the motor terminals. Place any needed extra filtering capacitors on the power supply lines.

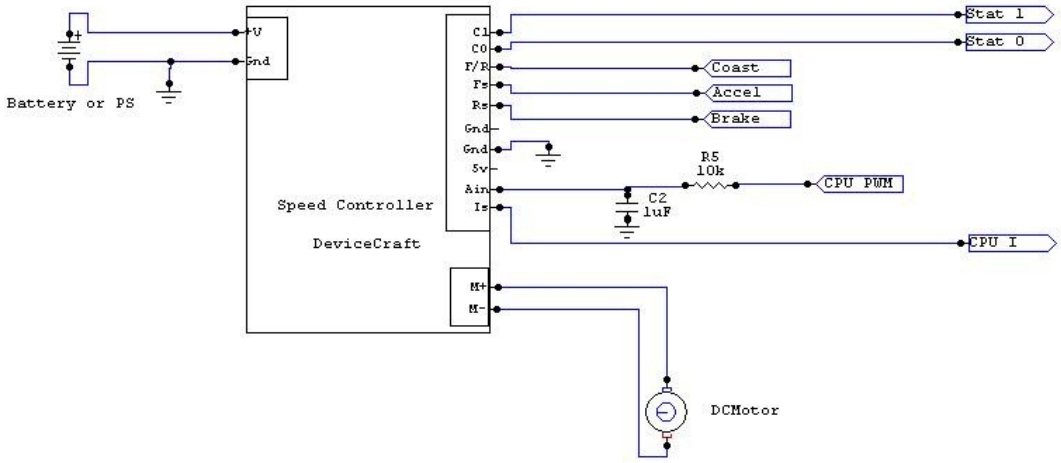


Figure 3: CPU controlled hookup diagram

Notes:

1) If Coast and Brake lines are not needed then leave open(unconnected)
2) Is(pin 1) can be used to monitor current otherwise leave open
3) C0(pin 9) and C1(pin 8) can be used to check status otherwise leave open
4) Ain(pin 2) is a analog input, a filtered PWM can be used to create a analog signal. A external DAC can also be used.

Description

The H-Bridge portion of the circuit is based around standard design recommended by International Rectifier Corporation. The H-Bridge DC motor controller consist of 4 power MOSFETs, 2 high side/low side MOSFET drivers, hall effect high side current sensor, step down regulator circuitry, micro-controller, thermistor, and miscellaneous capacitors, diodes, resistors, and connectors. The circuit board is attached to an aluminum mounting plate that also serves as the heat sink for the power MOSFETs. Two screw terminal connectors are used to connect the motor and power supply. A 10 pin connector is used for motor control and status sensing.

Three LED indicators:

1) Green LED (tied to C0 on 10 pin connector)
    A) Flashes twice to indicate start up initialization complete
    B) Continuously ON – normal operation
    C) OFF – When stop, over temperature, over current active
2) Red LED. (tied to C1 on 10 pin connector)
    A) Continuously ON - Reverse or Forward stop active.
    B) Flash 1 second interval – Over temperature active
    C) Flash ¼ second interval – Over Current active

Motor Outputs:

1) M+ This output receives the pulsed width control of the same voltage as the +V of the supply when operating in the forward condition. When operating in the reverse the M+ line is tied to ground through the low side of the power MOSFET. This line also has high current diodes to both the +V supply and ground. The high current diodes will allow this driver to also act as a rectifier to charge a battery. Depending on the required current the wires to this line on the screw terminal should be made as large as possible.
2) M- This output receive the pulsed width control of the same voltage as the +V of the supply when operating in the reverse condition. When operating in the forward the M- line is tied to ground through the low side of the power MOSFET. This line also has high current diodes to

both the +V supply and ground. The high current diodes will allow this driver to also act as a rectifier to charge a battery. Depending on the required current the wires to this line on the screw terminal should be made as large as possible.

Power Supply Inputs:

1) V+ Input powers the motor and control circuitry. Do not reverse the V+ and ground, reversing the power supply will damage the power MOSFETs. The power MOSFETs have an internal diode from the source to the drain. Consider using thick solid wire of at least 20AWG. Stranded wire should be used with care.

2) Gnd input is the unit ground. This input is also tied to the 10 pin control connector Ground inputs.

Wire Resistance Table

AWG	Diameter	Resistance per foot
24	20 mils (thousands of inches)	26 milliohms
22	25 mils	16 milliohms
20	32 mils	10 milliohms
18	40 mils	6.2 milliohms
16	50 mils	4 milliohms
14	64 mills	2.5 milliohms
12	80 mils	1.6 milliohms

At 20amps 1 foot of 24 AWG wire would dissipate

PWR=I^2 * R = 20*20*.026 = 10.4 watts

At 20amps 1 foot of 14 AWG wire would dissipate

PWR=I^2 * R = 20*20*.0025 = 1.0 watts

Over Current Protection:

The H-Bridge motor driver provides for over current protection. The current is sensed with a Hall Effect sensor located on the +V power supply line. The sensor is place strategically between the large capacitor and the H-Bridge. The placement before the large +V capacitor would not allow for quick capture of over current conditions. The output of the Hall Effect current sensor also is routed to the 10 pin control connector. The normal 0 ampere output of the sensor is 2.5volts. With an increase in current the output increases. When in regeneration mode the voltage will drop below 2.5volts. The current protection is hardware based and is always monitored. When an over current level is met, all the MOSFET switches in the H-Bridge are shut down (coast). In a case where the motor outputs are shorted the protection circuitry will shut down within about 6usec. The over current is monitored by the microprocessor and will normally reset in ½ a second. The RED will flash at ¼ second intervals.

Over Temperature Protection:

The H-Bridge driver contains over temperature protection. A thermistor bead is positioned under the circuit board in close contact with the heat sink/ mounting plate. The on board micro controller measures the temperature many times per second and if necessary places the H-Bridge in shut down mode with all Power MOSFETS off(coast). Currently the driver shuts down the H-Bridge at 80C and then resets at 70C. The RED LED will blink at 1sec intervals while shutdown. When operating at high currents the mounting plate should be mounted to a good heat-conducting object. Heat sink grease should be placed between the two objects.

An Over Current condition could also cause an Over Temperature condition and power should be removed as soon as possible.

Cautions

1) Do not allow high ripple currents on the power supply capacitor.
2) Do not place capacitors across the motor leads.
3) Do not allow the device to run in a short circuit condition for an extended period on time.
4) Do not reverse bias the power supply.
5) The over temperature thermistor cannot detect fast spot heating. Do no allow the device to operate in a hot environment. Overheating is the major cause of MOSFET damage. MOSFETs typically short when damaged.
6) Do not operate this device in a machine that could cause harm till fully tested.
7) The digital input lines are susceptible to noise. The noise can be created by ground loop problem, capacitive coupling, and magnetic coupling. The firmware has a noise reduction routine built in but, the user should still keep the lines short or shielded if possible.

Dimensions

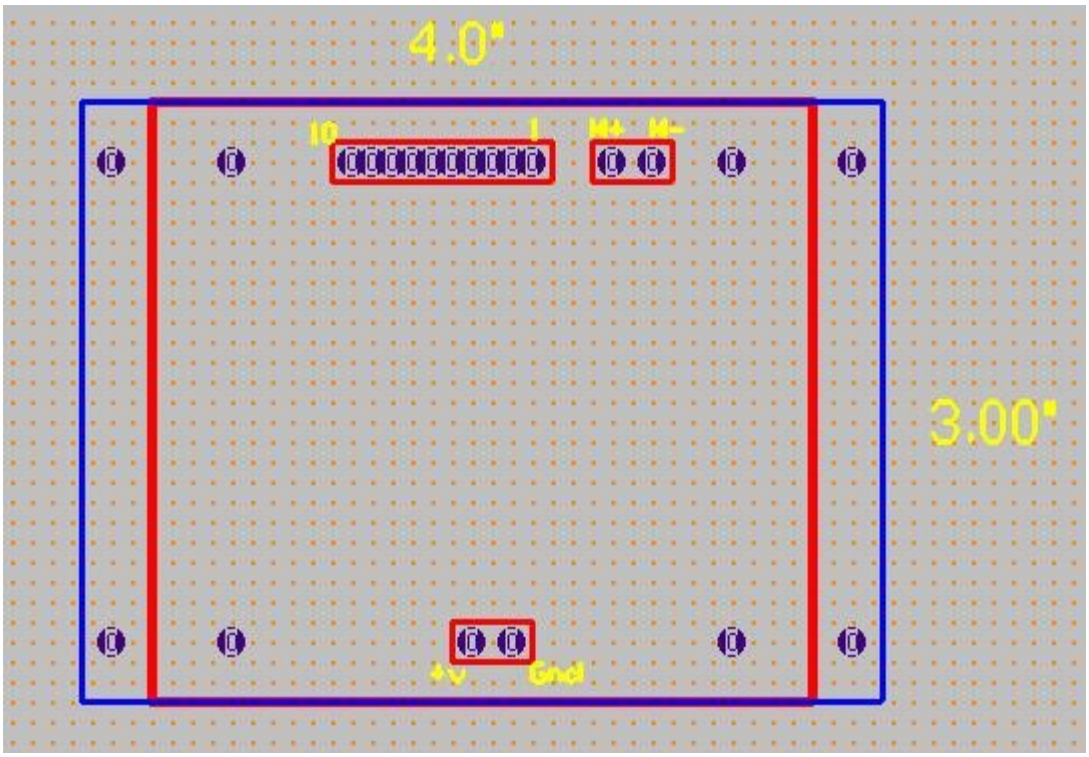
Circuit Board Dimensions: ~ 3.0” x 3.3”

Mounting plate Dimensions: ~3.0” x 4.0”

Mount Hole Diameter: .125”

Mounting Hole Spacing: .2” in from long side .3” in from short side

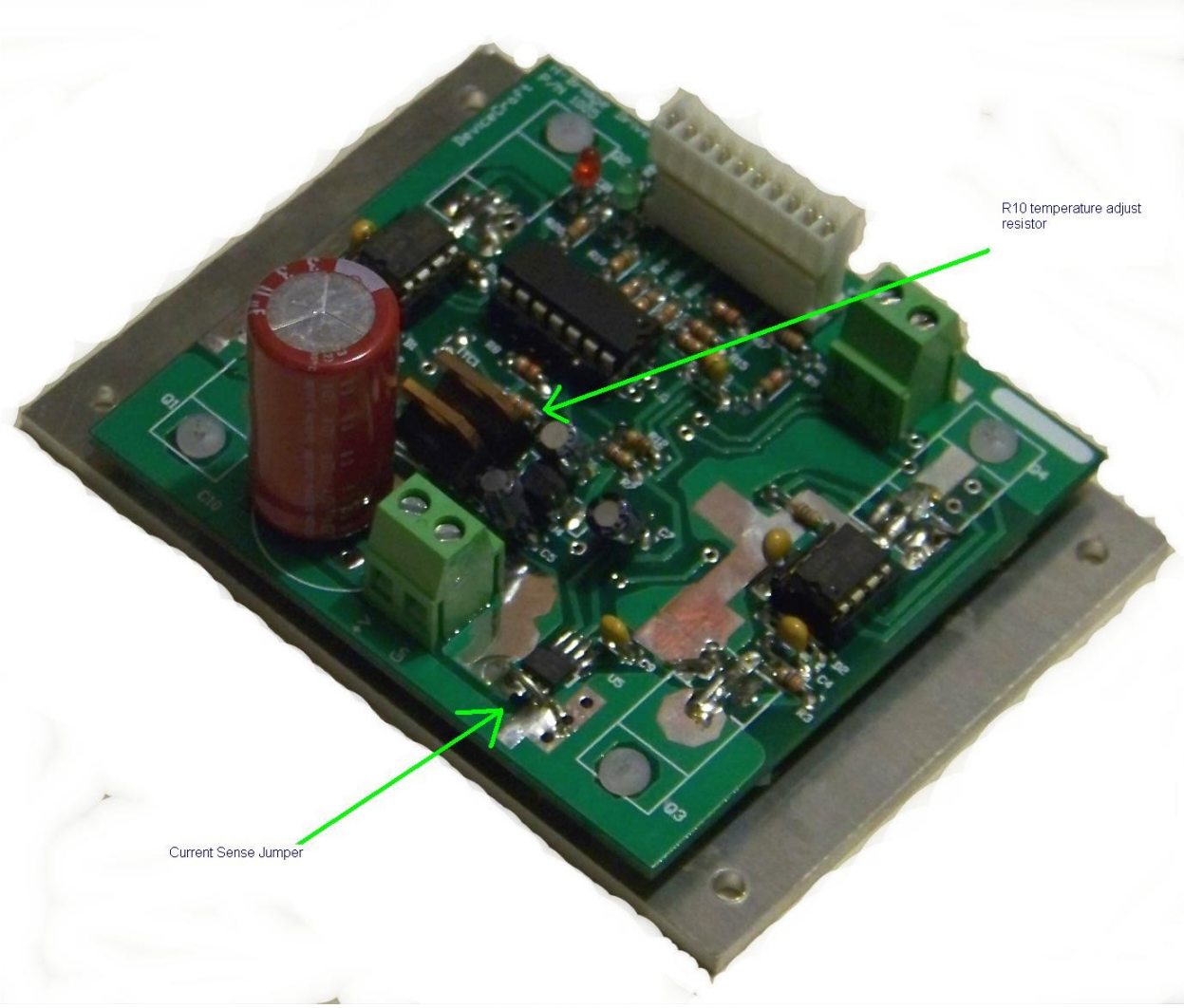
Spacing between holes 3.6” long side and 2.4” short side



User Modifications:

1) The user may want to increase the over current protection level. The over current protection may trigger during start-up or for high current pulsed application. To increase the current a soldering iron is required. The Hall effect device U5 senses the high side current. The current into the MOSFETs flows from pins 1&2 to pins 3&4. A jumper wire is also soldered across the pins 1&2/3&4. To increase the current limit, the jumper wire can be made shorter or thicker. An extra piece of wire across the jumper will also increase the current limit.

2) The over temperature protection trigger can also be modified. Currently the voltage is monitored at a junction in between a 10k thermistor TC1 and a 20k standard resistor R10. To increase the temperature limit lower the value of R10. Increasing the temperature limit can be achieved by lowering R10 from 20k to a lower value by soldering a extra 1/8watt resistor in parallel with R10 or by replacing the resistor with a lower value.


R10 temperature adjust resistor
Current Sense Jumper