H-Bridge DC Motor Driver / Speed Controller

P/N 1016BA 30Amps (~15 Amps for 180v version)

Available with power supply voltages 30V, 50v, 90v, 180v

Note: 30volt unit operates down to 10Volts

Features:

- High power discrete MOSFET construction
- Analog Forward/Reverse input speed control (0 to 5Volt, 1 to 4v, PCM, TTL RS232)
- Onboard Blade fuse.
- Nonvolatile EEprom storage of parameters
- Synchronous operation(diodes are not used for conduction except during transitions)
- Optional differential motor current sensing and ~20usec over current protection

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- High Power Discrete MOSFET H-Bridge configuration
- On board regulator with a +5v regulated output for powering circuitry
- Thermistor based over temperature protection
- Ultra Quiet ~15Khz Pulse Width Modulation 99+% Duty cycle
- LED indicators for normal and fault condition
- Conservative Current specifications
- Over/Under voltage protection
- Shut down feature
- Forward and Reverse stop
- Isolated Aluminum mounting plate
- IR compensation (optional auto increase current with higher load)
- Power supply, current, I/O lines readable from RS232 connections
- Low drop out regulator for operation down to ~9.5V
- Active current (torque) or duty cycle (voltage) control.
- 10bit duty cycle resolution

**Improvements from model 1015**

1. Enclosure
2. Push button to change mode
3. On board potentiometer to change acceleration and optional current limit
4. 1/4” quick disconnect connectors for power and motor connections
5. Filtering and protection improvements
6. Various control connection options
7. Optional on board potentiometers to control acceleration and current
8. Current sensor is optional
9. Improved RS232 operation
10. Improved error handling
11. Power line noise filtering

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Illustration 2: Bottom image showing thermal slug
Applications:

- Simple DC brush motor control
- Torque controller for valves
- Microscope axis movement
- Pump controllers
- Exercise equipment
- Machine automation
- Robots

Description

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, blade fuse, mounting plate, thermistor, and miscellaneous capacitors, diodes, resistors, and connectors.

Speed control is achieved by pulse width modulating the power supply voltage. The pulse width modulator allows the motor speed to be controlled without changing the power supply voltage. The H-Bridge configuration allows the polarity of the voltage to be reversed without reversing the power supply leads. The reversing is fully solid state and allows the rate of direction change to be controlled. If reversing is not needed the reversing can still be used to quickly drive the motor to a stop.

The on board re-programmable micro controller allows for various configurations. The micro-controller controls all switching operations, monitors faults, controls acceleration, dead times, and can be quickly reprogrammed to suit individual applications. The unit can be customized for various interfaces such as single speed control line or forward and reverse controlled separately.

This unit can be customized for direct system plug in. Customized units can reduce parts count by leaving off components such as the push button switch and potentiometer. Custom labels can be ordered with customer part numbers. Parameters such as over voltage, under voltage, acceleration, current settings, blade fuse rating can be set before shipment. Custom adapters are also available.

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## Specifications for (P/N 1016)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Voltage</td>
<td>9V to 180V (depends on MOSFETS)</td>
</tr>
<tr>
<td>Current Limit Setting</td>
<td>~40Amps</td>
</tr>
<tr>
<td>Over Current Response Time</td>
<td>~6us</td>
</tr>
<tr>
<td>Over Temperature On</td>
<td>80°C</td>
</tr>
<tr>
<td>Over Temperature Off</td>
<td>70°C</td>
</tr>
<tr>
<td>Startup Time</td>
<td>~1Sec</td>
</tr>
<tr>
<td>Ramp Rate (stop to full speed)</td>
<td>~0 to 4Sec depends on settings</td>
</tr>
<tr>
<td>Duty Cycle</td>
<td>0 to ~99.9%</td>
</tr>
<tr>
<td>PWM switching rate</td>
<td>~15 Khz</td>
</tr>
<tr>
<td>Digital Input low</td>
<td>Below 2.5V not digital, measured with ADC</td>
</tr>
<tr>
<td>Digital Input High</td>
<td>Above 2.5V not digital, measured with ADC</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>~16mA</td>
</tr>
<tr>
<td>Note: Optional hall effect current draws</td>
<td>10mA  Green LED draws 3ma</td>
</tr>
<tr>
<td>MOSFET On resistance</td>
<td>depends on MOSFETS normally</td>
</tr>
<tr>
<td>Reversing Delay Time</td>
<td>0 sec</td>
</tr>
</tbody>
</table>

## Dimensions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>1.60”</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>3.10”</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>2.10”</td>
<td></td>
</tr>
<tr>
<td>Mounting hole spacing</td>
<td>3.47”</td>
<td></td>
</tr>
<tr>
<td>Mount Base width</td>
<td>4.10”</td>
<td></td>
</tr>
<tr>
<td>Mounting holes</td>
<td>0.19”</td>
<td></td>
</tr>
</tbody>
</table>
Control Input/Output Pins :

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
</table>
| 1   | Is   | Current monitor output.  
No current 2.5v increases with increasing current.  
1 hall effect turn 20mv/Amp  
2 hall effect turn 40 mv/Amp |
| 2   | IL   | Analog input (0v to 5v) Selects max current  
50K(R8) to 5v  
100(R10) ohm input resistor  
1uF(C7) to gnd capacitor for filter  
Option 50k to gnd R9 |
| 3   | Gnd  | Ground output for powering potentiometers |
| 4   | T/Coast | Thermistor voltage output  
Or pulling to ground will activate coast, during coast all MOSFETs are turned off. |
| 5   | Of   | Applying 2v to 28v with shut down the unit leave open or gnd for normal operation |
| 6   | P    | Programing pin, leave open or can be digital read with RS232 connection |
| 7   | F/R  | Digital Input Forward/Reverse selection  
0v reverse  
5v forward  
10k Pull up to 5v on board  
Below 2.5v is low above 2.5v is high. |
| 8   | Rx   | RS232 receive input  
50k pullup to 5v |
| 9   | Tx   | RS232 transmit output  
50k pullup to 5v |
| 10  | Gnd  | 2nd ground line for powering external circuit |
| 11  | +5v  | +5v DC output  
Only a small <10ma of current should be drawn from this pin for powering potentiometers and hall effect throttles. |
| 12  | AI   | Analog input (0v to 5v) Selects max current  
50K to 5v (not installed)  
50k to Gnd  
100 ohm input resistor  
4700pF to gnd capacitor for filter |
| 13  | SR   | Stop reverse input.  
Normally high with pullup resistor on board, pull to ground to stop  
Can be read with RS232 line. |
| 14  | SF   | Stop forward input.  
Normally high with pullup resistor on board, pull to ground to stop  
Can be read with RS232 line |
| 15  | ST   | Status led output, 1kohm in series with output for direct LED drive |
| 16  | Gnd  | 3rd ground line for powering external circuit |
LED indicators:

1) Green LED
   A) Continuously ON – normal operation
   B) Off during shutdown or no power

2) Red LED
   A) Flash 1 second interval – Over temperature active
   B) Flash 1/2 second interval – Forward Stop Active
   C) Flash 1/3 second interval – Reverse Stop Active
   D) Flash ¼ second interval – Over or Under Voltage

Heat sinking

The bottom of the unit has a heat sinking slug installed. At low current levels heat sinking may not be required. Thermal grease is recommended to be applied to the round area at the bottom of the unit before mounting.

The higher voltage units normal have higher heat dissipation due to the resistance of the MOSFETs. A 40 Volt MOSFET will have 4 milliohms of resistance where a 200 Volt unit may have 40 milliohms of resistance. The resistance of the MOSFET is greater at higher temperatures, doubling from 25°C to 100°C. Adequate heat sinking improves efficiency and increases lifetime.

Typically if the lower voltage units are subjected to constant current above 20Amps and High voltage units are subjected to constant current levels above 10amps, thermal grease and heat sinking is required.

Power connection:

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.

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.

Power Supply Inputs:

1) V+ Input powers the motor and control circuitry. Do not reverse the V+ and ground, reversing the power supply may damage the power MOSFETs or hopefully the blade fuse will blow.

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2) Gnd input is the unit ground.

Illustration 3: 1/4" Quick Disconnect terminals for Motor and Power

Common 1/4" quick disconnects female terminals are used for the power supply and motor connections. Tab thickness is .032" These connectors are normally crimped on to the wires. These Female connectors can be found at most online electrical and electronic distributors, they are also available at most hardware and auto-parts stores. The quick disconnects are available with and without insulation. They are available to be used with various wire gauges from 10awg to 26+awg. Various color insulation is available from distributors. Higher gauge sizes may require more insertion or removal force varying from 3lbs to 16 lbs.

A ratcheting crimpers are recommended for production and quality of crimp. The correct die for the terminal should be chosen.
Illustration 4: Crimped on 1/4 quick disconnect terminals

Illustration 5: Ratcheting terminal crimper set with various dies
## Wire Resistance Table

<table>
<thead>
<tr>
<th>AWG</th>
<th>Diameter</th>
<th>Resistance per foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>20 mils (thousands of inches)</td>
<td>26 milliohms</td>
</tr>
<tr>
<td>22</td>
<td>25 mils</td>
<td>16 milliohms</td>
</tr>
<tr>
<td>20</td>
<td>32 mils</td>
<td>10 milliohms</td>
</tr>
<tr>
<td>18</td>
<td>40 mils</td>
<td>6.2 milliohms</td>
</tr>
<tr>
<td>16</td>
<td>50 mils</td>
<td>4 milliohms</td>
</tr>
<tr>
<td>14</td>
<td>64 mils</td>
<td>2.5 milliohms</td>
</tr>
<tr>
<td>12</td>
<td>80 mils</td>
<td>1.6 milliohms</td>
</tr>
</tbody>
</table>
Control connection:

The control connector is 16 pins. The spacing is two rows spaced .1” apart. A standard 2x8P 16P 16pin pitch= 2.54mm IDC Cable Plug Connector can be used to connect to make connection. The 16 pin IDC cable is available with a crimp on standard 15pin DSUB connector. Adapter boards for connection are shown below, one breakout is shipped with sample quantities unit unless otherwise specified. Wires can also be soldered directly to the pins.

The control connector allows the system to control the operation of the unit and to sense the status.
10pc 2x5P 2x5 10P 2.54x2.54mm IDC Cable Plug Connector with Strain Relief

5pc DB-15FP D-sub IDC Cable Female Connector 15P with plastic shell flange RoHS
Illustration 6: 16 pin adapter boards

Illustration 7: Control connector adapter options

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Speed and Direction:

There are several methods to control the direction and speed of the motor controller. With the standard Mode 0 mode the speed is controlled with a external source of 0 to 5 volts and the direction is controlled with the FR line on the 16 pin control connector. The 5volts and ground are available on the control connector.

The motor speed and direction can be controlled with the RS232 port. The speed is controlled with the SDC command. A value of -1023 is full reverse. A value of 1023 is full forward.

In PCM mode the speed is determined by the pulse width on the Ain line. A pulse width of 1000uses is full reverse and 2000usec is full forward. 1500Usec is stop.

The maximum duty cycle can be set to a value from 0 to 1023 with the MXD command. This will limit the speed of the motor.

Over Current Protection and Current Measurement:

The H-Bridge motor driver provides for over current protection. The blade fuse protects the unit from damage. The blade fuse is a standard size automotive type.

Setting the under voltage is a low cost simple method of detecting for over current conditions. When a short circuit or over current condition occurs the voltage will drop due to the resistance of battery and wires. For a 12 volt battery setting the under voltage to 11v will prevent the motor controller from ramping up the duty cycle.

The current can also be sensed with a optional hall effect current sensor. The current can be sensed on the motor wire or the power supply wire. When apply a hall effect current sensor the level can be sensed on the 16 pin control connector IS pin. The output will be centered at 2.5v.

When applying a hall effect current sensor the maximum current level can be adjusted dynamically by setting a voltage on the IL pin on the 16 pin connector. The input is scaled to accept a level from 0 to 5volts DC. The maximum level can also be set in firmware by setting the STE to enable and setting the MIL value.

The IMT command can be change from the default value of 4 to scale the maximum desired current level. For example, if the current sensor range is 40Amps setting the IMT to ~40 will lower the maximum level from 40amps down to 4amps.

When applying a hall effect current sensor the offset with zero current can be adjusted by setting the OFS command. Normally values from from -9 to 9 are needed.

The current level can be read with the RS232 interface. The ISS? Command will return the binary sensed level on the IS analog line. The level is 1 bit per 4.88millivolts. 511 is subtracted from the reading to return binary vales from -511 to 511, given the center is 2.5v.

In most cases, accept where the duty cycle is 100%, the power supply current will not equal the motor current. At 10% duty cycle the motor current will be about 9 times the power supply current. With inductors or a stalled motor the current in the motor will build till the current limit trips, with little indication from the power supply.

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The current delivered to the motor can be controlled with the I limit value. The value is default selected with the filtered IL pin on the 16 pin connector or can be overridden with an RS232 value. If the value is overridden with the RS232 value the IL line can be used to measure a external voltage.

The IL analog input line ranges from 0 to 5v. 5Volts being max current. This value is compared against the hall effect current sensor output – 2.5volts x 2. As indicated the hall effect current sensor is scaled to a 0 to 5v range before comparison. Negative hall effect currents will be converted to a positive value. Increasing the loops through the current sensor will effect the current limiting. Increasing the loops will lower the current limiting value and provide more resolution at a lower current level.

Acceleration

The acceleration is controllable from 0 seconds to many ? seconds. A controlled acceleration reduces wear on the motor, gears, and power source. A controlled acceleration can prevent the over current protection circuitry from triggering during start-up or reversing. The acceleration can be controlled by adjusting the values stored the the micro controller nonvolatile EEprom.

The acceleration values stored in the nonvolatile memory range from 1 to 30000. A value of 1 will produce the slowest acceleration and 30000 will produce the fastest.

For Normal ramp: 300
For fast current control: ~ 3000

The acceleration can be modified with the on-board potentiometer. The on-board potentiometer can be disabled with the STE command.

The stop acceleration can be adjusted with the AST command. This will be used if one of the forward or reverse stops are activated on the control connector.

Shutdown

Shutdown mode will reduce the idle power supply current consumption. The shut down line is activated by applying 2v to 28v to the Of line, on the 16 pin control connector. This shuts down the power to the unit. A series resistor can be place to lower the current into this pin. At voltages over 15V a series resistor is recommend (>50k). The unit typically draws ~.6mA during shut down.

Temperature Measurement

This motor controller has a temperature measurement and protection feature. The temperature is sensed with a thermistor located on the circuit board. The temperature is measured by sensing the voltage at the junction of a 10k resistor and a 10k thermistor. The sense voltage is available on the control connector for external sensing and testing. The voltage will drop with increasing temperature. At room temperature at about 23C the junction sense voltage will be about 2.5v and will drop with increasing temperature.

The binary value can also be read with the RS232 interface. The TEM? Command will return the junction voltage in a range of 0 to 5volts scaled in binary to a range of 0 to 1023. A value of 511 will indicate room temperature. The curve of the voltage is exponential and non linear. A binary value 130 is about 80C.

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The unit will shut down if the over temperature set point is reach. During shutdown all motor switches are turned off in a coast condition. The red led will flash if over temperature condition has occurred. The over temperature set point is set to a default value of 130, for 80°C triggering. The over temperature set point can be adjusted with the OTM command. There is a 2°C hysteresis once the temperature has been exceeded, requiring a 2°C drop in temperature to return to normal operation.

Forward and Reverse Stop

The motor has a forward and reverse stop feature. The function needs to be activitated by setting bits 0 (add 1) and bit 1 (add 2). The polarity can be inverted with the INV command by setting bits 1 (add 2) and bit 2 (add 4). Bit 0 (add 1) in the INV command inverts the forward reverse line.

The default value for these lines is set to off to avoid problems and will need to be activated with the STE command.

The input to the forward and reverse stop are available on the control connector. The input has a 10k ohm resistor to the 5 volt power supply line. The are unoccupied area on the circuit board to pull the inputs to ground if modification is needed. The input can be shorted to ground pulling down the input. The inputs are label SR and SF.

The RS232 interface can be used to read the analog voltage on the SR and SF line. SRM? And SFM? Will reutrn the value in a range of 0 to 1023. A value below 511 is low.

The SR line can be used to enable or disable the unit. The STE bit 2 (add 4) line needs to be set to enable this function. This allows for a push button enable line to be used to run the motor controller. The SR line can be inverted for this operation.

Ain input filtering

There is a Ain input filter. The 100ohm series with a 4700pf/50k to ground. There is an optional location for a 0603 pullup if needed.

There is a 100ohm 1uf 50k to 5v filter on the IL input.

Over/Under Voltage

The motor controller will detect over and under voltage conditions on the power supply. Over voltage can occur during deceleration as the motor and controller regenerated sourcing current back to the power source. The over voltage can damage the power supply and motor controller. If the under or over voltage is reached the motor controller will temporary shut down and wait till the voltage condition is again in range. Over voltage is less of a fault with battery power sources.

Under voltage can also sensed. A under voltage can occur if the battery is depleted or the operator does not desire to have a battery be completely discharged. Apparently Lithium Ion batteries can be damaged if output voltage drops under a specified level.

The voltage is sensed with a resistor divider network. There is also a filter capacitor C10(1uf). The divide ratio is about 1/41. The serial port command OVS and UVS will set the trigger levels in nonvolatile memory.

Example: 24volt trigger level.

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24v/41 = .585v
10bit ADC  5v/2^10 = 4.89mv/bit
.585v/.00489 = 119

serial command:
OVS 119
or
UVS 119

The scale is about 5bits per volt.

If the power supply is 24v then the over voltage will need to be set higher than 119 and the under voltage set lower than 119. Reading the power supply voltage with the VS? Command can establish a reference point.

Example:
OVS 130;
UVS 110;

IR compensation:

The motor controller allow for IR compensation. The IR compensation allows the duty cycle to increase automatically for an increase in load. The load is sensed from the current drawn, measured with the optional hall effect current sensor. As the current increases a value will be added to the duty cycle. The IR compensation compensates for resistive losses in the motor. The amount of compensation is limited to 25% of the duty cycle. A offset value is also, included for possible improved linearity. The commands IRM and IFO set the IR compensation.

The calculation is kept simple to allow for various turns on the the hall effect current sensor.

The IRM command sets the multiplier and the IFO sets the offset. For testing purposes the IFO should be set to zero and latter added to trim.

This mode is always activated by setting bit 6 in the STE, if both the IRM and IFO values are set to ZERO the IR compensation will have no effect. IFO is added to the current reading.

Regeneration

When the motor slow or decelerated the motor can regenerate power. During regeneration the motor acts as a battery in series with a large inductance, usually of many mill Henry. The inductance is used to act as a inductor in a DC-DC converter. Current is built up in the inductor when shorted. When the short is opened the inductor will produce a very high voltage, higher than the supply voltage. The voltage is limited by the battery or over voltage setting.

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With a battery the regenerated current or power goes back into the battery. The amount of power returned to the battery depends on the deceleration time, speed, motor, and momentum. The motor controller does not make adjustments unless the over current limit has been reached.

With a power supply the regenerated current can cause problems. Most power supplies do not accept reverse current. Some power supplies will reset in an over voltage condition. Some power supplies have a shorting feature during over voltage requiring the AC power to be cycled.

The over voltage setting on the motor controller can be set to a value slightly above the power supply voltage. The OVS command will change this setting. Setting the deceleration will also help lower the regenerated power ADW and AST should be adjusted.

External circuitry can be added to prevent regeneration faults. Adding a TVS across the power supply will absorb power once their voltage rating has been reached. A more complex power resistor Mosfet zener type circuit can be applied to improve performance.

Error Code

The motor controller reports most operation errors. Error codes can be viewed with the Red led or directly read with the RS232 serial interface. Type /; will print out the actual error. The Error code can be read by the computer with the ERR? Command.

The common errors are over temperature, over voltage, undervoltage, forward stop, and reverse stop. Other error can be examined by reading the control line inputs. The unit should be checked for correct mode. Typing DFS will set the unit back to a default state, however this setup may not be correct for the application.

Modes

The Mode allows for various control options without requiring custom software changes.

The mode can be changed with the internal push button switch. The mode switch must be held down for ~400 milliseconds for the mode to increment to the next mode. The LED will flash if successful. The mode switch allows the operator to change the mode without computer RS232 connection. The mode switch should be removed for production versions to avoid inadvertent mode changes.

The mode can also be changed using the RS232 interface with the MDS command. Example MDS 0;

Custom modes can also be ordered with a non reaccuring charge.

**Mode 0**: Operates in the full 0-5v Ain range. The F/R line is active. Grounding the F/R line will reverse the motor. 0V is stop, 5v is full speed. Grounding the TC line will activate coast mode, simulating a over temperature condition. There is a buffer near 0v and 5v to compensate for signals not able to fully reach 0v and 5v.

**Mode 1**: Operates in the full 0-5v Ain range. The F/R line is inactive. 0V is full reverse 5v is full forward and 2.5v is stop. Grounding the TC line will activate coast mode, simulating a over temperature condition. There is a buffer range of .05volts near 5v, 0v, 2.5v to allow for full speed and stop.

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Mode 2: Operates in the 1-4v Ain range. Many hall effect throttles on the market have an output range of 1v to 4v. The F/R line is active. Grounding the F/R line will reverse the motor. Below 1V is stop above 4v is full speed. Grounding the TC line will activate coast mode, simulating a over temperature condition.

Mode 3: Operates in the 1-4v Ain range. The F/R line is inactive. Below 1V is full reverse 4v is full forward and 2.5v is stop. Grounding the TC line will activate coast mode, simulating a over temperature condition. There is a buffer +/- .25 near 2.5v to allow for full stop.

Mode 5: This mode accepts the Duty cycle only from the Uart RS232 TTL connection. SDC command (-1023 to 1023) will set the duty cycle.

Mode 6: NA

Mode 7: This mode excepts PCM(pulse code modulation) digital signals on the Ain line. PCM is typically used for RC receivers. F/R will reverse the direction.

A 1000us pulse is full reverse. A 2000us pulse is full forward. A 1500us pulse is stop. There is about a 300us buffer zone at the low and high ends to allow for full speed forward and reverse. Above and below the 300us buffer range the controller will not respond.

If no signal is present on the Ain line for more than ~3 seconds the controller will stop. If a invalid pulse width input occurs, the unit will not respond and require ~3 good pulses to restart.

Serial Port RS232 TTL Codes

This unit features a serial port for control and parameter settings. Once the parameters are set the serial is not required for normal operation. The serial port is needed to set up the acceleration, over temperature, over/under voltage, maximum duty, optional IR multiplier, and optional ID.
<table>
<thead>
<tr>
<th>Code</th>
<th>Input range</th>
<th>Example</th>
<th>Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDS</td>
<td>0 to 7</td>
<td>MDS 1</td>
<td>MDS?</td>
</tr>
<tr>
<td>MXD</td>
<td>0 to 1023</td>
<td>MXD 780</td>
<td>MXD?</td>
</tr>
<tr>
<td>AUP</td>
<td>1 to 30000</td>
<td>AUP 2000</td>
<td>AUP?</td>
</tr>
<tr>
<td>ADW</td>
<td>1 to 30000</td>
<td>ADW 2000</td>
<td>ADW?</td>
</tr>
<tr>
<td>AST</td>
<td>1 to 30000</td>
<td>AST 2000</td>
<td>AST?</td>
</tr>
<tr>
<td>OVS</td>
<td>1 to 1023</td>
<td>OVS 100</td>
<td>OVS?</td>
</tr>
<tr>
<td>UVS</td>
<td>1 to 1023</td>
<td>UVS 50</td>
<td>UVS?</td>
</tr>
<tr>
<td>OTM</td>
<td>0 to 1023</td>
<td>OTM 130</td>
<td>OTM?</td>
</tr>
<tr>
<td>IMT</td>
<td>2 to 64</td>
<td>ITM 4</td>
<td>ITM?</td>
</tr>
<tr>
<td>IOF</td>
<td>-100 to 100</td>
<td>IOF -5</td>
<td>IOF?</td>
</tr>
<tr>
<td>MIL</td>
<td>-1000 to 1000</td>
<td>MIL 100</td>
<td>MIL?</td>
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<td>ECH 0</td>
<td>ECH?</td>
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<tr>
<td>STE</td>
<td>0 to 256</td>
<td>STE 16</td>
<td>STE?</td>
</tr>
</tbody>
</table>

**Nonvolatile commands**

Sets the mode of operation
Sets maximum duty cycle
Sets ramp up acceleration (bit 4(16) of STE needs to be set to 0)
Sets ramp down acceleration
Sets ramp during stop condition
Over voltage setting (5 bits per volt)
Under voltage setting
Sets over temperature (lower for higher temp, 130 is about 80C)
Multiplies Current Sense (divided by 4)
Current sense offset adjust
Software current limit (bit 3 of STE) needs to be set. Use this if you would like the current limit to be set by firmware rather than the analog IL pin

<table>
<thead>
<tr>
<th>Illustration 8: Nonvolatile RS232 commands</th>
</tr>
</thead>
</table>

The motor controller can be completely controlled with the serial port. The output current can be measured as well as the power supply voltage, analog input pins, status and temperature.
<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td><strong>Volatile measurement commands not settable</strong></td>
<td></td>
<td></td>
<td></td>
<td>return values all (0 to 1023) for (0 to 5 volts)</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>AIN?</td>
<td>AIN?</td>
<td></td>
<td>Reads the Ain duty cycle analog input line</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td></td>
<td>VS?</td>
<td>VS?</td>
<td></td>
<td>Reads the divided down power supply line</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td></td>
<td>FRL?</td>
<td>FRL?</td>
<td></td>
<td>Reads the FRL transistor collector forward reverse line</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td></td>
<td>SRM?</td>
<td></td>
<td></td>
<td>Reads the SR line (0 to 1023)</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>SFM?</td>
<td></td>
<td></td>
<td>Reads the SF line (0 to 1023)</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td></td>
<td>TEM?</td>
<td>TEM?</td>
<td></td>
<td>Reads the thermometer output</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td></td>
<td>ACC?</td>
<td></td>
<td></td>
<td>Reads the acceleration pot</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td></td>
<td>ISS?</td>
<td></td>
<td></td>
<td>Reads the Current sensor line</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td></td>
<td>ILM?</td>
<td></td>
<td></td>
<td>Reads the Current limit line</td>
<td></td>
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<td>45</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td><strong>Volatile set commands</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>47</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>SDC</td>
<td>-1023 to 1023</td>
<td>SDC -500</td>
<td>Sets the duty cycle with the UART</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td></td>
<td>SDC?</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>50</td>
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<tr>
<td>51</td>
<td><strong>Volatile status</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>52</td>
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</tr>
<tr>
<td>53</td>
<td></td>
<td>DCC?</td>
<td>DCC?</td>
<td></td>
<td>Reads the current duty cycle</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td></td>
<td>DSC?</td>
<td>DSC?</td>
<td></td>
<td>Reads the scaled version of the input duty cycle</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td></td>
<td>ERR?</td>
<td>ERR?</td>
<td></td>
<td>Show the current error code</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td></td>
<td>Bit 0(1) over temperature</td>
<td></td>
<td></td>
<td>Bit 1(2) over voltage</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td></td>
<td>Bit 2(4) under voltage</td>
<td></td>
<td></td>
<td>Bit 3(8) over current</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td></td>
<td>Bit 4(16) SR active</td>
<td></td>
<td></td>
<td>Bit 5(32) SF active</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>60</td>
<td><strong>Group Commands</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>61</td>
<td></td>
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<td></td>
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<tr>
<td>62</td>
<td></td>
<td>HLP</td>
<td>HLP</td>
<td></td>
<td>Print help command (not operational)</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td></td>
<td>EEM</td>
<td>EEM</td>
<td></td>
<td>Print all nonvolatile commands</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td></td>
<td>MMM</td>
<td>MMM</td>
<td></td>
<td>Print all volatile readings</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td></td>
<td>MOD</td>
<td>MOD</td>
<td></td>
<td>Print all modes (not functional)</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td></td>
<td>DFS</td>
<td>DFS</td>
<td></td>
<td>Set unit to default state</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td></td>
<td>RST</td>
<td>RST</td>
<td></td>
<td>Reset unit (not useful)</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td></td>
<td>/ or ?</td>
<td>?</td>
<td></td>
<td>Print every parameter</td>
<td></td>
</tr>
</tbody>
</table>
A USB to TTL converter plugs directly into a USB port. The motor control unit must be powered up for communication to begin. Three wires RX, TX, and Gnd are attached to the motor controller. A program such as HyperTerminal is used to communicate with the unit. There are several programs available online for serial port communication such as HyperTerminal which is on all XP computers, and putty which is free online. Most programming languages can access the serial ports.

The communication settings are 9600 Baud rate, 8 bits, None for hardware feedback. Computers could have several configured COM ports, the correct COM port must be selected.

The command is executed after a return or semicolon is received.

Example:

AUP 100;

This will set the acceleration to 100. One being the slowest and 30000 being the fastest.

Example:

?;

?<RTN>

/<RTN>

Will all display the volatile and nonvolatile parameters and measurements.

Example:

ADW 200;

**STE**

The STE command enables and disables functions.

Example:

STE 3;

Will enable the function of the forward and reverse stop pins on the control connector. The INV setting may need to be adjusted for the correct polarity.

**MDS**

www.devicecraft.com
The MDS will set the mode.

Example:

```
MDS 0
```

```
ILM000572:RIP000255:
DCY000126:DCO000124:SDC000000:
TMRO00000:QLD00000:BAD00000:MAI00000:
CIA00000:CIV00000:CLM000552:IRAO00000:
STP000000:ERR000000:
Status:
STE codes:
0(1) Enable SF 1(2) Enable SR 2(4) Enable SR enable 3(8) Use EE I max 
4(16) PTO for Accel 5(32) Use PS I 6(64) Enable I Lim 7(128) Enable IR
INV codes:
0(1) SF invert 1(2) SR invert 2(4) FR inver
```
Serial Port Troubleshooting

- Download the correct driver for the USB to serial cable for your operating system and computer from the WEB. The USB to Serial TTL we are currently shipping is for a Prolific PL2303. Other USB to serial TTL are also sold through distributors. The current link is www.prolificusa.com/pl-2303hx-drivers

- Other RS232 to TTL adapter can be used

- A Full speed USB isolator is recommended if you are experiencing ground loop spikes.

- On the prolific cable the blue wire is RX, red TX, and orange is ground

- Select the correct COM port, baud rate, data bits, parity, stop bits, and flow control.

- Without connection the cable to the motor controller, the RX and TX lines can be connected together to test if the cable is functioning properly. With the TX and RX shorted the character typed should echo to the terminal emulator.

www.devicecraft.com
• Verify the USB-Serial-TTL cable show up the the operating system device manager. Reboot computer if you are experiencing problems.

• With high voltage and high current signals emanating from the motor controller noise pickup could be a issue. A capacitor or filter maybe need on the RX and TX lines to eliminate spikes for continuous RS232 setups. Reboot if necessary.

• The motor controller must be powered up for communication. Use of a lower voltage power supply can be used for setup.
Illustration 9: Simple Hookup Diagram

Note: The forward / reverse switch is not needed for testing and single knob control
Illustration 10: Hookup with current limit, coast, Serial port, and stops

Note: STE must be set correctly for stops to be active. If the current limit is set internally then the IL line can be used as a coast which provides additional filtering.
Illustration 11: Input Filters
Note a USB to RS232 TTL serial cable can be used to setup parameters and control the unit.
Low Voltage Modification

If you have a high voltage motor controller and would like to allow for operation down to 10 volts the following modification can be performed. The modification will my pass the high voltage regulator allowing operation from 10Volt to 30Volts.

Jumper pins 2 and 3 of the centered MOSFET. The MOSFET can also be removed. The other crossed out components can be removed to reduce power supply quiescent current by 1 milliamp.
Illustration 12: Motor Controller with Standard cover