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## Scorpion HX User Manual R/C Version

<http://www.robot.power.com>

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Thank you for purchasing the Robot Power Scorpion HX speed control. This unit has been carefully engineered and tested to provide superior performance and control of small robots. This document covers the features and operation of the Scorpion commanded via R/C control. A serial command firmware version is under development to allow control of the Scorpion via TTL-level serial commands. Contact Robot Power for details on this and other special versions of the Scorpion.

The Scorpion HX controller was designed for use in 1 lb. (ant weight) and 3 lb. (beetle weight) combat robots: but it is suitable for a variety of small mobile robots such as sumo, firefighting, and maze runner types.

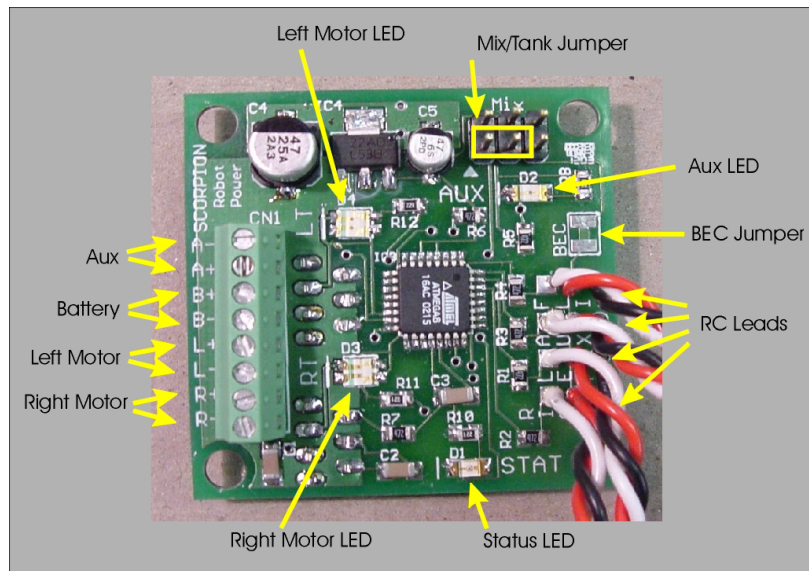
## Features

The Scorpion contains the following features:

- Size: 1.6" x 1.6" x .5"
- Weight: 22g with RC cables installed
- Four R/C input leads for
  - Left and Right Drive
  - Auxiliary Weapon - forward only (optional)
  - Flip Control (optional)
- 4.8V to 22V battery voltage
- 6A peak, 2.5A (5A with heatsink) continuous current on each Left and Right drive channels. May be combined into a single 5A continuous forward/reverse channel
- 35A peak, 12A continuous current on the Aux/Weapon channel. This can be used to drive a forward-only motor such as a spinning weapon or sumo vacuum system. *Note, the 12A figure must be derated for power settings less than 100%.*

- Flip input reverses motor direction when the robot is inverted. May be operated via an R/C channel or via a mechanical (gravity) or optical etc. switch.
- Indicator LEDs for Left/Right speed and direction and Aux speed. A status LED shows the R/C signal status and other information (see below)
- Left/Right channel mixing is the default – may be disabled
- Drive mirroring causes both motor outputs to “mirror” a single RC input channel if only one is connected. This allows the use of a single larger motor per Scorpion or a slaved pair of motors. Thus, two Scorpions can be used with mirroring to drive a dual 5A motor robot or a 4-motor robot without needing R/C splitter cables.
- Receiver battery eliminator circuit (BEC) standard – may be disabled. This can provide up to 100 mA of current at 5V to the RC receiver and other attached electronic circuits. Do not attempt to run servos or other motors using the Scorpion regulator as the current source. Doing so may damage the regulator and cause the Scorpion to cease working.
- Safe start for Aux channel disables the robot at power up until the Aux channel is in the off position.
- Failsafe shuts off motors and weapon if R/C signal is lost
- FLASH-based microcontroller with upgradeable software via in-circuit programming header

## Connections



## Setup

Your Scorpion HX controller comes completely assembled and tested and programmed with the latest version of the firmware available.

The Scorpion firmware is programmed to respond properly to R/C signals from all major radio control brands and should operate right out of the box. The following procedure will set your radio system to match the parameters of the Scorpion.

**Important!** Do not reverse the battery polarity to the Scorpion. On the green screw terminal block the battery connections are marked **B+** and **B-**. Connect the battery positive to B+ and the negative to B-. Reversing polarity even briefly may damage the Scorpion.

- ❑ Connect the scorpion to an R/C receiver as follows
  - Right to receiver channel 1 (steering or aileron)
  - Left to channel 2 (throttle or elevator)

- Do NOT use a receiver battery unless the BEC is disabled (see *Disabling the BEC below*)

- ❑ Connect the Scorpion to a suitable battery (6V to 22V – 18V maximum recommended) but do not connect the motors yet. It is recommended that a suitable power switch be connected in-line with the battery for testing and for use on the robot.
- ❑ Power on RC transmitter then the Scorpion. The Status LED should flash rapidly several times and then turn on solidly. The LT and RT LEDs should be off.
- ❑ Manipulate the RC controls and observe the LT and RT LEDs. The LEDs should turn gradually brighter green in one control direction and red in the other as the transmitter controls are moved. By default Left/Right channel mixing is enabled so when the throttle control is moved both LEDs should respond. Moving the steering control with throttle at neutral should make one LED green and one red. If necessary turn everything off and swap the receiver channels until things are working properly.
- ❑ Verify that the LEDs are brightest at full stick travel. If they suddenly cut off at full throw then the RC travel is too wide. Gradually reduce throw on the problem channel using the ATV adjustment on your radio until you can go to full travel with both the steering and throttle controls.
- ❑ Verify that the LEDs are off at stick center. Adjust the trim center point until they are solidly off at center position.

## Drive Mirroring

- ❑ The Scorpion automatically detects which R/C cables are connected to the receiver at startup. If either the Left or Right cable is not connected

to the receiver the Scorpion goes into drive Mirror Mode. In this mode the signal from either the Left or Right input is mirrored to both of the output channels. This is designed to allow easy use of two Scorpions with 4 motors without requiring R/C “Y” cables to the receiver. Transmitter mixing must be used when using Mirror Mode.

- ❑ Connect either the Left or Right input connector to the R/C receiver and leave the other unconnected.
- ❑ Turn on the transmitter then the Scorpion and observe that both output channels respond to the single input channel.
- ❑ For added resistance to electrical interference in the unused cable, connect the signal wire (yellow or white) to the ground wire (brown or black) with a short jumper wire. This will ensure that no noise can be seen as a valid R/C signal on that cable.

### Flip Control Not Used

- ❑ **Important!** If you are not using the Flip control you should tie the yellow or white signal wire of the Flip R/C cable to the red center (+5V) wire to prevent any interference from inadvertently tripping the Flip function. You can either place a small jumper wire in the end of the R/C connector or clip off the Flip cable near the Scorpion board and solder the two wires together.

### RC Flip Control

- ❑ If you are using the RC Flip function then turn everything off and connect the Flip RC lead to the appropriate receiver channel. Channel 5 (landing gear) is commonly used on aircraft receivers and channel 3 on pistol style car radios. Power on the RC transmitter and then the Scorpion. Verify that the drive channels

respond as before. If there is no response on the drive channels verify that the Flip RC cable is properly inserted into the receiver. If the problem persists it is likely that the throw on the Flip channel is too wide. Reduce this travel using the ATV adjustment until the drive begins to work again. Be sure to reduce the ATV on both ends of the throw and verify that the drive channels work with the Flip control in both positions.

- ❑ Activate the transmitter Flip channel and verify that the controls are reverse. This is easy to see if you activate the flip control while the drive channels are active and see that the LEDs change color when the Flip control is activated.

### Mechanical Flip Control

- ❑ If you are using a gravity switch to activate the Flip control you will need to connect a normally open switch to the Flip RC lead. Use care to avoid shorting the center (+5V) and outer (ground) wires on the RC lead together. This can damage the Scorpion.
- ❑ One switch contact should connect to the black (or brown) wire closest to the edge of the board - this is the ground wire. The other should connect to the white or yellow wire closest to the center of the board – this is the signal wire. The center wire is available to provide +5V if an optical or other electronic switch is used. When the switch is closed the signal wire will be connected to the ground wire and provide a 0V signal level on the signal wire.
- ❑ If an optical or other electronic switch is used, the normal signal level is +5V on the signal wire for normal operation and 0V for flipped operation.
- ❑ Verify that the drive channels operate properly with the switch in both positions. If not, disconnect the Flip switch and carefully look for

shorts and verify with a multimeter that the switch is pulling the signal wire to ground when closed.

### Auxiliary Weapon Control (optional)

- ❑ If you are using the Aux control to drive a weapon or vacuum motor it is important to understand that this is a forward only control. There is no reverse on this channel. The speed increases proportionally from off at center stick position to 100% at full throw. This allows PCM radios (that output a center stick position signal in a fail-safe condition) to properly shut off the Aux output if the signal is lost. The brightness of the Aux LED indicates the relative power applied to that motor.
- ❑ Turn everything off and connect the Aux RC input lead to the appropriate receiver channel. The throttle channel (3) is commonly used here for proportional speed or channel 5 may be used for on-off control.
- ❑ For safety the Aux channel must be in the off position before the robot will activate either the weapon or drive. If the Scorpion is powered on with the Aux control in a non-zero location the Scorpion will wait until the Aux is safe before allowing the robot to move. A blinking status code will signal that the Scorpion is waiting for a safe start position on the Aux channel.
- ❑ Turn on the transmitter and observe the Status LED. It should blink rapidly several times and then either begin a slow blink or go solid. If the Status LED is blinking move the Aux control to the off position. The Status LED should go solid and the drive and Aux channels should respond.
- ❑ Once the Status LED is solid you should be able to advance the Aux RC control and see the Aux LED increase in brightness all the way up to full travel. If the Aux LED suddenly cuts out near full control throw the RC travel is too wide and

should be reduced via the ATV control on your transmitter. Gradually reduce the top end travel point until the Aux LED lights up with full brightness.

- ❑ If the Scorpion refuses to respond when the Aux channel is in the extreme off position it means the RC travel is too wide in that direction. Reduce the low-end throw on that channel using the ATV adjustment until the drive works normally at all Aux control positions.

### Setting Tank Steering

The Scorpion comes with Left/Right channel mixing on by default. To disable this mixing a jumper should be soldered into the holes where indicated in the Connections photo above. When the jumper is in place the Left and Right inputs will each control one motor independently from the other. This is useful for tank steering in certain robots or where transmitter mixing is preferred. Note, the photo shows a pin header in these holes. Production Scorpions do not have this header installed and instead have empty holes at this location.

### Disabling the BEC

The Scorpion comes with a 5V regulator to run its microprocessor and other logic circuits. This 5V is available to power the RC receiver and “eliminates” the need for a separate RC receiver battery. To disable this function locate the two pads marked BEC near the RC cables. There are two bare pads connected by a short trace. To disable the BEC function carefully cut this trace with a sharp knife. Make sure to completely cut the trace and leave a visible space between the cut conductors. To restore the BEC simply solder a small wire across the two pads.

### Setup Complete

That completes the setup of your Scorpion board and your RC transmitter. Connect the motors to the

screw terminal block and verify that the motors respond smoothly and properly to commands.

If the motors glitch or have large variations in speed with a constant command input it is possible there is interference being generated and coupled into the Scorpion or the RC receiver. A small 0.1 uF ceramic capacitor across the motor leads is recommended to reduce this electronic noise. In extreme cases three capacitors should be used; one from each motor terminal to the motor case and one across the terminals.

Also, if high current draw motors are used it is possible the drive chips will overheat and go into safety shut down. If your motors are cutting out after a period of normal operation, feel the power chips mounted on the bottom of the Scorpion. If they are painfully hot to the touch then it is likely you are exceeding the ratings of the chips. For reliable operation you should reduce the battery voltage and/or use smaller motors. For sustained operation near the maximum current you may add a heatsink to the bottom of the board to help with heat dissipation. Commonly available Celeron/Pentium CPU heatsinks with insulated adhesive tape on the back are available at low cost from surplus and computer dealers. You can press these onto the drive chips to help greatly with heat dissipation at the expense of additional weight and space.

## Status Codes

The Status LED is the main means of communicating information on the state of the Scorpion board. The following are the status codes seen under various conditions:

- Steady On – this indicates normal operation and should be seen at all times the Scorpion is operating properly.
- Fast Blink – this indicates a loss of radio signal or no signal on any of the drive channels at

startup. At startup a fast blink signal indicates the transmitter is off or that the receiver is not getting a signal.

- Slow Blink – at startup this indicates that the Aux channel is not in the safe position.

## Mounting your Scorpion

The Scorpion should be mounted properly for the most reliable operation. For use in combat robots shock mounting is important. Do not simply bolt the Scorpion down to the frame of your robot. The mounting holes provided at the corners of the Scorpion should be large enough for a rubber grommet and 4-40 mounting screws. Placing the rubber grommet in the holes with washers and nuts to suspend the Scorpion by the rubber will provide adequate shock mounting. Alternately using foam rubber servo tape or "mouse pad" rubber can provide a secure shock mounting. If a heat sink is desired to increase the current handling of the board a flat plate should be pressed tightly against the metal tabs of the power driver chips located on the bottom side of the Scorpion. These tabs are electrically connected to the battery ground so care should be taken to avoid shorts. Using a small amount of heat sink compound a.k.a. thermal grease will help heat transfer to the heat sink.

## Notes on PCM radios

The Scorpion will work properly with AM, FM and PCM radios at all common pulse update rates (50 Hz in the US, 40 Hz in the UK and elsewhere). However there are several issues related to failsafe operation in PCM radios that must be understood for reliable and safe operation.

First, if possible, the fail-safe function on the radio should be disabled for all channels controlled by the Scorpion. This will allow the signal lost and out of range functions in the Scorpion software to function properly. If fail-safe cannot be disabled completely it should be

set to move the control to a fixed position rather than “last command hold”. In this way setting the drive channels to 50% and the Aux channel to 50% (usually the default) will cause the motors to shut off if the transmitter signal is lost.

Note, the default settings hard-coded into the RC receiver may not match the desired settings for proper shutdown of the Scorpion. Testing with your radio will be required for the proper settings and procedures to be determined.

## **Service and Support**

Service and support for the Scorpion are available from Robot Power. The Robot Power Web site (<http://www.robot-power.com/>) maintains current contact information for all Robot Power products.

## **Limitations and Warrantees**

The Scorpion is intended for personal experimental and amusement use and in no case should be used where the health or safety of persons may depend on its proper operation. Robot Power provides no warrantee of suitability or performance for any purpose for the Scorpion. Use of the Scorpion software and or hardware is with the understanding that any outcome whatsoever is at the users own risk. Robot Power's sole guarantee is that the software and hardware perform in compliance with this document at the time it was shipped to the best of our ability given reasonable care in manufacture and testing.

Products that have been used in robot combat competitions or other competition situations are not eligible for defective replacement. All claims for defective product repair or replacement must be made prior to the competitive use of the product. In the event of a defective product, Robot Power will replace or repair products or refund money in exchange for the original product. Robot Power products purchased through resellers or dealers must contact the dealer for repair or replacement service.