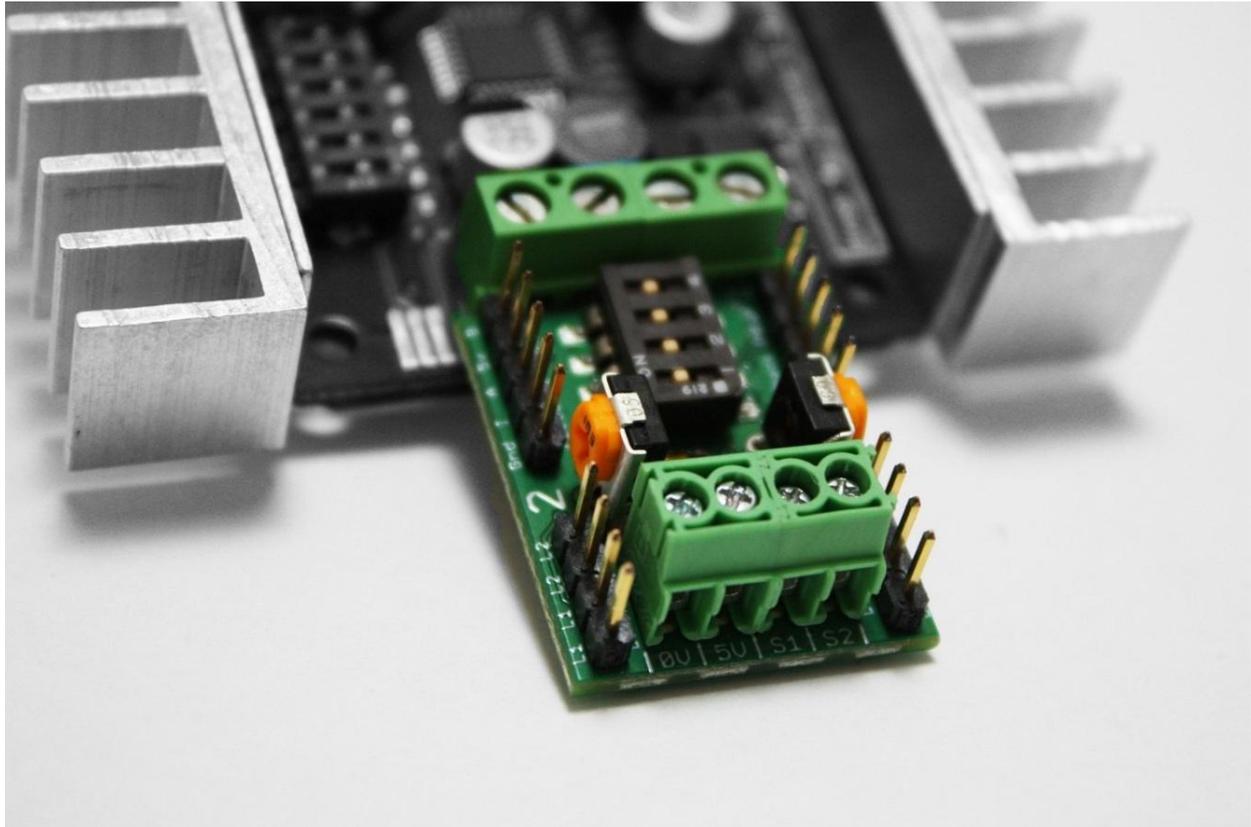


Kangaroo x2

Motion Controller

March 2013



Kangaroo x2 adds feedback and motion control capabilities to Dimension Engineering's SyRen and Sabertooth families of motor drivers. It is capable of reading one or two quadrature encoder or analog feedback sources and controlling one or two motors. It can be used to control position, speed, or both. Kangaroo can be commanded with analog signals, radio control, a microcontroller or a PC.

Kangaroo x2 is self-tuning for ease of setup. No experience with control systems or feedback tuning is necessary. It automatically detects the direction, gain and system parameters of the attached motor and device. If limit switches are connected it seeks out the operating range during the tune procedure and homes on startup automatically. The maximum speed can be adjusted with onboard potentiometers. There is optional PC software for editing, saving and loading tuning parameters for mass production. The range, speed and other parameters can also be changed with this PC software.

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Position Control

If the Kangaroo is set up for position control, it will directly command the position of the output mechanism. Even if there is a load placed on the mechanism, the Kangaroo will apply as much power as is necessary to put or keep the device in the commanded position. By changing the commanded position, you can make the device move or stop in a controlled manner.

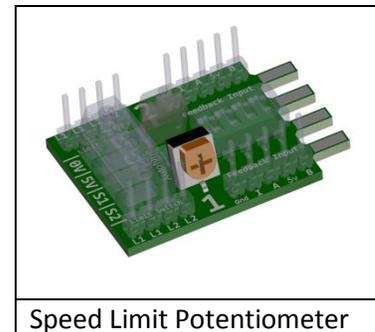
Examples of devices that are position controlled include

- Assembly robots
- R/C servos
- 3d printers
- CNC machines
- Positioning stages
- Home automation for doors, screens or windows
- Valves and flaps
- Elevators
- Humans

If DIP switch 3 is set to ON, Kangaroo x2 is in position control mode. You can use analog voltages, R/C servo type signals or serial commands to set the position. You can change from position to speed control at any time. It does not require a re-tune or a reboot.

Speed Limit

Pure position control will make the mechanism go to the commanded position as quickly as the system is able. Often this is not desirable. For example, with a lawn mowing robot, you would want the robot to move to the commanded position (the end of the lawn) at a controlled speed. This is done by adjusting the corresponding speed limit potentiometer, or sending a combined position/speed command in one of the serial modes. Because kangaroo has a true velocity controller, the system will position at the commanded speed, even if it encounters a disturbance. Rotating the potentiometer towards the Limit Switch inputs corresponds to slower speed.



Speed Limit Potentiometer

Mixed Mode

Setting DIP switch 4 to OFF selects Mixed mode. This is for differential drive mobile robots, or any other system that utilizes tank style steering. In this mode, instead of having independent control of Motor 1 and Motor 2, there is a Drive and Turn channel. The system will tune moving both motors at once. The reason this is done is many 4wd and especially tracked systems require much more power to turn than they do to drive forwards and backwards. You can command Drive and Turn positions. For example, you can tell the robot to drive forward 3 feet, turn 90 degrees and then drive forward 3 additional feet.

Speed Control

If the Kangaroo is set up for speed control, it will command the device to move at a specific speed. Speed control works like the cruise control in a car: if the device encounters resistance such as going up a hill, it will apply more power to keep the speed to exactly the commanded speed. If it encounters less resistance than it is expecting, it will apply well power, or even apply braking, to keep the speed to what is commanded.

Examples of devices that are speed controlled include

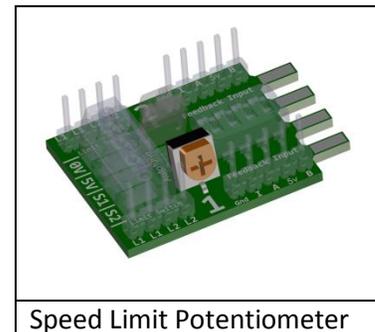
- Cruise control in a car
- Wood routers
- Spindles in CNC machines
- Mobile robots

By using speed control rather than just controlling the output power directly, like you would with a standard Sabertooth, you can often control to much lower speeds with good results. This is because at low speeds without speed control it does not take much force to stop the device. However, with speed control the Kangaroo can command up to full motor power even at very low speeds. This makes it nearly impossible for a disturbance to stop the device.

If DIP switch 3 is set to OFF, Kangaroo x2 is in speed control mode. You can use analog voltages, R/C servo type signals or serial commands to set the speed. You can change freely from position to speed control at any time. It does not require a re-tune or a reboot.

Speed Limit

During tuning, the Kangaroo determines the maximum speed the system can go. The onboard speed limit potentiometer can be used to set a slower range. By default, the kangaroo is set to 75% of the maximum speed the system can go. 75% is used as the default in order to give the system some headroom. For example, with a mobile robot, if the maximum speed was determined by tuning on flat ground, it would not be able to hold 100% speed up a hill. This is because the system wouldn't have any extra power available to climb. The user can adjust the potentiometer to make the input range from 1% to 150% of the detected speed. This is primarily useful because, even though a motor may be able to go 10,000 rpm, the designer might want to limit it to 1000 rpm or some other value to make the system work properly. Rotating the potentiometer towards the Limit Switch inputs corresponds to slower speed.



Speed Limit Potentiometer

Mixed Mode

Setting DIP switch 4 to OFF selects Mixed mode. This is for differential drive mobile robots, or any other system that utilizes tank style steering. You can command Drive and Turn speeds. For example, you could tell the robot to drive forward at 5 mph or turn at 20 rpm.

Feedback

Kangaroo x2 requires a sensor telling the controller where the device is and how fast it is going. This sensor signal is called feedback. Kangaroo supports two different kinds of sensors, quadrature encoders and potentiometers.

Quadrature Encoder

Quadrature encoders are used to determine the position, speed and direction of a system. The biggest advantage of encoders is they can rotate continuously: the same sensor can position to within less than a degree in one rotation or five thousand rotations. The optical, magnetic and capacitive types of encoders have essentially infinite lifespan and can turn quickly. Motors can often be purchased with quadrature encoders already installed. They sense in discrete counts. The number of counts is often printed on the encoder or motor. Values from 16 counts per revolution to over 1000 are common. The downside to quadrature encoders is they are relative sensors – they only know where they are relative to where they have been. Some sort of startup routine is necessary to find their position when first powered on. Kangaroo x2 provides a variety of automatic startup routines for encoders, such as limit switches, index pulses and mechanical stops. They can also be somewhat expensive – depending on the specifications. Quadrature encoders usually have four or five wires. Mobile robots and CNC machines are examples of devices that would use encoders.



A quadrature encoder

Potentiometer

Potentiometers are analog feedback devices. They typically turn only about 3/4ths of a rotation, though there are also multiple rotation types. The biggest appeal of using potentiometers for feedback is they can be very inexpensive – only a few dollars in single quantities. If you are designing a mechanism that only moves half a rotation or so, this is a big advantage. Also, potentiometers are absolute position sensors – they always know exactly where they are. As a result, they are ready to work as soon as they're powered on, with no homing or startup necessary. The main downside to using potentiometers for feedback is they are limited in their rotational range, so they are only appropriate for some systems. Inexpensive potentiometers only have rotational lives of 50,000 or less turns, and even expensive sensor grade models are usually limited to a few million. Because they are analog sensors, they may have slight noise on their signals, so the control is sometimes not as smooth. Radio control hobby type servos and robot arms often use potentiometers for feedback.



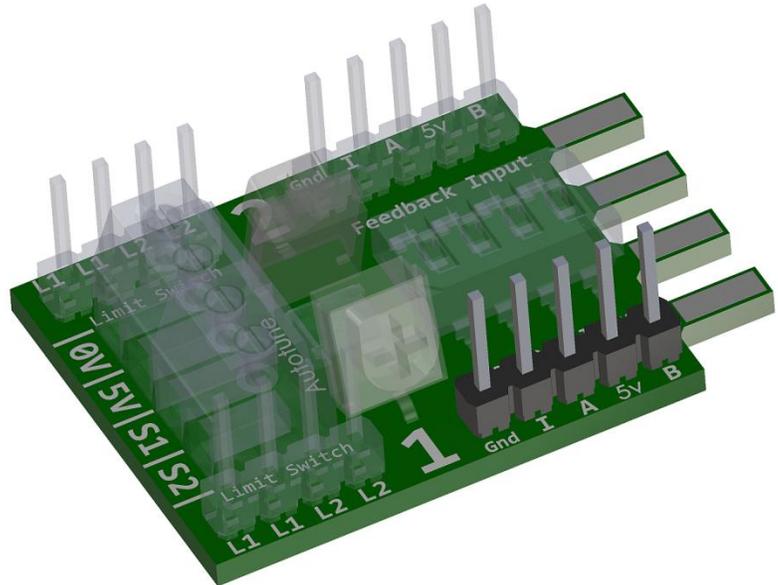
A sensor grade potentiometer

Kangaroo x2 Inputs and Connections

Kangaroo x2 requires at minimum one signal input, one feedback input, one motor and must be connected to a Sabertooth or SyRen motor driver to operate.

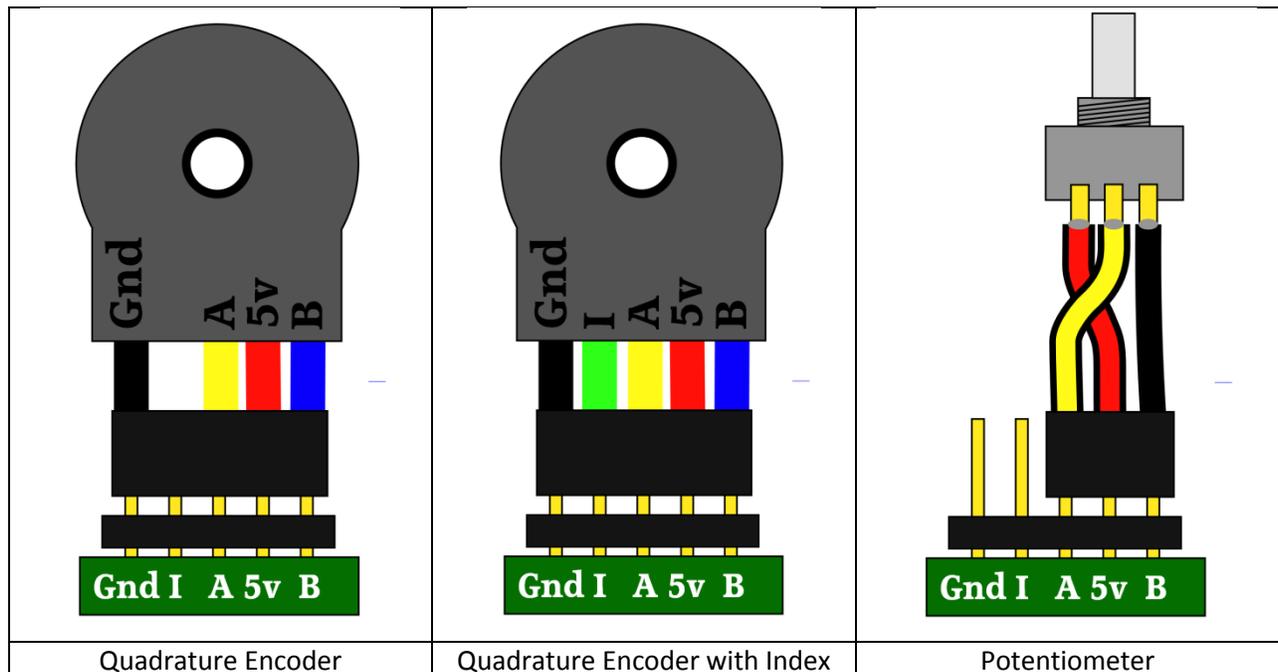
Feedback Input

Kangaroo supports 5v optical, magnetic or mechanical quadrature encoders. Index pins may be used to make the homing and range more accurate if desired. Connections are to the GND, I, A, 5v and B pins in a single row .1" pitch pin header type connection. Encoders can be either push-pull or open collector type. With open collector encoders, it may be necessary to add stronger 1k ohm pull-ups between the A,B and I channels and 5V if a long encoder cable is used.



Kangaroo also supports 0-5v analog feedback for use with potentiometers.

To use analog feedback, connect the potentiometer's wiper to the A feedback input. Connect one side of the potentiometer to the 5V terminal and the other side to the B terminal.

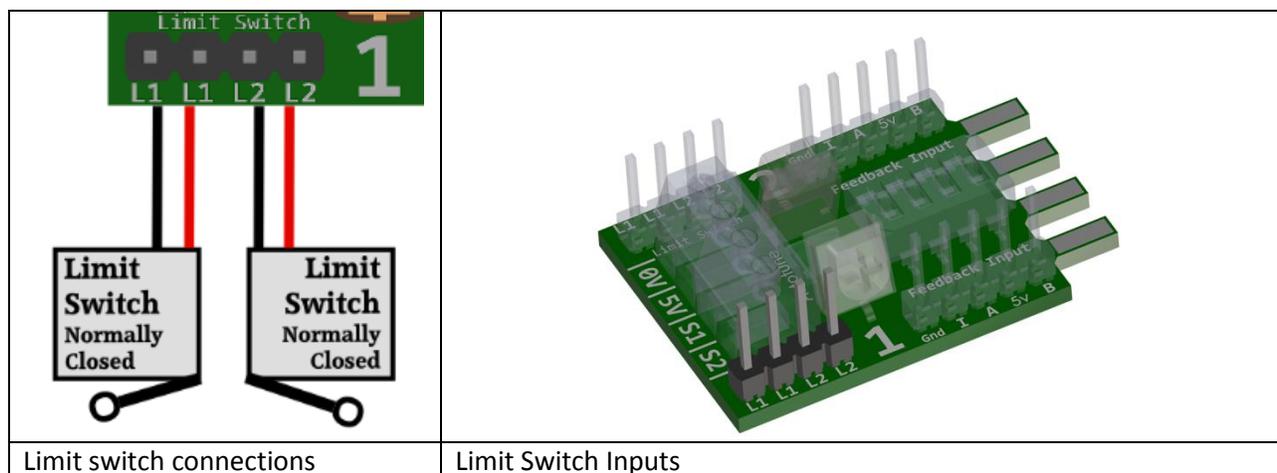


Motion Range

Kangaroo supports several ways of defining the tuning and travel range. These are limit switches, mechanical stops and teach range.

Limit Switches

Limit Switches are switches placed at the extreme ends of the device's travel range. When the device moves to or past the limit switch, the switch is pressed. It is a good practice to set the limit switch up on the side of the mechanism rather than directly in front of it. That way, if the device moves slightly too far, the limit switch is not damaged. If you are using limit switches with a Kangaroo x2, they should be wired normally closed. You must do a Limit Switch Tune (Mode 2) in order to tell the device you are using limit switches. The limit switches for channel 1 connect across the L1 and L2 inputs as shown below. In either position or speed mode, when using limit switches, the device will stop at the limit switches, even if you are commanding farther travel. When using limit switches, positions are repeatable regardless of where the system was parked, as the device will automatically home to one of the limit switches before operating. Because differential drive robots are non-holonomic, limit switches are not meaningful in mixed mode, and are therefore not supported.



Mechanical Stops

For systems that do not need as much precision, or as much setup time, physical stops are very convenient. Instead of limit switches you would use physical stops at the end of travel to stop the device. Rubber bumpers are a common type of stop that works well. To enable physical stops, perform a Mechanical Stop tune (Mode 3.) During tuning and at startup, the mechanism will slowly and gently travel until it stops at the end. Once tuned and homed, the stops work just like limit switches. Although the Kangaroo uses a slow speed and reduced power to seek out the ends of travel, you should still only use this method of setting the motion range on physically robust systems. You should also not use this mode with mobile robots, because on startup the robot will drive over or through whatever is in its path until it encounters something sturdy enough to force it to a stop.

Teach Range

Instead of having the kangaroo automatically determine the travel range, you can also teach it a range manually. To do this, during tuning you select Teach Tune (Mode 1) then move the mechanism from one end of its travel to the other. The Kangaroo will save this range. During the tune, the Kangaroo will move the system between the positions you have taught in order to calculate the tuning parameters. If you are using velocity mode, for example with a mobile robot, what you are defining is a safe range of motion for tuning only. In velocity mode the robot can travel any distance as long as a velocity is commanded. When operating in position mode, this range will be the travel unless you are using serial inputs, in which case you can command any distance or speed. When using quadrature encoders and position mode with a teach tune, you must ensure the mechanism is in the startup position before applying power.

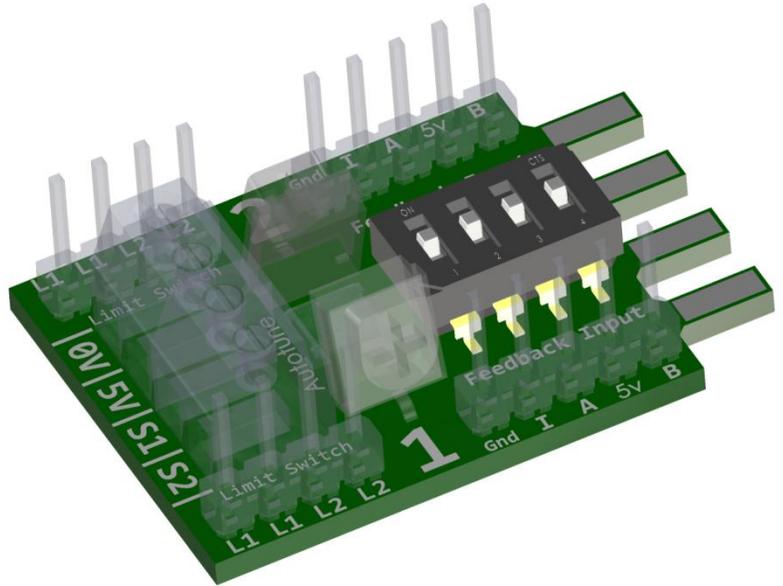
Teaching the range is especially useful when you are using a potentiometer for feedback and are commanding only two positions. In this case, by teaching both desired positions you can select the output position with a simple toggle switch on the input between S1 and 5v. Analog input would be used for this purpose. Mechanisms such as screens (retracted or lowered), doors (open or closed) and chutes (right or left) are good examples of this type of system.

Soft limits

In any of the position limited modes, software limits can be set inside the maximum travel range, to prevent physically contacting the limits except in a fault case. This is often a good practice. By default, the soft range is set to 99% of the hardware range unless you are using Teach Range. This can be modified using the DEScribe software.

DIP switches

The main Kangaroo operating modes and options are set using a four position DIP switch. The individual switches have numbers printed on one side, and the word “ON” on the opposite side. For the purposes of this document, the switch is considered to be ON when the toggle is towards the word ON, and OFF when the toggle is towards the number. The switches use flush actuators, so a pen or similar tool is necessary to switch them. This prevents accidental changing of mode during operating.

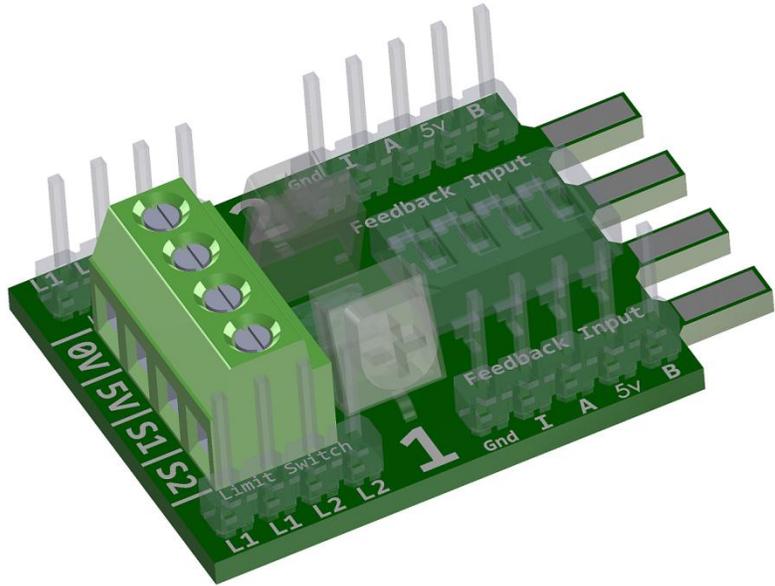


OFF setting		ON setting
1 off: Analog input. Connect 0-5V analog signals to the S1 and S2 inputs.		1 on: Digital input Connect TTL serial, TX to S1 and RX to S2, or R/C servo signals to S1 and S2
2 off: Analog feedback Connect a 0-5V signal to Feedback Input A		2 on: Quadrature feedback Connect an encoder to Feedback Inputs A and B
3 off: Velocity control Motor speed and direction are controlled by the input signal		3 on: Position control Motor position is controlled by the input signal
4 off: Mixed mode The outputs are mixed together for differential drive mobile robots		4 on: Independent mode The outputs are independent. S1 controls motor 1 and S2 controls motor 2.

DIP switches 1 and 3 can be changed without redoing the tune. If switches 2 and 4 are different from the setting recorded during the tune, the kangaroo will not operate the motors until the switch is changed back or the system is tuned again.

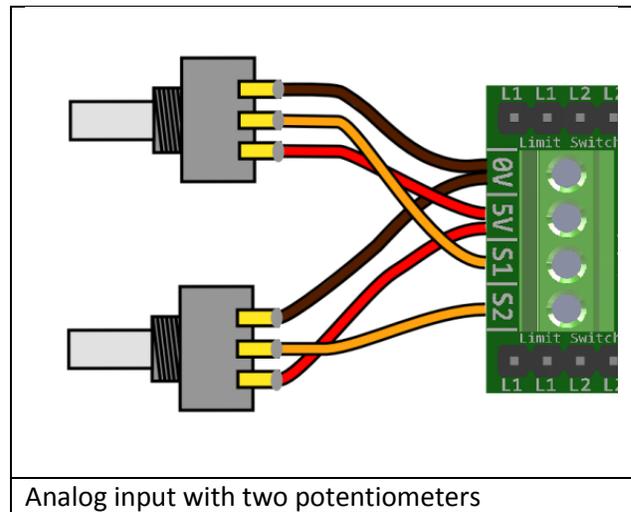
Control Inputs

The control inputs on a Kangaroo x2 are the screw terminals labeled 0V, 5V, S1 and S2. 0V is the logic ground for the device, and must be connected to the ground of the device generating the signal. 5V is a 5V output that can optionally be used to power the potentiometer, receiver, microcontroller or other device that is generating the signals. If the signaling device is self-powering, it should be left unconnected. S1 and S2 are signal connections. DIP switch 1 is used to select which type of input is being used.



Analog Input

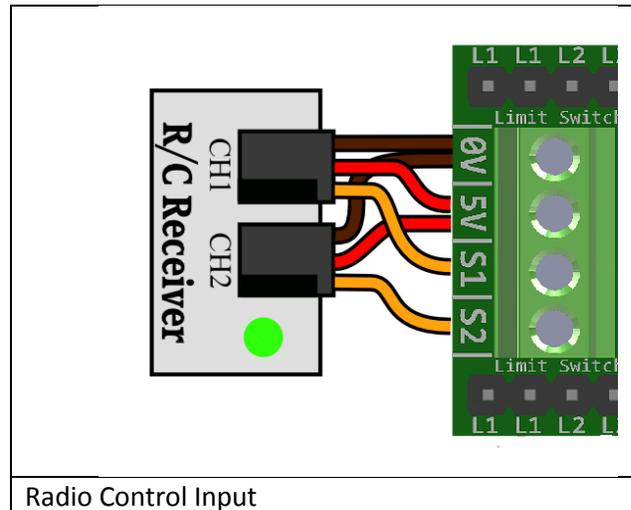
In Analog Input mode, the position or velocity is proportional to a 0-5v analog input. This is useful for controlled feed rates in power feeds, joystick controls for actuators or cameras, cruise control for ride-on vehicles or positioning stages driven by dials or sliders. It also makes it easy to build arm followers for tele-operation. Analog input can also be used with switches or other analog signal sources such as a DAC or CNC controller. For analog input, set DIP switch 1 to OFF. By default, in velocity mode 2.5 volts is zero speed, 0v is full speed reverse and 5v is full speed forward. In position mode, 0v is full travel in one direction and 5v is full travel in the other. The input center and range can be calibrated with tune mode 4, or programmed with the DEScribe software.



Analog input with two potentiometers

Radio Control Input

In R/C mode, the output position or velocity is controlled by an incoming R/C signal. This could be used for cruise control, automatically going the same speed up or down hills, with varying load and resistance. It can also be used to create arbitrarily large R/C servos, proper steering or other applications. This is also an easy mode to use with microcontroller boards, because nearly all microcontroller modules from Basic Stamps to Arduinos can output an R/C servo formatted signal. For R/C input, set DIP switch 1 to ON. R/C Input with velocity mode automatically calibrates to the input from your transmitter. R/C mode with

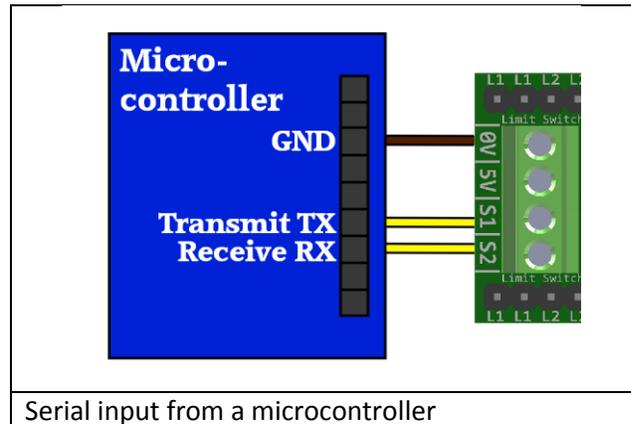


Radio Control Input

position control uses a pulse range from 1000us to 2000us, with the center at 1500us. This can be calibrated with tune mode 4, or programmed with the DEScribe software.

Serial Input

With serial input, a TTL level serial signal is used to control positions, speed, or both simultaneously. Serial input allows reading the position or speed back to the microcontroller or computer, and a finer level of control than the other modes. Serial mode is selected by setting DIP switch 1 to ON. The default serial settings are 9600 baud, 8N1. This can be changed to a faster baud rate with the DEScribe software if desired. There are two different serial protocols supported: Simplified serial and packet serial.



Serial input from a microcontroller

Simplified Serial

With simplified serial input, commands are sent and received as plain text. Even with no programming knowledge, you could connect the Kangaroo to a PC via a USB-serial adapter, open a terminal program and start typing commands. With simplified serial, you can command position, velocity or combined moves, report the current position or velocity and change units and parameters. Simplified serial is used with microcontrollers, PCs or PLCs. Examples of simplified serial commands are:

1,p400 s50

2, getp

1, units 180 degrees = 5000 millivolt

Simplified Serial Commands

Kangaroo supports plain text TTL level simplified serial input. The default serial settings to use this mode are 9600 baud, 8N1. All commands follow the same format. Spaces are ignored and can be added for readability.

All commands consist of a channel number, followed by a comma, the command and a newline (Enter key)

Channel Number tells which motor to move

Channel Number	Channel mode and result
1	Motor 1
2	Motor 2
D	Drive channel. Both motors .Forward/Backwards in Mixed Mode
T	Turn channel. Both motors. Right/Left in Mixed Mode

Motion Commands are used to command motion. They do not respond back

Command	Result	Examples
p	Position command. The motor will go to the specified position, in units	1,p100 T,p45
s	Speed command. The motor will go at the specified speed, in units per second	2, s-400
pi	Incremental position command. The motor will go the specified increment from its current position.	1,pi100 2.pi-333
si	Incremental speed command. The motor will go faster or slower than its current speed by the commanded increment.	2,si2
powerdown	Power down. This command will turn off the motor and control system. You can still read position and speed with the motor powered off. This is used to allow the system to freewheel or to save power.	1, powerdown 2, powerdown
A position and the speed command can be on one line. The same can be done with incremental position commands. For the combined commands, the speed cannot be negative. This will make the device move to the commanded position at the commanded speed.		1,p1000 s200 2,p-333 s10 D,pi100s5000

Readback Commands are used to read the position, speed and status of the device. They respond back in plain text on the S2 input.

Command	Result	Examples
getp	Get position. Returns the channel number, followed by a comma, followed by a capital P if the move is completed or a lowercase p if the move is still going on, followed by the position in units (plain text) followed by a return and a newline	1,getp might return 1,p1235\r\n 2,getp might return 2,P3000\r\n
gets	Get speed. Returns the channel number, followed by a comma, followed by a capital S if the device is up to max speed or a lowercase s if the device is still accelerating, followed by the position in units (plain text) followed by a return and a newline	1,gets might return 1,s1235 2,gets might return 2,S3000\r\n
getpi	Get incremental position. Returns the channel number, followed by a comma, followed by a capital P if the move is completed or a lowercase p if the move is still going on, followed by the position in units (plain text) relative to the position the device was in when it received the last command, followed by a return and a newline	1,getpi might return 1,p302\r\n T,getpi might return T,P20\r\n
getsi	Get incremental speed. Returns the channel number, followed by a comma, followed by a capital S if the device is up to max speed or a lowercase s if the device is still accelerating, followed by the position in units (plain text) relative to the speed the device was in when it received the last command, followed by a return and a newline	1,getsi might return 1,s302\r\n T,getsi might return T,S20\r\n
getmax	Get max position. Returns the channel number, followed by a comma, followed by a capital P, followed by the maximum position in units (plain text) followed by a return and a newline. For example. In some cases, such as a rover, the maximum position may not be meaningful.	1,getmax might return 1,P10000\r\n
getmin	Get minimum position. Returns the channel number, followed by a comma, followed by a capital P, followed by the minimum position in units (plain text) followed by a return and a newline. For example. In some cases, such as a rover, the maximum position may not be meaningful.	1,getmin might return 1,P-10000\r\n

Note: \r\n is not visible in a terminal program, but must be included when using a function such as scanf to designate the end of the message

Setup Commands are used to define and initialize the motion environment. They must be sent each time the Kangaroo is powered up if they are used. They do not respond back.

Command	Result	Example
start	This command must be sent before any other commands to the axis. Commands sent before a start command will be ignored or return an error.	1,start 2,start T,start D,start
units	This command is used to change the input from machine units (millivolts or encoder lines) to a user defined unit system. Please note that commands use whole numbers only, and design your program to use appropriate units. For example, for a system with four inches of travel, thousandths of an inch is more appropriate than inches. The first value is the user units, then an equals sign, followed by the second value in the machine units, followed by a newline. The system only acts on the numbers, the text strings are optional and for code clarity.	1,units 4 ticks = 1 line 2, units 1 rotation = 100 lines D, units 1000 thou = 256 lines 2, units 180 degrees = 5000 millivolts
home	This command is used on startup to move the system to its home position. When using a quadrature encoder with a limit switch or crash limit tune , only incremental commands will be accepted until the channel is homed. Home is not meaningful in mixed mode.	1, home 2, home

Example Simplified Serial program

The following set of commands would start up the kangaroo, then command a X-Y positioner to draw a 1" by 1" box at five inches per second. This positioner has a 256 line encoder on the motor and a 4 turn per inch lead screw.

```

1,start
2,start
1, units 1000 thousandths = 1024 lines
2, units 1000 thousandths = 1024 lines
1,home
2,home
Delay 5 seconds to wait for homing to finish
1, getp (verify that you are at position 0)
2, getp
1,p1000 s5000
2,p1000 s5000
1,p0 s5000
2,p0 s5000

```

Error Codes

If the Kangaroo is unable to respond appropriately to a readback command, it will respond with an error code instead of the usual return. Error codes begin with either an uppercase or a lowercase letter e.

Error Code	Result	Example
E1	Not started. The channel has not been started, or the Kangaroo has lost power during operation	1,getpi\r\n might return 1,E1
E2	Not homed. The channel has been started successfully, but has not homed in a mode that requires homing, so absolute commands are not meaningful	2,getp\r\n might return 2,E2
e2	Homing in progress. The home command for this axis has been sent, but has not completed yet.	2,getp\r\n might return 2,e2
E3	Control error, channel disabled. Check to make sure your feedback sources are working and the system matches how it was set up during the tune.	2,getp\r\n might return 2,E3
E4	System is in the wrong mode. You must tune again to use this mode.	2,gets\r\n might return 2,E4
E5	Readback Command not recognized. The kangaroo is unable to understand this command.	2,getmeasandwich\r\n will return 2,E5
E6	Signal lost. The Kangaroo lost communication with the PC or microcontroller since the last command.	2,getp\r\n might return 2,E6

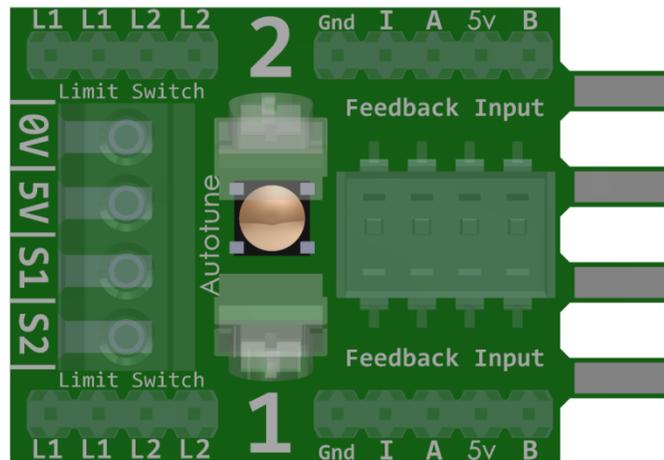
Note: \r\n is not visible in a terminal program, but must be included when using a function such as scanf to designate the end of the message

Packet Serial

With packet serial input, a 0-3V or 0-5v binary serial signal with robust checksum is used to command position, velocity or combined moves, report the current position or velocity, set up and execute tuning and change units and parameters. This is used with microcontrollers, PCs or PLCs for position or velocity control tasks. Open-source libraries for Arduino and PC are available. For serial input, set DIP switch 1 to ON. The packet serial protocol is described fully in a separate document.

Autotuning

Kangaroo has a button labeled “Autotune” between the speed limit potentiometers. During autotuning, the motor and any devices attached to it will move. For best results, have a representative load applied to the mechanism before starting the tuning sequence. For example, if you are building a positioning stage that will support from 0 to 200 lb, a good test load for tuning purposes would be 100 lb. Ensure that the mechanisms are near the center of their range of motion before starting the tune. The tune procedure will take between 30 seconds and several minutes per axis, depending on how rapidly the system being tuned responds. Systems that can accelerate faster and have smaller travels will tune faster.



Selecting the tuning mode

To enter tuning mode, press and hold the Autotune button for at least one second. The LED will begin to blink 1 blink, followed by a pause. Release the Autotune button. The LED will continue to blink one blink. To confirm your selection of mode number 1, click and release the Autotune button. To instead change to mode 2, press and hold the Autotune button. The LED will stop blinking, then after one second will begin blinking two blinks followed by a pause. To confirm this mode, click the button. To go on to mode 3, hold down the button again and so on. In mode 4, holding down the button will bring you back to mode 1.

In short, pressing and holding the autotune button selects between tune modes. Clicking the autotune button confirms the current mode and begins setup of that tune. At any point before the tune is completed, you may abort by unpowering and repowering the system. Kangaroo has four tuning modes.

Tune Modes

Number	Mode	Overview
1	Teach Tune	Move the mechanism to define the tuning range
2	Limit Switch Tune	Normally closed limit switches define the tuning and operating range
3	Crash Limit Tune	Physical stops define the tuning and operating range
4	Input Calibrate Mode	This mode calibrates the R/C or analog inputs.

Setting up the tune parameters

In setup mode, the tune number will continue to blink, but dimmer and more rapidly. Depending on the tune mode, there may be specific things that must be done with the system and inputs at this stage.

Mode 1: Teach Tune

In teach tune mode, you must physically move the system to teach the kangaroo the acceptable travel range for tuning. The motors will not be powered at this point. Push each axis to one end of its travel range, then to the other end of its travel range. Finally, push the system to the center of its travel range and leave it there. For systems such as mobile robots that do not have defined travel ranges, use a distance that will be safe when the device moves under its own power. Remember that you must define the range for both channels, if you have motors attached to both channels 1 and 2.

To confirm the range and begin the teach tune cycle, click and release the autotune button again. The LED will begin a countdown blink, first slowly and then rapidly. After a delay of 10 seconds, the tune cycle will start. To increase the delay before the motors will move, click the button multiple times. Each click adds 10 seconds to the delay.

The system will move automatically. Stay a safe distance away.

Mode 2: Limit Switch Tune

In limit switch tune mode, all that is required is to make sure the system starts up near the center of its travel range, and none of the limit switches are depressed. Everything else will be handled automatically. To begin the limit switch tune cycle, click and release the autotune button again. The LED will begin a countdown blink, first slowly and then rapidly. After a delay of 10 seconds, the tune cycle will start. To increase the delay before the motors will move, click the button multiple times. Each click adds 10 seconds to the delay.

The system will move automatically. Stay a safe distance away.

Mode 3: Mechanical Stop Tune

Because using crash limits requires the mechanism to physically stop at the end of travel (though at a low motor power) make sure that the mechanism will not bind up, jam or break when driven to the end of its travel. To set up crash limit mode, move the system to approximately the center of its travel range. To begin the limit switch tune cycle, click and release the autotune button again. The LED will begin a countdown blink, first slowly and then rapidly. After a delay of 10 seconds, the tune cycle will start. To increase the delay before the motors will move, click the button multiple times. Each click adds 10 seconds to the delay.

The system will move automatically. Stay a safe distance away.

Mode 4: Input Calibrate Mode

Input Calibrate mode is not technically a tune. Instead, it is used to calibrate the input signals. This is used in R/C and analog mode. Before entering input calibrate mode, make sure your input signals are connected, your transmitter is powered on if using radio control, and the inputs at their desired neutral position. Once in the tune mode, move each input slowly all the way to one side, and then to the other. Return the inputs to the desired center. The motors will not move. The signal range the kangaroo has been sent during this Calibrate Mode setup will be recorded as the full scale signal range, and the positions the inputs are in at the end of setup are recorded as the neutral value. To save the input, click and release the autotune button again. Please note that you must calibrate both channels if you are using both channels. Although calibrate mode is not a tune, you must power cycle the system to use the new calibration.

The autotune cycle:

During the autotune cycle, the kangaroo measures various system parameters to calculate the control settings. The cycle happens automatically. The system will move itself within the range selected during setup. Depending on the system it may move rapidly. Ensure that the system will not cause damage or injury during the tune cycle. Also be sure it is well mounted before starting the tune.

The tune cycle consists of a series of oscillations and linear moves between various points within the defined range at different speeds and motor powers. If two channels are used, the motion will alternate between the two channels.

When the tune cycle has finished successfully, the motors will stop and the LED will turn on solid. If the LED is instead blinking, it means that the tune was not successful. The number of blinks corresponds to the error number that caused the tune to fail.

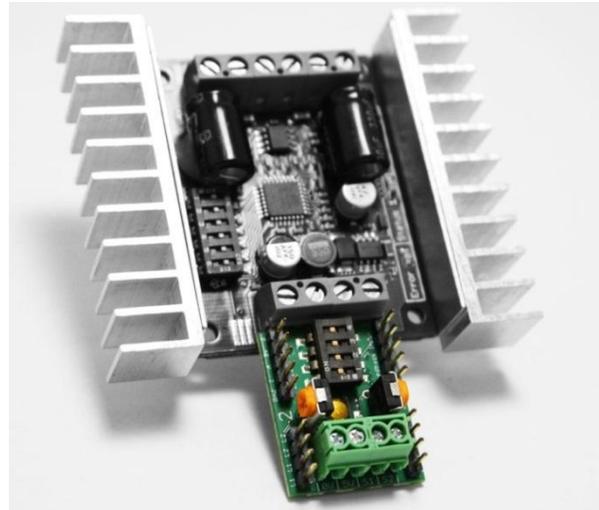
Tuning error number (blinks)	Error description
1	Wiring error. Check your connections and make sure everything is connected correctly.
2	System Range. The system can't tune in the range provided or reached one of the limits. Make sure you started the tune in the center of motion.
3	Control Error. The system either lost control, failed to move or can't stop.
4	Wrong Mode. Some combination of inputs and settings are invalid. For example, mixed mode with limit switches is an invalid combination and will return this error.
5	Tune Aborted. You have stopped the tune in the center.
6	Limit Switch. You either hit a limit switch during the tune or have started the tune with a limit switch depressed.
7	Index error. Either the system failed to see an index pulse it expected, or saw one in the wrong position. Index pulses should be normally low.

After tuning

After tuning, you must power the device off and back on to use the new tune. Kangaroo will start back up under control in the mode defined by the DIP switch settings. If the tune failed, you must still power the device off and back on. However, the settings will not be saved.

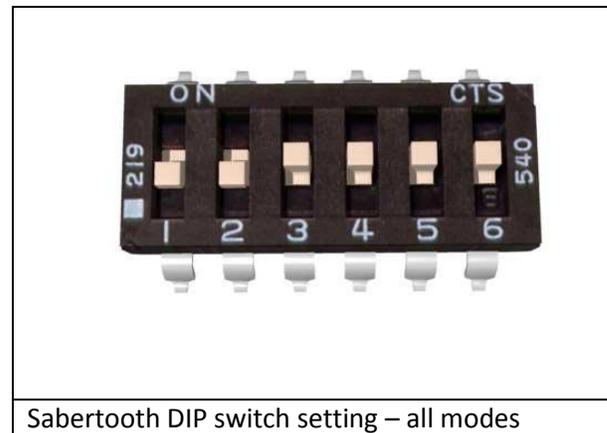
Installation

Kangaroo x2 will work with any Dimension Engineering motor driver with screw terminal inputs. To mount the Kangaroo x2, insert the PCB tabs labeled 0V 5V S1 and S2 into the 0v 5v S1 S2 terminal block of the Sabertooth or SyRen instead of wires, then tighten the terminal block down on the PCB of the Kangaroo to make connection. Set the motor driver to packet serial mode at address 128 as shown.



Channels 1 and 2

Kangaroo x2 can support one or two motor channels. If using only one channel with a SyRen or Sabertooth driver, use the limit switch, feedback input and speed limit potentiometer on the side labeled 1. Control with the S1 input on the kangaroo and connect the motor to the M1 outputs a Sabertooth. If using two channels with a Sabertooth motor driver, connect the inputs on the side labeled 2 to the motor connected to the M2 outputs .



Sabertooth DIP switch setting – all modes

Feedback Inputs

Quadrature encoders or analog potentiometers are connected to the 5 pin header labeled “Feedback Input.” If the system moves in the opposite direction from what is desired and it is not practical to reverse the input, power the system off and swap the encoder A and B channels. **Hold down the tune button while powering back up, or the system will run away.** Then retune, and the system will move the opposite direction. If using analog feedback, the same procedure applies, but swap the 5v and B channels. **Make sure to hold down the tune button when applying power to prevent the system from trying to run with reversed feedback.** After you have retuned the system it will again be under control.

Limit switches

The limit switches, if used, are wired normally closed. One end’s limit switch connects across both L1 connections, and the other end’s connects across L2 as shown. During tuning the kangaroo will automatically seek out the limit switches and determine which is on which end.

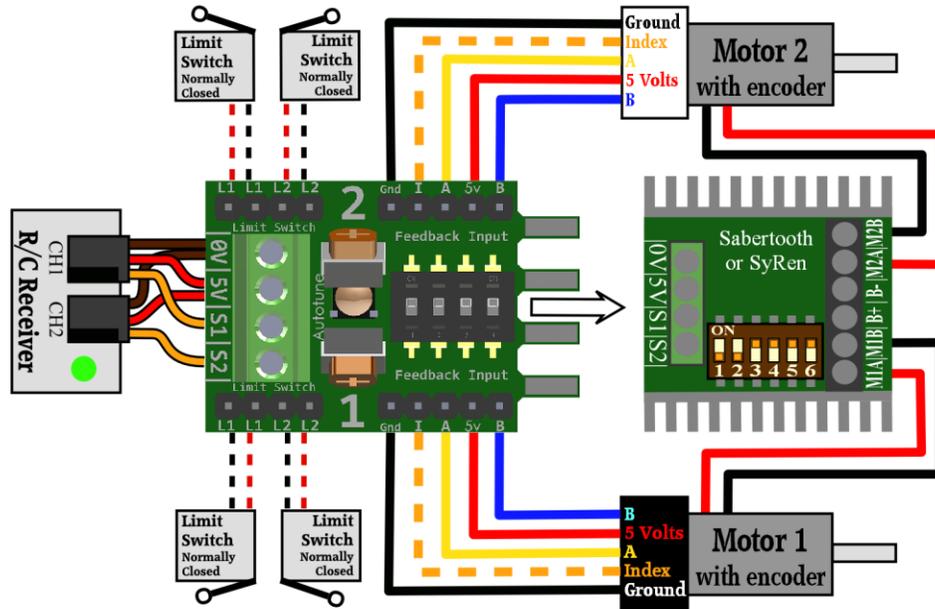
Signal inputs

Route the signal inputs to the green screw terminals of the kangaroo. Refer to the input section for how to hook up each mode.

Cheat Sheet

This is a copy of the instruction sheet that ships with the Kangaroo X2.

Kangaroo x2 Sample Wiring Diagram



Operating mode DIP switch settings

1 OFF: Analog Input.

Connect 0-5V analog signals to the S1 and S2 inputs.

2 OFF: Analog Feedback

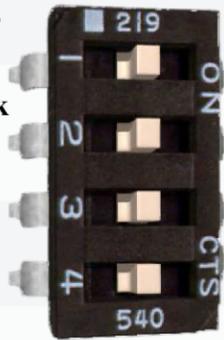
Connect a 0-5V signal to Feedback Input A

3 OFF: Velocity Control

Motor speed and direction are controlled by the input signal

4 OFF: Mixed Mode

The outputs are mixed together for differential drive



1 ON: Digital Input

R/C to S1 and S2 or connect serial TX to S1 and RX to S2

2 ON: Quadrature Feedback

Connect an encoder to Feedback Inputs A and B

3 ON: Position Control

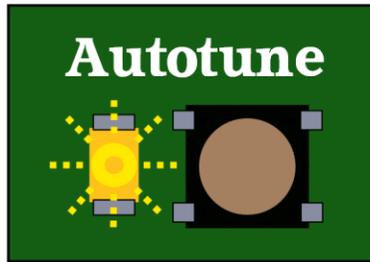
Motor position is controlled by the input signal

4 on: Independent mode

The outputs are independent. S1 controls motor 1 and S2 motor 2

For the full manual, example videos, libraries, serial protocols and other documentation, please visit

www.dimensionengineering.com/kangaroo



Tuning

Before being used, Kangaroo x2 must learn about the system. This is called tuning. Make sure everything is connected, then begin the appropriate tune sequence for your system.

Entering Tune mode To enter tune mode, **press and hold the Autotune button for 2 seconds**. The yellow LED will begin to slowly flash one flash, followed by a pause. This indicates tune mode 1. To change to the next mode, press and hold the Autotune button for 2 seconds. **To accept the current tune mode and begin setup, click and release the Autotune button.** To cancel, remove power.

Mode 1 Teach	Mode 2 Limit Switches	Mode 3 Physical Stops
In this mode, an acceptable range of motion for tuning is taught by manually moving the device.	In this mode, normally closed limit switches are used to set the tuning and travel range.	In this mode, the device will gently move to physical stops at each end of the travel range.
With the LED flashing rapidly one blink, push each axis to one end of its travel range, then the other, then return it to the center. For rovers, push it a few feet each way, then back to center.	With the LED flashing rapidly two blinks and the limit switches connected, make sure each axis is near the center of its travel range.	With the LED flashing rapidly three blinks, make sure each axis is near the center of its travel range. Make sure the device is strong enough to stop the motor at slow speed at the ends of travel.
When you have finished the tune setup, click and release the Autotune button for a second time. GET CLEAR. In 10 seconds the device will begin to move automatically. When the tune cycle is finished and the device has stopped moving, if the tune succeeded the yellow LED will be on continuously. The settings are saved and the system is tuned. Remove and reconnect the power to use the device. If the light is blinking, the kangaroo encountered an error. See the manual for details.		

To calibrate the inputs, if necessary: Put both inputs into the neutral position, enter tune mode 4 then move each input to the maximum position, hold for 1 second, move to minimum position, hold for 1 second, then place it back into the neutral position. When finished, click the Autotune button a second time to save, and then re-power.

For the full manual, example videos, libraries, serial protocols and other documentation, please visit

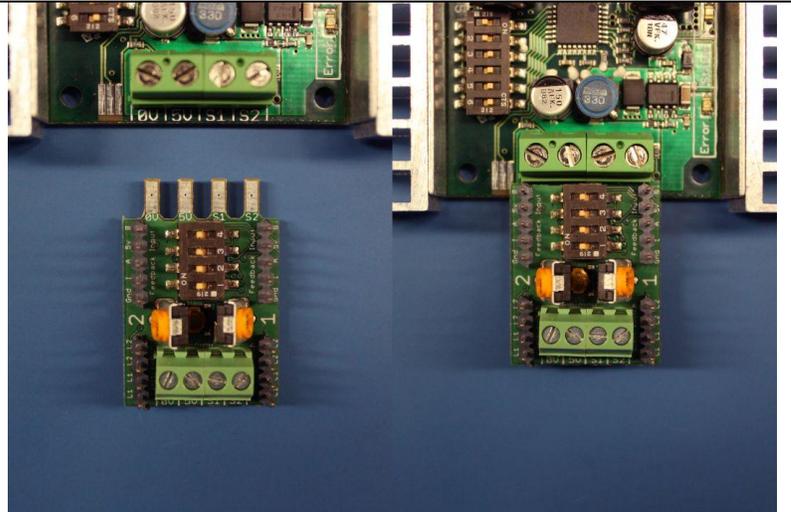
www.dimensionengineering.com/kangaroo

Quick Start Tutorial

The following tutorial will set up a system with one motor, quadrature encoder feedback, radio control input and a Sabertooth 2x25 motor driver. This tutorial uses a Teach Tune with a bare motor. We recommend this tutorial for anyone unfamiliar with feedback controls, or new to the Kangaroo x2 motion controller.

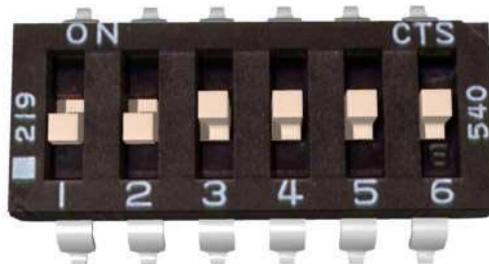
Step 1:

Connect the Kangaroo x2 Motion Controller to the input screw terminal of the Sabertooth as shown. Tighten all four connections.



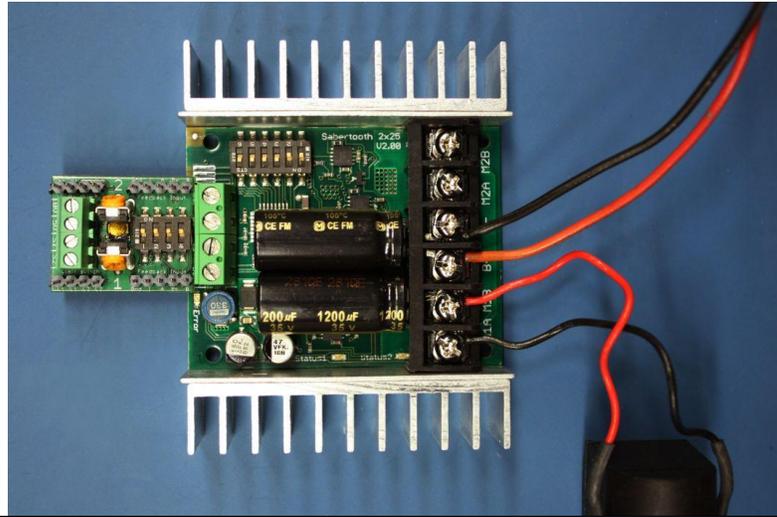
Step 2:

Set the DIP switches of the Sabertooth as shown.



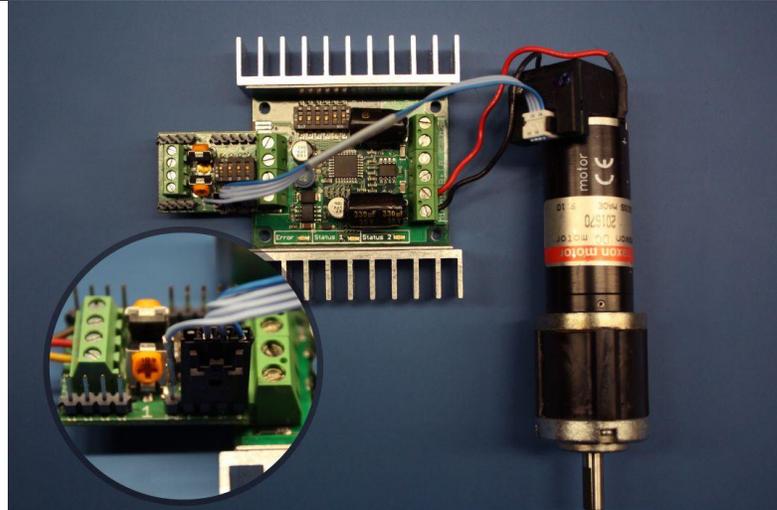
Step 3:

Connect the motor and battery leads to the Sabertooth. For the purposes of this tutorial, connect the motor to M1A and M1B. Leave the Sabertooth unpowered for now.



Step 4:

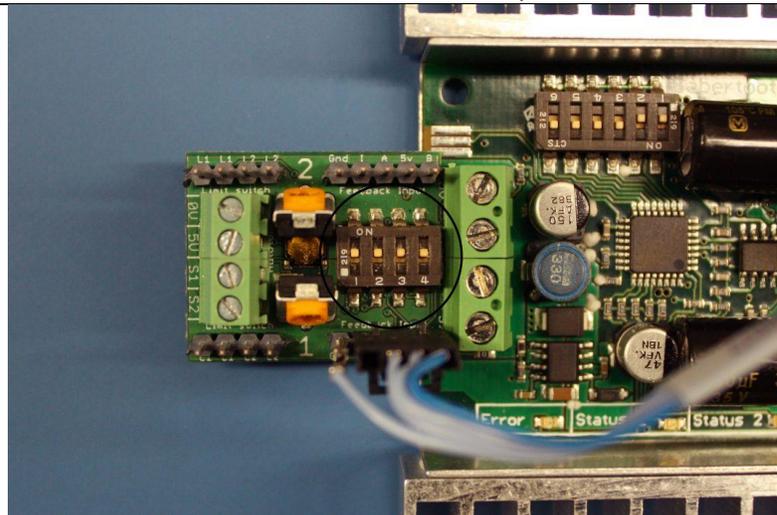
Connect the motor's quadrature encoder to the #1 Feedback Input, as shown. At a minimum, connect the Kangaroo's GND, A, 5V and B pins to the corresponding pins on the encoder. If the encoder has an index channel, connect it to the I pin. Depending on your encoder, you may have to make an adapter cable or change the pinout of the existing adapter cable.



In this example, we have changed the encoder's connector by removing one of the wires from the shroud. In production, you would want to insulate this wire or use a 5 position shroud.

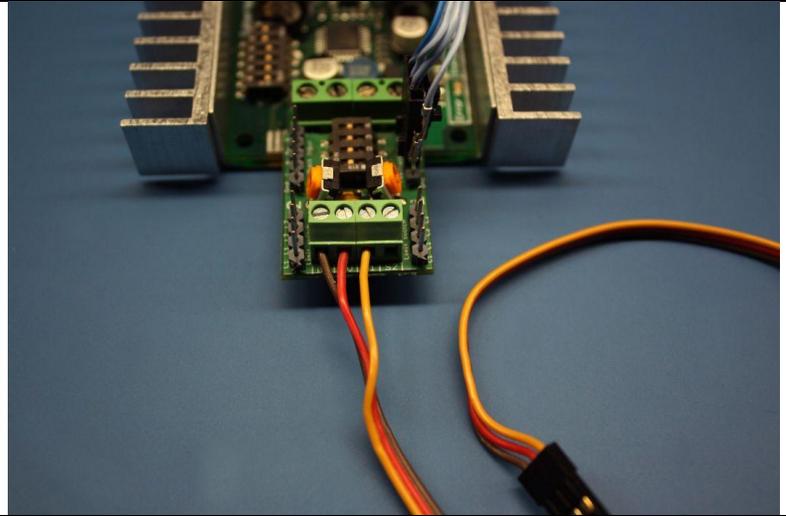
Step 5:

Set the DIP switches on the kangaroo as shown. (All switches ON)



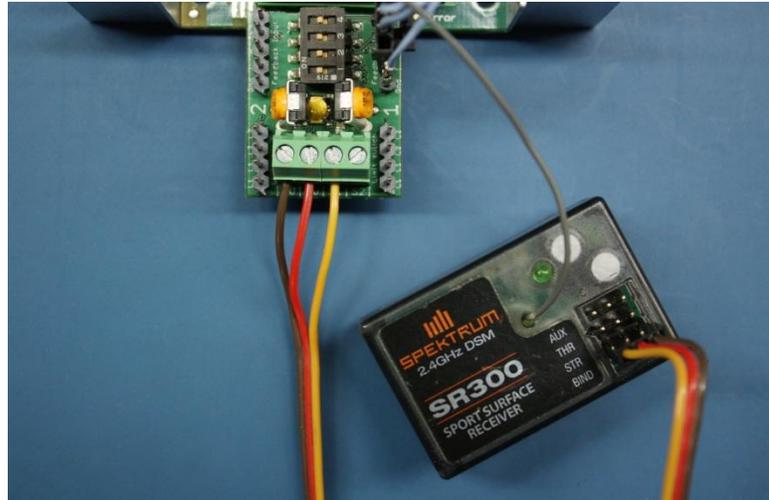
Step 6:

Connect a servo type pigtail to the 0V, 5V and S1 screw terminals of the kangaroo, as shown. The receiver will be powered by the Sabertooth's BEC in this configuration.



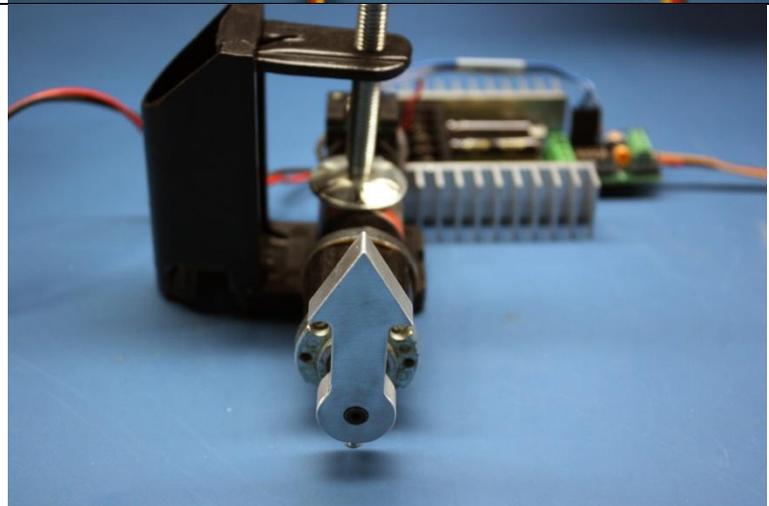
Step 7:

Connect an R/C receiver to the servo pigtail. Power up the corresponding transmitter, but leave in neutral.

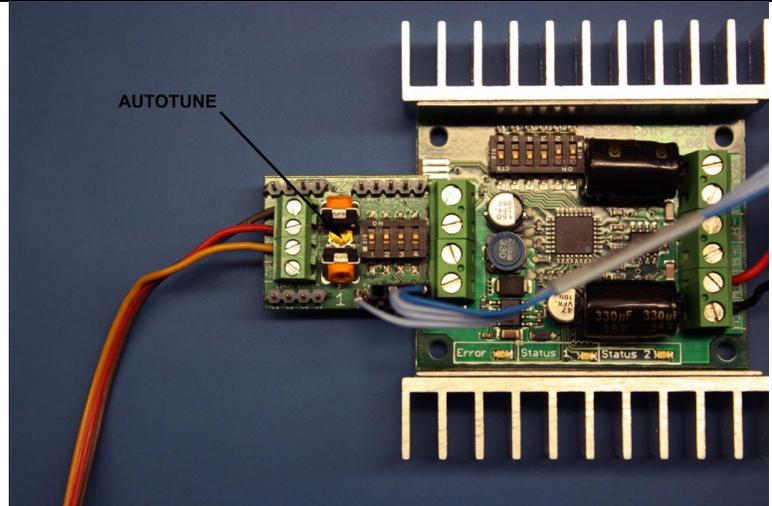


Step 8:

Secure the motor to your workbench or mount it in your robot. During the tuning. The motor will move back and forth. You want to make certain it is not going to roll off the bench while it does this.



Step 9: Power up the Sabertooth. The motor should not move. Press and hold the Autotune button for two seconds, until the LED begins to repeatedly blink one blink, then release. This is Teach Tune mode. To select this mode and enter Teach tune setup, click the Autotune button again.



Step 10: Turn the motor shaft half a turn to the right (or more, if you want the output range to be larger), then half a turn to the left (or more). Finally, turn the motor back to the center. This tells the Kangaroo how far you want the motor to be able to move and where to start the tune cycle.



Turn to one side

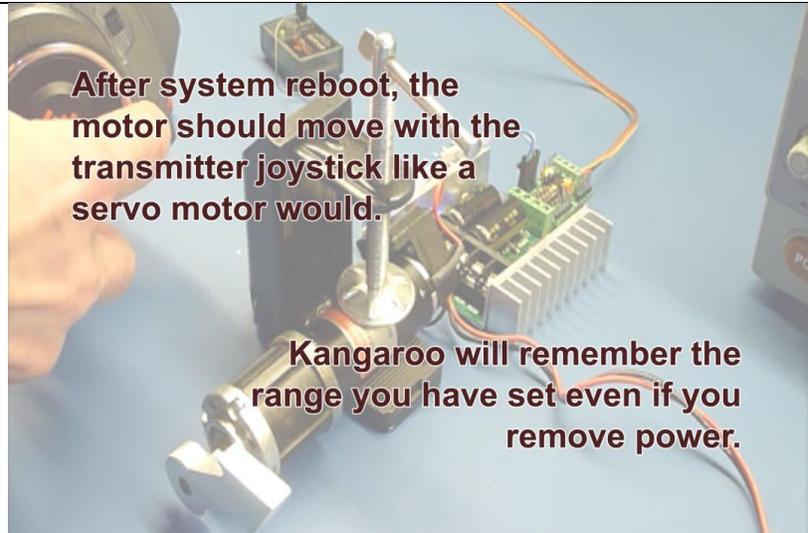
Turn to the other

Turn to the center

Step 11: Press the Autotune button again to start the tuning cycle. The light will begin a series out countdown blinks. Ten seconds after you press the button the tune cycle will start. During the tune cycle, the kangaroo will command the motor to move back and forth automatically. Please remain clear of your device while this is happening. The tune cycle takes approximately one minute to complete. Once the tune is done, the Kangaroo will blink continually.



Step 12: Make sure the transmitter is on. Reboot the system by removing power to the Sabertooth and waiting until all LEDs go out. Then power the sabertooth back up. Move the transmitter joystick. The motor should move with the transmitter joystick like a servo motor would. The kangaroo system is now tuned. The Kangaroo will remember the range you have set and the tuning parameters to keep the motor under control from this point onwards, even if you remove power. You can, of course, retune if you want it to have a different response.



Further explorations:

Speed limit

The maximum speed of the motor is set with the #1 speed limit potentiometer. Turning the potentiometer towards the kangaroo's input will make the motor move to the commanded position slower. Try turning the speed down to about 10% as shown in the picture and then moving the motor.

Velocity control

Kangaroo can also be used to set a controlled velocity, which acts like the cruise control on a car. Switch to velocity mode by setting DIP switch 3 to OFF. Command a very slow speed with your transmitter, and try to stop the motor. With most motors, you will find this very difficult, if not impossible. The Speed Limit potentiometer is used to set the maximum speed, just like in position mode.

Analog input

Kangaroo can use an analog input source rather than R/C as shown in the example. You can use this with a potentiometer to dial in a position or a velocity. DIP switch 1 on the Kangaroo controls analog or digital input. Set DIP switch 1 to OFF for analog input. Connect a potentiometer to the input, with the wiper going to the S1 input and the outer terminals to 0V and 5V

Two motors

Kangaroo can control one or two motors, either independently or Mixed together for differential drive vehicles. To use a second motor, plug the motor into the M2A and M2B outputs of the Sabertooth, then connect the encoder to the #2 feedback input, and the control signal to the S2 input. It will be necessary to tune again. Kangaroo will detect there is a second motor being used automatically.

Homing

With a teach tune using a quadrature encoder, you must position the system at the startup position before powering it on. This is not necessary with analog feedback or if using one of the more advanced tune modes such as Limit Switch or Crash Limit tuning. To use these modes, as well as learn about other things the kangaroo can do, please see the full kangaroo manual.

Troubleshooting

Some common problems and solutions.

My system does not stop when doing a Mechanical Stop tune. The wheels slip instead.	If the stops can't prevent the mechanism from moving, you will need to use limit switches instead.
My system moves REALLY fast in the middle of the teach tune cycle.	The system is trying to figure out how fast it can go, so this is technically correct. However, using a smaller teach tune range will prevent it from moving so fast.
I've used my Sabertooth before, and I can't seem to get a decent tune. The tune either fails, or the motion isn't smooth.	If you used the DEScribe software to change the motor driver, this can cause problems. Use the software again to set ramping, exponential, deadband and timeouts back to the factory defaults before using Kangaroo x2. Also, be sure the baud rate for the Sabertooth is set to 9600 baud.
It seems like my system should be going faster.	By default, the controlled speed is set to 75% of the theoretical max speed for the system. Turn the speed limit potentiometer for the channel up. If you are using a very high resolution encoder (1000 lines or more) you may need to switch to a lower resolution. The kangaroo internally limits the maximum count rate.
My system moves too fast.	Turn the speed limit potentiometers down. If you are using a serial mode, send a combined position and speed command.
Kangaroo doesn't seem to like my encoder	Some encoders need stronger external pull-ups to give good signal levels. This is especially true for magnetic encoders. See you encoder's datasheet for more details. If you don't have a datasheet, try adding a 1k ohm pull-ups between each quadrature channel and 5V.
I can't reprogram my Arduino when connected to Kangaroo x2.	If you are using hardware serial on an Arduino, it may not share the serial port properly for reprogramming. Use software serial on other pins instead, or disconnect the Kangaroo while you reprogram the Arduino. Newer Arduinos like the Arduino Leonardo do not have this limitation.
I can't make Kangaroo x2 work with my Sabertooth 2x5.	By default, Sabertooth 2x5 in packet serial uses 38400 baud instead of 9600 baud. The Dimension Engineering website has PC utility for changing the setting.