Directions for Wiring and Using The GEARS II OR III (2) Channel Combination Controllers

PWM Input Signal Cable for the Valve Controller

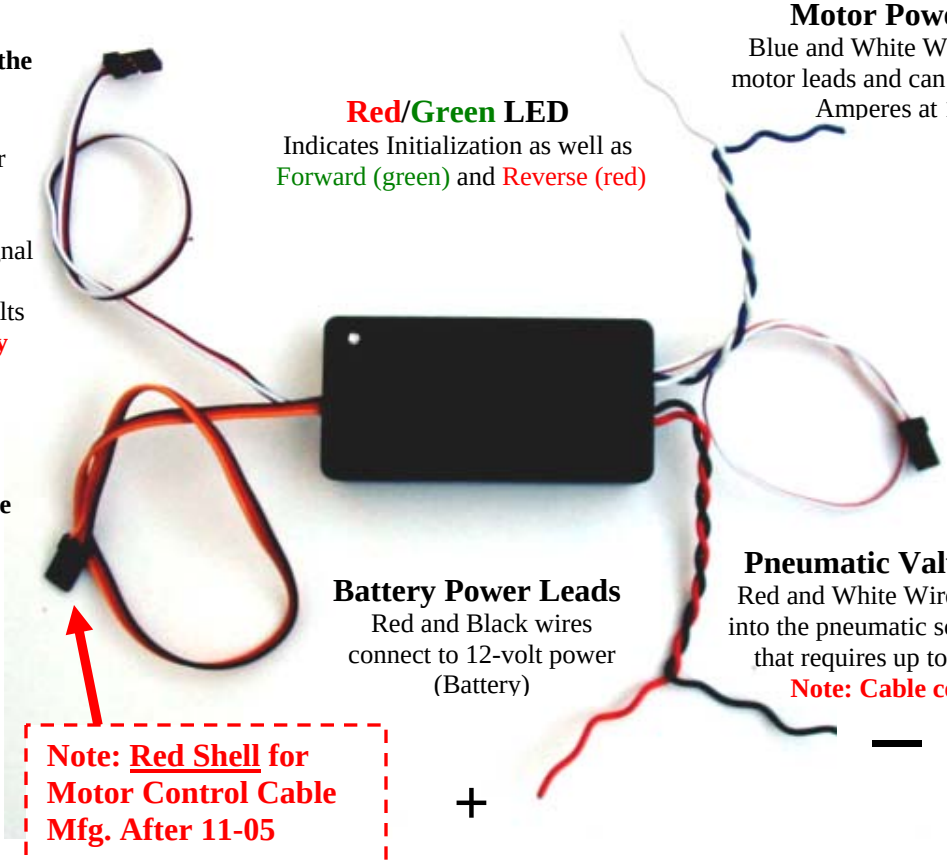
Plugs into the RC Receiver or Microprocessor Signal line.

White/orange = PWM Input Signal
Red = Positive + 5 volts
Black/brown = Negative – 5 volts
Note: Cable colors may vary

PWM Input Signal Cable for the Motor Controller
Plugs into the RC Receiver or Microprocessor Signal line.
Orange = PWM Input Signal
Red = Positive + 5 Volt
Brown = Negative – 5 Volt

Red/Green LED
Indicates Initialization as well as Forward (green) and Reverse (red)

Motor Power Leads
Blue and White Wires connect to motor leads and can deliver up to 15 Amperes at 12 volts.



Battery Power Leads
Red and Black wires connect to 12-volt power (Battery)

Pneumatic Valve Power Leads
Red and White Wire and connector plug into the pneumatic solenoid valve or relay that requires up to 300ma at 12 volts.
Note: Cable colors may vary

Note: Red Shell for Motor Control Cable Mfg. After 11-05

The GEARS II or III (2) Channel Combination Controller offers These Advantages:

- 400 steps forward, and 400 steps of reverse resolution provide a total of 800 steps of smooth response from either joystick or microcontroller inputs.
- Frame (Refresh) rate for the FET's is 10 KHz
- Reverse polarity protection on the battery power leads.
- 1 Ampere BEC.
- LED feedback for initialization and current direction.
- Supports continuous current draw of 10-12 Amperes at 12 volts.
- Integrated PWM controlled, current reversing switch rated at 300MA, 12 volts. This switch operates at about 80% of full forward or full reverse, or at a PWM signal value of 1.100ms or less for reverse current, and 1.900ms or greater for forward current.
- 500ms "Latching" of last PWM signal before "timing out" insures that the motor controller will deactivate ½ second after a radio or microcontroller failure. This provides a margin of safety for radio controlled operation and minimizes the serial controller workload by reducing the required signal refresh rate by a factor of 25X.

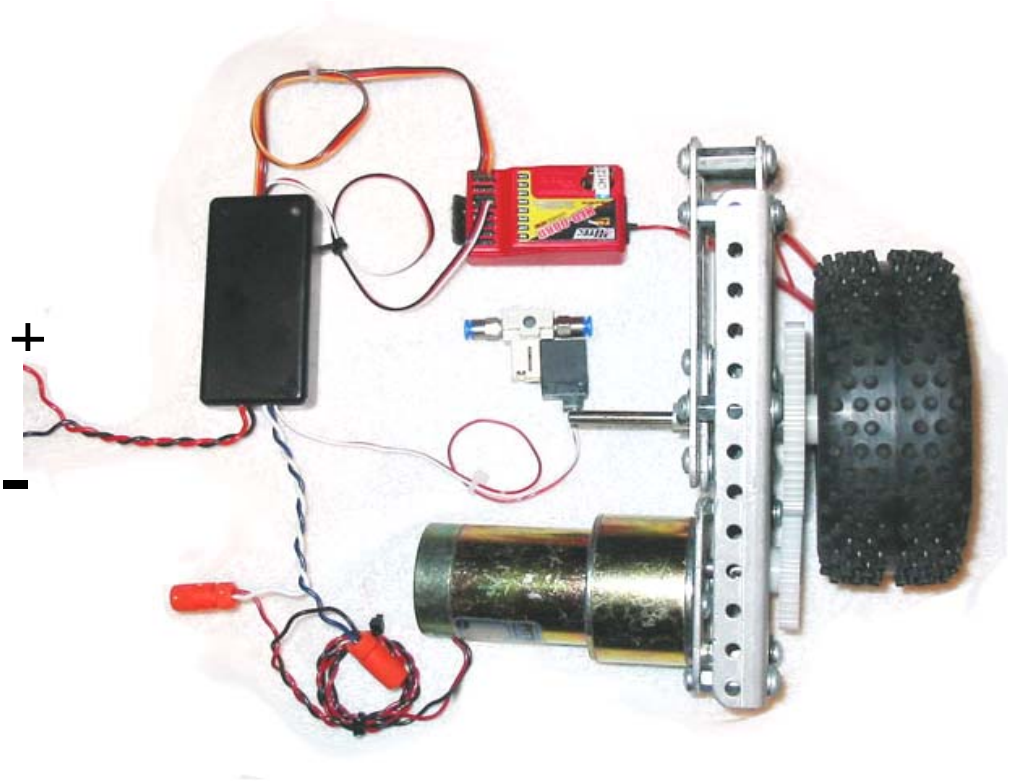
Safety Protocols

The GEARS II or III Combination Controllers are programmed with a built in safety protocol and will not become operational until they detect a neutral (~1.520ms) signal from either an RC radio or a microcontroller. This is done to minimize the chances that a robot or other GEARS projects, will inadvertently move at start up.

The radio or microcontroller must initialize the speed controller by sending a neutral (stop) signal, thus ensuring that the mechanism begins operation in a stopped position. Moreover, the GEARS II or III Combination Controller will default to "Dead End" condition if a PWM signal is not detected after a period of more than 500ms. In this case the LED indicator will blink red and the unit will have to be restarted by cycling the power off and on (rebooting the unit). This "Dead End" condition ensures that the speed control unit becomes inoperative in the event of radio failure or failure of the microcontroller circuit.

LED Indicator

The LED glows red during power-up. If a PWM signal is detected on channel 1 (motor control) the LED signifies this with one green blink. If a PWM signal is detected on channel 2 (valve control), the LED signals this with two quick green blinks. If both channels are active then the LED will give one slow green blink, followed by two quick green blinks. After the signal is detected, the led glows red until the unit is initialized with a neutral signal on the motor control channel. The neutral signal (~1.520ms) should be repeated several times to ensure the Speed Controller recognizes it. Once the neutral signal is recognized the controller becomes operational and the led will go dark. When the motor control is operated the led will show green for forward and red for reverse. The intensity of the led indicates the motor speed—dim for slow and bright for fast.



Note: If the motor control channel is not activated or used, then a neutral signal is not required for operation of the 300mA PWM, Current Reversing switch. If neither channel is active the GEARS II or III Combination Controller will dead end into a deactivated state and the led will continuously blink red. The power must be cycled to restart the unit once it is in the deactivated state.

The picture above illustrates how to connect the GEARS II or III Combination Controller to the RC receiver, Gear Head Motor, Pneumatic Solenoid Valve and the Battery (Not Shown).

Programming with the GEARS II OR III Combination Speed Controller (Channel 1)
If you've already programmed GEARS robots with the original speed controllers, you will find the that the new GEARS III Combination Controller will behave similarly. Programs written for the original controllers should work with the new GEARS II OR III Combination Controllers. Below is a, sample code to get your GEARS II or III Combination Controllers up and running easily and quickly.

Understanding the Basics
The GEARS II or III Combination Controllers are used to run motors and pneumatic solenoid valves using Pulse Width Modulation, PWM for short. PWM signals are a series of short +5v pulses separated by 20ms pauses. The length of each pulse can range from 1 to 2 ms (Milliseconds or 1/1000 of a second).

A pulse width of 1 ms sent to the speed controller will drive a motor full speed in reverse, a pulse width of approximately 1.5ms will stop the motor, and a pulse width of 2 ms will drive a motor full speed forward. *(This of course also depends on the polarity of the motor connections. If the motor does not rotate in the expected direction, then simply reverse the order of the blue/white controller and black/red motor leads. This will cause the motors to rotate in the opposite direction.)*

The pulse widths can be varied within the range of 1-2 ms to directly vary the speed and direction of the motor. The Basic Stamp microcontroller can be easily programmed to generate PWM signals using the PULSOUT command.

The PULSOUT Command
PULSOUT values represent units of 2µs (Millionths of a second) each, thus a PULSOUT value of 1 = 2 µs or 2 millionths of a second. A PULSOUT value of 500 is therefore equal to 1000 µs, (1000 millionths of a second) or 1 ms, (Microsecond) and a PULSOUT value of 1000 equals 2 ms.

Basic Stamp microcontroller is programmed using the P-Basic programming language. The P-Basic command: PULSOUT 14, 500 would make a GEARS II or III Combination Speed Controller connected to pin 14 drive a motor at high speed in reverse. Likewise, the command: PULSOUT 14,750 would slow the motor to a near stop.

The full reverse, neutral and full forward PULSOUT values for the GEARS II or III Combination Controllers are 560, 760, and 960, respectively.

Programming with the GEARS II or III Combination Solenoid Valve Controller (Channel 2)
To control the GEARS II or III Combination Solenoid Valve Controller, the controller uses a 760 off or neutral value and 960 or 460 PULSOUT value to toggle the current direction of the solenoid valve controller.

Using a Sample Program
The GEARS II or III Combination Controllers has several safety features that help to prevent a robot from starting at full speed and that cause the robot to shut down in the event that a control signal is lost. The latter feature helps to prevent "Run Away Robots"

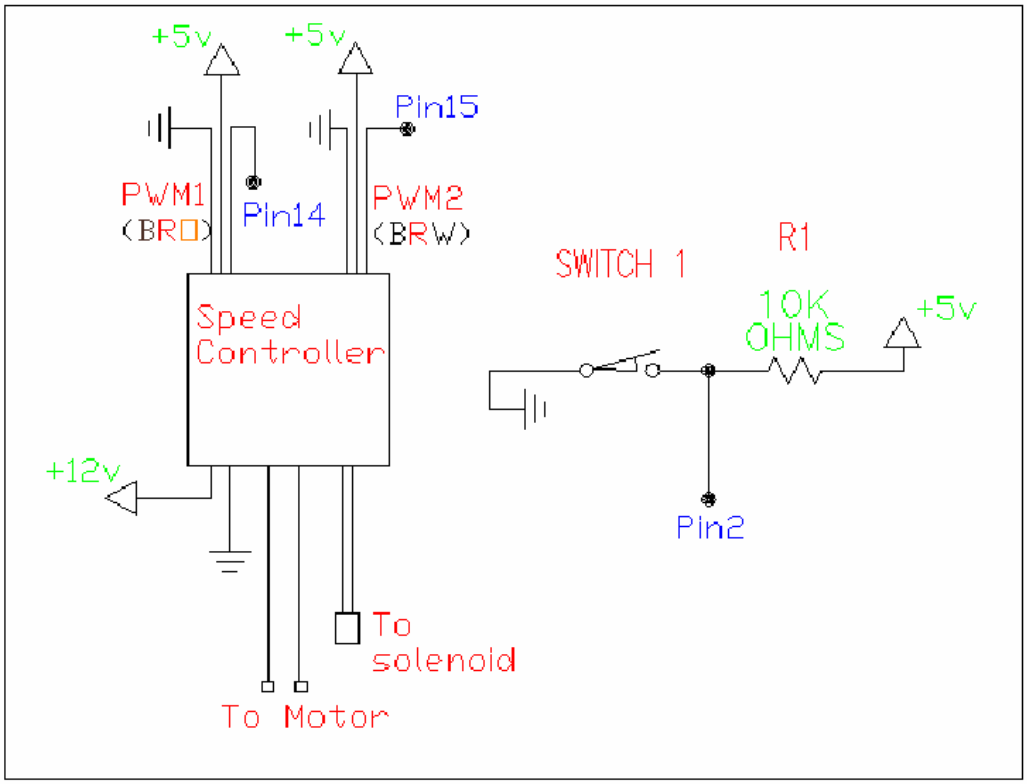
If the motor control channel is used it is necessary for the unit to be “initialized” after power up. This means you have to send a neutral PWM value (A PULSOUT value of 760) on the motor control channel for a certain amount of time before they will drive the motors. This prevents the robot from moving inadvertently at start up. If the motor control channel is not used then this initialization step is not required and the controller will operate a pneumatic cylinder with the valve control feature without need for initialization.

The initialization requirement prevents accidents with both radio controlled and microprocessor controlled mechanisms; GEARS II or III Combination Controllers have been specifically designed so they will not operate a motor powered device until the radio control joystick has been centered or until a microprocessor has given the controller a neutral signal.

GEARS II or III Combination Controllers also prevent accidents in the event of a loose wire or an interrupted signal. The controllers will automatically turn off if they do not receive a signal after 500ms (half a second) . This is not a problem using radio control since the radio systems refresh the signals every 20ms. However, programmers must be conscious of the program run times: Program loops cannot exceed 500ms (½ second) without sending at least one PWM signal to both the speed control and to the valve control of the GEARS II OR III Combination Controller. This should not be a problem given the operating speeds of the current generation of micro controllers or Basic Stamps.

Sample Program

Still not making sense? No problem! Let’s try an example program to see how this works. For this program, wire up an integrated speed/valve controller and a bump switch as pictured in the diagram below.



What the Program Does
The program must initialize the GEARS II or III Combination Controller after giving it time to complete the start up sequence. The initialization sequence causes the GEARS II or III Combination Controller to recognize which functions are being used (speed control and/or valve control) and sets them both to a neutral position. The program must then execute the command sequences contained in the program loop while continuing to refresh the signals sent to both the speed and valve control every 500ms or less.

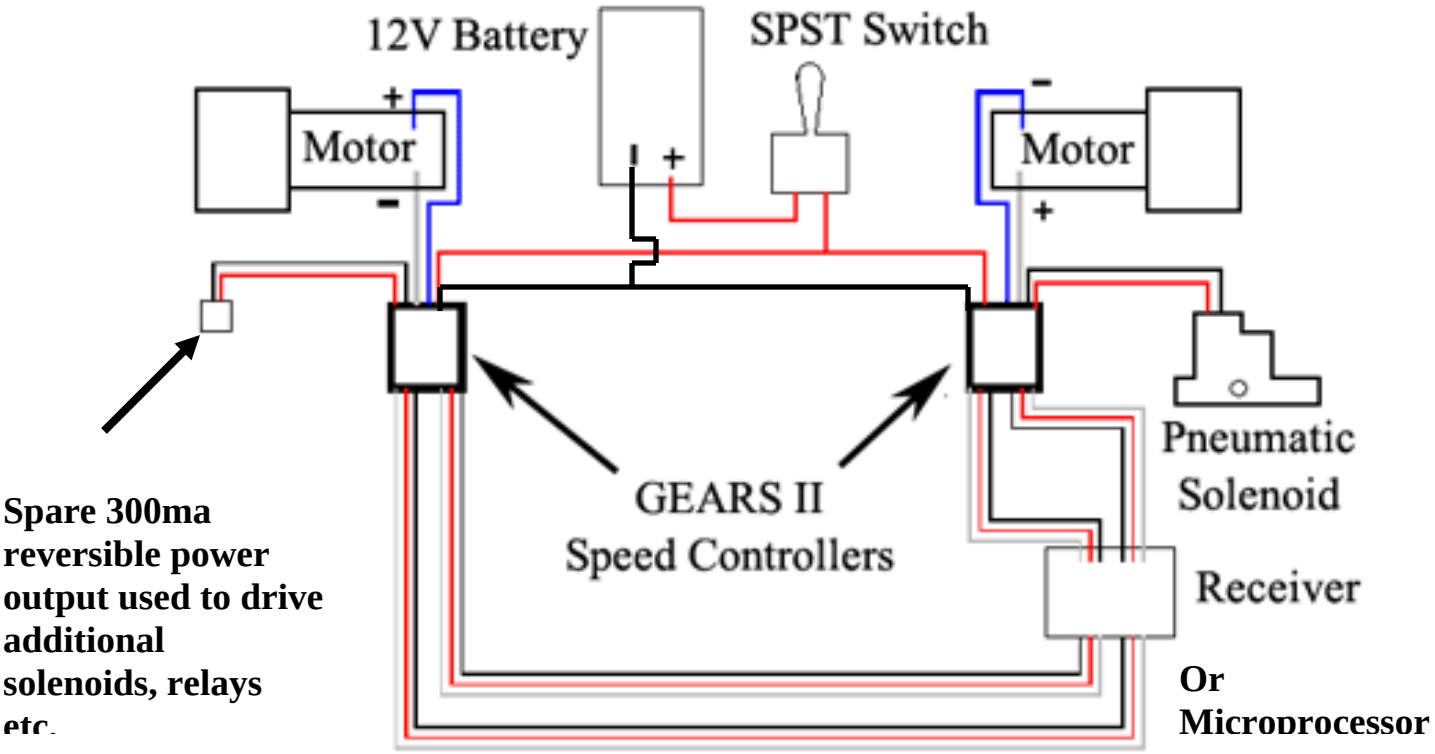
Study the Program Example
Since the motor control feature is used, the sample program starts with an initialization routine, labeled "Init." Next, the program enters the main program loop and begins to drive the motor. The program is a continuous loop; during this loop the motor accelerates to top speed and decelerates back to zero, then starts again. Each time through the loop, the program directs the Basic Stamp microprocessor to send a PWM signal to both the motor controller and the valve controller. This way, both the speed controller signal and valve controller signal are refreshed and neither will cause a "time out" and force the system to reset or to "dead end".

If the bump switch is depressed, the valve controller operates the solenoid. When the bump switch is released the program reverts to sending the valve controller a PWM value of 1520ms or a PULSOUT value of 760.

Build and program your own electro-pneumatic system. Download the demonstration program from the GEARS Educational Systems website. Open it and download it to your Basic Stamp using the Basic Stamp editor. Once you have the program working correctly, it will be easy to experiment with changes by modifying the values and noting how the mechanisms behave. The program is written below and can be found on the GEARS web site at this address:
http://www.gearseds.com/files/GEARSII_DOC_TUTORIAL.zip

```
'{$STAMP BS2}
'{$PBASIC 2.5}
'
'Title: GEARS II Integrated Speed Controller Tutorial
'Author: Rob Block
'Date Created: 7/29/05
'
'------------------Variables and Constants------------------'
DLAY CON 20
MOTOR_1 CON 14
PISTON_1 CON 15

X VAR Word
'----------------------Initialization----------------------'

Init:                   'This Init: routine initializes both speed controller
                        'and solenoid channels.
PAUSE 100
```

```
FOR x = 1 TO 100        'The controller first looks for a string of pulses from each
PULSOUT MOTOR_1,760              'input and recognizes which channels need to be active

PULSOUT PISTON_1,760             ' Use mid or neutral values for these pulses(760).
PAUSE 20
NEXT
PAUSE 100

FOR x = 1 TO 100                 'Next, the controller needs to see a string of neutral
                                 ‘pulses for
 PULSOUT MOTOR_1, 760            'each input. This insures that the mechanism is in a
                                 ‘stop mode.
PULSOUT PISTON_1, 760            'This FOR NEXT loop should run 2 seconds (100
                                 ‘cycles * 20ms)
PAUSE 20                         ‘Less time might work, so experiment.
NEXT


'MAKE SURE YOU SEND A PWM TO EACH CHANNEL EVERY 500ms or sooner! It's
best to
'update the valve whenever you update the speed control.

'----------------------Main Program-----------------------'
Main:
  FOR X = 760 TO 960             'This loop will repeat 200 times. from rest,
  PULSOUT MOTOR_1,X              'MOTOR_1 will increment speed each time
  IF IN2 = 0 THEN                'until it reaches the maximum value of 960
  PULSOUT PISTON_1,960
  ELSE                           'if the switch is pressed, the solenoid fires,
     PULSOUT PISTON_1,760        'if not, the solenoid receives a neutral value
  ENDIF                          'of 760
  PAUSE 20
  NEXT

  FOR X = 960 TO 760             'same as above, except this time the motor
  PULSOUT MOTOR_1,X              'will decelerate from full speed to stop
  IF IN2 = 0 THEN
  PULSOUT PISTON_1,960
  ELSE
  PULSOUT PISTON_1,760
  ENDIF
 PAUSE 20
  NEXT

  GOTO Main
```

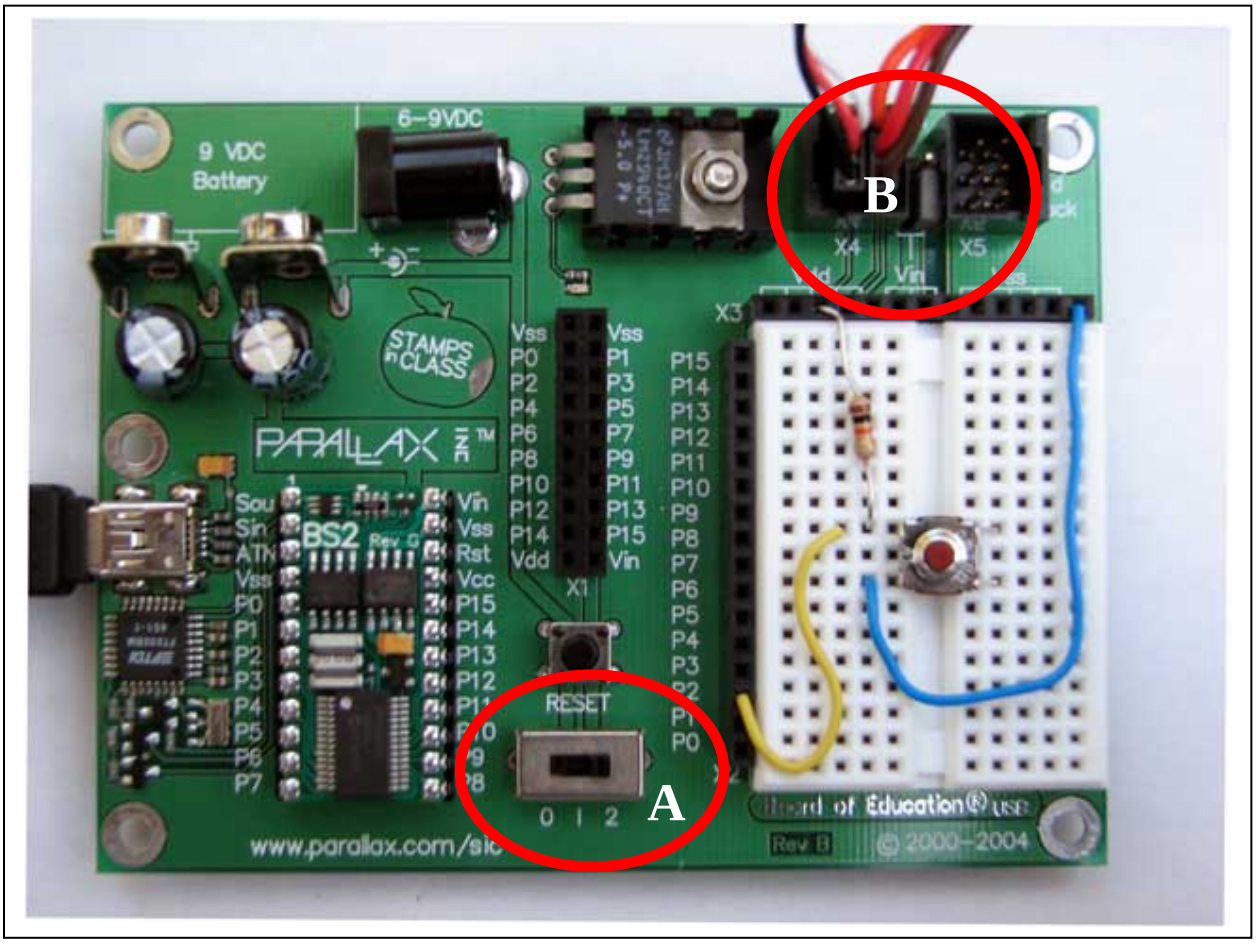


Using the GEARS II or III Speed Controllers with the Parallax Rev A, B and C Boards of Education

The photograph on the following page illustrates the wiring, jumper and switch position used with the Parallax BOE boards and the sample code provided above. These settings apply to the REV A, B and C boards.

NOTE: Pay particular attention to the settings of the Vin jumper and the position of the BOE 3 position switch. It is important to remember that while you can power the BOE using the GEARS-II Speed Controllers, you should never use them in combination with any other power source such as a power supply or 9 volt battery attached to the BOE.

Note: The wiring colors of the PWM cables used on the GEARSII or III Speed Controllers changes from time to time. The color combinations most often used are red, white and black and/or Orange, Brown and Red. Always remember that the dark colors, brown and black are equivalent and the light colors orange and white are equivalent . Red is always red.



This is the wiring that allows the example code to operate the two channels of a GEARS II or III Speed Controller. The circuit on the breadboard is the same circuit shown in the schematic on page 4.

Be certain that the 3 position switch (A) is on the Number #2 position.

Be certain that the jumper (B) is in the Vin position as shown in the picture above.

NEVER USE A POWER SUPPLY OR BATTERY IN COMBINATION WITH THE GEARS MOTOR CONTROLLERS. Doing that will damage both the Basic Stamp Module and the GEARS Controller!

If you are uncertain of how to move the jumper (B) consult the documentation that came with your Parallax products.

Understanding Your GEARS III Combination Controller

Power-up Sequence & LED Indicators

1. There are two LED indicators on the 3rd generation GEARS controller. The STATUS LED is on the control end of the unit and the MOTOR LED is on the motor/power end of the unit. The STATUS LED indicator initially glows red when power is applied, and the MOTOR LED remains dark until the motor receives power from the controller. The MOTOR LED indicates the motor direction by color, and relative speed by brightness.

2. The GEARS controller dynamically determines which control channels (2) are active during power-up. Since the controller searches for PWM signals for about a second before it gives up, it is always wise to turn on your transmitter or microcontroller first then power up your project. If a PWM signal is detected on the motor control channel, the STATUS LED signals this with one green blink. If a PWM signal is detected on the pneumatic-valve control channel (the current-reversing switch), the STATUS LED will signal this with two green blinks. If both control channels are active then the STATUS LED will give one green blink, followed by two green blinks.

3. If the motor control channel is active, the GEARS controller will wait for an initialization signal before it becomes operational *(For an explanation of the initialization signal see item 4).* The initialization requirement is for SAFETY—it prevents the motor from unexpectedly turning on if the motor control stick or knob on your transmitter is inadvertently moved during power-up.

Note: If the motor control channel is not activated or used, then initialization is not required for operation of the current-reversing switch. If neither channel is used, the controller will dead-end into a deactivated state and the STATUS LED will continuously blink red. The power must be cycled (turned off then turned on) to restart the unit once it is in the deactivated state.

4. After the active control channels are detected, the STATUS LED will glow red until the unit is initialized with a neutral signal (~1.520ms PWM signal) on the motor control channel. Center your control stick or knob, and your trim if you have one. Sometimes the neutral signal is not exactly in the center of the control but slightly to one side. Slowly adjust your knob or trim to locate the neutral signal. Once the neutral signal is recognized, the GEARS controller will become operational and the STATUS LED will go dark. If your project is controlled by a BASIC Stamp or other microcontroller, the neutral signal should be repeated several times to ensure the GEARS controller recognizes it and becomes operational.

5. When the motor control is operated, the MOTOR LED will show green for forward and red for reverse. The intensity of the MOTOR LED is a rough indicator of motor speed—dim when slow, brighter for faster.

6. When the pneumatic-valve control is operated, the STATUS LED will show green for normal polarity and red for reversed polarity.

7. To protect the controller from over-current damage, the 3rd generation GEARS controller is programmed to deactivate when the motor pulls approximately 12 to 13 amps. If this occurs the unit will deactivate until a neutral signal (~1.520ms PWM signal) on the motor control channel is given. This will be indicated by the STATUS LED showing constant red. Once the neutral signal is given, the STATUS LED will go dark and the unit will again be operational.

8. The GEARS controllers are programmed to "Time out" or default to an inactive state in the event of a loss of signal lasting more than 500 milliseconds (1/2 second). This safety feature cannot be disabled and exists to prevent "Runaway" conditions due to loss of radio signal or microprocessor control.

Initialization Override

Note: Performing this operation negates the built in safety features of the GEARS II or III controllers. Any damages that result from overriding the initialization are not warranted and are the responsibility of the person using the controller.

Note: The GEARS controller is equipped with a two pin jumper on the circuit board. Removing this jumper **disables the initialization sequence.** It is important to understand that disconnecting this jumper means that approximately 1 second after power up, both controller channels will be active and will respond **TO ANY SPEED AND DIRECTIONAL SIGNAL** they detect. **Removing this jumper negates the programmed null signal safety feature of the GEARS controller. Deactivation of the initialization feature is available to help to simplify microprocessor control of the GEARS 2 channel controller and should only be employed by persons who thoroughly understand the purpose and consequences associated with removing the jumpe**r. The 500 millisecond "Time out" feature will remain in effect regardless of the position of the 2 pin jumper.

Note: It is not necessary to remove the jumper from the circuit board. In order to prevent loosing the jumper, simply remove it from one of the two connector pins and allow it to remain fixed to the remaining pin.