Sensor

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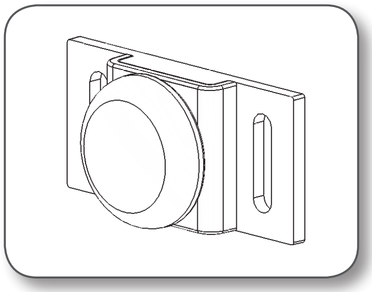
Introduction to the Sensor Subsystem

A robot is more than just a radio-controlled vehicle with extra parts. Both a radio-controlled car and a robot can move around using onboard power and motors, and both can be controlled via radio waves. The robot, however, has two critical capabilities that the simple R/C car does not. The robot can sense its environment, and the robot can adjust its own behaviors based on that knowledge.

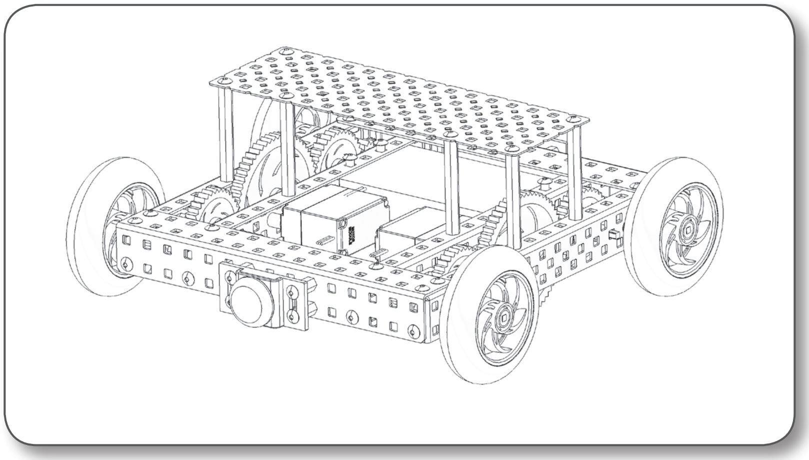
Sensors are the beginning of that process. A sensor will generally tell the robot about one very simple thing in the environment, and the robot's program will interpret that information to determine how it should react.



The Bumper Switch sensor, for instance, will tell the robot whether it is in contact with a physical object or not. Depending on how the sensor is set up, this can tell the robot a lot of different things. If the sensor is mounted on the front bumper, the robot could use this information to tell whether it has run into an obstacle, like a wall inside a maze.

By making good use of sensors to detect the important aspects of its environment, a robot can make things much easier for its human operator. A robot can even operate completely independent of human control, autonomously.

There are a myriad of sensor options available to you in the VEX Robotics Design System. Some of these include ultrasonic range finders and light sensors. For a full list of all sensors available, please visit **www.VEXrobotics.com** for more information.



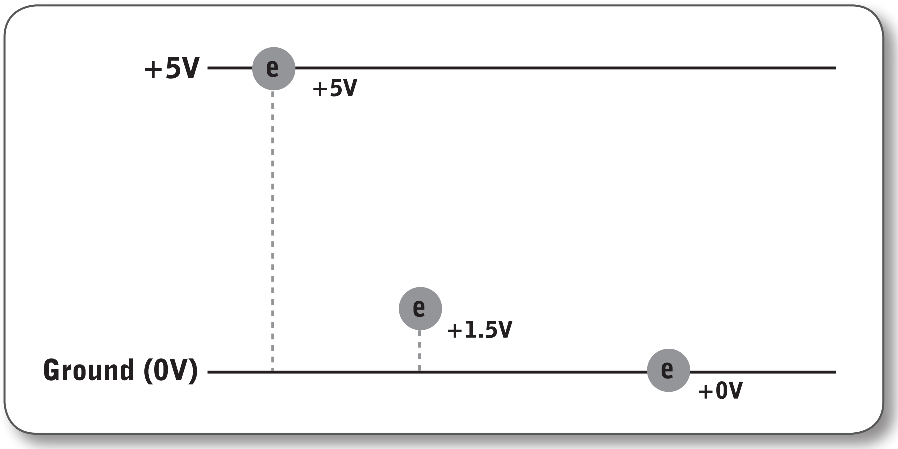
05/08

Concepts to Understand

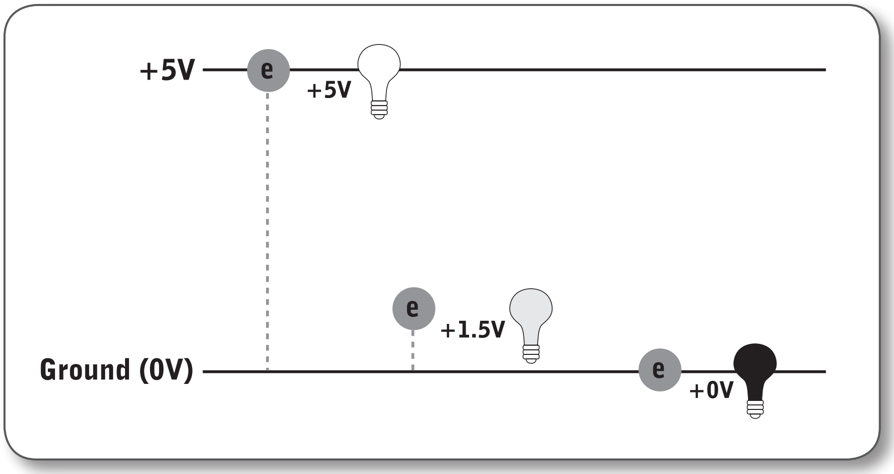
Analog vs. Digital

Among sensors, there are two main electrical "languages" spoken: Analog and Digital.

Analog sensors communicate with the Microcontroller by sending it an electrical voltage along a wire. By measuring where the sent voltage falls between zero and maximum voltage, the Microcontroller can interpret the voltage as a numeric value for processing. Analog sensors can therefore detect and communicate any value in a range of numbers.



A light sensor, for instance, can communicate how bright a light is by sending a zero voltage for total darkness, sending maximum voltage for a very bright light, or sending an in-between voltage for any other amount of light, depending on exactly how bright it is.

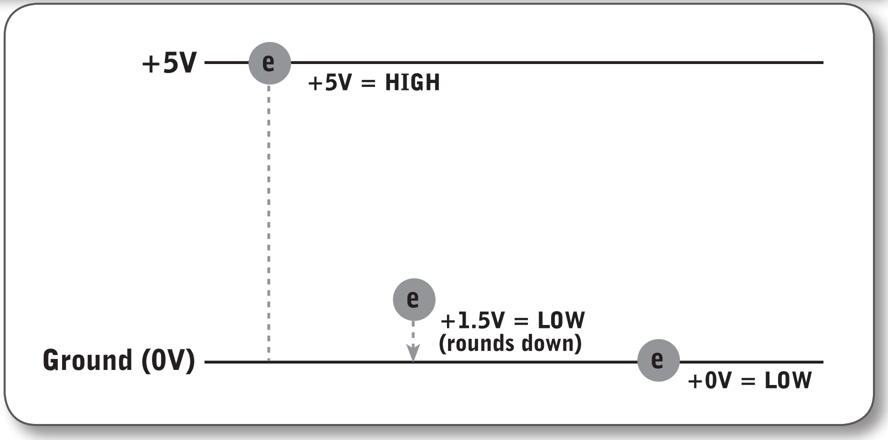


Example:
Analog = Shades of Gray and Black and White
Digital = Black or White

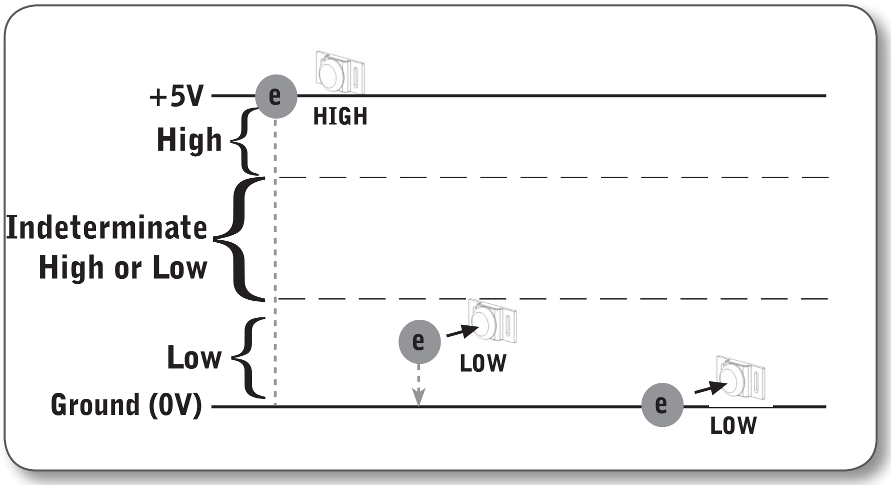
Concepts to Understand, continued

Analog vs. Digital, continued

A weakness of analog sensors is that it is very difficult to send and maintain an exact, specific voltage on a wire in a live circuit. Digital sensors, on the other hand, can send signals very reliably, even in electrically "noisy" conditions. However, they do so by sacrificing the ability to indicate the entire range of values. Digital signals can only have one of two values: either HIGH or LOW.



A digital sensor sends a voltage, just like an analog sensor, but instead of sending a voltage between zero and maximum, it will send only zero OR maximum. If the Microcontroller detects a voltage that is above a guaranteed Low or below a guaranteed High the results cannot be determined, it can be reported as a High or Low.

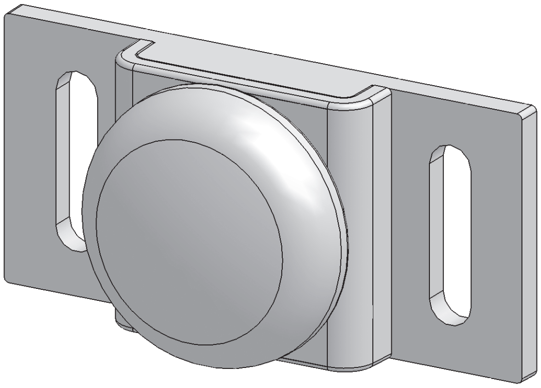


It may seem like a terrible loss to only be able to indicate two values rather than a whole range, but in many situations, this is preferable. For instance, the Bumper Switch Sensor is a digital sensor. Since the purpose of the sensor is to detect whether something is pushing the bumper in or not, two values are all it needs to do its job.

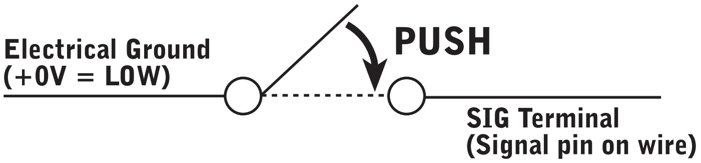
Concepts to Understand, continued

Bumper Switch Sensor

Bumper Switch Sensor
Signal: Digital
Description: The bumper sensor is a physical switch. It tells the robot whether the bumper on the front of the sensor is being pushed in or not.



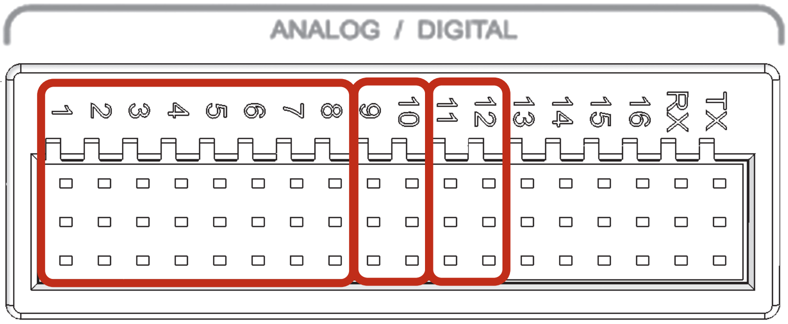
Technical Info:
Type: SPST switch ("Single Pole, Single Throw") configured for Normally Open behavior.
Signal Behavior: When the switch is not being pushed in, the sensor maintains a digital HIGH signal on its sensor port. This High signal is coming from the Microcontroller. When an external force (like a collision or being pressed up against a wall) pushes the switch in, it changes its signal to a digital LOW until the switch is released. An unpressed switch is indistinguishable from an open port.



Signal pin is HIGH when switch is open
Pushing switch brings the signal pin voltage to LOW

Note: You can connect multiple switches to the same port using a y-cable.

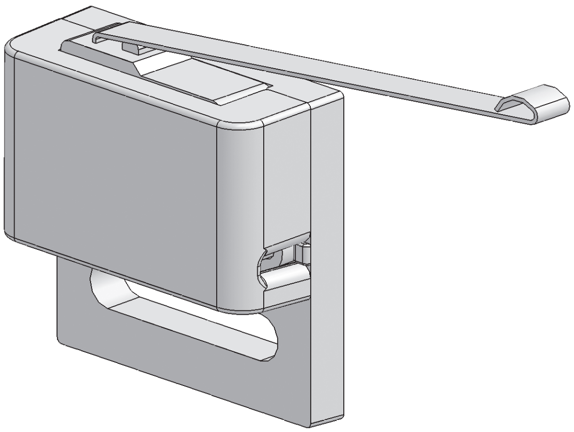
Microcontroller Default Code Behavior Info:
Usable Ports: Analog/Digital 1-8 (Limit Switch Behavior), 9-10 (Tag Behavior), 11-12 (Autonomous Behavior)
For more info, see Programmed Behaviors later in this section.



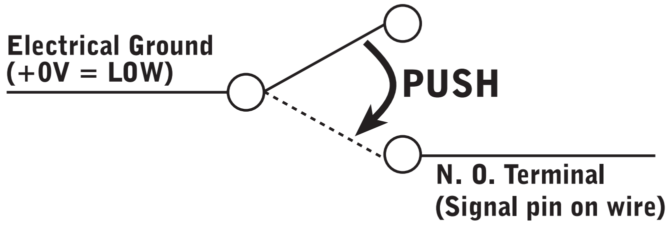
Concepts to Understand, continued

Limit Switch Sensor

Limit Switch Sensor
Signal: Digital
Description: The limit switch sensor is a physical switch. It can tell the robot whether the sensor's metal arm is being pushed down or not.



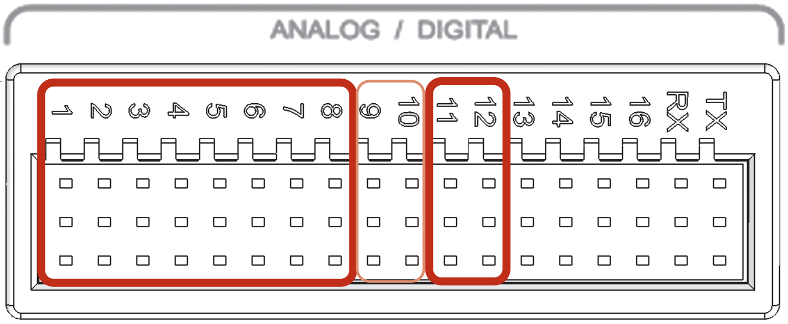
Technical Info:
Type: SPDT microswitch, configured for SPST Normally Open behavior.
Behavior: When the limit switch is not being pushed in, the sensor maintains a digital HIGH signal on its sensor port. This High signal is coming from the Microcontroller. When an external force (like a collision or being pressed up against a wall) pushes the switch in, it changes its signal to a digital LOW until the limit switch is released. An unpressed switch is indistinguishable from an open port.



Pushing switch brings the signal pin voltage to LOW

Note: You can connect multiple switches to the same port using a y-cable.

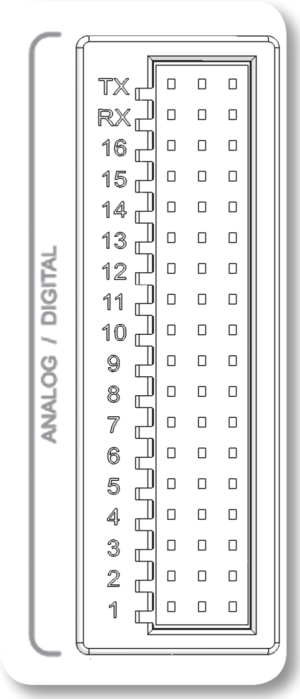
Microcontroller Default Code Behavior Info:
Usable Ports: Analog/Digital 1-8 (Limit Switch Behavior), 9-10 (not recommended), 11-12 (Autonomous Behavior)
For more info, see Programmed Behaviors later in this section.



Concepts to Understand, continued

Default Code Sensors—Programmed Behaviors

Normally sensors connect to the Analog/Digital port bank on the VEX Microcontroller. Some sensors must use an Interrupt Port on the Microcontroller. Different behaviors of the Default Code will be activated depending on which port you plug the sensors into. The following behaviors are activated when Bumper Switch or Limit Switch Sensors are plugged into the indicated ports. More detailed information about each behavior can be found on the next few pages.



Jumper Ports

Port	Function
Analog/Digital Port 13	Enables Autonomous Mode

Sensor Ports

Port	Category	Behavior
Analog/Digital Port 12	Autonomous Mode Collision Detection Ports	Back up and turn left
Analog/Digital Port 11		Back up and turn right
Analog/Digital Port 10	Collision Emergency Stop Ports	Stop for 2 seconds
Analog/Digital Port 9		Stop for 2 seconds
Analog/Digital Port 8	Limit Switch Behavior	Motor 7 ignores CW
Analog/Digital Port 7		Motor 7 ignores CCW
Analog/Digital Port 6		Motor 6 ignores CW
Analog/Digital Port 5		Motor 6 ignores CCW
Analog/Digital Port 4		Motor 5 ignores CW
Analog/Digital Port 3		Motor 5 ignores CCW
Analog/Digital Port 2		Motor 4 ignores CW
Analog/Digital Port 1		Motor 4 ignores CCW

CW = Clockwise
CCW = Counter Clockwise

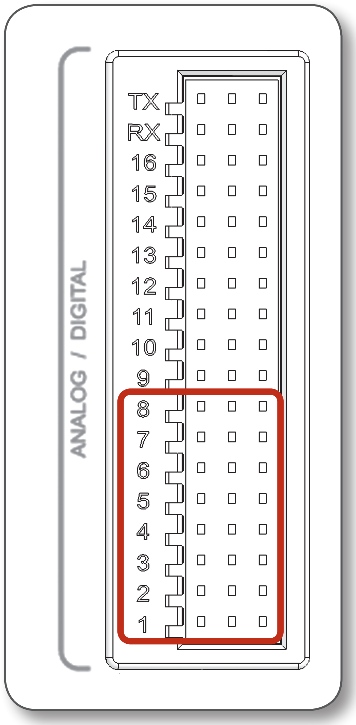
Other Ports
Ports 14-16, RX, TX, and Interrupt Ports are not used by the Default Code.

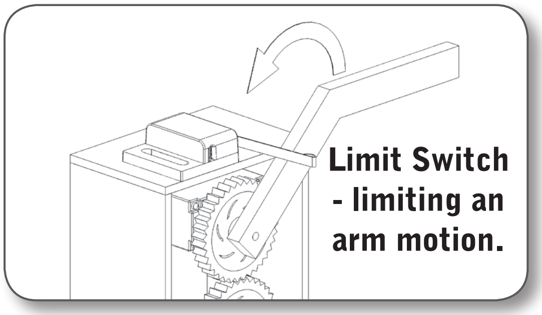
Note:
These behaviors are included in the VEX Microcontroller Default Code. Custom code can be created for new behaviors.

Concepts to Understand, continued

Default Code Sensors—Programmed Behaviors

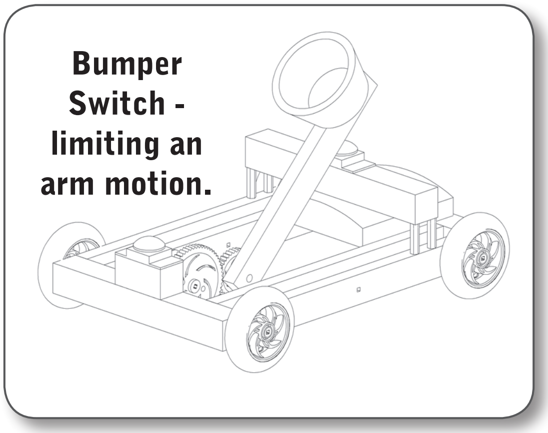
Limit Switch Primary Behavior: Mechanical Limit Switch (Ports 1-8)
Bumper Switch Secondary Behavior: High Durability Limit Switch (Ports 1-8)





Limit Switch - limiting an arm motion.

Bumper Switch - limiting an arm motion.



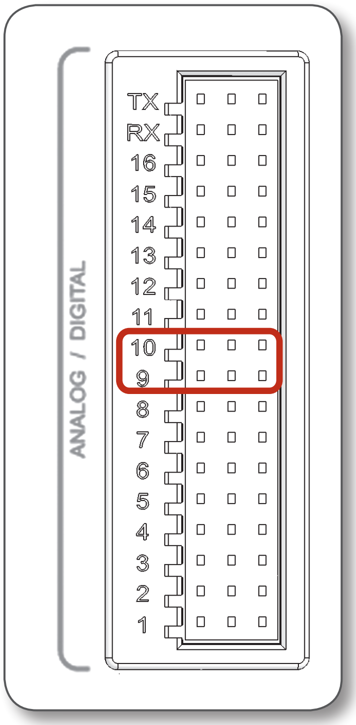
Mechanical/High Durability Limit Switch

- Plug the Bumper or Limit Switch Sensor into a port from 1 to 8 to use this behavior. You may use more than one port if desired (but only one sensor per port). each port controls a different behavior.
- When pressed, a switch on ports 1-8 will limit the motion of one of the motor ports in one direction only:
  - Analog/Digital Port 1 pressed: Motor port 4 will ignore commands to run Counterclockwise
  - Analog/Digital Port 2 pressed: Motor port 4 will ignore commands to run Clockwise
  - Analog/Digital Port 3 pressed: Motor port 5 will ignore commands to run Counterclockwise
  - Analog/Digital Port 4 pressed: Motor port 5 will ignore commands to run Clockwise
  - Analog/Digital Port 5 pressed: Motor port 6 will ignore commands to run Counterclockwise
  - Analog/Digital Port 6 pressed: Motor port 6 will ignore commands to run Clockwise
  - Analog/Digital Port 7 pressed: Motor port 7 will ignore commands to run Counterclockwise
  - Analog/Digital Port 8 pressed: Motor port 7 will ignore commands to run Clockwise
- This behavior is used to limit the motion of a motor in order to make sure that it does not turn too far (for instance, a gripper claw does not attempt to open too wide). The sensor is placed at the outer limit of desired movement, so that any attempt to move farther will trigger the sensor.
- Use a Bumper Switch for this behavior only if a standard limit switch sensor will not work (for example, because the expected impact is too strong for the limit switch). A normal limit switch is better than the bumper switch in most situations because the bumper switch is less precise (due to the bumper's more rugged construction).
- Suggested use: Motion-limiting switch for custom attachments and other moving parts.

Concepts to Understand, continued

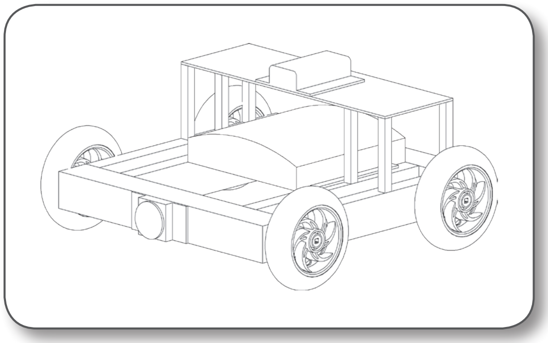
Default Code Sensors—Programmed Behaviors

Bumper Switch Primary Behavior: Tag/Emergency Stop Sensor (Ports 9-10)



Tag/Emergency Stop Sensor

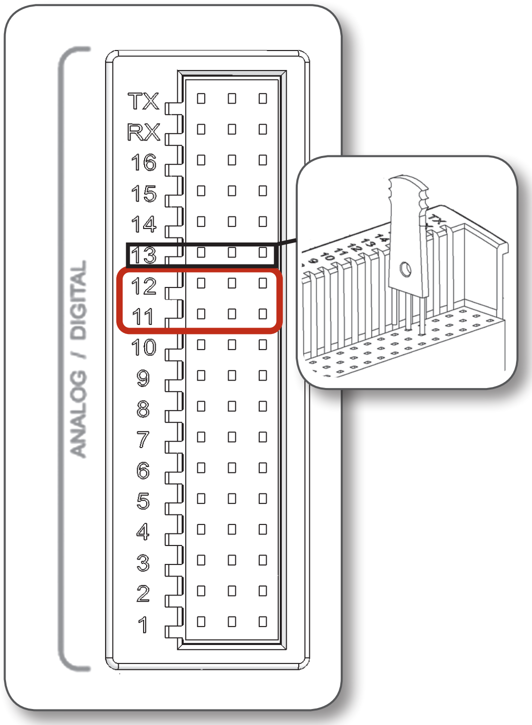
- Plug the Bumper Switch Sensor into Port 9 or 10 to use this behavior. You may use both ports if desired (one sensor per port, they do the same thing).
- When the bumper sensor on one of these ports is pressed, the robot will come to a halt and operator control will be disabled for 2 seconds. To create a visual indicator that the bumper was triggered and the motor ports were disabled, attach a motor or servomotor to Motor Port 6. This motor will oscillate back and forth for 2 seconds when the bumper is hit.
- When control is returned, the sensor has no effect for another 2-3 seconds in order to allow the operator to move away from the hazard or the other robot.
- This behavior is not recommended for use with the Limit Switch Sensor due to durability considerations.
- Suggested uses: Collision detection.



Concepts to Understand, continued

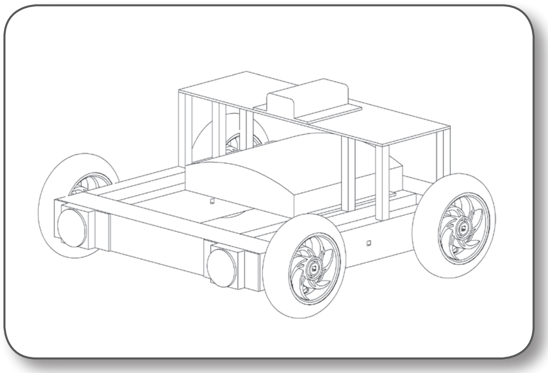
Default Code Sensors—Programmed Behaviors

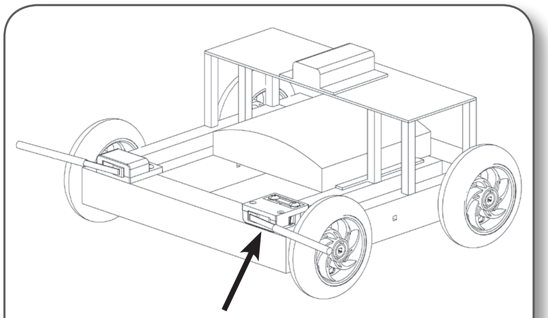
Autonomous Behavior: Autonomous Mode Obstacle Detector (Ports 11-12 + Jumper 13)



Autonomous Mode Obstacle Detector

- You must enable Autonomous Mode in order for these ports to work. Place a Jumper Clip in Analog/Digital Port 13 to enable Autonomous Mode operation.
- The robot should be set up in a 2-motor configuration for autonomous mode operation. The left motor should be plugged into Motor Port 3, and the right motor should be plugged into Motor Port 2. Both motors should use a single gear reduction between the motor and each wheel to insure wheels spin in the correct direction.
- Plug Bumper or Limit Switch Sensors into Ports 11 and 12 to use this behavior. You should use both ports (one sensor per port), because they perform different functions, both of which are needed for correct performance.
- If using Limit Switches, do not place them directly on the front of the robot, or you risk damage to the sensors. Attach semi-flexible "antenna" pieces to the limit switches to hang out in front of the robot and act as "feelers" that can trigger the sensitive limit switch without letting anything hit the switch itself. The picture in the bottom left shows the sensors with straws used as antenna pieces.
- The robot will drive straight forward without human control when in Autonomous Mode. When the bumper switch on input port 11 is pushed in, the robot will interpret this as an indication that it has run into an immovable obstacle on the left side, and will turn to the right until the switch is no longer pushed in. The bumper switch on input port 12 does the same thing, but monitors the right side and makes the robot turn left when it is pushed.
- Suggested use: Autonomous Mode Obstacle Detector





In order to mount the left limit switch, position it upside down using spacers to support the area where the screws are applied.

Subsystem Interactions

How does the Sensor Subsystem interact with...

...the Structure Subsystem?

- The Structure Subsystem provides a mounting and stabilization platform for sensors on the robot. Often, sensors need to be held in a specific position to function properly, and the Structural Subsystem must be designed to accommodate these needs.

...the Motion Subsystem?

- Robots often have motors and other Motion components controlled by sensors (for instance, the emergency stop function stops the motors when the bumper switch sensor is pushed). However, the Sensor Subsystem does not directly control the Motion Subsystem. Instead, the Sensors provide information to the Microcontroller, which takes that information into account, and then decides what command to send to the Motion Subsystem. The decision is made from the Default or User Code stored in the Microcontroller.

...the Power Subsystem?

- Sensors, like all electronic components, require power in order to function. VEX sensors draw power indirectly from the Power Subsystem through the Microcontroller (Logic Subsystem). There are exceptions like the Bumper and Limit Switches. They do not draw power from the Microcontroller and only drive a Ground or Low Signal.

...the Control Subsystem?

- The Control and Sensor Subsystems compliment each other to achieve better control of the robot. The Control Subsystem provides human control over the robot, but the human operator does not always have perfect control, or the perfect point of view to see the robot's position. The Sensor Subsystem gives the robot the ability to make its own informed decisions, and can be a substantial aid to the human operator.

... the Logic Subsystem?

- The Logic Subsystem relies on feedback from the Sensor Subsystem to provide information about the robot's environment. It uses this data to make informed decisions about how the robot should behave.
- The actual behavior that is activated when a sensor is triggered depends on which port the sensor is plugged into on the Microcontroller and the Code being executed.

User Sensor Notes