

VACCEL

Accel & Tilt Sensor For VEX robotic system

Keep your robot level or measure it's acceleration.

What is an acceleration sensor ?

Acceleration is a change in speed. When you push the gas pedal of a car, and the car speeds up, this is acceleration. The Dual Acceleration/Tilt Sensor (Accel) measures acceleration by it's effect on a small mass. The sensing mass is also affected by gravity. Because of this, the sensor can be used to measure gravity, and thereby measure tilt.

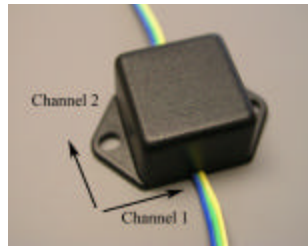
Measuring gravity (tilt).

Gravity is constant, and points straight down. Since the Accel sensor can measure gravity, you can use it as a tilt sensor. The sensor is most sensitive to tilt when it is mounted so the sensing channels are perpendicular to gravity. (the sensor is flat to the ground) In this position the vector component of gravity applied to the sensor is zero, and the VEX value is around 500. The value will increase or decrease depending on the direction of tilt.

Using only one channel

If you are using only one channel, you must use channel 1. This is identified by a white dot on the black three pin connector. The sensor gets power through this connector and not the other one.

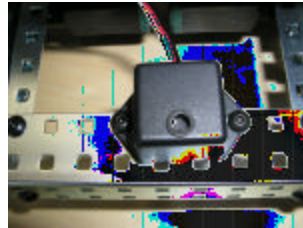
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Direction of measurement.

The axis of measurement (sensitive direction) is shown in the picture above. The axis are perpendicular to each other, and parallel to the bottom of the sensor.

Mounting the sensor



Use 8-32 screws to mount sensor

Measuring acceleration.

Most robots move at a constant speed. This means there is a burst of acceleration when the robot starts to move, and then no acceleration while the robot continues to move at a constant speed. To measure the true acceleration, you would need a very fast sample rate, faster than the VEX is capable. The Accel sensor makes the job easier by integrating (averaging) the instantaneous acceleration over time. The sensor has a bandwidth of approximately 50 Hz. This means your program needs to

sample the sensor output at least 100 times per second to get a reasonable picture of rapidly changing acceleration. This is most important in building an inertial navigation system. Note: Accurate inertial guidance requires fast and highly accurate acceleration measurements. This sensor and the VEX do not have the speed or accuracy needed for good inertial guidance.

Connecting to Vex



Use analog sensor ports 1-4

Programming

The Accel & Tilt Sensor is programmed like a light sensor. Use the "Light Sensor" block in EasyC to generate the statement `YourVariable = GetAnalogInput (1)`

This reads the sensor on port 1 and loads the value into the variable named YourVariable. The sensor value is an integer with range 0-1023. (This is actually reading the 10 bit A/D converter in the VEX computer.)

Specifications

- Size 1.05 x 1.05 x 0.8 inches
Mounting ears extend 0.35 inches on each side..
- Two cables with 3-pin connectors for VEX
- Range: +/- 1.1 g. (gravity)
- Bandwidth: 50 Hz.

Technical Description

The sensor element is a micromachined polysilicon structure suspended over a silicon wafer by polysilicon springs. The structure forms a differential capacitor with the wafer below. Acceleration causes movement of the suspended structure relative to the wafer, and thus a change in capacitance. The capacitance is measured and converted to an output to the VEX.

Testing the sensor

Connect the sensor to any of ports 1 and 2 on the VEX computer analog/digital connector. Connect the VEX computer to your personal computer using the serial port cable. Start the "Intelitek EasyC for VEX" program. Click on the "Build and Download" menu and select "Terminal Window". Select the "Online" tab. (You may need to download the online code) Turn on the VEX computer. It should now display all the port values. You may want to connect a touch sensor to make sure the program is working. Rotate the ACCEL sensor. You should see the values change in the windows for sensor 1 and 2.

Sensor Output Values

The Accel sensor must be programmed as a light sensor. With zero acceleration, it has a VEX light sensor value around 500. With one "g" (one gravity) of acceleration in the forward direction, the output will be around 900. One "g" in the reverse direction will give an output around 100. The sensor response is linear between +1g and -1g.

www.techno-stuff.com

Calibrating the sensor

Connect the sensor to the VEX computer and use the “online” tab on the “Terminal Window” to view the sensor outputs. See “Testing the sensor” on the other side of this page.

Place the sensor on a horizontal surface and record the sensor output for both channel 1 and channel 2. These values should be around 500. This corresponds to zero acceleration or zero gravity because gravity is perpendicular to the sensing directions. A scientist would say the vector component along the sensing axis is zero.

Slowly rotate the sensor around one horizontal axis. Record the maximum and minimum values you see. Repeat for the other horizontal axis. You should see maximums around 900 and minimums around 100. These correspond to plus and minus one gravity (1g) which is an acceleration of 9.8 meters per second squared.

Use the formula below to convert the sensor output to acceleration in terms of gravity. Use then numbers you just recorded for A, B, and C.

A = sensor value at zero acceleration (around 500)

B = Sensor value for + 1g acceleration (The maximum you measured)

C = Sensor value for -1g acceleration. (The minimum you measured)

y = The sensor value you want to convert into acceleration.

z = The acceleration that created the sensor value y.

$$z = 2(y - A) / (B - C)$$

If you want the value in meters per second squared, multiply “z” by 9.8

Here is an example calculation.

Suppose you do the calibration process above and find

A = 550, B = 920, C = 110.

You run an experiment and find the sensor output (y) is 730.

What is the acceleration in terms of gravity?

Use the formula above with your numbers.

$$z = 2 (730 - 550) / (920 - 110)$$

$$z = 0.44 \text{ g.}$$

If you get a negative number it just means the acceleration is in the opposite direction.

If you want to convert this to MKS units, multiply by 9.8.

$$z = 0.44 * 9.8$$

$$z = 4.3 \text{ meters per second squared.}$$

Error factors

Motor and gear movement causes a VEX robot to vibrate. This is acceleration that is recorded by the sensor and may appear to be noise in the data. You can reduce the problem by mounting the sensor on foam rubber. Often you will need to remove the vibration component by averaging many sensor readings. This method is shown on the web page ???.

Small movement does not mean small acceleration. Small movement may be caused by large acceleration for a short time. When a robot goes over a bump on the ground there is usually a large vertical acceleration for a short time.

Robots do not always stay level. You may think you are measuring acceleration in the horizontal plane, but when your robot goes up a hill the sensor will also read a component of gravity.

Example

An example of using this sensor can be found at www.techno-stuff.com/VAccel Demo.htm. In this example you will make your robot go up a hill and stop at the top. The sensor measures tilt to determine when the robot is going uphill and when it reaches the top. The example web page also includes downloadable Easy C code and program listing, and a .pdf version of this user's guide.