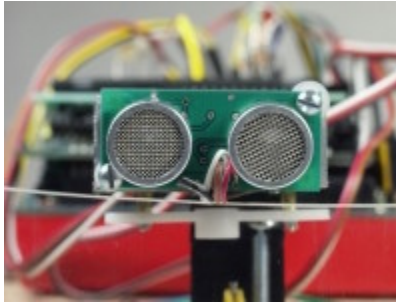# Sonar Made Simple

Overview

With the Devantech SRF04 sonar range finder sensor and the IntelliBrain™ robotics controller, you can enable your robot to see its surroundings through a set of sonar "eyes".

Theory of Operation

A sonar range finder works by generating a short burst of sound – a "ping" – then listening for the echo of the sound when it bounces off the nearest object, as shown in Figure 1.
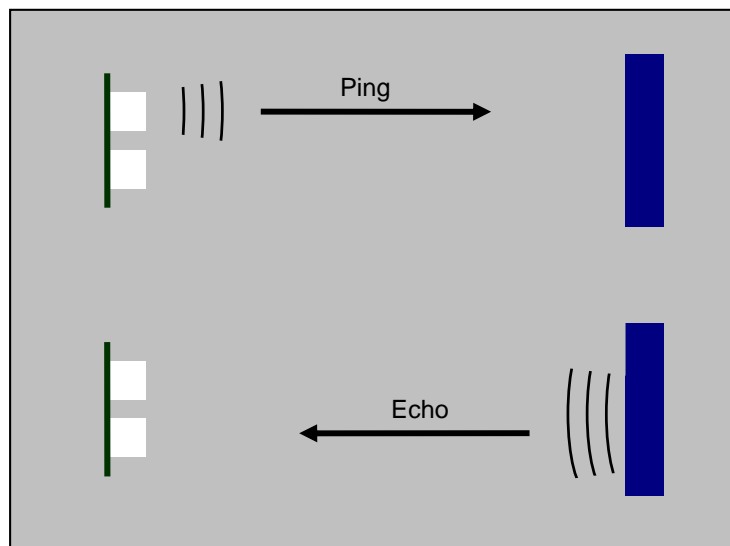

Figure 1 - Sonar Ping and Echo

By accurately measuring the time from the start of the ping until the echo returns back to the sensor, the distance to the nearest object can be easily calculated. Sound travels at 1116.4 feet/second (340.29 meters/second) at sea level. The distance to the nearest object can be calculated by dividing the elapsed time

(time between issuing the sound and hearing the echo) by twice the speed of sound, as follows:

```
distance = elapsedTime / (2 * SPEED_OF_SOUND);
```

The reason for dividing by <u>twice</u> the speed of sound is that the distance to the object is only half the distance the sound wave actually travels. The sound wave must travel to the object and back to the sensor in order for the sensor to hear the echo.

Sensor Operation

The Devantech SRF04 sonar range finder is operated by generating a pulse on its trigger input signal. This causes the range finder to issue a ping. The range finder enables its receiver 100 microseconds after the ping and raises the sensor's echo output signal. (The delay in enabling the receiver prevents the receiver from hearing the transmission of the ping.) When the receiver hears the echo it drops the output signal. The elapsed time in microseconds between the ping and the echo can be determined by measuring the pulse duration on the echo line and adding 100 microseconds, as follows:

```
elapsedTime = pulseDuration + 100;
```
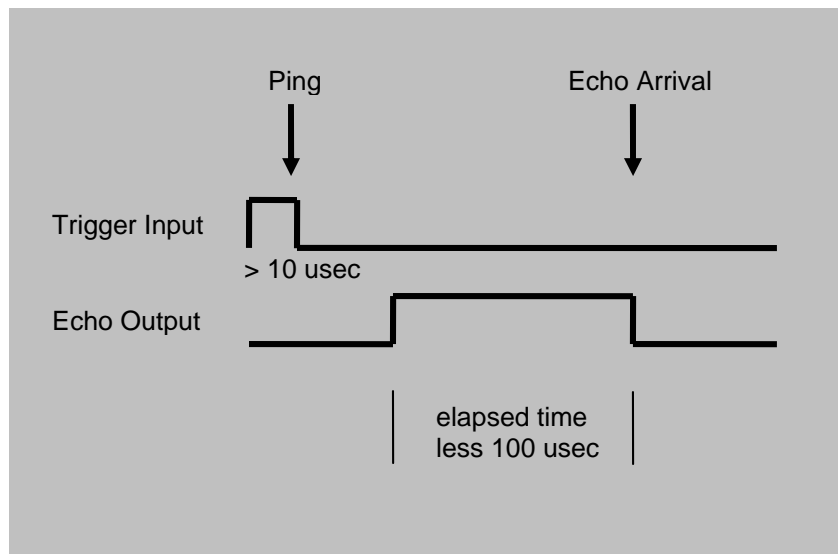

Figure 2 - Devantech SRF04 Signals

Sensor Connections

You must construct a cable to connect the Devantech SRF04 to the IntelliBrain robotics controller. The cable requires four wires (26 AWG stranded wire recommended): power (red), ground (black), trigger input (green) and echo output (white). Solder the wires to the SRF04 sensor, as shown in Figure 3. You will need to attach two connectors to the IntelliBrain end of the cable, as shown in Figure 4. The connector parts and tools you will need are listed in Table 1.
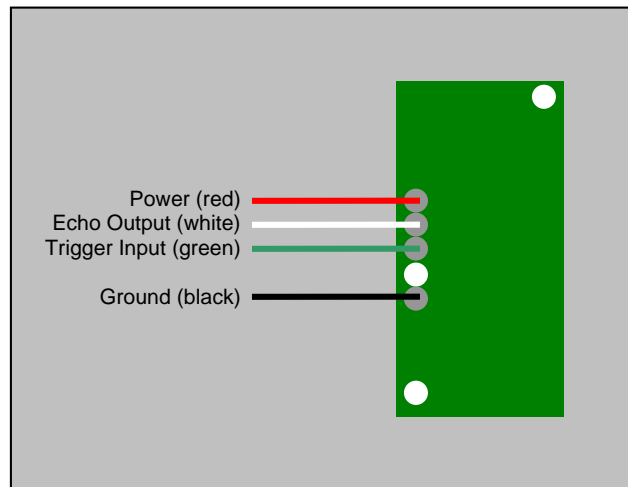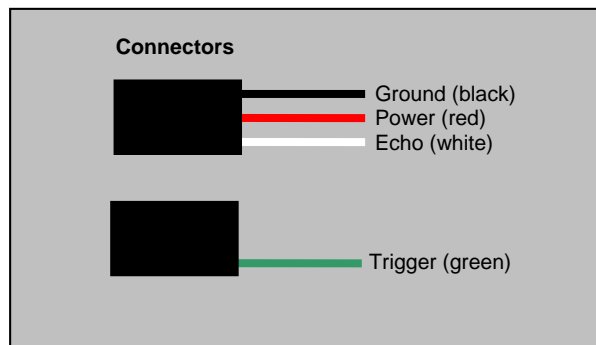

Figure 3 - Devantech SRF04 Connections

Figure 4 - Range Sensor Connector

Table 1 - Connector Parts and Tools

Part	Molex Part Number	Digi-Key Part Number
Crimp Terminals	16-02-1109	WM2555-ND
3 Circuit Housing	50-57-9003	WM2801-ND
Universal Crimp Tool	63811-1000	WM9999-ND
Insertion Tool	11-02-0022	WM9911-ND
Wire Cutter & Stripper		

Attach the trigger signal connector to digital I/O port 1 on the IntelliBrain as indicated in Figure 5. Attach the echo signal connector to digital I/O port 4. (Note: You may connect the SRF04 to other digital I/O ports; but, the example program uses ports 1 and 4).
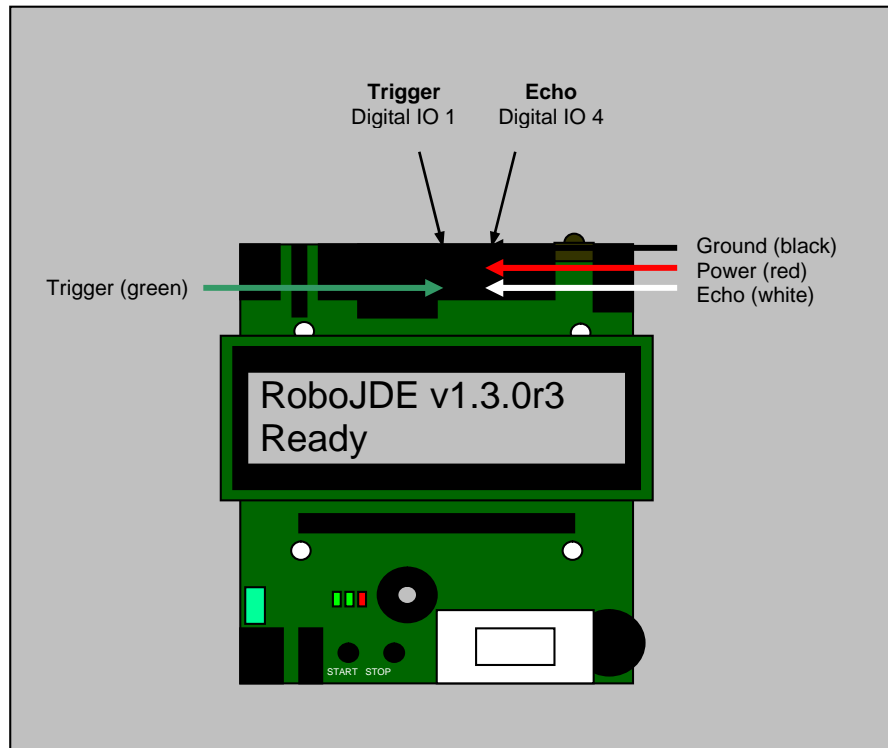
Figure 5 – Connections to the IntelliBrain Controller

Interfacing to the Sonar Sensor in Software

The `DevantechSRF04` class in the RoboJDE class library supports the SRF04 sonar sensor. Conveniently, this class makes it very easy to use the sensor by doing the necessary pulse measurement and calculations to find the distance to the nearest object. Interfacing with the sensor only requires the following steps:

1. Configure the trigger port as an output.
2. Construct a `DevantechSRF04` object.
3. Call the `ping()` method.
4. Wait while the sound travels to an object and back.
5. Call the `getDistanceInches()` or `getDistanceCm()` method to read the distance.

Configuring the Trigger Port

The digital I/O ports on the IntelliBrain are configured as input ports by default. Since the SRF04 trigger is an output from the IntelliBrain, the following Java statements are needed to configure the trigger port as an output.

```
IntelliBrainDigitalIO trigger = IntelliBrain.getDigitalIO(1);
trigger.setDirection(true);
```

Constructing the Range Finder Object

The DevantechSRF04 range finder object in the RoboJDE class library requires references to the two ports it uses to interface to the sensor. The following statement constructs the range finder object passing it references to the trigger port and the echo port (digital I/O 4).

```
RangeFinder rangeFinder = new DevantechSRF04(trigger,
                              IntelliBrain.getDigitalIO(4));
```

Taking a Reading

The following statements are all that is required to take a distance reading from the sensor.

```
rangeFinder.ping();
Thread.sleep(40);
float distance = rangeFinder.getDistanceInches();
```

The call to the `ping()` method instructs the range finder to issue a ping. The next statement puts the current thread to sleep for 40 milliseconds, giving the sound burst time to travel from the sensor to the nearest object and back to the sensor. When the thread wakes up, the call to `getDistanceInches()` reads the distance measured by the sensor in inches. This method will return -1 in the event the sensor did not sense an echo signal. The sensor will not sense the echo if it is too far to the nearest object or if the sensor wiring is incorrect.

The maximum measurable distance by the Devantech SRF04 is a little bit less than 20 feet. The minimum measurable distance is about 3 inches.

Example Application

RoboJDE includes a small example application that continually takes sonar readings using the Devantech SRF04 and displays the measurement on the IntelliBrain controller's LCD screen.

Conclusion

With the IntelliBrain robotics controller and the RoboJDE Java-enabled robotics software development environment, adding a Devantech SRF04 sonar range finder to your robot is a simple and inexpensive way to enable your robot to "see" its surroundings through sonar "eyes."