Basic Express
Application Note

Using an Ultrasonic Rangefinder with BasicX

Introduction

The Polaroid ultrasonic rangefinder can measure distances ranging from 405 mm to 10.7 m (1.33 feet to 35 feet). Absolute accuracy is typically ±1 % of the reading over the entire range. The Polaroid 6500 Series Sonar Ranging Module operates by transmitting an acoustic ping and detecting the resulting echo. The ping consists of 16 pulses at a frequency of 49.4 kHz.

A microprocessor can easily be used to measure the time delay between the ping and echo. By knowing the speed of sound, which for air at room temperature is about 344 m/s (1129 ft/s), the range in meters can be found by multiplying the echo delay (in seconds) by 344/2, or 172.0.

Hardware interface

Figure 1 (below) illustrates the hardware interface between a rangefinder and BasicX system:

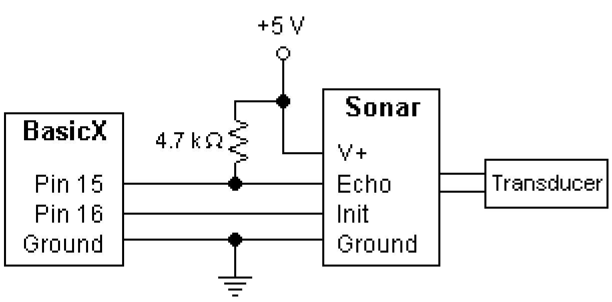

Figure 1

The Echo line on the rangefinder is an open collector transistor output, which means it needs a 4.7 kΩ pull-up resistor between the line and V+.

The rangefinder requires about 100 mA when it's quiescent. During acoustic transmission, current requirements peak at about 2 A for short periods. This means you may need a separate 5 V power supply. However, it may be possible to power the processor and rangefinder from a common source if you add a 100 µF, 16 V decoupling capacitor to the rangefinder.

The transducer is a combination speaker/microphone. During transmission of the acoustic pulse, the transducer is driven at a peak voltage of 400 V. After transmission, the transducer acts as a microphone, during which time a DC bias of 200 V is maintained on the transducer.

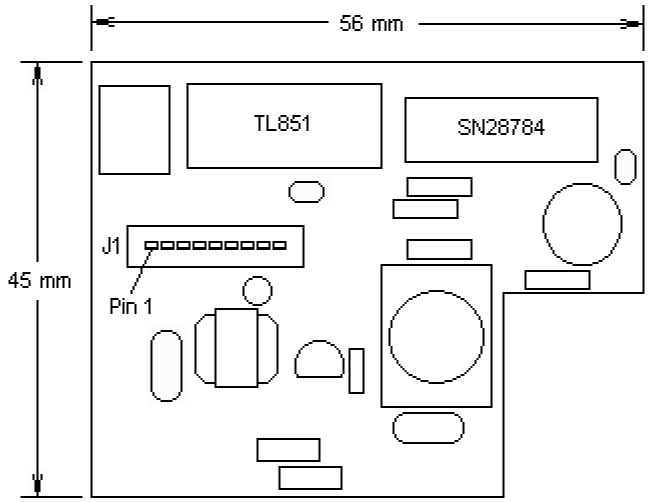

Figure 2

Figure 2 (at left) shows the layout of a 6500 Ranging Module. Pin numbering for J1 is as follows:

Pin	Function
1	GND
2	BLNK
3	
4	INIT
5	
6	OSC
7	ECHO
8	BINH
9	V+

Software interface

To operate the rangefinder, the processor raises the Init line to trigger an acoustic pulse. Afterwards, the processor measures the time delay until the rangefinder detects an echo and raises the Echo line.

The first step is to configure both I/O lines. We'll use pin 15 for the Echo input, and pin 16 for the Init output. The Echo pin is set to input-tristate, and the Init pin is set to output-low:

```
Const EchoPin As Byte = 15
Const InitPin As Byte = 16

' Configure I/O pins.
Call PutPin(EchoPin, bxInputTristate)
Call PutPin(InitPin, bxOutputLow)
```

Now we trigger an acoustic ping by raising the Init line:

```
Call PutPin(InitPin, bxOutputHigh)
```

At this point we need to measure the time interval until the rangefinder raises the Echo pin. Procedure RCtime is used for this purpose:

```
Dim EchoDelay As Single

' Measure how long the pin stays at logic low (0).
Call RCtime(EchoPin, 0, EchoDelay)
```

RCtime has a resolution of about 1.085 µs, which translates to a distance resolution of 0.187 mm for air at room temperature. That resolution is typically much better than the accuracy of the device as a whole.

The next step is to get ready for the next cycle by lowering the Init pin:

```
Call PutPin(InitPin, bxOutputLow)
```

The last step is to convert time to distance. Here we need to know the speed of sound, which is about 344 m/s for air at room temperature:

```
Dim Range As Single
Const SpeedOfSound As Single = 344.0 ' m/s
Range = (EchoDelay / 2.0) * SpeedOfSound
```

You can refer to the last section if you need more details on finding the speed of sound as a function of temperature and type of gas.

Example code

An example program is provided as a separate file called SonarExample.bas.

Advanced capabilities

The 6500 module is actually capable of detecting objects as close as 152 mm (6 inches), and is also capable of detecting multiple echoes from a single ping. More I/O lines are needed for these capabilities. Refer to Polaroid documentation for details.

Speed of sound

How can we predict the speed of sound in air?

For an ideal gas, it turns out that the speed of sound is a function of temperature *only*. The behavior of air is very close to that of an ideal gas unless the temperature or pressure is very high or very low compared to standard sea level conditions.

In other words, air can usually be treated as an ideal gas for which the speed of sound is a function of temperature only. The speed of sound c for an ideal gas is

$$c = \sqrt{\gamma R T}$$

where

c = Speed of sound, m/s
γ = Ratio of specific heats. For dry air γ = 1.4 (nondimensional)
R = Gas constant. For dry air, R = 286.9 N·m/(kg·K)
T = Absolute temperature (Kelvin), where 0°C = 273.16 K

For example, the speed of sound at room temperature (22°C, 71.6°F) is

$$c = \sqrt{1.4\,(22 + 273.16)\,(286.9)} = 344 \text{ m/s}$$

The speed of sound also depends on the type of gas. Suppose we want to operate a sonar rangefinder on Mars? How do we determine the speed of sound there?

The atmosphere on Mars is about 95.3 % carbon dioxide. For CO_2, the ratio of specific heats γ = 1.29, and the gas constant R = 188.9 N·m/(kg·K). Assuming a pure CO_2 atmosphere, the speed of sound at room temperature -- which on Mars is a hot day -- is as follows:

$$c = \sqrt{1.29\ (295.16)\ (188.9)} = 268 \text{ m/s}$$

Notice that neither pressure nor density appear in this equation. Even though surface pressure on Mars is only a tiny fraction of that on Earth, the low pressure has essentially no effect on the speed of sound.

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