“ECHO” -
Ultrasonic Distance Sensor
PWM Output
This "ECHO" Ultrasonic Distance Sensor from Rhydolabz is an amazing product that provides very short (2CM) to long-range (4M) detection and ranging. The sensor provides precise, stable non-contact distance measurements from 2cm to 4 meters with very high accuracy. Its compact size, higher range and easy usability make it a handy sensor for distance measurement and mapping. The board can easily be interfaced to microcontrollers where the triggering and measurement can be done using one I/O pin. The sensor transmits an ultrasonic wave and produces an output pulse that corresponds to the time required for the burst echo to return to the sensor. By measuring the echo pulse width, the distance to target can easily be calculated.

### ECHO SENSOR FEATURES

- Professional EMI/RFI Complaint PCB Layout Design for Noise Reduction
- Range : 2 cm to 4 m
- Accurate and Stable range data
- Data loss in Error zone eliminated
- Modulation at 40 KHz
- Mounting holes provided on the circuit board
- Triggered externally by supplying a pulse to the signal pin
- 5V DC Supply voltage
- Current - < 20mA
- Bidirectional TTL pulse interface on a single I/O pin can communicate with 5 V TTL or 3.3V CMOS microcontrollers
- Echo pulse: positive TTL pulse, 87 µs minimum to 30 ms maximum(PWM)
- On Board Burst LED Indicator shows measurement in progress
- 3-pin header makes it easy to connect using a servo extension cable, no soldering required
**PIN DEFINITION**

<table>
<thead>
<tr>
<th>PIN</th>
<th>PIN NAME</th>
<th>DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC</td>
<td>Power Supply</td>
<td>Power Supply Input (+5V)</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td>Ground Level of Power supply</td>
</tr>
<tr>
<td>SIGNAL</td>
<td>Signal I/O</td>
<td>This pin reads the trigger pulse from the host microcontroller and returns the pulse based on the</td>
</tr>
</tbody>
</table>

**COMMUNICATION PROTOCOL**

- **Trigger pulse** 10uS Minimum
- **Echo pulse** - 100uS to 25mS
  
  Times out after 30mS if no object detected

Under control of a host microcontroller (trigger pulse), the ECHO sensor emits a short 40 kHz (ultrasonic) wave. This burst travels through the air, hits an object and then bounces back to the sensor. The ECHO sensor provides an output pulse to the host (through its signal pin) when the echo is detected; hence the distance to the target can be measured from the width of this pulse.
<table>
<thead>
<tr>
<th>Host Device</th>
<th>Input Trigger Pulse</th>
<th>$t_{OUT}$</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECHO Sensor</td>
<td>Echo Holdoff</td>
<td>$t_{HOLDOFF}$</td>
<td>700 µs (700 µs)</td>
</tr>
<tr>
<td></td>
<td>Burst Frequency</td>
<td>$t_{BURST}$</td>
<td>200 µs @ 40KHz</td>
</tr>
<tr>
<td></td>
<td>Echo Return Pulse Minimum</td>
<td>$t_{IN-MIN}$</td>
<td>87 µs</td>
</tr>
<tr>
<td></td>
<td>Echo Return Pulse Maximum</td>
<td>$t_{IN-MAX}$</td>
<td>30 ms</td>
</tr>
<tr>
<td></td>
<td>Delay before next measurement</td>
<td></td>
<td>32 ms</td>
</tr>
</tbody>
</table>

**INTERFACING THE ‘ECHO’ SENSOR**

- Interfacing the ECHO Sensor with PIC 16F877 microcontroller

![Diagram of PIC 16F877A and ECHO sensor connection](image-url)
Finding the Distance

The figure above depicts the interfacing of an ECHO sensor to PIC16F877A.

As per the figure, the signal I/O pin of the ECHO sensor is to be connected to RB2 (Pin<35>) of the HOST controller. Pin RB2 of your host controller has to be configured to both input and output accordingly to the function. It is your host controller that has to trigger the functioning of an ECHO sensor. At this time the pin RB2 of the host controller has to be configured as output so that it can give (o/p) a trigger signal to the sensor. The trigger pulse should be of range 10µsec - 100µsec, typical value is 10µsec.

After triggering the sensor, pin RB2 has to be configured as input so that your host controller switches to the receiving mode. Any pin configured as input should be provided with either pull-up or pull-down voltages so that it isn’t affected by small static field variations. But here no external pull-ups or pull-downs are required since, the signal I/O pin of the ECHO sensor which is to be connected to pin RB2 has been provided with pull-down on-board.

In the receiving mode, the host controller has to wait for the Low to High transition in the SIG pin. When a transition is detected, the host controller should start counting the time. The host controller can use a timer or any other programming logic to calculate the time. The counting should terminate when the next High to Low transition is detected. The time gap between transitions will vary (PWM) with respect to the distance to the target. The obtained value (pulse-width) in µSeconds represents the echo time and further calibrations of this data gives you the obstacle distance. ie, the echo time in micro-seconds divided by 58 (at 30° C) gives you the obstacle distance in centimeters and the same divided by 148 (at 30° C) gives the distance in inches. i.e Echo time in µsec /58 = distance in cm and Echo time in µsec /148= distance in inches. The calculated distance can be either displayed in an LCD or transmitted to your PC.

Calculations to be performed by your host microcontroller

- Speed of ultrasonic wave is 347 m/s equivalent to 0.0347cm/µsec (Temperature dependent). Timer count multiplied with 200nsec (0.2µsec), internal clock period gives the echo time (say, Et).
- As per the eqn: Speed = distance/time => echo distance (Ed) = echo speed(Ev) * echo time(Et)  ie, distance (Ed) = 0.0347cm per µsec (Ev) * Et µsec
- The obtained distance will be twice the actual distance since it gives the to and fro distance of the object as per the to and fro time equated to the equation: (ie, Et stands for 2Et).
Thus the obtained distance divided by 2 gives actual distance of the obstacle. ie, Actual distance = \( Ed/2 \)

As per the above illustration your equation is,

\[ Ed = Ev \times (Et/2) \implies Et = 2 \times Ed / Ev \text{ equivalent to } Et = (2/0.0347) \times Ed \]

Implies \( Et = 58 \times Ed \) equivalent to \( Ed \text{ (in cm)} = Et \text{ (in µsec)} / 58 \)

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**DIMENSIONS (mm)**

![Dimensions Diagram](image)

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**PRACTICAL CONSIDERATION FOR USE**

- **Object Positioning**

The ECHO sensor cannot accurately measure the distance to an object that:

- Is more than 4 meters away, Fig 1
- That has its reflective surface at a shallow angle so that sound will not be reflected back towards the sensor (Angle \( \theta < 90^\circ \)), Fig 2. or
- Is too small to reflect enough sound back to the sensor. In addition, if your ECHO sensor is mounted low on your device, you may detect sound reflecting off the floor.
- **Target Object Material**

  In addition, objects that absorb sound or have a soft or irregular surface, such as a stuffed animal, may not reflect enough sound to be detected accurately. The ECHO sensor will detect the surface of water; however it is not rated for outdoor use or continual use in a wet environment. Condensation on its transducers may affect performance and lifespan of the device.

- **Air Temperature**

  Temperature has an effect on the speed of sound in air that is measured by the ECHO sensor. If the temperature (degree Celsius) is known, the formula is

  \[ C_{\text{air}} = 331.5 + (0.6 \times T_c) \text{ m/s} \]

  The percent error over the sensor’s operating range of 0 to 70 °C is significant, in the magnitude of 11 to 12 percent. The use of conversion constants to account for air temperature may be incorporated into your program.
The important features of an ECHO sensor which is to be noted:

- **VCC** -- Power supply input marked ‘A’
  
  5V supply has to be provided for its reliable performance

- **SIG** -- Signal Output pin marked ‘B’
  
  This pin is used for output serial data to the host controller

- **GND** -- Ground level of Power supply marked ‘C’
  
  The marking ‘D’ points to the Burst LED Indicator that shows measurement in progress.
TECHNICAL SUPPORT

If you are experiencing a problem that is not described in this manual, please contact us. Our phone lines are open from 9:00 AM – 5:00 PM (Indian Standard Time) Monday through Saturday excluding holidays. Email can be sent to support@rhydolabz.com

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