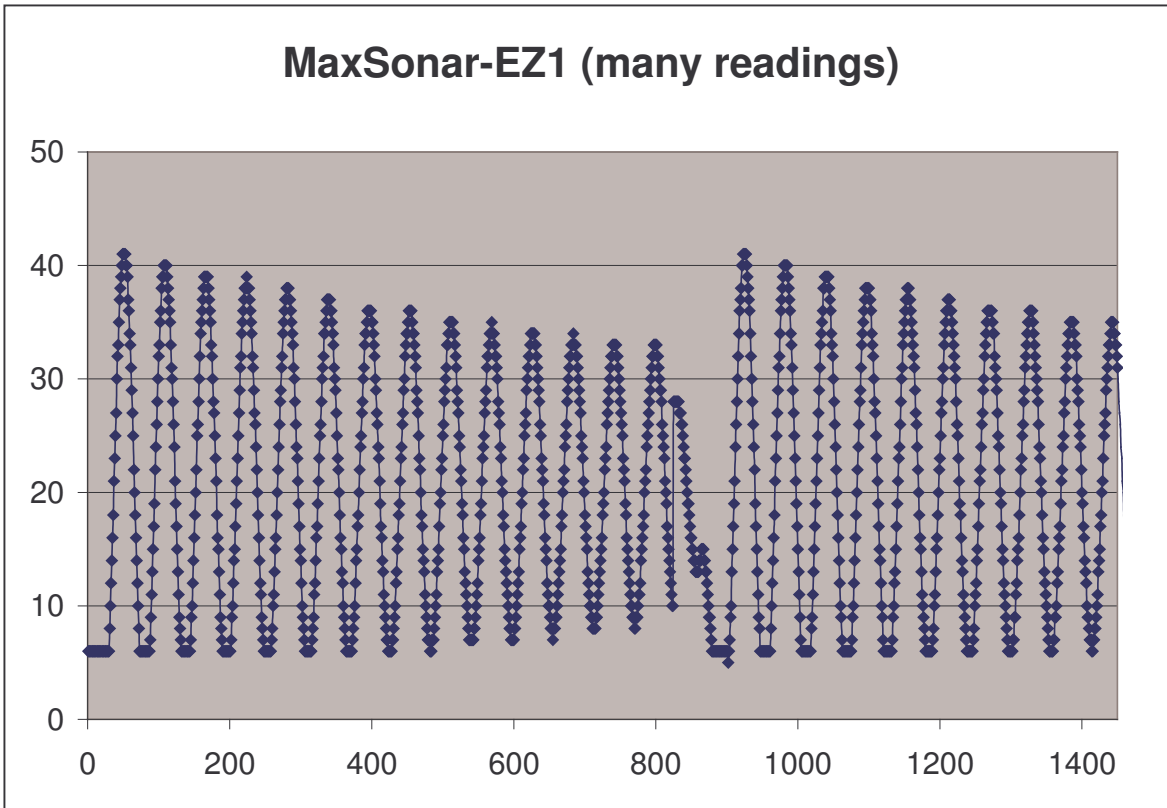


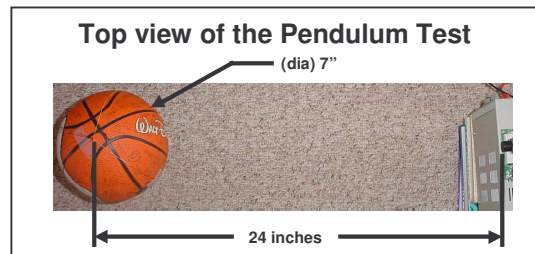
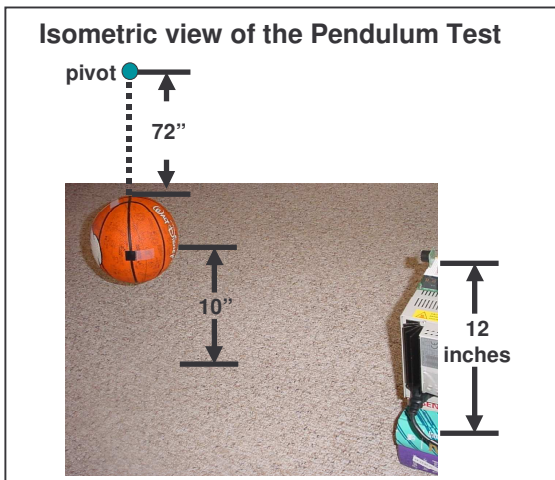
Pendulum Test Results for the LV-MaxSonar[®]-EZ1[™]

(and the original MaxSonar-EZ1, and some other selected competing sensors) 01/16/2007

A simple gravity pendulum can be used to provide a basic movement that can be measured by an ultrasonic range finder. This pendulum allows testing in a lab environment. In addition, the test can be duplicated easily, (by setting up the test in the same manner). It represents real world operation. Examples include the movement of a sensor mounted on a moving robot, or a stationary sensor looking at a moving object. This test allows easy verification of the ultrasonic range finder's operation over the range of travel provided by the pendulum. For example, the plot below (from a MaxSonar[®]-EZ1[™]) shows the distance moved by the pendulum. For this plot over 1400 readings were taken. At about reading 850 the ball was repositioned at the MaxSonar[®]-EZ1[™] sensor face and released again. No readings were incorrect. (At about reading 910 the MaxSonar[®]-EZ1[™] sensor correctly stated the range of 5" instead of the normal minimum range of 6".) (The new & improved LV-MaxSonar[®]-EZ1[™] sensor line is 100% verified to also pass this test!)



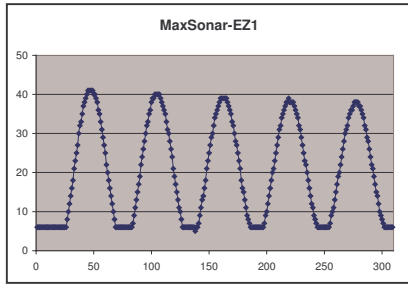
The pendulum for this test was constructed with a child's basketball and a fishing line. The fishing line measured 72" from the top of the ball to the pivot point of the pendulum. The center of the ball was located 10" off the floor. The bottom of the sensor is 12" from the floor and 24" from the center of the ball.



- All tests begin with the ball touching the front sensor face. The ball is released. As the ball is moving away, all readings should increase and as the ball moves closer all readings should decrease.
- Results from at least five swings are recorded.
- Beginning 1/1/2007 all -EZ1[™] sensors are tested for and must pass the pendulum test.

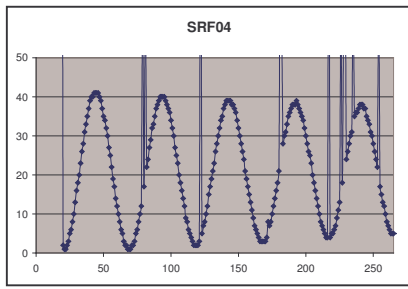
Pendulum Test Results for the LV-MaxSonar®-EZ1™

(and the original MaxSonar-EZ1, and some other selected competing sensors)



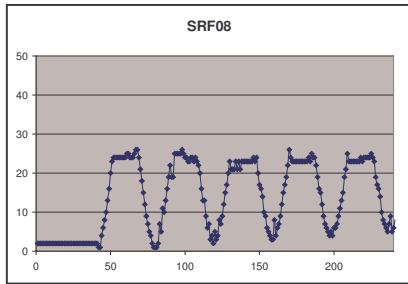
MaxSonar®-EZ1™ (by MaxBotix® Inc.)

- When the ball is pressing against the MaxSonar®-EZ1™, all readings report 6". (The LV- MaxSonar®-EZ1™ performance is identical.)
- No ranging anomalies occur. (One up close reading correctly reports 5" instead of the nominal 6" minimum distance.)
- This plot is typical. We warrantee this result. In addition, all EZ1™ sensors shipping after 1/1/2007 have this parameter 100% verified.



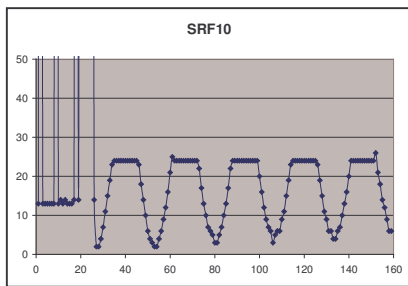
SRF04 (by Devantech Ltd.)

- When the ball is pressing against the SRF04 the sensor does not detect the ball. (Very slight gap allows the ball to be detected.)
- A few random ranging anomalies occur. And some readings appear to not detect the ball, but instead range a more distant object or report maximum range.



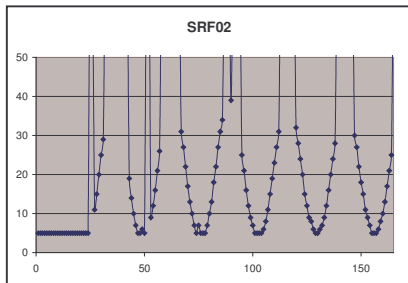
SRF08 (by Devantech Ltd.)

- When the ball is pressing against the SRF08, the sensor reports a continuous low range (3"). (Slight gap allows closer readings.)
- A few random ranging anomalies occur with incorrect estimates of about 2" to 4".
- Above 24" only the berber carpet on the floor is detected. (The wide beam width of the sensor detects the carpet.)



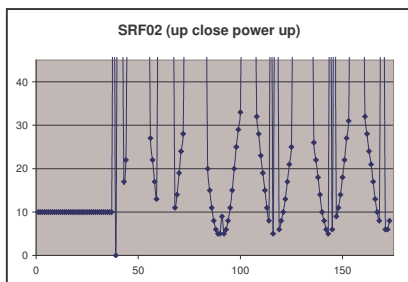
SRF10 (by Devantech Ltd.)

- When the ball is pressing against the SRF10, the sensor reports 12" (i.e. the distance to the carpet on the *floor) and also has intermittent maximum range readings. (Slight gap allows closer readings.)
- Ranging anomalies appear to occur up close.
- Above 24" only the berber carpet on the floor is detected. (The wide beam width of the sensor detects the carpet. The SRF10 detects some floors and most walls for over 180°.)



SRF02 (by Devantech Ltd.)

- When the ball is pressing against the SRF02, the sensor reports 5" or 10". In addition, although not shown here, sometimes the SRF02 reports 0", but sometimes 0" is reported when the sensor does not detect an object (i.e. when in a large open space).
- Many random ranging anomalies occur. Up close, sometimes the SRF02 does not detect the ball. Past 30", in general, it does not detect the ball, (but the SRF02 will, in general, detect the ball, if stationary).
- Two plots are shown because of the "AutoTune" feature.
 - The top plot shows the results with the sensor turned on before the ball is pressing against the sensor.
 - The bottom plot shows the results with the sensor turned on with the ball pressing against the sensor.
 - The SRF02 appears to perform better when powered up without an object close to the sensor.
- Not sure what "best in class performance" means or what parameter(s) apply.



Pendulum Test Results for the LV-MaxSonar[®]-EZ1[™]

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Notes:

First, it is not normal for the MaxSonar-EZ1 to have unstable range readings.

The MaxSonar-EZ1 sensor was designed with the pendulum test in mind. This was (and still is) a common test during the engineering phase of the MaxSonar-EZ1 product line. In addition, MaxBotix Inc., was concerned that people might think that unstable readings were normal, especially if they were familiar with the competitor's sensors. Because MaxBotix Inc., could measure the performance of the competitor's sensors using the same methods that we use on the MaxSonar-EZ1, we felt this data would be of service to our users. As such, MaxBotix Inc., felt that it needed to publish the pendulum test results for the Devantech sensor line, because MaxBotix Inc., needed people to understand that the MaxSonar-EZ1 is a much different sensor than the competitor's sensors.

Parts that shipped previous to 1/1/2007 were not 100% tested with the pendulum test parameter, so it is possible that some of the fielded MaxSonar-EZ1 sensors do not meet this test. Year 2006 warranty returns for the MaxSonar-EZ1 is 0.3%, and of these 0.2% have unstable* readings, (and it appears that the others were connected up incorrectly). Because of the warranty returns (albeit, very low returns) MaxBotix Inc., has now included this pendulum test in our final test. *In addition, our circuit board provider, assembled some of the MaxSonar-EZ1 product with capacitors that were of a lower grade than was specified by MaxBotix Inc. (Even so, most parts were built with the correct capacitors.) Specifically, the 0.01uF capacitor in the integrator stage of the sensor, was specified by MaxBotix Inc., to have a tolerance of $\pm 20\%$, but our vendor sometimes used -20% to $+80\%$ capacitors. Capacitor values greater than $+50\%$ affected the gain algorithms in some of the MaxSonar-EZ1 sensors, causing some unstable readings, and yield loss at our factory. MaxBotix Inc., believes that it is possible that more than 0.2% of the Original-MaxSonar-EZ1 sensors had this problem, but we did not test 100% for this parameter. As such we believe that it is possible that up to 1% -2% may have had this problem, but because we did not test for this parameter, we did not catch these sensors. Also had the concern that many users would not return the product because they were so familiar with the competitor's product's unstable range readings, and even our "poor" sensors performed better than any of the competitor's sensors, that we tested.

Please, if the product doesn't work we would like to send a replacement sensor. Any MaxSonar-EZ1 sensors shipped during 2006 that provide unstable readings for distances 7" and greater, MaxBotix Inc., will replace. (Currently we will be replacing Original-MaxSonar-EZ1 sensors with the improved LV-MaxSonar-EZ1 available 1/2007).

Limited Test Samples

For the Devantech Ltd., sensors, only one sensor of every part was tested. Because of this it is possible that the results are not typical.

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Data taken and report written by MaxBotix Inc.