

# Test Report: Wave Energy Converter Device for AquaHarmonics

## Department of Energy Wave Energy Prize 2015

Test dates: January 11 – 15, 2016

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Marine Hydrodynamics Laboratory  
Department of Naval Architecture and Marine Engineering

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## Description of Test Facilities

The UM MHL and its Physical Modeling Basin (PMB) have a long history at UM and as a strategic asset in Midwest. Initial construction in the West Engineering Building (now West Hall) was completed in 1904 to support both the Naval Architecture and Marine Engineering department and Civil Engineering department. The PMB has had numerous upgrades through the decades and has been in continuous operation since its founding, supporting education, research and commercial activity.

### *Physical Model Basin*

The Physical Model Basin (towing tank) is nominally 360 feet long, by 21.5 feet wide, by 9.5 feet deep. The length of basin available for free-surface operations is nominally 300 feet, due to the size and position of the wavemaker and wave-absorbing beach. Figure 1, shown below, is a view along the length of the basin from the wavemaker toward the beach. The carriage can be seen in the far end of the towing basin. The foreground shows the ballast well and wavemaker.



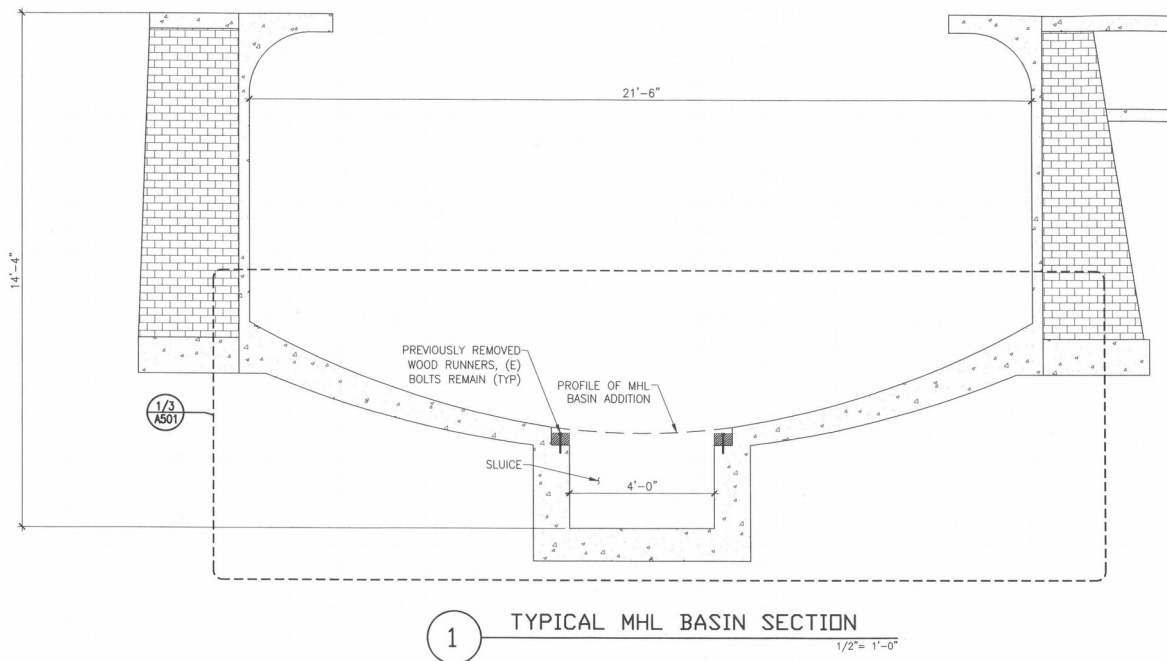
**Figure 1: View of the Physical Model Basin looking from the wavemaker toward the beach.**

The basin has a curved floor and a trench along the center that is nominally 4 feet wide, 3 feet deep, and running the length of the tank, as shown in Figure 2. This feature has a neutral impact on normal free-surface testing operations.

The PMB has four doors along its west wall and is completely secured; only select staff have keyed access. It is climate controlled with HVAC systems, etc., and is relatively comfortable to work in year-round. The PMB is relatively well lit by florescent lighting and large glass block windows along its length to the east (good diffuse light, but no visibility from outside). A few windows do allow visibility along a portion of the west wall to a public access hallway; these windows can be covered or remain uncovered. The basin (lower) walls are painted white and the floor coating is a medium-shade green-

grey; optical conditions in the water is decent and additional lighting will be used if necessary.

The water quality is excellent, being chlorinated (Ann Arbor city) fresh potable water. The water is continuously processed with a fine-mesh filtration system and regularly refreshed. The water temperature is nominally 65 degrees Fahrenheit +/- 3 degrees year round; the temperature is measured to within 0.1 degree Fahrenheit during testing.



**Figure 2: Cross-sectional view of the Physical Model Basin.**

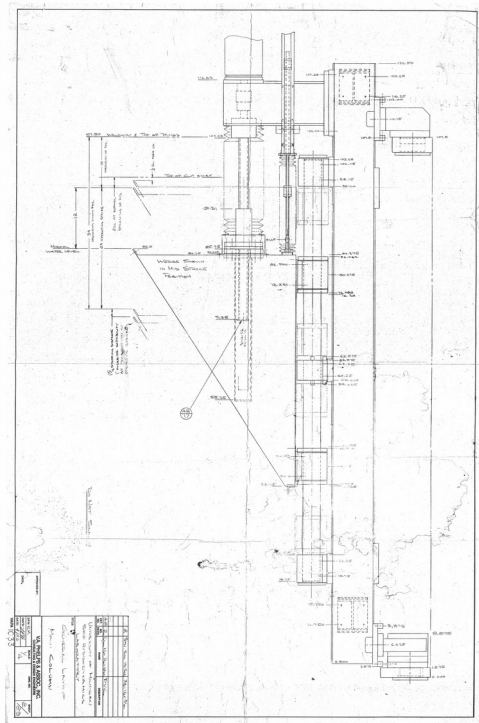
### *Wavemaker*

The wavemaker consists of a vertically plunging wedge that runs on linear rails, as shown in Figures 3 and 4.



**Figure 3: Wavemaker in operation, producing irregular wave conditions.**

It is capable of producing regular plane waves and irregular plane waves for a variety of standard wave spectra. It can be locally or remotely controlled by computer. The wavemaker generally operates between frequencies of 0.4 Hz to 3.0 Hz.



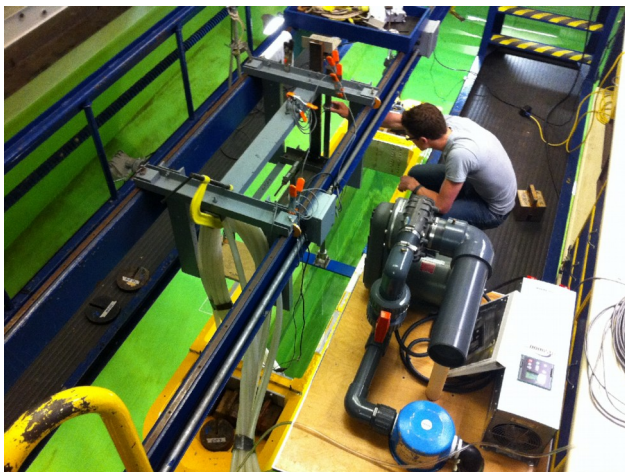
**Figure 4: Profile view of the basin wavemaker.**



### *Carriage (powered)*

The tank carriage spans the width of the tank and can traverse the length of the tank between the wavemaker and beach. It is self-powered and equipped with a variety of support equipment and platforms. Two views of the carriage are shown in Figure 5. It is primarily designed for towed-model testing, and also makes an excellent platform for fixed model testing. The carriage is capable of testing models at speeds up to 20 feet/second; the higher the speed the shorter the steady-state duration at that speed.

The carriage also supports the data acquisition system and the ability to initiate wavemaker control and other external systems such as remote video, wave height sensors, etc.



**a) Testing on-board the carriage**



**b) Carriage view from aft**

**Figure 5: Tank carriage system**

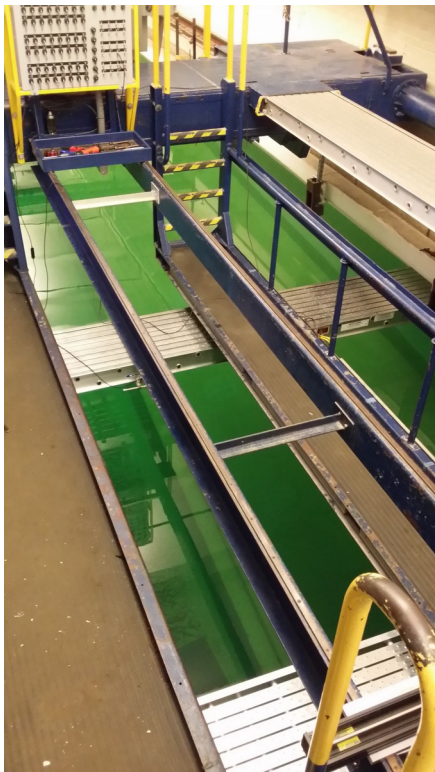
### **Description of Test Setup**

For the Wave Energy Prize testing campaign, the carriage was secured in-place, and augmented with additional platforms to enhance the ergonomics of setting up and adjusting the WEC devices. Figure 6 is a view from the wavemaker end of the basin, west side. In the foreground a cross-structure is visible where three ultrasonic wave probes (WP1, WP 2 and WP3) are located. These probes measure the undisturbed wave coming from the wavemaker to the WEC device.



**Figure 6: Carriage in WEC testing configuration and upstream wave probes**

Figure 7 shows the area for testing the WEC devices between the carriage walkways (blue and black with yellow handrails). Additional cross-structure (aluminum scaffolding) is visible, passing beneath the carriage walkways. A set of c-channel rails (blue) pass longitudinally above the open water area; these are used to support instruments and cameras, etc.



**Figure 7: Open area between walkways on the carriage where the WEC devices are tested.**

A top-view sketch of the Physical Model Basin equipment arrangement for testing the WEC devices is shown in Figure 8. The sketch is not drawn to scale, however, key dimensions are identified.

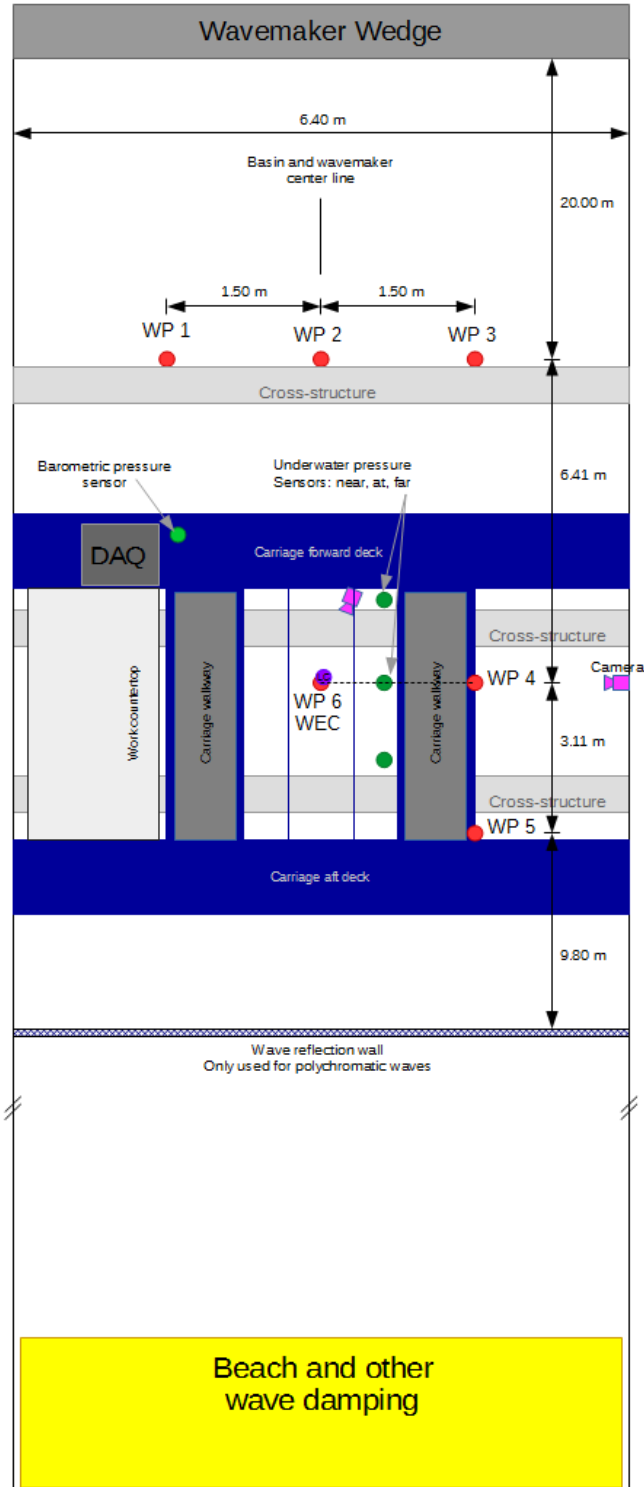


Figure 8: Top-view conceptual diagram of the testing equipment layout along with key dimensions

The array of instruments used for each of the WEC tests, as shown in Figure 8, includes the following instruments, listed in Table 1.

<b>Instrument Function</b>	<b>Symbol</b>	<b>Make</b>	<b>Model</b>
Wave probes – ultrasonic	Red circle	Senix	ToughSonic 30
Underwater pressure sensor	Green circle	Impress Sensors	IMCL-G0360
		Omega Engineering	PX2300-10DI
Barometric air pressure	Light green circle	Omega Engineering	PX409-26BI
Load cell	Purple circle	Omega Engineering	LSHD-50
Digital camera	Magenta square/triangle		
3D Motion Tracking	Not shown	OptiTrack	Prime 41 cameras

**Table 1: UM MHL supplied instrumentation**

The location of the wave probes with respect to the front edge of the wavemaker is identified in Figure 8. Wave probe number 6 (WP6) was used for characterizing the wave conditions in the basin before the testing program started. This probe was located where the WEC devices were tested for each case. For the monochromatic wave cases, wave probe number 4 (WP4) was used to identify the timing between the incoming waves and the behavior of the WEC device. Since WP6 would not be available to record the data when the WEC was located there, the values from other wave probes were used to estimate the wave conditions at the WEC device.

A mapping between the average of the wave conditions at WP1, WP2, WP3 and WP4 and those at WP6 was developed for each of the monochromatic cases and used for data analysis. The results are shown in the following table:

<b>Wave case</b>	<b>WP6 – WP1,2,3,4</b>	<b>WP6 – WP1,2,3,4</b>
	<b>Avg Amplitude (%)</b>	<b>Avg Frequency (%)</b>
M1 s 80	4.68	0.04
M2 s 80	7.00	0.13
M3 s 80	1.20	-0.09
M4 s 80	1.57	-0.01
M5 s 80	-4.84	-0.04
M6 s 80	-29.50	0.02
M7 s 80	1.51	0.03
M1 s 40	-0.95	0.10
M2 s 40	3.49	0.03
M3 s 40	0.14	-0.07
M4 s 40	0.69	-0.05
M5 s 40	-3.52	-0.04

**Table 2: Average wave amplitude correlation at WEC**



Monochromatic test case M6\_s\_80 stands out for being so different in average wave amplitude. This condition is due to a resonance near this frequency in the basin. It is dealt with by performing longer wavemaker runs for this case, getting the wave phenomena to 'lock-in' after 15 periods, and utilizing the data from that point afterward. The typical monochromatic wave test run consisted of operating the wavemaker for a duration of 25 periods plus 10 seconds (to account of 5 seconds of ramp-up and ramp-down time). The exceptions were cases M6s80 where the wavemaker was run for 40 periods plus the ramp-up/down time, and M1s80 where the wavemaker was run for 50 periods plus ramp-up/down time.

For the polychromatic test cases, the WEC was required to be exposed to the prescribed irregular wave conditions for the equivalent of 30 minutes full-scale time (4.24 minutes duration model-scale time). Running the wavemaker for this duration would obviously result in reflected energy, since the beach system is not a perfect absorber. Given the fact that reflection was going to be present, it was decided to influence the reflection conditions by installing a wave reflector wall approximately 14.4 meters from the WEC device. The wavemaker parameters were tested and determined assuming a relatively high degree of wave reflection. For the polychromatic cases, the wave data from wave probe number 2 (WP2) was used, assuming the conditions would be similar at the WEC location.

For both the monochromatic and polychromatic wave cases, the wavemaker motion control signals were defined and stored for repeated use. Each prescribed test case was run with an identical input signal, regardless of when it was run, or which WEC team it was run for. This strategy was instituted in order to minimize the differences between identical test cases.

The instrumentation data sheets and calibration records for the load cells and the wave probes are included in Appendix A. The factory calibration values were used for the three pressure sensors used underwater and for the barometric air pressure sensor.

## Instrumentation and Data Channel Lists

The data was collected on a National Instruments M-Series USB-6225 data acquisition unit coupled with the SC-2345 signal conditioning system and other input devices, which allow for the use of voltage, current, strain, digital and frequency input and output (control). National Instruments LabVIEW 2015 software was used to control the data acquisition system and collect the data. The data is stored in the LabVIEW native TDMS file format, which is more flexible than a traditional flat-file spreadsheet. The TDMS files may be easily read by LabVIEW software, or exported to a spreadsheet format for viewing/analysis.

The following file naming convention was used for data collection:

- Raw numerical: R\_M/PX\_s\_Y0\_Z\_TeamName\_DataRun#
- Raw numerical gain and offset: R\_M/PX\_s\_Y0\_Z\_TeamName\_ParametersRun#
- Raw 3D motion: M\_M/PX\_s\_Y0\_Z\_TeamName\_run#
- Video: V\_M/PX\_s\_Y0\_Z\_TeamName\_DataRun#
- Processed: P\_M/PX\_s\_Y0\_Z\_TeamName\_DataRun#

The M/P value refers to the monochromatic and polychromatic wave cases, respectively. The X refers to the M or P run identifier. The Y is the steepness identifier (either '4' for 40, or '8' for 80). The Z is the wave direction identifier (either 0, 20 or 50). The DataRun# or run# suffix was utilized to keep track of repeat runs for a given condition.

For the processed data files, the raw numerical and motion data are integrated into the file in order to be processed by the LabVIEW DiaDEM data analysis and reporting tool.

The raw data channel list is shown in table 3, below:

Data File	Channel Name	Description	Unit	Sensor	Sample Rate
R_M/PX_s_Y0_Z	Wave Probe 1	WP 1 water level	cm	Senix ToughSonic 30	200 Hz
R_M/PX_s_Y0_Z	Wave Probe 2	WP 2 water level	cm	Senix ToughSonic 30	200 Hz
R_M/PX_s_Y0_Z	Wave Probe 3	WP 3 water level	cm	Senix ToughSonic 30	200 Hz
R_M/PX_s_Y0_Z	Wave Probe 4	WP 4 water level	cm	Senix ToughSonic 30	200 Hz
R_M/PX_s_Y0_Z	Wave Probe 5	WP 5 water level	cm	Senix ToughSonic 30	200 Hz
R_M/PX_s_Y0_Z	Wave Probe 6	Not used - WEC location		Senix ToughSonic 30	200 Hz
R_M/PX_s_Y0_Z	Underwater Pressure Near	Pressure at basin floor - nearest to wavemaker	Pa	Impress IMCL-G0360	200 Hz
R_M/PX_s_Y0_Z	Underwater Pressure At	Pressure at basin floor - at WEC device	Pa	Impress IMCL-G0360	200 Hz
R_M/PX_s_Y0_Z	Underwater Pressure Far	Pressure at basin floor - furthest from wavemaker	Pa	Omega PX2300-10DI	200 Hz
R_M/PX_s_Y0_Z	Barometric	Barometric air pressure	inHg	Omega PX409-26BI	200 Hz
R_M/PX_s_Y0_Z	Mooring LC 1	Not used			
R_M/PX_s_Y0_Z	Mooring LC 2	Not used			
R_M/PX_s_Y0_Z	Mooring LC 3	Central tether force	N	Omega LSDH-50	200 Hz
R_M/PX_s_Y0_Z	Mooring LC 4	Not used			
R_M/PX_s_Y0_Z	WECVI1	Not used			
R_M/PX_s_Y0_Z	WECVI2	Not used			
R_M/PX_s_Y0_Z	WECVI3	Not used			
R_M/PX_s_Y0_Z	WECVI4	Not used			
R_M/PX_s_Y0_Z	WECVI5	Not used			
R_M/PX_s_Y0_Z	WECVI6	Not used			
R_M/PX_s_Y0_Z	WECSG1	PTO dynamic channel - force	N	FUTEK TFF325	200 Hz
R_M/PX_s_Y0_Z	WECSG2	Not used			
R_M/PX_s_Y0_Z	Untitled 23	PTO kinematic channel - motion	m	CUI AMT10 encoder	200 Hz
M_M/PX_s_Y0_Z	Time	Time	s	Optitrack 3D motion	100 Hz
M_M/PX_s_Y0_Z	X	Pitch	deg	Optitrack 3D motion	100 Hz
M_M/PX_s_Y0_Z	Y	Yaw	deg	Optitrack 3D motion	100 Hz
M_M/PX_s_Y0_Z	Z	Roll	deg	Optitrack 3D motion	100 Hz
M_M/PX_s_Y0_Z	X1	Sway	cm	Optitrack 3D motion	100 Hz
M_M/PX_s_Y0_Z	Y1	Heave	cm	Optitrack 3D motion	100 Hz
M_M/PX_s_Y0_Z	Z1	Surge	cm	Optitrack 3D motion	100 Hz

**Table 3: Data channel list for raw numerical and motion data**

The processed data channel lists are shown in the following tables: the monochromatic wave data format is shown in Table 4 and the polychromatic wave data format is shown in Table 5.

Data File	Channel Name	Description	Unit	Sensor	Sample Rate
P_MX_s_Y0_Z	WEC Wave	Summary statistics	m		
P_MX_s_Y0_Z	FilteredSignalCopyYWave Probe 1	WP 1 water level - windowed, filtered	cm	Senix ToughSonic 30	200 Hz
P_MX_s_Y0_Z	FilteredSignalCopyYWave Probe 2	WP 2 water level - windowed, filtered	cm	Senix ToughSonic 30	200 Hz
P_MX_s_Y0_Z	FilteredSignalCopyYWave Probe 3	WP 3 water level - windowed, filtered	cm	Senix ToughSonic 30	200 Hz
P_MX_s_Y0_Z	FilteredSignalCopyYWave Probe 4	WP 4 water level - windowed, filtered	cm	Senix ToughSonic 30	200 Hz
P_MX_s_Y0_Z	UnderwaterPressure	Summary statistics	Pa		
P_MX_s_Y0_Z	FilteredCopyYUnderwater Pressure Near	Pressure at basin floor - nearest to wavemaker - windowed, filtered	Pa	Impress IMCL-G0360	200 Hz
P_MX_s_Y0_Z	FilteredCopyYUnderwater Pressure At	Pressure at basin floor - at WEC device - windowed, filtered	Pa	Impress IMCL-G0360	200 Hz
P_MX_s_Y0_Z	FilteredCopyYUnderwater Pressure Far	Pressure at basin floor - furthest from wavemaker - windowed, filtered	Pa	Omega PX2300-10DI	200 Hz
P_MX_s_Y0_Z	Mooring	Summary statistics			
P_MX_s_Y0_Z	FilteredCopyYMooring LC 3	Central tether force - windowed, filtered	N	Omega LSDH-50	200 Hz
P_MX_s_Y0_Z	PTO	Summary statistics			
P_MX_s_Y0_Z	PTO Power	Time series and summary statistics	W		
P_MX_s_Y0_Z	PTO Dynamic	PTO dynamic channel - force - windowed, filtered	N		
P_MX_s_Y0_Z	FilteredSignalCopyYWECSG1	PTO dynamic channel - force - windowed, filtered	N	FUTEK TFF325	200 Hz
P_MX_s_Y0_Z	PTO Kinematic	PTO kinematic channel - velocity	m/s		
P_MX_s_Y0_Z	FilteredSignalCopyYUntitled 23	PTO kinematic channel - motion - windowed, filtered	m	CUI AMT10 encoder	200 Hz
P_MX_s_Y0_Z	WEC Motion	Summary statistics			
P_MX_s_Y0_Z	FilteredCopyYX Pitch	Pitch - windowed, filtered	deg	Optitrack 3D motion	100 Hz
P_MX_s_Y0_Z	FilteredCopyYY Yaw	Yaw - windowed, filtered	deg	Optitrack 3D motion	100 Hz
P_MX_s_Y0_Z	FilteredCopyYZ Roll	Roll - windowed, filtered	deg	Optitrack 3D motion	100 Hz
P_MX_s_Y0_Z	FilteredCopyYX1 Sway	Sway - windowed, filtered	cm	Optitrack 3D motion	100 Hz
P_MX_s_Y0_Z	FilteredCopyYY1 Heave	Heave - windowed, filtered	cm	Optitrack 3D motion	100 Hz
P_MX_s_Y0_Z	FilteredCopyYZ1 Surge	Surge - windowed, filtered	cm	Optitrack 3D motion	100 Hz

**Table 4: Data channel list for monochromatic processed numerical and motion data**

Data File	Channel Name	Description	Unit	Sensor	Sample Rate
P_PX_s_Y0_Z	WP24PSDAvg	WP 2 & 4 average spectrum and summary statistics	cm <sup>2</sup> /s		
P_PX_s_Y0_Z	FilteredSignalCopyYWave Probe 1	WP 1 water level - windowed, filtered	cm	Senix ToughSonic 30	200 Hz
P_PX_s_Y0_Z	FilteredSignalCopyYWave Probe 2	WP 2 water level - windowed, filtered	cm	Senix ToughSonic 30	200 Hz
P_PX_s_Y0_Z	FilteredSignalCopyYWave Probe 3	WP 3 water level - windowed, filtered	cm	Senix ToughSonic 30	200 Hz
P_PX_s_Y0_Z	FilteredSignalCopyYWave Probe 4	WP 4 water level - windowed, filtered	cm	Senix ToughSonic 30	200 Hz
P_PX_s_Y0_Z	UnderwaterPressure	Summary statistics	Pa		
P_PX_s_Y0_Z	FilteredCopyYUnderwater Pressure Near	Pressure at basin floor - nearest to wavemaker - windowed, filtered	Pa	Impress IMCL-G0360	200 Hz
P_PX_s_Y0_Z	FilteredCopyYUnderwater Pressure At	Pressure at basin floor - at WEC device - windowed, filtered	Pa	Impress IMCL-G0360	200 Hz
P_PX_s_Y0_Z	FilteredCopyYUnderwater Pressure Far	Pressure at basin floor - furthest from wavemaker - windowed, filtered	Pa	Omega PX2300-10DI	200 Hz
P_PX_s_Y0_Z	Mooring	Summary statistics			
P_PX_s_Y0_Z	FilteredCopyYMooring LC 3	Central tether force - windowed, filtered	N	Omega LSDH-50	200 Hz
P_PX_s_Y0_Z	PTO Power	Time series and summary statistics	W		
P_PX_s_Y0_Z	PTO Dynamic	Time series and summary statistics	N		
P_PX_s_Y0_Z	PTODynPSDAvg	PTO dynamic channel - average DFT spectrum	N	FUTEK TFF325	200 Hz
P_PX_s_Y0_Z	PTO Kinematic	Time series and summary statistics	m/s		
P_PX_s_Y0_Z	PTOKinPSDAvg	PTO kinematic channel - average DFT spectrum	m	CUI AMT10 encoder	200 Hz
P_PX_s_Y0_Z	WEC Motion	Summary statistics			
P_PX_s_Y0_Z	FilteredCopyYX Pitch	Pitch - windowed, filtered, summary statistics (m)	deg	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	FilteredCopyYY Yaw	Yaw - windowed, filtered, summary statistics (m)	deg	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	FilteredCopyYZ Roll	Roll - windowed, filtered, summary statistics (m)	deg	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	FilteredCopyYX1 Sway	Sway - windowed, filtered, summary statistics (m)	cm	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	FilteredCopyYY1 Heave	Heave - windowed, filtered, summary statistics (m)	cm	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	FilteredCopyYZ1 Surge	Surge - windowed, filtered, summary statistics (m)	cm	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	WECMotionPitchPSDAvg	Pitch - average DFT spectrum	dg <sup>2</sup> /s	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	WECMotionYawPSDAvg	Yaw - average DFT spectrum	dg <sup>2</sup> /s	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	WECMotionRollPSDAvg	Roll - average DFT spectrum	dg <sup>2</sup> /s	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	WECMotionSwayPSDAvg	Sway - average DFT spectrum	m <sup>2</sup> /s	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	WECMotionHeavePSDAvg	Heave - average DFT spectrum	m <sup>2</sup> /s	Optitrack 3D motion	100 Hz
P_PX_s_Y0_Z	WECMotionSurgePSDAvg	Surge - average DFT spectrum	m <sup>2</sup> /s	Optitrack 3D motion	100 Hz

**Table 5: Data channel list for polychromatic processed numerical and motion data**



## Appendix A

### Instrumentation and Calibration Information

# ToughSonic® 30 Level and Distance Sensor

Windows PC or Button Setup, Liquid Tight, Multiple Outputs

Formerly TSPC-15S

Senix sensors and SenixVIEW software put the power of ultrasonics in your hands yet retain the simplicity of push-button TEACH setup. You can quickly adjust, optimize, save and clone your applications without calibration!

ToughSonic sensors contain a rugged transducer potted in a stainless steel housing for long life.

Outputs respond to measured distance and non-contact technology means nothing touches your materials.

Many applications exist in all industries. Contact Senix today to discuss your specific needs.

## Button TEACH or PC Configured Non-Contact Ultrasonic Distance Measurement

### Features

#### Distance Measurements

- Long range, short dead band
- Unaffected by optical factors like color and transparency
- PC or button "teachable" setup
- Narrow beam with adjustments to optimize performance
- Temperature compensated

#### Packaging & Performance

- Quick mounting
- Durable sealed housing for wet or dirty applications
- Short & overload protected I/O
- Multi-sensor synchronization
- Adjustable sensitivity
- Rear status indicators (3)

#### Free Functionality

Use adjustable interface features like switch hysteresis and time delays to build complete solutions such as pump or material flow controllers. Save cost by eliminating PLCs, delay circuits and time delay relays!

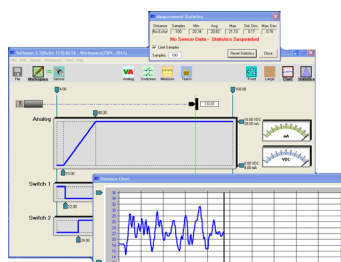
Up to 30-ft. (9.1 m) maximum range in IP68 rated cylindrical housing



SenixVIEW PC  
Software included!

### PC Setup Power!

Use SenixVIEW software (see separate data sheet) to select and adjust all interfaces, timing parameters, filters and modes. Then view, analyze or log data to optimize your application.



Several push-button "teach" features also provide common adjustments without the PC.

#### Stock, repairs, OEMs

Flexible configuration means fewer parts to stock and quick duplication! Higher volume OEM options are available.

### Multiple Outputs

In addition to the model's serial data interface there are five simultaneous outputs. All have SenixVIEW configurable features including ranges, target responses and time delays.

#### Analog Outputs (3)

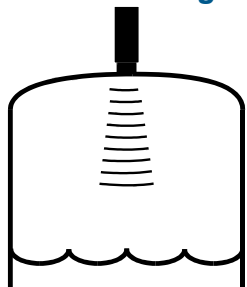
These include voltage (0-10 VDC) and two current loops (4-20 mA sinking and sourcing).

The analog slope can increase or decrease value with distance. The analog output limits can be set any distance, and have user-selected voltage/current values.

#### Switches (2)

Two switches are SenixVIEW configurable as either "PNP" or "NPN" type (sourcing or sinking). Each has adjustable set point, hysteresis, window, initial conditions, ON delay, OFF delay and loss of target response for ultimate flexibility.

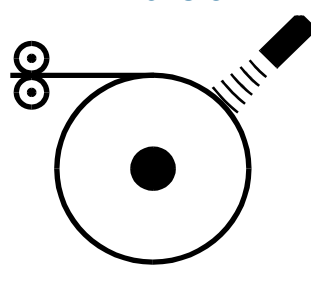
#### Level or Height



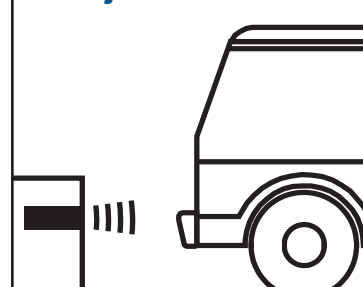
#### Distance-Proximity



#### Dimension



#### Object Detection





# Senix ToughSonic® 30 Level and Distance Sensor

## Specifications

<b>Optimum Range</b>	10 in.- 20 ft. (25.4 cm- 6.1m)	<b>Max Range</b>	30 feet (9.1 meters)
<b>Case Material</b>	316 stainless steel	<b>Adjustment</b>	Button "teach" or SenixVIEW
<b>Temperature</b>	-40 to 158 F (-40 to 70 C)	<b>Configuration</b>	Stored in non-volatile memory
<b>Humidity</b>	0 to 100% operating	<b>Transducer</b>	Ruggedized piezoelectric
<b>Compensation</b>	Temperature compensated	<b>Protection</b>	NEMA-4X, NEMA-6P, IP68
<b>Resolution</b>	Digital: 0.0068 in. (0.172 mm); Analog: 4099 steps (0-10 VDC), 3279 steps (4-20 mA)		
<b>Repeatability</b>	Nominal 0.3% of range @ constant temp. Affected by target, distance, environment		
<b>Update Rate</b>	10 Hz (100 ms), SenixVIEW adjustable; affected by SenixVIEW filter selections		
<b>Voltage Output</b>	0-10, 0-5 VDC or PC customized; 10 mA max. (*)		
<b>Current Loop #1</b>	Current sourcing 4-20 mA or PC customized, max. loop 450Ω (*)		
<b>Current Loop #2</b>	Current sinking 4-20 mA or PC customized, max. loop 450Ω (*)		
<b>Sinking Switch</b>	150 mA max. @ 40 VDC max., teachable set point & polarity, fault indication		
<b>Sourcing Switch</b>	150 mA max. @ input voltage, teachable set point & polarity, fault indication		
<b>RS-232, RS-485</b>	Modbus protocol, 9600-115200 baud (selectable), 8 data bits, 1 stop, no parity		
<b>SYNC feature</b>	Permits up to 32 sensors to operate in close proximity without interaction		

### Target Requirements

<b>Objects</b>	Detects flat or curved objects. Surface must reflect ultrasound back to sensor.
<b>Max. Distance</b>	Affected by size, shape, orientation of target (sound level reflected back to sensor)
<b>Orientation</b>	Flat surfaces should be oriented perpendicular to sensor output beam
<b>Optical</b>	Unaffected by target color, transparency, light, or other optical characteristics

## Connections

Cable Connection	Wire	Description
Power	Brown	10-30 VDC @ 70 mA maximum; Typical: 45 mA @ 24 VDC (**)
Ground	Blue	Power and interface common
Voltage Output *	Violet	0-10 VDC, 0-5 VDC or custom end values between 0 and 10 VDC
Current Loop Output *	Green	4-20 mA sourcing (adjustable end values between 4 and 20 mA)
Current Loop Output *	Orange	4-20 mA sinking (adjustable end values between 4 and 20 mA)
Switch #1 Output	Black	Sinking ("NPN") or Sourcing ("PNP"), user selected
Switch #2 Output	White	Sinking ("NPN") or Sourcing ("PNP"), user selected
RS-232 out / RS-485-	Gray	Serial data connection (depends on model - see model selection)
RS-232 in / RS-485+	Yellow	Serial data connection (depends on model - see model selection)

(\*) Analog outputs share common distance endpoints. Both 4-20 mA outputs share the same adjustable max / min end values. The maximum loop resistance is derated below 15 VDC input voltage.

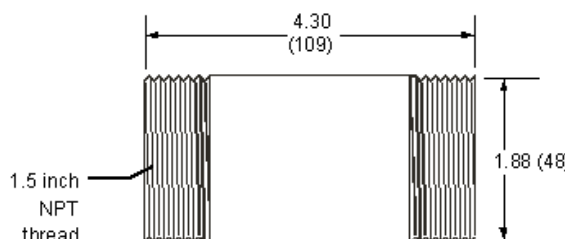
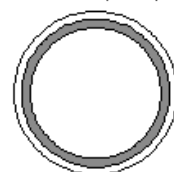
(\*\*) At default update rate. Output currents not included. Sensitivity reduced below 15 VDC input voltage.

## Part Numbers

Model Number	Description
TSPC-15S-232	Serial RS-232 interface (PC COM port compatible)
TSPC-15S-485	Serial RS-485 interface (allows addressable multi-sensor networks)
Senix also offers interconnection, communications, mounting, and display components	

## Dimensions

Dimensions in  
Inches (mm)



### Mechanical

Mounting: 1.5 inch NPT thread, top or bottom

Attached Cable: 6.5ft (2 m)

Total Weight: 22.6 oz. (0.64 kg)

# WET/WET DIFFERENTIAL PRESSURE TRANSDUCER

## UNI-DIRECTIONAL AND BI-DIRECTIONAL RANGES

**0-1 to 0-100 psid Uni-Directional**  
**±0.5 to ±50 psid Bi-Directional**

### PX2300 Series



- ✓ **0.25% Accuracy**
- ✓ **NEMA 4 (IP65) Rating**
- ✓ **Wet/Wet Corrosive Environments**
- ✓ **Ideal for Measuring Pressure Drop Across Filters**

OMEGA's PX2300 Series high-output, low differential pressure transducers are compatible with most media, from dry air to corrosive liquids. All wetted parts are stainless steel with elastomer seals. The electronics are housed in a NEMA 4 (IP65) enclosure. A high working pressure and high overpressure ratings ensure dependability in harsh industrial environments. These transducers are ideal for measuring pressure drop across filters and other process devices.

### SPECIFICATIONS

**Excitation:** 24 Vdc nominal

**Max:** 30 + 0.004 x  
(loop resistance Ω) Vdc

**Min:** 11 + 0.02 x  
(loop resistance Ω) Vdc

**Loop Resistance:** 0 to 1000 Ω

**Output:** 4 to 20 mA

**Accuracy:** ±0.25% RSS FS at constant temperature (includes linearity, repeatability and hysteresis)

**Linearity:** ±0.20% FS

**Hysteresis:** 0.10% FS

**Repeatability:** ±0.05% FS

**Operating Temperature Range:**

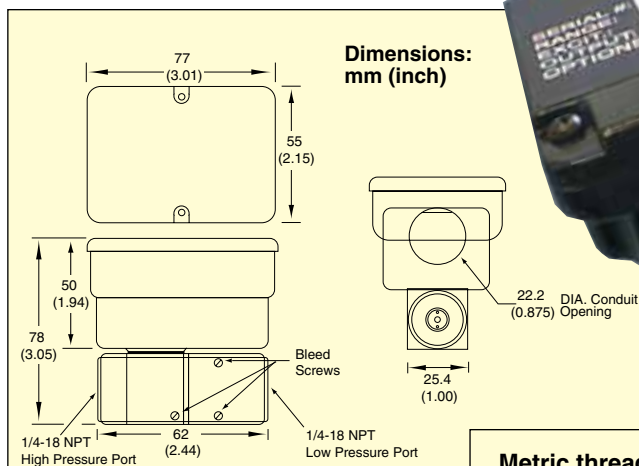
-18 to 80°C (0 to 176°F)

**Compensated Temperature Range:**

-1 to 65°C (30 to 149°F)

**Thermal Zero Effect:** <±0.02% FS/°F

**Thermal Span Effect:** <±0.02% FS/°F



**Sensor:** Capacitive

**Maximum Line Pressure:** 250 psig

**Maximum Overpressure:**

**High Side:** 1 to 5 psi = 20 x FS,  
10 to 25 psi = 10 x FS, 50 psi = 5 x FS,  
100 psi = 2.5 x FS

**Low Side:** 2.5 x FS (shift recoverable)

The zero will shift slightly when high differential pressure is applied. The shift may be as much as ±10% FS with overpressure applied to the low port. (Other parameters will not shift.) The shift may be recovered by a positive overpressure or if the overpressure is always in one direction, the user may apply this pressure to pre-set the sensor. Subsequent overloads of less pressure will not cause any further shift.

**Metric thread adaptors and snubbers available, visit us online.**

PX2300-1DI, shown smaller than actual size.

**Wetted Parts:** Air and fluids compatible with 17-4 and 300 stainless steel, FKM, and silicone O-rings

**Cavity Volume:** 0.27/0.08" pos./neg. port

**Case:** NEMA 4 (IP65)

**Pressure Port:** ¼ NPT internal

**Electrical Connection:** Internal barrier strip with 22.2 mm (0.875") conduit opening

**Response Time:** 50 ms (water)

**Weight:** 410 g (14.4 oz)

### To Order

RANGE (psid)	MODEL NO.	COMPATIBLE METERS
0 to 1	PX2300-1DI	DP41-E, DP25B-E, DP-7700
0 to 2	PX2300-2DI	DP41-E, DP25B-E, DP-7700
0 to 5	PX2300-5DI	DP41-E, DP25B-E, DP-7700
0 to 10	PX2300-10DI	DP41-E, DP25B-E, DP-7700
0 to 25	PX2300-25DI	DP41-E, DP25B-E, DP-7700
0 to 50	PX2300-50DI	DP41-E, DP25B-E, DP-7700
0 to 100	PX2300-100DI	DP41-E, DP25B-E, DP-7700
<b>BI-DIRECTIONAL RANGE</b>		
±0.5	PX2300-0.5BDI	DP41-E, DP25B-E, DP-7700
±1	PX2300-1BDI	DP41-E, DP25B-E, DP-7700
±2.5	PX2300-2.5BDI	DP41-E, DP25B-E, DP-7700
±5	PX2300-5BDI	DP41-E, DP25B-E, DP-7700
±10	PX2300-10BDI	DP41-E, DP25B-E, DP-7700
±25	PX2300-25BDI	DP41-E, DP25B-E, DP-7700
±50	PX2300-50BDI	DP41-E, DP25B-E, DP-7700

Comes complete with operator's manual.

**Ordering Examples:** PX2300-5BDI, bi-directional range -5 to 5 psid transducer with current output.

PX2300-1DI, 0 to 1 psid range transducer with current output.



# IMPRESS

SENSORS & SYSTEMS

Unit 6 Mercury House, Calleva Park  
Aldermaston, Berkshire, RG7 8PN  
Tel: +44 (0)118 981 7980  
Fax: +44 (0)118 981 7990  
e-mail: sales@impress-sensors.co.uk  
Website: www.impress-sensors.co.uk

Pressure - Temperature - Level - Distance - Control - Indication - Data logging

## Calibration Certificate

Customer Order Number Brent Cragi		Impress Sales Order IMPS-19808 Line 1	
Type IMCL-G0360-5B2-BAV-012-000		Operator Joseph Witherall	Date 23/11/15
Supply 9 - 32V dc	Range 0 - 3.6mW G	Output 4 - 20mA / 2-wire	Test Voltage 12Vdc

0 - 35300 Pa

Serial Number	Zero	FSO	Span	Non-Linearity
360870	4.030	20.000	15.970	-0.016
360871	4.010	20.040	16.030	0.016

360870  $0 - 3.6 \text{ mW/G} \Rightarrow \frac{3.6}{0.015970} = 225.4226675$   
 $0 - 35,300 \text{ Pa} \Rightarrow \frac{35300}{0.015970} = 2,210,394.4896681$

360871  $0 - 3.6 \text{ mW/G} \Rightarrow \frac{3.6}{0.016030} = 224.5789145$   
 $0 - 35,300 \text{ Pa} \Rightarrow \frac{35300}{0.016030} = 2,202,121.0230817$

Note: Non-Linearity = % of Span BFSL

## Wiring Designation

		PUR Sheath	PVC Sheath	FEP Sheath
2-wire	+ve Supply	Red	Brown	Brown
	-ve Supply	Blue	White	White
	Housing	White	Pink	Pink
	Cable Screen	Green	Green	Green
3-wire	+ve Supply	Red	Brown	Brown
	-ve Supply	Blue	White	White
	+ve Output	Yellow	Yellow	Yellow
	Housing	White	Pink	Pink
4-wire	Cable Screen	Green	Green	Green
	+ve Supply	Red	Brown	Brown
	-ve Supply	Blue	White	White
	+ve Output	White	Pink	Pink
	-ve Output	Yellow	Yellow	Yellow
	Cable Screen	Green	Green	Green

# HIGH ACCURACY TRANSDUCERS

## MICRO-MACHINED SILICON

### FOR BAROMETRIC PRESSURE MEASUREMENT

**Barometric Pressure Absolute Pressure**  
**Outputs: mV/V, 0 to 5V, 0 to 10V**  
**or 4 to 20 mA**  
**0 to 32, 16 to 32 or 26 to 32 inHg**  
**0 to 1100, 550 to 1100, 880 to 1100 hPa**

## PX409 Series



Standard

- ✓ **High Accuracy**  
±0.08% BSL Includes Linearity, Hysteresis, and Repeatability
- ✓ **Broad Temperature Compensated Range**  
-18 to 85°C (0 to 185°F)
- ✓ **Premium Temperature Performance**  
Span: ±0.5% Over Compensated Range
- ✓ **5-Point NIST Traceable Calibration Included**
- ✓ **All Stainless Steel Wetted Parts**
- ✓ **Fast Response Time**
- ✓ **Solid State Reliability and Stability**
- ✓ **400% Proof Pressure**

OMEGA's PX409 series electronic barometers are high-accuracy barometers available in three ranges: 16 to 32 inHg, 26 to 32 inHg, or 0 to 32 inHg (absolute pressure) for laboratory or industrial test applications. Models with integral cables (PX409) are IP67 while connector styles (PX419 and PX429) are IP65 rated. They feature all stainless steel construction, which makes them ideal for harsh industrial environments. Their high operating

temperature, broad compensated range, and excellent temperature compensation allow stable readings in applications with fluctuating temperatures commonly found where barometric pressure must be monitored. Models are available with millivolt, voltage or current outputs.

Metric threads available

Cable style

**M12 Connector also Available See To Order Chart**

IP67 rated  
PX409-32BV

Twist-lock style

IP65 rated  
PX429-26BI

mini DIN style

IP65 rated  
PX419-16B5V

All shown actual size.

## SPECIFICATIONS

### Output:

**Millivolt:** 10 mV/V (100 mV @ 10 Vdc)

**Amplified Voltage:** 0 to 5 Vdc or 0 to 10 Vdc

**Current Loop:** 4 to 20 mA

### Power Requirements:

**Millivolt:** 5 to 10 Vdc (5 mA @ 10 Vdc)

### Amplified Voltage:

**0 to 5 Vdc Supply Voltage:**

10 to 30 Vdc @ 10 mA

**0 to 10 Vdc Supply Voltage:**

15 to 30 Vdc @ 10 mA

**Current Loop:** 9 to 30 Vdc

[max loop res = (Vs-9) x 50];  
[9 to 20 Vdc above 105°C (229°F)]

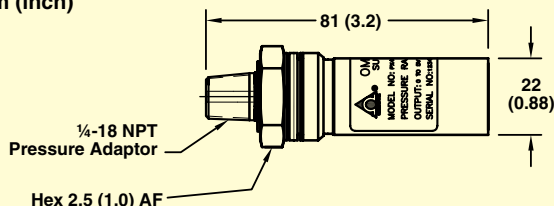
### Accuracy (Combined Linearity, Hysteresis and Repeatability):

±0.08% BSL

**Zero Balance:** ±0.5% FS typical, 1% max

**Span Setting:** ±0.5% FS typical, 1% max; calibrated in vertical direction with fitting down

Dimensions: mm (inch)



# HIGH ACCURACY, MICRO-MACHINED SILICON TRANSDUCERS

All models shown  
smaller than actual size.



IP67 rated  
PX409-32BV



IP65 rated  
PX419-16B5V



IP65 rated  
PX429-26BI

PX409 and PX409C CABLE CONNECTION			
COLOR	mV	5/10V	mA
Black	- EXC	Common	- Supply
White	+ SIG	+ Output	NC
Green	- SIG	NC	NC
Red	+ EXC	+ EXC	+ Supply

PX419 and PX459 PIN OUT			
PIN	mV	5/10V	mA
1	+ EXC	+ EXC	+ Supply
2	- EXC	Common	- Supply
3	+ SIG	+ Output	NC
4	- SIG	NC	NC

PX429 TWIST LOCK PINOUT			
PIN	mV	5/10V	mA
A	+ EXC	+ EXC	+ Supply
B	- EXC	Common	- Supply
C	+ SIG	+ Output	NC
D	- SIG	NC	NC
E	NC	NC	NC
F	NC	NC	NC

**Operating Temperature Range:**  
-45 to 121°C (-49 to 250°F) [-45 to 115°C (-49 to 240°F) for voltage or current outputs]

**Compensated Temperature:**  
**Ranges > 5 psi:** -29 to 85°C (-20 to 185°F)  
**Ranges ≤ 5 psi:** -18 to 85°C (0 to 185°F)

**Thermal Effects Span (Over Compensated Range):**  
**Ranges > 5 psi:** ±0.5% span  
**Ranges ≤ 5 psi:** ±1% span

**Long Term Stability (1-Year):**  
±0.1% FS typical

**Shock:** 50 g, 11 ms half sine, vertical and horizontal axis

**Vibration:** 5-2000-5 Hz, 30 minute cycle, Curve L, Mil-Spec 810 figure 514-2-2, vertical and horizontal axis

**Response Time:** <1 ms

**Bandwidth:** DC to 1 kHz typical

**Proof Pressure:** 400% of span

**Burst Pressure:** 1000 psia

**Electrical Termination:**

**PX409:** Integral 2 m (6') cable

**PX419:** mini DIN

**PX429:** Twist-lock

**Mating Connectors:**

**PX419:** CX5302 (included)

**PX429:** PT06F10-6S

(sold separately)

**Environmental Protection:**

**PX409:** IP67

**PX419:** IP65

**PX429:** IP65

**PX459:** IP65

**Wetted Parts:** 316 SS

**Pressure Port:** ¼-18 NPT male

**Weight:** 115 to 200 g (4 to 7 oz)  
depending upon configuration

## To Order

CALIBRATED RANGE		mV/V OUTPUT	5 Vdc** OUTPUT	4 to 20 mA OUTPUT
inHg	hPa			
BAROMETRIC RANGES (Absolute Pressure)				
0 to 32 inHg	—	PX4[*]9-32BV	PX4[*]9-32B5V	PX4[*]9-32BI
16 to 32 inHg	—	PX4[*]9-16BV	PX4[*]9-16B5V	PX4[*]9-16BI
26 to 32 inHg	—	PX4[*]9-26BV	PX4[*]9-26B5V	PX4[*]9-26BI
—	0 to 1100 hPa	PX4[*]9-32HBV	PX4[*]9-32HB5V	PX4[*]9-32HBI
—	550 to 1100 hPa	PX4[*]9-16HBV	PX4[*]9-16HB5V	PX4[*]9-16HBI
—	880 to 1100 hPa	PX4[*]9-26HBV	PX4[*]9-26HB5V	PX4[*]9-26HBI

## ACCESSORIES

MODEL NO.	DESCRIPTION
PT06F10-6S	Mating connector for PX429 series, sold separately
CX5302	Spare mating connector for PX419 series; one included with each unit
M12C-PVC-4-S-F-5	PVC cable, straight 4-pin M12 female connector one end, flying leads one end, 5 m (16.4') long, fits PX459
M12C-PVC-4-R-F-5	PVC cable, right angled 4-pin M12 female connector one end, flying leads one end, 5 m (16.4') long, fits PX459
-MB	Mounting bracket, factory installed

\*\* For 0 to 10 Vdc output replace "5V" with "10V" in model number.

[\*] Select Electrical Termination (no extra charge).

Insert "0" for 2 m (6') cable with flying leads.

For ½ NPT conduit connector order **PX409CS**.

Insert "1" for Mini DIN connector (mating connector included).

Insert "2" for Twist-lock connector (mating connector **PT06F10-6S** sold separately).

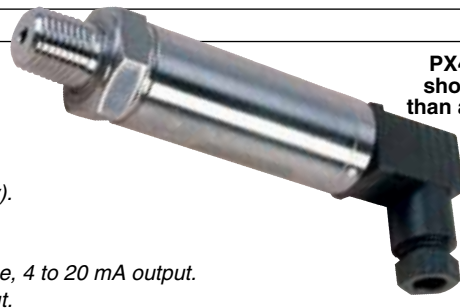
Insert "5" for M12 connector, M12 cables sold separately.

Custom configurations also available.

**Ordering Examples:** **PX409-32BI**, cable termination, 0 to 32 inHg barometric range, 4 to 20 mA output.

**PX459-32HB5V**, M12 connector, 0 to 1100 hPa barometric range, 0 to 5 Vdc output.

**PX419-16HBV** mini DIN termination, 550 to 1100 hPa barometric range, mV/V output.



PX419-26B5V,  
shown smaller  
than actual size.

mini DIN  
style

VOLTAGE OUTPUT  
PRESSURE TRANSDUCERS  
**B**



# LFS 242 - TENSION/COMPRESSION CELL

The LFS 242 is a low range load cell, which provides high accuracy for weighing or force measurement applications. This cell is made of aluminum, but is durable enough for most applications. The LFS 242 has 10-32 UNC threads on both ends of the transducer for easy installation.

## SPECIFICATIONS

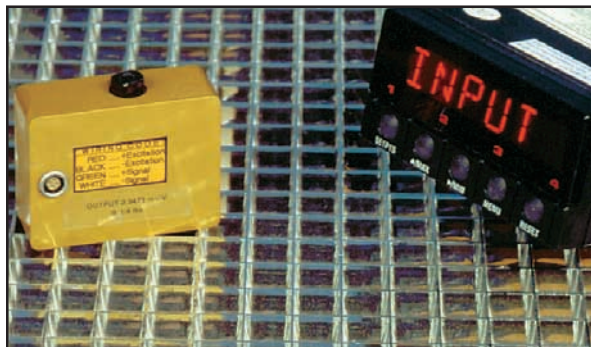
LOAD RANGES:	.25 lb to 100 lb
LINEARITY:	±0.05%
HYSTERESIS:	±0.05%
REPEATABILITY:	±0.05%
MATERIAL:	Aluminum
TEMPERATURE RANGE:	60° to 160° F
OUTPUT:	2 mv/v
BRIDGE RESISTANCE:	1000 ohm
EXCITATION:	18Vdc Max
SAFE OVERLOAD:	150% of capacity
CABLE:	Connector & cable assembly optional - 10 Ft standard

## AVAILABLE RANGES

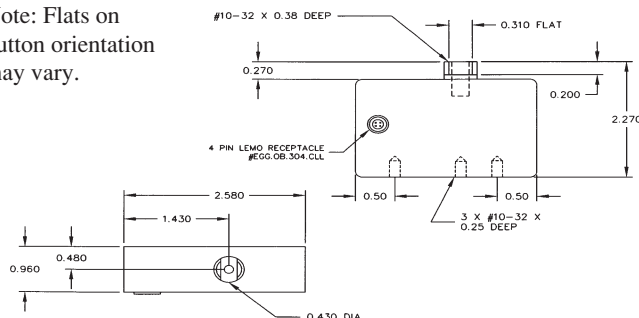
.25, .5, 1, 2.2, 5, 10, 25, 50, 100 lbs.

10 gram range unit available, consult Cooper for specifications.

- ALUMINUM CONSTRUCTION
- COMPACT SIZE
- HIGH ACCURACY



Note: Flats on button orientation may vary.



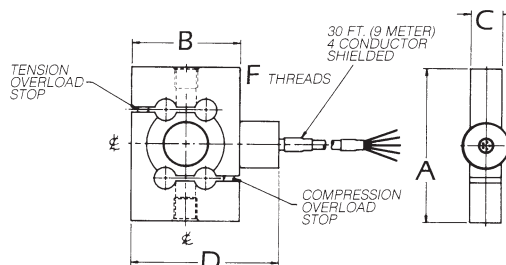
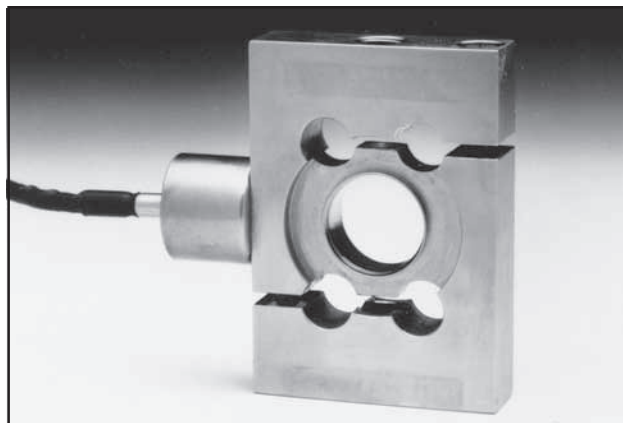
# LFS 250 - HERMETICALLY SEALED S-BEAM

The LFS 250 is a dual cantilevered, hermetically sealed, stainless steel beam load cell. This cell is designed for both tension and compression and harsh environments, where other cells will not work. It is capable of withstanding significant side load without physical damage. The LFS 250 uses proven sealing techniques that provide superior waterproofing and combines welded metal seals and a water block cable entry system which will resist leakage.

## SPECIFICATIONS

LOAD RANGES:	100 to 10,000 lbs
ACCURACY:	0.03% F.S.
REPEATABILITY:	0.01% F.S.
MATERIAL:	Stainless Steel
TEMPERATURE RANGE:	0° to 150° F
OUTPUT:	3 ±.003 mv/v
BRIDGE RESISTANCE:	350 ohm
EXCITATION:	15Vdc Max
SAFE OVERLOAD:	150% F.S.
CABLE:	30 Ft

- 100 TO 10,000 LBS
- WELDED STAINLESS STEEL
- EXCEEDS NEMA 6 FOR WASHDOWN



## AVAILABLE RANGES

	A"	B"	C"	D"	F"
100, 250 lb	3.32	2.48	0.94	3.36	3/8-24 UNF
500 lb	3.50	2.44	0.71	3.32	1/2-20 UNF
1000 lb	3.50	2.94	0.71	3.81	1/2-20 UNF
2500 lb	3.75	2.44	0.95	3.31	1/2-20 UNF
5,000, 10,000 lb	4.75	2.44	1.44	3.31	1-14 UNS



# ***LOW PROFILE LOAD CELLS***

## ***WATERPROOF FOR WET OR WASHDOWN APPLICATIONS***

**5 to 500,000 lb Capacities**  
**2.3 kgf to 225T Capacities**

## ***LSHD Series Compression***



### Standard

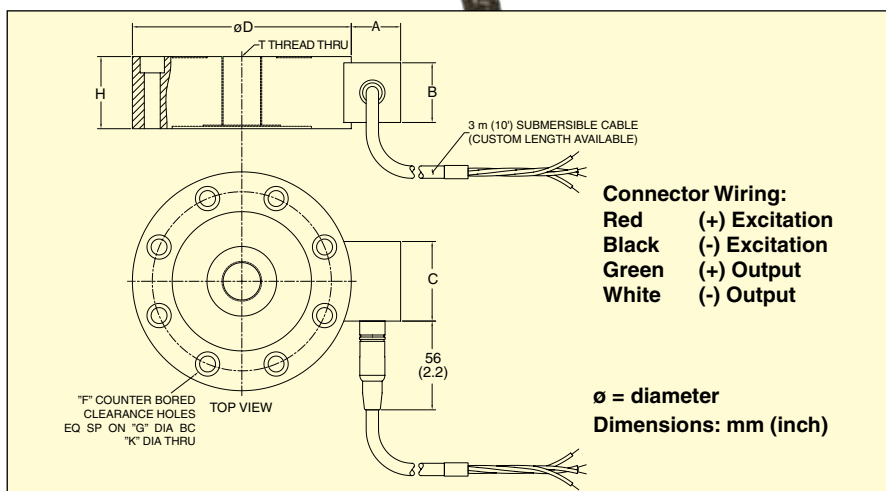
- ✓ **High Accuracy**
- ✓ **5-Point NIST Traceable Calibration Included**
- ✓ **Hermetically Sealed for Wet and Submerged Applications**
- ✓ **All Stainless Steel Construction for Harsh Industrial Environments**
- ✓ **1% Interchangeability for Scale Applications**
- ✓ **High Capability to Resist Side Loads**
- ✓ **Low Profile for Easy Installations**
- ✓ **3 m (10') Waterproof Cable Standard**

The LSHD Series load cells are hermetically sealed and have a high pressure, high temperature molded cable seal to assure long life in wet or submerged applications such as truck or rail scales. They are supplied with a standard length of 3 m (10') of cable, however longer lengths are available. Many standard lengths are stocked plus custom lengths are also available.



LSHD

**Waterproof high pressure molded cable connection.**



## SPECIFICATIONS

**Excitation:** 10 Volts, 15 Vdc maximum

**Output Ranges  $\leq 25$  lb: 2 mV/V  $\pm 1\%$**

Ranges > 25 lb: 3 mV/V  $\pm$  1%

**Calibration:** 5 points in tension  
0%, 50%, 100%, 50%, 0% capacity

**Linearity  $\leq 25$  lb:  $\pm 0.2\%$  FSO**

Ranges > 25 lb:  $\pm 0.1\%$  FSO

**Hysteresis**  $\leq 25$  lb:  $\pm 0.1\%$  FSO  
 Ranges  $> 25$  lb:  $\pm 0.08\%$  FSO

**Repeatability**  $\leq 25$  lb:  $\pm 0.1\%$  FSO  
Ranges  $> 25$  lb:  $\pm 0.03\%$  FSO

**Zero Balance:  $\pm 1\%$  FSO**

**FS Deflection:** 0.025 to 0.075 mm  
(0.001 to 0.003")

**Operating Temperature:** -18 to 82°C  
(0 to 180°F)

**Compensated Temperature:**  
15 to 71°C (60 to 160°F)

### Thermal Effects:

**Span:**  $\pm 0.0036\%$  rdg/ $^{\circ}\text{C}$

**Zero:**  $\pm 0.0036\%$  FSO/ $^{\circ}\text{C}$

### Safe Overload: 150% Capacity

### Ultimate Overload: 300% Capacity

CAPACITY (LBS)	Dimensions: mm (inch)								
	D	H	K	G	F	T-THREADS	B	C	A
5 to 25	64 (2.50)	20 (0.80)	4.6 (0.18)	51 (2.00)	6	¼ – 28UNF–2B	19 (0.75)	32 (1.25)	23 (0.92)
50 to 1000	76 (3.00)	25 (1.00)	7 (0.28)	57 (2.25)	6	⅜ – 24UNF–2B	19 (0.75)	32 (1.25)	23 (0.92)
2000 to 5000	89 (3.50)	25 (1.00)	9 (0.34)	67 (2.63)	6	½ – 20UNF–2B	19 (0.75)	32 (1.25)	23 (0.92)
7500 to 15,000	140 (5.50)	46 (1.80)	10 (0.40)	114 (4.50)	8	1 – 14UNS–2B	38 (1.50)	51 (2.00)	32 (1.24)
20,000 to 50,000	152 (6.00)	46 (1.80)	13 (0.53)	124 (4.88)	8	1½ – 12UNF–2B	38 (1.50)	51 (2.00)	32 (1.24)
75,000 to 100,000	229 (9.00)	64 (2.50)	17 (0.66)	197 (7.75)	12	2 – 12UN–2B	38 (1.50)	51 (2.00)	32 (1.24)
150,000 to 200,000	279 (11.00)	76 (3.00)	20 (0.78)	241 (9.50)	12	2½ – 12UN–2B	38 (1.50)	51 (2.00)	32 (1.24)
300,000 to 500,000	356 (14.00)	108 (4.25)	25 (1.00)	298 (11.75)	12	3½ – 8UN–2B	38 (1.50)	51 (2.00)	32 (1.24)

# WATERPROOF LOAD CELLS

**Bridge Resistance:** 350  $\Omega$  nominal

**Protection Level:** IP68

**Electrical Connection:** 3 m (10')  
submersible cable

*Other lengths available see table*

**Construction:** 17-4 pH stainless steel

**Submersible Depth:**

**5 to 10K Range:** 3 m (10')

**20 to 50K Range:** 6 m (20')

**75 to 500K Range:** 15 m (50')

## SUBMERSIBLE CABLE

LENGTH	LENGTH cont'd
0.6 m (2')	15.2 m (50')
1.5 m (5')	18.3 m (60')
3.0 m (10')	19.8 m (65')
4.5 m (15')	22.8 m (75')
6.0 m (20')	30.4 m (100')
7.6 m (25')	45.7 m (150')
9.1 m (30')	60.9 m (200')
12.2 m (40')	91.4 m (300')

*Custom cable length available.*

## POPULAR OPTIONS

DESCRIPTION	SUFFIX
<b><math>\pm 5</math> Vdc Output</b> (calibrated 0 to 5 Vdc in tension)	<b>“-5T”</b> (Ranges 75k)
<b>Overload Stops</b>	<b>Consult factory</b>
<b>Dual Bridge</b>	<b>Available</b>

## To Order

CAPACITY		MODEL NO.	COMPATIBLE METERS	LOAD BUTTON	ROD END
lb	kg				
5	2.3	LSHD-5	DP41-S, DP25B-S, DPi8-S	LBC-14	REC-014M
10	4.5	LSHD-10	DP41-S, DP25B-S, DPi8-S	LBC-14	REC-014M
25	11	LSHD-25	DP41-S, DP25B-S, DPi8-S	LBC-14	REC-014M
50	23	LSHD-50	DP41-S, DP25B-S, DPi8-S	LBC-38	REC-038M
100	45	LSHD-100	DP41-S, DP25B-S, DPi8-S	LBC-38	REC-038M
250	114	LSHD-250	DP41-S, DP25B-S, DPi8-S	LBC-38	REC-038M
500	227	LSHD-500	DP41-S, DP25B-S, DPi8-S	LBC-38	REC-038M
1000	455	LSHD-1K	DP41-S, DP25B-S, DPi8-S	LBC-38	REC-038M
2000	909	LSHD-2K	DP41-S, DP25B-S, DPi8-S	LBC-012	REC-012M
3000	1.3T	LSHD-3K	DP41-S, DP25B-S, DPi8-S	LBC-012	REC-012M
4000	1.8T	LSHD-4K	DP41-S, DP25B-S, DPi8-S	LBC-012	REC-012M
5000	2.2T	LSHD-5K	DP41-S, DP25B-S, DPi8-S	LCB-012	REC-100M
7500	3.4T	LSHD-7.5K	DP41-S, DP25B-S, DPi8-S	LBC-100	REC-100M
10,000	4.5T	LSHD-10K	DP41-S, DP25B-S, DPi8-S	LBC-100	REC-100M
15,000	6.8T	LSHD-15K	DP41-S, DP25B-S, DPi8-S	LBC-100	REC-100M
20,000	9.1T	LSHD-20K	DP41-S, DP63900-S	LBC-112	REC-112M
30,000	13T	LSHD-30K	DP41-S, DP63900-S	LBC-112	REC-112M
50,000	22T	LSHD-50K	DP41-S, DP63900-S	LBC-112	REC-112M
75,000	34T	LSHD-75K	DP41-S, DP63900-S	—	—
100,000	45T	LSHD-100K	DP41-S, DP63900-S	—	—
150,000	68T	LSHD-150K	DP41-S, DP63900-S	—	—
200,000	90T	LSHD-200K	DP41-S, DP63900-S	—	—
300,000	135T	LSHD-300K	DP41-S, DP63900-S	—	—
400,000	180T	LSHD-400K	DP41-S, DP63900-S	—	—
500,000	225T	LSHD-500K	DP41-S, DP63900-S	—	—

*Comes complete with 5-point NIST traceable calibration certificate, 59K shunt data, and 3 m (10') cable.*

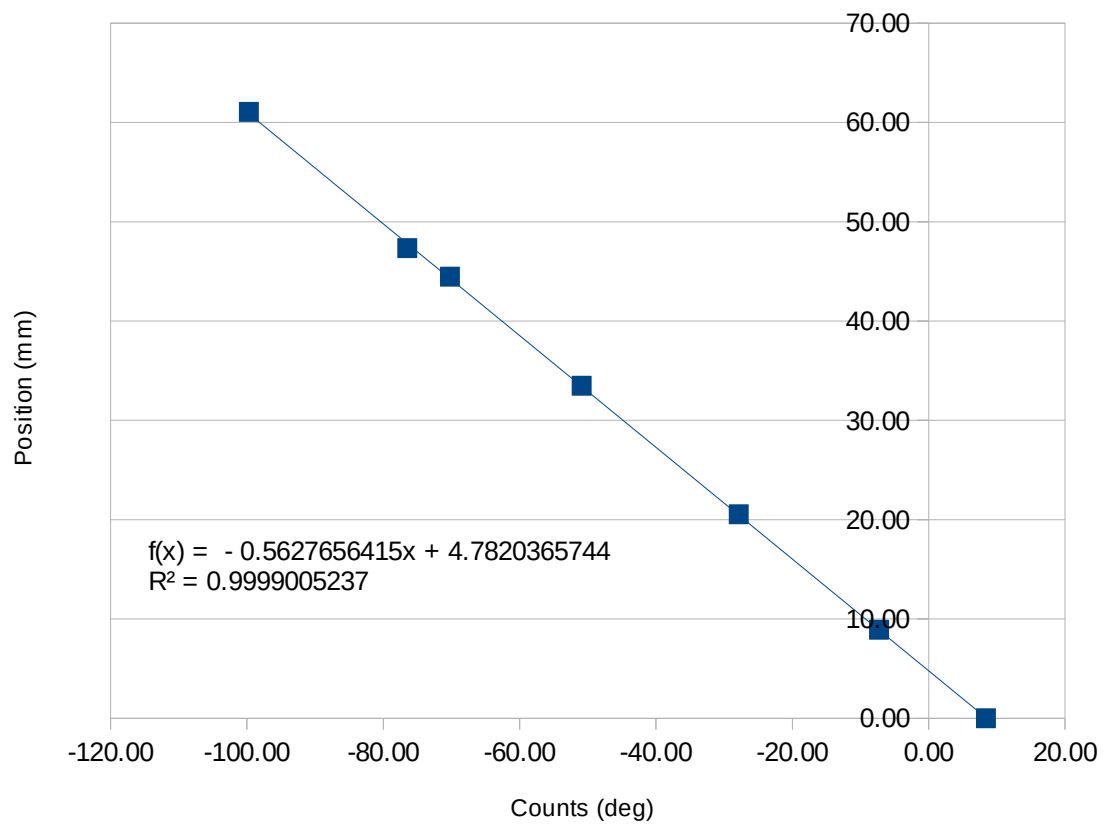
**Note:** Ranges over 300,000 lb are calibrated at 300,000 lb.

**Ordering Examples:** LSHD-500 is a 500 lb range waterproof load cell.

LSHD-20K, 20,000 lb range waterproof load cell.

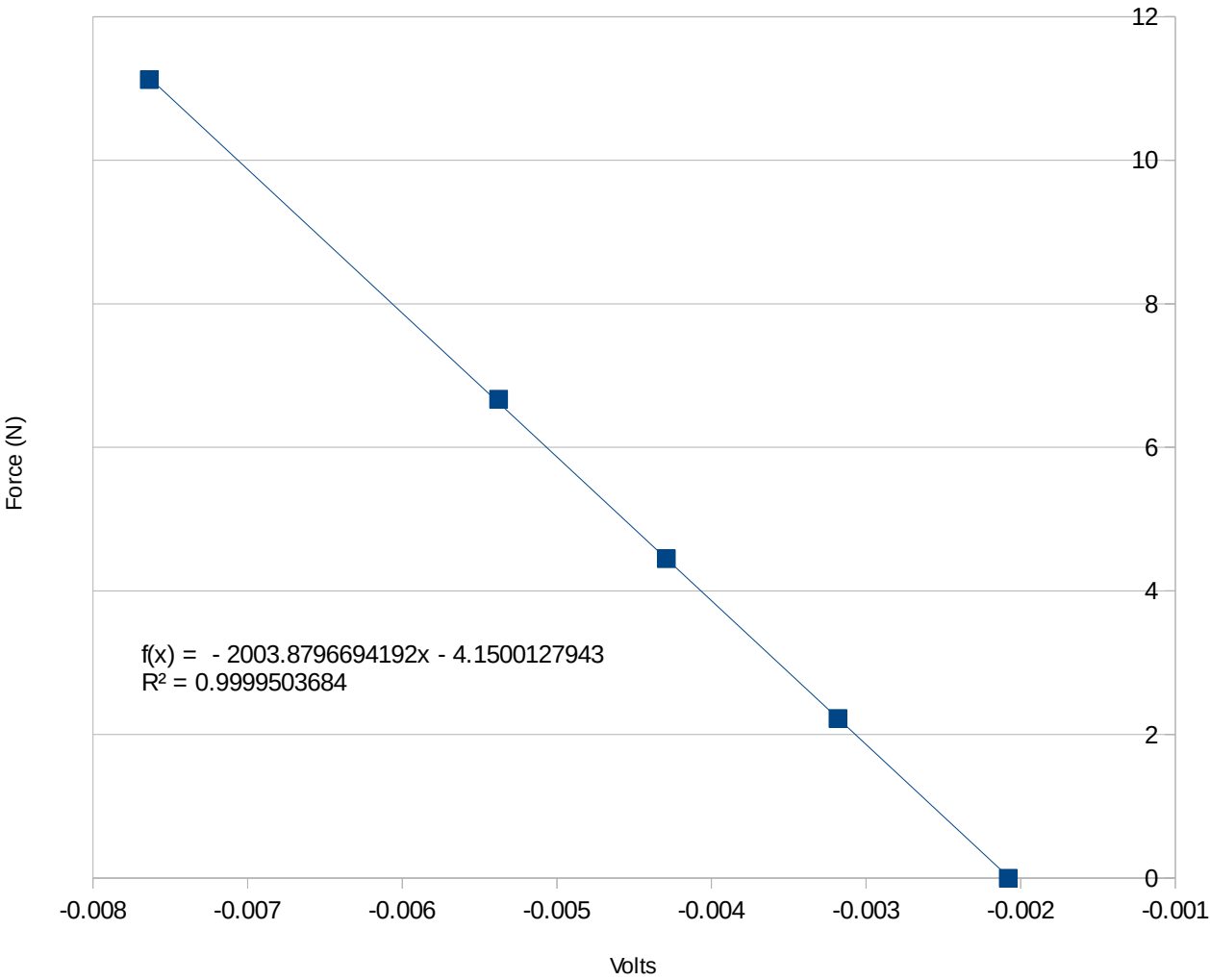
Counts (deg)	Position (mm)
8.393556	0.00
-7.294922	8.91
-27.861328	20.55
-50.888672	33.49
-70.224609	44.48
-76.464844	47.35
-99.711914	61.06

Rotary Encoder Calibration



Volts	Moment arm inches	Moment arm mm	Weight grams	Moment Gram-mm	Moment Inch-pounds	Moment N-m	Force Newtons
-0.002080496	1.2755	32.3977	0	0	0	0	0
-0.003181283	1.2755	32.3977	226.7	7344.55859	0.637479527	0.072025515	2.223167555
-0.004290965	1.2755	32.3977	453.7	14698.83649	1.275802652	0.144146345	4.449277105
-0.005376204	1.2755	32.3977	680.4	22043.39508	1.913282179	0.21617186	6.67244466
-0.007635618	1.2755	32.3977	1134.1	36742.23157	3.189084831	0.360318205	11.12172177

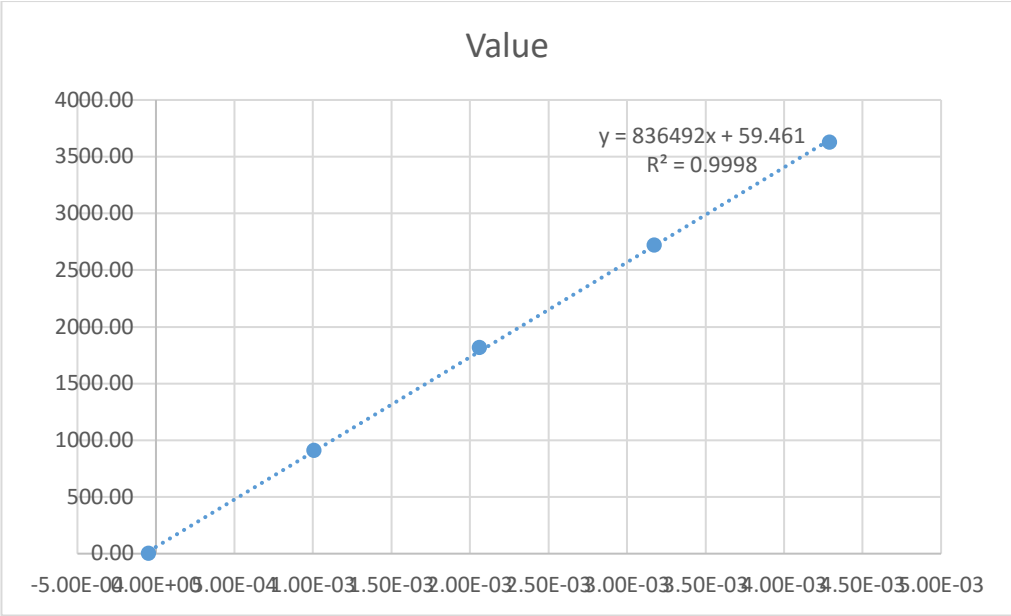
Torque Sensor Calibration





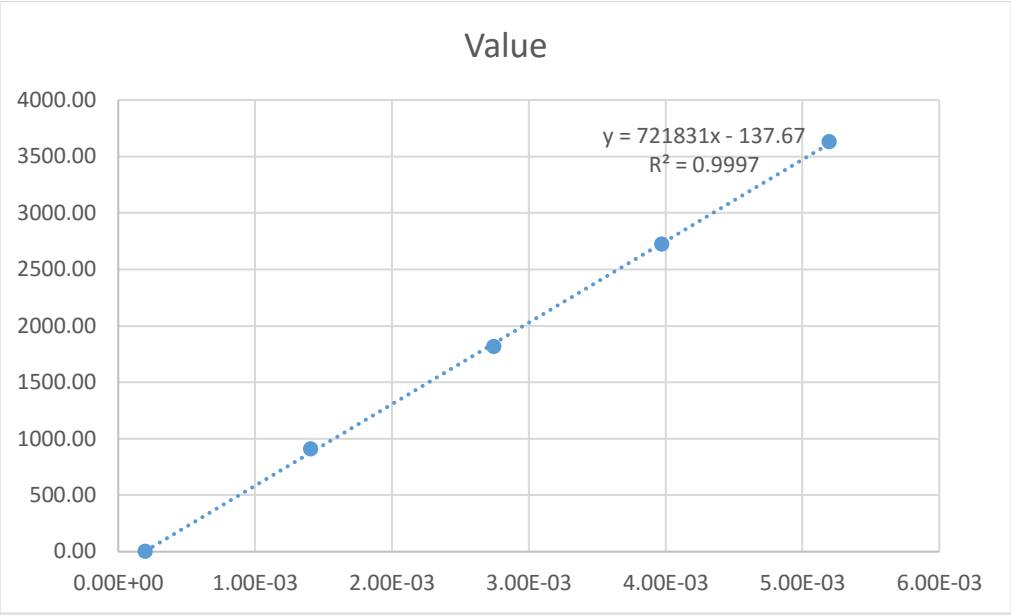
LC1

Volts	Value
-0.000046898	0.00
0.001008290	907.20
0.002061702	1814.10
0.003174659	2721.00
0.004289967	3627.90



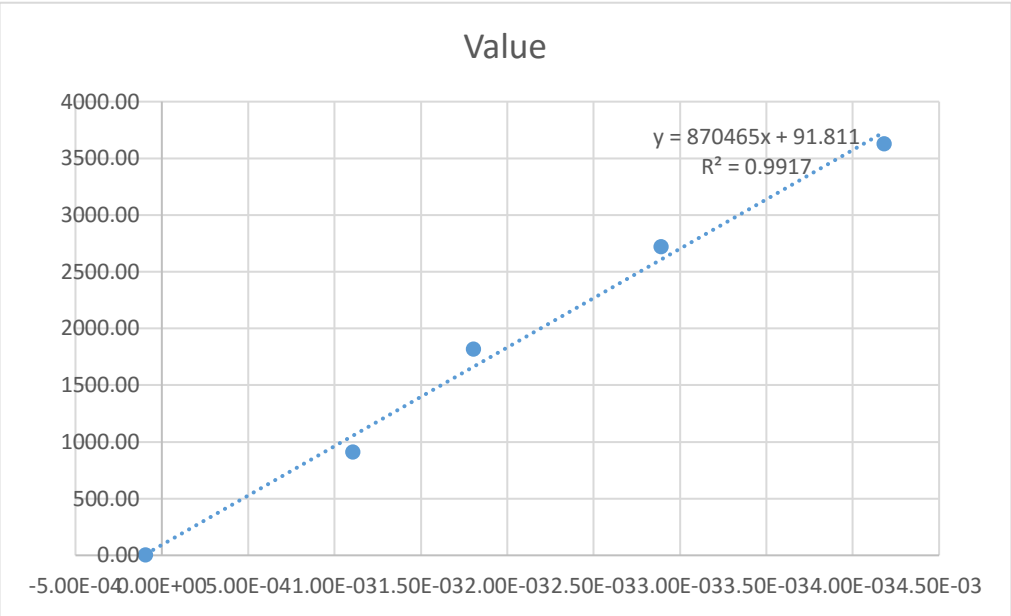
LC2

Volts	Value
0.000198811	0.00
0.001406245	907.20
0.002744715	1814.10
0.003973473	2721.00
0.005195947	3627.90



LC3

Volts	Value
-0.000092145	0.00
0.001106929	907.20
0.001804983	1814.10
0.002890607	2721.00
0.004182205	3627.90



LC4

Volts	Value
0.000260554	0.00
0.001415309	907.20
0.002625235	1814.10
0.003852582	2721.00
0.005070189	3627.90

