Calibration and Quality Assurance Certificate

Date: November 8, 2010

Model: **HydroRad-2 / Series 300** **Serial Number:** HR061152

Instrument Specifications

Channel A--Ed		**Channel B—NA**	
Spectrometer:	S2000	Spectrometer:	S2000
Grating:	600 lines @ 400nm	Grating:	600 lines @ 400nm
Lens:	L2	Lens:	L2
Slit:	50 micron	Slit:	50 micron
Filter:	Second order	Filter:	Second order
Pixel Resolution:	<0.4 nm	Pixel Resolution:	<0.4 nm
Collector:	Irradiance, water-optimized	Collector:	Radiance, 6° FOV in water
External fiber:	3 meters, 200 micron core	External fiber:	3 meters, 200 micron core
Channel C—NA		**Channel D—NA**	
Spectrometer:		Spectrometer:	
Grating:		Grating:	
Lens:		Lens:	
Slit:		Slit:	
Filter:		Filter:	
Pixel Resolution:		Pixel Resolution:	
Collector:		Collector:	
External fiber:		External fiber:	

Calibration Type: Comprehensive **Last Cal:** **February 2007**

Technician: DRD

Notes: _____

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Calibration and Quality Assurance Statement

HOBI Labs certifies that this instrument was carefully calibrated and thoroughly tested for scientific accuracy and proper operating condition at our factory calibration facility. The radiometric calibration is performed with a NIST traceable light source using scientifically accepted methods. Wavelength calibration is performed using a Mercury-Argon light source. Nonlinear responses are measured over the entire dynamic range of each spectrometer and corrected for. Dark signal is measured over the entire operating temperature range and integration times for automatic dark signal corrections. Immersion correction is measured in a wet tank for irradiance collectors. Radiometric calibration is tested against the calibrated light source as well as in sunlight against a second, calibrated, known spectrometer for consistency and repeatability.

Calibration and Quality Control Results

A synopsis of the calibration and quality control tests of each spectrometer channel are shown graphically below. A brief description for interpreting these graphs follows. Please contract HOBI Labs for additional information.

Graph Title: **Wavelengths**

Description: The channel is illuminated with a Mercury-Argon light source, which emits narrow peaks at known wavelengths. The peaks in the measured spectrum are correlated with the known wavelengths and a second-order polynomial fit is calculated to translate pixel number (from 1 to 2048) into wavelength (in nm).

Graph Title: **Integration Time Intercept and Nonlinearity Correction**

Description: Under stable illumination, the integration time is varied over a wide range of values, with dark exposures taken at each time as well. The plot on the left shows output versus integration time. When extrapolated, these lines should intercept zero signal at zero integration time. Any offset is measured by this process and accounted for in subsequent calibration steps. The plot on the right shows deviation from a linear relationship between signal and integrated illumination over the entire dynamic range. Deviations are measured and fit with an additive correction function (ACF). The ACF is added to future raw signals to compensate for this nonlinearity.

Graph Title: **Radiometric Calibration and Saturation Limit**

Description: The light collector is illuminated with a NIST-traceable irradiance standard, in a carefully controlled setup. The known irradiance or radiance is divided by the spectrometer's response, after compensating for dark offsets, integration time, and nonlinearity. The left axis of the plot is the resulting calibration factor. The right axis shows the maximum measurable signal.

Graph Title: **Comparison to Calibrated Source**

Description: After the full calibration is completed, it is verified by applying it to measurements of the same standard used for the radiometric calibration.

Graph Title: **Example Calibrated Data**

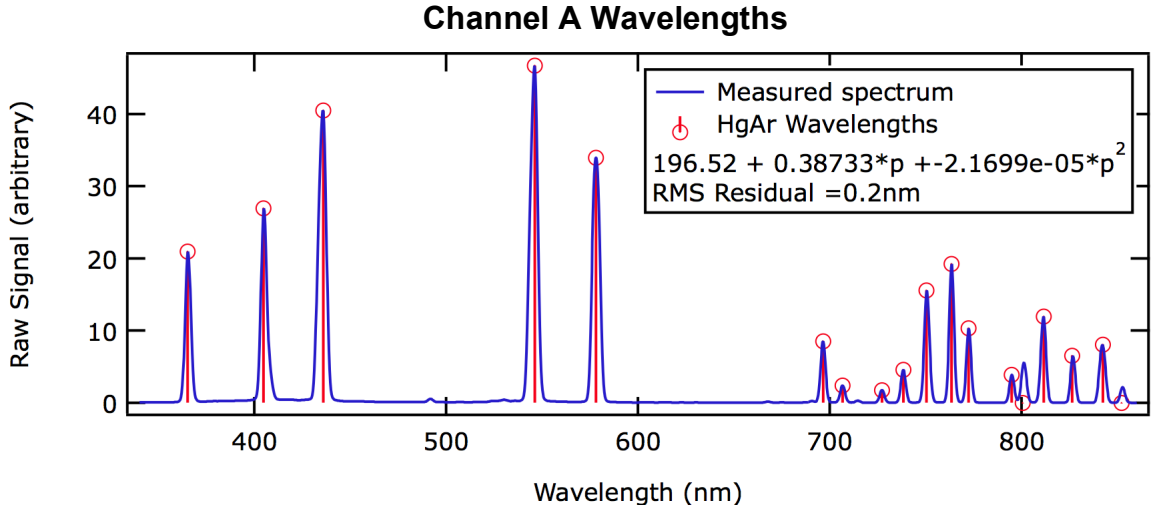
Description: The fully calibrated system is used to measure the natural spectrum outdoors, to verify that it functions properly under non-laboratory conditions, and with the complex solar spectrum.

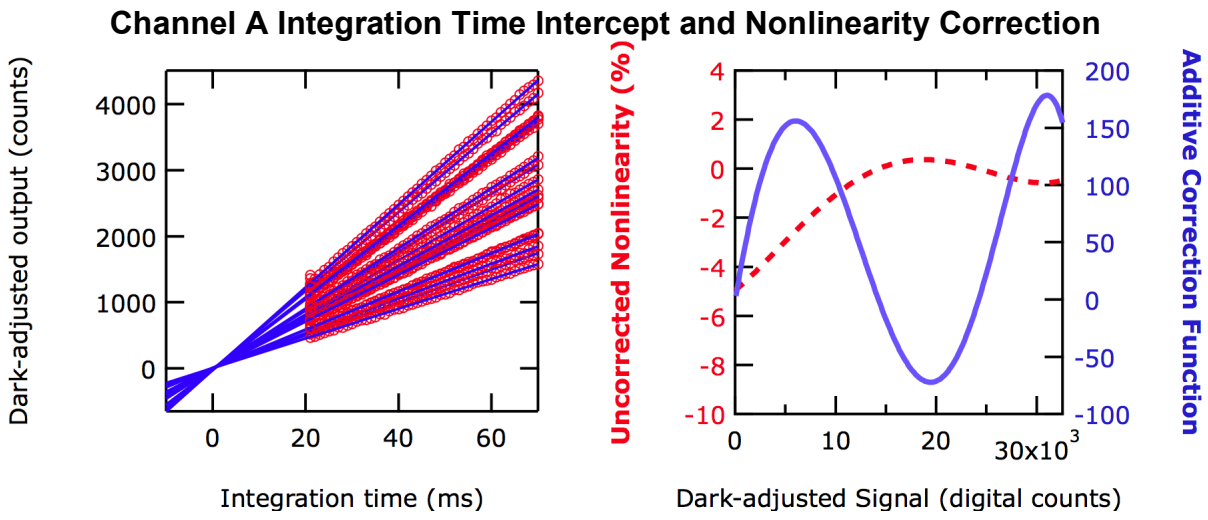
Graph Title: **Immersion Factor**

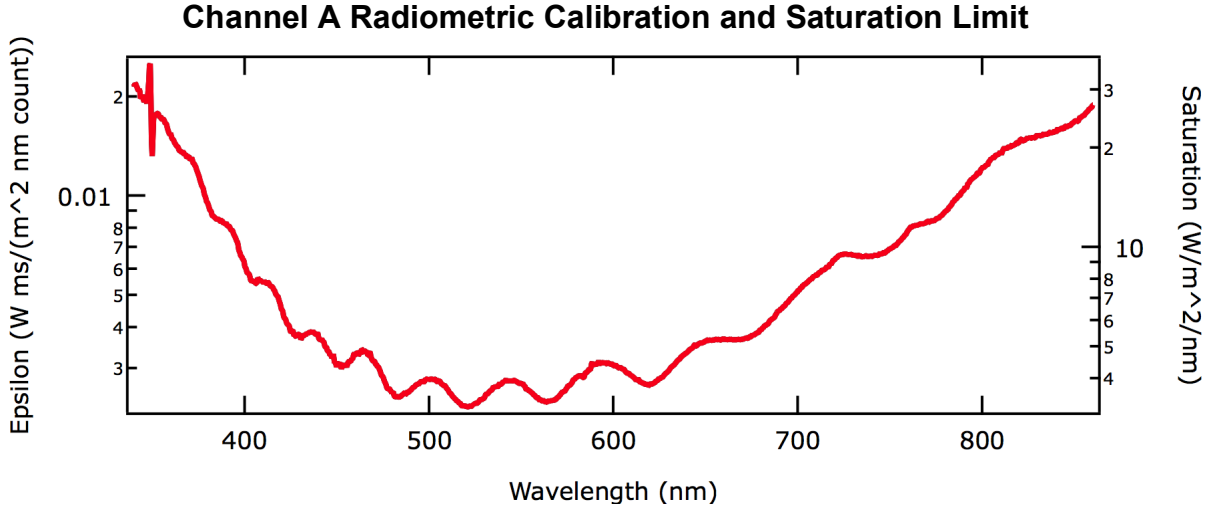
Description: For irradiance collectors, the immersion factor is measured by illuminating it with a stable source while immersing it to a known depth. Various geometric factors and the attenuation of the water are also accounted for.

Instrument: HR061152, HydroRad-2 series 300

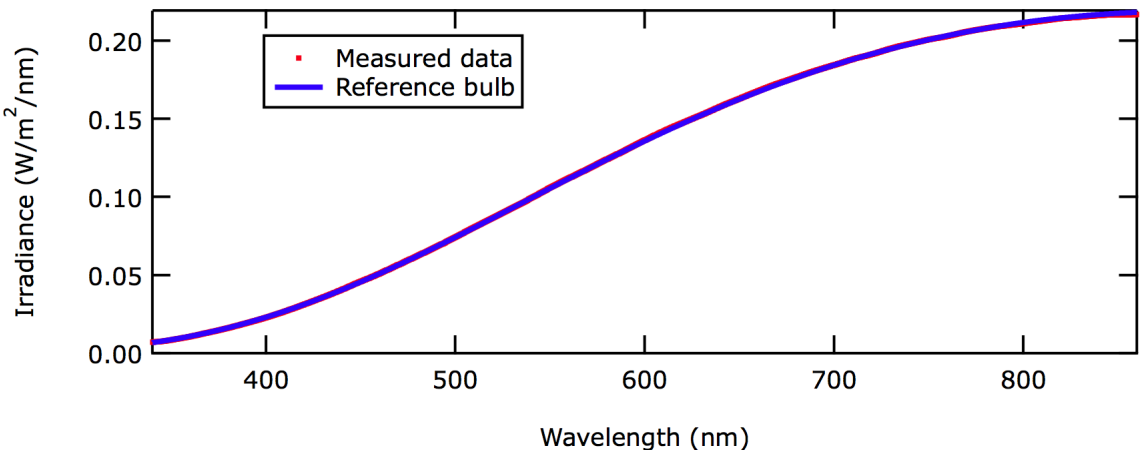
Channel A: "Ed" (Irradiance, W/m^2/nm)



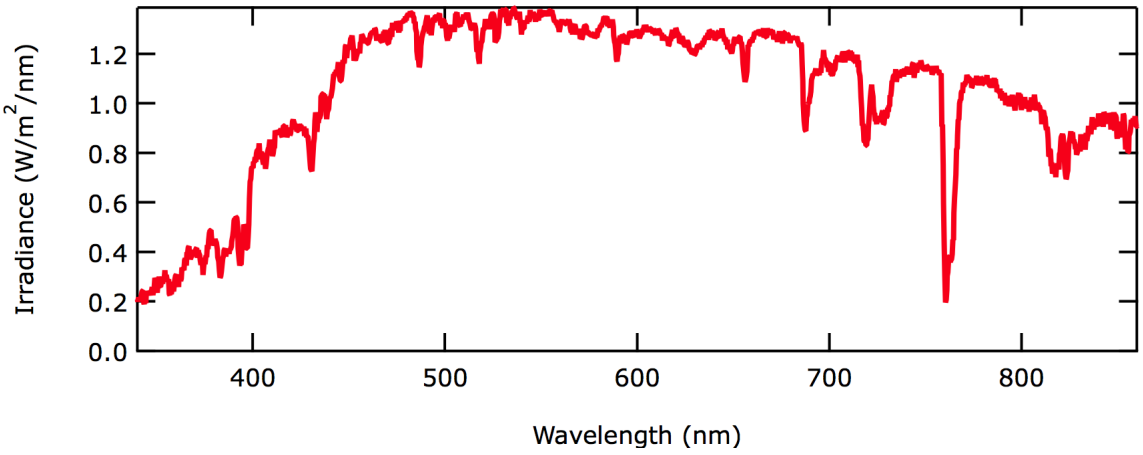




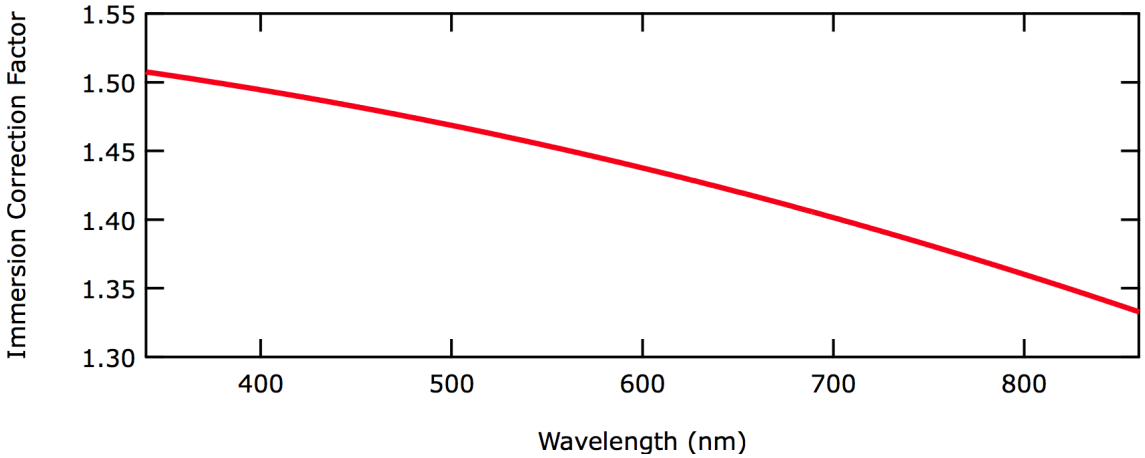
Channel A Comparison to Calibrated Source



Channel A Example Calibrated Data (Morning Sun)

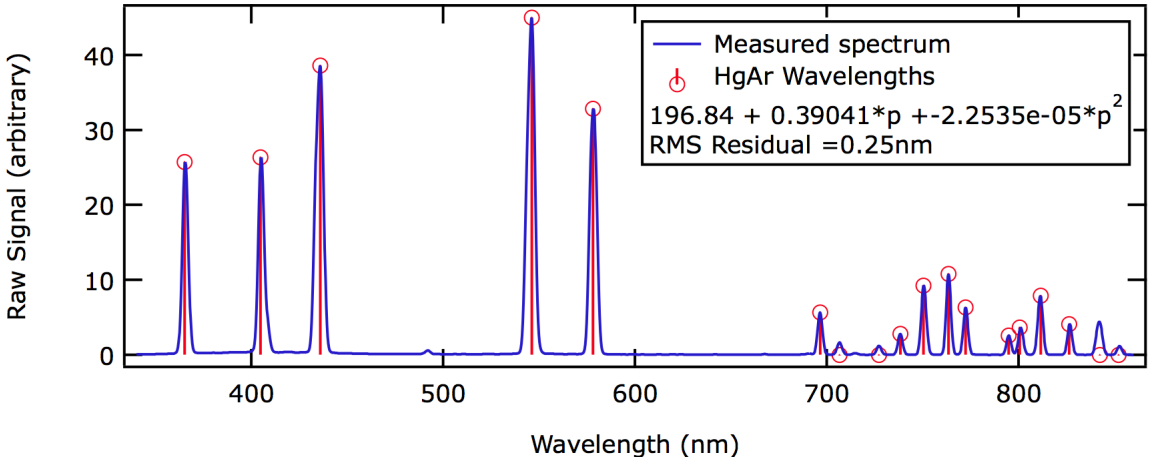


Channel A Immersion Factor

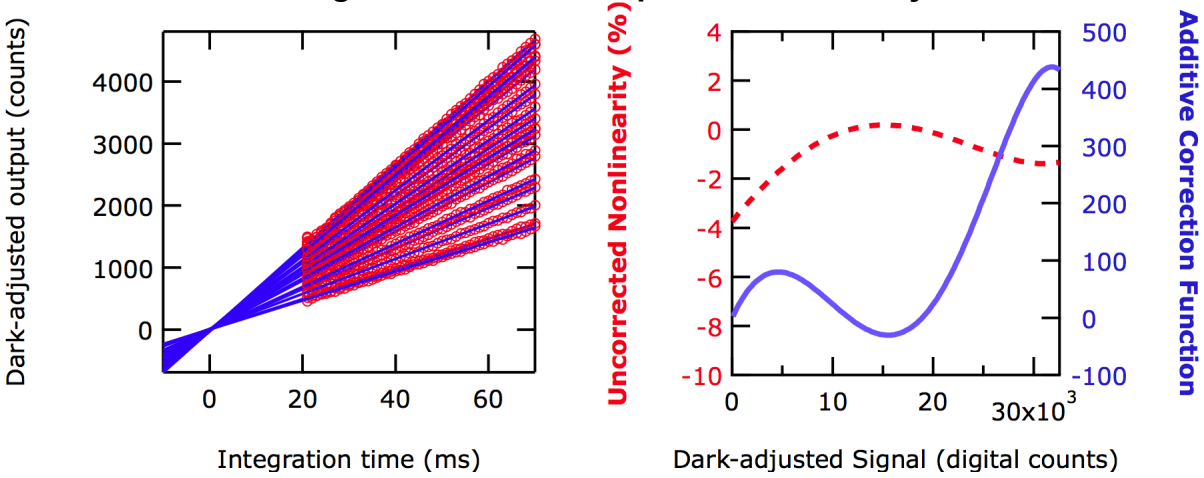


Channel B: "Lu" (Radiance, W/m^2/sr/nm)

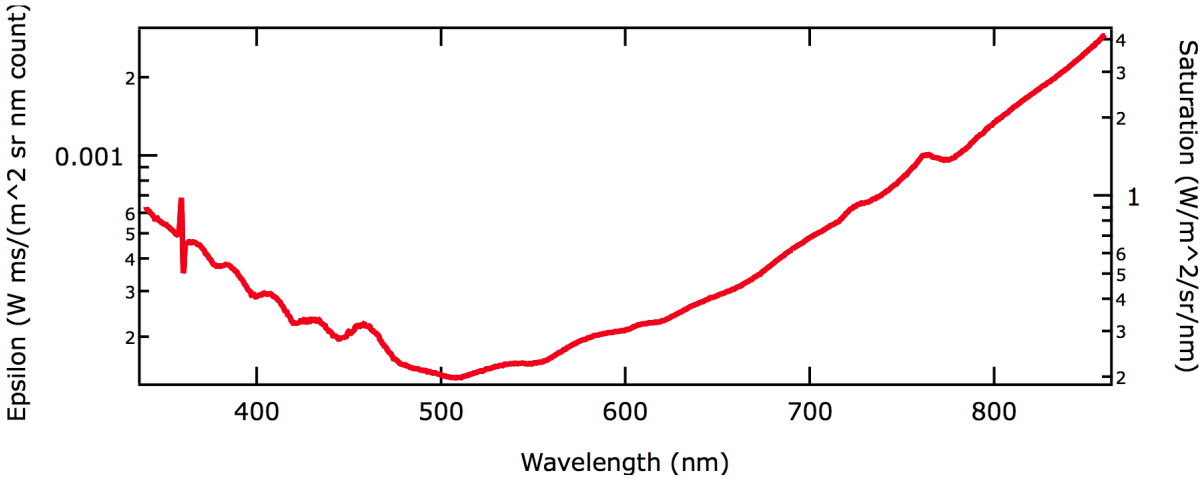
Channel B Wavelengths

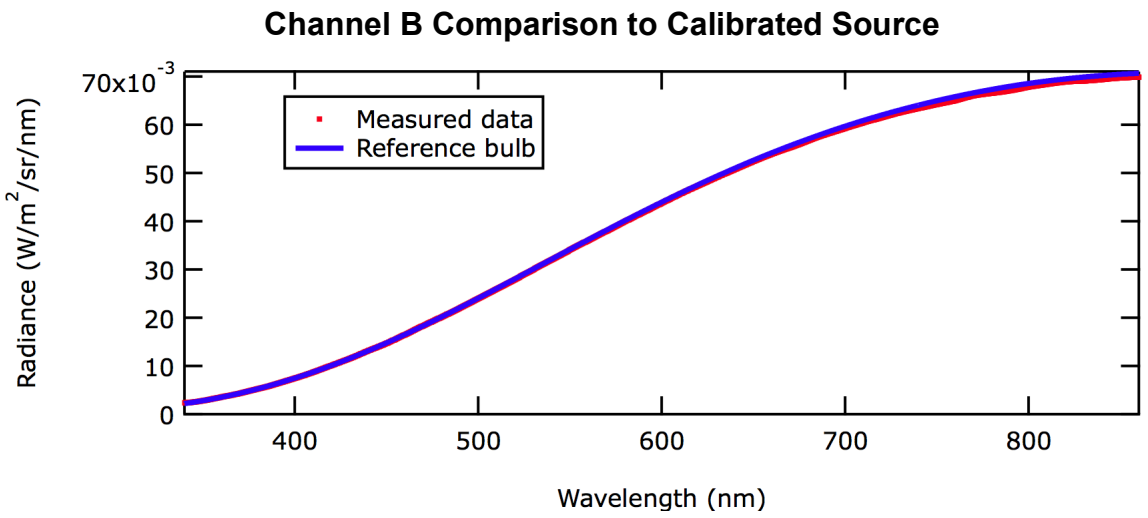


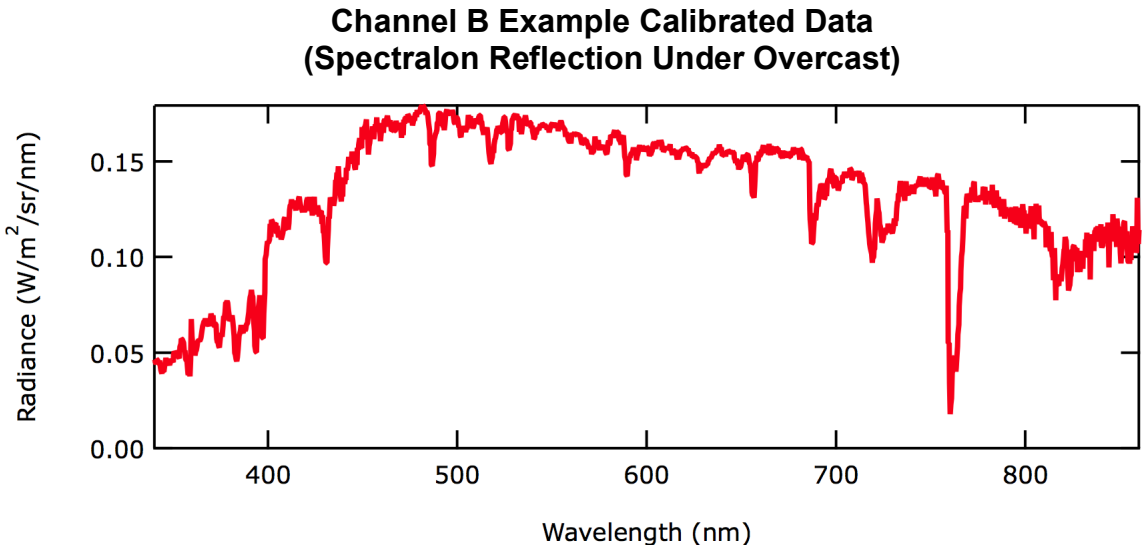
Channel B Integration Time Intercept and Nonlinearity Correction

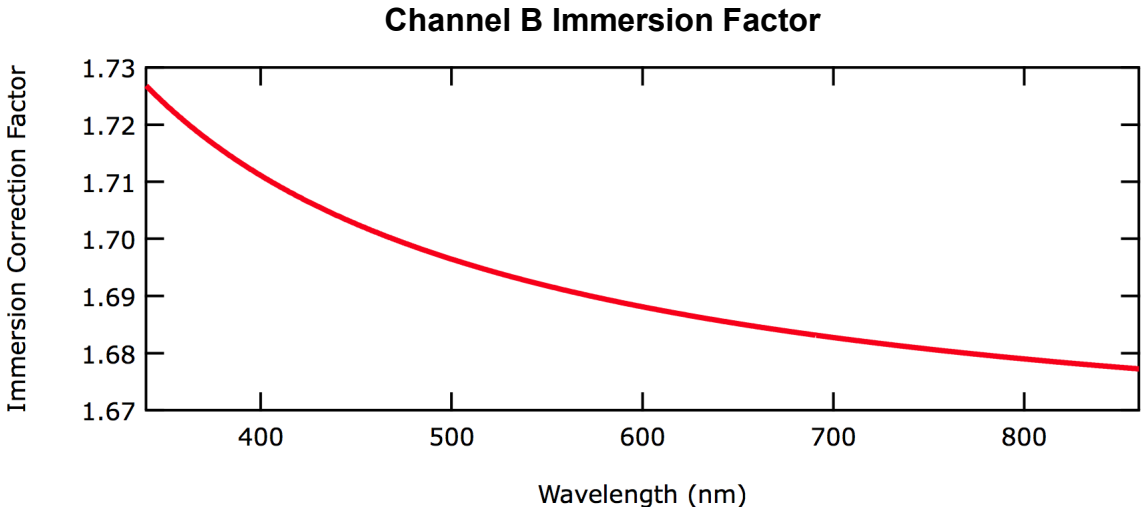


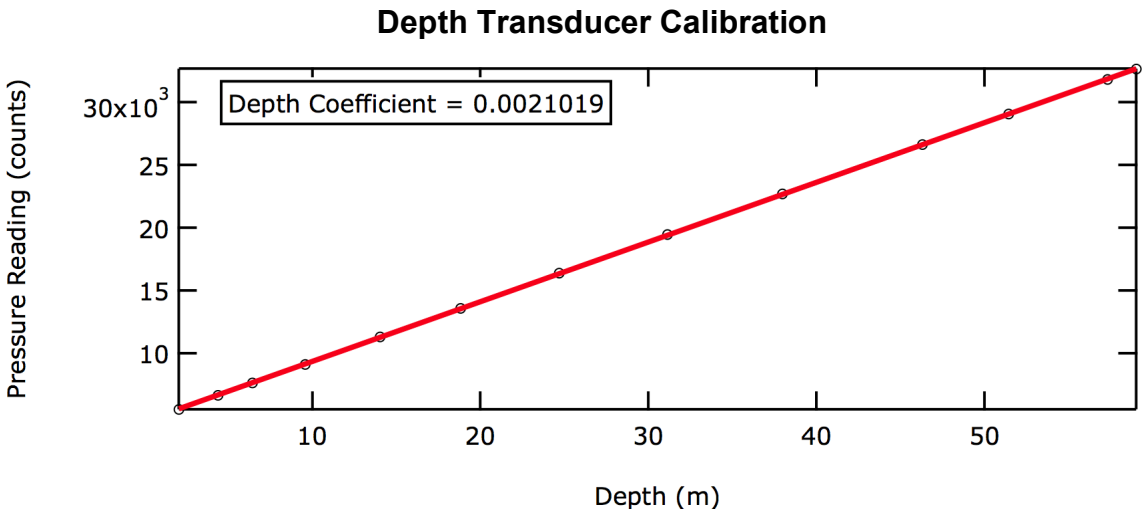
Channel B Radiometric Calibration and Saturation Limit




Channel B Comparison to Calibrated Source
70x10^-3
60
50
40
30
20
10
0
Radiance (W/m^2/sr/nm)
Measured data
Reference bulb
400
500
600
700
800
Wavelength (nm)


Channel B Example Calibrated Data
(Spectralon Reflection Under Overcast)
0.15
0.10
0.05
0.00
Radiance (W/m^2/sr/nm)
400
500
600
700
800
Wavelength (nm)


Channel B Immersion Factor
1.73
1.72
1.71
1.70
1.69
1.68
1.67
Immersion Correction Factor
400
500
600
700
800
Wavelength (nm)


Depth Transducer Calibration
Depth Coefficient = 0.0021019
30x10^3
25
20
15
10
Pressure Reading (counts)
10
20
30
40
50
Depth (m)