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Definitions

True System Output Value

True output of the system without any noise.

Average of Monte-Carlo

Average value of all runs with applied error.

Max Error 95% of the Time/max_2std_error

95% of all readings are within this error of the true value.

Max Error 99.73% of the Time/max_3std_error

99.73% of all readings are within this error of the true value.

Isolated Sensitivity Analysis

Only the specified input has applied error which has an 'error gain' multiplied to only its error. Every other input has zero applied error.

Non-Isolated Sensitivity Analysis

Every input has applied error. The specified input has an 'error gain' multiplied to only its error.

Sensitivity Ratio

The ratio of (specified error gain):(error with error gain = 1).

Confidence Level of Regression Fiting

The regression fits up to a 4th degree polynomial, exponential, or log function. Confidence is $1 / (1st\ best\ RMSE):(2nd\ best\ RMSE)$.

Range Analysis

The specified input has its 'true value' swept over a range while other inputs are held constant. Error is applied throughout the system.

System Governing Equation

$$(((\text{DensityLookup}(\{\text{PT } 1\}, \{\text{RTD } 1\}) * 3.141592653589793) * \{\text{Flow Sensor } 1\}) * (((\{\text{Pipe Diameter}\} / 12) / 2) ** 2))$$

System Error Settings

PT 1

{'k': 2, 'fso': 100, 'static_error_band': 0.15, 'repeatability': 0.02, 'hysteresis': 0.07, 'non-linearity': 0.15, 'temperature_zero_error': 0.005, 'temperature_offset': 30, 'static_error_stdev': 0.075, 'repeatability_error_stdev': 0.01, 'hysteresis_error_stdev': 0.035, 'non-linearity_error_stdev': 0.075, 'thermal_error_offset': 0.15}

RTD 1

{'k': 3, 'class': 'A', 'error_stdev': 0.23533333333333337}

Flow Sensor 1

{'k': 2, 'fso': 20, 'static_error_band': 0.25, 'static_error_stdev': 0.025, 'repeatability_error_stdev': 0.0, 'hysteresis_error_stdev': 0.0, 'non-linearity_error_stdev': 0.0, 'temperature_offset': 0.0, 'thermal_error_offset': 0.0}

Pipe Diameter

{'tolerance': 0.05, 'cte': 8.8e-06, 'temperature_offset': -100, 'k': 3, 'uncertainty': None, 'std_dev': 0.016666666666666666}

Entire System Text Results

True System Output Value: 0.0032872627168151446

Median: 0.00331273575438073

Average of Monte-Carlo: 0.0033138810901973347

Average Percent Difference: 0.8097428065615417 %

Minimum Value: 0.0028220047681432785

Maximum Value: 0.00384843803780837

Standard Deviation: ±0.00011180804642872607

Standard Deviation Percent: 3.4012507079766046 %

Mean Absolute Error: 9.151173888641018e-05

Mean Absolute Percent Error: 2.7838279678197146 %

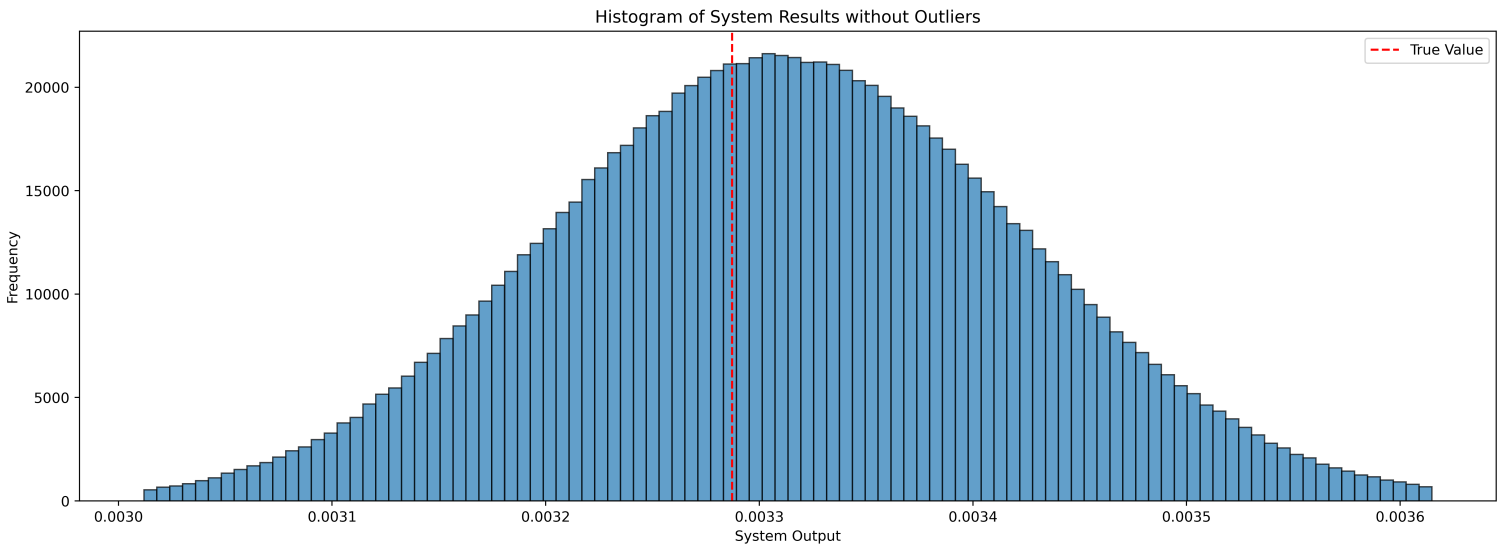
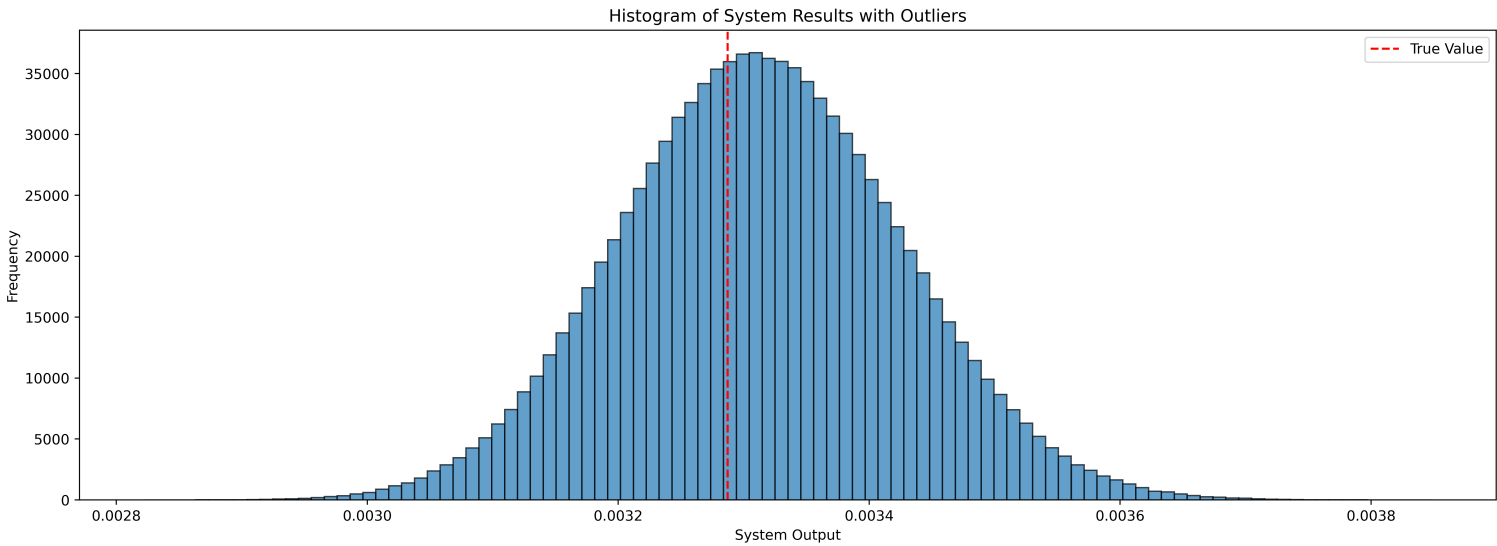
Max Error 95% of the Time: 0.00025023446623964217

Max Percent Error 95% of the Time: 7.612244222514747 %

Max Error 99.73% of the Time: 0.0003620425126683682

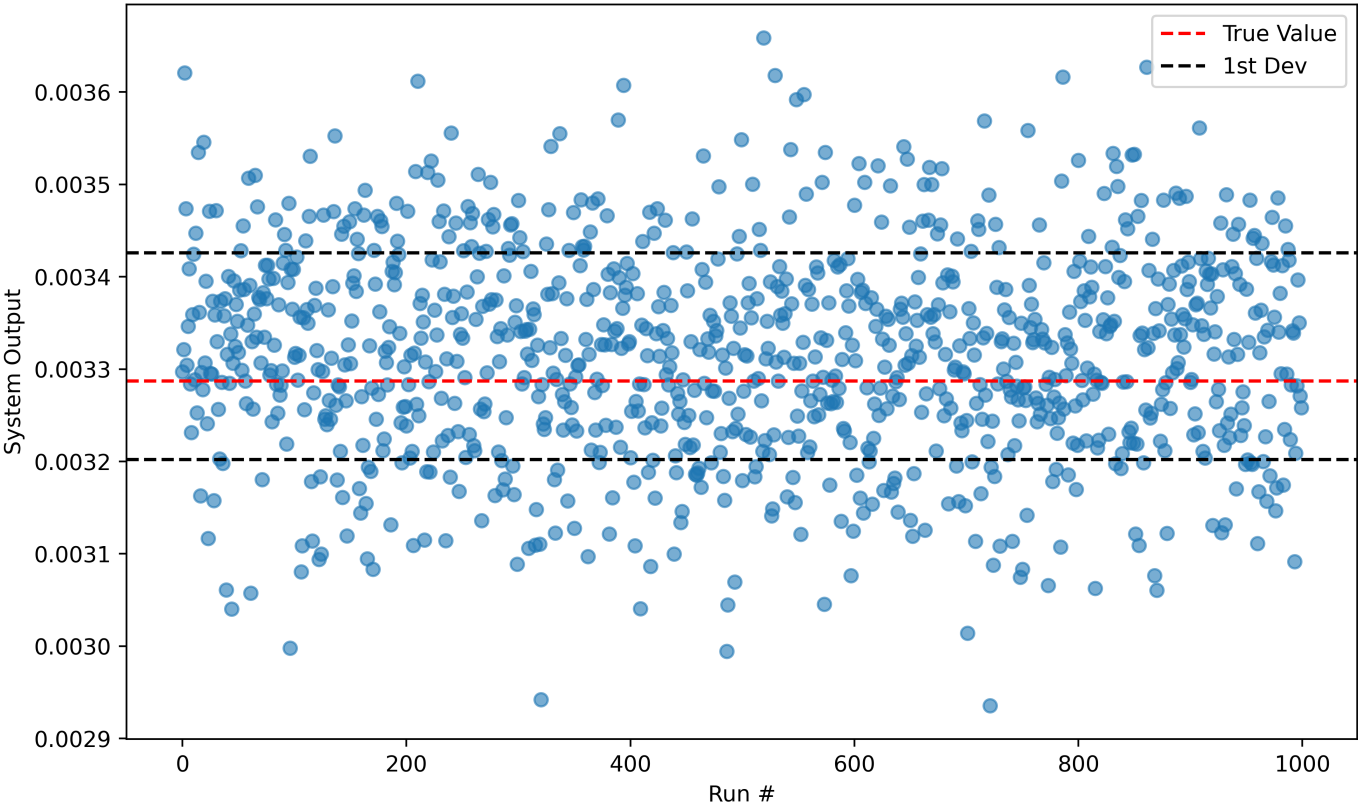
Max Percent Error 99.73% of the Time: 11.013494930491351 %

Entire System Histograms

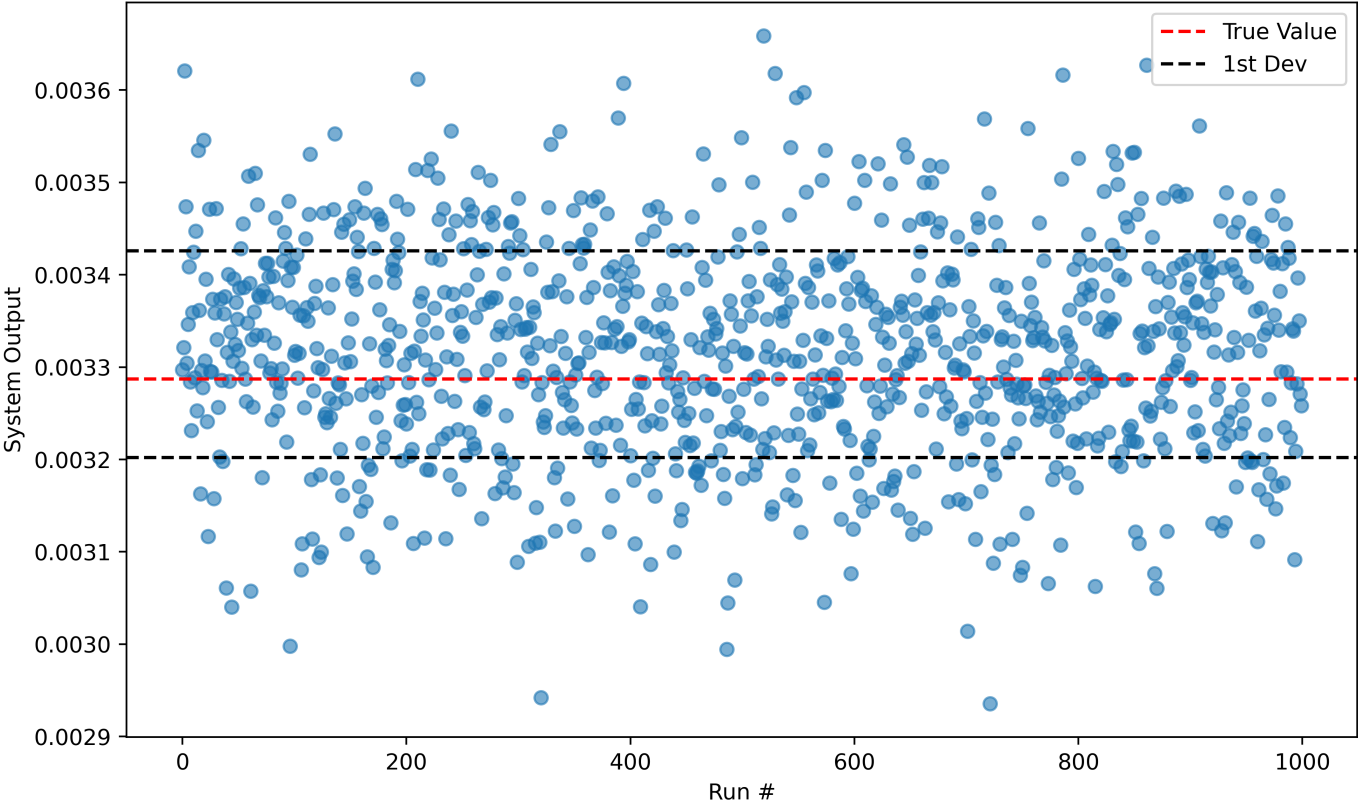


Entire System Scatter Plots

Scatter Plot of System Results with Outliers



Scatter Plot of System Results with Outliers

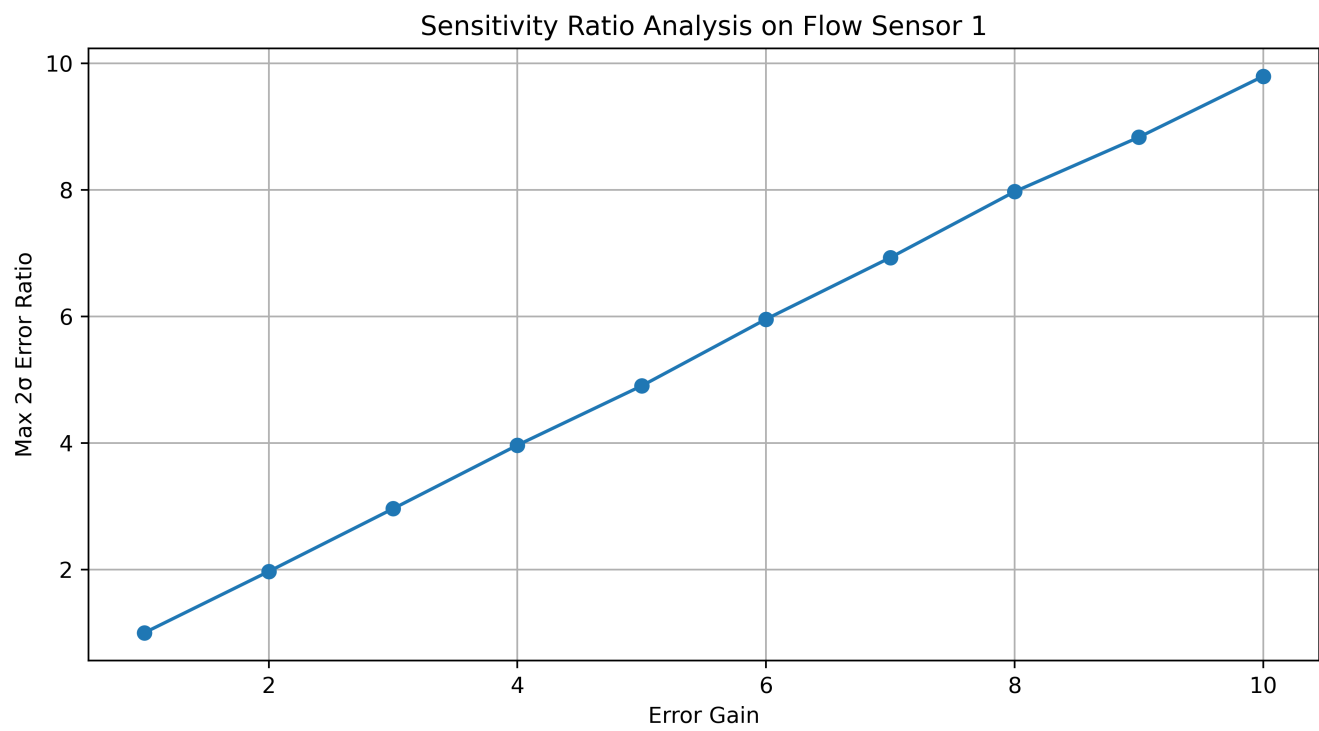
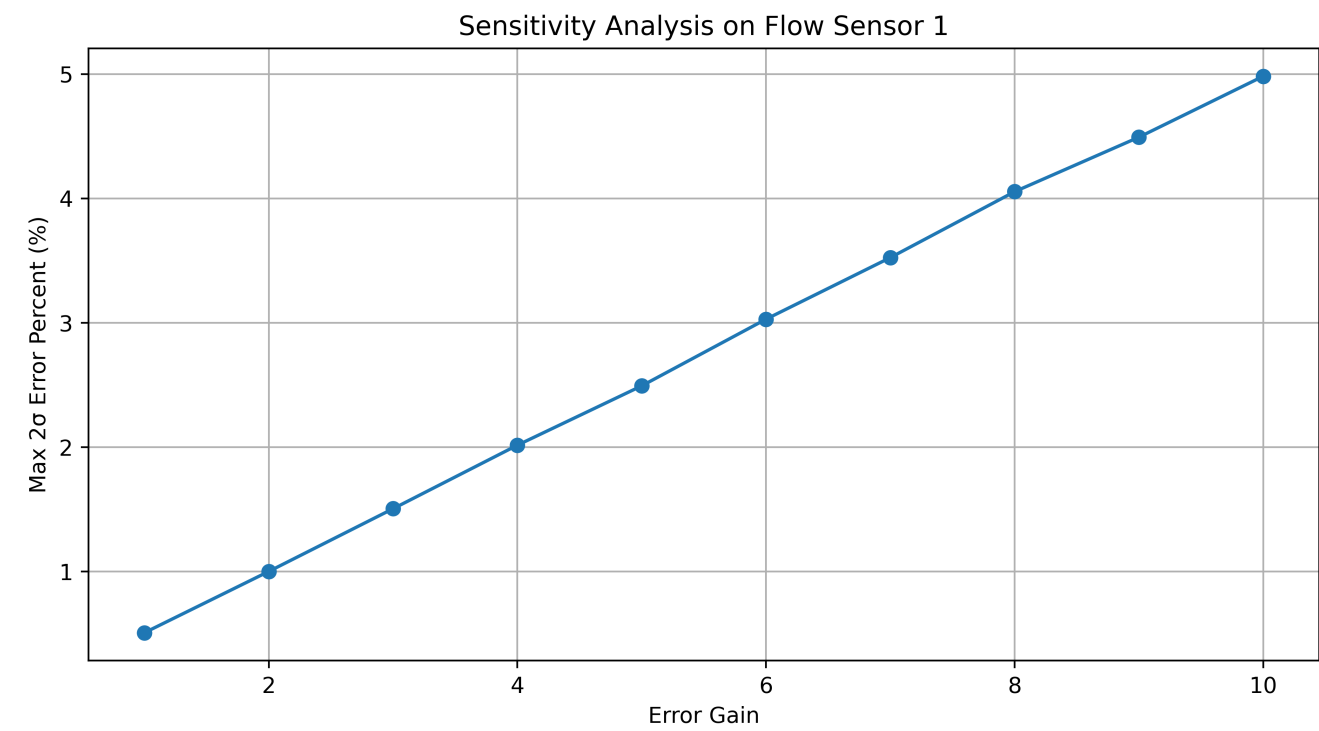


Isolated Sensitivity Analysis on Flow Sensor 1

Impact of Flow Sensor 1 Noise Gain on System without Noise

Metrics/Sensor Noise Gain	1	2	3	4	5	6	7	8	9	10
true_value	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873
median	0.003287	0.0032874	0.0032875	0.0032873	0.0032864	0.0032863	0.0032869	0.003286	0.0032855	0.003287
average	0.0032871	0.0032872	0.0032872	0.0032875	0.0032868	0.0032864	0.0032872	0.0032855	0.0032864	0.0032872
average_percent_difference	-0.0057229	-0.00052637	-0.001076	0.006878	-0.01446	-0.02748	-0.0031793	-0.052653	-0.025602	-0.0029724
min_val	0.0032551	0.0032267	0.003201	0.0031583	0.0031256	0.0030655	0.0030581	0.0030309	0.0030344	0.0029632
max_val	0.003318	0.0033567	0.0033836	0.0034084	0.003443	0.0034566	0.0034993	0.0035391	0.003565	0.0035878
std_dev	8.2677e-06	1.6451e-05	2.4733e-05	3.3029e-05	4.0745e-05	4.9341e-05	5.788e-05	6.578e-05	7.3425e-05	8.185e-05
std_dev_percent	0.25151	0.50045	0.7524	1.0048	1.2395	1.501	1.7607	2.0011	2.2336	2.4899
mean_absolute_error	6.5728e-06	1.3074e-05	1.9759e-05	2.6369e-05	3.2567e-05	3.9206e-05	4.6068e-05	5.2468e-05	5.8723e-05	6.5248e-05
mean_absolute_percent_error	0.19995	0.39772	0.60107	0.80215	0.9907	1.1927	1.4014	1.5961	1.7864	1.9849
max_2std_error	1.6723e-05	3.2919e-05	4.9502e-05	6.6284e-05	8.1965e-05	9.9585e-05	0.00011586	0.00013329	0.00014769	0.0001638
max_2std_percent_error	0.50874	1.0014	1.5059	2.0164	2.4934	3.0294	3.5246	4.0548	4.4929	4.9828
max_3std_error	2.4991e-05	4.937e-05	7.4235e-05	9.9313e-05	0.00012271	0.00014893	0.00017374	0.00019907	0.00022112	0.00024565
max_3std_percent_error	0.76024	1.5019	2.2583	3.0211	3.7329	4.5304	5.2854	6.0558	6.7265	7.4727

Isolated Sensitivity Analysis on Flow Sensor 1 Plots



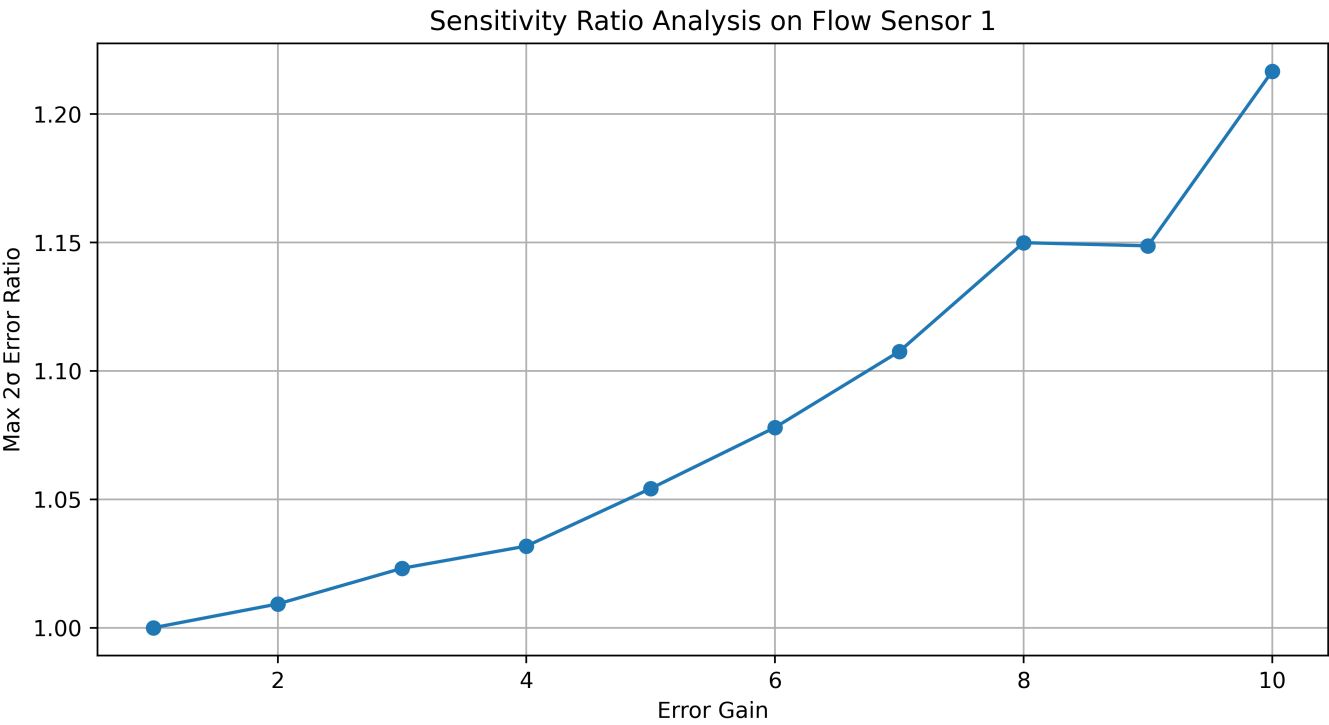
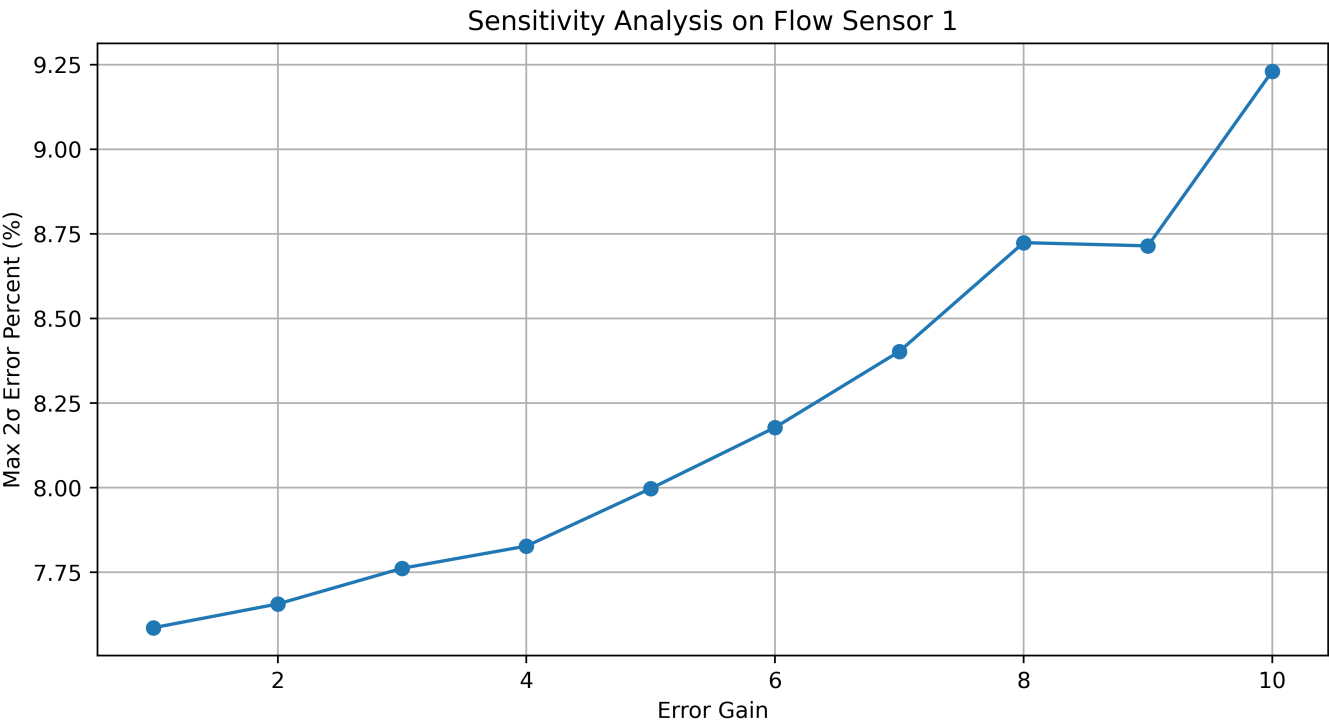
Relationship between sensor Error Gain and Max 2σ Error Percent (%) is: linear with a confidence level of 94.29 %.
The equation of best fit is: $0.0106 + 0.5001 \cdot x^1$.

Non-Isolated Sensitivity Analysis on Flow Sensor 1

Impact of Flow Sensor 1 Noise Gain on System with Noise

Metrics/Sensor Noise Gain	1	2	3	4	5	6	7	8	9	10
true_value	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873
median	0.0033141	0.0033117	0.0033132	0.0033132	0.0033313	0.0033145	0.0033106	0.0033118	0.0033073	0.0033101
average	0.0033145	0.0033129	0.0033146	0.0033125	0.0033132	0.0033142	0.0033124	0.0033131	0.0033105	0.0033127
average_percent_difference	0.83006	0.77844	0.83154	0.76917	0.79021	0.81802	0.76346	0.78726	0.70811	0.77361
min_val	0.0029135	0.0028621	0.0028817	0.0028538	0.0028454	0.002875	0.0028908	0.0028954	0.0028225	0.0027797
max_val	0.0037374	0.0037758	0.003766	0.0038155	0.0039056	0.0038259	0.003823	0.0038452	0.0038119	0.0038968
std_dev	0.00011105	0.00011305	0.00011391	0.00011601	0.00011846	0.00012097	0.00012556	0.00013045	0.0001316	0.000139
std_dev_percent	3.3782	3.4391	3.4652	3.5292	3.6037	3.68	3.8195	3.9683	4.0032	4.2284
mean_absolute_error	9.1033e-05	9.2448e-05	9.3142e-05	9.4816e-05	9.6538e-05	9.8455e-05	0.00010194	0.00010585	0.00010622	0.00011203
mean_absolute_percent_error	2.7693	2.8123	2.8334	2.8843	2.9367	2.995	3.1011	3.2201	3.2314	3.4081
max_2std_error	0.00024939	0.00025169	0.00025516	0.00025731	0.0002629	0.00026883	0.00027621	0.00028678	0.00028647	0.00030343
max_2std_percent_error	7.5864	7.6566	7.762	7.8276	7.9977	8.178	8.4026	8.7239	8.7145	9.2303
max_3std_error	0.00036044	0.00036475	0.00036907	0.00037333	0.00038137	0.0003898	0.00040177	0.00041723	0.00041806	0.00044242
max_3std_percent_error	10.965	11.096	11.227	11.357	11.601	11.858	12.222	12.692	12.718	13.459

Non-Isolated Sensitivity Analysis on Flow Sensor 1 Plots



Relationship between sensor Error Gain and Max 2σ Error Percent (%) is: quadratic with a confidence level of 62.47 %.

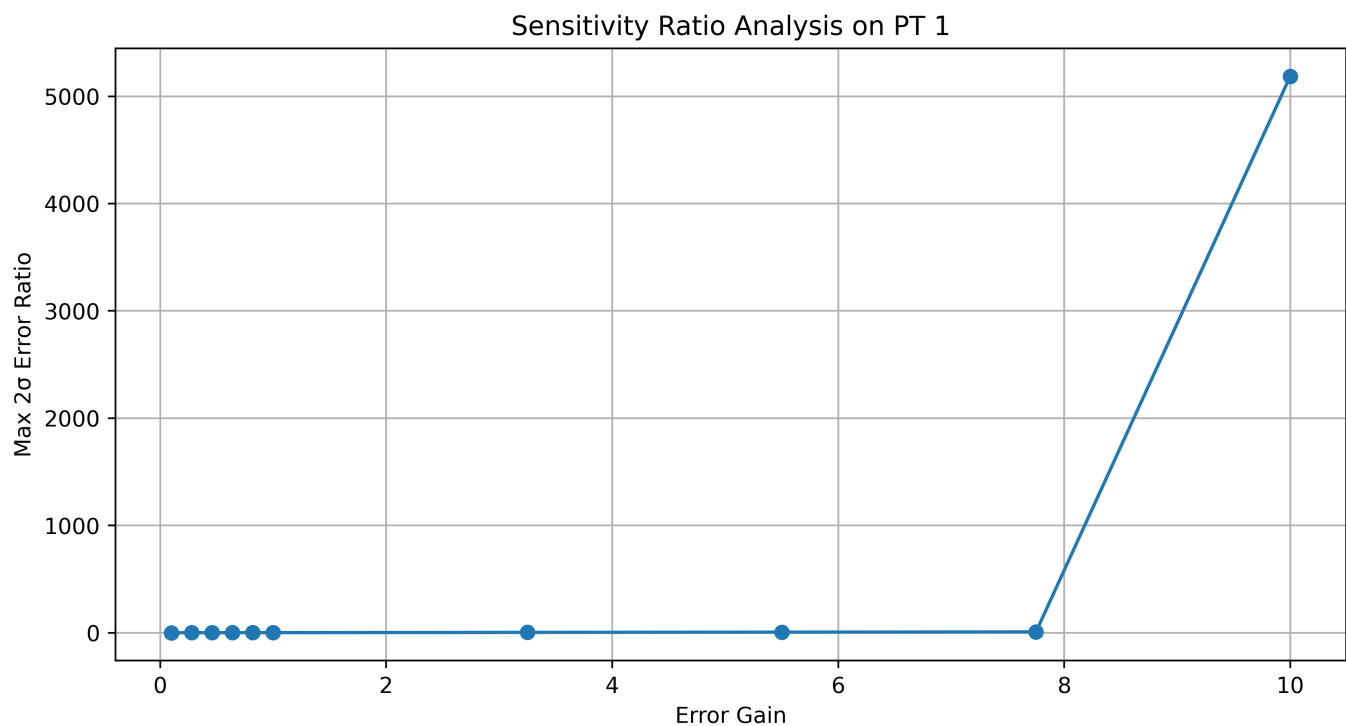
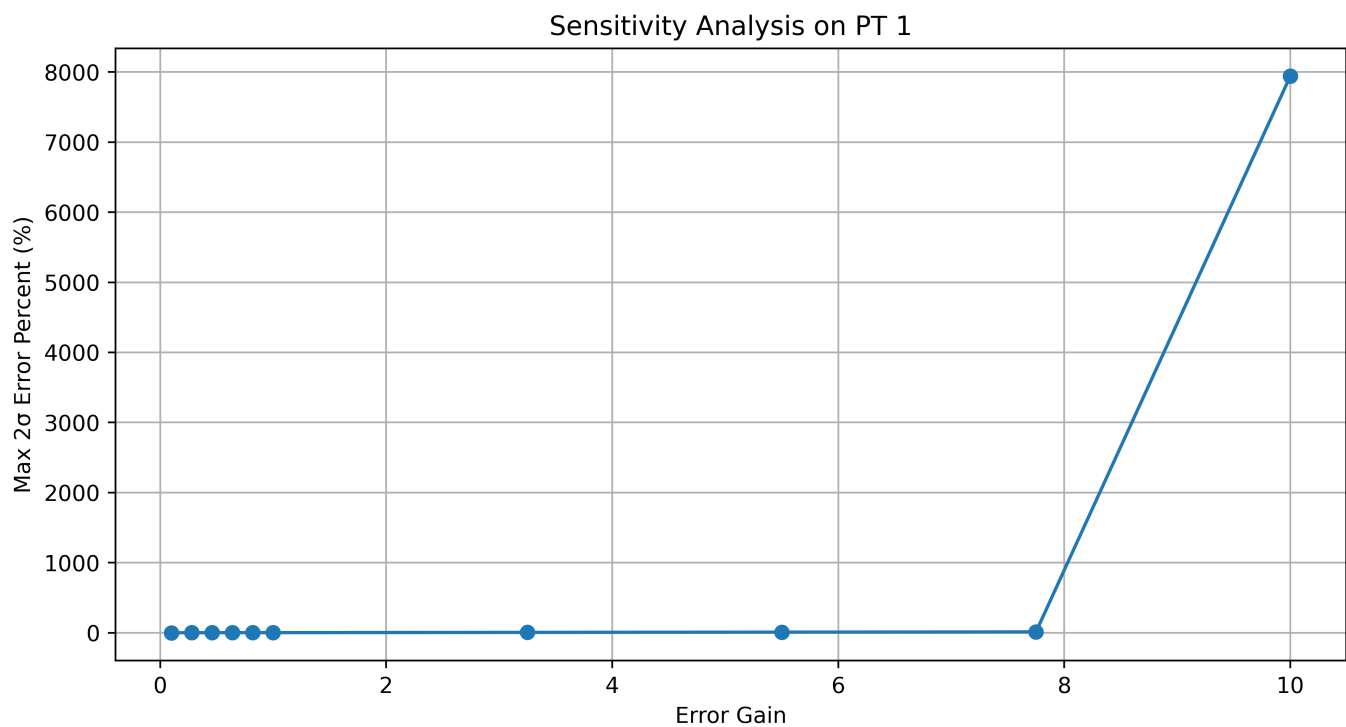
The equation of best fit is: $7.5578 + 0.0184 \cdot x + 0.0143 \cdot x^2$.

Isolated Sensitivity Analysis on PT 1

Impact of PT 1 Noise Gain on System without Noise

Metrics/Sensor Noise Gain	0.1	0.28	0.46	0.64	0.82	1	3.25	5.5	7.75	10
true_value	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873
median	0.003289	0.0032925	0.0032964	0.0032999	0.0033035	0.0033072	0.0033529	0.0033986	0.0034436	0.0034901
average	0.003289	0.0032926	0.0032964	0.0032999	0.0033036	0.0033071	0.0033525	0.0033987	0.0034434	0.0086074
average_percent_difference	0.054095	0.16345	0.27776	0.38583	0.49738	0.60395	1.9845	3.3903	4.7489	161.84
min_val	0.0032837	0.0032767	0.0032684	0.0032598	0.0032559	0.003248	0.0031732	0.0031078	0.0029974	0.0029648
max_val	0.0032944	0.0033087	0.0033221	0.0033378	0.0033496	0.0033682	0.0035218	0.0037281	0.0038911	3.2025
std_dev	1.4973e-06	4.1923e-06	6.8695e-06	9.4956e-06	1.2426e-05	1.5236e-05	4.8604e-05	8.3059e-05	0.0001162	0.12786
std_dev_percent	0.045548	0.12753	0.20897	0.28886	0.37801	0.46349	1.4786	2.5267	3.5347	3889.5
mean_absolute_error	1.9504e-06	5.7499e-06	9.7149e-06	1.3461e-05	1.7465e-05	2.1271e-05	6.9306e-05	0.00011811	0.00016605	0.0053332
mean_absolute_percent_error	0.059333	0.17492	0.29553	0.40949	0.5313	0.64706	2.1083	3.5929	5.0512	162.24
max_2std_error	4.7728e-06	1.3758e-05	2.2869e-05	3.1675e-05	4.1202e-05	5.0326e-05	0.00016245	0.00027757	0.0003885	0.26104
max_2std_percent_error	0.14519	0.41851	0.6957	0.96355	1.2534	1.5309	4.9417	8.4438	11.818	7940.9
max_3std_error	6.2701e-06	1.795e-05	2.9739e-05	4.117e-05	5.3629e-05	6.5562e-05	0.00021105	0.00036063	0.0005047	0.38889
max_3std_percent_error	0.19074	0.54604	0.90467	1.2524	1.6314	1.9944	6.4202	10.97	15.353	11830

Isolated Sensitivity Analysis on PT 1 Plots



Relationship between sensor Error Gain and Max 2σ Error Percent (%) is: quartic with a confidence level of 56.11 %.

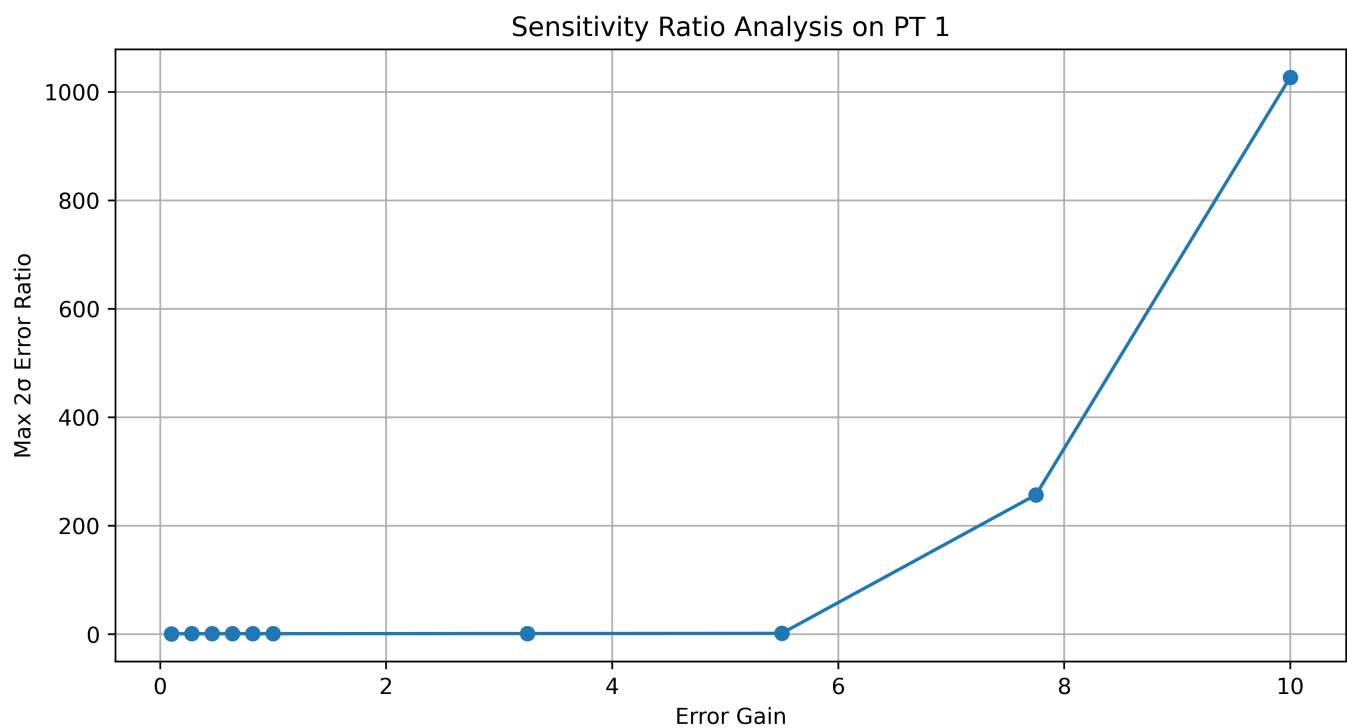
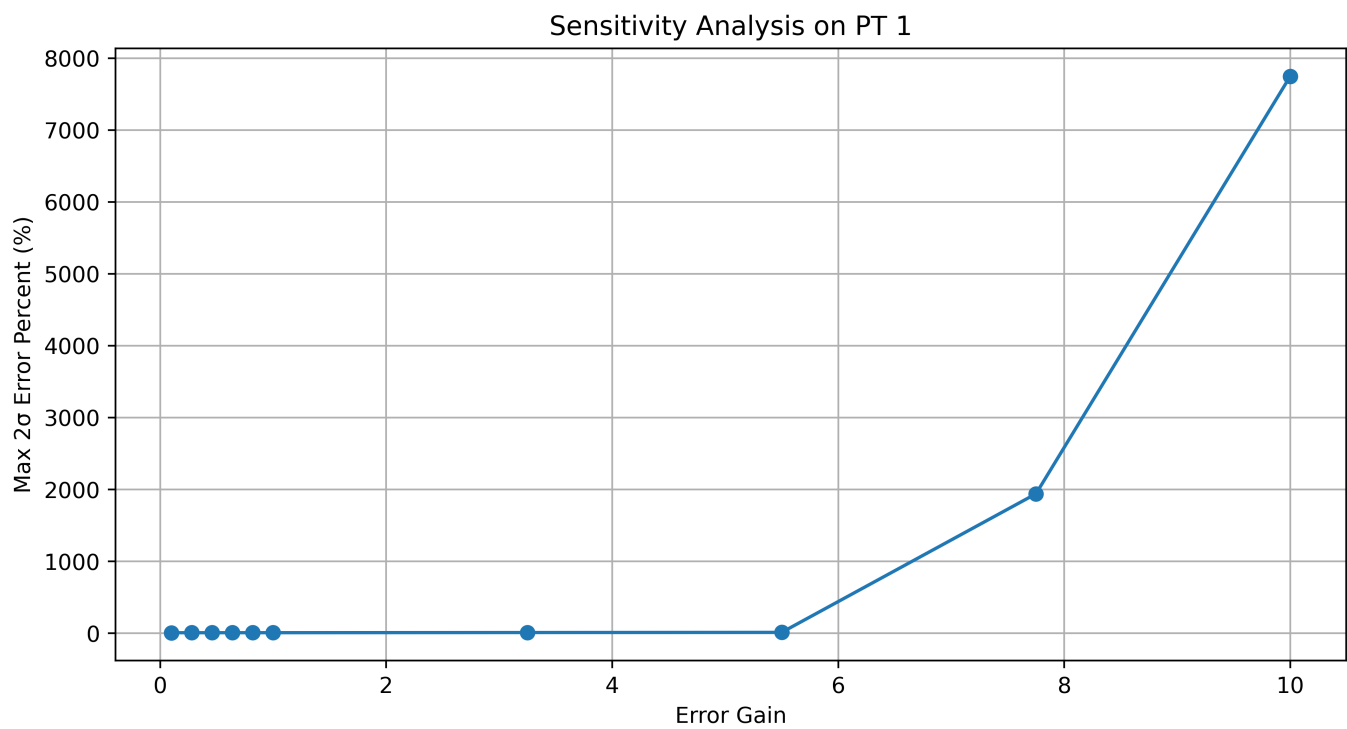
The equation of best fit is: $191.0581 + -687.6646 * x^1 + 517.0302 * x^2 + -118.5183 * x^3 + 8.1421 * x^4$.

Non-Isolated Sensitivity Analysis on PT 1

Impact of PT 1 Noise Gain on System with Noise

Metrics/Sensor Noise Gain	0.1	0.28	0.46	0.64	0.82	1	3.25	5.5	7.75	10
true_value	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873
median	0.0032975	0.0032985	0.0033017	0.0033071	0.0033064	0.0033113	0.0033572	0.0034005	0.0034477	0.0034935
average	0.0032974	0.0033	0.0033026	0.0033072	0.0033083	0.0033131	0.0033595	0.0034035	0.0037671	0.0083281
average_percent_difference	0.30916	0.38786	0.46651	0.60603	0.63883	0.78548	2.1978	3.535	14.596	153.34
min_val	0.0029324	0.0029055	0.002906	0.0028993	0.0029082	0.0029015	0.0028403	0.0029243	0.0028888	0.0027722
max_val	0.0037321	0.0037396	0.0037244	0.0037067	0.0037321	0.0037311	0.0037989	0.0039295	3.1682	3.4391
std_dev	0.00011128	0.00011049	0.00011159	0.00011133	0.00011144	0.0001111	0.00012327	0.00013881	0.031646	0.12484
std_dev_percent	3.3851	3.361	3.3946	3.3867	3.39	3.3798	3.75	4.2225	962.69	3797.7
mean_absolute_error	8.9433e-05	8.8303e-05	8.9657e-05	9.0301e-05	9.0227e-05	9.0858e-05	0.00011449	0.00014631	0.00050622	0.0050665
mean_absolute_percent_error	2.7206	2.6862	2.7274	2.747	2.7448	2.7639	3.4827	4.4509	15.4	154.12
max_2std_error	0.00023272	0.00023372	0.00023851	0.00024258	0.00024388	0.00024803	0.00031879	0.00039381	0.063772	0.25472
max_2std_percent_error	7.0794	7.1099	7.2557	7.3794	7.4188	7.5451	9.6978	11.98	1940	7748.7
max_3std_error	0.000344	0.00034421	0.0003501	0.00035391	0.00035531	0.00035913	0.00044206	0.00053262	0.095419	0.37956
max_3std_percent_error	10.464	10.471	10.65	10.766	10.809	10.925	13.448	16.203	2902.7	11546

Non-Isolated Sensitivity Analysis on PT 1 Plots



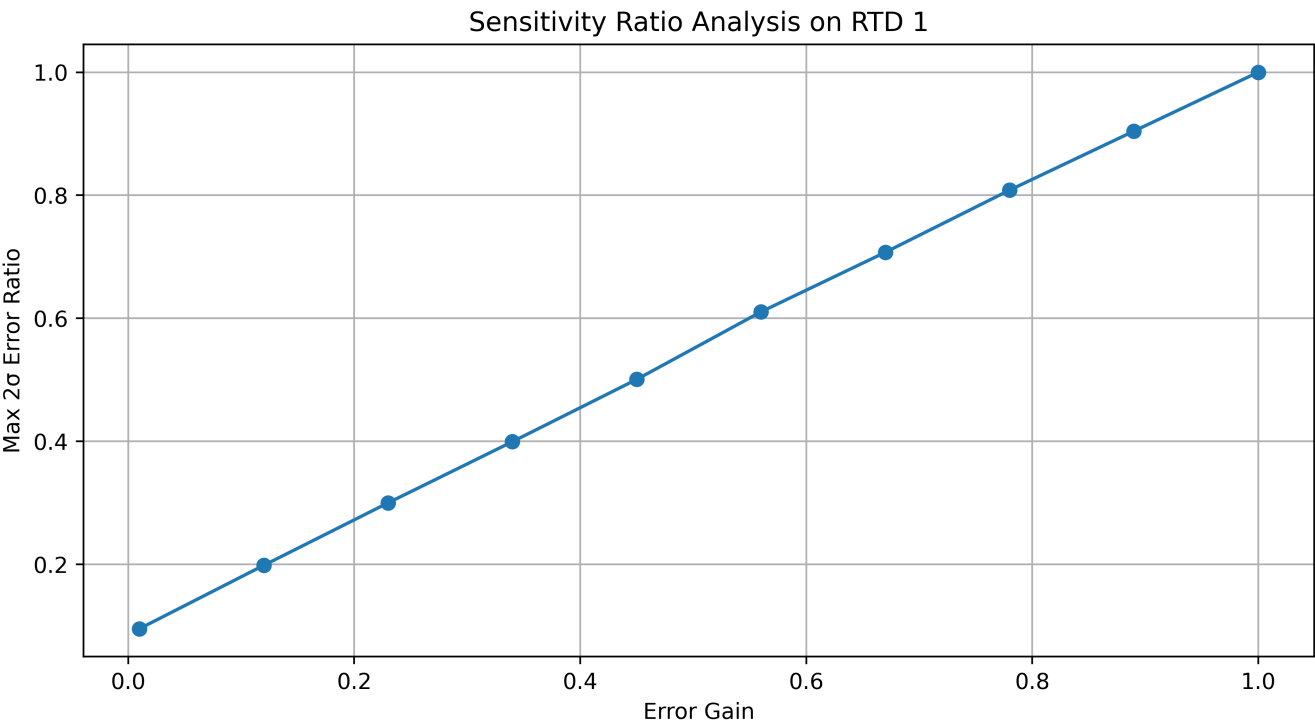
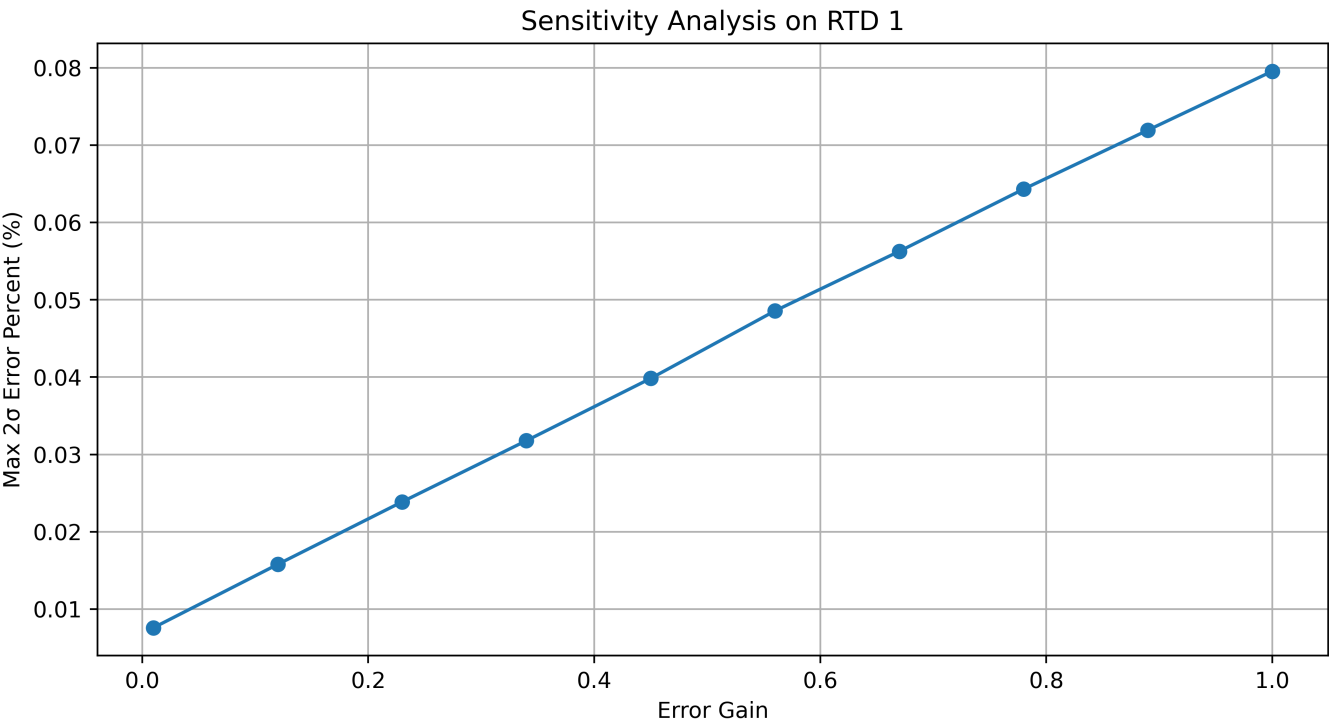
Relationship between sensor Error Gain and Max 2σ Error Percent (%) is: quartic with a confidence level of 64.88 %.
The equation of best fit is: $-35.0132 + 120.1046 \cdot x^1 + -45.4373 \cdot x^2 + -2.6022 \cdot x^3 + 1.3734 \cdot x^4$.

Isolated Sensitivity Analysis on RTD 1

Impact of RTD 1 Noise Gain on System without Noise

Metrics/Sensor Noise Gain	0.01	0.12	0.23	0.34	0.45	0.56	0.67	0.78	0.89	1
true_value	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873
median	0.003287	0.003287	0.003287	0.003287	0.003287	0.003287	0.003287	0.003287	0.003287	0.003287
average	0.003287	0.003287	0.003287	0.003287	0.003287	0.003287	0.003287	0.003287	0.0032871	0.0032871
average_percent_difference	-0.0068575	-0.0069011	-0.0069485	-0.0067547	-0.0065839	-0.0069784	-0.0072335	-0.0067013	-0.0063263	-0.0063515
min_val	0.003287	0.0032865	0.003286	0.0032853	0.0032851	0.0032846	0.003284	0.0032834	0.0032831	0.0032825
max_val	0.0032871	0.0032876	0.0032881	0.0032886	0.003289	0.0032894	0.0032901	0.0032905	0.0032911	0.0032917
std_dev	1.2078e-08	1.4607e-07	2.7807e-07	4.1132e-07	5.4647e-07	6.8358e-07	8.0594e-07	9.4686e-07	1.0784e-06	1.2032e-06
std_dev_percent	0.00036743	0.0044436	0.008459	0.012512	0.016624	0.020795	0.024517	0.028804	0.032806	0.0366
mean_absolute_error	2.2542e-07	2.3471e-07	2.9226e-07	3.7558e-07	4.6993e-07	5.7637e-07	6.7297e-07	7.7328e-07	8.7969e-07	9.7753e-07
mean_absolute_percent_error	0.0068575	0.0071401	0.0088908	0.011425	0.014296	0.017533	0.020472	0.023524	0.026761	0.029737
max_2std_error	2.4958e-07	5.19e-07	7.8455e-07	1.0447e-06	1.3094e-06	1.5966e-06	1.8497e-06	2.114e-06	2.3648e-06	2.6151e-06
max_2std_percent_error	0.0075924	0.015788	0.023867	0.03178	0.039832	0.048568	0.056268	0.064309	0.071937	0.079552
max_3std_error	2.6166e-07	6.6508e-07	1.0626e-06	1.456e-06	1.8558e-06	2.2801e-06	2.6556e-06	3.0609e-06	3.4432e-06	3.8182e-06
max_3std_percent_error	0.0079598	0.020232	0.032326	0.044292	0.056456	0.069363	0.080785	0.093113	0.10474	0.11615

Isolated Sensitivity Analysis on RTD 1 Plots



Relationship between sensor Error Gain and Max 2σ Error Percent (%) is: linear with a confidence level of 95.49 %.

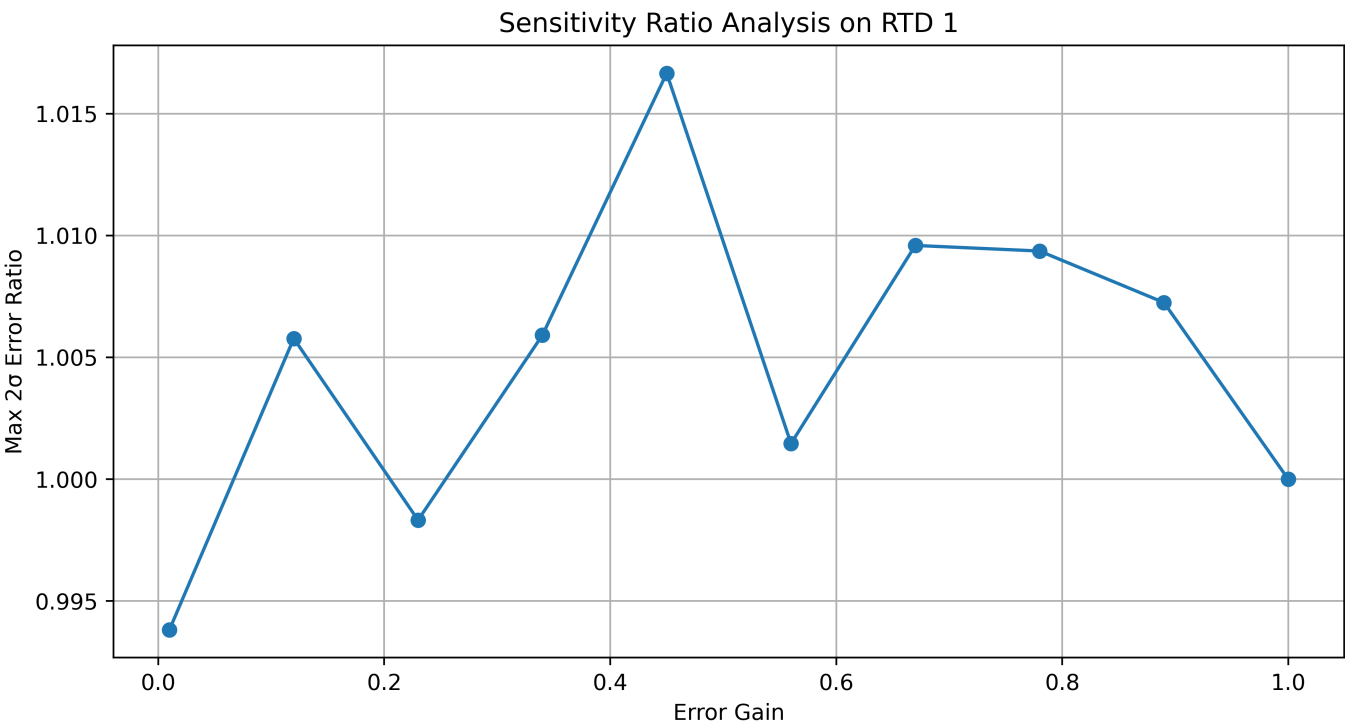
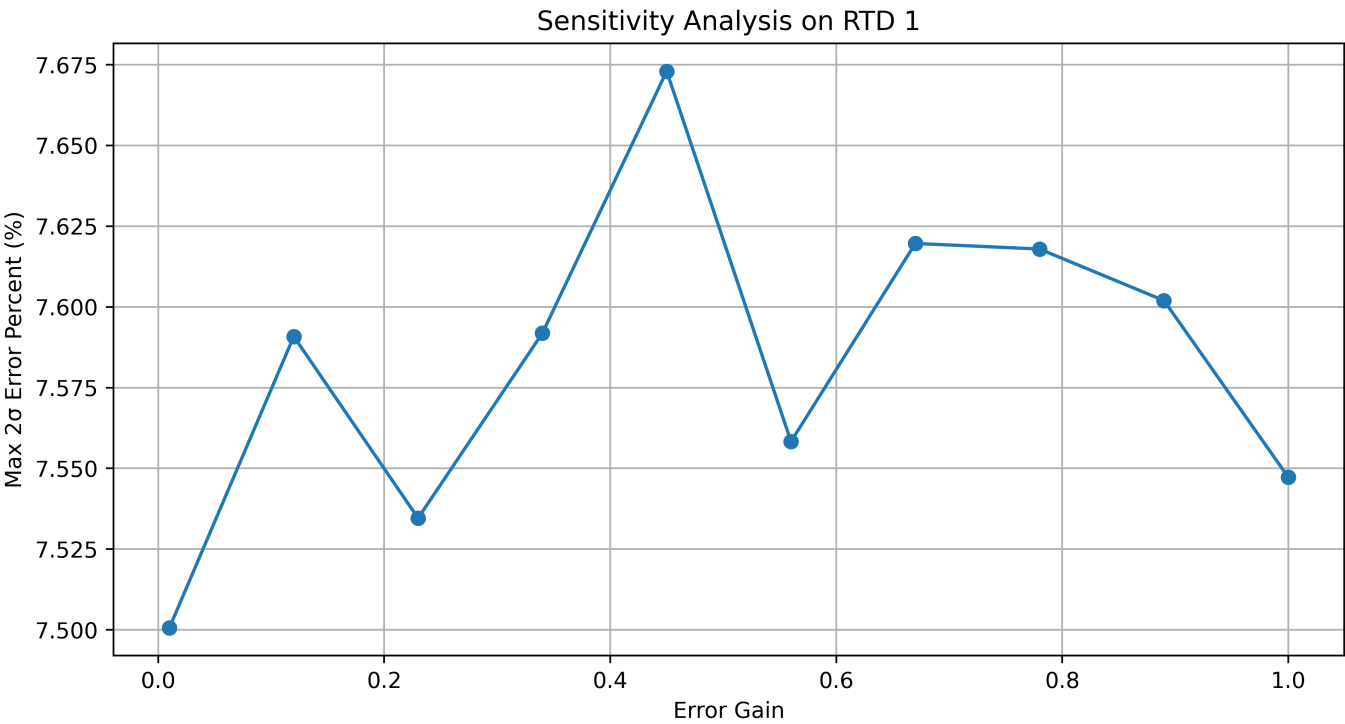
The equation of best fit is: $0.0071 + 0.0730 \cdot x^1$.

Non-Isolated Sensitivity Analysis on RTD 1

Impact of RTD 1 Noise Gain on System with Noise

Metrics/Sensor Noise Gain	0.01	0.12	0.23	0.34	0.45	0.56	0.67	0.78	0.89	1
true_value	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873	0.0032873
median	0.0033131	0.0033132	0.0033119	0.0033138	0.0033127	0.0033114	0.0033129	0.0033124	0.0033151	0.0033128
average	0.003314	0.0033143	0.0033126	0.0033146	0.0033157	0.0033124	0.0033149	0.0033145	0.0033155	0.0033127
average_percent_difference	0.81276	0.82312	0.77008	0.83202	0.86505	0.7648	0.84141	0.82961	0.85803	0.77362
min_val	0.0028933	0.0028823	0.0029007	0.0029231	0.0029262	0.00286	0.0028768	0.0028508	0.0029153	0.0029125
max_val	0.0037225	0.0037131	0.0036892	0.0037304	0.0037041	0.0037918	0.0037664	0.0037851	0.0037653	0.003759
std_dev	0.00010992	0.00011124	0.00011118	0.00011111	0.0001119	0.00011166	0.00011141	0.00011157	0.00011085	0.00011133
std_dev_percent	3.3439	3.3839	3.3823	3.3799	3.404	3.3968	3.3891	3.3942	3.372	3.3868
mean_absolute_error	9.0109e-05	9.1036e-05	9.1105e-05	9.1422e-05	9.186e-05	9.1666e-05	9.1535e-05	9.1408e-05	9.1132e-05	9.1436e-05
mean_absolute_percent_error	2.7412	2.7693	2.7714	2.7811	2.7944	2.7885	2.7845	2.7807	2.7723	2.7815
max_2std_error	0.00024657	0.00024953	0.00024768	0.00024956	0.00025223	0.00024846	0.00025048	0.00025042	0.0002499	0.0002481
max_2std_percent_error	7.5006	7.5909	7.5346	7.5919	7.673	7.5583	7.6197	7.6179	7.602	7.5473
max_3std_error	0.00035649	0.00036077	0.00035887	0.00036067	0.00036413	0.00036012	0.00036189	0.000362	0.00036074	0.00035943
max_3std_percent_error	10.845	10.975	10.917	10.972	11.077	10.955	11.009	11.012	10.974	10.934

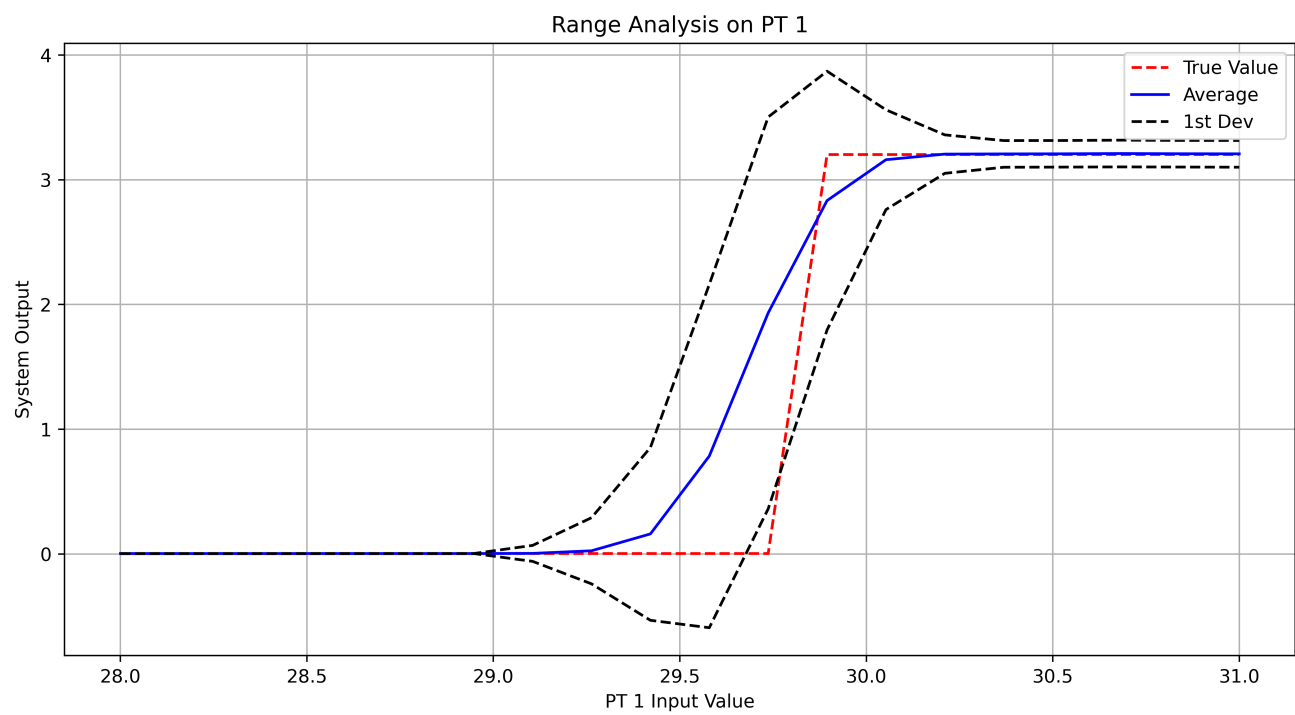
Non-Isolated Sensitivity Analysis on RTD 1 Plots



Relationship between sensor Error Gain and Max 2σ Error Percent (%) is: logarithmic with a confidence level of 53.36 %.

The equation of best fit is: $7.6067 + 0.0202 \cdot \ln(x)$.

Range Analysis on PT 1



Range Analysis on RTD 1

