



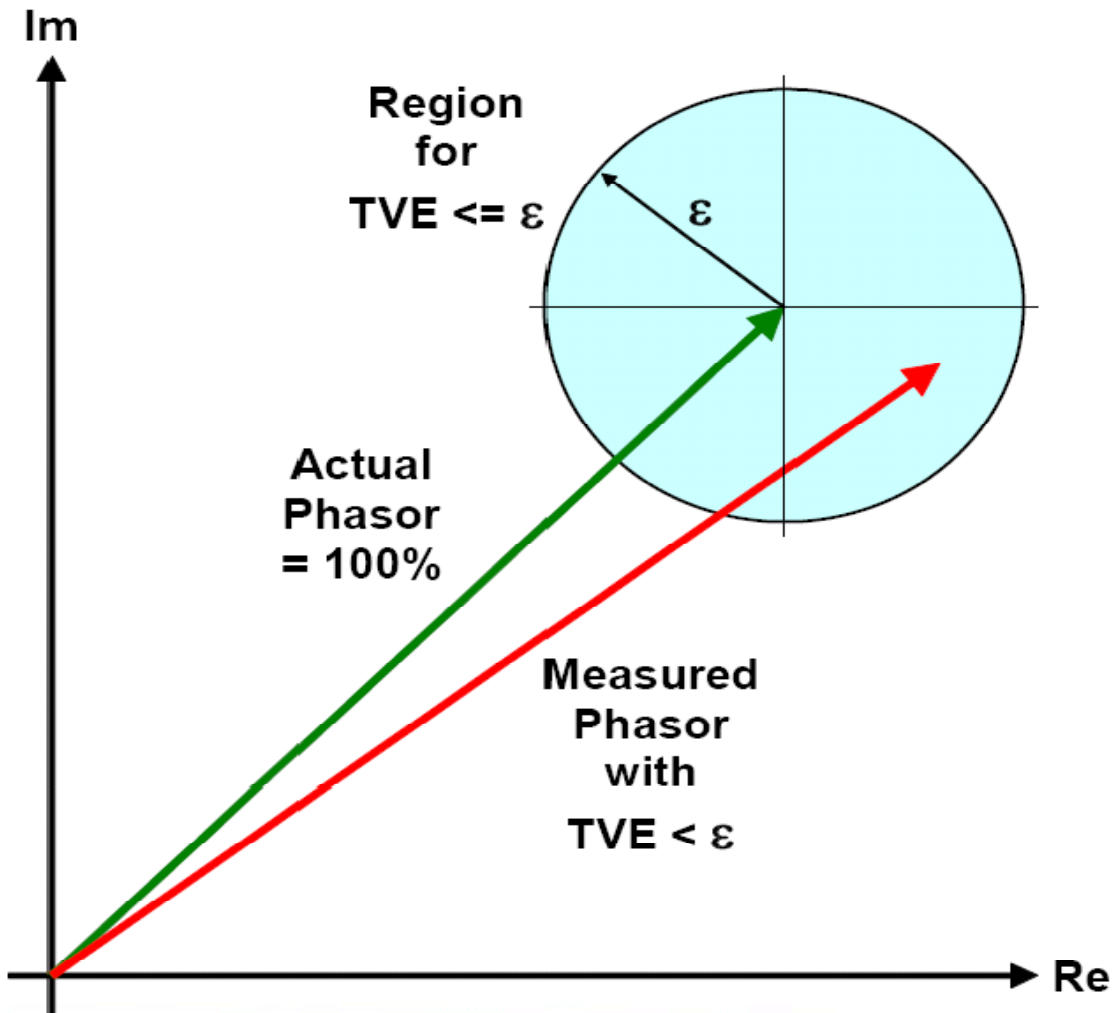
Real time synchronized data consumption and archival for the power grid

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OSIsoft
Center of Excellence

March 14, 2011

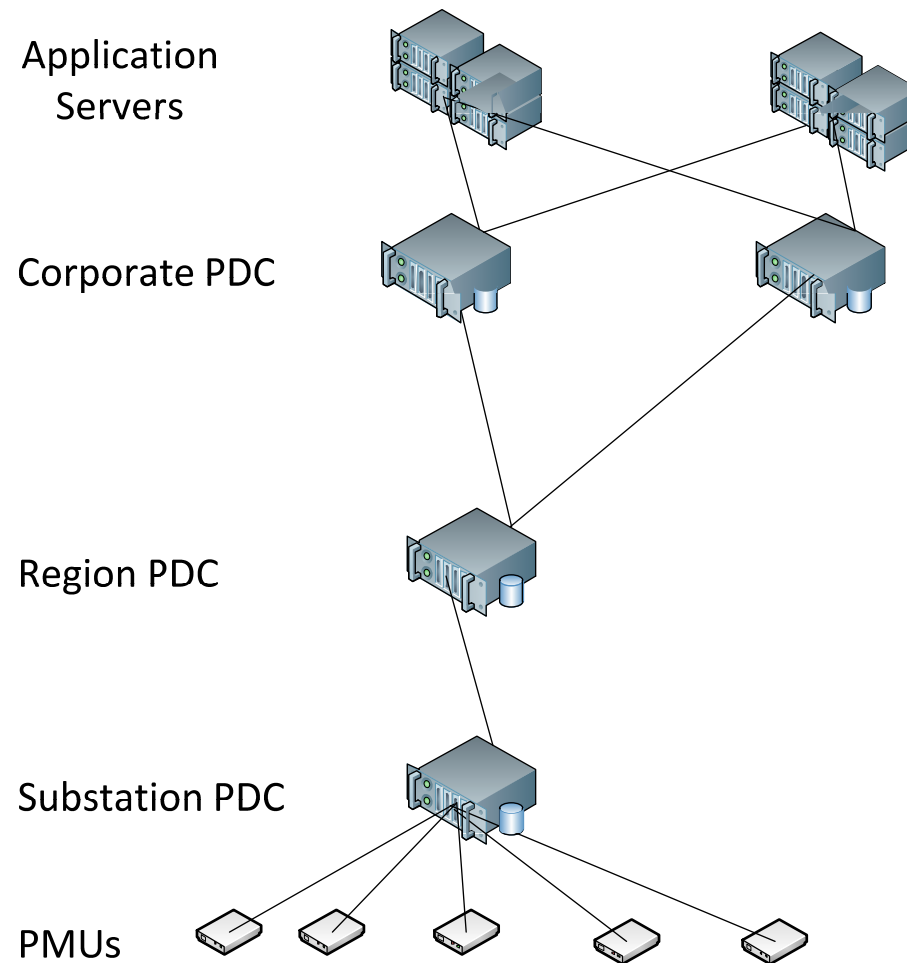


PMU accuracy

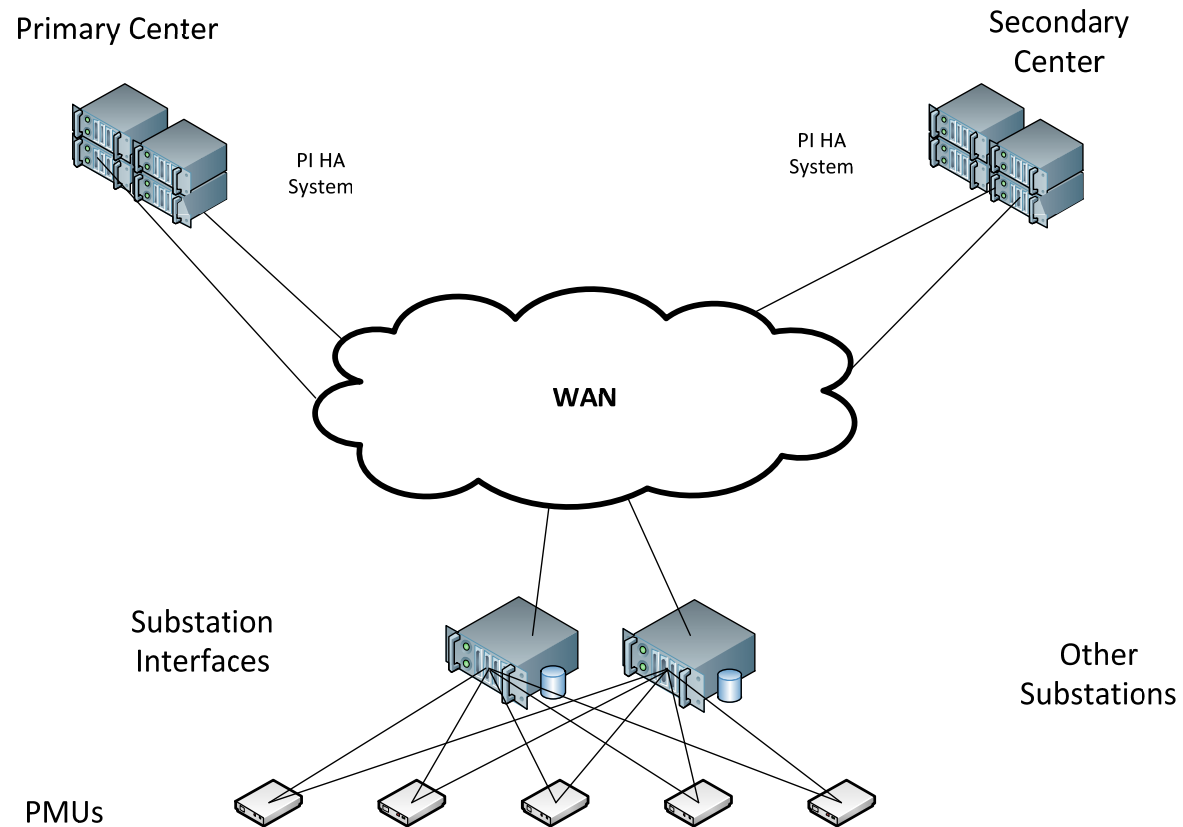


- One percent total vector error
- $\pm 26 \mu \text{ sec}$

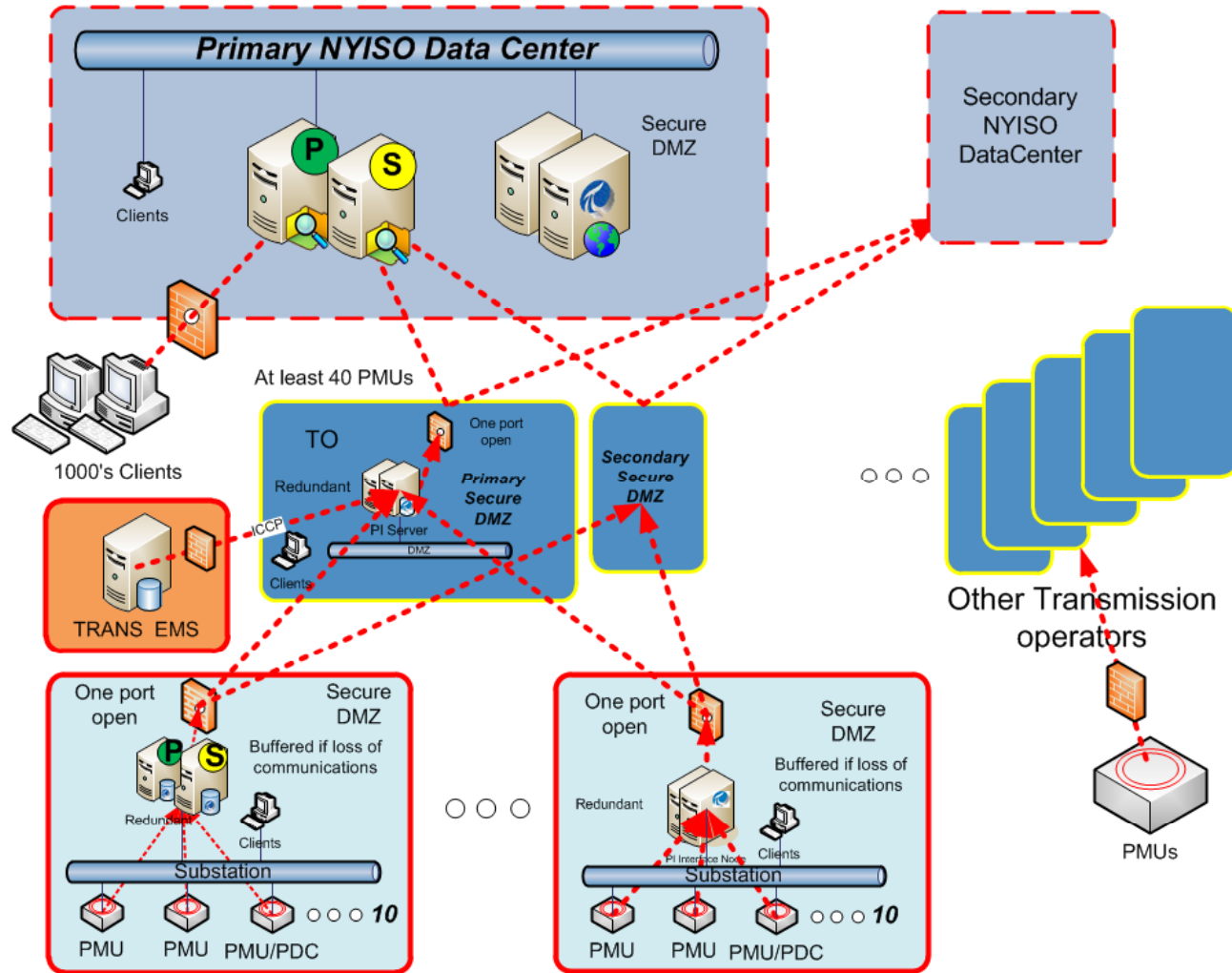
PDC Stacking



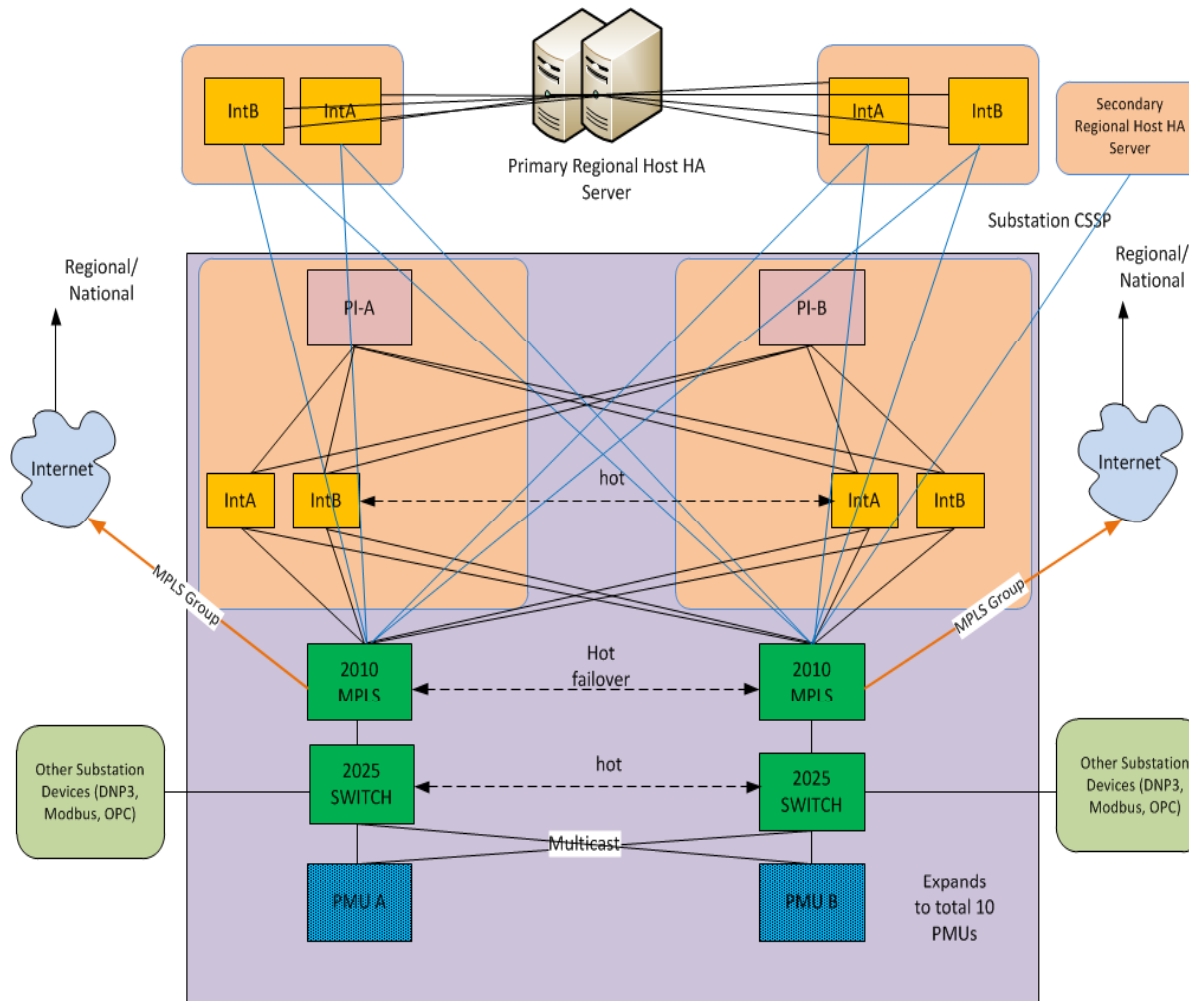
Common architecture



Reference Architecture

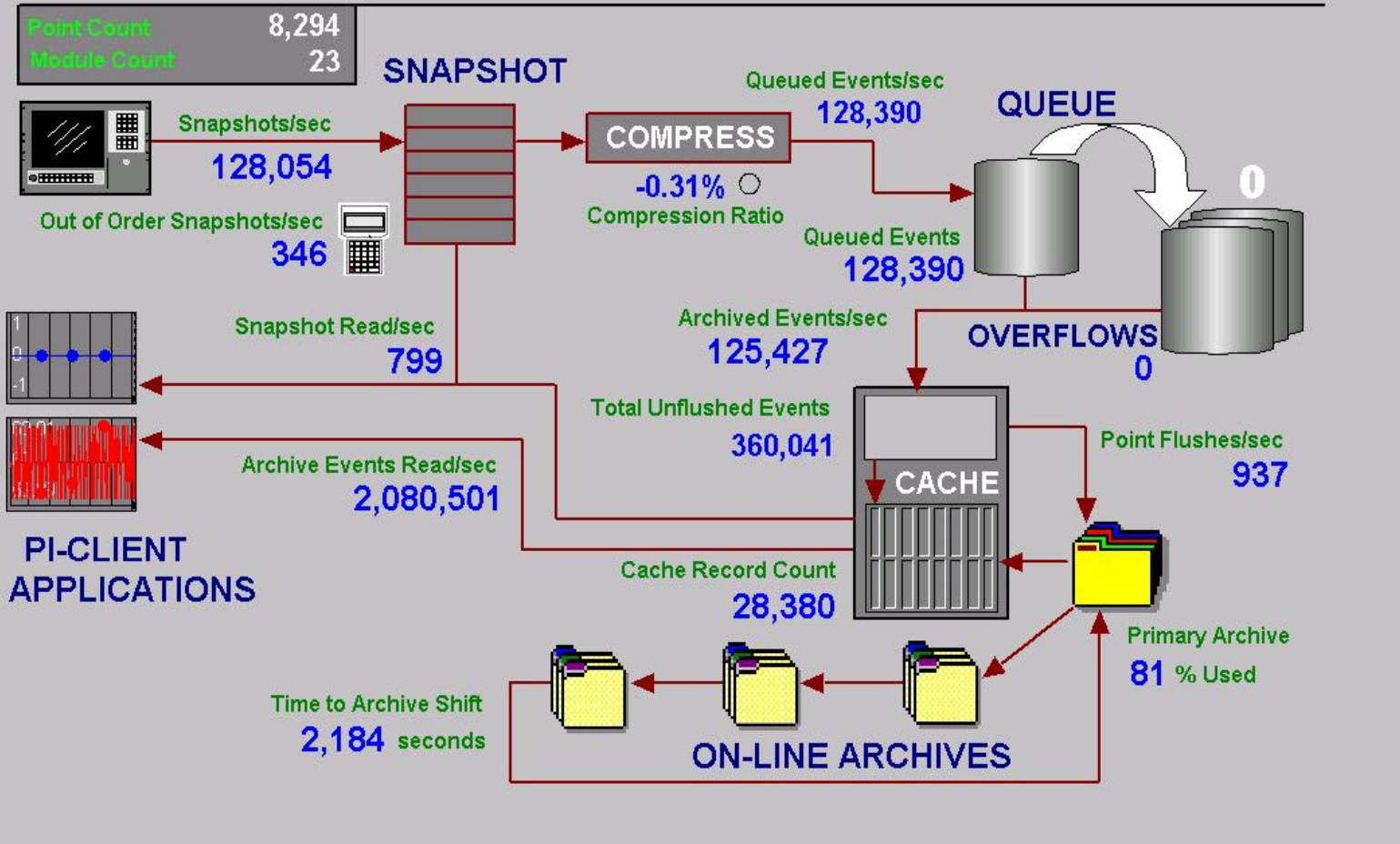


Substation detail

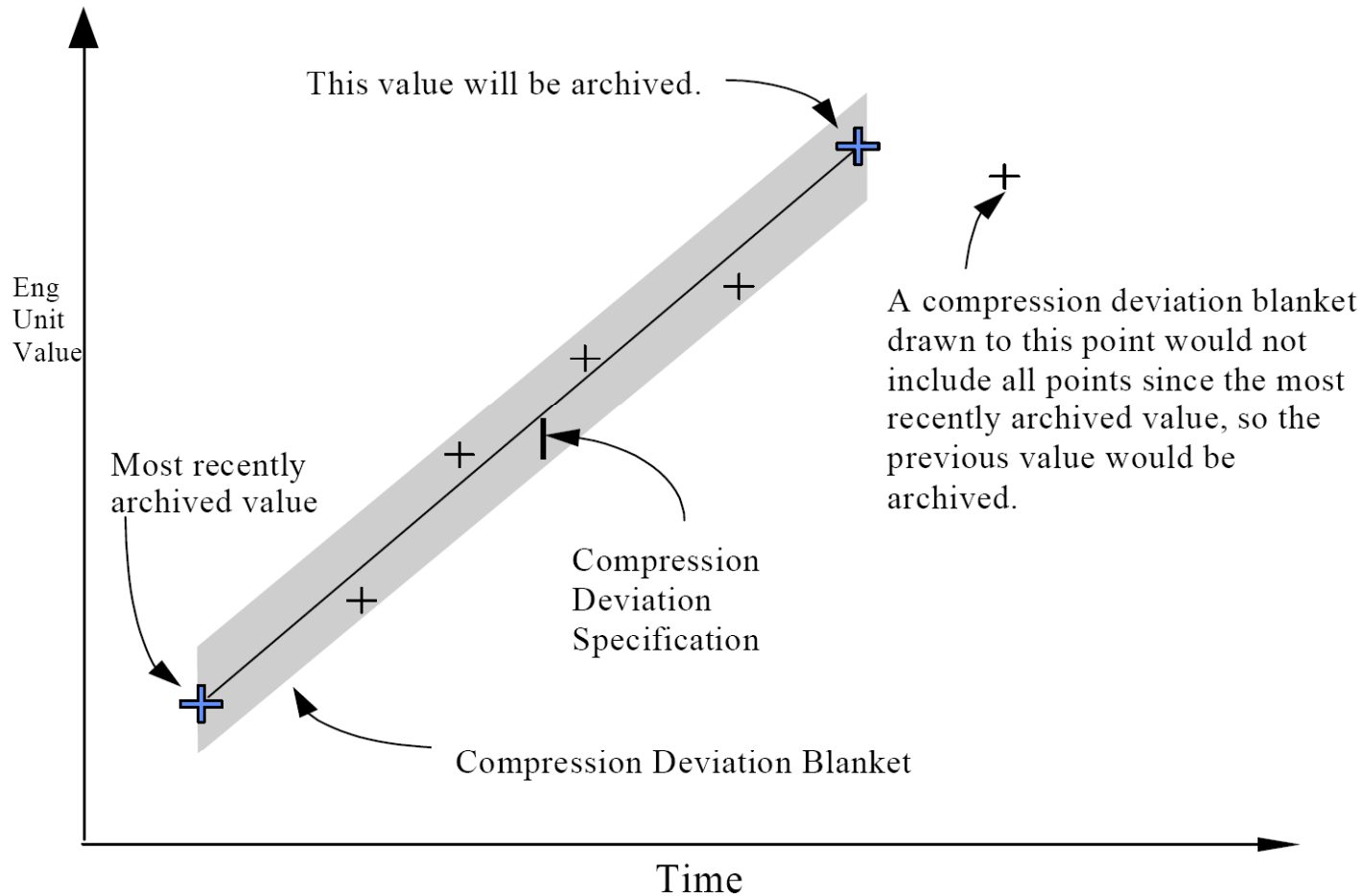


Performance

PI Server 3.4 Overview



Compression



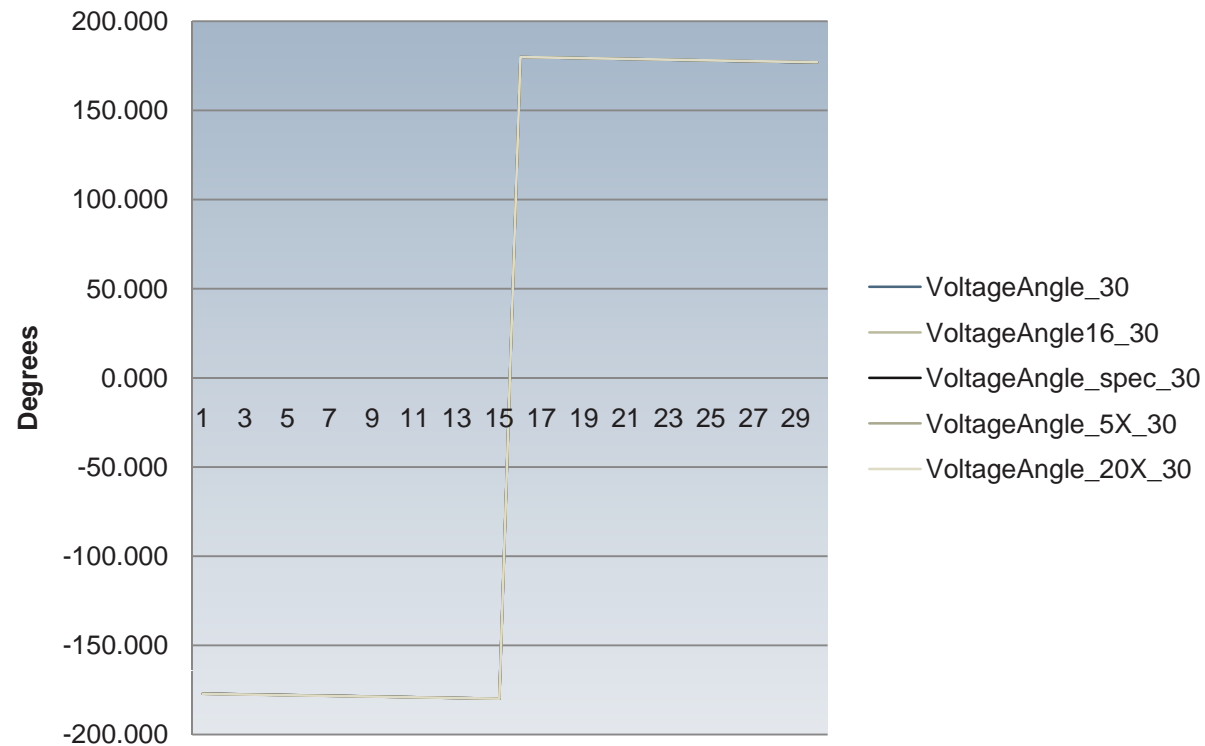
Voltage Angle results

	A	B	C	D	E	F	G	H	I	J
1		VoltageAngle_30	VoltageAngle16_30	Delta	VoltageAngle_spec_30	Delta	VoltageAngle_5X_30	Delta	VoltageAngle_20X_30	Delta
54004	Average	-23.777	-23.777	0.000	-23.777	0.000	-23.777	0.000	-23.775	-0.002
54005	Variance	10364.174	10364.170	0.000	10364.177	0.000	10364.381	0.001	10365.345	0.014
54006	Maximum	179.990	179.989	0.005	179.990	0.010	179.990	0.050	179.990	0.200
54007	Minimum	-179.998	-180.000	-0.005	-179.998	-0.010	-179.998	-0.050	-179.998	-0.200
54008	Compdev					0.010		0.050		0.200
54009	Archived events	54001	54001		14813		1979		766	
54010	% Compression	0	0		72.6%		96.3%		98.6%	

Table 1 Comparison of three levels of compression

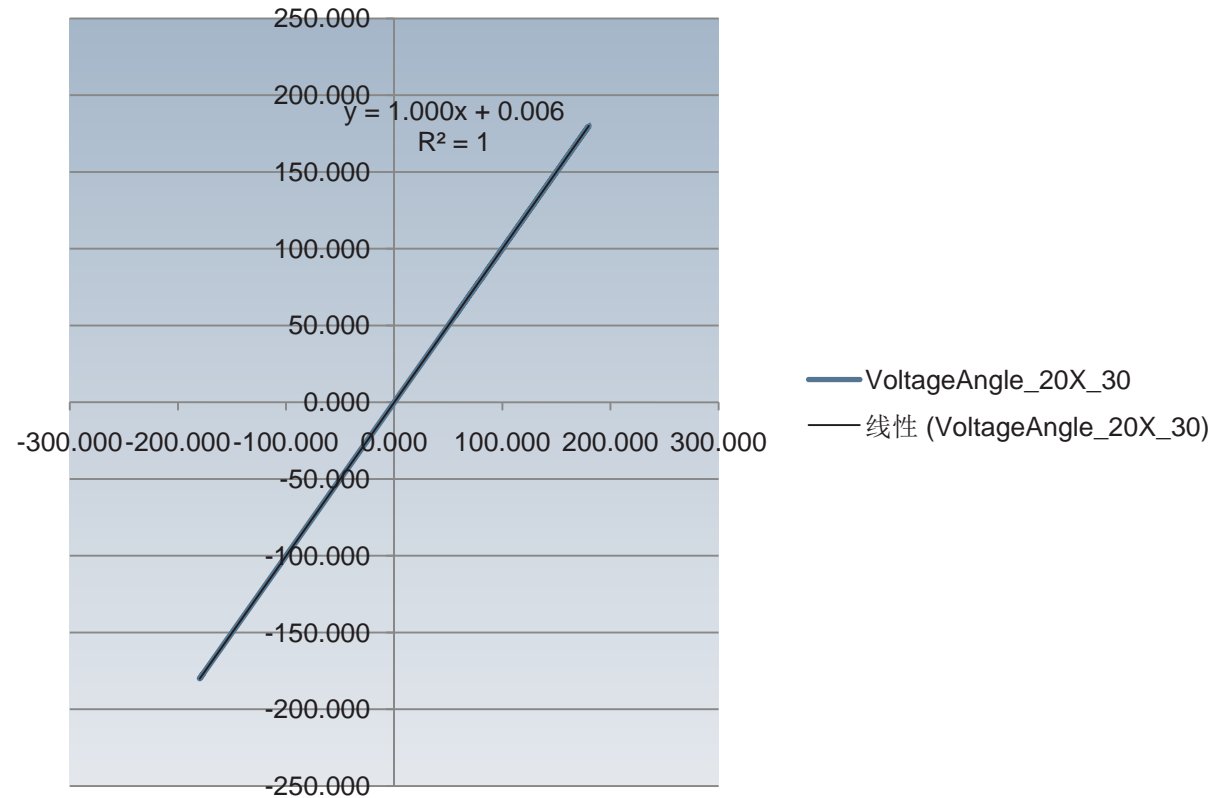
Angle compression results

Voltage Angle versus time (30 samples per second)



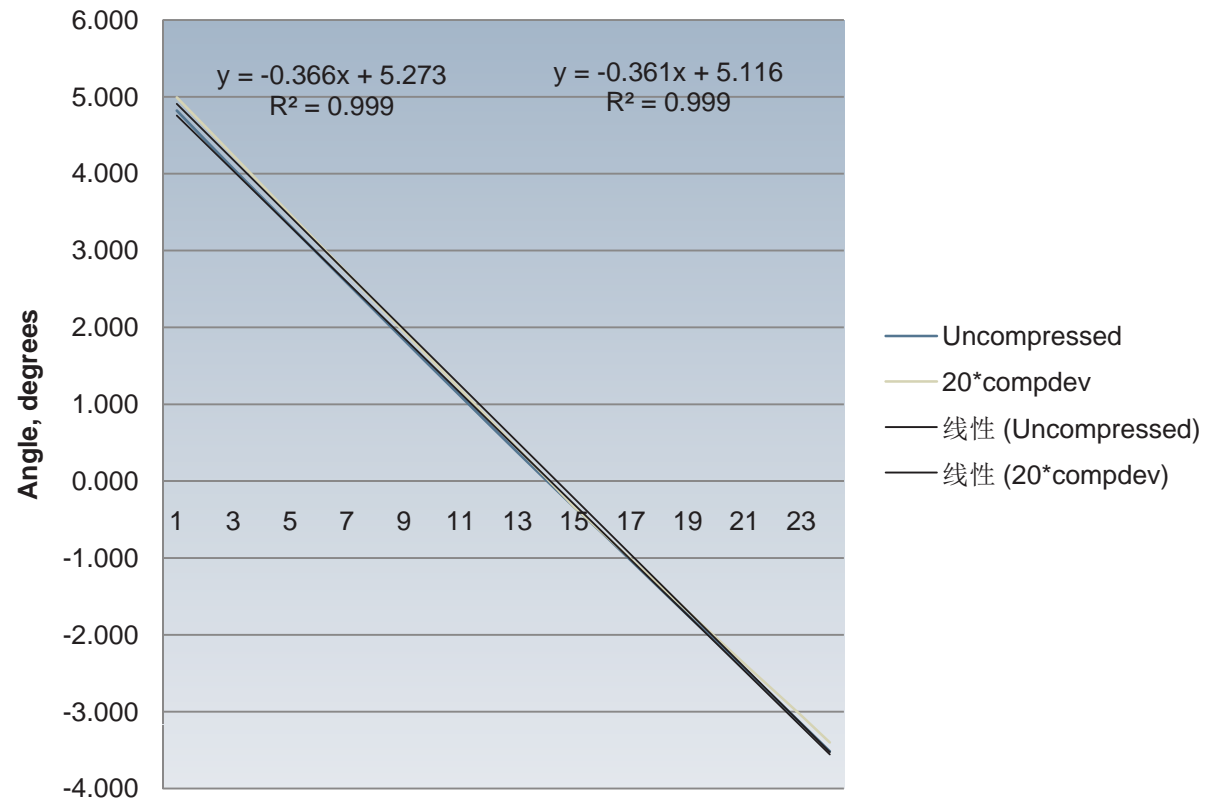
Voltage angle comparison

VoltageAngle_20X_30



Zero crossing comparison

Angle zero crossing



Tables (Voltage Magnitude and Current angle

A	B	C	D	E	F	G	H	I	J
	VoltageMag_30	VoltageMag16_30	Delta	VoltageMag_spec_30	Delta	VoltageMag_5X_30	Delta	VoltageMag_20X_30	Delta
Average	286.386572	286.386581	-0.000009	286.384490	0.002083	286.335517	0.051055	286.747078	-0.360506
Variance	0.073778	0.073806	0.000028	0.073327	0.000619	0.079891	0.012695	0.008674	0.041996
Maximum	287.094666	287.099823	0.009155	287.065155	0.056366	287.047974	0.281799	286.908386	0.190887
Minimum	285.567078	285.561707	-0.005155	285.567078	-0.056366	285.659576	-0.281219	286.585754	-1.081024
Compdev					0.056368		0.281841		1.127366
Archived events	54001	54001		2552		135		0	
% Compression	0	0		95.3%		99.8%		100.0%	

A	B	C	D	E	F	G	H	I	J
	CurrentAngle_30	CurrentAngle16_30	Delta	CurrentAngle_spec_30	Delta	CurrentAngle_5X_30	Delta	CurrentAngle_20X_30	Delta
Average	-25.952	-25.952	0.000	-25.953	0.000	-25.954	0.001	-25.955	0.002
Variance	11079.841	11079.841	0.000	11079.841	0.000	11079.845	0.000	11079.726	0.008
Maximum	179.998	180.000	0.005	179.998	0.010	179.998	0.050	179.998	0.200
Minimum	-179.996	-180.000	-0.005	-179.996	-0.010	-179.996	-0.050	-179.996	-0.200
Compdev	0	0	0		0.01		0.05		0.20
Archived events	54001	54001		42815		19867		3436	
% Compression	0	0		20.7%		63.2%		93.6%	

Current magnitude and VA

A	B	C	D	E	F	G	H	I	J
	CurrentMag_30	CurrentMag16_30	Delta	CurrentMag_spec_30	Delta	CurrentMag_5X_30	Delta	CurrentMag_20X_30	Delta
Average	110.91319	110.91318	0.00000	110.91364	-0.00045	110.92317	-0.00998	110.99160	-0.07841
Variance	11.22509	11.22508	0.00002	11.22435	0.00033	11.21006	0.01634	10.79176	0.22518
Maximum	136.02931	136.03625	0.00763	136.02931	0.05502	136.02931	0.27509	136.02931	1.10043
Minimum	102.38154	102.37434	-0.00763	102.38154	-0.05502	102.52757	-0.27511	103.23901	-1.10039
Compdev	0		0		0.05502		0.27512		1.10047
Archived events	54001	54001		35344		11118		1609	
% Compression	0	0		34.5%		79.4%		97.0%	

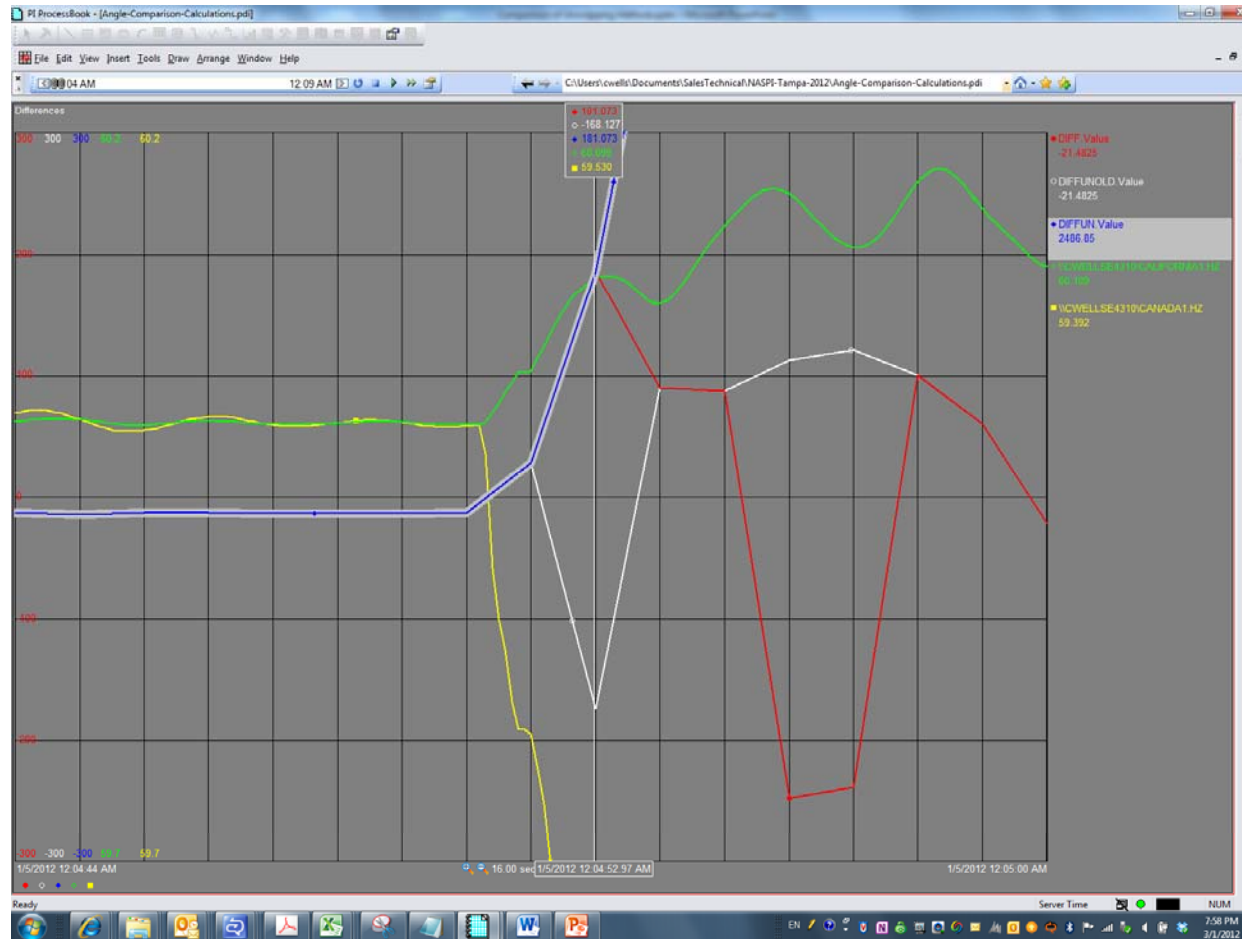
A	B	C	D	E	F	G	H	I	J
	VA_30	VA16_30	Delta	VA_spec_30	Delta	VA_5X_30	Delta	VA_20X_30	Delta
Average	31763.4284	31763.4270	0.0014	31763.4992	-0.0708	31765.6848	-2.2564	31777.9052	-14.4768
Variance	882450.2707	882462.7340	0.7773	882411.5961	16.4871	881633.8320	894.8653	862104.7056	12121.7097
Maximum	38863.8594	38865.3203	1.5273	38863.8594	13.0820	38863.8594	65.4473	38863.8594	261.7676
Minimum	29360.5273	29361.8574	-1.5273	29360.5273	-13.0879	29403.2168	-65.4414	29444.3438	-261.7324
Compdev	0.0000		0.0000		13.0895		65.4476		261.7906
Archived events	54001	54001		37791		13513		2013	
% Compression	0	0		30.0%		75.0%		96.3%	

VAR and frequency

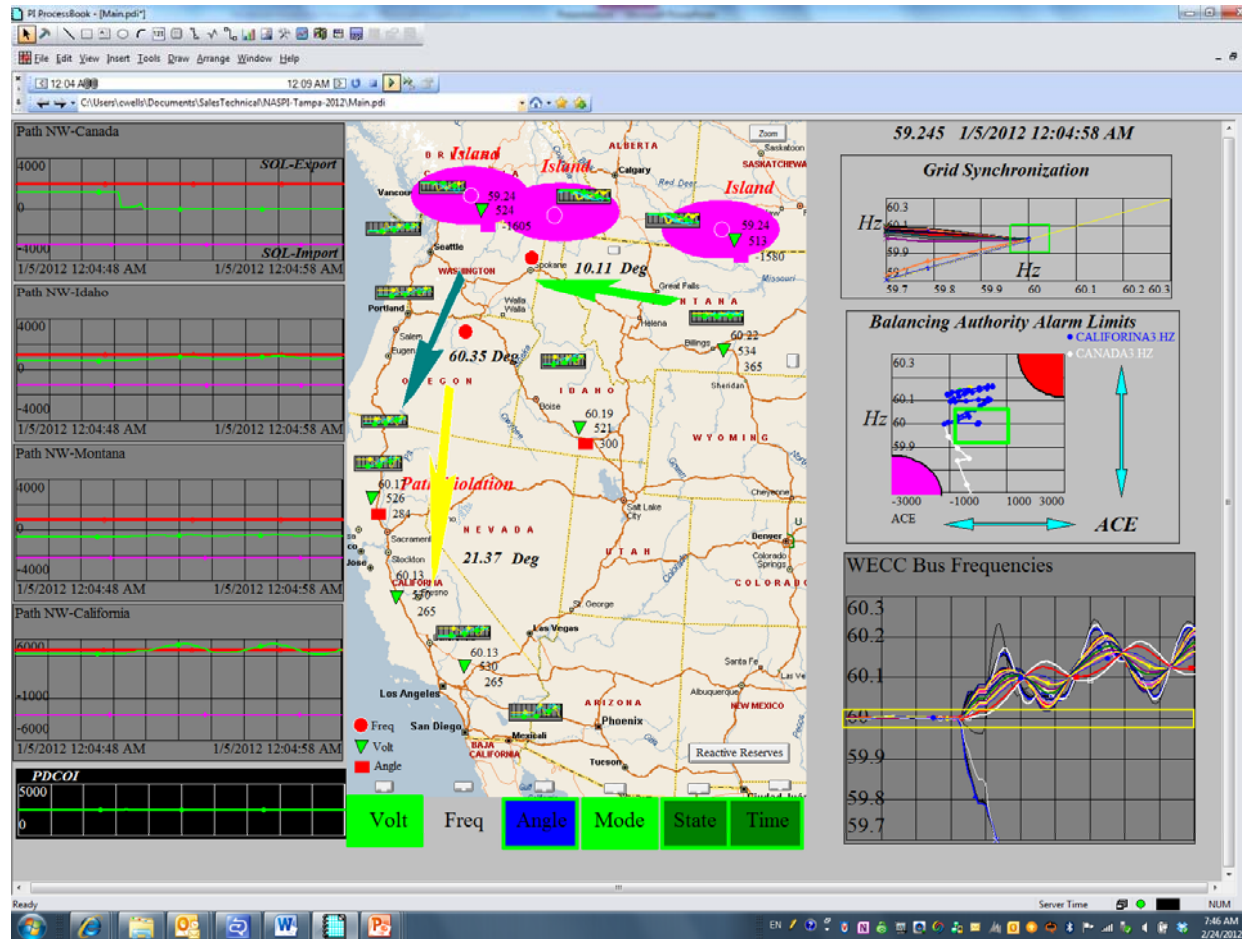
A	B	C	D	E	F	G	H	I	J
	VAR_30	VAR16_30	Delta	VAR_spec_30	Delta	VAR_5X_30	Delta	VAR_20X_30	Delta
Average	9253.44962	9253.45127	-0.00165	9253.45610	-0.00648	9253.88072	-0.43111	9257.11393	-3.66431
Variance	464815.73667	464815.97962	0.19366	464815.15704	0.78254	464759.52293	63.83568	463569.45473	1428.92089
Maximum	14566.08105	14566.48438	0.76270	14566.08105	4.15039	14566.08105	20.74316	14566.08105	83.00293
Minimum	7156.90820	7156.59033	-0.76270	7156.90820	-4.14844	7156.90820	-20.75098	7170.46924	-82.99805
Compdev	0		0		4.15021		20.75104		83.00416
Archived events	54001	54001		46591		27190		7435	
% Compression	0	0		13.7%		49.6%		86.2%	

A	B	C	D	E	F	G	H	I	J
	Frequency_30	Frequency16_30	Delta	Frequency_spec_30	Delta	Frequency_5X_30	Delta	Frequency_20X_30	Delta
Average	59.9968750	59.9968747	0.0000003	59.9968750	0.0000000	59.9968759	-0.0000008	59.9968732	0.0000018
Variance	0.0001222	0.0001222	0.0000000	0.0001222	0.0000000	0.0001222	0.0000000	0.0001219	0.0000003
Maximum	60.0349197	60.0350952	0.0003052	60.0349197	0.0000611	60.0349197	0.0003014	60.0349197	0.0011979
Minimum	59.9657326	59.9655151	-0.0003052	59.9657326	-0.0000611	59.9657326	-0.0003014	59.9657326	-0.0011979
Compdev	0.0000000		0.0000000		0.0000600		0.0002998		0.0011990
Archived events	54001	54001		48319		30763		10946	
% Compression	0	0		10.5%		43.0%		79.7%	

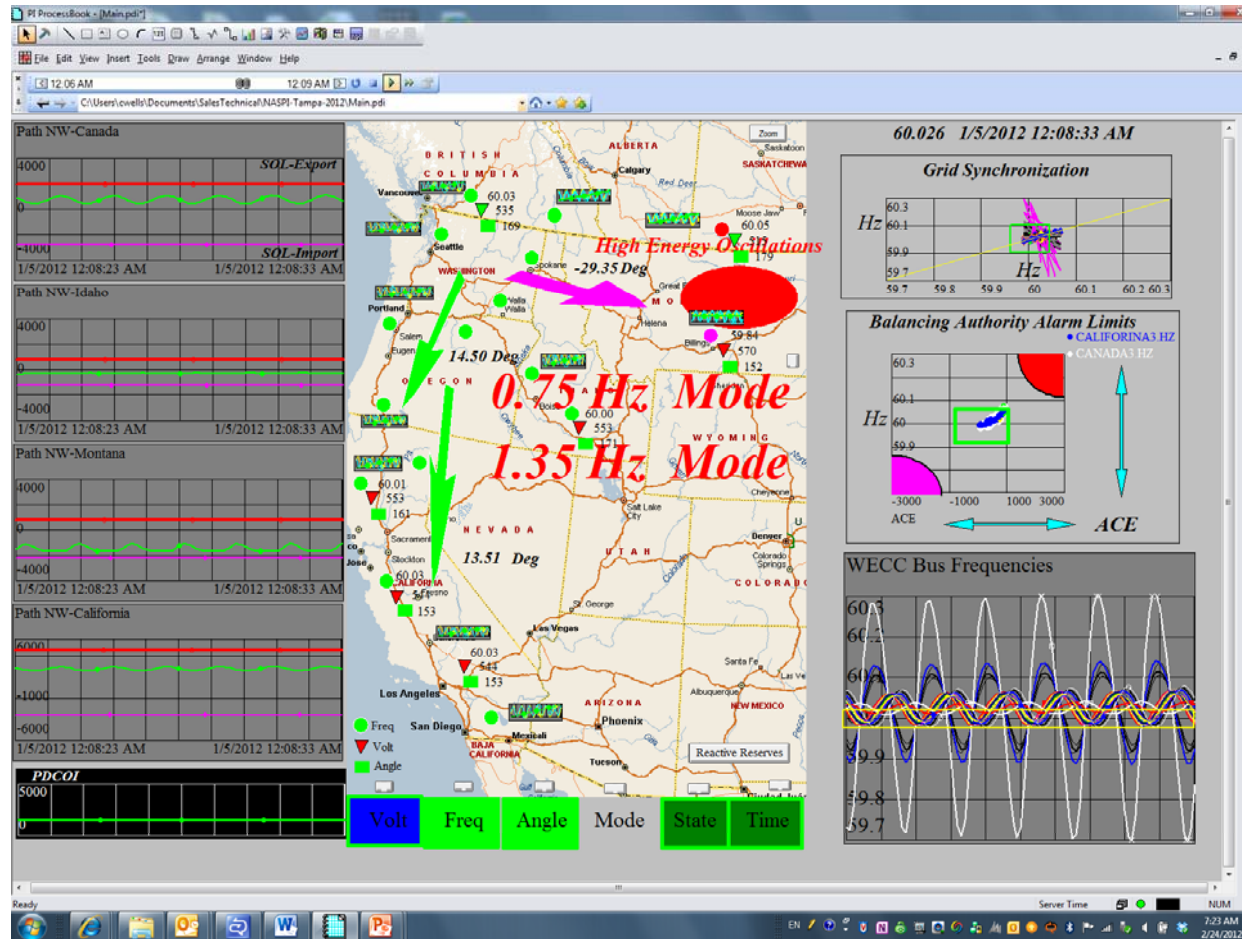
Unwrapping comparison



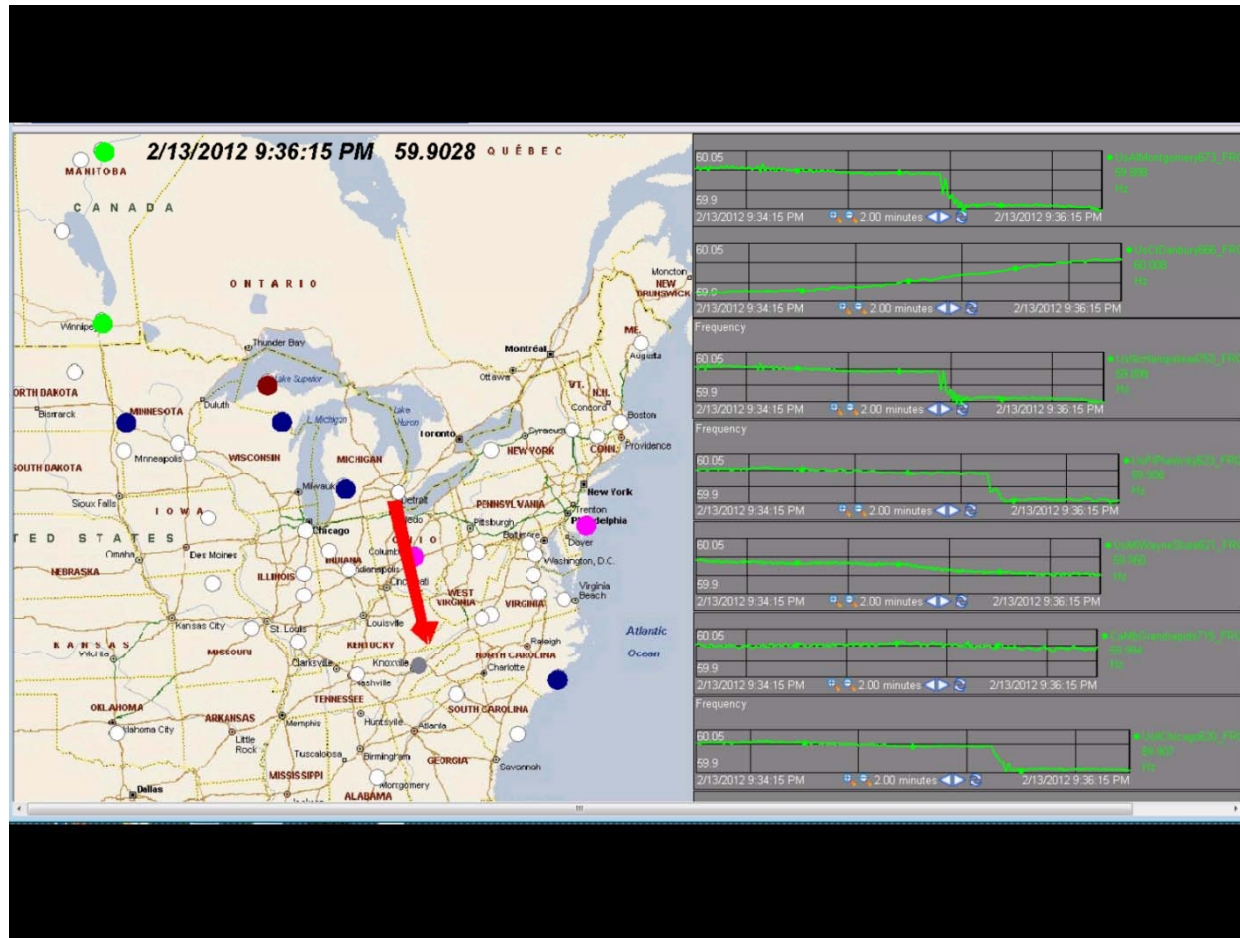
Visualization of phasor data



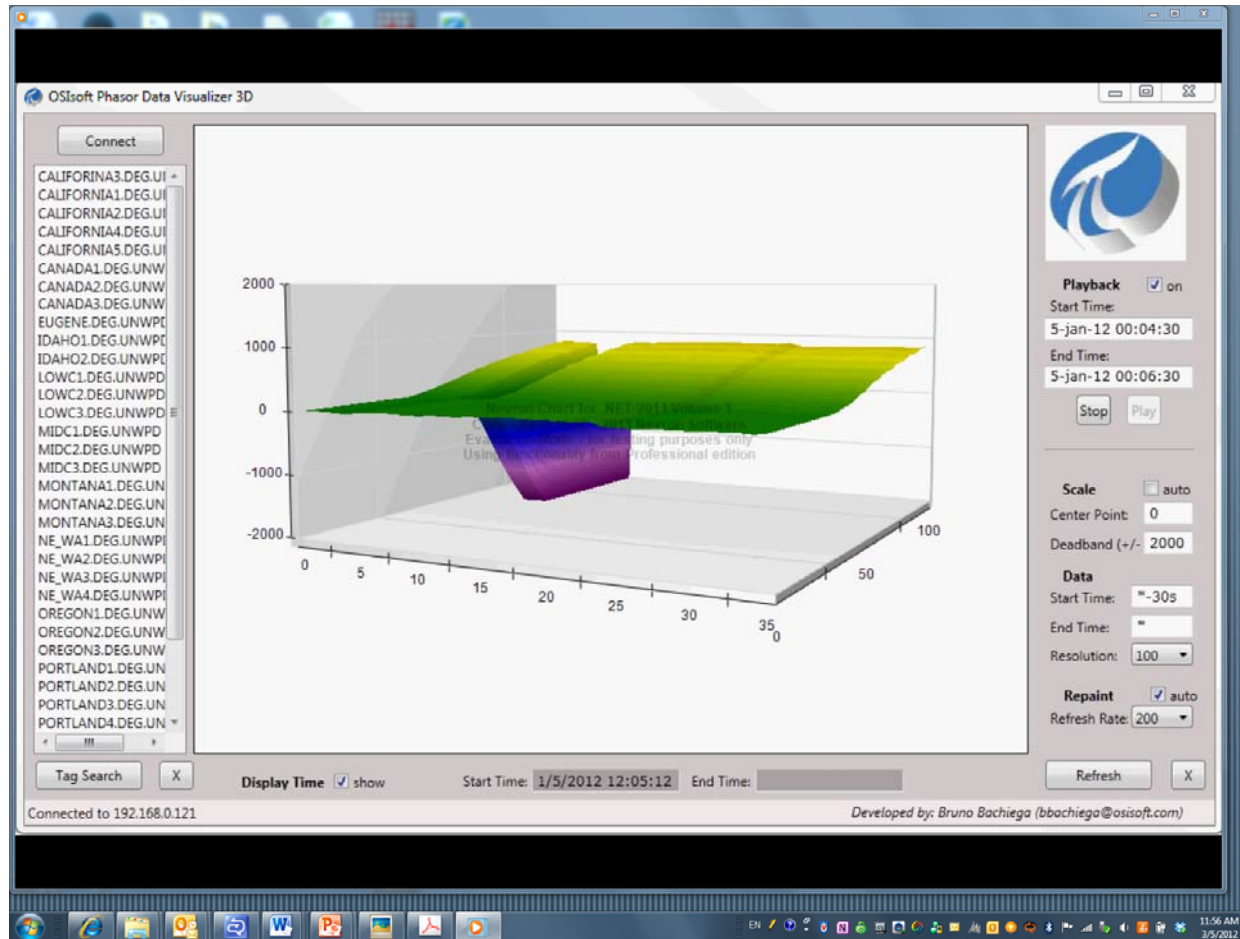
Visualization of phasor data



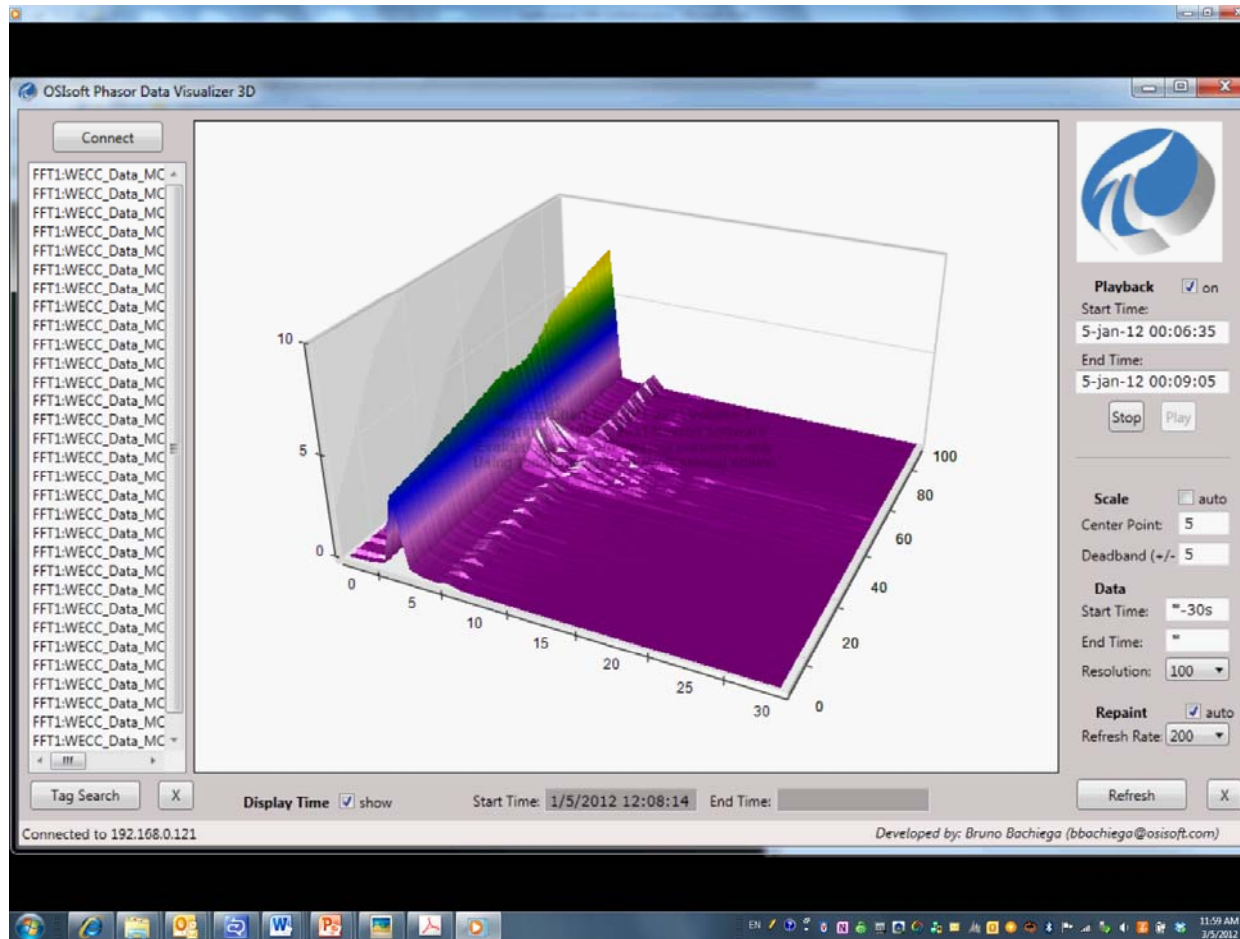
Eastern Interconnection oscillation



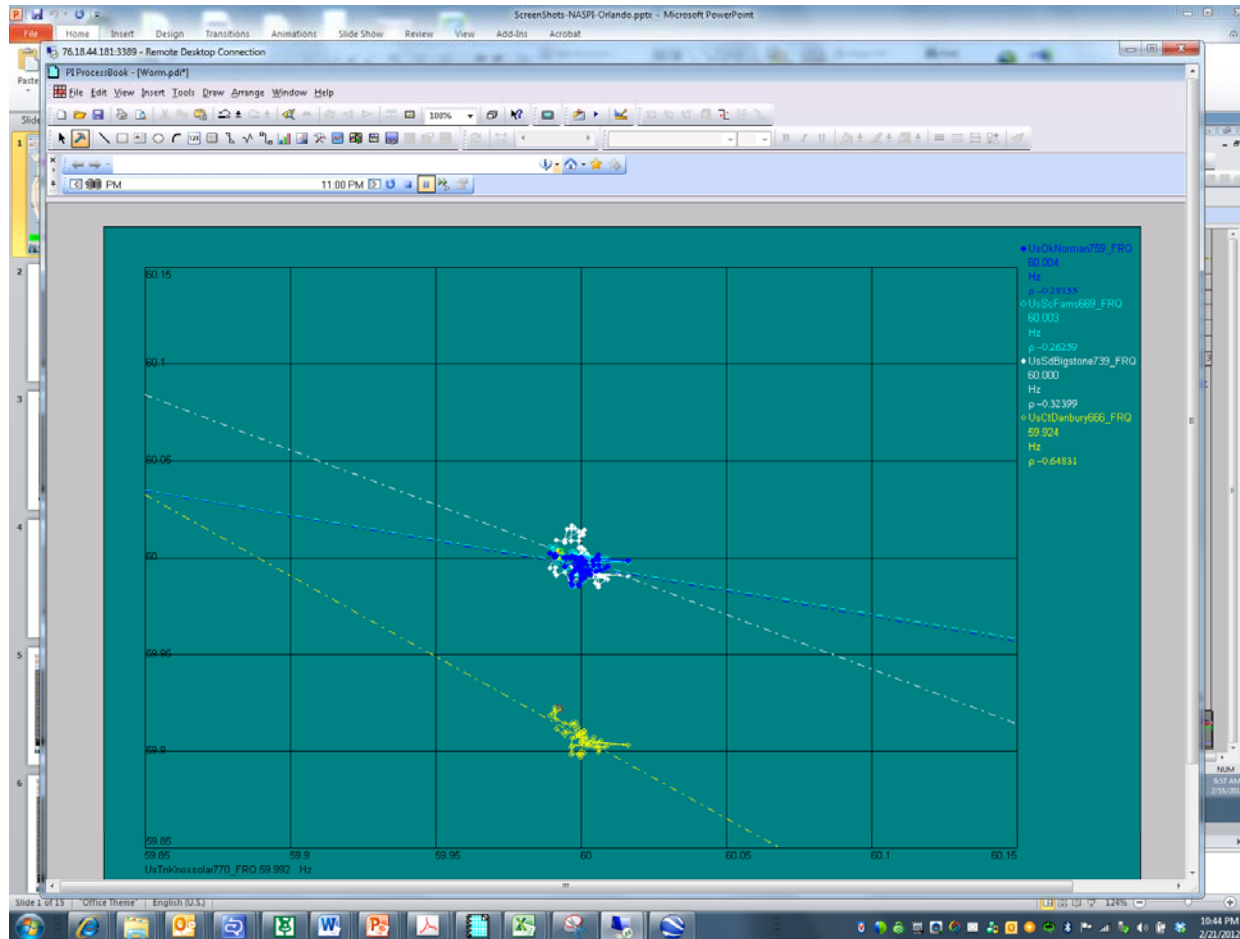
Angle surface



FFT Waterfall



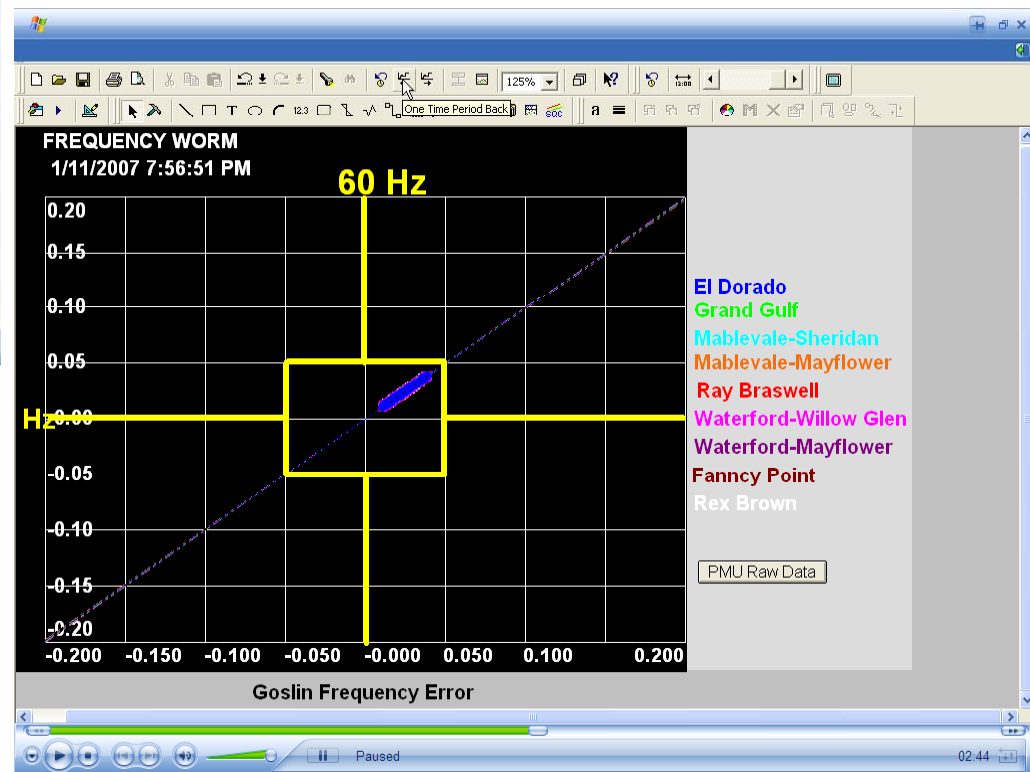
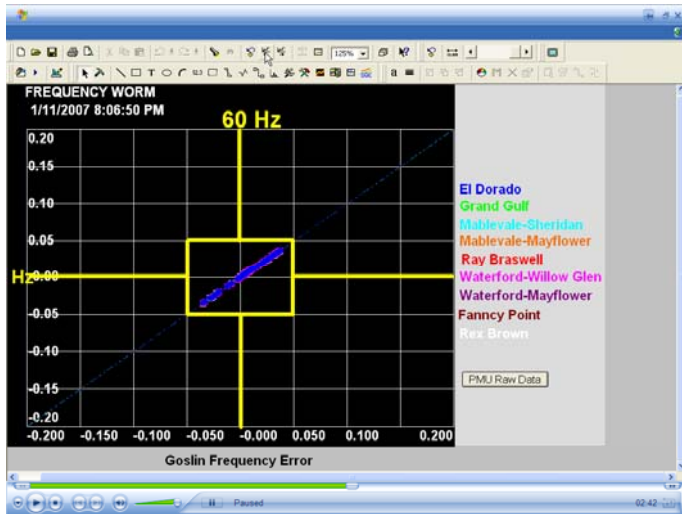
WORM chart



Customer Examples- Prior to major blackout



Customer Examples- Grid coherency



Real time FFTs, Phase portraits, SQC

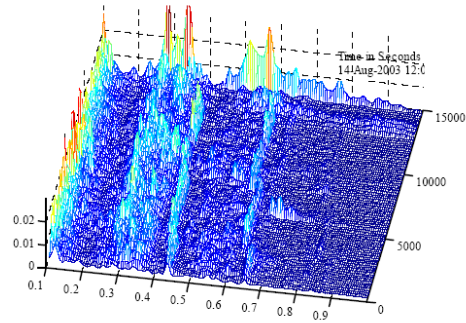
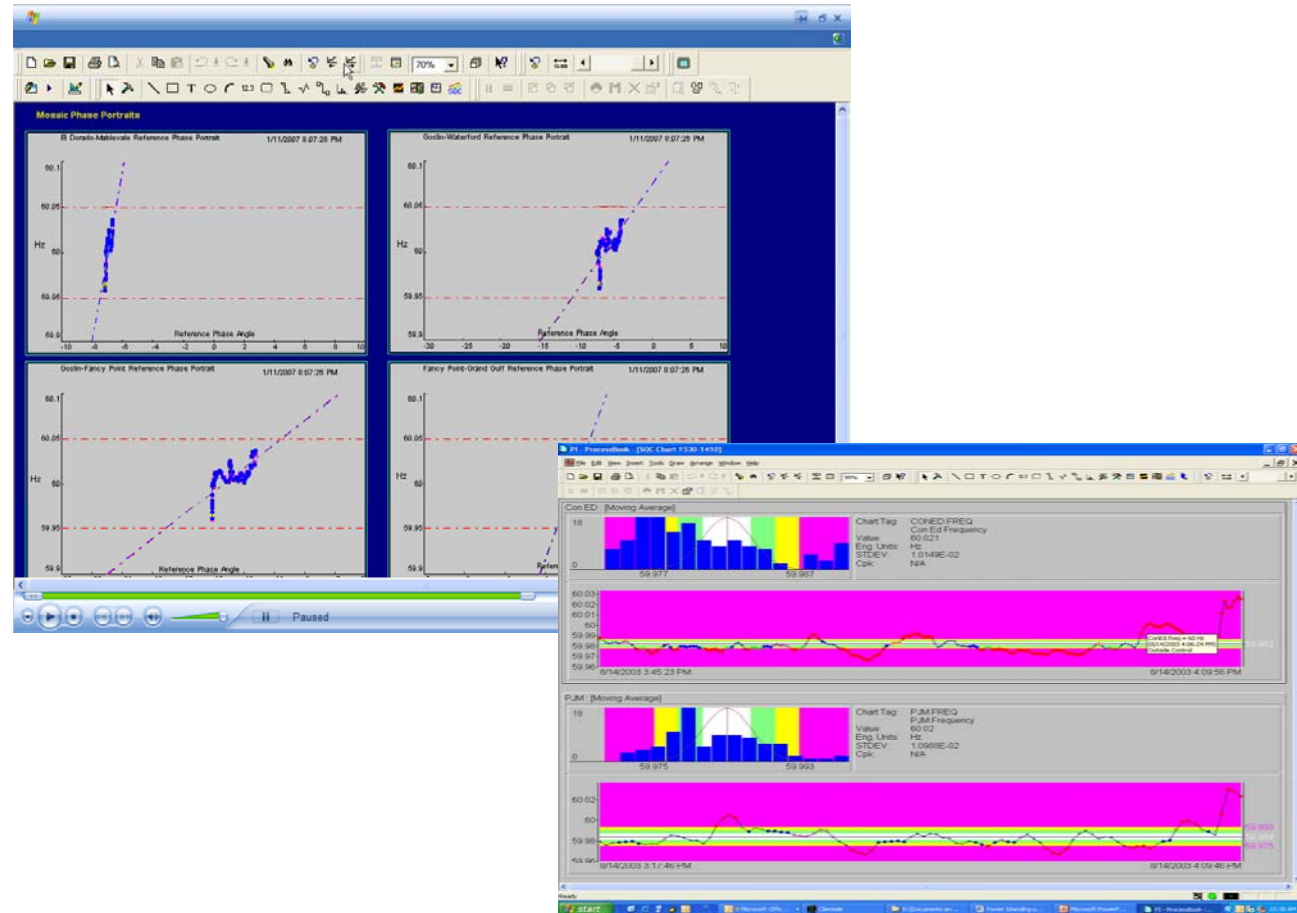
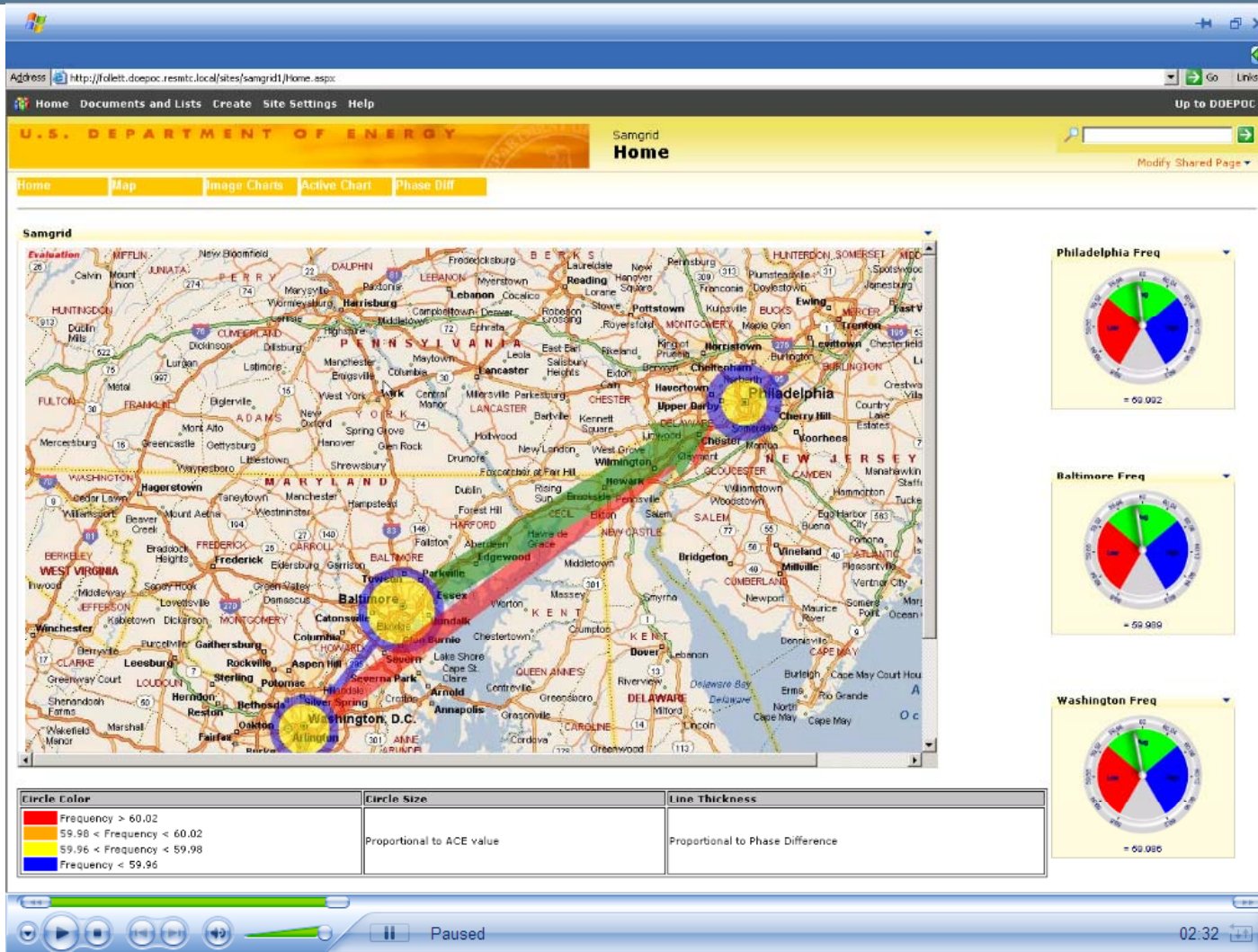


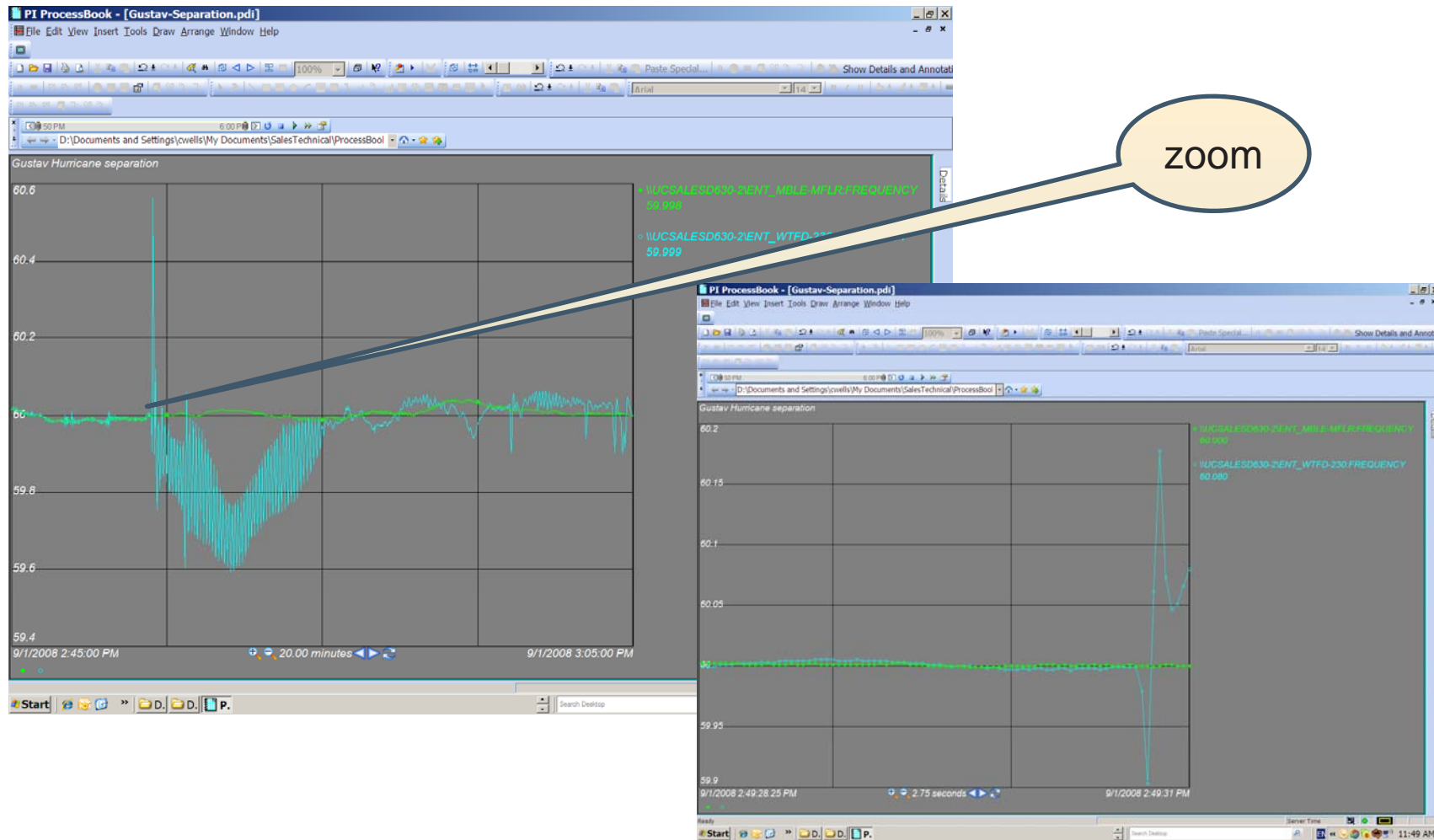
Fig. 12. Spectral history of AEP Kanawha River bus frequency for August 14 Blackout. 12:00-16:10 EDT



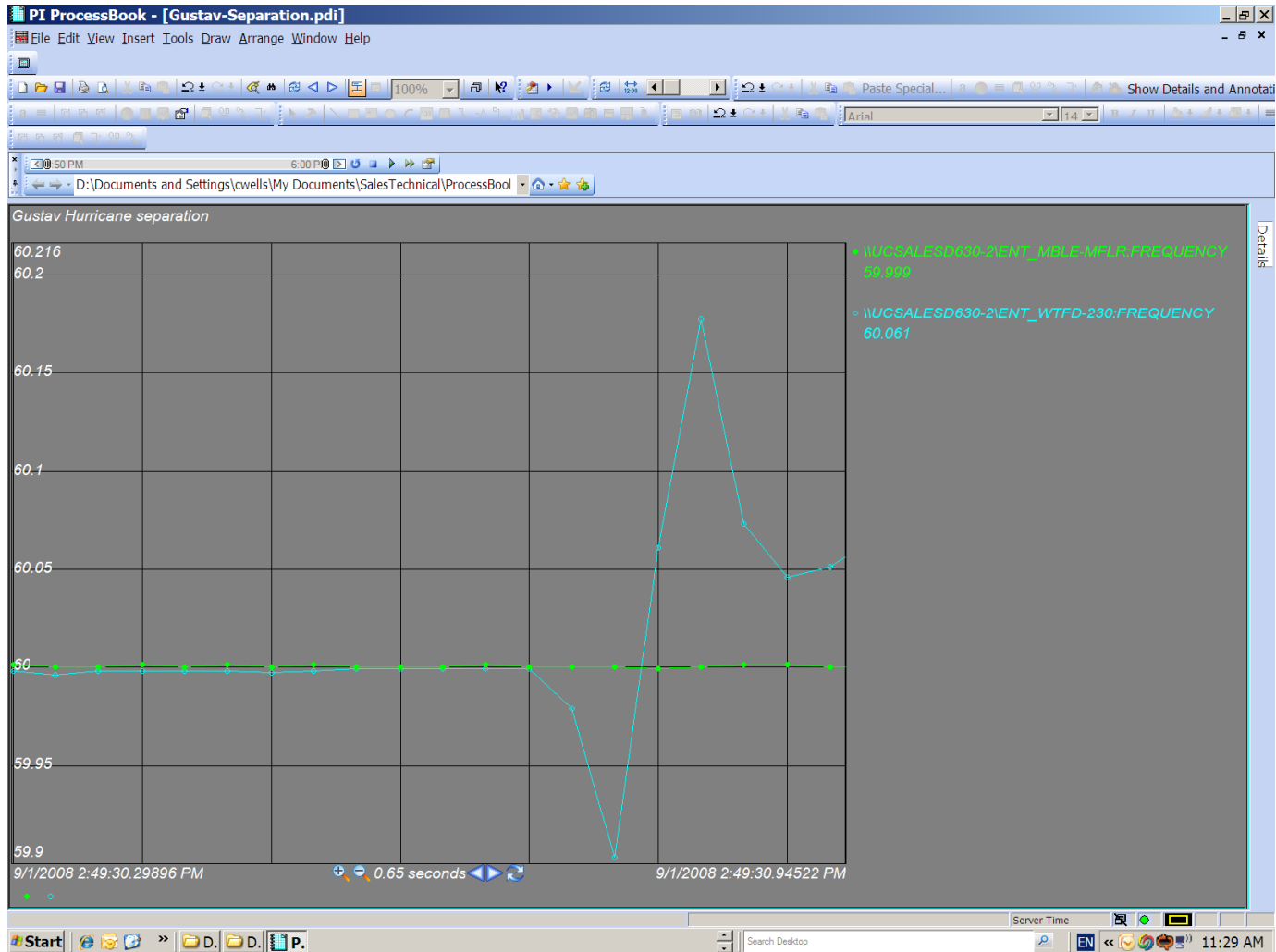
Customer Examples



Customer Examples- Island formation

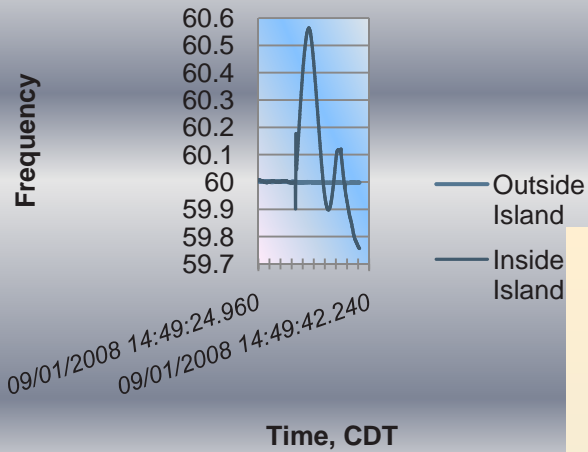


Customer Examples- Island formation

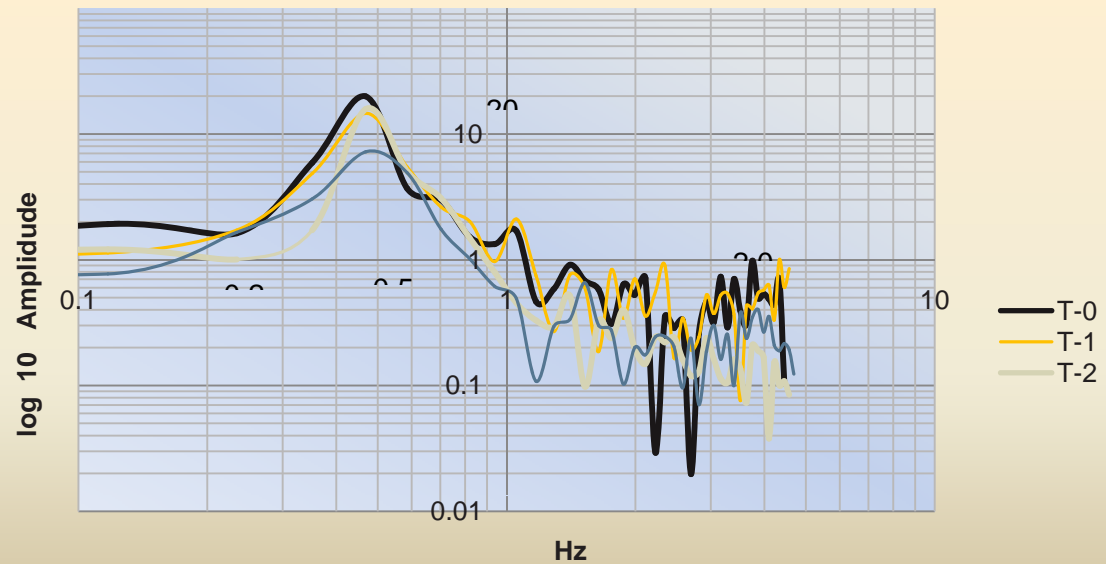


Customer Examples - (DataLink)

Separation Event



Bode Plots, prior to separation



Customer Examples- (DataLink)

	A	B	C	D	E
1	Timestamp	Outside	Inside	Out Angle	In Angle
2	09/01/2008 14:45:00.000	60.017	60.016	-62.112	-53.047
3	09/01/2008 14:45:00.033	60.017	60.016	-61.905	-52.86
4	09/01/2008 14:45:00.066	60.017	60.016	-61.699	-52.668
5	09/01/2008 14:45:00.100	60.017	60.015	-61.492	-52.475
6	09/01/2008 14:45:00.133	60.018	60.016	-61.285	-52.283
7	09/01/2008 14:45:00.166	60.018	60.016	-61.078	-52.091
8	09/01/2008 14:45:00.200	60.017	60.016	-60.871	-51.898
9	09/01/2008 14:45:00.233	60.017	60.016	-60.664	-51.706
10	09/01/2008 14:45:00.266	60.017	60.017	-60.458	-51.5
11	09/01/2008 14:45:00.300	60.017	60.017	-60.251	-51.295
12	09/01/2008 14:45:00.333	60.018	60.017	-60.044	-51.09
13	09/01/2008 14:45:00.366	60.017	60.017	-59.837	-50.885
14	09/01/2008 14:45:00.400	60.018	60.017	-59.629	-50.68
15	09/01/2008 14:45:00.433	60.017	60.017	-59.422	-50.475
16	09/01/2008 14:45:00.466	60.017	60.018	-59.215	-50.254
17	09/01/2008 14:45:00.500	60.017	60.018	-59.007	-50.034
18	09/01/2008 14:45:00.533	60.017	60.018	-58.8	-49.813
19	09/01/2008 14:45:00.566	60.017	60.018	-58.593	-49.593

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