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PMU-based EMS and Power Network Analysis Applications





Linear State Estimation: Foundation for Measurement-Based Advanced Applications

- The framework was pioneered by V&R Energy during NASPI Voltage Stability Workshop on October 22, 2014:
 - Introduced the concept of a "PMU-based State Estimator Case" or "LSE Case"
 - Prior to this, "standard" output of LSE was conditioned and expanded PMU stream
- Only the use of LSE produced accurate results







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2014 NASPI Voltage Stability Case 1

NASP North American SynchroPhasor Initiative

• Correct results announced by NASPI at the Workshop

Voltage Stability Case 1

First Time of Unacceptable Operating Conditions	303.4 sec
Shunt Cap Switching Time	247.8 sec
Pre-Switching Real Power Margin	343.75 MW
Post-Switching Real Power Margin	400.00 MW
Real Power Margin @ 0 sec	618.75 MW
Real Power Margin @ 150 sec	506.25 MW
Real Power Margin @ 305 sec	112.50 MW
Real Power Margin @ 445 sec	400.00 MW
Description of Method	PV Analysis



Results submitted by vendors one week before the Workshop



1		Electric Power Group	RPI	V&R	Alstom Grid	ABB
ì	First Time of Unacceptable	170	None	303.5	None	None
	Operating Conditions					
	Shunt Cap Switching Time	247	247.8	245	247.8	248
	Pre-Switching Real Power Margin	23.53 kV/100 MW	411	335	29	92
	Post-Switching Real Power Margin	7.5 kV/100 MW	461	391	86	92
	Real Power Margin @ 0 sec	0.38 kV/100 MW	645	617	Not Available	196
	Real Power Margin @ 150 sec	3.1 kV/100 MW	520	515	76	193
	Real Power Margin @ 305 sec	6 kV/100 MW	190	111	46	32
	Real Power Margin @ 445 sec	2.9 kV/100 MW	388	385	69	107
	Description of Method	Voltage Sensitivity to	AQ Bus Method	Linear State	RVII – local voltage	Equivalencing, PV
		Change in Real Power		Estimation, PV/QV	instability detector	analysis
				Analysis		

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VOLTAGE STABILITY CASE 1 RESULTS AND COMMENT SHEET

2014 NASPI Voltage Stability Case 2

 Correct results announced by NASPI at the Workshop

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VOLTAGE STABILITY CASE 2 RESULTS AND COMMENT SHEET

		North Am	erican
		SynchroPhasor	Initiative

Voltage Stability Case 2

Analysis, VS assessment (PV/QV, Sensitivity)

First Time of Insecure (N-1) Operating Condition	1312 seconds
Reason(s) for Insecurity	Voltage Violation in Zone 10 – N-1 Outages
First Time of Unacceptable N-0 Operating Condition	None
Reason for Unacceptable Condition	N/A
Time of Instability	4012 seconds
Security Margin (Transfer into Zone 10) @ 1500 sec	50.0 MW
Stability Margin (Transfer into Zone 10) @ 1500 sec	250.0 MW
Security Margin (Transfer into Zone 10) @ 4000 sec	0.0 (-) – Insecure
Stability Margin (Transfer into Zone 10) @ 4000 sec	0.0 (-) – N-1 Unstable
Assumptions Used	50/50 Pickup
Noticeable System Changes	1. Line 115-130 Trips
	2. Line 115-130 Returned to Service
	3. Bus 122 STATCOM Trips
	4. Bus 122 STATCOM Switched Back In
	Bus 112 Shunt Cap Switches In
	6. Line 116-120 Trips - Unstable
Description of Method	PV, Contingency Analysis

	Alstom Grid	V&R Energy
First Time of Insecure (N-1) Operating Condition	2410	1312
Reason(s) for Insecurity	Line L02	Contingency L02
		Contingency L11
First Time of Unacceptable N-0 Operating Condition	4064	None
Reason for Unacceptable Condition	Voltage Violation @ Bus 113	N/A
Time of Instability	4070	4012
Security Margin (Transfer into Zone 10) @ 1500 sec	730	40
Stability Margin (Transfer into Zone 10) @ 1500 sec	760	250
Security Margin (Transfer into Zone 10) @ 4000 sec	170	Negative
Stability Margin (Transfer into Zone 10) @ 4000 sec	200	Negative
Assumptions Used	-Total generation is the sum of three branches:	Ignored 500kV equivalents & their voltages
	 Bus 151 to Bus 156 CKT 1 	
	 Bus 151 to Bus 156 CKT 2 	←
	 Bus 136 to Bus 130 CKT 1 	
	-Upper bound voltage limit criteria was relaxed	
	-Bus 136 generator Pmax increased from	
	1000MW to 1070MW for transfer analysis	
Noticeable System Changes	At t=502s, line 130-115 circuit 1 tripped and	Event 1 - 502 s. Switching off line 130-115 "1".
	reconnected at t=800s	Event 2 - 802 s. Line 130-115 "1" switched back.
	At t=2246s, first shunt cap (100 MVAR at bus	Event 3 - 1302 s. Switching off FACTS at bus 122
	112) gets switched in at load in zone 10=912MW	Event 4 - 1602 s. Switching in FACTS at bus 122.
	At t=2868s, Second shunt cap (125 MVAR at bus	Event 5 - 2462 s. Shunt cap switching at bus 112
	120) gets switched in at load in zone	Event 6 - 2868 s. ("non-switching"). Increase in
	10=1152MW	transformer 116-117 flow. FACTS reaches
		reactive limit, loses control of bus 116 voltage.
		Event 7 - 4012 s. Contingency 116-120 which
		causes system collapse at 4012 s. There is no
		State Estimator solution after this N-1
		contingency occurs.
Description of Method	PV Analysis	Linear State Estimation, AC Contingency

 Results submitted by vendors one week before the Workshop

PMU-ROSE LSE at Peak RC

 Provides the mechanism for selecting, viewing, and analyzing the input data and LSE result

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Interval	90 s	15.35 55	75 95 115	13s 15s 17s	19 s 21 s 23 s	25 c 27 s 29 s 31 s		39s 41s 48s 45s	47 s 49 s 51 s 5	1 35 555 575 595	Im 2s lm Si	s lm8s lr	m 12 s 1 m 1	6 s 1 m 20 s	1m 24 s 1 m	28 5	Off	air 🕨	Ð 🕻) 1	*. ==		K
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PMU ROSE at TNB: Estimating Values Using LSE and Cascading Analysis

• LSE results:

- LSE (dark green line) successfully suppresses the error and estimates voltage with a difference of less than 0.01% compared to the true value
- Substation with multiple PMU measurements with random errors and noise denoted by yellow, light green and red lines
- The true value is blue line



- Cascading results:
 - Cascading Viewer visualizes results of online cascading analysis
 - 1877 N-1 initiating events are analyzed in one run
 - 41 critical cascading events were identified and ranked based on severity measured using the Performance Index (PI)



PMU ROSE at TNB: Effect of Remedial Actions

- A critical Initiating event results in stability violation
- The initiating event was tripping a transformer which leads to overload on other branches



- Optimal mitigation measures are identified to alleviate this stability violation
- The effect of these measures can be seen in the PMU Viewer





LSE calculation accurately represents transient event



PMU-Based Linear State Estimator at SDG&E[®]:

Implementation and Drivers

Robin Manuguid September 26-27, 2023



About SDG&E®

- SDG&E is a regulated public utility in southern California, U.S.A.
- Serves San Diego & Southern Orange Counties: 1.46 million electric and 892,000 gas meters
- System Peak = 4,890 MW (9/16/14)
- Service area span 4,100 square miles.
- NERC-Registered: TO/P, GO/P, TP, LSE

San Onofre

 Within the CAISO BA area boundary in the RC West footprint; Coordinated Functional Registration (CFR) with the CAISO for TOP Reliability Standards





Importance of Linear State Estimator

- Linear State Estimator (LSE) is based on PMU measurements of voltage and current:
 - Voltage and current vectors are considered as the state variable

• Advantages of LSE:

- Improves real-time resilience:
 - A backup to the conventional SE solution if it fails to solve or SCADA data is not available
- Improves real-time reliability:
 - A check/validation for the quality of conventional state estimator
- High speed of state estimation due to using a direct non-iterative solution
 - Solves at PMU sample rate (30 times/sec)



 Conventional SE/RTCA
 EMS (GE) network model

		CA Conting	ency Case	Report - (Case O: C	ASE CO	NTAINS (GED SOLU	TION	
File	Action	s Navigation CAC									
«	<	Page 1 of 7	> >>				R	2	≥ Total	Records:	505
	ALL LIMIT VIOLATIONS										
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	520	TL20010-TL20071	1	<u>cknowledge</u>	Full Solu	tion	0.0	1	31.6	i 2	Harmless in CA
	504	50003-50001 NC	A		Full Solu	tion	0.0	2	393.6	i 1	Harmless in CA
	500	50001-03_23050 NC	2 3		Full Solu	tion	0.0	3	12.5	i 4	Harmful by CA,
	78	TL50001+TL230541	8 - 2 <u>A</u>		Full Solu	tion	0.0	4	94.7	' 3	Harmless in CA
	575	50001_IVGN_23050			Full Solu	tion	0.0	5	0.0) 5	Harmless in CA
	540	TE20004-TE20000 (<u> </u>	<u>cknowledge</u>	Full Solu	tion	0.0	6	0.0) 6	Harmless in CA
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 Conventional SE/RTCA
 EMS (GE) network model

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Study Case : 0	02/23/21 10:51:3	20.045 PST: RTNA:	SE: time execut	tion	
Note:					
Status: CASE CO	NTAINS NON-CONVER	RGENT SOLUTION			
	VOL 0.001 3		179 7		
192 0.5360E+04	ANG -0.19 3	14 EXWE MORGAN	166 16		
	VOL 0.001 3	4 EXWB_YAVAPA	179 10		
193 0.5360E+04	ANG -0.09 3	24 EXWB_MORGAN	166 30		
	VOL 0.002 3	14 EXWB_YAVAPA	179 20		
194 U.5361E+U4	ANG U.44 3	E4 EXWE_MURGAN	166 150 * 179 122		
195 0.5364E+04	ANG 0.36 3	14 EXWB_TAVAFA	166 3		
	VOL 0.001 3	4 EXWE_YAVAPA	179 1		
196 0.5361E+04	ANG 0.27 3	4 EXWE_MORGAN	166 2		
	VOL 0.001 3	14 EXWB_YAVAPA	179 7		
197 0.5360E+04	ANG 0.19 3	14 EXWB_MORGAN	166 9		
108 0 53005-04	VOL 0.001 3	I A EXWELYAVAPA	179 10		
190 0.53606+04	XNG 0.11 3	A FYUR YAVARA	106 17		
199 0.5361E+04	ANG -0.46 3	14 EXWE MORGAN	166 153 *		
	VOL -0.022 3	4 EXWE_YAVAPA	179 119		
200 0.5364E+04	ANG -0.37 3	24 EXWB_MORGAN	166 10		
	VOL 0.001 3	94 EXWB_YAVAPA	179 1		
STATE ESTIMATOR	CONVERGENCE SUMM	ARY - FULL SYSTEM			
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PERFORMANCE INDI	EX : 0.53638E+04				
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ISLAND NO. O	F PERFORMANCE				
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1 748		STATE ESTIMATOR	NOT SOLVED		
x		- State estimat	or not converged ·	in	
		maximum number	r of iterations.		





EMS Display with PMU data





 Voltage Stability – use RC West's EMS model export in CIM15 loaded in V&R's ROSE





 Synchrowave Operations System – (SEL) power system monitoring and visualization, oscillation detection, notification





 Synchrowave Operations System – (SEL) power system detection, notification, visualization





SDG&E PMU ROSE Architecture

Abbreviations:

SDGE

- LSE PMU LSE result at PMU locations
- LSE RAW PMU-based State Estimator cases in Siemens PSS/E .raw data format
- Observable PMU LSE result at locations
 observable with existing PMUs
- RAW PMU Voltage magnitude and phase and current amplitude and phase from conventional State Estimator cases, converted to IEEE standard C37.118
- RTCA Real-Time Contingency Analysis
- SE in RAW Power flow cases (e.g., conventional State Estimator cases) in Siemens PSS/E .raw data format
- POM Physical and Operational Margins applications (POM Core)

3 apps: LSE POM Server, POM-RTCA, RTCA Viewer







SDG&E PMU-Based LSE



LSE is performed 30 fps and includes:

- Bad data detection and conditioning
- Observability analysis
- Creation of conditioned and expanded PMU data streams
- Creation of PMU-based state estimator case (e.g., LSE Case) for the use by RTCA

Scalable System

- More PMU measurements available
- More distributed PMUs across the system
- More accurate LSE/Base Case

Drivers:

- Backup of conventional SE
- Faster analysis
- Improve PMU data quality
- Increase system observability



SDG&E PMU-Based LSE: Conditioned streams

WASA Dashboard: LSE PMU, SE SCADA, SCADA

LSE is performed 30 fps and includes:

- Bad data detection and conditioning
- Observability analysis
- Creation of conditioned and expanded PMU data streams

LSE PMU System WLS RealTim	e	
▲ LSE PMU Server	PMU Server Configuration	
Enable	\checkmark	
▲ LSE PMU Connection	Address: 127.0.0.1:10500 DeviceIdCode: 1000	
Address	127.0.0.1:10500	
Device Id Code	1000	
▲ LSE PMU Power Connection	Address: 127.0.0.1:10600 DeviceIdCode: 1000	
Address	127.0.0.1:10600	
Device Id Code	1000	
▲ BaseCase PMU Connection	Address: 127.0.0.1:10501 DeviceIdCode: 1000	
Address	127.0.0.1:10501	
Device Id Code	1000	
▲ BaseCase PMU Power Connection	Address: 127.0.0.1:10601 DeviceIdCode: 1000	
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Device Id Code	1000	
 Observable PMU Connection 	Address: 127.0.0.1:10502 DeviceIdCode: 1000	
Address	127.0.0.1:10502	
Device Id Code	1000	
A Observable PMU Power Connec	Address: 127.0.0.1:10602 DeviceIdCode: 1000	
Address	127.0.0.1:10602	
Device Id Code	1000	
Frame Rate	30	
Use PMU Time	\checkmark	
Maximum Number Of Clients	0	

SEL	Synchrowave Operations			Q			Engineering System	(RB)			Early Access SEL App	lications are installed. 🛛 A 🔳 🛋	: ::: RManugui
Sep. 2	2, 2023				Real-Time Data					08:11:42			
42	07:45	07:48	07:51	07:54	07:57	08:00	08:03	08:06	08:09	08:12 🛗 09/22/2023	User T	J Frequency Z Angle	P Power
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-	Measurement Points	Phase1 Current Magnitude		Measurement Points	Phase1 Current Magnitude	P + C3 E Magnitude	Measurement Points 🔺	Phase1 Current Magnitude	Phase1 Voltage Magnitude	Measurement Points	ThreePhase Power Real	Measurement Points A	ThreePhase Power Real
♥	TA TI 23030	LseDeltaPct		AL.TL6904	43.632 A	40.433 kV	LSE.AL.TL6904	43.885 A	40.432 kV	AV.TL691	1.930 kW	PLAV.TL691	-580.279 W
▲	VN TI 604			AV.TL691	0.088 A	39.987 kV	LSE.AV.TL691	0.159 A	39.981 kV	AV.TL698	-29.846 MW	PLAV.TL698	-29.790 MW
	TA TI 23052			AV.TL698	250.038 A	39.979 kV	LSE.AV.TL698	250.697 A	39.981 kV	BB.TL23020	-265.369 MW	PI.BB.TL23020	-264.900 MW
	TA TL23007			BB.TL23020	680.700 A	133.420 kV	LSE.BB.TL23020	646.152 A	133.420 kV	BB.TL23026	381.179 MW	PI.BB.TL23026	379.200 MW
	SX.TL23071			BB.TL23026	977.375 A	133.422 kV	LSE.BB.TL23026	1.116 kA	133.420 KV	BB.TL23042	-263.292 MW	PI.BB.TL23042	-263.400 MW
	SX.TL23055			BB.TL23042	676.020 A	133.439 kV	LSE.BB.TL23042	636.438 A	133.420 KV	DW.TL23066	259.278 MW	PI.DW.TL23066	258.000 MW
	SX.TL23054			DW.TL23066	645.674 A	134.131 kV	LSE.DW.TL23066		-	DW.TL23067	-164.549 MW	PI.DW.TL23067	-163.000 MW
	SX.TL23051			DW.TL23067	409.732 A	133.970 kV	LSE.DW.TL23067		-	EA.TL13852	302.802 kW	PI.EA.TL13852	500.000 kW
	SX.TL23041			EA.TL13852	1.357 A	80.290 kV	LSE.EA.TL13852	0.953 A	80.291 kV	EA.TL23003	78.864 MW	PI.EA.TL23003	78.000 MW
	SX.TL13820			EA.TL23003	194.873 A	133.167 kV	LSE.EA.TL23003	169.713 A	133.138 kV	EA.TL23012	-40.728 KW	PI.EA.TL23012	0.000 W
	SO.TL23052			EA.TL23012	0.221 A	133.143 kV	LSE.EA.TL23012	0.000 A	133.138 kV	EA.TL23053	32.742 kW	PI.EA.TL23053	0.000 W
	SG.TL23028			EA.TL23053	0.461 A	133.061 kV	LSE.EA.TL23053	0.000 A	133.138 kV	EA.TL23074	300.070 kW	PI.EA.TL23074	1.000 MW
	SG.TL23026			EA.TL23074	3.777 A	133.111 kV	LSE.EA.TL23074	3.834 A	133.138 kV	ECO.TL13844	-59.135 MW	PI.ECO.TL13844	-58.600 MW
	SCR.TL50003			ECO.TL13844	356.064 A	78.758 KV	LSE.ECO.TL13844	368.367 A	78.744 KV	ECO.TL23018	-84.178 MW	PI.ECO.TL23018	-84.000 MW
	SCR.TL23056			ECO.TL23018	211.718 A	132.459 kV	LSE.ECO.TL23018	184.691 A	132.472 kV	ECO.TL50001	1452.940 MW	PI.ECO.TL50001	1455.300 MW
	SCR.TL23055			ECO.TL50001	1.595 kA	303.681 kV	LSE.ECO.TL50001	1.217 kA	303.882 kV	ECO.TL50004	-1310.130 MW	PI.ECO.TL50004	-1310.900 MW
	SA.TL6966			ECO.TL50004	1.437 kA	304.753 kV	LSE.ECO.TL50004	726.149 A	303.882 KV	IV.TL23043	59.597 MW	PI.IV.TL23043	58.000 MW
	SA.TL6912			IV. IL23043	149.116 A	133.490 KV	LSE.IV.1L23043	148.161 A	133.437 KV	IV.TL23050	-79.737 MW	PI.IV.TL23050	-73.100 MW
	SA.TL23011			IV. IL23047	626.009 A	-	LSE.IV.1L23047	-		IV.TL23061	-27.671 MW	PI.IV.TL23061	-27.000 MW
		Phase1 Voltage		IV. TL23050	181.133 A	133.932 KV	LSE.IV.TL23050	181.362 A	134.015 KV	IV.TL23066	-257.572 MW	PI.IV.TL23066	-256.000 MW
	Measurement Points	Magnitude		IV. IL23061	70.092 A	133.503 KV	LSE.IV.1L23061	69.845 A	133.437 KV	IV.TL23082	-68.778 MW	PI.IV.TL23082	-70.000 MW
	TA TI 23030			IV. IL23066	644.747 A	133.456 kV	LSE.IV. 1L23066	642.413 A	133.437 KV	IV.TL230S	-19.078 MW	PI.IV.TL230S	-21.000 MW
	LSE.TA.TL23030			IV. 1L23082	174.545 A	133.303 kV	LSE.IV.1L23082	181.862 A	133.437 KV	IV.TL50002	-1310.870 MW	PI.IV.TL50002	-1316.000 MW
	VN TI 604			IV.TL230S	145.404 A	133.422 kV	LSE.IV.TL230S			IV.TL50004	1314.740 MW	PI.IV.TL50004	1315.000 MW
	TA TI 23052			IV.TL50002	1.451 kA	304.058 kV	LSE.IV.TL50002	343.352 A	304.150 kV	IV.TL50005	1022.020 MW	PI.IV.TL50005	1022.000 MW
	TA TI 23007			IV.TL50004	1.441 kA	304.135 kV	LSE.IV.TL50004	725.301 A	304.150 kV	LCS.TL13824	-75.166 MW	PI.LCS.TL13824	-75.300 MW
	SX TI 23071			IV.TL50005	1.122 kA	304.306 kV	LSE.IV.TL50005	1.251 kA	304.150 kV	LI.TL688	-33.981 MW	PI.LI.TL688	-34.000 MW
	SX TI 23055			LCS.TL13824	313.112 A	80.510 kV	LSE.LCS.TL13824	460.631 A	80.490 kV	LI.TL6932	24.651 MW	PI.LI.TL6932	19.250 MW
	SX TI 23054			LI.TL688	279.202 A		LSE.LI.TL688	280.430 A		ME.TL680B	-20.484 MW	PI.ME.TL680	-20.413 MW
	OA.1E23034			LI.TL6932	155.410 A	40.539 kV	LSE.LI.TL6932	160.407 A	40.532 kV				



SDG&E PMU-Based LSE: RTCA



- Internal SE model produced by SDGE EMS is used
- LSE (e.g., PMU-based State Estimator) cases are sent by the LSE to RTCA application
- AC contingency analysis is performed using contingency list from EMS
- Output is archived and visualized using RTCA Viewer application
- Can be connected with automated remedial actions program, voltage stability, cascading analysis

Drivers:

Compare SE-based and LSE-based RTCA results

POM Core 2022		– O X			
ile Tools Help					
🍤 🕶 🖻 Skin Blue 🔹 🛷 🔀					
🗄 100% 🔻 Root Bus: Depth: 2 🎼 🔻	SDGE RTCA 🗸 🗸 🗸				
	Off-Line Real-Time Critical Contingencies Calculation	Buses Branch Sections Transformers Generators Loads Shunts Svds Areas Zones			
	Full Calculation Apply Consecutively Threads 2 Solve Arguments Contingency Swing Output Directory	Dc Buses Dc Lines Dc Converters Owners Transformer Adjustment Tables Reactive Capabilities N1 Contingencies			
	Real Time Options Input Directory Input File Name Pattern	Find Basecase Equilibrium Iterations 1 SDGE RTCA			
	RTCA Server Options	Options:			
<u>44</u>	Enable Address	Sequential: False			
	v	.			
Oneline Charts	• X	Project Manager Output			
Tables					
Root Bus: 1 2 3 ZONE	AREA OWNER AII				
Buses Branch Sections Transformers Generators Loads Shur	s Controlled Shunts Areas Zones Dc Buses Dc Lines Dc Converters Transformer A	djustment Table Reactive Capabilities			
User Name Number Name Nominal Voltage	us Type Scheduled Voltage Voltage Magnitude VA AREA ZONE Max Voltage Min	Voltage OWNER			
► 69.00000	oad 1.02008 1.02009 -51.271 1 1 1.0507	0.9493 0			
69.00000	oad 1.01724 1.01725 -49.892 1 1 1.0507	0.9493 0			
69.00000	oad 1.02129 1.02129 -50.963 1 1 1.0507	0.9493 0			
eady		Copyright © 1997-2022 V&R Energy Systems Research, Inc. All rights reserved			

SDGE PMU ROSE: RTCA

SDGE

SDG&E PMU-Based LSE: RTCA



- 522 Contingencies in SE/RTCA
- So far 146 valid contingencies

Six Violation types:

- Stability Violation;
- Voltage Min Violations;
- Voltage Max Violations;
- Thermal Violations on Line;
- Thermal Violations on Transformer;
- Not Enough Compensation.
- Angle diffs (not included)





SDG&E PMU-Based LSE: RTCA

Bus (SDG&E- owned)	Count	SCADA Coverage	PMU Coverage
500kV	5	5/5	100%
230kV	22	100%	100%
138kV	31	30/31	6/26
69kV	88	85/88	11/88 *

Observability	Initial (before bad data detection)	Stages				LSE Case
		1	2	3	4	
buses	44	106	118	119	119	109
branches	89	192	212	212	213	157



Pacific Southwest Major Corridors (Pacific Southwest Blackout in 2011 took about 11 minutes)

* Optimal PMU placement to identify additional PMU locations to achieve full SDG&E network observability has been conducted.



Conclusions

- SDGE PMU ROSE is installed at SDG&E for LSE and RTCA.
- "Bad data" and modelling/mapping errors are being investigated
- Multiple PMUs in one location does not help expand observability.
- Engaging vendor, IT, and EMS support early will help identify and resolve problems faster.
- More PMUs are being installed and existing stand-alone PMUs to be relocated, which will increase system observability, and the size of LSE case (in terms of number of buses, lines, etc.)





Thank you

Question?

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Robin Manuguid



Robin is a staff engineer in Grid Operations and leads the long-term outage coordination studies to sequence multi-phase transmission projects and successful completion of major projects. He provides realtime support for real-time tools (i.e., SE, RTCA, and near-RTVSA) and conducts next-day studies. He reviews and updates operating procedures which are often triggered by operating studies. Robin joined SDG&E in 1992 after earning his BSEE from Cal Poly, San Luis Obispo. Since joining the Electric Grid Operations in 2004, he's been engaging with WECC activities, coordinating with SDG&E SMEs on various NATF programs. He is a Principal Engineer with SDG&E. He is an IEEE member.



Back up slide





LSE Project Alignment with the ERO RRP

The Five Risks:

- 1. Grid Transformation
 - · Batteries on weak grid
- 2. Security Risks
 - · Batteries on weak grid
 - Network model accuracy.
- 3. Resilience to extreme events
 - Loss of comm paths
- 4. Critical Infrastructure Interdependecies
 - Polled SCADA data vs streams
- 5. Energy Policy

2023 ERO Reliability Risk Priorities Report

RISC Approved: July 24, 2023 Board of Trustees Accepted: August 17, 2023

