Figure 12-9: Maximum Overvoltage for STP-Jones Creek ckt 18 – Jones Creek side open without Line-Arrestor

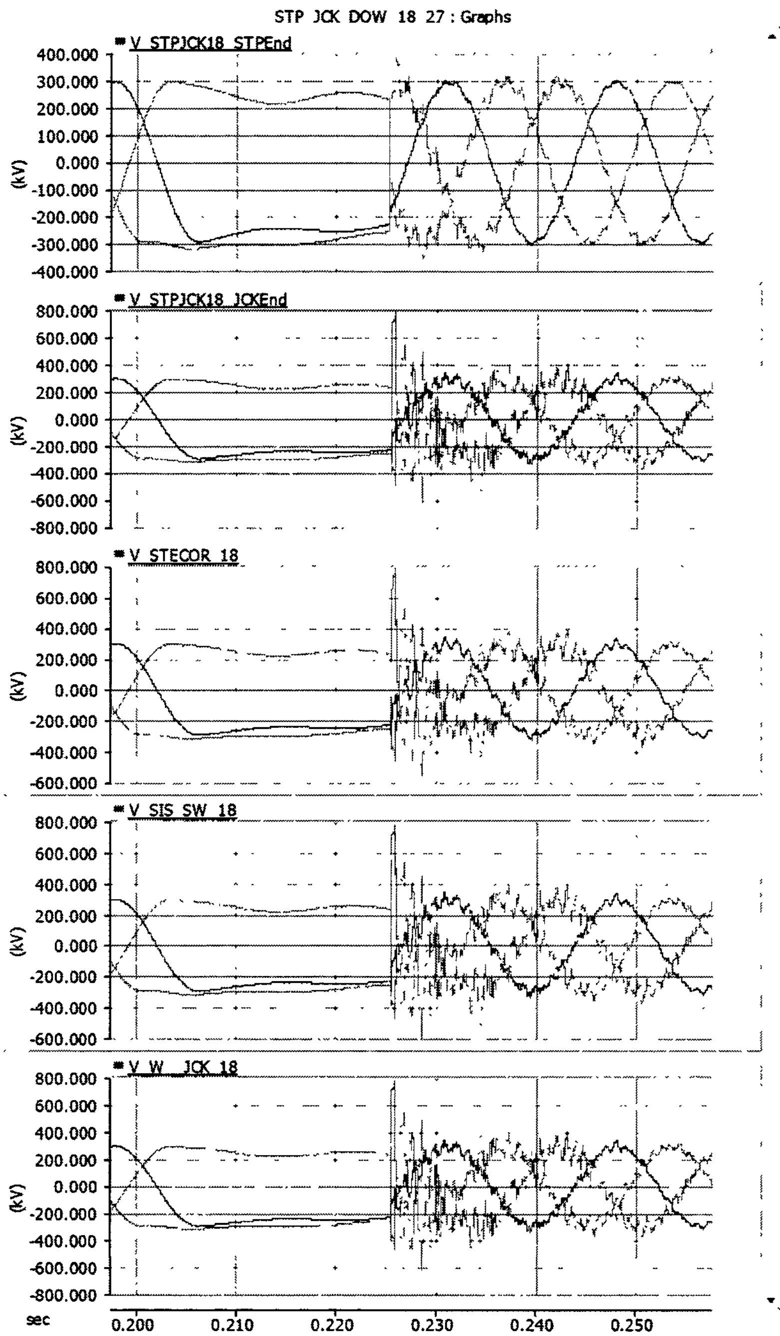


Figure 12-10: Maximum Overvoltage for STP-Jones Creek ckt 18 – Jones Creek side open with Line-Arrestor

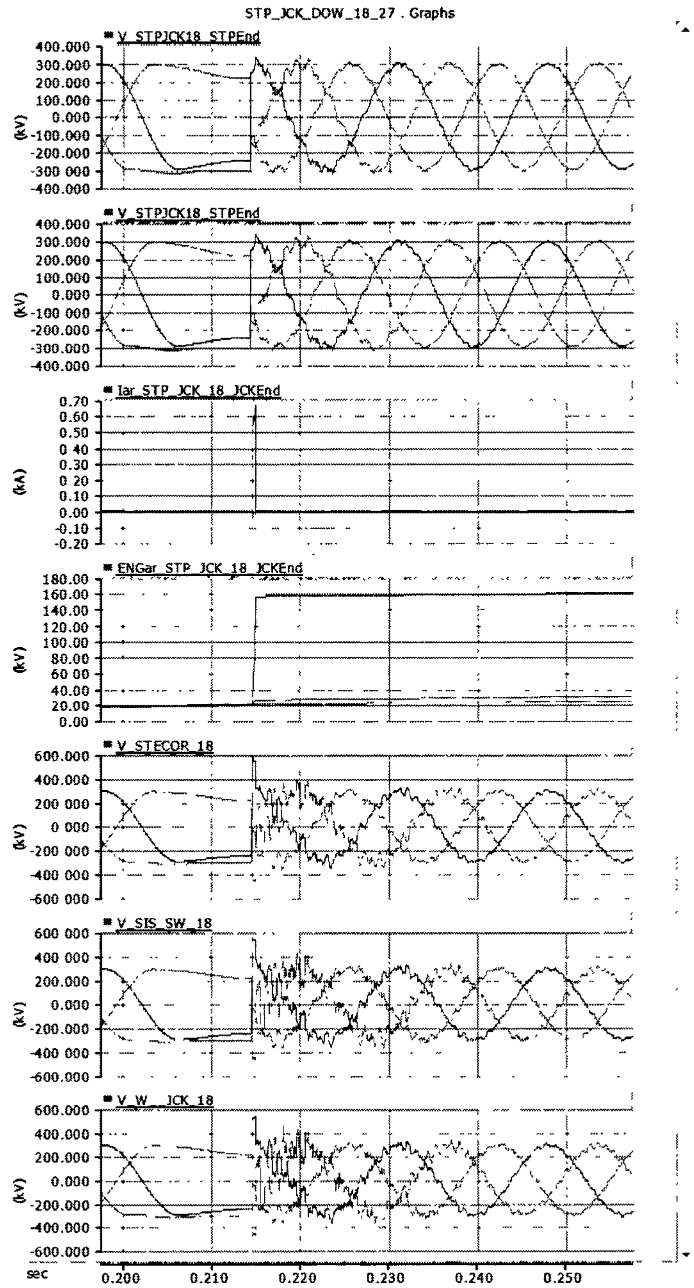


Figure 12-11: Maximum Overvoltage for Jones Creek - DOW ckt 18 – DOW side open without Line-Arrestor

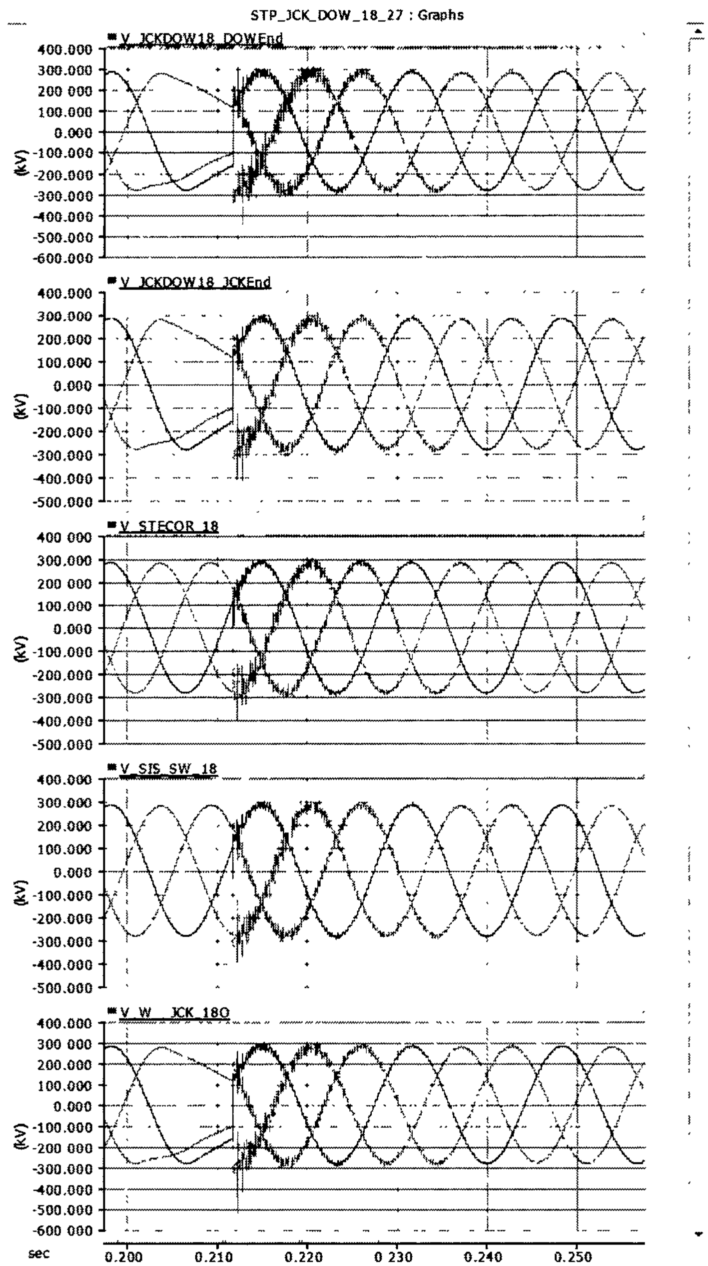


Figure 12-12: Maximum Overvoltage for Jones Creek - DOW ckt 18 – DOW side open with Line-Arrestor

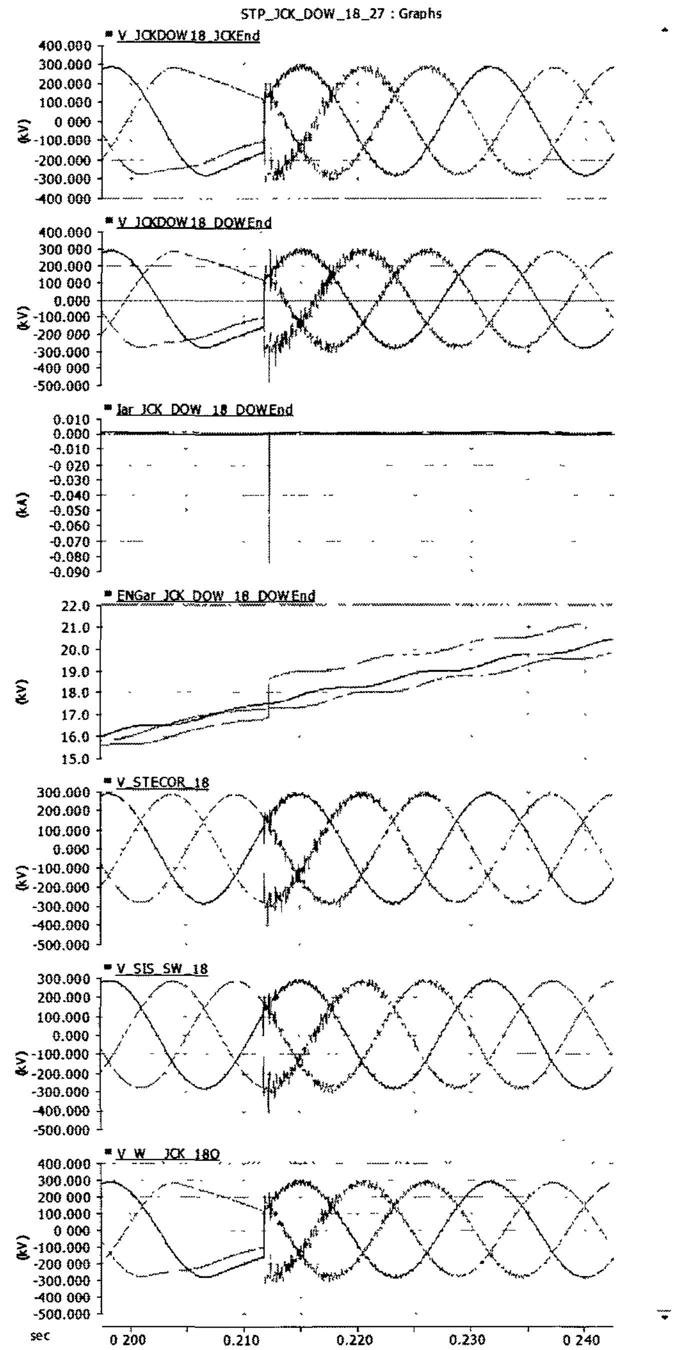


Figure 12-13: Maximum Overvoltage for Jones Creek - DOW ckt 18 – Jones Creek side open without Line-Arrestor

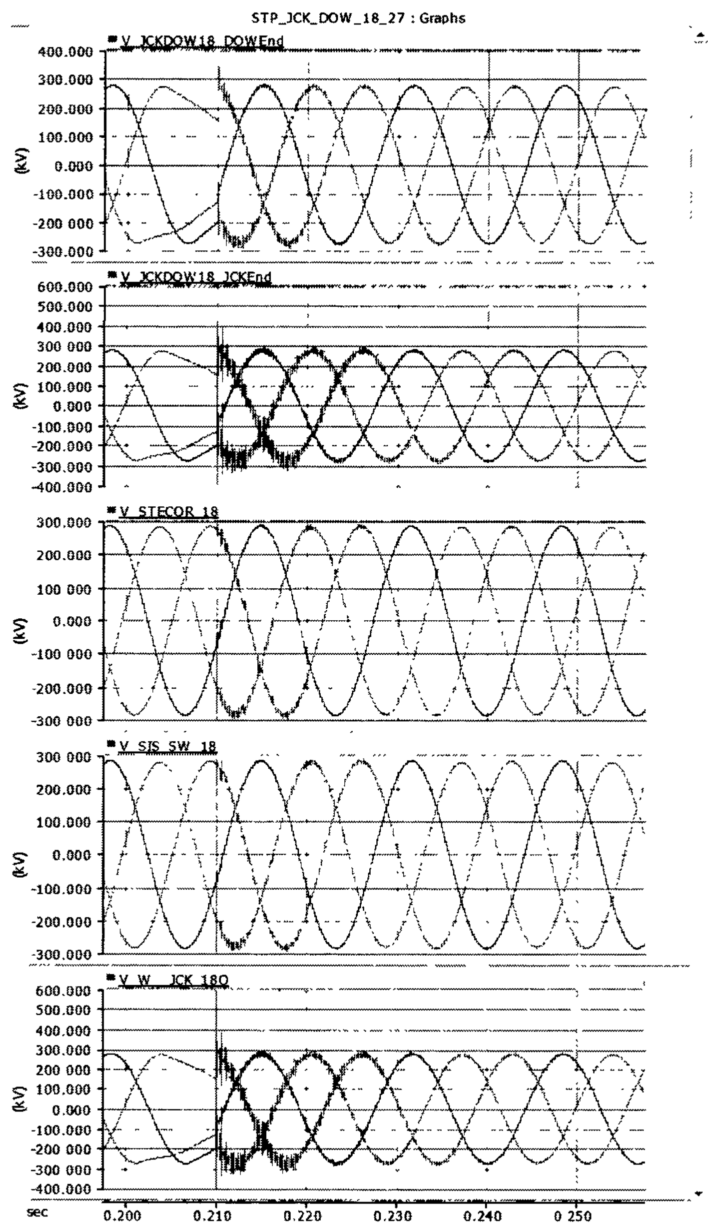
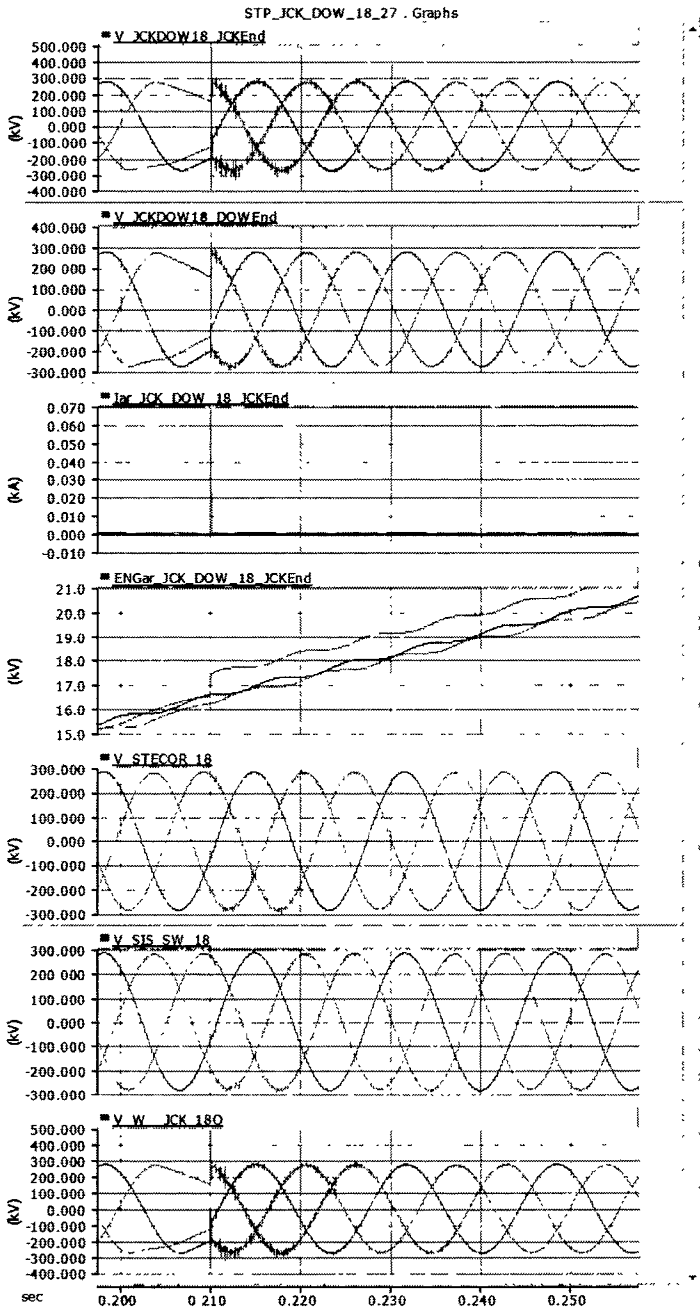


Figure 12-14: Maximum Overvoltage for Jones Creek - DOW ckt 18 – Jones Creek side open with Line-Arrestor



12.4 345 kV W.A. Parish to Jeanetta ckt 72 & 64

The W.A.Parish to Jeanetta ckt 72 and ckt 64, are identical and on the same double circuit tower but going to different W.A.Parish 345 kV switchyards. They will be modeled in four independent sections of 2.09, 8.62, 6.01, and 3.3 miles as described in Table 12-3

Results for the maximum Transient Overvoltage for a Fault with restrike are shown in Table 12-14. CenterPoint has added to this maximum overvoltage a safety factor of 10%, which should be used in calculating the Minimum Approach Distance. The table also shows the location on the circuit where the maximum overvoltage was obtained (referred to Figure 12-2). TOV plots are shown from Figure 12-17 to Figure 12-24.

Table 12-11 and Table 12-12.Basic Information for the circuit sections in these tables as well and conductor's information is provided in Table 12-2 and Table 12-3

Results for the maximum Transient Overvoltage for a Fault with restrike are shown in Table 12-14. CenterPoint has added to this maximum overvoltage a safety factor of 10%, which should be used in calculating the Minimum Approach Distance. The table also shows the location on the circuit where the maximum overvoltage was obtained (referred to Figure 12-2). TOV plots are shown from Figure 12-17 to Figure 12-24.

Table 12-11: W.A.Parish – Jeanetta ckt 72 – Configuration

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JENETA-JN_COR	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.12	2040*	2645
JN_COR-WZ_TAP	345DDP	3/8EHS	3/8EHS	2-2167ACSR	1.11	2040*	2645
WZ_TAP-WZLOOP	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.06	2040*	2645
WZLOOP-AF_COR	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.80	2040*	2645
JENETA-AF_COR	**345DDP**	**3/8EHS**	**3/8EHS**	**2-2167ACSR**	**2.09**	**2040***	**2645**
AF_COR-SANBEL	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.26	2040*	2645
SANBEL-HIGHST	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.11	2040*	2645
HIGHST-ALIEF_	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	1.35	2040*	2645
ALIEF_-AF_SUB	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.05	2040*	2645
AF_SUB-E_TP11	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	4.08	2040*	2645
E_TP11-CHG_09	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.54	2040*	2645
CHG_09-TRF_35	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.01	2040*	2645
TRF_35-TRF_12	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.03	2040*	2645
TRF_12-TF1235	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.03	2040*	2645
TF1235-TF_TAP	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.01	2040*	2645
TF_TAP-MC5TAP	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	2.15	2040*	2645
AF_COR-MC5TAP	**345DDT2**	**3/8EHS**	**3/8EHS**	**2-2167ACSR**	**8.62**	**2040***	**2645**
MC5TAP-IM_TAP	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	1.38	2040*	2645
IM_TAP-NBRZOS	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	3.69	2040*	2645
NBRZOS-SBRZOS	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.19	2040*	2645
SBRZOS-SIETAP	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.08	2040*	2645
SIETAP-BRZCOR	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.67	2040*	2645
MC5TAP-BRZCOR	**345DDT2**	**3/8EHS**	**3/8EHS**	**2-2167ACSR**	**6.01**	**2040***	**2645**
BRZCOR-02CHG1	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.39	2040*	2645
02CHG1-02CHG2	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.08	2040*	2645
02CHG2-HOSBYU	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	1.94	2040*	2645
HOSBYU-TAXING	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.74	2040*	2645
TAXING-SMRCOR	345DDT1	3/8EHS	3/8EHS	2-2167ACSR	0.08	2040*	2645
SMRCOR-W_A_P_	345DDT1	3/8EHS	3/8EHS	2-2167ACSR	0.06	2040*	2645
BRZCOR-W_A_P_	**345DDT2**	**3/8EHS**	**3/8EHS**	**2-2167ACSR**	**3.29**	**2040***	**2645**
47300- 44000							

Table 12-12: W.A.Parish – Jeanetta ckt 64 – Configuration

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JENETA-JN_COR	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.12	2040*	2645
JN_COR-WZ_TAP	345DDP	3/8EHS	3/8EHS	2-2167ACSR	1.11	2040*	2645
WZ_TAP-WZLOOP	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.06	2040*	2645
WZLOOP-AF_COR	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.80	2040*	2645
JENETA-AF_COR	**345DDP**	**3/8EHS**	**3/8EHS**	**2-2167ACSR**	**2.09**	**2040***	**2645**
AF_COR-SANBEL	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.26	2040*	2645
SANBEL-HIGHST	345DDP	3/8EHS	3/8EHS	2-2167ACSR	0.11	2040*	2645
HIGHST-ALIEF_	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	1.35	2040*	2645
ALIEF_-AF_SUB	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.05	2040*	2645
AF_SUB-E_TP11	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	4.08	2040*	2645
E_TP11-CHG_09	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.54	2040*	2645
CHG_09-TRF_35	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.01	2040*	2645
TRF_35-TRF_12	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.03	2040*	2645
TRF_12-TF1235	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.03	2040*	2645
TR1235-TF_TAP	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.01	2040*	2645
TF_TAP-MC5TAP	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	2.15	2040*	2645
AF_COR-MC5TAP	**345DDT2**	**3/8EHS**	**3/8EHS**	**2-2167ACSR**	**8.62**	**2040***	**2645**
MC5TAP-IM_TAP	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	1.38	2040*	2645
IM_TAP-NBRZOS	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	3.69	2040*	2645
NBRZOS-SBRZOS	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.19	2040*	2645
SBRZOS-SIETAP	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.08	2040*	2645
SIETAP-BRZCOR	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.67	2040*	2645
MC5TAP-BRZCOR	**345DDT2**	**3/8EHS**	**3/8EHS**	**2-2167ACSR**	**6.01**	**2040***	**2645**
BRZCOR-02CHG1	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.39	2040*	2645
02CHG1-02CHG2	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.08	2040*	2645
02CHG2-HOSBYU	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	1.94	2040*	2645
HOSBYU-TAXING	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.74	2040*	2645
TAXING-SMRCOR	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.09	2040*	2645
SMRCOR-W_A_P_	345DDT2	3/8EHS	3/8EHS	2-2167ACSR	0.06	2040*	2645
BRZCOR-W_A_P_	**345DDT2**	**3/8EHS**	**3/8EHS**	**2-2167ACSR**	**3.30**	**2040***	**2645**
47300- 44005							

Figure 12-15: Tower Configuration (segment JENETA-AFCOR Tower Type 345 DDP)

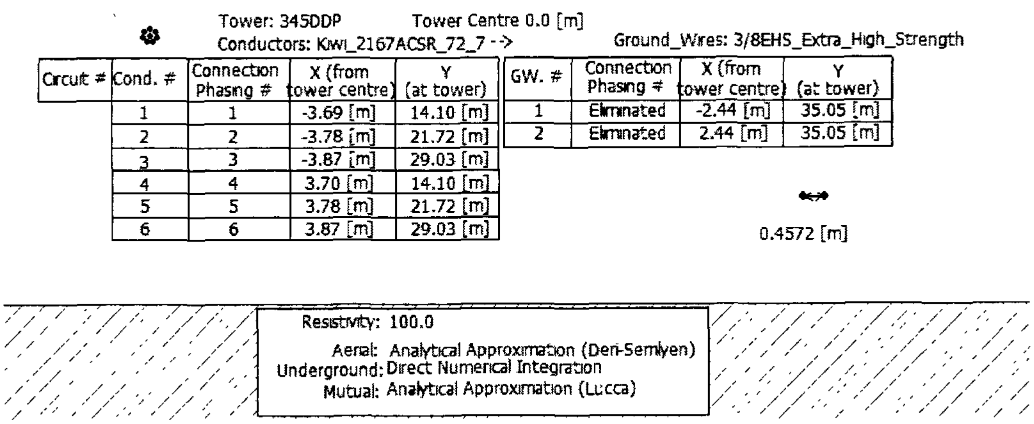


Table 12-13: PSCAD Input Data for Phase Conductor for ckt 72 & 64

Conductor Type	kcmil	Stranding	Steel Strands	Number of Layers (Al)	Total Number of Inner Strands	Diameter		DC Resistance	PSCAD Entries				
						Al	Complete Cable		Total Number of Strands (AL Only)	Total Number of Outer Strands	Outer Radius	Strand Radius	DC Resistance
						Inches	Inches	Ohms/Mile			Meters	Meters	Ohm/km
Kiwi	2167	72	7	4	9	0.1734785	1 735	0 0423	72	27	0.0220345	0.00220342	0.02628407

Table 12-14: Maximum TOV values W.A.Parish – Jenetta ckt 72 and 64 (Fault with Restrike)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
W.A Parish	Jenetta	72	345	W.A.Parish	WAPJN72_WAPA	2.70	2.97	AF_COR_72	2.23	2.45
W.A.Parish	Jenetta	72	345	Jenetta	BRZCOR_72	2.48	2.73	BRZCOR_72	2.03	2 24
W A Parish	Jenetta	64	345	W.A.Parish	WAPJN64_WAPB	2.70	2.97	AF_COR_64	2.25	2.48
W.A.Parish	Jenetta	64	345	Jenetta	WAPJN64_JNEn	2.48	2.73	MC5TAP_64	2.06	2 27

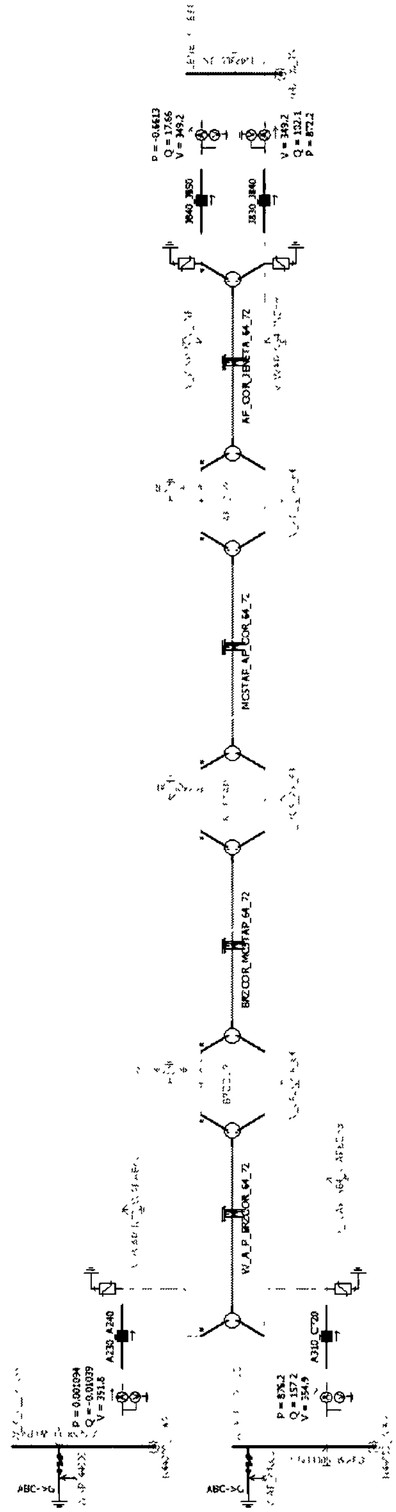


Figure 12-16: PSCAD MODEL W.A. Parish – Jenetta ckt 72 and 64

Figure 12-17: Maximum Overvoltage for W.A.Parish -Jenetta ckt 72 – W.A.Parish side open without Line-Arrestor

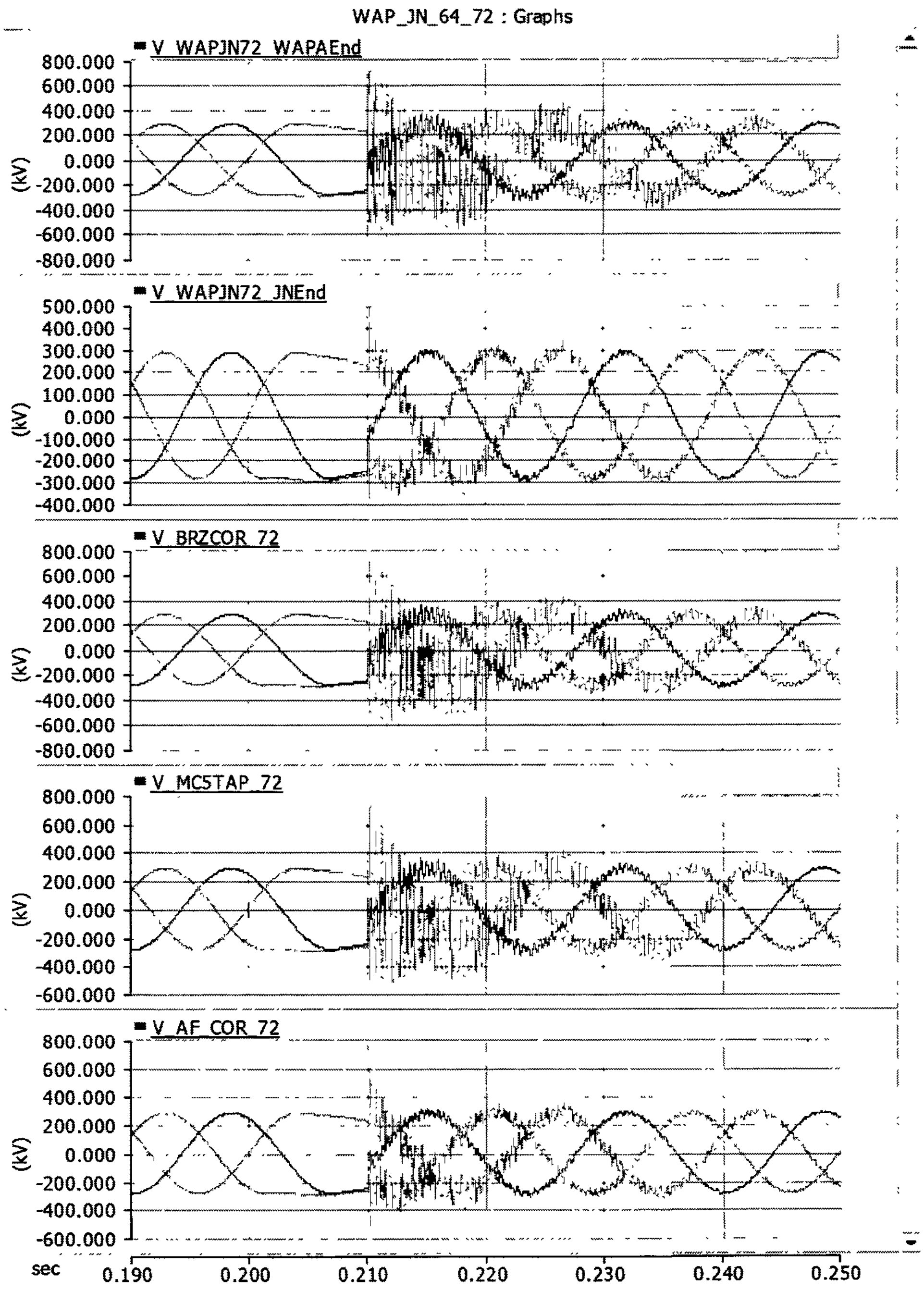


Figure 12-18: Maximum Overvoltage for W.A.Parish -Jenetta ckt 72 – W.A.Parish side open with Line-Arrestor

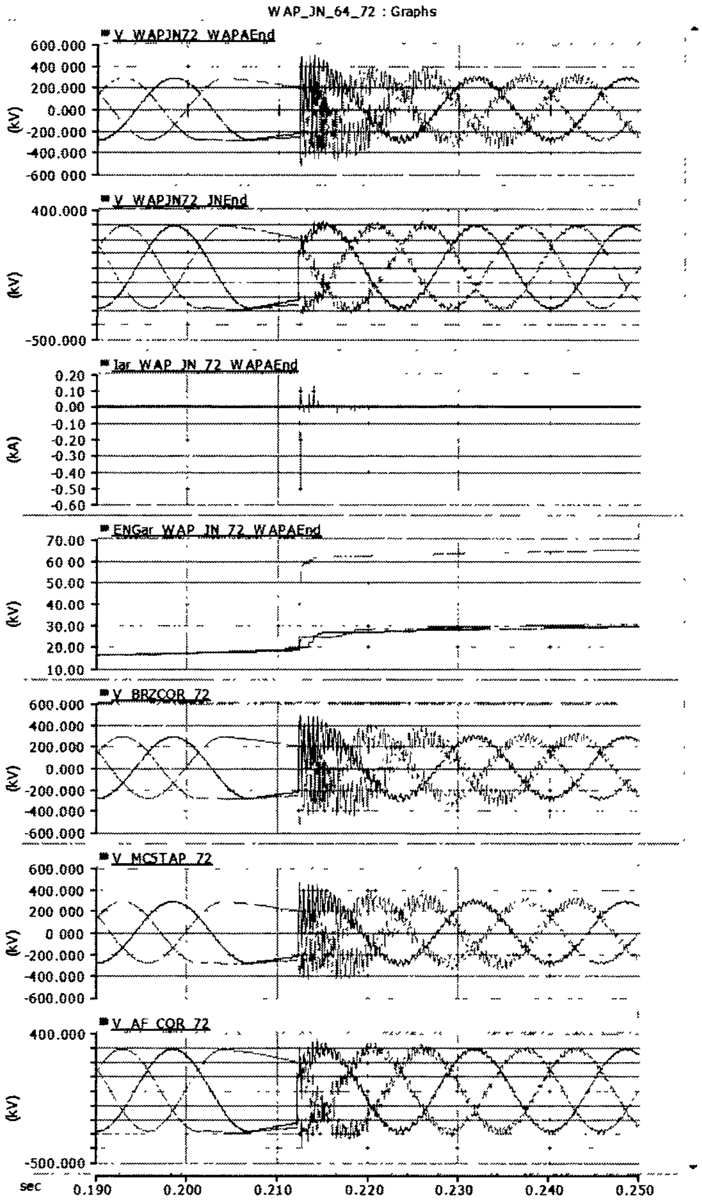


Figure 12-19: Maximum Overvoltage for W.A.Parish -Jenetta ckt 72 – Jenetta side open without Line-Arrestor

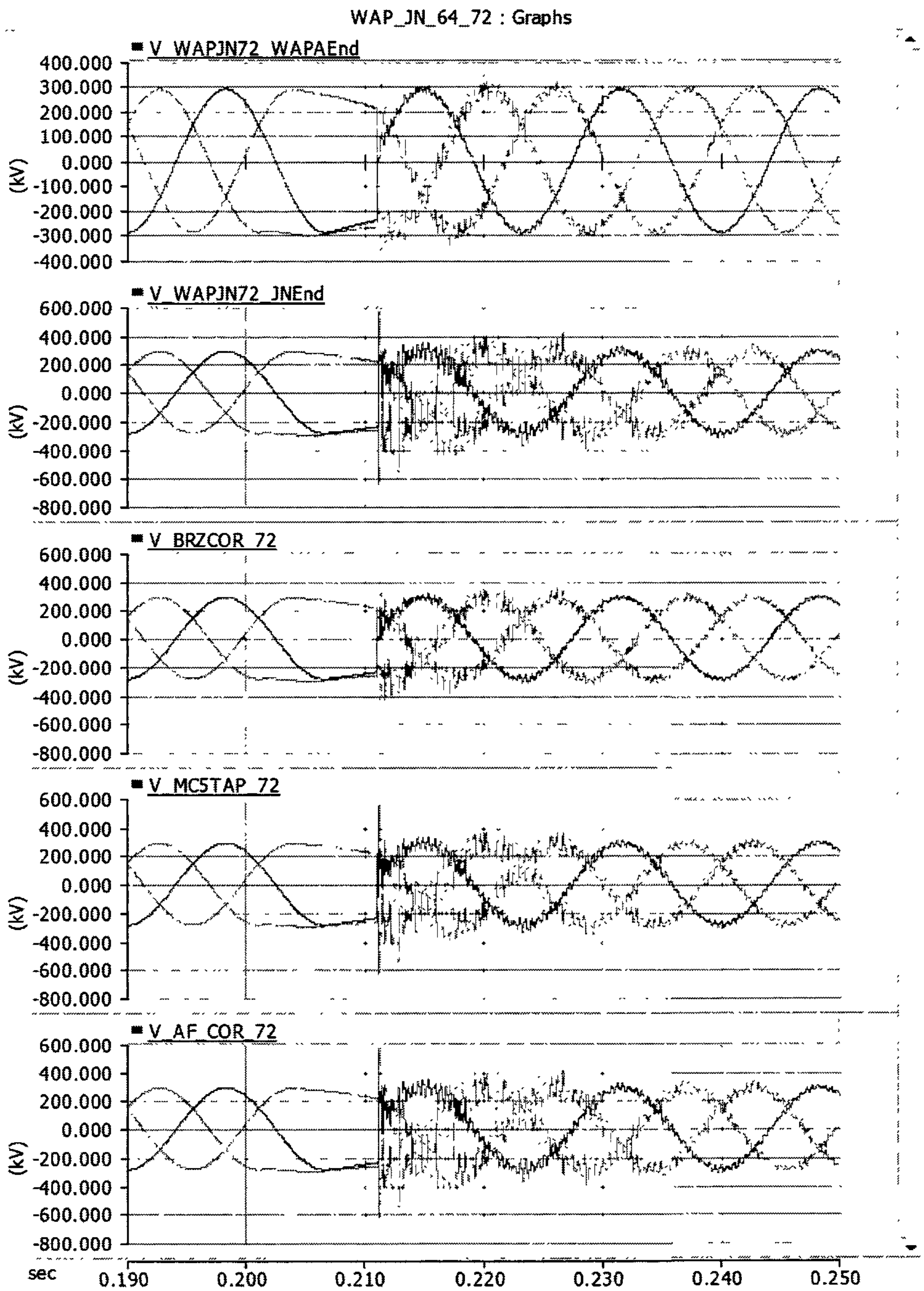


Figure 12-20: Maximum Overvoltage for W.A.Parish -Jenetta ckt 72 – Jenetta side open with Line-Arrestor

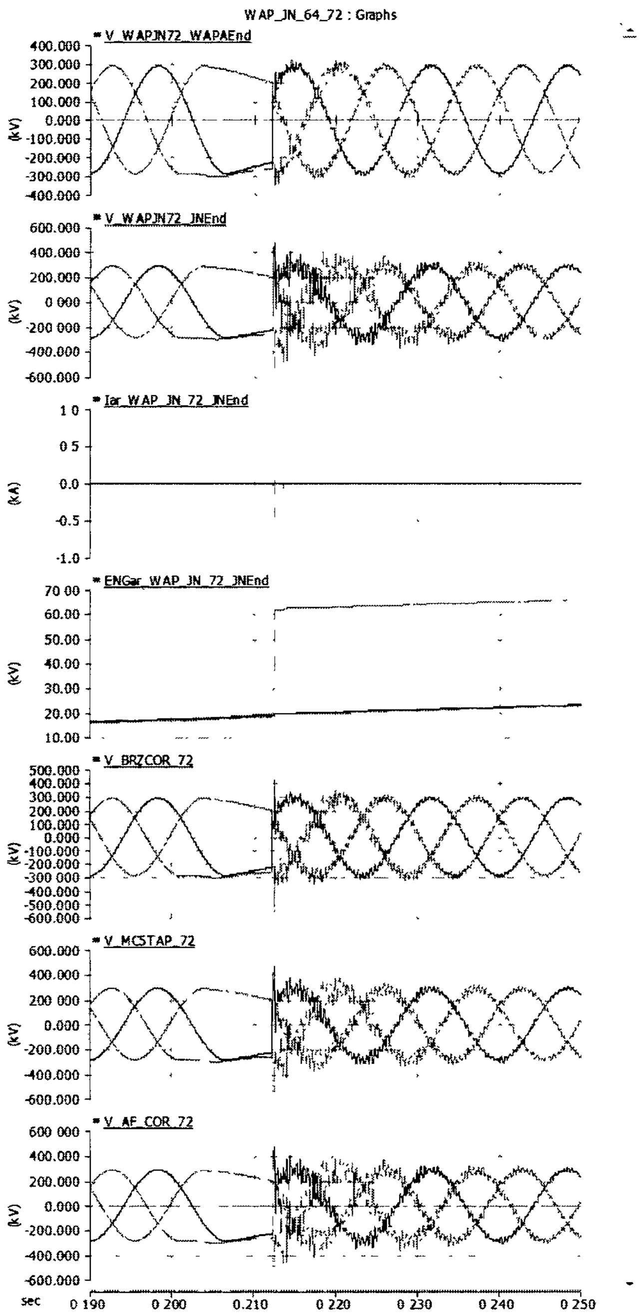


Figure 12-21: Maximum Overvoltage for W.A.Parish -Jenetta ckt 64 – W.A.Parish side open without Line-Arrestor

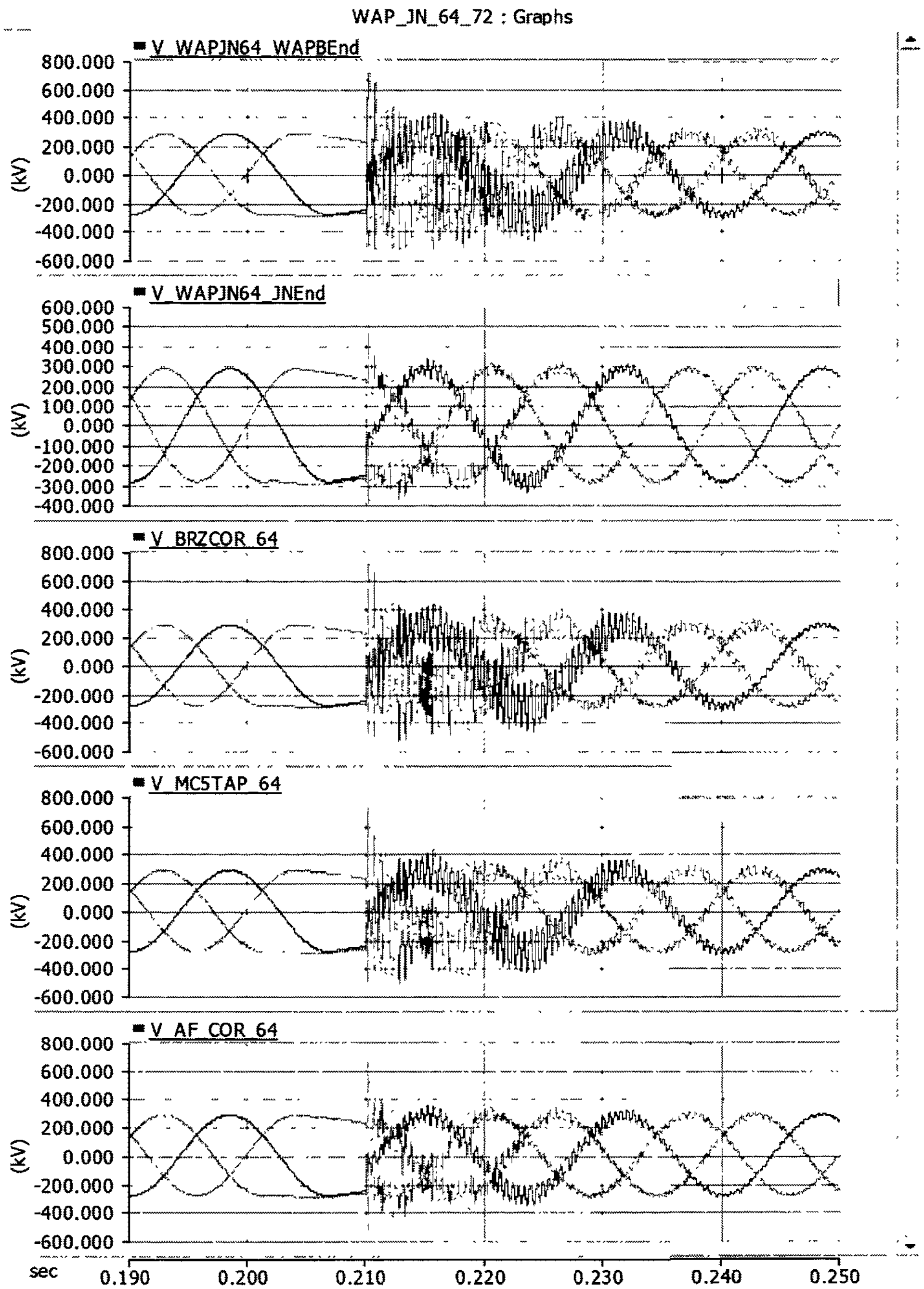


Figure 12-22: Maximum Overvoltage for W.A.Parish -Jenetta ckt 64 – W.A.Parish side open with Line-Arrestor

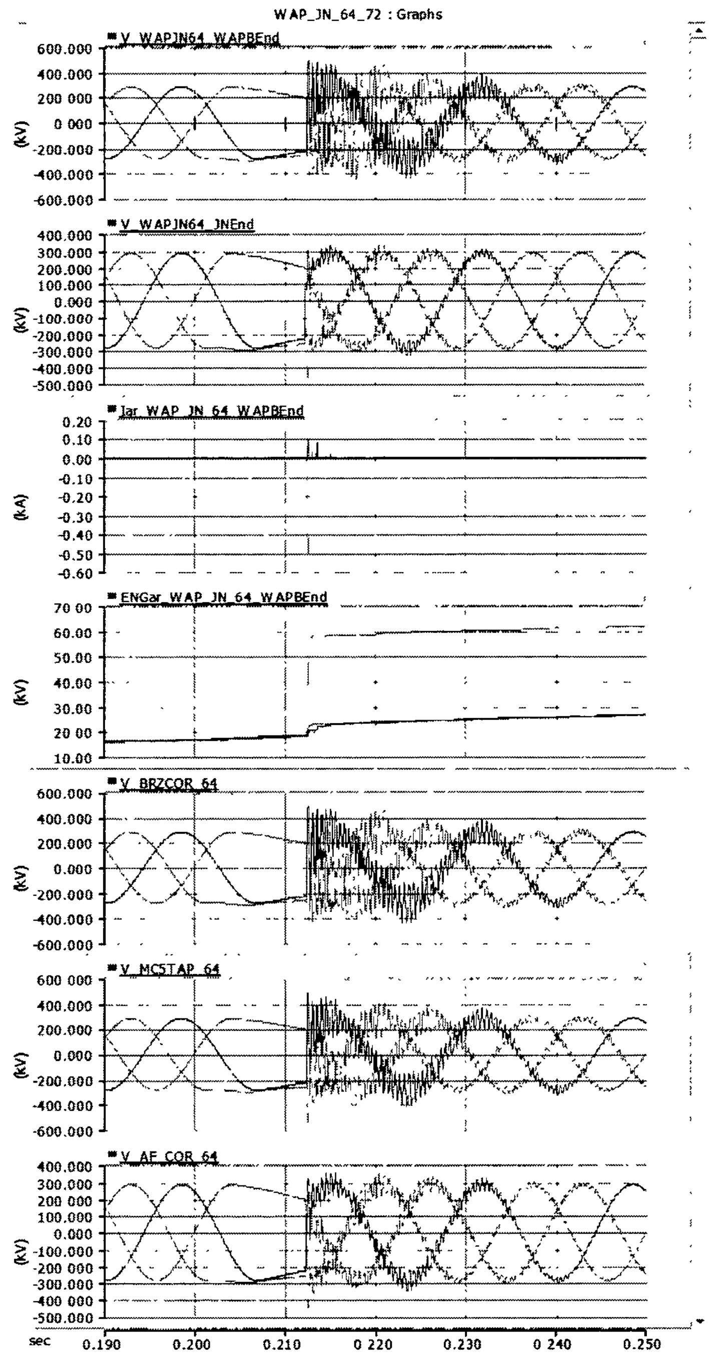


Figure 12-23: Maximum Overvoltage for W.A.Parish -Jenetta ckt 64 – Jenetta side open without Line-Arrestor

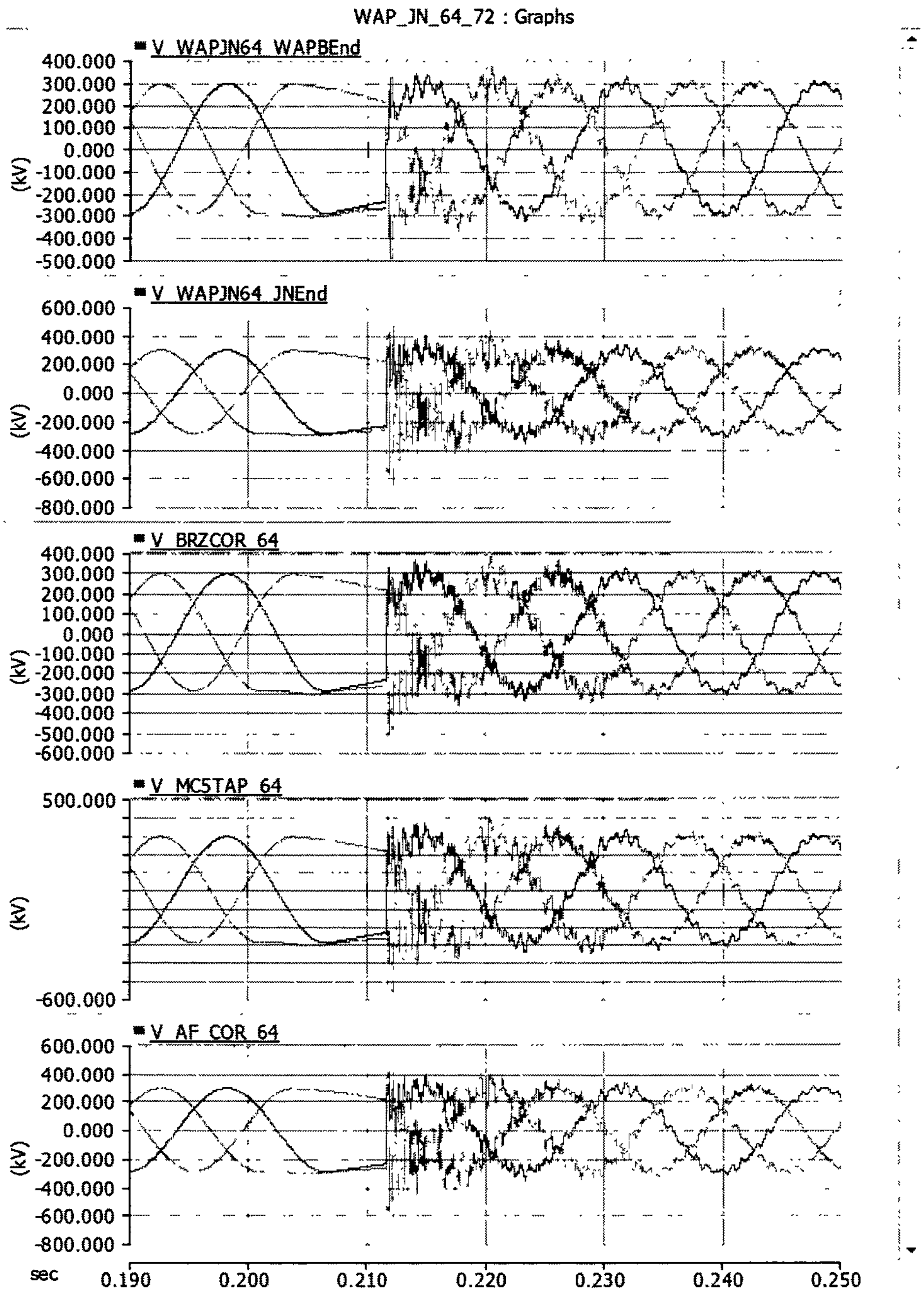
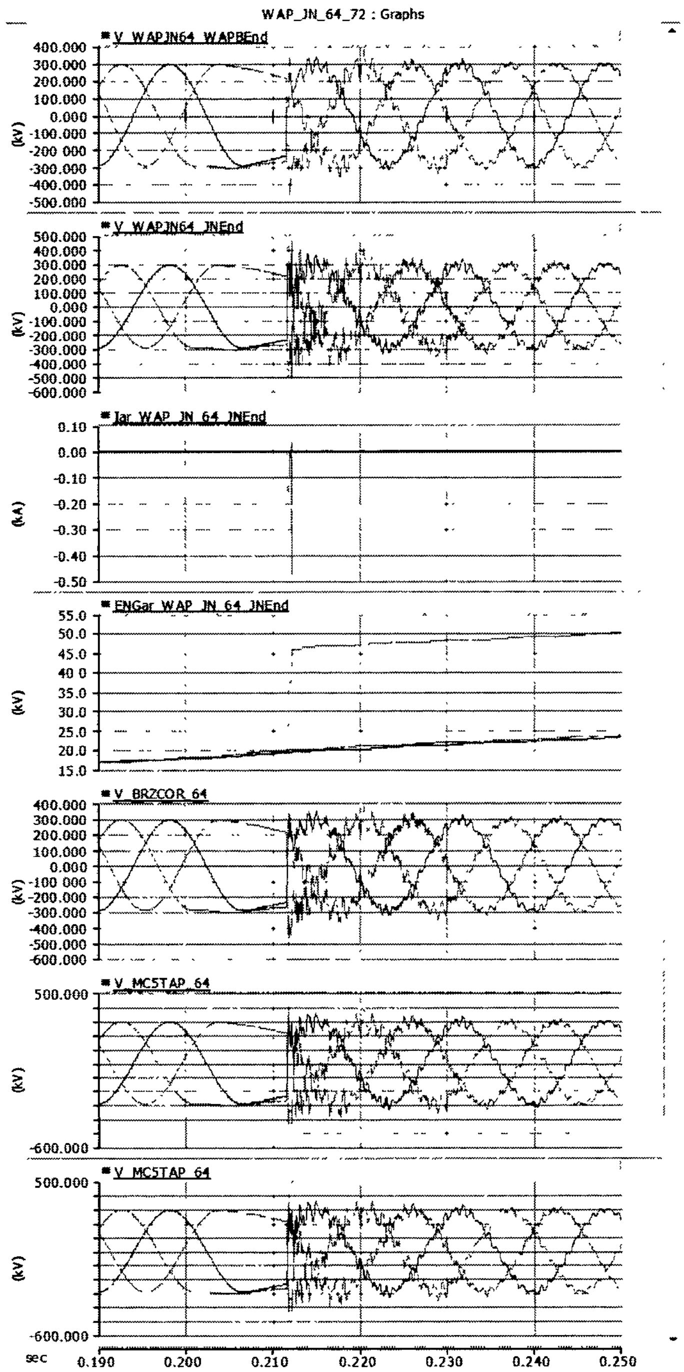


Figure 12-24: Maximum Overvoltage for W.A.Parish -Jenetta ckt 64 – Jenetta side open with Line-Arrestor



12.1 345 kV Gibbons Creek to Zenith ckt 18 & 50

The Gibbons Creek to Zenith ckt 18 and ckt 50 are identical and on the same double circuit. They will be modeled in five independent sections of 8.43, 32.37, 7.13, 2.51 and approximate 7.92 miles as described in Table 12-15 and Table 12-16. All these sections with the exception of the 2.51 mi ROBERT_ZUBERD share right-of-way (TROW) with similar sections on ckts 98 and 99 Zenith to Singleton as shown on Figure 12-26. Mutual coupling has been modeled for these line section an example of data entry is shown in Figure 12-27 for the TLINE configuration parameters.

Basic Information for the circuit sections in these tables as well and conductor's information is provided in Table 12-17 and Table 12-3.

Results for the maximum Transient Overvoltage for a Fault with restrike are shown in Table 12-18. CenterPoint has added to this maximum overvoltage a safety factor of 10%, which should be used in calculating the Minimum Approach Distance. The table also shows the location on the circuit where the maximum overvoltage was obtained (referred to Figure 12-26). TOV plots are shown from Figure 12-28 to Figure 12-35.

Table 12-15: Gibbons Creek – Zenith ckt 50 – Configuration

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GIBCRK-XGCAPP	345DDP	3/8EHS	3/8EHS	3-959ACSST	8.39	3146	3352
XGCAPP-MACNTH	345DDP	3/8EHS	3/8EHS	3-959ACSST	32.37	3146	3352
MACNTH-ROBERT	345DDP	3/8EHS	3/8EHS	3-959ACSST	7.13	3146	3352
ROBERT-LUCIA_	345DDP	3/8EHS	3/8EHS	3-959ACSST	0.77	3146	3352
LUCIA_-ZUBERD	**345DDP**	**3/8EHS**	**3/8EHS**	**3-959ACSST**	1.74	3146	3352
ROBERT_ZEBERD					2.51	3146	3352
ZUBERD-ZEN_A3	345DDP	3/8EHS	3/8EHS	3-959ACSST	7.69	3146	3352
ZEN_A3-ZENITH	**345DDP**	**3/8EHS**	**3/8EHS**	**3-959ACSST**	0.24	3146	3352
ZUBERD-ZENITH					7.93	3146	3352
GIBCRK-ZENITH					58.33	3146	3352
967- 44900							

Table 12-16: Gibbons Creek – Zenith ckt 18 – Configuration

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GIBCRK-XGCAPP	-R	345DDP	3/8EHS	3/8EHS	3-959ACSST	8.43	3146	3352
XGCAPP-MACNTH	-R	345DDP	3/8EHS	3/8EHS	3-959ACSST	32.37	3146	3352
MACNTH-ROBERT	-R	345DDP	3/8EHS	3/8EHS	3-959ACSST	7.13	3146	3352
ROBERT-LUCIA_	-R	345DDP	3/8EHS	3/8EHS	3-959ACSST	0.77	3146	3352
LUCIA_-ZUBERD	-R	345DDP	3/8EHS	3/8EHS	3-959ACSST	1.74	3146	3352
ROBERT_ZEBERD						2.51	3146	3352
ZUBERD-ZEN_A3	-R	345DDP	3/8EHS	3/8EHS	3-959ACSST	7.69	3146	3352
ZEN_A3-ZENITH	-R	**345DDP**	**3/8EHS**	**3/8EHS**	**3-959ACSST**	0.23	3146	3352
ZUBERD-ZENITH						7.92	3146	3352
GIBCRK-ZENITH						58.36	3146	3352
967- 44900								

Figure 12-25: Tower Configuration (segment Gibbons Creek to Zenith Tower Type 345 DDP)

Tower: 345DDP Tower Centre 0.0 [m]
Conductors: Suwannee_959ACSSTW>22_7 Ground_Wires: 3/8EHS_Extra_High_Strength

Circuit #	Cond. #	Connection Phasing #	X (from tower centre)	Y (at tower)
	1	1	-3.69 [m]	14.10 [m]
	2	2	-3.78 [m]	21.72 [m]
	3	3	-3.87 [m]	29.03 [m]
	4	4	3.70 [m]	14.10 [m]
	5	5	3.78 [m]	21.72 [m]
	6	6	3.87 [m]	29.03 [m]

GW. #	Connection Phasing #	X (from tower centre)	Y (at tower)
1	Eliminated	-2.44 [m]	35.05 [m]
2	Eliminated	2.44 [m]	35.05 [m]

0.4572 [m]

Resistivity: 100.0
Aerial: Analytical Approximation (Deri-Semlyen)
Underground: Direct Numerical Integration
Mutual: Analytical Approximation (Lucca)

Table 12-17: PSCAD Input Data for Phase Conductor for ckt 18 & 50

Conductor Type	kcmil	Stranding	Steel Strands	Number of Layers (Al)	Total Number of Inner Strands	Diameter				DC Resistance	PSCAD Entries				
						Al	Steel	Steel Core	Complete Cable		Total Number of Strands (AL Only)	Total Number of Outer Strands	Outer Radius	Strand Radius	DC Resistance
						Inches	Inches	Inches	Inches	Ohms/Mile			Meters	Meters	Ohm/km
Suwannee/ACSS/TW	959 6	22	7	2	8	[illegible]		0 4479	1 11	0 0907	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 12-18: Maximum TOV values Gibbons Creek – Zenith ckt 18 and 50 (Fault with Restrike)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gibbons Creek	Zenith	18	345	Gibbons Creek	ZENGC18_GCEn	2.87	3.16	MACNTH_18	2.38	2.62
Gibbons Creek	Zenith	18	345	Zenith	ZENGC18_ZENE	3.20	3.52	XGCAPP_18	2 18	2.39
Gibbons Creek	Zenith	50	345	Gibbons Creek	ZENGC50_GCEn	2 93	3.23	MACNTH_50	2.40	2.64
Gibbons Creek	Zenith	50	345	Zenith	ZENGC50_ZENE	3.29	3.62	XGCAPP_50	2.19	2.41

Figure 12-26: PSCAD MODEL Gibbons Creek – Zenith ckt 18 and 50

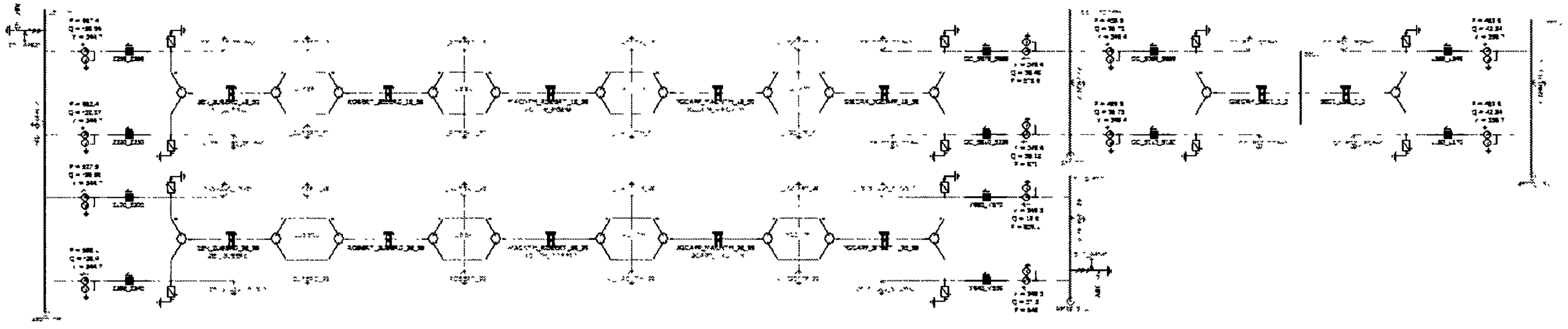


Figure 12-27: Mutual Coupling Data Entry example for section ZEN_ZUBERD ckt 18

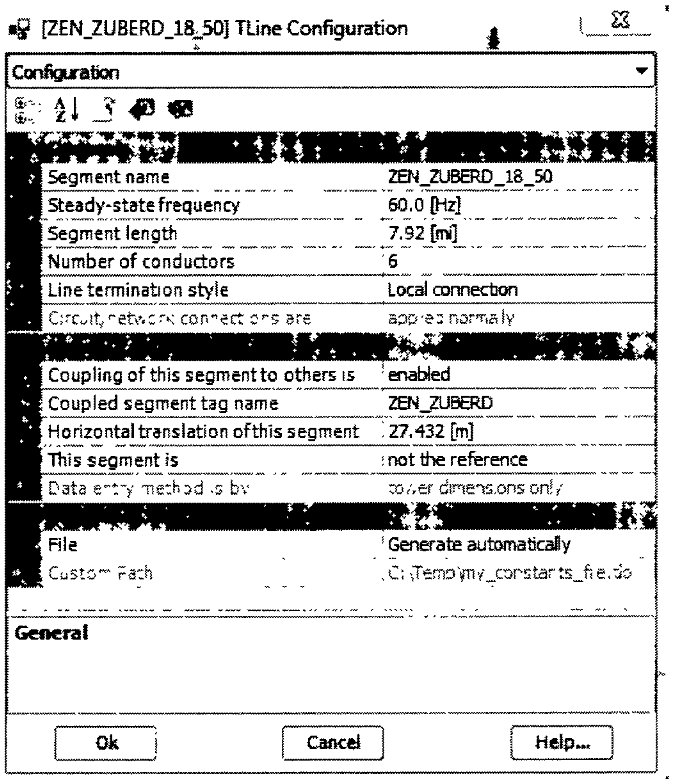


Figure 12-28: Maximum Overvoltage for Gibbons Creek – Zenith ckt 18 – Gibbons Creek side open without Line-Arrestor

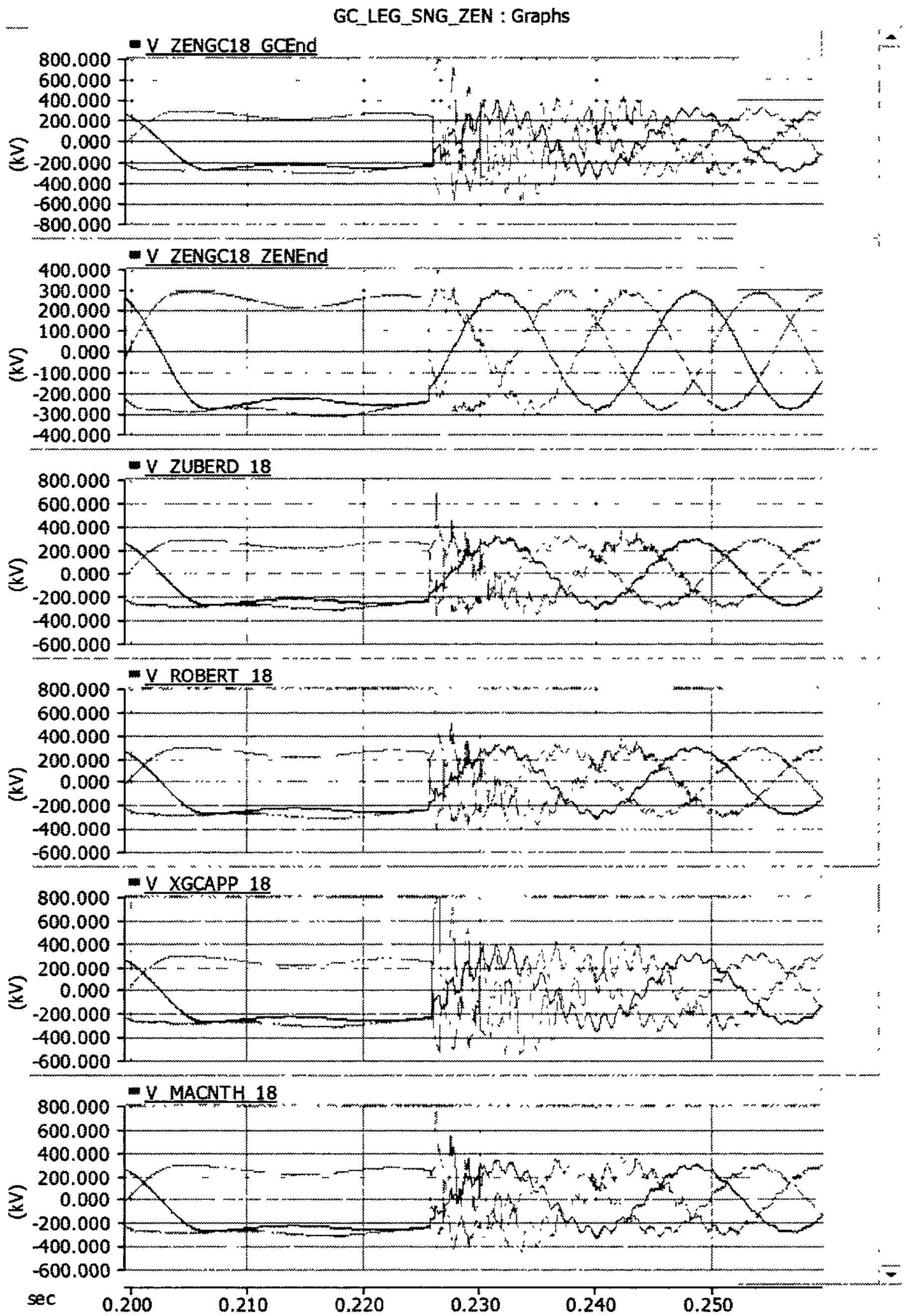


Figure 12-29: Maximum Overvoltage for Gibbons Creek – Zenith ckt 18 – Gibbons Creek side open with Line-Arrestor

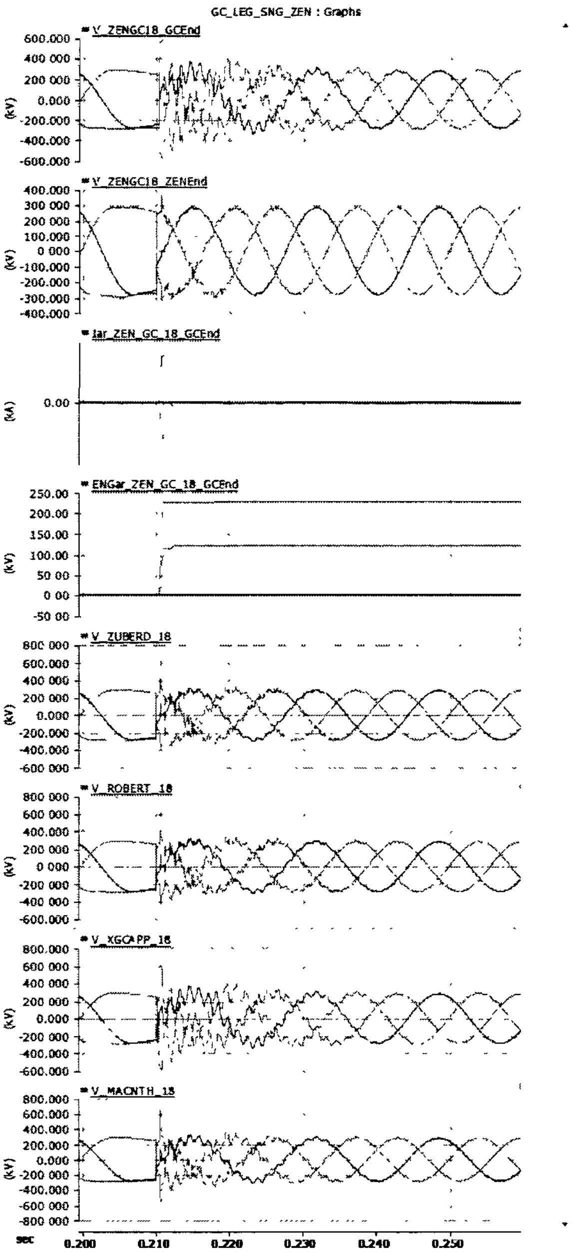


Figure 12-30: Maximum Overvoltage for Gibbons Creek – Zenith ckt 18 – Zenith side open without Line-Arrestor

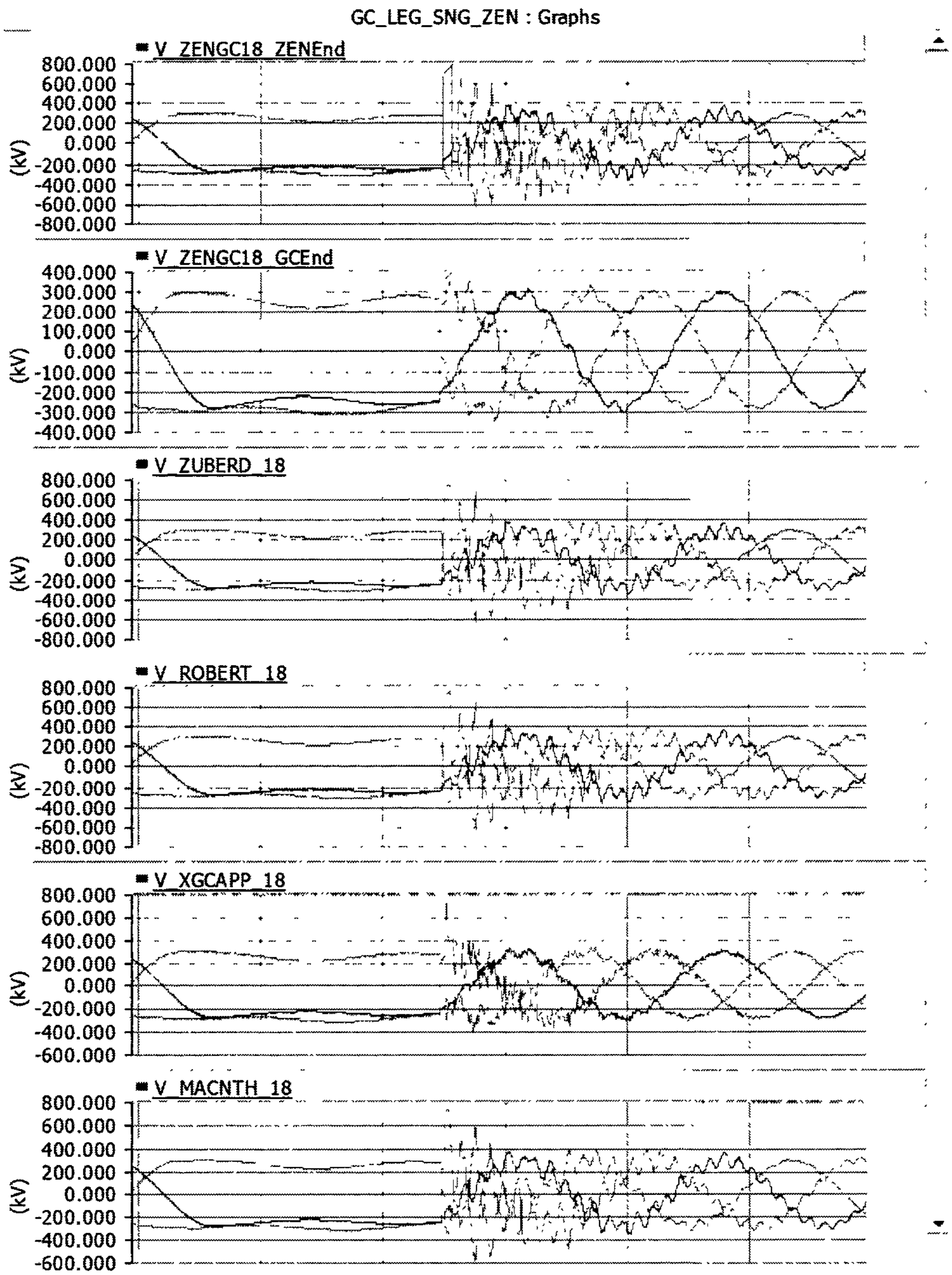


Figure 12-31: Maximum Overvoltage for Gibbons Creek – Zenith ckt 18 – Zenith side open with Line-Arrestor

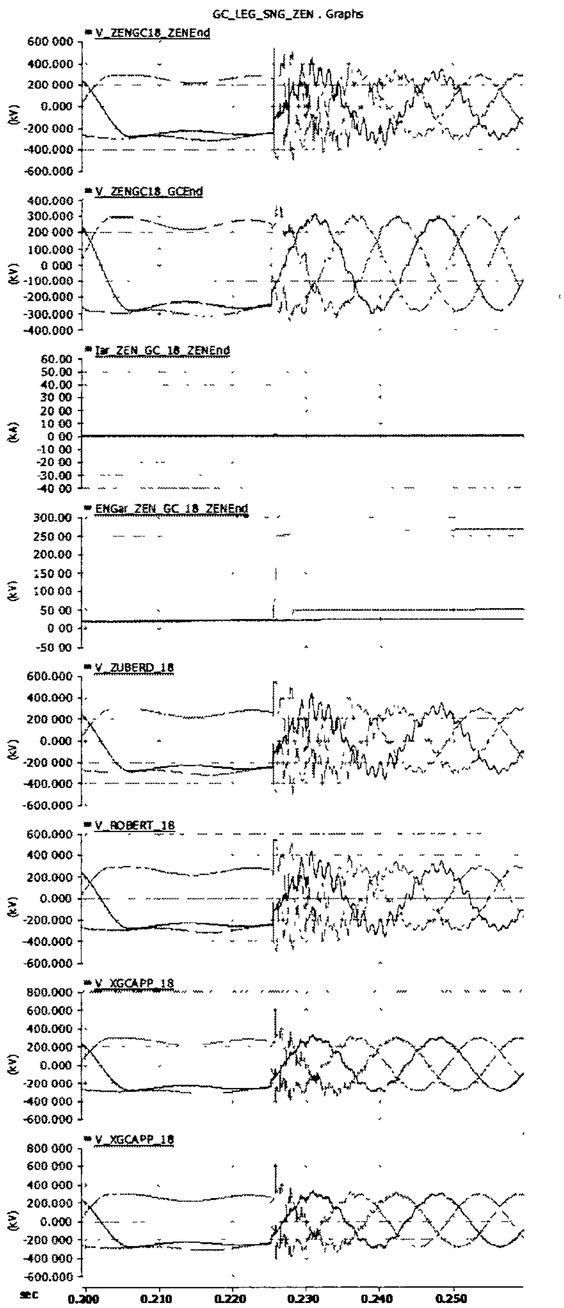


Figure 12-32: Maximum Overvoltage for Gibbons Creek – Zenith ckt 50 – Gibbons Creek side open without Line-Arrestor

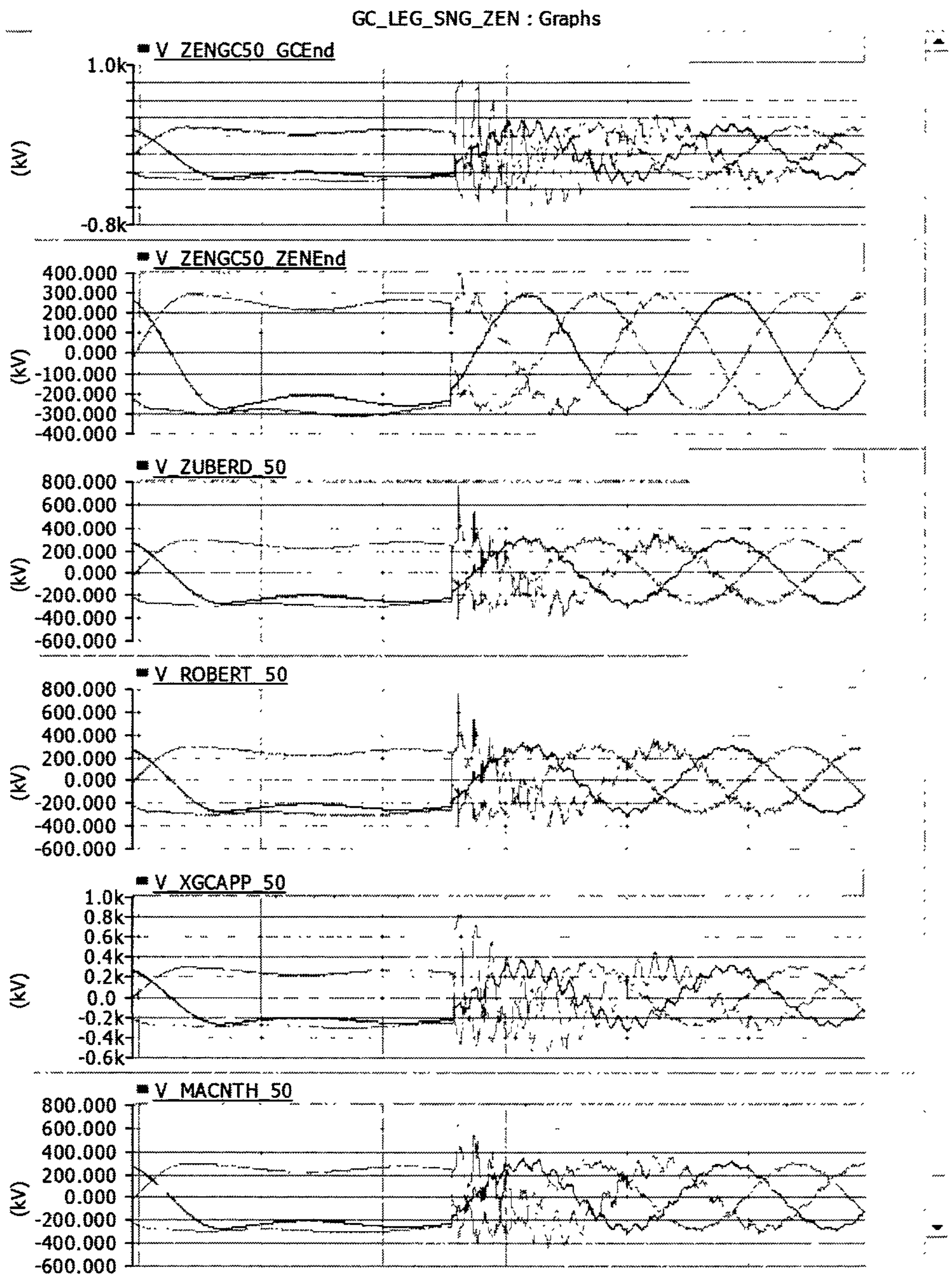


Figure 12-33: Maximum Overvoltage for Gibbons Creek – Zenith ckt 50 – Gibbons Creek side open with Line-Arrestor

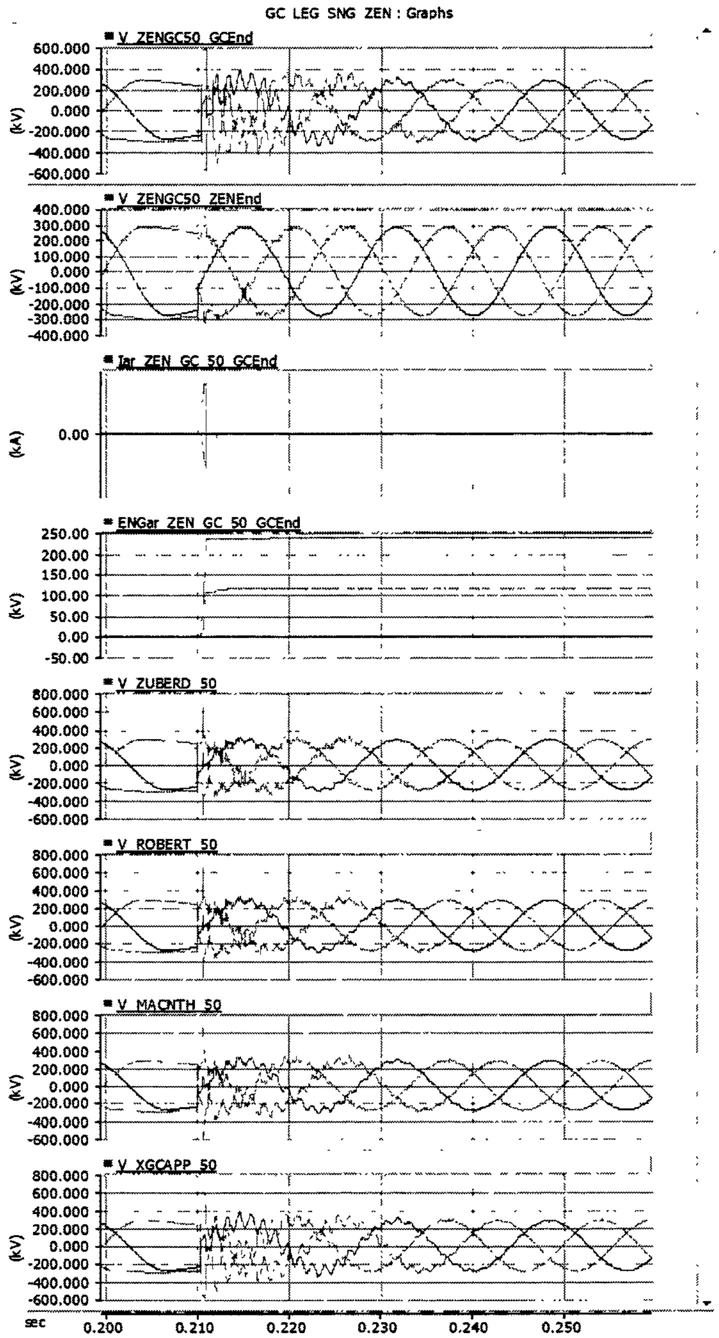


Figure 12-34: Maximum Overvoltage for Gibbons Creek – Zenith ckt 50 – Zenith side open without Line-Arrestor

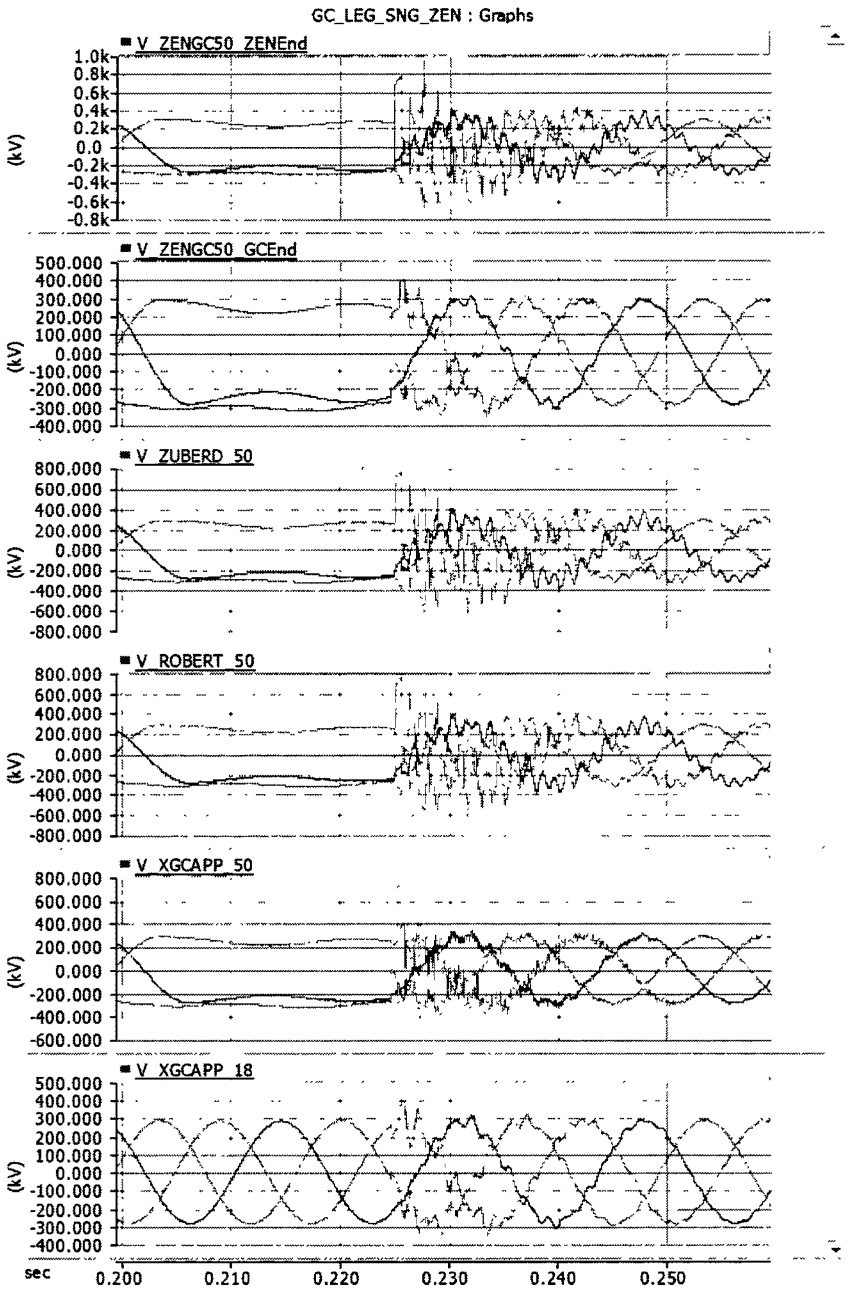
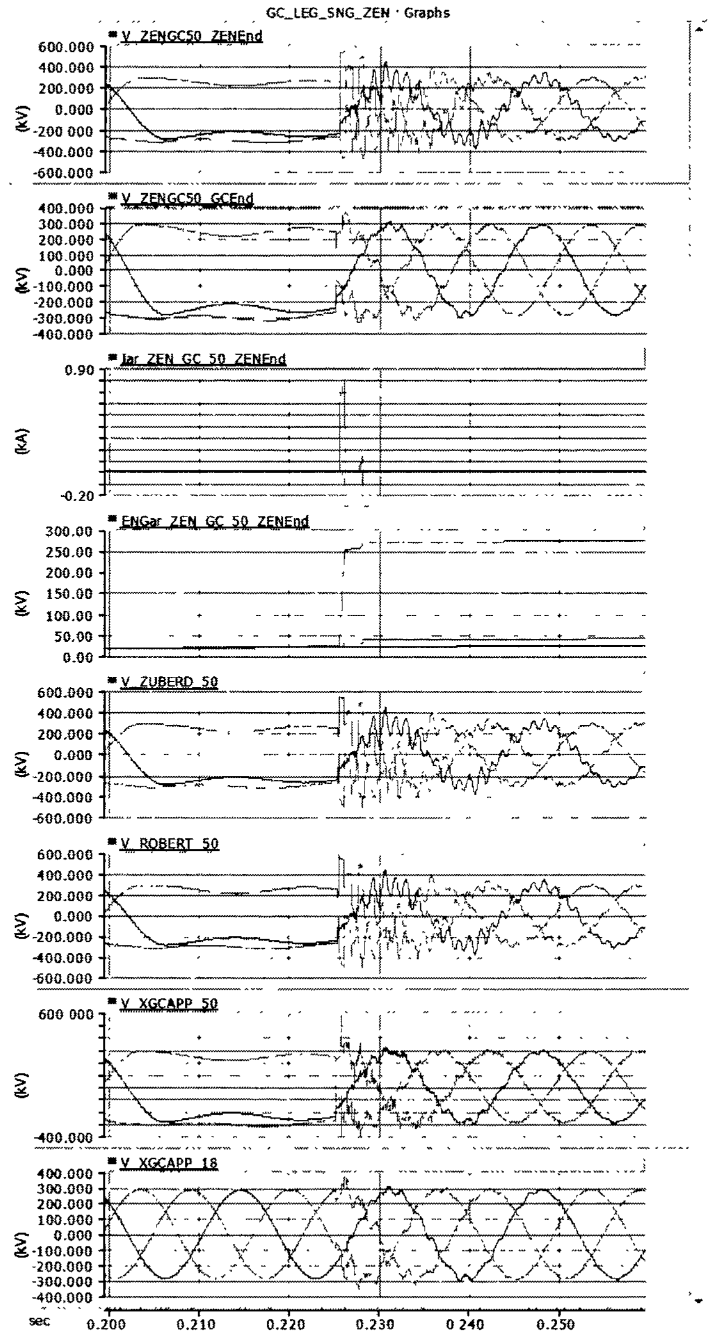


Figure 12-35 Maximum Overvoltage for Gibbons Creek – Zenith ckt 50 – Zenith side open with Line-Arrestor



12.1 345 kV Singleton to Zenith ckt 98 & 99

The Singleton to Zenith ckt 98 and ckt 99 are identical and on the same double circuit. They will be modeled in five independent sections of 4.14, 32.37, 7.13, 1.72 and approximate 7.93 miles as described in Table 12-19 and Table 12-20. All these sections with the exception of the 1.72 mi ROBERT_ZUBERD share right-of-way (TROW) with similar sections on ckts 18 and 50 Zenith to Gibbons Creek as shown Figure 12-37. Mutual coupling has been modeled for these line sections and an example of data entry is shown in Figure 12-38 for the TLINE configuration parameters.

Basic Information for the circuit sections in these tables as well and conductor's information is provided in Table 12-21 and Table 12-3.

Results for the maximum Transient Overvoltage for a Fault with restrike are shown in Table 12-22 CenterPoint has added to this maximum overvoltage a safety factor of 10%, which should be used in calculating the Minimum Approach Distance. The table also shows the location on the circuit where the maximum overvoltage was obtained (Figure 12-37) TOV plots are shown from Figure 12-39 to Figure 12-35.

Table 12-19: Singleton – Zenith ckt 98 – Configuration

Line Section [illegible]	[illegible]	[illegible]	R Static [illegible]	Config [illegible]	[illegible]	[illegible]	[illegible] Rating
SNGLTN-SNG_A4	345DDT2		3/8EHS	2-795ACSR	0.05	1137*	1450
SNG_A4-SNG_A3	345DDT2		3/8EHS	2-1590ACSR	0.01	1710*	2194
SNG_A3-XGCAPP	**345DDT1**	**3/8EHS**	**3/8EHS**	**2-795ACSR**	4.08	1137*	1450
SNGLTN-ZGCAPP					4.14	1137*	1450
XGCAPP-MACNTH	345DDT1	3/8EHS	3/8EHS	2-795ACSR	32.37	1137*	1450
MACNTH-ROBERT	345DDT1	3/8EHS	3/8EHS	2-795ACSR	7.13	1137*	1450
ROBERT-ZUBERD	345DDT1	3/8EHS	3/8EHS	2-795ACSR	1.72	1137*	1450
ZUBERD-ZEN_A3	**345DDT1**	**3/8EHS**	**3/8EHS**	**2-795ACSR**	7.68	1137*	1450
ZEN_A3-ZENITH	345DDT2	3/8EHS	3/8EHS	2-795ACSR	0.26	1137*	1450
ZUBERD-ZENITH					7.94	1137*	1450
SNGLTN-ZENITH					53.30	1137*	1450
44645- 44900							

Table 12-20: Singleton – Zenith ckt 99 – Configuration

SNGLTN-SNG_A4	-R	345DDT1	3/8EHS		2-795ACSR	0.05	1137*	1450
SNG_A4-SNG_A3	-R	345DDT1	3/8EHS		2-795ACSR	0.01	1137*	1450
SNG_A3-XGCAPP	-R	**345DDT1**	**3/8EHS**	**3/8EHS**	**2-795ACSR**	4.08	1137*	1450
SNGLTN-ZGCAPP						4.14	1137*	1450
XGCAPP-MACNTH	-R	345DDT1	3/8EHS	3/8EHS	2-795ACSR	32.37	1137*	1450
MACNTH-ROBERT	-R	345DDT1	3/8EHS	3/8EHS	2-795ACSR	7.13	1137*	1450
ROBERT-ZUBERD	-R	345DDT1	3/8EHS	3/8EHS	2-795ACSR	1.72	1137*	1450
ZUBERD-ZEN_A3	-R	345DDT1	3/8EHS	3/8EHS	2-795ACSR	7.68	1137*	1450
ZEN_A3-ZENITH	-R	345DDT2	3/8EHS	3/8EHS	2-795ACSR	0.25	1137*	1450
ZUBERD-ZENITH						7.93	1137*	1450
SNGLTN-ZENITH						53.29	1137*	1450
44645- 44900								

Figure 12-36: Tower Configuration (segment Singleton to Zenith Tower Type 345 DDT1)

Tower: 345DDT1 Tower Centre 0.0 [m]
Conductors: Drake_795ACSR_26_7-> Ground_Wires: 3/8EHS_Extra_High_Strength

Circuit #	Cond. #	Connection Phasing #	X (from tower centre)	Y (at tower)
	1	1	-9.16 [m]	26.21 [m]
	2	2	-12.97 [m]	18.59 [m]
	3	3	-5.33 [m]	18.59 [m]
	4	4	9.16 [m]	26.21 [m]
	5	5	12.97 [m]	18.59 [m]
	6	6	5.33 [m]	18.59 [m]

GW. #	Connection Phasing #	X (from tower centre)	Y (at tower)
1	Eliminated	-7.07 [m]	32.92 [m]
2	Eliminated	7.07 [m]	32.92 [m]

0.4572 [m]

Resistivity: 100.0
Aerial: Analytical Approximation (Deri-Semlyen)
Underground: Direct Numerical Integration
Mutual: Analytical Approximation (Lucca)

Table 12-21: PSCAD Input Data for Phase Conductor Singleton to Zenith for ckt 98 & 99

Conductor Type	kcmil	Stranding	Steel Strands	Number of Layers (Al)	Total Number of Inner Strands	Diameter				DC Resistance	PSCAD Entries				
						Al	Steel	Steel Core	Complete Cable		Total Number of Strands (AL Only)	Total Number of Outer Strands	Outer Radius	Strand Radius	DC Resistance
						Inches	Inches	Inches	Inches	Ohms/Mile			Meters	Meters	Ohm/km
Drake	795	26	7	2	[illegible]	[illegible]	0 136	0 406	1 108	0 1129	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 12-22: Maximum TOV values Singleton – Zenith ckt 98 and 99 (Fault with Restrike)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Singleton	Zenith	98	345	Singleton	ZUBERD_98	2 96	3.26	ZUBERD_98	2.30	2 53
Singleton	Zenith	98	345	Zenith	ZENSNG98_ZEN	3 34	3.67	XGCAPP_98	2 27	2.50
Singleton	Zenith	99	345	Singleton	ZENSNG99_SNG	2.97	3.27	ZUBERD_99	2.27	2.50
Singleton	Zenith	99	345	Zenith	ZENSNG99_ZEN	3.40	3.74	XGCAPP_99	2 23	2.45

Figure 12-37: PSCAD MODEL Singleton – Zenith ckt 98 and 99

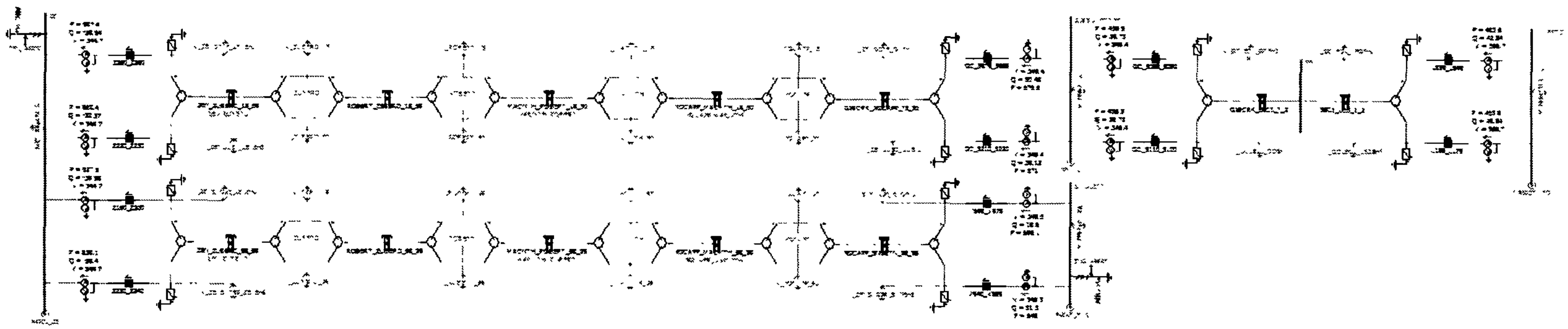


Figure 12-38: Mutual Coupling Data Entry example for section ZEN_ZUBERD ckt 18

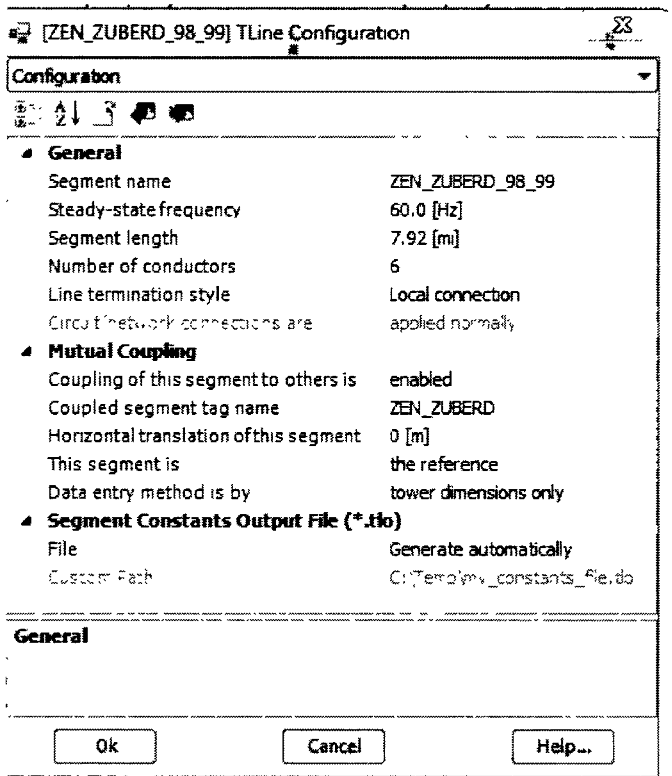


Figure 12-39: Maximum Overvoltage for Singleton – Zenith ckt 98 – Singleton side open without Line-Arrestor

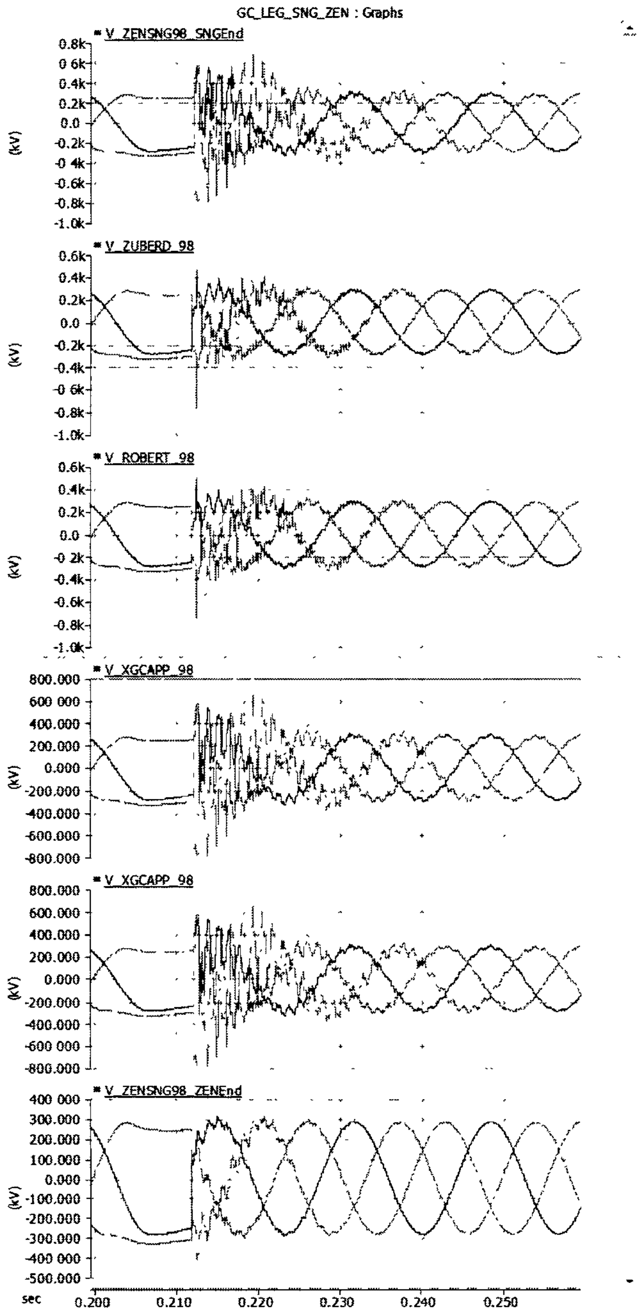
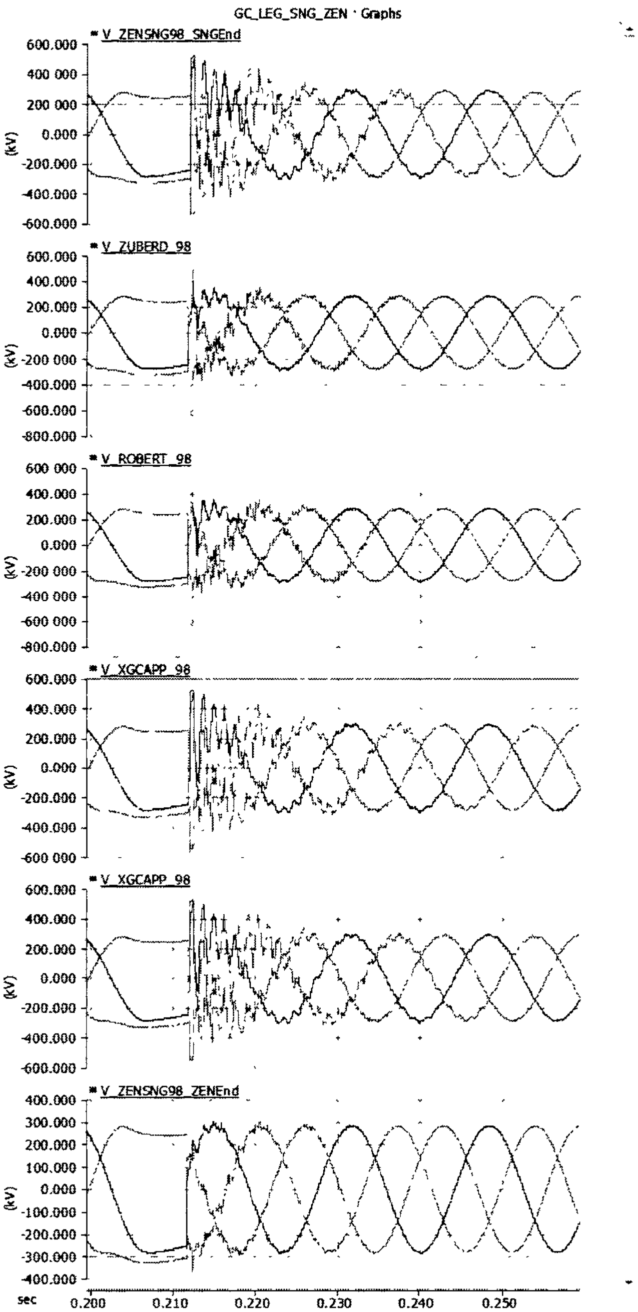


Figure 12-40: Maximum Overvoltage for Singleton – Zenith ckt 98 – Singleton side open with Line-Arrestor



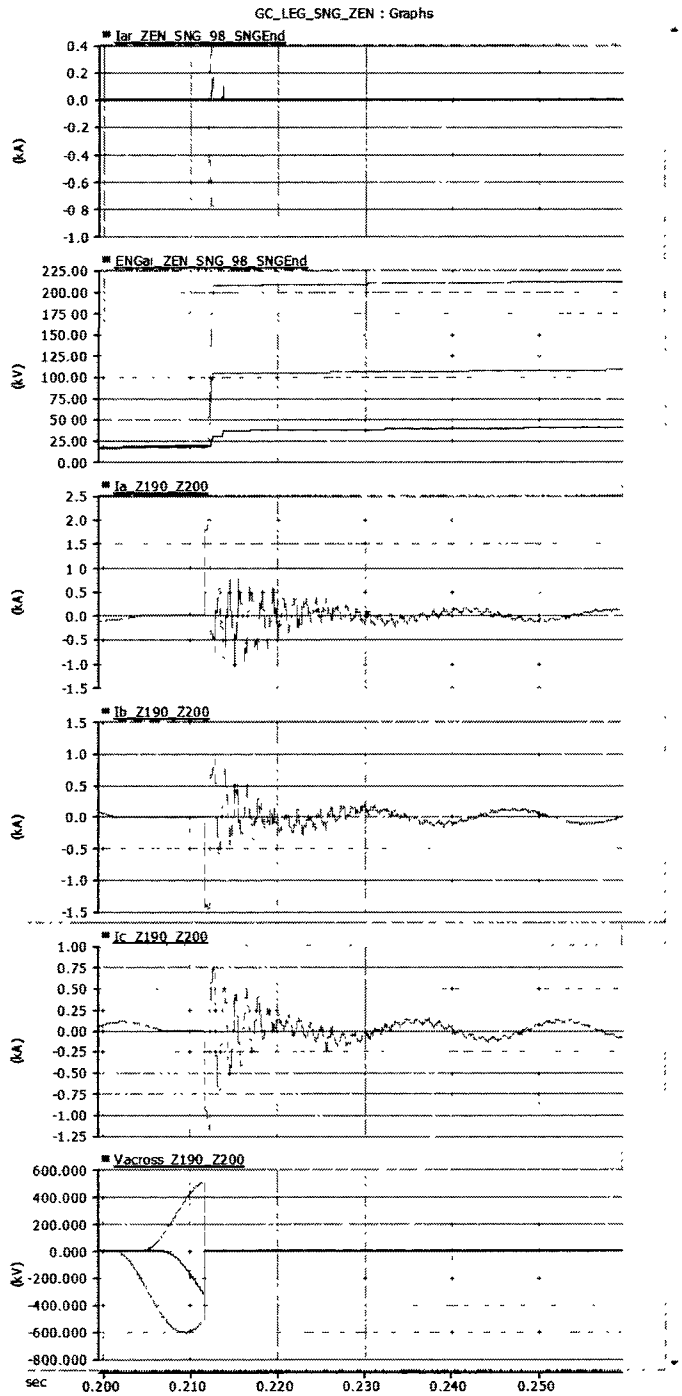

GC_LEG_SNG_ZEN : Graphs
Iar_ZEN_SNG_98_SNGEnd
ENGar_ZEN_SNG_98_SNGEnd
Ia_Z190_Z200
Ib_Z190_Z200
Ic_Z190_Z200
Vacross_Z190_Z200
(kA)
(kV)
sec
0.200
0.210
0.220
0.230
0.240
0.250

Figure 12-41: Maximum Overvoltage for Singleton – Zenith ckt 98 – Zenith side open without Line-Arrestor

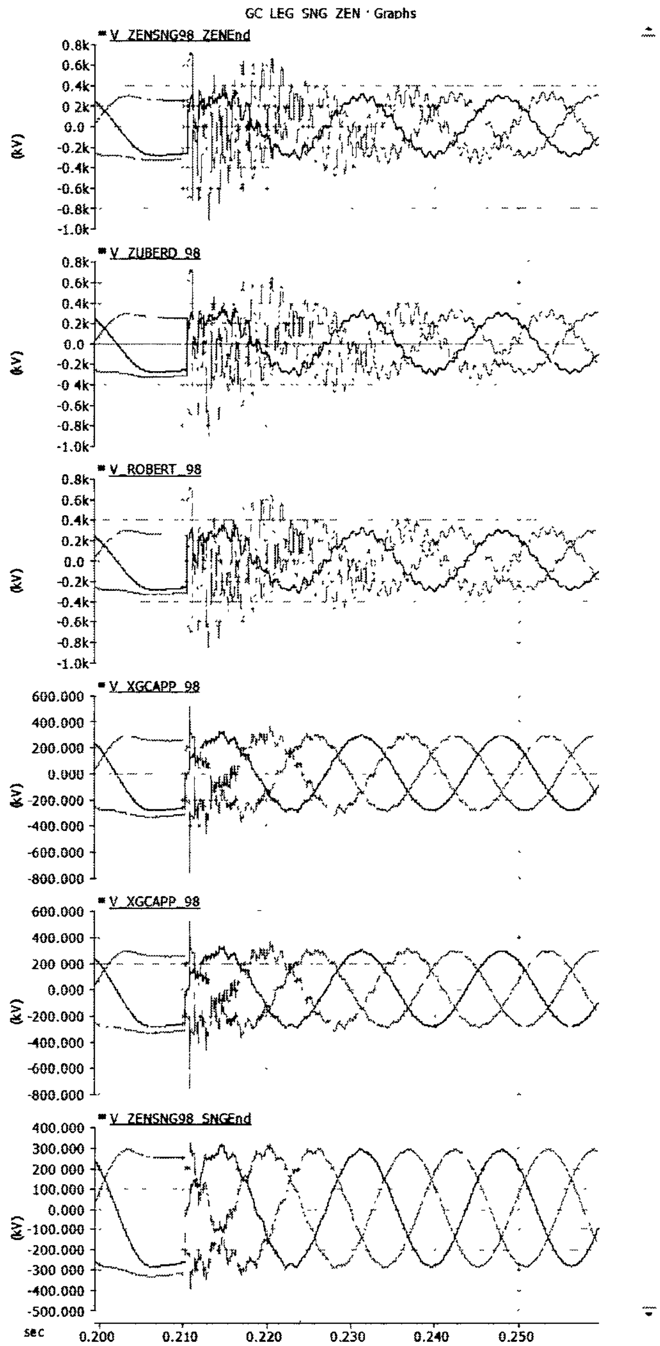
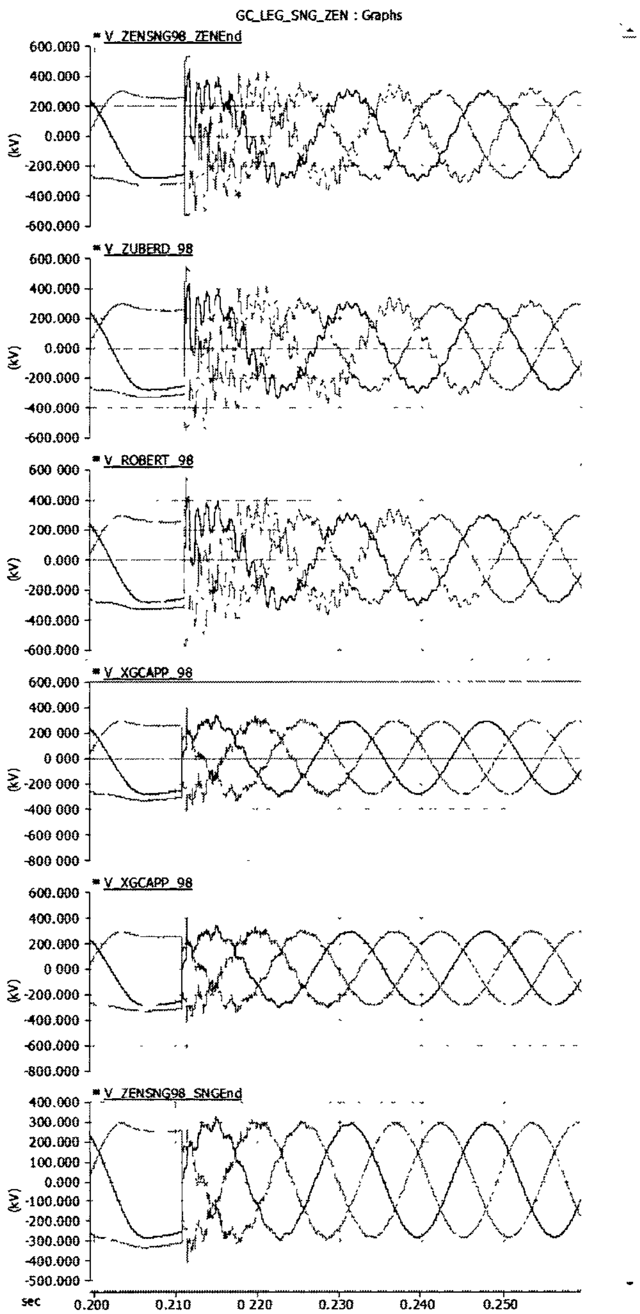


Figure 12-42: Maximum Overvoltage for Singleton – Zenith ckt 98 – Zenith side open with Line-Arrestor



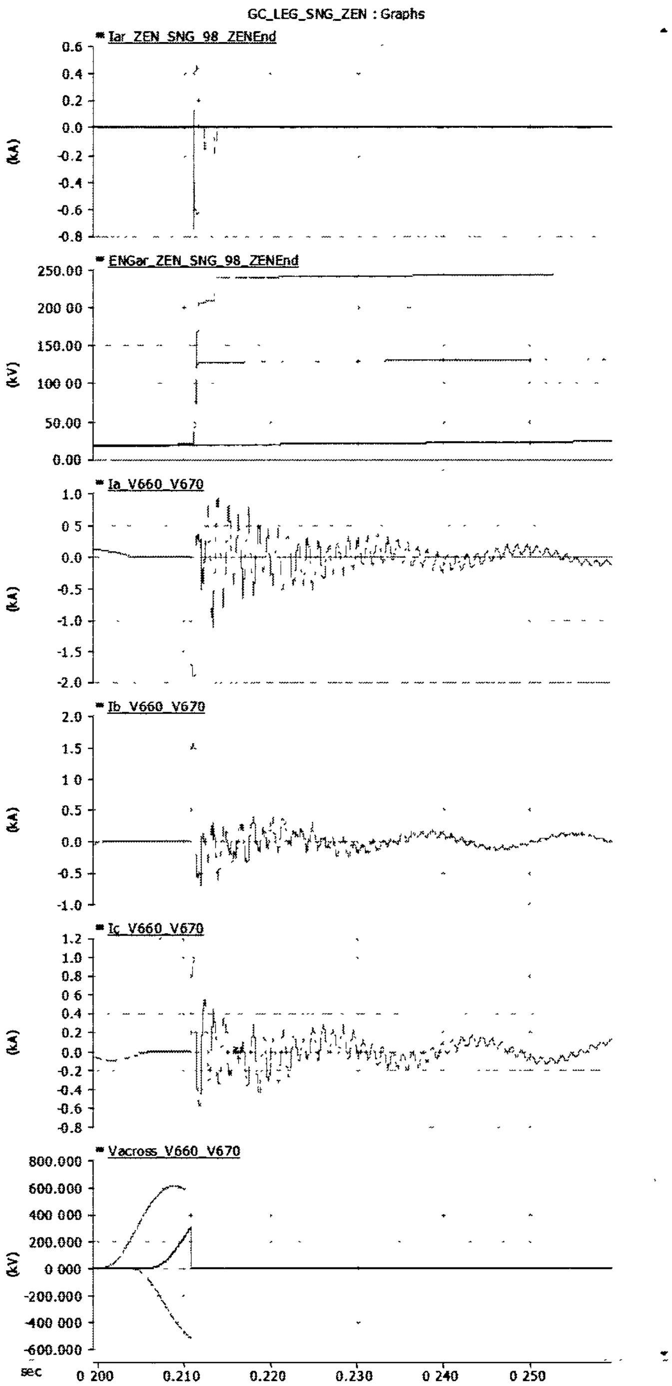

GC_LEG_SNG_ZEN : Graphs
Iar_ZEN_SNG_98_ZENEnd
(kA)
ENGar_ZEN_SNG_98_ZENEnd
(kV)
Ia_V660_V670
(kA)
Ib_V660_V670
(kA)
Ic_V660_V670
(kA)
Vacross_V660_V670
(kV)
sec
0.200
0.210
0.220
0.230
0.240
0.250

Figure 12-43: Maximum Overvoltage for Singleton – Zenith ckt 99 – Singleton side open without Line-Arrestor

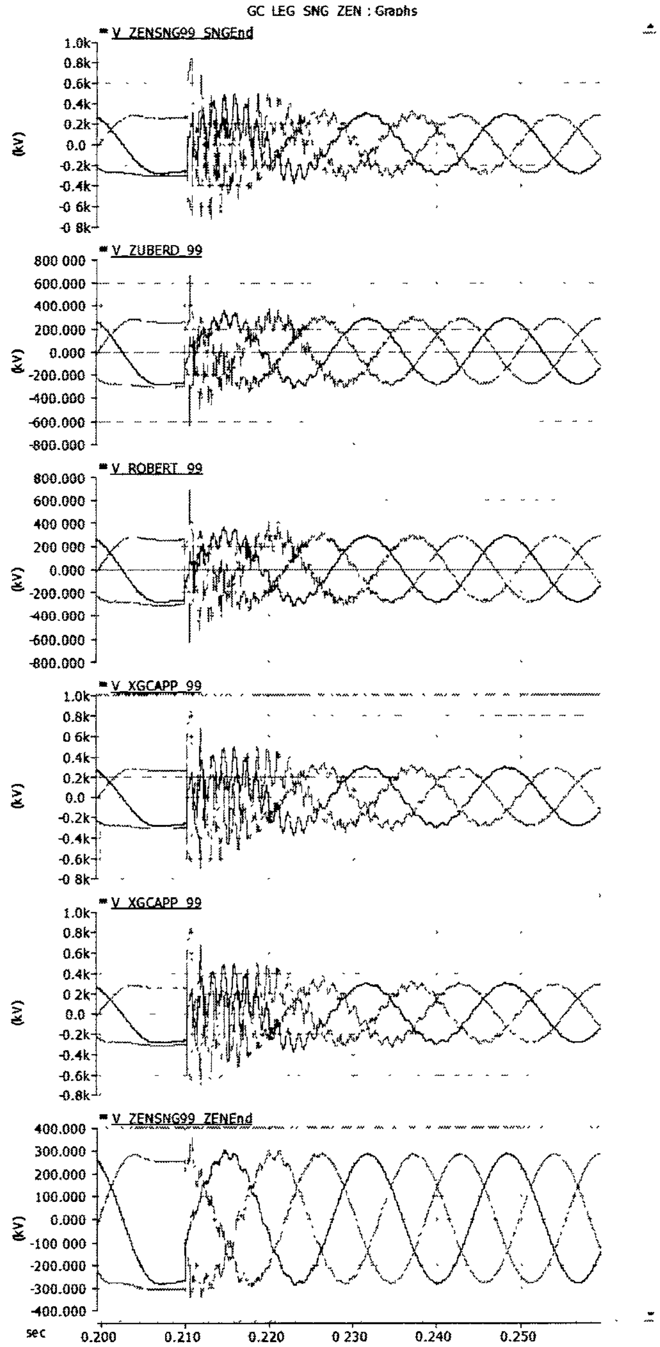
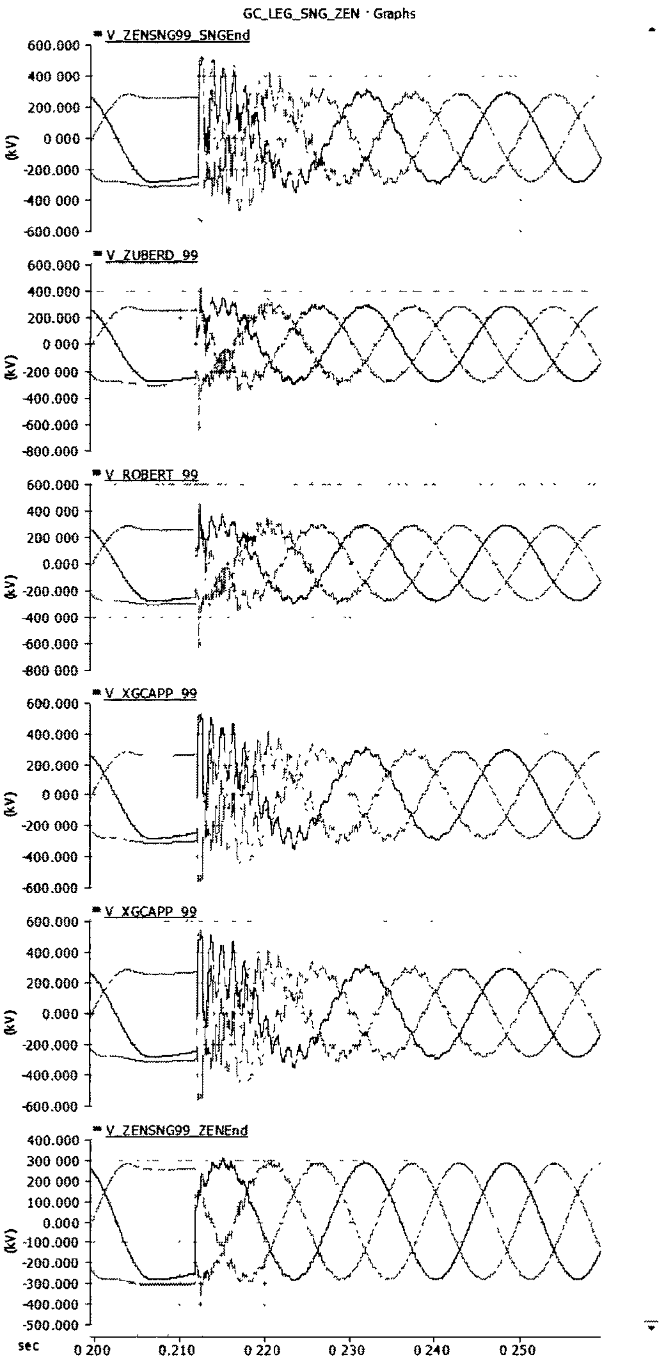


Figure 12-44: Maximum Overvoltage for Singleton – Zenith ckt 99 – Singleton side open with Line-Arrestor



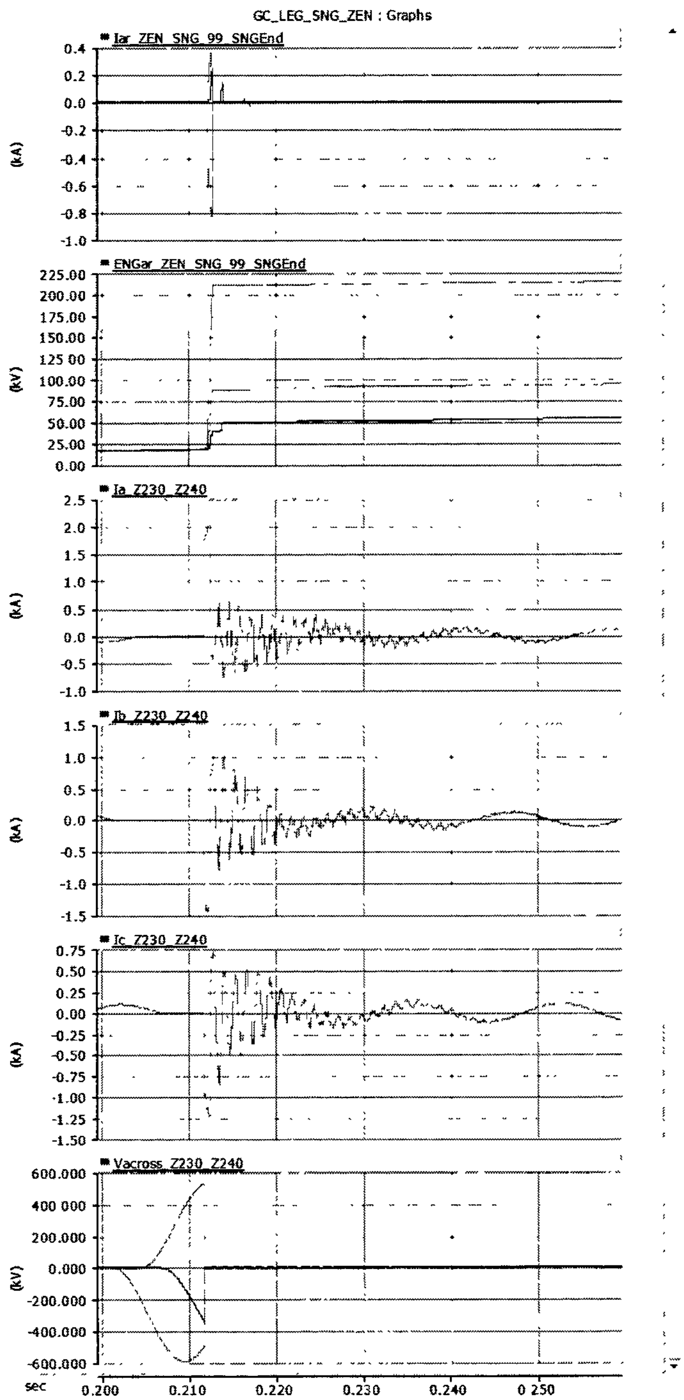

GC_LEG_SNG_ZEN : Graphs
Iar_ZEN_SNG_99_SNGEnd
(kA)
ENGar_ZEN_SNG_99_SNGEnd
(kV)
Ia_Z230_Z240
(kA)
Ib_Z230_Z240
(kA)
Ic_Z230_Z240
(kA)
Vacross_Z230_Z240
(kV)
sec
0.200
0.210
0.220
0.230
0.240
0.250

Figure 12-45: Maximum Overvoltage for Singleton – Zenith ckt 99 – Zenith side open without Line-Arrestor

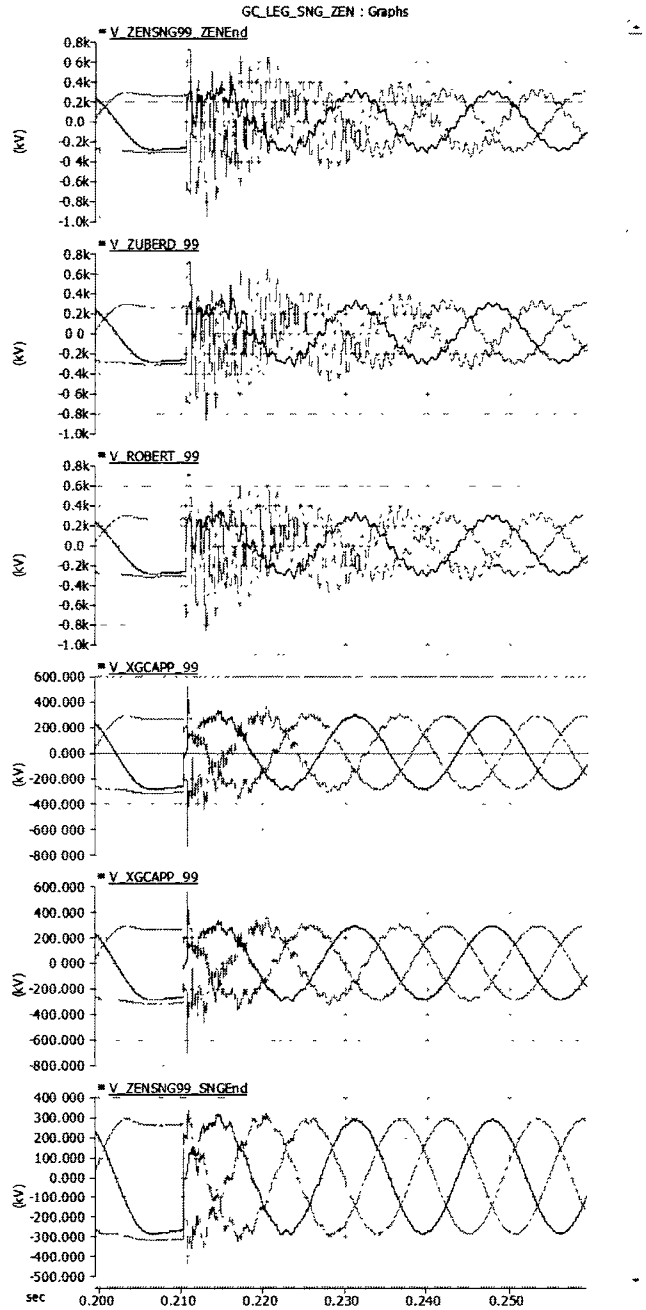
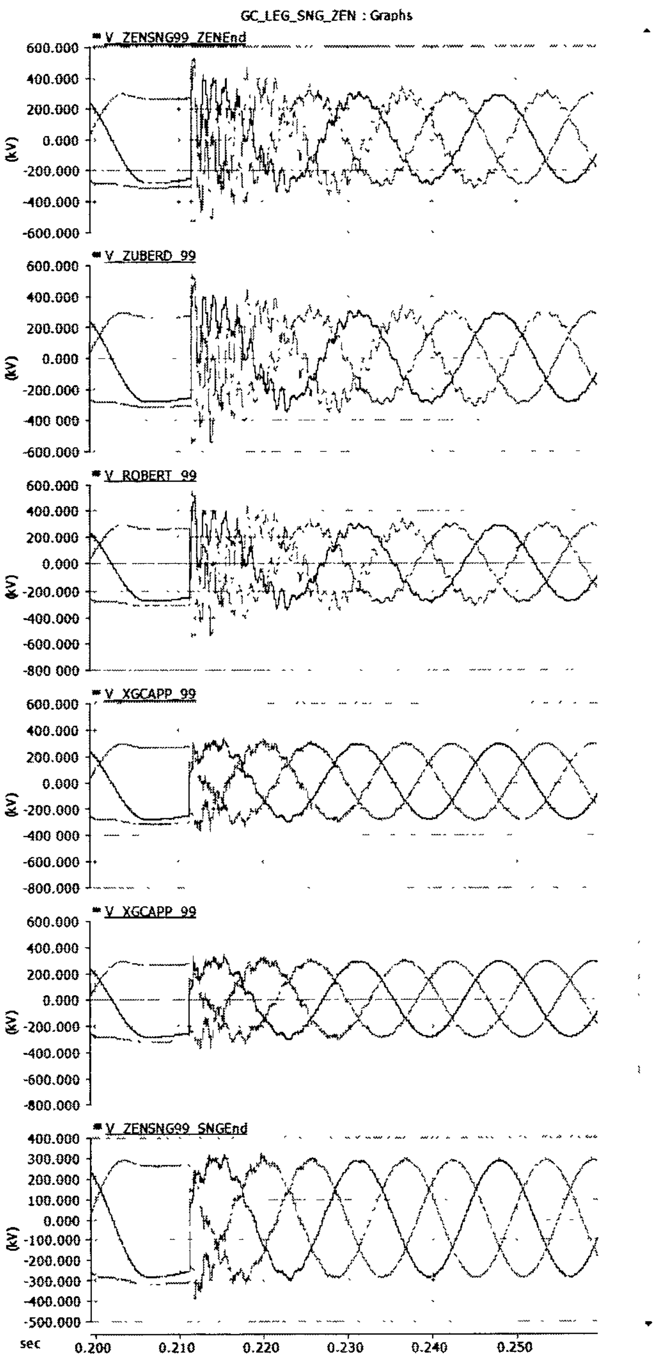
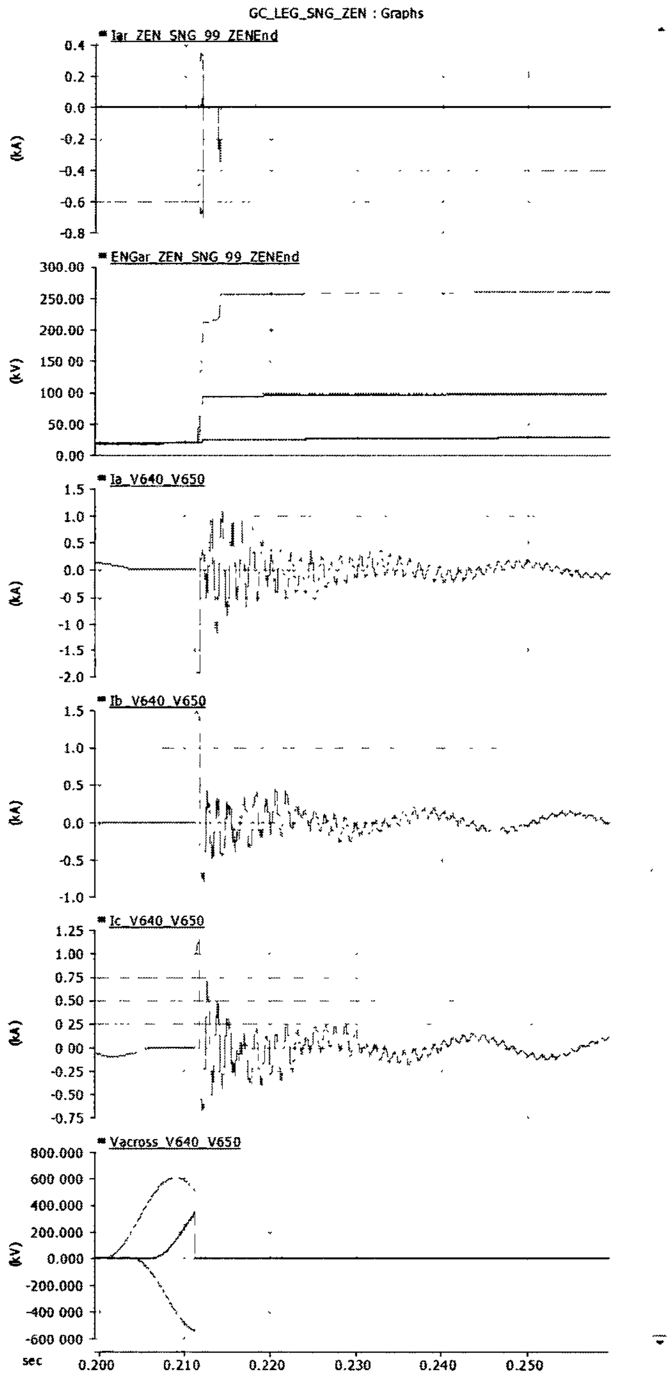


Figure 12-46 Maximum Overvoltage for Singleton – Zenith ckt 99 – Zenith side open with Line-Arrestor




GC_LEG_SNG_ZEN : Graphs
Iar_ZEN_SNG_99_ZENEnd
(kA)
ENGar_ZEN_SNG_99_ZENEnd
(kV)
Ia_V640_V650
(kA)
Ib_V640_V650
(kA)
Ic_V640_V650
(kA)
Vacross_V640_V650
(kV)
sec
0.200
0.210
0.220
0.230
0.240
0.250

12.1 345 kV Center to Cedar Bayou Plant and Center to P.H. Robinson ckt 97

The Center to Cedar Bayou and Center to P.H. Robinson ckt 97 are identical and on the same double circuit tower for approximately 8.58 mi, and they are on an independent 345 kV circuit tower for the rest of their length which is equivalent to an additional 16.45 mi for the Circuit to P.H. Robinson and 9.5 mi for the circuit to Cedar Bayou Plant. The circuit description for the Center to P.H. Robinson and the Center to Cedar Bayou are in Table 12-23 and Table 12-24 correspondingly The shared double circuit tower will be modeled as two sections of 4.52 miles and 4.06 miles, while the independent 345 kV circuit tower is modeled as one section of 16.45 miles for the circuit to P.H.Robinson and two sections of 5.61 miles and 3.89 miles for the circuit to Cedar Bayou.

Basic Information for the conductor's information is provided in Table 12-2 and Table 12-3 while Figure 12-47 and Figure 12-48 shows the tower configuration used for the single circuit portion of each line

Results for the maximum Transient Overvoltage for a Fault with restrike are shown in Table 12-27. CenterPoint has added to this maximum overvoltage a safety factor of 10%, which should be used in calculating the Minimum Approach Distance. The table also shows the location on the circuit where the maximum overvoltage was obtained (referred to Figure 12-49). TOV plots are shown from Figure 12-50 to Figure 12-57

Table 12-23: Center – P.H.Robinson ckt 97 – Configuration

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CENTER-CTR_A1	345DDP	3/8HSS	3/8HSS	3-959ACSST	0 02	3146	3352
CTR_A1-CTRCOR	345DDP	3/8HSS	3/8HSS	3-959ACSST	1.94	3146	3146
CENTER_CTRCOR					1.96	3146	3146
CTRCOR-DPTAP1	345DDP	3/8HSS	3/8HSS	3-959ACSST	0 90	3146	3146
DPTAP1-DE__A1	345DDP	3/8HSS	3/8HSS	3-959ACSST	0 15	3146	3146
CTRCOR-DE__A1					1.05	3146	3146
DE__A1-DPTAP2	345DDP	3/8HSS	3/8HSS	3-959ACSST	1.46	3146	3146
DPTAP2-DP__UW	345DDP	3/8HSS	3/8HSS	3-959ACSST	0 05	3146	3146
DE__A1-DP__UW					1.51	3146	3146
DP__UW-UW_TAP	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0 82	3146	3146
UW_TAP-UW_COR	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0 25	3146	3146
UW_COR-AZ_ROW	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0 83	3146	3146
DP__UW-AZ_ROW					1.9	3146	3146
AZ_ROW-OLDLAP	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0 88	3146	3146
OLDLAP-DP_COR	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0 24	3146	3146
DP_COR-MRPCOR	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0 92	3146	3146
MRPCOR-DU_COR	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0 05	3146	3146
DU_COR-DU_ROW	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0 07	3146	3146
AZ_ROW-DU_ROW					2.36	3146	3146
DU_ROW-BB_COR	345DDT2	3/8EHS		2-795ACSR1	0 54	1306	1450
BB_COR-E_TAP6	345DDT2	3/8EHS		2-795ACSR1	0 13	1306	1450
E_TAP6-E_TAP5	345DDT2	3/8EHS		2-795ACSR1	0 81	1306	1450
E_TAP5-LPTAP2	345DDT2	3/8EHS		2-795ACSR1	0 62	1306	1450
LPTAP2-SLVCOR	345DDT2	3/8EHS		2-795ACSR1	0 62	1306	1450
SLVCOR-OLDTRI	345DDT2	3/8EHS		2-795ACSR1	0 34	1306	1450
OLDTRI-B5_COR	345DDT2	3/8EHS		2-795ACSR1	0 30	1306	1450
DU_ROW-B5_COR					3.36	1306	1450
B5_COR-MCBCOR	345DDT2	3/8EHS		2-795ACSR1	0 14	1306	1450
MCBCOR-SWITCH	345DDT2	3/8EHS		2-795ACSR1	0 16	1306	1450
SWITCH-B3_COR	345DDT2	3/8EHS		2-795ACSR1	0 71	1306	1450
B5_COR-B3_COR					1.01	1306	1450
B3_COR-FC_COR	345DDT2	3/8EHS		2-795ACSR1	0 29	1306	1450
FC_COR-S3_COR	345DDT2	3/8EHS		2-795ACSR1	0 18	1306	1450
S3_COR-SEP_LP	345DDT2	3/8EHS		2-795ACSR1	0 52	1306	1450
SEP_LP-BW_COR	345DDT2	3/8EHS		2-795ACSR1	0 93	1306	1450
B3_COR-BW_COR					1.92	1306	1450
BW_COR-HO_COR	345DDT2	3/8EHS		2-795ACSR1	0 36	1306	1450
HO_COR-CREEK_	345DDT2	3/8EHS		2-795ACSR1	3 12	1306	1450
CREEK_-CUTOFF	345DDT2	3/8EHS		2-795ACSR1	0 50	1306	1450
CUTOFF-KM_COR	345DDT2	3/8EHS		2-795ACSR1	0 89	1306	1450
BW_COR-KM_COR					4.87	1306	1450
KM_COR-STATIC	345DDT2	3/8EHS		2-795ACSR1	2 95	1306	1450
STATIC-SH_146	345DDT2	3/8EHS		2-795ACSR1	0 44	1306	1450
SH_146-CAN_CR	345DDT2	3/8EHS		2-795ACSR1	0 95	1306	1450
CAN_CR-P_H_R_	345DDT2	3/8EHS		2-795ACSR1	0 95	1306	1450
KM_COR-P_H_R_					5.29	1306	1450
CENTER-P_H_R_					25.03	1306	1450
40240- 42000							

Table 12-24: Center – Cedar Bayou ckt 97 – Configuration

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CEDARP-CU5COR	345DDT2		3/8EHS	2-795ACSR1	0.09	1306	1450
CU5COR-FM1405	345DDT2	3/8EHS		2-795ACSR1	0.32	1306	1450
FM1405-US_COR	**345DDT2**	**3/8EHS**	**3/8EHS**	**2-795ACSR1**	2.41	1306	1450
CEDARP-US_COR					**2.82**	**1306**	**1450**
US_COR-TRICTY	345DDT2	3/8EHS		2-795ACSR1	1.02	1306	1450
TRICTY-SPLTUP	**345DDT2**	**3/8EHS**		**2-795ACSR1**	0.05	1306	1450
US_COR-SPLTUP					**1.07**	**1306**	**1450**
SPLTUP-HOGI_N	345DDT2	3/8EHS		2-795ACSR1	1.12	1306	1450
HOGI_N-HOGISL	345DDT2	3/8EHS	3/8EHS	2-795ACSR1	1.05	1306	1450
HOGISL-HOGI_S	345DDT2	3/8EHS	3/8EHS	2-795ACSR1	0.84	1306	1450
HOGI_S-SPILL_	**345DDT2**	**3/8EHS**	**3/8EHS**	**2-795ACSR1**	1.72	1306	1450
SPILL_-UB_COR	345DDT2	3/8EHS		2-795ACSR1	0.75	1306	1450
UB_COR-DU_ROW	345DDT2	3/8EHS		2-795ACSR1	0.13	1306	1450
SPLTUP-DU_ROW					**5.61**	**1306**	**1450**
DU_ROW-DU_COR	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0.07	3146	3146
DU_COR-MRPCOR	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0.05	3146	3146
MRPCOR-DP_COR	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0.92	3146	3146
DP_COR-OLDLAP	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0.24	3146	3146
OLDLAP-AZ_ROW	**345DDT2**	**3/8HSS**	**3/8HSS**	**3-959ACSST**	0.88	3146	3146
DU_ROW-AZ_ROW					**2.16**	**3146**	**3146**
AZ_ROW-UW_COR	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0.83	3146	3146
UW_COR-UW_TAP	345DDT2	3/8HSS	3/8HSS	3-959ACSST	0.25	3146	3146
UW_TAP-DP__UW	**345DDT2**	**3/8HSS**	**3/8HSS**	**3-959ACSST**	0.82	3146	3146
AZ_ROW-DP__UW					**1.9**	**3146**	**3146**
DP__UW-DPTAP2	345DDP	3/8HSS	3/8HSS	3-959ACSST	0.05	3146	3146
DPTAP2-DE__A1	**345DDP**	**3/8HSS**	**3/8HSS**	**3-959ACSST**	1.46	3146	3146
DP__UW-DE__A1					**1.51**	**3146**	**3146**
DE__A1-DPTAP1	345DDP	3/8HSS	3/8HSS	3-959ACSST	0.15	3146	3146
DPTAP1-CTRCOR	**345DDP**	**3/8HSS**	**3/8HSS**	**3-959ACSST**	0.90	3146	3146
DE__A1-CTRCOR					**1.05**	**3146**	**3146**
CTRCOR-CTR_A1	345DDP	3/8HSS	3/8HSS	3-959ACSST	1.94	3146	3146
CTR_A1-CENTER	**345DDP**	**3/8HSS**	**3/8HSS**	**3-959ACSST**	0.02	3146	3146
CTRCOR-CENTER					**1.96**	**3146**	**3146**
40000- 40240							

Figure 12-47: Tower Configuration (segment CENTER - DP__UW_97 Tower Type 345 DDP2)

Tower: 345DDP2 Tower Centre 0.0 [m]
Conductors: Suwannee_959ACSSTW> 22_7 Ground_Wires: 3/8HHS_High_Strength

Circuit #	Cond. #	Connection Phasing #	X (from tower centre)	Y (at tower)
	1	1	-3.69 [m]	14.10 [m]
	2	2	-3.78 [m]	21.72 [m]
	3	3	-3.87 [m]	29.03 [m]
	4	4	3.70 [m]	14.10 [m]
	5	5	3.78 [m]	21.72 [m]
	6	6	3.87 [m]	29.03 [m]

GW. #	Connection Phasing #	X (from tower centre)	Y (at tower)
1	Eliminated	-2.44 [m]	35.05 [m]
2	Eliminated	2.44 [m]	35.05 [m]

0.4572 [m]

Figure 12-48: Tower Configuration (segment SPLT_UB_CBY_97 - Tower Type 345 DDT2)

Tower: 345DDT2 Tower Centre 0.0 [m]
Conductors: Drake --> Ground_Wires: 3/8EHS_ExtraHigh_Strength

Circuit #	Cond. #	Connection Phasing #	X (from tower centre)	Y (at tower)
	1	1	5.34924 [m]	32.004002 [m]
	2	2	5.34924 [m]	24.079201 [m]
	3	3	5.34924 [m]	16.1544 [m]

GW. #	Connection Phasing #	X (from tower centre)	Y (at tower)
1	Eliminated	-7.62 [m]	38.709602 [m]
2	Eliminated	7.62 [m]	38.709602 [m]

0.4572 [m]

Resistivity: 100.0
Aerial: Analytical Approximation (Deri-Semlyen)
Underground: Direct Numerical Integration
Mutual: Analytical Approximation (Lucca)

Table 12-25: PSCAD Input Data for Phase Conductor for ckt 97

Conductor Type	kcmil	Stranding	Steel Strands	Number of Layers (Al)	Total Number of Inner Strands	Diameter		DC Resistance	PSCAD Entries				
						Al	Complete Cable		Total Number of Strands (AL Only)	Total Number of Outer Strands	Outer Radius	Strand Radius	DC Resistance
						Inches	Inches	Ohms/Mile			Meters	Meters	Ohm/km
Drake	795	26	7	2	10	0 17440577	1 108	0 1129	26	16	[illegible]	[illegible]	[illegible]
Suwannee/ACSS/TW	959 6	22	7	2	8	0.20865403	1 11	0 0907	22	14	[illegible]	[illegible]	[illegible]

Table 12-26: PSCAD Input Data for Ground Conductor for ckt 97

Conductor Type	kcmil	Number of Strands	Diameter		DC Resistance	PSCAD Entries		
			Steel	Complete Cable		Outer Radius	Strand Radius	DC Resistance
			Inches	Inches	Ohms/Mile	Meters	Meters	Ohm/km
3/8 EHS		7	0.12002415	0.36	6 63	0.004572	0.00152431	4.11970124
3/8 HHS		7	0.12002415	0 36	6 4	[illegible]	[illegible]	3.97678551

Table 12-27: Maximum TOV values Center – P.H. Robison ckt 97 (Fault with Restrike)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Center	P.H. Robinson	97	345	Center	CTRPHR97_CTR	3.03	3.34	DU_ROW_PHR97	2.37	2.61
Center	P.H. Robinson	97	345	P.H. Robinson	CTRPHR97_PHR	2.96	3.26	DU_ROW_PHR97	2.20	2.42
Center	Cedar Bayou Plant	97	345	Center	CTRCBY97_CTR	2.74	3.02	DU_ROW_CBY97	2.16	2.38
Center	Cedar Bayou Plant	97	345	Cedar Bayou Plant	CTRCBY97_CBY	2.67	2 94	DP__UW_CBY97	2.07	2.28

Figure 12-49: PSCAD MODEL Center– P.H. Robinson and Center – Cedar Bayou ckt 97

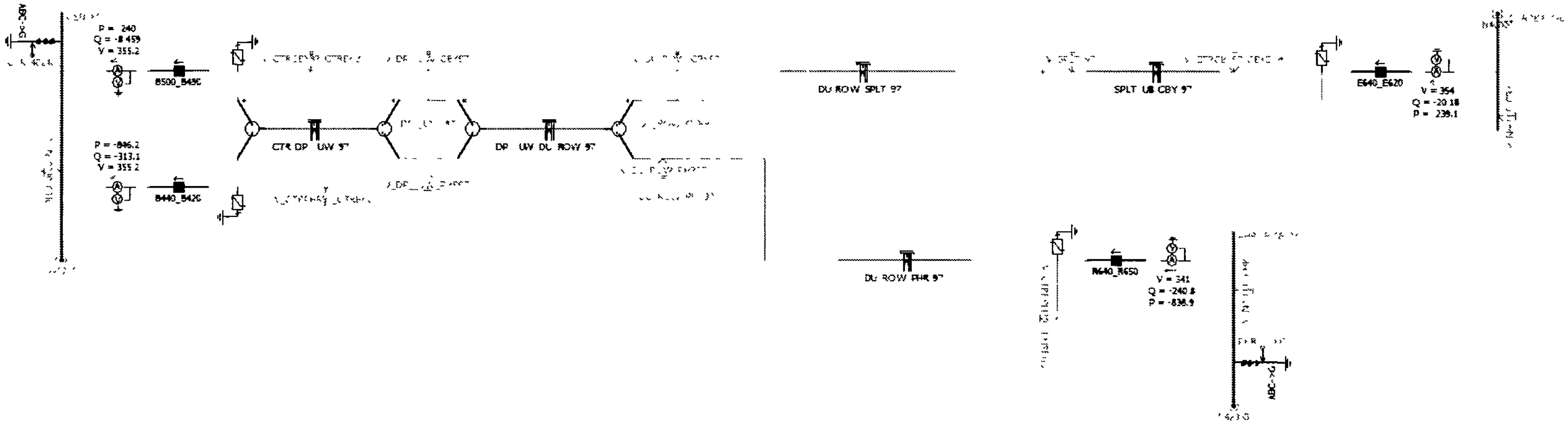


Figure 12-50: Maximum Overvoltage for Center – P.H.Robinson ckt 97 – P.H.Roinson side open without Line-Arrestor

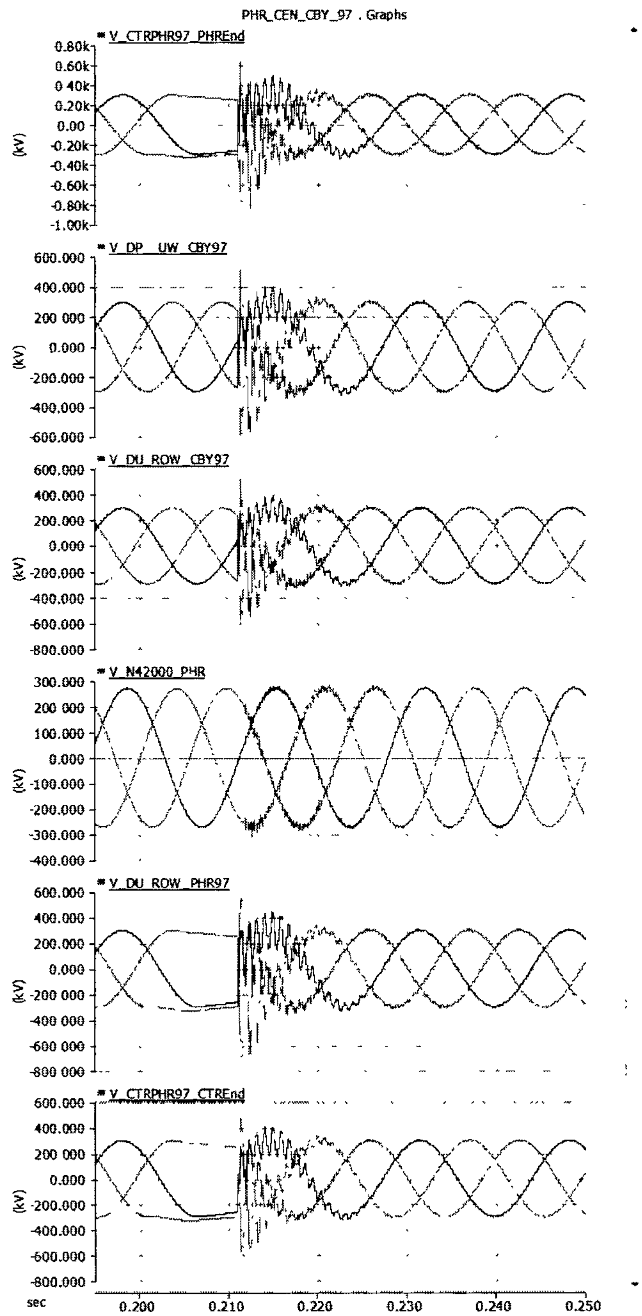


Figure 12-51: Maximum Overvoltage for Center – P.H.Robinson ckt 97 – P.H.Robinson side open with Line-Arrestor

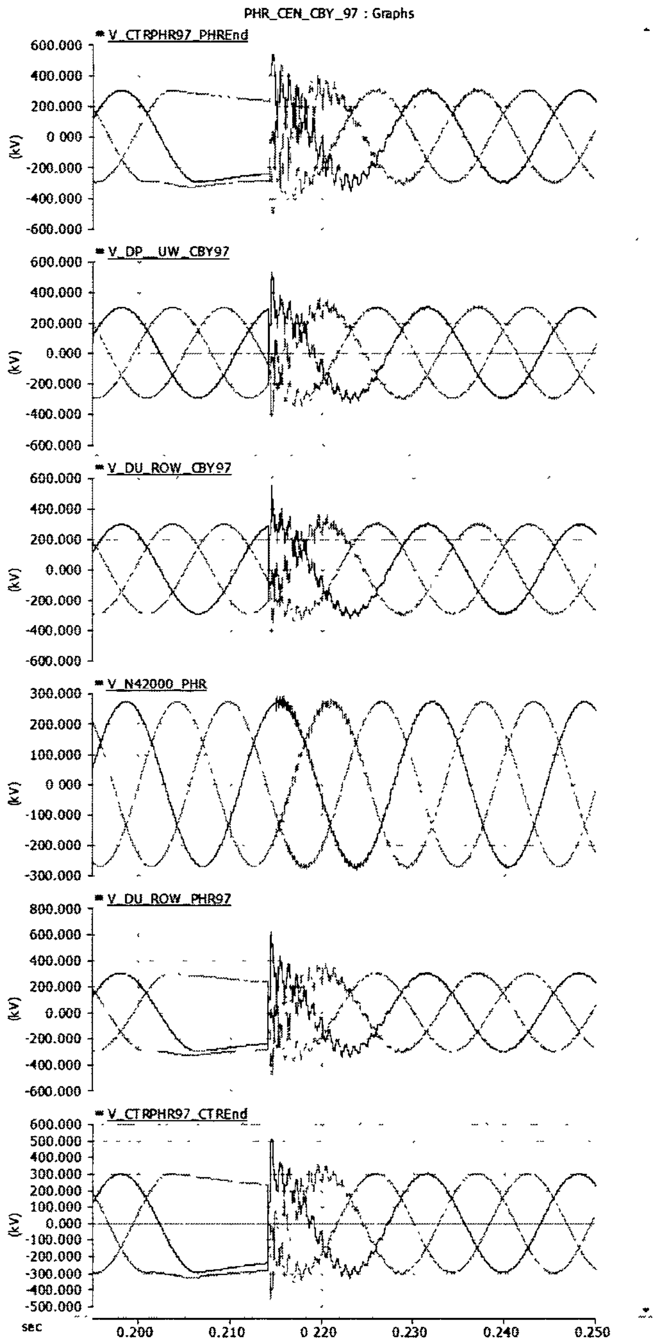


Figure 12-52: Maximum Overvoltage for Center – P.H.Robinson ckt 97 – Center side open without Line-Arrestors

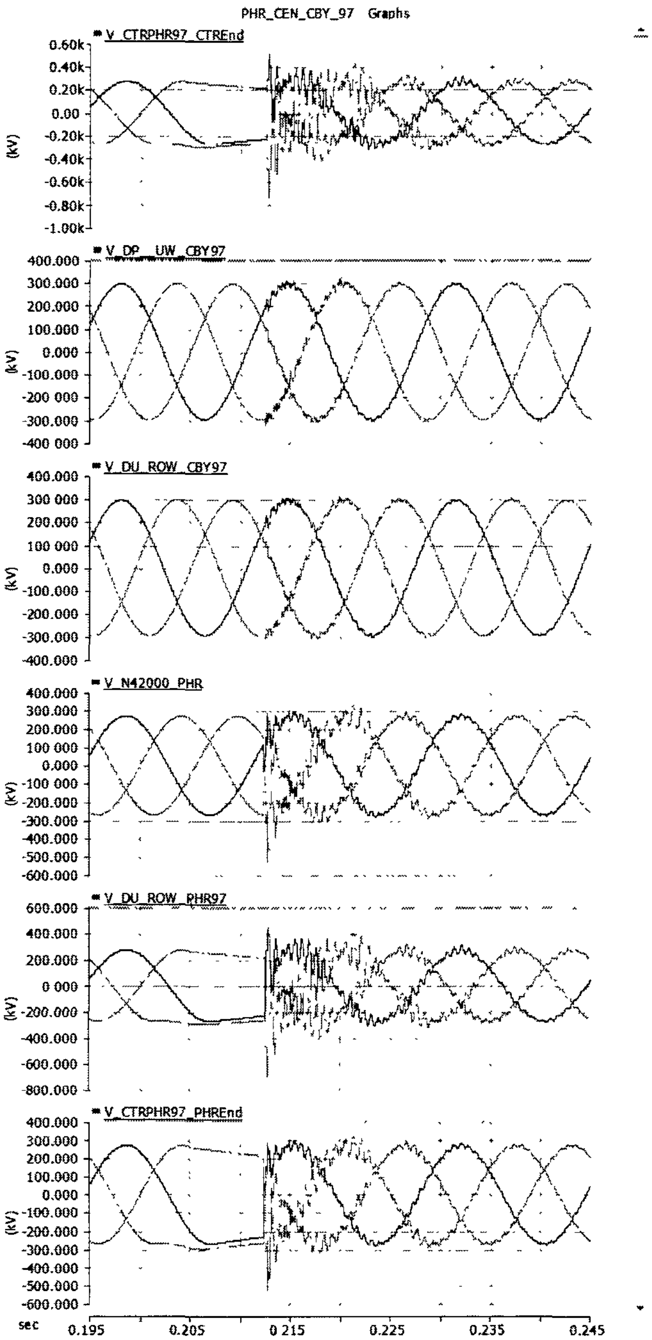


Figure 12-53: Maximum Overvoltage for Center – P.H.Robinson ckt 97 – Center side open with Line-Arrestors

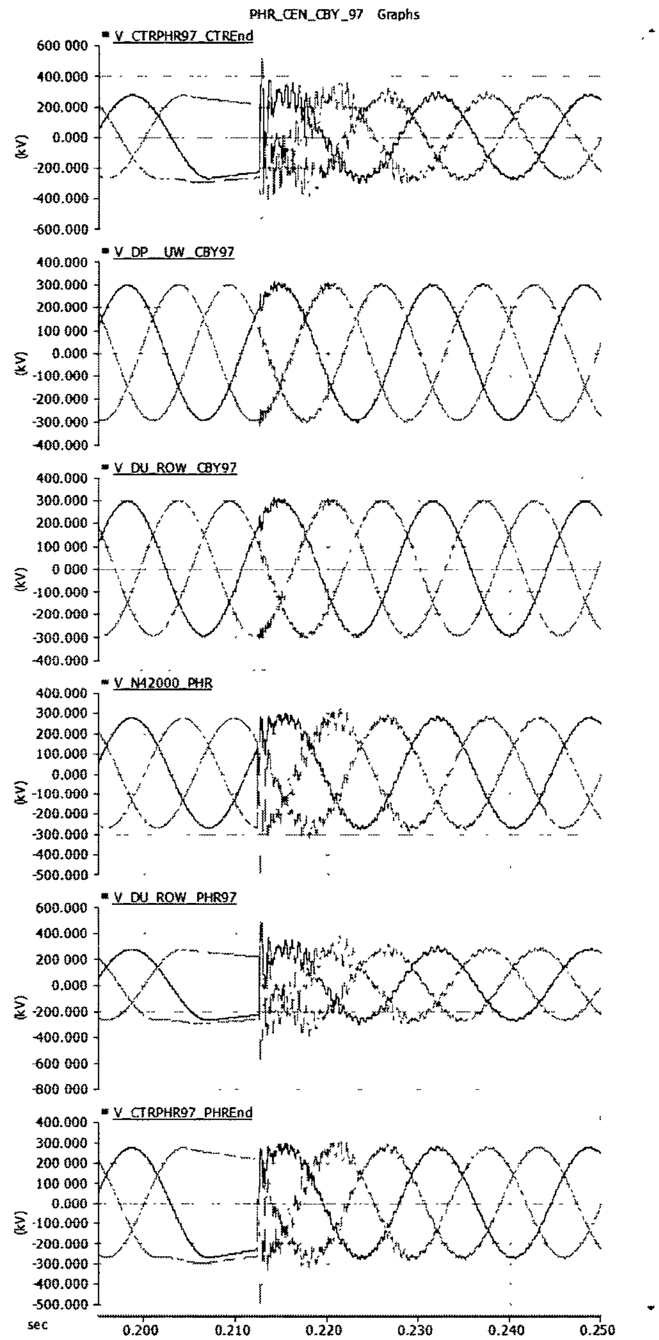


Figure 12-54: Maximum Overvoltage for Center – Cedar Bayou ckt 97 – Cedar Bayou side open without Line-Arrestors

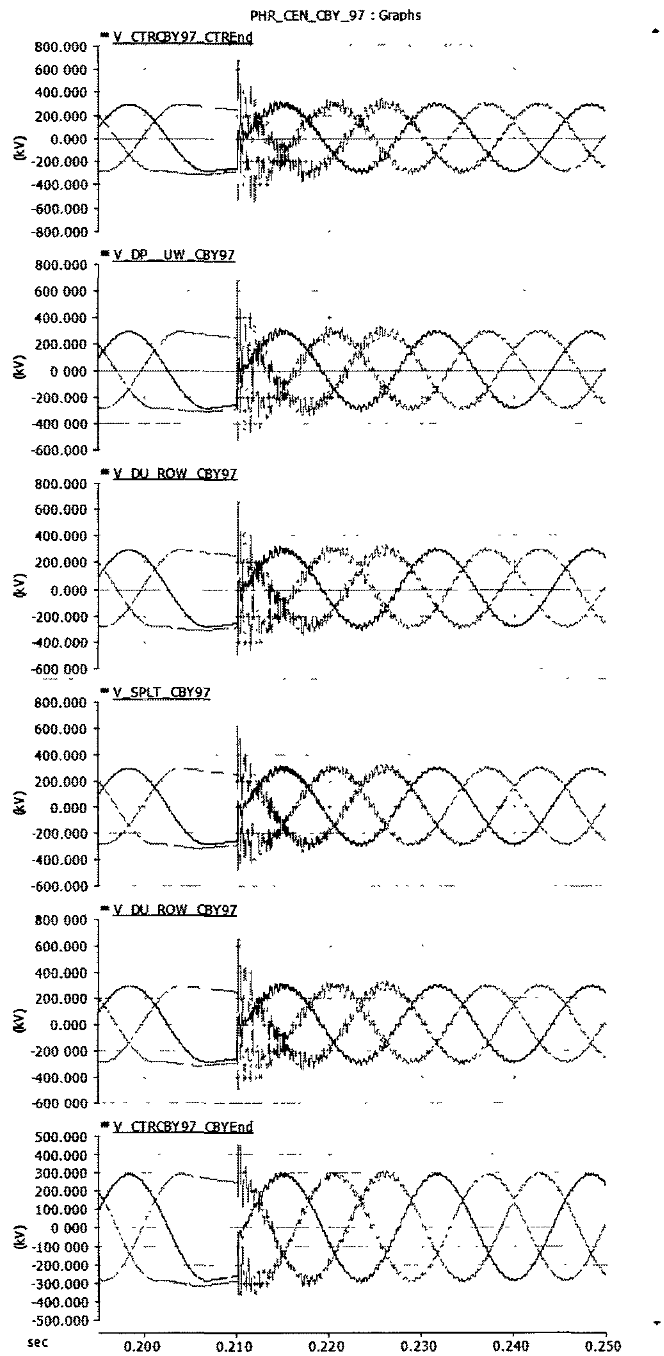


Figure 12-55: Maximum Overvoltage for Center – Cedar Bayou ckt 97 – Cedar Bayou side open with Line-Arrestors

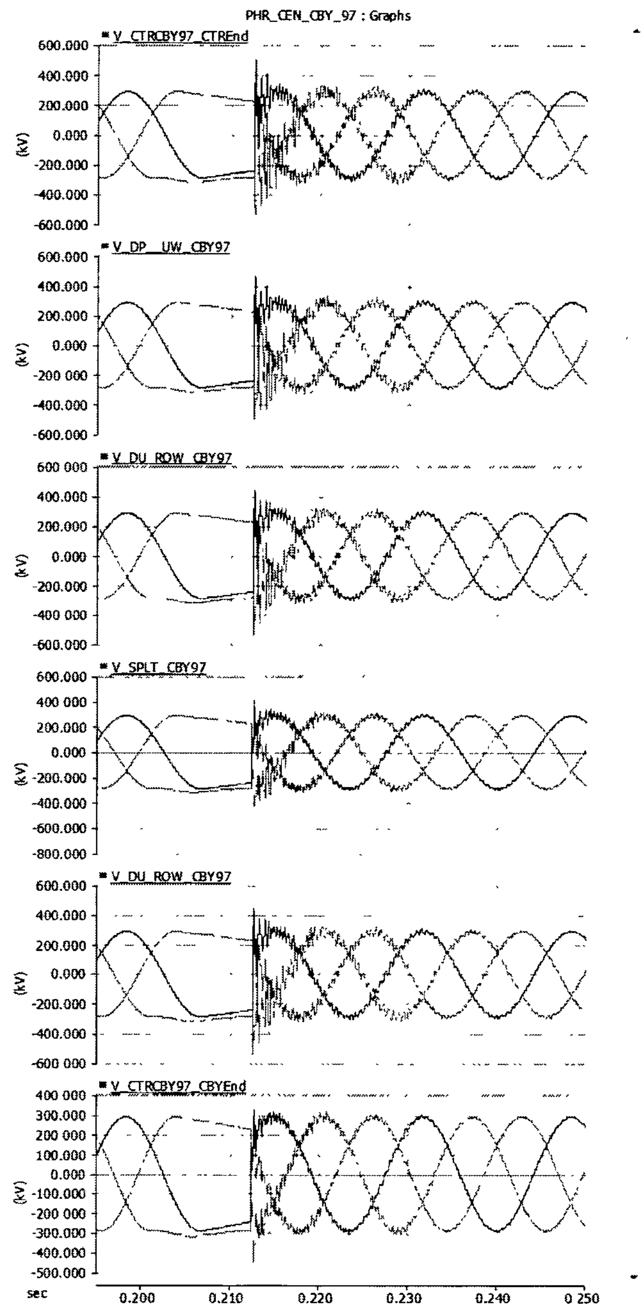


Figure 12-56: Maximum Overvoltage for Center – Cedar Bayou ckt 97 – Center side open without Line-Arrestors

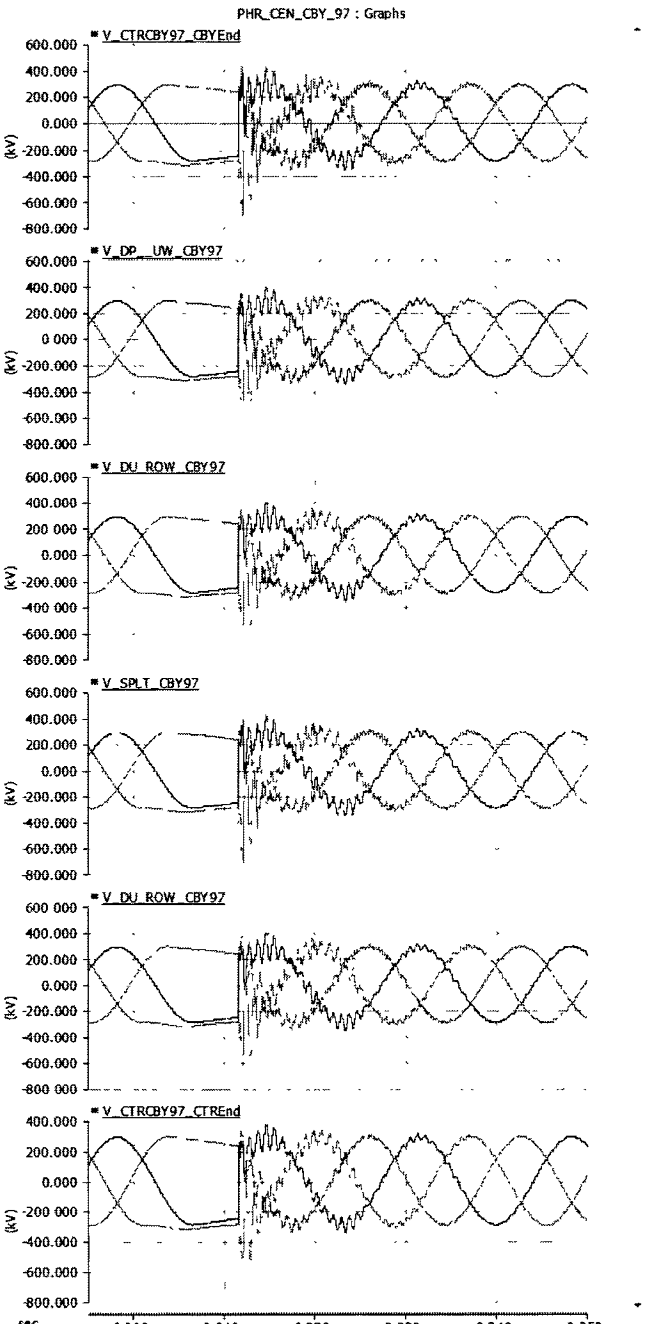
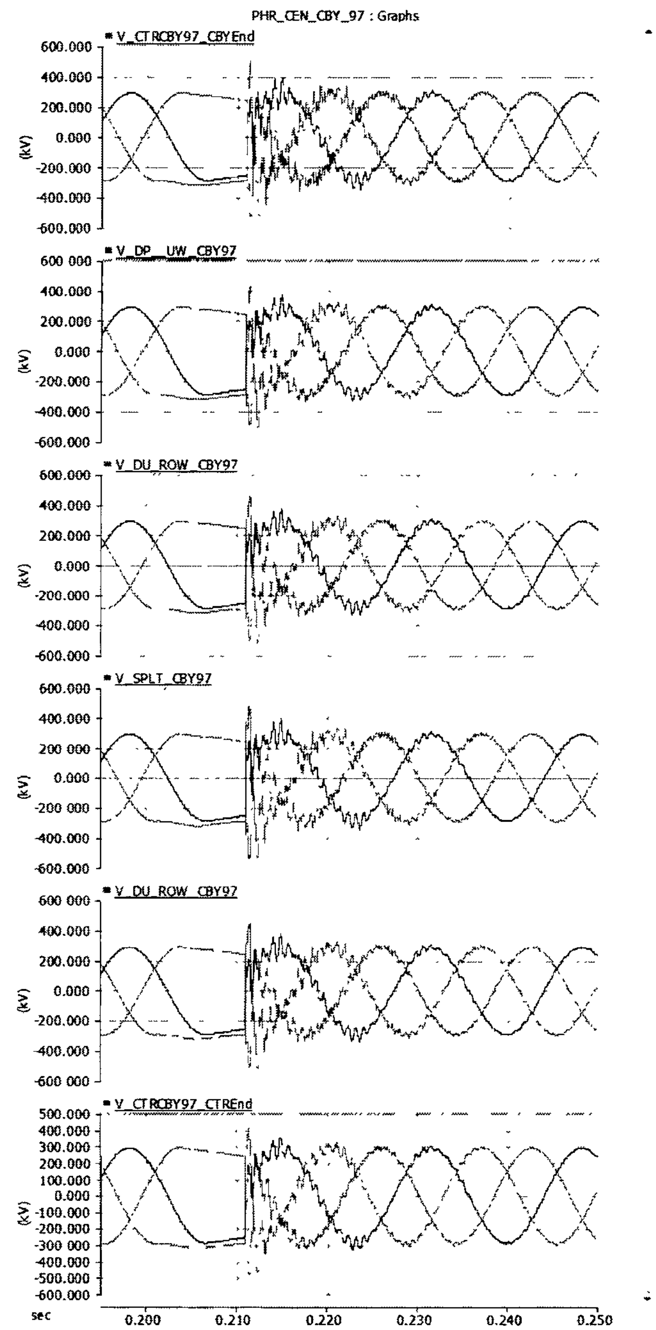


Figure 12-57: Maximum Overvoltage for Center – Cedar Bayou ckt 97 – Center side open with Line-Arrestors



e-LoadForecast®
Load Forecasting Tool

About e-LoadForecast®

CenterPoint Energy

- Pattern Recognition Technology (PRT)
- Founded by the creators of the original AANNSTLF algorithm developed from EPRI
- Now use a refined set of algorithms to learn and predict new patterns

View Window Help

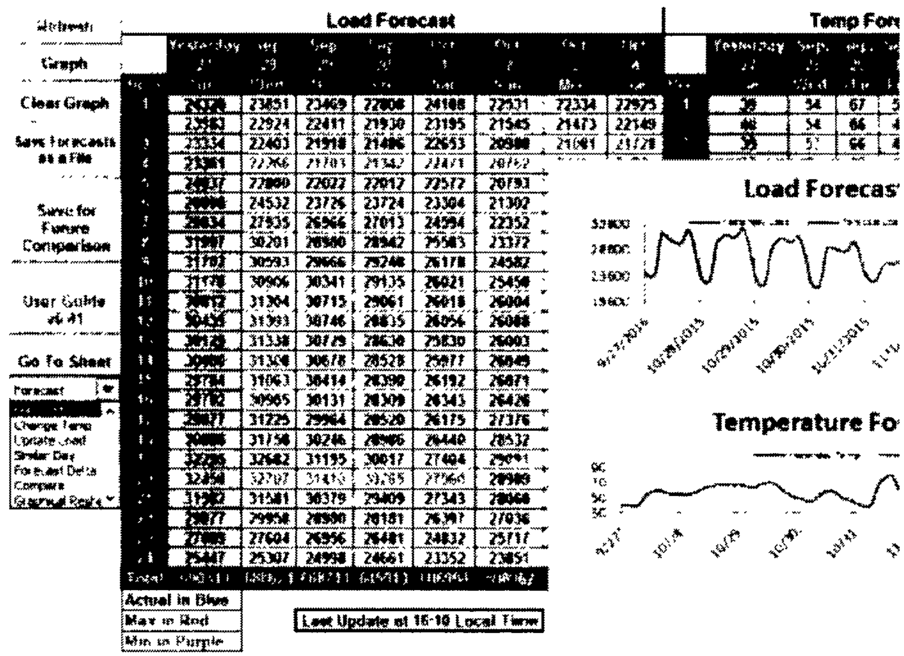
Region: Region1 100%

Temperature RUN

	Yesterday Load Thu 06/15	Yesterday Temp Thu 06/15	Today Load Fri 06/16	Today Temp Fri 06/16	Today Forcst Temp Fri 06/16	Temp Sat 05/17	Temp Sun 06/18	Te
01:00	11275	80	11375	80	80	79	80	
02:00	10678	79	10756	79	79	79	80	
03:00	10317	79	10308	79	79	78	80	
04:00	10128	79	10081	78	78	78	79	
05:00	10162	79	10048	77	77	78	78	
06:00	10477	78			77	77	79	
07:00	10782	78			77	78	79	
08:00	11153	80			80	80	81	
09:00	11940	82			83	83	84	
10:00	12931	86			86	86	87	
11:00	13970	88			88	89	89	
12:00	14669	89			90	90	90	
13:00	15549	92			92	92	92	
14:00	16229	92			93	93	93	
15:00	16626	94			94	94	94	
16:00	16836	94			96	95	96	
17:00	16802	94			94	93	93	
18:00	16528	93			93	91	91	
19:00	15906	90			90	89	89	
20:00	15313	88			87	87	87	
21:00	14773	86			85	84	84	
22:00	14213	84			83	82	82	
23:00	13257	82			82	82	82	
24:00	12226	81			80	81	80	
Total	**322740**		**52568**					

Load Forecasting Service

- Conceptually similar to AANNSTLF
  - Uses historical load and weather data to build a model
  - Uses forecasted weather data to predict future states
- Actual and forecasted weather data provided by PRT in affiliation with four major weather service providers
- Runs hourly producing a 7-Day load forecast
- Access via Web & Interactive Excel Interface



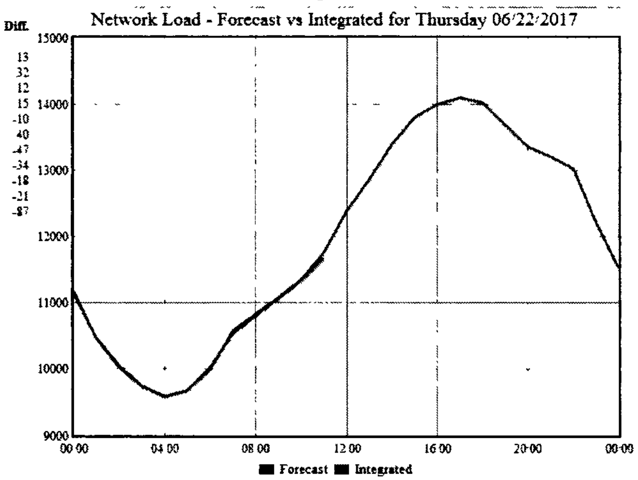
PRT Trial Results

CenterPoint Energy

- Given marginally accurate weather forecasts, PRT produced a load forecast within a 5% accuracy margin
- During shoulder months when load was more volatile, PRT has shown to rebound quicker to sudden temperature changes
- Since PRT runs their forecasting tool an accurate and revised forecast was available 24/7
- Data integrity was monitored continually by forecast specialists to ensure optimal results

06/22/2017 Instantaneous Peak 11 988 Time 11 33 2017 Corrected Integrated Peak Load 16,998 Date 06 19 2017 Hour 1700

Hr	Forecast	Integrated	Diff.
01	10459	10472	13
02	10026	10058	32
03	9738	9750	12
04	9582	9597	15
05	9686	9676	-10
06	10000	10040	40
07	10583	10536	-47
08	10833	10799	-34
09	11085	11067	-18
10	11354	11333	-21
11	11766	11679	-87
12	12385		
13	12858		
14	13400		
15	13802		
16	14000		
17	14100		
18	14025		
19	13688		
20	13354		
21	13205		
22	13022		
23	12210		
24	11522		
TL	286683	115007	



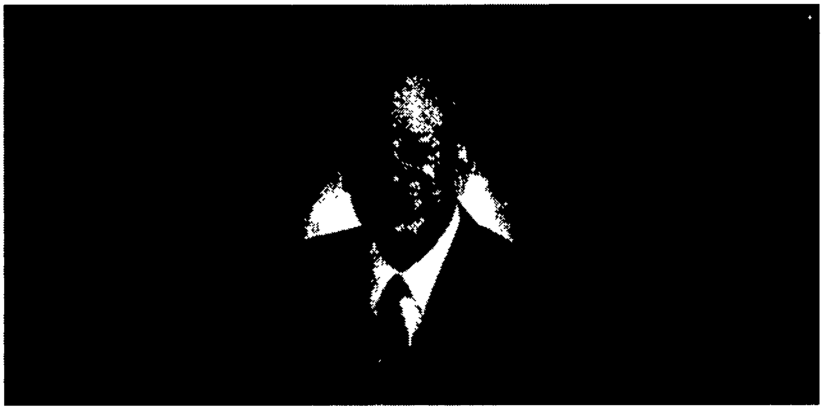
566

Benefits of e-LoadForecast®

CenterPoint Energy

- Fully automated and updated hourly
- Increased accuracy and availability allows for greater reliability for the Operators
  - REDE Real Time Security Analysis and Future Power Flow utilizes load forecast
- Compatible with fail-over processes if forced to move to AOC
- Easily incorporated into daily routines thus relieving manual processes performed by RTO Engineering and the Operators
- Web interface and EMSWeb compatibility
  - Automatic email notifications to recipients
- PRT has dedicated staff available to resolve any issues that arise

Enterprise Products to move forward on NGL expansions in Texas



Reporter Houston Business Journal
Updated Nov 1, 2018 10:55am EDT

COMPANIES IN THIS ARTICLE

Enterprise Products Partners

Houston-based Enterprise Products Partners LP (NYSE: EPD) has decided to move forward on two expansions to its natural gas liquids network in Texas.

One is a 40,000-barrel-per-day natural gas processing plant near Midland-Odessa in Loving County, Texas, according to an Oct. 31 press release announcing the start of construction. The plant is meant to enter service in the first quarter of 2020, according to the release.

The Loving County plant will cost about $412 million and employ 10 people paid $65,000 a year, according to a Chapter 313 tax incentive application filed with the Texas comptroller in August. The comptroller has yet to approve the tax incentive, but it has a deadline to make a decision by Dec. 13, said a comptroller spokesman.

The second expansion is another 150,000-barrel-per-day expansion of Enterprise Products' Mont Belvieu NGL fractionation capacity, according to another Oct. 31 press release. The expansion has an in-service date in the second quarter of 2020. This is the second such expansion the company has recently announced, with the first due online in the first quarter of 2020, according to the release.

Enterprise Products has reached agreements on tax incentives covering two NGL fractionation trains in Mont Belvieu with a capacity of 300,000 barrels per day, with commercial operations starting in the second quarter of 2020. The two trains are expected to cost about $789.7 million total, according to comptroller filings.

The incentives the midstream company is chasing for these expansions are Chapter 313 agreements, in which a company building certain kinds of assets can seek abatements from school districts. The districts can agree to tax only a certain amount of the new asset's value for a period of 10 years.

Enterprise Products CEO Jim Teague thinks the fractionation market will be tight through 2019, he said on the company's third-quarter earnings call Oct. 31. It's managed to support the Mont Belvieu expansions with long-term contracts.

"We are having people come to us and ask for fractionation capacity, and we're looking at the levers that we can pull to accommodate them," Teague said on the call. "Frankly we like to tie those opportunities to longer-term deals."

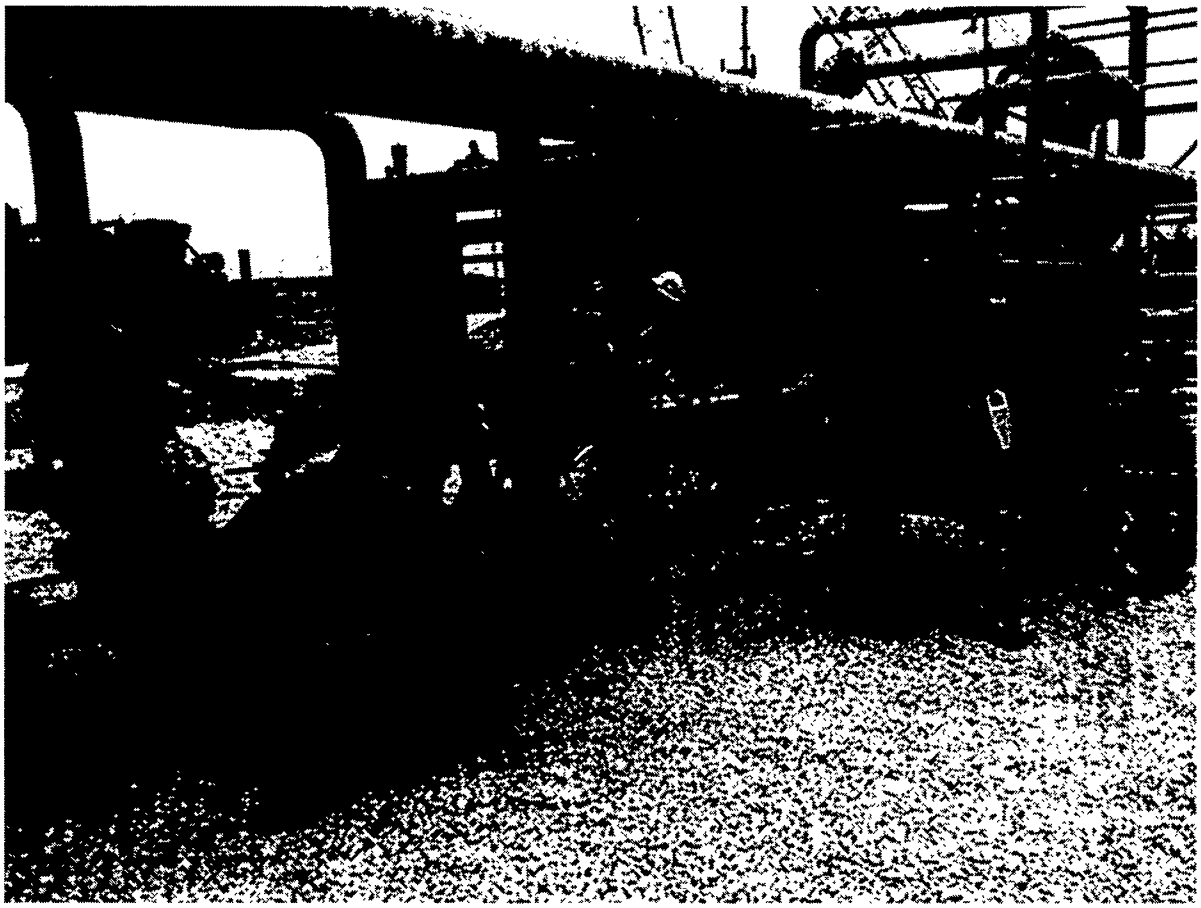
Enterprise Products has plenty of real estate in Mont Belvieu for it to build fractionators as long as the market needs it, Teague said.

Enterprise Products produced $9.59 billion in revenue during the third quarter, according to the company's third-quarter earnings report. Of that, $1.33 billion was net income, according to the report.

BUSINESS // ENERGY

Energy Transfer, Targa announce Mont Belvieu and pipeline expansions

Jordan Blum
Nov 8, 2018



Targa Resources' profits fell 58 percent to $45.8 million
Photo: NA, Targa Resources

Houston's Targa Resources and Dallas' Energy Transfer said Thursday they're both building new facilities east of Houston in Mont Belvieu to process all of the natural gas liquids pumped out of onshore shale wells, especially from West Texas' booming Permian Basin.

Energy Transfer also said it is expanding its Lone Star Express NGL pipeline system by adding a new 352-mile pipeline from the Permian to the Fort Worth area. The existing pipeline network extends to Mont Belvieu. The project is expected to be completed by the end of 2020.

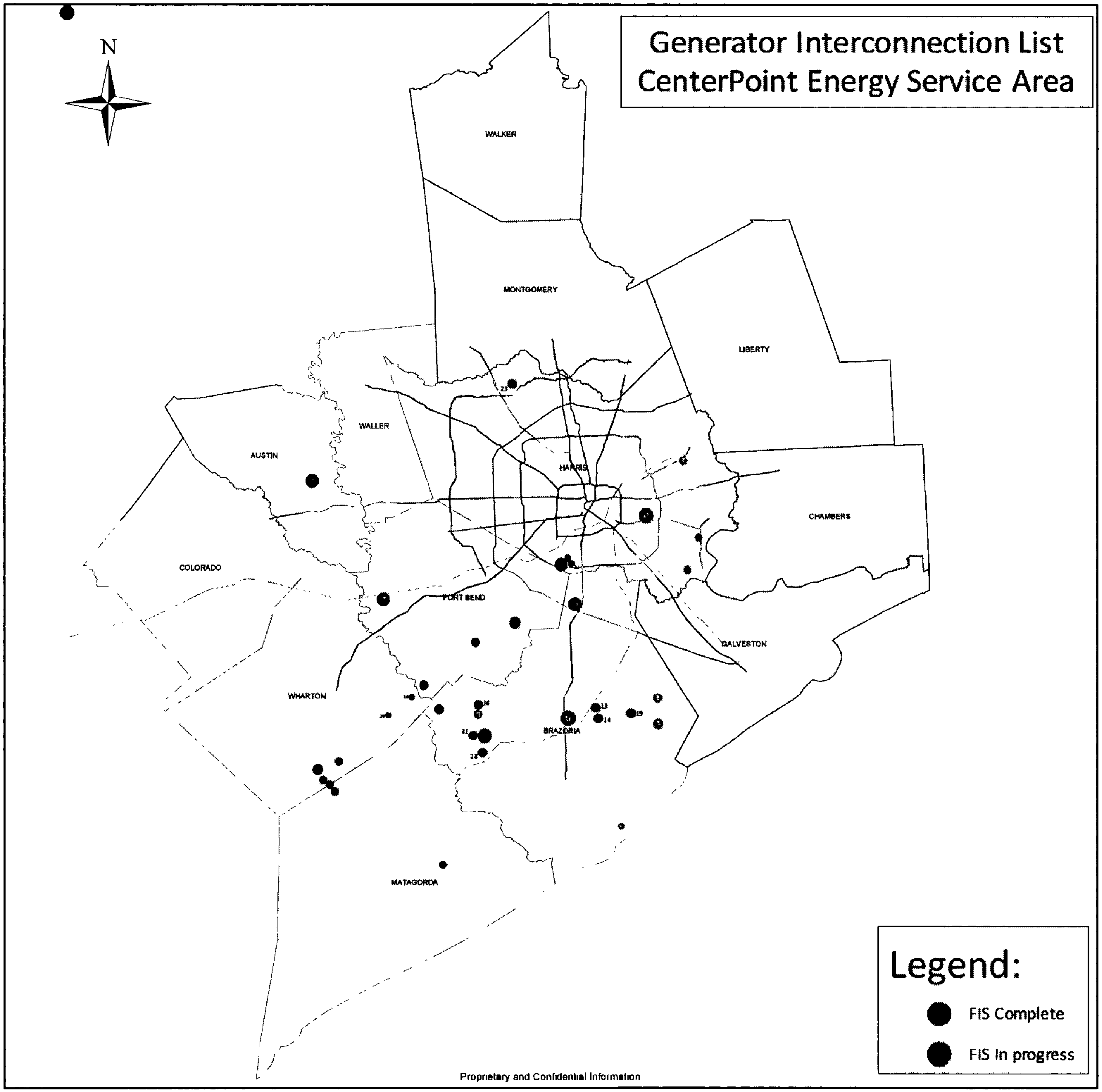
In Mont Belvieu, Targa and Energy Transfer are building new fractionator facilities. Fractionators take the streams of natural gas liquids from oil and gas wells and separate the NGLs into their individual parts, such as ethane, butane and propane.

RELATED: How the ethane molecule changed the Gulf Coast — and the world

The ethane, especially, is the primary feedstock for the expanding petrochemical sector in the Houston area. The processed ethane is the primary building block for the most common plastics.

Targa said it is building two new fractionators that will each process 110,000 barrels of NGLs per day that will be up and running by mid-2020.

Energy Transfer said it is building its seventh fractionator in the area to process 150,000 barrels of NGLs a day. Energy Transfer's sixth facility there is currently under construction.



WP MWN-10
FIS System Map
Page 1 of 1

Annual System Net Load

Year	Annual Total System Net Load (MWH)	Annual Distribution System Net Load (MWH)	Annual Transmission System Net Load (MWH)
2010	81,136,196	63,668,456	17,467,740
2011	84,346,790	66,674,330	17,672,460
2012	82,713,525	64,868,152	17,845,373
2013	84,437,122	65,231,800	19,205,322
2014	86,152,406	65,840,988	20,311,418
2015	88,225,204	67,547,642	20,677,562
2016	91,321,626	68,214,763	23,106,863
2017	93,017,644	68,586,326	24,431,318
2018	94,736,491	70,202,197	24,534,294

APPLICATION OF CENTERPOINT ENERGY HOUSTON ELECTRIC, LLC FOR AUTHORITY TO CHANGE RATES	**§ § §**	**PUBLIC UTILITY COMMISSION OF TEXAS**

DIRECT TESTIMONY

OF

DALE BODDEN

ON BEHALF OF

CENTERPOINT ENERGY HOUSTON ELECTRIC, LLC

April 2019

TABLE OF CONTENTS

LIST OF EXHIBITS

GLOSSARY OF ACRONYMS AND DEFINED TERMS

1.	ADMS	Advanced Distribution Management System
2.	CAIDI	Customer Average Interruption Duration Index: the average length of an outage.
3.	kV	Kilo-volts
4.	KVA	Kilovolt-amperes: total power.
5.	KVAR	Kilovolt-amperes reactive: reactive power.
6.	MAIFI	Momentary Average Interruption Frequency Index: the average number of times that a customer was momentarily out of service over a period of time, usually a year. Momentary operations are less than one minute and are usually due to instantaneous circuit breaker operations.
7.	PF	Power factor: ratio of real power (kW or kilowatts) to total power (KVA or kilovolt-amperes) or PF = KW / KVA
8.	PURA	Public Utility Regulatory Act
9.	RCCS	Remote Control Capacitor System
10.	SAIDI	System Average Interruption Duration Index: average number of outage minutes per customer per year.
11.	SAIFI	System Average Interruption Frequency Index: average number of times that a customer's service is interrupted.
12.	URD	Underground Residential Distribution

EXECUTIVE SUMMARY OF DALE BODDEN

CenterPoint Energy Houston Electric, LLC's ("CenterPoint Houston" or the "Company") Engineering & Asset Optimization Division provides engineering, planning, design and capital budgeting support for the Company's distribution and transmission system, as well as support for compliance with NERC Reliability Standards.

My testimony:

- describes the Engineering & Asset Optimization Division;
- supports the reasonableness and necessity of Operations and Maintenance ("O&M') costs incurred by the Engineering & Asset Optimization Division during the 2018 test year in the amount of approximately $19.3 million;
- supports the reasonableness and necessity of Distribution Capital Costs from 2010 through 2018 in the amount of approximately $5.4 million which were necessary to support Engineering and Asset Optimization; and
- describes the processes used to plan, monitor, and control investments and expenditures for the transmission and distribution system.

In conjunction with the testimonies of Randal M. Pryor and Martin W. Narendorf, my testimony demonstrates that the Company's capital expenditures have been prudently managed and controlled during the period January 1, 2010 to December 31, 2018 and that test year O&M expenses for both distribution and transmission services provided by the Engineering & Asset Optimization Division are reasonable, necessary, and representative of the costs to provide service to customers of CenterPoint Houston and thus, should be included in the Company's cost of service.

DIRECT TESTIMONY OF DALE BODDEN

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME AND POSITION.

A. My name is Dale Bodden and I am employed by CenterPoint Energy Houston Electric, LLC ("CenterPoint Houston" or "the Company") as Vice President of Engineering & Asset Optimization.

Q. PLEASE DESCRIBE YOUR EDUCATIONAL AND PROFESSIONAL BACKGROUND.

A. I graduated with High Honors from the University of Florida with a bachelor's degree in Mechanical Engineering. I am a registered professional engineer in the state of Texas. I have been employed by CenterPoint Energy, Inc. and its predecessor companies for the past 36 years. My career experiences include power plant engineering, customer relations, rates and regulatory, gas and oil fuels, transmission policy, distribution operations, and reliability policy and compliance. I have served on various industry committees of the Edison Electric Institute and also on the Board of Directors of the Gulf Coast Power Association. Currently, I am Vice President of Engineering & Asset Optimization.

Q. WHAT ARE YOUR CURRENT RESPONSIBILITIES?

A. As Vice President of Engineering & Asset Optimization, my responsibilities include overseeing the engineering, planning and design of the distribution and transmission system, including asset management, material standards and the Company's North American Electric Reliability Corporation ("NERC") Compliance program, as well as providing capital budgeting support.

Q. ON WHOSE BEHALF ARE YOU TESTIFYING IN THIS PROCEEDING?

A. I am testifying on behalf of CenterPoint Houston.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THIS PROCEEDING?

A. The electric organization consists of four divisions, the Distribution Operations division, the Power Delivery Solutions division, the Engineering & Asset Optimization division, and the High Voltage Operations division. I support the approximately $19.3 million in Operations and Maintenance ("O&M") expense associated with activities performed by the Engineering & Asset Optimization division.

My testimony identifies the functions of the Engineering & Asset Optimization division and describes how the division is structured and staffed to accomplish the goal of providing a reliable power delivery system at a reasonable cost. My testimony demonstrates that the O&M costs associated with the Engineering & Asset Optimization division are effectively and carefully managed and maintained through business planning, budget plan review, and ongoing budget plan monitoring. As a result, I conclude that these costs are reasonable and necessary expenditures that should be recovered in the Company's rates.

Together with Company witnesses, Randal M. Pryor and Martin W. Narendorf Jr., I also support the prudence of the Company's total capital investment in its transmission and distribution system from January 1, 2010 to December 31, 2018 by describing the Company's detailed and thorough processes used to plan, monitor, and control investments and expenditures.

Q. PLEASE DESCRIBE THE INTERACTION OF YOUR TESTIMONY WITH OTHER WITNESSES IN THIS CASE.

A. My testimony describes the engineering, planning, design, and capital budgeting and management process for the distribution and transmission system. Mr. Pryor sponsors the total capital investment that has been made in the Company's distribution system since January 1, 2010 and his testimony also describes the operation, system maintenance, trouble response and meter maintenance of the distribution delivery system. Company witness Julienne P. Sugarek's testimony describes the customer interface, customer support and power quality solutions that directly impact our customers. My testimony and that of Mr. Pryor and Ms. Sugarek explain the reliability and maintenance programs for which the witness is responsible.

Mr. Narendorf's testimony describes the transmission system and how it provides energy to the distribution delivery system as well as the invested capital spent for transmission, substation and major underground assets. Mr. Narendorf similarly supports the maintenance and operation of these assets. I support the reasonableness and necessity of the O&M costs associated with the Engineering & Asset Optimization division.

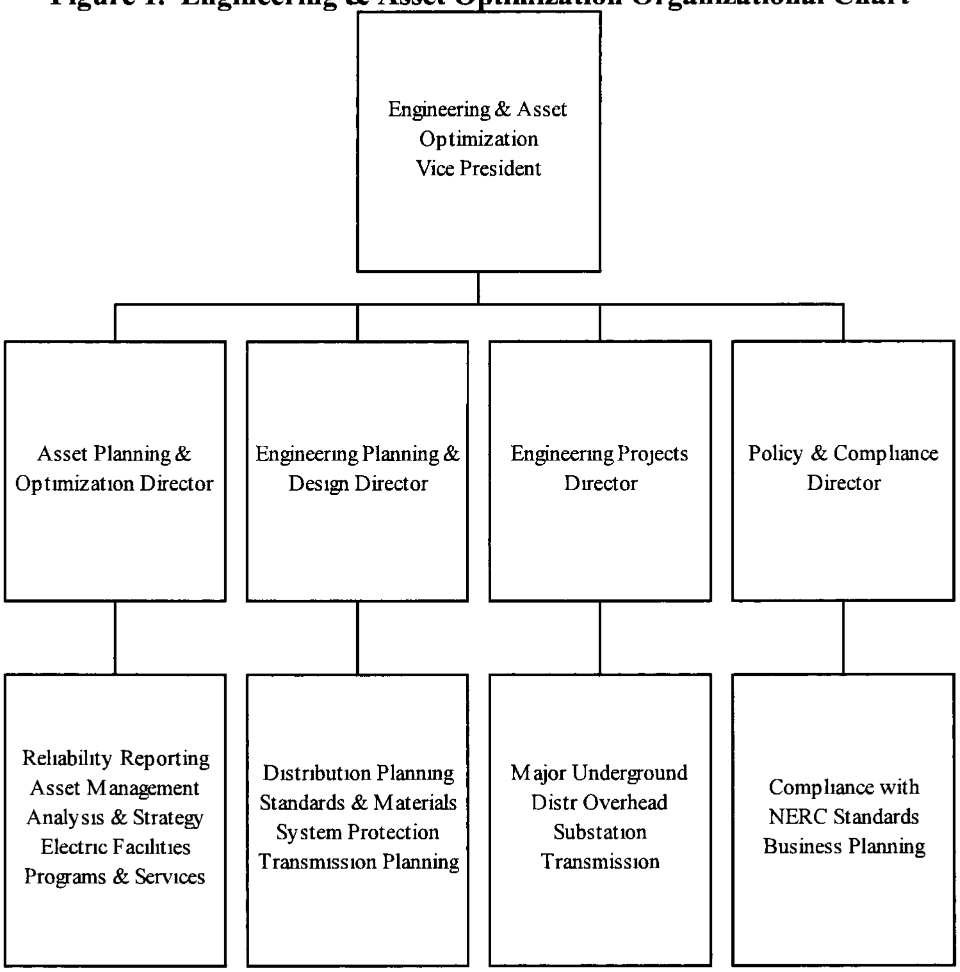
Company witness Michelle M. Townsend describes the services provided by CenterPoint Energy Service Company, LLC and CenterPoint Energy Resources Corp. and demonstrates the reasonableness of the Company's affiliate costs. Company witness Kristie L. Colvin testifies to the overall cost of service and cost of service adjustments.

II. ENGINEERING & ASSET OPTIMIZATION

Q. HOW IS ENGINEERING & ASSET OPTIMIZATION ORGANIZED?

A. Engineering & Asset Optimization provides engineering, planning, design and capital budgeting support for the distribution and transmission system. In 2018, this division included the Asset Planning & Optimization Department, the Planning & Design Department, the Engineering Projects Department, and the Policy & Compliance Department. Please see Figure 1 for the organizational chart for Engineering & Asset Optimization.

Figure 1. Engineering & Asset Optimization Organizational Chart



Q. WHAT ARE THE TEST YEAR O&M EXPENDITURES FOR THE ENGINEERING & ASSET OPTIMIZATION DIVISION?

A. Engineering & Asset Optimization incurred approximately $19.3 million in reasonable and necessary expenses during the test year. Figure 2 shows the test year expense for each department.

Figure 2. Test-Year O&M Expense by Department for Engineering & Asset Optimization

Engineering & Asset Optimization O&M by Department	Total Test Year Expense
Asset Planning & Optimization	$10,321,292
Engineering Planning & Design	$4,452,900
Engineering Projects	$2,115,814
Policy & Compliance	$1,830,389
Administration & General	$605,216
Total	$19,325,611

Q. PLEASE EXPLAIN THE O&M COSTS ASSOCIATED WITH ENGINEERING & ASSET OPTIMIZATION.

A. Because the categories for these expenses closely correspond to the individual departments in Engineering & Asset Optimization, I will explain the costs on that basis. This includes the Asset Planning & Optimization Department, the Planning & Design Department, the Engineering Projects Department and the Policy & Compliance Department. Please refer back to Figure 2.

Q. PLEASE DESCRIBE THE RESPONSIBILITIES AND O&M COSTS ASSOCIATED WITH ASSET PLANNING & OPTIMIZATION.

A. Asset Planning & Optimization primarily develops strategies designed to implement regulatory requirements of the Public Utility Commission of Texas

("Commission"), the Federal Communications Commission ("FCC"), and the Federal Energy Regulatory Commission ("FERC"). For the test year, Asset Planning & Optimization O&M-related costs were approximately $10.3 million. Asset Planning & Optimization is responsible for the strategy and governance for certain O&M expenditures and capital asset expenditures across Electric Operations, including distribution, substation, and transmission assets. Asset Planning and Optimization's goal is to provide strategy and decision-making tools so that the Company optimizes investments for safety, customer reliability, asset utilization and financial performance. The organization includes the Electric Facilities Programs and Services group, Asset Management Analysis and Strategy team, and Reliability Reporting.

The Facilities group coordinates transmission inspections and rehabilitation to maintain the integrity of our transmission system. The group also coordinates third-party use of transmission ROWs for pipelines, third-party wireless communication carriers use of transmission towers for cell sites, and attachments to distribution poles by third-party telecommunication companies as mandated by the FCC. Transmission towers that are accessed by wireless communication carriers are licensed under a private agreement between CenterPoint Houston and the wireless carrier. Telecommunication companies who are registered with the Commission and have executed a distribution pole attachment agreement with CenterPoint Houston are billed annually for their use of our distribution poles based on the total number of pole attachments using the FCC-approved pole attachment rate formula. The O&M for this department includes the cost of the transmission wireless work, the cost to coordinate the use of transmission ROWs, and the cost to coordinate distribution pole attachments. The revenues for the third-party use of all of these facilities are attributed to a miscellaneous revenue account and credited against the Company's total cost of service, as addressed by Ms. Colvin.

The Asset Management Analysis and Strategy group is responsible for developing comprehensive asset strategies in support of engineering and operational activities. Asset management activities include investment prioritization, asset life cycle analytics, risk assessment and project/program development and management.

Reliability Reporting creates the required documentation for regulating entities such as the Commission and FERC on metrics such as reliability performance and infrastructure count. Reliability Reporting also uses engineering analytics to improve operational practices by providing actionable, relevant and timely reports or dashboards.

Q. **PLEASE DESCRIBE THE RESPONSIBILITIES AND O&M COSTS ASSOCIATED WITH ENGINEERING PLANNING & DESIGN.**

A. For the test year, Engineering Planning & Design O&M-related costs were approximately $4.5 million. The department is responsible for Distribution Planning, Transmission Planning, Engineering Standards and Materials, and System Protection.

The distribution planning group performs studies and develops plans for the construction of new distribution circuits, new distribution substations, and other facilities that support a reliable and cost-effective distribution system.

The transmission planning group is responsible for creating and maintaining transmission system models, which are used to perform transmission system studies, transmission customer interconnection studies and generation interconnection studies. These studies evaluate options and recommend cost-effective solutions for the safe and reliable expansion and modification of the transmission system to ensure compliance with applicable standards and regulations, as well as good engineering practice.

The standards and materials group is responsible for construction standards, policies, practices, and materials that are needed to build electric distribution, substation, and transmission facilities in a consistent, reliable, safe, and cost-effective manner. The group reviews and updates these standards as necessary to incorporate new requirements and enable new technologies.

The system protection group is responsible for the electrical protection of the distribution, substation, and transmission systems by developing and evaluating system protection criteria for the safe and reliable operation of the system at all voltage levels. System protection calculates relay settings for protection and control systems which implement automatic fault detection, isolation, and restoration actions in response to disturbances on the transmission or distribution systems.

Q. PLEASE DESCRIBE THE RESPONSIBILITIES AND O&M COSTS ASSOCIATED WITH ENGINEERING PROJECTS.

A. For the test year, Engineering Projects O&M-related costs were $2,115,814. Engineering Projects is responsible for engineering design, material planning, project scheduling, and budget management for Distribution Overhead, Major Underground, Substation, and Transmission Projects. The consolidation of these groups in one department provides the Company with a system-wide perspective that improves project coordination and execution.

The distribution overhead projects group is responsible for providing engineering design and construction support services for the Company's overhead electric distribution facilities necessary to address load growth and to accommodate governmental roadway projects. Engineering design and construction support services includes scheduling support, engineering drawings, work orders, and material review.

The major underground projects group is responsible for providing engineering design and construction support services associated with the Company's three phase underground electric distribution facilities. This includes designated underground areas, such as downtown Houston, the Texas Medical Center, and George Bush Intercontinental Airport, as well as individual commercial loads served with three-phase padmount transformers, underground getaways from substations, and underground dips under freeways. Engineering design and construction services includes budget development, schedule management, engineering drawings, work orders, and material and equipment review, acquisition and management. This group is also responsible for the development and engineering support of major underground hardening and resiliency projects.

The substation projects group is responsible for engineering design and construction support services for the installation of and modification to the

Company's substations, as well as engineering support for the installation and modification of required Company-owned equipment in customer-owned substations. Engineering design and construction services includes budget development, schedule management, engineering drawings, work orders, and material and equipment review, acquisition and management. This group is also responsible for the development and engineering support associated with substation physical infrastructure security, hardening and resiliency efforts.

The transmission projects group is responsible for engineering design and construction support services for the installation and modification of the Company's transmission system. Engineering design and construction services include budget development, schedule management, engineering drawings, work orders, and material and equipment review, acquisition and management. This group is also responsible for the development and engineering support of transmission line clearance, hardening, and resiliency efforts. In addition, transmission projects provides civil and structural engineering services for the substation and distribution projects groups.

Q. **PLEASE DESCRIBE THE RESPONSIBILITIES AND O&M COSTS ASSOCIATED WITH POLICY AND COMPLIANCE.**

A. For the test year, Policy and Compliance O&M-related costs were $1,830,389. The department is responsible for overseeing the Company's NERC Reliability Standards compliance program and supporting the various operations departments in their compliance efforts. This includes understanding the requirements of NERC Reliability Standards and providing support to sufficiently demonstrate compliance with the NERC Reliability Standards. Policy and Compliance functions as the point of contact and coordinator for communications with FERC, NERC, and Texas Reliability Entity ("Texas RE") for compliance-related activities. The department also provides support for business planning and regulatory activities.

Q. WHAT ACTIVITIES AND O&M COSTS ARE ASSOCIATED WITH ADMINISTRATIVE AND GENERAL?

A. For the test year, administrative and general O&M-related costs were $605,216. These expenses include managerial labor, administrative support and miscellaneous general expenses for the Engineering & Asset Optimization Division.

Q. ARE ALL OF THE O&M EXPENDITURES ASSOCIATED WITH THE ENGINEERING & ASSET OPTIMIZATION DIVISION REASONABLE AND NECESSARY?

A. Yes. As the O&M expenses for Engineering & Asset Optimization are related to necessary functions that directly impact the reliability and operation of the distribution and transmission system to serve both existing and new customers.

Q. WERE ANY CAPITAL INVESTMENTS INCURRED TO SUPPORT ENGINEERING & ASSET OPTIMIZATION FROM 2010 - 2018?

A. Yes. From January 1, 2010 to December 31, 2018, approximately $5.4 million in capital investment was necessary to support Engineering and Asset Optimization. The investments were for a number of small projects including: a distribution planning gateway project that supported a program written by CYME International, Inc. to extract CenterPoint Houston's electrical network from the Company's

Geographic Information System and collect load data from various sources, a project to install equipment to monitor power quality on a smart home with solar panels, the purchase of Automated External Defibrillators for certain crew vehicles, the remodel of the Galveston Test Site which is used to test materials, and the purchase of infra-red cameras and power quality monitors for distribution system reliability investigations.

Q. WERE THE CAPITAL INVESTMENTS INCURRED TO SUPPORT ENGINEERING & ASSET OPTIMIZATION REASONABLY AND NECESSARILY INCURRED?

A. Yes. These capital investments were needed to support distribution planning, material analysis, reliability investigations and technical research, as well as for employee safety.

III. PLANNING AND COST CONTROL

Q. HOW DOES CENTERPOINT HOUSTON ENSURE THAT ITS NECESSARY CAPITAL INVESTMENTS AND O&M EXPENSES ARE REASONABLE?

A. CenterPoint Houston carefully plans investments, O&M activities and related expenses, and monitors and controls costs on an ongoing basis. The Company uses several processes to accomplish this oversight. These processes include: 1) the workforce planning process, 2) budgeting and cost control, 3) the use of contractors, 4) the distribution planning process, and 5) the transmission planning process. Mr. Pryor's and Mr. Narendorf's testimonies discuss various aspects of these processes. The distribution planning process and the transmission planning process are discussed below.

A. Distribution Planning Process

Q. WHAT IS THE DISTRIBUTION PLANNING PROCESS?

A. This annual process, performed within the Engineering Planning and Design department, uses peak load information for all substations and all distribution circuits as the basis for a five-year distribution substation load forecast and for distribution studies known as Distribution Development Plans ("DDP"). To forecast load growth for each substation, the Company considers peak load information as well as information from new load requests that are received throughout the year from the service centers, including information regarding future developments, knowledge of the area, and historical values for growth at each substation. For each DDP, the distribution planner uses a computerized circuit model to evaluate loading and voltage drop for each of the distribution circuits for the substation that is being studied. The study starts with existing peak load conditions, and adjusts the load on the circuits based on the five-year load forecast. The distribution planner then evaluates the results to determine if there are any violations of planning design criteria for voltage drop and circuit overload under normal and contingency conditions.

Q. WHAT ARE THE DISTRIBUTION PLANNING DESIGN CRITERIA?

A. The distribution planning design criteria are guidelines used to provide a cost-effective and reliable plan for accommodating changes in distribution system load under normal and contingency conditions that often arise during severe weather. The criteria address: (1) circuit loading, (2) power factor, and (3) switching flexibility. See Exhibit DB-1 for details on the distribution planning design criteria.

Q. WHAT HAPPENS IF THE DISTRIBUTION PLANNING DESIGN CRITERIA ARE NOT MET IN ANY GIVEN INSTANCE?

A. If distribution planning design criteria are not met, various solutions are identified and evaluated. The solutions with the best combination of effectiveness and cost are then recommended. The recommended construction is reviewed and approved by the Lead Planning Engineer, certain service center employees and their management, and the Distribution Planning Manager. If the failure to meet the design criteria is not addressed, then the reliability of the system is compromised.

Q. DOES THE COMPANY HAVE DISTRIBUTION PLANNING DESIGN CRITERIA FOR SUBSTATIONS?

A. Yes. In addition to circuit loading, distribution planners evaluate loading on distribution substation transformers. The planning design criteria for distribution substation transformers state that (1) under normal conditions, no substation transformer shall be loaded to greater than its continuous rating, and (2) after the outage of a substation transformer, no remaining substation transformer shall be loaded to greater than its firm rating.

Eventually, load growth on the distribution system may exceed the capacity of the existing distribution substations to serve that load. When this condition occurs, it becomes more economical to build a new distribution substation rather than to try to extend circuits from the existing substations. The Company's distribution planners review these situations and recommend new substations as appropriate.

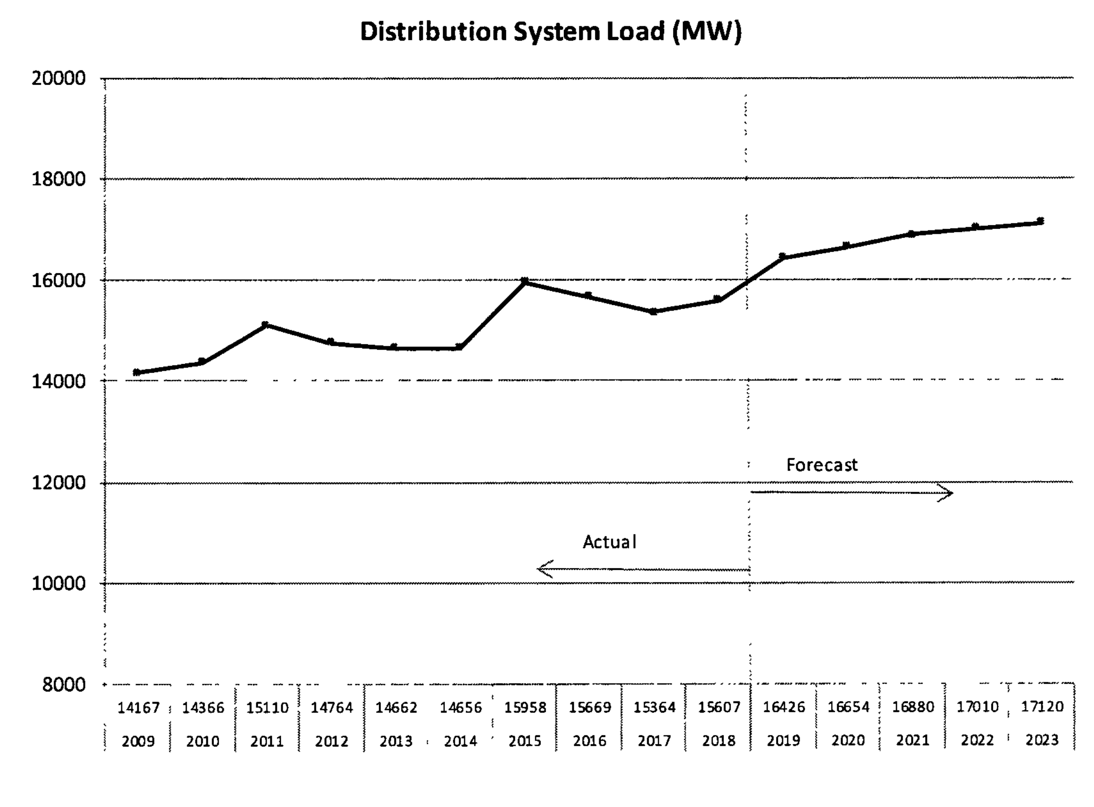
Q. DOES THE COMPANY'S DISTRIBUTION PLANNING PROCESS DETERMINE WHETHER CAPITAL INVESTMENTS ARE NECESSARY FOR DISTRIBUTION INFRASTRUCTURE EXPANSIONS?

A. Yes. The primary determinant for capital investments for distribution infrastructure improvement projects is the distribution planning process. This includes distribution improvements, new distribution circuits, substation work for a new distribution substation, including new substation transformers and new transmission lines, if required.

Q. DID THE COMPANY EXPERIENCE LOAD GROWTH REQUIRING CAPITAL INVESTMENTS FOR DISTRIBUTION INFRASTRUCTURE EXPANSION PROJECTS SINCE THE LAST BASE RATE CASE?

A. Yes. The Company has experienced distribution growth of approximately 1,440 MW, or an average load growth of 144 MW per year since 2009. This is reflected in Figure 3 below.

Figure 3. Distribution System Load Growth



The Company added 359,525 new residential customers from January 1, 2010 through December 31, 2018. Over the past four years, overhead distribution pole miles (feeder-main and laterals) have increased an average of 171 miles per year, while Underground Residential Distribution (URD) circuit miles have increased an average of 257 miles per year.

Q. DOES CENTERPOINT HOUSTON HAVE A PROCESS TO REVIEW THE NEED FOR NEW DISTRIBUTION SUBSTATIONS?

A. Yes. CenterPoint Houston has an in-house process that our Distribution Planning personnel use to provide an advanced review of the need and location for new distribution substations. The need for new distribution substations is based on several factors, including (1) load growth in the area, (2) loading on existing circuits from adjacent substations, (3) loading on existing substation transformers, (4) circuit capacity to pick up load from other circuits under outage contingency conditions, and (5) the increasing difficulty in constructing additional circuits from adjacent existing substations.

Q. IS THE LOCATION OF THE NEW DISTRIBUTION SUBSTATION IMPORTANT?

A. Yes. The optimum location or siting of a new substation is critical to the cost-effectiveness of the substation. Foremost, potential new substation sites must be located near the load center and offer multiple viable circuit routes and substation get-a-ways (overhead, underground, road ROWs, and utility easements). Multiple substation land sites are identified that are closest to the load center. To evaluate the connection of the new substation to the transmission system, transmission routing studies are created to assess the most viable route. To minimize transmission costs and regulatory delays, most new substation sites are located near existing transmission lines.

Q. AS A RESULT OF THESE EVALUATIONS FOR THE NEED AND LOCATION OF A NEW DISTRIBUTION SUBSTATION, DO THE DISTRIBUTION PLANNERS PRESENT THEIR FINDINGS FOR MANAGEMENT APPROVAL?

A. Yes. For most new distribution substations, a presentation is prepared and presented to management for their approval. Additionally, Distribution Planning prepares a DDP that shows the new distribution circuits that are to be built out of the new substation and how these new circuits will connect to the existing circuits of the existing adjacent substations. An electrical model is also prepared that shows the loading on the new circuits. The new circuits will take load off of the overloaded adjacent substations, as well as serve some of the new load in the area. Some of the new load in the area will be served by adjacent substations, since they now have additional capacity to serve more load. Along with the DDP, an Engineering Project Justification is prepared that explains the new load that is specifically served by the new substation and the load switched from adjacent substations.

Q. CAN YOU EXPLAIN SOME OF THE CONSIDERATIONS RELEVANT TO DETERMINING THE NEED FOR NEW SUBSTATIONS?

A. Yes, the Springwoods substation, for example, was in an area served by and surrounded by the Kuykendahl, Rayford, Louetta, Westfield and Treaschwig substations, which were heavily loaded. The load growth in the area included the Springwoods development (1100 acres - 54MW of new loads, including hotels, hospitals, residential, and other commercial loads) and Exxon's development (400 Acres - 70MW, multiple high-rise buildings, data center and new main headquarters campus). The existing circuits and substations in the area did not have the capacity for this new load growth. Three potential substation land sites were identified near the load center and transmission routing studies were completed. The optimum substation location was selected that enabled multiple distribution circuit routes out of the new substation and an adjacent transmission connection.

Q. WHAT TYPES OF PROJECTS HAVE BEEN BUILT IN THE LAST NINE YEARS FOR DISTRIBUTION INFRASTRUCTURE DEVELOPMENT?

A. Over the last nine years (2010 – 2018), the Company has issued and completed the work on approximately 306 DDPs for distribution improvements such as new pole top switches, new capacitor banks, overhead distribution line extensions, new line reclosers or IGSDs, and new switching configurations to balance feeder loading under normal conditions and to accommodate contingency switching. Also, included on these plans is the construction of approximately 221 new distribution feeders.

Q. WHAT TYPES OF PROJECTS HAVE BEEN BUILT IN THE LAST NINE YEARS FOR DISTRIBUTION SUBSTATION INFRASTRUCTURE DEVELOPMENT?

A. CenterPoint Houston installed approximately 221 new substation feeder positions to accommodate the new distribution feeders, 55 new substation transformers, size upgrades for 12 substation transformers, and six new distribution substations.

Q. WHAT NEW DISTRIBUTION SUBSTATIONS DID CENTERPOINT HOUSTON BUILD FROM 2010 – 2018?

A. New distribution substations included Fry Road (2014), Sandy Point (2017), Springwoods (2014), Tanner (2016), and Village Creek (2017). Jordan (2014) is a 35kV substation that was built in the yard of the existing transmission substation, so no siting was required. Each of these substations went through the distribution planning process. Exhibit DB-5 presents Engineering Project Justification and Construction Summaries.

Q. COULD YOU PROVIDE INFORMATION ON LOADING, SITING AND COST FOR THESE NEW DISTRIBUTION SUBSTATIONS?

A. Yes. For the Springwoods substation, which was built in 2014 and included eight 35kV circuits, the loading on the adjacent substations was: Kuykendahl substation – 132MW, Rayford substation – 127MW, Louetta substation – 143MW, Westfield substation – 240MW, and Treaschwig substation – 116MW. The new load in the area was 94MW. The location of Springwoods substation is in north Houston, near the intersection of the Grand Parkway (Hwy 99) and I-45, between Rayford and Rothwood substations. The transmission connection is a loop off of 138kV line 22. Fifteen thousand feet of transmission construction was required. The cost of the new substation was $12.7 million.

For the Fry Road substation, which was built in 2014 and included six 35kV circuits, the loading on the adjacent substations was: Gertie substation – 227MW, CyFair substation – 231MW, and Franz substation – 237MW. The new load in the area was 40MW. The location of Fry Road substation is in northwest Houston, near the intersection of Fry Road and Longenbaugh Dr., between Zenith and Gertie substations. The transmission connection is a double tap off of 138kV lines 09 and 76. Two hundred fifty feet of transmission construction was required. The cost of the new substation was $9.2 million.

For the Tanner substation, which was built in 2016 and included six 35kV circuits, the loading on the adjacent substations was: Addicks substation – 168MW, Satsuma substation – 301MW, and Fairbanks substation – 216MW. The new load in the area was 159MW. The location of Tanner substation is in Spring Branch, on

Tanner road east of Beltway 8, between Satsuma and Addicks substations. The transmission connection is a double tap off of 138kV lines 24 and 76. Five thousand and one hundred feet of transmission construction was required. The cost of the new substation was $12.5 million.

For the Village Creek substation, which was built in 2017 and included four 35kV circuits, the loading on the adjacent substations was: Katy substation – 187MW, Franz substation – 241MW, Gertie substation – 198MW, and Fry Road substation – 139MW. The new load in the area was 359MW. The location of Village Creek substation is north of Katy, just west of the intersection of Beckendorf road and the Grand Parkway (Hwy 99), between Franz and Zenith substations. The transmission connection is a loop off of 138kV line 09. Two hundred feet of transmission construction was required. The cost of the new substation was $12.2 million.

For the Sandy Point substation, which was built in 2017 and included four 12kV circuits, the loading on the adjacent LaPorte substation was 49MW. The new load in the area was 20MW. The location of Sandy Point substation is in LaPorte, east of the intersection of Hwy 225 and Hwy 146 near the Port of Houston, between LaPorte and Alkane substations. The transmission connection is a loop off of 138kV line 96. Two thousand and two hundred feet of transmission construction was required. The cost of the new substation was $10.7 million.

Q. **HOW DOES THE COMPANY ENSURE THAT, ONCE A DISTRIBUTION PROJECT IS FOUND TO BE NECESSARY, THE CAPITAL EXPENDITURES ARE MONITORED AND CONTROLLED?**

A. Since distribution capital projects can range in size from a few thousand dollars to several million dollars, there is a range in the level of project controls used to monitor the capital spend. Please refer to the section in Mr. Narendorf's testimony on planning and cost control.

Q. **WHAT IS THE COMPANY'S FORECASTED LOAD GROWTH FOR THE NEXT FIVE YEARS?**

A. As discussed above, the distribution planning personnel forecast load growth for each substation based on peak load information, as well as information from new load requests that are received throughout the year from the service centers, including information regarding future developments, knowledge of the area, and historical values for growth at each substation. This serves as the basis for the system load forecast. The projected distribution load growth for the five years, from 2018 through 2023, is approximately 1,513 MW, or an average load growth of 302.6 MW or 1.8% per year.

Q. **IS PLANNING FOR DISTRIBUTION LOAD GROWTH PROJECTS A NEW PROCESS AT CENTERPOINT HOUSTON?**

A. No. This process has been in use for many years. The planning process, along with prudent design criteria, results in a cost-effective, safe and reliable distribution system.