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LOCKHEED MARTIN ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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HARMONIC ANALYSIS
of
ELECTRICAL DISTRIBUTION SYSTEMS

Appendices

- Appendix A** *RMS and Average Measurements for Determination of Harmonics in Buildings*
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March 1996

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Appendix A

RMS and Average Measurements for Determination of Harmonic Concentrations in Buildings

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Lockheed Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

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ORNL Buildings Tested for Harmonics

Bldg. No.	Description and/or Use	Year Built	Voltage Distribution	Type Construction	Gross Floor Area	Non-Linear Loads
1000	Engineering Offices	1946	120/240 V	wood frame	57,018	Cmptrs, Printers, VDTs
1053A	Engineering Offices	1972	120/240 V	trailer	720	Cmptrs, Printers, VDTs
1053B	Engineering Offices	1972	120/240 V	trailer	720	Cmptrs, Printers, VDTs
1054	Engineering Offices	1972	120/240 V	trailer	720	Cmptrs, Printers, VDTs
1505	Environmental Sciences Lab	1978	120/208 V	brick	97,925	Cmptrs, Lab Inst
2000	Solid State Lab Annex	1948	120/240 V	steel frame, metal siding	22,680	Cmptrs, Lab Inst, Lasers
2001	Information Center Complex	1948	120/240 V	steel frame, metal siding	25,863	Cmptrs, Printers, VDTs
2024	Quality Assurance & Inspection	1956	120/208/240V	concrete block	10,300	Cmptrs, Lab Inst
3130	Waste Oper. Control Center	1981	120/208 V	reinforced concrete	4,100	UPS, Cmptr Control Cntr
4508	Metals & Ceramics Laboratory	1962	120/208 V	brick	99,030	Furnaces, Lab Inst
6011	Cmpting & Telecom Offices	1988	120/208 V	brick	10,000	Cmptrs, Printers, VDTs
7002	Garage & Iron Working Shop	1947	120/208 V	steel frame, metal siding	28,263	Welders, HID Ltg
7930	Research Reac Devel Center	1966	120/208 V	concrete block	33,215	Robotic Manipulators
7965A	Office Trailer	1987	120/240 V	trailer	1,680	Cmptrs, Printers, VDTs
7965B	Office Trailer	1987	120/240 V	trailer	1,680	Cmptrs, Printers, VDTs
7965B	Office Trailer	1987	120/240 V	trailer	1,680	Cmptrs, Printers, VDTs

K-25 Buildings Tested for Harmonics

Bldg. No.	Description and/or Use	Year Built	Voltage Distribution	Type Construction	Gross Floor Area	Non-Linear Loads
K-1001	Adminisitrative Offices	1944	120/208/240	wood	78300	Cmptrs, Printers, VDTs
K-1004L	Laboratory Facility	1975	120/208	masonry	16100	Mainframe Cmptrs, Prntrs
K-1005	Office Building	1975	120/208	masonry	14400	Cmptrs, Printers, VDTs
K-1024	Office Building	1944	120/208	wood	37950	Cmptrs, Printers, VDTs
K-1035	Mainten. Office Bldg & Shops	1944	120/208	steel/block	46400	Cmptrs, Printers, VDTs
K-1320	Engineering Offices	1970	120/208	masonry	50800	Miniframe Cmptrs, Prntrs
K-1330	Environmental Restor. Offices	1990	120/208	masonry	3600	Cmptrs, Printers, VDTs
K-1580	Engineering Offices	1980	120/208	masonry	11500	Cmptrs, Printers, VDTs

Y-12 Buildings Tested for Harmonics

Bldg. No.	Description and/or Use	Year Built	Voltage Distribution	Type Construction	Gross Floor Area	Non-Linear Loads
9706-2	Medical, Plant Control Center	1945	120/240	wood	8000	X-Ray, Cmptr Cntr
9709	Training Facility	1950	120/208/240	wood	38000	Cmptrs, Prntrs, Welders
9733-1	Engineering Offices	1944	120/240	wood	7150	Cmptrs, Printers, VDTs
9733-2	Engineering Offices	1944	120/208/240	wood	7150	Cmptrs, Printers, VDTs
9733-3	Engineering Offices	1944	120/240	wood	7150	Cmptrs, Printers, VDTs
9733-4	Engineering Offices	1944	120/208	masonry	7150	Cmptrs, Printers, VDTs
9737	Fabrication & Maintenance	1950	120/240	masonry	45000	Cmptrs, Prntrs, Welders

Building 1000												
Panel Label												
Main Size	Measured Values					Calculated Values					Date/	
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time	
Panel N	True RMS Current	73.1	72.4		0.8						7-Jul	
225A	Average Current	80.6	80.2		0.3	Current Form Factor	0.91	0.90		2.00	12:50	
120/240V	Peak Current	104	102.4		0.8	Current Crest Factor	1.42	1.41		1.33		
	True RMS Voltage	116.8	116.3									
	Peak Voltage	160.4	159.2			Voltage Crest Factor	1.37	1.37				
Pnl H, Rm222	True RMS Current		53.9		16.2						7-Jul	
225 A	Average Current		48.7		14.7	Current Form Factor		1.11		1.10	11:00	
120/240V	Peak Current		127.2		49.2	Current Crest Factor		2.36		3.04		
	True RMS Voltage	115.3	115.5									
	Peak Voltage	155.2	155.2			Voltage Crest Factor	1.35	1.34				
DP1-4	True RMS Current	360.1	366.7		34.5						7-Jul	
600 A	Average Current	337.5	342.3		20	Current Form Factor	1.07	1.07		1.73	9:30	
120/240 V	Peak Current	673	689			Current Crest Factor	1.87	1.82		0.00		
	True RMS Voltage	115.6	115.7									
	Peak Voltage	160.6	160.6			Voltage Crest Factor	1.39	1.39				
Panel V	True RMS Current	81.4	81.6		4.7						7-Jul	
225 A	Average Current	84.7	84.7		4.2	Current Form Factor	0.96	0.96		1.12	13:05	
120/240 V	Peak Current	116.8	117.2		6.4	Current Crest Factor	1.43	1.44		1.36		
	True RMS Voltage	116.7	116.9									
	Peak Voltage	161.6	161.2			Voltage Crest Factor	1.38	1.38				
Panel XX	True RMS Current	15.45	15.5		0.1						7-Jul	
100 A	Average Current	15.03	15.05		0	Current Form Factor	1.03	1.03			13:15	
120/240 V	Peak Current	22.2	23.3		0.04	Current Crest Factor	1.44	1.50		0.40		
	True RMS Voltage	116.7	116.8									
	Peak Voltage	160.4	161.2			Voltage Crest Factor	1.37	1.38				
DP3-2	True RMS Current	152.8	169.2		10.57						7-Jul	
400 A	Average Current	137.5	131.8		11	Current Form Factor	1.11	1.28		0.96	10:15	
120/240 V	Peak Current	278.8	238.4			Current Crest Factor	1.82	1.41		0.00		
	True RMS Voltage	115.4	115.5									
	Peak Voltage	158.8	163.6			Voltage Crest Factor	1.38	1.42				
Panel K	True RMS Current	45.3	44.1		1.96						7-Jul	
225 A	Average Current	33.5	33		1.5	Current Form Factor	1.35	1.34		1.31	13:30	
120/240 V	Peak Current	76	63.6		4.68	Current Crest Factor	1.68	1.44		2.39		
	True RMS Voltage	117.3	117.4									
	Peak Voltage	162.4	162.4			Voltage Crest Factor	1.38	1.38				
Panel Z	True RMS Current	7.55	14.5		7.3						7-Jul	
60 A	Average Current	6.1	11.2		5.8	Current Form Factor	1.24	1.29		1.26	10:50	
120/240 V	Peak Current	15.84	27.92		27.8	Current Crest Factor	2.10	1.93		3.81		
	True RMS Voltage	114.4	114.4									
	Peak Voltage	157.2	156.8			Voltage Crest Factor	1.37	1.37				
Panel Y	True RMS Current	38.4	35.7		3.7						7-Jul	
100 A	Average Current	36.4	32.2		3.4	Current Form Factor	1.05	1.11		1.09	11:10	
120/240 V	Peak Current	77.6	66.4		6.12	Current Crest Factor	2.02	1.86		1.65		
	True RMS Voltage	114.4	114.4									
	Peak Voltage	158	157.2			Voltage Crest Factor	1.38	1.37				
Pnl H, 2nd Fl	True RMS Current	75.2	74.1		2.3						7-Jul	
225 A	Average Current	78.2	78.2		1.7	Current Form Factor	0.96	0.95		1.35	13:45	
120/240 V	Peak Current	112.4	104.8		2.4	Current Crest Factor	1.49	1.41		1.04		
	True RMS Voltage	116.2	116.7									
	Peak Voltage	159.2	160.4			Voltage Crest Factor	1.37	1.37				

Building 1000											
Panel Label											
Main Size	Measured Values					Calculated Values					Date/
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time
Panel X	True RMS Current	87.4	87.4		13.1						7-Jul
150 A	Average Current	80.4	80.5		2.8	Current Form Factor	1.09	1.09		4.88	11:20
120/240 V	Peak Current	122.4	121.6		26.8	Current Crest Factor	1.40	1.39		2.05	
	True RMS Voltage	114.3	114.3								
	Peak Voltage					Voltage Crest Factor	0.00	0.00			
Pnl W, Elec R	True RMS Current	30.9	30.9		15.4						7-Jul
225 A	Average Current	23.8	25		6.5	Current Form Factor	1.30	1.24		2.37	10:10
120/240 V	Peak Current	44	49.6		22.4	Current Crest Factor	1.42	1.61		1.45	
	True RMS Voltage	116	116.6								
	Peak Voltage	156.4	158			Voltage Crest Factor	1.35	1.36			
Panel CR1W	True RMS Current	5.9	17.4		9.2						7-Jul
50 A	Average Current	4.1	7.3		4.5	Current Form Factor	1.44	2.38		2.04	13:50
120/240 V	Peak Current	40	55.4		18.4	Current Crest Factor	6.78	3.18		2.00	
	True RMS Voltage	115.4	115.4								
	Peak Voltage	159.6	158			Voltage Crest Factor	1.38	1.37			
Panel C1W	True RMS Current	39.3	47.8		9						7-Jul
100 A	Average Current	38.3	46.6		8.3	Current Form Factor	1.03	1.03		1.08	13:55
120/240 V	Peak Current	56.4	68.4		12	Current Crest Factor	1.44	1.43		1.33	
	True RMS Voltage	115.4	115.5								
	Peak Voltage	159.2	158.4			Voltage Crest Factor	1.38	1.37			
Panel CR2W	True RMS Current	2.7			2.7						7-Jul
50 A	Average Current	0.7			1.4	Current Form Factor	3.86			1.93	14:15
120/240 V	Peak Current	4.4			6	Current Crest Factor	1.63			2.22	
	True RMS Voltage	115.4	115.4								
	Peak Voltage	159.2	158.4			Voltage Crest Factor	1.38	1.37			
Panel C2W	True RMS Current	36.6	44.1		3.7						7-Jul
100 A	Average Current	34.8	42.9		3.1	Current Form Factor	1.05	1.03		1.19	14:20
120/240 V	Peak Current	52.8	62.4		4.8	Current Crest Factor	1.44	1.41		1.30	
	True RMS Voltage	115.2	115.3								
	Peak Voltage	159.2	158.4			Voltage Crest Factor	1.38	1.37			
Panel A1W	True RMS Current	47.3	46.9		19.9						7-Jul
225 A	Average Current	44.9	42.1		17.1	Current Form Factor	1.05	1.11		1.16	15:35
120/240 V	Peak Current	86.8	75.2		56	Current Crest Factor	1.84	1.60		2.81	
	True RMS Voltage	115	115								
	Peak Voltage	158.4	158.8			Voltage Crest Factor	1.38	1.38			
Panel A2W	True RMS Current	18.27	17.25		3.12						7-Jul
225 A	Average Current	17.2	17.2		2.3	Current Form Factor	1.06	1.00		1.36	15:30
120/240 V	Peak Current	33.68	25.6		8.36	Current Crest Factor	1.84	1.48		2.68	
	True RMS Voltage	115.2	114.9								
	Peak Voltage	158.4	158.8			Voltage Crest Factor	1.38	1.38			
Pnl W, Rm122	True RMS Current	92.4	88.9		8.09						7-Jul ⁸
225 A	Average Current	66.4	74.6		7.8	Current Form Factor	1.39	1.19		1.04	10:15
120/240 V	Peak Current	130.8	129.6		12	Current Crest Factor	1.42	1.46		1.48	
	True RMS Voltage	114.8	111.2								
	Peak Voltage	158	157.2			Voltage Crest Factor	1.38	1.41			

[illegible]

Building 1505											
Panel Label	Measured Values					Calculated Values					Date/
Main Size											Time
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	
IPB	True RMS Current	54.7			54.6						8-Jul
40 A	Average Current	45.8			45.8	Current Form Factor	1.19			1.19	11:10
120 V	Peak Current	113.6			112.8	Current Crest Factor	2.08			2.07	
	True RMS Voltage	114.6									
	Peak Voltage	153.6				Voltage Crest Factor	1.34				
IPC	True RMS Current	6.6	4.4		0.8						8-Jul
40 A	Average Current	2.4	2.3		0	Current Form Factor	2.75	1.91			11:35
120/240 V	Peak Current	12	11.6		0.8	Current Crest Factor	1.62	2.64		1.00	
	True RMS Voltage	120	116								
	Peak Voltage	164	160			Voltage Crest Factor	1.37	1.38			
PP-1	True RMS Current	4.1	0.56	3.34	4.1						8-Jul
100 A	Average Current	2.56	1.05	2.61	3.66	Current Form Factor	1.80	0.53	1.28	1.12	9:25
120/208 V	Peak Current	12.84	4.56	7.76	7.12	Current Crest Factor	3.13	8.14	2.32	1.74	
	True RMS Voltage	116.8	115.8	116.8							
	Peak Voltage	159.6	157.2	159.2		Voltage Crest Factor	1.37	1.36	1.36		
PP-2	True RMS Current	22	24.4	23	20.6						8-Jul
100 A	Average Current	22.6	11.42	17.69	19.11	Current Form Factor	0.97	2.14	1.30	1.08	13:00
120/208 V	Peak Current	43.2	61.2	40	56.4	Current Crest Factor	1.96	2.51	1.74	2.74	
	True RMS Voltage	116.6	115.2	116.5							
	Peak Voltage	158.4	156.4	158		Voltage Crest Factor	1.36	1.36	1.36		
PP-2B	True RMS Current	3.99	0.12	0.61	3.58						8-Jul
100 A	Average Current	3.93	0.05	0.37	3.68	Current Form Factor	1.02	2.40	1.65	0.97	11:15
120/208 V	Peak Current	5.76	0.24	1.6	5.36	Current Crest Factor	1.44	2.00	2.62	1.50	
	True RMS Voltage	116.1	115.4	116.4							
	Peak Voltage	158.4	156	158.4		Voltage Crest Factor	1.36	1.35	1.36		
PP-2C	True RMS Current	9.6	2.02	12.9	0.12						8-Jul
100 A	Average Current	5.5	1.12	7.77	0.11	Current Form Factor	1.75	1.80	1.66	1.09	11:15
120/208 V	Peak Current	40.28	5.56	43.6	0.8	Current Crest Factor	4.20	2.75	3.38	6.67	
	True RMS Voltage	115.8	115.8	116.1							
	Peak Voltage	158	156.8	158.4		Voltage Crest Factor	1.36	1.35	1.36		
PP-3	True RMS Current	9	12.5	17.4	4.8						8-Jul
100 A	Average Current	7.87	11.77	17.19	4.25	Current Form Factor	1.14	1.06	1.01	1.13	10:40
120/208 V	Peak Current	18	19.6	24.4	5.6	Current Crest Factor	2.00	1.57	1.40	1.17	
	True RMS Voltage	116.6	115.9	116.6							
	Peak Voltage	158	156.4	158.8		Voltage Crest Factor	1.36	1.35	1.36		
PP-4	True RMS Current	14.6	32	8	24.2						8-Jul
100 A	Average Current	10.9	25.2	4.1	28.6	Current Form Factor	1.34	1.27	1.85	0.85	11:25
120/208 V	Peak Current	58.8	62	14	107.6	Current Crest Factor	4.03	1.94	1.75	4.45	
	True RMS Voltage	115.2	114.5	116.2							
	Peak Voltage	154.8	154	158		Voltage Crest Factor	1.34	1.34	1.36		
PP-5	True RMS Current	18.2	10.2	7	21.2						8-Jul
100 A	Average Current	11.51	6.53	4.1	19.46	Current Form Factor	1.58	1.56	1.71	1.09	13:20
120/208 V	Peak Current	49.6	76	16.8	38.4	Current Crest Factor	2.73	7.45	2.40	1.81	
	True RMS Voltage	116.4	115.5	116.8							
	Peak Voltage	157.6	156.8	158.4		Voltage Crest Factor	1.35	1.36	1.36		
PP-7	True RMS Current	24.5	17.8	18.5							8-Jul
100 A	Average Current	16.5	9.33	9.92	23.7	Current Form Factor	1.48	1.91	1.88		13:40
120/208 V	Peak Current	64	35.2	52	54.4	Current Crest Factor	2.61	1.98	2.81		
	True RMS Voltage	115.4	115.3	116.4							
	Peak Voltage	159.2	155.6	157.2		Voltage Crest Factor	1.38	1.35	1.35		

Building 1505											
Panel Label											
Main Size	Measured Values					Calculated Values					Date/
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time
N/E-1	True RMS Current	10.2	16.2	3.5	15.1						8-Jul
100 A	Average Current	5.5	19.38	2.05	14.32	Current Form Factor	1.85	0.84	1.71	1.05	10:30
120/208 V	Peak Current	50.4	35.6	5.2	24	Current Crest Factor	4.94	2.20	1.49	1.69	
	True RMS Voltage	117.1	115.9	117.4							
	Peak Voltage	163.6	160	163.6		Voltage Crest Factor	1.40	1.38	1.39		
N/E-1A	True RMS Current	11.4	11.4	11.3	0.4						8-Jul
100 A	Average Current	10.89	11.04	10.84	6.18	Current Form Factor	1.05	1.03	1.04	0.06	10:45
120/208 V	Peak Current	15.6	15.6	15.2	0.8	Current Crest Factor	1.37	1.37	1.35	2.00	
	True RMS Voltage										
	Peak Voltage					Voltage Crest Factor					
N/E-2	True RMS Current	0.18	1.69	4.69	5.92						9-Jul
100 A	Average Current	0.11	0.15	3.55	2.25	Current Form Factor	1.64	11.27	1.32	2.63	9:20
120/208 V	Peak Current	0.12	2.2	11.28	20.8	Current Crest Factor	0.67	1.30	2.41	3.51	
	True RMS Voltage	118.4	116.8	118.4							
	Peak Voltage	164.4	162	166		Voltage Crest Factor	1.39	1.39	1.40		
N/E-3	True RMS Current	28.4	10.4	11.2	4.8						9-Jul
100 A	Average Current	16.43	8.88	8.68	7.82	Current Form Factor	1.61	1.17	1.29	0.61	9:30
120/208 V	Peak Current	40.4	16.4	12.8	6.4	Current Crest Factor	1.53	1.58	1.14	1.33	
	True RMS Voltage	117.6	116.8	117.6							
	Peak Voltage	171.6	167.6	164		Voltage Crest Factor	1.46	1.43	1.39		
N/E-4	True RMS Current	1.87	2.41	3.89	3.76						9-Jul
100 A	Average Current	1.73	1.54	2.03	3.86	Current Form Factor	1.08	1.56	1.92	0.97	9:00
120/208 V	Peak Current	2.64	7.4	11.24	9.48	Current Crest Factor	1.41	3.07	2.89	2.52	
	True RMS Voltage	117.6	116.8	117.8							
	Peak Voltage	165.2	162	165.2		Voltage Crest Factor	1.40	1.39	1.40		

Building 1505											
Panel Label											
Main Size	Measured Values					Calculated Values					Date/
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time
N/E-5	True RMS Current	2.57	2.98	3.8	3.4						9-Jul
100 A	Average Current	1.55	1.92	2	3	Current Form Factor	1.66	1.65	1.90	1.13	9:10
120/208 V	Peak Current	7.68	29.68	12.96	27.56	Current Crest Factor	2.99	9.96	3.41	8.11	
	True RMS Voltage	118.4	116.8	118.4							
	Peak Voltage	165.2	162.4	165.2		Voltage Crest Factor	1.40	1.39	1.40		
N/E-6	True RMS Current	21.09	40.1	17.9	4.1						8-Jul
100 A	Average Current	18.79	36.9	15.23	3.87	Current Form Factor	1.12	1.09	1.18	1.06	15:35
120/208 V	Peak Current	34.28	67.2	30.4	4.8	Current Crest Factor	1.63	1.68	1.70	1.17	
	True RMS Voltage	116.8	115.9	118.4							
	Peak Voltage	163.6	160.4	163.6		Voltage Crest Factor	1.40	1.38	1.38		
N/E-7	True RMS Current	12.9	6.4	12.6	3.8						8-Jul
100 A	Average Current	12.6	5.78	12.19	3.78	Current Form Factor	1.02	1.11	1.03	1.01	15:20
120/208 V	Peak Current	17.6	8.4	17.6	6.4	Current Crest Factor	1.36	1.31	1.40	1.68	
	True RMS Voltage	117.3	116.8	118.4							
	Peak Voltage	164.4	160.4	163.6		Voltage Crest Factor	1.40	1.37	1.38		
N/E-8	True RMS Current	3.2	6.4	2.9	6.3						8-Jul
100 A	Average Current	1.57	5.86	2.58	6.5	Current Form Factor	2.04	1.09	1.12	0.97	13:55
120/208 V	Peak Current	3.6	8	4	22	Current Crest Factor	1.13	1.25	1.38	3.49	
	True RMS Voltage	116.7	113	117.6							
	Peak Voltage	162.4	168.8	162.8		Voltage Crest Factor	1.39	1.49	1.38		
N/E-9	True RMS Current	0.1	9.4	3.9	5.6						9-Jul
100 A	Average Current	0.13	7.03	0.81	3.86	Current Form Factor	0.77	1.34	4.81	1.45	14:15
120/208 V	Peak Current	0.8	20.4	32.4	12.8	Current Crest Factor	8.00	2.17	8.31	2.29	
	True RMS Voltage	116.8	116	117.6							
	Peak Voltage	167.2	163.6	162.8		Voltage Crest Factor	1.43	1.41	1.38		
N/E-10	True RMS Current	21.5	13.7	10	12.6						8-Jul
100 A	Average Current	32.6	27.26	9.	11.9	Current Form Factor	0.66	0.50	1.06	1.06	14:30
120/208 V	Peak Current	44.8	18	14	22	Current Crest Factor	2.08	1.31	1.41	1.75	
	True RMS Voltage	116.8	115.2	116.8							
	Peak Voltage	167.6	158.8	162		Voltage Crest Factor	1.43	1.38	1.39		

Building 2000												
Panel Label												
Main Size	Measured Values					Calculated Values					Date/	
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time	
Panel D1	True RMS Current	35.3	32.3		2.6						15-Jul	
120/240 V	Average Current	28.6	25.8		2.9	Current Form Factor	1.23	1.25		0.90	13:15	
60 A	Peak Current	48.4	44.4		3.6	Current Crest Factor	1.37	1.37		1.38		
	True RMS Voltage	114	113.7									
	Peak Voltage	156.4	155.6			Voltage Crest Factor	1.37	1.37				
Panel 7A	True RMS Current	19.6	1.2		15.7						15-Jul	
120/240 V	Average Current	19.2	0.98		15.5	Current Form Factor	1.02	1.22		1.01	13:20	
100 A	Peak Current	28	1.2		22.8	Current Crest Factor	1.43	1.00		1.45		
	True RMS Voltage	113.2	114.6									
	Peak Voltage	155.2	157.6			Voltage Crest Factor	1.37	1.38				
Panel C	True RMS Current	13.1	12.7		0.66						15-Jul	
120/240 V	Average Current	11.86	11.5		0.37	Current Form Factor	1.10	1.10		1.78	13:30	
200 A	Peak Current	17.6	17.2		0.72	Current Crest Factor	1.34	1.35		1.09		
	True RMS Voltage	113.6	114.5									
	Peak Voltage	155.6	156			Voltage Crest Factor	1.37	1.38				
Panel B	True RMS Current	54.1	52.8		3.5						15-Jul	
120/240 V	Average Current	51.5	51.2		3.1	Current Form Factor	1.05	1.03		1.13	13:40	
200 A	Peak Current	79.2	76.4		4.4	Current Crest Factor	1.46	1.45		1.26		
	True RMS Voltage	115	115.8									
	Peak Voltage	156.8	157.2			Voltage Crest Factor	1.36	1.38				
Panel G	True RMS Current	19.1	21.6		3.2						15-Jul	
120/240 V	Average Current	16.5	20.1		2.5	Current Form Factor	1.16	1.07		1.28	13:50	
100 A	Peak Current	64	46		3.6	Current Crest Factor	3.35	2.13		1.13		
	True RMS Voltage	115.6	114.7									
	Peak Voltage	157.6	157.2			Voltage Crest Factor	1.36	1.37				
PNL 1	True RMS Current	0.2	12.6		5.9						15-Jul	
120/240 V	Average Current	0.1	5.7		5.6	Current Form Factor	2.00	2.21		1.05	13:55	
	Peak Current	0.8	20.4		9.2	Current Crest Factor	4.00	1.62		1.56		
	True RMS Voltage	114.3	114.8									
	Peak Voltage	156.8	156.8			Voltage Crest Factor	1.37	1.37				
LPC	True RMS Current	31.6	66.4		32.1						15-Jul	
120/240 V	Average Current	31.7	66.9		31.6	Current Form Factor	1.00	0.99		1.02	15:10	
200 A	Peak Current	43.6	93.6		47.2	Current Crest Factor	1.38	1.41		1.47		
	True RMS Voltage	114.5	113.7									
	Peak Voltage	155.2	155.6			Voltage Crest Factor	1.36	1.37				
PNL Z	True RMS Current	6.07	13.32		3.39						15-Jul	
100 A	Average Current	5.7	13.2		2.9	Current Form Factor	1.06	1.01		1.17	15:20	
110/240	Peak Current	10.76	18.92		5.6	Current Crest Factor	1.77	1.42		1.65		
	True RMS Voltage	115.3	114									
	Peak Voltage	156.4	155.6			Voltage Crest Factor	1.36	1.36				
PNL A	True RMS Current	46.5	69.3		18						15-Jul	
200 A	Average Current	45.9	67.5		16.3	Current Form Factor	1.01	1.03		1.10	15:30	
110/220	Peak Current	62.4	126.8		59.6	Current Crest Factor	1.34	1.83		3.31		
	True RMS Voltage	114.8	115.5									
	Peak Voltage	156.4	156.4			Voltage Crest Factor	1.36	1.35				

Building 2001											
Panel Label	Measured Values					Calculated Values					Date/
Main Size											Time
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	
PNL A	True RMS Current	33	52.1								15-Jul
200 A	Average Current	27.3	54.2			Current Form Factor	1.21	0.96			13:50
120/240 V	Peak Current	116	108			Current Crest Factor	3.52	2.07			
	True RMS Voltage	116.7	116.3								
	Peak Voltage	160.4	157.2			Voltage Crest Factor	1.37	1.35			
PNL B	True RMS Current	7	37.8		26.1						15-Jul
200 A	Average Current	6.7	30.8		23.3	Current Form Factor	1.04	1.23		1.12	13:40
120/240 V	Peak Current	31.6	66		75.6	Current Crest Factor	4.51	1.75		2.90	
	True RMS Voltage	118.3	115.2								
	Peak Voltage	164.4	155.6			Voltage Crest Factor	1.39	1.35			
PNL C	True RMS Current	4.8	10.6		4.9						15-Jul
50 A	Average Current	3.35	7.99		3.17	Current Form Factor	1.10	1.33		1.55	13:30
120/240 V	Peak Current	6	18		18.4	Current Crest Factor	1.25	1.70		3.76	
	True RMS Voltage	116.4	116.6								
	Peak Voltage	158.4	158.4			Voltage Crest Factor	1.36	1.36			
PNL D	True RMS Current	57.1	69.1								15-Jul
200 A	Average Current	47.3	73.5			Current Form Factor	1.21	0.94			14:15
120/240 V	Peak Current	129.2	124.8			Current Crest Factor	2.26	1.81			
	True RMS Voltage	118	118.2								
	Peak Voltage	157.2	160.8			Voltage Crest Factor	1.33	1.36			
PNL E	True RMS Current	24.4	29.5		11.1						15-Jul
200 A	Average Current	22	32.24		4.35	Current Form Factor	1.11	0.92		2.55	9:10
120/240 V	Peak Current	44.8	56		24.8	Current Crest Factor	1.84	1.90		2.23	
	True RMS Voltage	118.1	117.1								
	Peak Voltage	166.4	162			Voltage Crest Factor	1.41	1.38			
PNL F	True RMS Current	5.51	5.49		0.49						15-Jul
200 A	Average Current	5.49	5.42		0.36	Current Form Factor	1.00	1.01		1.36	13:10
120/240 V	Peak Current	9.28	9.08		0.76	Current Crest Factor	1.68	1.65		1.55	
	True RMS Voltage	117.9	118.2								
	Peak Voltage	158.4	161.2			Voltage Crest Factor	1.34	1.36			
PNL H	True RMS Current	16.64	9.04		6.3						15-Jul
225 A	Average Current	16.1	8.8		5.9	Current Form Factor	1.03	1.03		1.07	14:10
120/240 V	Peak Current	24.9	14.36		9.04	Current Crest Factor	1.50	1.59		1.43	
	True RMS Voltage	116.2	117.1								
	Peak Voltage	158.4	158.4			Voltage Crest Factor	1.36	1.35			
PNL J	True RMS Current	4.88	12.08		4.08						15-Jul
100 A	Average Current	3.2	10.8		3.5	Current Form Factor	1.63	1.12		1.17	9:20
120/240 V	Peak Current	25.72	21.04		11.04	Current Crest Factor	5.27	1.74		2.71	
	True RMS Voltage	117.8	116.8								
	Peak Voltage	161.6	161.4			Voltage Crest Factor	1.37	1.38			
PNL L	True RMS Current	41.5	43.1								15-Jul
225 A	Average Current	37.9	37.5			Current Form Factor	1.09	1.15			13:15
120/240 V	Peak Current	72.4	74.4			Current Crest Factor	1.74	1.73			
	True RMS Voltage	116.5	116.8								
	Peak Voltage	158.4	161.2			Voltage Crest Factor	1.36	1.38			
PNL M	True RMS Current	2.5	1.1		2.3						15-Jul
125 A	Average Current	2.52	2.05		1.75	Current Form Factor	0.99	0.54		1.31	13:05
120/240 V	Peak Current	29.6	3.56		3.2	Current Crest Factor	11.84	3.24		1.39	
	True RMS Voltage	122	120								
	Peak Voltage	156	152			Voltage Crest Factor	1.28	1.27			

[illegible]

Building 2024												
Panel Label												
Main Size	Measured Values					Calculated Values					Date/	
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time	
A1	True RMS Current	28.1	68	22.2	40.8						15-Jul	
100 A	Average Current	24.8	52.9	20.8	40	Current Form Factor	1.13	1.29	1.07	1.02	15:40	
120/208	Peak Current	78.4	140	40.8	97.2	Current Crest Factor	2.72	2.08	1.84	2.38		
	True RMS Voltage	116	116.7	116.2								
	Peak Voltage	158	159.2	159.6		Voltage Crest Factor	1.36	1.36	1.37			
Q	True RMS Current	26.18	30.6		5.1						15-Jul	
100 A	Average Current	26.55	28.98		4.8	Current Form Factor	0.99	1.08		1.08	8:15	
120/240	Peak Current	38.84	49.2		5.6	Current Crest Factor	1.48	1.81		1.10		
	True RMS Voltage	117.2	117.7									
	Peak Voltage	160.4	160			Voltage Crest Factor	1.37	1.36				
PNL E	True RMS Current	1.7	1.38		1.46						15-Jul	
100 A	Average Current	1.3	1.38		1.26	Current Form Factor	1.31	1.00		1.16	8:30	
120/240 V	Peak Current	4.8	1.68		3.48	Current Crest Factor	2.82	1.22		2.38		
	True RMS Voltage	117.4	117.7									
	Peak Voltage	160.4	160.8			Voltage Crest Factor	1.37	1.37				
PNL B	True RMS Current	39	34		7						15-Jul	
100 A	Average Current	38.4	32.2		7.04	Current Form Factor	1.02	1.08		0.99	8:40	
120/240 V	Peak Current	64.8	65.6		29.2	Current Crest Factor	1.66	1.93		4.17		
	True RMS Voltage	116.9	117.3									
	Peak Voltage	160.4	160			Voltage Crest Factor	1.37	1.36				
PNL F	True RMS Current	7.5	8.3		4.4						15-Jul	
100 A	Average Current	5.37	6.89		1.5	Current Form Factor	1.40	1.20		2.93	8:50	
120/240 V	Peak Current	12.8	38.8		22.2	Current Crest Factor	1.71	4.67		5.05		
	True RMS Voltage	117.3	116.9									
	Peak Voltage	160.4	161.6			Voltage Crest Factor	1.37	1.38				
PNL CR	True RMS Current	0.8	0.4	4.2	4.07						15-Jul	
225 A	Average Current	0.13	0.05	2.51	2.41	Current Form Factor	6.15	8.00	1.87	1.89	9:00	
120/208 V	Peak Current	0.8	0.8	10.4	12.36	Current Crest Factor	1.00	2.00	2.48	3.04		
	True RMS Voltage	115.3	116.2	117.6								
	Peak Voltage	159.6	158.4	160.4		Voltage Crest Factor	1.38	1.36	1.36			

[illegible]

Building 4508											
Panel Label											
Main Size	Measured Values					Calculated Values					Date/
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time
DP-2D-5	True RMS Current	46.2	39.3	48.4	12.23						12-Jul
225 A	Average Current	43.8	35.5	44.4	10.55	Current Form Factor	1.05	1.11	1.09	1.16	9:00
120/208 V	Peak Current	103.6	68.8	83.6	29.2	Current Crest Factor	2.24	1.75	1.73	2.39	
	True RMS Voltage	119.2	119.5	120.1							
	Peak Voltage	164.8	166	166.8		Voltage Crest Factor	1.38	1.39	1.39		
2ELP2	True RMS Current	2.25	1.62	1.27	2.85						12-Jul
100 A	Average Current	1.5	1.52	0.78	2.16	Current Form Factor	1.50	1.07	1.63	1.32	9:05
120/208 V	Peak Current	6.04	2.16	3.8	4.04	Current Crest Factor	2.68	1.33	2.99	1.42	
	True RMS Voltage	120	119.9	120.4							
	Peak Voltage	165.6	168.4	172		Voltage Crest Factor	1.38	1.40	1.43		
LP "O"	True RMS Current	10.7	43.2	21.3	26.4						12-Jul
225 A	Average Current				25.5	Current Form Factor				1.04	10:05
120/208 V	Peak Current	22.3	87	32.5	77	Current Crest Factor	2.08	2.01	1.53	2.92	
	True RMS Voltage	124	123.3	122.4							
	Peak Voltage	168	170.8	166.8		Voltage Crest Factor	1.35	1.39	1.36		
Panel Z	True RMS Current	11.8	11.29	18.94	12.01						12-Jul
100 A	Average Current	11.65	11.03	16.05	11.82	Current Form Factor	1.01	1.02	1.18	1.02	10:35
120/208 V	Peak Current	16.16	15.4	27.44	17.56	Current Crest Factor	1.37	1.36	1.45	1.46	
	True RMS Voltage	122.2	123.3	122.7							
	Peak Voltage	167.6	170.8	166.8		Voltage Crest Factor	1.37	1.39	1.36		
BP 16	True RMS Current	1.79	0.91	0.18	0.13						12-Jul
120/208 V	Average Current	1	0.86	0.09	0.08	Current Form Factor	1.79	1.06	2.00	1.63	10:45
225 A	Peak Current	5.28	1.12	0.72	0.08	Current Crest Factor	2.95	1.23	4.00	0.62	
	True RMS Voltage	122.8	122.4	123.7							
	Peak Voltage	167.6	167.6	168.8		Voltage Crest Factor	1.36	1.37	1.36		
LP N	True RMS Current	36	37.9	44	13.1						12-Jul
120/208 V	Average Current	34.9	34.4	42.1	12.7	Current Form Factor	1.03	1.10	1.05	1.03	10:50
225 A	Peak Current	106.4	52	86.4	45.2	Current Crest Factor	2.96	1.37	1.96	3.45	
	True RMS Voltage	122.1	122	123.2							
	Peak Voltage	171.6	168	168.4		Voltage Crest Factor	1.41	1.38	1.37		
BP 14	True RMS Current	2.7	1.6	1.8	13.7						12-Jul
120/208 V	Average Current	2.3	0.8	1.1	12.6	Current Form Factor	1.17	2.00	1.64	1.09	11:05
225 A	Peak Current	3.2	5.2	4	19.6	Current Crest Factor	1.19	3.25	2.22	1.43	
	True RMS Voltage	123.8	122.4	122.5							
	Peak Voltage	170	170.4	168.4		Voltage Crest Factor	1.37	1.39	1.37		
LP J	True RMS Current	52.3	39.8	45.3	14						12-Jul
120/208 V	Average Current	48.8	37.9	44.7	13	Current Form Factor	1.07	1.05	1.01	1.08	11:05
225 A	Peak Current	82.4	92.8	102.8	40	Current Crest Factor	1.58	2.33	2.27	2.86	
	True RMS Voltage	114.6	114.7	115.9							
	Peak Voltage	157.6	157.6	159.2		Voltage Crest Factor	1.38	1.37	1.37		
LP K	True RMS Current	48.9	27		20.9						12-Jul
120/208 V	Average Current	51.2	33.1		19.8	Current Form Factor	0.96	0.82		1.06	11:10
100 A	Peak Current	70	70		37.6	Current Crest Factor	1.43	2.59		1.80	
	True RMS Voltage	113.7	114.1	116.3							
	Peak Voltage	158	157.2	168		Voltage Crest Factor	1.39	1.38	1.44		

Building 4508											
Panel Label											
Main Size	Measured Values					Calculated Values					Date/
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time
LP A	True RMS Current	61.7	36.3	74.5	25.8						12-Jul
225 A	Average Current	64.3		72.3	23.7	Current Form Factor	0.96		1.03	1.09	12:45
120/208 V	Peak Current	84.8	51	118	38.5	Current Crest Factor	1.37	1.40	1.58	1.49	
	True RMS Voltage	112.7	1113.4	114.8							
	Peak Voltage	157.6	156	157.6		Voltage Crest Factor	1.40	0.14	1.37		
LP B	True RMS Current		54.5	38.6	27.5						12-Jul
225 A	Average Current					Current Form Factor					12:55
120/208 V	Peak Current		76	44.5	49.7	Current Crest Factor		1.39	1.15	1.81	
	True RMS Voltage	122	121.3	122.3							
	Peak Voltage	168.4	170.4	174		Voltage Crest Factor	1.38	1.40	1.42		
IP-4A	True RMS Current	1.03	0.12	0.08	0.99						12-Jul
100 A	Average Current	0.81	0	0	0.8	Current Form Factor	1.27			1.24	13:10
120/208 V	Peak Current	2.04	0.12	0.08	1.88	Current Crest Factor	1.98	1.00	1.00	1.90	
	True RMS Voltage	113.3	112.7	112.9							
	Peak Voltage	157.2	156.4	162		Voltage Crest Factor	1.39	1.39	1.43		
BP-8	True RMS Current	5.45	7.55	0.14	0.13						12-Jul
225 A	Average Current	2.78	4.2	0.01	0.01	Current Form Factor	1.96	1.80	14.00	13.00	13:15
120/208 V	Peak Current	17.64	17.24	0.04	0.04	Current Crest Factor	3.24	2.28	0.29	0.31	
	True RMS Voltage	119.2	117.9	113.7							
	Peak Voltage	156.8	157.6	156		Voltage Crest Factor	1.32	1.34	1.37		
Em Pnl E	True RMS Current	0.11	7	5.3	0.15						12-Jul
100 A	Average Current	0	4.86	4.64	0	Current Form Factor		1.44	1.14		13:20
120/208 V	Peak Current	0.008	36.08	36.36	0.6	Current Crest Factor	0.07	5.15	6.86	4.00	
	True RMS Voltage	113.3	112.9	113.7							
	Peak Voltage	156.8	157.6	156		Voltage Crest Factor	1.38	1.40	1.37		
BP-7	True RMS Current	0.09	3.38	0.9	3.33						12-Jul
100 A	Average Current	0.02	2.1	0.62	2.32	Current Form Factor	4.50	1.61	1.45	1.44	13:30
120/208 V	Peak Current	0.04	8.4	2.12	8.04	Current Crest Factor	0.44	2.49	2.36	2.41	
	True RMS Voltage	123.3	121.9	122.5							
	Peak Voltage	169.2	167.6	168.4		Voltage Crest Factor	1.37	1.37	1.37		
LP "E"	True RMS Current	32.8	25.25	28.65	11.6						12-Jul
100 A	Average Current	31.59	25.53	28.73	11.8	Current Form Factor	1.04	0.99	1.00	0.98	13:40
120/208 V	Peak Current	45.2	35.96	40.84	18.8	Current Crest Factor	1.38	1.42	1.43	1.82	
	True RMS Voltage	119.2	118.7	119.3							
	Peak Voltage	164.8	164.4	168		Voltage Crest Factor	1.38	1.39	1.41		
LP "G"	True RMS Current	50.7	33.3	43.5	21.6						12-Jul
225 A	Average Current	51.7	32.6	37.6	16.9	Current Form Factor	0.98	1.02	1.16	1.28	13:50
120/208 V	Peak Current	121.6	70.4	98	62.8	Current Crest Factor	2.40	2.11	2.25	2.81	
	True RMS Voltage	121.7	121.7	123.1							
	Peak Voltage	167.2	167.2	168		Voltage Crest Factor	1.37	1.37	1.36		
BP-2	True RMS Current	5.7	20.2	11.3	16.3						12-Jul
225 A	Average Current	3.7	19.4	7.1	15.1	Current Form Factor	1.54	1.04	1.59	1.08	14:00
120/208 V	Peak Current	10.4	31.6	25.6	27.6	Current Crest Factor	1.82	1.56	2.27	1.69	
	True RMS Voltage	116.4	115.7	117.5							
	Peak Voltage	159.6	158.4	167.6		Voltage Crest Factor	1.37	1.37	1.43		
LP "D"	True RMS Current	45.5	46.3	48.2	24.4						12-Jul
100 A	Average Current	44.3	42.8	45.4	23.5	Current Form Factor	1.03	1.08	1.06	1.04	14:10
120/208 V	Peak Current	100	74.8	77.2	57.2	Current Crest Factor	2.20	1.62	1.60	2.34	
	True RMS Voltage	117.1	115.3	116							
	Peak Voltage	159.2	157.2	165.6		Voltage Crest Factor	1.36	1.36	1.43		

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Appendix A

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Building K-1320											
Panel Label											
Main Size	Measured Values					Calculated Values					Date/
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time
PNL A	True RMS Current	29	22.9	17.9	21.6						
	Average Current	27	21	11.5	21	Current Form Factor	1.07	1.09	1.66	1.03	
120/208 V	Peak Current	76.4	62.4	56.4	61.6	Current Crest Factor	2.63	2.72	3.15	2.85	
	True RMS Voltage	119	119	120							
	Peak Voltage	114	115	116		Voltage Crest Factor	0.98	0.97	0.97		
PNL C	True RMS Current	10.6	8.5	1.9	7.4						
	Average Current	11	4	2	8	Current Form Factor	0.98	2.13	0.95	0.93	
120/208 V	Peak Current	14.4	12	2.8	11.2	Current Crest Factor	1.36	1.41	1.47	1.51	
	True RMS Voltage	119	119	120							
	Peak Voltage	163	163	164		Voltage Crest Factor	1.37	1.37	1.37		
PNL D	True RMS Current	18.9	20.9	21	14.9						
	Average Current	18	20	16	15.5	Current Form Factor	1.05	1.05	1.31	0.98	
120/208 V	Peak Current	59.6	52	62.8	32.4	Current Crest Factor	3.15	2.49	2.99	2.17	
	True RMS Voltage	118	116	119							
	Peak Voltage	162	163	163		Voltage Crest Factor	1.37	1.41	1.37		
PNL F	True RMS Current	20	23.8	14.4	10.7						
	Average Current	19.5	22	14	11.5	Current Form Factor	1.03	1.08	1.03	0.93	
120/208 V	Peak Current	29.6	67.2	55.2	59.2	Current Crest Factor	1.48	2.82	3.83	5.63	
	True RMS Voltage	117	118	119							
	Peak Voltage	161	162	162		Voltage Crest Factor	1.38	1.37	1.36		
PNL G	True RMS Current	19.7	19.8	25.1	16.5						
	Average Current	22	19	26	14	Current Form Factor	0.90	1.04	0.97	1.18	
120/208 V	Peak Current	61.6	98	68.8	79.6	Current Crest Factor	3.13	4.95	2.74	4.82	
	True RMS Voltage	119	119	120							
	Peak Voltage	163	164	164		Voltage Crest Factor	1.37	1.38	1.37		
PNL K	True RMS Current	37.4	19	12.1	26.5						
	Average Current	36	18	11	23	Current Form Factor	1.04	1.06	1.10	1.15	
120/208 V	Peak Current	98.4	57.2	32	72.8	Current Crest Factor	2.63	3.01	2.64	2.75	
	True RMS Voltage	118	119	120							
	Peak Voltage	162	164	164		Voltage Crest Factor	1.37	1.38	1.37		

Building K-1330												
Panel Label												
Main Size	Measured Values					Calculated Values					Date/	
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time	
PNL A	True RMS Current	42.5	37.6	48.3	19.2							
	Average Current	36	30	39	19	Current Form Factor	1.18	1.25	1.24	1.01		
120/208 V	Peak Current	91.6	83.6	102.8	61.2	Current Crest Factor	2.16	2.22	2.13	3.19		
	True RMS Voltage	120.5	120.9	121.8								
	Peak Voltage	165.6	166	167.2		Voltage Crest Factor	1.37	1.37	1.37			
PNL B	True RMS Current	16.5	4	34.5	15.3							
	Average Current	13	3.5	12	15	Current Form Factor	1.27	1.14	2.88	1.02		
120/208 V	Peak Current	112.4	37.2	99.6	81.2	Current Crest Factor	6.81	9.30	2.89	6.31		
	True RMS Voltage	120.6	120.9	121.6								
	Peak Voltage	165.2	166	166.4		Voltage Crest Factor	1.37	1.37	1.37			
PNL C	True RMS Current	11.5	12	9	8.1							
	Average Current	13	27	32.5	6	Current Form Factor	0.88	0.44	0.28	1.35		
120/208 V	Peak Current	15.2	16	12	11.2	Current Crest Factor	1.32	1.33	1.33	1.38		
	True RMS Voltage	120.6	120.9	121.6								
	Peak Voltage	165.6	165.6	166.8		Voltage Crest Factor	1.37	1.37	1.37			
PNL D	True RMS Current	29.6	42.7	26.5	19.3							
	Average Current	28	43	25	18	Current Form Factor	1.06	0.99	1.06	1.07		
120/208 V	Peak Current	87.2	102	84.8	64	Current Crest Factor	2.95	2.39	3.20	3.32		
	True RMS Voltage	122.9	122.9	123.1								
	Peak Voltage	169.6	168.8	169.6		Voltage Crest Factor	1.38	1.37	1.38			
PNL E	True RMS Current	3.6	2.1	17.2	15.3							
	Average Current	3.5	1.5	15	16	Current Form Factor	1.03	1.40	1.15	0.96		
120/208 V	Peak Current	30.8	33.6	38.4	90.4	Current Crest Factor	8.56	16.00	2.23	5.91		
	True RMS Voltage	121	120.7	121.3								
	Peak Voltage	165.6	166	166		Voltage Crest Factor	1.37	1.38	1.37			
PNL F	True RMS Current	33.4	29.1	5.5	9.2							
	Average Current	33	29	5.5	9.5	Current Form Factor	1.01	1.00	1.00	0.97		
120/208 V	Peak Current	46.4	40.8	7.6	12	Current Crest Factor	1.39	1.40	1.38	1.30		
	True RMS Voltage	121	120.9	121.4								
	Peak Voltage	166	166	166.4		Voltage Crest Factor	1.37	1.37	1.37			

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Building 9709											
Panel Label											
Main Size	Measured Values					Calculated Values					Date/
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time
LC#1	True RMS Current	28	8		10						20-Jul
225 A	Average Current	22	12		10	Current Form Factor	1.27	0.87		1.00	20:00
120/240 V	Peak Current	40	16		24	Current Crest Factor	1.43	2.00		2.40	
	True RMS Voltage	125.7	126.4								
	Peak Voltage	177.6	177.2			Voltage Crest Factor	1.41	1.40			
LC#2	True RMS Current	21	12		14						21-Jul
225 A	Average Current	14	5		17	Current Form Factor	1.50	2.40		0.82	7:30
120/240 V	Peak Current	36	8		28	Current Crest Factor	1.71	0.87		2.00	
	True RMS Voltage	125.1	126.6								
	Peak Voltage	178	178			Voltage Crest Factor	1.41	1.39			
LC#3	True RMS Current	105	98		24						21-Jul
225 A	Average Current	112	68		15	Current Form Factor	0.94	1.44		1.60	8:00
120/240 V	Peak Current	188	140		36	Current Crest Factor	1.79	1.46		1.50	
	True RMS Voltage	124.5	124.8								
	Peak Voltage	174	172.8			Voltage Crest Factor	1.40	1.38			
LC#4	True RMS Current	34	48		17						
225 A	Average Current	40	45		16	Current Form Factor	0.85	1.07		1.08	
120/240 V	Peak Current	60	56		24	Current Crest Factor	1.78	1.17		1.41	
	True RMS Voltage	126.1	126.4								
	Peak Voltage	177.2	176.8			Voltage Crest Factor	1.41	1.40			
LP#2	True RMS Current	90	120		48						21-Jul
225 A	Average Current	90	110		48	Current Form Factor	1.00	1.09		1.00	14:00
120/240 V	Peak Current	112	144		84	Current Crest Factor	1.24	1.20		1.75	
	True RMS Voltage	126.1	126.4								
	Peak Voltage	178	178			Voltage Crest Factor	1.41	1.41			
143B-1-3-1-1	True RMS Current	24	24	23	24						21-Jul
225 A	Average Current	16	12	26	15	Current Form Factor	1.50	2.00	0.88	1.60	10:15
120/208V	Peak Current	52	60	36	68	Current Crest Factor	2.17	2.50	1.57	2.83	
	True RMS Voltage	124.9	126.4	124.8							
	Peak Voltage	175.2	176.4	173.6		Voltage Crest Factor	1.40	1.40	1.39		
143A.22.A	True RMS Current	8	28		20						21-Jul
100 A	Average Current	9	20		20	Current Form Factor	0.89	1.40		1.00	15:00
120/240 V	Peak Current	16	44		28	Current Crest Factor	2.00	1.57		1.40	
	True RMS Voltage	125.6	124								
	Peak Voltage	175.2	174.8			Voltage Crest Factor	1.39	1.41			

Building 9733-2											
Panel Label											
Main Size	Measured Values					Calculated Values					Date/
Voltage Type		Phase A	Phase B	Phase C	Neutral		Phase A	Phase B	Phase C	Neutral	Time
LTG PNL A	True RMS Current	66	56		14						20-Jul
225 A	Average Current	66	58		13	Current Form Factor	1.00	0.97		1.08	13:00
120/240 V	Peak Current	92	72		20	Current Crest Factor	1.39	1.29		1.43	
	True RMS Voltage	120.3	120.8								
	Peak Voltage	167.2	166			Voltage Crest Factor	1.39	1.37			
LTG PNL B	True RMS Current	66	64		16						20-Jul
225 A	Average Current	60	64		12	Current Form Factor	1.10	1.00		1.33	13:30
120/240 V	Peak Current	124	100		32	Current Crest Factor	1.88	1.56		2.00	
	True RMS Voltage	120.8	120.8								
	Peak Voltage	166	166			Voltage Crest Factor	1.37	1.37			
LTG PNL C	True RMS Current	52	44		13						20-Jul
225 A	Average Current	48	44		9.5	Current Form Factor	1.08	1.00		1.37	14:00
120/240 V	Peak Current	96	52		24	Current Crest Factor	1.85	1.18		1.85	
	True RMS Voltage	120	120.8								
	Peak Voltage	164.8	168			Voltage Crest Factor	1.37	1.39			
LTG PNL D	True RMS Current	72	40		38						20-Jul
225 A	Average Current	82	50		35	Current Form Factor	0.88	0.80		1.09	14:30
120/240 V	Peak Current	92	76		48	Current Crest Factor	1.28	1.90		1.28	
	True RMS Voltage	118.7	120.8								
	Peak Voltage	164	166.8			Voltage Crest Factor	1.38	1.38			
LP-184-1A	True RMS Current	13	16	6	11						20-Jul
225 A	Average Current	12	10	5	9	Current Form Factor	1.08	1.60	1.20	1.22	13:45
120/240 V	Peak Current	32	32	16	16	Current Crest Factor	2.46	2.00	2.67	1.45	
	True RMS Voltage	123.8	124	123.2							
	Peak Voltage	172.8	173.2	173.2		Voltage Crest Factor	1.40	1.40	1.41		

Appendix B

Fluorescent Ballast Harmonic Data

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Martin Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

APPENDIX B - CONTENTS

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Harmonic Current and Voltage Comparison for Magnetic and Electronic Ballasts

Building 3147, First Floor - Lighting Panel B

Harmonic	Phase A Current Spectrum			Phase B Current Spectrum			Phase C Current Spectrum			Neutral Current Spectrum		
	Magnetic Ballast	Electronic Ballast	% Change	Magnetic Ballast	Electronic Ballast	% Change	Magnetic Ballast	Electronic Ballast	% Change	Magnetic Ballast	Electronic Ballast	% Change
THD:	8.4	13.9	65%	10.5	14.3	36%	19.4	20.6	6%	171.2	44.0	-74%
3rd	6.7	3.4	-49%	9.4	2.4	-74%	15.8	5.0	-68%	169.8	11.9	-93%
5th	4.8	8.1	69%	4.4	8.9	102%	11.0	18.0	64%	16.6	31.6	90%
7th	1.4	5.3	279%	1.3	5.1	292%	2.0	5.3	165%	3.3	3.7	12%
9th	0.6	3.7	517%	0.7	3.8	443%	1.1	4.2	282%	12.7	20.1	58%
11th	0.3	3.8	1167%	0.3	3.8	1167%	0.0	2.8		2.3	2.0	-13%
13th	0	3.7		0.2	3.6	1700%	0.6	2.9	383%	2.5	4.1	64%
15th	0	2.5		0	2.6		0.3	1.1	267%	3.4	10.1	197%
17th	0	2.4		0	2.2		0.2	1.7	750%	0	3.2	
19th	0	2.6		0	2.5		0	1.6		0.7	3.1	343%
21st	0	2.4		0	2.3		0	1.3		0.5	9.6	1820%
23rd	0	2.0		0	2.1		0	1.1		0	1.5	
25th	0	2.2		0	2.5		0	0.9		0.4	3.7	825%
27th	0	1.9		0	2.1		0	1.0		0	8.2	
29th	0	1.7		0	2.1		0	0.6		0	3.0	
31st	0	1.7		0	2.1		0	0.6		0	3.5	
33rd	0	1.6		0	1.9		0	0.7		0	6.4	
RMS (A)	41.9	7.6	-82%	46.8	16.1	-66%	30.3	17.7	-42%	13.2	8.0	-39%
RMS (V)	123.2	124.7	1%	124.5	125.7	1%	124.5	125.0	0%			
THD (V)	2.7	3.6	33%	2.6	3.8	46%	2.6	3.7	42%			

Harmonic Current and Voltage Comparison for Magnetic and Electronic Ballasts

Building 3147, Second Floor - Lighting Panel D

	Phase A Current Spectrum			Phase B Current Spectrum			Phase C Current Spectrum			Neutral Current Spectrum		
	Magnetic	Electronic	%	Magnetic	Electronic	%	Magnetic	Electronic	%	Magnetic	Electronic	%
Harmonic	Ballast	Ballast	Change	Ballast	Ballast	Change	Ballast	Ballast	Change	Ballast	Ballast	Change
THD:	14.2	16.7	18%	15	15.1	1%	15.7	22.5	43%	111.3	126.6	14%
3rd	10.4	4.9	-53%	11.7	2.2	-81%	12.8	15.8	23%	109.0	49.7	-54%
5th	9.1	10.1	11%	8.9	9.8	10%	8.6	8.6	0%	16.5	65.3	296%
7th	2.8	6.2	121%	2.6	5.4	108%	2.2	8.2	273%	4.9	40.2	720%
9th	1.5	4.5	200%	1.3	4	208%	1.6	7.1	344%	13.6	64.4	374%
11th	0.8	4.1	413%	0.7	4	471%	0.9	4.1	356%	1.5	4.4	193%
13th	0.4	4	900%	0.5	3.5	600%	0.7	3.9	457%	1.2	0.7	-42%
15th	0.3	2.7	800%	0.4	2.7	575%	0.3	2.7	800%	2.9	34.0	1072%
17th	0.3	2.3	667%	0.2	2.4	1100%	0	1.1		0.5	6.7	1240%
19th	0	2.8		0	2.7		0	1.9		1.7	3.5	106%
21st	0	2.5		0	2.5		0	1.2		1.4	27.3	1850%
23rd	0	2.5		0	2.3		0	1.8		0.2	7.1	3450%
25th	0	2.5		0	2.3		0	2		0	2.1	
27th	0	2.4		0	2.1		0	1.8		0.4	27.1	6675%
29th	0	2.2		0	2.1		0	1.6		0	5.2	
31st	0	2.1		0	2		0	1.2		0	3.4	
33rd	0	2.4		0	2.2		0	1.4		0	25.7	
RMS (A)	27.6	7.6	-72%	34.9	16.1	-54%	41.7	17.7	-58%	16.0	8.0	-50%
RMS (V)	122.7	124.8	2%	124.0	126.0	2%	123.5	125.2	1%			
THD (V)	2.2	3.4	55%	2.2	3.9	77%	2.6	3.4	31%			

STATUS REPORT

9:33 AM

PH A-NEUT (Voltage Channel 1)

Voltage: 123.2 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 124.5 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 124.5 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.1 Vrms
High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 41.9 Arms

PHASE B (Current Channel 2)

Current: 46.8 Arms

PHASE C (Current Channel 3)

Current: 30.3 Arms

NEUT (Current Channel 4)

Current: 13.2 Arms

HARMONIC REPORT

9:34 AM

3147 PANEL B MAG

Aug 25, 1994

PH A-NEUT VOLTAGE SPECTRUM

9:34:17.49 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	0ø	
3rd	0.7%	115ø	
5th	2.5%	178ø	
7th	0.5%	34ø	
Odd: 2.7%		Even: 0.0%	
Thd: 2.7%

PHASE A CURRENT SPECTRUM

9:34:17.49 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.3%	273°
3rd	6.7%	300°	4th		
5th	4.8%	347°	6th		
7th	1.4%	81°	8th		
9th	0.6%	184°	10th		
11th	0.3%	253°			
Odd: 8.4%			Even: 0.3%		
Thd: 8.4%

PH B-NEUT VOLTAGE SPECTRUM

9:34:17.49 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.5%	146°	4th		
5th	2.6%	173°	6th		
7th	0.2%	10°			
Odd: 2.6%			Even: 0.0%		
Thd: 2.6%

PHASE B CURRENT SPECTRUM

9:34:17.49 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	9.4%	231°	4th		
5th	4.4%	225°	6th		
7th	1.3%	276°	8th		
9th	0.7%	312°	10th		
11th	0.3%	11°	12th		
13th	0.2%	33°			
Odd: 10.5%			Even: 0.0%		
Thd: 10.5%

PH C-NEUT VOLTAGE SPECTRUM

9:34:17.49 AM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase		Sine	Harmonic Percent Phase		Sine
Fund	100.0%	0°	2nd		
3rd	0.5%	141°	4th		
5th	2.6%	173°	6th		
7th	0.3%	357°			
Odd: 2.6%			Even: 0.0%		
Thd: 2.6%

PHASE C CURRENT SPECTRUM

9:34:17.49 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.3%	236°
3rd	15.8%	287°	4th		
5th	11.0%	301°	6th		
7th	2.0%	43°	8th		
9th	1.1%	80°	10th		
11th			12th		
13th	0.6%	190°	14th		
15th	0.3%	318°	16th		
17th	0.2%	15°			
Odd: 19.4%			Even: 0.3%		
Thd: 19.4%

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.6%	99°
3rd	169.8%	91°	4th	0.3%	58°
5th	16.6%	231°	6th	0.5%	321°
7th	3.3%	129°	8th		
9th	12.7%	243°	10th		
11th	2.3%	257°	12th		
13th	2.5%	205°	14th		
15th	3.4%	98°	16th		
17th			18th		
19th	0.7%	171°	20th		
21st	0.5%	189°	22nd		
23rd			24th		
25th	0.4%	114°			
Odd: 171.2%			Even: 0.8%		
Thd: 171.2%

STATUS REPORT

9:23 AM

PH A-NEUT (Voltage Channel 1)

Voltage: 124.7 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 125.7 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 125.0 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.0 Vrms
High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 7.6 Arms

PHASE B (Current Channel 2)

Current: 16.1 Arms

PHASE C (Current Channel 3)

Current: 17.7 Arms

NEUT (Current Channel 4)

Current: 8.0 Arms

HARMONIC REPORT

9:24 AM

3147 PANEL B ELECTR

Oct 25, 1994

PH A-NEUT VOLTAGE SPECTRUM

9:24:07.79 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.9%	125°	4th		
5th	3.5%	141°	6th		
7th	0.4%	101°	8th		
9th	0.3%	281°	10th		
11th	0.2%	156°			
Odd: 3.6%			Even: 0.0%		
Thd: 3.6%

PHASE A CURRENT SPECTRUM

9:24:07.79 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	3.4%	90°	4th		
5th	8.1%	151°	6th		
7th	5.3%	86°	8th		
9th	3.7%	344°	10th		
11th	3.8%	246°	12th		
13th	3.7%	169°	14th		
15th	2.5%	84°	16th		
17th	2.4%	353°	18th		
19th	2.6%	268°	20th		
21st	2.4%	179°	22nd		
23rd	2.0%	84°	24th		
25th	2.2%	352°	26th		
27th	1.9%	252°	28th		
29th	1.7%	160°	30th		
31st	1.7%	51°	32nd		
33rd	1.6%	315°			
Odd: 13.9%			Even: 0.0%		
Thd: 13.9%

PH B-NEUT VOLTAGE SPECTRUM

9:24:07.79 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd			4th		
5th	3.8%	135°	6th		
7th	0.3%	114°	8th		
9th			10th		
11th	0.2%	164°			
Odd: 3.8%			Even: 0.0%		
Thd: 3.8%

HASE B CURRENT SPECTRUM

9:24:07.79 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.6%	124°
3rd	2.4%	63°	4th		
5th	8.9%	198°	6th		
7th	5.1%	133°	8th		
9th	3.8%	54°	10th		
11th	3.8%	330°	12th		
13th	3.6%	271°	14th		
15th	2.6%	201°	16th		
17th	2.2%	119°	18th		
19th	2.5%	57°	20th		
21st	2.3%	346°	22nd		
23rd	2.1%	268°	24th		
25th	2.5%	186°	26th		
27th	2.1%	107°	28th		
29th	2.1%	15°	30th		
31st	2.1%	289°	32nd		
33rd	1.9%	200°			
Odd: 14.3%			Even: 0.6%		
Thd: 14.3%

PH C-NEUT VOLTAGE SPECTRUM

9:24:07.79 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.3%	129°	4th		
5th	3.7%	131°	6th		
7th	0.3%	95°	8th		
9th	0.3%	271°			
Odd: 3.7%			Even: 0.0%		
Thd: 3.7%

PHASE C CURRENT SPECTRUM

9:24:07.79 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	5.0%	332°	4th		
5th	18.0%	190°	6th		
7th	5.3%	114°	8th		
9th	4.2%	353°	10th		
11th	2.8%	266°	12th		
13th	2.9%	207°	14th		
15th	1.1%	127°	16th		
17th	1.7%	66°	18th		
19th	1.6%	327°	20th		
21st	1.3%	271°	22nd		
23rd	1.1%	157°	24th		
25th	0.9%	76°	26th		
27th	1.0%	7°	28th		
29th	0.6%	282°	30th		
31st	0.6%	185°	32nd		
33rd	0.7%	101°			
Odd: 20.6%			Even: 0.0%		
Thd: 20.6%

NEUT CURRENT SPECTRUM

9:24:07.79 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	1.3%	169°
3rd	11.9%	187°	4th		
5th	31.6%	151°	6th		
7th	3.7%	113°	8th		
9th	20.1%	183°	10th		
11th	2.0%	269°	12th		
13th	4.1%	181°	14th		
15th	10.1%	310°	16th		
17th	3.2%	48°	18th		
19th	3.1%	278°	20th		
21st	9.6%	73°	22nd		
23rd	1.5%	184°	24th		
25th	3.7%	356°	26th		
27th	8.2%	168°	28th		
29th	3.0%	280°	30th		
31st	3.5%	54°	32nd		
33rd	6.4%	240°			
Odd: 44.0%			Even: 1.3%		
Thd: 44.0%

STATUS REPORT

10:32 AM

PH A-NEUT (Voltage Channel 1)

Voltage: 122.7 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 124.0 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 123.5 Vrms
Frequency: 60.0 Hz
High freq noise: 0.3 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.0 Vrms
High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 27.6 Arms

PHASE B (Current Channel 2)

Current: 34.9 Arms

PHASE C (Current Channel 3)

Current: 41.7 Arms

NEUT (Current Channel 4)

Current: 16.0 Arms

HARMONIC REPORT

10:33 AM

3147 PANEL D MAG

Aug 25, 1994

PH A-NEUT VOLTAGE SPECTRUM

10:33:38.93 AM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase

Sine

Sine
Harmonic Percent Phase

Fund	100.0%	0°
3rd	0.7%	90°
5th	2.1%	177°
7th	0.5%	32°

2nd

4th

6th

Odd: 2.2%

Even: 0.0%

Thd: 2.2%

PHASE A CURRENT SPECTRUM

10:33:38.93 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.9%	263°
3rd	10.4%	253°	4th		
5th	9.1%	288°	6th		
7th	2.8%	336°	8th		
9th	1.5%	54°	10th		
11th	0.8%	116°	12th		
13th	0.4%	174°	14th		
15th	0.3%	246°	16th		
17th	0.3%	297°			
Odd: 14.2%			Even: 0.9%		
Thd: 14.2%

3147 PANEL D MAG

Aug 25, 1994

PH B-NEUT VOLTAGE SPECTRUM

10:33:38.93 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	0.2%	48°	4th		
5th	2.2%	180°	6th		
7th	0.3%	26°	8th		
9th	0.2%	283°	10th		
11th	0.2%	330°			
Odd: 2.2%			Even: 0.0%		
Thd: 2.2%

PHASE B CURRENT SPECTRUM

10:33:38.93 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.4%	172°
3rd	11.7%	261°	4th		
5th	8.9%	291°	6th		
7th	2.6%	338°	8th		
9th	1.3%	51°	10th		
11th	0.7%	116°	12th		
13th	0.5%	179°	14th		
15th	0.4%	267°	16th		
17th	0.2%	298°			
Odd: 15.0%			Even: 0.4%		
Thd: 15.0%

PH C-NEUT VOLTAGE SPECTRUM

10:33:38.93 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.7%	93°	4th		
5th	2.4%	182°	6th		
7th	0.5%	29°	8th		
9th	0.2%	254°	10th		
11th	0.2%	245°	12th		
13th	0.2%	47°			
Odd: 2.6%			Even: 0.0%		
Thd: 2.6%

HASE C CURRENT SPECTRUM

10:33:38.93 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.9%	263°
3rd	12.8%	237°	4th		
5th	8.6%	299°	6th		
7th	2.2%	292°	8th		
9th	1.6%	35°	10th		
11th	0.9%	76°	12th		
13th	0.7%	173°	14th		
15th	0.3%	211°			
Odd: 15.7%			Even: 0.9%		
Thd: 15.7%

NEUT CURRENT SPECTRUM

10:33:38.93 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	3.2%	115°
3rd	109.0%	325°	4th	0.4%	126°
5th	16.5%	124°	6th	0.3%	323°
7th	4.9%	55°	8th	0.4%	258°
9th	13.6%	274°	10th		
11th	1.5%	341°	12th	0.3%	69°
13th	1.2%	171°	14th		
15th	2.9%	260°	16th		
17th	0.5%	89°	18th		
19th	0.7%	20°	20th		
21st	1.4%	205°	22nd		
23rd	0.2%	233°	24th		
25th			26th		
27th	0.4%	193°			
Odd: 111.3%			Even: 3.3%		
Thd: 111.3%

STATUS REPORT

9:46 AM

PH A-NEUT (Voltage Channel 1)

Voltage: 124.8 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 126.0 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 125.2 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.0 Vrms
High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 10.5 Arms

PHASE B (Current Channel 2)

Current: 12.8 Arms

PHASE C (Current Channel 3)

Current: 10.4 Arms

NEUT (Current Channel 4)

Current: 3.6 Arms

HARMONIC REPORT

9:47 AM

PH A-NEUT VOLTAGE SPECTRUM

9:47:11.35 AM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase

		Sine
Fund	100.0%	0°
3rd	0.8%	111°
5th	3.3%	135°
7th	0.4%	77°
9th	0.3%	310°

Harmonic Percent Phase

	Sine
2nd	
4th	
6th	
8th	

Odd:	3.4%
Thd:	3.4%

Even:	0.0%
-------	------

PHASE A CURRENT SPECTRUM

9:47:11.35 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	4.9%	53°	4th		
5th	10.1%	155°	6th		
7th	6.2%	77°	8th		
9th	4.5%	338°	10th		
11th	4.1%	236°	12th		
13th	4.0%	160°	14th		
15th	2.7%	73°	16th		
17th	2.3%	346°	18th		
19th	2.8%	257°	20th		
21st	2.5%	173°	22nd		
23rd	2.5%	81°	24th		
25th	2.5%	341°	26th		
27th	2.4%	245°	28th		
29th	2.2%	151°	30th		
31st	2.1%	49°	32nd		
33rd	2.4%	307°			
Odd: 16.7%			Even: 0.0%		
Thd: 16.7%

PH B-NEUT VOLTAGE SPECTRUM

9:47:11.35 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	2nd	
3rd		4th	
5th	3.9%	6th	
7th		8th	
9th	0.2%	10th	
11th	0.2%		
Odd: 3.9%		Even: 0.0%	
Thd: 3.9%

PHASE B CURRENT SPECTRUM

9:47:11.35 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.7%	117°
3rd	2.2%	56°	4th		
5th	9.8%	169°	6th		
7th	5.4%	93°	8th		
9th	4.0%	3°	10th		
11th	4.0%	268°	12th		
13th	3.5%	198°	14th		
15th	2.7%	120°	16th		
17th	2.4%	31°	18th		
19th	2.7%	310°	20th		
21st	2.5%	229°	22nd		
23rd	2.3%	140°	24th		
25th	2.3%	44°	26th		
27th	2.1%	320°	28th		
29th	2.1%	229°	30th		
31st	2.0%	129°	32nd		
33rd	2.2%	34°			
Odd: 15.1%			Even: 0.7%		
Thd: 15.1%

PH C-NEUT VOLTAGE SPECTRUM

9:47:11.35 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.4%	78°	4th		
5th	3.3%	126°	6th		
7th	0.4%	88°	8th		
9th	0.5%	291°	10th		
11th	0.2%	151°			
Odd: 3.4%			Even: 0.0%		
Thd: 3.4%

PHASE C CURRENT SPECTRUM

9:47:11.35 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	1.0%	286°
3rd	15.8%	180°	4th	0.9%	119°
5th	8.6%	42°	6th	0.7%	320°
7th	8.2%	166°	8th	0.5%	166°
9th	7.1%	7°	10th	0.3%	336°
11th	4.1%	243°	12th	0.2%	245°
13th	3.9%	174°	14th		
15th	2.7%	62°	16th		
17th	1.1%	341°	18th		
19th	1.9%	272°	20th		
21st	1.2%	202°	22nd		
23rd	1.8%	122°	24th		
25th	2.0%	3°	26th		
27th	1.8%	277°	28th		
29th	1.6%	171°	30th		
31st	1.2%	70°	32nd		
33rd	1.4%	343°			
Odd: 22.4%			Even: 1.7%		
Thd: 22.5%

NEUT CURRENT SPECTRUM

9:47:11.35 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	6.8%	353°
3rd	49.7%	202°	4th	3.3%	143°
5th	65.3%	324°	6th	2.3%	228°
7th	40.2%	86°	8th	2.3%	12°
9th	64.4%	146°	10th	1.3%	126°
11th	4.4%	80°	12th	1.0%	261°
13th	0.7%	248°	14th	0.5%	339°
15th	34.0%	333°	16th	0.6%	166°
17th	6.7%	335°	18th	0.5%	255°
19th	3.5%	191°	20th	0.6%	6°
21st	27.3%	183°	22nd	0.4%	181°
23rd	7.1%	138°	24th		
25th	2.1%	342°	26th		
27th	27.1%	3°	28th	0.3%	339°
29th	5.2%	330°	30th	0.2%	208°
31st	3.4%	176°	32nd		
33rd	25.7%	166°			
Odd: 126.4%			Even: 8.5%		
Thd: 126.6%

Appendix C

Variable Frequency Drive Harmonic Data

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Martin Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

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STATUS REPORT

10:09 AM

PHASE A-B (Voltage Channel 1)

Voltage: 477.9 Vrms

Frequency: 60.0 Hz

High freq noise: 9.7 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 479.8 Vrms

Frequency: 60.0 Hz

High freq noise: 9.4 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 477.5 Vrms

Frequency: 60.0 Hz

High freq noise: 10.6 Vpp

PHASE A (Current Channel 1)

Current: 1.4 Arms

PHASE B (Current Channel 2)

Current: 1.8 Arms

PHASE C (Current Channel 3)

Current: 1.6 Arms

HARMONIC REPORT

10:10 AM

HASE A-B VOLTAGE SPECTRUM

10:10:11.28 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic Percent Phase		Harmonic Percent Phase	
Fund	100.0%	0°	
3rd		2nd	
5th	1.1%	4th	
7th	0.5%	6th	
Odd:	1.2%	Even:	0.0%
Thd:	1.2%

PHASE A CURRENT SPECTRUM

10:10:11.28 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	24.0%	257°	4th		
5th	74.0%	156°	6th		
7th	57.7%	342°	8th		
9th	6.4%	243°	10th	0.7%	8°
11th	27.3%	127°	12th		
13th	19.6%	289°	14th		
15th	3.5%	97°	16th		
17th	9.8%	32°	18th		
19th	10.4%	195°	20th	0.4%	233°
21st	1.3%	81°	22nd	0.4%	10°
23rd	4.8%	323°	24th		
25th	4.7%	103°	26th		
27th	1.8%	222°	28th		
29th	1.7%	263°	30th		
31st	2.6%	340°	32nd		
33rd	1.5%	132°			
Odd: 104.1%			Even: 0.9%		
Thd: 104.1%

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic Percent Phase		Harmonic Percent Phase	
Fund	100.0%	0ø	
3rd		2nd	
5th	1.4%	4th	
7th	0.6%	6th	
Odd: 1.5%		Even: 0.0%	
Thd: 1.5%

PHASE B CURRENT SPECTRUM

10:10:11.28 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	7.9%	239°	4th		
5th	71.5%	173°	6th		
7th	62.2%	353°	8th		
9th	8.8%	189°	10th	0.6%	199°
11th	23.2%	147°	12th		
13th	19.5%	312°	14th	0.4%	55°
15th	3.9%	134°	16th		
17th	9.5%	60°	18th		
19th	10.1%	228°	20th		
21st	2.7%	35°	22nd	0.3%	71°
23rd	2.8%	251°	24th		
25th	3.6%	214°	26th		
27th	1.0%	359°	28th		
29th	1.5%	241°	30th		
31st	1.7%	27°	32nd		
33rd	0.9%	192°			
Odd: 101.4%			Even: 0.7%		
Thd: 101.5%

PHASE C-A VOLTAGE SPECTRUM

10:10:11.28 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic Percent Phase		Harmonic Percent Phase	
Fund	100.0%	0°	
3rd			
5th	1.3%	254°	
7th	0.6%	347°	
9th			
11th	0.2%	117°	
Odd: 1.5%		Even: 0.0%	
Thd: 1.5%

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	30.5%	110°	4th		
5th	76.2%	238°	6th		
7th	53.4%	58°	8th		
9th	13.1%	138°	10th		
11th	31.7%	278°	12th		
13th	14.1%	91°	14th	0.4%	216°
15th	7.5%	115°	16th		
17th	13.5%	274°			
19th	6.4%	68°			
21st	3.8%	13°		0.6%	344°
23rd	6.4%	271°			
25th	1.5%	95°			
27th	2.9%	62°			
29th	2.9%	296°			
31st	0.2%	186°	30th		
33rd	2.1%	13°	32nd	0.2%	56°
Odd: 106.4%			Even: 0.7%		
Thd: 106.4%

STATUS REPORT

10:19 AM

PHASE A-B (Voltage Channel 1)

Voltage: 435.6 Vrms

Frequency: 509.7 Hz

High freq noise: 20.0 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 437.1 Vrms

Frequency: 507.9 Hz

High freq noise: 20.0 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 438.9 Vrms

Frequency: 507.9 Hz

High freq noise: 20.0 Vpp

PHASE A (Current Channel 1)

Current: 2.8 Arms

PHASE B (Current Channel 2)

Current: 2.8 Arms

PHASE C (Current Channel 3)

Current: 2.7 Arms

HARMONIC REPORT

10:19 AM

PHASE A-B SNAPSHOT

PHASE A-B VOLTAGE

PHASE A CURRENT

5.0 milliseconds/division horizontal

9113 AB VS DR LOAD

Jun 13, 1994

10:19:40 AM

HASE A-B VOLTAGE SPECTRUM

10:19:40.19 AM

Fundamental frequency: 50.6 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd			4th	0.8%	17°
5th	1.0%	140°	6th		
7th			8th		
9th			10th		
11th	0.3%	121°	12th		
13th	0.2%	342°	14th		
15th			16th	1.0%	16°
17th	11.0%	255°	18th		
19th	18.8%	241°	20th	5.4%	247°
21st			22nd	6.2%	241°
23rd	21.7%	67°	24th		
25th	13.7%	54°	26th	1.9%	58°
27th			28th	0.8%	354°
29th	0.6%	206°	30th		
31st	0.4%	130°	32nd		
33rd			34th	0.6%	214°
35th	2.1%	27°	36th		
37th	9.6%	278°	38th	4.4%	270°
Odd:	35.1%		Even:	9.6%	
Thd:	36.4%

PHASE A CURRENT SPECTRUM

10:19:40.19 AM

Fundamental frequency: 50.5 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	1.6%	52°	4th	2.5%	103°
5th	4.9%	186°	6th		
7th			8th		
9th			10th		
11th	0.5%	33°	12th		
13th	0.6%	143°	14th		
15th			16th		
17th	8.3%	332°	18th		
19th	13.1%	75°	20th	3.5%	55°
21st	0.3%	62°	22nd	3.8%	171°
23rd	13.1%	330°	24th		
25th	7.5%	74°	26th		
27th	0.2%	37°	28th	0.4%	179°
29th	0.3%	203°	30th		
31st	0.3%	49°	32nd		
33rd			34th	0.3%	174°
35th	0.7%	338°	36th		
37th	3.3%	330°	38th	1.5%	294°
39th	0.3%	195°			
Odd: 22.6%			Even: 6.0%		
Thd: 23.3%

PHASE B-C VOLTAGE SPECTRUM

10:19:40.19 AM

Fundamental frequency: 50.6 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd			4th	0.7%	16°
5th	0.8%	143°	6th		
7th			8th	0.2%	91°
9th			10th		
11th	0.3%	134°	12th		
13th			14th	0.3%	224°
15th			16th	1.1%	100°
17th	11.0%	256°	18th		
19th	18.8%	242°	20th	5.3%	248°
21st			22nd	6.2%	245°
23rd	21.6%	67°	24th		
25th	13.7%	54°	26th	1.9%	52°
27th			28th	0.7%	354°
29th	0.7%	187°	30th		
31st	0.3%	136°	32nd		
33rd			34th	0.7%	210°
35th	2.1%	29°	36th		
37th	9.4%	279°	38th	4.3%	269°
Odd:	35.0%		Even:	9.5%	
Thd:	36.2%

PHASE B CURRENT SPECTRUM

10:19:40.19 AM

Fundamental frequency: 50.5 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	2.7%	196°	4th	2.2%	97°
5th	3.3%	160°	6th		
7th	0.6%	285°	8th		
9th	0.3%	344°	10th		
11th	0.4%	354°	12th		
13th	0.4%	127°	14th	0.3%	36°
15th			16th	0.6%	284°
17th	8.3%	315°	18th		
19th	13.5%	54°	20th	3.4%	32°
21st	0.4%	165°	22nd	3.8%	150°
23rd	13.3%	307°	24th		
25th	7.5%	49°	26th	1.1%	37°
27th			28th	0.5%	91°
29th	0.2%	214°	30th		
31st	0.3%	21°	32nd		
33rd			34th	0.3%	108°
35th	0.8%	299°	36th		
37th	3.3%	294°	38th	1.5%	258°
39th	0.2%	44°			
Odd: 22.7%			Even: 5.9%		
Thd: 23.5%

PHASE C-A VOLTAGE SPECTRUM

10:19:40.19 AM

Fundamental frequency: 50.6 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd			4th	0.8%	9°
5th	1.0%	148°	6th		
7th			8th		
9th			10th		
11th	0.2%	137°	12th		
13th			14th	0.2%	212°
15th			16th	1.2%	84°
17th	11.1%	256°	18th		
19th	18.8%	242°	20th	5.4%	248°
21st			22nd	6.2%	243°
23rd	21.6%	67°	24th		
25th	13.7%	54°	26th	1.9%	64°
27th			28th	0.7%	351°
29th	0.7%	186°	30th		
31st	0.3%	116°	32nd		
33rd			34th	0.7%	216°
35th	2.1%	29°	36th		
37th	9.5%	279°	38th	4.4%	272°
Odd:	35.1%		Even:	9.6%	
Thd:	36.4%

PHASE C CURRENT SPECTRUM

10:19:40.19 AM

Fundamental frequency: 50.5 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	1.1%	85°	4th	2.2%	82°
5th	3.1%	200°	6th		
7th	0.8%	138°	8th		
9th	0.2%	169°	10th		
11th	0.4%	15°	12th		
13th	0.4%	117°	14th	0.3%	21°
15th			16th	0.7%	194°
17th	8.2%	319°	18th		
19th	13.3%	60°	20th	4.1%	39°
21st	0.3%	197°	22nd	3.9%	155°
23rd	13.3%	310°	24th		
25th	7.5%	53°	26th	1.0%	20°
27th	0.2%	91°	28th	0.4%	102°
29th	0.3%	237°	30th		
31st	0.3%	47°	32nd	0.2%	49°
33rd			34th	0.3%	155°
35th	0.7%	312°	36th	0.3%	351°
37th	3.5%	300°	38th	1.8%	264°
Odd: 22.4%			Even: 6.5%		
Thd: 23.4%

=====

9737 VS DR LINE

Jun 14, 1994

STATUS REPORT

10:24 AM

PHASE A-B (Voltage Channel 1)

Voltage: 447.6 Vrms
Frequency: 60.0 Hz
High freq noise: 20.0 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 452.7 Vrms
Frequency: 60.0 Hz
High freq noise: 20.0 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 450.0 Vrms
Frequency: 60.0 Hz
High freq noise: 20.0 Vpp

PHASE A (Current Channel 1)

Current: 63.1 Arms

PHASE B (Current Channel 2)

Current: 71.8 Arms

PHASE C (Current Channel 3)

Current: 58.3 Arms

=====

HARMONIC REPORT

10:22 AM

9737 VS DR LINE

Jun 14, 1994

PHASE A-B VOLTAGE SPECTRUM

10:22:09.31 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.5%	116°	4th		
5th	3.5%	189°	6th		
7th	1.6%	4°	8th		
9th			10th		
11th	0.3%	235°	12th		
13th	0.5%	351°			
Odd: 4.0%			Even: 0.0%		
Thd: 4.0%

PHASE A CURRENT SPECTRUM

10:22:09.31 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	25.3%	124°	4th		
5th	59.9%	228°	6th		
7th	38.8%	48°	8th		
9th			10th		
11th			12th		
13th	5.0%	298°	14th		
15th			16th		
17th	3.5%	109°	18th		
19th			20th		
21st	0.8%	259°	22nd		
23rd			24th	2.0%	52°
25th			26th	0.9%	118°
27th			28th		
29th			30th	1.2%	306°
31st			32nd	0.5%	65°
33rd	0.4%	184°			
Odd: 76.0%			Even: 2.6%		
Thd: 76.0%

PHASE B-C VOLTAGE SPECTRUM

10:22:09.31 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	0.3%	314°	4th		
5th	3.0%	184°	6th		
7th	1.5%	12°	8th		
9th	0.3%	260°	10th		
11th	0.2%	236°	12th		
13th	0.4%	349°			
Odd: 3.4%			Even: 0.0%		
Thd: 3.4%

PHASE B CURRENT SPECTRUM

10:22:09.31 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd			4th		
5th	57.6%	160°	6th		
7th	38.3%	336°	8th		
9th	3.9%	144°	10th		
11th			12th		
13th	5.1%	145°	14th		
15th			16th		
17th	1.9%	238°	18th		
19th			20th		
21st			22nd		
23rd	0.8%	41°	24th		
25th			26th	1.2%	33°
27th			28th	0.7%	240°
29th	0.5%	274°	30th		
31st			32nd	0.7%	355°
Odd:	69.5%		Even:	1.6%	
Thd:	69.5%

PHASE C-A VOLTAGE SPECTRUM

10:22:09.31 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	2nd	0%
3rd		4th	
5th	3.2%	6th	
7th	1.3%	8th	
9th	0.2%	10th	
11th	0.5%	12th	
13th	0.4%	14th	
15th		16th	
17th	0.3%		
Odd: 3.5%		Even: 0.0%	
Thd: 3.5%

PHASE C CURRENT SPECTRUM

10:22:09.31 AM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase		Sine	Harmonic Percent Phase		Sine
Fund	100.0%	0°	2nd		
3rd			4th		
5th	70.6%	142°	6th		
7th	33.6%	316°	8th		
9th	7.4%	282°	10th		
11th	4.9%	60°	12th		
13th	4.4%	103°	14th		
15th			16th		
17th	3.6%	219°	18th		
19th			20th		
21st			22nd		
23rd			24th	1.9%	119°
25th			26th	1.1%	223°
27th			28th		
29th			30th		
31st			32nd	0.7%	183°
Odd:	78.9%		Even:	2.3%	
Thd:	79.0%

=====

9737 VS DR LOAD

Jun 14, 1994

STATUS REPORT

10:15 AM

PHASE A-B (Voltage Channel 1)

Voltage: 343.4 Vrms

Frequency: 45.0 Hz

High freq noise: 20.0 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 331.4 Vrms

Frequency: 45.0 Hz

High freq noise: 20.0 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 356.2 Vrms

Frequency: 45.0 Hz

High freq noise: 20.0 Vpp

PHASE A (Current Channel 1)

Current: 78.3 Arms

PHASE B (Current Channel 2)

Current: 47.6 Arms

PHASE C (Current Channel 3)

Current: 85.0 Arms

=====

HARMONIC REPORT

10:15 AM

PHASE A-B VOLTAGE SPECTRUM

10:15:54.91 AM

Fundamental frequency: 45.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd			4th	2.2%	93°
5th			6th		
7th	1.7%	114°	8th		
9th	0.9%	20°	10th	1.2%	6°
11th			12th	0.5%	165°
13th	0.7%	15°	14th	0.4%	356°
15th	0.3%	263°	16th		
17th	0.5%	322°	18th		
19th	0.3%	160°	20th		
21st			22nd	0.3%	239°
23rd	0.2%	155°	24th	0.2%	156°
Odd: 2.1%			Even: 2.6%		
Thd: 3.3%

PHASE A CURRENT SPECTRUM

10:15:54.91 AM

Fundamental frequency: 45.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd			4th		
5th	2.2%	263°	6th		
7th	0.8%	266°	8th	0.6%	264°
9th	0.8%	316°	10th	1.1%	12°
11th	0.6%	242°	12th	0.6%	314°
13th	0.3%	197°	14th	0.3%	35°
15th	0.3%	300°	16th		
17th	0.3%	224°			
Odd: 2.6%			Even: 1.4%		
Thd: 2.9%

PHASE B-C VOLTAGE SPECTRUM

10:15:54.91 AM

Fundamental frequency: 45.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	3.0%	282°	4th	2.5%	333°
5th			6th		
7th	2.0%	43°	8th		
9th	0.8%	168°	10th		
11th	0.8%	359°	12th		
13th	0.8%	260°	14th		
15th			16th		
17th	0.5%	197°	18th		
19th	0.4%	104°	20th	0.2%	276°
21st			22nd	0.3%	110°
23rd			24th	0.2%	242°
25th	0.2%	255°	26th		
27th			28th	0.2%	312°
Odd:	3.8%		Even:	2.5%	
Thd:	4.6%

PHASE B CURRENT SPECTRUM

10:15:54.91 AM

Fundamental frequency: 45.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th	5.1%	187°
5th			6th	2.9%	96°
7th	2.1%	327°	8th	1.0%	48°
9th	0.9%	269°	10th	1.0%	41°
11th	0.9%	233°	12th		
13th	1.2%	182°	14th		
15th			16th		
17th	0.3%	127°	18th	0.2%	309°
19th	0.3%	18°			
Odd: 2.8%			Even: 6.0%		
Thd: 6.6%

PHASE C-A VOLTAGE SPECTRUM

10:15:54.91 AM

Fundamental frequency: 45.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th	1.5%	222°
5th			6th	0.9%	105°
7th	0.5%	43°	8th	0.5%	73°
9th			10th	0.8%	21°
11th	0.7%	48°	12th	0.5%	281°
13th	0.4%	275°	14th		
15th	0.3%	356°	16th		
17th	0.6%	209°	18th		
19th			20th		
21st			22nd		
23rd	0.3%	87°			
Odd:	1.2%		Even:	2.1%	
Thd:	2.4%

PHASE C CURRENT SPECTRUM

10:15:54.91 AM

Fundamental frequency: 45.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	4.7%	244°	4th	2.6%	83°
5th	2.7%	80°	6th	1.9%	267°
7th			8th	0.5%	28°
9th	0.5%	144°	10th		
11th	0.9%	247°	12th	0.7%	128°
13th	0.4%	111°	14th		
15th	0.2%	46°	16th		
17th	0.3%	25°			
Odd: 5.5%			Even: 3.3%		
Thd: 6.5%

Appendix D

Switch Mode Power Supply Harmonic Data

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Martin Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

APPENDIX D - CONTENTS

WAVEFORM SNAPSHOTS AND HARMONIC SPECTRUM DATA

Receptacle with Computer, Monitor, and Printer Switch Mode Power Supplies D-1

Three-Phase 120/208 V Panel with Many Single Phase Switch Mode Power Supplies ..D-9

STATUS REPORT

10:22

LINE-NEUT (Voltage Channel 1)

Voltage: 109.6 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

NEUT-GND (Voltage Channel 2)

Voltage: 0.8 Vrms

High freq noise: 0.1 Vpp

LINE (Current Channel 1)

Current: 10.5 Arms

NEUT (Current Channel 2)

Current: 10.9 Arms

HARMONIC REPORT

13:06

LINE-NEUT VOLTAGE SPECTRUM

13:06:42.56

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase

Sine

Fund	100.0%	0°
3rd	2.2%	26°
5th	2.7%	189°
7th	0.6%	11°
9th		
11th	0.3%	158°

Odd: 3.5%

Thd: 3.5%

Harmonic Percent Phase

Sine

2nd
4th
6th
8th
10th

Even: 0.0%

LINE CURRENT SPECTRUM

13:06:42.56

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	2.9%	243°
3rd	83.1%	174°	4th		
5th	56.8%	348°	6th	1.7%	333°
7th	29.5%	161°	8th	1.0%	316°
9th	8.8%	325°	10th	0.7%	72°
11th	3.2%	17°	12th	0.3%	6°
13th	4.3%	160°	14th	0.3%	247°
15th	1.6%	288°	16th	0.4%	229°
17th	2.9%	10°	18th	0.3%	10°
19th	3.7%	171°	20th		
21st	2.0%	348°	22nd	0.4%	354°
23rd	0.7%	300°	24th	0.4%	303°
25th	2.2%	133°	26th	0.3%	130°
27th	2.0%	306°	28th		
29th	0.6%	134°	30th	0.2%	187°
31st	0.8%	80°	32nd	0.3%	53°
33rd	1.2%	255°			
Odd: 105.6%			Even: 3.7%		
Thd: 105.6%

NEUT-GND VOLTAGE SPECTRUM

13:06:42.56

Fundamental frequency: 60.0 Hz

Harmonic	Percent	Phase	Sine	Harmonic	Percent	Phase	Sine
Fund	100.0%		0°	2nd	2.5%		113°
3rd	15.3%		203°	4th			
5th	4.7%		55°	6th	0.4%		102°
7th	4.2%		237°	8th			
9th	0.9%		353°	10th			
11th	1.4%		111°	12th			
13th	1.4%		265°	14th			
15th	0.4%		33°	16th			
17th	1.0%		136°	18th			
19th	0.8%		313°	20th			
21st				22nd			
23rd				24th			
25th	0.4%		39°	26th			
27th				28th			
29th	0.4%		116°	30th			
31st	0.4%		343°				
Odd:	16.8%			Even:	2.6%		
Thd:	17.0%

NEUT CURRENT SPECTRUM

13:06:42.56

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	2.9%	243°
3rd	83.2%	174°	4th		
5th	56.9%	348°	6th	1.7%	335°
7th	29.6%	161°	8th	1.0%	312°
9th	8.9%	324°	10th	0.7%	74°
11th	3.2%	19°	12th	0.4%	6°
13th	4.3%	160°	14th	0.3%	110°
15th	1.5%	285°	16th	0.4%	229°
17th	2.9%	8°	18th	0.3%	6°
19th	3.7%	172°	20th		
21st	2.0%	348°	22nd	0.3%	355°
23rd	0.8%	298°	24th	0.5%	307°
25th	2.3%	129°	26th	0.3%	126°
27th	2.0%	305°	28th		
29th	0.6%	124°	30th	0.2%	173°
31st	0.8%	77°	32nd	0.3%	42°
33rd	1.2%	248°			
Odd: 105.7%			Even: 3.7%		
Thd: 105.8%

STATUS REPORT

9:45 AM

PH A-NEUT (Voltage Channel 1)

Voltage: 120.2 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 119.1 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 120.2 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.6 Vrms

High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 21.7 Arms

PHASE B (Current Channel 2)

Current: 14.3 Arms

PHASE C (Current Channel 3)

Current: 28.0 Arms

NEUT (Current Channel 4)

Current: 27.2 Arms

HARMONIC REPORT

9:46 AM

PH A-NEUT VOLTAGE SPECTRUM

9:46:04.71 AM

Fundamental frequency: 60.0 Hz

Harmonic	Percent Phase	Sine	Harmonic	Percent Phase	Sine
Fund	100.0%	0°	2nd		
3rd	1.9%	60°	4th		
5th	2.2%	228°	6th		
7th	1.2%	20°	8th		
9th	0.7%	112°	10th		
11th	0.6%	212°	12th		
13th	0.5%	338°	14th		
15th	0.4%	89°	16th		
17th	0.3%	177°	18th		
19th	0.3%	305°	20th		
21st	0.2%	34°	22nd		
23rd	0.2%	147°	24th		
25th	0.2%	252°	26th		
27th	0.2%	333°	28th		
29th			30th		
31st			32nd		
33rd	0.2%	220°			
Odd:	3.5%		Even:	0.0%	
Thd:	3.5%

PHASE A CURRENT SPECTRUM

9:46:04.71 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	37.1%	167°	4th		
5th	24.1%	333°	6th		
7th	10.3%	131°	8th		
9th	4.3%	246°	10th		
11th	3.9%	357°	12th		
13th	2.6%	138°	14th		
15th	1.7%	245°	16th		
17th	1.5%	0°	18th		
19th	1.1%	136°	20th		
21st	0.9%	243°	22nd		
23rd	0.8%	0°	24th		
25th	0.7%	129°	26th		
27th	0.6%	227°	28th		
29th	0.5%	329°	30th		
31st	0.5%	75°	32nd		
33rd	0.5%	172°			
Odd: 46.0%			Even: 0.0%		
Thd: 46.0%

PH B-NEUT VOLTAGE SPECTRUM

9:46:04.71 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	2.7%	44°	4th		
5th	2.2%	231°	6th		
7th	1.2%	6°	8th		
9th	0.8%	109°	10th		
11th	0.6%	197°	12th		
13th	0.6%	325°	14th		
15th	0.4%	59°	16th		
17th	0.4%	153°	18th		
19th	0.3%	198°	20th		
21st	0.3%	353°	22nd		
23rd			24th		
25th	0.3%	189°			
Odd:	3.9%		Even:	0.0%	
Thd:	3.9%

PHASE B CURRENT SPECTRUM

9:46:04.71 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.4%	131°
3rd	38.3%	168°	4th		
5th	25.1%	339°	6th		
7th	11.4%	139°	8th		
9th	3.6%	257°	10th		
11th	3.2%	359°	12th		
13th	2.8%	137°	14th		
15th	1.9%	258°	16th		
17th	1.1%	20°	18th		
19th	1.0%	132°	20th		
21st	1.0%	240°	22nd		
23rd	0.6%	2°	24th		
25th	0.6%	115°	26th		
27th	0.7%	197°	28th		
29th	0.6%	305°	30th		
31st	0.4%	104°	32nd		
33rd	0.6%	126°			
Odd: 47.6%			Even: 0.4%		
Thd: 47.6%

PH C-NEUT VOLTAGE SPECTRUM

9:46:04.71 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	2.6%	47°	4th		
5th	2.2%	231°	6th		
7th	1.3%	9°	8th		
9th	0.8%	99°	10th		
11th	0.6%	208°	12th		
13th	0.6%	322°	14th		
15th	0.5%	55°	16th		
17th	0.4%	157°	18th		
19th	0.3%	199°	20th		
21st	0.3%	351°	22nd		
23rd	0.2%	100°	24th		
25th	0.3%	205°	26th		
27th			28th		
29th	0.2%	26°			
Odd:	3.9%		Even:	0.0%	
Thd:	3.9%

PHASE C CURRENT SPECTRUM

9:46:04.71 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.5%	124°
3rd	60.7%	187°	4th	0.3%	313°
5th	36.2%	6°	6th		
7th	13.1%	167°	8th		
9th	6.8%	268°	10th		
11th	6.8%	56°	12th		
13th	3.2%	201°	14th		
15th	2.7%	291°	16th		
17th	2.7%	77°	18th		
19th	1.6%	209°	20th		
21st	1.7%	310°	22nd		
23rd	1.6%	86°	24th		
25th	1.1%	216°	26th		
27th	1.0%	310°	28th		
29th	1.1%	75°	30th		
31st	0.8%	199°	32nd		
33rd	0.6%	294°			
Odd: 72.7%			Even: 0.6%		
Thd: 72.7%

NEUT-GND VOLTAGE SPECTRUM

9:46:04.71 AM

Fundamental frequency: 180.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	26.7%	350°	4th		
5th	14.1%	231°	6th	0.3%	60°
7th	9.3%	108°	8th		
9th	5.8%	333°	10th	0.3%	29°
11th	4.2%	191°			
Odd: 32.4%			Even: 0.4%		
Thd: 32.4%

NEUT CURRENT SPECTRUM

9:46:04.71 AM

Fundamental frequency: 60.1 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	213.9%	216°	4th		
5th	26.4%	33°	6th		
7th	5.1%	218°	8th		
9th	23.3%	20°	10th		
11th	6.6%	137°	12th		
13th			14th		
15th	9.8%	110°	16th		
17th	2.2%	215°	18th		
19th	1.0%	147°	20th		
21st	5.4%	188°	22nd		
23rd	1.2%	323°	24th		
25th	1.0%	220°	26th		
27th	3.0%	260°	28th		
29th	1.1%	37°	30th		
31st	0.9%	327°	32nd		
33rd	2.0%	287°			
Odd: 217.3%			Even: 0.0%		
Thd: 217.3%

Appendix E

Uninterruptible Power Supply Harmonic Data

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Martin Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

APPENDIX E - CONTENTS

WAVEFORM SNAPSHOTS AND HARMONIC SPECTRUM DATA

Three-Phase RTE Deltec UPS in Building 9710-3 480 V Input (Line)	E-1
Three-Phase RTE Deltec UPS in Building 9710-3 120/208 V Output (Load)	E-11
Split-Phase Best UPS in Building 9710-3 120/240 V Input (Line)	E-25

STATUS REPORT

8:46 AM

PHASE A-B (Voltage Channel 1)

Voltage: 456.8 Vrms

Frequency: 60.0 Hz

High freq noise: 16.3 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 457.3 Vrms

Frequency: 60.0 Hz

High freq noise: 16.6 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 458.8 Vrms

Frequency: 60.0 Hz

High freq noise: 17.1 Vpp

PHASE A (Current Channel 1)

Current: 17.9 Arms

PHASE B (Current Channel 2)

Current: 17.4 Arms

PHASE C (Current Channel 3)

Current: 17.4 Arms

HARMONIC REPORT

8:47 AM

9710.3 UPS LINE

Jun 3, 1994

PHASE A-B VOLTAGE SPECTRUM

8:47:37.43 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.2%	300°	4th		
5th	1.3%	181°	6th		
7th	0.2%	199°	8th		
9th			10th		
11th	0.3%	358°			
Odd: 1.4%			Even: 0.0%		
Thd: 1.4%

PHASE A CURRENT SPECTRUM

8:47:37.43 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.8%	97°
3rd	0.9%	287°	4th	0.2%	56°
5th	12.9%	8°	6th		
7th	4.6%	16°	8th		
9th	0.2%	111°	10th		
11th	10.0%	31°	12th		
13th	0.8%	108°	14th		
15th			16th		
17th	3.0%	42°	18th		
19th	2.4%	48°	20th		
21st			22nd		
23rd	3.2%	51°	24th		
25th	1.0%	62°	26th		
27th			28th		
29th	1.8%	45°	30th		
31st	1.5%	45°			
Odd: 17.9%			Even: 0.8%		
Thd: 17.9%

PHASE B-C VOLTAGE SPECTRUM

8:47:37.43 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	2nd	
3rd		4th	
5th	1.4%	6th	
7th	0.4%	8th	
9th		10th	
11th	0.4%		
Odd: 1.5%		Even: 0.0%	
Thd: 1.5%

PHASE B CURRENT SPECTRUM

8:47:37.43 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.9%	217°
3rd	0.7%	249°	4th	0.2%	312°
5th	14.5%	8°	6th		
7th	4.5%	30°	8th		
9th			10th		
11th	10.5%	39°	12th		
13th	0.9%	115°	14th		
15th			16th		
17th	3.2%	53°	18th		
19th	2.5%	62°	20th		
21st			22nd		
23rd	3.4%	66°	24th		
25th	1.1%	83°	26th		
27th			28th		
29th	1.9%	63°	30th		
31st	1.6%	65°			
Odd: 19.4%			Even: 0.9%		
Thd: 19.4%

PHASE C-A VOLTAGE SPECTRUM

8:47:37.43 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.8%	175°	6th		
7th	0.3%	179°	8th		
9th			10th		
11th	0.4%	0°	12th		
13th			14th		
15th			16th		
17th	0.2%	15°			
Odd: 1.8%			Even: 0.0%		
Thd: 1.8%

PHASE C CURRENT SPECTRUM

8:47:37.43 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.8%	327°
3rd	1.7%	81°	4th	0.2%	152°
5th	14.7%	4°	6th		
7th	5.1%	15°	8th		
9th			10th		
11th	10.4%	18°	12th		
13th	0.8%	86°	14th		
15th			16th		
17th	3.2%	21°	18th		
19th	2.6%	28°	20th		
21st			22nd		
23rd	3.4%	26°	24th		
25th	1.1%	34°	26th		
27th			28th		
29th	1.9%	10°	30th		
31st	1.6%	5°			
Odd: 19.7%			Even: 0.8%		
Thd: 19.7%

STATUS REPORT

9:17 AM

PH A-NEUT (Voltage Channel 1)

Voltage: 123.9 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 120.7 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 121.5 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.0 Vrms
High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 24.4 Arms

PHASE B (Current Channel 2)

Current: 28.8 Arms

PHASE C (Current Channel 3)

Current: 36.8 Arms

NEUT (Current Channel 4)

Current: 31.4 Arms

HARMONIC REPORT

9:18 AM

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	16.1%	89°	4th	0.4%	205°
5th	3.2%	98°	6th		
7th	3.0%	275°	8th		
9th	1.5%	238°	10th		
11th	0.2%	352°	12th		
13th	0.7%	97°	14th		
15th	0.4%	164°	16th		
17th	0.4%	121°	18th		
19th	0.3%	2°	20th		
21st	0.5%	214°	22nd		
23rd	0.5%	108°	24th		
25th	0.5%	332°	26th		
27th	0.3%	223°	28th		
29th	0.2%	128°			
Odd: 16.8%			Even: 0.4%		
Thd: 16.8%

PHASE A CURRENT SPECTRUM

9:18:18.84 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.2%	301°
3rd	24.6%	205°	4th	0.6%	340°
5th	12.0%	332°	6th	0.9%	175°
7th	21.1%	122°	8th	0.8%	31°
9th	11.8%	314°	10th	0.4%	309°
11th	4.9%	70°	12th	0.5%	220°
13th	7.7%	237°	14th	0.4%	68°
15th	4.4%	81°	16th		
17th	0.7%	24°	18th		
19th	2.0%	271°	20th		
21st	1.3%	108°	22nd		
23rd			24th		
25th	0.6%	313°	26th		
27th			28th		
29th	0.5%	145°	30th		
31st	0.6%	314°	32nd		
33rd	0.5%	99°			
Odd: 37.9%			Even: 1.6%		
Thd: 38.0%

PH B-NEUT VOLTAGE SPECTRUM

9:18:18.84 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.3%	325°
3rd	4.2%	132°	4th	0.4%	321°
5th	5.0%	28°	6th	0.3%	303°
7th	4.3%	28°	8th		
9th	1.2%	198°	10th		
11th			12th		
13th	1.0%	91°	14th		
15th	0.6%	160°	16th		
17th	0.4%	345°	18th		
19th	0.4%	114°	20th		
21st	0.4%	211°	22nd		
23rd	0.4%	337°	24th		
25th	0.3%	69°	26th		
27th	0.3%	219°	28th		
29th	0.3%	307°			
Odd: 8.0%			Even: 0.5%		
Thd: 8.1%

PHASE B CURRENT SPECTRUM

9:18:18.84 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	35.4%	225°	4th	0.6%	155°
5th	16.3%	104°	6th	0.8%	357°
7th	12.2%	20°	8th	0.6%	212°
9th	5.5%	227°	10th	0.4%	57°
11th	2.6%	227°	12th	0.3%	166°
13th	1.0%	108°	14th	0.4%	328°
15th	3.4%	70°	16th	0.3%	171°
17th	3.2%	269°	18th		
19th	0.5%	338°	20th		
21st	2.4%	139°	22nd		
23rd	1.5%	353°	24th		
25th	0.5%	261°	26th		
27th	0.5%	239°	28th		
29th	1.1%	89°	30th		
31st	0.6%	290°	32nd		
33rd	0.3%	257°			
Odd: 41.7%			Even: 1.4%		
Thd: 41.7%

PH C-NEUT VOLTAGE SPECTRUM

9:18:18.84 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	11.8%	7°	4th		
5th	1.9%	174°	6th		
7th	4.2%	190°	8th		
9th	1.1%	208°	10th		
11th			12th		
13th	0.8%	149°	14th		
15th	0.5%	179°	16th		
17th	0.4%	269°	18th		
19th	0.4%	255°	20th		
21st	0.5%	243°	22nd		
23rd	0.5%	248°	24th		
25th	0.3%	272°	26th		
27th	0.3%	261°	28th		
29th	0.3%	231°			
Odd: 12.8%			Even: 0.0%		
Thd: 12.8%

PHASE C CURRENT SPECTRUM

9:18:18.84 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	1.2%	30°
3rd	35.8%	230°	4th	1.4%	260°
5th	19.1%	84°	6th	1.0%	119°
7th	10.8%	303°	8th	0.3%	314°
9th	6.7%	154°	10th		
11th	2.1%	106°	12th	0.3%	156°
13th	4.5%	355°	14th		
15th	0.9%	175°	16th		
17th	2.4%	243°	18th		
19th	1.3%	59°	20th		
21st	0.3%	161°	22nd		
23rd	0.8%	297°	24th		
25th	0.9%	71°	26th		
27th	0.3%	161°	28th		
29th	0.6%	314°	30th		
31st	0.5%	113°	32nd		
33rd	0.4%	133°			
Odd: 42.9%			Even: 2.1%		
Thd: 43.0%

NEUT-GND VOLTAGE SPECTRUM

9:18:18.84 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	341.3%	136°	4th		
5th	117.6%	273°	6th		
7th	128.5%	150°	8th		
9th	53.6%	173°	10th		
11th	81.2%	167°	12th		
13th	10.1%	124°	14th		
15th			16th	10.9%	0°
17th	15.3%	288°	18th		
19th			20th		
21st	20.4%	147°	22nd	42.6%	119°
23rd	12.3%	101°	24th	10.7%	97°
25th	10.7%	6°	26th	14.0%	275°
27th	12.8%	185°	28th		
29th			30th	20.3%	83°
31st	8.5%	17°			
Odd: 396.9%			Even: 51.5%		
Thd: 400.3%

NEUT CURRENT SPECTRUM

9:18:18.84 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	3.1%	179°
3rd	188.0%	176°	4th	5.4%	17°
5th	42.6%	356°	6th	1.5%	251°
7th	44.2%	289°	8th		
9th	11.1%	351°	10th		
11th	0.9%	346°	12th	0.5%	193°
13th	3.0%	10°	14th		
15th	2.9%	320°	16th		
17th	2.0%	49°	18th		
19th	1.5%	60°	20th		
21st	2.1%	45°	22nd		
23rd	1.6%	72°	24th		
25th	1.2%	43°	26th		
27th	0.9%	82°	28th		
29th	0.9%	60°	30th		
31st	0.5%	28°			
Odd: 198.1%			Even: 6.4%		
Thd: 198.3%

STATUS REPORT

10:10 AM

LNE-NEU A (Voltage Channel 1)

Voltage: 197.0 Vrms

Frequency: 60.0 Hz

High freq noise: 2.4 Vpp

NEU-GND A (Voltage Channel 2)

Voltage: 113.2 Vrms

High freq noise: 3.7 Vpp

LNE-NEU B (Voltage Channel 3)

Voltage: 119.8 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

NEU-GND B (Voltage Channel 4)

Voltage: 0.0 Vrms

High freq noise: 0.2 Vpp

LINE A (Current Channel 1)

Current: 3.5 Arms

NEUT A (Current Channel 2)

Current: 3.6 Arms

LINE B (Current Channel 3)

Current: 1.5 Arms

EUT B (Current Channel 4)

Current: 1.2 Arms

HARMONIC REPORT

10:07 AM

LNE-NEU A VOLTAGE SPECTRUM

10:07:59.49 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	0.5%	166°	4th		
5th	1.2%	352°	6th		
7th	0.2%	97°	8th		
9th			10th		
11th	0.4%	356°			
Odd: 1.4%			Even: 0.0%		
Thd: 1.4%

LINE A CURRENT SPECTRUM

10:07:59.49 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	4.4%	63°
3rd	50.5%	235°	4th	3.3%	33°
5th	33.0%	209°	6th	1.2%	1°
7th	16.0%	153°	8th	0.2%	304°
9th	7.9%	137°	10th	0.3%	77°
11th	3.1%	17°	12th	0.2%	73°
13th	1.3%	133°	14th		
15th	2.4%	249°	16th		
17th	2.0%	77°	18th	0.2%	127°
19th	0.7%	116°	20th		
21st	1.5%	337°	22nd		
23rd	0.9%	119°	24th	0.2%	10°
25th	0.5%	220°	26th		
27th	0.6%	110°	28th		
29th			30th		
31st	0.4%	209°	32nd		
33rd	0.2%	97°			
Odd: 63.1%			Even: 5.7%		
Thd: 63.4%

NEU-GND A VOLTAGE SPECTRUM

10:07:59.49

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.5%	93°	4th		
5th	1.5%	160°	6th		
7th	0.3%	241°	8th		
9th			10th		
11th	0.4%	347°			
Odd: 1.7%			Even: 0.0%		
Thd: 1.7%

NEUT A CURRENT SPECTRUM

10:07:59.49 AM

Fundamental frequency: 60.0 Hz

Harmonic	Percent	Phase	Sine	Harmonic	Percent	Phase	Sine
Fund	100.0%	0°		2nd	4.5%	244°	
3rd	51.3%	238°		4th	3.3%	220°	
5th	33.5%	214°		6th	1.2%	189°	
7th	16.2%	159°		8th	0.2%	155°	
9th	8.0%	145°		10th	0.4%	259°	
11th	3.1%	30°		12th	0.4%	283°	
13th	1.3%	148°		14th			
15th	2.4%	268°		16th			
17th	2.0%	87°		18th	0.2%	329°	
19th	0.7%	202°		20th			
21st	1.6%	354°		22nd			
23rd	0.9%	146°		24th			
25th	0.5%	139°		26th			
27th	0.7%	55°		28th			
29th				30th			
31st	0.4%	321°					
Odd:	64.1%			Even:	5.7%		
Thd:	64.3%

LNE-NEU B VOLTAGE SPECTRUM

10:07:59.49 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.2%	194°
3rd	6.1%	4°	4th		
5th	3.5%	6°	6th		
7th	1.3%	170°	8th		
9th	2.1%	190°	10th		
11th	0.8%	183°	12th		
13th	0.9%	192°	14th		
15th			16th		
17th	0.4%	16°	18th		
19th			20th		
21st			22nd		
23rd			24th		
25th	0.3%	180°	26th		
27th			28th		
29th			30th		
31st			32nd		
33rd	0.2%	317°			
Odd:	7.5%		Even:	0.2%	
Thd:	7.5%

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	1.1%	136°
3rd	77.2%	204°	4th	1.0%	10°
5th	54.8%	31°	6th	1.2%	185°
7th	30.7%	227°	8th	0.9%	355°
9th	10.5%	59°	10th	0.5%	186°
11th	2.1%	31°	12th	0.3%	315°
13th	7.3%	263°	14th		
15th	6.5%	88°	16th	0.3%	212°
17th	3.0%	270°	18th	0.2%	126°
19th	0.4%	66°	20th		
21st	2.3%	128°	22nd	0.4%	29°
23rd	1.7%	221°	24th	0.3%	61°
25th	1.0%	74°	26th	0.2%	52°
27th	0.5%	172°	28th		
29th	1.0%	54°	30th		
31st	0.7%	160°	32nd	0.2%	45°
33rd	0.6%	266°			
Odd: 100.7%			Even: 2.3%		
Thd: 100.7%

'EU-GND B VOLTAGE SPECTRUM

10:07:59.49 AM

Fundamental frequency: 59.7 Hz

Sine
Harmonic Percent Phase

Fund	100.0%	0°
3rd	77.2%	335°
5th	49.5%	325°
7th	35.3%	6°
9th	35.3%	294°
11th	105.9%	293°
13th		
15th		
17th		
19th		
21st	18.6%	13°
23rd		
25th		
27th		
29th	17.7%	90°
31st		
33rd	21.2%	316°

Odd: 152.4%

Thd: 167.2%

Sine
Harmonic Percent Phase

2nd	13.9%	260°
4th		
6th	19.4%	113°
8th		
10th	19.3%	295°
12th	14.7%	105°
14th	16.2%	313°
16th		
18th	15.3%	32°
20th	14.9%	341°
22nd	45.2%	337°
24th	17.0%	186°
26th	19.4%	15°
28th		
30th		
32nd	12.6%	10°

Even: 68.9%

NEUT B CURRENT SPECTRUM

10:07:59.49 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	1.1%	329°
3rd	76.8%	201°	4th	1.1%	161°
5th	54.2%	28°	6th	1.1%	19°
7th	30.3%	224°	8th	0.8%	176°
9th	10.5%	50°	10th	0.3%	32°
11th	2.3%	29°	12th	0.2%	202°
13th	7.2%	254°	14th		
15th	6.4%	83°	16th	0.3%	178°
17th	3.1%	261°	18th	0.3%	329°
19th	0.5%	235°	20th	0.2%	313°
21st	1.9%	38°	22nd	0.2%	87°
23rd	2.1%	285°	24th		
25th	0.8%	156°	26th	0.2%	283°
27th	0.5%	106°	28th		
29th	1.0%	37°	30th	0.2%	327°
31st	0.6%	134°	32nd		
33rd	0.4%	175°			
Odd: 99.9%			Even: 2.2%		
Thd: 99.9%

Appendix F

Georator Geosine Harmonic Data

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Martin Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

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GEO SINE BY GEORATOR

Series 102 GeoSine Harmonic Line Conditioner

208V/120 Three Phase Y 60 Hz Only

Model No. 102-6020-Y

Serial No. 44862

Rated Current: 80 Amps

Weight, LBS: 570

Horsepower: 20 HP

Max. Amb. C: 50

Input Voltage: 208V/120 +/- 10% Volts

Output Voltage: +/- 5% of input with non-linear load

Patent Pending

Georator Corporation
9617 Center Street
Manassas, Virginia 22110

(800) 523-9936

Impedance of Geosine Filter

		Impedance of Parallel Filter (Ohms)	Impedance of Series Inductance (Ohms) $2 \cdot \pi \cdot f \cdot L$	Impedance of Parallel Inductance (Ohms) $2 \cdot \pi \cdot f \cdot L$	Impedance of Parallel Capacitance (Ohms) $-1/(2 \cdot \pi \cdot f \cdot C)$
Harmonic Order	Frequency (Hertz)				
0.01	0.6	0.04	0.01	0.04	-392.98
0.05	3	0.19	0.03	0.19	-78.60
0.1	6	0.39	0.06	0.39	-39.30
0.5	30	2.58	0.32	1.94	-7.86
1	60	326.45	0.64	3.88	-3.93
3	180	1.48	1.92	11.65	-1.31
5	300	0.82	3.20	19.42	-0.79
7	420	0.57	4.49	27.18	-0.56
9	540	0.44	5.77	34.95	-0.44
11	660	0.36	7.05	42.71	-0.36
13	780	0.30	8.33	50.48	-0.30
15	900	0.26	9.61	58.25	-0.26
17	1020	0.23	10.90	66.01	-0.23
19	1140	0.21	12.18	73.78	-0.21
21	1260	0.19	13.46	81.54	-0.19
23	1380	0.17	14.74	89.31	-0.17
25	1500	0.16	16.02	97.08	-0.16
27	1620	0.15	17.30	104.84	-0.15
29	1740	0.14	18.59	112.61	-0.14
31	1860	0.13	19.87	120.37	-0.13
33	1980	0.12	21.15	128.14	-0.12

GEOSINE MEASUREMENT POINTS

Harmonic Currents and Voltages with Geosine

Building 1505 - 1.7 mH Line Inductance with 10.3 mH Inductance and 0.675 mF Capacitance in Parallel

Harmonic	Phase A Current Spectrum			Phase B Current Spectrum			Phase C Current Spectrum			Neutral Current Spectrum		
	Geosine Line Side	Geosine Load Side	% Change	Geosine Line Side	Geosine Load Side	% Change	Geosine Line Side	Geosine Load Side	% Change	Geosine Line Side	Geosine Load Side	% Change
THD:	57.3	39.4	45%	64.8	50.6	28%	52.9	47.5	11%	468.4	305.6	53%
3rd	57	33	73%	64.7	42.9	51%	52.7	40.1	31%	467.1	305.6	53%
5th	5.9	19.2	-69%	1.3	25	-95%	4.9	23.8	-79%	20.6	0	
7th	1.6	3.1	-48%	0.5	2.2	-77%	0.7	2.2	-68%	17.7	4.8	269%
9th	1.4	6.5	-78%	1.7	5.7	-70%	1.3	7	-81%	15.7	0	
11th	0.3	3.6	-92%	0.3	4.4	-93%	0.4	3	-87%	11.7	0	
13th	0.3	2.9	-90%	0	4.8	-100%	0.3	2.9	-90%	8.3	0	
15th	0	3.2	-100%	0.2	2.6	-92%	0.3	1.9	-84%	5.2	0	
17th	0	1.1	-100%	0	0.9	-100%	0	1.7	-100%	3.8	0	
19th	0	2	-100%	0	1.1	-100%	0	1.3	-100%	1.1	0	
21st	0	1	-100%	0	0.7	-100%	0	1	-100%		0	
23rd	0	0.6	-100%	0	0.9	-100%	0	0.6	-100%	1.5	0	
25th	0	0.9	-100%	0	0.6	-100%	0	0.8	-100%	1.6	0	
27th	0	0.4	-100%	0	0.2	-100%	0	0.4	-100%	1.8	0	
29th	0	0		0	0.5	-100%	0	0.3	-100%	1.4	0	
31st	0	0.5	-100%	0	0.4	-100%	0	0.4	-100%	1	0	
33rd	0	0.2					0	0.2	-100%		0	
Harmonic	Phase A Voltage Spectrum			Phase B Voltage Spectrum			Phase C Voltage Spectrum					
	Geosine Line Side	Geosine Load Side	% Change	Geosine Line Side	Geosine Load Side	% Change	Geosine Line Side	Geosine Load Side	% Change			
THD:	3	22.8	660%	3.8	21.7	471%	3.9	23.1	492%			
3rd	1.4	21.7	1450%	2.7	21	678%	2.7	22.2	722%			
5th	2.2	6.8	209%	2.1	5.6	167%	2.1	6.4	205%			
7th	1	0.8	-20%	1.2	0.4	-67%	1.3	0.4	-69%			
9th	0.6	1.1	83%	0.7	0.8	14%	0.7	0.8	14%			
11th	0.4	0.4	0%	0.5	0.4	-20%	0.6	0.3	-50%			
13th	0.4	0.3	-25%	0.5	0.3	-40%	0.6	0.2	-67%			
15th	0.3	0.2	-33%	0.3		-100%	0.5		-100%			
17th	0.2	0	-100%	0.2		-100%	0.4		-100%			
19th	0.3	0	-100%	0.3		-100%	0.3		-100%			

Harmonic Testing with Geosine

Building 1505 - No Line Inductance & 10.3 mH Inductance with 0.675 mF Capacitance in Parallel

Harmonic	Phase A Current Spectrum			Phase B Current Spectrum			Phase C Current Spectrum			Neutral Current Spectrum		
	Geosine	Geosine	Line Side	Geosine	Geosine	Line Side	Geosine	Geosine	Line Side	Geosine	Geosine	Line Side
THD:	83.5	86.9	-4%	82.1	71.4	15%	101.2	48.2	110%	392.8	180.2	118%
3rd	56.8	68.8	-17%	61.4	56.7	-9%	44.6	36.3	23%	338.5	171.6	97%
5th	44.3	45.8	-3%	40.2	38.2	5%	46.7	27	73%	62.3	41.9	49%
7th	24.3	21.4	14%	25	16.5	52%	33.7	13.4	151%	31.2	25.5	22%
9th	18.7	8.7	115%	22.8	6.1	274%	30.4	4.5	576%	143.9	20.6	599%
11th	15.3	9.7	68%	14	7.6	84%	24	5.3	353%	39.6	7.7	414%
13th	17.3	8.3	108%	27.2	6.7	306%	49.4	6	723%	49.4	8.8	461%
15th	14.9	2.1	610%	15	2.1	614%	17	3.3	415%	97.8	5.8	1586%
17th	6.8	1.8	278%	10.9	0.8	1263%	23.1	0.9	2467%	11		400%
19th	5	2.2	127%	5.9	1.6	269%	9.3	0.4	2225%	6.6	2.4	175%
21st	2.8	1.1	155%	3.1	0.9	244%	2	1	100%	17.6	2.2	700%
23rd	3.3	0.6	450%	3.4	0.3	1033%	6.7	0.8	738%	3.4	1.2	183%
25th	0.4	1.2	-67%	0.8	0.5	60%	3.2	0.3	967%	3.3	1.2	175%
27th	1.2	1.1	9%	0.7	0.5	40%	0.6	0		5.1	1.6	219%
29th	1.5	0.5	200%	1.1	0		1.4	0.3	367%	1.9	0.5	280%
31st	1	0.3		1.3	0.3	333%	2.9	0.3	867%	1.7	0.7	143%
33rd	0.3	0.3	0%		0.3	-100%	1.1	0.3	267%	1.1		
Phase A RMS Current (Amps)			Phase B RMS Current (Amps)			Phase C RMS Current (Amps)			Neutral RMS Current (Amps)			
Geosine	Geosine	Line Side	Geosine	Geosine	Line Side	Geosine	Geosine	Line Side	Geosine	Geosine	Line Side	
Change	Change	Load Side	Change	Change	Load Side	Change	Change	Load Side	Change	Change	Load Side	Change
%	%		%	%		%	%		%	%		%
With Line Inductance	40.7	37.2	9%	37.6	24.6	53%	34.8	37.1	-6%	72.4	40.5	79%
W/O Line Inductance	31.2	24.7	26%	24.5	20	23%	18.4	10.4	77%	37.5	31.1	21%

STATUS REPORT

10:48

PH A-NEUT (Voltage Channel 1)

Voltage: 119.3 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 118.5 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 119.3 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.8 Vrms

High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 40.7 Arms

PHASE B (Current Channel 2)

Current: 37.6 Arms

PHASE C (Current Channel 3)

Current: 34.8 Arms

NEUT (Current Channel 4)

Current: 72.4 Arms

HARMONIC REPORT

10:48

PH B-NEUT SNAPSHOT

PH B-NEUT VOLTAGE PHASE B CURRENT

5.0 milliseconds/division horizontal

1505 GEOSINE LINE

Mar 2, 1994

10:48:59

PH A-NEUT VOLTAGE SPECTRUM

10:48:59.78

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	1.4%	16°	4th		
5th	2.2%	268°	6th		
7th	1.0%	34°	8th		
9th	0.6%	147°	10th		
11th	0.4%	263°	12th		
13th	0.4%	21°	14th		
15th	0.3%	102°	16th		
17th	0.2%	270°	18th		
19th	0.3%	359°			
Odd: 3.0%			Even: 0.0%		
Thd: 3.0%

PHASE A CURRENT SPECTRUM

10:48:59.78

Fundamental frequency: 60.1 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0ø	2nd		
3rd	57.0%	107ø	4th		
5th	5.9%	89ø	6th		
7th	1.6%	57ø	8th		
9th	1.4%	210ø	10th		
11th	0.3%	242ø	12th		
13th	0.3%	91ø			
Odd: 57.3%			Even: 0.0%		
Thd: 57.3%

PH B-NEUT VOLTAGE SPECTRUM

10:48:59.78

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	0ø	
3rd	2.7%	22ø	
5th	2.1%	264ø	
7th	1.2%	10ø	
9th	0.7%	124ø	
11th	0.5%	220ø	
13th	0.5%	347ø	
15th	0.3%	83ø	
17th	0.2%	123ø	
19th	0.3%	308ø	
Odd: 3.8%		Even: 0.0%	
Thd: 3.8%

PHASE B CURRENT SPECTRUM

10:48:59.78

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	64.7%	170°	4th	0.4%	156°
5th	1.3%	155°	6th		
7th	0.5%	59°	8th		
9th	1.7%	332°	10th		
11th	0.3%	134°	12th		
13th			14th		
15th	0.2%	64°			
Odd: 64.8%			Even: 0.4%		
Thd: 64.8%

PH C-NEUT VOLTAGE SPECTRUM

10:48:59.78

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	2.7%	25°	4th		
5th	2.1%	252°	6th		
7th	1.3%	7°	8th		
9th	0.7%	116°	10th		
11th	0.6%	214°	12th		
13th	0.6%	331°	14th		
15th	0.5%	69°	16th		
17th	0.4%	164°	18th		
19th	0.3%	288°	20th		
21st	0.3%	13°	22nd		
23rd	0.2%	52°	24th		
25th	0.3%	208°	26th		
27th			28th		
29th	0.2%	114°			
Odd:	3.9%		Even:	0.0%	
Thd:	3.9%

PHASE C CURRENT SPECTRUM

10:48:59.78

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	52.7%	149°	4th		
5th	4.9%	219°	6th		
7th	0.7%	62°	8th		
9th	1.3%	288°	10th		
11th	0.4%	11°	12th		
13th	0.3%	194°	14th		
15th	0.3%	12°			
Odd: 52.9%			Even: 0.0%		
Thd: 52.9%

NEUT-GND VOLTAGE SPECTRUM

10:48:59.78

Fundamental frequency: 60.5 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	9.5%	308°
3rd	886.2%	122°	4th	8.3%	217°
5th	61.4%	171°	6th	3.3%	273°
7th	48.9%	94°	8th		
9th	150.1%	161°	10th	3.5%	204°
11th	39.0%	113°	12th	2.4%	262°
13th	21.5%	289°	14th		
15th	75.5%	39°	16th		
17th	25.9%	317°	18th		
19th	17.6%	162°	20th		
21st	31.1%	266°	22nd	2.7%	267°
23rd	19.5%	238°	24th		
25th	16.9%	303°	26th		
27th	16.0%	95°	28th		
29th	20.3%	71°	30th	2.2%	266°
31st	11.8%	117°	32nd		
33rd	8.3%	314°			
Odd: 908.4%			Even: 14.1%		
Thd: 908.5%

NEUT CURRENT SPECTRUM

10:48:59.78

Fundamental frequency: 60.4 Hz

Sine		Sine	
Harmonic Percent Phase		Harmonic Percent Phase	
Fund	100.0%	0°	
3rd	467.1%	293°	
5th	20.6%	59°	
7th	17.7%	268°	
9th	15.7%	100°	
11th	11.7%	32°	
13th	8.3%	279°	
15th	5.2%	105°	
17th	3.8%	68°	
19th	1.1%	232°	
21st			
23rd	1.5%	261°	
25th	1.6%	254°	
27th	1.8%	59°	
29th	1.4%	290°	
31st	1.0%	197°	
Odd: 468.4%		Even: 1.3%	
Thd: 468.4%

STATUS REPORT

10:36

PH A-NEUT (Voltage Channel 1)

Voltage: 116.8 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 113.9 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 116.7 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 1.1 Vrms

High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 37.2 Arms

PHASE B (Current Channel 2)

Current: 24.6 Arms

PHASE C (Current Channel 3)

Current: 37.1 Arms

NEUT (Current Channel 4)

Current: 40.5 Arms

HARMONIC REPORT

10:34

PH A-NEUT VOLTAGE SPECTRUM

10:34:19.58

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0ø	2nd		
3rd	21.7%	7ø	4th		
5th	6.8%	354ø	6th		
7th	0.8%	281ø	8th		
9th	1.1%	147ø	10th		
11th	0.4%	96ø	12th		
13th	0.3%	1ø	14th		
15th	0.2%	248ø			
Odd: 22.8%			Even: 0.0%		
Thd: 22.8%

PHASE A CURRENT SPECTRUM

10:34:19.58

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	33.0%	146°	4th		
5th	19.2%	297°	6th		
7th	3.1%	231°	8th		
9th	6.5%	131°	10th		
11th	3.6%	80°	12th		
13th	2.9%	6°	14th		
15th	3.2%	294°	16th		
17th	1.1%	293°	18th		
19th	2.0%	193°	20th		
21st	1.0%	109°	22nd		
23rd	0.6%	56°	24th		
25th	0.9%	18°	26th		
27th	0.4%	249°	28th		
29th			30th		
31st	0.5%	229°	32nd		
33rd	0.2%	46°			
Odd: 39.4%			Even: 0.0%		
Thd: 39.4%

PH B-NEUT VOLTAGE SPECTRUM

10:34:19.58

Fundamental frequency: 59.9 Hz

Harmonic Percent Phase

Sine

Sine
Harmonic Percent Phase

Fund	100.0%	0°
3rd	21.0%	9°
5th	5.6%	333°
7th	0.4%	292°
9th	0.8%	98°
11th	0.4%	138°
13th	0.3%	349°

2nd
4th
6th
8th
10th
12th

Odd: 21.7%

Even: 0.0%

Thd: 21.7%

PHASE B CURRENT SPECTRUM

10:34:19.58

Fundamental frequency: 60.1 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	42.9%	175°	4th		
5th	25.0%	3°	6th		
7th	2.2%	4°	8th		
9th	5.7%	245°	10th		
11th	4.4%	331°	12th		
13th	4.8%	218°	14th		
15th	2.6%	233°	16th		
17th	0.9%	187°	18th		
19th	1.1%	119°	20th		
21st	0.7%	114°	22nd		
23rd	0.9%	9°	24th		
25th	0.6%	305°	26th		
27th	0.2%	187°	28th		
29th	0.5%	285°	30th		
31st	0.4%	217°			
Odd: 50.6%			Even: 0.0%		
Thd: 50.6%

PH C-NEUT VOLTAGE SPECTRUM

10:34:19.58

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	22.2%	14°	4th		
5th	6.4%	358°	6th		
7th	0.4%	300°	8th		
9th	0.8%	147°	10th		
11th	0.3%	149°	12th		
13th	0.2%	326°			
Odd: 23.1%			Even: 0.0%		
Thd: 23.1%

PHASE C CURRENT SPECTRUM

10:34:19.58

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	40.1%	153°	4th		
5th	23.8%	328°	6th		
7th	2.2%	342°	8th		
9th	7.0%	187°	10th		
11th	3.0%	210°	12th		
13th	2.9%	124°	14th		
15th	1.9%	10°	16th		
17th	1.7%	96°	18th		
19th	1.3%	320°	20th		
21st	1.0%	272°	22nd		
23rd	0.6%	302°	24th		
25th	0.8%	179°	26th		
27th	0.4%	235°	28th		
29th	0.3%	209°	30th		
31st	0.4%	55°	32nd		
33rd	0.2%	105°			
Odd: 47.5%			Even: 0.0%		
Thd: 47.5%

NEUT-GND VOLTAGE SPECTRUM

10:34:19.58

Fundamental frequency: 179.9 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0ø	2nd		
3rd	12.5%	195ø	4th	0.4%	200ø
5th	4.2%	200ø	6th		
7th	3.1%	218ø	8th		
9th	1.1%	293ø	10th	0.2%	44ø
11th	0.9%	184ø			
Odd: 13.6%			Even: 0.4%		
Thd: 13.6%

NEUT CURRENT SPECTRUM

10:34:19.58

Fundamental frequency: 58.6 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0 %	0°	2nd		
3rd	305.6 %	280°	4th		
5th			6th		
7th	4.8 %	344°	8th		
9th			10th		
11th			12th		
13th			14th		
15th			16th		
17th			18th		
19th			20th		
21st			22nd		
23rd			24th		
25th			26th		
27th			28th		
29th			30th		
31st			32nd		
33rd			34th	0.7 %	137°
Odd: 305.6 %			Even: 0.7 %		
Thd: 305.6 %

STATUS REPORT

8:07 PM

PH A-NEUT (Voltage Channel 1)

Voltage: 121.2 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 121.2 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 122.6 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.8 Vrms
High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 31.2 Arms

PHASE B (Current Channel 2)

Current: 24.5 Arms

PHASE C (Current Channel 3)

Current: 18.4 Arms

NEUT (Current Channel 4)

Current: 37.5 Arms

HARMONIC REPORT

8:08 PM

1505 GEOSINE WO LINE

May 12, 1994

PH A-NEUT VOLTAGE SPECTRUM

8:08:10.46 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	1.8%	58°	4th		
5th	2.0%	250°	6th		
7th	1.2%	33°	8th		
9th	1.1%	127°	10th		
11th	0.6%	206°	12th		
13th	0.7%	353°	14th		
15th	0.6%	12°	16th		
17th	0.2%	187°			
Odd: 3.3%			Even: 0.0%		
Thd: 3.3%

HASE A CURRENT SPECTRUM

8:08:10.46 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	56.8%	169°	4th		
5th	44.3%	346°	6th	0.8%	323°
7th	24.3%	149°	8th	0.3%	191°
9th	18.7%	267°	10th	0.5%	233°
11th	15.3%	5°	12th	0.4%	340°
13th	17.3%	171°	14th	0.3%	150°
15th	14.9%	210°	16th	0.3%	131°
17th	6.8%	17°	18th	0.4%	240°
19th	5.0%	86°	20th	0.4%	25°
21st	2.8%	209°	22nd	0.3%	192°
23rd	3.3%	0°	24th		
25th	0.4%	70°	26th	0.4%	186°
27th	1.2%	172°	28th	0.3%	14°
29th	1.5%	332°	30th	0.3%	145°
31st	1.0%	107°	32nd		
33rd	0.3%	202°			
Odd:	83.5%		Even:	1.4%	
Thd:	83.5%

PH B-NEUT VOLTAGE SPECTRUM

8:08:10.46 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	2.0%	45°	4th		
5th	1.8%	265°	6th		
7th	1.2%	25°	8th		
9th	1.3%	130°	10th		
11th	0.6%	257°	12th		
13th	1.1%	326°	14th		
15th	0.5%	11°	16th		
17th	0.4%	165°			
Odd: 3.5%			Even: 0.0%		
Thd: 3.5%

PHASE B CURRENT SPECTRUM

8:08:10.46 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	51.4%	177°	4th	0.3%	234°
5th	40.2%	9°	6th		
7th	25.0%	174°	8th	0.2%	327°
9th	22.8%	299°	10th	0.6%	356°
11th	14.0%	78°	12th	0.4%	321°
13th	27.2%	189°	14th	0.8%	300°
15th	15.0%	249°	16th	0.7%	276°
17th	10.9%	65°	18th	0.9%	15°
19th	5.9%	132°	20th	0.4%	98°
21st	3.1%	288°	22nd	0.4%	24°
23rd	3.4%	74°	24th	0.4%	111°
25th	0.8%	266°	26th	0.4%	217°
27th	0.7%	20°	28th	0.2%	186°
29th	1.1%	150°	30th		
31st	1.3%	225°			
Odd: 82.1%			Even: 1.8%		
Thd: 82.1%

PH C-NEUT VOLTAGE SPECTRUM

8:08:10.46 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0ø	2nd		
3rd	1.3%	51ø	4th		
5th	1.7%	269ø	6th		
7th	1.2%	52ø	8th		
9th	1.2%	148ø	10th		
11th	0.7%	278ø	12th		
13th	1.3%	0ø	14th		
15th	0.4%	46ø	16th		
17th	0.5%	178ø			
Odd: 3.2%			Even: 0.0%		
Thd: 3.2%

HASE C CURRENT SPECTRUM

8:08:10.46 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	44.6%	167°	4th	0.4%	314°
5th	46.7%	354°	6th	0.4%	250°
7th	33.7%	157°	8th	0.5%	168°
9th	30.4%	265°	10th		
11th	24.0%	37°	12th	0.7%	235°
13th	49.4%	140°	14th	0.4%	131°
15th	17.0%	179°	16th	0.9%	34°
17th	23.1%	329°	18th	0.5%	351°
19th	9.3%	46°	20th	0.3%	203°
21st	2.0%	69°	22nd	0.3%	256°
23rd	6.7%	287°	24th	0.2%	229°
25th	3.2%	83°	26th		
27th	0.6%	231°	28th		
29th	1.4%	327°	30th	0.4%	146°
31st	2.9%	28°	32nd		
33rd	1.1%	174°			
Odd: 101.2%			Even: 1.6%		
Thd: 101.2%

NEUT-GND VOLTAGE SPECTRUM

8:08:10.46 PM

Fundamental frequency: 180.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.8%	284°
3rd	70.3%	19°	4th	1.1%	161°
5th	47.8%	201°	6th	1.0%	129°
7th	8.2%	93°	8th	0.4%	174°
9th	3.1%	314°	10th		
11th	0.8%	52°			
Odd: 85.5%			Even: 1.8%		
Thd: 85.5%

Fundamental frequency: 60.4 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	338.5%	345°	4th		
5th	62.3%	279°	6th	2.8%	128°
7th	31.2%	106°	8th	1.8%	42°
9th	143.9%	81°	10th	2.3%	308°
11th	39.6%	258°	12th	2.8%	105°
13th	49.4%	17°	14th	1.5%	269°
15th	97.8%	6°	16th	2.8%	252°
17th	11.0%	188°	18th	2.4%	169°
19th	6.6%	329°	20th	0.9%	13°
21st	17.6%	356°	22nd		
23rd	3.4%	114°	24th		
25th	3.3%	350°	26th		
27th	5.1%	326°	28th		
29th	1.9%	213°	30th		
31st	1.7%	320°	32nd		
33rd	1.1%	100°			
Odd: 392.7%			Even: 6.4%		
Thd: 392.8%

STATUS REPORT

8:12 PM

PH A-NEUT (Voltage Channel 1)

Voltage: 120.9 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 121.0 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 122.5 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 1.1 Vrms

High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 24.7 Arms

PHASE B (Current Channel 2)

Current: 20.0 Arms

PHASE C (Current Channel 3)

Current: 10.4 Arms

NEUT (Current Channel 4)

Current: 31.1 Arms

HARMONIC REPORT

8:12 PM

1505 GEOSINE WO LOAD

May 12, 1994

PH A-NEUT VOLTAGE SPECTRUM

8:12:46.00 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	2.0%	52°	4th		
5th	2.0%	246°	6th		
7th	1.3%	28°	8th		
9th	1.3%	123°	10th		
11th	0.7%	201°	12th		
13th	0.8%	348°	14th		
15th	0.9%	10°	16th		
17th	0.3%	169°			
Odd: 3.7%			Even: 0.0%		
Thd: 3.7%

PHASE A CURRENT SPECTRUM

8:12:46.00 PM

Fundamental frequency: 60.1 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	68.8%	176°	4th	0.5%	150°
5th	45.8%	349°	6th	0.8%	320°
7th	21.4%	154°	8th	0.4%	172°
9th	8.7%	275°	10th	0.2%	272°
11th	9.7%	33°	12th	0.3%	74°
13th	8.3%	200°	14th	0.2%	166°
15th	2.1%	336°	16th	0.3%	346°
17th	1.8%	40°	18th	0.3%	175°
19th	2.2%	186°	20th		
21st	1.1%	7°	22nd		
23rd	0.6%	30°	24th		
25th	1.2%	184°	26th		
27th	1.1%	346°	28th		
29th	0.5%	127°	30th		
31st	0.3%	286°	32nd		
33rd	0.3%	35°			
Odd: 86.9%			Even: 1.2%		
Thd: 86.9%

1505 GEOSINE WO LOAD

May 12, 1994

PH B-NEUT VOLTAGE SPECTRUM

8:12:46.00 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	2.3%	41°	4th		
5th	1.8%	263°	6th		
7th	1.3%	27°	8th		
9th	1.5%	126°	10th		
11th	0.6%	264°	12th		
13th	1.2%	328°	14th		
15th	0.7%	14°	16th		
17th	0.5%	165°			
Odd: 3.8%			Even: 0.0%		
Thd: 3.8%

PHASE B CURRENT SPECTRUM

8:12:46.00 PM

Fundamental frequency: 60.1 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	56.7%	209°	4th		
5th	38.2%	45°	6th	0.3%	134°
7th	16.5%	234°	8th		
9th	6.1%	7°	10th		
11th	7.6%	156°	12th		
13th	6.7%	340°	14th		
15th	2.1%	188°	16th		
17th	0.8%	116°	18th		
19th	1.6%	10°	20th		
21st	0.9%	161°	22nd		
23rd	0.3%	179°	24th		
25th	0.5%	53°	26th		
27th	0.5%	338°	28th		
29th			30th		
31st	0.3%	55°	32nd		
33rd	0.3%	206°			
Odd: 71.4%			Even: 0.3%		
Thd: 71.4%

1505 GEOSINE WO LOAD

May 12, 1994

PH C-NEUT VOLTAGE SPECTRUM

8:12:46.00 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	1.5%	45°	4th		
5th	1.8%	269°	6th		
7th	1.2%	51°	8th		
9th	1.3%	140°	10th		
11th	0.8%	275°	12th		
13th	1.4%	3°	14th		
15th	0.6%	34°	16th		
17th	0.6%	186°			
Odd: 3.5%			Even: 0.0%		
Thd: 3.5%

HASE C CURRENT SPECTRUM

8:12:46.00 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	36.3%	167°	4th		
5th	27.0%	335°	6th		
7th	13.4%	139°	8th		
9th	4.5%	258°	10th		
11th	5.3%	0°	12th		
13th	6.0%	143°	14th		
15th	3.3%	317°	16th		
17th	0.9%	46°	18th		
19th	0.4%	170°	20th		
21st	1.0%	300°	22nd		
23rd	0.8%	112°	24th		
25th	0.3%	175°	26th		
27th			28th		
29th	0.3%	126°	30th		
31st	0.3%	100°	32nd		
33rd	0.3%	3°			
Odd: 48.2%			Even: 0.0%		
Thd: 48.2%

NEUT-GND VOLTAGE SPECTRUM

8:12:46.00 PM

Fundamental frequency: 180.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	1.2%	283°
3rd	73.6%	31°	4th	1.0%	174°
5th	56.8%	227°	6th	1.2%	118°
7th	11.6%	129°	8th	0.3%	334°
9th	3.9%	0°	10th		
11th	0.9%	254°			
Odd: 93.8%			Even: 2.0%		
Thd: 93.8%

Fundamental frequency: 180.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.6%	182°
3rd	11.5%	106°	4th		
5th	3.9%	209°	6th	0.2%	6°
7th	1.6%	214°	8th		
9th	1.0%	171°	10th		
11th	0.4%	93°			
Odd: 12.3%			Even: 0.6%		
Thd: 12.3%

Appendix G

Delta-Wye Transformer Harmonic Data

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Martin Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

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DELTA-WYE TRANSFORMER MEASUREMENT POINTS

Table I: Triplen Harmonic Reduction Due to Delta - Wye Transformation

Building 1505 Transformer T-6

Harmonic	Phase A Current Spectrum			Phase B Current Spectrum			Phase C Current Spectrum		
	Xlmr	T-6 Pri	T-6 Sec	Xlmr	T-6 Pri	T-6 Sec	Xlmr	T-6 Pri	T-6 Sec
THD:	30.1	63.5	-53%	26.2	40.4		33.7	44.1	-24%
3rd	4.8	51.8	-91%	3.2	32.9	-90%	2.3	37.6	-94%
5th	26.6	32.4	-18%	24	20.9	15%	30.6	20.4	50%
7th	12.4	14.8	-16%	9.1	9	1%	12.7	8.9	43%
9th	0.4	6	-93%	0.4	4.1	-90%	0	4.5	-100%
11th	3.3	4.5	-27%	3.2	2.8	14%	3.9	2.6	50%
13th	2.6	3.1	-16%	1.8	1.8	0%	2.5	1.7	47%
15th	0.5	1.7	-71%	0	1.3	-100%	0.4	1.5	-73%
17th	0.9	1.4	-36%	1.2	1		1.5	0.9	67%
19th	1	1.3	-23%	0.7	0.6		1	0.7	43%
21st	0.4	0.9	-56%	0	0.6	-100%	0	0.7	-100%
23rd	0.3	0.8	-63%	0.5	0.4	25%	0.8	0.3	167%
25th	0.7	0.8	-13%	0.4	0.4	0%	0.5	0.4	25%
27th	0.3	0.7	-57%	0	0.2	-100%	0.3	0.3	0%
29th	0.6	0.6	-100%	0.4	0.3	33%	0.7	0	
31st	0.4	0.7	-43%				0.3	0	
33rd	0.4	0.7	-43%						
2nd	0.7	0.3	133%	0.6	0.3	100%	0.9	0	
4th				0.4	0		0.3	0	

STATUS REPORT

1:42 PM

PHASE A-B (Voltage Channel 1)

Voltage: 480.8 Vrms

Frequency: 60.0 Hz

High freq noise: 1.4 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 482.7 Vrms

Frequency: 60.0 Hz

High freq noise: 1.4 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 486.5 Vrms

Frequency: 60.0 Hz

High freq noise: 1.5 Vpp

PHASE A (Current Channel 1)

Current: 83.1 Arms

PHASE B (Current Channel 2)

Current: 93.9 Arms

PHASE C (Current Channel 3)

Current: 82.6 Arms

PHASE A-B VOLTAGE SPECTRUM

1:43:26.82 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.3%	32°	4th		
5th	1.2%	278°	6th		
7th	0.5%	72°			
Odd: 1.4%			Even: 0.0%		
Thd: 1.4%

PHASE A CURRENT SPECTRUM

1:43:26.82 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.7%	109°
3rd	4.8%	206°	4th		
5th	26.6%	170°	6th		
7th	12.4%	335°	8th		
9th	0.4%	135°	10th		
11th	3.3%	48°	12th		
13th	2.6%	188°	14th		
15th	0.5%	324°	16th		
17th	0.9%	248°	18th		
19th	1.0%	27°	20th		
21st	0.4%	125°	22nd		
23rd	0.3%	112°	24th		
25th	0.7%	197°	26th		
27th	0.3%	339°	28th		
29th			30th		
31st	0.4%	338°	32nd		
33rd	0.4%	71°			
Odd: 30.1%			Even: 0.7%		
Thd: 30.1%

PHASE B-C VOLTAGE SPECTRUM

1:43:26.82 PM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	2nd	
3rd	0.2%	4th	
5th	1.0%	6th	
7th	0.5%		
Odd: 1.1%		Even: 0.0%	
Thd: 1.1%

PHASE B CURRENT SPECTRUM

1:43:26.82 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.6%	256°
3rd	3.2%	24°	4th	0.4%	227°
5th	24.0%	220°	6th		
7th	9.1%	46°	8th		
9th	0.4%	27°	10th		
11th	3.2%	162°	12th		
13th	1.8%	314°	14th		
15th			16th		
17th	1.2%	57°	18th		
19th	0.7%	216°	20th		
21st			22nd		
23rd	0.5%	301°	24th		
25th	0.4%	79°	26th		
27th			28th		
29th	0.4%	136°			
Odd:	26.2%		Even:	0.8%	
Thd:	26.2%

PHASE C-A VOLTAGE SPECTRUM

1:43:26.82 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.5%	198°	4th		
5th	1.0%	267°	6th		
7th	0.6%	87°			
Odd: 1.3%			Even: 0.0%		
Thd: 1.3%

PHASE C CURRENT SPECTRUM

1:43:26.82 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.9%	19°
3rd	2.3%	130°	4th	0.3%	195°
5th	30.6%	255°	6th		
7th	12.7%	95°	8th		
9th			10th		
11th	3.9%	232°	12th		
13th	2.5%	48°	14th		
15th	0.4%	41°	16th		
17th	1.5%	177°	18th		
19th	1.0%	345°	20th		
21st			22nd		
23rd	0.8%	115°	24th		
25th	0.5%	259°	26th		
27th	0.3%	200°	28th		
29th	0.7%	1°	30th		
31st	0.3%	164°			
Odd: 33.6%			Even: 1.0%		
Thd: 33.7%

STATUS REPORT

1:24 PM

PH A-NEUT (Voltage Channel 1)

Voltage: 120.6 Vrms

Frequency: 60.0 Hz

High freq noise: 0.0 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 118.8 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 119.3 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.6 Vrms

High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 83.1 Arms

PHASE B (Current Channel 2)

Current: 127.0 Arms

PHASE C (Current Channel 3)

Current: 128.5 Arms

NEUT (Current Channel 4)

Current: 106.0 Arms

PH A-NEUT SNAPSHOT

333V

500A

0V

0A

-333V

-500A

PH A-NEUT VOLTAGE

PHASE A CURRENT

5.0 milliseconds/division horizontal

BMI

1505 PPD1 MAIN

Nov 4, 1993

1:25:39 PM

PH A-NEUT VOLTAGE SPECTRUM

1:25:39.92 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	2.0%	57°	4th		
5th	2.5%	226°	6th		
7th	1.2%	20°	8th		
9th	0.8%	106°	10th		
11th	0.6%	208°	12th		
13th	0.5%	332°	14th		
15th	0.4%	66°	16th		
17th	0.3%	162°	18th		
19th	0.3%	292°	20th		
21st	0.3%	35°	22nd		
23rd	0.3%	139°	24th		
25th	0.3%	222°	26th		
27th	0.2%	48°	28th		
29th	0.2%	47°	30th		
31st	0.3%	157°	32nd		
33rd	0.3%	204°			
Odd: 3.8%			Even: 0.0%		
Thd: 3.8%

PHASE A CURRENT SPECTRUM

1:25:39.92 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	51.8%	196°	4th	0.3%	326°
5th	32.4%	20°	6th		
7th	14.8%	204°	8th		
9th	6.0%	343°	10th		
11th	4.5%	116°	12th		
13th	3.1%	281°	14th		
15th	1.7%	50°	16th		
17th	1.4%	178°	18th		
19th	1.3%	334°	20th		
21st	0.9%	105°	22nd		
23rd	0.8%	251°	24th		
25th	0.8%	7°	26th		
27th	0.7%	138°	28th		
29th	0.6%	261°	30th		
31st	0.7%	29°	32nd		
33rd	0.7%	126°			
Odd: 63.5%			Even: 0.3%		
Thd: 63.5%

PH B-NEUT VOLTAGE SPECTRUM

1:25:39.92 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	2.8%	45°	4th		
5th	2.4%	228°	6th		
7th	1.3%	6°	8th		
9th	0.8%	91°	10th		
11th	0.6%	194°	12th		
13th	0.5%	317°	14th		
15th	0.4%	42°	16th		
17th	0.3%	143°	18th		
19th	0.3%	246°	20th		
21st	0.3%	340°	22nd		
23rd			24th		
25th	0.3%	186°			
Odd:	4.1%		Even:	0.0%	
Thd:	4.1%

PHASE B CURRENT SPECTRUM

1:25:39.92 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.3%	313°
3rd	32.9%	166°	4th		
5th	20.9%	320°	6th		
7th	9.0%	126°	8th		
9th	4.1%	245°	10th		
11th	2.8%	348°	12th		
13th	1.8%	126°	14th		
15th	1.3%	233°	16th		
17th	1.0%	337°	18th		
19th	0.6%	108°	20th		
21st	0.6%	205°	22nd		
23rd	0.4%	291°	24th		
25th	0.4%	62°	26th		
27th	0.2%	44°	28th		
29th	0.3%	236°			
Odd: 40.4%			Even: 0.3%		
Thd: 40.4%

PH C-NEUT VOLTAGE SPECTRUM

1:25:39.92 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	2.6%	44°	4th		
5th	2.4%	227°	6th		
7th	1.2%	13°	8th		
9th	0.9%	93°	10th		
11th	0.7%	201°	12th		
13th	0.5%	321°	14th		
15th	0.5%	51°	16th		
17th	0.4%	151°	18th		
19th	0.3%	260°	20th		
21st	0.3%	348°	22nd		
23rd	0.2%	10°			
Odd: 4.0%			Even: 0.0%		
Thd: 4.0%

PHASE C CURRENT SPECTRUM

1:25:39.92 PM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	0 $\emptyset$	
3rd	37.6%	197 $\emptyset$	
5th	20.4%	13 $\emptyset$	
7th	8.9%	182 $\emptyset$	
9th	4.5%	322 $\emptyset$	
11th	2.6%	90 $\emptyset$	
13th	1.7%	228 $\emptyset$	
15th	1.5%	356 $\emptyset$	
17th	0.9%	123 $\emptyset$	
19th	0.7%	266 $\emptyset$	
21st	0.7%	24 $\emptyset$	
23rd	0.3%	142 $\emptyset$	
25th	0.4%	252 $\emptyset$	
27th	0.3%	21 $\emptyset$	
Odd: 44.1%		Even: 0.0%	
Thd: 44.1%

NEUT-GND VOLTAGE SPECTRUM

1:25:39.92 PM

Fundamental frequency: 59.8 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	5.0%	137°
3rd	741.6%	232°	4th	5.2%	238°
5th	11.6%	7°	6th		
7th	34.6%	92°	8th	3.0%	289°
9th	209.1%	319°	10th	2.7%	51°
11th	15.2%	15°	12th	2.3%	71°
13th	21.8%	58°	14th	3.0%	135°
15th	104.6%	307°	16th	2.5%	205°
17th	9.4%	20°	18th		
19th	16.8%	32°	20th	2.0%	328°
21st	61.3%	286°	22nd		
23rd	18.7%	329°	24th	1.7%	123°
25th	19.2%	1°	26th		
27th	37.8%	239°	28th		
29th	18.1%	253°	30th	5.5%	218°
31st	25.5%	307°	32nd	3.6%	10°
33rd	29.5%	175°			
Odd: 784.1%			Even: 11.8%		
Thd: 784.2%

NEUT CURRENT SPECTRUM

1:25:39.92 PM

Fundamental frequency: 59.9 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	262.6%	306°	4th		
5th	4.4%	182°	6th		
7th	6.7%	15°	8th		
9th	30.5%	309°	10th		
11th	1.8%	119°	12th		
13th	1.8%	265°	14th		
15th	9.1%	225°	16th		
17th	1.0%	53°	18th		
19th	1.3%	166°	20th		
21st	4.0%	126°	22nd		
23rd	1.2%	291°	24th		
25th	1.1%	42°	26th		
27th	2.0%	3°	28th		
29th	1.0%	132°	30th		
31st	1.2%	252°	32nd		
33rd	1.4%	225°			
Odd: 264.7%			Even: 0.0%		
Thd: 264.7%

ISOLATION TRANSFORMER MEASUREMENT POINTS

Triplen Harmonic Reduction Due to Delta - Wye Transformation

Building 1505 - Isolation Transformer (Neutral and Ground Bonded)

Phase A Current Spectrum				Phase B Current Spectrum				Phase C Current Spectrum			
Harmonic	Iso Xlmr		Pri	Reduction	Iso Xlmr		Pri	Reduction	Iso Xlmr		Sec
	%				%				%		
THD:	40.5	83.7	-52%		32.5	46.1	-30%		39.4	83.6	-53%
3rd	8.1	68.9	-88%		7.9	34.3	-77%		15.8	64.1	-75%
5th	36.3	43.1	-16%		28.7	24.4	18%		31.7	46.4	-32%
7th	13.9	18.3	-24%		12.1	13.6	-11%		15.4	24.4	-37%
9th	1.9	4	-53%		1.2	5.8	-79%		3.1	10.1	-69%
11th	3.5	3.2	9%		2	1.2	67%		2.2	2.9	-24%
13th	5.4	4.4	23%		2.5	0.9	178%		5.6	0.6	833%
15th	2.2	3	-27%		0.8	1.1	-27%		2.5	1.6	56%
17th	1.4	1.5	-7%		1.5	0.3	400%		0.4	2.3	-83%
19th	1.3	1.1	18%		2.7	1	170%		2.2	2.5	-12%
21st	1.4	0.5	180%		0.6	0.3	100%		1.1	1.2	-8%
23rd	1.2	0.4	200%		0.9	0.3	200%		1.1	0.8	38%
25th	0.3	0.3	0%		0.7	0.4	75%		0.7	1.1	-36%
27th	0.2	0.4	-50%		0	0.5	-100%		0	0.5	-100%
29th	0.2	0.7	-71%		0	0.3	-100%		0.3	0.3	0%
31st	0.4	0.2	100%		0.6	0.3	100%		0.3	0.3	0%
33rd	0.5	0							0.2	0.5	-60%

Triplen Harmonic Reduction Due to Delta - Wye Transformation

Building 1505 - Isolation Transformer (Neutral and Ground not Bonded)

	Phase A Current Spectrum			Phase B Current Spectrum			Phase C Current Spectrum		
	Iso Xfmr	Iso Xfmr	%	Iso Xfmr	Iso Xfmr	%	Iso Xfmr	Iso Xfmr	%
Harmonic	Pri	Sec	Reduction	Pri	Sec	Reduction	Pri	Sec	Reduction
THD:	34.8	70.4	-51%	34.6	55.3	-37%	43.1	69	-38%
3rd	12.5	60.5	-79%	6.9	44	-84%	10.9	57.2	-81%
5th	29.9	33.9	-12%	31	29.6	5%	38.1	35.4	8%
7th	10.2	10.9	-6%	12.9	14.7	-12%	14.3	14.5	-1%
9th	3.1	1	210%	1.3	5.1	-75%	2.8	3.2	-13%
11th	3.6	3.4	6%	1.9	0.7	171%	4.4	1.3	238%
13th	3.7	3.2	16%	3.4	0.7	386%	6.5	2	225%
15th	2.8	2.6	8%	1	1.8	-44%	2.6	2.6	0%
17th	2.4	0.4	500%	1.6	0.8	100%	1.1	1.6	-31%
19th	1.5	0.6	150%	1.6	0.9	78%	0.6	1.2	-50%
21st	1.1	0.4	175%	1.6	0.3	433%	0.4	0.3	33%
23rd	0.6	0.5	20%	0.5	0		1.3	0.5	160%
25th	0	0.4	-100%	0.8	0.4	100%	0.8	0.4	100%
27th	0.3	0		0.2	0.7	-71%	0.3	0.3	0%
29th	0.3	0		0.3	0.4	-25%	0.7	0.3	133%
31st	0.3	0		0.3	0		0	0.5	-100%
33rd	0.3	0		0.3	0.3	0%	0	0.5	-100%

G-30

STATUS REPORT

08:48

PHASE A-B (Voltage Channel 1)

Voltage: 119.9 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 119.9 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 120.3 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 25.5 Arms

PHASE B (Current Channel 2)

Current: 23.1 Arms

PHASE C (Current Channel 3)

Current: 25.4 Arms

HARMONIC REPORT

08:49

PHASE A-B VOLTAGE SPECTRUM

08:49:23.34

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	1.4%	68°	4th		
5th	1.4%	271°	6th		
7th	1.0%	37°	8th		
9th	0.7%	164°	10th		
11th	0.4%	271°	12th		
13th	0.4%	18°	14th		
15th	0.4%	171°	16th		
17th	0.3%	264°	18th		
19th	0.2%	316°			
Odd: 2.4%			Even: 0.0%		
Thd: 2.4%

PHASE A CURRENT SPECTRUM

08:49:23.34

Fundamental frequency: 60.1 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	0 σ	
3rd	8.1%	64 σ	
5th	36.3%	144 σ	
7th	13.9%	313 σ	
9th	1.9%	245 σ	
11th	3.5%	319 σ	
13th	5.4%	38 σ	
15th	2.2%	314 σ	
17th	1.4%	325 σ	
19th	1.3%	321 σ	
21st	1.4%	156 σ	
23rd	1.2%	180 σ	
25th	0.3%	177 σ	
27th	0.2%	228 σ	
29th	0.2%	26 σ	
31st	0.4%	311 σ	
33rd	0.5%	34 σ	
Odd: 40.5%		Even: 0.0%	
Thd: 40.5%

PHASE B-C VOLTAGE SPECTRUM

08:49:23.34

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	2.0%	48°	4th		
5th	1.6%	274°	6th		
7th	1.1%	24°	8th		
9th	0.8%	144°	10th		
11th	0.5%	251°	12th		
13th	0.5%	355°	14th		
15th	0.3%	122°	16th		
17th	0.3%	223°	18th		
19th	0.2%	325°	20th		
21st	0.2%	16°			
Odd: 3.0%			Even: 0.0%		
Thd: 3.0%

PHASE B CURRENT SPECTRUM

08:49:23.34

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	7.9%	23°	4th		
5th	28.7%	144°	6th		
7th	12.1%	314°	8th		
9th	1.2%	187°	10th		
11th	2.0%	332°	12th		
13th	2.5%	38°	14th		
15th	0.8%	331°	16th		
17th	1.5%	16°	18th		
19th	2.7%	280°	20th		
21st	0.6%	10°	22nd		
23rd	0.9%	154°	24th		
25th	0.7%	239°	26th		
27th			28th		
29th			30th		
31st	0.6%	158°			
Odd:	32.5%		Even:	0.0%	
Thd:	32.5%

PHASE C-A VOLTAGE SPECTRUM

08:49:23.34

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	2.2%	58°	4th		
5th	1.4%	258°	6th		
7th	1.2%	17°	8th		
9th	0.8%	150°	10th		
11th	0.5%	247°	12th		
13th	0.6%	346°	14th		
15th	0.4%	96°	16th		
17th	0.3%	195°	18th		
19th	0.2%	318°	20th		
21st	0.3%	86°			
Odd: 3.1%			Even: 0.0%		
Thd: 3.1%

PHASE C CURRENT SPECTRUM

08:49:23.34

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.5%	165°
3rd	15.8%	247°	4th	0.4%	265°
5th	31.7%	164°	6th		
7th	15.4%	352°	8th	0.2%	346°
9th	3.1%	86°	10th		
11th	2.2%	350°	12th		
13th	5.6%	129°	14th		
15th	2.5%	228°	16th		
17th	0.4%	219°	18th		
19th	2.2%	350°	20th		
21st	1.1%	44°	22nd		
23rd	1.1%	276°	24th		
25th	0.7%	348°	26th		
27th			28th		
29th	0.3%	114°	30th		
31st	0.3%	309°	32nd		
33rd	0.2%	356°			
Odd: 39.4%			Even: 0.6%		
Thd: 39.4%

STATUS REPORT

08:42

PH A-NEUT (Voltage Channel 1)

Voltage: 119.1 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 118.4 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 119.7 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.1 Vrms

High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 29.5 Arms

PHASE B (Current Channel 2)

Current: 21.7 Arms

PHASE C (Current Channel 3)

Current: 24.1 Arms

NEUT (Current Channel 4)

Current: 35.2 Arms

HARMONIC REPORT

08:42

PH C-NEUT SNAPSHOT

250V

300A

0V

0A

-250V

-300A

PH C-NEUT VOLTAGE

PHASE C CURRENT

5.0 milliseconds/division horizontal

1505 ISO XFMR LOAD G

Apr 20, 1994

08:43:01

PH A-NEUT VOLTAGE SPECTRUM

08:43:01.45

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.3%	197°
3rd	1.9%	45°	4th		
5th	1.8%	181°	6th		
7th	0.3%	71°	8th		
9th	0.6%	172°	10th		
11th	1.0%	241°	12th		
13th	1.6%	332°	14th		
15th	1.1%	5°	16th		
17th	0.4%	79°	18th		
19th			20th		
21st	0.3%	0°	22nd		
23rd	0.3%	0°			
Odd: 3.5%			Even: 0.3%		
Thd: 3.5%

PHASE A CURRENT SPECTRUM

08:43:01.45

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	1.5%	249°
3rd	68.9%	186°	4th	1.0%	61°
5th	43.1%	5°	6th	0.5%	221°
7th	18.3%	185°	8th	0.5%	346°
9th	4.0%	343°	10th	0.3%	152°
11th	3.2%	24°	12th		
13th	4.4%	149°	14th		
15th	3.0%	256°	16th		
17th	1.5%	81°	18th		
19th	1.1%	250°	20th		
21st	0.5%	282°	22nd		
23rd	0.4%	320°	24th		
25th	0.3%	96°	26th		
27th	0.4%	333°	28th		
29th	0.7%	122°	30th		
31st	0.2%	279°			
Odd: 83.7%			Even: 1.9%		
Thd: 83.7%

PH B-NEUT VOLTAGE SPECTRUM

08:43:01.45

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.7%	335°
3rd	1.5%	87°	4th	0.7%	347°
5th	1.6%	168°	6th	0.4%	3°
7th	0.3%	89°	8th		
9th	0.6%	219°	10th		
11th	0.7%	291°	12th		
13th	0.9%	354°	14th		
15th	0.6%	98°	16th		
17th	0.5%	88°	18th		
19th	0.3%	76°	20th		
21st	0.3%	118°			
Odd: 2.7%			Even: 1.1%		
Thd: 2.9%

PHASE B CURRENT SPECTRUM

08:43:01.45

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	10.0%	102°
3rd	34.3%	188°	4th	5.1%	108°
5th	24.4%	7°	6th	0.5%	209°
7th	13.6%	191°	8th	0.7%	141°
9th	5.8%	10°	10th	0.3%	168°
11th	1.2%	184°	12th		
13th	0.9%	103°	14th	0.3%	116°
15th	1.1%	257°	16th	0.3%	151°
17th	0.3%	24°	18th		
19th	1.0%	245°	20th		
21st	0.3%	14°	22nd		
23rd	0.3%	239°	24th		
25th	0.4%	320°	26th		
27th	0.5%	202°	28th		
29th	0.3%	26°	30th		
31st	0.3%	193°			
Odd: 44.7%			Even: 11.3%		
Thd: 46.1%

PH C-NEUT VOLTAGE SPECTRUM

08:43:01.45

Fundamental frequency: 60.0 Hz

Harmonic	Percent	Phase	Sine	Harmonic	Percent	Phase	Sine
Fund	100.0%		0°	2nd			
3rd	1.1%		72°	4th			
5th	1.2%		177°	6th			
7th	0.5%		115°	8th			
9th	0.7%		197°	10th			
11th	0.7%		267°	12th			
13th	1.2%		355°	14th			
15th	0.3%		102°	16th			
17th				18th			
19th	0.6%		354°	20th			
21st	0.4%		40°	22nd			
23rd	0.4%		113°				
Odd: 2.5%				Even: 0.0%			
Thd: 2.5%

PHASE C CURRENT SPECTRUM

08:43:01.45

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	2.0%	119°
3rd	64.1%	207°	4th	0.6%	272°
5th	46.4%	38°	6th	0.6%	132°
7th	24.4%	231°	8th	0.2%	265°
9th	10.1%	52°	10th		
11th	2.9%	201°	12th		
13th	0.6%	273°	14th		
15th	1.6%	344°	16th		
17th	2.3%	172°	18th		
19th	2.5%	332°	20th		
21st	1.2%	109°	22nd		
23rd	0.8%	314°	24th		
25th	1.1%	135°	26th		
27th	0.5%	335°	28th		
29th	0.3%	307°	30th		
31st	0.3%	57°	32nd		
33rd	0.5%	189°			
Odd: 83.6%			Even: 2.2%		
Thd: 83.6%

NEUT-GND VOLTAGE SPECTRUM

08:43:01.45

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	31.2%	49°
3rd	547.2%	98°	4th	26.3%	336°
5th	72.5%	27°	6th		
7th	35.1%	278°	8th		
9th	135.3%	37°	10th		
11th	54.5%	162°	12th		
13th	32.5%	74°	14th		
15th			16th		
17th	15.3%	252°	18th		
19th	16.1%	33°	20th		
21st	19.3%	226°	22nd		
23rd			24th		
25th	10.6%	175°	26th	12.7%	261°
27th	15.0%	126°	28th		
29th	33.0%	302°	30th	12.1%	303°
31st	17.9%	337°	32nd	13.8%	69°
33rd	16.3%	105°			
Odd: 575.4%			Even: 46.5%		
Thd: 577.3%

NEUT CURRENT SPECTRUM

08:43:01.45

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	29.2%	216°
3rd	347.4%	77°	4th	16.3%	150°
5th	35.8%	36°	6th	2.4%	149°
7th	9.0%	308°	8th	2.1%	48°
9th	39.9%	32°	10th	0.8%	336°
11th	12.5%	204°	12th		
13th	6.2%	133°	14th	1.1%	132°
15th	12.1%	65°	16th	1.2%	102°
17th	3.4%	354°	18th		
19th	1.1%	93°	20th		
21st	3.0%	298°	22nd		
23rd	1.6%	57°	24th		
25th	0.9%	53°	26th		
27th	1.9%	324°	28th		
29th	1.5%	87°	30th		
31st			32nd		
33rd	1.2%	183°			
Odd: 352.2%			Even: 33.7%		
Thd: 353.8%

STATUS REPORT

13:43

PHASE A-B (Voltage Channel 1)

Voltage: 120.0 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 119.4 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 120.6 Vrms

Frequency: 60.0 Hz

High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 44.5 Arms

PHASE B (Current Channel 2)

Current: 39.8 Arms

PHASE C (Current Channel 3)

Current: 34.4 Arms

HARMONIC REPORT

13:44

PHASE A-B VOLTAGE SPECTRUM

13:44:42.60

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	1.5%	65°	4th		
5th	1.5%	271°	6th		
7th	1.1%	42°	8th		
9th	0.8%	153°	10th		
11th	0.5%	264°	12th		
13th	0.3%	26°	14th		
15th	0.5%	174°	16th		
17th	0.4%	245°	18th		
19th	0.3%	33°	20th		
21st	0.2%	122°	22nd		
23rd	0.2%	240°			
Odd: 2.7%			Even: 0.0%		
Thd: 2.7%

PHASE A CURRENT SPECTRUM

13:44:42.60

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.4%	76°
3rd	12.5%	71°	4th		
5th	29.9%	142°	6th		
7th	10.2%	304°	8th		
9th	3.1%	207°	10th		
11th	3.6%	300°	12th		
13th	3.7%	348°	14th		
15th	2.8%	296°	16th		
17th	2.4%	288°	18th		
19th	1.5%	296°	20th		
21st	1.1%	121°	22nd		
23rd	0.6%	147°	24th		
25th			26th		
27th	0.3%	73°	28th		
29th	0.3%	113°	30th		
31st	0.3%	254°	32nd		
33rd	0.3%	60°			
Odd: 34.8%			Even: 0.4%		
Thd: 34.8%

PHASE B-C VOLTAGE SPECTRUM

13:44:42.60

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	2nd	0%
3rd	2.5%	4th	50%
5th	1.7%	6th	262%
7th	1.2%	8th	14%
9th	0.8%	10th	129%
11th	0.5%	12th	232%
13th	0.6%	14th	338%
15th	0.4%	16th	84%
17th	0.4%	18th	192%
19th	0.3%		287%
Odd: 3.5%		Even: 0.0%	
Thd: 3.5%

PHASE B CURRENT SPECTRUM

13:44:42.60

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	6.9%	319°	4th		
5th	31.0%	184°	6th		
7th	12.9%	16°	8th		
9th	1.3%	151°	10th		
11th	1.9%	29°	12th		
13th	3.4%	158°	14th		
15th	1.0%	291°	16th		
17th	1.6%	155°	18th		
19th	1.6%	78°	20th		
21st	1.6%	134°	22nd		
23rd	0.5%	291°	24th		
25th	0.8%	81°	26th		
27th	0.2%	181°	28th		
29th	0.3%	301°	30th		
31st	0.3%	146°	32nd		
33rd	0.3%	120°			
Odd: 34.6%			Even: 0.0%		
Thd: 34.6%

PHASE C-A VOLTAGE SPECTRUM

13:44:42.60

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	2.2%	53°	4th		
5th	1.6%	260°	6th		
7th	1.2%	21°	8th		
9th	0.9%	148°	10th		
11th	0.6%	233°	12th		
13th	0.6%	332°	14th		
15th	0.4%	97°	16th		
17th	0.3%	196°	18th		
19th	0.3%	310°	20th		
21st	0.3%	49°			
Odd: 3.3%			Even: 0.0%		
Thd: 3.3%

PHASE C CURRENT SPECTRUM

13:44:42.60

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.6%	351°
3rd	10.9%	217°	4th		
5th	38.1%	124°	6th		
7th	14.3%	286°	8th		
9th	2.8%	351°	10th		
11th	4.4%	242°	12th		
13th	6.5%	346°	14th		
15th	2.6%	69°	16th	0.2%	303°
17th	1.1%	181°	18th		
19th	0.6%	245°	20th		
21st	0.4%	37°	22nd		
23rd	1.3%	57°	24th		
25th	0.8%	98°	26th		
27th	0.3%	247°	28th		
29th	0.7%	316°			
Odd: 43.1%			Even: 0.6%		
Thd: 43.1%

STATUS REPORT

13:49

PH A-NEUT (Voltage Channel 1)

Voltage: 118.9 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 117.9 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 118.3 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 19.4 Vrms
High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 34.9 Arms

PHASE B (Current Channel 2)

Current: 33.4 Arms

PHASE C (Current Channel 3)

Current: 31.9 Arms

NEUT (Current Channel 4)

Current: 45.9 Arms

HARMONIC REPORT

13:50

NEUT-GND SNAPSHOT

PH A-NEUT VOLTAGE SPECTRUM

13:50:10.23

Fundamental frequency: 60.0 Hz

Harmonic	Percent	Phase	Sine	Harmonic	Percent	Phase	Sine
Fund	100.0%		0°	2nd			
3rd	2.7%		39°	4th			
5th	2.3%		178°	6th			
7th				8th			
9th				10th			
11th	1.1%		216°	12th			
13th	1.3%		291°	14th			
15th	1.4%		325°	16th			
17th	0.9%		14°	18th			
19th	0.4%		48°				
Odd:	4.3%			Even:	0.0%		
Thd:	4.3%						

PH A-NEUT VOLTAGE SPECTRUM

125 Hz/division horizontal

1505 5&7 ISO TR LOAD

Mar 14, 1994

13:50:10.23

PHASE A CURRENT SPECTRUM

13:50:10.23

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	0ø	
3rd	60.5%	178ø	
5th	33.9%	354ø	
7th	10.9%	167ø	
9th	1.0%	229ø	
11th	3.4%	337ø	
13th	3.2%	90ø	
15th	2.6%	189ø	
17th	0.4%	107ø	
19th	0.6%	242ø	
21st	0.4%	189ø	
23rd	0.5%	194ø	
25th	0.4%	331ø	
Odd: 70.4%		Even: 0.0%	
Thd: 70.4%

PH B-NEUT VOLTAGE SPECTRUM

13:50:10.23

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase		Sine	Harmonic Percent Phase		Sine
Fund	100.0%	0°	2nd		
3rd	1.9%	69°	4th		
5th	1.6%	175°	6th		
7th			8th		
9th	0.6%	217°	10th		
11th	0.6%	254°	12th		
13th	0.7%	348°	14th		
15th	0.8%	74°	16th		
17th	0.7%	60°	18th		
19th	0.3%	86°	20th		
21st	0.3%	137°			
Odd: 2.9%			Even: 0.0%		
Thd: 2.9%

PHASE B CURRENT SPECTRUM

13:50:10.23

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	44.0%	189°	4th		
5th	29.6%	12°	6th	0.2%	117°
7th	14.7%	197°	8th		
9th	5.1%	15°	10th		
11th	0.7%	176°	12th		
13th	0.7%	78°	14th		
15th	1.8%	239°	16th		
17th	0.8%	51°	18th		
19th	0.9%	261°	20th		
21st	0.3%	44°	22nd		
23rd			24th		
25th	0.4%	337°	26th		
27th	0.7%	223°	28th		
29th	0.4%	38°	30th		
31st			32nd		
33rd	0.3%	292°			
Odd: 55.3%			Even: 0.2%		
Thd: 55.3%

PH C-NEUT VOLTAGE SPECTRUM

13:50:10.23

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	2.0%	57°	4th		
5th	1.6%	180°	6th		
7th	0.3%	88°	8th		
9th	0.5%	149°	10th		
11th	1.1%	224°	12th		
13th	1.3%	312°	14th		
15th	0.8%	355°	16th		
17th	0.3%	51°	18th		
19th			20th		
21st	0.4%	321°	22nd		
23rd	0.2%	53°			
Odd: 3.2%			Even: 0.0%		
Thd: 3.2%

PHASE C CURRENT SPECTRUM

13:50:10.23

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase		Sine	Harmonic Percent Phase		Sine
Fund	100.0%	0°	2nd		
3rd	57.2%	186°	4th		
5th	35.4%	6°	6th		
7th	14.5%	186°	8th		
9th	3.2%	343°	10th		
11th	1.3%	29°	12th		
13th	2.0%	95°	14th		
15th	2.6%	229°	16th		
17th	1.6%	44°	18th		
19th	1.2%	191°	20th		
21st	0.3%	325°	22nd		
23rd	0.5%	242°	24th		
25th	0.4%	51°	26th		
27th	0.3%	350°	28th		
29th	0.3%	40°	30th		
31st	0.5%	152°	32nd		
33rd	0.5%	328°			
Odd: 69.0%			Even: 0.0%		
Thd: 69.0%

NEUT-GND VOLTAGE SPECTRUM

13:50:10.23

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	1.0%	205°
3rd	5.0%	345°	4th	0.3%	125°
5th	1.0%	324°	6th		
7th			8th		
9th	0.5%	207°	10th		
11th	0.9%	119°	12th		
13th	0.6%	214°	14th		
15th	1.9%	154°	16th		
17th	0.6%	86°	18th		
19th	0.5%	52°	20th		
21st	0.3%	287°	22nd		
23rd			24th		
25th	0.2%	201°	26th		
27th	0.3%	241°			
Odd: 5.6%			Even: 1.1%		
Thd: 5.7%

NEUT CURRENT SPECTRUM

13:50:10.23

Fundamental frequency: 180.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0ø	2nd		
3rd	4.5%	155ø	4th		
5th	4.2%	18ø	6th		
7th			8th		
9th	0.4%	10ø			
Odd: 6.2%			Even: 0.0%		
Thd: 6.2%

Appendix H

Westinghouse SureSine Harmonic Data

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Martin Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

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STATUS REPORT

11:04 AM

LINE-NEUT (Voltage Channel 1)

Voltage: 124.4 Vrms
Frequency: 60.0 Hz
High freq noise: 0.0 Vpp

NEUT-GND (Voltage Channel 2)

Voltage: 1.0 Vrms
High freq noise: 0.1 Vpp

LINE (Current Channel 1)

Current: 18.4 Arms

NEUT (Current Channel 2)

Current: 18.6 Arms

LINE-NEUT VOLTAGE SPECTRUM

11:05:06.24 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.9%	40°	4th		
5th	2.4%	173°	6th		
7th	0.7%	111°	8th		
9th	0.3%	229°			
Odd: 2.7%			Even: 0.0%		
Thd: 2.7%

LINE CURRENT SPECTRUM

11:05:06.24 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	83.5%	160°	4th	0.3%	339°
5th	61.4%	324°	6th	0.3%	153°
7th	38.3%	129°	8th	0.2%	348°
9th	17.7%	285°	10th	0.2%	199°
11th	5.6%	50°	12th	0.3%	32°
13th	4.9%	136°	14th	0.3%	210°
15th	4.4%	275°	16th		
17th	2.4%	47°	18th		
19th	1.9%	146°	20th		
21st	2.1%	276°	22nd		
23rd	1.2%	71°	24th		
25th			26th		
27th	1.1%	228°	28th		
29th	1.2%	24°	30th		
31st	0.5%	194°	32nd		
33rd	0.2%	115°			

Odd: 112.3%

Even: 0.6%

Thd: 112.3%

NEUT-GND VOLTAGE SPECTRUM

11:05:06.24 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	84.9%	178°	4th	0.4%	322°
5th	64.0%	350°	6th	0.4%	353°
7th	41.0%	162°	8th		
9th	19.9%	331°	10th	0.4%	226°
11th	5.5%	103°	12th	0.5%	70°
13th	5.7%	194°	14th	0.4%	281°
15th	5.5%	343°	16th		
17th	3.2%	112°	18th		
19th	2.7%	215°	20th		
21st	2.9%	274°	22nd		
23rd	1.7%	65°	24th	0.2%	144°
25th	1.2%	187°	26th	0.3%	298°
27th	1.8%	49°	28th		
29th	1.8%	147°	30th		
31st	0.9%	318°	32nd		
33rd	0.4%	275°			
Odd: 116.3%			Even: 1.0%		
Thd: 116.3%

NEUT CURRENT SPECTRUM

11:05:06.24 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	83.7%	161°	4th	0.3%	338°
5th	61.6%	326°	6th	0.3%	151°
7th	38.5%	132°	8th	0.2%	347°
9th	17.8%	289°	10th	0.2%	205°
11th	5.6%	53°	12th	0.2%	31°
13th	4.9%	141°	14th	0.2%	215°
15th	4.5%	281°	16th		
17th	2.4%	51°	18th		
19th	1.9%	151°	20th		
21st	2.1%	284°	22nd		
23rd	1.2%	74°	24th		
25th			26th		
27th	1.1%	241°	28th		
29th	1.2%	41°	30th		
31st	0.5%	213°	32nd		
33rd	0.3%	132°			
Odd: 112.6%			Even: 0.6%		
Thd: 112.6%

STATUS REPORT

11:09 AM

LINE-NEUT (Voltage Channel 1)

Voltage: 125.6 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

NEUT-GND (Voltage Channel 2)

Voltage: 1.0 Vrms

High freq noise: 0.1 Vpp

LINE (Current Channel 1)

Current: 18.0 Arms

NEUT (Current Channel 2)

Current: 18.2 Arms

LINE-NEUT VOLTAGE SPECTRUM

11:09:58.86 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.9%	36°	4th		
5th	2.2%	175°	6th		
7th	0.9%	111°	8th		
9th	0.3%	213°			
Odd: 2.5%			Even: 0.0%		
Thd: 2.5%

LINE CURRENT SPECTRUM

11:09:58.86 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.4%	171°
3rd	86.0%	172°	4th	0.5%	12°
5th	65.0%	345°	6th	0.4%	144°
7th	41.8%	156°	8th	0.3%	111°
9th	21.5%	318°	10th		
11th	9.4%	97°	12th	0.2%	60°
13th	6.8%	218°	14th	0.2%	265°
15th	5.6%	1°	16th		
17th	3.1%	145°	18th		
19th	2.0%	253°	20th		
21st	2.4%	25°	22nd		
23rd	1.9%	181°	24th		
25th	0.7%	324°	26th		
27th	0.8%	12°	28th		
29th	1.1%	167°	30th		
31st	0.8%	327°			

Odd: 118.4%

Even: 0.9%

Thd: 118.4%

NEUT-GND VOLTAGE SPECTRUM

11:09:58.86 AM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase

Sine

Harmonic Percent Phase

Sine

Fund	100.0%	0°
3rd	85.5%	178°
5th	65.8%	351°
7th	44.0%	161°
9th	23.9%	327°
11th	9.8%	106°
13th	8.2%	222°
15th	6.8%	7°
17th	4.2%	145°
19th	3.0%	255°
21st	3.7%	32°
23rd	3.0%	186°
25th	0.9%	297°
27th	1.4%	37°
29th	1.6%	231°
31st	1.4%	325°

2nd	0.5%	85°
4th	0.6%	356°
6th	0.3%	287°
8th		
10th		
12th	0.3%	57°
14th		
16th		
18th		
20th		
22nd		
24th		
26th	0.7%	146°
28th		
30th	0.8%	172°
32nd	0.5%	179°

Odd: 120.0%

Even: 1.5%

Thd: 120.0%

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.4%	172°
3rd	86.1%	173°	4th	0.5%	21°
5th	65.2%	345°	6th	0.4%	142°
7th	41.9%	157°	8th	0.2%	114°
9th	21.6%	319°	10th		
11th	9.5%	98°	12th	0.2%	75°
13th	6.8%	218°	14th	0.3%	268°
15th	5.6%	2°	16th	0.2%	85°
17th	3.1%	146°	18th		
19th	2.0%	252°	20th		
21st	2.4%	24°	22nd		
23rd	1.9%	182°	24th		
25th	0.7%	326°	26th		
27th	0.8%	20°	28th		
29th	1.2%	170°	30th		
31st	0.8%	341°			
Odd: 118.6%			Even: 0.9%		
Thd: 118.6%

STATUS REPORT

11:00 AM

LINE-NEUT (Voltage Channel 1)

Voltage: 119.8 Vrms

Frequency: 60.0 Hz

High freq noise: 0.1 Vpp

NEUT-GND (Voltage Channel 2)

Voltage: 1.4 Vrms

High freq noise: 0.5 Vpp

LINE (Current Channel 1)

Current: 32.1 Arms

NEUT (Current Channel 2)

Current: 32.1 Arms

LINE-NEUT SNAPSHOT

250V

100A

0V

0A

-250V

-100A

LINE-NEUT VOLTAGE

LINE CURRENT

5.0 milliseconds/division horizontal

K731 CMPTRS SURESINE

Nov 18 93

11:01:40 AM

LINE-NEUT VOLTAGE SPECTRUM

11:01:40.33 AM

Fundamental frequency: 60.0 Hz

Harmonic	Percent	Phase	Sine	Harmonic	Percent	Phase	Sine
Fund	100.0%		0ø				
Odd:	0.0%			Even:	0.0%		
Thd:	0.0%

LINE CURRENT SPECTRUM

11:01:40.33 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.5%	344°
3rd	3.8%	128°	4th	0.8%	27°
5th	3.7%	225°	6th	0.3%	343°
7th	3.1%	101°	8th	0.6%	339°
9th	0.4%	30°	10th		
11th			12th		
13th			14th		
15th			16th	0.2%	4°
17th			18th		
19th			20th		
21st			22nd		
23rd			24th		
25th	0.2%	341°	26th		
27th			28th		
29th	0.3%	161°			
Odd:	6.1%		Even:	1.2%	
Thd:	6.3%

NEUT-GND VOLTAGE SPECTRUM

11:01:40.33 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.7%	346°
3rd	4.7%	53°	4th	0.9%	55°
5th	0.5%	157°	6th	0.3%	324°
7th	6.2%	128°	8th	0.7%	349°
9th	1.5%	201°	10th		
11th	0.9%	313°	12th	0.2%	339°
13th	0.7%	342°	14th	0.2%	196°
15th	0.2%	52°	16th	0.3%	191°
17th	0.4%	317°	18th	0.3%	12°
19th			20th	0.4%	239°
21st			22nd	0.4%	187°
23rd			24th		
25th	0.3%	329°	26th	0.3%	160°
27th	0.5%	274°	28th	0.3%	37°
29th	0.5%	323°	30th		
31st	0.3%	239°	32nd	0.4%	225°
33rd	0.3%	177°			
Odd: 8.1%			Even: 1.7%		
Thd: 8.3%

NEUT CURRENT SPECTRUM

11:01:40.33 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.5%	342°
3rd	3.8%	129°	4th	0.8%	27°
5th	3.8%	225°	6th	0.3%	335°
7th	3.1%	102°	8th	0.6%	339°
9th	0.4%	34°	10th		
11th			12th		
13th			14th		
15th			16th	0.2%	8°
17th			18th		
19th			20th		
21st			22nd	0.2%	90°
23rd			24th		
25th			26th		
27th			28th		
29th	0.3%	168°			
Odd:	6.2%		Even:	1.2%	
Thd:	6.3%

Wiring Diagram for Wye-Wye Configuration of Three Single Phase SureSines

ELECTRICAL CONNECTION

Harmonic Current Reduction with Three Single Phase SureSine APLC

Building 1505 Test Setup

Harmonic	Phase A Current Spectrum			Phase B Current Spectrum			Phase C Current Spectrum			Neutral Current Spectrum		
	SureSine Load	SureSine Line	% Change	SureSine Load	SureSine Line	% Change	SureSine Load	SureSine Line	% Change	SureSine Load	SureSine Line	% Change
THD:	102.2	5.3	-95%	96.5	4.9	-95%	108.4	14.4	-87%	683.2	243.1	-64%
3rd	81.4	0.8	-99%	73.3	1.6	-98%	75.7	3.9	-95%	679.8	238	-65%
6th	54.4	3.5	-94%	53.6	2.5	-95%	62.3	8.5	-86%	37.7	20.2	-46%
7th	26.8	0.7	-97%	29.9	1.2	-96%	39.9	4.5	-89%	37.3	12.6	-66%
9th	6.3	1.2	-81%	12	1.7	-86%	21.5	2.7	-87%	10.2	32.8	222%
11th	4.8	1.5	-69%	2.4	0.9	-63%	7.2	2.3	-68%	23.5	4.6	-80%
13th	6.5	0.9	-86%	2.1	1	-52%	1.2	2.8	133%	21.4	8.1	-62%
15th	3.5	0.6	-83%	2.1	1.4	-33%	3.1	3.6	16%	16.8	20.3	21%
17th	1.6	1.2	-25%	1.4	1	-29%	1.9	2.5	32%	10.6	6.7	-37%
19th	2.2	1.1	-50%	0.5	0.8	60%	0.4	2.1	425%	5.4	5.3	-2%
21st	1.7	0.8	-53%	0.5	1	100%	2.3	3.3	43%	11.8	11.4	-3%
23rd	1	1	0%	1.2	0.9	-25%	3.1	2	-35%		3.4	
25th	1.5	0.8	-47%	1.3	0.7	-46%	2.3	3	30%	5.3	3.4	-36%
27th	1	1.1	10%	0.7	0.9	29%	0.9	3.5	289%	3.6	5.9	64%
29th	0.7	0.9	29%	0.6	0.8	33%	0.3	2.9	867%	2.6	2.3	-12%
31st	0.4	0.8	100%	0.3	0.6	100%	0.5	1.9	280%		2.2	
33rd	0.6	1.3	117%	0.3	0.6	100%	0.6	2.3	283%	1.7	4.3	153%
Current	Phase A Current			Phase B Current			Phase C Current			Neutral Current		
	SureSine Load	SureSine Line	% Change	SureSine Load	SureSine Line	% Change	SureSine Load	SureSine Line	% Change	SureSine Load	SureSine Line	% Change
THD	102.2	5.3	-95%	96.5	4.9	-95%	108.4	14.4	-87%	683.2	243.1	-64%
Crest Factor	2.16	1.17	-46%	2.92	1.50	-49%	3.01	1.53	-49%	1.65	1.40	-15%
RMS (A)	23.4	22.5	-4%	14.1	12	-15%	7.5	7.8	4%	42.3	24.3	-43%

H-26

SURESINE MEASUREMENT POINTS

STATUS REPORT

10:18 AM

PH A-NEUT (Voltage Channel 1)

Voltage: 119.5 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 118.8 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 119.4 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 1.1 Vrms
High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 22.5 Arms

PHASE B (Current Channel 2)

Current: 12.0 Arms

PHASE C (Current Channel 3)

Current: 7.8 Arms

NEUT (Current Channel 4)

Current: 24.3 Arms

HARMONIC REPORT

10:19 AM

PH A-NEUT VOLTAGE SPECTRUM

10:19:07.87 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	1.8%	53°	4th		
5th	2.3%	247°	6th		
7th	1.2%	20°	8th		
9th	0.8%	121°	10th		
11th	0.5%	230°	12th		
13th	0.5%	345°	14th		
15th	0.3%	99°	16th		
17th	0.3%	205°	18th		
19th	0.3%	314°	20th		
21st			22nd		
23rd	0.3%	167°	24th		
25th			26th		
27th	0.2%	5°			
Odd:	3.4%		Even:	0.0%	
Thd:	3.4%

PHASE A CURRENT SPECTRUM

10:19:07.87 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.2%	351°
3rd	0.8%	57°	4th		
5th	3.5%	169°	6th		
7th	0.7%	273°	8th		
9th	1.2%	19°	10th		
11th	1.5%	70°	12th		
13th	0.9%	135°	14th		
15th	0.6%	219°	16th		
17th	1.2%	295°	18th		
19th	1.1%	4°	20th		
21st	0.8%	54°	22nd		
23rd	1.0%	118°	24th		
25th	0.8%	196°	26th	0.2%	115°
27th	1.1%	237°	28th		
29th	0.9%	254°	30th		
31st	0.8%	355°	32nd		
33rd	1.3%	357°			
Odd: 5.3%			Even: 0.3%		
Thd: 5.3%

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	2.6%	44°	4th		
5th	2.2%	255°	6th		
7th	1.3%	11°	8th		
9th	0.9%	115°	10th		
11th	0.5%	215°	12th		
13th	0.6%	338°	14th		
15th	0.5%	75°	16th		
17th	0.3%	163°	18th		
19th	0.4%	298°	20th		
21st	0.3%	301°	22nd		
23rd	0.2%	129°	24th		
25th	0.2%	303°	26th		
27th	0.2%	19°			
Odd: 3.9%			Even: 0.0%		
Thd: 3.9%

PHASE B CURRENT SPECTRUM

10:19:07.87 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.5%	211°
3rd	1.6%	18°	4th		
5th	2.5%	197°	6th		
7th	1.2%	26°	8th		
9th	1.7%	80°	10th		
11th	0.9%	140°	12th		
13th	1.0%	305°	14th		
15th	1.4%	356°	16th		
17th	1.0%	58°	18th		
19th	0.8%	197°	20th		
21st	1.0%	240°	22nd		
23rd	0.9%	335°	24th		
25th	0.7%	138°	26th		
27th	0.9%	182°	28th		
29th	0.8%	179°	30th		
31st	0.6%	272°	32nd		
33rd	0.6%	270°			
Odd: 4.8%			Even: 0.5%		
Thd: 4.9%

PH C-NEUT VOLTAGE SPECTRUM

10:19:07.87 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	2.9%	41°	4th		
5th	2.4%	236°	6th		
7th	1.3%	1°	8th		
9th	0.9%	93°	10th		
11th	0.7%	189°	12th		
13th	0.6%	303°	14th		
15th	0.6%	40°	16th		
17th	0.4%	126°	18th		
19th	0.3%	241°	20th		
21st	0.4%	326°	22nd		
23rd	0.3%	57°	24th		
25th	0.3%	152°	26th		
27th	0.3%	222°	28th		
29th	0.2%	311°			
Odd: 4.3%			Even: 0.0%		
Thd: 4.3%

PHASE C CURRENT SPECTRUM

10:19:07.87 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	3.9%	297°	4th	0.2%	322°
5th	8.5%	75°	6th		
7th	4.5%	107°	8th		
9th	2.7%	134°	10th		
11th	2.3%	170°	12th		
13th	2.8%	209°	14th		
15th	3.6%	216°	16th		
17th	2.5%	225°	18th		
19th	2.1%	267°	20th	0.2%	338°
21st	3.3%	270°	22nd		
23rd	2.0%	18°	24th	0.3%	21°
25th	3.0%	287°	26th	0.2%	227°
27th	3.5%	285°	28th	0.3%	125°
29th	2.9%	286°	30th	0.5%	106°
31st	1.9%	264°	32nd		
33rd	2.3%	290°			
Odd: 14.3%			Even: 0.8%		
Thd: 14.4%

NEUT-GND VOLTAGE SPECTRUM

10:19:07.87 AM

Fundamental frequency: 180.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	27.3%	28°	4th	0.5%	243°
5th	14.3%	298°	6th	1.1%	123°
7th	7.4%	194°	8th	0.8%	235°
9th	3.8%	162°	10th	0.7%	43°
11th	2.7%	5°			
Odd: 32.0%			Even: 1.6%		
Thd: 32.0%

NEUT CURRENT SPECTRUM

10:19:07.87 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	238.0%	347°	4th	2.5%	36°
5th	20.2%	216°	6th		
7th	12.6%	219°	8th	1.8%	297°
9th	32.8%	91°	10th	1.4%	333°
11th	4.6%	111°	12th	0.9%	202°
13th	8.1%	259°	14th	2.1%	243°
15th	20.3%	125°	16th		
17th	6.7%	96°	18th	1.1%	147°
19th	5.3%	216°	20th	1.0%	183°
21st	11.4%	137°	22nd	0.9%	47°
23rd	3.4%	111°	24th	0.8%	148°
25th	3.4%	225°	26th	0.7%	96°
27th	5.9%	215°	28th	1.1%	141°
29th	2.3%	201°	30th	0.9%	159°
31st	2.2%	0°	32nd		
33rd	4.3%	99°			
Odd: 243.0%			Even: 4.8%		
Thd: 243.1%

STATUS REPORT

10:12 AM

PH A-NEUT (Voltage Channel 1)

Voltage: 119.8 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 119.8 Vrms
Frequency: 60.0 Hz
High freq noise: 0.3 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 120.5 Vrms
Frequency: 60.0 Hz
High freq noise: 0.3 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 4.7 Vrms
High freq noise: 0.5 Vpp

PHASE A (Current Channel 1)

Current: 23.4 Arms

PHASE B (Current Channel 2)

Current: 14.1 Arms

PHASE C (Current Channel 3)

Current: 7.5 Arms

NEUT (Current Channel 4)

Current: 42.3 Arms

HARMONIC REPORT

10:14 AM

PH C-NEUT SNAPSHOT

250V

75A

0V

0A

-250V

-75A

PH C-NEUT VOLTAGE

PHASE C CURRENT

5.0 milliseconds/division horizontal

LOAD WYE 3 SURESINES

May 25, 1994

10:14:33 AM

LOAD WYE 3 SURESINES

May 25, 1994

PH A-NEUT VOLTAGE SPECTRUM

10:14:33.63 AM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase

Fund	100.0%	0°
3rd	0.5%	339°

Odd: 0.5%

Thd: 0.5%

Harmonic Percent Phase

2nd

Even: 0.0%

LOAD WYE 3 SURESINES

May 25, 1994

10:14:33.63 AM

PHASE A CURRENT SPECTRUM

10:14:33.63 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.9%	138°
3rd	81.4%	165°	4th	0.8%	351°
5th	54.4%	334°	6th	0.6%	165°
7th	26.8%	142°	8th	0.7%	325°
9th	6.3%	300°	10th	0.7%	125°
11th	4.8%	310°	12th	0.5%	283°
13th	6.5%	106°	14th	0.2%	64°
15th	3.5%	262°	16th	0.3%	94°
17th	1.6%	334°	18th	0.3%	272°
19th	2.2%	110°	20th	0.3%	17°
21st	1.7%	251°	22nd	0.3%	188°
23rd	1.0%	330°	24th		
25th	1.5%	85°	26th	0.3%	8°
27th	1.0%	219°	28th	0.3%	128°
29th	0.7%	39°	30th		
31st	0.4%	241°	32nd		
33rd	0.6%	48°			
Odd: 102.2%			Even: 1.9%		
Thd: 102.2%

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0ø	2nd		
3rd	0.4%	341ø			
Odd: 0.4%			Even: 0.0%		
Thd: 0.4%

PHASE B CURRENT SPECTRUM

10:14:33.63 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.5%	209°
3rd	73.3%	202°	4th	0.4%	30°
5th	53.6%	30°	6th	0.3%	164°
7th	29.9%	226°	8th	0.3%	357°
9th	12.0%	65°	10th		
11th	2.4%	297°	12th		
13th	2.1%	244°	14th		
15th	2.1%	99°	16th	0.3%	177°
17th	1.4%	310°	18th	0.3%	20°
19th	0.5%	136°	20th	0.2%	190°
21st	0.5%	221°	22nd	0.2%	195°
23rd	1.2%	28°	24th	0.2%	167°
25th	1.3%	197°	26th		
27th	0.7%	119°	28th		
29th	0.6%	166°	30th		
31st	0.3%	17°	32nd		
33rd	0.3%	20°			
Odd: 96.5%			Even: 0.9%		
Thd: 96.5%

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd	0.4%	329°			
Odd: 0.4%			Even: 0.0%		
Thd: 0.4%

PHASE C CURRENT SPECTRUM

10:14:33.63 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.9%	111°
3rd	75.7%	194°	4th	0.7%	326°
5th	62.3%	19°	6th	0.7%	160°
7th	39.9%	207°	8th	0.5%	0°
9th	21.5%	32°	10th	0.4%	188°
11th	7.2%	212°	12th	0.3%	354°
13th	1.2%	301°	14th		
15th	3.1%	74°	16th		
17th	1.9%	257°	18th	0.3%	15°
19th	0.4%	200°	20th	0.5%	194°
21st	2.3%	74°	22nd	0.6%	29°
23rd	3.1%	263°	24th	0.7%	209°
25th	2.3%	86°	26th	0.7%	34°
27th	0.9%	295°	28th	0.6%	169°
29th	0.3%	233°	30th	0.4%	43°
31st	0.5%	151°	32nd		
33rd	0.6%	333°			
Odd: 108.4%			Even: 2.1%		
Thd: 108.4%

NEUT-GND VOLTAGE SPECTRUM

10:14:33.63 AM

Fundamental frequency: 180.1 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	0.7%	354°
3rd	22.2%	270°	4th	0.9%	211°
5th	5.4%	77°	6th	0.7%	46°
7th	1.6%	125°	8th		
9th	3.3%	296°	10th		
11th	2.5%	140°			
Odd: 23.3%			Even: 1.4%		
Thd: 23.4%

FUT CURRENT SPECTRUM

10:14:33.63 AM

Fundamental frequency: 59.4 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	679.8%	81°	4th	2.4%	66°
5th	37.7%	232°	6th	2.2%	199°
7th	37.3%	313°	8th	1.8%	342°
9th	10.2%	140°	10th	2.3%	57°
11th	23.5%	124°	12th		
13th	21.4%	171°	14th		
15th	16.8%	58°	16th		
17th	10.6%	295°	18th	1.7%	62°
19th	5.4%	302°	20th		
21st	11.8%	207°	22nd		
23rd			24th		
25th	5.3%	12°	26th		
27th	3.6%	62°	28th		
29th	2.6%	142°	30th		
31st			32nd		
33rd	1.7%	177°			
Odd: 683.1%			Even: 4.7%		
Thd: 683.2%

PH A-NEUT Vrms

12:00:05 AM

Voltage: 119.3 Vrms min, 120.1 Vrms max

PH A-NEUT Vrms

12:00:05 AM

Voltage: 78.1 Vrms min, 120.3 Vrms max

PH A-NEUT VOLTAGE SAG

5:05:46 AM

78.1 Vrms minimum

0.4 seconds below threshold

PH A-NEUT WAVESHAPE FAULT

5:05:46.22 AM

Appendix I

Liebert Datawave Harmonic Data

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Martin Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

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DATAWAVE MEASUREMENT POINTS

Harmonic Current Reduction with Liebert Datawave Mangetic Synthesizer

Building 1505 - Power Panel 4

Harmonic	Phase A Current Spectrum			Phase B Current Spectrum			Phase C Current Spectrum		
	Datawave	Datawave	%	Datawave	Datawave	%	Datawave	Datawave	%
	Line	Load	Reduction	Line	Load	Reduction	Line	Load	Reduction
THD:	3.9	53.0	-93%	4.3	44.4	-90%	4.5	46.7	-90%
3rd	2.1	40.1	-95%	2.1	34.7	-94%	2.4	36.0	-93%
5th	2.5	28.2	-91%	3.1	23.2	-87%	2.8	25.6	-89%
7th	0.5	11.8	-96%	0.3	9.2	-97%	0.3	10	-97%
9th	0	2.4	-100%	0	1.7	-100%	0	0.9	-100%
11th	0.8	7.5	-89%	0.8	6.6	-88%	0.8	6.5	-88%
13th	0	6.6	-100%	0	5.7	-100%	0	6.1	-100%
15th	0	4.6	-100%	0	3.9	-100%	0	3.9	-100%
17th	0	1.2	-100%	0	1.3	-100%	0	0.7	-100%
19th	0	0.8	-100%	0	0.4	-100%	0	1	-100%
21st	0	1.6	-100%	0	0.8	-100%	0	1.4	-100%
23rd	0	1.3	-100%	0	0.8	-100%	0	0.8	-100%
25th	0	0.7	-100%	0	0.5	-100%	0	0.5	-100%
27th	0	0.7	-100%	0	0.6	-100%	0	0.7	-100%
29th	0	0.2	-100%	0	0.4	-100%	0	0	-100%
2nd	1.9	4.8	-60%	1.9	5.9	-68%	2.3	3	-23%
4th	0.4	9.8	-96%	0.5	1.9	-74%	0.3	3.6	-92%
6th	0	2.4	-100%	0	1.9	-100%	0	1.5	-100%
8th	0	1	-100%	0	1	-100%	0	0.8	-100%
10th	0	1.2	-100%	0	0.5	-100%	0	0.3	-100%
12th	0	1	-100%	0	0	-100%	0	0.6	-100%

I-2

STATUS REPORT

2:44 PM

PHASE A-B (Voltage Channel 1)

Voltage: 472.4 Vrms

Frequency: 60.0 Hz

High freq noise: 0.3 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 477.8 Vrms

Frequency: 60.0 Hz

High freq noise: 0.3 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 476.8 Vrms

Frequency: 60.0 Hz

High freq noise: 0.4 Vpp

PHASE A (Current Channel 1)

Current: 7.9 Arms

PHASE B (Current Channel 2)

Current: 7.9 Arms

PHASE C (Current Channel 3)

Current: 8.4 Arms

HARMONIC REPORT

2:45 PM

PHASE C-A SNAPSHOT

1000V

50A

0V

0A

-1000V

-50A

PHASE C-A VOLTAGE

PHASE C CURRENT

5.0 milliseconds/division horizontal

1505 DATAWAVE LINE

Sep 30, 1994

2:45:20 PM

PHASE A-B VOLTAGE SPECTRUM

2:45:20.74 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.4%	320°	6th		
7th	0.4%	170°	8th		
9th			10th		
11th			12th		
13th			14th		
15th			16th		
17th			18th		
19th			20th		
21st			22nd		
23rd			24th		
25th			26th		
27th			28th		
29th	0.3%	180°			
Odd:	1.5%		Even:	0.0%	
Thd:	1.5%

PHASE A CURRENT SPECTRUM

2:45:20.74 PM

Fundamental frequency: 60.0 Hz

Sine		
Harmonic	Percent	Phase
Fund	100.0%	0°
3rd	2.1%	228°
5th	2.5%	62°
7th	0.5%	262°
9th		
11th	0.8%	341°
<hr/>		
Odd:	3.4%	
<hr/>		
Thd:	3.9%	

Sine		
Harmonic	Percent	Phase
2nd	1.9%	2°
4th	0.4%	174°
6th		
8th		
10th		
<hr/>		
Even:	1.9%

PHASE B-C VOLTAGE SPECTRUM

2:45:20.74 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.3%	329°	6th		
7th	0.4%	168°	8th		
9th			10th		
11th			12th		
13th			14th		
15th			16th		
17th			18th		
19th			20th		
21st			22nd		
23rd			24th		
25th			26th		
27th			28th		
29th	0.3%	231°			
Odd:	1.4%		Even:	0.0%	
Thd:	1.4%

PHASE B CURRENT SPECTRUM

2:45:20.74 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	1.9%	140°
3rd	2.1%	124°	4th	0.5%	78°
5th	3.1%	62°	6th		
7th	0.3%	261°	8th		
9th			10th		
11th	0.8%	330°			
Odd:	3.8%		Even:	1.9%	
Thd:	4.3%

PHASE C-A VOLTAGE SPECTRUM

2:45:20.74 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd		
3rd	0.2%	200°	4th		
5th	1.2%	322°	6th		
7th	0.4%	175°	8th		
9th			10th		
11th			12th		
13th			14th		
15th			16th		
17th			18th		
19th			20th		
21st			22nd		
23rd			24th		
25th			26th		
27th			28th		
29th	0.3%	225°			
Odd:	1.3%		Even:	0.0%	
Thd:	1.3%

PHASE C CURRENT SPECTRUM

2:45:20.74 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	2.3%	256°
3rd	2.4%	5°	4th	0.3%	340°
5th	2.8%	93°	6th		
7th	0.3%	299°	8th		
9th			10th		
11th	0.8%	16°			
Odd: 3.8%			Even: 2.4%		
Thd: 4.5%

STATUS REPORT

2:27 PM

PH A-NEUT (Voltage Channel 1)

Voltage: 120.7 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PH B-NEUT (Voltage Channel 2)

Voltage: 120.6 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PH C-NEUT (Voltage Channel 3)

Voltage: 119.6 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

NEUT-GND (Voltage Channel 4)

Voltage: 0.2 Vrms
High freq noise: 0.2 Vpp

PHASE A (Current Channel 1)

Current: 15.3 Arms

PHASE B (Current Channel 2)

Current: 11.5 Arms

PHASE C (Current Channel 3)

Current: 24.5 Arms

NEUT (Current Channel 4)

Current: 22.0 Arms

HARMONIC REPORT

2:28 PM

PH C-NEUT SNAPSHOT

250V

100A

0V

0A

-250V

-100A

PH C-NEUT VOLTAGE

PHASE C CURRENT

5.0 milliseconds/division horizontal

1505 DATAWAVE LOAD

Sep 30, 1994

2:28:11 PM

PH A-NEUT VOLTAGE SPECTRUM

2:28:11.59 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.7%	243°
3rd	1.1%	30°	4th	0.4%	231°
5th	1.2%	41°	6th		
7th	0.3%	23°	8th		
9th			10th		
11th	2.4%	18°	12th		
13th	0.7%	346°	14th		
15th	0.2%	174°	16th		
17th			18th		
19th			20th		
21st			22nd		
23rd	0.3%	31°			
Odd:	3.1%		Even:	0.8%	
Thd:	3.2%

PHASE A CURRENT SPECTRUM

2:28:11.59 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	4.8%	114°
3rd	40.1%	191°	4th	9.8%	105°
5th	28.2%	17°	6th	2.4%	253°
7th	11.8%	197°	8th	1.0%	92°
9th	2.4%	307°	10th	1.2%	146°
11th	7.5%	68°	12th	1.0%	272°
13th	6.6%	238°	14th	1.1%	148°
15th	4.6%	57°	16th	0.8%	204°
17th	1.2%	240°	18th	0.3%	355°
19th	0.8%	257°	20th	0.5%	173°
21st	1.6%	60°	22nd	0.3%	230°
23rd	1.3%	236°	24th	0.3%	9°
25th	0.7%	15°	26th	0.3%	218°
27th	0.7%	142°	28th		
29th	0.2%	26°			
Odd: 51.7%			Even: 11.4%		
Thd: 53.0%

PH B-NEUT VOLTAGE SPECTRUM

2:28:11.59 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.6%	105°
3rd	0.5%	86°	4th	0.2%	301°
5th	0.9%	58°	6th		
7th			8th		
9th			10th		
11th	2.5%	19°	12th		
13th	0.6%	340°	14th		
15th	0.3%	212°	16th		
17th			18th		
19th			20th		
21st			22nd		
23rd	0.3%	102°			
Odd: 2.8%			Even: 0.6%		
Thd: 2.9%

PHASE B CURRENT SPECTRUM

2:28:11.59 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	5.9%	96°
3rd	34.7%	194°	4th	1.9%	252°
5th	23.2%	18°	6th	1.9%	95°
7th	9.2%	203°	8th	1.0%	263°
9th	1.7%	291°	10th	0.5%	96°
11th	6.6%	73°	12th		
13th	5.7%	249°	14th	0.3%	296°
15th	3.9%	69°	16th	0.3%	119°
17th	1.3%	260°	18th		
19th	0.4%	271°	20th		
21st	0.8%	69°	22nd		
23rd	0.8%	251°	24th		
25th	0.5%	0°	26th		
27th	0.6%	159°	28th		
29th	0.4%	6°			
Odd: 43.9%			Even: 6.6%		
Thd: 44.4%

PH C-NEUT VOLTAGE SPECTRUM

2:28:11.59 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	0.7%	358°
3rd	0.8%	16°	4th	0.2%	85°
5th	1.2%	61°	6th		
7th	0.4%	29°	8th		
9th			10th		
11th	2.4%	18°	12th		
13th	0.8%	348°	14th		
15th	0.3%	216°	16th		
17th			18th		
19th			20th		
21st			22nd		
23rd	0.3%	106°			
Odd:	3.0%		Even:	0.8%	
Thd:	3.1%

PHASE C CURRENT SPECTRUM

2:28:11.59 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd	3.0%	321°
3rd	36.0%	230°	4th	3.6%	175°
5th	25.6%	72°	6th	1.5%	46°
7th	10.0%	280°	8th	0.8%	270°
9th	0.9%	357°	10th	0.3%	272°
11th	6.5%	177°	12th	0.6%	154°
13th	6.1%	9°	14th	0.6%	11°
15th	3.9%	214°	16th	0.3%	237°
17th	0.7%	80°	18th		
19th	1.0%	86°	20th		
21st	1.4%	272°	22nd		
23rd	0.8%	124°	24th		
25th	0.5%	228°	26th		
27th	0.7%	46°	28th		
29th			30th		
31st			32nd		
33rd	0.3%	67°			
Odd: 46.4%			Even: 5.1%		
Thd: 46.7%

NEUT-GND VOLTAGE SPECTRUM

2:28:11.59 PM

Fundamental frequency: 60.1 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	18.0%	352°
3rd	288.7%	283°	4th	33.7%	300°
5th	28.5%	130°	6th		
7th	17.7%	62°	8th	3.4%	108°
9th	20.3%	146°	10th	6.5%	189°
11th	29.7%	300°	12th	4.9%	220°
13th	19.5%	200°	14th	3.9%	301°
15th	82.7%	70°	16th		
17th			18th	3.6%	20°
19th	6.4%	335°	20th		
21st	32.7%	196°	22nd	3.6%	305°
23rd	6.0%	11°	24th	4.4%	102°
25th	4.3%	40°	26th	2.9%	289°
27th	19.9%	61°	28th		
29th	6.7%	61°	30th		
31st			32nd		
33rd	9.1%	200°			
Odd: 307.7%			Even: 40.0%		
Thd: 310.3%

NEUT CURRENT SPECTRUM

2:28:11.59 PM

Fundamental frequency: 60.2 Hz

Sine			Sine		
Harmonic	Percent	Phase	Harmonic	Percent	Phase
Fund	100.0%	0°	2nd	21.6%	191°
3rd	336.8%	321°	4th	32.7%	179°
5th	22.7%	208°	6th	3.9%	29°
7th	16.7%	184°	8th	2.3%	129°
9th	13.8%	309°	10th	3.7%	147°
11th	5.6%	110°	12th	2.2%	270°
13th	8.7%	69°	14th	1.8%	60°
15th	37.7%	332°	16th	2.6%	127°
17th	2.7%	42°	18th	1.7%	191°
19th	2.5%	342°	20th	0.9%	330°
21st	11.4%	223°	22nd	1.1%	44°
23rd	1.2%	285°	24th	1.0%	106°
25th			26th		
27th	5.9%	197°	28th		
29th	1.1%	356°	30th		
31st			32nd		
33rd	1.7%	63°			
Odd: 340.8%			Even: 39.9%		
Thd: 343.1%

Appendix J

Active Injection Mode Filter Data

Harmonic Analysis of Electrical Distribution Systems

March 1996

U.S. Department of Energy

Martin Marietta Energy Systems

Work for Others Program

Report for the U.S. Army Center for Public Works

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Waveform Snapshots and Harmonic Spectrum Data

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AIM FILTER MEASUREMENT POINTS

=====

PDP1 MAIN AIM OFF

Jul 24, 1995

STATUS REPORT

10:25 AM

PHASE A-B (Voltage Channel 1)

Voltage: 474.9 Vrms
Frequency: 60.0 Hz
High freq noise: 0.1 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 478.3 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 478.0 Vrms
Frequency: 60.0 Hz
High freq noise: 0.3 Vpp

PHASE A (Current Channel 1)

Current: 45.8 Arms

PHASE B (Current Channel 2)

Current: 46.8 Arms

PHASE C (Current Channel 3)

Current: 44.9 Arms

=====

PDP1 MAIN AIM OFF

Jul 24, 1995

PHASE A-B VOLTAGE SPECTRUM

10:23:30.40 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.3%	164°	6th		
7th	0.2%	57°			
Odd: 1.3%			Even: 0.0%		
Thd: 1.3%

PHASE A CURRENT SPECTRUM

10:23:30.40 AM

Fundamental frequency: 59.9 Hz

Sine
Harmonic Percent Phase

Fund	100.0%	0°
3rd	0.9%	119°
5th	0.9%	112°
7th	0.6%	10°

Odd: 1.4%

Thd: 1.4%

Sine
Harmonic Percent Phase

2nd
4th
6th

Even: 0.0%

PHASE B-C VOLTAGE SPECTRUM

10:23:30.40 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.2%	167°	6th		
7th	0.3%	70°			
Odd: 1.2%			Even: 0.0%		
Thd: 1.2%

PHASE B CURRENT SPECTRUM

10:23:30.40 AM

Fundamental frequency: 59.9 Hz

Harmonic Percent Phase

Sine

Fund	100.0%	0°
3rd	1.0%	315°
5th	1.0%	113°
7th	0.6%	5°

Odd: 1.5%

Thd: 1.5%

Harmonic Percent Phase

Sine

2nd
4th
6th

Even: 0.0%

PHASE C-A VOLTAGE SPECTRUM

10:23:30.40 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.2%	161°	6th		
7th	0.3%	67°			
Odd: 1.3%			Even: 0.0%		
Thd: 1.3%

PDP1 MAIN AIM OFF

Jul 24, 1995

PHASE C CURRENT SPECTRUM

10:23:30.40 AM

Fundamental frequency: 59.9 Hz

Sine		Sine	
Harmonic Percent Phase		Harmonic Percent Phase	
Fund	100.0%	0ø	
3rd		2nd	
5th	1.1%	4th	
7th	0.5%	6th	
Odd: 1.2%		Even: 0.0%	
Thd: 1.2%

=====

PDP1 MAIN AIM ON

Jul 24, 1995

STATUS REPORT

10:22 AM

PHASE A-B (Voltage Channel 1)

Voltage: 477.9 Vrms

Frequency: 60.0 Hz

High freq noise: 13.3 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 481.8 Vrms

Frequency: 60.0 Hz

High freq noise: 18.8 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 480.3 Vrms

Frequency: 60.0 Hz

High freq noise: 14.8 Vpp

PHASE A (Current Channel 1)

Current: 51.8 Arms

PHASE B (Current Channel 2)

Current: 50.8 Arms

PHASE C (Current Channel 3)

Current: 52.4 Arms

=====

=====

PDP1 MAIN AIM OFF

Jul 24, 1995

HARMONIC REPORT

10:23 AM

HARMONIC REPORT

10:19 AM

PDP1 MAIN AIM ON

Jul 24, 1995

PHASE A-B VOLTAGE SPECTRUM

10:19:15.59 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	2nd	
3rd		4th	
5th	1.3%	6th	
7th	0.3%		
Odd: 1.3%		Even: 0.0%	
Thd: 1.3%

PHASE A CURRENT SPECTRUM

10:19:15.59 AM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase		Sine	Harmonic Percent Phase		Sine
Fund	100.0%	0°	2nd		
3rd	1.1%	270°	4th		
5th	2.1%	217°	6th		
7th	0.3%	152°	8th		
9th	0.2%	180°	10th		
11th			12th		
13th			14th		
15th			16th		
17th			18th		
19th			20th		
21st			22nd		
23rd	0.3%	63°			
Odd:	2.5%		Even:	0.0%	
Thd:	2.5%

PHASE B-C VOLTAGE SPECTRUM

10:19:15.59 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.2%	166°	6th		
7th	0.3%	78°			
Odd: 1.2%			Even: 0.0%		
Thd: 1.2%

PHASE B CURRENT SPECTRUM

10:19:15.59 AM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase		Sine	Harmonic Percent Phase		Sine
Fund	100.0%	0°	2nd		
3rd	1.2%	93°	4th		
5th	1.9%	218°	6th		
7th	0.6%	190°	8th		
9th	0.2%	110°	10th		
11th			12th		
13th			14th		
15th			16th		
17th			18th		
19th			20th		
21st			22nd		
23rd	0.3%	218°			
Odd: 2.3%			Even: 0.0%		
Thd: 2.3%

PHASE C-A VOLTAGE SPECTRUM

10:19:15.59 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.2%	160°	6th		
7th	0.3%	59°			
Odd: 1.3%			Even: 0.0%		
Thd: 1.3%

PHASE C CURRENT SPECTRUM

10:19:15.59 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	0ø	
3rd		2nd	
5th	1.9%	4th	
7th	0.5%	6th	
9th	0.3%	8th	
11th		10th	
13th		12th	
15th		14th	
17th		16th	
19th		18th	
21st		20th	
23rd	0.2%	22nd	
	35ø		
Odd:	2.0%	Even:	0.0%
Thd:	2.0%

=====

9211 PDP1 AIM

Jul 24, 1995

STATUS REPORT

9:53 AM

PHASE A-B (Voltage Channel 1)

Voltage: 477.9 Vrms

Frequency: 60.0 Hz

High freq noise: 12.1 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 480.3 Vrms

Frequency: 60.0 Hz

High freq noise: 11.8 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 483.8 Vrms

Frequency: 60.0 Hz

High freq noise: 15.2 Vpp

PHASE A (Current Channel 1)

Current: 66.7 Arms

PHASE B (Current Channel 2)

Current: 64.6 Arms

PHASE C (Current Channel 3)

Current: 66.8 Arms

=====

HARMONIC REPORT

9:52 AM

PHASE A-B VOLTAGE SPECTRUM

9:52:26.43 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.2%	159°	6th		
7th	0.4%	63°			
Odd: 1.3%			Even: 0.0%		
Thd: 1.3%

PHASE A CURRENT SPECTRUM

9:52:26.43 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic Percent Phase		Harmonic Percent Phase	
Fund	100.0%	0ø	
3rd		2nd	
5th	1.7%	4th	
7th	0.5%	6th	
9th	0.2%	8th	
Odd: 1.8%		Even: 0.0%	
Thd: 1.8%

PHASE B-C VOLTAGE SPECTRUM

9:52:26.43 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.3%	162°	6th		
7th	0.2%	54°			
Odd: 1.3%			Even: 0.0%		
Thd: 1.3%

PHASE B CURRENT SPECTRUM

9:52:26.43 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic Percent Phase		Harmonic Percent Phase	
Fund	100.0%	0 ϕ	
3rd		2nd	
5th	1.9%	4th	
7th	0.5%	6th	
Odd:	2.0%	Even:	0.0%
Thd:	2.0%

PHASE C-A VOLTAGE SPECTRUM

9:52:26.43 AM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.2%	164°	6th		
7th	0.3%	76°			
Odd: 1.2%			Even: 0.0%		
Thd: 1.2%

PHASE C CURRENT SPECTRUM

9:52:26.43 AM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	0 $\emptyset$	
3rd		2nd	
5th	1.8%	4th	
7th	0.3%	6th	
Odd: 1.8%		Even: 0.0%	
Thd: 1.8%

STATUS REPORT

1:02 PM

PHASE A-B (Voltage Channel 1)

Voltage: 478.4 Vrms
Frequency: 60.0 Hz
High freq noise: 0.2 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 477.8 Vrms
Frequency: 60.0 Hz
High freq noise: 0.7 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 480.0 Vrms
Frequency: 60.0 Hz
High freq noise: 0.4 Vpp

PHASE A (Current Channel 1)

Current: 196.9 Arms

PHASE B (Current Channel 2)

Current: 189.1 Arms

PHASE C (Current Channel 3)

Current: 191.2 Arms

=====

=====

SWGR 191E5 AIM OFF

Jul 24, 1995

HARMONIC REPORT

1:02 PM

SWGR 191E5 AIM OFF

Jul 24, 1995

PHASE A-B VOLTAGE SPECTRUM

1:02:48.41 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.3%	159°			
Odd: 1.3%			Even: 0.0%		
Thd: 1.3%

PHASE A CURRENT SPECTRUM

1:02:48.41 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0ø	2nd		
3rd	0.5%	300ø	4th		
5th	2.2%	77ø			
Odd: 2.2%			Even: 0.0%		
Thd: 2.2%

PHASE B-C VOLTAGE SPECTRUM

1:02:48.41 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.4%	155°			
Odd: 1.4%			Even: 0.0%		
Thd: 1.4%

SWGR 191E5 AIM OFF

Jul 24, 1995

PHASE B CURRENT SPECTRUM

1:02:48.41 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	2.2%	83°			
Odd: 2.2%			Even: 0.0%		
Thd: 2.2%

PHASE C-A VOLTAGE SPECTRUM

1:02:48.41 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0ø	2nd		
3rd			4th		
5th	1.4%	156ø			
Odd: 1.4%			Even: 0.0%		
Thd: 1.4%

SWGR 191E5 AIM OFF

Jul 24, 1995

PHASE C CURRENT SPECTRUM

1:02:48.41 PM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase		Sine
Fund	100.0%	0ø
3rd	0.5%	104ø
5th	2.2%	67ø
Odd:		2.3%
Thd:		2.3%

Harmonic Percent Phase		Sine
2nd		
4th		
Even:		0.0%

=====

SWGR 191E5 AIM ON

Jul 24, 1995

STATUS REPORT

1:08 PM

PHASE A-B (Voltage Channel 1)

Voltage: 480.7 Vrms
Frequency: 60.0 Hz
High freq noise: 11.7 Vpp

PHASE B-C (Voltage Channel 2)

Voltage: 480.5 Vrms
Frequency: 60.0 Hz
High freq noise: 9.2 Vpp

PHASE C-A (Voltage Channel 3)

Voltage: 482.8 Vrms
Frequency: 60.0 Hz
High freq noise: 9.0 Vpp

PHASE A (Current Channel 1)

Current: 168.0 Arms

PHASE B (Current Channel 2)

Current: 162.5 Arms

PHASE C (Current Channel 3)

Current: 163.7 Arms

HARMONIC REPORT

1:06 PM

PHASE A-B VOLTAGE SPECTRUM

1:06:31.10 PM

Fundamental frequency: 60.0 Hz

Sine			Sine		
Harmonic Percent Phase			Harmonic Percent Phase		
Fund	100.0%	0°	2nd		
3rd			4th		
5th	1.3%	158°			
Odd: 1.3%			Even: 0.0%		
Thd: 1.3%

SWGR 191E5 AIM ON

Jul 24, 1995

PHASE A CURRENT SPECTRUM

1:06:31.10 PM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic	Percent Phase	Harmonic	Percent Phase
Fund	100.0%	0 $\emptyset$	
3rd	0.6%	251 $\emptyset$	
5th	2.0%	355 $\emptyset$	
7th	0.2%	159 $\emptyset$	
Odd: 2.1%		Even: 0.0%	
Thd: 2.1%

PHASE B-C VOLTAGE SPECTRUM

1:06:31.10 PM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase		Sine	Harmonic Percent Phase		Sine
Fund	100.0 %	0ø	2nd		
3rd			4th		
5th	1.3 %	154ø			
Odd:		1.3 %	Even:		0.0 %
Thd:		1.3 %

SWGR 191E5 AIM ON

Jul 24, 1995

PHASE B CURRENT SPECTRUM

1:06:31.10 PM

Fundamental frequency: 60.0 Hz

Harmonic Percent Phase

Sine

Sine
Harmonic Percent Phase

Fund	100.0%	0°
3rd	0.2%	146°
5th	2.1%	1°

2nd
4th

Odd: 2.1%

Even: 0.0%

Thd: 2.1%

PHASE C-A VOLTAGE SPECTRUM

1:06:31.10 PM

Fundamental frequency: 60.0 Hz

Sine		Sine	
Harmonic Percent Phase		Harmonic Percent Phase	
Fund	100.0%	0ø	
3rd		2nd	
5th	1.4%	4th	
Odd: 1.4%		Even: 0.0%	
Thd: 1.4%

SWGR 191E5 AIM ON

Jul 24, 1995

PHASE C CURRENT SPECTRUM

1:06:31.10 PM

Fundamental frequency: 60.0 Hz

Sine	
Harmonic	Percent Phase
Fund	100.0%
3rd	0.6%
5th	2.1%
Odd: 2.1%	
Thd: 2.1%	

Sine	
Harmonic	Percent Phase
2nd	
4th	
Even: 0.0%