A MAGNETIC DEVICE FOR IMPROVING POWER QUALITY

by

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ABSTRACT

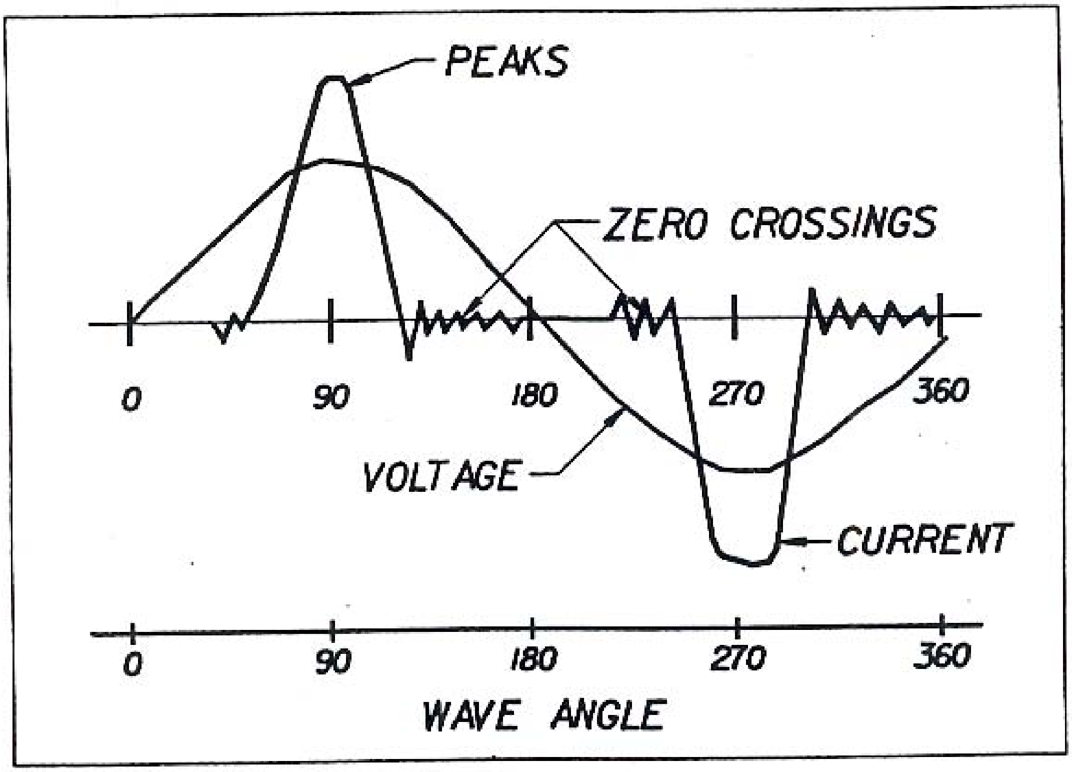
Power Quality can be described as the best quality power to operate specific equipment or process with the lowest level of operating problems.

Several techniques such as providing harmonic mitigation, power factor improvement, and transient suppression devices are available for power quality improvement. Reduction of L.C. resonance, the phase balancing of voltages and load currents also enhances power quality. A circuit comprised of symmetrical wrap-around magnetic chokes between all three(3) phases, simultaneously accomplishes all the above improvements to various degrees. Basic understanding of Power Quality, Device Overview, and Test Data of this simple and rugged device are presented.

BASIC UNDERSTANDING OF POWER QUALITY

It is necessary to understand non-linear loads, harmonics, power factor, sags, surges, and transients.

Non-Linear Load - The Current Waveform does not look like the Voltage Waveform.



Harmonics - Harmonics are currents or voltages with frequencies that are integer multiples of fundamental power frequency. If the fundamental is 60Hz, the second harmonic is 120Hz, the third harmonic is 180Hz, etc.. Harmonics are created by non-linear pulses that draw current in abrupt pulses rather than in a smooth sinusoidal manner. These pulses cause distorted current wave shapes which in turn cause harmonic currents to flow back to other parts of the Power System.

Each harmonic has a name, frequency, and sequence. The sequence refers to phasor rotation with respect to fundamental (F); i.e., in aninduction motor, a positive sequence harmonic would generate a magnetic field that is rotated in the same direction as the fundamental. A negative sequence harmonic would rotate in the reverse direction.

The first nine(9) harmonics, along with the effects, are listed below:

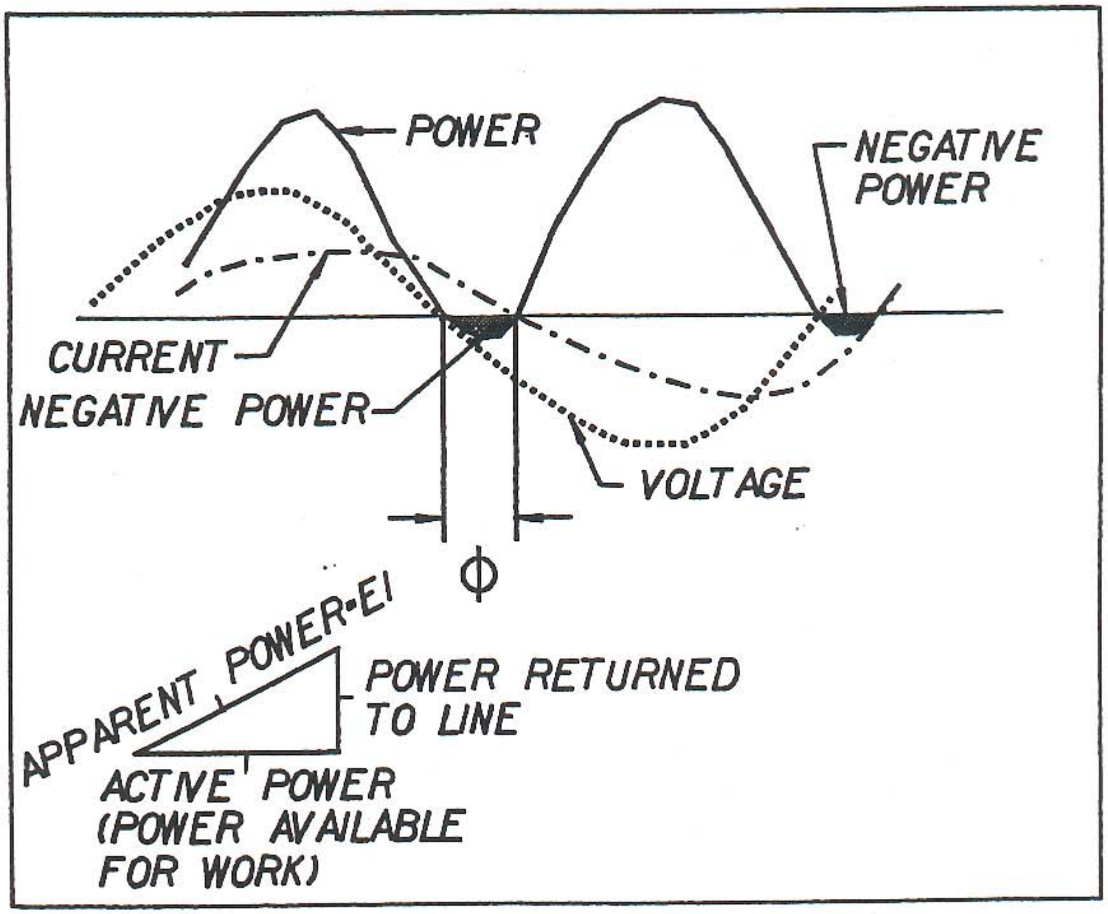
Name	First	2nd*	3rd	4th*	5th	6th*	7th	8th*	9th
Frequency	60	120	180	240	300	360	420	480	540
Sequence	+	-	0	+	-	0	+	-	0

* Even harmonics disappear when waves are symmetrical.

Sequence	Rotation	Effects (From skin effects, eddy currents, etc...)
Positive	Forward	Heating of Conductors and Breakers, etc.
Negative	Reverse	Heating as above + Motor problems
Zero	None	Heating + add on Neutral of 3-Phase, 4-wire system

Zero Sequence Harmonics and Odd Multiples of the 3rd are called "Triplens".

Power Factor: - Power Factor is defined as the "active" power divided by the "apparent" power.* During the part of each cycle, when the voltage is negative but the current is positive, their product is negative. This is negative power and it is not available for work. It is actually the power returned to the line.

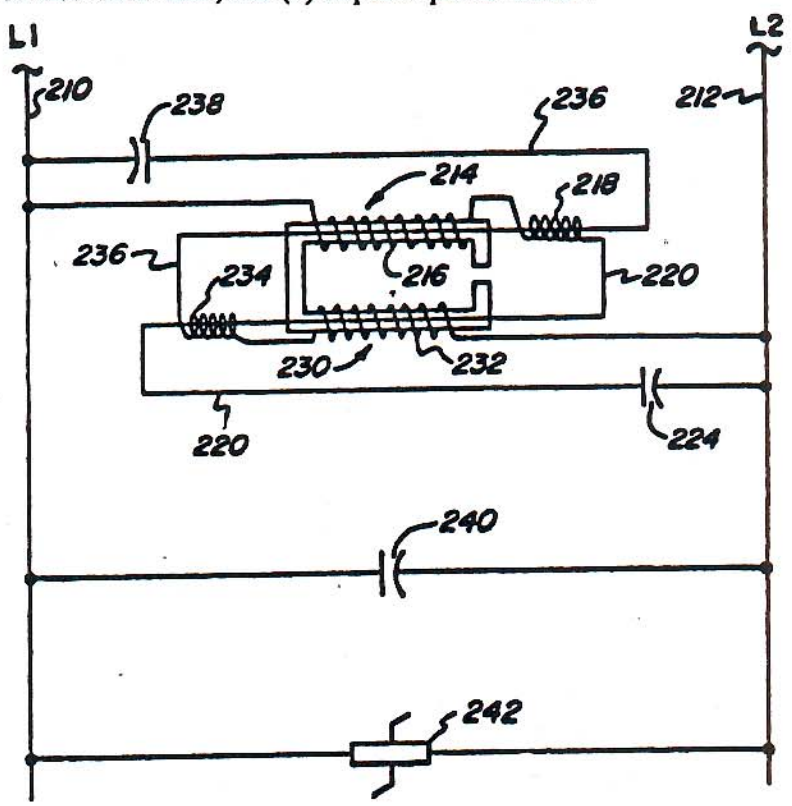


Sags and surges can be described as current and voltage fluctuations in milliseconds or more. Sags and surges are caused by severe weather - lightning, power line switching, large motors and inductive loads

turning off / on, short circuits, copiers / printers, fault / fuse clearing. Sags and surges cause data disruptions, damage to sensitive electronic devices, damage to power supplies, and total system failures. Transients are high-speed and high energy electrical noise. Transients relate to voltage or current excursions of microseconds and nanoseconds duration. Atmospheric lightning represents the most dangerous transients in transmission and distribution networks. Bolts of lightning have voltages between 500kv and 1000kv, durations between .5 and .20 microseconds and amperages 1,000 and 50,000 amps. If lightning strikes a transmission line, disturbances can travel from 10 to 20 miles within an electrical distribution system.

DEVICE OVERVIEW

The magnetic device for power quality improvement is called "USES" unit. "USES" units are installed at electrical panels supplying inductive load or at the disconnect links for large motors, i.e. elevators, air-conditioning units, heavy-duty machinery, etc. Units are also recommended for any panel at which surge protection is a major concern.. The "USES" is a single phase or three-phase passive line conditioner that functions to (a) reduce demand from the power system, (b) provide transient surge protection, (c) reduce harmonics, and (d) improve power factor.



The USES Circuit in Single Phase System

FIGURE 1

In FIGURE 1, two(2) chokes designated as **214** and **230** are used. Choke **214** comprises a first winding **216** in series with second winding **218**. The choke terminates in a line **220** that is passed through the windings **232, 234** of choke **230**. Line **220** is coupled to a capacitor **224** and the series combination of choke **214** and capacitor **224** is coupled across an AC power source comprising line **210** and line **212**. Similarly, choke **230** with the line **236** passing through the windings of choke **214**, is coupled in series with a capacitor **238**. The series combination of choke **230** and capacitor **238** is coupled across AC power source. A capacitor **240** and surge suppressor **242** are also coupled across the power source.

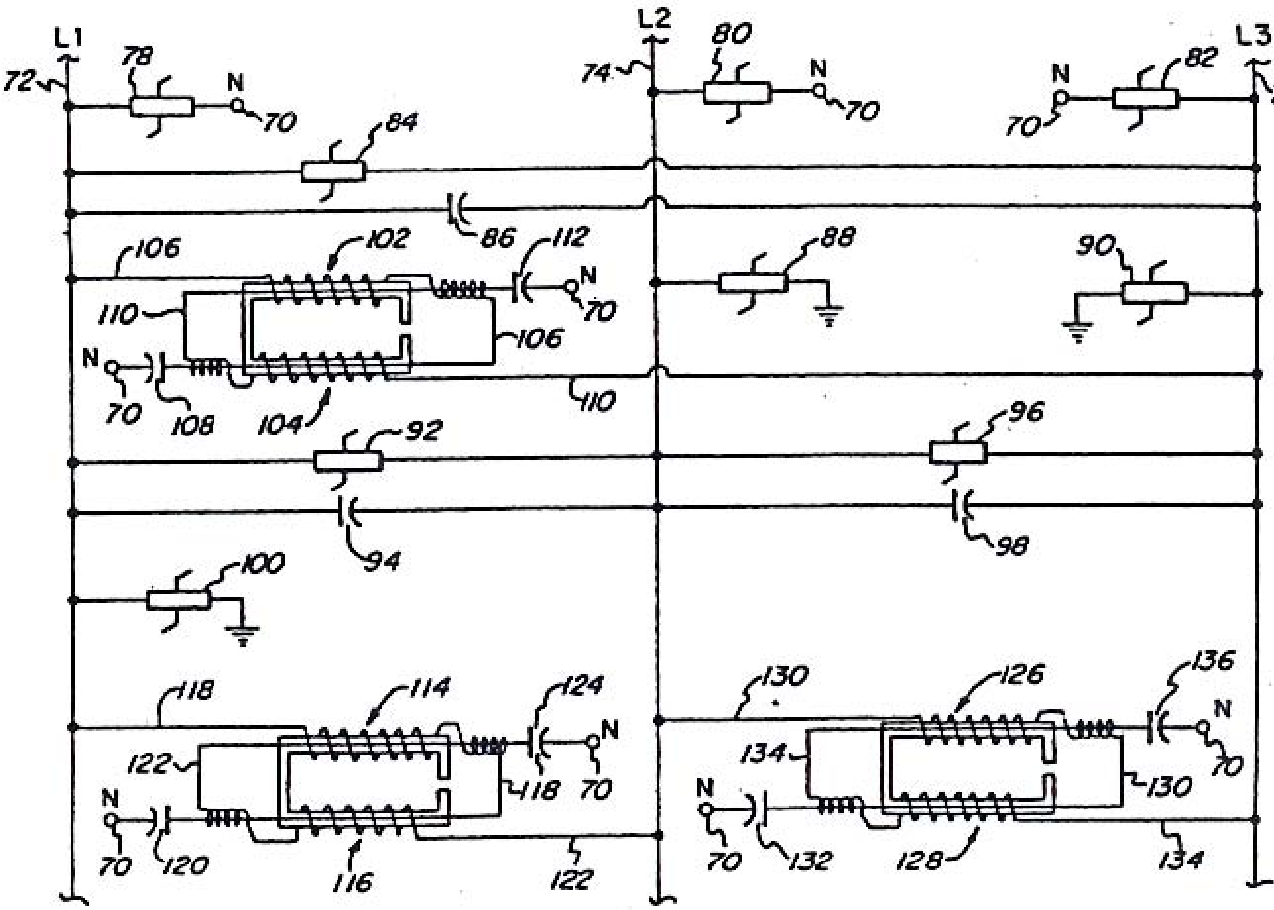


FIGURE 2

A three-phase embodiment of the power conditioner is illustrated in **FIGURE 2**. Again, the power conditioner can be placed at the service panel where incoming power is received from a utility. Additional power conditioners can also be placed at or near significant loads. The power conditioner is coupled to the three(3) incoming power lines **L1, L2, L3** represented by reference numerals **72, 74,** and **76**, respectively, and also to neutral as represented at terminal **70.** MOV devices **78, 80,** and **82** provide transient suppression from each line to neutral. MOV devices **84, 92,** and **96** provide transient suppression between the various power lines. MOV devices **88, 90,** and **100** provide transient suppression from each respective line to ground. Capacitors **86, 94,** and **98** are coupled between respective power lines to provide filtering and power factor correction.

Chokes **114** and **116** are coupled between lines **72** and **74.** Choke **114** and series capacitor **120** provide a first path **118** from line **72** to neutral. Choke **116** and series capacitor **124** provide a second path **122** from line **74** to neutral.

In a similar fashion, two other pairs of chokes couple lines **74** and **76** and lines **72** and **76.** The three sets of wrap-around chokes provide magnetic coupling between the three electric phases: **L1, L2** and **L3.**

Chokes **102** and **104** are coupled between lines **72** and **76.** Choke **102** and series capacitor **108** provide a fifth path **106** from line **72** to neutral. Choke **104** and series capacitor **112** provide a sixth path **110** from line **76** to neutral.

TESTING

The USES unit is connected to a 150 HP compressor motor, identified at Northrop Grumman, Sykes-ville, Maryland facility as "Chiller 2A". The motor is a 460 volt induction motor started across-the-line. The USES unit under test is Model # CMES3D480, as noted on the Installation picture on page 8.

The Chiller 2A is rated 150 HP at 460 v, with full load current (running load amperes, RLA) equal to 182A. The USES unit is connected in parallel to the 3-phase motor feed on the line side of the motor starter contactor. The USES unit has its own 30A molded case breaker for switched isolation.

The one-line diagram on page 7 shows the electrical configuration of Chiller 2A and its feed from Substation #4, 225A molded case breaker. Also shown on this one-line diagram are the connection points of both the USES and the power monitoring.

Motor / Compressor Data

Manufacturer: McQuay International, Inc.
460 V, 3-phase, 60 Hz, 182 FLA (RLA), 409 LRA (Wye), 1,228 LRA (Delta), 0.882 rated power factor (FLA)

Power Analyzer Description

The Power Platform PPI, manufactured by Dranetz-BMI, Inc., Edison, NJ, was used as the primary recording device for this project. The PPI, when used with the Task 8000 Task card, allows the meter to measure and record power parameters for both single phase and three phase systems. These parameters include : voltage, current, real power, reactive power, apparent power, power factor and voltage and current harmonics.

In conjunction with the PPI, two(2) other power meters were used as comparable data measurements. These were the ACE 2000, manufactured by CPM, Inc., Toronto, Canada, and the Fluke 41B.
Data from these units are not included in this report; however, verification of recorded parameters of these units compared very closely with the Dranetz PPI data.

Test Procedure

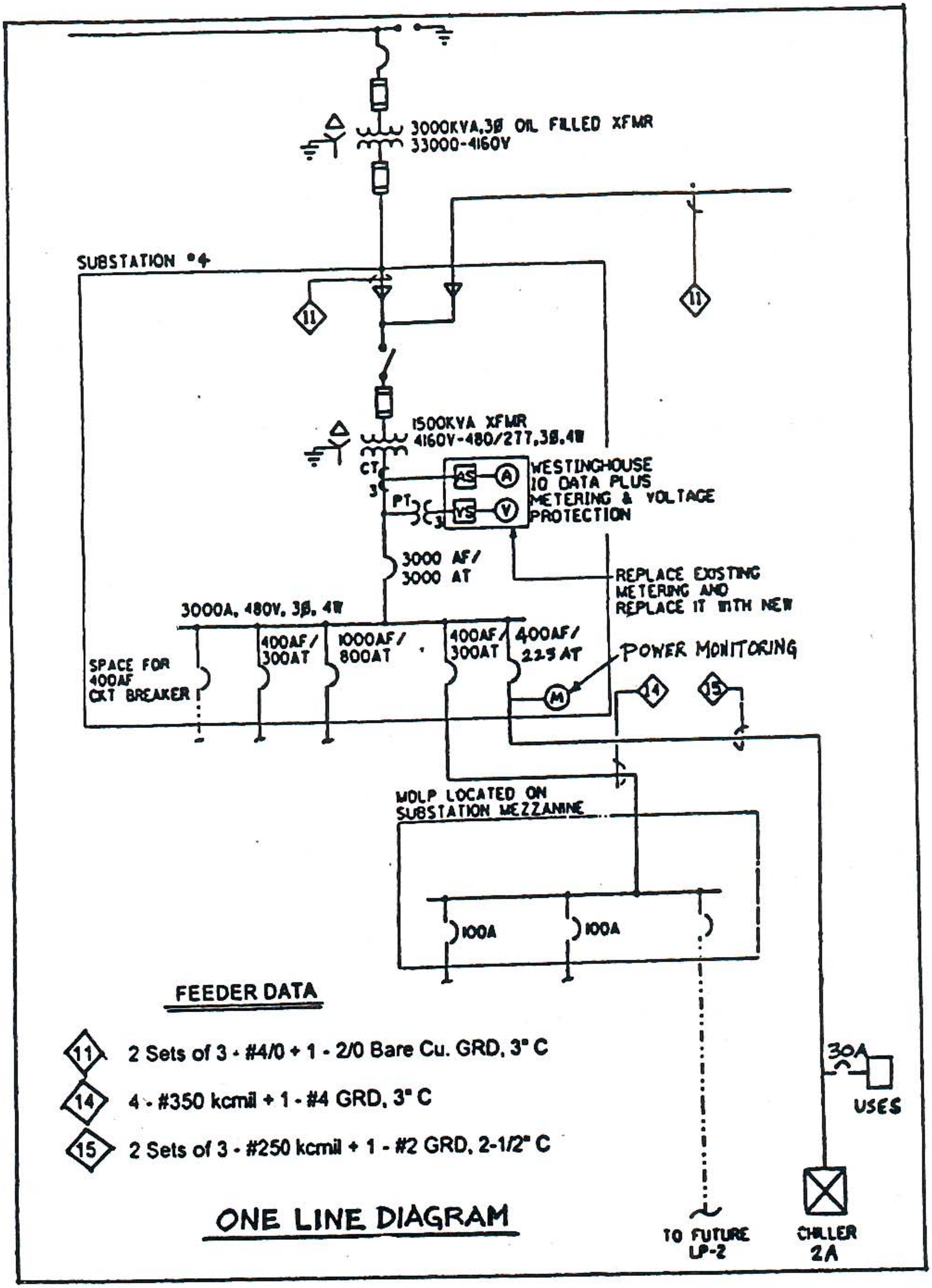
The overall purpose of this testing was to measure and record power parameters of Chiller 2A under various load conditions both with and without the USES unit connected to the feeder. The power analyzer (PPI) was connected to the load side of the 225A feeder breaker. Power measurements were recorded by manual initiation as opposed to threshold triggering during specific loading conditions and USES operation. For instance, with Chiller 2A running at 100% RLA, and the USES unit breaker closed, measurements were initiated. At the same loading, the USES breaker was opened, and a new set of measurements was recorded. Load was changed on the chiller by varying the programmable chilled water temperature point. This adjustment allowed for a load range from 100% to 50% RLA. Consequently, power measurements were recorded under 100%, 90%, 75% and 50% load conditions for the USES connected and disconnected to the feeder.

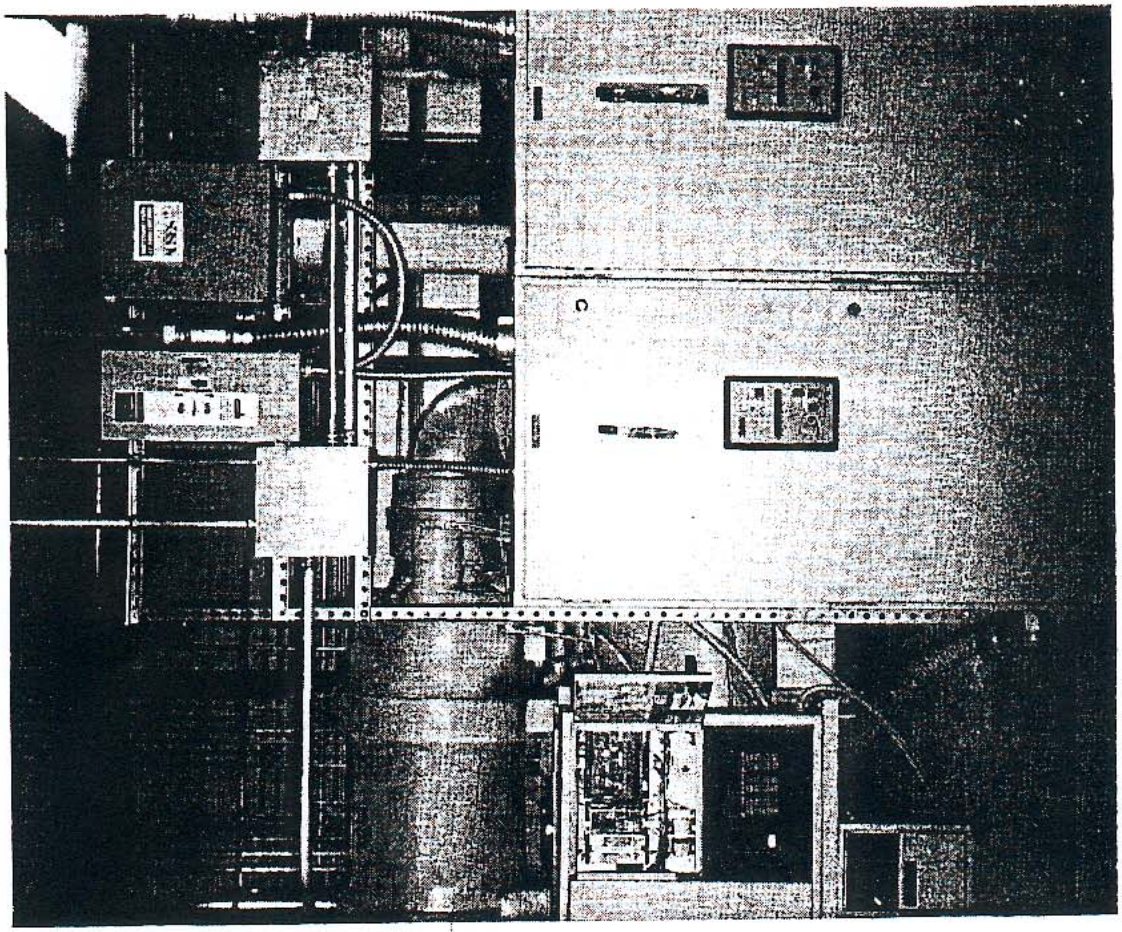
Test Results

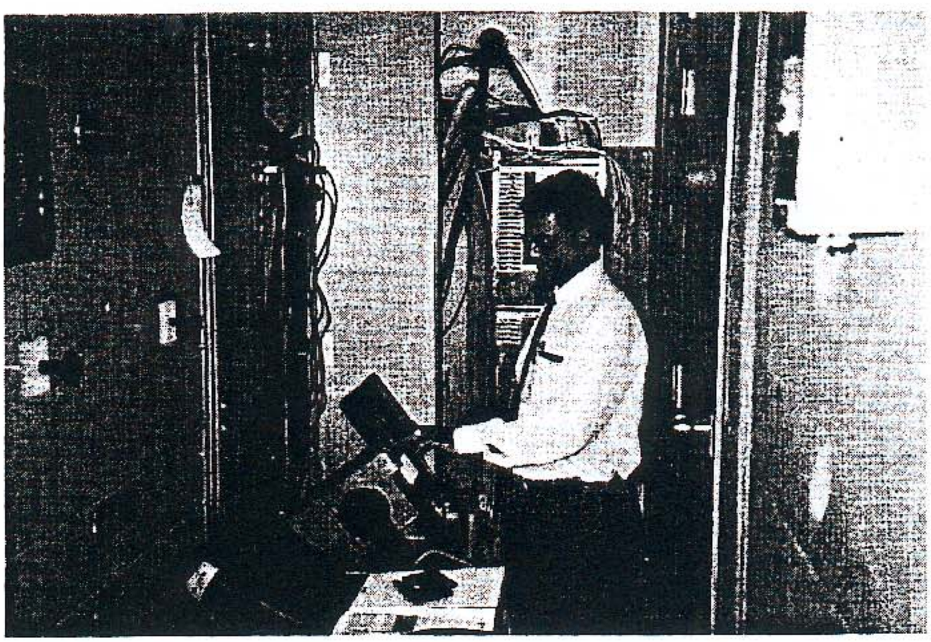
Pointed results from the PPI recorded measurements are provided on pages 10 through 13 for 75% loading. These data sheets contain power measurements, voltage, current phases diagrams, sinusoidal waveforms, and harmonic data. For ease of comparison, these measurements are summarized in the Data Summary Table below for each load condition and with the USES unit switched on and off.

DATA SUMMARY TABLE

	100% RLA		90% RLA		75% RLA		50% RLA	
	ON	OFF	ON	OFF	ON	OFF	ON	OFF
V_{LL}	495.3	495.5	497.2	495.8	496.1	497.3	497.9	495.8
Abs.Chg.	-0.2		1.4		-1.2		2.1	
I_L	170.6	188.6	143.1	162.4	115.4	131.2	69.9	93.2
% Chg.	-9.5%		-11.9%		-12.0%		-25.0%	
PF	0.998	0.996	1.000	0.991	0.997	0.968	0.915	0.836
% Chg.	0.20%		0.90%		2.90%		7.90%	
kW	84.3	93.1	71.1	79.8	57.1	63.1	31.8	38.6
% Chg.	-9.5%		-10.9%		-9.5%		-17.6%	
kVARS	-5.1	8.1	0.6	10.9	4.1	16.3	14.1	25.4
% Chg.	-163.0%		-94.5%		-74.8%		-44.5%	
kVA	84.5	93.5	71.0	80.5	57.2	65.2	34.8	46.2
% Chg.	-9.6%		-11.8%		-12.3%		-24.7%	
V_{THD}	1.965	1.949	2.084	1.932	2.026	1.965	2.119	2.033
% Chg.	0.8%		7.9%		3.1%		4.2%	
I_{THD}	1.938	2.844	2.372	3.310	2.884	4.206	3.990	4.911
% Chg.	-31.9%		-28.3%		-31.4%		-18.8%	


3000KVA,3Ø OIL FILLED XFMR
33000-4160V
SUBSTATION #4
1500KVA XFMR
4160V-480/277,3Ø,4W
CT
PT
WESTINGHOUSE
IQ DATA PLUS
METERING & VOLTAGE
PROTECTION
3000 AF/
3000 AT
REPLACE EXISTING
METERING AND
REPLACE IT WITH NEW
3000A, 480V, 3Ø, 4W
SPACE FOR
400AF
CKT BREAKER
400AF/
300AT
1000AF/
800AT
400AF/
300AT
400AF/
225 AT
POWER MONITORING
MDLP LOCATED ON
SUBSTATION MEZZANINE
100A
100A
FEEDER DATA
11 2 Sets of 3 - #4/0 + 1 - 2/0 Bare Cu. GRD, 3" C
14 4 - #350 kcmil + 1 - #4 GRD, 3" C
15 2 Sets of 3 - #250 kcmil + 1 - #2 GRD, 2-1/2" C
30A
USES
ONE LINE DIAGRAM
TO FUTURE
LP-2
CHILLER
2A





75% RLA – USES ON

DRANETZ PP1-8000 N-G 2A 14:25:46 Apr-08-99
ALL CHANNELS SUMMARY REPORT f= 60.00hz (A)

	==A==	==B==	==C==	==D==	==ABC=
V	495.6	497.0	495.8	0.038	496.1
I	111.7	115.5	118.9	0.000	346.1
W	55.27k	57.10k	58.84k	0.000	171.2k
PF	0.998	0.995	0.998	0.000	0.997
VA	55.36k	57.38k	58.95k	0.000	171.7k
VAR	3.186k	5.664k	3.584k	0.000	12.43k
VCF	1.401	1.396	1.394	2.248	
ICF	1.448	1.447	1.418	0.000	
Vthd	2.026	1.865	1.885	0.000	
Ithd	2.884	2.792	2.845	0.000	
Vtif	7.235k	7.844k	5.980k	0.000	
Itif	5.806k	7.384k	6.415k	0.000	
TDF	0.997	0.996	0.997	1.000	
DPF	0.999	0.996	0.999	0.000	
PH V	859.6	859.8	858.5	0	

PRESENT DEMAND: 171.2kW PROJ. DEMAND: 190.5kW
ACCUM ENERGY: 1.458MWHR

75% RLA – USES OFF

DRANETZ PP1-8000 N-G 2A 14:33:39 Apr-08-99
ALL CHANNELS SUMMARY REPORT f= 59.99hz (A)

	==A==	==B==	==C==	==D==	==ABC=
V	496.5	498.6	496.8	0.038	497.3
I	126.3	132.0	135.2	0.000	393.5
W	60.99k	63.09k	65.34k	0.000	189.4k
PF	0.972	0.959	0.973	0.000	0.968
VA	62.72k	65.79k	67.15k	0.000	195.6k
VAR	14.65k	18.64k	15.49k	0.000	48.79k
VCF	1.398	1.396	1.394	3.402	
ICF	1.427	1.405	1.393	0.000	
Vthd	1.965	1.825	1.853	0.000	
Ithd	4.206	3.934	3.841	0.000	
Vtif	4.115k	4.182k	3.906k	0.000	
Itif	2.096k	1.958k	2.115k	0.000	
TDF	0.997	0.997	0.997	1.000	
DPF	0.974	0.960	0.974	0.000	
PH V	861.8	862.1	860.2	0	

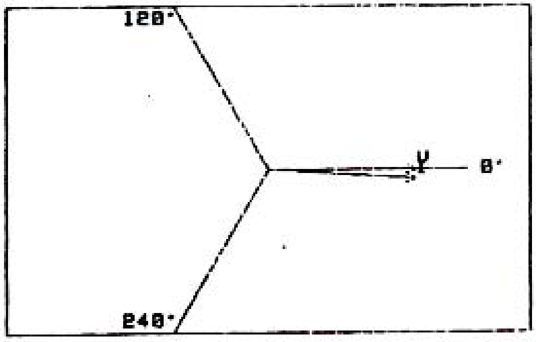
PRESENT DEMAND: 189.4kW PROJ. DEMAND: 178.1kW
ACCUM ENERGY: 1.481MWHR

75% RLA – USES ON

DRANETZ PP1-8000 N-G 2A 14:27:58 Apr-08-99

PHASOR: A

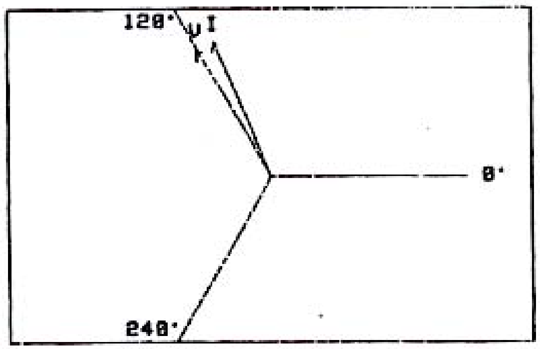
VOLTAGE:
497 @ 000°
CURRENT:
106 @ 356°



DRANETZ PP1-8000 N-G 2A 14:28:05 Apr-08-99

PHASOR: B

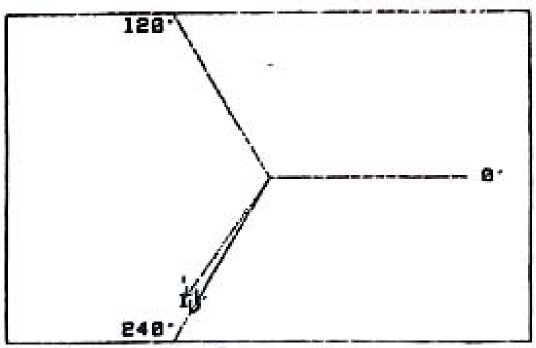
VOLTAGE:
498 @ 120°
CURRENT:
111 @ 113°



DRANETZ PP1-8000 N-G 2A 14:28:10 Apr-08-99

PHASOR: C

VOLTAGE:
497 @ 240°
CURRENT:
114 @ 236°

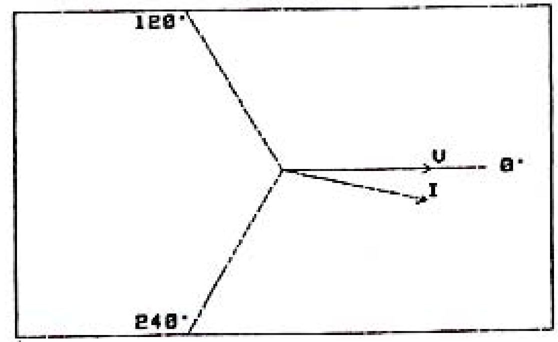


75% RLA – USES OFF

DRANETZ PP1-8000 N-G 2A 14:34:28 Apr-08-99

PHASOR: A

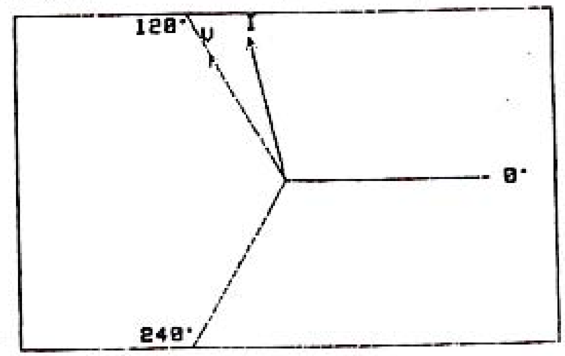
VOLTAGE:
497 @ 000°
CURRENT:
126 @ 346°



DRANETZ PP1-8000 N-G 2A 14:34:33 Apr-08-99

PHASOR: B

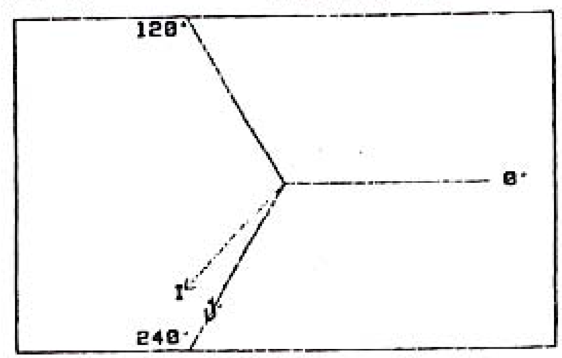
VOLTAGE:
499 @ 120°
CURRENT:
132 @ 103°



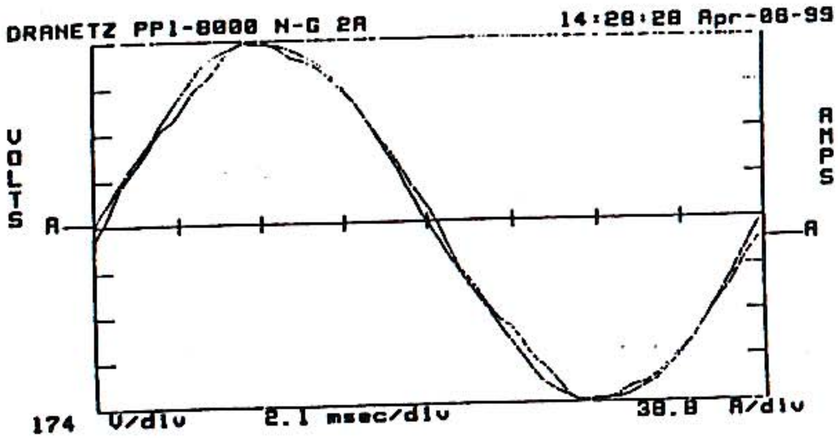
DRANETZ PP1-8000 N-G 2A 14:34:37 Apr-08-99

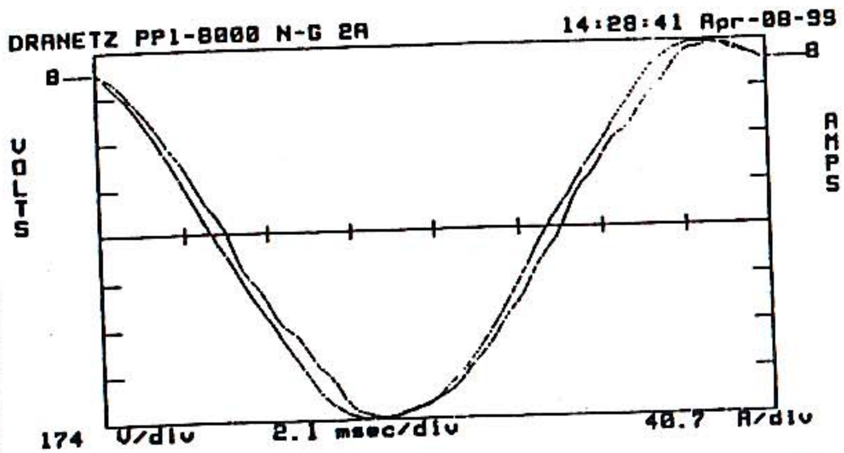
PHASOR: C

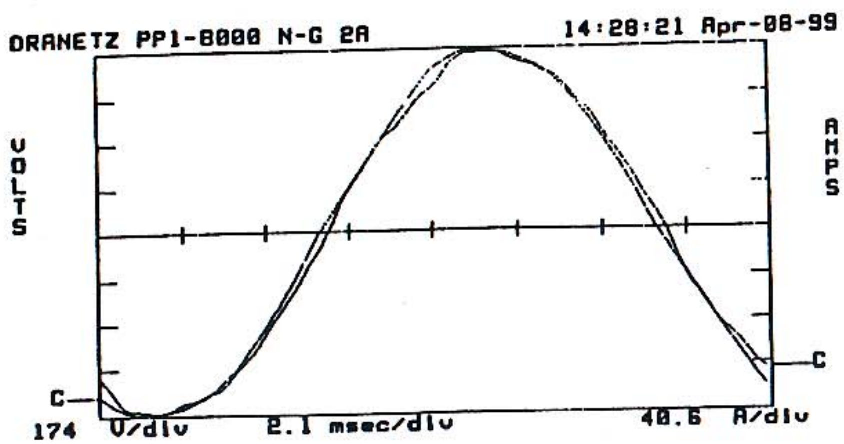
VOLTAGE:
497 @ 240°
CURRENT:
135 @ 227°



75% RLA – USES ON







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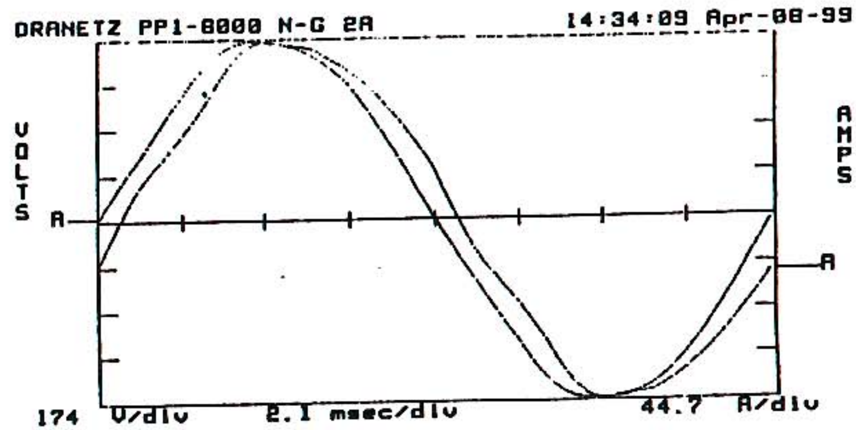

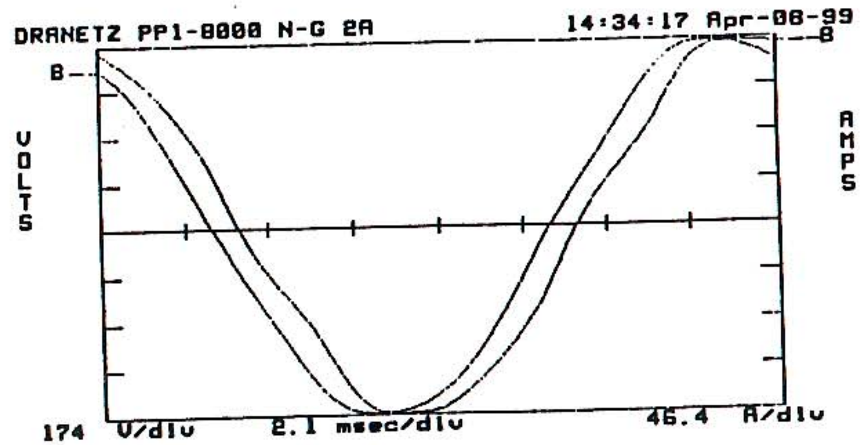

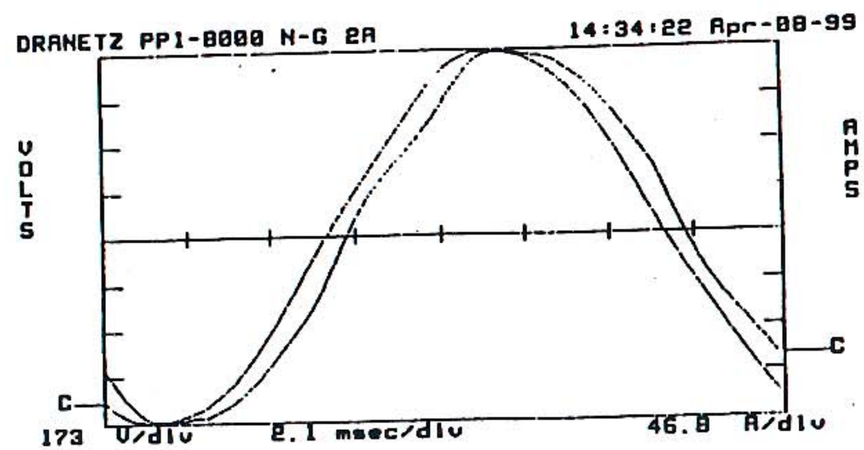

75% RLA – USES ON

DRANETZ PP1-8000 N-G 2A — Apr-08-99 14:29:22
HARMONICS:CH A REF 109.4 A. 60.0Hz
%FUND Ithd 2.943 %

H#	MAG%	PHS	H#	MAG%	PHS	H#	MAG%	PHS
02	0.165	229	19	0.264	046	36	0.000	087
03	1.055	050	20	0.033	166	37	0.000	268
04	0.066	063	21	0.066	109	38	0.000	214
05	1.879	047	22	0.033	289	39	0.000	058
06	0.033	271	23	0.165	266	40	0.000	012
07	1.714	117	24	0.000	248	41	0.000	287
08	0.000	351	25	0.033	271	42	0.000	114
09	0.033	077	26	0.000	002	43	0.000	160
10	0.033	265	27	0.033	300	44	0.000	182
11	0.396	136	28	0.000	146	45	0.000	166
12	0.000	256	29	0.033	105	46	0.000	291
13	0.231	317	30	0.000	275	47	0.000	337
14	0.033	184	31	0.033	063	48	0.000	067
15	0.033	219	32	0.000	332	49	0.000	304
16	0.000	317	33	0.000	180	50	0.000	028
17	0.791	319	34	0.000	191			
18	0.066	056	35	0.000	353			

DRANETZ PP1-8000 N-G 2A — Apr-08-99 14:29:27
HARMONICS:CH B REF 113.8 A. 0.0Hz
%FUND Ithd 2.729 %

H#	MAG%	PHS	H#	MAG%	PHS	H#	MAG%	PHS
02	0.252	192	19	0.568	096	36	0.000	249
03	0.694	340	20	0.000	218	37	0.000	069
04	0.063	066	21	0.158	296	38	0.000	086
05	1.703	058	22	0.000	078	39	0.000	318
06	0.032	165	23	0.126	002	40	0.000	221
07	1.735	140	24	0.000	177	41	0.032	049
08	0.032	046	25	0.032	262	42	0.000	319
09	0.095	203	26	0.000	104	43	0.000	305
10	0.032	241	27	0.000	247	44	0.000	318
11	0.315	184	28	0.000	197	45	0.000	347
12	0.000	107	29	0.032	199	46	0.000	252
13	0.315	349	30	0.000	043	47	0.000	119
14	0.032	289	31	0.032	144	48	0.000	198
15	0.284	125	32	0.000	140	49	0.000	163
16	0.032	022	33	0.000	225	50	0.000	207
17	0.599	356	34	0.000	180			
18	0.032	297	35	0.032	125			

DRANETZ PP1-8000 N-G 2A — Apr-08-99 14:29:33
HARMONICS:CH C REF 118.0 A. 0.0Hz
%FUND Ithd 2.844 %

H#	MAG%	PHS	H#	MAG%	PHS	H#	MAG%	PHS
02	0.122	148	19	0.519	073	36	0.000	061
03	1.374	203	20	0.000	204	37	0.000	261
04	0.061	057	21	0.122	021	38	0.000	304
05	1.526	046	22	0.031	237	39	0.000	339
06	0.031	033	23	0.153	207	40	0.000	319
07	1.679	118	24	0.000	215	41	0.031	283
08	0.031	331	25	0.031	174	42	0.000	119
09	0.122	343	26	0.000	116	43	0.000	191
10	0.031	226	27	0.000	106	44	0.000	137
11	0.397	150	28	0.000	202	45	0.000	099
12	0.000	144	29	0.000	079	46	0.000	085
13	0.366	325	30	0.000	222	47	0.000	324
14	0.031	131	31	0.061	077	48	0.000	035
15	0.244	263	32	0.000	022	49	0.000	054
16	0.031	009	33	0.000	327	50	0.000	270
17	0.549	323	34	0.000	121			
18	0.031	239	35	0.031	355			

75% RLA – USES OFF

DRANETZ PP1-8000 N-G 2A — Apr-08-99 14:35:41
HARMONICS:CH A REF 126.8 A. 60.0Hz
%FUND Ithd 4.172 %

H#	MAG%	PHS	H#	MAG%	PHS	H#	MAG%	PHS
02	0.142	263	19	0.057	077	36	0.000	169
03	0.910	083	20	0.000	255	37	0.000	336
04	0.057	123	21	0.028	243	38	0.000	315
05	3.414	082	22	0.000	063	39	0.000	287
06	0.028	297	23	0.085	126	40	0.000	015
07	2.134	206	24	0.000	303	41	0.000	053
08	0.028	338	25	0.028	020	42	0.000	147
09	0.057	063	26	0.000	286	43	0.000	039
10	0.028	289	27	0.000	156	44	0.000	170
11	0.512	260	28	0.000	359	45	0.000	106
12	0.000	275	29	0.028	102	46	0.000	103
13	0.142	142	30	0.000	190	47	0.000	063
14	0.000	205	31	0.000	358	48	0.000	212
15	0.028	240	32	0.000	138	49	0.000	032
16	0.000	295	33	0.000	130	50	0.000	344
17	0.142	215	34	0.000	219			
18	0.000	170	35	0.000	061			

DRANETZ PP1-8000 N-G 2A — Apr-08-99 14:35:47
HARMONICS:CH B REF 133.4 A. 0.0Hz
%FUND Ithd 3.880 %

H#	MAG%	PHS	H#	MAG%	PHS	H#	MAG%	PHS
02	0.108	216	19	0.108	125	36	0.000	304
03	0.619	010	20	0.000	302	37	0.000	094
04	0.081	113	21	0.027	196	38	0.000	023
05	3.122	093	22	0.000	193	39	0.000	092
06	0.027	198	23	0.027	170	40	0.000	339
07	2.153	225	24	0.000	314	41	0.000	170
08	0.027	063	25	0.081	087	42	0.000	289
09	0.242	303	26	0.000	021	43	0.000	042
10	0.000	236	27	0.027	221	44	0.000	158
11	0.323	265	28	0.000	127	45	0.000	356
12	0.000	041	29	0.000	147	46	0.000	028
13	0.108	152	30	0.000	289	47	0.000	279
14	0.000	181	31	0.027	053	48	0.000	334
15	0.054	251	32	0.000	159	49	0.000	168
16	0.000	235	33	0.000	215	50	0.000	357
17	0.054	252	34	0.000	169			
18	0.000	006	35	0.000	230			

DRANETZ PP1-8000 N-G 2A — Apr-08-99 14:35:52
HARMONICS:CH C REF 135.9 A. 0.0Hz
%FUND Ithd 3.867 %

H#	MAG%	PHS	H#	MAG%	PHS	H#	MAG%	PHS
02	0.080	168	19	0.106	076	36	0.000	070
03	1.273	226	20	0.000	243	37	0.000	286
04	0.080	118	21	0.027	028	38	0.000	229
05	2.944	078	22	0.000	108	39	0.000	210
06	0.053	060	23	0.053	127	40	0.000	089
07	2.069	202	24	0.000	072	41	0.000	286
08	0.027	351	25	0.053	029	42	0.000	103
09	0.212	096	26	0.000	271	43	0.000	273
10	0.027	227	27	0.027	309	44	0.000	197
11	0.398	265	28	0.000	102	45	0.000	186
12	0.000	100	29	0.027	141	46	0.000	051
13	0.186	130	30	0.000	288	47	0.000	009
14	0.000	298	31	0.027	336	48	0.000	117
15	0.053	035	32	0.000	239	49	0.000	081
16	0.000	239	33	0.000	273	50	0.000	165
17	0.106	232	34	0.000	071			
18	0.000	053	35	0.000	101			

DISCUSSION OF THE DATA

To study the effects of the USES Unit over a range of motor amperage, the power parameters were recorded at four (4) load levels, 50%, 75%, 90% and 100% rated load amperage (RLA). The Data Summary Table, at all load levels, shows that the USES Unit decreases the amperage and power demand and increases the motor voltage and power factor. KVAR is reduced considerably and the amperage THD is reduced by about 30 %. The data summary predicts that the motor operation will use less power and will be cooler and smoother both mechanically and electrically. To gain insight into the USES mechanism however, we must compare the individual phase data.

For each on/off measurement condition, the average deviation of the three (3) phase amperages and voltages were calculated. The average deviations between phases with USES are uniformly smaller by 0.3 A and 0.2 V at the three upper load levels, but not at 50%. The regular pattern of convergence demonstrates that USES balances, through the magnetic chokes, the phase amperages and voltages. Within the induction motor, improved phase balance would result in more symmetrical magnetic fields and reduced eddy currents. At 50% load level where motor operation is less efficient, although USES caused greater reduction in amperage, other factors cause the phase conditions to diverge slightly. Through this phase balancing of amperage and voltage, USES would attenuate both amperage and voltage transients that appear on only one phase. The balancing would also capture and distribute energy between phases, thus making it available to 3-phase machinery. We have given the complete 3-phase data for the 75% load level. The data for the other load levels can be found in the Cutler Hammer Report.

During the testing, measurements were also made with the motor off but with USES on. Each phase drew 27 amps at 498 volts. From the 3-phase USES Circuit Diagram in Figure 2, it is apparent that the wrap-around magnetic chokes co-generate the 27 amp signals from the adjacent phases, and that each signal would be 120 degrees out-of-phase with respect to the main phase amperages. At the points of connection of the USES leads, there is vectorial addition of the 27 amp signal to the main phase amperage. In each phase, the 27 amp signal is capacitive reactive current which seeks to cancel inductive reactive current produced by the inductive loads. This cancellation causes the amperage demand reduction up line from the point of USES connection and is the mechanism for displacement power factor correction. USES is a superior method of power factor correction because only a small, out-of-phase current does the job. Traditional power factor correction capacitors, because of the large currents involved, must be located near the motors or at the service entrance where the cables are heavy-duty. Eliminating the capacitors reduces RCL resonance and other motor-related problems. Also, USES does not heat up or fail in high harmonic environments.

By comparing the harmonic data in the Summary Data Table and in the phase data tables, it is seen that with USES the current harmonic distortion, ITHD, is reduced by 30% while the VTHD is increased by 4%. The harmonic distortion is generated within the motor, and the 30% decrease in ITHD is evidence of smoother electrical and mechanical operation, which leads to higher efficiency and longer motor life. Study of the effects of USES on transient attenuation, and on ITHD and VTHD will be the goals of future testing.

CONCLUSION

This Study provides conclusive evidence that by providing passive magnetic linkage between electrical phases, the USES Unit does reduce amperage demand and power demand for inductive loads. The USES Circuit and the Testing are precisely described. Analysis of the data in three (3) phases suggests mechanisms by which USES attenuates transients, improves displacement power factor and balances electrical phases. The USES Unit reduces inductive circuit current harmonics by 30% which suggests that the power quality is significantly improved. The other pronounced functions of harmonic distortion reduction and transient voltage suppression are to be further tested separately in the future.

References:

1. The USES Unit - The Inductive Solution to the Inductive Circuit Efficiency Problem - March 24, 1999 By: Robert T. Emmet, PhD

2. Power Measurement Report of USES for Northrop Grumman Corporation Facility at at Sykesville, Maryland By: Alton W. Baum, P.E. - CUTLER-HAMMER

3. USES Manufacturing, Inc. - "An A-C Power Conditioning System", U.S. Patent # 5,105,327, April 1992. By: E. B. Wohlforth