Environmental Potentials

Power Quality For The Digital Age

FUJI DRIVES

A Report by Environmental Potentials'
Research & Development Department

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Introduction

The objective of this project is to perform an efficiency test on a Fuji Frenic 5000P11 AC drive. This project is divided into two parts. In part 1, the Fuji drive was tested in a third party testing laboratory, EMC solutions, on a 26HP motor. In part 2, the testing was done at Environmental Potentials R&D Div4 with 5HP motor. Both these testings were performed to check the efficiency of the Fuji drive before and after installing an EP unit.

Part 1

Testing Location

EMC Solutions/CW Silver 535 W 700 S, Salt Lake City, Utah 84101

Testing Engineers

Naveen Tera (EP), Robert Rawlings (EP) and Barry Christiansen (EMC Solutions)

EUT (Equipment Under Test)

Fuji Frenic 5000P11 AC drive, EP-20003D480

Testing equipment used

The power quality and data logging was recorded with one PS4000 (manufactured by summit technologies www.powersight.com), one PS-FAO module to monitor the high frequency noise on voltage and current, one Fluke 43B series power quality analyzer, PSM software to monitor and record PS4000 data.

Electrical Environment

480V delta at 60Hz. The load is a 26HP eddy current braking motor.

Testing Setup

The Fuji drive is connected to the motor. The PS 4000 is connected on the line side of the drive to analyze the power quality. The output of the drive is set at approximately 17A while the load was maintained constant throughout the testing process in order to compare the results accurately. The PS4000 was set to log the transients, swells, dips and consumption data during the testing process. After the logging is recorded, the PS meter was set to record the high frequency noise on voltage and current with the help of its FAO module.

Testing Procedure

1) The load is connected to the Fuji drive and a test run was conducted to ensure the drive was outputting the required amperage needed for testing.

2) Once all the parameters on the drive are set for the load, the testing process began.

3) PS4000 is connected to the line side of the drive to record the logging data.

Results

The following data was collected using PSM software. “Before readings” are defined as the measurements taken on Fuji drive before adding an EP unit. “After readings” are defined as the measurements taken on Fuji drive after adding an EP unit.

Before Readings

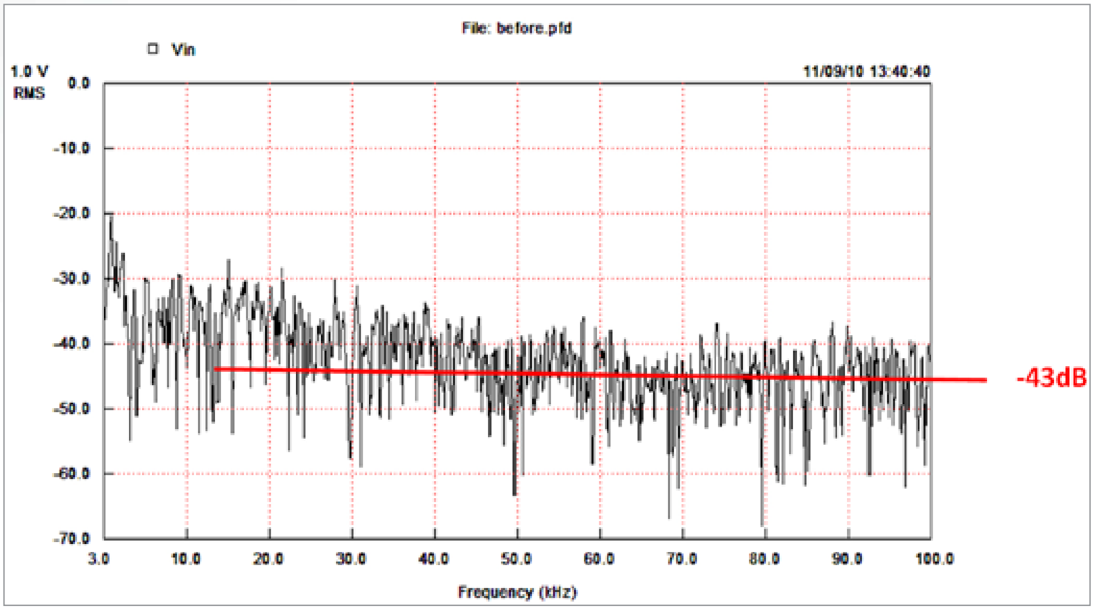

Figure 1: Voltage high frequency noise between phase B and C before EP added

Figure 1 shows the voltage high frequency noise between phases B and C between 3-100kHz. In this frequency range the noise averaged at -43dB. Voltage noise under these frequencies indicate that the electrical system is not efficiently used for the available power. This level of noise indicates skin effect on wire, and/or eddy currents and hysteresis losses on the motor windings. A typical facility have noise levels of -30dB on voltage. Figure 1 measurement is taken at the line side of the Fuji drive which was connected to one AC induction motor. This means that the above noise is coming out of a single load (Motor and drive), and is considered high in magnitude. Reducing this noise will result in energy loss reduction.

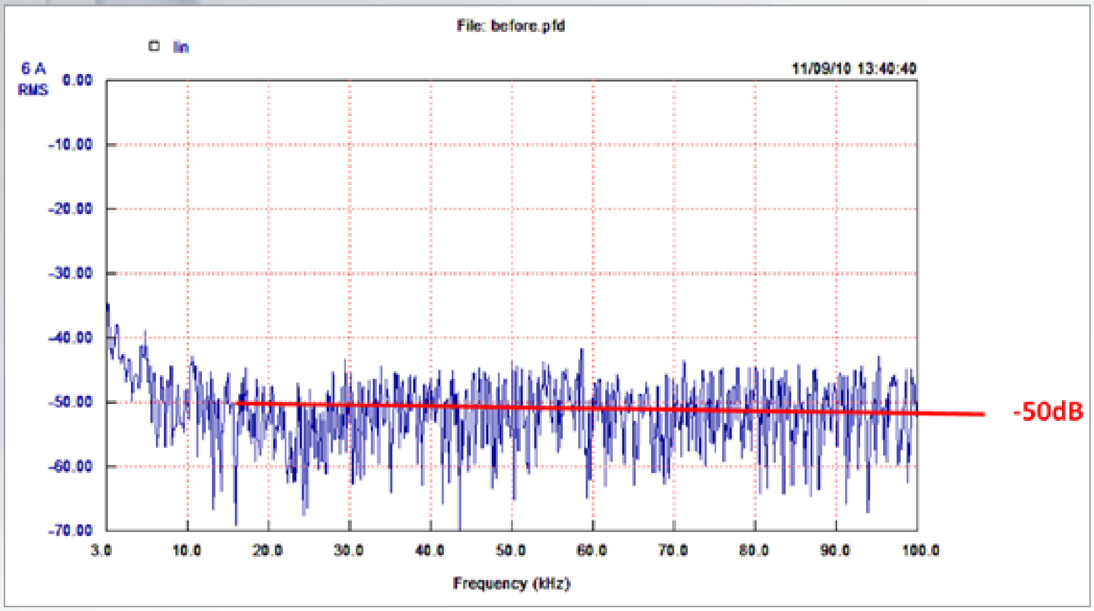

Figure 2: Current high frequency noise on phase A before EP added

Figure 2 shows the current noise from 3-100 kHz. This noise is mainly due to the capacitive nature of the Fuji drive. This noise is observed on all the loads that are transistor driven. Fuji drive is a sophisticated digital load that comprises of lots of timing circuits, digital circuits and sensors. In order for operation of the mentioned circuits, huge numbers of transistors are used. These transistors are generating the above current high frequency noise.

This level of noise can cause 1) erratic behavior of the drive 2) false alarm indicators 3) decrease in the life time of the drive 4) permanent failure of the drive.

Current high frequency noise can cause false triggering of the transistors which can cause erratic behavior of the drive and false alarm indicators. Current noise can also puncture the walls of capacitors and the dielectric medium, which further decreases the capacitive nature of the drive. This process will decrease the lifetime of the drive as it is losing its component values. At some point, when the capacitive reactance of the drive matches with the inductive reactance of the drive (due to its wire), ferro-electro magnetic resonance phenomenon occurs which will further amplify the noise. At this point of time, the noise will cause permanent damage to the drive. This can even cause the communication data from PLC machines to become corrupted due to the false triggering of the transitors in drive. (A detailed case study can be found in EP library with the file name "powerline communications". This case study shows the effectiveness of EP unit at the VFD in correcting the data signal that is transmitted through the powerlines)

Therefore, it is very important to reduce the current high frequency noise to protect the digital circuitry within the drive.

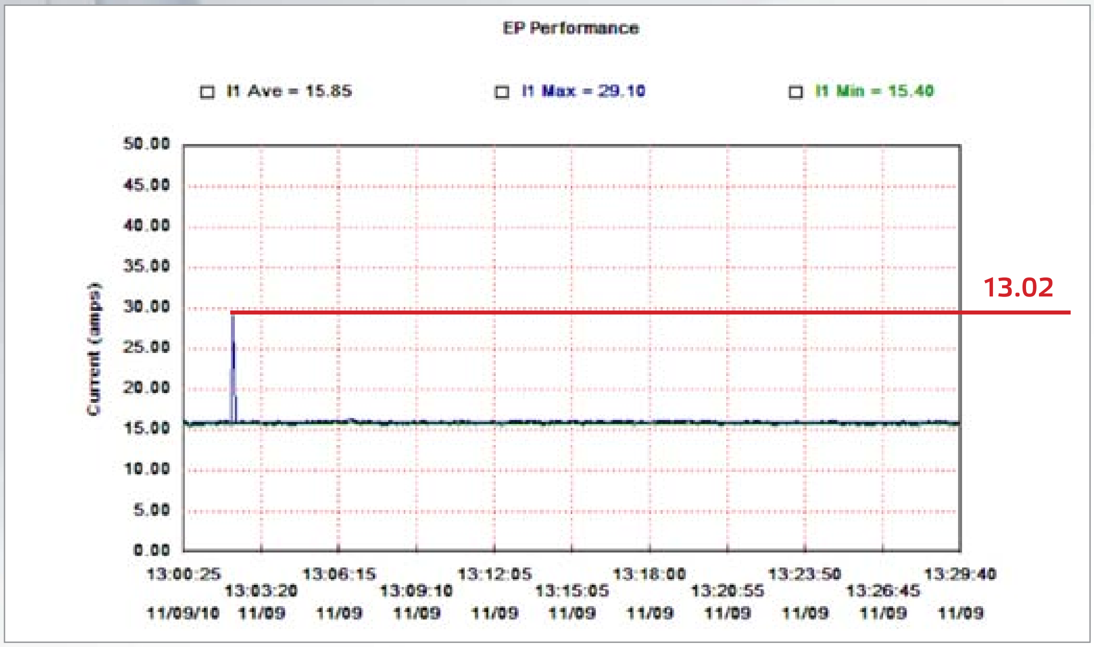

Figure 3: Current log on phase A

Figure 3 is the log of current on phase A. The current magnitude stayed constant over a period of time except at 13.02. At 13.02 a current spike was measured with a magnitude of 29.10A at 60Hz frequency. If this magnitude was above 30A, it would have tripped the breaker at the load panel.

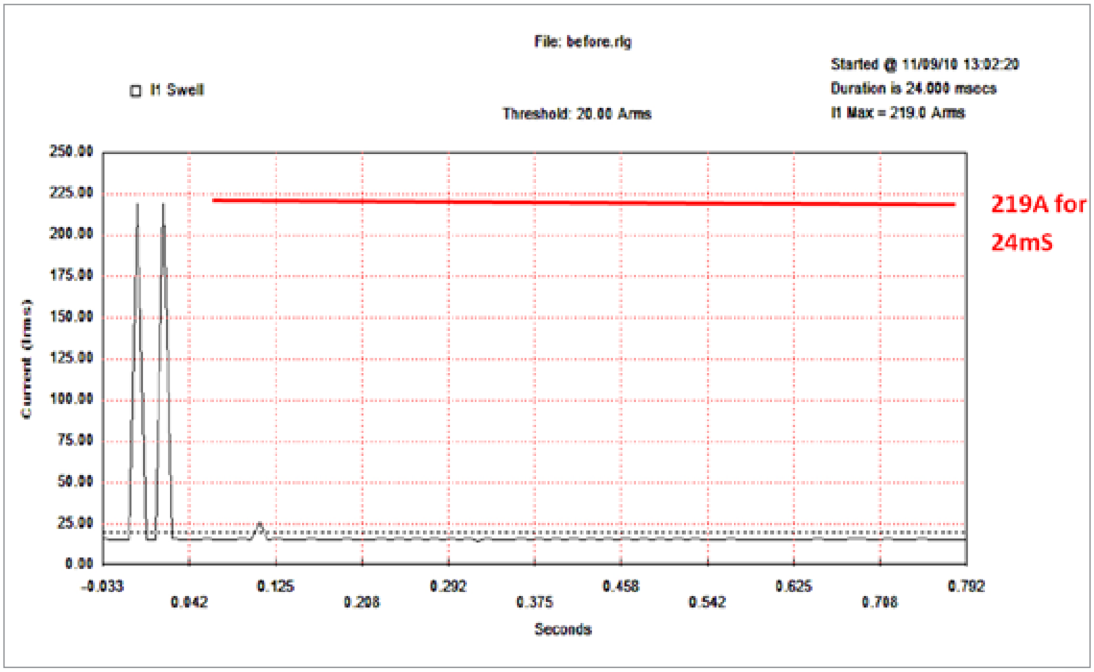

Figure 4: Transient on phase A current waveform

Figure 4 shows the transients observed on phase A of the current waveform. This shows the high frequency magnitude of the same spike shown in figure 3 of 29.10A at 13.02. Figure 4 measures about 219A at 13.02 for duration of 24ms. The measurement stamp on figure 4 shows the transient duration and magnitude. Based on figure 3 and figure 4 measurements, it can be said that the current waveform saw a transient at 13.02 which has a magnitude of 29.10A at 60Hz for less than a couple of seconds. This same transient has the magnitude of 219A for 24 mS.

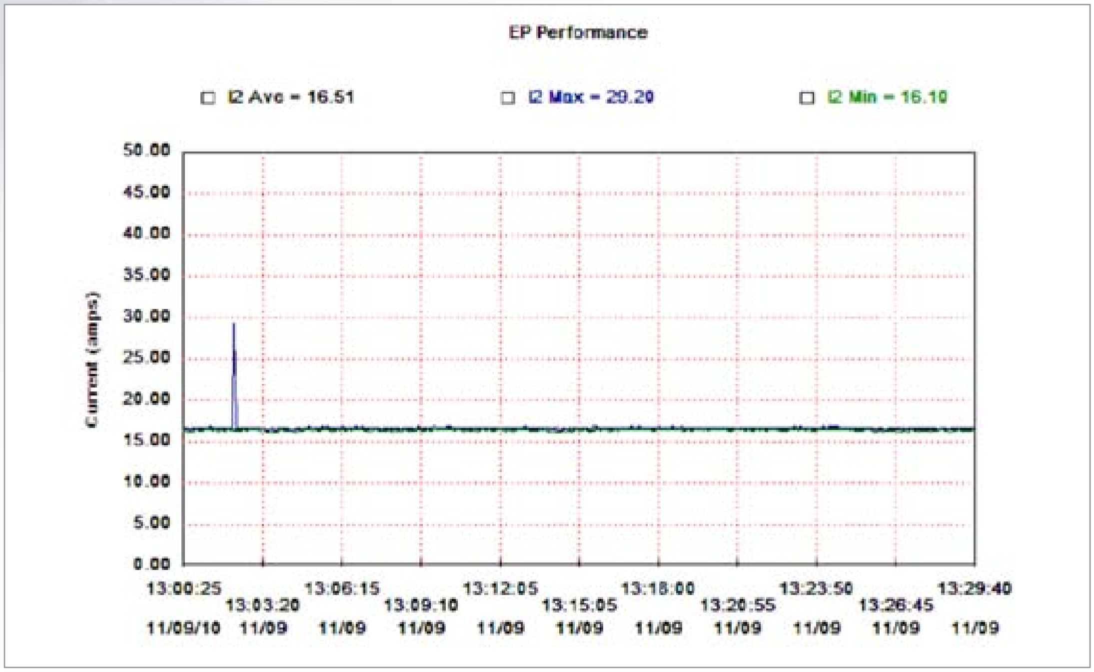

Figure 5: Current log on phase B

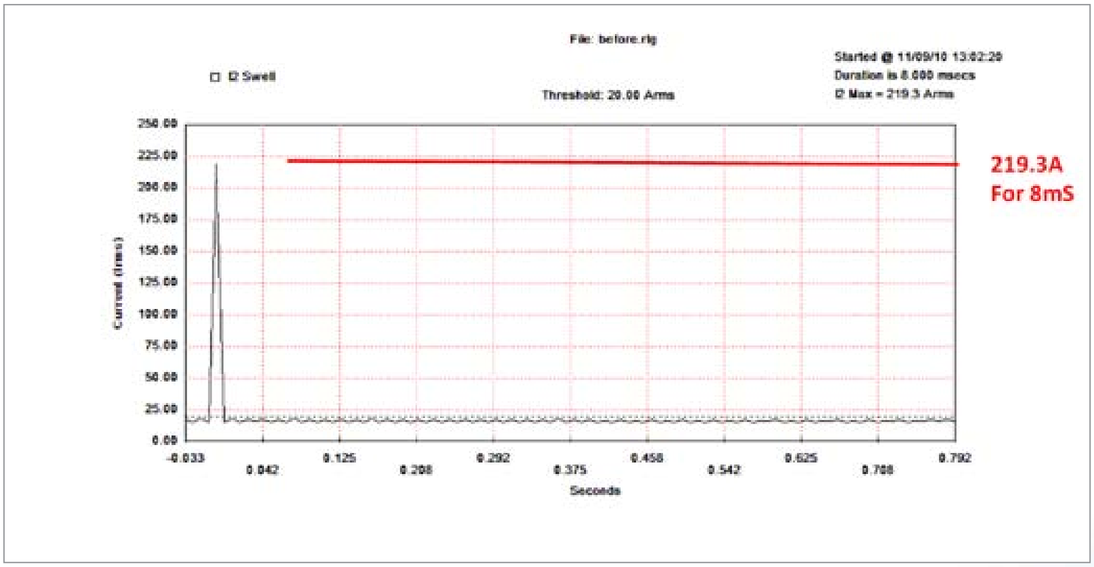

Figure 6: Transient log on phase B

The same theoretical application of phase A applies on here on phase B. It is very important to know there is no transient is observed on phase C. Transients are observed and measured on phase A and Phase B, but not on Phase C. This is because: power to this testing panel is coming directly from outside the facility. There are no other loads connected from this testing panel other than the Fuji drive and the motor under test.

However, there is a high leg delta transformer connected to the main power supply that is feeding this testing panel. This high leg transformer was feeding other loads in the facility on two of its 480V legs. This means the facility loads are using only two phases (current on phase A and phase B) and the center tapped reference for its operation. Since the facility loads are using only two phases, transients are generated only on these two phases. Transients generated on the load side of the high leg delta were able to travel to the main power supply through its phases as return path of the current and reach the testing setup. Hence, transients are observed only on two phases.

These two transients were large enough in magnitude on the two phases to be extremely dangerous to the digital circuitry of the VFD. These high magnitude currents can easily blow the transistors in the drive. A typical facility sees at least 100 of these transients every day.

After Readings

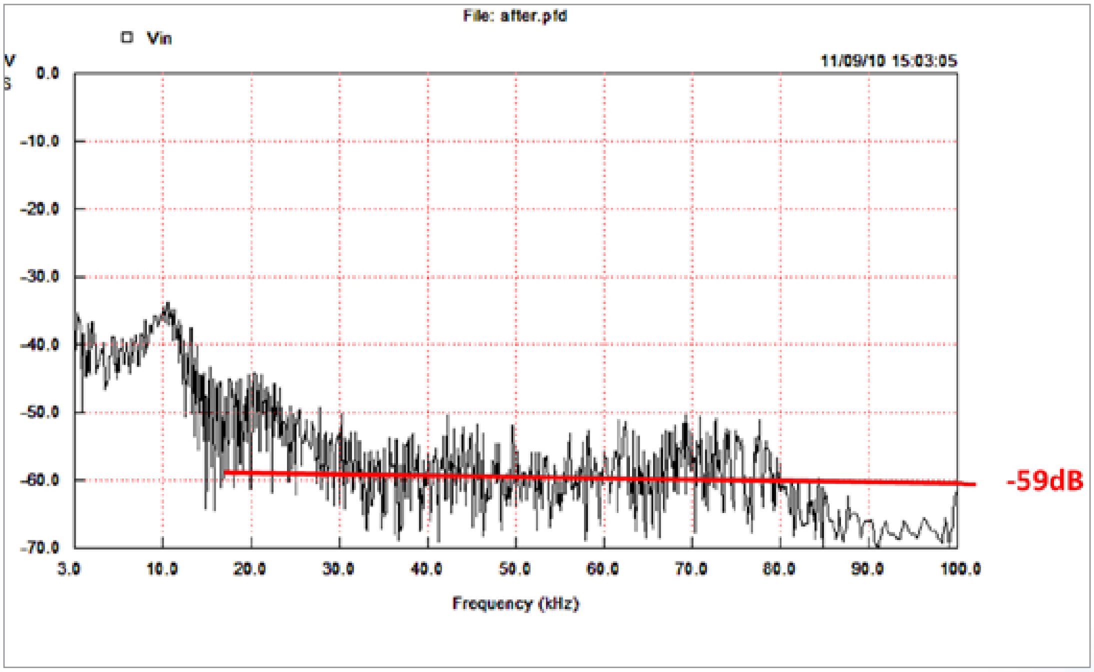

Figure 7: Voltage high frequency noise between phase B and C after EP added

Figure 7 was taken immediately after adding one EP-2000 filter in parallel to the line side of the Fuji drive. The voltage high frequency noise is averaged at around -59dB, which is 16dB less than the before EP level of -43dB. This indicates that the EP unit is removing the skin effect on the wire, removing eddy currents and hysteresis losses in the motor. Therefore, reduction in the voltage high frequency noise will reduce the power consumption of the load.

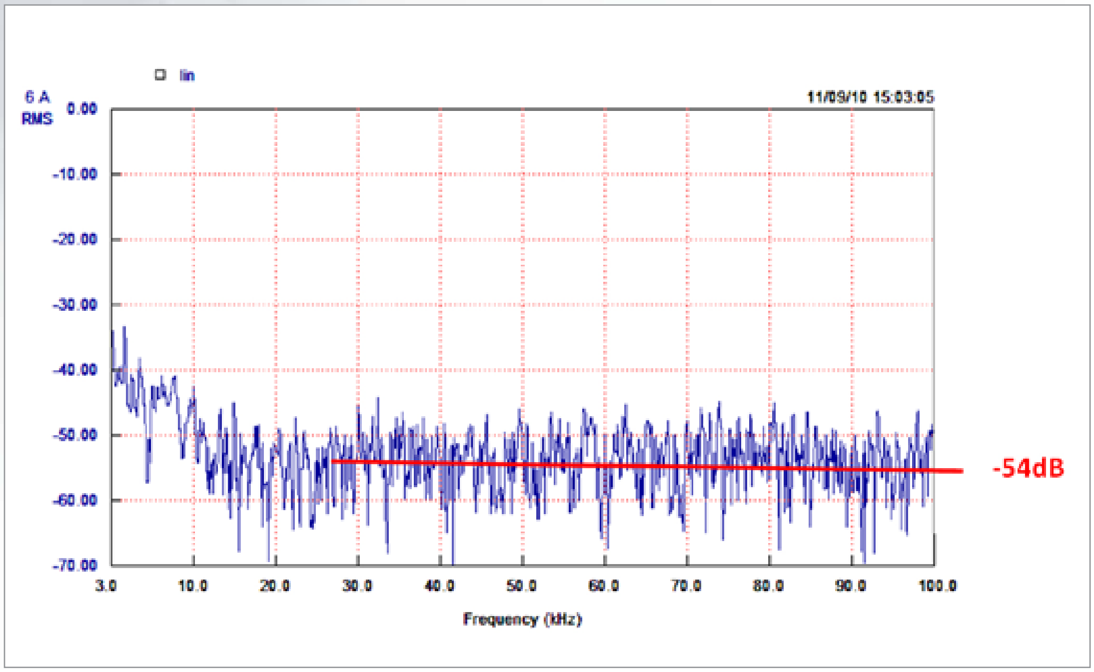

Figure 8: Current high frequency noise on phase A after adding one EP unit

Figure 8 was taken on current from 3-100kHz. The noise is averaged at -54dB, which is 4dB less than the before EP. This reduction in the current high frequency noise will increase the performance of the drive, by correcting the trigger times on the transistors. This reduction in the current high frequency noise is also indicates that the EP unit is adding protection to the digital circuitry of drive.

One limitation of the PS-4000 meter is it can only log the transients it sees. The PS4000 didn't record any transients after adding an EP-2000, indicating that the EP-2000 suppressed all the transients.* (Please ask EP engineering team for a copy of the before and after transient log files which can be only seen with the PSM software)

Consumption data Log

The PS-4000 meter logged a detailed consumption of the testing setup.

The following table compares before and after adding one EP-2000.

Measurement	Before	After	Units	Change	%Change
1) Voltage, Phase 1, Ave:	489.1	489.1	volts	0.0	0.0 %
2) Voltage, Phase 1, Max:	490.8	490.3	volts	-0.5	-0.1 %
3) Voltage, Phase 1, Min:	485.1	485.4	volts	0.3	0.1 %
4) Voltage, Phase 2, Ave:	483.5	484.0	volts	0.6	0.1 %
5) Voltage, Phase 2, Max:	485.1	485.2	volts	0.1	0.0 %
6) Voltage, Phase 2, Min:	479.3	480.1	volts	0.8	0.2 %
7) Voltage, Phase 3, Ave:	483.3	483.5	volts	0.2	0.0 %
8) Voltage, Phase 3, Max:	484.7	484.8	volts	0.1	0.0 %
9) Voltage, Phase 3, Min:	479.2	480.0	volts	0.8	0.2 %
10) Current, Phase 1, Ave:	15.9	15.1	amps	-0.7	-4.5 %
11) Current, Phase 1, Max:	29.1	15.6	amps	-13.5	-46.4 %
12) Current, Phase 1, Min:	15.5	14.5	amps	-1.0	-6.5 %
13) Current, Phase 2, Ave:	16.5	15.8	amps	-0.7	-4.1 %
14) Current, Phase 2, Max:	29.2	16.3	amps	-12.9	-44.2 %
15) Current, Phase 2, Min:	16.1	15.1	amps	-1.0	-6.2 %
16) Current, Phase 3, Ave:	13.2	12.7	amps	-0.5	-4.0 %
17) Current, Phase 3, Max:	13.5	13.1	amps	-0.4	-3.0 %
18) Current, Phase 3, Min:	12.9	11.9	amps	-1.0	-7.8 %
19) Total True Power Ave:	8263.6	7983.7	Watts	-279.8	-3.4 %
20) Total VA Power Ave:	12777.9	12244.9	VA	-533.0	-4.2 %
21) Total Power Factor:	0.65	0.65	0.01		0.8 %
22) Energy, Total Elapsed:	3.85747	3.72689	KWH	-0.13058	-3.4 %
23) Energy, estimated per month:	**6038.3**	**5833.9**	**KWH**	**-204.4**	**-3.4 %**
24) Cost, Total Elapsed:	$0.42	$0.41	$	($0.01)	-3.4 %
25) Cost, estimated per month: (at $0.11000/KWH)	$664.21	$641.73	$	($22.48)	-3.4 %

This consumption data proves the EP-2000 unit reduced the energy consumption by 3.4%. This is primarily achieved by reducing the voltage high frequency noise by 16dB. The EP-2000 also balanced the phase currents and removed the transients on the two phases.

Conclusion

Part 1 of this testing was conducted at EMC Solutions in Salt Lake City, UT. Adding one EP-2000 unit to the Fuji Frenic 5000P11 AC drive removed the dangerous current transients that can harm the digital circuitry of Fuji Drive. The efficiency of the drive is increased by ***3.4%***. Environmental Potentials' patented waveform correction technology removes voltage and current high frequency noise and maintains the sinusoidal nature of the waveform.

All of EP's patented circuits have passed IEEE/ANSI IEEE C62.41 standard testing. This testing describes surges and transients in the low voltage range applications. The waveform correction technology is designed such a way that it absorbs and dissipates the noise within the unit itself and will not shunt any part of the noise back into the electrical system. This is a significant advantage over other power quality equipment.

Advantage over line reactors

Line reactors are chokes (inductors) that can slow down the current transients. However, this application is not suitable for capacitive loads such as VFD's. VFD's are capacitive loads and when matched with the inductor's reactance, it amplifies the noise due to ferro-electro magnetic resonance phenomenon. This phenomenon will further decrease the life of drive, by constantly decreasing the capacitance value on capacitors. A line reactor will also cause power pollution by adding noise to the ground. Environmental Potentials' waveform correction technology completely removes this noise from the system. EP units come standard with a rugged and robust protection circuit and can easily absorb and dissipate huge amounts of electrical noise. The line reactors do not have a mechanism to dissipate the electrical noise.

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