PQSoft Case Study

IEEE 519 Compliance

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References			

Abstract:

IEEE Standard 519-1992 is a standard that addresses the need for limiting the harmonic current a customer injects onto the utility system. It also protects the customer by specifying maximum harmonic voltage distortion levels that utilities can supply.

The installation of a 3% choke on each drive and a 150kVAr harmonic filter on the bus reduced the harmonic currents to acceptable values.

This case presents the evaluation of IEEE 519 compliance for an industrial facility supplying adjustable-speed drives.

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RELATED STANDARDS

IEEE Standard 519-1992

GLOSSARY AND ACRONYMS

ASD	Adjustable-Speed Drive
DPF	Displacement Power Factor
PCC	Point of Common Coupling
PF	Power Factor
PWM	Pulse Width Modulation
POI	Point of Interference
SCR	Short Circuit Ration
TDD	Total Demand Distortion
THD	Total Harmonic Distortion
TPF	True Power Factor

PROBLEM STATEMENT

A wastewater treatment plant is installing five (5) 100 HP pulse width modulation (PWM) adjustable-speed drives (ASDs). The utility has specified that IEEE 519 current limits must be met.

The combined drive load has the following characteristics:

Drive Rating: .....500 HP
Bus Voltage:.....480 V
Fundamental Current: .....600 A

SYSTEM CONFIGUATION

Figure 1 illustrates the oneline diagram used for the analysis of IEEE 519 compliance.

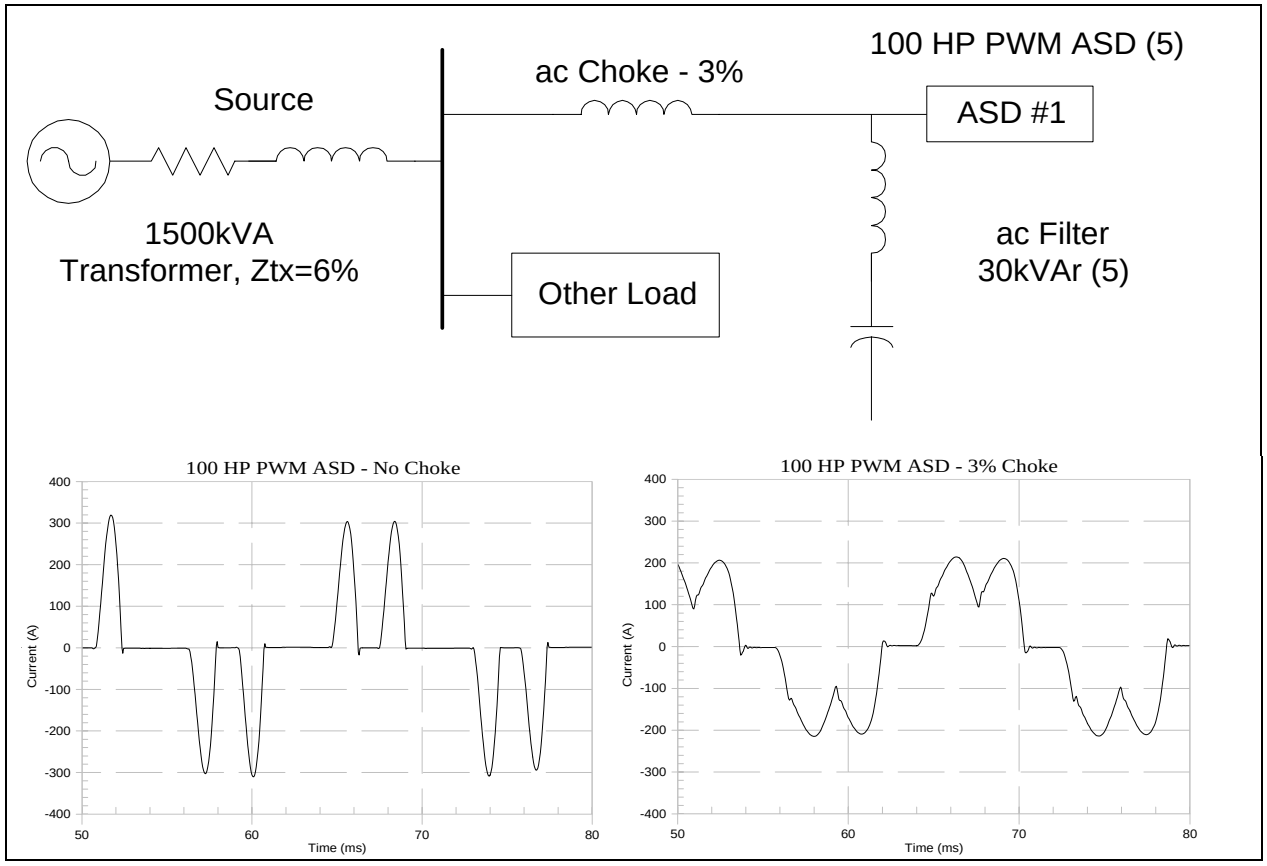

Figure 1 - Oneline Diagram for IEEE 519 Case

Short circuit and load information:

ISC(short circuit) .....26750 Amps @ 480 Volts
IL(maximum average demand load current).....1200 Amps
ISC/IL (low side PCC) 22

IEEE 519 CURRENT LIMITS

IEEE Standard 519-1992 is a standard that addresses the need for limiting the harmonic current a customer injects onto the utility system. It also protects the customer by specifying maximum harmonic voltage distortion levels that utilities can supply. The standard should be used for guidance in the design of power systems with nonlinear loads. Table 1 summarizes the current requirements.

Table 1 - Current Limits for Individual Customers (120V - 69kV)

Isc/I(load)	<11	11<h<17	17<h<23	23<h<35	35<h	THD
<20	4.0	2.0	1.5	0.6	0.3	5.0
20 - 50	7.0	3.5	2.5	1.0	0.5	8.0
50 - 100	10.0	4.5	4.0	1.5	0.7	12.0
100 - 1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

where:

SCR: ratio of the short circuit current at the point of common coupling to the maximum average demand load current (I_{sc}/I_{load})

TDD: Total Demand Distortion, current distortion in percent of the maximum average demand load current

IEEE 519 defines the point of common coupling (PCC) as:

A point of metering or any point as long as both the utility and the customer can either access the point for direct measurement of the harmonic indices meaningful to both or estimate the harmonic indices at a point of interference (POI) through mutually agreeable methods.

LOAD CURRENT EVALUATION

Table 2 summarizes the current requirements for the initial case with no harmonic current reduction. This evaluation illustrates the need for harmonic current mitigation. As can be seen in the table, most of the individual harmonic currents and the total demand distortion are exceeded for this case. In addition, the bus voltage distortion of 9.8% is higher than the generally accepted limit of 5%.

The transformer impedance can be determined from:

$$Z_{tx(\Omega)} = \left(\frac{kV^2}{MVA}\right) * Z_{tx(\%)} = \left(\frac{0.480^2}{15}\right) * 6\% = 0.0092\Omega$$

The harmonic voltages are determined by multiplying the current injection times the impedance at each harmonic. The maximum average demand load current is used to scale the individual harmonic currents for comparison with the specified limits.

Table 2 - Evaluation of Current Limits for Base Case

Harmonic Number h	Harmonic Current (% Fund) Ih	Harmonic Current (Amps) Ih	System Impedance (Ohms) Xh	Harmonic Voltage (Volts) Vh	Harmonic Current (% Demand) Id	IEEE 519 Current Limit (%) (Table 10.2)	Value Exceeds Limit
5	66.9	401.4	0.046	18.5	33.5	7.0	Yes
7	43.6	261.6	0.064	16.7	21.8	7.0	Yes
11	8.7	52.2	0.101	5.3	4.4	3.5	Yes
13	7.3	43.8	0.119	5.2	3.7	3.5	Yes
17	4.8	28.8	0.157	4.5	2.4	2.5	No
19	3.9	23.4	0.175	4.1	2.0	2.5	No
23	3.5	21.0	0.212	4.5	1.8	1.0	Yes
25	2.1	12.6	0.230	2.9	1.0	1.0	Yes
Total:	**80.5 %**			**9.8 %**	**40.6 %**	**8.0 %**	**Yes**

Note:

I_d is based on the average maximum demand load current

MITIGATION TECHNIQUES

Several techniques for reducing the harmonic current were evaluated:

1. Installation of a 3% choke on each drive (refer to Figure 1 for new current waveform)
2. Installation of a 3% choke and a 30kVAr, 5th harmonic filter on each drive
3. Installation of a 3% choke on each drive and a 150kVAr, 5th harmonic filter on the 480 volt bus

Table 3 summarizes the results from the computer simulations.

Table 3 - Evaluation of Current Limits for Various Solutions

Case	Total Drive Load	Choke Size	Filter Size and Location	Load Current THD	Bus Voltage THD	Xfmr Current TDD	Low Side Harmonics Exceeded	High Side Harmonics Exceeded
1	500 HP	None	None	80.5 %	9.8 %	40.6 %	5,7,11,13 23,25,TDD	5,7,TDD
2	500 HP	3 %	None	37.7 %	4.6 %	18.9 %	5,11,TDD	5,TDD
3	500 HP	3 %	30 kVAr @ ASD	29.0 %	3.4 %	14.5 %	5,23,TDD	5
4	500 HP	3 %	150 kVAr @ Bus	29.0 %	2.2 %	7.8 %	None	None

SUMMARY

IEEE Standard 519-1992 is a standard that addresses the need for limiting the harmonic current a customer injects onto the utility system. It also protects the customer by specifying maximum harmonic voltage distortion levels that utilities can supply.

The installation of a 3% choke on each drive and a 150kVAr harmonic filter on the bus reduced the harmonic currents to acceptable values.

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