POWER QUALITY CHARACTERISTICS OF COMPUTER LOADS

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Abstract: Computer Loads and systems can be found in all of society's industrial, commercial, and residential sectors. The nature of these loads in such that they distort the line-current waveforms and, in some cases, can significantly distort the supply-voltage waveforms causing disruption in computer system performance. The voltage (i.e. line-to-line, line-to-neutral and neutral-to-ground) and the phase current waveform characteristics of many computer loads are similar. This paper will present several case studies to reveal the unique power quality characteristics of several commonly used computer systems (e.g. workstations, heating plant process computers). This paper will also discuss the impact of the computer loads on the supply voltage waveforms.

Key words: harmonic characteristic, computer loads, supply voltage

1. INTRODUCTION

The initial objective of the study was to capture a set of samples, to attempt to determine the harmonic characteristics of the phase current, line-to-neutral voltages, and the neutral-to-ground voltages of the various computers loads and systems.
In a majority of the site surveys, the users allowed sufficient monitoring time (e. g. 2-7 days) to capture the essential harmonic characteristics of their computer load and systems and correlate them with any computer system operational problems.
The initial sites selected were problematic from a user's point of view. Some of the questions passed by the included the following.
1) If the phase - current waveform of a single computer work – station is known, then is the phase current at the electrical panel serving a number of identical computer workstations a multiple of a single – computer workstations characteristics?
2) What is total harmonic distortion (THD) of a single-computers work station a phase current, and does it vary significantly with loading patterns?
3) If the phase-current waveform is significantly distorted?
4) What is the harmonic distortion of the neutral-ground voltage at an individual computer workstation and at the electrical panel serving a number of computer work-stations?
This paper will attempt to answer some oh the above questions.

2. SINGLE–AND MULTIPLE–COMPUTER- WORKSTATION(S). POWER QUALITY CHARACTERISTICS

2.1. Individual Computer Workstation Phase Currents (Range 0,92 - 0,95 A rms)

The typical characteristics phase-current wave shapes of each individual computer workstation are illustrated above and beside each computer workstation – made power supply of the individual computer workstation shown in Fig. 1.

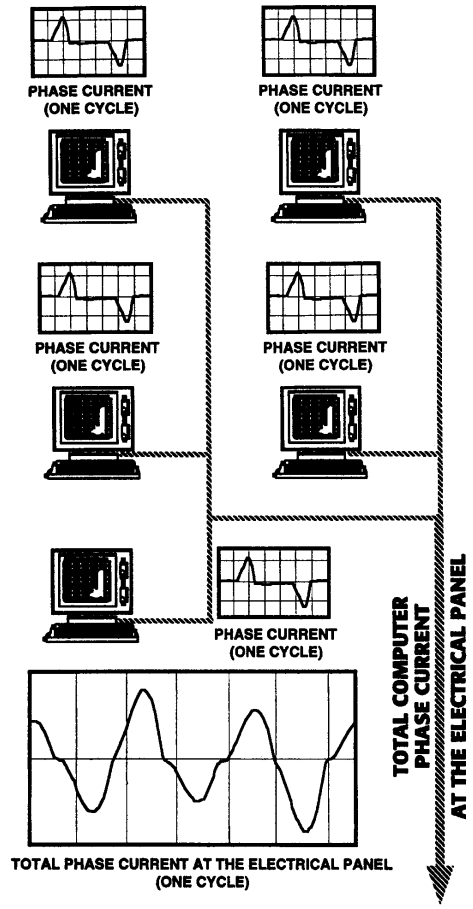

Fig. 1. Computer workstation schematic diagram.

The wave shape at the phase currents of a switched - made power supply of the individual computer workstations were approximately the same. A figure showing the percent THD and the contributions of the dominant harmonic components (i.e., third, fifth, seventh and ninth) oh the phase current characterizing a single – computer workstation is shown in Fig. 2.

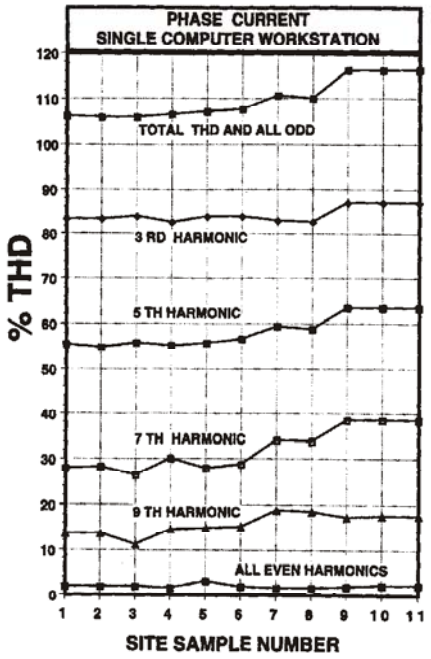

Fig. 2. Phase current percent THD and harmonic contribution of an individual computer workstation.

Each sample was taken at different times of the day, to characterize the loading cycle of a single – computer workstation.

The harmonic content of the waveform was dominated by the add harmonics. The contribution of all the even harmonic components of the phase current was negligible.

The dominant phase current harmonic was the third, followed by the fifth, seventh, and ninth harmonic. The total THD averaged around 110% for all the samples taken.

Once we had captured the power quality characteristics of a single – computer workstation, our the electrical panel serving a multiple number of identical computer workstations would be:

1) phase current at the panel would have the same wave shape;
2) the harmonic content of the phase current measured at the electrical panel would be identical;
3) the total phase – current harmonic distortion would be the same as a single – computer workstation would be:

1) phase current at the panel would have the same wave shape;
2) the harmonic content of the phase current measured at the electrical panel would be identical;
3) the total phase – current harmonic distortion would be the same as a single – computer workstation.

2.2. Phase Current at Computer Workstation Electrical Panel (Range: 23.0 – 23.5 A rms)

With reference to Fig. 1, the phase – current waveform measured at the panel was not a multiple of a single – computer workstation.

The unique waveform oh the phase current at the panel remained essentially the same throughout the monitoring period.

The harmonic content of the phase current measured at the electrical panel is shown in Fig. 3 and Fig. 4.

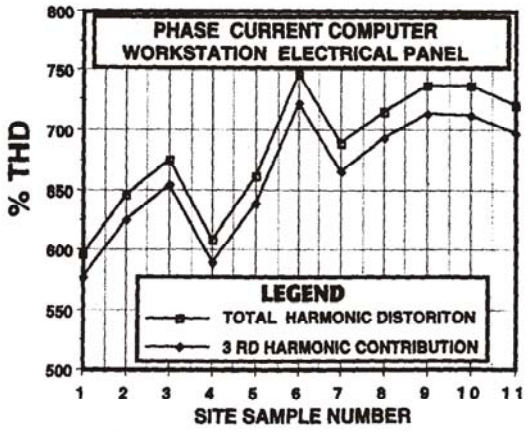

Fig. 3. **Phase current** percent THD and third harmonic contribution at the computer workstation electrical panel.

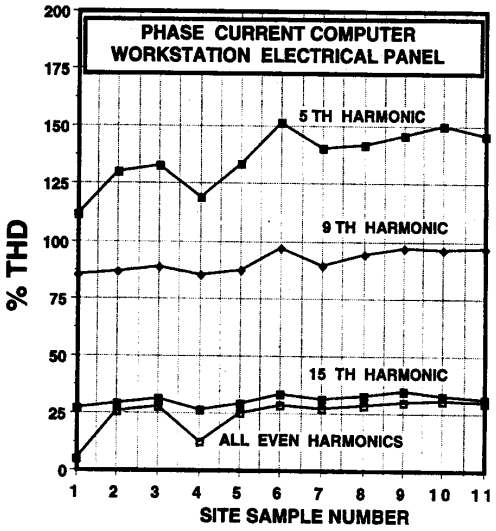

Fig. 4. **Phase current** dominant harmonic contributions at the computer workstation electrical panel.

The total harmonic content of the electrical panel phase current (i.e., averaging around 700%) significantly exceeded the THD of a single – computer workstation (i.e., 110%). The dominant phase current harmonics at the panel were the third, followed by the fifth, ninth, and fifteenth and not the third, fifth, seventh, and ninth exhibited by a single – computer workstation.

2.3. Line-to-Neutral and Line-to-Line Voltage at Computer Workstation Electrical Panel (120/208 Vrms)

The THD of the phase-to-neutral voltage measured at a single-computer workstation and the electrical panel is shown in Fig. 5.

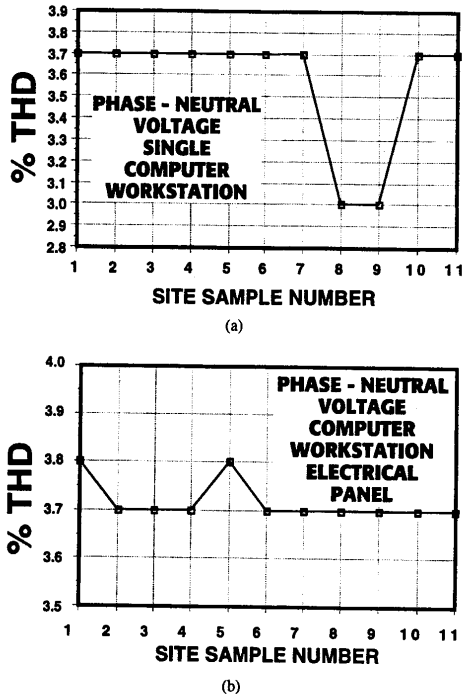

Fig. 5. **Phase-neutral voltage** percent THD measured at a single-computer workstation and at the electrical panel.

The THD remained constant (i.e. 3,7%) at the terminals of the individual computer workstations, independent of the change in work-station loading patterns.

The THD of the line-to-line voltage measured at the electrical panel is shown in Fig. 6 and remained constant at 1,4% significantly less than the THD of the phase-neutral voltages.

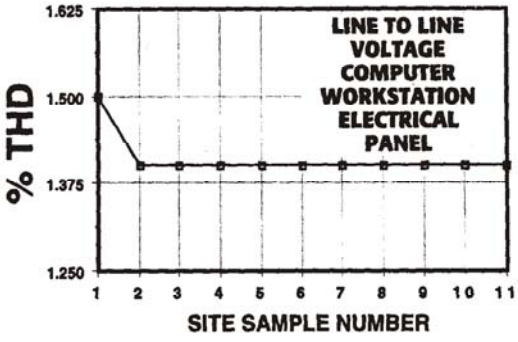

Fig. 6. **Line to line voltage** percent THD at the computer workstation's electrical panel.

2.4. Neutral-Ground Voltages (Range: 0,92 – 0,95 Vrms at a Single Computer Workstation and 0,97 – 1,02 Vrms at the Electrical Panel).

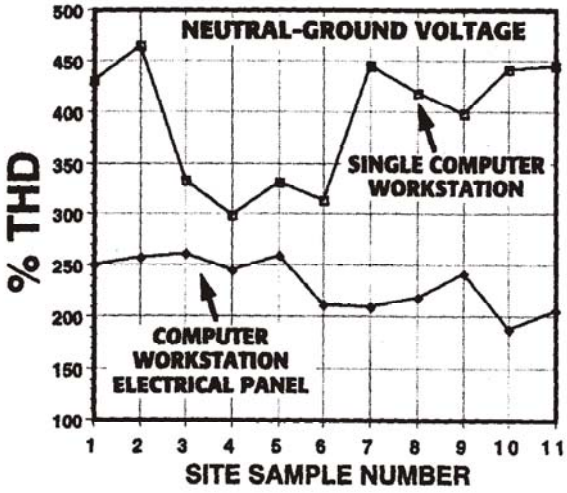

Fig. 7. **Neutral-ground voltage** percent THD at a single-computer workstation and at the electrical panel.

The THD of the neutral-ground voltages measured at a single – computer workstation and at the electrical panel a shown in Fig. 7.

The waveform of the neutral-to-ground voltages was constantly distorted and often did not exhibit any cyclic behavior. The THD of the neutral-ground voltage at a single-computer workstation averaged 400% while at the electrical panel it averaged 225%.

3. HEATING PLANT COMPUTER PANEL POWER QUALITY CHARACTERISTICS

3.1. Heating Plant Circuit Phase Current (Range: 1,8 -14,9 Arms)

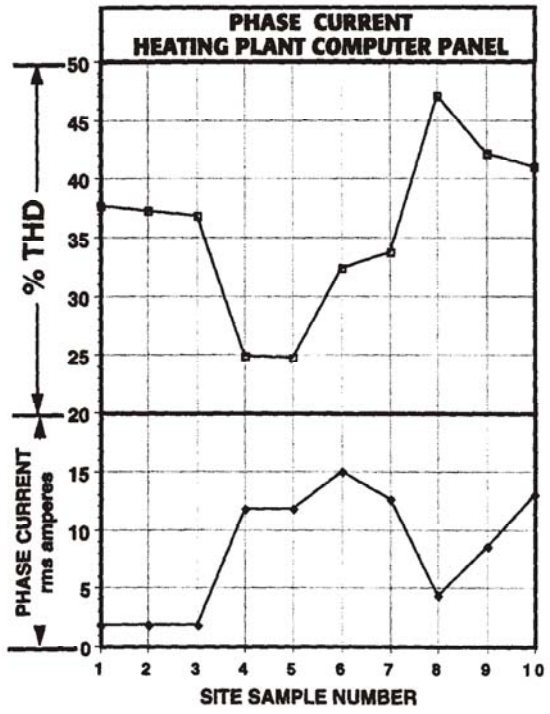

Fig. 8. **Phase current** percent THD—heating plant computer panel.

The percent THD of the phase current is sown in Fig. 8.

The THD of the phase current appears to increase during light load conditions and decreases during heavy load conditions. The THD for this computer panel is significantly lower than the phase current of the computer workstation (i.e. approximately 40% compared to 700%). The significant difference in THD was attributed to the difference in the computer system's technology and the diversity in the number o different types of computer systems. The dominant harmonic component ah the phase current was the third harmonic and did not change significantly with the load cycles.

3.2. Line to neutral and Line-to-Line Voltages at Computer Workstation Electrical Panel (120/208 V)

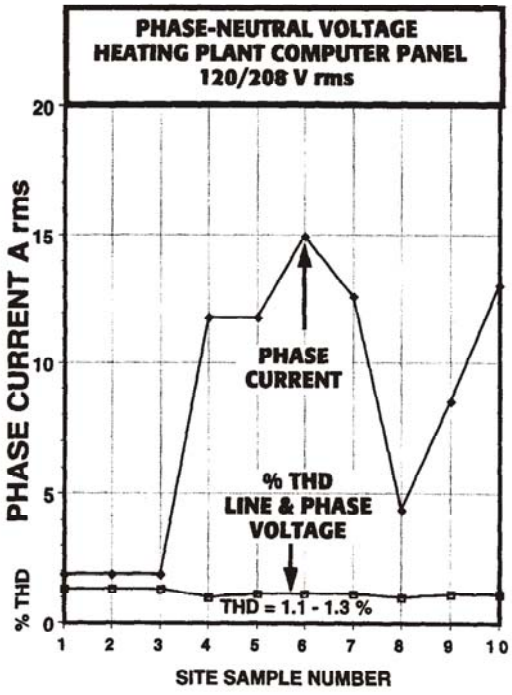

Fig. 9. **Phase-neutral and line voltage** percent THD—heating plant computer panel.

The percent THD of the phase-neutral and line-to-line voltage is shown in Fig. 9.
Note that the THD for the phase-neutral and the line-to-line voltages is approximately constant over the entire loading cycle. The dominant harmonic components of the phase-neutral and line voltages were the third and seventh harmonics.

3.3 Neutral-Ground Voltages (Range: 0,58 – 0,60 V)

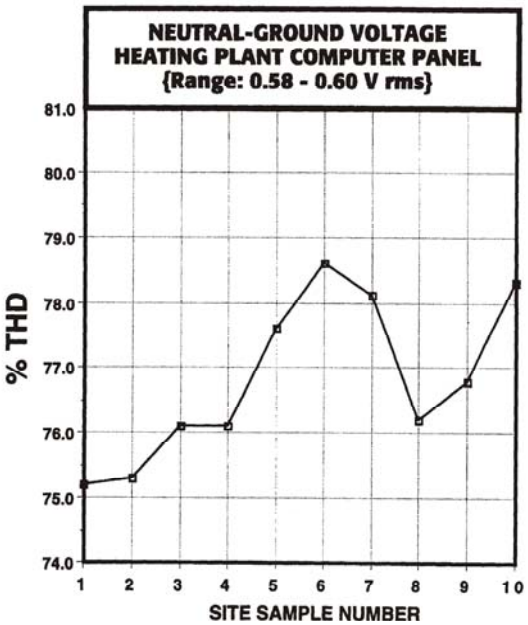

Fig. 10. **Neutral-ground voltage** percent THD—heating plant computer panel.

The THD of the neutral-ground voltages is shown in Fig. 10.
Note that for this particular computer panel, the THD of the neutral-that voltage remained fairly constant (i.e. 75% - 78,5%), almost independent of the magnitude of the phase current. The dominant harmonic component of the neutral-ground voltage was the third harmonic.

4. CONCLUSION

The power quality characteristics of the various computer loads will be summarized in two tables. The average THD of the phase-current, phase-neutral, line-to-line and neutral-ground voltages are shown in Table I.

Table I. Average total harmonic distortion oh the monitored electrical variables

Computer system	%THD phase current	% THD phase-neutral voltage	% THD line –line voltage	% THD neutral-ground voltage
Individual Computer Workstation	100.0	3.7	1.4	400.0
Multiple Computer Workstations (at Panel)	700.0	3.7	1.4	225.0
Dedicated Computer Circuit Heating	40 (light load) 20 (heavy load)	1.1	1.1	77.0

The THD of the individual computer workstations phase currents averaged 110%, however the phase current measured at the electrical panel serving five computer workstations was 700%, an anomaly which requires further research and field testing.
The dominant harmonic components and their percentage contribution oh the phase-current, phase-neutral, line-to-line and neutral-ground voltages are shown in Table II.

Table II. Contribution oh the monitored electrical variables

Computer system	Dominant harmonic and percent contribution () PHASE CURRENT	Dominant harmonic and percent contribution () PHASE-NEUTRAL VOLTAGE	Dominant harmonic and percent contribution () LINE-LINE VOLTAGE	Dominant harmonic and percent contribution () NEUTRAL-GROUND VOLTAGE
Individual Computer Workstation	3^{rd} (84 %) 5^{th} (55 %) 7^{th} (28 %)	3^{rd} (2.9 %) 5^{th} (1.9 %) 9^{th} (0.9 %)	5^{rd} (1.3 %) 3^{th} (0.4 %) 13^{th}(0.3 %)	3^{rd} (395 %) 9^{th} (132 %) 5^{th} (60 %)
Multiple Computer Workstations (at Panel)	3^{rd} (577 %) 5^{th} (111 %) 9^{th} (85 %)	3^{rd} (3.0 %) 5^{th} (1.9 %) 9^{th}(0.9 %)	5^{rd} (1.3 %) 3^{th} (0.4 %) 13^{th} (0.3 %)	3^{rd} (222 %) 9^{th} (71 %) 7^{th}(32 %)
Dedicated Computer Circuit Heating Plant	3^{rd} (36 %) 5^{th} (8.8 %) 11^{th} (4.7 %)	3^{rd} (0.9 %) 7^{th} (0.7 %) 13^{th} (0.3 %)	7^{rd} (0.7 %) 3^{th} (0.5 %) 5^{th} (0.3 %)	3^{rd} (67 %) 7^{th} (20 %) 11^{th} (15 %)

The third harmonic component was the dominant harmonic in the phase-neutral voltages, and the fifth harmonic component dominated the line-to-line voltages. The third and the ninth harmonic components dominated the neutral-ground voltage.
The computer systems presented in this paper experienced few operational problems and, when these events occurred, there was no correlation with any of the monitored power quality characteristics.

REFERENCES

1. T.S. Key, *Diagnosis power-quality computer problems*, IEEE Trans. Ind. Applicat. vol 11 pp 381-393, July/Aug. 1975
2. F. Martzloff and T. Gruz, *Power quality site surveys: Facts, fiction and fallacies*, IEEE Trans. Ind. Applicat. vol. 24 pp 1005-1018, Nov/Dec. 1988