

Heating Effects from Harmonics on 208V Busway Distribution

SASCO was recently involved as the Design/Build electrical contractor for a very large manufacturing facility. This fast paced project consisted of renovating an existing six-story, 750,000 square foot, manufacturing facility to provide for four towers of office structures. The owner's intention was to try to build greater teamwork between assemblers and white-collar workers.

The original basis of design called for the 480Y/277V, 3-phase, 4-wire power to be transformed down to 208Y/120V 3-phase, 4-wire at a central location with harmonics mitigating transformers and then power was to be distributed through long horizontal runs of busway. The "plug" style busway was utilized for easy "plug and play" for all future remodels. During the value engineering process, various methods of providing for the 120V power requirements were evaluated from the standpoint of good design and cost.



1,200A "Plug & Play" busway & Cable Tray Infrastructure



1,200 A Busway distributed up and around drop clouds & Infrastructure

Engineering issues involved in this type of dense 120V power distribution with moderate levels of harmonics included both voltage drop and I²R heating effects. Moderate levels of harmonics cause heating on the neutrals from the 208Y/120V 3-phase, 4-wire distribution panels to the secondary side of the 208Y/120V 3-phase, 4-wire transformers. The relatively low impedance from the busway allowed for long distances to be achieved at 120V without exceeding voltage tolerances.

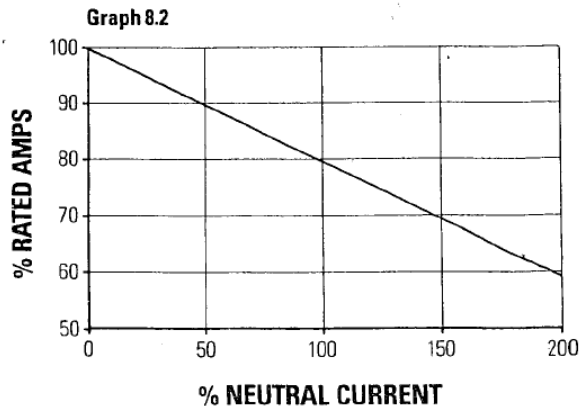
The harmonics issue represented a more complex problem. In a typical distribution, the power is distributed at 480Y/277V, 3-phase to locally mounted 208Y/120V 3-phase, 4-wire transformers. The distribution from the step down transformers to the distribution panels that serve harmonics producing switch mode power supplies found in the typical high tech office would include either

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oversized neutral or double neutrals to accommodate the heating effect of the 3rd harmonic. Theoretically, the neutral can carry up to 173% of the current found in one of the phase conductors. In a typical distribution the 3rd harmonics found in the neutral are stopped at the step down transformer as they end up circulating in the delta windings of the primary of the transformer. Therefore the 3rd harmonic heating component is typically not a problem on the 480Y/277V side of the distribution. K-rated transformers are required to handle the extra heating caused by the 3rd harmonic currents found in an environment with moderate to high levels of harmonic producing loads.

With conventional pipe and wire distribution, the insulated conductors can only occupy up to 40% of the area of the conduit (per the NEC). When these fill ratios are met, the heat from the neutral conductors does not affect the current carrying capacity of the phase conductors. The only de-rating that must occur is based on the fact that neutral conductors are considered to be current carrying when a major part of the load consists of non-linear loads. Additional de-rating may be required in cases where the addition of the neutral as a current carrying conductor pushes the assembly to the next level of required de-rating (NEC – Table 310.15(B)(2)(a)). This potential de-rating is often offset by the fact that the 90-degree rating of the conductor can be used when de-rating based on the number of current carrying conductors. The NEC, Section 110.14 (C) states: "Conductors with temperature ratings higher than specified for terminations shall be permitted to be used for ampacity adjustments, corrections or both".

Busway is sized by heat rise, not cross sectional area. With busway, the harmonics found in the neutral current heat up the entire assembly and the phase conductors also have to be de-rated. As you can see from the chart below, at 173% for the neutral current (theoretical maximum under worst case condition with rectifier conduction angles of 60 degrees) the entire busway assembly would have to be de-rated to 65%. On the Boeing project, each ½ tower required 300-kVA for the 208Y/120V 3-phase, 4-wire distribution. A 1,200 ampere busway was designed to be used on the secondary side of each 300-kVA transformer. To supply power to the harmonics producing loads, the busway would have to be sized at 2,000 ampere. This was a big deal, in a typical pipe and wire distribution only the neutral would have to be oversized, in a busway distribution, the entire assembly would have to be oversized.



* Chart from GE Spectra Series Documentation

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After running several price comparisons, it became apparent that harmonics mitigating 300-kVA transformers with 1,200 ampere busway was more cost effective than providing K-13, 300-kVA transformers with 2,000 ampere busway.

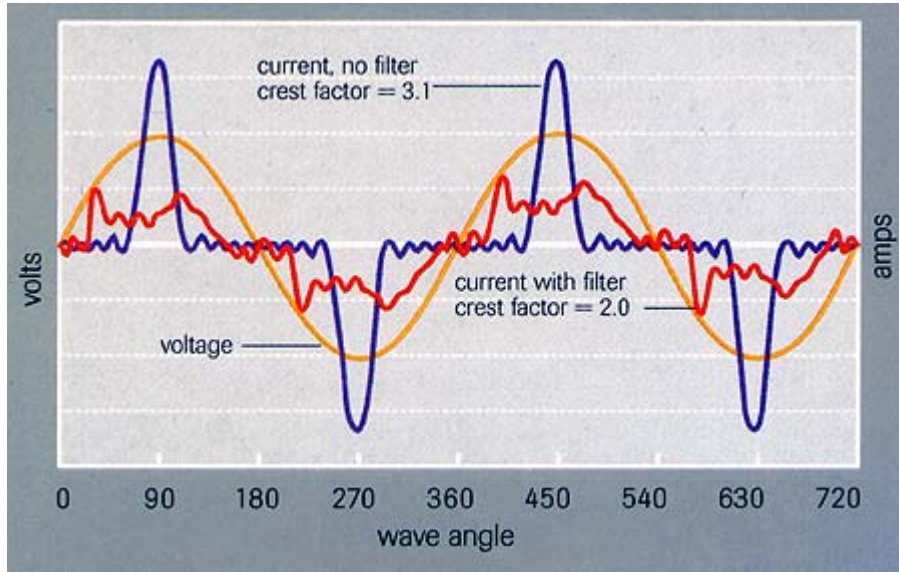


300 kVA harmonics mitigating transformer (left) routed with pipe and wire to a 1,200 A disconnect and transition to busway (right)

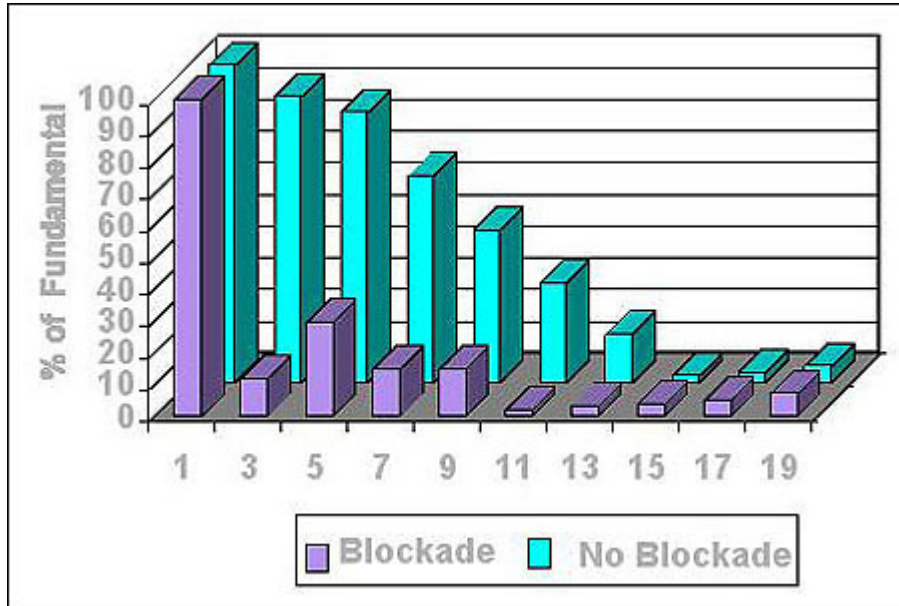


Side view of the transition to 1,200 A busway

Life Cycle Cost savings was another consideration for the use of the harmonics mitigating transformers. We utilized Harmonics Limited transformers with “Blockade” technology to suppress the harmonic current at the source. These types of transformers also provided for Life Cycle Efficiencies. In addition to reducing the total harmonic distortion and the neutral current, this technology; increased the number of computer loads that can be carried per circuit, reduced I²R heat losses in the transformer and in building wiring, decreased air conditioning expense needed to remove I²R heat from the circulating 3rd harmonic in the delta windings. Real power-cost savings due to reduced I²R heating were achieved and will apply for the life of the building.



* This diagram is from Harmonics Limited and represents the harmonic distortion with and without a filter.



* This chart is from Harmonics Limited and represents individual phase currents with and without a harmonic suppression system.



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In addition to the flexibility gained from the “plug and play” busway, the electrical distribution from the electrical panels tapped off of the busway to the individual work areas was achieved through a Tate access floor system. CII whips and power distribution modules were used in conjunction with the Tait access floor system. The CII modular system was mated with premanufactured furniture systems to allow for ultimate flexibility for future moves adds or changes.

This manufacturing facility project represented a unique electrical distribution system. The goals included providing the most effective and flexible distribution system over long horizontal runs in an environment with moderate levels of harmonics. Through an understanding of the effects of harmonics and the applications of appropriate technologies as well as providing in depth cost analysis, SASCO was able to provide the client the most efficient product.

End of Article

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