Data Bulletin

Replaces 5600DB0802, 08/2008

Harmonic Applications in Busway

Accomplishing a 200% Neutral for All Harmonic Applications
Class 5600

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Introduction

There are two schools of thought on proper application of busway when loads with high harmonic content are anticipated.

- The first offers a simplistic approach which doubles the cross sectional area of the neutral conductor. This approach is based on the rationale that the theoretical maximum impact of harmonics is to increase the current flow in the neutral to 173% of the load in a phase conductor. Therefore, to address this concern, all you need to do is double the capacity of the neutral.
- A second, more conservative approach takes into account the additional heat generation as well. Increased cross section of the neutral is required to handle the increased neutral current, but must also compensate for the added heat generated within the busway by current flowing in the neutral.

To answer the question of which approach should be used, this paper will compare the performance of busway using each method.

Comparing Applications

The key to this comparison is understanding that carrying the additional 173% of phase current in the neutral actually represents a considerable increase in the total load on the busway. To appreciate this, look at how busway is tested for temperature rise.

UL857, Underwriters Laboratories standard for busway products, establishes the maximum temperature rise allowed for busway in heat rise tests. The qualifying test for UL857 is conducted on a worst case application using a three-wire sample under balanced load conditions. The rationale for using this testing method is that in a four-wire system the current flow in the neutral is assumed to be zero. If the loads in the four-wire busway system were balanced, an additional conductor in the neutral would actually be a mass that contributes to dissipating heat. Therefore, between equally rated three and four pole busway systems, the four pole system would exhibit a lower temperature rise.

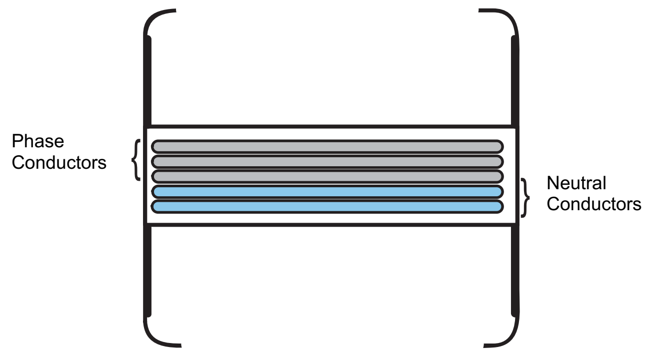
The rated load of a three-wire busway is based on loading each phase to 100% of the rating. Therefore, adding the equivalent of 173% of phase current to the neutral results in a 58% increase in the total load on the busway.

Since standard tests do not directly address the issues caused by any current flow in the neutral, the question becomes how to safely apply busway when harmonic currents contribute a substantial neutral current.

Doubling the Cross Sectional Area of the Neutral Conductor

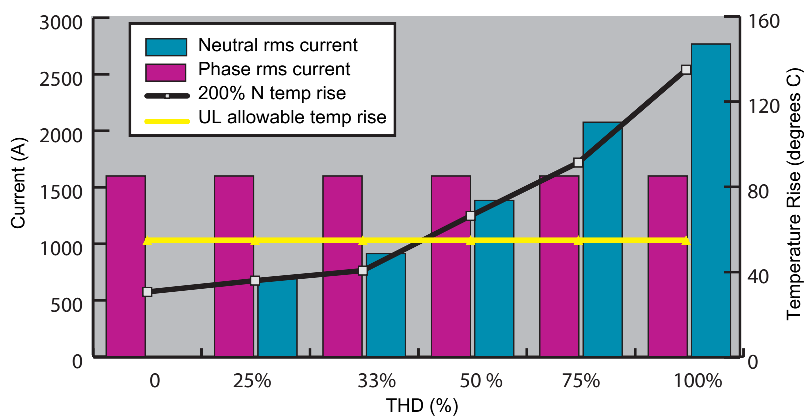
First, consider the results of simply doubling the neutral. The diagram in Figure 1 shows that this results in the total bus bar cross sectional area being increased 25% by adding one additional bus bar to the stack.

Figure 1: Bus Bar Cross Section



To study the heating effect of busway applied with harmonic contribution, a 1600 A busway sample with the added (doubled) neutral bar was heat rise tested. The results are shown in the graph in Figure 2. The yellow line is the allowable temperature rise permitted in the UL standard.

Figure 2: Heat Rise Test Results

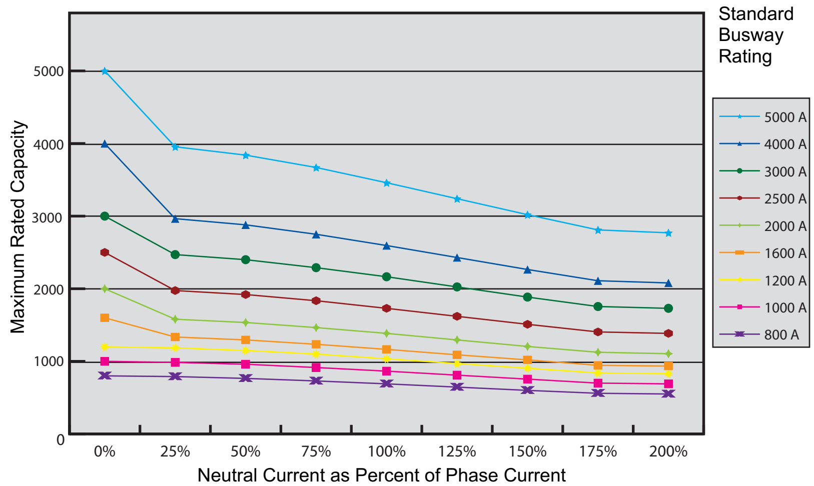


As expected, in the four wire system the additional conductor in the neutral is actually a mass that contributes to dissipating heat. The issue that must be addressed is with harmonic distortion. The current in the neutral increases and the busway will reach the temperature rise limit allowed under the UL standard when the current from the contribution of the harmonics reaches only 40% of the rating of the phase conductor.

Sizing the Neutral Conductor to Accommodate the Heat Generated by Increased Neutral Current

Now, consider the second method of rating busway for harmonic applications. What needs to be done to maintain the operating temperature of the busway at intended levels? The added heat generated by current flowing in the neutral must be managed. The total heat generated within the system cannot exceed the total heat generated in a standard 3 phase, 3 wire system. To do this, the total bus bar cross sectional area must be increased. Additionally, the neutral must be sized to carry the full current of the expected harmonic load based on the required cross sectional area of the phase conductors. Applying these two criteria results in application of busway based on the table in Figure 3.

Figure 3: Maximum Applicable Rating with Unbalanced Neutral Current



To compare the two approaches to accommodating increased neutral current, look at the results of applying each approach with the assumption that harmonics contribute current equal to 100% of phase current in the neutral choosing a 1600 A application.

The temperature rise of the busway with the 200% neutral would be more than double the maximum allowed by UL standards while the derated busway would still meet the standard temperature limit. The effect of the higher temperature rise would likely result in premature failure of the 200% neutral bus system.

For comparison, the total cross sectional area of the bus bars with the derated solution would be 10.0 square inches while the cross section of the 200% neutral solution would be from 5.3 to 5.6 square inches depending upon which manufacturer’s product is used.

Recommendation

In conclusion, to properly allow for the impact of harmonics, busway should be rated based on the following two factors.

- a neutral cross section based on the anticipated current caused by the harmonic distortion
- the capability of the busway design to dissipate the heat generated from current flowing in the neutral

Specifications should address the requirement that the busway be applied based on these factors. When building loads are not known, it may be difficult to estimate the anticipated current caused by the harmonic distortion. In these instances, a worst case factor of 173% should be applied. As each manufacturer’s busway design will dissipate heat differently, the manufacturer should be required to provide application information addressing both the current capacity of the neutral and the ability of the busway to dissipate the heat generated with the maximum anticipated load.

For further information on Neutral Current in Three Phase Wye Systems reference document no. 0104ED9501R8/96. This paper:

- shows that neutral conductor oversizing is not necessary in 480Y/277V systems, but may be necessary in 208Y/120V systems under unusual conditions.
- discusses current signatures of single phase non-linear loads and examines the relationship of these signatures to neutral current in wye connected three phase electrical systems.
- establishes formulas for estimating total harmonic distortion (THD) levels for both balanced and unbalanced load conditions.

Schneider Electric USA, Inc.
5735 College Corner Pike
Oxford, OH 54056 USA
1-888-778-2733
www.schneider-electric.us