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TECHNICAL BULLETIN

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Harmonic Currents in Neutral of Cables and Busbar Trunking Systems (Busways)

BEAMA*Installation's* Engineered Systems Product Group (ESPG) highlights the issues associated with harmonic currents in neutral of cables and busbar trunking systems. The implications are addressed In the context of Component Standards, Wiring Regulations and Electricity Association Engineering Recommendations.

The high harmonic currents produced by electronic loads result in a neutral current through cables and busbars. To control the temperature of the cables and busbars, double-size neutral conductors and current de-rating may be required. But, the high-harmonic load-current will pollute the supply so extra equipment may be required at the load.

Component Standards assume that the phase currents in 3-phase cables and busbar trunking are balanced, so the neutral conductor carries no current. Hence the use of a conductor for neutral, which is only 50% of the phase conductor size.

In addition BS 7671 (IEE Wiring Regulations) states in 524-02-02: "In a polyphase circuit the neutral conductor shall have a current-carrying capacity for the maximum current likely to flow in it under normal operating conditions. When assessing the maximum likely neutral current, account shall be taken of:

(i) inequality of phase loading

(ii) inequality of power factor in each phase

(iii) harmonic currents in the neutral conductor."

While BS 7671 (IEE Wiring Regulations) states in 524-02-03: "In a discharge lighting circuit, and polyphase circuits where the harmonic content of the phase currents is greater than 10% of the fundamental current, the neutral conductor shall have a cross-sectional area not less than that of the phase conductors."

Electronic non-linear loads produce a high harmonic content of the load current. The third harmonic content for a switching-mode power supply (as used in computers) is approximately 70% of the fundamental current. If the loading of the 3 phases is balanced by carefully connecting the 1-phase loads, then in the worse case the phase current can be approximated by:

$$(I_{(L)1}^2 + I_{(L)3}^2)^{1/2}$$
$$= (1.0^2 + 0.7^2)^{1/2}$$
$$= 1.220$$

The neutral current can be approximated by: $(I_{(L1)3} + I_{(L2)3} + I_{(L3)3})$

$$= (0.7 + 0.7 + 0.7)$$
$$= 2.1$$

So $I_{neutral} / I_{phase} = 2.1 / 1.220 = 1.72.$

Therefore, the neutral conductor should be almost twice the cross-sectional area of the phase conductors when the load is completely electronic equipment.

Extra heat

The extra heat produced by a neutral current leads to a current de-rating to maintain the total heat produced at the same level, and so the temperature-rise within the cable or busbar limits.

Neutral current due to harmonics	Rating Factor	
	100% neutral	200% neutral
0%	1.0	1.0
50%	0.96	0.98
100%	0.87	0.93
150%	-	0.85

Responsibility

Electricity Association Engineering Recommendation G5/4 gives system designers the responsibility to ensure the user of the electrical network does not pollute the supply with harmonics in the neutral.

However, the system designer is not the manufacturer of the cables, busbar or other components, and is normally not the owner/occupier of the building. Often it is usually the consulting engineer, or occasionally the electrical installation contractor, who is responsible for the design of the electrical system as-installed in a building.

This may require additional equipment in the form of harmonic filters at the load. With the reduction in neutral current, this may allow the use of standard 100% rated cables and busbar while complying with BS 7671.

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