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Engineer Technical
Letter 1110-3-403

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Engineering and Design
ELECTRICAL POWER SYSTEMS FOR NONLINEAR LOADS

1. Purpose. This letter provides interim guidance and design criteria to design and calculate 3-phase, 4-wire electrical distribution systems below 600 volts for buildings or parts of buildings where significant numbers of electrical equipment items will be furnished with nonlinear, solid state component loads. Most administrative and office buildings fall into this category.

2. Applicability. This letter applies to all HQUSACE/OCE elements and field operating activities (FOA) having Army military design and construction responsibility.

3. Discussion. Rapid development in the application of solid state switching mode power supply components in equipment such as computers, printers, uninterruptible power supply (UPS), motors with variable speed drives, ballasts, dimmers etc., has led to unexpected serious electrical distribution problem. These loads are creating a different voltage and current phase relation in the alternating current (AC) distribution systems. The above equipment items represent nonlinear electrical loads, which distort the shape of the sine wave and generate high harmonics, eddy currents, increase hysteresis losses and skin effects. Consequently, wiring systems, transformers, motors and generators are overheating and deteriorating equipment performance. Such equipment is typically supplied from a single phase circuit stemming from a 3-phase, 4-wire distribution network. One of the most frequent results of nonlinear loads is overloading of the neutral conductor.

4. Action to be Taken. The following actions should be taken on projects on a selective basis. These are not necessarily applicable across the board. Projected electrical loads on new projects will be analyzed to determine whether or not they are considered potential nonlinear loads. The following are recommended design practices for circuits supplying nonlinear loads:

a. Use one 3-phase transformer with common core, delta connected primary and wye secondary, in lieu of using 3 single-phase transformers connected for 3-phase service. Transformers are available for high harmonic-content power distribution systems without derating.

b. Derate transformer, motor and generator outputs, to prevent overheating or burnout. Where standby generators represent the only power source when the normal power fails, sizing the generators should take into consideration the type of loads on the system. If a large amount of loads are the above listed ones, use a multiplying factor of 1.3 - 1.5 to upgrade the generator size in order to compensate for the predicted heat losses. A special voltage regulator should be specified to achieve proper voltage regulation in high harmonic content and distorted sine wave load conditions.

c. The neutral conductor(s) between the transformer and the panelboard shall be a minimum of 1.73 times the ampacity of a phase conductor.

d. The neutral bar in the panelboard shall be a minimum of 1.73 times the ampacity of a phase conductor.

e. Provide isolation transformers close to high harmonic-producing equipment.

f. Provide line filters to minimize the effects of the harmonics, in the close vicinity of the loads.

g. A separate neutral conductor for each phase to serve 120 volt outlet receptacles is preferred. This includes prewired workstations or system furniture. Where a shared neutral conductor for a 208Y/120 volt system must be used for multiple phases, the neutral conductor shall be a minimum of 1.73 times the ampacity of a phase conductor.

h. Provide true root means square (RMS) sensing meters, relays and circuit breaker trip elements.

5. Implementation. This letter will have special implementation as defined in paragraph 6c, ER 1110-345-100.

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