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**1. What are non-linear loads and why are they a concern today?**

A load is considered non-linear if its impedance changes with the applied voltage. The changing impedance means that the current drawn by the non-linear load will not be sinusoidal even when it is connected to a sinusoidal voltage. These non-sinusoidal currents contain harmonic currents that interact with the impedance of the power distribution system to create voltage distortion that can affect both the distribution system equipment and the loads connected to it.

In the past, non-linear loads were primarily found in heavy industrial applications such as arc furnaces, large variable speed drives, heavy rectifiers for electrolytic refining, etc. The harmonics they generated were typically localized and often addressed by knowledgeable experts.

Times have changed. Harmonic problems are now common in not only industrial applications but in commercial buildings as well. This is due primarily to new power conversion technologies, such as the Switch-mode Power Supply (SMPS), which can be found in virtually every power electronic device (computers, servers, monitors, printers, photocopiers, telecom systems, broadcasting equipment, banking machines, etc.). Another major influence is the more widespread use of variable frequency drives in commercial HVAC applications (chillers and fans) and industrial pumping (oil and gas, water/waste water, etc.). Their proliferation has made non-linear loads a substantial portion of the total load in most commercial buildings as well as industrial facilities.

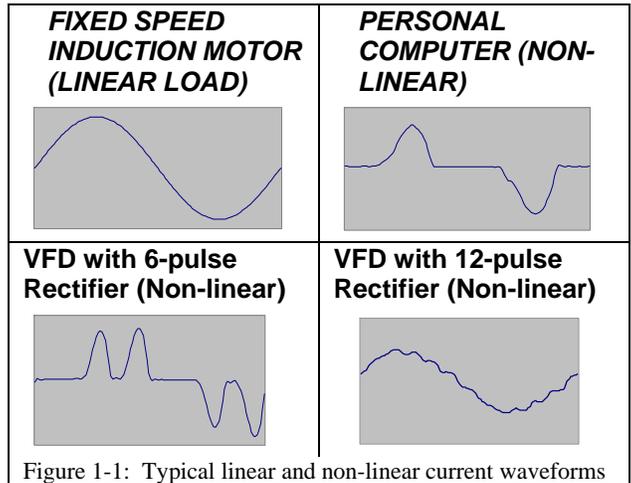


Figure 1-1: Typical linear and non-linear current waveforms

Examples of the current drawn by various types of equipment are shown in Figure 1-1. The most common form of distorted current is a pulse waveform with a high crest factor. The VFD is one such load since it consists of a 6-pulse rectifier bridge (to convert AC to DC) and a large filter capacitor on its DC bus. The VFD draws current in short, high-amplitude pulses that occur right at the positive and negative peaks of the 3-phase supply voltage. Typically these high current pulses will cause clipping or flat-topping of the voltage waveform. Further discussions on voltage flat-topping and its effect on connected equipment can be found in answers to Questions 6 and 7.