<Back to Questions>

4.   What is an SMPS and how does it generate harmonics?

The Switch-mode Power Supply (SMPS) is found in most power electronics today. Its reduced size and weight, better energy efficiency and lower cost make it far superior to the power supply technology it replaced.

Electronic devices need power supplies to convert the 120VAC receptacle voltage to the low voltage DC levels that they require. Older generation power supplies used large and heavy 60 Hz step-down transformers to convert the AC input voltage to lower values before rectification. The SMPS avoids the heavy 60 Hz step-down transformer by directly rectifying the 120VAC using an input diode bridge (Figure 4-1). The rectified voltage is then converted to lower voltages by much smaller and lighter switch-mode dc-to-dc converters using tiny transformers that operate at very high frequency. Consequently the SMPS is very small and light.
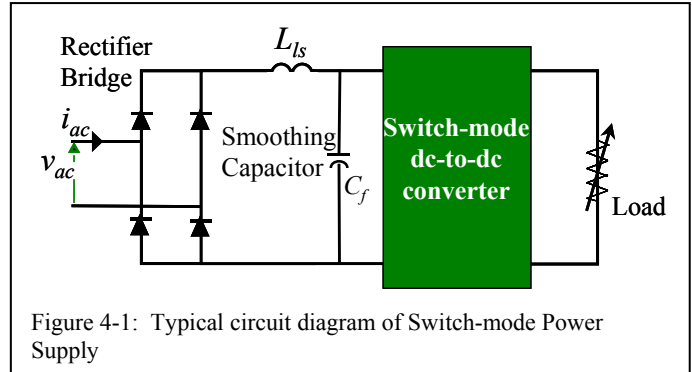

Figure 4-1: Typical circuit diagram of Switch-mode Power Supply

The SMPS is not without its downside, however. The operation of the diode bridge and accompanying smoothing capacitor is very non-linear in nature. That is, it draws current in non-sinusoidal pulses at the peak of the voltage waveform (see Figure 4-2). This non-sinusoidal current waveform is very rich in harmonic currents.
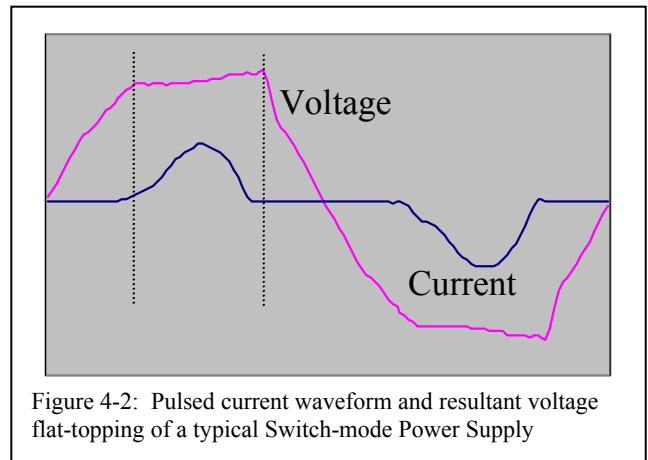
Because the SMPS has become the standard computer power supply, they are found in large quantities in commercial buildings. Acting together, the multitude of SMPS units can badly distort what started out as a sine wave voltage waveform.

Twice per cycle every SMPS draws a pulse of current to recharge its capacitor to the peak value of the supply voltage. Between voltage peaks the capacitor discharges to support the load and the SMPS does not draw current from the utility. The supply voltage peak is flattened by the instantaneous voltage drops throughout the distribution system caused by the simultaneous current pulses drawn by the multiple SMPS units. The expected sine wave with a peak of $120 \times \sqrt{2} = 169.4V$ instead starts to resemble a square wave. The flattened voltage waveform contains a lowered fundamental voltage component plus 3rd, 5th, 7th, 9th and higher voltage harmonics.

Figure 4-2: Pulsed current waveform and resultant voltage flat-topping of a typical Switch-mode Power Supply

For an alternate view of the relationship between current harmonics, voltage harmonics, Ohm's Law, and non-linear loads, please see Question 8.