

# Plain as the Nose on Your Face

Richard P. Bingham

Harmonics has been a popular word lately in the power quality community. Now, interharmonics, frequencies between the harmonic frequencies, are even beginning to receive attention. But the presence of current harmonics in electrical systems within facilities isn't a new phenomena. When searching for the source of harmonic pollution, one of the most obvious sources of such should not be overlooked: fluorescent lighting fixtures.

In many office and commercial facilities, fluorescent lighting, HVAC systems with adjustable speed drives, and information/communication equipment (computers, printers, faxes, copying machines) all contribute significant harmonic currents to the facility wiring. Harmonic currents follow the same rules as the fundamental frequency current. The sum of all currents in and out of at a junction point must equal zero (Kirchoff's Law) and harmonic currents multiplied by harmonic impedances produce harmonic voltages (Ohm's Law).

Fluorescent lights can comprise a significant portion of the electric load. Depending on the type of ballast and light source, the contribution from this common electrical appliance can be quite significant. In fact, some of the products touted as "energy efficient" may have current harmonic distortions (I thd) in excess of 100% of the fundamental current. Table 1 shows a typical harmonic spectrum from a fluorescent light. The third harmonic is the most dominate. Figure 1 and 2 show examples of harmonic currents from different types of fluorescent fixtures.

Harmonic # (Current)	Percent of Fundamental
2	4%
3	20%
4	1%
5	10%
6	1%
7	5%
9	6%

Table 1. Sample of Harmonic Values for Fluorescent lighting.

Heydt, GT, Electric Power Quality. Stars in the Circle Publication, Indianapolis, 1991 pg 240

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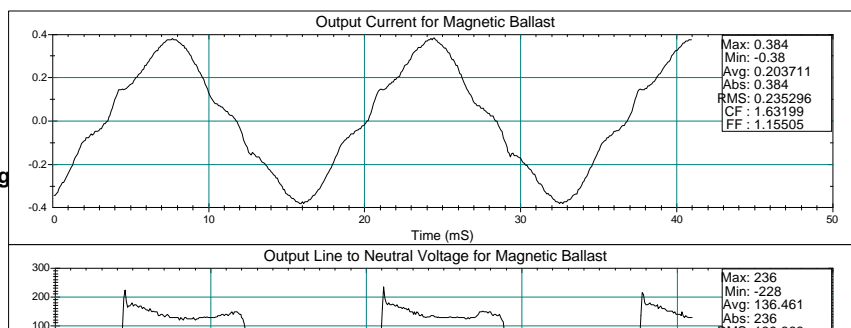


Figure 1. Current and Voltage at Magnetic Ballast Fixture

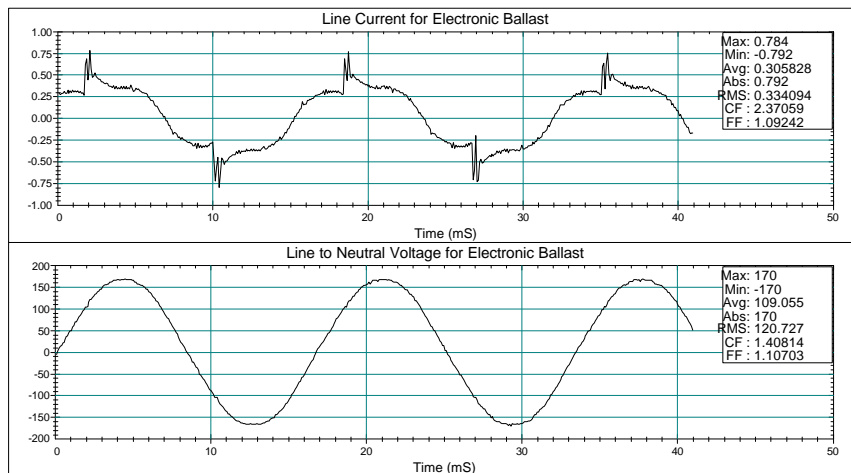


Figure 2. Current and Voltage at Electronic Ballast Fixture

Whereas there may be significant cancellation back at the service entrance of the higher harmonics (19th and up), due to phase shifts, the lower order ones and particular the triplen (3,6,9,12,15) can pose a significant problem. Triplen harmonics add in the neutral of 3-phase wye circuits instead of canceling out, since the 120 degree phase shift multiplied by 3 (or 6 or 9 or...) results in 360 degrees, or a complete circle.

In an office environment in the Pacific northwest, the computers operated fine, until one day, waving lines appeared on the screens and occasional lock-ups occurred. No new computers or LAN-based equipment had been added. No new loads were known to have been added. In fact, the power should have been reduced, as the lighting was recently changed to "energy-efficient lighting" as part of a DSM (demand side management) offer from the local electric utility. No one suspected that the "new" lighting was the source of their "new" problems. "How could it, it uses less power and only produces light." Stories abound about the infrared radiation emitted by some compact fluorescents during start-up, and their effect on remote control operated devices that use infrared transmitters and receivers.

There are three types of ballasts on the market: magnetic, electronic, and hybrid. The electronic ballasts are like small switching power supplies. They operate 1.25 to 1.5 times more efficiently than magnetic ballasts by switching power at 20KHz instead of the 60 Hz. The harmonic-rich current waveform of these devices will look similar to that found in most single-phase electronic equipment power supplies. Table 2 shows the current and voltage THD, along with individual harmonic values and the power factor (PF) for four different lighting fixtures tested with a Dranetz Power Platform.

Type of Fixture	I thd	%I -3rd	%I -5th	%I -7th	%I -9th	Lowest I harm# where
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Richard P. Bingham is the manager of technology and products for Dranetz-BMI.

						%fundamental is < 1%
Standard Magnetic	10.5	10.3	1.92	0.64	0	5th
Compact Fluorescent	102.	75.4	44.1	30.5	28.9	37th
Low Harmonic	17.3	14.6	8.05	3.17	2.20	11th
High Efficiency	26.9	24.2	10.2	2.73	1.91	9th

Table 2. Harmonic Currents from four types of fluorescent light fixtures

Harmonic producing loads can result in resonance with capacitors. These can be capacitors in the ballast itself (which may result in excessive heating and failure), or with power factor (PF) correction capacitors. "At a 900 KVA fluorescent installation, the full load condition operated well above the resonant point; at about half load, some neutral current values exceeded the corresponding phase current values, and the voltage distortion at some distribution boards exceed 20%. [Arrillaga, J. et al. Power System Harmonics. John Wiley & Sons. New York.1985, pg 109]

In summary, the source of your harmonic problem may be as "plain as the nose on your face", provided the lights are turned on so you can see it.