

POWER QUALITY DEGRADATION DUE TO LOW POWER ELECTRONIC LOADS

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ABSTRACT

The influence of low power electronic loads on power quality is discussed in this paper. Distortion of sinusoidal waveforms of current and voltage can occur due to nonlinear characteristics of low power electronic loads. Individual and cumulative impacts of these loads on generation of current harmonics and voltage distortion are investigated. It is concluded that many electronic loads may have significant influence on current/voltage distortions. Measurement results of recorded voltage and current waveforms in real commercial buildings ((larger company headquarters) of typical low voltage Bosnian and Herzegovina electrical networks are shown. It is concluded that measured results of current harmonics overcome permitted IEEE standards and at the same time, measured results of voltage harmonics remained within permitted standards.

1. INTRODUCTION

Recently, the increasing use of low power electronic loads has caused serious concerns. Typical examples of such loads are desktop and laptop computers, inkjet and laser printers, LCD and plasma TV sets, scanners, modem/router, firewalled, uninterruptible power supplies, fax machines, home entertainment equipment, high efficiency lights, light-dimmers, battery chargers, medical test equipment, etc. The power electronic converters, as nonlinear loads, used in this equipment, generate nonsinusoidal currents, which increase harmonics levels, and this presents serious power quality problems to utilities [1]-[3]. Harmonic currents generated by these low power electronic loads are, individually, too small to cause any appreciable distortion in distribution feeders. However, the number of these loads is increasing and the cumulative current harmonics may become a very significant problem, causing a gradual increase of voltage distortion levels on distribution feeders.

It is very interesting that these low power electronic loads are very sensitive to power quality problems i.e. they require high qualitative power supply voltage and, at the same time, these low power electronic loads, due to their nonlinear characteristics, inject harmonic currents into the electrical network [4].

These nonsinusoidal currents may have negative influence on power supply voltage distortions.

2. ANALYSIS OF CHARACTERISTICS OF INDIVIDUAL LOW POWER LOADS

This chapter will present the laboratory measurement results of individual current waveforms and harmonic characteristics of typical low power electronic loads: personal and laptop computer, scanner, inkjet and laser printer, switch, modem/router, firewalled etc. Figure 1 shows typical personal computer measured current waveform and its total harmonic content.

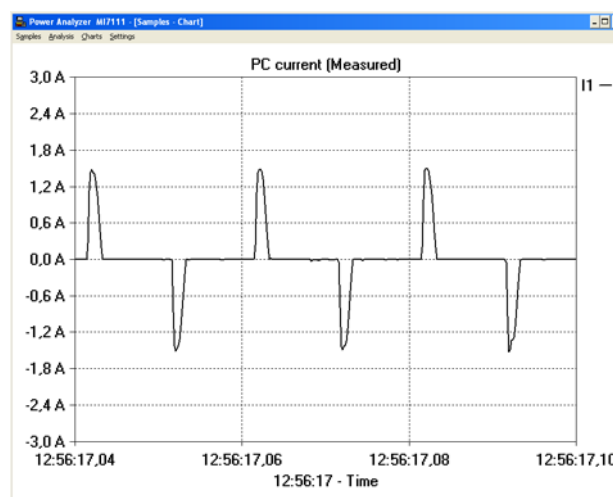


Figure 1. PC current: THDI = 162 %

Figures 2 to 5 show measured currents with corresponding total harmonic distortions (THD) for laptop computer, scanner, inkjet and laser printer.

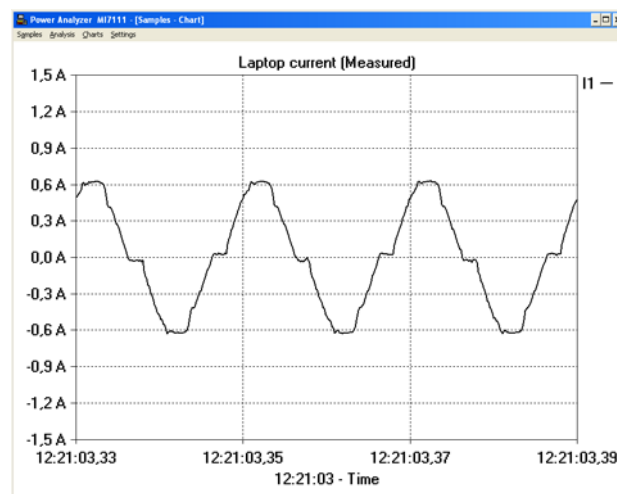


Figure 2. Laptop current: THDI = 16 %

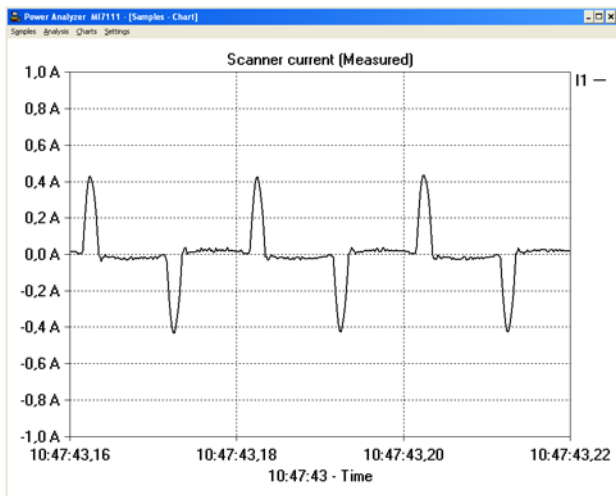


Figure 3. Scanner current: THDI = 151 %



Figure 4. Inkjet printer current: THDI = 141 %

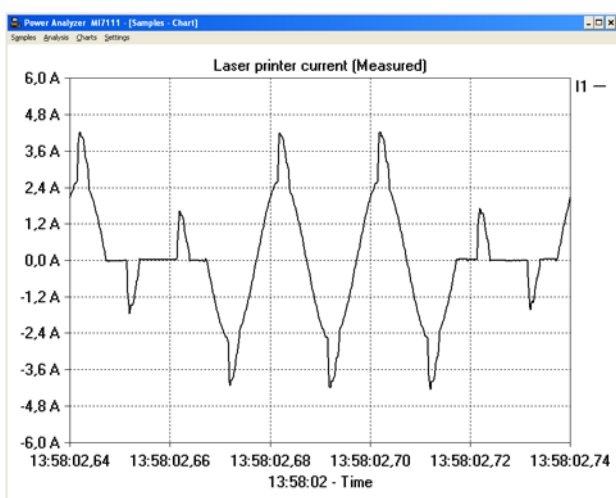


Figure 5. Laser printer current: THDI = 19% – 104%

It is noted that since laser printer current has no stationary waveform, it implies variable THDI per period of FFT calculations.

3. ANALYSIS OF CHARACTERISTICS OF CUMULATIVE LOW POWER LOADS

Figure 6 shows a simplified electrical model for cumulative effects of all the mentioned low power electronic loads.

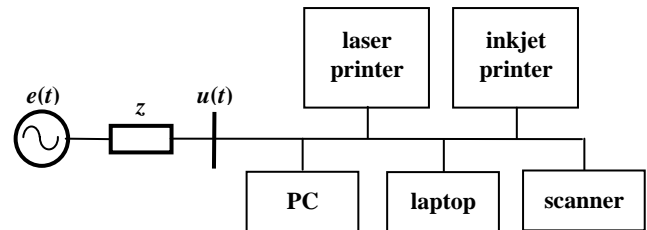


Figure 6. Collective effect of electronic loads – simplified model

Figure 7 shows measured results of total current waveform with corresponding THDI value during the time in the case no impedance i.e. $z = 0$.

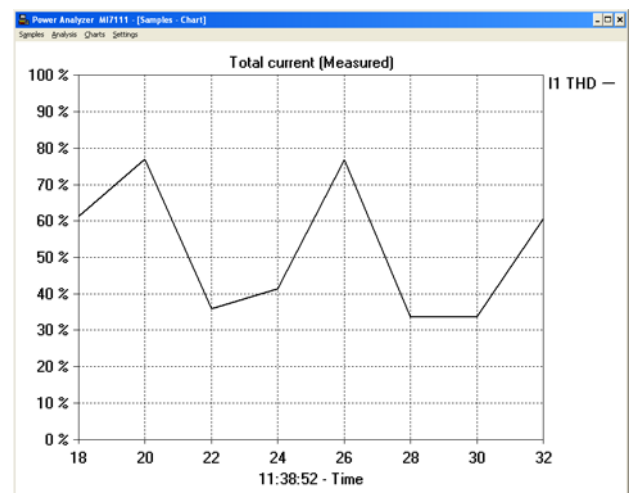
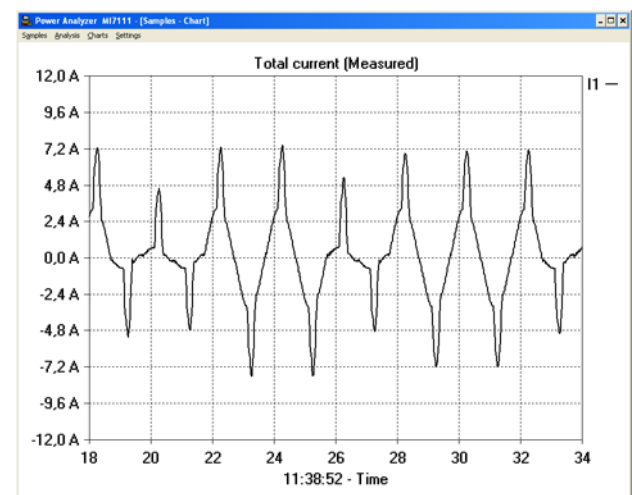


Figure 7. Total current without serial impedance: THDI = 34%–77%

In this case total harmonic distortion of power supply voltage

had the value $\text{THDU} = 2.80\%$. Furthermore, Figures 8 and 9 show results of measured total current and impedance voltage $u(t)$ with THD value, in the case of serial impedance $z = 5 \Omega$.

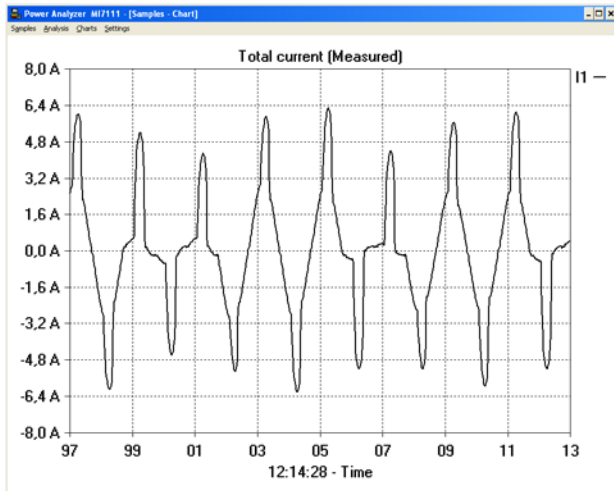


Figure 8. Total current with serial impedance:
 $\text{THDI} = 32\% - 76\%$

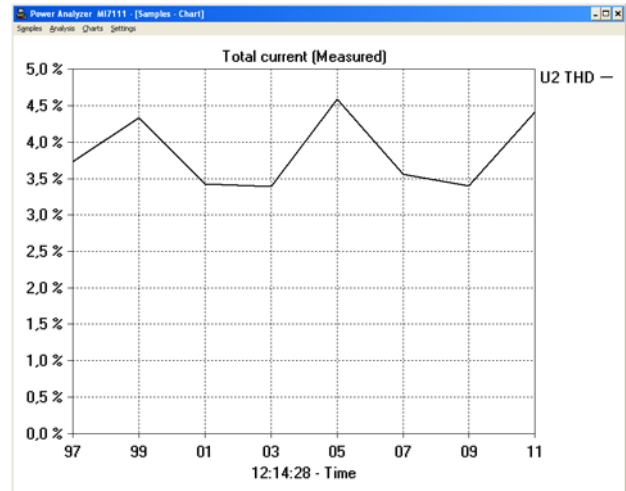
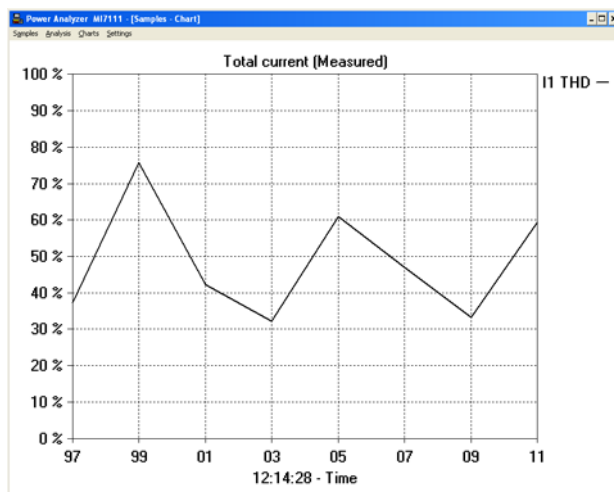


Figure 9. Resistor voltage with serial impedance:
 $\text{THDU} = 3.4\% - 4.6\%$

4. MEASUREMENTS IN REAL NETWORK

Finally, this part of the paper will show measured results in a real low voltage 400 V electrical distribution network. The measurements are obtained in a typical commercial building. This commercial building consists of about 120 low power electronic units which were operating simultaneously during the one week of measurements. Figure 10 shows the measured results of total harmonic distortion of line currents and power supply voltage waveforms. It can be seen that the levels of current harmonics are significant, exceeding IEEE Standard 519 limit levels. At the same time the levels of voltage harmonics are within IEEE Standard 519 limit levels. In view of this fact, it can be concluded that commercial or similar buildings are an important source of harmonics, and it potentially could be the source of current and voltage waveforms distortion, endangering other consumers. A similar situation can be expected in residential areas where dominant nonlinear loads are television apparatus or other modern low power home electronics appliances, where increase of current and voltage harmonics levels can be higher.

These facts lead us to the conclusion that nowadays, great attention should be given to low power electronic loads, as a dominant factor in the decrease of the power quality.

5. CONCLUSIONS

Individual and cumulative effects of modern low power single phase electronic loads such as personal computer, laptop computer, laser and inkjet printer, scanner etc. on power quality problems are described in this paper. It is shown, by laboratory measurements, that low power electronic loads have a high content of current harmonics, in a range from 16% to 151%, individually. However, due to their low power, the voltage distortion is relatively low. Voltage distortions are increasing with the increasing number of electronic loads. Furthermore, as the number of

low power electronic loads is rapidly growing, it can be expected that the THD level of the current and voltage will additionally increase in the future. Finally, in this paper, current and voltage measured results in a real low voltage electrical network, such as 400 V voltage level, are shown. It is concluded that measured results of current harmonics surpass permitted IEEE standards. In the same time, measured results of voltage harmonics keep within permitted standards. Finally, it must be pointed out that in the future, because of the increasing number of these loads, a great deal of attention should be given to low power electronic loads as causes of power quality degradation, and, at the same time, because of the great sensitivity of these loads on power quality problems.

6. REFERENCES

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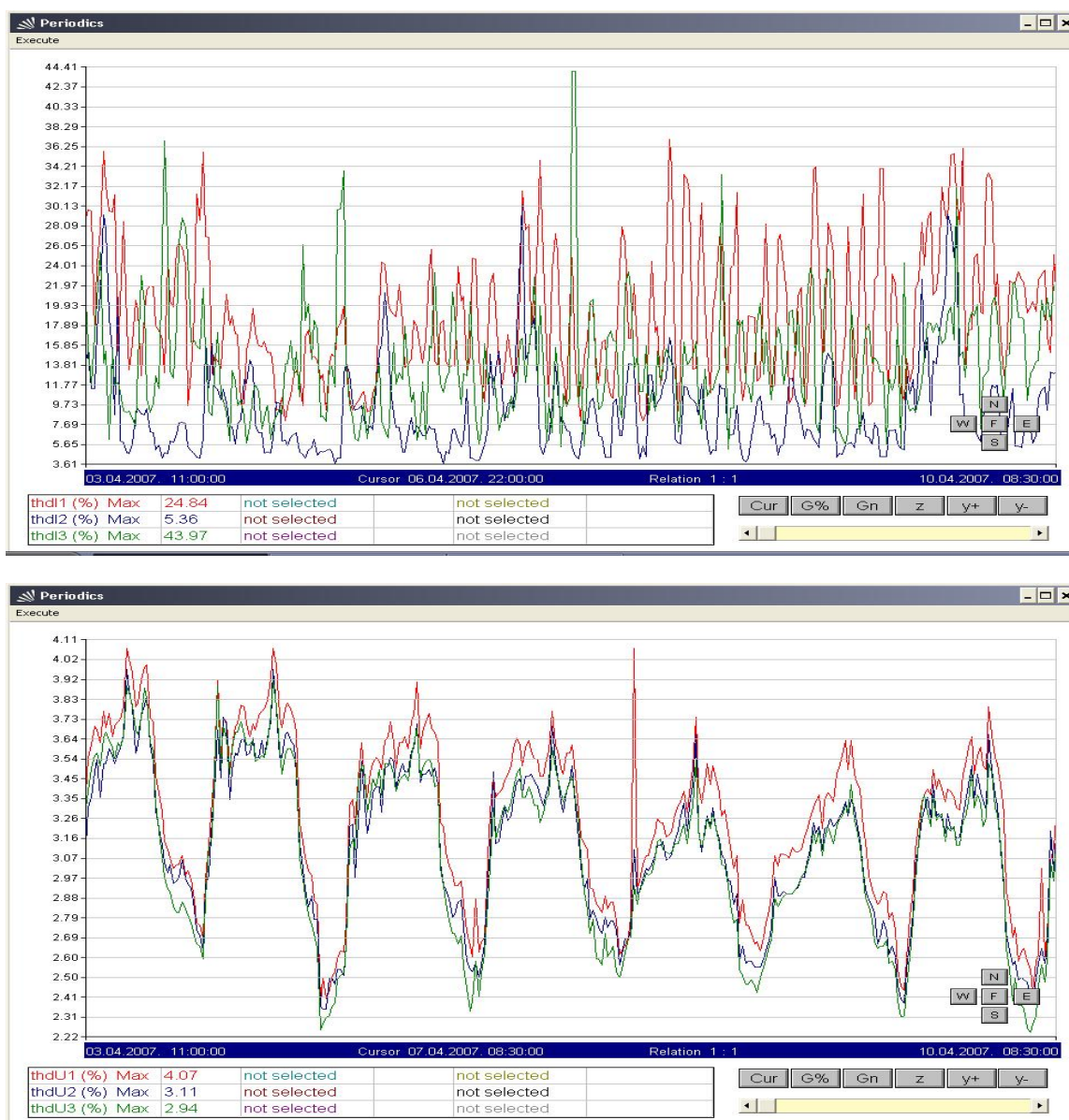


Figure 10. Current and voltage total harmonic distortions during one week