HARMONIC ANALYSIS AT POWER RECTIFIERS

P. Leonte, PhD, A. Pleşca, PhD
Gh. Asachi Technical University of Iassy

INTRODUCTION

The commonest source of harmonics and harmonic problems in power systems is almost certainly the three-phase Graetz bridge. This is widely used in motor drives of all types as well as in HVDC transmission and such equipment as uninterruptible power supplies (UPS). The growing use of power electronic application has increased the fraction of nonsinusoidal currents and voltages in buildings and utility networks. Nonlinear loads have always existed and traditionally included such items as arc furnaces and fluorescent lamps.

As the fraction of nonlinear loads has increased, so has the anxiety over the effect of these loads and whether they should be limited. Several standards organizations have or plan to issue limits for these loads. The limits are based on the effects of these loads and the best judgement of the members of the standards organizations.

1. POWER CONVERTERS LIKE HARMONIC SOURCES

The derivation of the harmonic currents produced by static power converters requires accurate information of the AC voltage waveforms at the converter terminals, converter configuration, type of control, AC system impedance and DC circuit parameters. The main sources of harmonic current are at present the phase angle controlled rectifiers and inverters. These can be conveniently grouped into the following three broad areas of different harmonic behaviour:

- large power converters such as those used in the metal reduction industry and high voltage DC transmission;
- medium size converters such as those used in the manufacturing industry for motor control and also in railway applications;
- low power rectification from single-phase supplies such as television sets and battery chargers.

The waveforms from the first group are the closest to the ideal and will be used as a basis for the derivation of the characteristic harmonic content of the standard converter configurations. This information is often used as a reference in the harmonic assessment of less ideal waveforms.

Some experimental tests were done using a semicontrolled three-phase bridge rectifier from the laboratory of Dipartimento di Ingegeneria Elettrica Industriale, Politecnico di Torino, made by SITRA AUTOMAZIONE, Alessandria, Italy. The parameters which could be varied were the load inductance and capacitance, and the firing angle.

The values of characteristic parameters of bridge rectifier are the following: frequency, f = 50Hz; line voltage supply, V_{sLL} = 380V; secondary inductance, L_s = 0.18mH; secondary resistance, R_s = 60mΩ; DC inductance, L_{DC} = 13mH; DC resistance, R_{DC} = 0.7Ω; load capacitance, C_{load} = 3260uF; load resistance, R_{load} = 14Ω; load inductance, L_{load} = 48mH; resistance of load inductance, R_L = 1.7Ω; firing angle, α - different values.

Below, are shown the curves of secondary current waveform and the simulation results using OrCAD PSpice software. Using the both graphics, experimental data and simulation results, it can see how far or closer by the real data are the simulation results, and in this way it can conclude about model simulation of bridge rectifier in different operating condition.

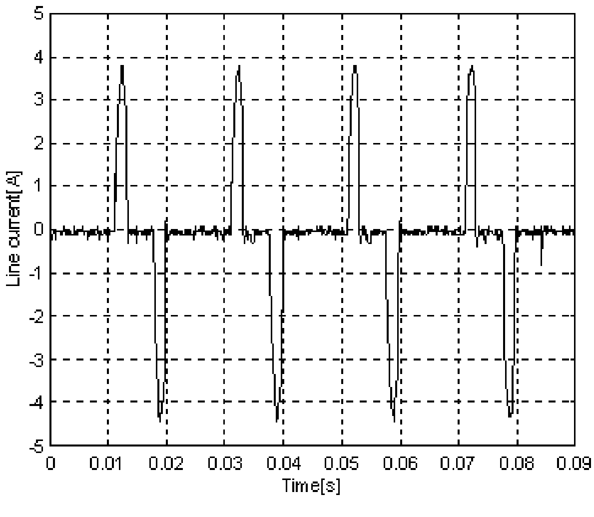

Figure 1. Experimental recorded waveform.

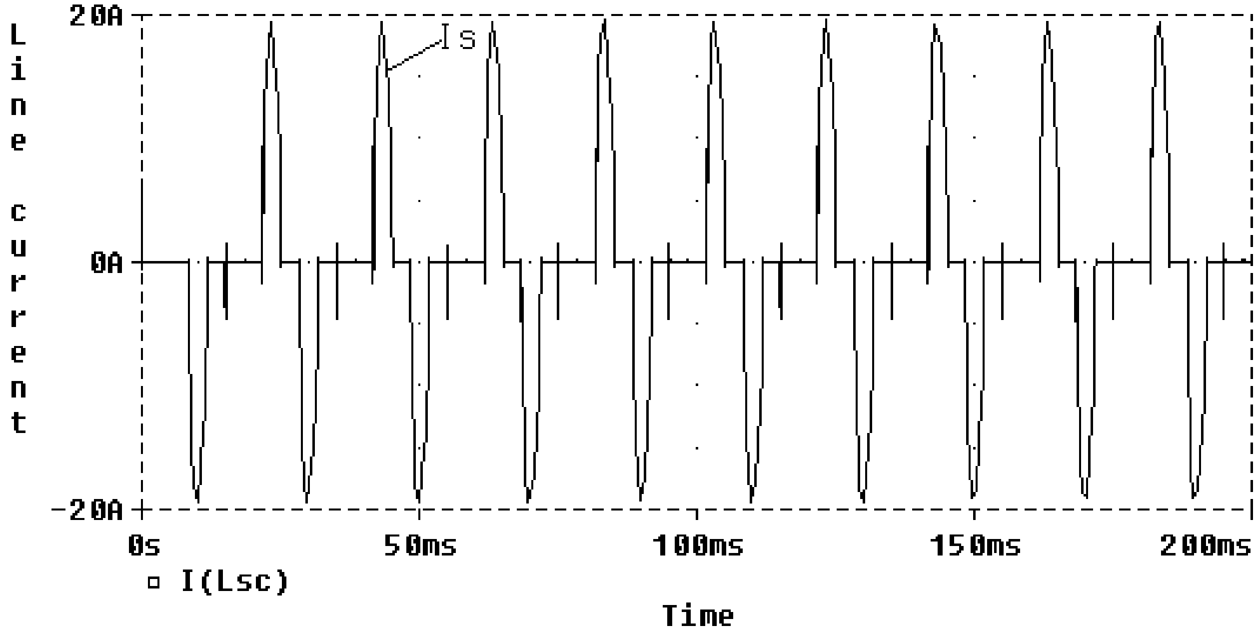

Figure 2. Simulation waveform.

The first case: $L_{load} = 0, C_{load} = 0$; $\alpha = 150.66°$

- $\alpha = 106.38°$

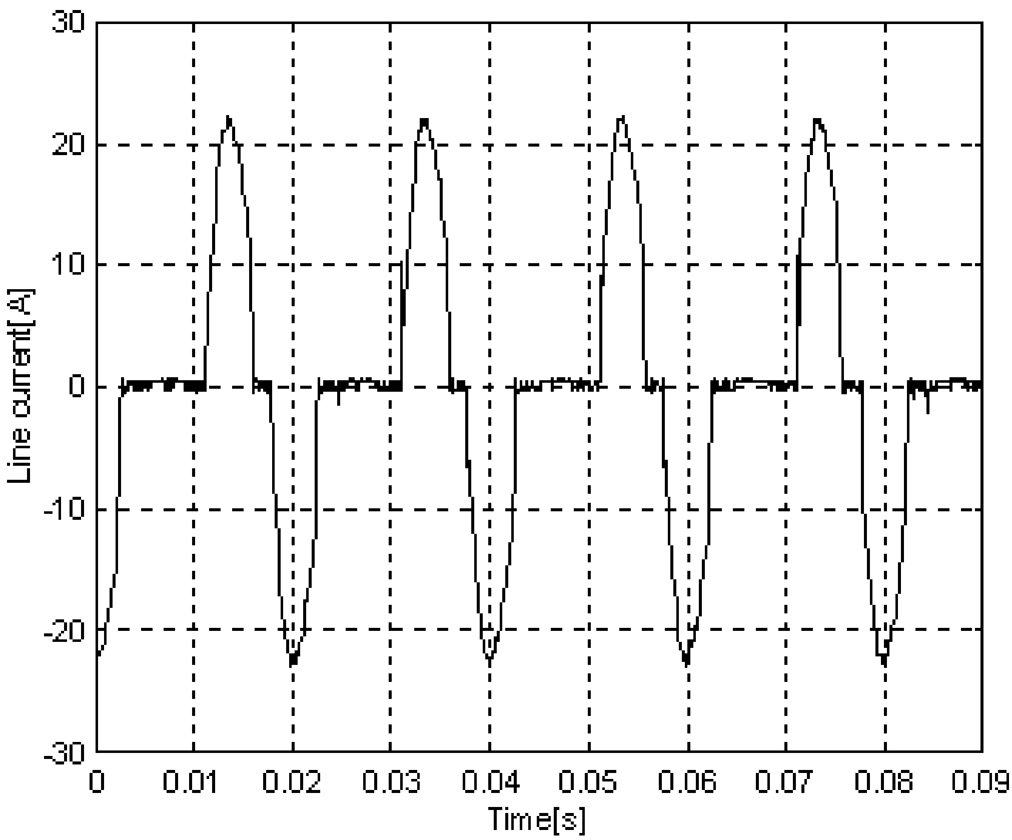

Figure 3. Experimental recorded waveform.

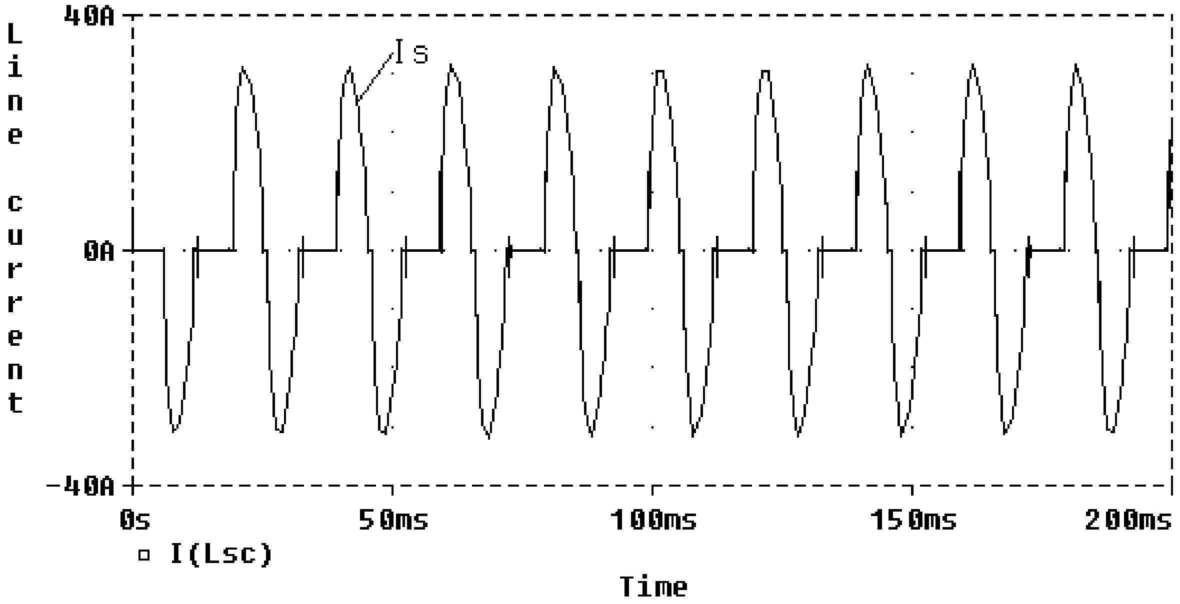

Figure 4. Simulation waveform.

The second case: L_{load} = 48mH and C_{load} = 3260uF.

- α = 150.66°

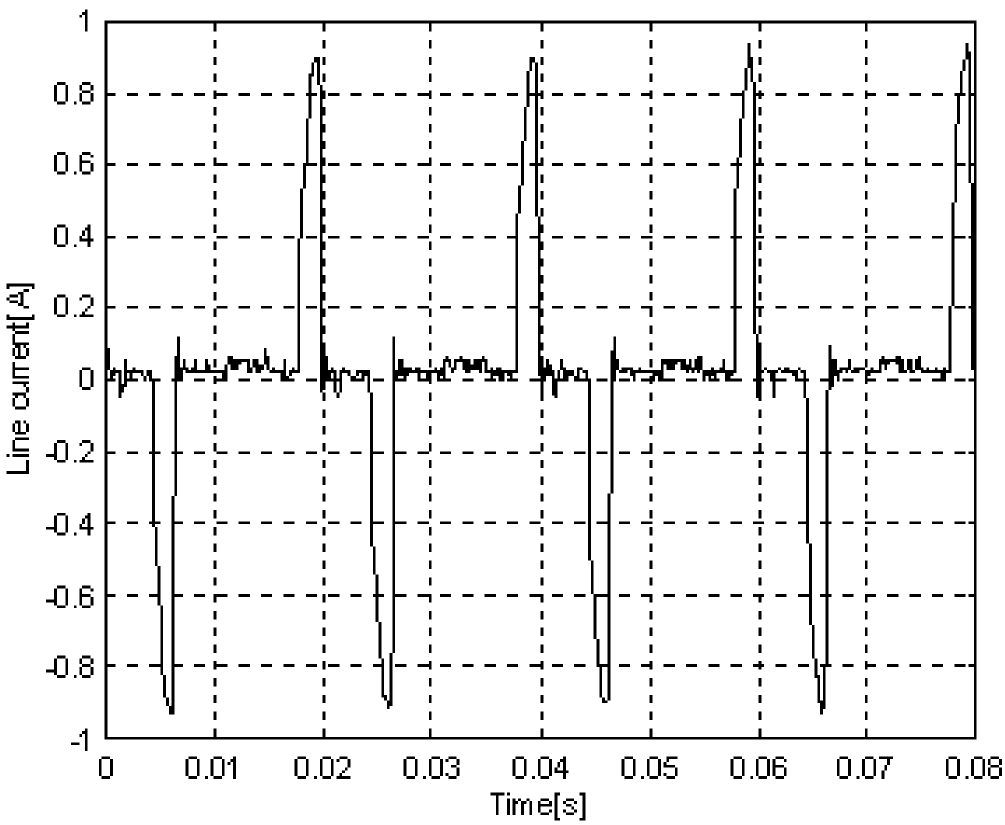

Figure 5. Experimental recorded waveform.

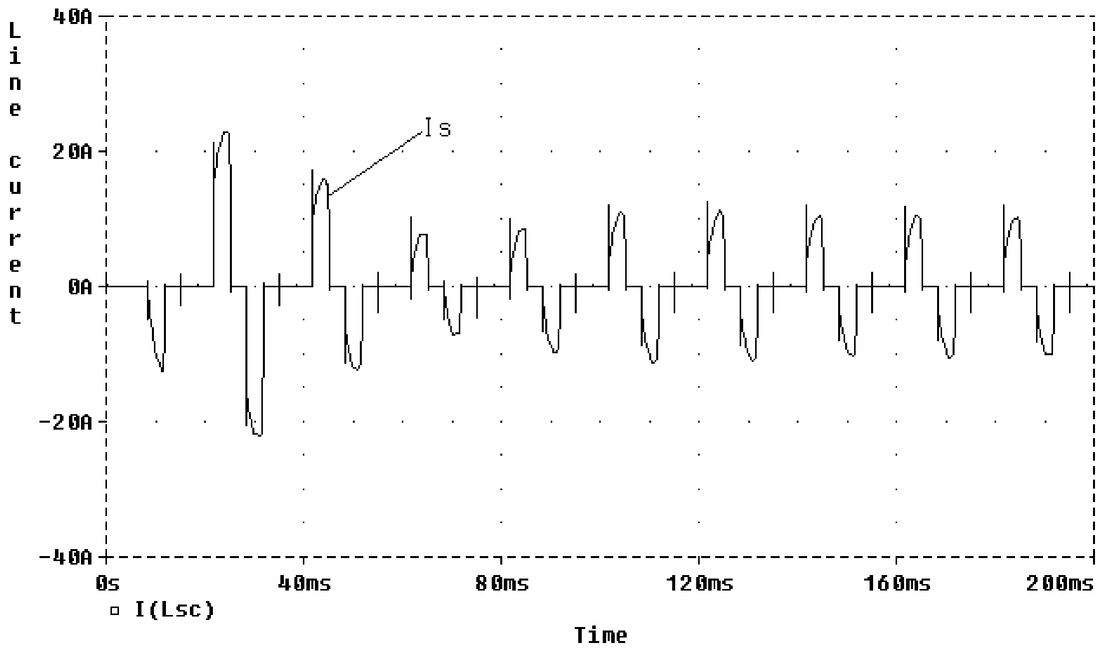

Figure 6. Simulation waveform.

- α = 106.38°

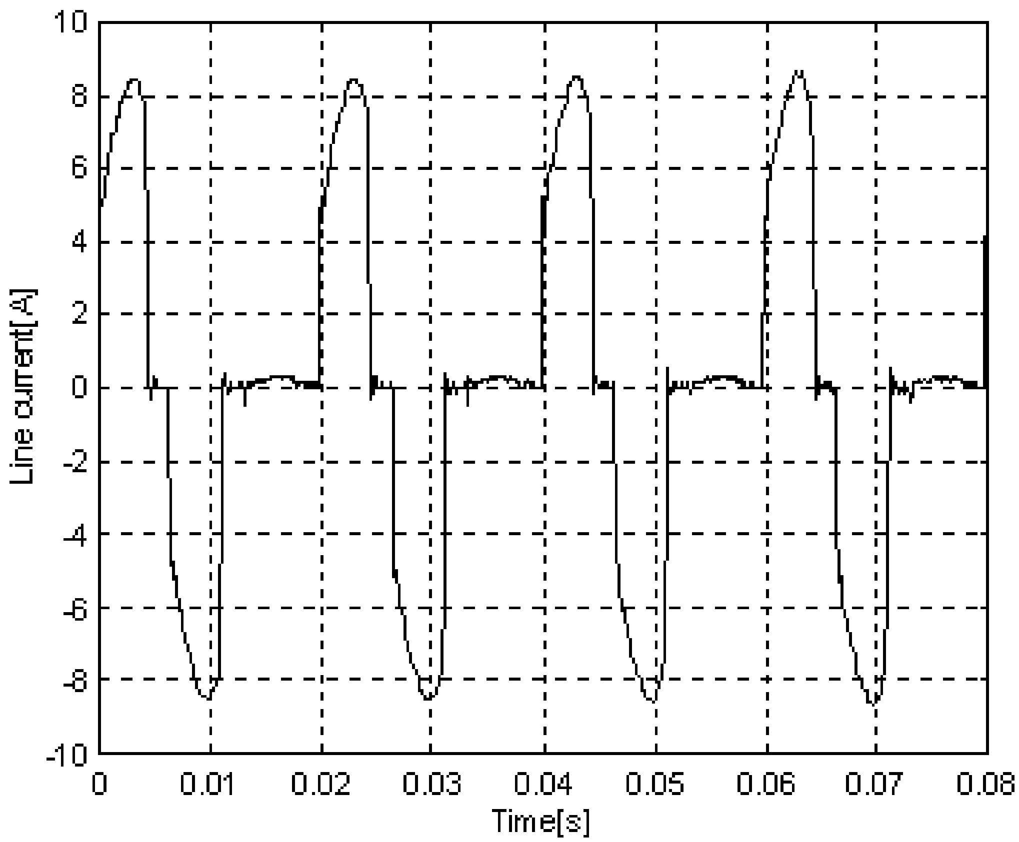

Figure 7. Experimental recorded waveform.

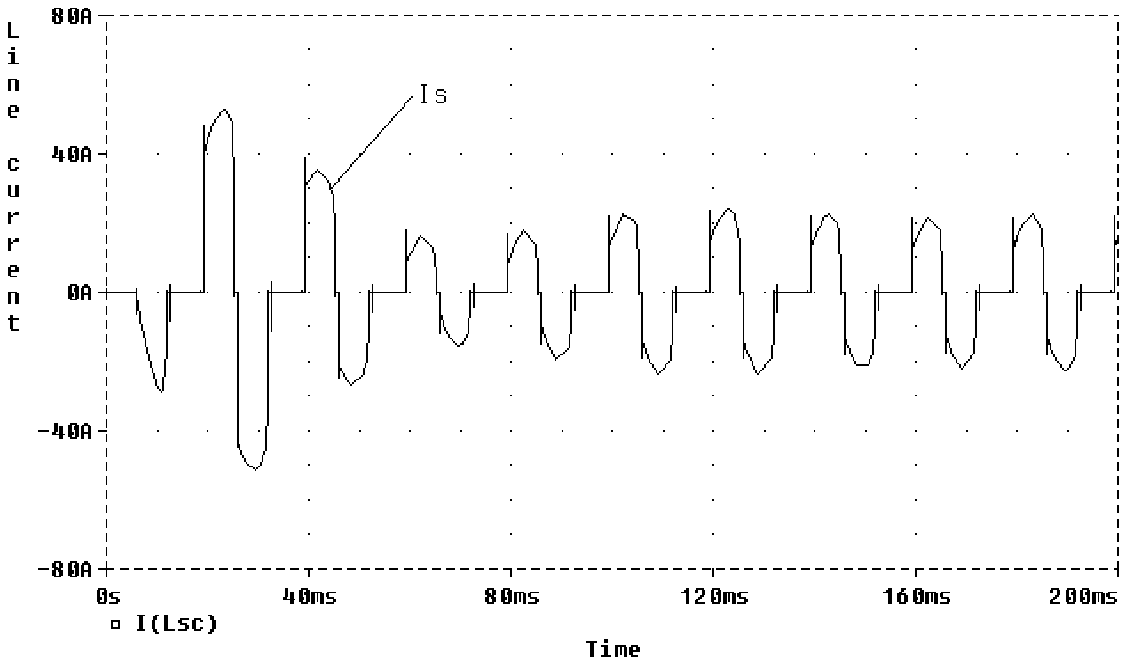

Figure 8. Simulation waveform.

CONCLUSIONS

From all this study which was done about the influence of firing angle and different kind of loads upon current harmonics at the input side of a three-phase semicontrolled rectifier it can conclude that the firing angle is the most important parameter which can influences very much the shape of current harmonics waveforms and the magnitude.

The nature of load influences a little the shape waveforms and more important is the magnitude influence. Knowing this kind of influences is very important in the case of fuses heating study, because the fuses are the current protection devices in the input side of power rectifiers and they have to be designed properly to protect in best condition the power semiconductor from rectifiers.

References

1. Arrillaga, J., Smith, C.B., Watson, R.N., Wood, A.R. *Power System Harmonic Analysis, John Wiley & Sons, Chichester, England, 1997.*

2. Arrillaga, J., Bradley, D.A., Bodger, P.S. *Power System Harmonics, John Wiley & Sons, Chichester, England, 1985.*

3. Mohan, N., Undeland, T.M., Robbins, W.P. *Power Electronics. Converters, Applications and Design. John Wiley & Sons, New York, 1995.*

4. *IEEE Guide for Harmonic Control and Reactive Compensation of Static Power Converters. ANSI/IEEE Std 519-1981.*

5. Update of Harmonics Standard IEEE-519. IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems, 1988.

6. Yacamini, R. *Power System Harmonics. Part 1. Harmonic Sources, Power Engineering Journal, August, pp.193-198, 1994.*

7. Yacamini, R.*Power System Harmonics. Part 2. Measurements and Calculations, Power Engineering Journal, February, pp.51-56, 1995.*

8. Yacamini, R. *Power System Harmonics. Part 3. Problems caused by distorted supplies, Power Engineering Journal, October, pp.233-238, 1995.*

9. Yacamini, R. *Power System Harmonics. Part 4. Interharmonics, Power Engineering Journal, August, pp.185-193 199.*

Recomandat spre publicare: 22.05.2008