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Sinusoidal Reference Technique for Power Factor Correction of a SEPIC Converter Fed from AC Supply

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Abstract

This paper presents a simple and efficient technique for power factor correction (PFC) and total harmonic distortion (THD) minimization of a SEPIC converter fed from AC supply. The performance of the SEPIC converter is studied through the power simulation program (PSIM) under different supply conditions with different loads. The obtained results have shown a very simple technique to obtain sinusoidal supply current at unity power factor with the different loads. Also, the proposed control technique can give sinusoidal supply current whatever the exciting supply contains harmonics or not.

Keywords: PFC, SEPIC, Simulation, THD minimization

1. Introduction

Single-ended primary-inductor converter (SEPIC) is a type of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of the SEPIC is controlled by the duty cycle of the control transistor. A SEPIC is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output voltage is of the same polarity as the input voltage), the isolation between its input and output (provided by a capacitor in series), and true shutdown mode. On the other hand, power factor correction converters are extensively used in the industrial life. These converters aim at increasing the power factor and decreasing the total harmonic distortion of the supply current. Power factor correction and minimization of total harmonic distortion find great interest from researchers [1-6]. The international standards such IEC 61000-3-2 [7] restrict the maximum allowable total harmonic distortion for the current drained from the electric system. This paper presents a simple control technique for PFC and THD minimization of a SEPIC converter fed from AC source to show the effectiveness of the proposed control strategy.

2. Proposed Control Technique

Fig. 1 shows a circuit diagram of the proposed control technique. The main idea of the control technique is to generate a reference sinusoidal supply current from the error signal which results from comparing the reference and the actual output voltage signal. The reference sinusoidal supply current must be synchronized with the supply voltage for the purpose of PFC. The THD will be also minimized as a result of using a reference sinusoidal signal for supply current. The important notice here, the supply current is expected to be sinusoidal if the supply voltage is sinusoidal or contains harmonics.

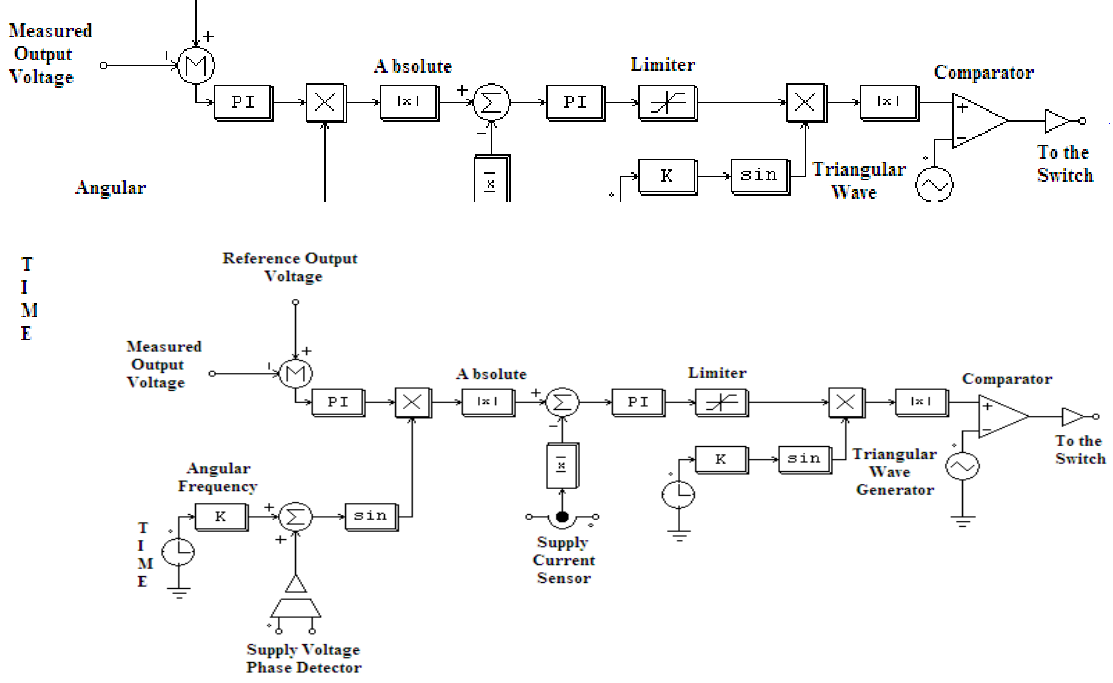

Figure 1. Circuit Diagram of the Proposed Control Technique

3. Performance of SEPIC with The Control Technique

Fig. 2 shows the circuit diagram of the well known SEPIC converter fed from an AC supply via a single-phase bridge rectifier. The proposed control technique which described in the previous section has been applied to the converter circuit at two different load types (e.g. Resistive & Resistive-Inductive Loads). Also, it has been applied under different supply conditions.

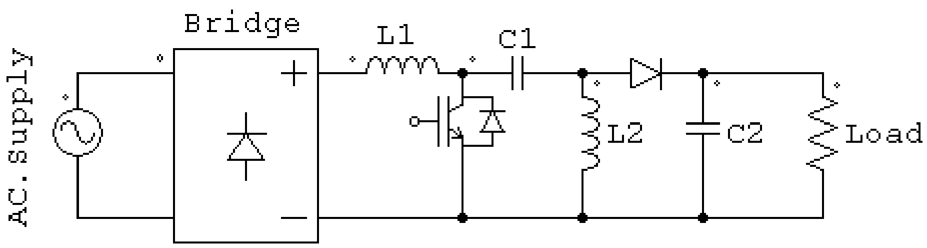

Figure 2. SEPIC Converter Fed from AC Source

4. Simulation Results with Resistive-Inductive (RL) Load

This section presents the simulation results of the SEPIC converter under the proposed control technique with RL load at two different cases of the AC supply voltage. Fig$_s$. 3a to 3d show the AC supply voltage, output voltage, supply current and the fast Fourier transform (FFT) of the supply current for a sinusoidal AC input voltage.

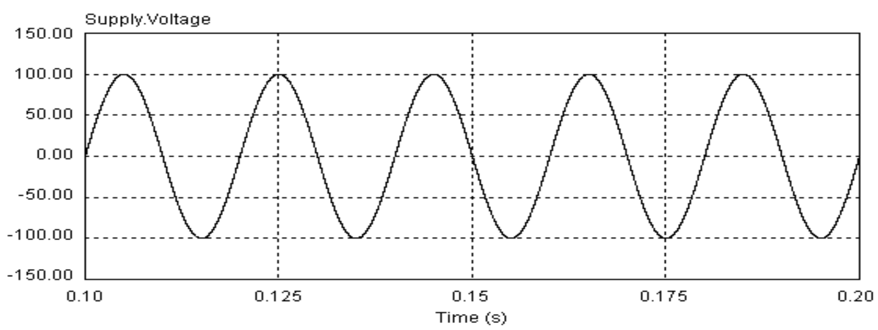

Figure 3a. Sinusoidal AC Supply Voltage

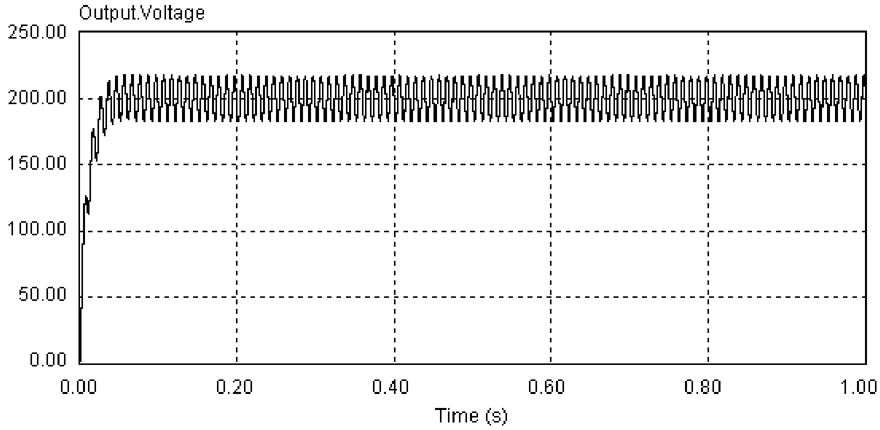

Figure 3b. Output Voltage at a Reference Signal of 200 Volt and RL-Load

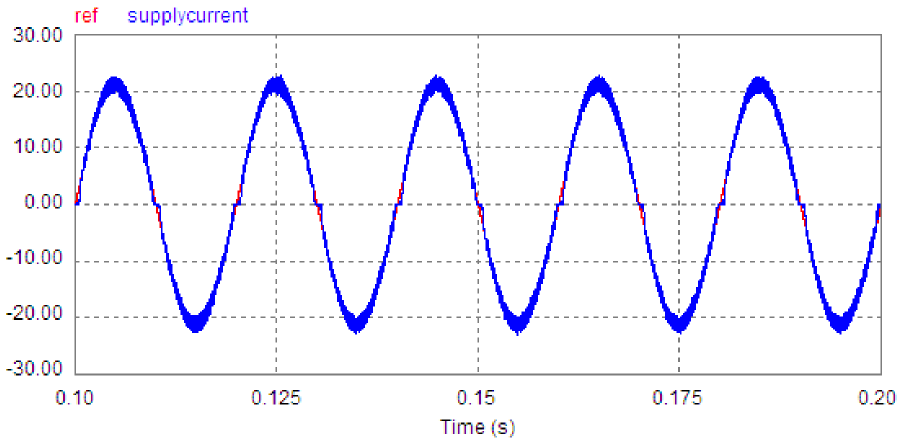

Figure 3c. Reference and Measured Supply Current at a Reference Signal of 200 Volt and RL-Load

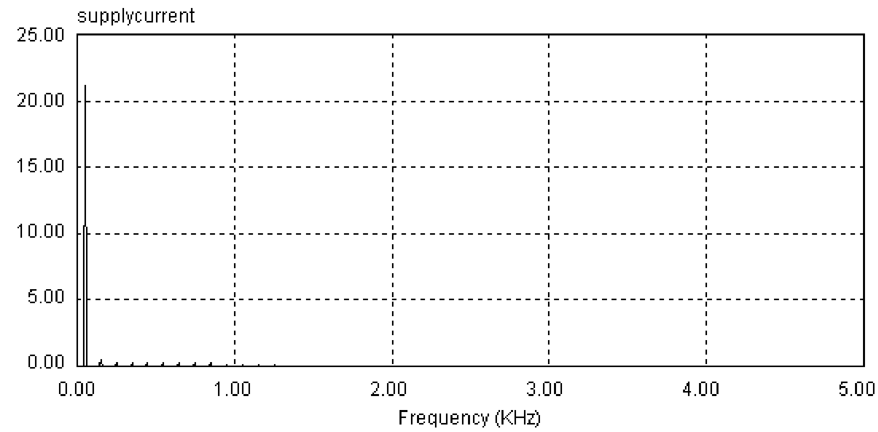

Figure 3d. FFT of Supply Current at a Reference Signal of 200 Volt and RL-Load

From the above figures, it can be seen that the circuit power factor is approximately equal to unity and the supply current is approximately sinusoidal which means a minimized THD. Fig_s. 4a to 4d show the

AC supply voltage, output voltage, supply current and the fast Fourier transform (FFT) of the supply current for an AC supply voltage contains harmonics.

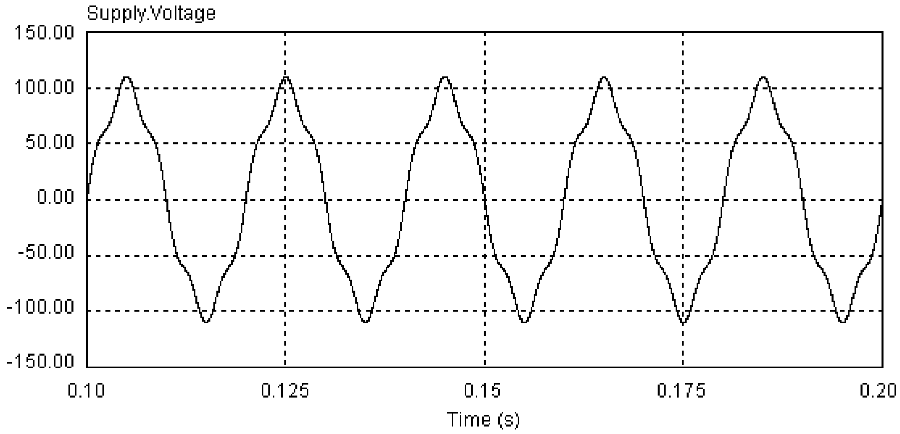

Figure 4a. AC Supply Voltage contains Harmonics

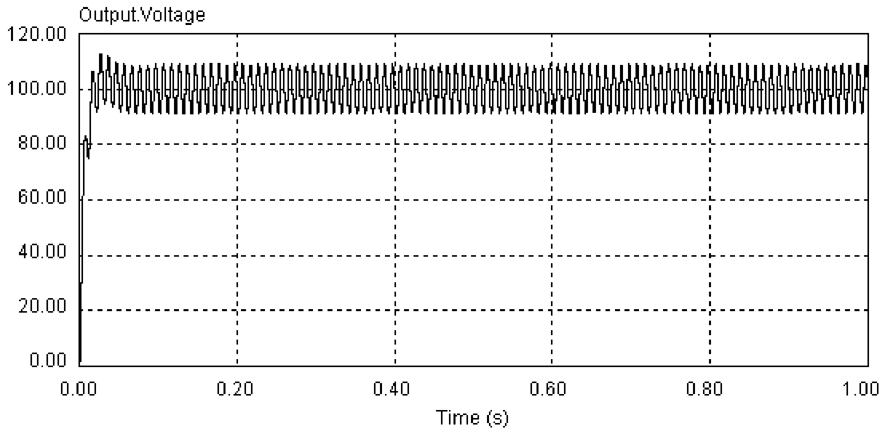

Figure 4b. Output Voltage at a Reference Signal of 100 Volt, Distorted Supply and RL-Load

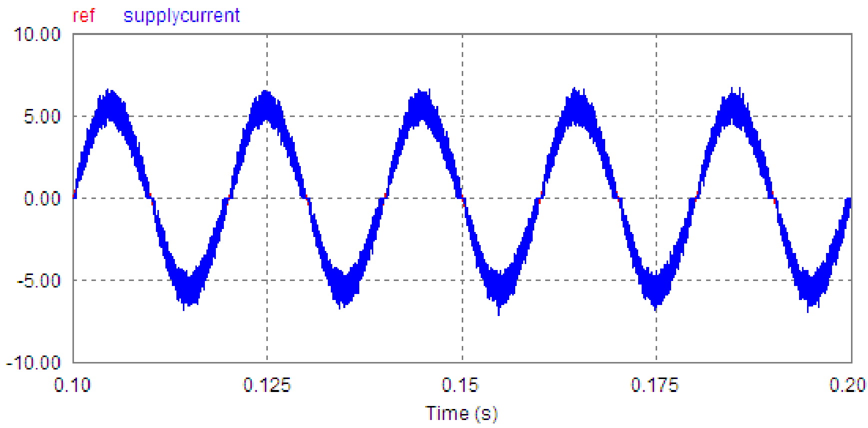

Figure 4c. Reference and Measured Supply Current at a Reference Signal of 100 Volt, Distorted Supply and RL-Load

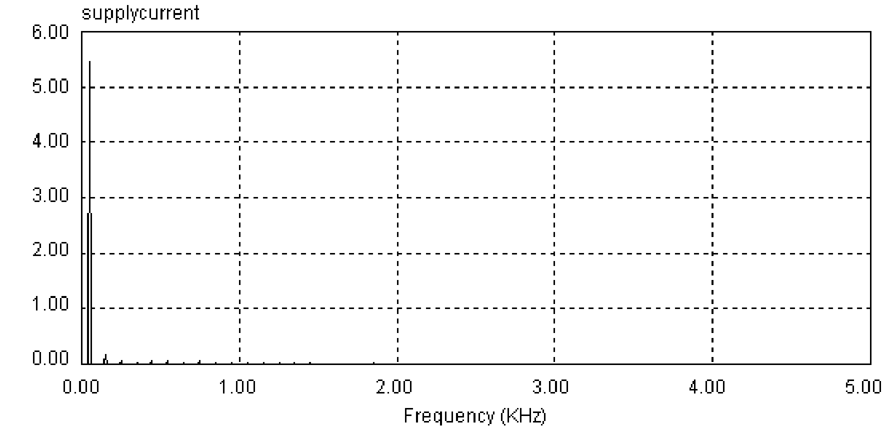

Figure 4d. FFT of Supply Current at a Reference Signal of 100 Volt, Distorted Supply and RL-Load

Also, the above figures illustrates that the THD in supply current is very small whatever the AC supply contains harmonics or not which support the proposed control technique.

5. Simulation Results with Resistive (R) Load

This section presents the simulation results of the SEPIC converter under the proposed control technique with R load when the AC supply voltage is distorted. Fig_s. 5a to 5d show the AC supply voltage, output voltage, supply current and the fast Fourier transform (FFT) of the supply current for a sinusoidal AC input voltage.

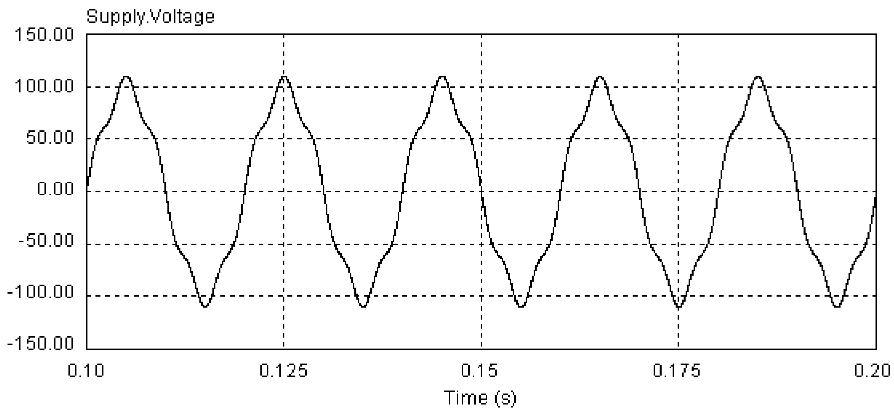

Figure 5a. AC Supply Voltage contains Harmonics

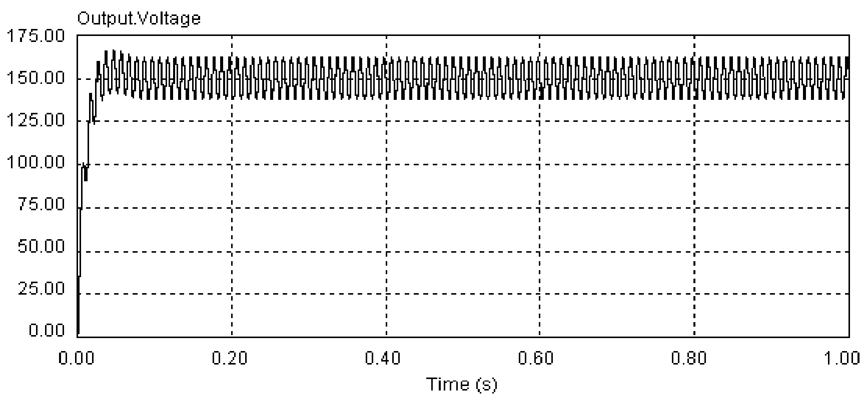

Figure 5b. Output Voltage at a Reference Signal of 150 Volt and R-Load

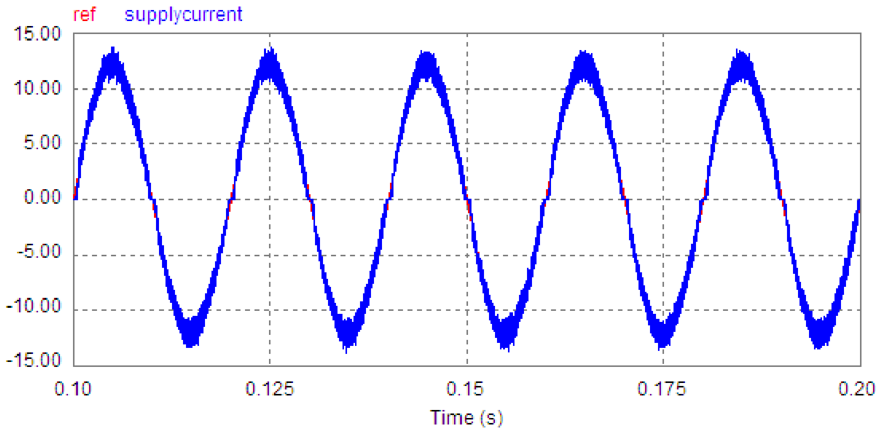

Figure 5c. Reference and Measured Supply Current at a Reference Signal of 150 Volt and R-Load

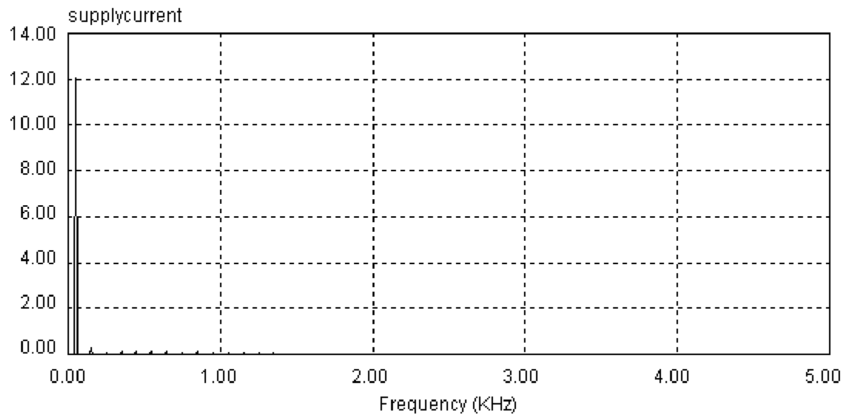

Figure 5d. FFT of Supply Current at a Reference Signal of 150 Volt and R-Load

6. Conclusion

A simple control technique for power factor correction and total harmonic distortion minimization of a SEPIC converter fed from AC supply has been presented. The performance of the SEPIC converter under the proposed control technique has been also presented at different conditions. The obtained results have shown a simple and efficient control technique that can be used for the proposed purpose.

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Appendix

Parameters of SEPIC Converter:

Inductance (L1 & L2) = 1 mH.
Capacitance (C1) = 10 micro Farad.
Capacitance (C2) = 500 micro Farad.
Load Resistance = 40 Ohm.
Load Inductance = 0.1 H.