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Power Factor Correction Using SEPIC AC-DC Converter

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ABSTRACT: Usage of electronic devices like laptops, computers and mobile phones increased nowadays there is a need for AC to DC converters in Indian power supply as it is built with AC of 230V and 50 Hz frequency. So, a usage of rectifier bridge is increased in the powerlines. This causes third order harmonic injection in the line current which increases the reactive power. And power factor is also reduced at the supply side. In this project, a Single Ended Primary Inductor Converter (SEPIC) is used to inject the compensation current towards the supply to maintain power factor and Total Harmonic Distortion (THD). MATLAB is used to test the performance of the circuit. Hardware prototype is built for checking the performance.

KEYWORDS: AC/DC converter, power factor correction, single-ended-primary inductor-converter (SEPIC).

I.INTRODUCTION

The input current harmonic content of AC-DC rectifiers followed by a bulk capacitor is very high and does not meet the international harmonic regulations and degrade the power factor at the mains. For that reason, a DC-DC converter at the DC-end of the rectifier is employed to make the input current track the input voltage profile through a correct control strategy. This strategy can be considered as an emulation of a pure resistive operation of the diode rectifier circuit. A converter with such a configuration is known as a power factor pre-regulator (PFP).

Different PFP configurations exist in the literature: the Buck, the Boost, the Buck-Boost, the Cuk , and the SEPIC topologies. The widely used PFP is a boost converter which has a simple topology in terms of power and control views . Nevertheless, Boost PFP suffers from difficult input-out high frequency isolation, output voltage higher than the peak input voltage, high starting current and no overload protection .

The control strategy in PFP can be realized in two approaches. The first is normally adopted with converters operating in continuous conduction mode (CCM), referred to as the multiplier approach. Two control loops are used; the external one controls the output voltage and the internal one ensures the wave shaping of the input current. This is achieved through multiplying the output of the voltage control loop by the input voltage to produce a sinusoidal reference current to the inner current loop.

The second approach is the voltage follower in which the converter operation is in discontinuous conduction mode (DCM), and only one simple voltage control loop is adopted to control the converter switching on time. In this scheme, the input current naturally tracks the sinusoidal line voltage waveform.

Adopting the voltage follower approach with Boost and Buck-Boost converters produces a harmonically enriched, distorted input current. For this reason, an input filter will be necessary. Conversely, with Cuk and SEPIC converters in DCM present sinusoidal input current, an input filter will be redundant .

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II.SYSTEM MODEL AND ASSUMPTIONS

The basic configuration of an isolated SEPIC AC-DC converter is shown in Fig. 1. To ensure SEPIC PFP operation in DCM, the conduction parameter k_{α} should be less than a critical value $k_{\alpha,crit}$. The following equations represent the converter design criteria.

$$k_{\alpha,crit} = \frac{1}{2(m+n)^2} \tag{1}$$

$$k_{\alpha} = \frac{2L_{eq}}{RT_S} \tag{2}$$

$$M = \frac{V_0}{V_1} \qquad v_{1r} = V_1|\mathrm{Sin}W_1t| \tag{3}$$

Where *n* is the transformer turn ratio, *M* is the output to peak input voltage ratio given by (3).

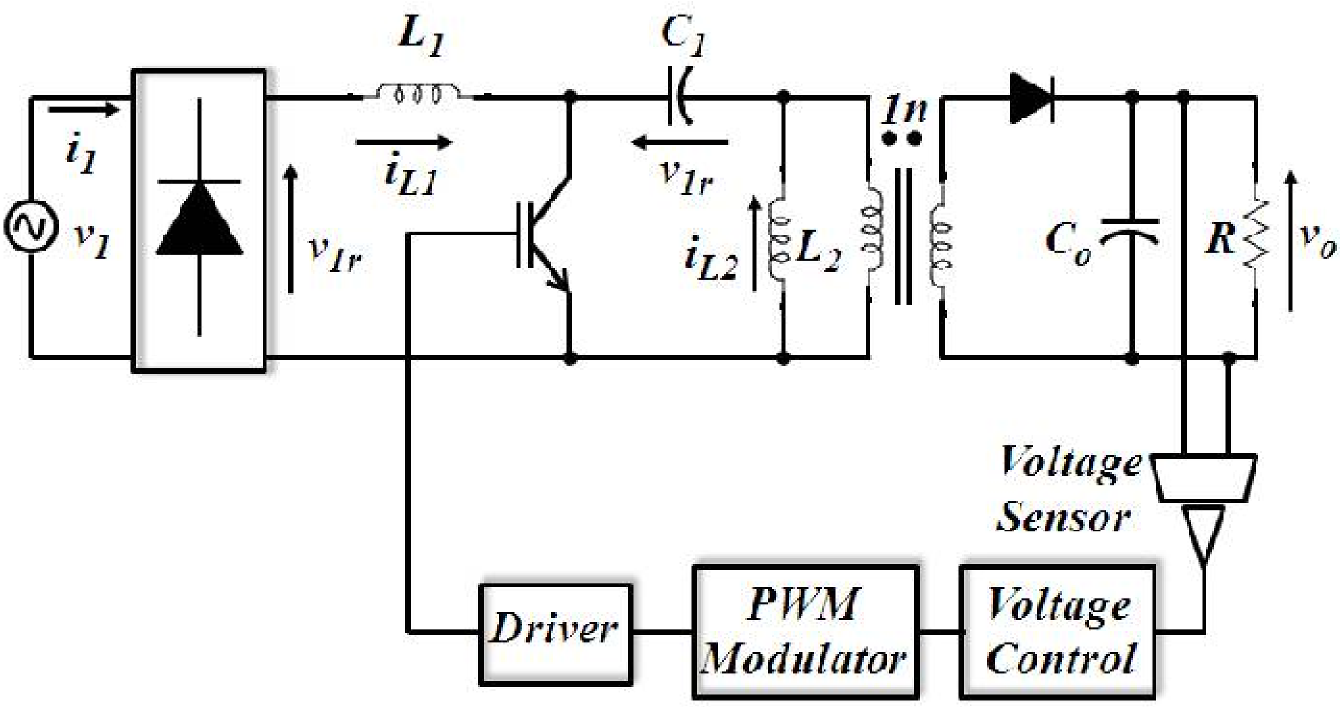

Fig. 1. Configuration of a single-phase AC-DC converter based on a SEPIC converter.

III.EFFICIENT COMMUNICATION

With a normal DC-DC converter, the output capacitor should be large enough to remove the switching frequency ripple. In contrast, when the DC-DC converter is integrated in PFP application, the output capacitor should be large enough to eliminate both switching and double line frequency ripples. Therefore, one can adopt two parallel connected capacitors; the first removes the high switching frequency ripple and the second removes the double line frequency ripple. Accordingly, for a variable line frequency AC-DC converter, the low line frequency at full load condition must

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be considered in the output capacitor design. The following equation can be used to calculate both the high frequency output capacitor and the low frequency output capacitor .

IV.SECURITY

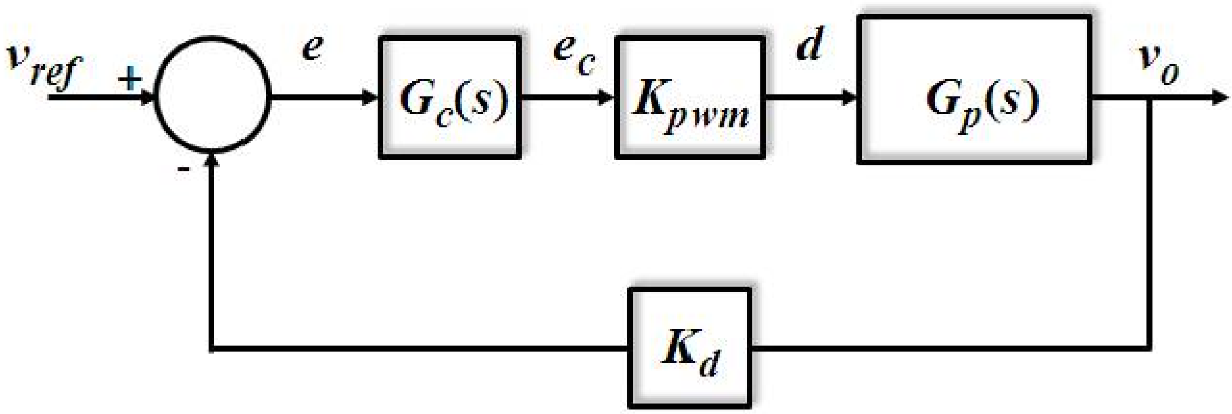

Fig. 2. Block diagram of the proposed control strategy

Figure 2 represents the voltage control block diagram of the SEPIC AC-DC converter. The output voltage is measured with a voltage sensor and compared with the desired magnitude. The error value (e) is utilized by a PI compensator to produce the desired control signal (e_c) that is fed to the pulse width modulator (PWM) to generate the necessary driving signal for the converter. The control to output transfer function (G_p(s))for the SEPIC APF converter operates in DCM supplying resistive load can be modelled by a first order transfer function .The transfer functions of the PI compensator ($G_C(s)$) and PWM (K_{pwm}) respectively. The voltage sensor gain K_d is adjusted by the designing.

V. RESULT AND DISCUSSION

A Matlab/Simulink model is used to validate the design steps. Simulation will be performed considering step change in the line frequency, input voltage and the load.
In this work, a single phase Isolated high power factor SEPIC DC-DC converter Operating in DCM is shown.The input current tracks the input voltage and the power factor is almost unity.The SEPIC converter shows a satisfactory behaviour when subjected to disturbances in load, input voltage and line frequency of the input voltage all of which makes this topology suitable for different application. The proposed model provides reduced cost, lower switching losses, lower conduction losses and higher efficiency.

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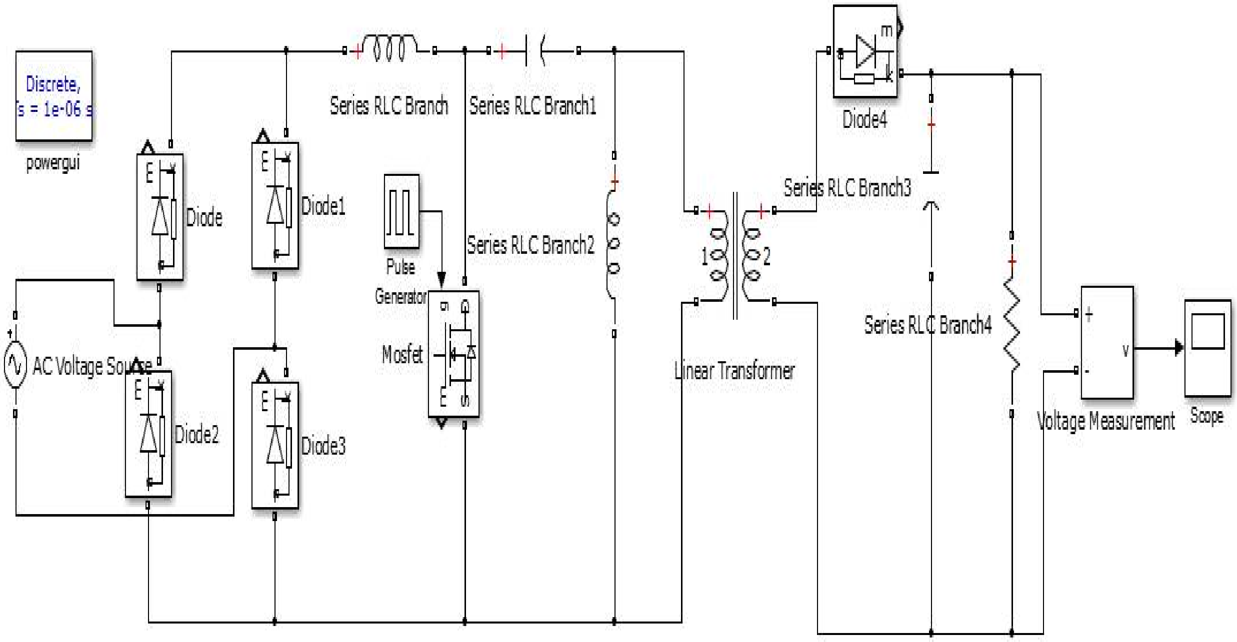

Fig 3: Open Loop Simulation Circuit of SEPIC Converter

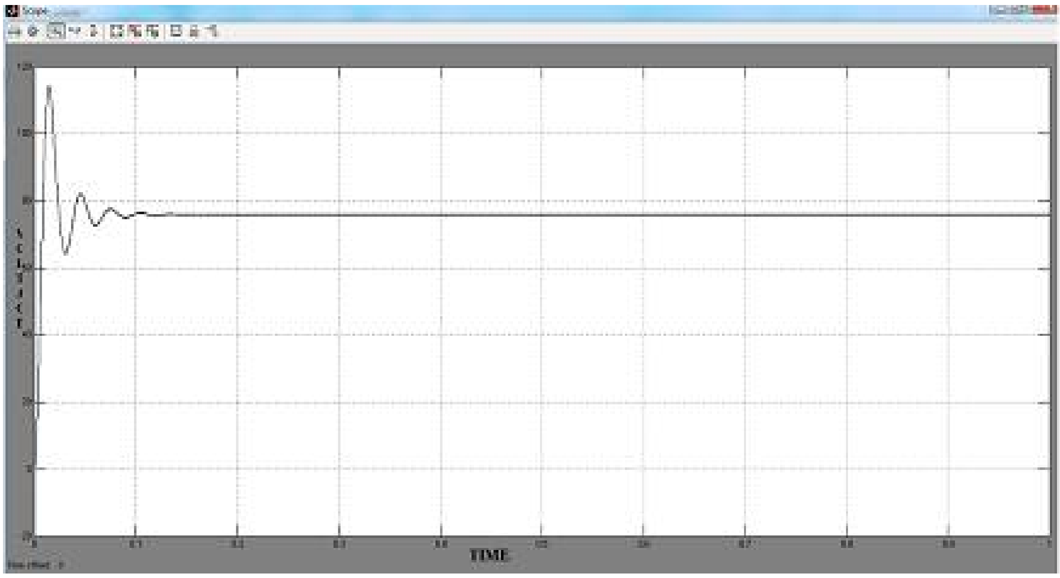

Fig 3.1: Voltage Waveform Of Open Loop Circuit

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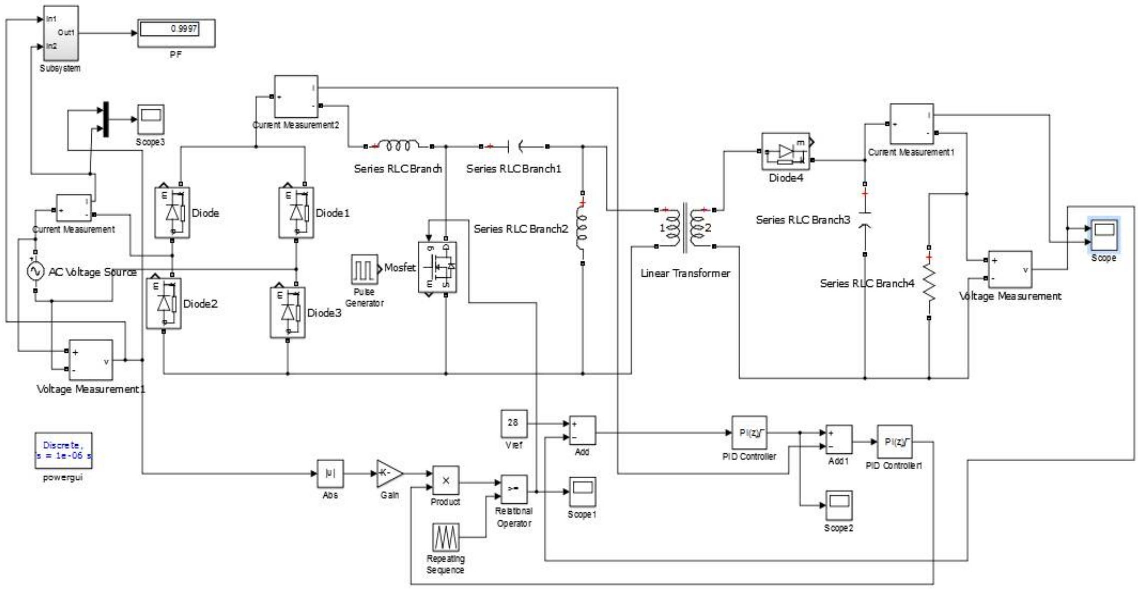

Fig 4: Closed Loop Simulation Circuit of SEPIC Converter

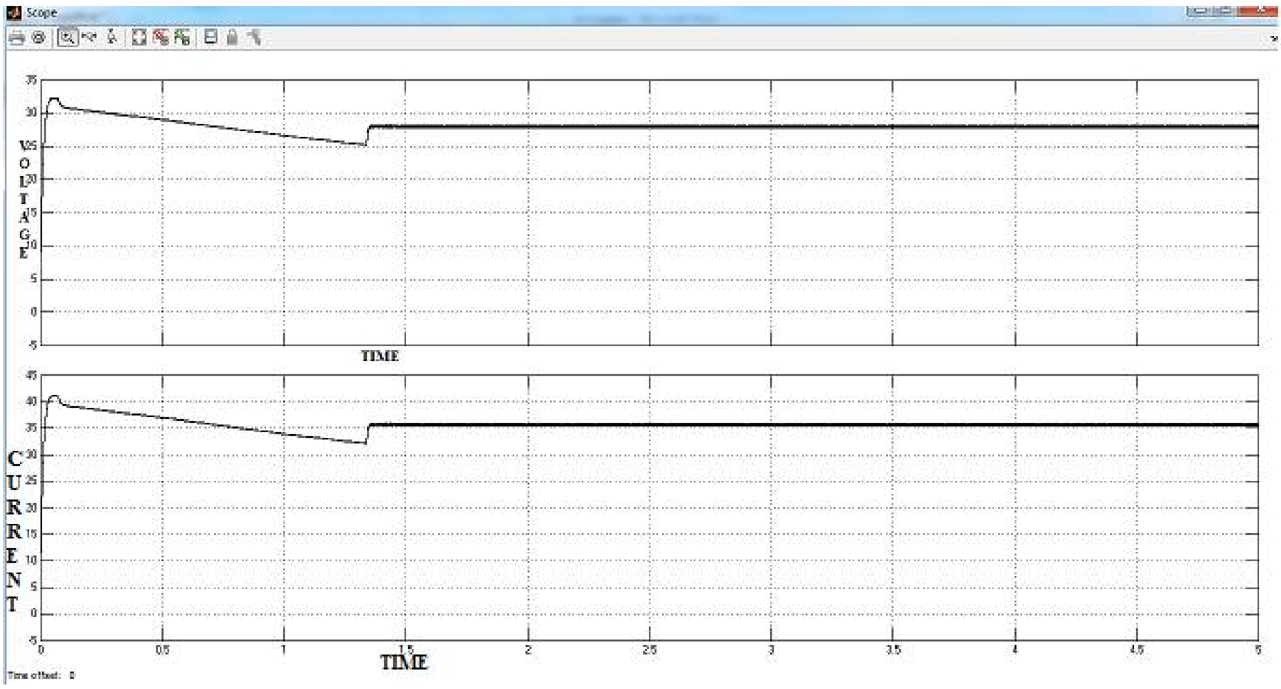

Fig 4.1: Voltage & Current Waveform Of Closed Loop Circuit

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VI.CONCLUSION

In this paper, a single-phase isolated high power factor ac-dc converter based on a sepic dc-dc converter operating in dcm is presented. The input current tracks the input voltage profile naturally and the power factor is almost unity. Step by step design equations are presented to ensure converter operation in dcm over a wide range mains frequency.

Numerical simulation has been conducted to confirm the design approach. Also, the converter performances are examined in terms of power factor, input current total harmonic distortion and output voltage regulation during transient and steady state conditions. The SEPIC PFP shows a satisfactory behaviour when subjected to disturbances in load, input voltage magnitude and the line frequency of the input voltage, all of which make this topology suitable for aircraft application.

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