Efficiency Analysis of Bridgeless PFC Boost Converter

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Abstract— AC rectification is a very inefficient process, resulting in waveform distortion of the current which is drawn from the source. This produces a large spectrum of harmonic signals that may interfere with other equipment. In input rectifier bridge the conventional boost PFC suffers from the high conduction loss. By using bridgeless boost converter higher efficiency can be achieved. The voltage sensing, current sensing and EMI noise has issues in this new circuit. In this paper at different voltage level by changing the duty ratio the affect of efficiency is studied.

Key words: Power factor correction, Duty ratio, Efficiency

I. INTRODUCTION

Energy crisis today has led to new technologies in the area of renewable energy like maximum power point tracking etc. and also in the area of improvement in power quality.[1-2] For notebooks, desktop computers, workstations, and servers, fast-escalating and extremely challenging high-efficiency there is requirements for ac/dc power supplies. To look for any possible opportunity to minimize power losses Environmental Protection Agency (EPA) Energy Star and climate savers computing initiative documents, are forcing designers. Many power supply manufacturers and some semiconductor companies have started looking into bridgeless PFC circuit topologies, recently, in an effort to improve the efficiency of the front-end PFC rectifiers. The conduction losses be reduce by reducing the number of semiconductor components in the line current path. For this generally, the bridgeless PFC topologies referred to as dual boost PFC rectifiers. So far, a number of bridgeless PFC boost rectifier implementations and their variations have been proposed The extensive use of dc power supplies inside most of electrical and electronic appliances lead to an increasing demand for power supplies that draw current with low harmonic Content and also have power factor close to unity.

In power electronics, Power-factor correction (PFC) has been an active research and significant efforts have been made on the developments of the PFC converters. [3]

Inside most of electrical and electronic appliances such as in computers, televisions, audio sets and others Dc power supplies are extensively used. The presence of nonlinear loads produce voltage fluctuations, harmonic currents and an imbalance in network system which results into low power factor operation of the power system. The basic block in many power electronic converters are uncontrolled diode bridge rectifiers with capacitive filter. Due to the nonlinear nature of bridge rectifiers, non-sinusoidal current is drawn from the utility and harmonics are injected into the utility lines. The bridge rectifiers contribute to high THD, low PF, and low efficiency to the power system. These harmonic currents cause several problems such as voltage distortion, heating, noises etc. which results in reduced efficiency of the power system. Due to this fact, there is a need for power supplies that draw current with low harmonic content and also have power factor close to unity.

In this paper, a systematic review of the bridgeless PFC boosts rectifier implementations that have received the most attention. Performance comparison between the conventional PFC boost rectifier and a representative member of the bridgeless PFC boost rectifier family is performed. Loss analysis and experimental efficiency evaluation for both continuous- conduction mode (CCM) and discontinuous-conduction mode (DCM)/CCM boundary operations are provided.[4]

II. CONVENTIONAL PFC BOOST CONVERTER

The conventional input stage for single phase power supplies operates by rectifying the ac line voltage and filtering with large electrolytic capacitors. This process results in a distorted input current waveform with large harmonic content. As a result, the power factor becomes very poor around .The reduction of input current harmonics and operation at high power factor (close to unity) is important requirements for power supplies. The conventional boost topology is the most widely used topology for PFC applications [6]. It consists of a front-end full-bridge diode rectifier followed by the boost converter. The technique usually employed to correct power factor of single-phase power supplies consists of a front-end full-bridge diode rectifier followed by a boost converter, as shown in fig 1. This approach is good for a low to medium power range. As the power level increases, the diode bridge becomes an important part of the application and it is necessary to deal with the problem of heat dissipation in limited surface area. The dissipated power is important from a efficiency point of view.

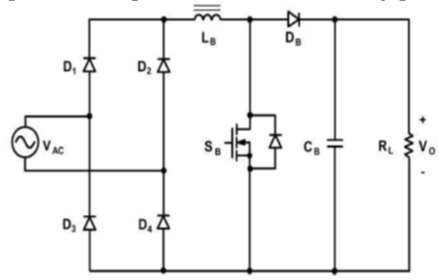

Fig.1: Conventional PFC Boost Converter

III. BRIDGELESS PFC BOOST CONVERTER

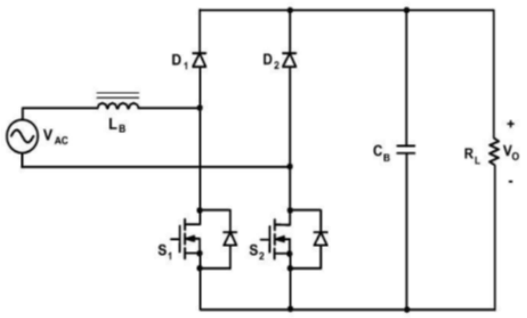

Fig.2: Bridgeless PFC Boost Converter

As shown in Fig.2. Bridge-boost topology is the most efficient for PFC applications. It uses a dedicated diode bridge to rectify the AC input voltage to DC, which is then followed by the boost section. This approach is good for a low to medium power range. As the power level increases, the diode bridge begins to become an important part of the application and it is necessary for the designer to deal with the problem of how to dissipate the heat in limited surface area. The dissipated power is important from an efficiency point of view. The bridgeless configuration topology presented in this paper avoids the need for the rectifier input bridge yet maintains the classic boost topology. This is easily done by making use of the intrinsic body diode connected between drain and source of Power MOS switches [7]. The circuit shown from a functional point of view is similar to the common boost converter. In the traditional topology current flows through two of the bridge diodes in series.[8] In the bridgeless PFC configuration, current flows through only one diode with the Power MOS providing the return path. To analyze the circuit operation, it is necessary to separate it into two sections. The first section operates as the boost stage and the second section operates as the return path for the AC input signal.

IV. Simulation Analysis

Simulation circuit of Bridgeless PFC boost rectifier is shown in Figure 3.It is operated at 24 Vrms line voltage. The distorted line current is shown in figure 4. The power factor is obtained as 0.9979 and efficiency is found to be 0.9136%. The FFT analysis of input current waveform is shown in Figure 5 and is found to be 3.87%.The simulation of the model was done for t=0.05s for input voltage= 24 V, 48V at different duty ratios from 10 to 80 and the result are tabulated in table 1-2.Efficiency measurements are presented in figure 6- 7.The table shows that as duty ratio increases the efficiency decreases as losses Increases. Losses include switching losses and conduction losses which depend upon switching frequency and duty ratio. The switching loss of the boost switches is based on the turn-on loss due to the effective capacitance of the MOSFET.

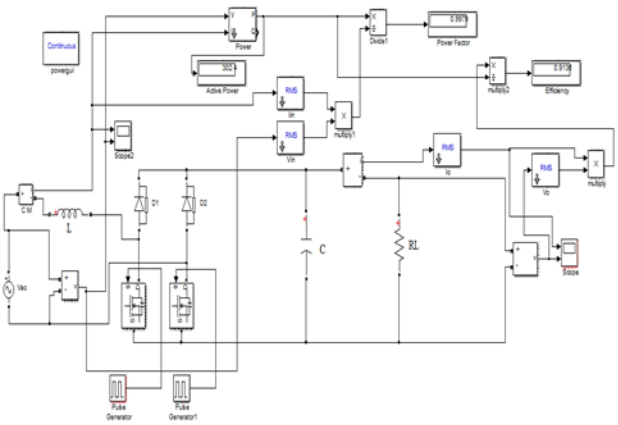

Fig.3: Bridgeless PFC Boost Converter

A. Result:

The result of Simulink model of basic bridgeless PFC Boost Converter has been given below.

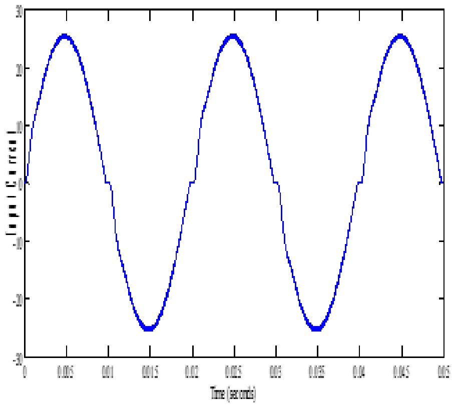

Fig.4: Input Current

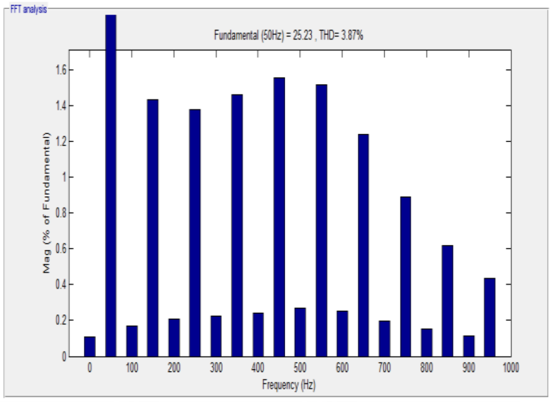

Fig. 5: FFT Analysis of Input Current

B. At 24 Volt:

Duty Ratio	Efficiency
10	91.43
20	90.92
30	90.19
40	89.01
50	87.01
60	83.36
70	76.14

Table.1: Efficiency Vs Duty Ratio

C. At 48 Volt:

Duty Ratio	Efficiency
10	85.42
20	85.17
30	84.70
40	83.82
50	82.16
60	78.94
70	72.31

Table.2: Efficiency Vs Duty Ratio

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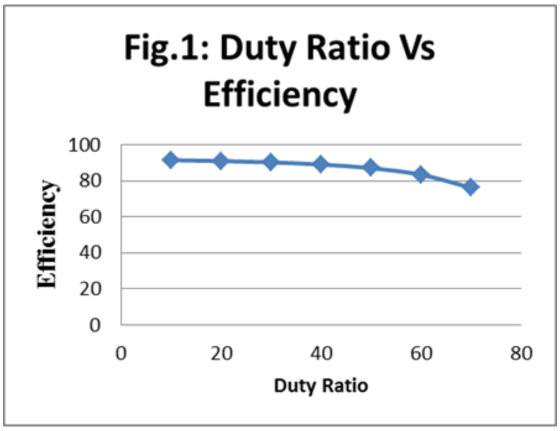

Fig. 6: Duty Ratio vs. Efficiency curve at 24 volt

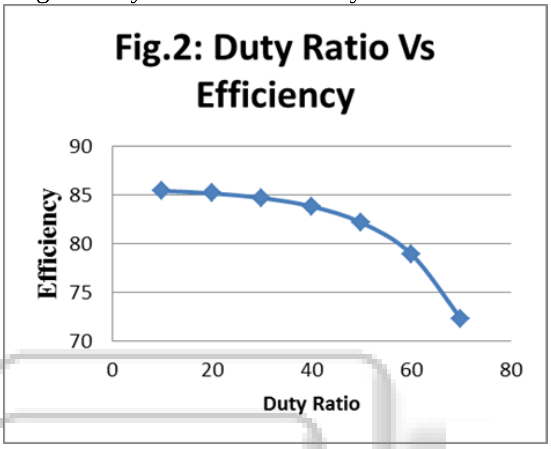

Fig. 7: Duty Ratio vs. Efficiency curve at 48 volt

V. CONCLUSION

A single Phase Bridgeless PFC Boost converter is modelled and simulated. The results show that bridgeless PFC Boost Converter not only improves the power factor but it also seen that as duty ratio changes the efficiency of the system changes as the losses of the system varies. Losses include switching losses and conduction losses which depend upon switching frequency and duty ratio. The switching loss is based on the turn-on loss due to the effective capacitance of the MOSFET.

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