

Design of a New AC–DC Single-Stage Full-Bridge PWM Converter with Two Controllers

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Abstract

Single phase power factor correction ac-dc converters are widely used in industry for ac-dc power conversion from single phase ac mains to an required output dc voltage. In case of high power application these types of converter use an ac-dc boost converter followed by dc-dc converter. These converters has the features of excellent input power factor, continuous input and output currents, and intermediate dc bus voltage and reduce the number of semiconductor devices for such cost-effective applications.

Index terms: AC–DC power conversion, bridgeless power factor correction (PFC) converter, full-bridge converters, pulse-width modulated (PWM), single-stage converters.

I. INTRODUCTION

The conversions of ac-dc power converter are designed with two converter stages. The first stage is used to convert ac-dc boost converter such that the input ac voltage into an intermediate dc bus voltage. The second stage is dc-dc converters which convert the dc bus voltage into the required dc output voltage. This type of converter has integrate the features of power factor correction and isolated dc-dc conversion.

Single stage ac-dc converter is widely used for industry application which is constructed by ac-dc flyback and forward converter(<250 W).

In case of high power application larger variation in output load. The design process is difficult for single stage converter to perform PFC and dc-dc conversion for wide load variation. Single stage ac-dc full bridge converter are divided into current fed and voltage fed converter. In case of single phase current fed converter, which has the input boost inductor connected to the input side. This type of current fed current are used in limited applications. Where as voltage fed converter, which has the large energy storage capacitor connected across the input side and this of voltage fed converter is widely used for more applications.

Two stage ac-dc converter are designed with two controller as each converter stage act as controller that is used to regulate the output voltage. In most of the cases single stage converter are typically implemented with a single controller to regulate the output voltage to reduce the cost, size, and complexity. As a result there is no second controller available to regulate the dc bus capacitor voltage that is on the primary side of the main power transformer.

Due to the lack of such controller in single stage converter means that (1) the primary side of the dc bus voltage is vary with line and load condition become excessive under high input line and light output load condition. (2) the absence of second controller is available to shape the input current. There is no second controller at the input section causes the most of Drawbacks of previously proposed single stage converter.

- Single stage converter has the resonant converter that use variable switching frequency control in order to prevent the dc bus capacitor voltage. The use of variable switching frequency control makes it difficult to optimize the design of these converter.
- Various control method has proposed to reduce the dc bus capacitor voltage in fixed frequency pulse width modulated single stage converter operating with only one controller. By using the only one controller the dc bus capacitor voltage is not regulated, and its affected the energy exist between the energy transferred to the dc bus capacitor from the input and energy that is transferred from the capacitor to the converter output.

These dc bus voltage reduction techniques include the use of very low value of output inductance such as auxiliary winding taking from the main transferred primary to extend the converter duty cycle or operating the converter with a semi-continuous input current.

Single stage converter with the one controller, have no controller to actively shape the input current, simultaneous input PFC and dc-dc conversion can only performed by keeping the converter duty cycle fixed over the entire input line cycle. Several one controller converter must operate

with non standard control techniques in order to perform input PFC and dc-dc conversion. In addition to the drawback associated with the second controller to regulate the dc bus capacitor voltage and to shape input current, many converter have drawbacks associated with increasing conduction losses.

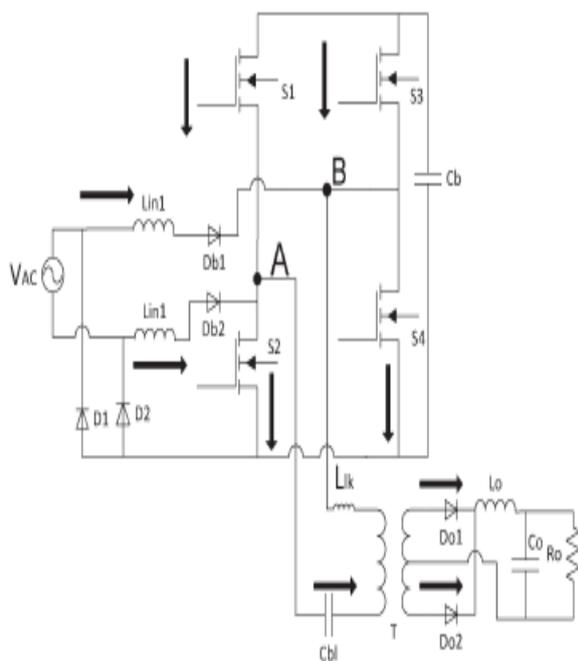


Fig. 1. Proposed single stage ac/dc converter.

A new voltage fed PWM ac-dc single stage full bridge converter has none of the drawbacks is proposed. The proposed converter can operate with excellent input power factor control, continuous input and output current, equal sharing of the input current.

The main reason for these features that can be implemented with an input section controller so that the converter works with two controller, one controller is used to regulate the output voltage and another controller is used to regulate the dc bus capacitor voltage. Although the second controller increase the cost, size, and complexity.

II. PROPOSED CONVERTER

Proposed ac-dc single stage full bridge converter consist of input inductor L_{in1} and L_{in2} And rectifying diodes D1 and D2 with a dc-dc section that is standard full bridge converter. Diodes D1 and D2 and input inductance L_{in1} and L_{in2} makes the bridgeless input, which is bridgeless converter. Blocking diodes Db1 and Db2 are included to prevent any dc circulating current. A dc blocking capacitor Cb is provided in series with the transformer primary.

The proposed converter has two independent controller, one is used to regulate the dc bus capacitor

Cb by providing the gating signal S2 and S4. The gating signal S1 and S3 are the complementary signal of S2 and S4. The other controller is used to regulate the output voltage.

III. CONVERTER DESIGN

I. Minimum Input Inductor Value

Since the proposed converter is an ac-dc PFC converter that operates with continuous input current, the minimum value of input inductor that will ensure that the input inductor current is continuous over the entire range of operating conditions can be determined using the same equations as those used for standard PFC converters.

$$\frac{V_M}{I_M} \leq \frac{2L_{in}}{T_{sw}}$$

Where V_M is the peak input ac voltage and I_M is the peak input ac current. This equation is applicable to any ac-dc PFC converter operating with continuous input current.

II. Duty Ratio Range for Lower Switches S2 and S4:

The input controller, which perform the PFC and controls the dc bus voltage, varies the instantaneous duty ratio of the lower switches of the bridge is

$$D_k = 1 - \frac{|V_M \sin \omega_s u t_k|}{V_{bus}}$$

The duty ratio of these switches is highest when the rectified input ac voltage is close to zero and is lowest when this voltage is at its peak.

III. Controller Design:

The implementation of the two converter controllers, the one for the ac-dc PFC and the one for the phase-shift PWM, can be decoupled and done in the exact same manner as is normally done for a two-stage converter, if the dynamics of the input section are much slower than the dynamics of the output section. This decoupling can be done if the closed-loop controlling the dc bus voltage with respect to the input ac has a crossover frequency that is much smaller than the crossover frequency of the closed loop controlling the dc output voltage with respect to the intermediate dc bus voltage.

Perfect decoupling of the two controllers can be done between the duty ratio of the lower switches of the full-bridge and the phase-shift between the two

legs of the full-bridge by restricting the duty ratio of the lower switches.

IV. MATLAB Simulink model of proposed AC-DC converter.

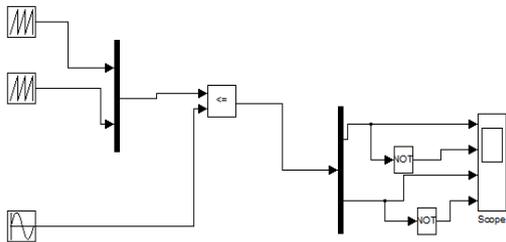


Fig.2. PWM generation method.



Fig.3. scope of PWM method.

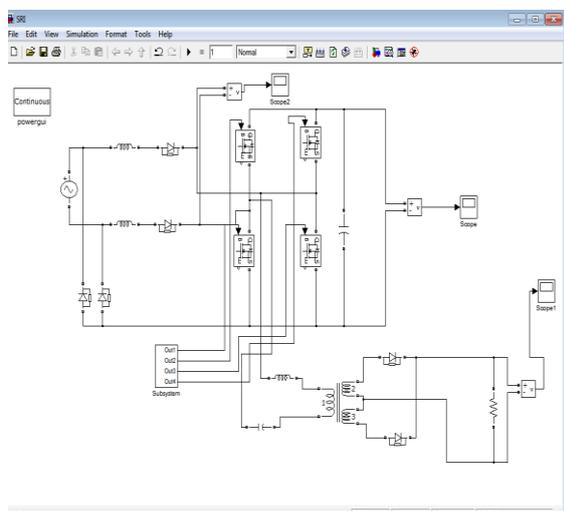


Fig.4. MATLAB Simulink model proposed converter.

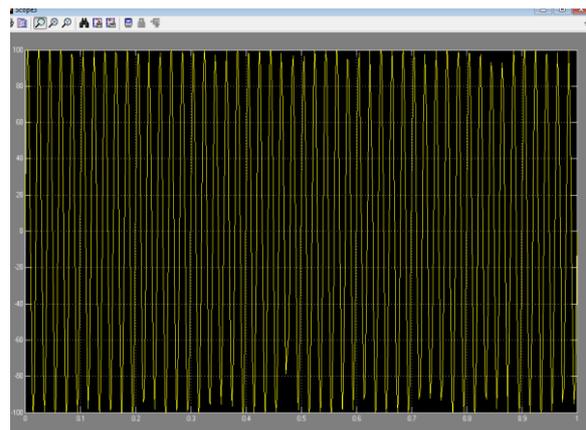


Fig.5. Input voltage of the converter.

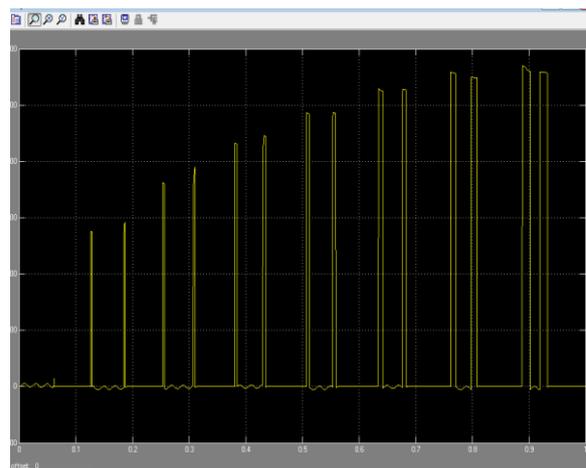


Fig.6. Intermediate DC bus voltage.

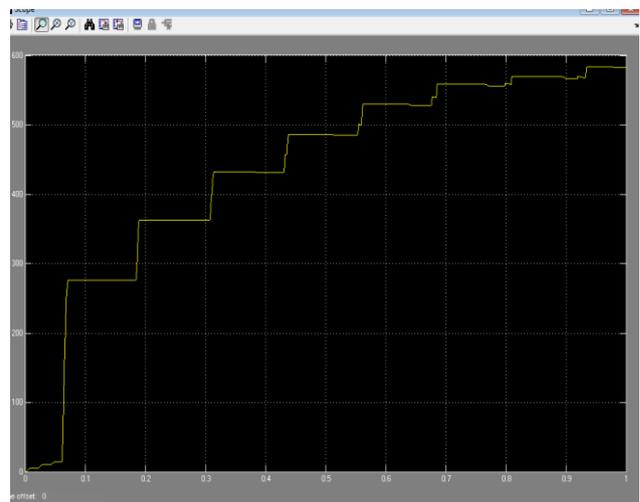


Fig.7. DC bus voltage across C_b .

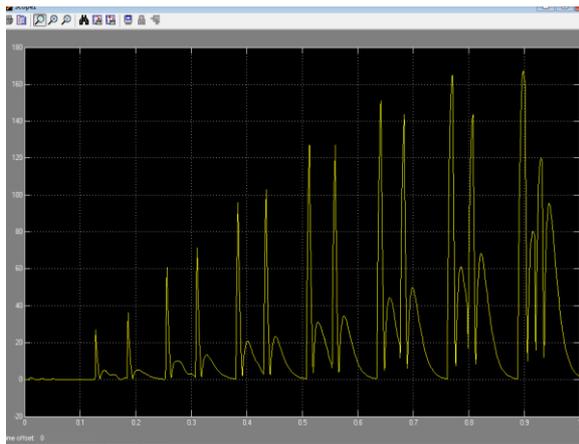


Fig.8. Load voltage across R_L .

Advantages of this proposed converter:

1. The proposed converter combines the best features of two stage converter and a single stage converter. It has two controller that allow it operate with continuous input line current, and regulate the dc bus voltage, like two stage converter have the fewer components like single stage converter.
2. The proposed converter has fewer semiconductor devices in the input current conduction path than other single stage converter, which reduce the conduction losses.
3. By turn on the upper MOSFET S1 or S3 and bottom MOSFET S2 or S4 with proper dead time, current from the input section can made flow through MOSFET instead of body diode. This reduces the conduction losses.
4. The proposed converter also has few turn-off losses and can be implemented with a input EMI filter than other single stage converter.

V. CONCLUSION

A new ac-dc single stage full bridge converter combines the best features of two stage and single stage converter. The converter is controlled using two controllers- one is used to actively control input power factor and the intermediate dc bus voltage, the other controller is used to control the output voltage. The single stage ac-dc full bridge converter is verified by MATLAB software.

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