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Single phase AC-DC power factor corrected converter with high frequency isolation using buck converter

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Abstract:
Single phase ac-dc converters having high frequency isolation are implemented in buck, boost, buck-boost configuration with improving the power quality in terms of reducing the harmonics of input current. The paperpropose the circuit configuration, control mechanism, and simulation result for the single phase ac-dc converter.

Index terms: AC-DC converter, harmonic reduction high frequency transformer, power quality converter, power factor corrected converter.

I. INTRODUCTION

AC-DC converter with high frequency transformer is most widely used in switched mode power supply (SMPS), uninterrupted power supply (UPS), battery charging, induction heater, electronic ballast. This ac-dc converter is implemented with two stages. In first stage, the ac voltage is converted into uncontrolled dc voltage by using the diode bridge rectifier circuits, followed by the second stage of dc-dc converter using high frequency transformer.

These two stages of power conversion has the problem of power quality in terms of harmonic current at ac mains, voltage distortion, reduced power factor, high peak factor and require a large size of dc capacitor filter at first stage. This ac-dc converter mainly used to improve the power quality and to reduce the number of components and to improve the efficiency.

In order to overcome this problem by using a newly developed single stage ac-dc converter with high frequency transformer isolation. There are several names for the converter known as input current shaper, high power factor converter, input single stage converter etc.

Based on the high frequency transformer isolation the converter design is classified into nine different converter such as single phase buck, boost, buck-boost ac-dc converter. Simultaneously these buck converter are further classified into forward, push-pull, and half bridge, full bridge configuration. Similarly the boost type converters are classified into forward, push-pull, half bridge, full bridge topologies.

Finally the buck-boost converter are classified into fly back, cuk, SEPIC, and ZETA converter.AC-DC converter with high frequency transformer isolation are developed in the range of several watts to several KW for the application of DC power in computer power supplies, UPS, battery charger, induction heater, electronic ballast etc.

The above mentioned application of power supplies is used to develop the power quality of low value of total harmonic distortion, and peak factor, high power factor, low value of EMI and RFI at ac mains are regulated and to reduce the ripple components and stabilize the dc voltage under varying loads.

These type of converter are controlled by the different control method as DSP, Microcontroller, and improved high efficiency buck, boost, buck-boost topologies with high frequency transformer isolation. Depending upon the voltage level require at the consumer side, the ac main voltage is connected into dc power to feed variety of loads through the single phase ac-dc converter, classified into buck, boost, buck-boost converter to improve the power quality at ac mains and dc loads.

These converter are implemented using high frequency transformer isolation with single or multiple converter such as buck, boost, buck-boost topologies. One of the major reason to develop the ac-dc converter is the availability of high frequency with switching devices like MOSFET which has the high switching capability with negligible losses.

II. CIRCUIT CONFIGURATION

Single phase improved power quality converter are classified basis on the voltage levels at the input and output as buck, boost converter are further classified with forward, push-pull, half bridge, full bridge converter. Similarly buck-boost converter are classified into fly back, cuk, SEPIC, and ZETA converter. This converter are constructed with diode bridge at input side used to convert single phase ac-dc feeding various type of load.

BUCK AC-DC CONVERTER

The single phase buck converter are further classified into four major types of converter namely as, forward, push-pull, half bridge, full bridge converter and this type of converter rating starts with low power rating to high power rating applications.

1.Buck forward ac-dc converter

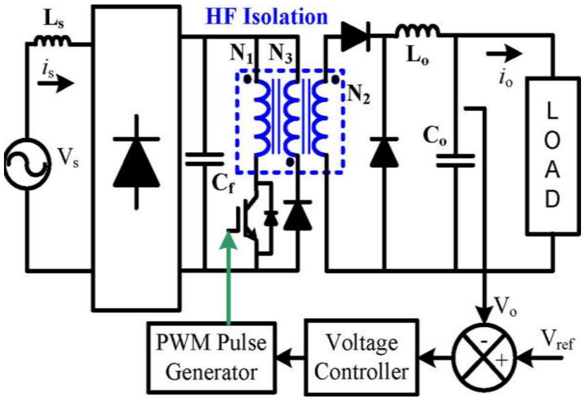

Fig.1.Buck forward AC-DC converter with voltage follower control.

This forward converter consist of diode bridge rectifier to convert the ac voltage into uncontrolled dc output voltage which is given to the forward converter. This forward converter convert uncontrolled dc voltage into ac voltage fed to high frequency transformer used to match the required output voltage. This forward converter provides the high efficiency.

Normally the dc voltage is controlled with feedback into controller which makes to adjust the duty cycle of the device to any sudden change of load or input ac voltage amplitude and/or frequency.

2. Buck push-pull ac-dc converter

The push-pull ac-dc converter which has the push-pull configuration of center-tapped transformer at both side.A low value of capacitor is used at intermediate dc bus to provide a developed voltage source type to the input of push-pull inverter.

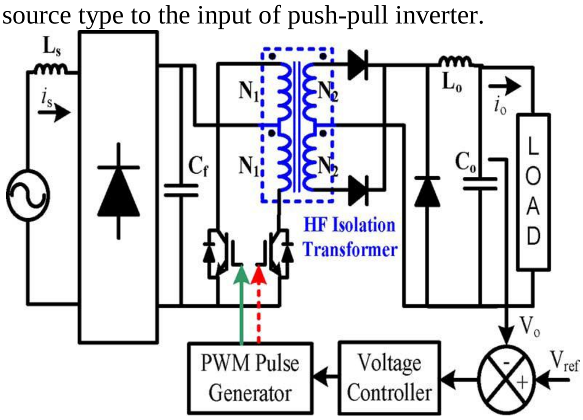

Fig.2. Buck push-pull AC-DC converter with voltage follower control

The turns ratio of the high frequency transformer employed for isolation is decided by the required voltage at dc output voltage and available range of input voltage. An LC filter is used to eliminate the EMI, RFI noises.

3. Buck half bridge ac-dc converter

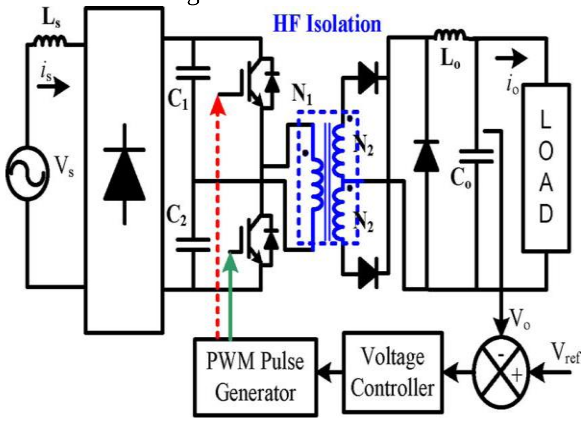

Fig.3. Half-bridge buck AC-DC converter with voltage follower control.

A single phase buck half bridge ac-dc converter topology with the output push-pull rectifier has two set of capacitor (C1 and C2) provides another ac terminal for this type of high frequency inverter which restrict the low power application.

4.Buck full bridge converter

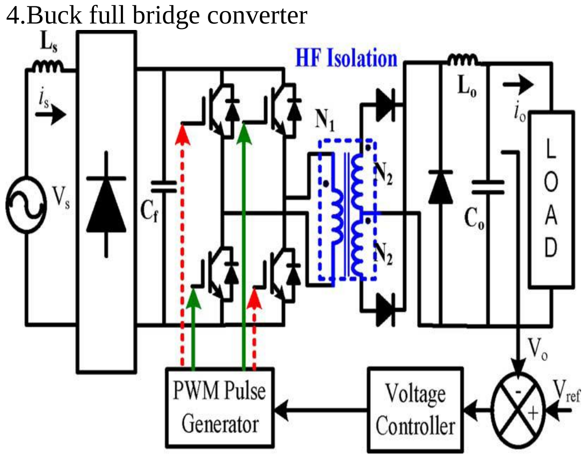

Fig.4.Buck full-bridge AC-DC converter with voltage follower control.

A buck full bridge converter consist of a small size LC filter to provide a dc voltage source to given the high frequency inverter to operate it buck converter. This type of converter provides the better efficiency due to reduced losses. The bridge inverter control either unipolar or bipolar control depend upon the ease of control mechanism.

III. CONTROL APPROACHES

Closed-loop control of output DC voltage of these isolatedAC-DC converters is the essential requirement during maintaining high level power quality at input AC mains isrequired in steady state and during transient operation. Alarge number of control schemes of these AC-DCconverters to meet these requirements along with fast dynamicresponse in different circuit configurations. However, the designof these converters is modified to simplify their control.

IV. MATLAB Simulink model buck converters.

The MATLAB Simulink model of buck converters namely as forward converter, push-pull converter, half bridge converter and full bridge converter output response is verified by simulating the converter using MATLAB software.

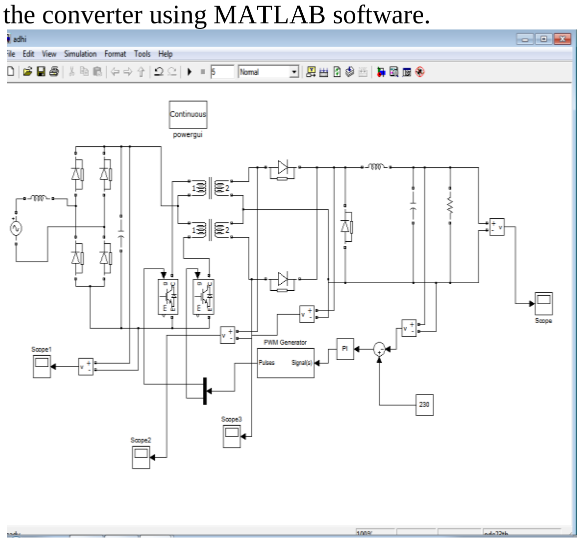

Fig.5.MATLAB Simulink model of buck push-pull ac-dc converter.

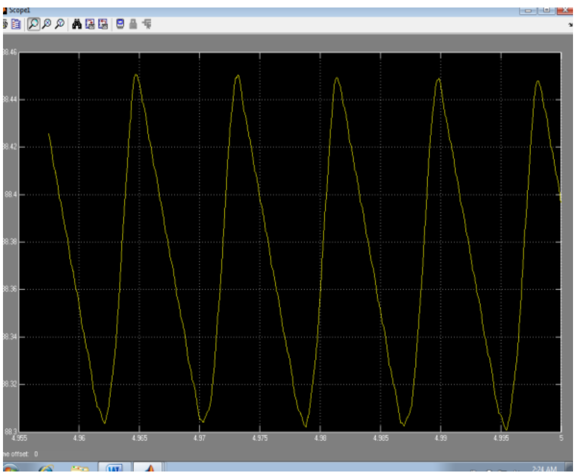

Fig.6. diode rectifier uncontrolled output voltage

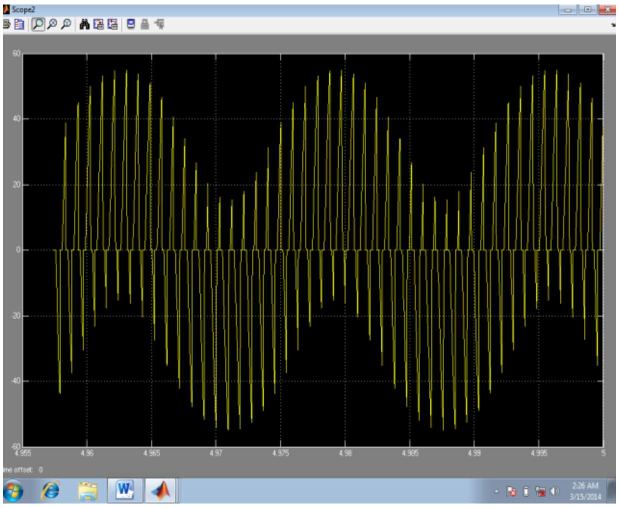

Fig.7. sinusoidal voltage at secondary side of the transformer for push-pull converter.

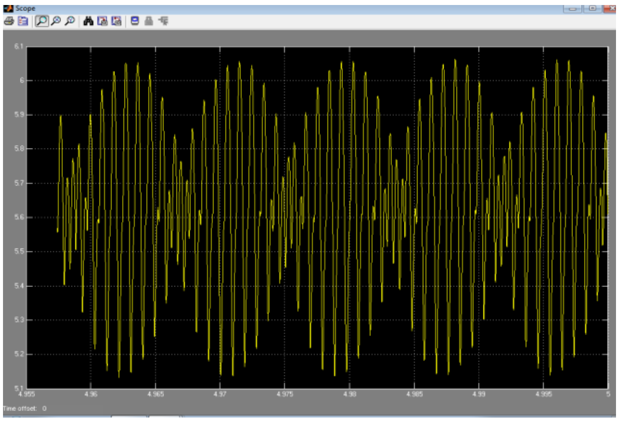

Fig.8.load voltage of push-pull converter.

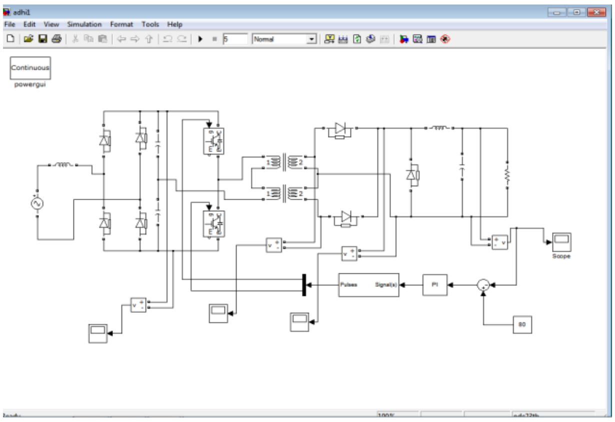

Fig.9.MATLAB model of half bridge converter.

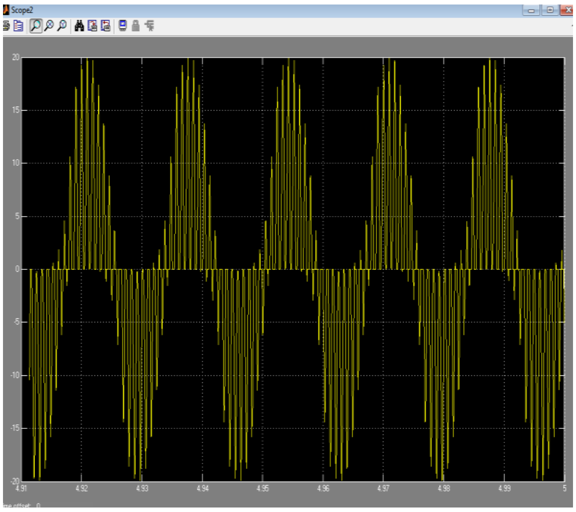

Fig.10. sinusoidal voltage at secondary side of transformer for half bridge converter.

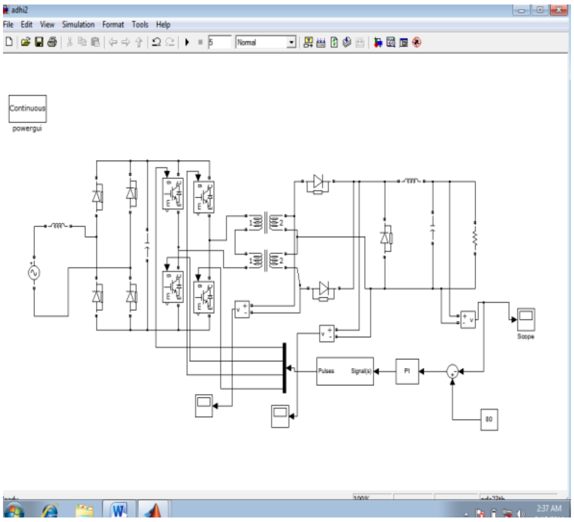

Fig.11.MATLAB Simulink model of full bridge converter.

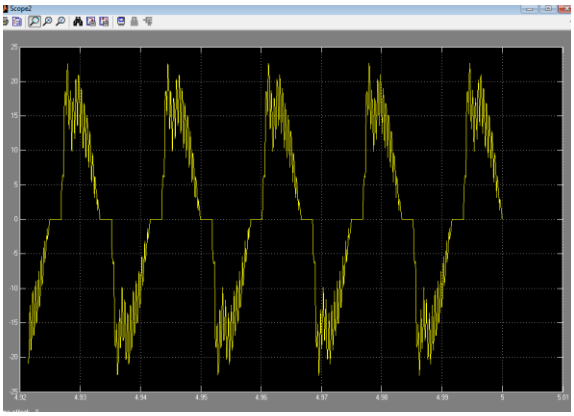

Fig.12. sinusoidal voltage at the secondary side of the transformer with harmonic content for full bridge converter.

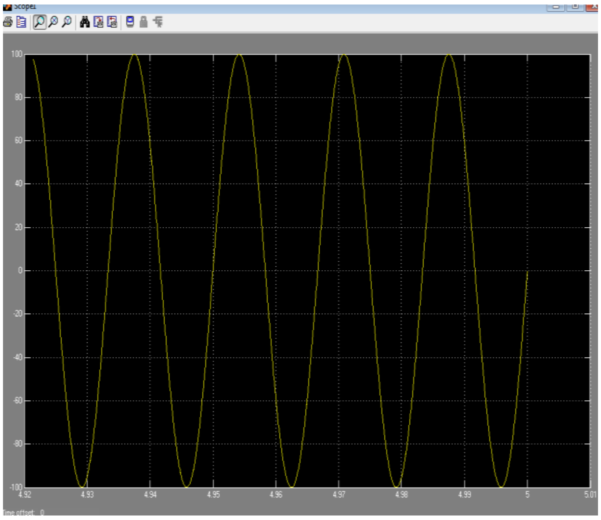

Fig.13. Input voltage for all converter.

V. CONCLUSION

Thus the single phase ac-dc converter provides a high level of power quality at ac mains and well regulated, ripple free dc outputs. Furthermore these converters to operate very wide range of ac main voltage and frequency variation.

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