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DESIGN AND IMPLEMENTATION OF FLYBACK BOOST PFC FOR IMPROVING EFFICIENCY

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ABSTRACT

Many researches are conducted on increasing the efficiency of Flyback boost converter (FBC) applied for power factor correction (PFC) by using high-performance power electronics devices and soft switching circuits, which is not helpful to reduce hardware cost and systematic complexity. In this paper, three intrinsic parameters affecting efficiency of FBC PFC are found and analyzed, including switching frequency value, boost inductor value and output voltage value. Based on the above findings, combining with limitations of current ripple, power factor, maximum magnetic flux density and volume of boost inductor, an optimization design method for high-efficiency FBC PFC is proposed. A PFC prototype is developed based on Si devices. Experimental result verifies that the proposed method can improve efficiency of FBC PFC with low-cost low-performance devices in the full-load range.

Keywords: Flyback boost converter (FBC), ZVS high frequency & pulse width modulation (PWM)

1.INTRODUCTION

Flyback boost converter (FBC) is commonly used for power factor correction (PFC) due to its advantages of low current ripple, small filtering volume and high power density, etc. Power-density is a key factor that limits application of FBC PFC, where requires small volume and light weight, such as on-board charger (OBC), laptop adapter and aircraft power supply. Heat sink, which is used to transfer heat generated by power loss to maintain working temperature of devices at the proper range, occupies a lot of volume in Flyback PFC. Therefore, it is necessary to reduce heat sink volume through increasing efficiency. If efficiency can be increased without adding any hardware cost and software cost, then total loss and heat can be decreased, heat sink volume can be reduced and power-density of FBC PFC can be increased. Many researchers have been conducted on improving efficiency of PFC by modifying topology to create soft switching condition for reducing switching loss.

2. LITERATURE REVIEW

2.1 A New Current Phasor-Controlled ZVS Twin Half-Bridge High-Frequency Resonant Inverter for Induction Heating

Tomokazu Mishima (2013): A novel soft-switching high-frequency (HF) resonant (HF-R) inverter for induction heating (IH) applications is presented in this paper. By adopting the current phasor control of changing a phase shift (PS) angle between two half-bridge inverter units, the IH load resonant current can be regulated continuously under the condition of wide range soft-switching operations. In addition to this, the dual mode power regulation scheme based PS angle control & asymmetrical pulse-width modulation (PWM) in one inverter unit is proposed for improving the efficiency in low output power settings. The essential performances on the output power regulation and soft-switching operations are demonstrated in an experiment using its 1kW- 60 kHz HF-R inverter prototype, then the topological validity is evaluated from a practical point of view.

2.2 High Power Density Series Resonant Inverter using an Auxiliary Switched Capacitor Cell for Induction Heating Applications

Bishwajit Saha, Rae-Young Kim (2013)- This project proposes a unique topology of voltage fed high frequency series load resonant inverter with a lossless snubber capacitor and an auxiliary switched cell for induction heating appliances. The main objective of this paper is to demonstrate how high power density can be achieved by including a switched capacitor cell with the capacitor-clamped half-bridge ZVS high frequency inverter circuit using the PWM control scheme. The operation principle of the proposed inverter circuit is based upon an asymmetrical duty cycle PWM control scheme. The operating performances of high frequency AC regulation and power conversion efficiency characteristics are shown through experiments with their soft-switching operating ranges.

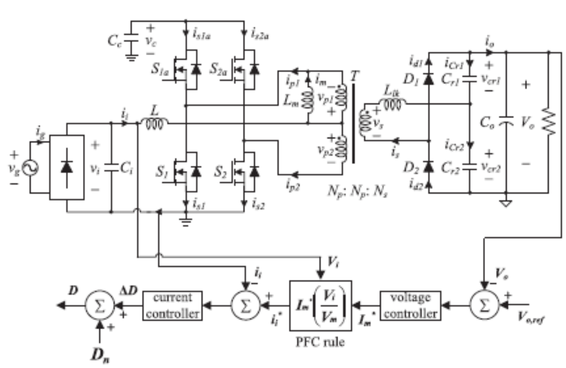
2.3 PV STRING PER-MODULE MAXIMUM POWER POINT ENABLING CONVERTERS

G.R. Walker (2011): Many grid connected PV installations consist of a single series string of PV modules and a single DCAC inverter. This efficiency of this topology can be enhanced with additional low power, low cost per panel converter modules. Most current flows directly in the series string which ensures high efficiency. However parallel Cuk or buck-boost DC-DC converters connected across each adjacent pair of modules now support any desired current difference between series connected PV modules. Each converter "shuffles" the desired difference in PV module currents between two modules and so on up the string. Spice simulations show that even with poor efficiency, these modules can make a significant improvement to the overall power which can be recovered from partially shaded PV strings.

3. EXISTING SYSTEM

The existing converter consists of a full-bridge diode rectifier, an isolated resonant dc–dc converter, and only one controller. The existing converter provides the PWM technique for all components operating at low frequency, allowing for an improvement in power density without a cost of power-conversion. Furthermore, by using a controls power factor and output power, the converter performs ac–dc power conversion in only a single-power processing step.

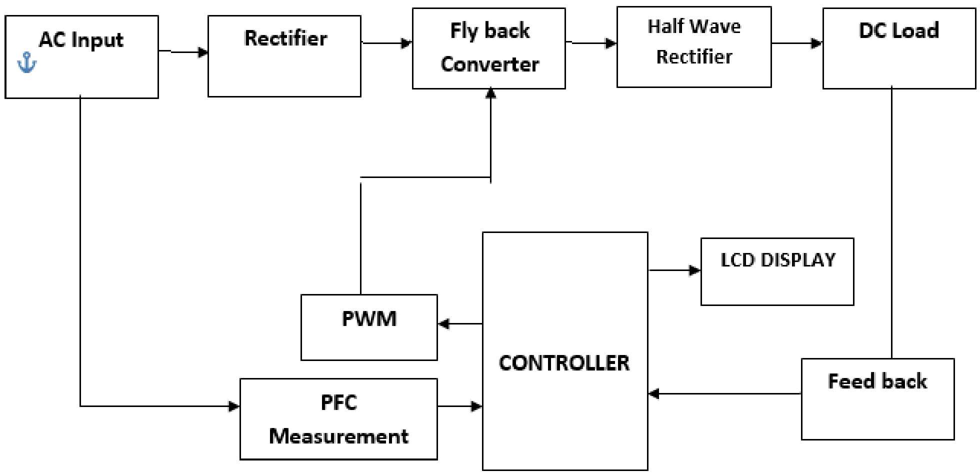
3.1 EXISTING BLOCK DIAGRAM



4. PROPOSED SYSTEM

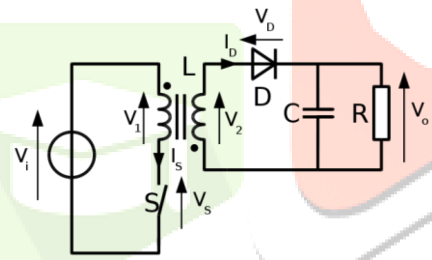
The development of new families of Boost flyback converter topologies used in the design of dc–dc and ac–dc converters with active power factor corrections (PFC's). The goal is to design high-efficiency and high-power density converters with improved power factor and low electromagnetic interference. In recent years, as the new standards became compulsory regarding limiting the total harmonic distortion and input power factor in power electronic circuits. Active PFC circuits that use pulse width modulation (PWM) switch-mode topologies such as the boost, buck–boost, and their derived ones have been used dominantly.

4.1 BLOCK DIAGRAM OF PROPOSED SYSTEM



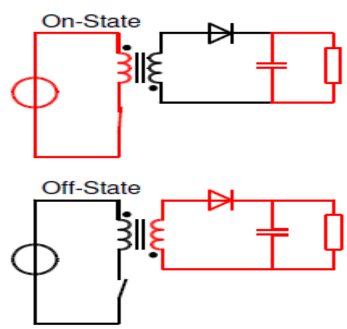
4.2 BLOCK DIAGRAM DESCRIPTION

4.2.1 FLYBACK CONVERTER



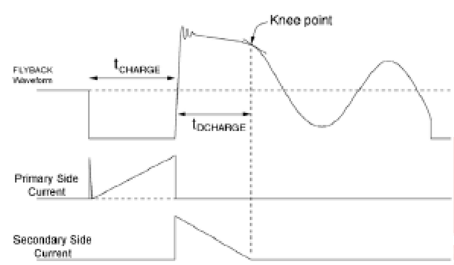
The **flyback converter** is used in both AC/DC and DC/DC conversion with galvanic between the input and any outputs. The flyback converter is a buck-boost converter with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation. When driving for example a plasma lamp or a voltage multiplier the rectifying diode of the boost converter is left out and the device is called a flyback transformer.

4.2.2 OPERATION



The flyback converter is an isolated power converter. The two prevailing control schemes are voltage mode control and current mode control (in the majority of cases current mode control needs to be dominant for stability during operation). Both require a signal related to the output voltage. There are three common ways to generate this voltage. The first is to use an optocoupler on the secondary circuitry to send a signal to the controller. The second is to wind a separate winding on the coil and rely on the cross regulation of the design. The third consists on sampling the voltage amplitude on the primary side, during the discharge, referenced to the standing primary DC voltage. The first technique involving an optocoupler has been used to obtain tight voltage and current regulation, whereas the second approach was developed for cost sensitive applications where the output did not need to be as tightly controlled but up to 11 components including the optocoupler could be eliminated from the overall design. Also, in applications where reliability is critical, optocouplers can be detrimental to the MTBF (Mean Time Between Failure) calculations. The third technique, primary-side sensing, can be as accurate as the first and more economical than the second, yet requires a minimum load so that the discharge-event keeps occurring, providing the opportunities to sample the 1: N secondary
voltage at the primary winding (during Tdischarge, as per Fig3).

4.2.3 WAVE FORM



A variation in primary-side sensing technology is where the output voltage and current are regulated by monitoring the waveforms in the auxiliary winding used to power the control IC itself, which have improved the accuracy of both voltage and current regulation. The auxiliary primary winding is used in the same discharge phase as the remaining secondaries, but it builds a rectified voltage referenced commonly with the primary DC, hence considered on the primary side. Previously, a measurement was taken across the whole of the flyback waveform which led to error, but it was realized that measurements at the so-called *knee point* (when the secondary current is zero, see Fig. 3) allow for a much more accurate measurement of what is happening on the secondary side. This topology is now replacing ringing choke converters (RCCs) in applications such as mobile phone chargers.

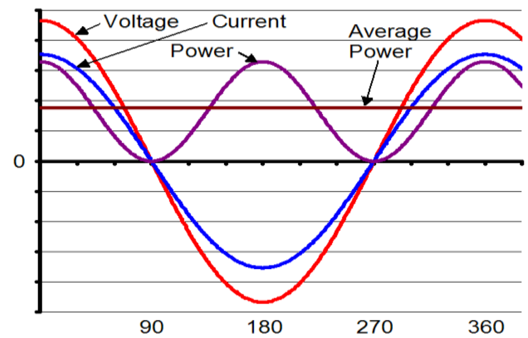
5. POWER FACTOR CORRECTION

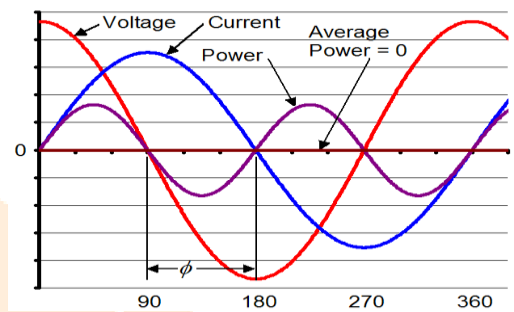
The power factor of an AC electric power system is defined as the ratio of the real power to the apparent power, and is a number between 0 and 1 (frequently expressed as a percentage, e.g. .5 pf = 50% pf). Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power can be greater than the real power. Low-power-factor loads increase losses in a power distribution system and result in increased energy costs.

Instantaneous and average power calculated from AC voltage and current with a unity power factor ($\varphi=0$, $\cos\varphi=1$)

Instantaneous and average power calculated from AC voltage and current with a zero power factor ($\varphi=90$, $\cos\varphi=0$)

Instantaneous and average power calculated from AC voltage and current with a lagging power factor (φ=45, cosφ=0.71)





AC power flow has the three components: real power (P), measured in watts (W); apparent power (S), measured in volt-amperes (VA); and reactive power (Q), measured in reactive volt-amperes (VAr).

The power factor is defined as:

In the case of a perfectly sinusoidal waveform, P, Q and S can be expressed as vectors that form a vector triangle such that:

If is the phase angle between the current and voltage, then the power factor is equal to, and:

Since the units are consistent, the power factor is by definition a dimensionless number between 0 and 1. When power factor is equal to 0, the energy flow is entirely reactive, and stored energy in the load returns to the source on each cycle. When the power factor is 1, all the energy supplied by the source is consumed by the load. Power factors are usually stated as "leading" or "lagging" to show the sign of the phase angle, where leading indicates a negative sign.

If a purely resistive load is connected to a power supply, current and voltage will change polarity in step, the power factor will be unity (1), and the electrical energy flows in a single direction across the network in each cycle. Inductive loads such as transformers and motors (any type of wound coil) consumes reactive power with current waveform lagging the voltage. Capacitive loads such as capacitor banks or buried cable generate reactive power with current phase leading the voltage. Both types of loads will absorb energy during part of the AC cycle, which is stored in the device's magnetic or electric field, only to return this energy back to the source during the rest of the cycle.

For example, to get 1 kW of real power if the power factor is unity, 1 kVA of apparent power needs to be transferred (1 kW ÷ 1 = 1 kVA). At low values of power factor, more apparent power needs to be transferred to get the same real power. To get 1 kW of real power at 0.2 power factor 5 kVA of apparent power needs to be transferred (1 kW ÷ 0.2 = 5 kVA).

It is often possible to adjust the power factor of a system to very near unity. This practice is known as *power factor correction* and is achieved by switching in or out banks of inductors or capacitors. For example, the inductive effect of motor loads may be offset by locally connected capacitors.

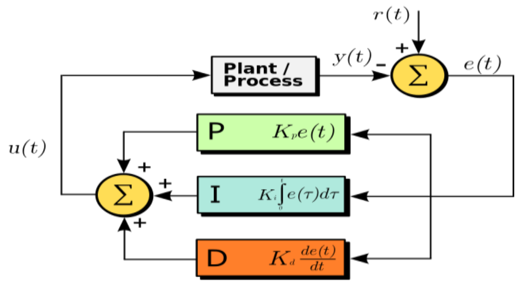
5.1 IMPORTANCE OF POWER FACTOR

A power factor of one or "unity power factor" is the goal of any electric utility company since if the power factor is less than one, they have to supply more current to the user for a given amount of power use. In so doing, they incur more line losses. They also must have larger capacity equipment in place than would be otherwise necessary. As a result, an industrial facility will be charged a penalty if its power factor is much different from 1. Industrial facilities tend to have a "lagging power factor", where the current lags the voltage (like an inductor). This is primarily the result of having a lot of electric induction motors - the windings of motors act as inductors as seen by the power supply. Capacitors have the opposite effect and can compensate for the inductive motor windings. Some industrial sites will have large banks of capacitors strictly for the purpose of correcting the power factor back toward one to save on utility company charges.

5.2 PROPORTIONAL-INTEGRAL-DERIVATIVE CONTROLLER (PID):

A **proportional-integral-derivative controller** (**PID controller**) is a control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an *error* value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the *error* by adjusting the process through use of a manipulated variable.

The PID controller algorithm involves three separate constant parameters, and is accordingly sometimes called **three-term control**: the proportional, the integral and derivative values, denoted *P*, *I*, and *D*.Simply put, these values can be interpreted in terms of time: *P* depends on the *present* error, *I* on the accumulation of *past* errors, and *D* is a prediction of *future* errors, based on current rate of change.[1] The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, a damper, or the power supplied to a heating element.



In the absence of knowledge of the underlying process, a PID controller has historically been considered to be the best controller. [2] By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the setpoint, and the degree of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system or system stability.

Some applications may require using only one or two actions to provide the appropriate system control. This is achieved by setting the other parameters to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are fairly common, since derivative action is sensitive to measurement noise, whereas the absence of an integral term may prevent the system from reaching its target value due to the control action.

6. SYSTEM SPECIFICATION

HARDWARE REQUIREMENTS

Personal Computer

SOFTWARE REQUIREMENTS

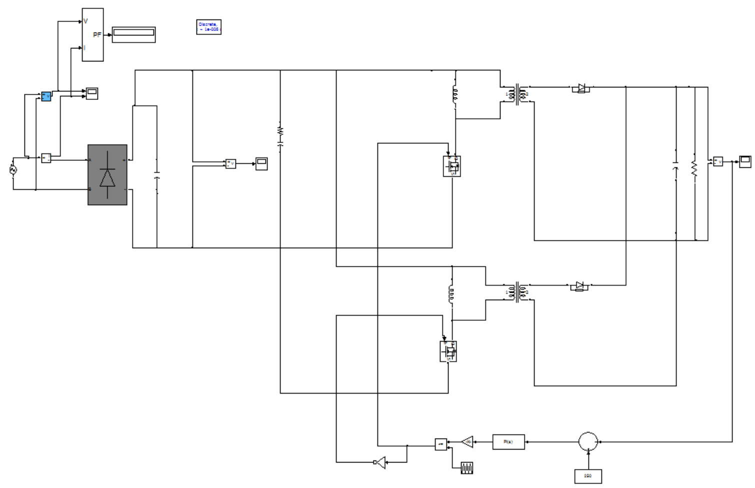
Matlab version 7.10

Windows XP operating system.

SOFTWARE SIMULATOR

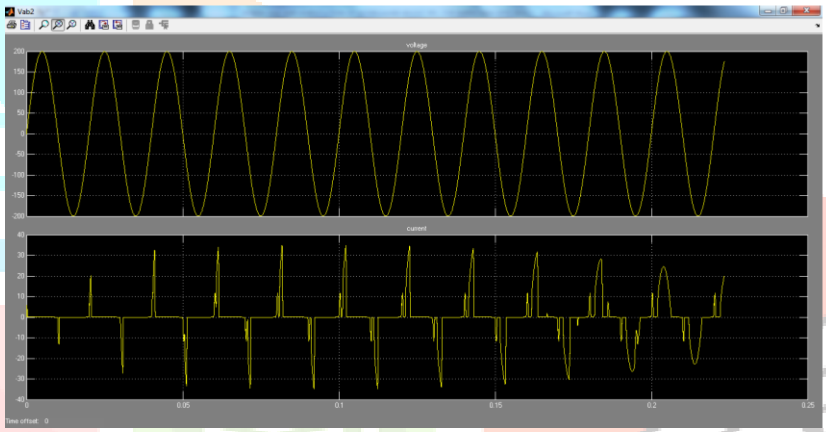
MATLAB

7. SIMULATION DIAGRAM

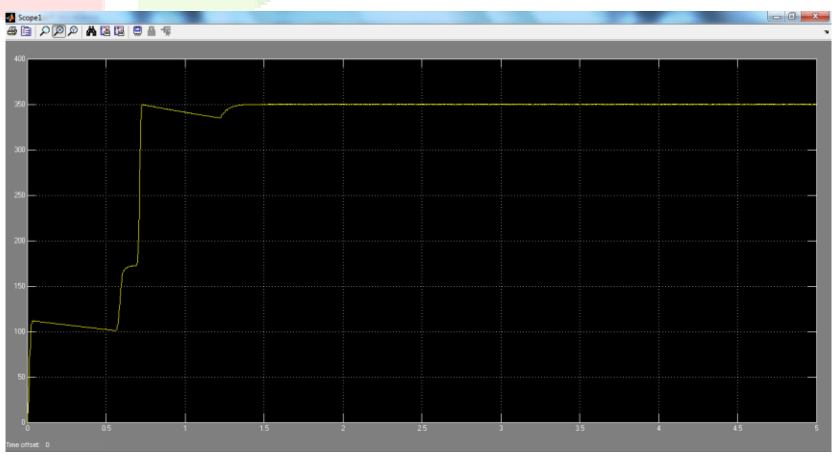


8. SIMULATION RESULT

8.1 INPUT VOLTAGE AND CURRENT



8.2 OUTPUT VOLTAGE AND CURRENT



9. CONCLUSION

To improve the power factor under the light load, we propose a duty-ratio feed-forward controller for the fly back PFC converter. The interleaved PFC converter features step-up/down ability, low cost, and high efficiency. However, it suffers from low power factor and total harmonic distortion under the light load due to the input capacitor effect. The proposed feed-forward controller aims at compensating the phase leaded current caused by the input capacitor. We describe the implementation of the controller, the required compensated current, and the controller structure in detail. We conducted experiments with a prototype to verify the operation of the proposed feed-forward controller. The proposed feed forward controller significantly increased the power factor of the converter. Meanwhile, the output voltage of the PFC converter is well regulated.

10. REFERENCES

[1] C. A. Gallo, F. L. Tofoli, and J. A. C. Pinto, “Two-stage isolated switch mode power supply with high efficiency and high input power factor,” *IEEE Trans. Ind. Electron.*, vol. 57, no. 11, pp. 3754–3766, Nov. 2010.

[2] K.Y. Lee andY. S. Lai, “Novel circuit design for two-stage ac/dc converter to meet standby power regulations,” *IET Power Electron*, vol. 2, no. 6, pp. 625–634, Nov. 2009

[3] H. Wang, S. Dusmez, and A. Khaligh, “Design considerations for a level-2 on-board PEV charger based on interleaved boost PFC and LLC resonant converters,” in *Proc. IEEE Trans. Elect. Conf. Expo.*, 2013, pp. 1–8.

[4] J.-H. Kim, M.-Y. Kim, C.-O. Yeon, and G.W. Moon, “Analysis and design of boost-LLC converter for high power density AC-DC adapter,” in *Proc. IEEE Energy Convers. Congr. Expo. Asia*, 2013, pp. 6–11.

[5] K. Raggl, T. Nussbaumer, G. Doerig, J. Biela, and J. W. Kolar, “Comprehensive design and optimization of a high-power-density single-phase boost PFC,” *IEEE Trans. Ind. Electron.*, vol. 56, no. 7, pp. 2574–2587, Jul. 2009.

[6] I.-O. Lee and G.-W. Moon, “A new asymmetrical half-bridge converter with zero DC-offset current in transformer,” *IEEE Trans. Power Electron.*, vol. 28, no. 5, pp. 2297–2306 May 2013.

[7] B.Whitaker *et al.*, “A high-density, high-efficiency, isolated on-board vehicle battery charger utilizing silicon carbide power device,” *IEEE Trans. Power Electron.*, vol. 29, no. 5, pp. 2606–2617 May 2014.

[8] S. Zong, H. Luo, W. Li, X. He, and C. Xia, “Theoretical evaluation of stability improvement brought by resonant current loop for paralleled LLC converters,” *IEEE Trans. Ind. Electron.*, vol. 62, no. 7, pp. 4170–4180, Jul. 2015.

[9] S.-H. Lee, C.-Y. Park, J.-M. Kwon, and B.-H. Kwon, “Hybrid-type full bridge dc/dc converter with high efficiency,” *IEEE Trans. Power Electron.*, vol. 30, no. 8, pp. 4156–4164, Aug. 2015.

[10] T. Yan, J. Xu, F. Zhang, J. Sha, and Z. Dong. “Variable-on-time-controlled critical-conduction-mode flyback PFC converter,” *IEEE Trans. Ind. Electron.*,
vol. 61, no. 11, pp. 6091–6099, Nov. 2014.