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DESIGN CONSIDERATIONS FOR HIGH VOLTAGE HIGH POWER FULL BRIDGE ZERO VOLTAGE SWITCHED CONVERTER

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Abstract:
This project presents a hybrid-type full-bridge dc/dc converter with high efficiency. Using a hybrid control scheme with a simple circuit structure, the proposed dc/dc converter has a hybrid operation mode. Under a normal input range, the proposed converter operates as a phase-shift full-bridge series-resonant converter that provides high efficiency by applying soft switching on all switches and rectifier diodes and reducing conduction losses. When the input is lower than the normal input range, the converter operates as an active-clamp step-up converter that enhances an operation range. Due to the hybrid operation, the proposed converter operates with larger phase-shift value than the conventional converters under the normal input range. Thus, the proposed converter is capable of being designed to give high power conversion efficiency and its operation range is extended. A 1-kW prototype is implemented to confirm the theoretical analysis and validity of the proposed converter

INTRODUCTION:

The demands on dc/dc converters with a high power density, high efficiency, and low electromagnetic interference (EMI) have been increased in various industrial fields. As the switching frequency increases to obtain high power density, switching losses related to the turn-on and turn-off of the switching devices increase. Because these losses limit the increase of the switching frequency, soft switching techniques are indispensable. Among previous dc/dc converters, a phase-shift full-bridge (PSFB) converter is attractive because all primary switches are turned on with zero- voltage switching (ZVS) without additional auxiliary circuits.

EXISTING SYSTEM:

Among previous dc/dc converters, a phase-shift full- bridge (PSFB) converter is attractive because all primary switches are turned on with zero-voltage switching (ZVS) without additional auxiliary. The PSFB converter has some serious problems such as narrow ZVS range of lagging-leg switches, high power losses by circulating current, and voltage ringing across rectifier diodes. Especially, with a requirement of wide input range, the PSFB converter is designed to operate with small phase-shift value under the normal input range; the design of the

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PSFB converter lengthens the freewheeling interval and causes the excessive circulating current which increases conduction losses. The PSFB converters extend ZVS range or reduce the circulating current by utilizing additional passive or active auxiliary circuits. The additional circuits result in complicated circuit configuration, complex control strategy, and extra power losses. In addition, some PSFB converters still require the extra snubber to prevent serious voltage ringing problem across rectifier diodes.

The PSFB converters employing a series-resonant converter have been introduced, namely, the PSFB series-resonant converters; they have many advantages such as soft switching techniques of all primary switches and rectifier diodes, elimination of circulating current, reduction of voltage stress on rectifier diodes,and a simple circuit structure. Active-clamp circuits have been commonly used to absorb surge energy stored in leakage inductance of a transformer. Moreover, the circuits provide a soft switching technique. Some studies have introduced dc/dc converters combining the active-clamp circuit and voltage doubler rectifier. The circuit configuration allows achieving a step-up function like a boost converter.The voltage stresses of rectifier diodes are also clamped at the output voltage and no extra snubber circuit is required.

PROSED SYSTEM:

A novel hybrid-type full-bridge (FB) dc/dc converter with high efficiency is proposed. The converter is derived from a combination of a

1.PSFB series-resonant converter and

2.An active-clamp step-up converter

3. Voltage doubler circuit.

Using a hybrid control scheme with a simple circuit structure, the proposed converter has two operation modes. Under the normal input range, the proposed converter operates as a PSFB series-resonant converter. The proposed converter yields high efficiency by applying soft switching techniques on all the primary switches and rectifier diodes and by reducing conduction losses. When the input voltage is lower than the normal input range, the converter operates as an active-clamp step-up converter. In this mode, the proposed converter provides a step-up function by using the active-clamp circuit on the primary side and the voltage doubler rectifier on the secondary side. Due to the hybrid operation, the proposed converter operates with larger phase-shift value than the conventional PSFB converters under the normal input range.Thus, the proposed converter has the following advantages:

1) Under the normal input range, the proposed converter can be designed to optimize power conversion efficiency;

2) When the input is lower than the normal input range, the proposed converter performs a step-up function, which enhances the operation range;

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3) Without complex circuit structures, the converter have high efficiency under the normal input range and extends the operation range.

TECHNOLOGY:

The following technology is used in the paper:

- Active-clamp circuit.
- Full-bridge circuit.
- Phase shift control.

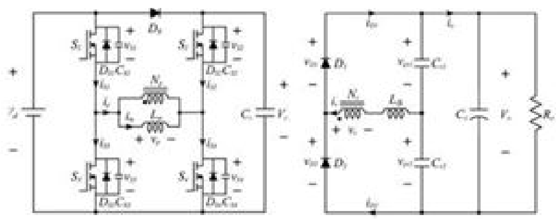

Fig. 1. Circuit diagram of the proposed hybrid-type full-bridge dc/dc converter.

WORKING PRINCIPLE:

Above figure shows a circuit diagram of the implementation of converter. On the primary side of the power transformer T, the proposed converter has an FB circuit with one blocking diode DB and one clamp capacitor Cc. On the secondary side, there is a voltage double rectifier. To analyze the steady-state operation of the proposed converter, several assumptions are made all switches S1 , S2 , S3 , and S4 are considered as ideal switches except for their body diodes and output capacitors, the clamp capacitor Cc and output capacitor Co are large enough, so the clamp capacitor voltage Vc and output voltage Vo have no ripple voltage, respectively, the transformer T is composed of an ideal transformer with the primary winding turns Np , the secondary winding turns Ns , the magnetizing inductance Lm , and the leakage inductance Llk. The capacitance of the resonant capacitors Cr1 and Cr2 is identical. Thus, Cr1 = Cr2.

Modes of operation:

A.PSFB Series-Resonant Converter Mode

B.Active-Clamp Step-Up Converter Mode

A.PSFB Series-Resonant Converter Mode:

Normal input voltage range, converter is operated by shifting phase control. In this mode, Vc is the same as the input voltage Vd and DB is conducted. All switches are driven with a constant duty ratio 0.5 and short dead time.

Mode 1 [t0 , t1]: Prior to t0 , the switches S1 and S2 are in onstate and the secondary current is is zero. The primary current ip flows through DB , S1 , S2 , and Lm . During this mode, the primary voltage vp and secondary voltage vs of the transformer T are zero

Mode 2 [t1 , t2]: At t1 , S2 is turned off. Because ip flowing through S2 is very low, S2 is turned off with near zero-current. In this mode, ip charges CS2 and discharges CS4

Mode 3 [t2 , t3]: At t2 , the voltage across S4 reaches zero. At the same time, ip flows through the body diode DS4 . Thus, S4 is turned on with zero-voltage while DS4 is conducted. In this mode, vsisnVd where the turn ratio n of the transformer is given by Ns/Np and the secondary current is begins to flow through D1.

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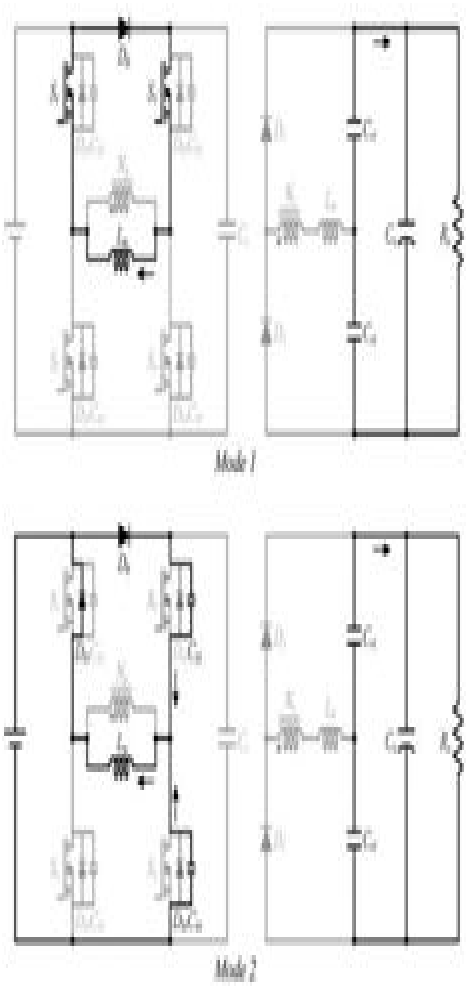
Mode 4 [t3 , t4]: This mode begins when S1 is turned off. The primary current ipcharges CS1 and discharges CS3 . When the voltage across S3 becomes zero, ip flows through the body diode DS3 . Thus, S3 is turned on with zero-voltage while DS3 is conducted. When vp is zero, D1 is still conducted and −vcr1 is applied to Llk .Thus, the secondary current is goes to zero rapidly. Since operations during the next half switching period are similar with Mode 1–4, explanations of **Mode 5**–8 are not presented.



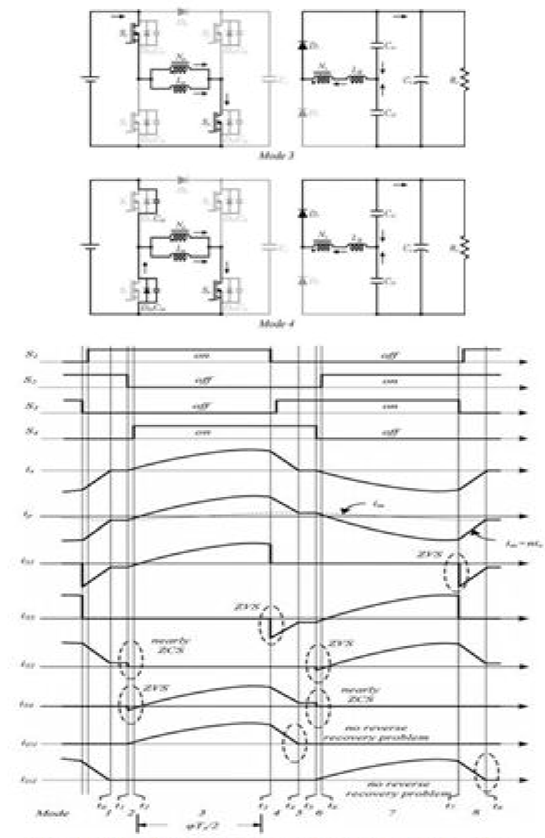


Fig. 2.Operation waveforms in the PSFB series-resonant converter mode.

B. Active-Clamp Step-Up Converter Mode:

As the input voltage decreases up to a certain minimum value of the normal input range, the phase- shift value ϕ increases up to its maximum value, 1. If the input voltage is lower than the minimum value of the normal input range, the proposed converter is operated by dual asymmetrical pulse width modulation (PWM) control. The switches (S1 , S4) and (S2 , S3) are treated as switch pairs and operated complementarily with short dead time. The duty D over 0.5 is based on (S1 , S4) pair. In this situation,the clamp capacitor voltage Vc is higher than Vd . Then, the blocking diode DB is the state

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equation is written as follows.

$$L_{lk}\frac{di_s(t)}{dt} = nV_d - v_{cr1}(t)$$

$$i_s(t) = C_{r1}\frac{dv_{cr1}(t)}{dt} - C_{r2}\frac{dv_{cr2}(t)}{dt} = C_r\frac{dv_{cr1}(t)}{dt},$$

$$i_s(t) = i_s(t_3)\cos\omega_r(t-t_3) - \frac{nV_c - v_{cr2}(t_3)}{Z_r}\sin\omega_r(t-t_3).$$

Mode 2 [t1 , t2]: At t1 , S1 and S4 are turned off. The primary current ip charges and discharges the output capacitors of the switches during very short time.

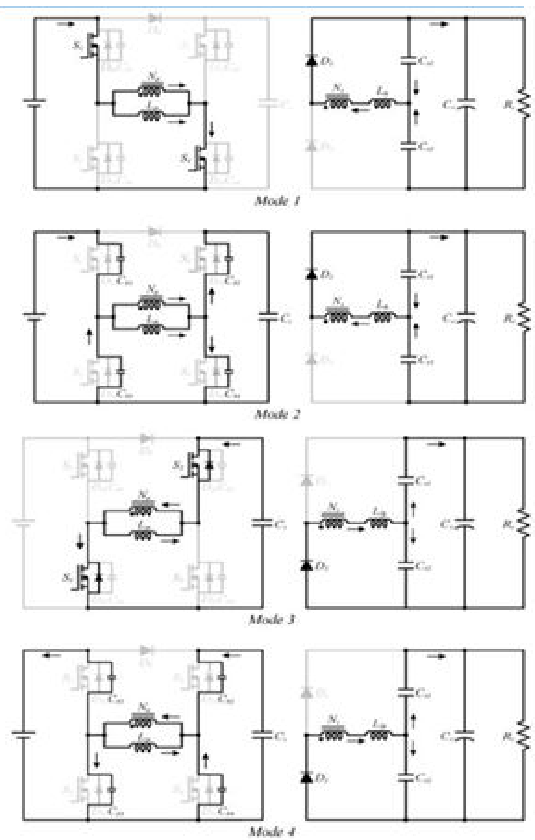

Figure 2: Equivalent circuits during a switching period in the active-clamp step up converter mode

Reverse biased and the proposed converter operates as the active-clamp step-up converter.

Mode 1 [t0 , t1]: At t0 , S1 and S4 are turned on. Since Vd is applied to Lm , the magnetizing current im is linearly increased and is expressed as

$$i_m(t) = i_m(t_0) + \frac{V_d}{L_m}(t - t_0).$$

Mode 3 [t2 , t3]: This mode begins when the voltages across S2 and S3 are zero. At the same time, ip flows through DS2 and DS3 . Thus, S2 and S3 are turned on with zero-voltage. Since the negative voltage −Vc is applied to Lm , the magnetizing current im decreases linearly.

Mode 4 [t3 , t4]: At t3 , S2 and S3 are turned off. The primary current ip charges CS2 , CS3 and discharges CS1 , CS4 during very short time.

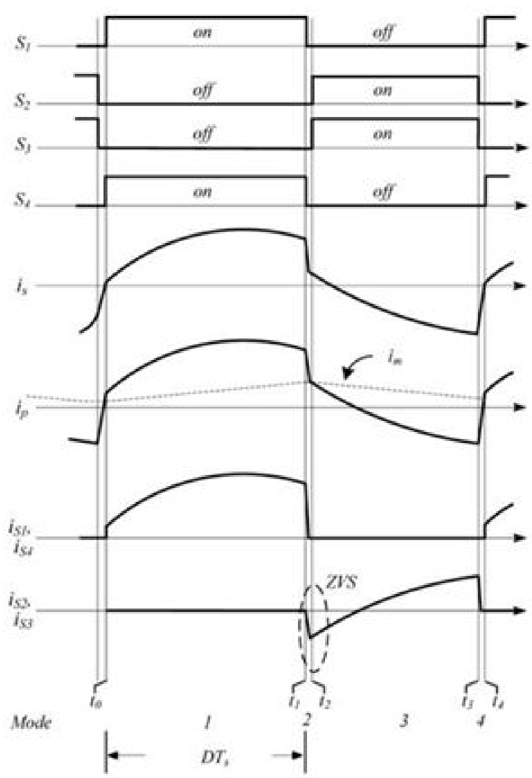

Figure 3: Active-clamp Step up converter mode waveform

Explanation:

In the PSFB series-resonant converter mode, Mode 4 is neglected since the duration of Mode 4 is relatively very short. During Mode 3, the secondary

current is in
(5) flows through D1 ; the current is the same as sum of the current charging Cr1 and current discharging Cr2 . As shown in Fig. 3, during the half switching period Ts/2, Cr2 is discharged as much as the load current io while Cr1 is charged. Thus, the

$$v_{cr1}(t_2) = \frac{V_o}{2} - \frac{\Delta v_{cr1}}{2} = \frac{V_o}{2} - \frac{1}{2C_{r1}} \int i_{cr1}(\tau) d\tau$$
$$= \frac{V_o}{2}\left(1 - \frac{T_s}{2C_{r1}R_o}\right) = \frac{V_o}{2}\left(1 - \frac{\pi Q}{2F}\right)$$

Where the frequency ratio F and quality factor Q are given by

$$F = \frac{f_s}{f_r}, \quad Q = \frac{4\omega_r L_{lk}}{R_o} = \frac{4}{\omega_r C_r R_o}.$$

Because the average value of the current flowing through D1 during Ts/2 is the same as 2io and is zero during next half switching period, the average value of the current flowing through D1 during Ts is equal to io. Thus, the load current io can be derived as

$$i_o = \frac{V_o}{R_o} = \frac{1}{T_s}\left[\int_{t_2}^{t_2+\varphi T_s/2} \frac{nV_d - v_{cr1}(t_2)}{Z_r} \sin \omega_r(\tau - t_2) d\tau\right]$$
$$= F\left[\frac{nV_d - v_{cr1}(t_2)}{2\pi Z_r}\left(1 - \cos\frac{\pi\varphi}{F}\right)\right]. \quad (18)$$

By the volt–second balance law for the magnetizing inductance Lm, the following equations are derived average value of the current flowing through D1 is the same as twice the load current during Ts/2. Due to the symmetric operation, the average value of the current flowing through D2 is also twice the load current during the next half switching period. Both average values of vcr1 and vcr2 are Vo/2 and vcr1 (t2) in (5) which are obtained from the ripple voltage Δvcr1 of Cr1

$$nV_d DT_s = \frac{n^2 L_m}{n^2 L_m + L_{lk}} V_{cr2}(1 - D)T_s$$

$$\frac{n^2 L_m}{n^2 L_m + L_{lk}} V_{cr1} DT_s = nV_c(1 - D)T_s$$

Where Vcr1 and Vcr2 are the average values of the voltages across Ccr1 and Ccr2 , respectively. The sum of Vcr1 and Vcr2 is Vo.

TABLE I: PARAMETERS OF THE PROTOTYP

Parameters	Symbols	Value
Input voltage	V_d	250–350 V
Output voltage	V_o	200 V
Switching frequency	f_s	50 kHz
Primary winding turns	N_p	24 turns
Secondary winding turns	N_s	8 turns
Magnetizing inductance	L_m	695 μH
Leakage inductance	L_{lk}	8.3 μH
Clamp capacitor	C_c	11 μF
Resonant capacitors	C_{r1}, C_{r2}	680 nF
Output capacitor	C_o	680 μF

IMPLEMENTATION:

A 1-kW prototype was built and tested. The operation range of the proposed converter is from 250 to 350 V. The output voltage is designated as 200 V and the normal input range is set up from 320 to 350 V. Considering power conversion efficiency under the normal input range, the proposed converter is designed. To obtain ZVS turn-on of the switches, the switching frequency fs should be higher than the resonant frequency fr . By the design rule proved in [15], the frequency ratio F (fs/fr) is

SOFTWARE TOOLS:

- Simulink

• It is a commercial tool for modeling, simulating and analyzing multi domain dynamic systems.

• Its primary interface is a graphical block diagramming tool and a

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customizable set of block libraries.

• Simulink is widely used in control theory and digital signal processing for multi domain simulation and Model based design.

➢ Other Features

• 2-D and 3-D graphics functions for visualizing data

• Tools for building custom graphical user interfaces

• Functions for integrating MATLAB based algorithms with external applications and languages, such as C, C++, Fortran, Java, COM, and Microsoft Excel.

• ADVANTAGES:

Thus, the proposed converter has the following advantages:

1) Under the normal input range, the proposed converter can be designed to optimize power conversion efficiency;

2) When the input is lower than the normal input range, the proposed converter performs a step-up function, which enhances the operation range;

3) Without complex circuit structures, the converter have high efficiency under the normal input range and extends the operation range

SIMULINK RESULTS AND OUTPUTS:

selected to be slightly more than one. If Q is too small, the proposed converter is operated with small ϕ under the normal input range.

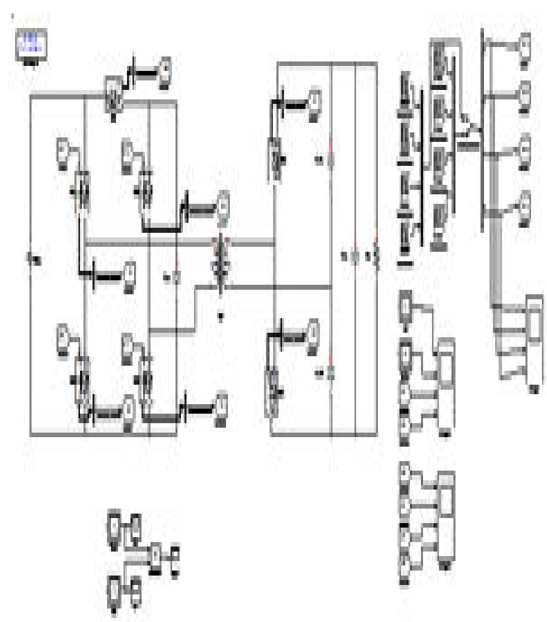
➢ **APPLICATIONS:**

1. Technical computing
2. Engineering and sciences applications

• Electrical Engineering
• DSP and DIP
• Automation
• Communication purpose
• Aeronautical
• Pharmaceutical Financial services

APPLICATION:

Where we need the following advantages, The proposed converter operates as a phase-shift full- bridge series-resonant converter that provides high efficiency by applying soft switching on all switches and rectifier diodes and reducing conduction losses. When the input is lower than the normal input range, the converter operates as an active-clamp step-up converter that enhances an operation range



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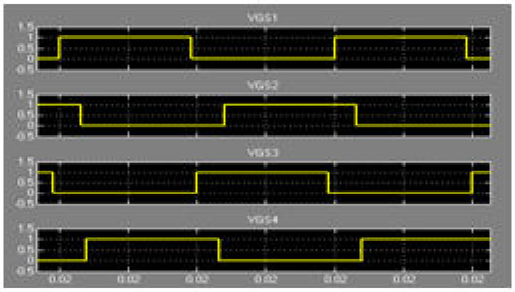
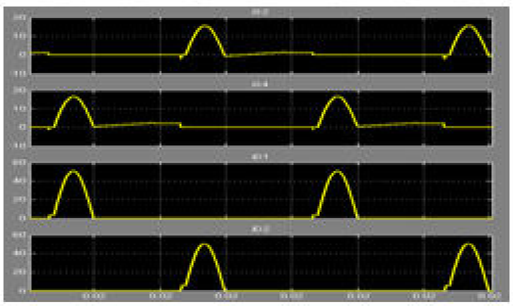
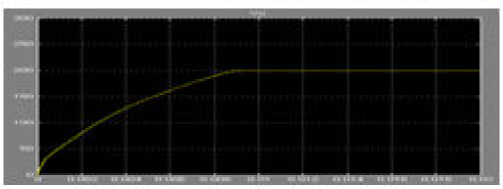
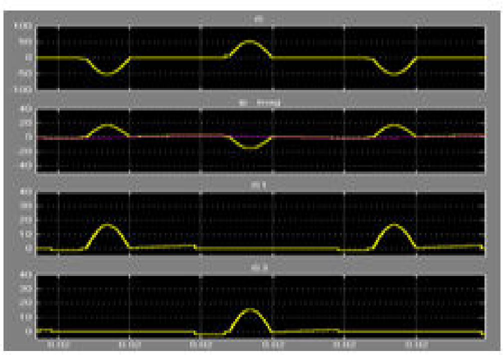
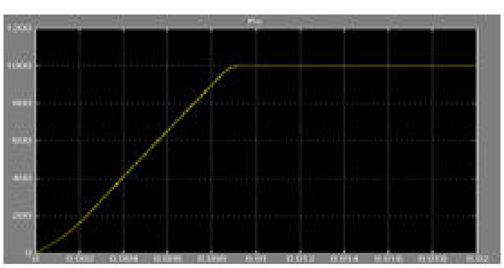




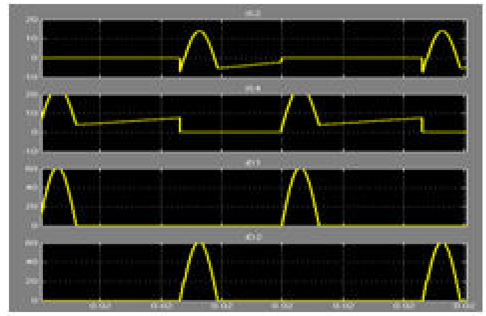


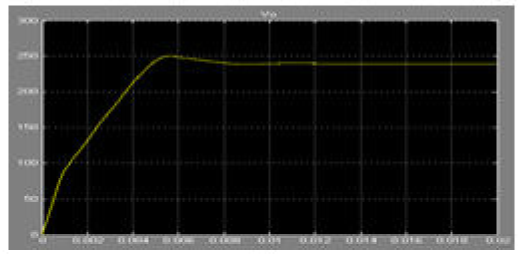


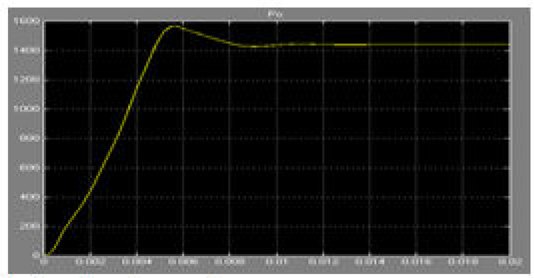


PSFB series-resonant converter mode wave forms.

a) Gate pulses b) transformer current and switch currents c)switch and diode currents d)output voltage e)output power







Active clamping mode

a) Gate pulses b) transformer current and switch currents c) switch and diode currents d)output voltage e)output power

CONCLUSION:

The novel hybrid-type full-bridge dc/dc converter with high efficiency has been introduced and verified by the analysis and experimental results. By using the hybrid control scheme with the simple circuit structure, the proposed converter has both the step-down and step-up functions, which ensure to cover the wide input range. Under the normal input range, the proposed converter achieves high efficiency by providing soft switching technique to all the switches and rectifier diodes, and reducing the current stress.

When the input is lower than the normal input range, the proposed converter provides the step-up function by using the active-clamp circuit and voltage doubler, which extends the operation range. To confirm the validity of the proposed converter, 1 kW Under the normal input range, the conversion efficiency is over 96% at full-load condition, and the input range from 250 to 350 V is guaranteed. Thus, the proposed converter has many advantages such as high efficiency and wide input range

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