The Applicant Research of Isolated Boost Full-Bridge Circuit on Aerial Ground Power System

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Abstract: It is necessary to develop a DC/DC converter power of high-power, low-voltage and heavy current inputting. On the basis of overall considering the different features between the converter topologies in our country, the author takes the isolated boost full-bridge circuit as the main circuit topology of the system and analyzes the theory and the modal of the boost full-bridge circuit. Also the author takes the double-loop PWM control strategy-voltage outer and current inner to control the circuit and analyzes it' s theory . Finally, according to the simulation analysis, the author provided the rationality and correctness of the scheme.

Key words: DC/DC, converter power of high-power, the isolated boost full-bridge circuit

1 Introduction

According to the new aviation ground power design requirements, the need to DC / AC module provides two sets of 180V DC, which means that 28.5VDC need to be converted to 180VDC. In this paper, as a single module power supply, a low voltage input for high current circuit topology-isolated boost full-bridge circuit was used to control circuits using two-loop PWM control strategy.

2 An isolated boost full-bridge circuit theory and modal analysis

From the characteristics of the circuit, it is known that switch off at the same time does not allow, since the energy which are stored in the inductor during the circuit without the release will form large voltage spikes. Therefore, switch drive pulse account air ratio should be greater than 0.5 and 180-degree phase difference during the design of steady-state work. In this condition, the controlled scheme is PWM.

The detailed main waveform of isolated boost full-bridge circuit is showed in Fig. 1, supposing the device is a stable state and ideal at t0. And the mode converter equivalent circuit of a switching cycle of the switch could be got from Fig. 2.

The following is the analysis of switch mode:

[t0-t1]: Power switch Q_1、Q_4 on and Q_2、Q_3 off, inductor forms a loop through Q1, transformer primary side Q4. The energy stored in the inductor and power transformer of energy is charged to the load provide energy by transferring to the secondary side through the output filter capacitor to.

[t1-t2]: Power switch Q_2、Q_3，Q_1、Q_4 on at the same time when the circuit is in Boost mode, the power of the input inductor charge.

[t2-t3]: Power switch Q_2、Q_3，Q_1、Q_4 off, and inductor forms a loop through Q_2 the transformer primary side Q_3. The energy stored in the inductor and power transformer of energy is charged to the load energy by transferring to the secondary side through to the output filter capacitor, which is similar with the switch mode of 1.

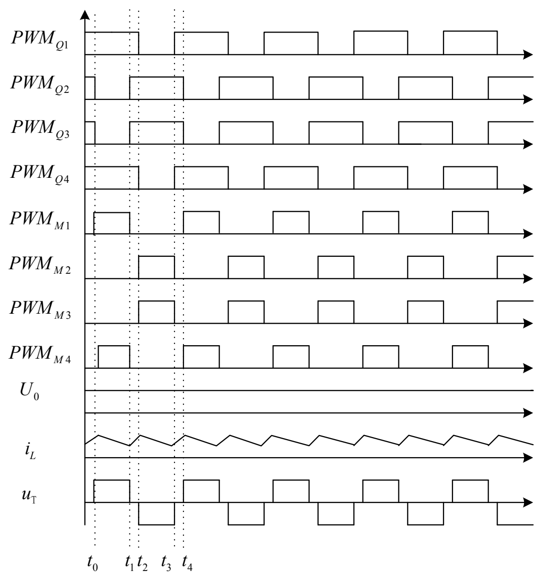

Figure 1 Main parts of circuit waveforms

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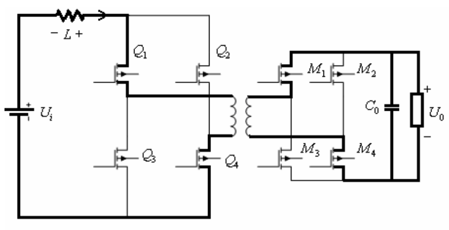
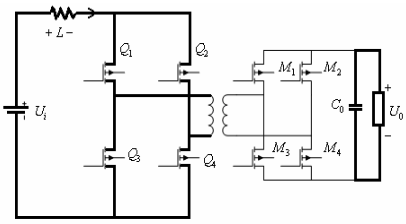
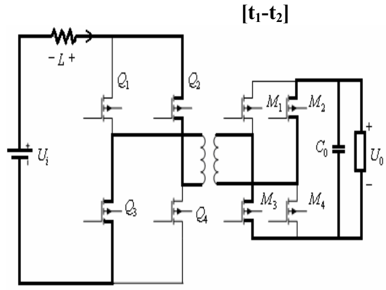
[t3-t4]: Power switch Q_1、Q_2、Q_3、Q_4 on at the same time, when the circuit is in Boost mode, the power of the input inductor charge, which is similar with the switch mode of 2.



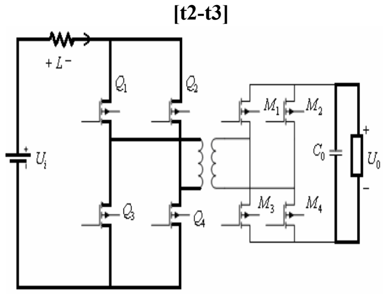
[t_0-t_1]



[t_1-t_2]



[t2-t3]



[t3-t4]

Figure 2 Switch mode

3 Work Principle of Control circuit

PWM control circuit is mainly constituted by the voltage loop proportional integral regulator and current loop comparator constituted. Using the instantaneous value of voltage and current double closed-loop feedback control to control the output voltage, the output voltage is always maintained at DC 180V.

3.1 Voltage proportional integral regulator

The primary role of voltage loop proportional integral regulator is as following: Giving the feedback voltage and the error between the reference voltage signal amplification integral processing, it could let the feedback voltage signal track a given reference voltage signal. To ensure the output voltage could track a given reference voltage, it need to reduce the static errors as much as possible. As a current loop output signal, same voltage regulator could make current feedback signal track the current loop shown in Fig.3.

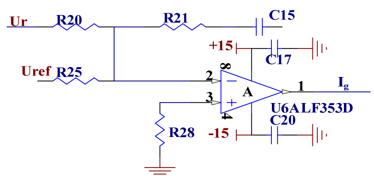


Figure 3 Voltage proportional integral regulator

Voltage regulator expression can be written as:

$$I_g = \left(\frac{U_{ref}}{R_{25}} - \frac{U_r}{R_{20}}\right) \times R_{21}\left(1 + \frac{1}{R_{21}C_{15}S}\right) \qquad (1)$$

Note: S is Laplace transform coefficients; Proportional coefficient $K_p = \frac{R_{21}}{R_{20}}$; Integral coefficient $K_I = \frac{1}{R_{20}C_{15}}$; Output voltage feedback coefficient $K_{vf} = \frac{R_{20}}{R_{25}}$; U_r is voltage reference signal; U_{ref} is voltage feedback signal.

3.2 Current signal comparator

Through the above analysis, it is obviously that after a voltage resulting from the current loop, PI regulator regulates a given signal as a current comparison signal compared with the current feedback signal Fig. 4.

A comparison is needed to do between U_v and feedback signal U_i through a subtraction. The feedback signal is controlled by LEM of the inductor, and the signal generated by comparing the expression is:

$$U_s = \frac{R_{18}}{R_{24}}(U_v - U_i) \qquad (2)$$

Since U_v is a constantly changing signal, it need to adjust current comparison signal because of two signals (large and small, or positive and negative). After comparison of the current signal through a comparator, if the current relatively large signal zero, then the resulting signal is positive (15V), which zero-hour to produce a zero signal (0V). The signal generated by the supply of logic is used to turn on and off the switch control as showed in Fig. 5.

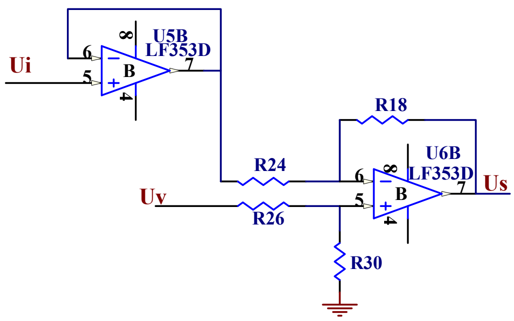


Figure 4. Current signal comparator

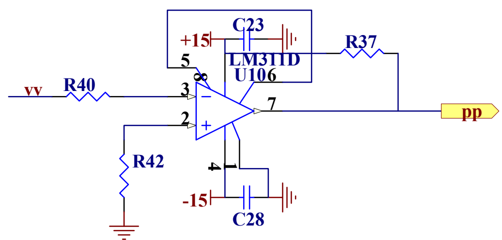


Figure. 5 Comparison of the signal current comparator

4 Simulation analysis

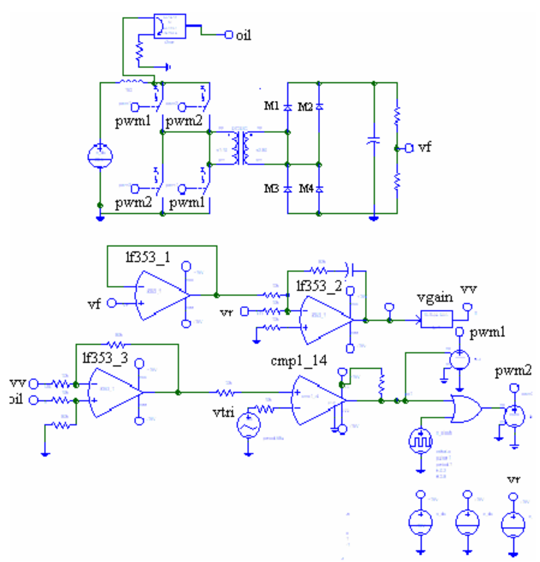


Figure 6 Modulation circuit isolation boost full-bridge simulation circuit under the control of pulse width

Parameters of power stage: $U_i = 28.5V$, $U_0 = 180V$, $L = 30\mu H$, $C_0 = 552\mu F$, $R_L = 20\Omega$, $n_T = 7$, $k_{PWM} = -0.42$, $L_e = 6e^{-3}, D_e = 1/12$.

Parameters of PI modem: $k_{vp} = 5$, $k_{vi} = 4.7$, $k_{ip} = 5$, $k_{ii} = 4.7$.

It could be seen from Fig. 6 that the main circuit is isolated boost circuit and control circuit is double closed loop control (voltage loop and current loop). The output voltage was sent to emitter follower with the end of the handle evacuation to the op-amp reverse side and superimposed with the reference voltage, after it was sampled by the sampling resistor, and the obtained signal was enlarged by the PI link to zoom VV. On other hand, PWM wave generated through two-way logic MOSFET drive signal in order to control the opening of the tube and MOSFET.

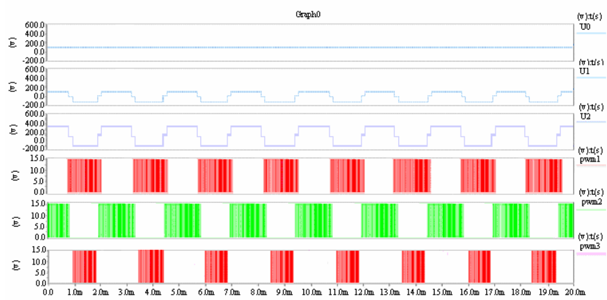


Figure 7 Figures of transformer primary side, secondary side and PWM pulse waveform

Pulse width modulation technology is more mature and more easily achieved, and the simulation results seen the simulated waveform is consistent with the theoretical analysis, so the pair of closed-loop pulse-width modulation circuit-based control circuit is selected.

5 Conclusion and Outlook

Through the simulation results of the analysis, it is obviously that the output waveform can be very good if dual closed-loop PWM control circuit to control the isolation step-up circuit, which the output voltage is 180V meeting the design requirements. Therefore, to design this kind of novel aviation ground power and DC power is reasonable and feasible.

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