# Research on DC high-voltage power supply topology

Liang Yan[1, a], Yingmin Yan[2, b] and Fengbiao Yang[2, c]

[1]Ordnance Engineering College, Shijiazhuang 050000, China;

[2] Ordnance Engineering College, Shijiazhuang 050000, China.

[a]yanliang116000@163.com

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**Abstract.** Aiming at the main circuit structure of DC high voltage power supply, the paper compares advantages and disadvantages of the common isolated DC-DC converter topology, and then introduces the main control of full-bridge converter, and finally built a bipolar control of the whole bridge converter simulation models. It demonstrates the full bridge converter is suitable for the main circuit configuration of the DC high voltage power supply.

## 1. Introduction

Different circuit topologies, with different applications. DC-DC converter is a DC input into required direct current by the circuit, there are isolated and non-isolated, commonly used circuit buck step-down circuit, boost booster circuit, buck-boost circuit, single-ended anti-pump circuit, single-ended forward circuit, half-bridge circuit, full bridge circuit and a push-pull circuit, etc. [1]. Voltage power supply circuit generally have a higher output voltage, a larger output power and the circuit operating frequency characteristics, so selecting the appropriate topology can be more effective. The output voltage of high voltage DC power supply circuit is higher, so that the circuit offen uses isolated converters, for example commonly used flyback converters, half-bridge converters, full-bridge inverter and push-pull converters.

## 2. Circuit topology analysis

### 2.1 Single-ended flyback converter.

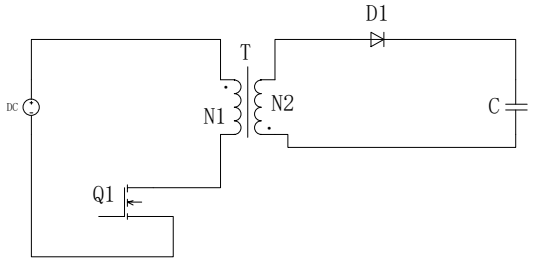


Fig. 1 Single-ended flyback converter topology

Single-ended flyback converter is commonly one of the switching power supply circuit, the circuit topology shown in Figure 1, T is the dot end at the opposite side of the transformer, Q1 is a switch, DC represents DC voltage applied by input side of circuit. When Q1 is turned on, the input voltage is applied across the primary winding of the transformer, because of the polarity of the secondary winding, the diode is turned off, current cannot flow through the secondary winding, the load is powered by a capacitor C; when Q1 is turned off, the primary winding circuit does not constitute a pathway, the diode of secondary winding conducts. During Q1 turns on the stored energy of transformer in the off-period supply power to the load [2]. The flyback converter has the following advantages, high efficiency, simple lines and can provide multiple outputs, but the output voltage has a larger ripple voltage. In addition, the voltage stress is large in the off-period of switch.

### 2.2 Push-pull converter.

Push-pull converter[3] circuit topology is shown in Figure 2, T is the transformer whose primary side and secondary side both with a center tap. When Q1 is turned on, Q2 is turned off, the input

 

voltage is applied across the primary winding N1 of the transformer, since the polarity of the secondary winding, the diode D1 is turned off, however D2 is turned on, the switch Q2 bears a greater voltage, besides since the polarity of the secondary winding, the diode D1 is turned on, and D2 is turned off; when Q2 is turned on, Q1 is turned off, the input voltage is applied to the transformer primary winding N2, the switch Q1 will withstand large voltage, the diode D2 is turned on, and D1 is off. Push-pull converter circuit structure is complex, especially need to have a center-tapped transformer, which have the risk of biased magnetic, and the not turned switch bear a larger voltage, but due to its high utilization, high efficiency, small output ripple voltage, it is suitable for one hundred watts to kilowatts switch circuit structure.

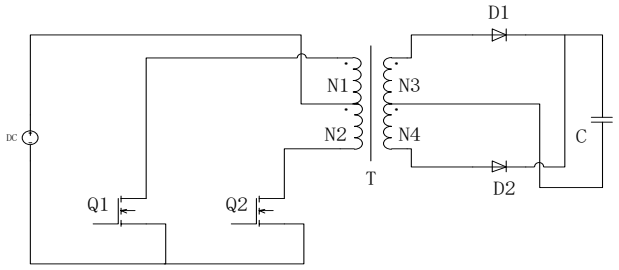


Fig. 2 Push-pull converter topologies

**2.3 Half-bridge converter.**

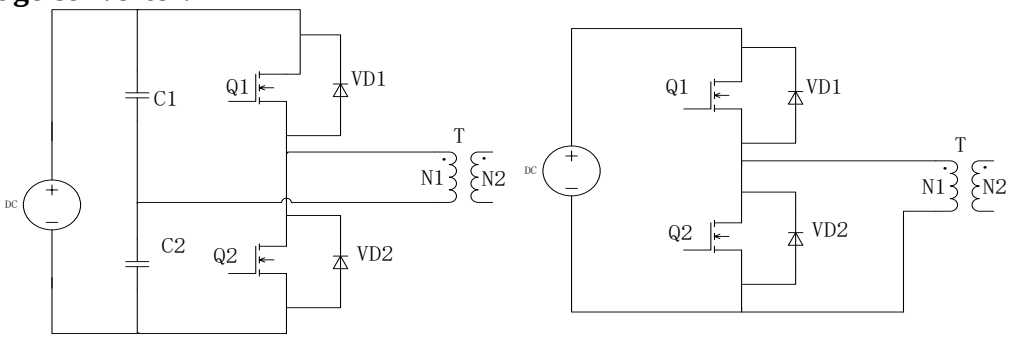


Fig. 3 Half-bridge converter topologies

There are two common half-bridge converter topologies shown in Figure 3. On the left of circuit diagram in Figure 3, when Q1 turns on, Q2 is turned off, the input voltage is applied across the primary winding N1 of the transformer, then when Q1 turns off, Q2 has not been turned on, the circuit current goes on through VD2; then Q2 is turned on, Q1 is turned off, the input voltage is applied to the reverse side of the transformer primary winding N1; when Q2 turns off, the circuit current goes on through VD1. On the left of circuit shown in Figure 3, two resonant capacitor, C1 and C2, corresponds to two inverter bridge arm, that is two capacitors in parallel connect with the load, so it is suitable for a hundred watts to kilowatt switching circuit, while the right half-bridge converter topologies are generally used in low-power field [4]. Overall, half-bridge DC-DC converter has easy to realize the advantages of high power. Besides the voltage value of switch used in half-bridge converter topology is not high, will not exceed the input voltage peaks. But voltage amplitude applied to the transformer in the half-bridge structure is only half of the input voltage, causing the output power is not high.

**2.4 Full-bridge converter.**

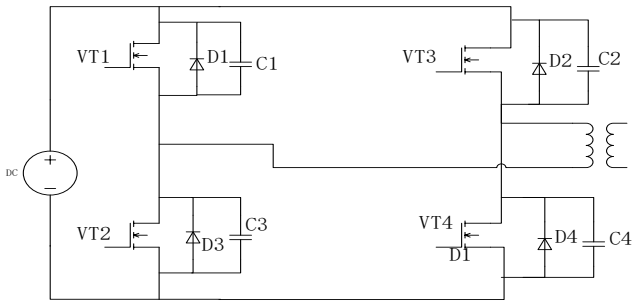


Fig. 4 Full-bridge converter topologies

As is shown in Figure 4, VT1, VT2, VT3 and VT4 are switches, D1-D4 is an internal parasitic diode, C1-C4 is the sum of internal parasitic capacitance of switchs and external capacitance. Compared with the half-bridge converter, the voltage inputed to transformer side of the full-bridge is twice. When the rated voltage value and current value of the switching device is the same, output power is in direct proportion to the number of using the power switch, in the all isolated switching circuit, full bridge circuit can achieve maximum power. Advantage of the full bridge circuit is that the output power is high, so that the circuit is commonly used in high-voltage output, large and medium-power applications, the output power is generally hundreds of watts to tens of kilowatts [5].

## 3. Common control mode of full-bridge converter

There are two commonly used control mode-phase shift control and bipolar control mode [6], to the full bridge converter, as is shown in Figures 5 and 6 respectively. In Figure 5, the switch in the same bridge arm (VT1 and VT3, VT2 and VT4) is turned $180^o$ complementary, the switch VT1 turns on ahead of the switch VT4 phase angle θ, Similarly switch VT2 lead VT3 phase angle θ, that is the shifting phase angle θ. By adjusting the phase shift angle to change the output voltage value, and then get the desired voltage. Full-bridge converter with Using phase shift control method can use transformer leakage inductance and stray capacitance of the switch , by changing the order of the switch which is turned off, we can achieve zero-voltage switching tube, to reduce the loss of switch.

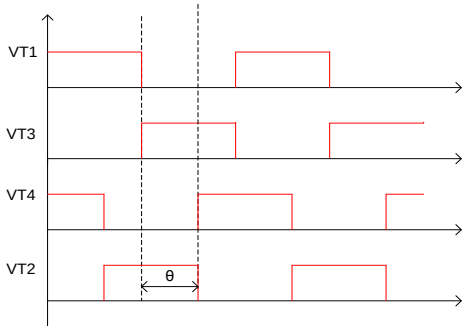


Fig. 5 Phase shift control mode

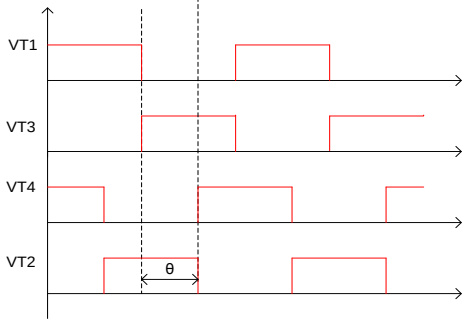


Fig. 6 Bipolar control mode

As is shown in Figure 6, the bipolar control mode is that switches (VT1, VT4 and VT2, VT3) in a diagonal position turned on and off at the same time, in order to prevent the power-through phenomenon of input voltage to happen, the switch duty cycle is less than 50%, leaving the dead time, so as not to burn switch, t is the dead time in the Fig. 6. Full-bridge converter with Bipolar control mode general use multi- resonant elements to achieve soft-switch technology, by current flowing through the switch or voltage across switch change in the form of a sinusoidal, theoretically can make depletion between turn on and off of switch zero.

## 4. Simulation Analysis of full-bridge converter

The establishment of full-bridge converter simulation model is shown in Figure 8, which uses bipolar control mode, the duty cycle is 40%, the dead time is 1μs, the input DC voltage is 270V, the output voltage is 1350V, the resonant inductor Lr is 42.85μH, resonant capacitor Cr is 59nF, magnetizing inductance Lm integrated in the transformer is 300μH, switching frequency is 100KHz.

The circuit uses a full-bridge inverter circuit, inverting DC to square wave AC, then input to the primary side of the transformer. Transformer secondary side uses voltage doubler rectifier circuit, alternating current into high-voltage direct current sented to the whole load.

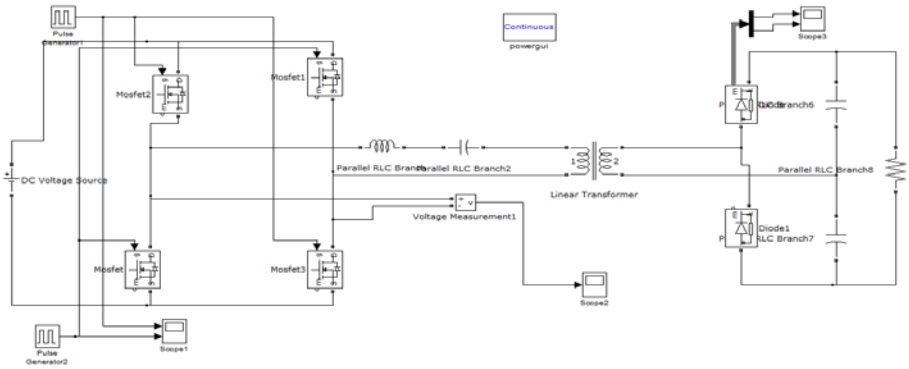


Fig. 7 Full-bridge converter simulation model

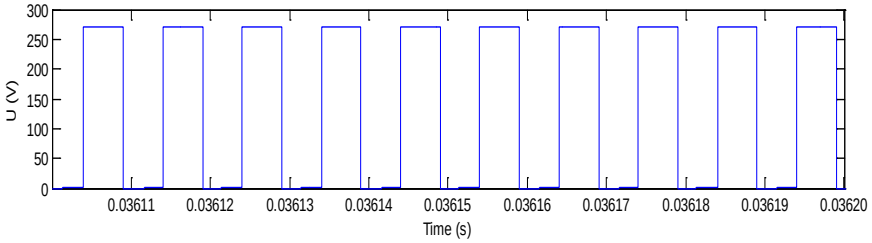


Fig. 8 Full bridge converter output voltage

As is shown in the simulation results of Figure 9, the DC is transformed to AC square wave voltage through full-bridge inverter circuit, and each switch which is turned off is subjected to 270V in the full-bridge topology, that voltage is not greater than the amplitude of the input voltage, Pressure value of each switch is not high, so we can reduce costs. Also full-bridge topologies can also use the transformer leakage inductance and stray capacitance of the switch to change resonates parameter settings to achieve soft switching technology to reduce switching losses.

## 5. Summary

In summary, the full bridge converter topologies are easy to achieve integrated magnetics, reducing the use of magnetic elements, and we can implement soft-switching technology through parameter setting, reducing the loss of the switch tube. As output power of full bridge converter is large, and the switch voltage stress is small topology, the full bridge converter is suitable for high-voltage power supply circuit.

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