

A Kind of New Switching Power Supply with Multiple Isolated Outputs Used in High-voltage Static Synchronous Compensator

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Abstract. The background of this paper is the power supply driven by High-voltage Static Synchronous Compensator series module, a kind of applicable to high voltage power module is proposed in this paper. Using High-voltage Static Synchronous Compensator, this device Switching Power Supply has the advantages of small in volume, light in weight, high efficiency and reliability. Compared with the high voltage of the insulation frequency transformer, this device overcoming many shortcomings, such as huge in volume and high price. This device is more suitable for distributed application, therefore it is very easy to realize multiple outputs of the power.

Introduction

Compared with compensation current, the High-voltage Static Synchronous Compensator through pouring into the equal and opposite current to realize reactive power compensation and high order harmonic elimination .thereby, the device can greatly improve reliability, security and stability of the power system, and the device is one of the most important Flexible AC Transmission System. At present, the High-voltage Static Synchronous Compensator make leading role in the market, most of the devices adopt module series structure. Therefore, the drive power source design of every module is an important part of the whole system and the crucial design is making a power supply with multiple isolated outputs. At present, there exist two major kinds of scheme to solve the problem of high voltage isolation power: one is adopting the primary side and the secondary side between high voltage insulation industrial frequency transformer in isolation; Another kind of scheme to industrial frequency power rectifier and filter get dc voltage, and then will dc voltage inverter get high frequency bus, and adopts high voltage insulation of high frequency transformer in isolation [1]. In the first scheme, due to adopting the industrial frequency transformer with high voltage , lead to the drive power huge in volume and expensive; The second scheme adopts the high frequency transformer and the drive power greatly reduce the volume, output power can be isolated in the scope of any increase is allowed, design and application become more convenient. The background of this paper is the second scheme, A kind of applicable to high Switching power Supply with Multiple Isolated Outputs is proposed ,and is adopted in high voltage Static Synchronous Compensator system.

System architecture

I.A side main circuit structure design

*The voltage type high frequency busbar circuit as shown in figure 1, the first part is a single-phase rectifier, it consists of four diodes, it realized the function of the rectifier circuit, at the same time ,it rectifier the power frequency ac voltage which is input of the main circuit power into direct current; The second part of the use through a full - bridge converter realized the function of power conversion: the amplitude of the constant dc voltage is transformed into a constant amplitude, the direction of alternating cyclical square wave voltage, and then through a filter formation of high frequency voltage busbar.

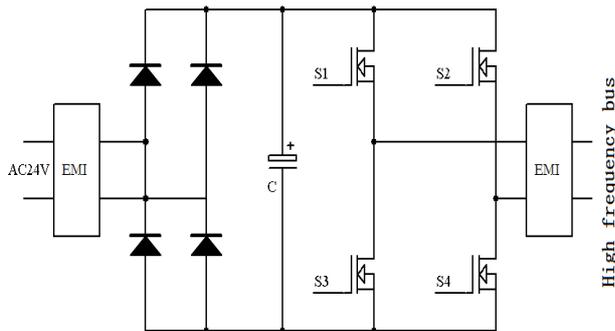


Fig. 1 The voltage type isolation power the original side structure

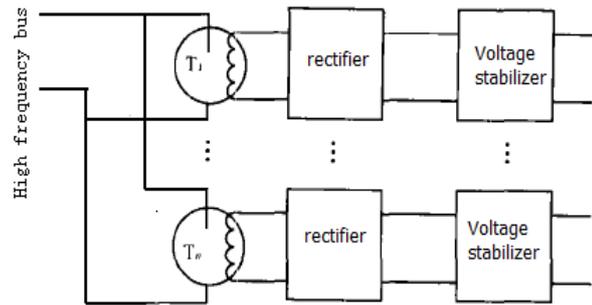


Fig. 2 Parallel the voltage type high frequency busbar structure

High frequency bus structure as shown in figure 2, each unit output module parallel connected with ac busbar, the bus can output high frequency ac voltage signal, every output module can take on the bus by transformer alternating voltage, and the secondary side rectifier voltage circuit, filter, then is required for dc voltage, which can meet the requirements of the multiple isolation output. Here, they can using the magnetic output transformer, the original edge of each output transformer winding only have one circle, and according to the practical need, the deputy edge winding magnet ring choose proper circles. Use this parallel voltage type ac bus structure, because the secondary side circuit can integrate with magnet ring, as long as the module input parallel connects with the ac busbar, the device can t output dc voltage, driver output poems can be easily increase or decrease, and at the same time, as long as deal with the transformer, can achieve high voltage isolation.

II. Design of magnet ring transformer

They set work frequency of the magnetic ring transformer in 50 kHz, so they choose higher frequency magnetic core material, and because each of the original edge of magnet ring transformer windings only have one circle, in the design, we choose high permeability of magnetic core material, and the length of magnetic circuit should be as short as possible, the sectional area as much as possible, to get good electromagnetic coupling effect, reduce exciting current. For ferrite magnetic cores the higher magnetic permeability, the higher efficiency of the iron core transmission of energy and wastage caused mainly by the hysteresis effect, the eddy-current loss small; For amorphous iron core, although has a greater magnetizing inductance, the amorphous core have very low resistivity, in higher switching frequency condition, the more eddy current loss, In the same situation, the efficiency is smaller than high magnetic conductance ferrite magnetic core.

III. A side of the whole bridge driving circuit structure

According to the structure of bridge type inverter main circuit, the driving signal, control circuit and signal main circuit will be cut off from each other. Isolation drive can be divided into electromagnetic isolation and photoelectric isolation, photoelectric isolation has small in volume, simple in structure, and other advantages, but the ability of common mode rejection is poor and transmission speed is slow [2]; Electromagnetic isolation choose pulse transformer as isolation components, have fast response, the former vice side of the insulation intensity is high, but the biggest signal transmission speed is restricted by magnetic saturation characteristics, and therefore the top of the signal transmission is difficult, and pulse transformer is big in volume, heavy in weight and processing is complex. Isolation driving have another disadvantage is that every drive need a set of auxiliary power, the whole bridge single-phase converter need at least three groups isolated power, and suspended each other, so it increased the complexity of the circuit.

According to the problems of Bridge type driving circuit, this device apply the driver of IR2110 of IR company, through the high-end suspended bootstrap circuit the chip can create their own circuit for driving power, reduce the number of the drive power, and have advantages such as small in volume of optically – isolated and high in speed of electromagnetic isolation, the chip is widely used in small and medium-sized power changing device [3].

This article used the bridge driving circuit structure as shown in figure 3, we use the fixed duty cycle as the control mode, through TL494 which is in the front of the circuit outputs complementary pulse signal, the two roads drive signal are respectively sent to IR2110 drive, and then produce 4 ways separated driver signals, which controls the opened and shut off of S1, S2, S3, S4, then it can produces high-frequency ac line voltage.

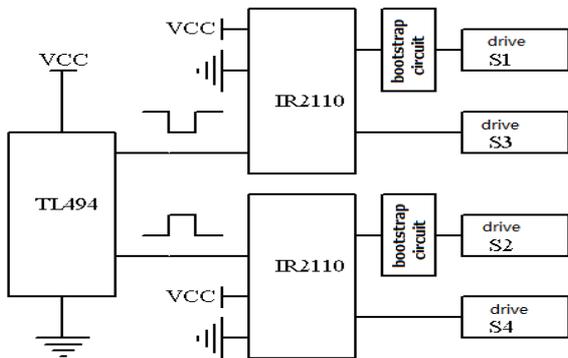


Fig. 3 Full bridge driving circuit structure

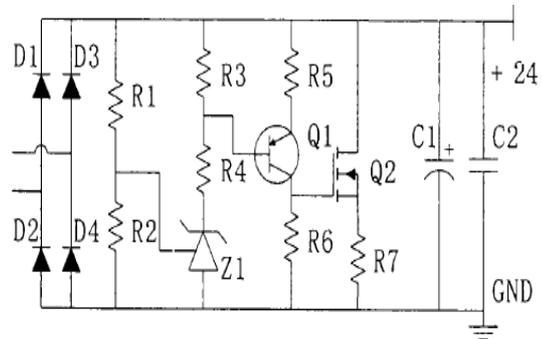


Fig. 4 Secondary side voltage-stabilizing circuit structure

Secondary side stabilizing-voltage circuit design

The magnetic ring transformer make the exchanged Ac bus voltage into the same frequency secondary side high frequency voltage, and make high frequency voltage which is rectified filtering in diode into a dc voltage, then provide dc voltage source for driving circuit; Because of the variational change of load, the dc voltage fluctuate obviously, if we want to get the stability dc voltage source which is used in drive Circuit, there must be a voltage-stabilizing circuit.

The common voltage-stabilizing circuit is divided into linear voltage stabilizer and switching voltage stabilizer, according to the require of the design, we choose the linear voltage stabilizer, because the linear voltage stabilizer structure is simple and ,design is flexible. Figure 4 is the secondary side of the circuit structure, D1, D2 and D3, the D4 is rectifying circuit, they will make ac voltage it stable dc voltage, Z1 is the precision voltage stabilizer for TL431, R1, R2, R3, R4, R5, R6, Z1 and Q1 compose the driving circuit of Q2, and control switch tube of Q2, made it open and off, Q2, R7, C1 and C2 compose the voltage-stabilizing circuit, it provide stability dc voltage source to driver circuit. When the circuit is working, the output voltage through the resistance R1 and R2 to divide voltage, compared with the 2.5 V voltage reference of TL431, and then it form negative feedback circuit to adjust the size of the output voltage, make dc voltage stability in 24 V, this circuit has the advantages such as simple in structure, low cost and high reliability.

Holistic test

The holistic test is divided into a side of the whole bridge inverter of debugging and secondary side commissioning of the voltage circuit, in view of the characteristics of the system, the whole bridge with fixed driver of duty ratio control, accounting for 45%, the control signal is sent by power supply chip TL494, figure 5 is the complementary drive signal of TL494, the two signals produce 4 ways isolated driver signal after pass two pieces of IR2110 drive, control switch tube open and shut of the S1, S2, S3 and S4, and then it produce high-frequency communication bus voltage, figure 6 is the complementary drive signal waveform than is outputted by one piece of IR2110, figure 7 is the voltage waveform of the magnet ring transformer after pass the bridge converter transformer, figure 8 is the voltage waveform that is outputted by the secondary side which is come from magnet ring transformer.



Fig. 5 TL494 output of complementary drive signal waveform

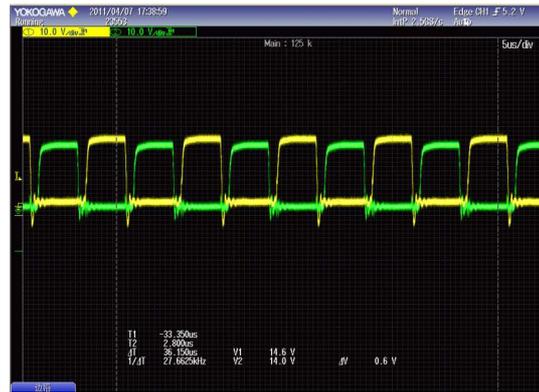


Fig. 6 IR2110 output of complementary drive signal waveform

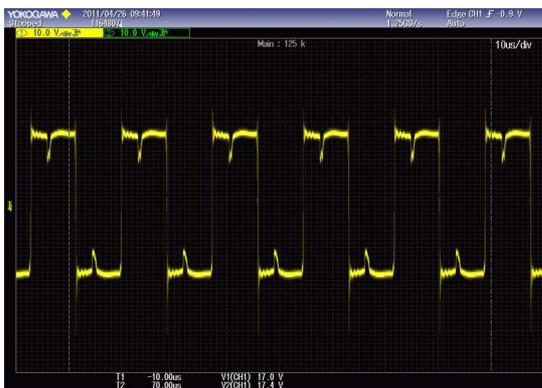


Fig. 7 Transformer the original edge voltage waveform

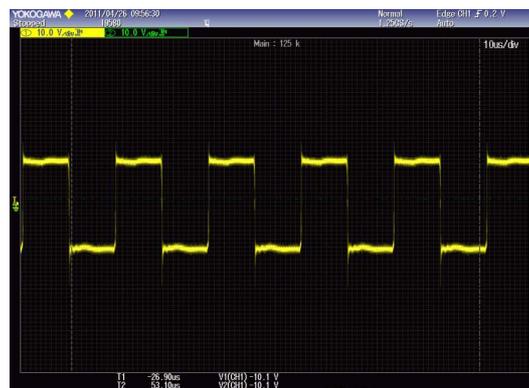


Fig. 8 Transformer voltage waveform vice edge

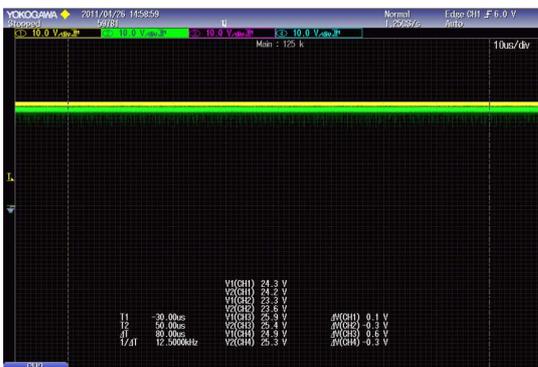


Fig. 9 Secondary side when light load output voltage waveform



Fig. 10 Second focusing on when voltage waveform in output

In secondary side of voltage circuit commissioning process, we used the 48 ohm metal resistance as light load test, figure 9 is the voltage waveform which is outputted by two voltage circuits, when the load is aggravating, the resistance reduced to 20 ohm, the output voltage waveform as figure 10 shown, when compared the figure 9 with figure 10, we can see the secondary side circuit can be a very good to adapt to the change of load, and the ripple is smaller, the circuit will be stable and reliable.

Results

The background of this paper is the power supply driven by High-voltage Static Synchronous Compensator series module, a kind of applicable to new switching power supply with multiple isolated outputs is proposed in this paper. Through one side of the system of the whole bridge inverter circuit, secondary side of voltage circuit designing and debugging, the device realize the reliable and steady work in the range of circuit, and meet the requirements of drive the power components in the high voltage power electronics device. Through the introduction of the scheme and analysis of the test data and waveform, we may reach the conclusion that the drive power has the following advantages: driver output poems can be easily increase or decrease, each drive power has high voltage grade isolation, circuit is simple, high efficiency, small in volume, low cost and high reliability.

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