Research and Design of Soft Switch Technology in New Energy Vehicle Wireless Charging System

Jun Wang[1,2], Qiang Liu[1,2,3](✉), Jinming Huo[1,2], and Rosa Cantero[4]

[1] School of Automotive Engineering of Jilin Engineering, Normal University, Changchun, Jilin, China
liuyushuojldx@126.com
[2] Innovative Research Team of Jilin Engineering, Normal University (IRTJLENU), Changchun, Jilin, China
[3] State Key Laboratory of Automotive Simulation and Control, Jilin University, Changchun, Jilin, China
[4] University of Frankfurt, Frankfurt, Germany

Abstract. Wireless power supply technology as an emerging new energy vehicle power real-time supply technology to the development of new energy vehicles has brought a lot of convenience. The wireless power supply technology of new energy vehicles can reduce the amount of on-board batteries and even do not need to carry batteries. By laying the guide rail under the road, the electric energy is transmitted to the car in a non-electric contact way using electromagnetic technology for real-time use. However, the transmission efficiency of the wireless power supply system for new energy vehicles is not high, which greatly increases the loss of the system and reduces the effective energy supply of the system. The soft switching technology proposed in this paper can control the switching appliance under the zero voltage and zero current environment, so as to reduce the circuit switching loss. Therefore, soft switch technology is widely used in wireless power supply device can effectively improve the efficiency of the whole system.

Keywords: Soft Switching · Wireless power · Phase-shifting control

1 Introduction

Switching power supply is one of the important links in the charging system of new energy vehicles. To realize the lightweight and miniaturization development of power electronic devices, it is necessary to realize the high-frequency circuit. However, in the hard switching and high frequency environment, the electromagnetic interference and switching loss of traditional switching devices are also large, and the emergence of soft switching can effectively solve this problem. This technology can keep the primary inverter in the stable soft switching control state, reduce the loss and prolong the working life of the switch tube. This technology can keep the primary side of the inverter in the stable soft switching control state, reduce the loss and prolong the working life of the

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switch tube. This scheme design is of great significance for the promotion and large-scale application of wireless power supply technology for new energy vehicles in the future [1].

2 Application of Soft Switch Technology in New Energy Vehicle Wireless Charging System

2.1 Soft Switch Technology Introduction

Various new devices, new topological circuits and better control principles are applied to power supply equipment, which makes the rapid development of power supply technology and accelerates the wide application of high-frequency switching power supply in the field of new energy vehicles. The concept of soft switching is the counterpart of hard switching. There is a clear difference between hard and soft switching. In the process of hard switching controlling the circuit, the current and voltage will change very dramatically. Such drastic changes will not only cause great loss to the switch, but also produce great noise, which will not only reduce the efficiency of the circuit to a large extent, but also cause interference to the work of the peripheral electronic equipment. In addition, with the increase of switching frequency, switching loss will also increase, compared with hard switching, soft switching has a great improvement in this respect. Soft switch is based on hard switch, which is the inheritance and improvement of traditional hard switch. Different from hard switching, soft switching adds some resonant devices, including small inductors, capacitors and so on. The new resonant devices constitute the auxiliary conversion current network, and the condition of the switch has been greatly improved [2]. This problem has also been properly solved. With the support of soft switching technology, switching loss and switching noise are greatly reduced, and the efficiency of the circuit is greatly improved. Soft switch mainly includes two aspects, one is soft open, the other is soft off. Soft on can also be called zero voltage switch, and soft off is zero current switch. During operation, the voltage is usually dropped to zero, and then the current is raised to the on-state value, which is the ideal soft switching process. The ideal soft switching process will not produce switching loss and switching noise, in line with low carbon, energy saving, environmental protection requirements.

2.2 Wireless Charging System for New Energy Vehicles

A typical ev wireless charging system is divided into two parts: ground transmitter (ground terminal for short) and vehicle receiver (vehicle terminal for short), mainly including primary and secondary power converters, compensation network, controller and communication module. The ground terminal is connected with the mains as the power supply part of wireless charging; Vehicle-mounted terminal is connected with vehicle battery to convert the energy received from the ground terminal into the electricity required by the battery. Ground terminal and the vehicle-mounted terminal exchange information through wireless communication. In the process of energy transmission, the energy transmitting end and the energy picking end adopt non-contact mode, and there is no electrical connection completed by using cables, so the safety problems such as leakage caused by bad contact such as open circuit short circuit and so on are prevented. With the rapid development of wireless power supply technology for new energy vehicles, many research institutions and companies have joined in the research and application of this technology [3]. However, in the new energy vehicle wireless power supply system, the inverter switch tube is not in the soft switching state, which not only greatly shorts the working life of the switch tube, but also directly increases the loss of the switch tube, resulting in the low transmission efficiency of the system, large energy loss, and difficult to be widely popularized in the application of commercial.

Based on the background of the wireless power supply system of new energy vehicles, this paper researches the difficult technology of inverter soft switch control in the wireless power supply system of new energy vehicles, aiming at achieving the stable soft switch work of the wireless power supply system of new energy vehicles. The primary transmitting mechanism works in resonant state by soft switching method. And with certain technical means to make the new energy vehicle wireless power supply system to maintain a stable soft switch control state, reduce losses, improve the working life of the system, improve the energy transmission efficiency of the system. The main solutions are:

On the basis of the research status and development trend of switching power supply at home and abroad, the theoretical analysis, simulation calculation, system design and test of high power phase shift full bridge soft switching power supply are carried out. Using the technology of phase shift control and soft switching, the power semiconductor switching tube in the inverter circuit of high-power phase shift full-bridge soft switching power supply can realize the zero voltage switching (ZVS), reduce the switching loss of the power semiconductor switch tube, reduce the voltage and current stress of the power semiconductor switch tube, improve the efficiency of the whole machine. On the basis of the traditional phase-shift full bridge inverter, this paper adopts the scheme of adding “LC” auxiliary network to both bridge arms of the inverter, which can realize the ZVS of all bridge arms power semiconductor switch tubes in the full load range. The “LC” auxiliary network adopts asymmetric design, and appropriate auxiliary inductance is selected for each “LC” auxiliary network [4]. This design can help to reduce the conduction loss, reduce the resonant inductance and leakage inductance and their negative effects, and ensure that the bridge arm can realize the zero voltage switches. The selection basis of each component model and parameter in the circuit is given.

Design control and protection circuit, including phase shift control circuit, input current limiting current, output overvoltage and overcurrent detection and protection circuit, fault output and reset circuit, closed loop; The CHIP UC3875 is used to output PWM signal, and the phase shift Angle of the four-way PWM signal is controlled by closed-loop feedback loop. In view of the possible problems of the power supply, it is protected by the protection circuit.

3 Control Strategy and Implementation of the System

3.1 Basic Structure of Phase Shift Control Converter

Phase shift PWM control mode is a kind of soft switch control mode which is widely used in the whole bridge transformation in recent years, its working principle is actually the resonance technology and the conventional PWM technology combination, It is composed of input DC power supply, two bridge arms (four switch tubes), transformer, transformer output end rectifier diode, filter inductor, capacitor and load. The so-called phase shift control mode is the circuit of the switch tube M1 and M4, M2 and M3 turn on, conduction Angle 180° each; However, M1 and M3, M2 and M4 cannot be conducted at the same time. They need to be separated by an Angle, namely the phase shift Angle. The output voltage can be adjusted by adjusting the phase shift Angle. Since the switch tubes M1 and M3 are shut off before the switch tubes M4 and M2, respectively,M1 and M3 are called advanced bridge arms, and M2 and M4 are called hysteretic bridge arms [5].

In order to realize the soft switching of switching tube, a phase shift control zero voltage switching DC/DC full bridge converter is presented, It is main principle is to use the leakage inductance of transformer and junction capacitance of power switch tube to realize the ZVS switch. The circuit consists of one capacitor in parallel on the switching tube of the original full bridge circuit, When the switch tube is turned off, the primary side current of the transformer charges the shunt capacitor Cl or C4 of the switch tube and discharges C2 or C3 at the same time, in this way, the rise rate of M1 or M4 is limited when the M1 or M4 is turned off, and MI or M4 soft switch is realized.; As the voltage of C1 or C4 rises to Uin, the voltage of C2 or C3 drops to zero, and its inverse parallel diode conduction provides a zero-voltage conduction condition for M2 or M3 [6]. Full bridge converter with phase shift control has the advantages of simple circuit, constant frequency control and so on, which is widely used in medium and high power occasions; But because the power MOSFET tube conduction is equivalent to a resistance, its on-state loss is relatively large, and the frequency is smaller than IGBT, duty cycle loss is serious, based on this, a new phase – shift – controlled zero – voltage – zero – current full – bridge converter is presented.

3.2 Design of Control Circuit

The control circuit mainly includes: the high performance UC3875 as the core of the main controller, output voltage/current sampling module, various protection modules, isolated driver module.

The core technology of high-frequency switching power supply is pulse Width modulation (PWM) phase shift control module, it has a profound effect on the performance of switching power supply, it is main function is to make the full bridge inverter circuit two bridge arm MOSFET control signal conduction Angle stagger, further, multiple duty cycles are obtained, thus adjusting the output voltage, to make it stable. Its core is phase – shifted pulse – width modulation controller. The controller used in this design is UC3875, It is an integrated chip specially used for phase shift control, four phase – shift pulse width modulation control signals can be generated at one time, and its own sampling function, a voltage, current, and over voltage, over current and other protection circuit [7]. The main function of the converter control circuit is to control the phase shift Angle between the two bridge arms and provide some basic protection circuit. The control circuit of the system is mainly composed of the signal detection part, the control signal generation part, the power drive part, the isolated output part and the system protection part. This converter control system uses voltage control mode, control circuit to control the advance bridge arm and lag bridge arm phase shift Angle, thus control the output voltage value; In addition to provide some basic protection circuit, such as: short circuit protection, over voltage protection, current limiting protection circuit, to ensure the safe and reliable work of the converter.

UC3875 chip is the core of the control circuit, which is composed of reference power supply, oscillator, sawtooth generator, error amplifier, soft start, PWM comparator and trigger, output stage, over current protection, dead zone time setting, frequency setting and so on. The reference power supply provides a precision reference voltage source, as the voltage of the given signal is compared to the output voltage, and a resistor and capacitor at the frequency setting end (FREFSET) and the signal ground can set the switching frequency of the output stage. The oscillator oscillation frequency is thus set. The slope of the sawtooth wave is determined by the indirect resistance between the sawtooth wave slope setting end and the power supply to provide a constant current source for the sawtooth wave, and the indirect capacitance between the sawtooth wave pin and the signal ground. The output of 0UTA, OUTB, OUTC and OUTD is used to drive the four switching tubes of the full bridge converter. The dead time of output signals OUTA, OUTB and OUTC and OUTD can be determined by connecting resistance capacitors between the “DLY A/B” and “DLY C/D” terminals and the signal ground respectively [8]. The dead time provides the delay between the closing of one switch tube and the conduction of the other switch tube in the same branch. The setting of the two dead time can provide the respective delay for the two half Bridges to adapt to the difference in the charging current of the resonant capacitor. The SOFT START time is determined by the capacitance between the “SOFT – START” end and the signal ground. Therefore, the resonant switching time of each pair of output stages can be controlled separately. The advantages of phase shift control are fully reflected in the full bridge topology mode. The UC3875 operates in both voltage and current modes and has an over current shutdown for rapid protection from failure [9].

4 Software Design of Control System

In order to improve the response speed of the control system and the output characteristics of the power supply, the overall design structure of the combination of cycle and interrupt is adopted, the program modules of data sampling and processing subroutine, pulse signal generation subroutine, liquid crystal display and parameter setting subroutine, control policy subroutine, fault alarm and delay stop subroutine are designed. In the “AD” conversion subroutine to read the sample value, using power as the outer loop, the current as the inner loop double closed loop control strategy, with the peripheral frequency and voltage conversion and “PWM” pulse generator circuit, to achieve the accurate power supply output regulation [10].

5 Conclusions

Based on the analysis of the working principle of phase-shift control full bridge converter, this paper presents the realization method of new soft switching technology, and designs a practical wireless charging system for new energy vehicles. The integrated controller

UC3875 is adopted in the control circuit, which improves the reliability and efficiency of the wireless charging system. The research content of this paper has a strong application background, well solved the influence of the factors that will appear in the operation of the wireless power supply system of new energy vehicles on the system, and well realized the soft switching control.

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