电源学报
JOURNAL OF POWER SUPPLY
北大中文核心期刊
ISSN 2095-2805 CN 12-1420/TM



电源学报 ›› 2023, Vol. 21 ›› Issue (2) : 186-193. DOI: 10.13234/j.issn.2095-2805.2023.2.186

特种电源

# -70 kV高压低纹波电源的电路特性分析

郭翔, 张治国, 汪志勇

作者信息 +

# Analysis of Circuit Characteristics of -70 kV High-voltage Low-ripple Power Supply

GUO Xiang, ZHANG Zhiguo, WANG Zhiyong

Author information +

History +

## 摘要

首先,介绍了高压电源的基本工作原理,提出了倍压整流电路的等效电路。然后,讨论了谐振元件参数选择与低纹波实现之间的关联,指出变压器原边峰值电流与谐振电感参数是决定电路性能的重要因素。最后,推导了可用于实现输出电压低纹波的计算公式,给出满足设计需求的低纹波高压电源主要元器件参数,并且给出了仿真与实验结果。所提方法可精确反映这种高压电源的电路特性。

## Abstract

The basic operation principle for the high-voltage power supply is introduced at first, and the equivalent circuit of the voltage doubling rectifier is deduced. Then, the relationship between the selection of resonant component parameters and the realization of low-ripple is discussed, and it is pointed out that the primary-side peak current of transformer and the parameter of resonant inductance are the important factors that determine the circuit performance. Finally, the analytic expressions for realizing the low-ripple of output voltage are deduced, and a design method for the high-voltage low-ripple power supply which has appropriate components is formulated, and simulation and experimental results were also given. The proposed design method can accurately reflect the circuit characteristics of the high-voltage power supply.

## 关键词

高压电源 / 倍压整流 / 低纹波 / 电路特性 / 谐振元件

## Key words

high-voltage power supply / voltage doubling rectifier / low-ripple / circuit characteristics / resonant component



## 引用本文

导出引用

郭翔, 张治国, 汪志勇. -70 kV高压低纹波电源的电路特性分析. *电源学报*. 2023, 21(2): 186-193 https://doi.org/10.13234/j.issn.2095-2805.2023.2.186

GUO Xiang, ZHANG Zhiguo, WANG Zhiyong. Analysis of Circuit Characteristics of -70 kV High-voltage Low-ripple Power Supply. *Journal of Power Supply*. 2023, 21(2): 186-193 https://doi.org/10.13234/j.issn.2095-2805.2023.2.186

上一篇 下一篇

## 参考文献

[1] 杨晓光, 史冉冉, 高思佳, 等. 一种高压电源谐振升压倍压电路[J]. 强激光与粒子束, 2018, 30(9): 1-8.
Yang Xiaoguang, Shi Ranran, Gao Sijia, et al.A resonance boosting and voltage double circuit for high voltage power supply[J]. High Power Laser and Particle Beams, 2018, 30(9): 1-8 (in Chinese).
[2] 刘军, 石健将, 张仲超, 等. 具有最小电流峰值的电容滤波高频高压并联谐振变流器[J]. 电工技术学报, 2009, 24(11): 83-88.
Liu Jun, Shi Jianjiang, Zhang Zhongchao, et al.Minimum peak current for high voltage high frequency parallel resonant converter with capacitive output filter[J]. Transactions of China Electrotechnical Society, 2009, 24(11): 83-88 (in Chinese).
[3] Liu Jun, Sheng Licheng, Shi Jianjiang, et al.LCC resonant converter operating under discontinuous resonant current mode in high voltage, high power and high frequency applications[C]// 2009 Twenty-Fourth Annual IEEE Applied Power Electronics Conference and Exposition. Washington DC, USA, 2009: 1482-1486.
[4] 夏冰, 阮新波, 陈武. 高压大功率场合LCC谐振变换器的分析与设计[J]. 电工技术学报, 2009, 24(5): 60-66.
Xia Bing, Ruan Xinbo, Chen Wu.Analysis and design of LCC resonant converter for high voltage and high power applications[J]. Transactions of China Electrotechnical Society, 2009, 24(5): 60-66 (in Chinese).
[5] 钟和清, 徐至新, 邹云屏, 等. 寄生电容对串联谐振电容器充电电源特性的影响[J]. 中国电机工程学报, 2005, 25(10): 40-44.
Zhong Heqing, Xu Zhixin, Zou Yunping, et al.Effects of parasitical capacitors on charging characteristic of series resonant CCPS[J]. Proceedings of the CSEE, 2005, 25(10): 40-44 (in Chinese).
[6] 唐雄民, 孟志强, 彭永进, 等. 串联负载谐振式DBD型臭氧发生器电源的基波分析法[J]. 中国电机工程学报, 2007, 27(21): 38-42.
Tang Xiongmin, Meng Zhiqiang, Peng Yongjin, et al.A fundamental wave method of dielectric-barrier discharge type ozonier powered by serial load resonant inverter[J]. Proceedings of the CSEE, 2007, 27(21): 38-42 (in Chinese).
[7] Forsyth A J, Ward G A, Mollov S V.Extended fundamental frequency analysis of the LCC Resonant converter[J]. IEEE Transactions on Power Electronics, 2003, 18(6): 1286-1291.
[8] Diaz J, Saiz P J V, Martin-Ramos J A, el al. A high-voltage AC/DC resonant converter based on PRC with single capacitor as an output filter[J]. IEEE Transactions on Indus-trial Applications, 2010, 46(6): 2134-2142.
[9] 吴为麟, 邹家勇, 陈永延. 考虑分布电容的高压直流电源谐振参数设计[J]. 电力自动化设备, 2009, 29(9): 26-31.
Wu Weilin, Zou Jiayaong, Chen Yongyan.Design of resonance parameters for high-voltage DC power supply considering distributed capacitance[J]. Electric Power Automation Equipment, 2009, 29(9): 26-31 (in Chinese).
[10] 赵志英, 秦海鸿, 龚春英. 变压器分布电容对高频高压反激变换器的影响及其抑制措施[J]. 电工电能新技术, 2006, 25(4): 67-75.
Zhao Zhiying, Qin Haihong, Gong Chunying.Influences and suppression method of transformer winding capacitance in high-frequency high-voltage flyback converter[J]. Advanced Technology of Electrical Engineering and Energy, 2006, 25(4): 67-75 (in Chinese).
[11] 赵志英, 龚春英, 秦海鸿. 高频变压器分布电容的影响因素分析[J]. 中国电机工程学报, 2008, 28(9): 55-60.
Zhao Zhiying, Gong Chunying, Qin Haihong.Effect factors on stray capacitances in high frequency transformer[J]. Proceedings of the CSEE, 2008, 28(9): 55-60 (in Chinese).
[12] 杜慧聪, 刘方军, 张伟, 等. 150 kV高压逆变电源倍压整流电路仿真[J]. 北京航空航天大学学报, 2014, 40(7): 1001-1005.
Du Huicong, Liu Fangjun, Zhang Wei, et al.Simulation of voltage doubling rectifying circuit in 150 kV high-voltage inverter power suppl y[J]. Journal of Beijing University of Aeronautics and Astronauties, 2014, 40(7): 1001-1005 (in Chinese).
[13] 曲振江, 马文娟. 高压静电设备中倍压整流电路的工作状态分析[J]. 高电压技术, 2005, 31(10): 64-66.
Qu Zhengjing, Ma Wenjuan.Working-state analysis of the multiple-voltage rectifying circuit in high voltage electrostatic equipment[J]. High Voltage Engineering, 2005, 31(10): 64-66 (in Chinese).
[14] 张晋伟, 李建兵, 周东方. 基于定频控制的对称式倍压整流输出两级变换器[J]. 电源学报, 2013, 1(1): 59-65.
Zhang Jinwei, Li Jianbing, Zhou Dongfang.A two-stage converter with symmetrical voltage-multiplying rectifier output based on frequency-fixed control[J]. Journal of Power Supply, 2013, 1(1): 59-65 (in Chinese).
[15] 林志琦, 郎永辉, 王岩, 等. 倍压整流电路电容参数的优化设计[J]. 长春工业大学学报, 2009, 30(5): 551-555.
Lin Zhiqi, Lang Yonghui, Wang Yan, et al.Optimized design of voltage doubling rectifiers[J]. Journal of Changchun University of Technology, 2009, 30(5): 551-555 (in Chinese).