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 ›› 2022, Vol. 20 ›› Issue (1) : 28-35. DOI: 10.13234/j.issn.2095-2805.2022.1.28

新颖开关电源

基于柔性电感的恒频控制LLC谐振变换器

王锐，阚加荣

作者信息

Constant-frequency Controlled LLC Resonant Converter Based on Flexible Inductor

WANG Rui, KAN Jiarong

Author information

History

摘要

传统LLC谐振变换器采用变频控制，在输入电压变化范围较宽时开关频率变化范围宽，其磁性元件难以优化设计。将LLC谐振变换器中的谐振电感设计为柔性电感，通过改变柔性电感的电感而改变变换器的谐振频率，改变LLC变换器的输出特性，实现宽输入电压、宽负载范围内的恒频调压，进而可以实现变压器、电感、滤波电容等元件的优化设计。首先介绍了柔性电感的原理，分析了采用柔性电感的全桥LLC谐振变换器的工作特性，并给出了闭环恒频控制的实现方案。最后通过一台输入电压23~35 V、输出电压100 V、功率200 W的原理样机，验证了基于柔性电感的恒频控制LLC谐振变换器的可行性。

Abstract

The variable-frequency strategy is a commonly used method for regulating the voltage in an LLC resonant converter. If the input voltage varies widely, then the switching frequency of the converter will be operated in a wide range, which results in difficulty in designing magnetic components. In this paper, the resonant inductor in the LLC resonant converter is designed as a flexible inductor. The resonant frequency of the LLC resonant converter and its output characteristics can be regulated by changing the inductance of the flexible inductor. As a result, the constant-frequency voltage regulation can be realized even if the input voltage and loads vary widely. Moreover, the design of components such as transformer, inductor, and filter capacitor can be optimized. The principle of the flexible inductor is introduced, and the operation characteristics of the full-bridge LLC resonant converter with the flexible inductor are analyzed. The implementation scheme of closed-loop constant-frequency control was given, and the experimental results of a 200 W prototype with 23~35 V input voltage and 100 V output voltage validated the effectiveness of the constant-frequency controlled LLC resonant converter based on a flexible inductor.

关键词

LLC谐振;柔性电感;恒频控制

Key words

LLC converter;flexible inductor;constant-frequency control

PDF(1527 KB)

引用本文

导出引用

王锐，阚加荣. 基于柔性电感的恒频控制LLC谐振变换器. *电源学报*. 2022, 20(1): 28-35 https://doi.org/10.13234/j.issn.2095-2805.2022.1.28

WANG Rui, KAN Jiarong. Constant-frequency Controlled LLC Resonant Converter Based on Flexible Inductor. *Journal of Power Supply*. 2022, 20(1): 28-35 https://doi.org/10.13234/j.issn.2095-2805.2022.1.28

上一篇 下一篇

参考文献

[1] Jiang Zhenhua. Power management of hybrid photovoltaic-fuel cell power systems[C]//2016 IEEE Power Engineering Society General Meeting. Montreal, Que., Canada, 2006:1-6.
[2] 王栋, 程杨, 贾强. LCC谐振变换器研究现状的综述[J]. 通信电源技术, 2019, 36(1):36-38. Wang Dong, Cheng Yang, Jia Qiang. Overview of research status of LCC resonant converters[J]. Telecom Power Technologies, 2019, 36(1):36-38(in Chinese).
[3] Canales F, Barbosa P, Lee F C. A wide input voltage and load output variations fixed-frequency ZVS DC-DC LLC resonant converter[C]//Conference Record of the 2002 IEEE Industry Applications Conference. Pittsburgh, PA, USA, 2003:2306-2313.
[4] 孙孝峰, 申彦峰, 朱云娥, 等. 一种Boost型宽电压范围输入LLC谐振变换器[J]. 中国电机工程学报, 2015, 35(15):3895-3903. Sun Xiaofeng, Shen Yanfeng, Zhu Yune, et al. A Boost-integrated LLC resonant converter for wide input voltage range[J]. Proceedings of the CSEE, 2015, 35(15):3895-3903(in Chinese).
[5] 宫力. LLC串联谐振全桥DC/DC变换器的研究[D]. 武汉:华中科技大学, 2008. Gong Li. Research on LLC series resonant full-bridge DC/DC converter[D]. Wuhan:Huazhong University of Science and Technology, 2008(in Chinese).
[6] Sun Xiaofeng, Shen Yanfeng, Zhu Yune, et al. Interleaved boost-integrated LLC resonant converter with fixed-frequency PWM control for renewable energy generation applications[J]. IEEE Transactions on Power Electronics, 2015, 30(8):4312-4326.
[7] 李菊, 阮新波. 全桥LLC谐振变换器的混合式控制策略[J]. 电工技术学报, 2013, 28(4):72-79. Li Ju, Ruan Xinbo. Hybrid control strategy of full bridge LLC converters[J]. Transactions of China Electrotechnical Society, 2013, 28(4):72-79(in Chinese).
[8] Ido Ko, Doron S, Shmuel S B Y. Ceramic capacitor controlled resonant LLC converters[C]//2018 IEEE Applied Power Electronics Conference and Exposition(APEC). San Antonio, TX, USA, 2018:2162-2167.
[9] 潘志杰. 混合控制全桥LLC谐振变换器的优化设计[D]. 南京:南京航空航天大学, 2013. Pan Zhijie. Optimization of hybrid controlled full-bridge LLC resonant converter[D]. Nanjing:Nanjing University of Aeronautics and Astronautics, 2013(in Chinese).
[10] 陈骏杰. 基于混合控制LLC谐振变换器的优化航空二次电源研究[D]. 南京:南京航空航天大学, 2016. Chen Junjie. Research on aircraft secondary power supply based on hybrid controlled LLC resonant converter[D]. Nanjing:Nanjing University of Aeronautics and Astronautics, 2016(in Chinese).
[11] 王镇道, 张一鸣, 李炳璋, 等. 全桥软开关LLC变换器模型与设计[J]. 电源技术, 2017, 41(11):1633-1636. Wang Zhendao, Zhang Yiming, Li Bingzhang, et al. Modeling and design for LLC resonant full-bridge converter[J]. Power Technology, 2017, 41(11):1633-1636(in Chinese).
[12] Medini D, Benyaakov S. A current-controlled variable inductor for high frequency resonant power circuits[J]. 1994 IEEE Applied Power Electronics Conference and Exposition. Orlando, FL, USA, 1994:219-225.
[13] Perdigao M S, Menke M F, Seidel A R, et al. A review on variable inductors and variable transformers:Applications to lighting drivers[J]. IEEE Transactions on Industry Applications, 2016, 52(1):531-547.
[14] Alonso J M, Perdigao M S, Vaquero D G, et al. Analysis, design, and experimentation on constant-frequency DC-DC resonant converters with magnetic control[J]. IEEE Transactions on Power Electronics, 2012, 27(3):1369-1382.

基金

国家自然科学基金资助项目（51577164）；江苏省第五期333工程资助项目；江苏省六大人才高峰人才资助项目（XNY-045）；江苏省高校青蓝工程资助项目。