Analysis and Design of LLC Resonant Converters with Capacitor–Diode Clamp Current Limiting

Abstract

As electronic systems are miniaturized, power supply designers are placed under increasing pressure to reduce the size of their designs, imposing strict requirements on the chosen power supply topology, components, efficiency, and cooling requirements. Size reduction in hard switching converters (e.g., buck converters) can be achieved by increasing the switching frequency, which reduces the size of passive components. The drawback of this approach is the increase in switching losses, ultimately compromising converter efficiency. Resonant converters such as series resonant, parallel resonant, and multi resonant converters overcome this drawback by soft-switching, where the switching devices are switched under zero voltage (ZVS) or zero current (ZCS). One variation of the multi resonant converter, the LLC resonant converter, has become popular due to its narrow range of operating frequency for wide input voltage and load ranges when operated around the converter’s (series) resonant frequency, also referred as the load independent point (LIP). The narrow frequency range is the result of the resonant
tank components, $L_s$ and $C_r$, becoming a virtual short-circuit (zero impedance) at the resonant frequency. The operating frequency is adjusted mainly to compensate for the change in the input voltage with only small adjustments to the frequency to compensate for changes in the load. Unfortunately, due to the low impedance around the LIP, excessive current can flow to the load during transient and overload conditions, and so a current protection mechanism must be included.

**Existing system**

DAB converter is a preferred option, as it has a small component count, offers isolation, and allows for high power operation. In addition, it has the ability to accommodate a wide range of voltage levels, as it may be controlled to operate in buck or boost modes.

**Proposed system**

The resonant capacitor of an LLC converter is split into clamped and nonclamped portions to allow the desired current limiting performance to be obtained. A fundamental harmonic approximation (FHA)-based equivalent circuit model, is derived for the converter to predict the current limiting characteristic under overloading.
Tools and software

- MPLAB – microcontroller programming.
- ORCAD – circuit layout.
- MATLAB/Simulink – Simulation.
Block diagram

Input DC supply

Half bridge converter

Resonant with diode clamp circuit

Load

OPTO coupler circuit

12 V DC

BUFFER circuit

PIC controller circuit

5 V DC

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