Contribution ID: **51** Type: **Poster**

A Prototype of Low Voltage Power Supply Using Piezoelectric Transformer

Thursday 18 September 2008 16:15 (20 minutes)

A prototype of the low voltage power supply is implemented with a piezoelectric transformer provided by Tokin Corporation lately, where the piezoelectric transformer realizes ground isolation between the primary and the secondary. The low voltage power supply, integrating the piezoelectric transformer, produces the regulated output voltage of 1.5 V from the supply voltage around 48 V.

A carrier drives the piezoelectric transformer where the carrier is generated by a full bridge of FETs operated in a phase shift mode. The full-bridge phase shift switching realizes flexible control over the frequency and the amplitude of the carrier. The carrier is converted in amplitude by the transformer, and then rectified to be the output voltage of the power supply, which is fed back to the frequency and the amplitude of the carrier. The response of the output voltage is improved by the feedback.

The output voltage is stabilized by feedback. A feedback loop includes error amplifiers, FETs and a control IC for the full-bridge phase-shift switching. The control IC includes the circuitry necessary for the feedback, generating gate drive signals for FETs. The error amplifier detects the deviation of the output voltage from a reference voltage, supplying error signals to the control IC, The error signal changes the timing of the gate drive signals, thus modifying the amplitude of the carrier. The error signal also changes the switching frequency of the control IC, thus shifting the frequency of the carrier.

Summary

A prototype of the low voltage power supply using the piezoelectric transformer is implemented, where the piezoelectric transformer was provided by Tokin Corporation lately. The transformer realizes the ground isolation between the primary and the secondary. The prototype is used to validate stabilization learned from extensive simulation and theoretical investigation.

The low voltage power supply includes the piezoelectric transformer. The piezoelectric transformer includes an internal resonance circuit. A carrier drives the piezoelectric transformer. The carrier supplied at the input of the transformer is converted in amplitude at the output, with the input to output voltage ratio of the amplitude being an amplitude ratio that shows a resonance as a function of the driving frequency: the frequency of the carrier. Voltage conversion at the transformer depends on the driving frequency. The dependence is utilized for stabilization.

The carrier driving the piezoelectric transformer is generated by a full bridge of FETs operated in a phase shift mode. The full-bridge phase shift switching realizes flexible control over the frequency and the amplitude of the carrier. Thus the switching drives the piezoelectric transformer at a good efficiency. The carrier outputted by the transformer is rectified by a full bridge of diodes, which produces the output voltage of the power supply. The output voltage of the power supply is fed back to the frequency and the amplitude of the carrier, by which the response of the output voltage is improved.

The output voltage is stabilized by feedback. A feedback loop includes error amplifiers, FETs and a control IC for the full-bridge phase-shift switching. The control IC includes the circuitry necessary for the feedback, generating gate drive signals for FETs. The error amplifier detects the deviation of the output voltage from a reference voltage, supplying error signals to the control IC, The error signal changes the timing of the gate drive signals, thus modifying the amplitude of the carrier. The error signal also changes the switching frequency of the control IC, thus shifting the frequency of the carrier.

The power supply has been extensively simulated. Simulation is run for all sorts of feedback under the various conditions. Yet the circuit of the power supply used in simulation is different from the real circuit of the power supply for several reasons. One of the reasons is that simulation consumes time. The real circuit is simplified to the simulation circuit so that the simulation time can be shortened. It may happen that difference between the real and the simulation circuits becomes an issue.

In the simulation circuit, the piezoelectric transformer is represented by its equivalent circuit. The error amplifier is approximated by an ideal amplifier with low pass filters. FETs and other components are found to be modeled in SPICE libraries. So the simulation circuit is composed of standard SPICE models except for the control IC. The control IC includes various functions necessary for the phase shift switching. In the simulation

circuit, the control IC is implemented by a mathematical model partially because the simulation of the control IC is time-consuming.

The mathematical model is designed to be functionally equivalent to the control IC, which can be tested with the prototype. The mathematical model can be compared with the SPICE model of the control IC, which will be soon at hand. Stabilization of the feedback so far learned can be tested, and the theoretical investigation can be validated.

Author: IMORI, Masatosi (ICEPP, University of Tokyo)

Co-authors: KANADA, Yasumasa (Information Technology Center, University of Tokyo); UNNO, Yoshinobu (KEK)

Presenter: IMORI, Masatosi (ICEPP, University of Tokyo)

Session Classification: POSTERS SESSION