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Decoupling Capacitors for Power Distribution Systems with Multiple Power Supplies

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Abstract

Multiple power supply voltages are often used in modern high performance ICs such as microprocessors to decrease power consumption without affecting circuit speed. To maintain the impedance of a power distribution system below a specified level, multiple decoupling capacitors are placed at different levels of the power grid hierarchy. The system of decoupling capacitors used in power distribution systems with multiple power supplies is described in this paper. In order to minimize the total impedance of a multi-voltage power delivery system as seen from a particular power supply, a decoupling capacitor is placed between the power supplies, connecting the two power supplies. The noise at one power supply can propagate to the other power supply, causing power and signal integrity problems in the overall system. With the introduction of a second power supply, therefore, the interaction between the two power distribution networks should be considered.

The dependence of the impedance and magnitude of the voltage transfer function on the parameters of the power distribution system is investigated. An antiresonance phenomenon is intuitively explained in this paper. It is shown that the magnitude of the voltage transfer function is strongly dependent on the parasitic inductance of the decoupling capacitors, decreasing with smaller inductance. Design techniques to cancel and shift antiresonant spikes out of range of the operating frequencies are presented. It is also shown that it is highly desirable to maintain the effective series inductance of the decoupling capacitors as low as possible to decrease the overshoots of the response of the dual voltage power distribution system over a wide range of operating frequencies. A criterion for an overshoot-free voltage response is presented in the paper. It is noted that the frequency range of the overshoot-free voltage response can be traded off with the magnitude of the response.