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Case ID:M17-026P
Published: 3/14/2017

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A Programmable Digitally Controlled Point-of-Load DC-DC Buck Converter Suitable for Space Applications

Buck converters are essential to modern electronics as they can maintain an output voltage at a desired range. Two of the main methods to accomplish this are hysteretic control and pulse width modulation (PWM). Hysteretic controllers continually monitor the output voltage and adjust it if it is too high or too low, but have bad frequency control. On the other hand, PWM systems use an oscillator to control the high and low voltages, but have substantial lag time. As a solution, a hybrid system has been proposed that uses PWM for control that activates the hysteretic control circuitry if the voltage passes a certain threshold level. However, this system has a high transient response because the threshold limits must be set far enough away so hysteretic control is not triggered continuously. In addition, the amount of circuitry and complexity is increased. Thus, there is a need for a power supply controller that has good switching frequency control in addition to a good transient response.

Researchers at ASU have developed a hysteretic controller with a feedback circuit that monitors the output frequency of the controller, compares the current frequency to a reference generated either internally or externally by the user, and then adjusts the hysteresis of the controller according to the error measured in the comparison. A digital frequency synchronization (DFS) method tunes the hysteretic window and the converter shows a fixed switching frequency. An online auto zero (OAZ) topology cancels the hysteretic comparator input so that converter output voltage error is within ±1% range of the input voltage reference. A duty-cycle-calibrated delay line (DCC-DL) implements phase synchronization so that the duty cycle of each slave phase uses information of the master phase to achieve current balancing. Overall, the novel converter offers improved current balancing, switching frequency control, and transient response in a programmable digitally controlled system.

Potential Applications

- Central power distribution systems
- Battery chargers
- Consumer electronics
- Lighting
- Space Applications

Benefits and Advantages

- High Efficiency – The voltage regulator modules increase the efficiency to over 90%
- Improved Current Balancing – The DCC-DL balances current so current

mismatch is within ±1% among each phase

- Enhanced Switching Frequency Control – The DFS tunes the hysteretic window, allowing the converter to synchronize within ±1.5% range of the input reference clock and hence shows a fixed switching frequency
- Improved Transient Response – The system provides a quicker response period than previous hysteretic or PWM schemes

For more information about the inventor(s) and their research, please see:

Dr. Bertan Bakkaloglu's directory webpage