Abstract

The most of today's portable, low power electronic systems are powered by single rechargeable batteries. So, it is absolutely essential to use DC-DC converters for processing a wide range of unregulated supply from the battery before it can be applied to the system core. The converter may also have to provide multiple supply voltages required by different circuits in the system. It is also preferred to integrate the converter with the application circuits, on the chip for having a compact System-on-Chip solution. In this dissertation, three integrated DC-DC converters using inductor and switched-capacitor topologies, suitable for battery-operated, low power applications have been presented.

The first converter presented in this work is an inductor based, integrated, high frequency boost converter. The salient feature of the converter is very small output ripple which makes it suitable for analog applications sensitive to supply noise. Architecturally, it consists of a conventional boost converter followed by an L-C filter which has been realized using package bondwire inductance and on-chip capacitance. The converter uses very small value (20 nH) of power inductance intended for charge sharing from the input to the output. Total capacitance used in the design is 1.08 nF which is fully-integrated. The converter produces a regulated 3.2 V output from an input voltage ranging from 1.2 V to 2.7 V. The measured ripple of the converter is 0.62% of the output voltage. This achieved ripple performance is 6$\times$ better compared to that of the existing integrated converters.

The second converter presented in this work is a switched-capacitor based, fully integrated, time-interleaved step-down converter with ideal conversion ratio equals to $^1/_2$. All the switches in the converter have been implemented by normal transistor driven by clocks with optimum voltage swing exhibiting good performance trade-off. The clocks are generated by a proposed clock generation architecture working on the principle of current sharing among circuit stacks improving the overall efficiency further. Moreover, the architecture produces a set of strictly aligned clock phases needed for an existing power-efficient switching scheme called NRTI. The step-down converter uses only 0.66 nF flying capacitance to generate 1.45 V output from 3.5 V input supply while delivering 53.7 mA output current at 71.2% efficiency. The designed converter, in comparison with the existing works, shows better trade-off between efficiency and driving capability per unit capacitance.

The third converter presented in this work is a hybrid of the inductor based boost converter and the switched-capacitor based step-down converter. The hybrid architecture is an area-efficient approach of generating two regulated outputs from a single input. In this architecture, the boost converter is responsible for the desired line regulation. On the other hand, the step-down converter, which is supplied by the boost converter, is able to work with a fixed input voltage and hence, at maximum possible efficiency. The maximum combined efficiency of the hybrid converter is 77% for 2.7 V input, 33.8 mA of boost load and 14.6 mA of step-down converter load. To the best of the author's knowledge, this is the first attempt to combine the two different classes of switching converters in a composite unit within an integrated package.

Keywords- Boost, bondwire, switched-capacitor, time-interleaving, ripple, multi-output