Fully Integrated Step-Down Voltage Converter Simulated on 45nm to give Efficient Result

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Abstract.

DC-DC converters are also known as switching voltage regulators, are one of the main component of a power management unit. Their main role is to provide a constant, smooth output voltage to power the electronic devices. Switching mode DC-DC converters are critical building blocks in portable devices and hence their efficiency and power are a major issue. This paper describes design techniques to maximize the efficiency of fully integrated switched-capacitor (SC) DC-DC converters and decrease the switching losses. The measured performance of switched capacitor converter implemented on tanner EDA tool at 45 nm CMOS technology with 2V input voltage to support efficient output voltages**.**
Keywords- DC-DC conversion, switched-capacitor, switching converter.

Introduction

Every Electronic circuit is assumed to operate some supply voltage which is usually assumed to be constant in nature. A voltage regulator is a power electronic circuit that maintains a constant output voltage irrespective of change in load current or line voltage. Many different types of voltage regulators with a variety of control schemes are used. With the increase in circuit complexity and improved technology a more severe requirement for accurate and fast regulation is desired. This has led to need for newer and more reliable design of dc-dc converters. The dc-dc converter inputs an unregulated dc voltage input and outputs a constant or regulated voltage. The regulators can be mainly classified into linear and switching regulators [1,2] shown in fig-1. All regulators have a power transfer stage and a control circuitry to sense the output voltage and adjust the power transfer stage to maintain the constant output voltage. A DC-DC converter is a device that accepts a DC input voltage and produces a DC output voltage. Typically, the output produced is at a different voltage level than input. Portable electronic devices, such as cell phones, PDAs, pagers and laptops, are usually powered by batteries. After the battery has been used for a period of time, the battery voltage drops depending on the types of batteries and devices. This voltage variation may cause some problems in the operation of the electronic device powered by the batteries. So, DC-DC converters are often used to provide a stable and constant power supply voltage for these portable electronic devices. According to the components used for storing and transferring energy, there are two main kinds of topologies in DC-DC converters: inductive converters and switched capacitor converters. The inductive converter using inductor as energy storing and transferring component has been a power supply solution in all kinds of applications for many years. It is still a good way to deliver a high load current over 500mA. But in recent years, since the size of portable electronic device is getting smaller and smaller, and the load current and supply voltage are getting lower and lower, the inductor less converters based on switched capacitor are more and more popular in the space constrained applications with 10mA to 500mA load current. Such converters avoid the use of bulky and noisy magnetic components, inductors.

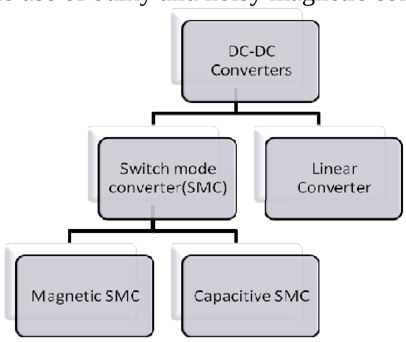


Fig1- Classification of converters

Switched Capacitor DC-DC Converter

Switched capacitor converters become popular for on-chip power conversion since there is no inductive component present, which on-chip with sufficiently low losses are large and difficult to manufacture, are required[3]. They uses only switches and capacitor. The switches in the circuit are operated by two distinct non-overlapping clock signal, so that switches turn on when the clock signal is high. To provide this clock signal we used the clock generator shown in fig-2. In a step-down converter which are intended to generate output voltages near the nominal process voltage, then the breakdown voltage of these switches will most likely to be smaller than the input voltage V_{BAT}, and therefore appropriate switch driving strategies are needed. Therefore a differential ring oscillator is used to meet the requirement of clock generation. The output of ring oscillator is used to drive two different phases of SC converter topologies. The output of ring oscillator is applied to AND gate with enable. here AND gate is designed because it provides buffering to the clock generator and clock produce with sharper edges, it also provides additional control from outside for enabling/disabling the clock generator .Some transistor in SC stage require different clock voltage to operate . This poses the requirement of level shifter[4] which can shift the voltage level of V_{drive} to GND. here V_{drive} is the optimum value of gate to source voltages at which the efficiency is higher. During phase 1, the charge-transfer capacitors get charged from the battery (V_{In}). In the phase2 of the clock, they dump the charge gained onto the load (V_{BAT}).

This paper presents the design and evaluation of a 2:1 and 2:5 voltage ratio down conversion switched capacitor converter shown in fig-3 and fig-4 implemented on 45nm technology on tanner tool. During the operation of SC topologies 2:1 and 2:5,these topologies switch into the circuit depending upon the load and input voltage requirements. Different capacitor arrangement in SC topology results in the unique no-load voltage at the output . During the closed loop operation of SC converter, these topologies will be configured in the main switching matrix based on the input voltage range and output voltage.

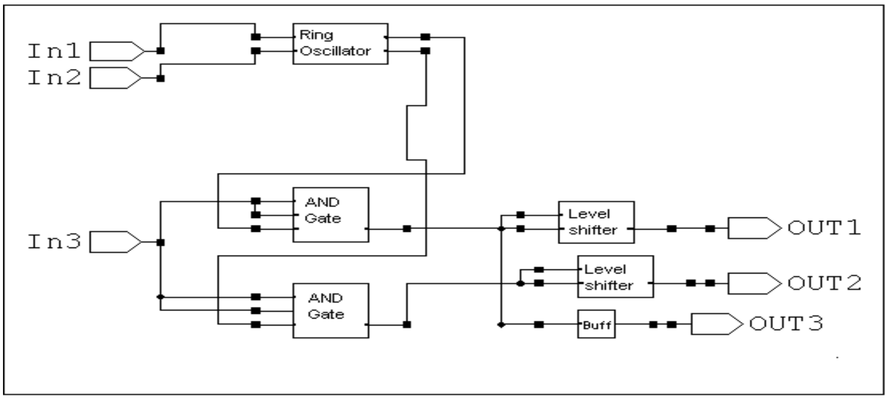


Fig2- Converter power switch control circuit

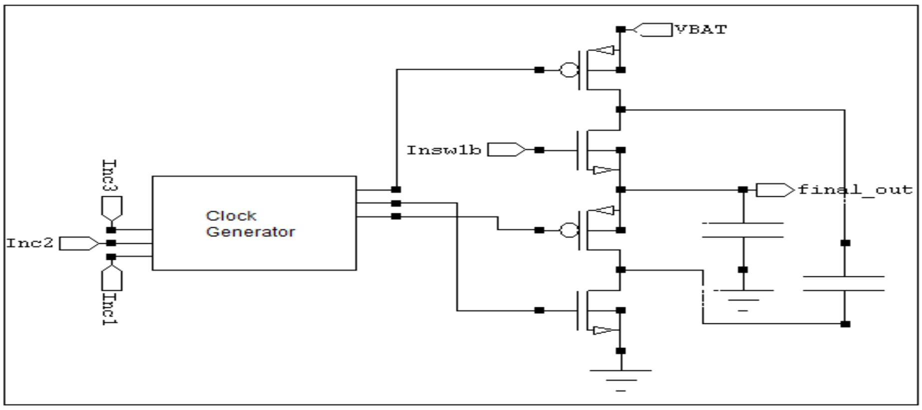


Fig3-2:1 converter with clock generator

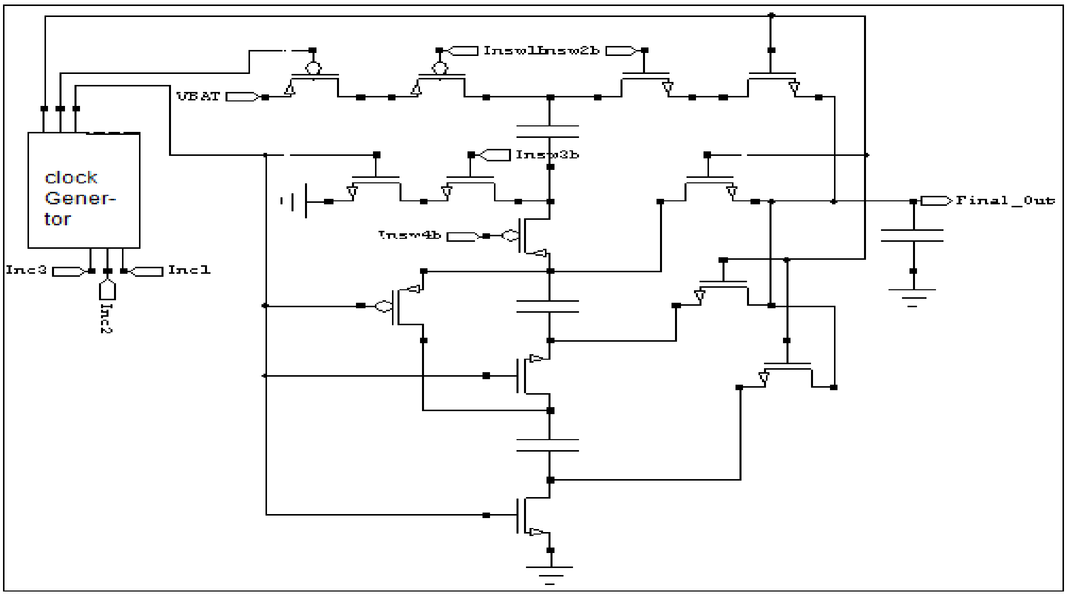
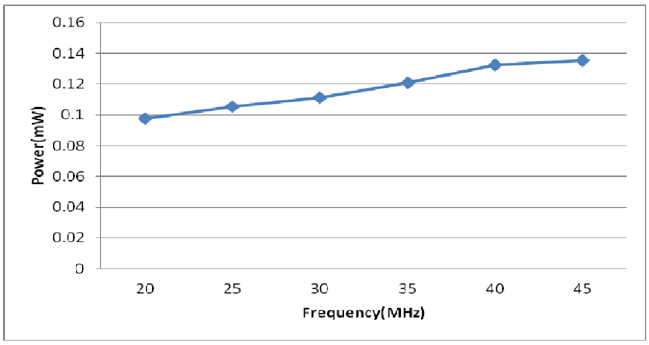


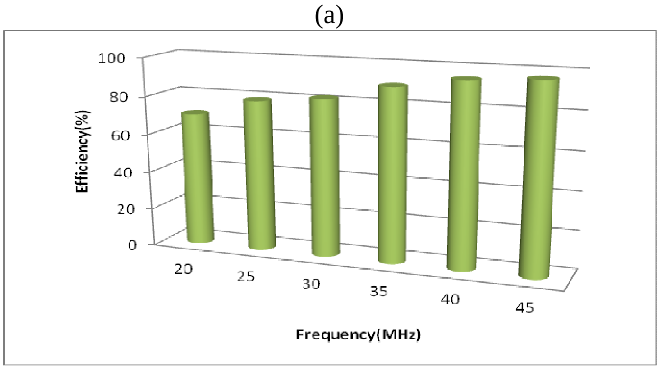
Fig4-2:5 converter with clock generator

Design and Implementation

This section discusses the design and implementation of the 2:1 and 2:5 SC converter integrated in a 45nm technology. In this work the demonstration of high efficiency voltage conversion is done by using the circuit shown in fig-3 and fig-4. In 2:1 and 2:5 conversion the output voltage is lower than the input voltage .This circuit for both topologies is simulated for power dissipation for different values of frequency on 45nm technology. Simulated figures are depicted from fig-5 to fig-6. Here it is shown that 2:1 topology gives better efficient result 98% and 2:5 gives 97% efficiency on 45nm technology each of them at 2v supply. Summary of work is shown in table-1.

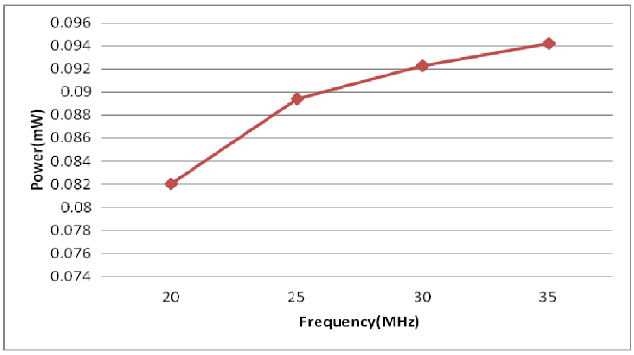


(a)



(b)

Fig5-(a) Power v/s Frequency and (b) efficiency v/s frequency which gives better efficient result at 45MHz for 2:5 topology



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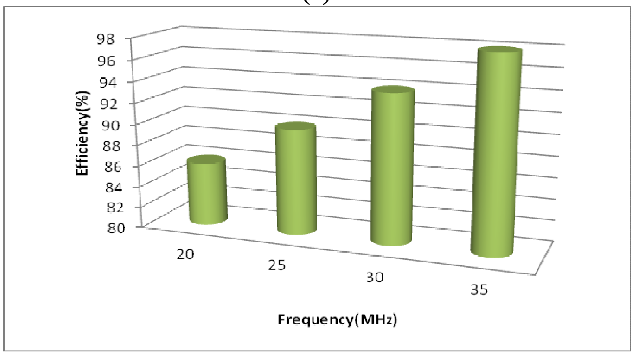

(b)

Fig6--(a) Power v/s Frequency and (b) efficiency v/s frequency which gives better efficient result at 35MHz for 2:1 topology

Table1- Summary of the 2:1 and 2:5 Converter at 45nm Technology

Topology	2:1	2:5
Process	45nm Tanner Tool	45nm Tanner Tool
Input Voltage	2v	2v
Output Voltage	0.974v	0.786v
Power	94.2uW	0.1352mW
Frequency	35MHz	45MHz
Efficiency	98%	97%

5. Comparison and Result

In Table. 2, the results presented in this paper are compared to previously published results on SC converters focusing on efficiency. This work is implemented on 90nm and 45nm Technology on Tanner EDA Tool and it gives
98% efficiency at low power for 2:1 topology on 45nm.

Table-2 Comparison of the work presented in this paper to previously published work

Reference	[5]	[6]	[This work]
Technology	45nm SOI	90nm BULK	45nm Tanner EDA Generic
Topology	2:1	2:1	2:1 and 2:5
Input Voltage	2V	2.4V	2V
Output Voltage	0.95V	1V	0.97
Power	2.6mV	1650mW	94.2uW
Frequency	100MHz	N/A	35MHz
Efficiency	90%	69%	98%

6. Conclusion

In this paper 2:5 and 2:1 topologies are simulated 45nm technology on Tanner EDA Tool. This work shows the better efficient result on 45nm technology for 2:1 topology when input voltage is 2V at 35MHz frequency which results in 0.97V output voltage more than 2:5 topology, 94.2uW power less than the power in 2:5 topology and 98% efficiency .

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