Design of Digitally controlled CMOS voltage mode DC-DC Buck Converter capable of controlling duty ratio with high resolution

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A digitally controlled buck converter insensitive to process is presented. Conventional digital-controlled buck converters utilized ADCs, counters and delay line circuits for accurate output voltage control, resulting in increasing the number of counter and delay line bits. This problem can be resolved by employing the 8-bit and 16-bit bidirectional shift registers, and this design technique leads a buck converter to be able to control duty ratio up to 128-bit resolution. The proposed buck converter was designed and fabricated with a CMOS 180 nm 1-poly 6-metal process, generating an output voltage of 0.9V to 1.8V with the input voltage range of 2.7V to 3.6V, a ripple voltage of 30mV, and a power efficiency of up to 92.3%. The transient response speed of the proposed circuit was measured to be 4us.

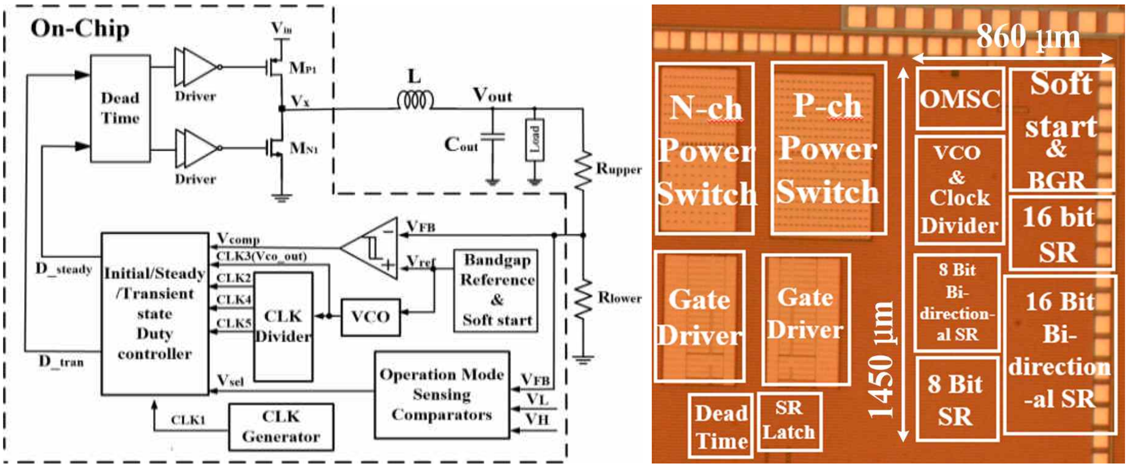

Fig 1.Top Cell

The proposed circuit is designed to efficiently use the battery driving time by using digital control circuits. In the conventional digital-controlled buck converter structure, ADC (Analog to Digital Converter), counter and delay line structures, etc. were used for accurate duty ratio control. Increasing the resolution of the ADC and the number of bits of the counter has the advantage that accurate duty ratio control is possible, but the higher the resolution and the number of bits, the more complex the circuit and consumes power [6]. To improve this, in this paper, 8-bit and 16-bit bidirectional shift registers are used instead of ADC, counter and delay line circuits to reduce circuit complexity and improve power conversion efficiency.

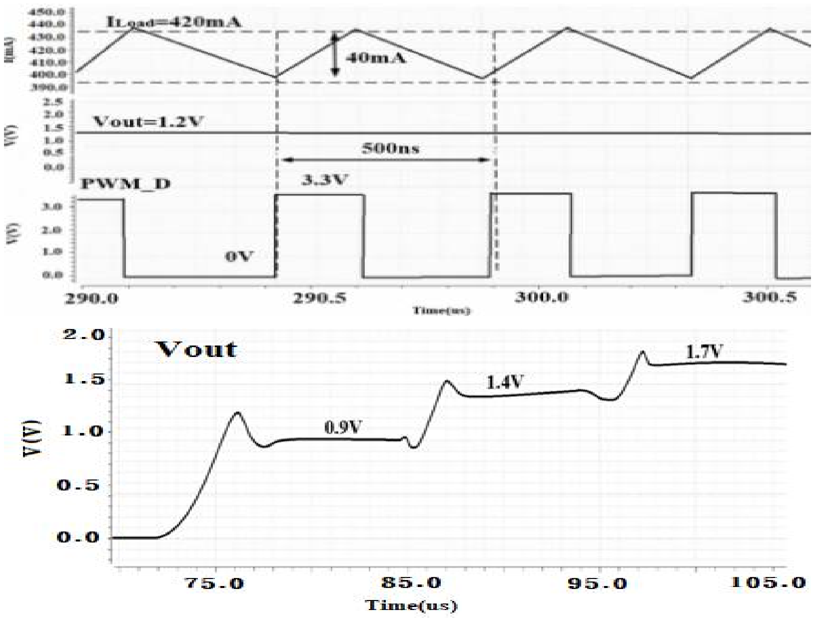

Fig 2. Simulation waveform of output voltage

The input voltage range of the proposed buck converter is 2.7V-3.6V, and the output voltage range is 0.9V-1.8V. The load current range is 80mA-450mA, and the output voltage ripple is approximately 30mV. Therefore, the proposed digitally controlled buck converter has a wide output voltage range and is expected to be applicable to applications of IoT and mobile devices that require a current of up to 450mA, as well as power management circuits such as CPUs.