Voltage Mode Control and Current Mode Control of Buck Converter using PSIM

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Abstract- *DC-DC Converters are drastically used in industries as well in field of research. The main drawback of these converters is unregulated voltage. To overcome these problems, there are various control techniques. In this paper, two control mode methods are compared to get a regulated output voltage of Buck Converter. Compensation Mechanism using Voltage Control Mode and Current Control Mode are used. PID compensator is designed by modifying open circuit buck converter circuit obtained using PSIM. The error signal is compared with saw-tooth ramp voltage and desired PWM signal.*

Keywords- Voltage Control Mode, Current Control Mode, Buck Converter, PID Compensator, Pulse Width Modulation, PSIM.

I. INTRODUCTION

DC-DC converters in power electronics circuits are those which convert direct current (DC) voltage input from one level to another. DC-DC converters are also known as switching converters, switching power supplies or switches. They play a vital role in field of power electronics. [1],[2],[3]. The main problem with operation of DC-DC converter is unregulated power supply, which leads to improper function of DC –DC converters. There are various analogue and digital control methods used for dc-dc converters and some have been adopted by industry including voltage and current mode control techniques[2],[4]. Application of a voltage regulator is that it should maintains a constant or fixed output voltage irrespective of variation in load current or input voltage. Various kinds of voltage regulators with a variety of control schemes are used to enhance the efficiency of DC-DC converters. Today due to the advancement in power electronics and improved technology a more severe requirement for accurate and reliable regulation is desired. This has led to need for more advanced and reliable design of controller for dc-dc converters.

II. VOLTAGE MODE CONTROL

In voltage mode control an external signal is compared with the control signal obtained for generating the duty cycle needed to have the wanted output voltage. The output voltage Vout is monitored and subtracted from the reference value Vref and an error signal Vcomp results. This error signal is then used for the resulting control signal. The control signal is then compared with the external ramp voltage Vramp and a pulse width modulated signal is sent to the drivers of the MOSFET so that converter can react in such a way so as to reduce the output error [5],[6],[7]. This VMC method is used in research as well as in industry due its easy implementation [8],[9]. It uses measured output and reference voltage to generate the control voltage. After this the control voltage is used to determine the switching duty ratio by comparison with a constant frequency waveform. This duty ratio is used to maintain the average voltage across the inductor. This will eventually bring the output voltage to its reference value and which help in the delivery of constant voltage without any variation.

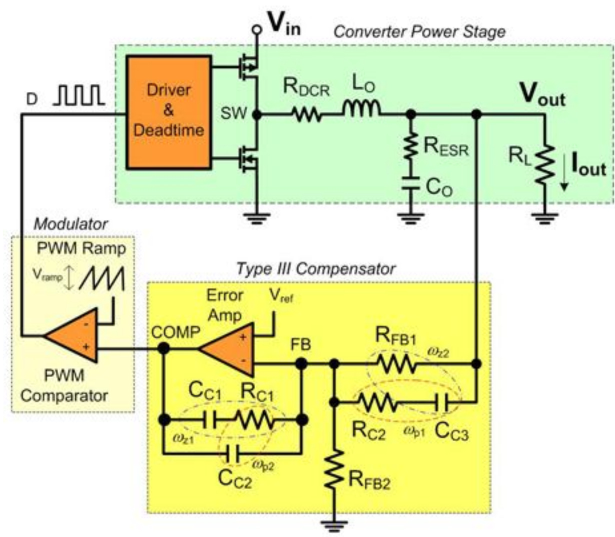

Fig.1 Block Diagram of Buck Converter using Voltage Mode Control

The voltage mode controlled buck converter circuit is shown in Figure 1. It consists of a controlled switch S_w (MOSFET), an uncontrolled switch diode D (diode), an inductor L, a capacitor C, and a load resistance R. The output filter consists of the output inductor and all of the output capacitance. It is important to include the DC resistance (DCR) of the output inductor and the total Equivalent Series

Resistance (ESR) of the output capacitor bank. The switch is controlled by analog PWM feedback logic. The generalized schematic of a single phase/channel buck converter using voltage mode control and a type III compensation circuit is embodied.

Voltage-mode control (VMC) is widely used because it is easy to design and implement, and has good community to disturbances at the references input. VMC only contains single feedback loop from the output voltage.

III. CURRENT MODE CONTROL

Current-mode controlled dc-dc converters usually have two feedback loops: a current feedback loop and a voltage feedback loop. The inductor current is used as a feedback state.

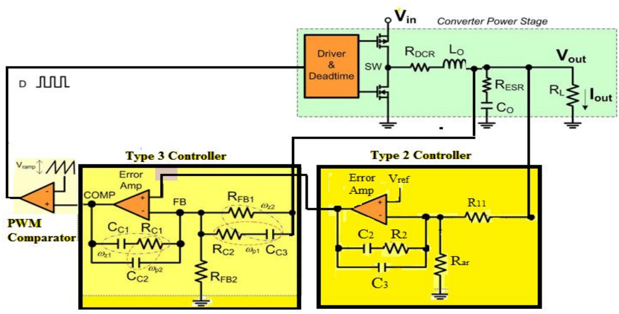

Fig.2 Block Diagram of Buck Converter using Current Mode Control

Current-mode control (CMC) is widely used in dc-dc converters for high-performance applications. [10][11][12] In spite of its implementation simplicity, the dynamics are complicated and designing the control loop can be challenging. The outer voltage loop with an error amplifier that compensates for the dynamic response of the output voltage. The current loop is an inner loop that provides tight control on the peak inductor current.

There are various applications of Current Mode Control for different applications. After sensing inductor current, an error signal is produced after comparing it with output voltage with fixed reference voltage. This error signal will produce the control signal. This control signal is compared with sensed induced current to generate duty cycle of particular frequency. This drives the switch of the Dc-DC Converter. [4]

IV. SIMULATION RESULTS

Both Voltage Mode control & Current Mode Control are implemented using PSIM. The Output Voltage of Buck Converter using both methods is compared.

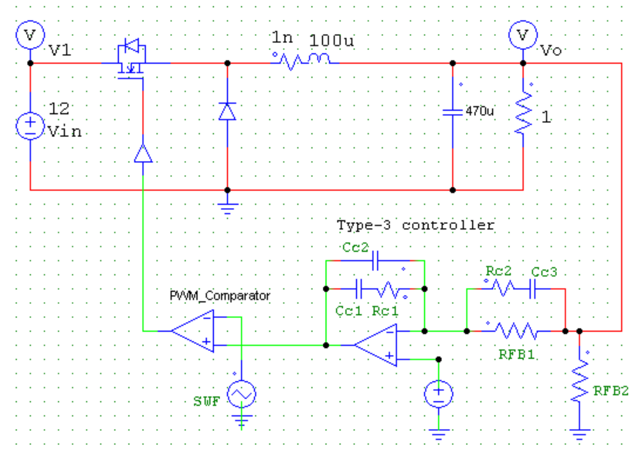

Fig.3 PSIM Model of Buck Converter using Voltage Mode Control

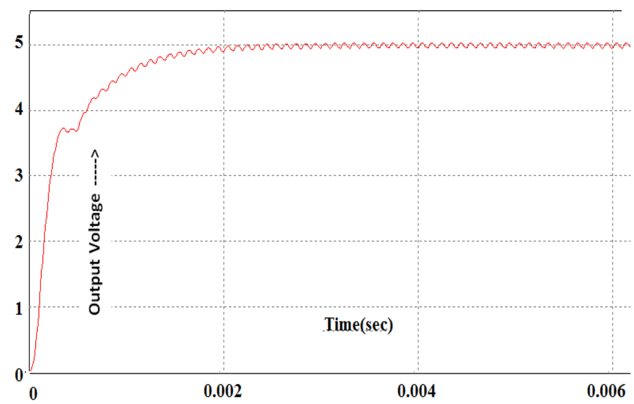

Fig.4 Output Voltage waveform of Buck Converter using Voltage Mode Control

The complete PSIM Model of Buck Converter using Voltage Mode Control is shown in Figure.3 Output Voltage waveform of VMC is shown in Figure 4. Here Type 3 Controller is used for compensation.

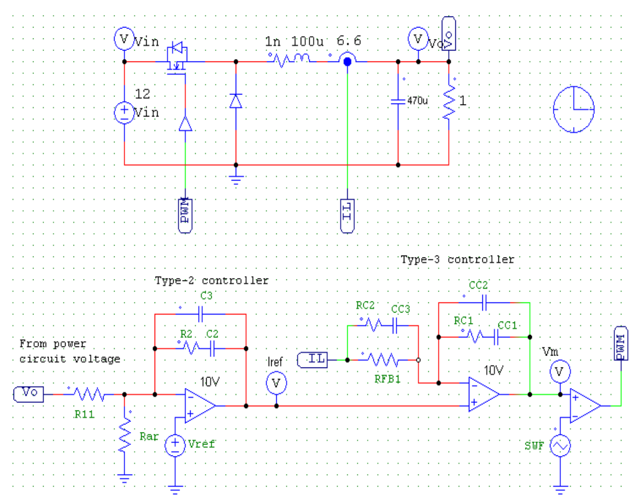

Fig.5 PSIM Model of Buck Converter using Current Mode Control

The complete PSIM Model of Buck Converter using Current Mode Control is shown in Figure.5 Output Voltage waveform of CMC is shown in Figure.6. Here Type-2 Controller is used for Output Voltage Control and Type -3 Controller is used for Inner Current Control.

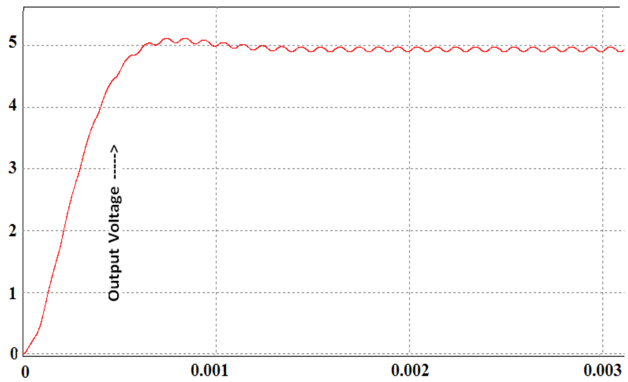

Fig.6 Output Voltage waveform of Buck Converter using Current Mode Control

Buck Converter using both Voltage Mode Control and Current Mode Control is simulated in PSIM. Output Voltage waveform is obtained.

V. CONCLUSION

Designing a voltage-mode and current-mode controlled buck converter is very challenging. The most difficult part is determining the compensation network and manipulating the poles and zeros to build a robust and balanced system. The PWM is a relatively simple concept, but a real world design of this block would be troublesome. Design and simulation of the circuit is done using PSIM. PID controller has been designed and the system operates in closed loop. In other words, feedback stabilizes the system. The PID compensator is designed by modifying the open loop buck converter circuit obtained from the simulation in PSIM. The error signal is compared with a saw-tooth ramp voltage and desired PWM signal.

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