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Modelling and Advance Control Techniques for DC-DC Converter with Improve Performance

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Abstract— **The switched mode DC-DC converter are some of the most widely used power electronics circuits for its high conversion efficiency and flexible output voltage. The different control techniques and method implemented on DC-DC converter. DC-DC converters are used to convert one DC voltage to other. As DC/DC converters are nonlinear and time-variant systems, the application of linear control techniques for the control of these converters are not suitable. In this paper, a new sliding mode controller is proposed as the indirect control method in order to control a buck converter and we summarized some other well developed control techniques voltage, current and PID for DC-DC converter. Their principal characteristics are illustrated using MATLAB and the Simulink block diagram system along with experimental results.**

Index Terms—**DC-DC Converter, Sliding Mode Control , PID Mode, Voltage and Current Control Method.**

I. INTRODUCTION

The switching converters convert one level of electrical voltage into another level by switching action. They are popular because of their smaller size and efficiency compared to the linear regulators. DC-DC converters have a very large application area. These are used extensively in personal computers, computer peripherals, and adapters of consumer electronic devices to provide dc voltages. DC-DC converters are one of the important electronic circuits, which are widely used in power electronics [1-3]. 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]. The DC-DC converter inputs are generally unregulated dc voltage input and the required outputs should be a constant or fixed voltage. 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.

Buck converter is one of the most important component of circuit it convert voltage signal from high DC signal to low voltage. In buck converter, a high speed switching devices are placed and the better efficiency of power conversion with the study state can be achieved. There are various types of DCDC converters required for particular purpose like Buck, Boost, Buck and Boost, Cuk and flyback. These all DC-DC converters have their specific configurations to complete their tasks. Varieties in DC-DC converter required different type of controlling techniques because single technique cannot be applied to all converters as the all have different specifications. This paper we discuss about the performance of various types of DC-DC converter.

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II. SLIDING MODE CONTROLLERS

Buck Converter is a time variable and a nonlinear switch circuit which possesses variable structure features. Sliding mode control is well known for its good dynamic response and stability due to its insensitive for parameters change and easier in implementation, so this control technique is used extensively for the control of dc-dc power converters. A typical SM controller for switching power converters has two control modes: voltage mode and current mode. Here, voltage mode control is employed, i.e. output voltage v_o , is the parameter to be controlled. [5]

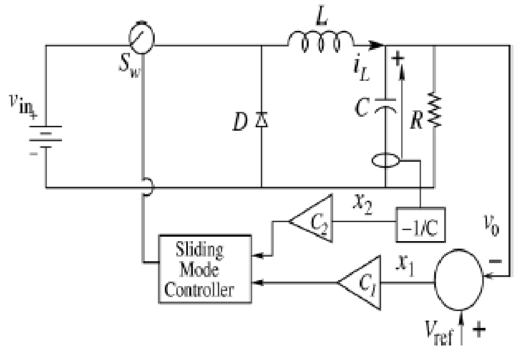

Figure 1. Basic structure of a sliding mode system

Figure 1 shows the schematic diagram of a SM voltage controlled buck converter. Here the state space description of the buck converter under SM voltage control, where the control parameters are the output voltage error and the voltage error dynamics is described.

SM controller is a type of non-linear controller. It is employed and adopted for controlling variable structured systems (VSSs). It is very easy to implement as compared to other types of nonlinear and classical controllers [6, 7]. Two important steps in SM control is to design a sliding surface in state space and then prepared a control law to direct the system state trajectory starting from any arbitrary initial state to reach the sliding surface in finite time, and at the end it should arrive to a point where the system equilibrium state exists that is in the origin point of the phase plane. There are three important factors responsible for the stability of SM controllers, existence, stability, and hitting condition. Sliding Mode control principle is graphically represented in figure-2

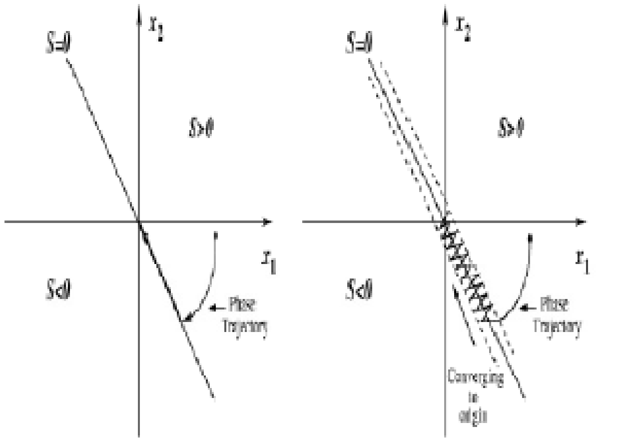

Figure 2. Graphical representation of SM control S=0 represent the sliding surface and $x1$ = the voltage error variable and $x2$ = voltage error dynamics respectively. [8]

The sliding line divides the phase plane into two main regions shown in the figure. Each region is represent by a switching state and when the trajectory comes at the system equilibrium point, in this case the system is considered as stable system. A unique feature of an ideal sliding mode control technique is that it operates at infinite switching frequency. But practical SM controllers are operated at finite switching frequencies only which represent a quasi-sliding mode.

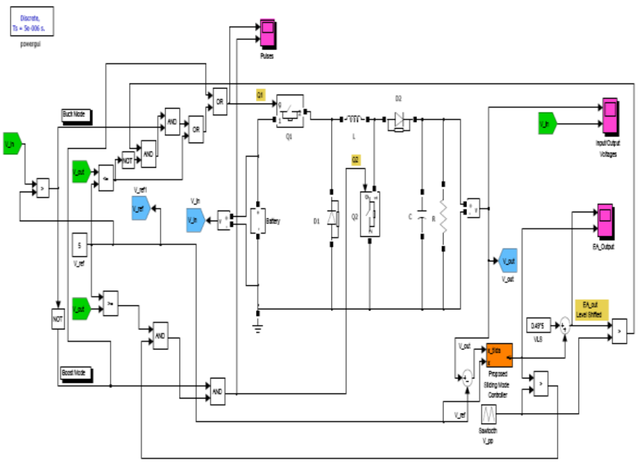

Figure 3. SIMULINK block diagram of Slide mode control

Figure 3 show an implemented in MATLAB simulation tool as per evaluation parameters based block diagram of Slide mode control.

III. Proportional, Integral and Derivative Controller (PID)

PID control is one of the oldest and classical control technique used for DC-DC converters [9, 10]. PID it is widely used for industrial applications in the area of power electronics. One of the main causes for the use of this classical technique still in industrial applications is easy implementation of tuning method like Ziegler-Nichols tuning procedure by which we can easily optimize proportional, integral and derivative term of this control method needed to achieve a desired closed-loop performance.

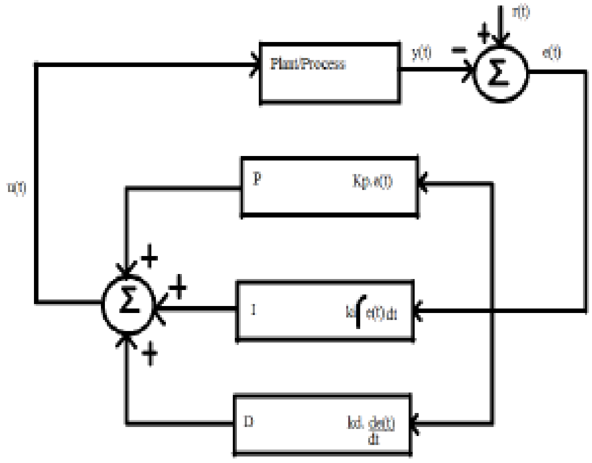

Figure 4. Block diagram of PID Controller

A proportional integral derivation controller (PID Controller) is a generic control loop feedback mechanism widely used in industrial control system as well as in research. This approach is often viewed as simple, reliable, and easy to implement. PID controllers are commonly used as controllers for boost converters in PV.

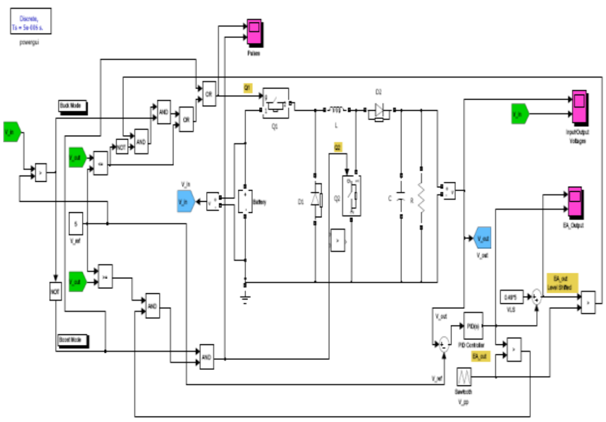

Figure 5. SIMULINK block diagram of PID Controller

Figure 5 show an implemented in MATLAB simulation tool as per evaluation parameters based block diagram of PID mode controller.

IV. Voltage Mode Control of DC-DC Converters

It is a type of single loop controller connected to a reference voltage, so at first output voltage is measured and compared to a reference voltage**.** The voltage feedback arrangement is known as voltage-mode control when applied to dc-dc converters. 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.

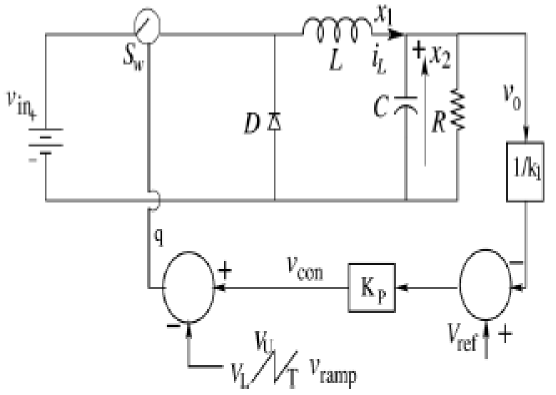

Figure 6. Block diagram of Voltage Mode Controller

This VMC method is used in research as well as in industry due its easy implementation [11, 12]. 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.

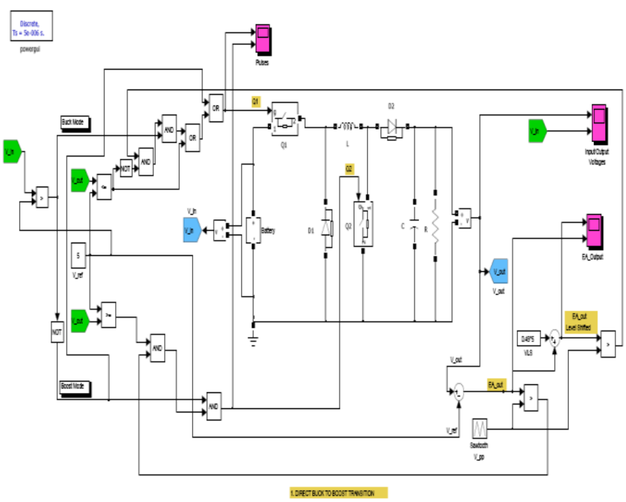

Figure 7. SIMULINK block diagram of Voltage Mode Controller

Figure 7 show an implemented in MATLAB simulation tool as per evaluation parameters based block diagram of Voltage mode controller.

V. CURRENT MODE CONTROL OF DC-DC CONVERTERS

Another control scheme that is widely used for dc-dc converters is 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.

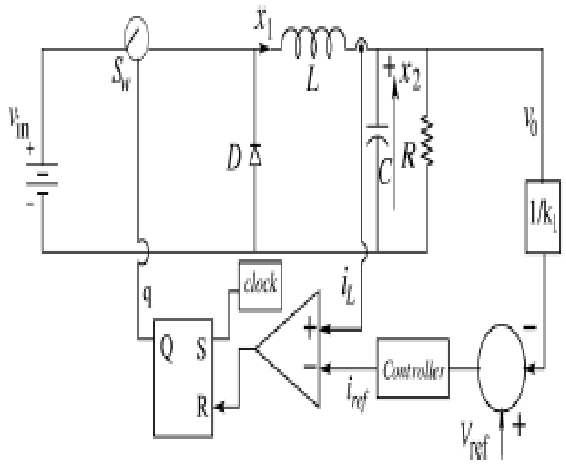

Figure 8. Block diagram of Current Mode Controller

A current mode controlled dc-dc buck converter circuit is shown in figure.8. At the beginning of a switching cycle, the clock signal sets the flip-flop (q=1), turning on the (MOSFET) switch. The switch current, which is equal to the inductor current during this interval, increases linearly. The inductor current i_l is compared with the control signal i_{ref} from the controller. When i_l, is slightly greater than i_{ref}, the output of the comparator goes high and resets the flip-flop (q=0), thereby turning off the switch. The switch will be turned on again by the next clock signal and the same process repeated.

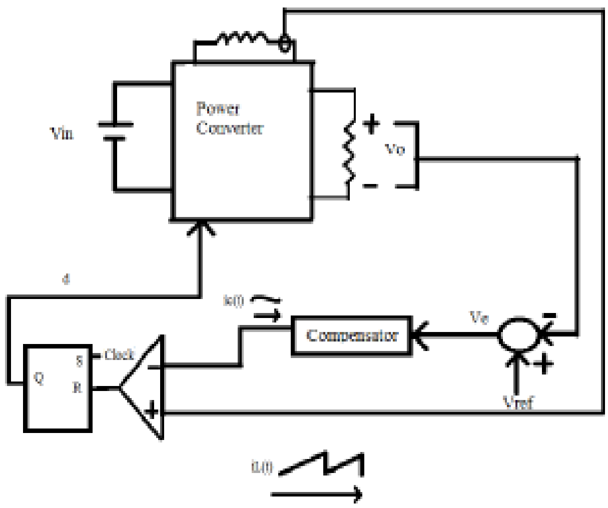

Figure 9. Current Mode Control of DC-DC Converter

It is more complex than VMC as it contain dual loop including voltage and current control loops show as Fig. 9. There are various application of CMC for different application [13,14]. After sensing the inductor current it is used to control the duty cycle. An error signal is produced after comparing the output voltage *Vo* with fixed reference voltage *Vref* and this error signal is used to generate control signal *ic*. The next step is to sense inductor current and compared with control signal *ic* to generate the duty cycle of particular frequency and drive the switch of the converter [4]. All response depend on the position of feedback loop as if the feedback loop is closed, the inductor current is proportional to the control signal *ic* and the output voltage becomes equal to reference voltage *Vref*.

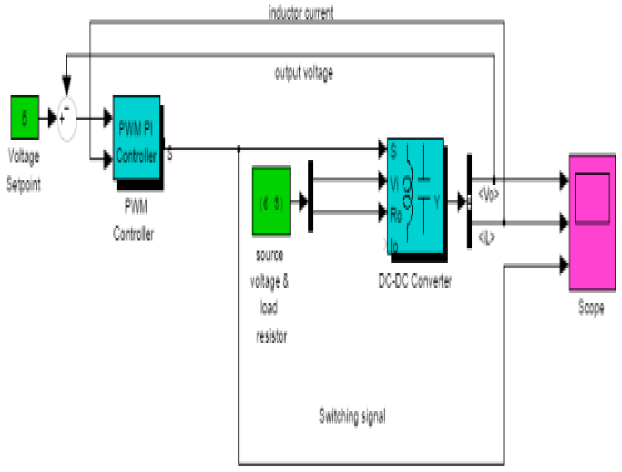

Figure 10. SIMULINK block diagram of Current Mode Controller

Figure 10 show an implemented in MATLAB simulation tool as per evaluation parameters based block diagram of Current mode controller.

VI. Conclusion

In this review we provided an overview of control techniques used for DC-DC converters. We briefly explained the basic concepts of each control techniques. Sliding Mode control of buck converter is implemented and different output parameter is observed. The output voltage and current is stable and satisfactory. The output is better than the PID control buck converter. Voltage and Current Mode Controller techniques used as specific purpose. All kind of control technique is needed for particular purpose. There is still scope for the development of more reliable and efficient control technique.

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