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ADVANCED CONTROL TECHNIQUES FOR DC-DC CONVERTERS

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Abstract

A buck converter is a ubiquitous and practical technology in the realm of contemporary power electronics. The network of contemporary high-voltage direct current (HVDC) power systems makes extensive use of it. For buck converter control, the proportional-integral-derivative (PID) controller is both the most popular and effective option. A PID controller is a common component of contemporary automated control systems. A non-linear control system is one of the more sophisticated ways to manage the converter. The sliding mode control method is one of the non-linear control techniques. While it's true that every control method has its pros and faults, there are situations in which one approach is more suitable than others. There is a lot of desire right now for the control approach that can deliver top-notch results no matter what.

Keywords-Advanced, Control,Dc-Dc, Converters.

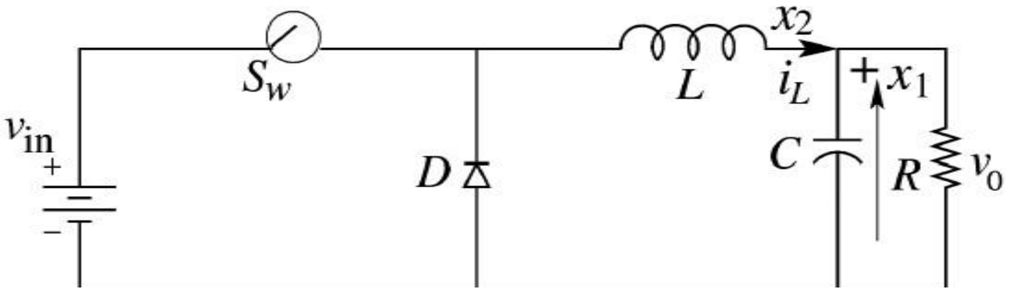
INTRODUCTION

The electrical voltage is changed from one level to another by means of switching in switching converters. When compared to linear regulators, they are far more appealing due to their efficiency and smaller size. Various applications call for DC-DC converters. Computers, computer peripherals, and adapters for consumer devices rely on them for dc voltage supply. The direct current to direct current converter is an essential electrical circuit that is widely used in power electronics [1-3]. A DC-DC converter's performance could be negatively impacted by power supply that are not properly controlled. The control of direct current to direct current converters may be achieved in a number of ways, some of which have found widespread use in industry, including voltage- and current-mode control systems [2, 4]. The inputs of a DC-DC converter are typically unregulated DC voltage, while the outputs must be a constant or fixed voltage. Regardless of variations in input voltage or load current, a voltage regulator's output voltage should be constant or steady. The buck converter, which transforms a signal with a high DC voltage into one with a low voltage, is an essential part of the circuit. To achieve better power conversion efficiency while keeping the studied condition, buck converters with high-speed switching components might be used. For specific tasks, you'll need a specific type of DCDC converter, such as a Buck, Boost, Buck and Boost, Cuk, or flyback. Kanpur Institute of Technology, Kanpur, India; Dipshikha Katiyar, M.Tech.; Rakesh Kumar Panday, Professor of

Electrical Engineering, teaches at the Kanpur Institute of Technology; and each of these DC-DC converters has its own unique arrangement. operation. varied types of DC-DC converters call for varied methods of regulation due to the fact that each converter has unique needs. Different types of DC-DC converters are analyzed in this study.

III.BASIC PRINCIPLES

By utilizing a circuit known as a buck converter, it is possible to convert a higher direct current (DC) input voltage into a lower DC output value. The graphic depicts the essential topology of a buck dc-dc converter. This topology is depicted using the graphic. To begin, it is composed of a controlled switch that is denoted by the letter Sw, a switch that is not controlled and is denoted by the letter D, an inductor of the letter L, a capacitor of the letter C, and a load resistance of the letter R.



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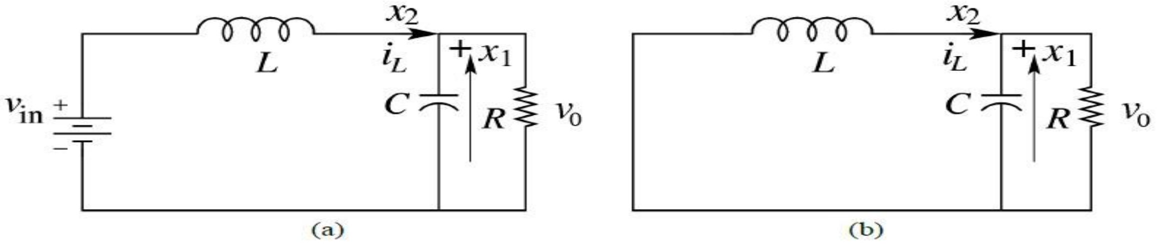

Figure 1:Dc-Dc Buck Converter Topology Figure 2: Buck Converter Circuit When Switch: (A) Turns On (B) Turns Off

Based on the description of the converter's working, it is presumed that all components are correct. Additionally, it is assumed that the converter performs under CCM conditions. When a CCM is operational, the inductor receives a constant current during the switching period. When the switching function is executed, the switch is either turned on or off, resulting in two distinct circuit states. The first sub-circuit condition happens when the switch is turned on, the diode is reverse biased, and the current from the inductor flows through the switch, as shown in figure 2(a). It is possible to differentiate this condition from the others. When the switch is turned off and current is allowed to flow freely through the diode, Figure 2(b) shows the second sub-circuit situation.

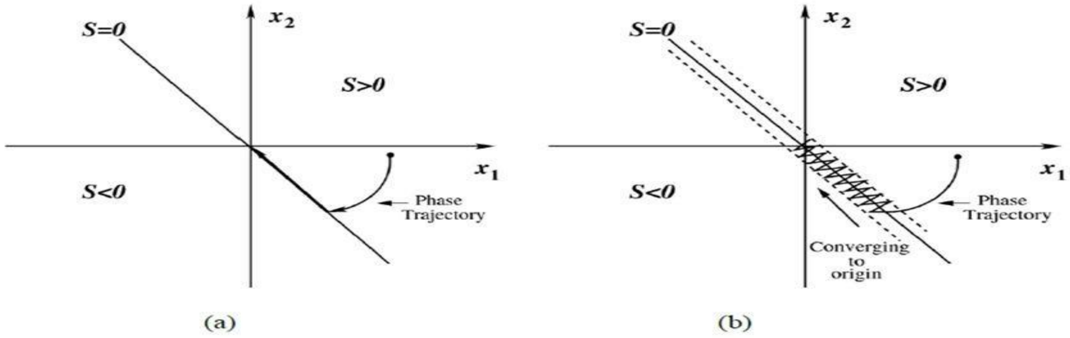

Figure 2: Phase Plot for (a) ideal SM Control (b) actual SM control

Building a sliding surface in state space is the initial phase of SM control, which can start from any beginning state. Developing a control law to guide the system state trajectory to the sliding surface within a certain period is the second phase. When everything else fails, the system should eventually reach the origin of the phase plane, where it will be in its equilibrium condition. At its core, SM control is based on this idea. Three things—the presence of the regulating mechanism, the stability of that mechanism, and the striking condition—determine the stability of sliding mode control. See Figure 3 for an example of the SM control principle in action; x1 represents the voltage error variable and x2 the voltage error dynamics. The slider is symbolized by the symbol. The sliding line separates the phase plane into two sections in any two-dimensional plane when a two-variable SM control system is in operation. Once the trajectory reaches the system's equilibrium point, the system is considered stable. A switching state is used to characterize each section.

SLIDING MODE CONTROLLERS

The Buck Converter is both a nonlinear switch circuit and a time variable circuit with structural features that may be changed. Sliding mode control is widely used to regulate dc-dc power converters due to its reputation for outstanding dynamic responsiveness and stability, its insensitivity to parameter changes, and its simplicity of implementation. Commonly encountered in SM controllers for switching power converters are two control modes. Both voltage and current modes are available. The circumstance calls for the regulation of the output voltage, which is why voltage mode control is employed. [5]

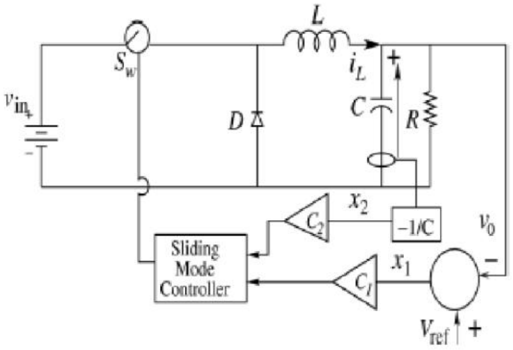

Figure 3. Fundamental components that make up a sliding mode system

Figure 3 is a schematic diagram showing the SM voltage controlled buck converter. This section provides the buck converter's state space description in the context of SM voltage control. The dynamics of the voltage error and the output voltage error serve as the control parameters. The SM voltage control system is now controlling the buck converter.

The SM controller is one type of non-linear controller. Variable structured systems (VSSs) management is another area where it finds use. Its implementation is basic and simple in comparison to other types of nonlinear and classical controllers [6, 7]. Key components of state-space sliding-mode control (SM control) include designing a sliding surface and preparing a control rule to guide the system state's trajectory from any beginning state to the sliding surface within a predetermined time limit. The goal is for the system to reach its equilibrium state at the beginning of the process, which is at the origin of the phase plane. There are three main factors that ensure SM controllers remain stable. Prevalence, steadiness, and impact state are some of these considerations. The descent

Mode control principle is graphically represented in figure-4

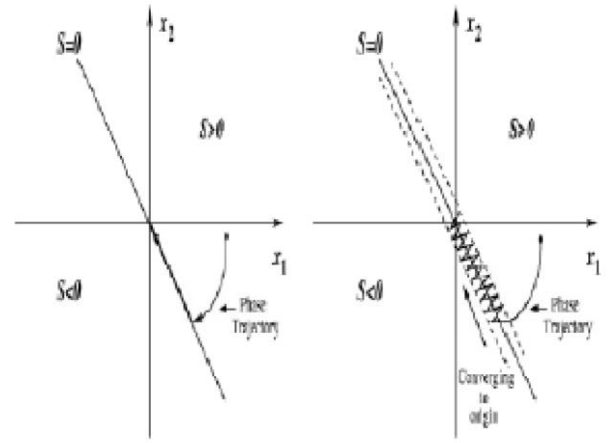

Figure 4. **S=0 represents the sliding surface in this SM control function image, x1 is the voltage error variable, and x2 is the dynamics of the voltage error.**

Two main zones are defined on the phase plane by the sliding line, as seen in the picture. The system is considered stable if and only if the trajectory reaches the equilibrium point. A switching state represents each section. Functioning at an infinite switching frequency is a distinguishing feature of an ideal sliding mode control technique. However, actual SM controllers operate in a quasi-sliding fashion due to their restricted switching frequencies.

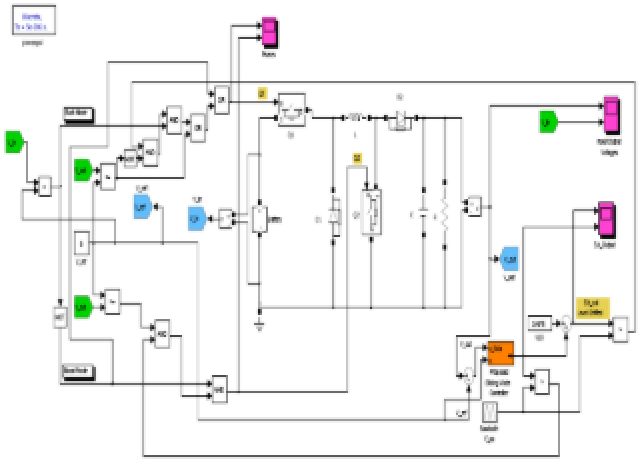

Figure 5. SIMULINK block diagram of Slide mode control

The slide mode control block diagram shown in Figure 5 is an example of a simulation tool that was created in MATLAB and has been based on evaluation parameters.

PROPORTIONAL, INTEGRAL AND DERIVATIVE CONTROLLER (PID)

One of the oldest and most reliable control methods for DC-DC converters is the proportional-integral-derivative (PID) approach [9, 10]. Among the many industrial uses of power electronics, PID is a common tool. To get the targeted closed-loop performance, it is essential to optimize the method's integral, derivative, proportional, and control terms, all of which may be accomplished with relative ease. One of the main reasons this traditional method is still employed in industrial settings is because of this. That tuning procedures like the Ziegler-Nichols tuning procedure are easy to adopt is another factor.

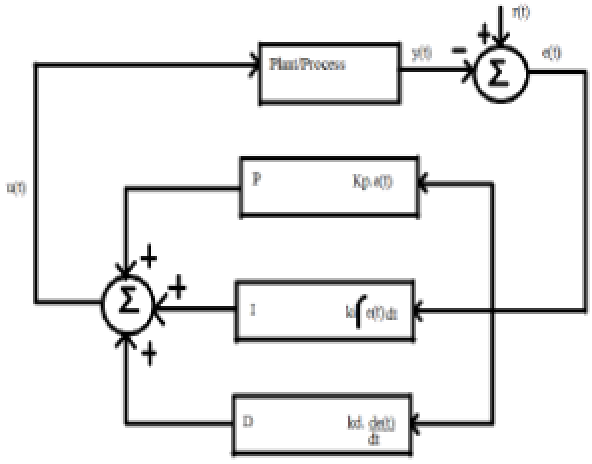

Figure 6 Block diagram of PID Controller

Both academic and industrial control systems frequently make use of control loop feedback mechanisms like proportional integral derivation controllers (PID Controllers). Many people think this approach is easy to understand, trustworthy, and implement. Boost converters in photovoltaic (PV) systems are often controlled using PID controllers.

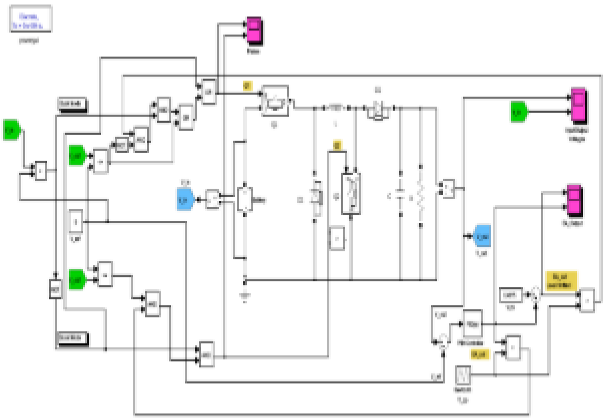

Figure7. SIMULINK block diagram of PID Controller

The block diagram of a PID mode controller is shown in Figure 7, which depicts a simulation tool that was written in MATLAB and implemented according to evaluation parameters.

VI. RESULT AND DISCUSSION

The model is validated in the MATLAB/Simulink environment. The input voltage of the buck converter is Vin, which is 24 volts DC, and the load is 10 ohms. The reference signal for the system is twenty-eight volts direct current. The output voltage, Vout, is 17.89 volts, as shown in figure 8 (a). Furthermore, the system's rising time is 0.1 seconds, and the output voltage does not overshoot.

The output current waveform is shown in the following image, 8 (b). This process is generating a current of 1.764 amps. It takes 0.08 seconds for everything to settle down.

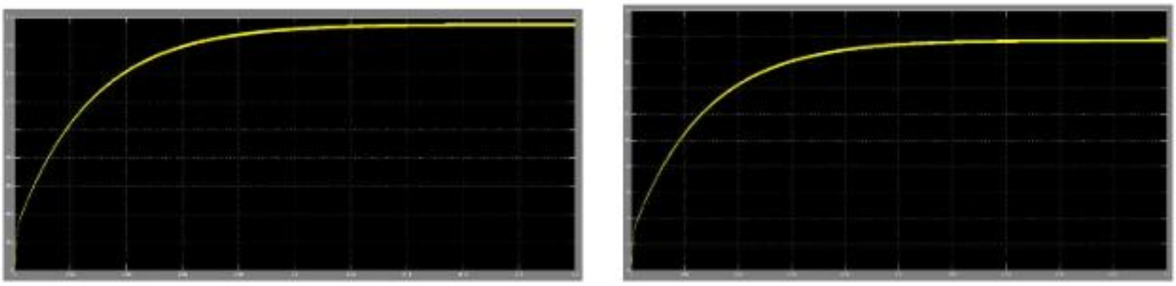

Figure 8: The current waveform and the voltage are the outputs of the SM mode.

The spectrum Both the input and output voltages at which the control approaches operate are similar, as are the characteristics of the power circuits. In order to run the simulation, we choose the following design criteria and circuit parameters: The values for the input voltage Vin, desired output voltage Vout, inductance L, capacitance, leakage inductance RL, leakage capacitance RC, and load resistance R are 24V, 18V, 100mH, 150µF, and 0.08 Ω, 0.03 Ω, respectively. Here, the sliding coefficients are 0.167. The switching frequency may be adjusted to 150 kHz. The output voltage is 17.97 volts, while the input current is 1.764 amps.

CONCLUSION

In order to observe different output parameters, this section concentrates on how to implement sliding mode control of buck converters. The user is satisfied with the constant output voltage and current. When compared to the buck converter's output, the PID control buck converter is far better. Very quickly, there is very little ripple, and the output is becoming close to stable. The output remains constant if the load stays within a certain range. Overall, the nonlinear control system performs satisfactorily, in contrast to the PID controller. Although it has ripple, the PID controller can get to its final value faster. Depending on the load and PID parameters, overrun may or may not happen. In contrast, the SM control shows no overshoot and produces a smooth output.

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