A survey on sliding mode controller for DC-DC converter

M. Mounika

PG student, Department of Electrical and Electronics of Engineering, GMR Institute of Technology, Rajam. Andhra Pradesh, India.

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Abstract – *DC-DC converters are widely used in industrial applications. In this paper for controlling of dc to dc converter siding mode controller is designed and analysed in detail. Dynamic equations describing the buck converter are derived and sliding mode controller is designed. The robustness of the sliding mode controlled buck converter system is tested for step load changes and input voltage variations. The fast-dynamic response of the output voltage and robustness to load and input voltage variations are obtained. The theoretical predictions are performed by use of simulations. The performance of the proposed control scheme has been verified with MATLAB / Simulink.*

***Key Words*:** **Switched-Mode Power Supplies, Buck Converter, DC-DC Converter, Sliding Mode Control.**

1. INTRODUCTION

DC-DC switched-mode converters are widely used in various power industrial systems like high voltage dc (HVDC) transmission, wind energy system, photovoltaic (PV) power systems, hybrid electric vehicles (HEV), adapters of electric devices, dc motor drives, and automotive industry etc due to their low cost, high efficiency, high reliability and simple structure.[1] Generally, DC-DC switched mode power converters are variable-structure and time-varying systems. Various challenges in the control of a dc-dc converter are parameter uncertainties and variations in input voltage. [2]

In order to supply voltage, current, and frequency needed for the load, and to guarantee the desired dynamics, electronics power converters must be suitably controlled. PID controllers failed to satisfactorily perform constrained specifications under large parameter variations and load disturbances.[3], In case of online fuzzy PID based control, where the gains of the PID controller are tuned online[4]. The performance of dc-dc converter under parametric variations can be enhanced by applying robust control techniques like sliding mode control [5], The performance of sliding mode control can be enhanced by estimating the net disturbance and including it in the sliding surface [1], [6]. The net disturbance affecting the converter is estimated using a nonlinear disturbance observer. A sliding surface based on system states and estimated disturbance is developed. A robust control law is designed which drives the converter output to the reference even under disturbances[1].

2. DC-DC BUCK CONVERTER

The working of a buck converter is shown in Figure 1. When the switch is in on position the circuit is connected to the dc input source resulting in an output voltage across the load resistor. If the switch is in off position, the capacitor voltage will discharge through the load then the output voltage can be maintained at a desired level that is lower than the input source voltage. Generally, in DC-DC converters, parameters will be varied based on load variations. From figure 1 we are applying sliding mode control to dc to dc converter, then it can give good performance.

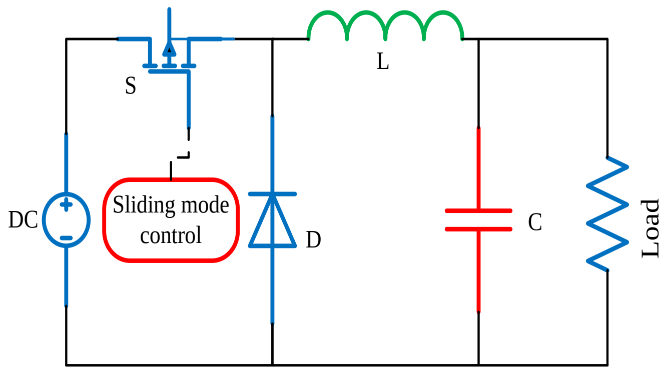

Fig-1: Buck Converter.

3. SLIDING MODE CONTROL

In control systems, sliding mode control (SMC) is a nonlinear control method that alters the dynamics of a nonlinear system by application of a discontinuous control signal that forces the system to "slide" along a cross-section of the system's normal behavior. SMC is designed to achieve sliding mode and it is having some advantages of robustness, insensitive to parameter variation [7]. Sliding mode control is still rarely applied in practical DC-DC converters. It is mainly due to the fact that no systematic procedure is available for the design of SMC in practical applications. The main drawback of SMC is chattering which means high-frequency oscillations.

4. LITARATURE SURVEY

In this paper, a novel sliding-mode control method is proposed to respond to the mismatched uncertainties in the system via a nonlinear disturbance observer. The mismatched uncertainties under consideration are possibly nonvanishing and do not necessarily satisfy the H2 norm-bounded condition. By designing a new sliding surface based on the disturbance estimation, the system states can be driven to the desired equilibrium asymptotically by sliding motion along the sliding surface even in the presence of a mismatched disturbance. And then a discontinuous control law with high frequency switching gain is designed to force the initial states to reach the designed sliding surface. There are mainly two remarkable features of the proposed method. First, the high frequency switching gain in the proposed control law is only required to be designed greater than the bound of the disturbance estimation error rather than that of the disturbance, which substantially alleviates the chattering problem. Second, the proposed method retains its nominal performance since the disturbance observer serves like a patch to the baseline controller and does not cause any adverse effects on the system in the absence of uncertainties, which will be shown by the simulation examples in this paper[1].

In this paper, a robust sliding mode controller for the control of dc-dc buck converter is designed and analyzed. Dynamic equations describing the buck converter are derived and sliding mode controller is designed. A two-loop control is employed for a buck converter. The robustness of the sliding mode controlled buck converter system is tested for step load changes and input voltage variations. The theoretical predictions are validated by means of simulations. MATLAB/Simulink is used for the simulations. The simulation results are presented. The buck converter is tested with operating point changes and parameter uncertainties. The fast dynamic response of the output voltage and robustness to load and input voltage variations are obtained.[2]

In this paper, the Sliding Mode Controller for DC-DC converter is discussed. The performance of the conventional PI controller and non-singular terminal sliding mode controller is tested for reference disturbance, line disturbance, and load disturbance conditions. A mathematical model of DC-DC Buck converter is derived and the simulations for the above discussed conditions are carried out in MATLAB/Simulink environment. It is observed that the response time, transient response and the time of convergence of Sliding Mode Controller is superior to that of the PI controller. The use of a sliding mode controller for buck converter is discussed and a novel solution is proposed to deal with the problems associated with the conventional Sliding mode control.[5]

In this paper is to design a Sliding mode controller for a buck converter to convert a dc input voltage to the required lower dc output voltage level for lower power application to solve the problem of voltage regulation and high power loss of the linear voltage regulator circuit. The converter uses a switching scheme which operates the switch MOSFET in cutoff and saturation region to reduce power loss across MOSFET. Then, the output voltage is controlled using Sliding mode control technique to get the desired output voltage level. The design is based on low power application such as laptop charger, mobile charger etc. The circuit is simulated using MATLAB/Simulink software to obtain the desired response.The Sliding mode control is a type of nonlinear control introduced initially as a means for controlling variable structure systems. The main advantage of the Sliding mode control over other types of nonlinear control methods is its ease of implementation. This makes it well suited for common DC–DC power regulation purposes. The Sliding mode control is naturally well suited for the control of variable structure systems. Characterized by switching, power converters are inherently variable structure systems.[8]

In this paper is to present an overall discussion to clarify the different aspects of the application of sliding mode controllers in DC-DC converters. The various problems of applying Sliding mode controllers to DC-DC converters are discussed. The practical issues related to its implementation are also addressed. The aim is to provide practicing engineers with feasible solutions that can be adopted for the development of practical Sliding mode controllers for DC-DC converters. Finally, the advantages of using the Sliding mode controllers as compared with the conventional linear controllers are discussed through some case-study examples.[9]

In this paper, a new sliding mode controller is proposed as the indirect control method and compared to a simple direct control method in order to control a buck converter in photovoltaic applications. The solar arrays are dependent power sources with nonlinear voltage-current characteristics under different environmental conditions. From this point of view, the DC-DC converter is particularly suitable for the application of the sliding mode control in photovoltaic application, because of its controllable states. The simulation results are presented for a step change in reference voltage and input voltage as well as step load variations. The simulations results of the proposed method are compared with the conventional PID controller. The results show the good performance of the proposed sliding mode controller.[10]

This paper deals with the small-signal analysis of DC-DC converters with sliding mode control. A suitable small-signal model is developed which allows selection of control coefficients, analysis of parameter variation effects, characterization of the closed-loop behavior in terms of audio weakness, output and input impedances, and reference to output transfer function. Unlike previous analyses, the model includes effects of the filters used to evaluate state variable errors. Simulated and experimental results demonstrate model potentialities.[11]

In this paper, aiming to improve the performance of the DC-DC buck converter system with mismatched/matched disturbances, a finite-time disturbance observer (FTDO) based nonsingular terminal sliding-modecontrol method is developed to completely counteract the mismatched/matched disturbances for the DC-DC system. By fully taking into account the estimation value of disturbances, a dynamic nonsingular terminal sliding mode surface is firstly designed which is insensitive to not only matched disturbances but also mismatched ones. As a result, the output voltage of the DC-DC buck converter system can be driven to track the reference signal in finite time by sliding motion along the nonlinear sliding mode surface. Note that the sliding mode surface here is specific since an estimate of the mismatched disturbances based on finite time disturbance observer is introduced. In addition, considering the typical disadvantages of having variable switching frequency operation in hysteresis modulation (HM) based controller, this paper adopts the fixed-frequency PWM-based controller which is easy to implement by power electronics engineers. Moreover, a better convergence performance and a stronger disturbance rejection ability against mismatched resistance load disturbances are achieved with the proposed control scheme, which has been shown by simulation and experimental results.[12]

5. CONCLUSION

In this paper for a novel sliding mode controlled buck converter is designed. The buck converter is having some remarkable features of robustness to load, and insensitive to parameter variation. In this, sliding mode controller can be applied to the DC-DC converter. The sliding mode controller can give the good performance. Finally, buck converter gives robust output voltage against load disturbances and input voltage variations without load instability. In this, we are observing the chattering problem also. chattering can be eliminated by replacing signum function by smoother choices like saturation, hyper tangent... etc.,

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