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Advance Control Techniques for Dc-Dc Buck Converter in Improvement of 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. Controller is proposed as the indirect control method in order to control a buck converter.

Keywords: switched mode DC-DC converter, Buck, regulated.

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].

The DC-DC converter inputs are generally unregulated dc voltage input and the required outputs should be a constant or fixed voltage [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.

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 As the simplest form of a SMPS circuit, a Buck Converter converts the unregulated input voltage into regulated output voltage which is lower level than input. A basic Buck Converter model is shown In Fig. 1. A buck converter contains a switch, a diode, an inductor, a capacitor and a load resistance. According to Fig. the switch (S) choppers the input voltage at high frequency and converts the input voltage with constant amplitude to rectangular waveform. Then average DC output voltage *Vo* is obtained from this rectangular waveform by passing through low-pass filter formed from inductor and Capacitor.

The turning-on time of the switch *(ton)* during one switching period *(Ts)* is called duty ratio *(D)* and *Vo* is controlling by changing D. A buck converter circuit has two operating mode according to cases of the switch. In first mode, when the switch is on, the input source provides energy to the L, C and R and the input current passing through these components [11].

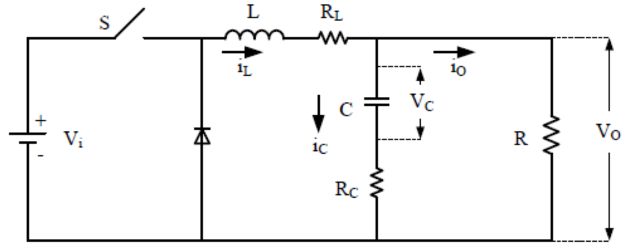

Fig. 1. The equivalent circuit of the buck converter.

The inductor current is equal to the input current and shows an increasing tendency. In second mode, when the switch is off, the inductor provides the own energy stored at previous mode to the 1.L, C and R and the inductor current passing through these components.

The inductor current shows a decreasing tendency at this mode. Mathematical model of the buck converter can be defined as follows according to both modes. When the switch is on

$$\frac{di_L}{dt} = \frac{V_i}{L} - i_L \frac{1}{L}\left(R_L + \frac{R \times R_C}{R + R_C}\right) - v_C \frac{1}{L}\left(1 - \frac{R_C}{R + R_C}\right) \quad (2)$$

$$\frac{dv_C}{dt} = i_L \frac{1}{C}\left(\frac{R}{R + R_C}\right) - v_C \frac{1}{C}\left(\frac{1}{R + R_C}\right) \quad (3)$$

When the switch is off:

$$\frac{di_L}{dt} = -i_L \frac{1}{L}\left(R_L + \frac{R \times R_C}{R + R_C}\right) - v_C \frac{1}{L}\left(1 - \frac{R_C}{R + R_C}\right) \quad (4)$$

$$\frac{dv_C}{dt} = i_L \frac{1}{C}\left(\frac{R}{R + R_C}\right) - v_C \frac{1}{C}\left(\frac{1}{R + R_C}\right) \quad (5)$$

where *Vi* is the input voltage, *RL* is the inductor resistance, *Rc* is the capacitor resistance, *iL* is the inductor current, *vc* is the capacitor voltage, *L* is the inductor, *C* is the capacitor and *R* is the load resistance. For many years, analog controllers have dominated the control of power electronics systems such as converters, inverters, etc. But the digital controls have continued to improve in cost and usability in the past several years. This has made digital controls more appealing to replace analog control in power electronic systems. So, the digital controllers are widely used in dc/dc converter such as Voltage Regulator (VR), Point of Load (POL) because of their low power consumption and easily to implement in complex control architecture. The advantages of digital controllers are programmability, improved flexibility, and improved system reliability due to usage of lower part count, less sensitive to noise. And changing a controller does not require alteration in the hardware, they provide improved sensitivity to parameter variations and potentially faster design process [1]. Conventional PID controllers are commonly used in industry because of their simplicity, clear functionality and ease of implementation [2]-[4]. Recent research trends in the control area are summarized in [5]. The process for designing controllers for industrial automation is elaborated and can be difficult in practice, if multiple and conflicting objectives are to be achieved. The gains for non-linear plants are very difficult to select on the analytical basis of closed loop stability and performance [6] [7]. Owing to their complexity and the need of exact plant models, many studies on control tend to be difficult for practicing engineers to fully understand and to competently apply practical systems. The difficulty is compounded applying the findings of research many practical devices, here tuning gains is the only thing users are allowed to do. controlled buck converter addresses the issue of improving transient performance of DC/DC buck converters using digital controllers. A Gain scheduling control scheme is proposed to achieve an improved transient response. The Gain scheduling control is a practical and useful adaptive control method [8]. It is a nonlinear feedback of special type; it has a linear controller whose parameters are changed as a function of operating condition in a preprogrammed way. Gain scheduling controller requires some knowledge about the plant and some auxiliary measured variables.

When scheduling variables has been determined, the controller parameters are calculated at a number of operating conditions by using pole zero cancellation method. The controller is thus tuned or calibrated for each operating condition. The stability and performance of the system are evaluated by simulation; particular attention is given to the transition between different operating conditions. The great advantage of this method is that the controller adapts quickly to changing conditions. The design method can be easily extended to different technologies or modification to fulfil a new set of specifications such as fewer output capacitors or small board size requirement with very fast time to market. The structure of this paper is as follows. The detail modeling of the synchronous buck converter is explained in we have presented the digital control of buck converter.

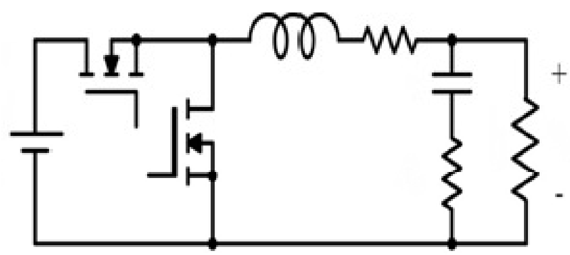

Fig. 2. Schematic of a Synchronous buck converter.

Gain scheduling scheme is an approach to the control of non-linear systems that uses a family of linear controllers, each of the linear controller provides satisfactory control for a different operating point of the system. One or more observable variables (scheduling variables) are used to determine what operating region the system is currently in and to enable the appropriate linear controller. Gain scheduling scheme based on measurements such as load current information for buck converters is often a good way to Compensate for variations in process parameters. semiconductor devices such as; metal oxide semiconductor field effect transistors (MOSFETs), Insulated gate bipolar transistors (IGBTs), Insulated gate conduction thyristors (IGCTs), MOS controlled Thyristors (MCTs), Gate turn off thyristors (GTOs), MOS turn off thyristors (MTOs), Emitter turn off thyristors (ETOs) etc, have widen the applications of power electronic converters due to their high efficiency, high switching speed and low cost [1-4]. Nowadays, these converters are available in compact size and can with stand high voltage, high power and high frequency. SSHB converter is most advance type of dc/dc converter in which a half bridge converter is connected on primary side of the transformer. In previous research [5-6], an extended state space technique was used to model the half bridge converter. A new control scheme (i-e Turn off time control at DCM) for half bridge converter was also introduced to control its dynamics. Such control scheme operates in continuous conduction mode (CCM) at heavy loads while at light load SAB topology enters into discontinuous conduction mode (DCM). When this topology enters into DCM it generates oscillations in output voltage as well as inductor current [5-7]. These oscillations create disturbances and degrade the performance of converter. Furthermore, disturbances generated due to the conventional techniques leads to the generation of abnormal harmonics which have deleterious effects not only on the systems network but affects badly the performance of the converter and also have adverse effects on loads. In previous works, the conventional PI regulators were used as feedback control techniques for half bridge converter. But control strategy design is fraught with some problems and is not giving desired results. These controllers have limitations in handling the nonlinear situations of the converters as reported by various researchers [2,7-10]. The PI controllers are generally based on linear functions and their control characteristics may fail during system variations.

II. RESULT

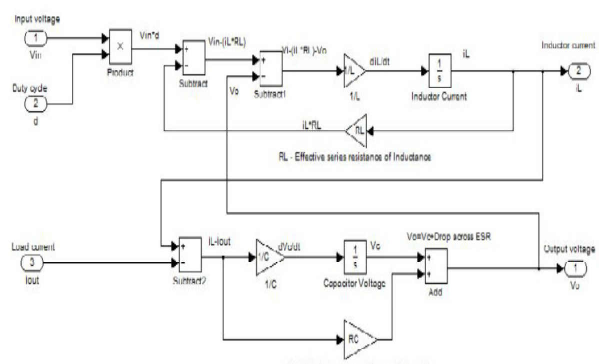

Fig. 3. Buck Converter Subsystem.

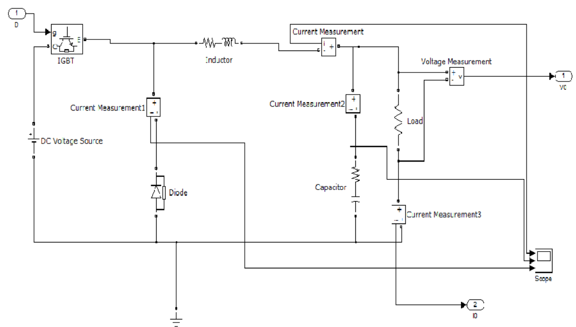

Fig. 4. Buck Converter Subsystem Electrical Model.

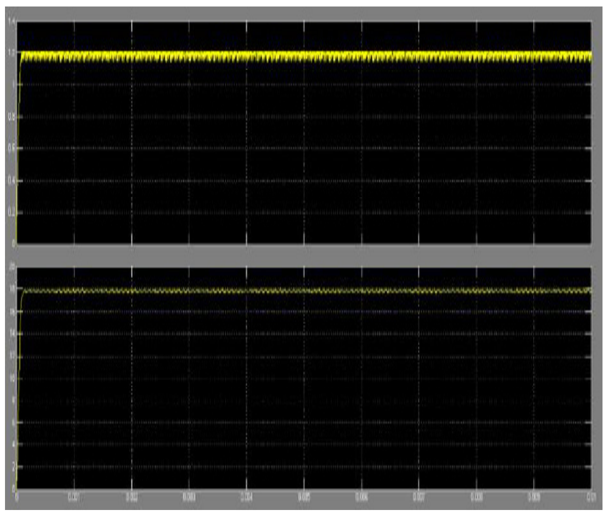

Fig. 5. Output Waveform of the Proposed Electrical & Mathematical Model Output Current.

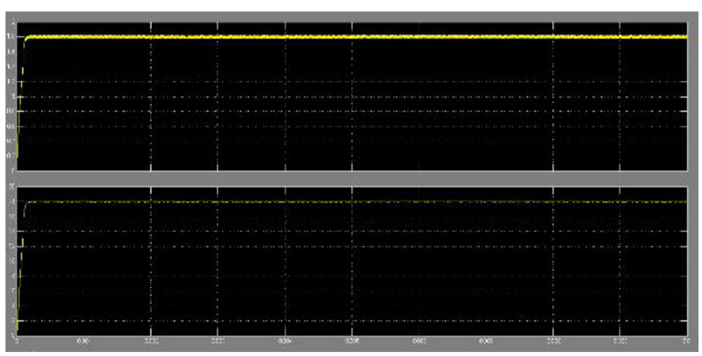

Fig. 6. Output Waveform of the Proposed Electrical & Mathematical Model Output Voltage.

In this model of buck converter the reference voltage Vref is 18 volt constant supply. The load resistance is 10 Ω. Input voltage of the converter is Vin is 24 volt dc supply. The output voltage of this converter is Vout and it is 17.66 volt and current Iout 1.794 amp. Both are rippled and fluctuating but magnitude is moderate.

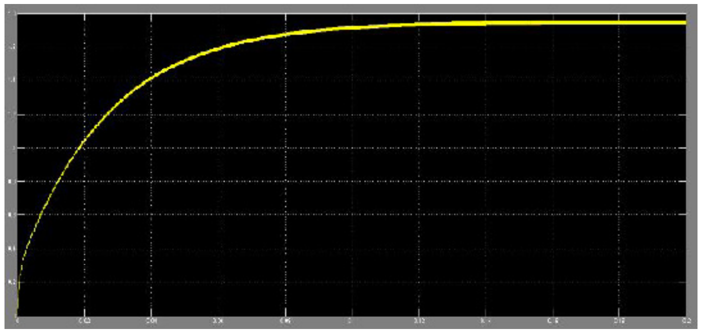

Fig. 7. SM Mode Output Current Waveform.

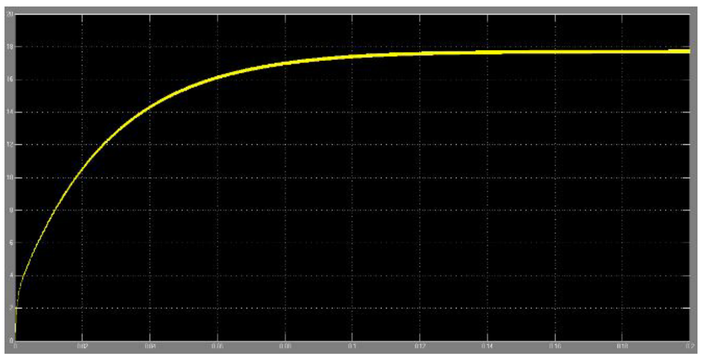

Fig. 8. SM Mode) Voltage Waveform.

The control methods have the same power circuit parameters and operate at the same input and output voltages. The design specifications and the circuit parameters, for simulation are chosen as: input voltage V_{in} =24V, desired output voltage V_{out} =18V, inductance L =100mH, capacitance =150µF, leakage inductance RL= 0.08 Ω, leakage capacitance RC = 0.03Ω load resistance R =10Ω. The sliding coefficients = 0.167. The switching frequency is set to 150 kHz. The output is V_{out} = 0.97 volt Io = 1.764 amp.

IIII. CONCLUSIONS

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 control buck converter. Output reaches stability quite fast and ripple is minimum. Load variation up to a certain range does not affect the output. The overall performance of nonlinear control is good as to the controller reaches its final value faster but contains ripple. For different load and parameters there overshoot may be seen. But in SM control the output is smooth and no overshoot observed.

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