Double Transistor Forward Function Control Strategy

Qiangnan Du, Di Gai, Yina Zhou

College of Electrical Information Engineering, Northeast Petroleum University, Daqing, 163318, China

Abstract

In view of the one-cycle control existence question, Research team proposed one kind of improvement one-cycle control new strategy, namely the exact cycle integral function control, and studied the exact cycle integral function control which the belt forward feed compensated in double transistor to stir up in the converter the application, has confirmed this control strategy validity and the feasibility through the simulation. For this purpose, research team proposed countermeasures which adopts exact cycle integral function controller with he function of automatic limiting integrator. The measure can solve the problem of system oscillation caused by the load jump of the converter.

Keywords

Function Control Strategy，The Exact Cycle Integral Function Control，Double transistor Forward

1. Introduction

One-Cycle Control uses a non-linear integrator, forces switch variable in each cycle is exactly equal to the control reference, improving the system dynamic response of inhibiting the input power disturbances and tracking control criterion change dramatically. However, One-Cycle Control has the disadvantages of slow load disturbance dynamic response and steady state error of the system[1-3].

Based on the above disadvantages of single-cycle control, research team proposed one kind of improvement one-cycle control new strategy, namely the exact cycle integral function control, and studied the exact cycle integral function control which the belt forward feed compensated in double transistor to stir up in the converter the application, has confirmed this control strategy validity and the feasibility through the simulation[4-6].

2. Features and improvements of exact cycle integral function control

Assume that the initial value of integrator at the time of t_1 is V_{r1}, then the integrator output V_{int} at the time of t_2 can be expressed as:

$$V_{\text{int}} = V_{r1} + \frac{k_1 \cdot k_2}{R_2 C_1}\int_{t_1}^{t_2} y(t)\cdot \mathrm{d}t = V_{ref}(t) \tag{1}$$

When the integrator output reaches comparator threshold, flip flop reverses, the integrator is reset. The initial value V_{r2} of integrator at the time of t_4 can be calculated with the following formula:

$$V_{r2} = V_{ref} + \int_{t_2}^{t_3}\left[\frac{-1}{R_1 C_1}\cdot V_{ref}(t) + \frac{k_1 \cdot k_2}{R_2 C_1}\cdot y(t)\right]\cdot \mathrm{d}t + \int_{t_3}^{t_4}\frac{y(t)}{R_2 C_1}\cdot \mathrm{d}t \tag{2}$$

In the formula: k_1, k_2—Sampling resistor divider ratio and proportional amplifier gain.

When the system is in steady state operation, the integrator initial value of converter adjacent switch cycle necessarily equal, that is $V_{r1} = V_{r2}$. So it can be deduced:

$$\int_{t_1}^{t_4}\frac{k_1 \cdot k_2}{R_2 C_1}\cdot y(t)\cdot dt = \int_{t_2}^{t_3}\frac{1}{R_1 C_1}V_{ref}(t)\cdot dt \tag{3}$$

Because the reset pulse generated by a narrow pulse generator is constant, assume that: $T_{reset} = t_3 - t_2$, switching cycle $T_s = t_4 - t_1$, then obtain the following equation:

$$\int_0^{T_s} \frac{k_1 \cdot k_2}{R_2 C_1} \cdot y(t) \cdot dt = \int_0^{T_{reset}} \frac{1}{R_1 C_1} V_{ref}(t) \cdot dt \tag{4}$$

The integral time for the upper left of the equation is T_s, that is in the time period after the capacitor is reset(Before the next clock comes), all output information of the controlled switch(Including the output due to the switching time of the power tube) will enter the integrator totally, which ensures that no output information is lost during the reset period, achieving a complete correction of the converter switching error[7-9].

Double transistor forward converters of exact cycle integral function control with feed-forward compensation is shown in Figure 1: Main topological structure uses double transistor forward converters. This is because the voltage stress of each switch tube is half of the output voltage, which reduces the cost of the converter. The control circuit is composed of integrator, comparator, D flip-flop, driver, narrow pulse generator. Double feed forward feedback control uses capacitive current and output voltage. Assume that the switching tube S_1、S_2、D_1、D_2、D_3、D_4 are all ideal components.

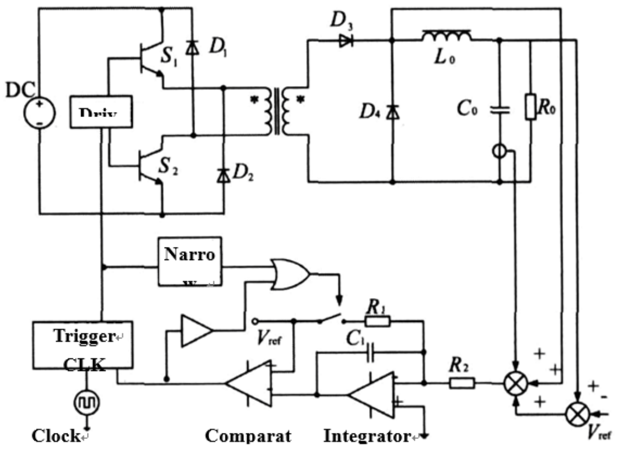

Figure 1 Double transistor forward converters of exact cycle integral function control with feed-forward compensation

Double transistor forward converters of exact cycle integral function control works as follows: At the time of the rising edge of the clock, because of the high level of the D trigger, the D trigger is set, and the output is high, the switch S1, S2 is turned on by the drive. The input voltage is reduced by the high frequency transformer, getting switching pulse V_D at the secondary side diode. The changing switching pulses enter the integrator in real time. When the integrator output V_{int} is equal to the control reference V_{ref}, comparator flips, so D flip flop reset. When the driver drives the switch tube S1, S2 to turn off, the switch of secondary side turns on to lead the energy stored in the inductor to continue to flow through the diode D4, maintaining stability of output voltage. At the same time the D trigger is reset, narrow pulse generator produces a narrow reset pulse, driving the reset switch W to reset integrator. This work cycles again and again.

So, after the introduction of double transistor forward converters of double feed-forward exact cycle integral function control, its steady state output is the same as that without double transistor forward converters of double feed-forward exact cycle integral function control. That is:

$$\int_0^{T_s} \frac{k_1 \cdot k_2}{R_2 C_1} \cdot V_D \cdot dt = \int_0^{T_{ret}} \frac{1}{R_1 C_1} \cdot V_{ref}(t) \cdot dt \tag{5}$$

By the above analysis, we can know that the disturbance of the load can be eliminated and achieve static no difference of the input power supply change[8-9].

3. Simulation of double transistor forward converters of exact cycle integral function control with feed-forward compensation

(1) Suppression of power disturbance simulation: Figure 2 is the diode voltage, the output of the integrator and driving waveform. Figure 3 is the input voltage, the output voltage and the inductor current. When the control reference and output load remain unchanged, and the input voltage jumps from 400V to 450V(The time is in 2ms), the diode voltage V_D changes, and effects, then accelerate the integrator output to reach control reference, reduce duty-cycle and keep the output voltage of the converter constant.

Figure 2 Diode voltage, output of the integrator and driving waveform

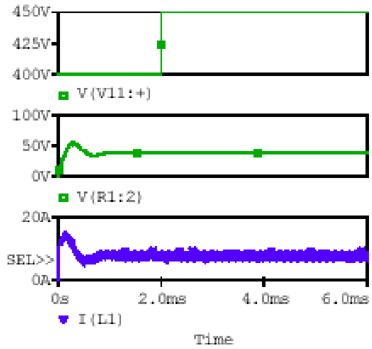

Figure 3 Input voltage, output voltage and inductor current

(2) Suppression of load disturbance simulation: Figure 4 is the inductor current, capacitance current and output voltage waveform. Figure 5 is the diode voltage, the output of the integrator and driving waveform. When the input power and control reference remain unchanged, and the load jumps from 5Ω to 10Ω in 2ms. It can be seen from the simulation results that double transistor forward converters of exact cycle integral function control with feed-forward compensation can effectively restrain the disturbance of the load and achieve the stability of output voltage.

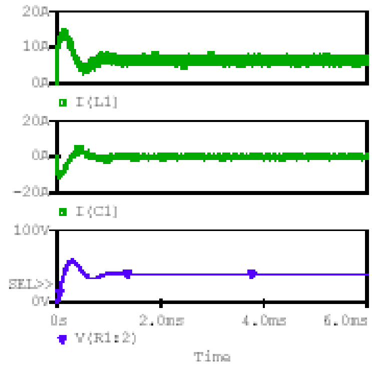

Figure 4 Inductor current, capacitance current and output voltage waveform

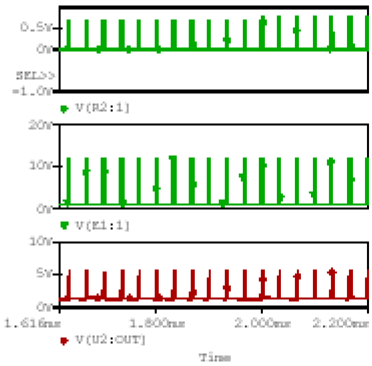

Figure 5 Diode voltage, output of the integrator and driving waveform

4. Conclusion

The one-cycle control through uses a non-linear integrator, forces the switch converter medium in each switch cycle in the datum, crossed the converter output stage, thus reduces the systems control step number, causes the system to suppress inputs the dynamic response which the power source disturbs to enhance greatly. It can concluded from theoretical analysis and simulation results that the exact cycle integral function control with feed-forward compensation basically achieves the optimal control, the dynamic response is fast and can achieve no errors at stable state.

Reference

[1] LIN Wei-ming. A New Open-Loop Control Strategy for a DC-DC Switching Converter with Fast Load Transient Response. Proceedings of the CSEE,2001,21(9)78~81

[2] Calderone，Pinola，Varoli. Optimal feed-forward compensation for PWM DC/DC converters. IEEE Power Electronics Specialists Conference，1990：235~241

[3] Pin Wang and Jianjun Xu, Investment model research based on inertia law[J]. J. Chem. Pharm. Res., 2014, 6(6):1540-1548

[4] Zhi Zhao, Pin Wang, Jianjun Xu*. The application of principal component analysis in frontal storms forecast. Energy Education Science and Technology Part A: Energy Science and Research, v 32, n 6, p -, 2014

[5] P. WANG, Haiping. HUANG RSI Investment Decision Based on Similar Function. International Journal of Applied Mathematics and Statistics 2013.12 Vol.50 No.20 pp.575-582

[6]Liu Zhengliang, Xu Jianjun, Li Hongyu. A kind of energy saving controller based on Y/Δ change-over. Sensors and Transducers, v 161, n 12, p 331-336, 2013

[7]Wang, Baoe; Xu, Jianjun;Yan, Limei. Brittleness simulation of electric power systems based on chart theory. Energy Education Science and Technology Part A: Energy Science and Research, v 31, n 3, p 1769-1778, 2013

[8] Alaeddin A, AydinerD, L.Smith. Detection of Buried Targets Using a New Enhanced Very Time Electromagnetic Prototype System[C]. IEEE Trans. Geo-science and Remote Sensing, 2011, 39(12):2702~2712.

[9] Michael E. Finite-difference time-domain simulation of electromagnetic propagation in magnetized plasma[J]. Computer Physics Communications, 2008,166(233):320～342.