

Research on High Frequency PI Section Control of Electrochemical DC Power Supply

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Abstract. In the chemical industry, a large pressure range, relatively stable voltage output DC power supply is often required. This paper mainly studied on the control method of DC conversion circuit. The full-bridge configuration electromagnetic isolation has advantages in efficiency and pressure range. The high-frequency PWM control mode was used in control circuit. The entire system using voltage feedback loop PI control method of segmentation and the pressure range is divided into multiple parts separately controlled. And MATLAB simulation results suggest that this control method can reduce the amount of ripple output voltage waveform.

Introduction

DC power supply is widely used in electrolysis and plating process. The changes of solution concentration lead to constant changes of the solution conductivity. In this case, the stability of voltage, constant current and large pressure regulating range are indispensable to DC supply [1]. This paper will use the full bridge isolated electromagnetic DC-DC converter circuit and high frequency Bi - Directional PWM control strategy to further reduce the pulse of output waveform. PI Section Control method is adopted in the process of voltage feedback closed loop control, to ensure the stability of output voltage so that system stability can be improved.

The electromagnetic isolated of full bridge converter circuit

In order to overcome the shortcomings of traditional buck chopper circuit, a full bridge DC convert circuit is designed. The circuit structure is shown as figure 1.

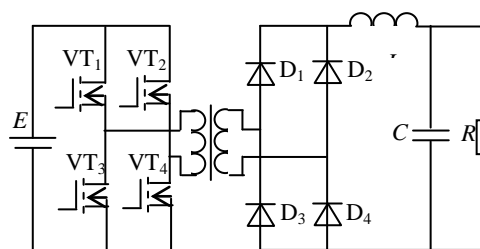


Fig.1. Electrical isolated full bridge circuit

The full bridge circuit transformer which is bidirectional excitation and has high efficiency, using four switches can achieve greater power. Meanwhile the structure of the circuit is symmetrical and doesn't produce magnetic bias. This circuit has the following features: it has larger pressure range, stable output, and relatively high efficiency [2]. Therefore, the DC power supply, in the process of electrochemical reaction, requires large voltage regulation range and stable voltage output.

High frequency PWM control strategy

To change the output voltage, we can modulate the pulse width and duty cycle. Applying the PWM control technology in the DC converter can realize the purpose of regulating voltage better.

With the increase of carrier frequency, isolation transformer will have a high efficiency. The pulse number of output current at unit time t is:

$$n = 2 \times \frac{t}{T} \quad (1)$$

In order to achieve the stability of the output, it is better to have more pulses during the time t . And in each cycle T the output energy E is:

$$E = DU_i \int_0^T i_i dt = U_0 \int_0^T i_0 dt \quad (2)$$

In the process of changing the duty ratio D , the smaller the pulsing current, the more ideal of the voltage regulating is.

PI Section Control strategy

The traditional PI control, which not only has a high control speed, but is also easy to be realized, is suitable for high frequency DC converter circuit [3]. The control can be expressed as:

$$u = K_p e + K_i \int_0^t e dt = U_0 \int_0^T i_0 dt \quad (3)$$

PI control can acquire good effect in linear systems, and are even applied in non-linear control systems which is coped as linear system by the appropriate transform. Because the electromagnetic isolation bridge DC convert circuit is not strictly linear systems [4], we adopt the section PI control which means that the voltage regulating range is divided into several sections. Schematic diagram as shown in figure 2 below.

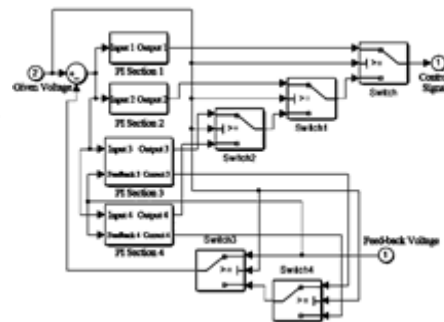
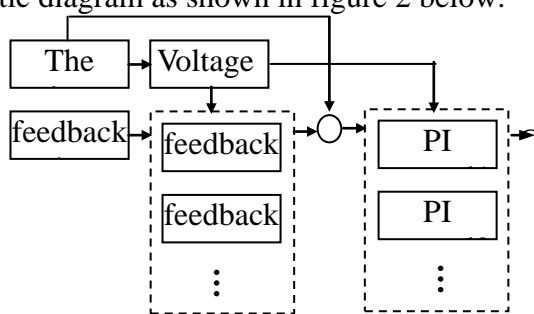


Fig.2. The section control principle diagram Fig.3.the model of Section PI control

According to the given voltage, the range of regulating voltage $[a, b]$ can be divided into several interval, such as: $[a, a_1], [a_1, a_2] \dots [a_n, b]$. First of all, an adjustment is made according to the error feedback signal in each interval. Then compare the given voltage and the feedback voltage to get the difference. Finally, to get the final control signal, in different sections diverse proportional and integral coefficients are adjusted.

Simulation and Analysis

The simulation model of voltage regulating system can be realized easily through MATLAB. The model of Section PI control as shown in figure 3.

The voltage of DC power supply is 110V and the frequency of PWM triangular carrier wave is 500Hz. Adjusting the isolation transformer turns ratio so that the range of the output voltage is 10V to 86V. The section Pi control according to the simulation results are divided into four sections: $[10,15], [15,30], [30,70]$ and $[70,86]$. At 3 seconds the output load resistor is paralleled a 10 k Ω resistor as a disturbance and set a voltage regulating process at 5 seconds. The allowed range of voltage error is less than 2%. In the section PI control, the given voltage changes from 86V to 76V, the output voltage waveform of the circuit as shown in Figure 4. And Figure 5 shows the result of the given voltage changed from 15V to 10V.

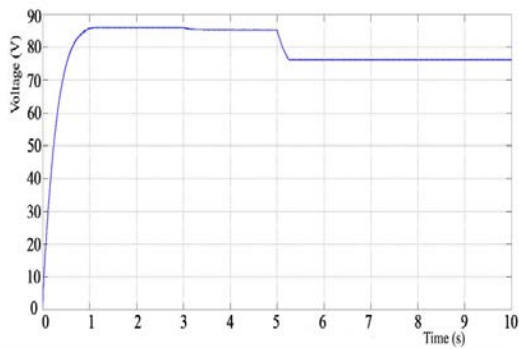


Fig.4.the output voltage waveform:
given voltage is from 86V to 76V

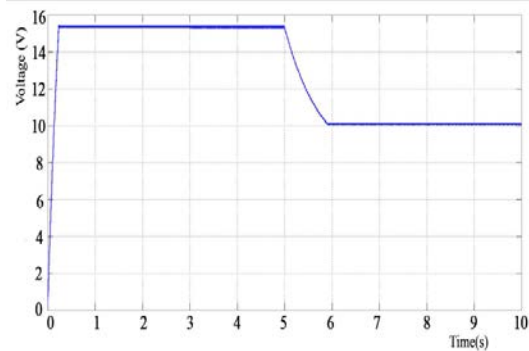


Fig.5.the output voltage waveform:
given voltage is from 15V to 10V

The simulation results suggest that the electromagnetic isolation bridge DC convert circuit with section PI control can regulate the voltage from 86V to 10V. The waveform of the output voltage is very stable, almost no pulse. In the process of the voltage regulating, the changing of the voltage is very smooth and the respond speed is fast greatly. Figure 6 shows the result of the given voltage changing from 30V to 25V with traditional PI control. While figure 7 illustrates the waveform of given voltage changing from 86V to 76V when the carrier frequency is down to 50Hz.

As is suggested in Figure 6, in the absence of section PI control, the output voltage ripple is relatively small. Therefore, without section Pi control the range of regulating voltage will be reduced to 86V to 30V. While Figure 7 shows that the amount of output voltage ripple will significantly increase and the overshoot will increase at the same time when the frequency of carrier signal is reduced. So the high frequency PWM control plays a key role in the system output voltage stability.

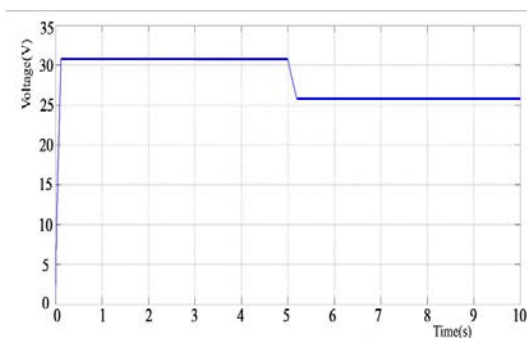


Fig.6.the output voltage of
the traditional PI control

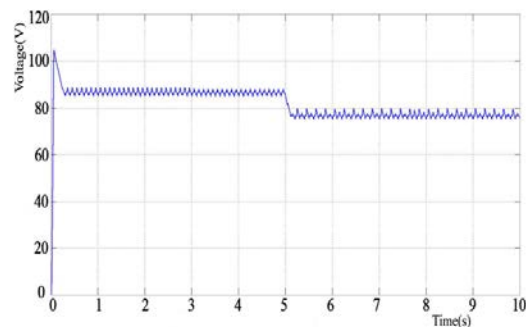


Fig.7.the output voltage when the
Carrier frequency down to 50Hz

Conclusion

This paper has mainly discussed the electrochemical DC power supply circuit and got the conclusion that electromagnetic isolated full bridge converter circuit is most suitable for electrochemical DC voltage regulating circuit by analyzing the DC converter circuit. As for the control circuit, adopting the high-frequency bipolar PWM signal and higher speed section PI control tragedy to improve output voltage regulating range and reduce the fluctuation. Finally, the experimental results shows show the feasibility and validity of the proposed section Pi control modulation scheme.

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