Advanced Engineering Forum *Online: 2012-06-04*
ISSN: 2234-991X, Vol. 4, pp 101-105
doi:10.4028/www.scientific.net/AEF.4.101

A Single Cycle Inverter Welding Power Control System

Pengfei Huang[1, a], Yangyang Lu[1,b], Shaojun Bai[1,c], Zhenyang Lu[1.d]

[1]College of Mechanical Engineering and Applied Electronics Technology, Beijing University of Technology, Beijing, China

[a]huangpf@bjut.edu.cn,[b]luyang2111399@163.com,

[c]baishaojun@bjut.edu.cn,[d]luzybjut@163.com

Keywords: Single-cycle,welding power,grid voltage disturbance

Abstract: Single cycle control technique is applied in the field of welding power which makes waveform control in the various stages of arc and circuit in the welding process respectively based on the characteristics of the welding process. A new welding power control has been put forward which is able to adjust the grid voltage disturbance in a very short time. We choose dual single-ended forward topology as the main circuit and make flux reset for the transformer in each cycle to ensure that the transformer magnetic saturation dose not occur, meanwhile, controlling the condition of arcing and short circuit respectively to achieve a better welding effect.

Introduction

At present, the control thought applied in the the field of welding power can be divided into single-loop control mode and double-loop control mode by the control mode and the thought can also be divided into voltage-type PWM control and current-type PWM control by the feedback type. The single-loop control mode and double-loop control mode are voltage-type PWM control, it can adjust to the errors as the load disturbances and power grid disturbances. The voltage error signals are modulated into duty cycle signals linearly in the voltage feedback control, when the input voltage and load changes, the output voltage, the voltage error signals, the duty cycle are also changes and after the dynamic adjustment the output voltage is back to the stable value, the duration of dynamic adjustment is determined by the loop-gain bandwidth which is usually more than one switch cycle time. Therefore, the voltage-type PWM control, whether single or double-loop control are not readily to compensate for the disturbance [1]. The current-feedback control makes use of the pulse and non-linear characteristics in the converter and the duty cycle is determined by the relation which contains a number of non-linear state feedback, when the input voltage increases, the current slope increases immediately, the duty cycle decreases, this dynamic adjustment has a good ability to respond quickly but this system has a static error, the accuracy can't meet the requirement, and if we use other compensation, the speed will be affected [2].

Single-cycle control technique is a non-linear control technology which changes non-linear switch into linear switch.It can control the output signal instantaneously for the disturbance from input voltage(grid voltage) if we use single-cycle control technique which dynamic performance is superior than the voltage-type and current-type control technology, therefore, it has important application value in the power conversion applications which require high dynamic performance. If we the single-cycle control technique is used in the welding power control system, it can give full play to the advantages of single-cycle control [3].

Design for the network disturbance rejection system

If we use the traditional voltage mode or current mode control, It will need several cycles of time to adjust before reaching the steady state because its response to the voltage fluctuations is slow. While, if we use single-cycle control, it can compensate the voltage fluctuations in a cycle, the speed of response is fast, which is fit to be applied in the output applications with high dynamic performance.Fig.1 shows the whole diagram of the welding process.

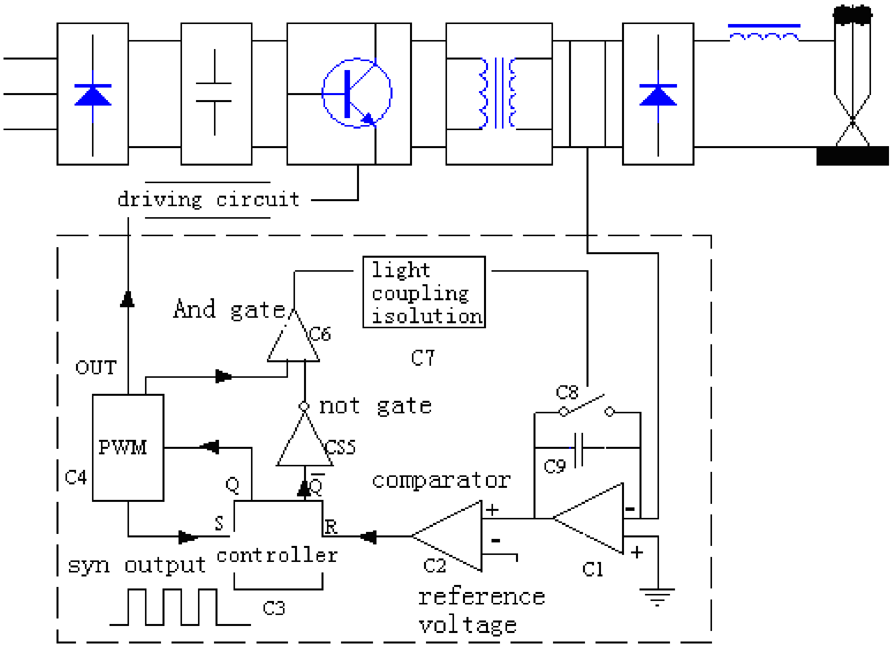

Fig.1 Overall diagram of control system

Single-cycle control theory. Single-cycle control is a new type non-linear PWM control strategy which is proposed by Keyue M.Smedley firstly,it make the average equal or proportional to the reference volume which is given by the control system in each PWM cycle through integrating the switching variable. So it achieves the control for the required target in a cycle and make the system reach steady state in a single cycle which will not leave the switching error in this cycle until the next cycle.

There are four types of single-cycle control, they are constant frequency PWM switching, constant cut-off time switch, constant on-time switch, change switch single-cycle control [4]. Constant frequency PWM switching make the switching integral value is equal to the reference value by adjusting the PWM duty cycle in a cycle which has constant PWM cycle. The design uses a constant frequency PWM control of the network to suppress the pressure disturbance.

The design uses a constant frequency PWM to control the disturbances of network voltage. Here mainly introduce the principle of constant frequency PWM switch, Figure 1 shows the circuit diagram [5].

Assuming the fix period of the switch is T , the switch frequency is f=1/T, during each cycle, Ton is the conducting-time,then $D = T_{on}/T$, the switching functions of the switch on and off can be described as

$$K(t) = \begin{cases} 1 & 0 < t < T_{on} \\ 0 & T_{on} < t < T \end{cases} \tag{1}$$

Assuming that the input signal is $U_{in}(t)$, and the output signal is $U_{out}(t)$, the relationship between them is

$$U_{out}(t) = K(t) \times U_{in}(t) \tag{2}$$

The average of $U_{out}(t)$ in a cycle is

$$U_{out}(t) = \frac{1}{T}\int_0^{Ton} U_{in}(t)dt \tag{3}$$

The sampling signal $kU_{in}(t)$ is the input of the integrator, during T_{on}, The output of the integrator is

$$U = k_1 \int_0^{Ton} U_{in}(t)dt \tag{4}$$

Where $k_1 = \frac{k}{RC}$, It's value is constant.

U is compared to a fixed reference volume U_r,when $U = U_r$, the PWM output is low . The current duty cycle is determined by:

$$U_r = k_1 \int_0^{DT} U_{in}(t)dt \tag{5}$$

From (1-5),we can see that duty cycle is a nonlinear function of $U_{in}(t)$ and U_r.
From (1-4) and (1-5), we can see

$$U_{out}(t) = k_2 U_r \tag{6}$$

Where $k_2 = \frac{1}{k_1 T}$, It's value is constant

Because the switching cycle is fixed, the converter output is equal or proportional to the amount of control , and it has nothing to do with the converter input. Therefore, the system is stable.

The fig.1 shows single-cycle control section structure, three-phase input voltage through the rectifier, inversion and then the rectifier is used for the voltage of weiding. Sampled the voltage signal sends to the op amp C1through A5, the PWM output cycle is T, and the inverting input signal of op amp is $x(t)$, so the output voltage can be :

$$V_{ref} = (1/C9)\int_0^{Ton} x(t)dt \tag{7}$$

When the output voltage of the op amp C1 is equal to the reference voltage, C2 comparator can output high level, and the controller C3 resets, so the PWM output signal is shut down immediately, which turns off the DC-DC inverter circuit A3 through driver circuit; Because the C3 has reset , the MOSFETC8 turns on by isolation optocoupler immediately,meanwhile, the capacitor C9 begins to discharge rapidly. The set side of controller C3 is sync crystal oscillator output signal, which can set the controller while the dead time of each cycle is coming. When the next cycle comes, the PWM pulse width modulation output pin is high ,and the MOSFETC8 is shut down by isolation optocoupler immediately [6].So the next cycle PWM and the integral control operation are prepared.

Experimental results

Single-cycle control test. The design is one-cycle control system of welding power supply, three-phase input voltage is AC380V ±10%, switching frequency is 100KHZ.Figure 2 shows the waveform 1 is t he reference voltage, waveform 2 is the output voltage waveform of the integrator, waveform 3 is the output PWM. From the fig.2,we can see that when the integrator output voltage is equal to the integral value of the reference voltage, the PWM output is low and thus achieving a net inhibitory effect of pressure perturbation.

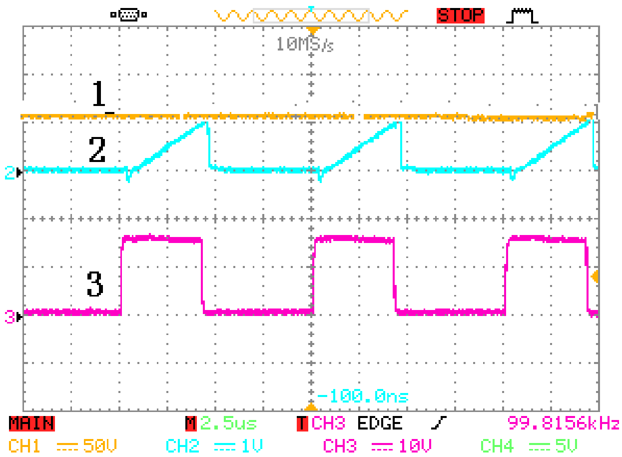

Fig.2 The waveform of PWM, reference voltage and Integral output voltage

Net voltage disturbance test. In order to verify the inhibitory effect of the voltage disturbance, we compared the output effect in open-loop and closed-loop system . Figure 3 is the the measured data curve,.Curve 1 shows the closed-loop system of single-cycle control, when the input is AC380V, output voltage is 23V , we can use regulator to simulate the closed-loop output data curve with ± 10% voltage disturbance . Curve 2 shows the converter output voltage disturbance data curve in open-loop test with voltage ± 10% ,when the input voltage is AC380V , the output voltage is 23V with a fixed duty cycle.

From figure 3, we can see when the grid voltage disturbances occur, output voltage is unstable in the open-loop conditions, In the process of adjusting the input voltage rise, the output voltage increases almost linearly. When the voltage inhibitory system is added, compared with the open-loop control, the output voltage error is small, and the inhibitory effect is more obvious with voltage disturbances.

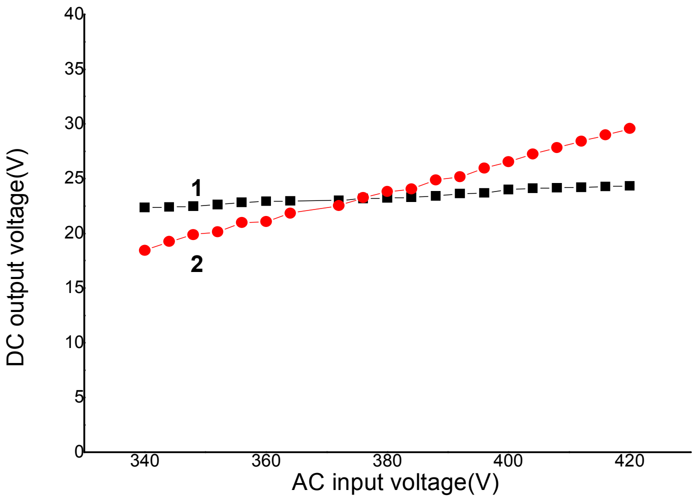

Fig.3 Data curve of nets pressure perturbations

Summary

The design of one -cycle control system is used in the field of welding power ,and we can set the constant voltage to control the output voltage . After the test, we can see net voltage disturbance system is effective obviously, which makes the welding control more accurately . Its advantages are as follows:

1 The single-cycle control technology is applied to the field of welding power sources whose dynamic performance is more advantage than the control technology of voltage, current-instantaneous value.

2 It can make the compensation for the voltage disturbance within one cycle.

3 For characteristics of welding process, we can control the two-stage waveforms Arcing and short circuits separately.

Acknowledgement
This research is funded by the National Nature Science Foundation of China (51075011) and Opto-Mechatronic Equipment Technology Beijing Area Major Laboratory(KF2010-2).

Reference

[1] Smedley K M.,Cuk S. One-cycle Control of Switching Converters[A].Power Electronics Specialists Conference Recond,22nd Annual IEEE,1991: 888-896

[2] C Qiao, K M Smedley.A General Three-phase PFC Controller for Rectifiers with a Series-connected Dual-Boost Topology[J].IEEE Trans, node on Ind.Appl,2002,38(1): 137-148

[3] C Qiao, K M Smedley. Unified Constant-frequency Integration Control of Three-phase Standard Bridge Boost Rectifiers with Power factor Correction[J].IEEE Trans,on Pow.Electr,2003,350(1): 100-107

[4] ZHU FENG , One Cycle Control for Boost DC/DCAnalysis and design of power converter technology application.2007,10(2): 5-9

[5] H Zongbo,Zhang Bo,Deng WeiHua. Feasibility Study on One Cycle Control for PWM Switched Covers[A].35th Annual IEE Power Electronics Specialists Conference, Aachen Germany 2004,353(1): 108-117

[6] Smedley K M.,Cuk S. One-cycle Control of Switching Converters[A].Power Electronics Specialists Conference Recond,22nd Annual IEEE,1991: 888-8