Design of Power Intelligent Control DCS Module Based on Improved PID

Chao Song(✉)

Dalian University of Science and Technology, Dalian, China
lxyh201712@163.com

Abstract. Distributed control system (DCS) is the core of power system control. A power intelligent control DCS module based on improved PID is studied to realize the output gain control of power electrical system and improve the control efficiency of power electrical system. Combined with integrated DSP information processing chip, a design of power intelligent control DCS module based on output power amplification and regulation is proposed. The overall model of DCS power control system is designed, and the DCS power control frequency doubling gain amplifier is constructed. The signal anti-interference design adopts cascade filter and output power amplification adjustment method to obtain the reset circuit of DCS controller. The output power amplification and adjustment algorithm are designed to equalize the gain distribution to improve the power control performance of DCS. The test results show that the output gain of intelligent power control is large, the adaptive performance is good, and the output stability is strong.

Keywords: Improved PID · Power intelligent control · DCS module · Amplification and regulation

1 Introduction

As one of the most important basic facilities, power system is related to the stability of people's life and the order of work and production. In the power system, the distribution of each power control node is scattered, so it is necessary to carry out effective decentralized control. How to use a reasonable control system to aggregate and dispatch the data information of each power node is the distributed control system (DCS) problems that need to be solved. With the development of integrated circuit and digital electronic technology, large-scale integrated chip is widely used in the design of power control system, and the accuracy of power control system is gradually improved. DCS is connected through PLC, executive components and data acquisition. It is of great significance to study the optimal design technology of power DSC control module based on PLC [1].

PLC programmable logic controller, which uses a class of programmable memory for its internal storage programs, performs logical operations, sequence control, timing, counting and arithmetic operations and other user-oriented instructions. The research on the optimization design of power intelligent control DCS module based on small Siemens PLC programmable logic controller has been paid more and more attention.

G. Gui and L. Yun (Eds.): ADHIP 2019, LNICST 301, pp. 498–506, 2019.
https://doi.org/10.1007/978-3-030-36402-1_53

the traditional controller design method mainly adopts PID control system and fuzzy neural network control system. Expert control system and other self-organizing learning and compound control schemes [2], in which the variable structure neural network control needs to monitor each separation unit in real time, and the synchronous tracking control performance is poor. In this paper, the improvement of control system design is carried out in the relevant literature, and a DCS power electromechanical control module design technology of small PLC based on adaptive fuzzy control technology is proposed in reference [3]. The global optimization method of deterministic bifurcation and boundary is used to improve the performance of power and electrical system, but the design scheme produces nonlinear distortion and the error compensation performance is not good. The linear combination control method in reference [4] changes the electromagnetic torque of the electric power generation system and obtains the learning input vector of the fuzzy PID neural network, but the operating environment of the model is harsh, which directly affects the economic benefit of the power generation system. A digital DCS power controller based on virtual impedance doubly-fed control is proposed in reference [5]. When the voltage rises sharply, the control performance decreases obviously and the energy constraint performance of power consumption is not good. In order to solve the above problems, combined with the integrated DSP information processing chip, this paper proposes a power intelligent control DCS module design based on output power amplification and regulation. Firstly, the overall design model and hardware design method of the system are described. The output power amplifier and regulation algorithm are designed for gain allocation equilibrium processing, which improves the power control performance of DCS. The integrated DSP information processing chip is used to realize the controller circuit design. Finally, the simulation experiment of the system is carried out, and the performance is verified.

The superior performance of the DCS controller designed in this paper is shown.

2 Overall Design Model and Hardware Design Method of DCS Power Control System

2.1 Description of PLC Programmable Logic Control Preparatory Knowledge and Construction of Its Overall Model

The power DSC controller adopts Siemens K9F1208UOB model PLC programmable logic control chip as NAND FLASH, its capacity is 64 MB, the working voltage is 2.7 V $\leq$ 3.6 V, and 3.3 V is used in this system. The performance of door small PLC programmable logic control is described as follows:

(1) PLC programmable logic control peripherals
In the hardware of PLC programmable logic control system, in addition to the main control component (MCU, DSP, EMPU, SOC), it also includes other hardware used to control storage, communication, debugging, display and other auxiliary performance, that is, PLC programmable logic control peripherals.

(2) PLC programmable logic control operating system
In order to make the PLC programmable logic control system develop more rapidly, it is necessary to have a software program which is responsible for managing memory allocation, interrupt processing, task scheduling and other functions, which is collectively called PLC programmable logic control operating system [6].
(3) PLC programmable logic control application software
PLC programmable logic control application software is aimed at a certain application area, based on a fixed program platform, to achieve the desired PLC programmable logic control software, because the user may have the goal of speed and accuracy. Therefore, some PLC programmable logic control programs need the support of PLC programmable logic control operating system.

The system design process includes the following aspects: (a) System requirement analysis: determining the design goal, planning and design specification commitment, and putting forward the acceptance standard of the design program. (b) Architecture design: design system to achieve functional and non-functional requirements, including hardware, software and system software, hardware selection and so on. (c) Hardware/software collaborative design: based on the architecture of the system software, hardware design in detail. (d) System integration: integrate the software, hardware and execution of the system into a development program to detect and improve the errors in the unit design process. (e) System test: debug the system program to check whether it meets the functional requirements [7].

According to the above analysis, the overall model of DCS power control system is designed. The data width of ISA bus is 16 bits and the working frequency is 8 MHz. Based on the low processing ability of 8086 and 80286, a bus standard with low performance of CPU is obtained [8]. The data line width of the K9F1208UOB of the power DSC controller is 8 bits, and the large storage performance of the NAND FLASH is encapsulated with the 48-foot TSOP. The system bus connection of the PLC programmable controller is shown in Fig. 1.

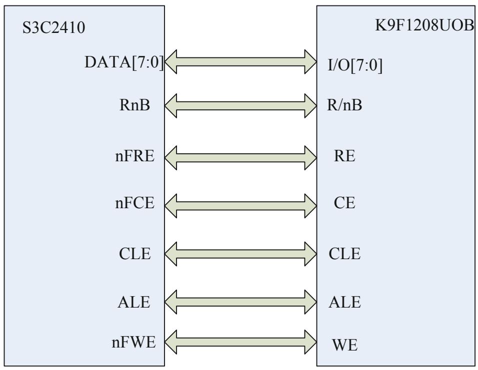

Fig. 1. System bus connection diagram of PLC programmable controller

2.2 Anti-interference FIR Filtering Controlled by Power DSC

The signal anti-interference design of power DSC controller adopts cascade filter, and the voltage stabilizing node of power DSC controller adopts triaxial acceleration sensor MMA7260Q. FIR band-pass filtering is based on PLC control chip. MMA7260Q-based PLC is a single-chip device that sensitively and accurately measures the fall, tilt, movement, placement, vibration and rocking of low gravity levels in three axis. Its package size is very small. Only small card space, battery power, to provide fast start and sleep mode. It can be widely used in falling detection, hard disk protection, electronic compass, seismic monitoring and other electronic products. In the design of DCS controller, PC automatically sets the number of signal output channels, signal center frequency [9], signal pulse width and output signal type (including CW, LFM, HFM, etc.) according to the received signal type information. The characteristics of the designed power DSC controller:

According to the above design index, the DCS power control frequency doubling gain amplifier is constructed, which is composed of processor, RF chip, external FLASH, USB bridge chip and other peripherals. Using small PLC programmable logic control software to improve DCS power control performance, the architecture of the whole small PLC programmable logic control system can be divided into four structures: PLC programmable logic control processor, Small PLC programmable logic control peripherals, small PLC programmable logic control operating system. The power DCS control signal output based on the improved PID is input to the main frequency amplifier through the tracker [10].

The improved PID is used to optimize the power control design. The induction potential energy T and high frequency noise components of the power DCS control system based on the improved PID are obtained:

$$\begin{aligned} T = & \frac{1}{2} M_{RL} \dot{X}_{RL}^2 + \frac{1}{2} M_{RR} \dot{X}_{RR}^2 + \frac{1}{2} J_{RL}\ \dot{\theta}_{RL}^2 \\ & + \frac{1}{2} J_{RR}\ \dot{\theta}_{RR}^2 + \frac{1}{2} M_p [(\dot{\theta}_P L \cos\theta_P + \dot{X}_{RM})^2 \\ & + (-\theta_P L \cos\theta_P)^2] + \frac{1}{2} J_{P\theta}\ \dot{\theta}_P^2 + \frac{1}{2} J_{P\delta}\ \dot{\delta}^2 \end{aligned} \tag{1}$$

$$V = M_p g L \cos_{\theta_p} \tag{2}$$

The transfer function of the control system is defined as:

$$\frac{Y(s)}{R(s)} = \frac{G_C(s) G_0(s) e^{-\tau s}}{1 + G_C(s) G_0(s)} \tag{3}$$

Wherein, $Y(s)$ is the output control parameter, $R(s)$ is the input control parameter, and $e^{-\tau s}$ is the fuzzy time delay characteristic parameter. Through the above analysis, the power DCS control system model based on improved PID is obtained. The step response curve method is used to suppress the time delay coupling of power electrical system, and the anti-interference FIR filter of power DSC control is realized [11].

3 Improved Design and Implementation of Power DCS Control Based on Output Power Amplification and Regulation

3.1 Output Power Amplification and Regulation Method

On the basis of the above model design and description, the output power amplification and regulation algorithm are used to realize the improvement of power DCS control coupling control based on improved PID [12]. According to the device manual and the actual requirements of the system, the reset circuit of DCS controller based on Siemens PLC chip is designed. The reset circuit of DCS controller is obtained by using the method of output power amplification and adjustment.

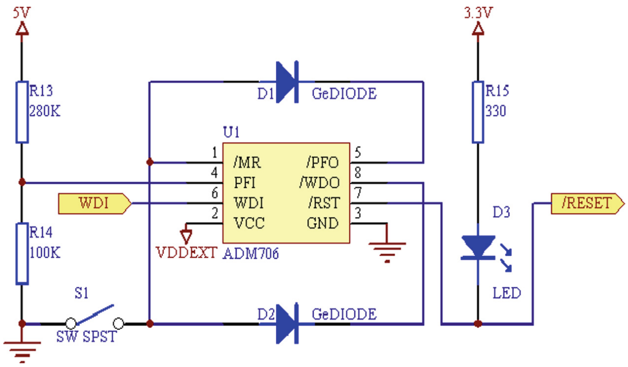

Fig. 2. Reset circuit of DCS controller

In Fig. 2, the PC0, PC1 controls the measurement range of the MMA7260 sensor, with a total of four 1.5G/2G/4G/6G ranges, corresponding to which the PC1, PC0 needs to enter a binary 0. 3. The PC2 of the amplitude modulation transmitter controls the dormancy mode of the MMA7260. When the PC2 input of the amplitude modulation transmitter is low, the MMA7260 enters the sleep mode, at which time there is only 3 μ A current consumption. PC3 provides power support for MMA7260. Thus, the power gain allocation balance is realized, and the input tuning loop signal is represented as follows:

$$h_1 = \omega_0^2 M_{sr}^2 L_l^2 + R_s R_r L_l^2 + R_s R_o M_{rl}^2 \tag{4}$$

Wherein, $rect(t) = 1$, $|t| \leq 1/2$, current signal of the medium high frequency signal is easily affected by the high frequency signal. E_t is the working frequency of the static operating point of the intermediate frequency oscillator, ω_c is the carrier frequency component, and the pre-whitening filter and cross-correlation receiver are used. After AC amplification, the gain distribution information of the amplitude modulation transmitter is obtained. the baseband signal of the amplitude modulation transmitter is filtered as follows:

$$w(t) = n(t) * h_w(t) \tag{5}$$

After frequency selection and filtering, the spectrum components falling in the passband of the system are equalized by gain allocation. At this time, the local oscillator oscillates and the output current amplitude is expressed as follows:

$$I_m = \frac{V_m}{Z} = \frac{V_S - V_{CE}}{Z} \tag{6}$$

When the phase margin of the closed-loop system is the maximum, the dynamic range of the analog preprocessing machine is −40 dB–+40 dB, and a large number of 80 dB is placed. The amplitude modulation transmitter adopts two-stage amplification to combat the interference of straight coupling noise, and adopts adaptive noise cancellation algorithm. Improve the anti-interference performance of the transmitter of power DSC controller.

3.2 Optimal Design and Implementation of Power DSC Controller

The power DSC controller system circuit is designed. The voltage signal output by D/A converter is between (0–4.095 V). Such a signal is not enough to provide enough transmission power to the acoustic array. VINB is connected to VREF and fixed to 2 V. So that the VINA range of the power DSC controller is 0–4 V. The level conversion circuit of power DSC controller is designed by ADG3301. ADG3301 is a single channel bidirectional level conversion chip produced by ADI. In this paper, the low frequency signal in high frequency signal can be detected by using phase detection method for reference. Sent to the low frequency circuit for amplification, the main point of the phase detection is to add the detected signal and the reference signal related to the detected to the input of the phase detection at the same time. The noise is effectively suppressed by using the characteristic that the output size is related to the phase difference between the two input signals, and the signal is extracted.

In this paper, the AC amplifier is designed by using double operational amplifier LM358, and a 16-order bandpass filter is composed of S3529 and S3528 stages. For the input signal S, the peak value is 2 V. The output voltage and output current collected by the data acquisition board are loaded into the MySQL database, and a lower sampling ratio is used to allow higher signal bandwidth, and a logic control circuit is designed. Finally, the optimal design of power intelligent control DCS module based on improved PID is realized. The core circuit of power DCS control based on PLC is shown in Fig. 3.

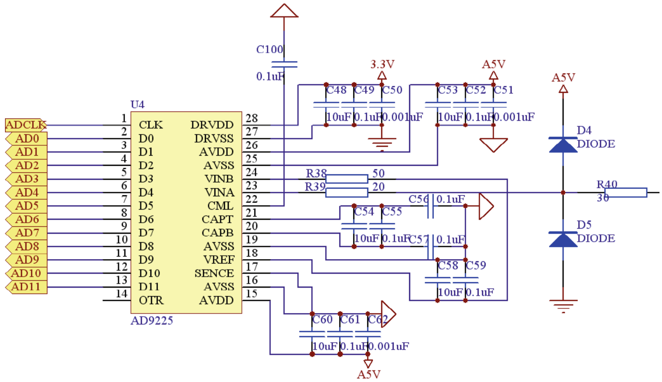

Fig. 3. Power DCS control based on PLC

4 Experimental Test and Result Analysis

In order to test the performance of the DCS power control module of the small PLC designed in this paper, the simulation experiment is carried out. The system simulation model is established based on the SIMULINK of MATLAB. The DCS power control system in the Machine library is selected as the controlled object, and the module resistance is $R_s = 0.7348\ \Omega$, the load resistance $R_r = 0.7402\ \Omega$, mutual inductance is $L_m = 0.1254$. In the power DCS control parameter setting based on improved PID, the stator resistance is $R_r = 0.7402\ \Omega$, power intelligent control DCS module, the efficiency is 96%, the torque output is 10 Nm. The total loss is 56.7 W. after the power supply circuit is normal, the crystal oscillator circuit should be checked. If the crystal oscillator is normal, there should be a square wave output of 25 MHz at the third foot of the crystal oscillator. The power DCS control crystal oscillator input signal based on improved PID is obtained as shown in Fig. 4.

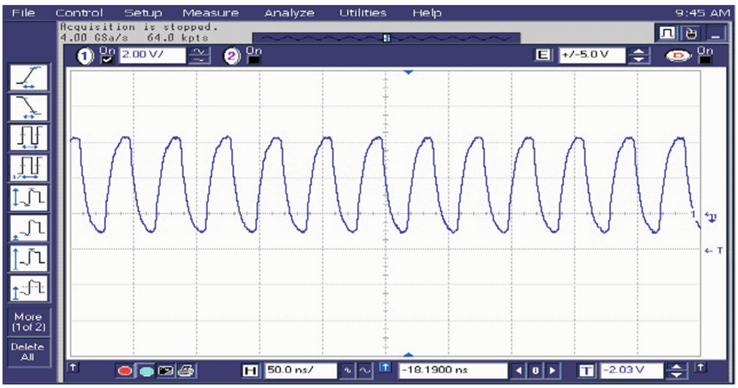

Fig. 4. Crystal oscillator input signal controlled by Power DCS based on improved PID

The sampling input signal is –4–0 V inusoidal signal, the voltage signal output by D/A converter is between (0–4.095 V), VINB is connected to VREF and fixed to 2 V, so that the VINA range of AM transmitter is 0–4 V. The level conversion circuit of amplitude modulation transmitter is designed by ADG3301. By using the control method designed in this paper, the output of power DCS control A/D sampling gain based on improved PID is obtained as shown in Fig. 5. It can be seen from the diagram that the traditional power DCS control model based on improved PID is used. The signal is composed of many narrow impulses, each pulse width is 2 V, the signal amplitude is less than 4 V, and there is a baseline drift of about 200 mV. Figure 5 shows the signal of the power control DCS baseline recovery after the output power amplification and adjustment control. It can be seen that the output base line of the power intelligent control DCS module is basically at zero level, which meets the compensation requirements, and after sudden loading, this paper has a shorter adjustment time, when the control process is stable, the rectifier coupling synchronous tracking control performance of the output voltage is better.

Fig. 5. Output gain control output of power intelligent control DCS module based on improved PID

5 Conclusions

In this paper, a power intelligent control DCS module based on improved PID is studied to realize the output gain control of power electrical system and improve the control efficiency of power electrical system. Combined with integrated DSP information processing chip, a design of power intelligent control DCS module based on output power amplification and regulation is proposed. The overall model of DCS power control system is designed, and the DCS power control frequency doubling gain amplifier is constructed. The signal anti-interference design adopts cascade filter and output power amplification adjustment method to obtain the reset circuit of DCS controller. The output power amplification and adjustment algorithm are designed to equalize the gain distribution to improve the power control performance of DCS. The test results show that the output gain of intelligent power control is large, the adaptive performance is good, and the output stability is strong. This method has good application value in power intelligent control.

References

1. Tu, B., Chuai, R., Xu, H.: Outlier detection based on K-mean distance outlier factor for gait signal. Inf. Control **48**(1), 16–21 (2019)
2. Wei, X.S., Luo, J.H., Wu, J.: Selective convolutional descriptor aggregation for fine-grained image retrieval. IEEE Trans. Image Process. **26**(6), 2868–2881 (2017)
3. Liu, Q., Guan, W., Li, S., Wang, F.: Indoor WiFi-PDR fusion location algorithm based on extended kalman filter. Comput. Eng. **45**(4), 66–71 (2019)
4. Wang, Z., Huang, M., et al.: Integrated algorithm based on density peaks and density-based clustering. J. Comput. Appl. **39**(2), 398–402 (2019)
5. He, H., Tan, Y.: Automatic pattern recognition of ECG signals using entropy-based adaptive dimensionality reduction and clustering. Appl. Soft Comput. **55**, 238–252 (2017)
6. Zhu, Y., Zhu, X., Wang, J.: Time series motif discovery algorithm based on subsequence full join and maximum clique. J. Comput. Appl. **39**(2), 414–420 (2019)
7. Sun, X., Li, X.G., Li, J.F., et al.: Review on deep learning based image super-resolution restoration algorithms. Acta Automatica Sinica **43**(5), 697–709 (2017)
8. Yan, S., Xu, D., Zhang, B., et al.: Graph embedding and extensions. a general framework for dimensionality reduction. IEEE Trans. Pattern Anal. Mach. Intell. **29**(1), 40–51 (2007)
9. Li, B., Wang, C., Huang, D.S.: Supervised feature extraction based on orthogonal discriminant projection. Neurocomputing **73**(1), 191–196 (2009)
10. Hou, C., Nie, F., Li, X., et al.: Joint embedding learning and sparse regression. a framework for unsupervised feature selection. IEEE Trans. Cybern. **44**(6), 793–804 (2014)
11. Liu, J., Luo, X.: Short-term optimal environmental economic hydrothermal scheduling based on handling complicated constraints of multi-chain cascaded hydropower station. Proc. CSEE **32**(14), 27–35 (2012)
12. Ding, Q., Lu, W., Xu, C., et al.: Passivity-based control of a three-phase shunt hybrid active power filter. J. Electr. Mach. Control **18**(05), 1–6 (2014)