FAULT ANALYSIS METHOD FOR LIQUID LEVEL CONTROL CIRCUIT OF A WATER SUPPLY SYSTEM

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某型供水系统液位控制电路的故障分析方法

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ABSTRACT

Agricultural irrigation is a very important link in agricultural production, but in the current situation of water shortage, reasonable control of agricultural water supply can not only achieve the purpose of irrigation, but also save water resources to the maximum extent. Therefore, this paper studies the agricultural water supply control system and its related circuits. According to the actual situation of agricultural irrigation, based on the nine-point controller in logic control, a control system of agricultural water supply based on nine-point controller is designed, and also the corresponding control circuit. The control system is verified by experiments. The results show that the control system circuit can meet the operation requirements under extreme conditions and has high stability. The experimental results of the control system show that the whole control system is obviously superior to the traditional PID control system, while the actual application results show that the whole control system has a good response and can control the water supply system in real time according to the actual situation of agricultural irrigation.

摘要

农业灌溉是农业生产中一个非常重要的步骤，但是在水资源逐渐短缺的今天，合理的控制农业供水既可以达到灌溉的目的，同时也能够尽可能的节约水资源，因此这里对农业供水系统中的控制系统及其相关电路进行研究。本研究根据农业灌溉的实际情况，以逻辑控制中的九点控制器为基础，设计了一个基于九点控制器的农业供水控制系统，并对其相应的控制电路进行了设计。然后通过实验的方式对该控制系统进行验证，验证结果表明控制系统的电路能够适应极端条件的运行需求，有较高的运行稳定性。而对控制系统的实验结果则证明了整个控制系统明显优于传统的 PID 控制系统，而实际的应用效果则表明整个控制系统具有良好的响应性，能够根据农业灌溉的实际情况对供水系统进行实时的控制。

INTRODUCTION

China is a country with a large population, but the corresponding cultivated land is very scarce, so it is very important to improve the efficiency of cultivated land planting, in which ensuring sufficient irrigation and water supply is an important way to improve the efficiency of planting. The national conditions determine the special importance of water supply in economic and social development *(Roy P., Kar B., and Roy B K., 2017)*. Correspondingly, China's water resources are not abundant, so we must improve the utilization rate of water resources. At this time, the only way to meet the dual requirements of irrigation and water conservation is to use automation technology to realize the precise control of agricultural water supply *(İsmail Bayram and Hapoglu H., Aldemir A., 2018)*. In agricultural automatic water supply control, liquid level control is one of the common control systems in agricultural production process. The liquid level control system has the characteristics of nonlinearity, time lag and inertia *(Tao J., Fan Q. and Ma L., 2017)*. However, the conventional control methods are sometimes difficult to meet the control requirements. On the one hand, the response time of water supply system control is relatively slow, on the other hand, it is the problem of frequent system failure caused by the longer operation time of water supply system *(Zhang B., Wei Y.J. and Liu W.Y., 2017)*. Therefore, it is necessary to design a water supply control system which can not only adapt to the harsh working environment, but also respond positively to the demand of agricultural water supply *(Kim S.W., Choi H.S. and Park D.U., 2018)*.

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According to the requirements of water saving, agricultural irrigation control and system safety in the current agricultural irrigation, this paper proposes a nine-point controller based agricultural water supply level control system, and the water supply system adopts the coaxial phase method of temperature resistance circuit to improve the safety of the whole system circuit. First of all, the agricultural liquid level control system based on nine-point controller can make real-time response to the whole water supply system according to the response curve of agricultural irrigation water, and adjust the size of water flow in the water supply system. Secondly, the temperature resistance circuit of coaxial phase method improves the adaptability of the whole system to the environment, and ensures that the system can reduce the failure rate under the continuous high temperature and long-time operation conditions.

The agricultural liquid level control water supply system based on the nine-point controller and the coaxial phase method temperature resistant circuit designed in this study overcomes the problem of water resource utilization efficiency in the process of agricultural irrigation on the one hand, and the problem of slow response speed in the traditional control method on the other hand; it also overcomes the system operation problem brought by the surrounding environment under the long-term continuous work security issues. That is to say, the design of the whole circuit can not only meet the needs of irrigation, but also ensure the stability of the system operation, so it has a certain degree of innovation.

The fault analysis method of the liquid level control circuit of a certain type of agricultural water supply system is studied by using the theory of agricultural irrigation coaxial phase method. The nine-point controller model based on the farmland water supply level system is constructed based on the liquid level circuit. The analysis of control faults proposed a temperature-resistant circuit control method based on the coaxial phase method water finder, and analysed the main principles and implementation flow of the model and method. Finally, the effectiveness of the system and model designed is verified by experiments.

In recent years, as liquid level control has been widely used in water supply systems, more and more scholars have conducted a lot of related research on their circuit control failures. Ye X designed a new automatic water level measurement and control system. The results show that the system has the characteristics of reasonable structure, fast response, stable and reliable, wide range of use, etc. It can carry out online real-time monitoring of liquid level of various conductive media *(Ye X. and Chen B., 2018).* Singh S combined with a large-scale new pumping station to design a variable-frequency constant-pressure water supply control system using PLC. The research results show that the system works stably, can meet the demand of constant pressure variables, and maintain the constant pressure at the end of the water supply pipe network, so that the water supply system is always in high efficiency and energy saving the best state *(Singh S. and Mohanty A.R., 2018)*. Paul R used a simple water tank and corresponding equipment to conduct a water supply test on a test water supply system in an agricultural park. The study found that the method is feasible, but it lacks a wide range of practicalities *(Paul R. and Sengupta A., 2017)*.

Byrdin V.M. designed the living water supply system of a living quarter in Kundulun District of Baotou City. It was found that the system realized the groundwater injected into the water tank of the residential pump house by the submersible pump, and then the water in the water tank was converted to constant pressure by the water pump. It was then available to the residents with effectiveness *(Byrdin V.M., 2017)*. Maurye P. analysed the liquid level control logic of the condenser vacuum pumping system, solved the fault, and proposed an improved method, which can be used for reference to solve the same problem *(Maurye P., Basu A. and Bandyopadhyay T.K., 2017)*. Gutiérrez E. designed a liquid level control system of the utility model. It was found that the system could generate control signals through the monitoring machine, control the water pump and valve of the water source well, and improve the efficiency and accuracy of the water level control without manual telephone notification *(Gutiérrez E., Balcázar N. and Bartrons E., 2017)*.

Agrawal A proposed a multi-boiler steam drum liquid level control energy-saving water supply control system and its control method. The research results show that the method can not only make the water supply control valve open the maximum boiler by dynamically adjusting the water supply to the mother pipe. It poses a safety hazard problem and enables the feed pump in a multi-boiler system to operate at optimum energy efficiency *(Agrawal A., Kothari A.K. and Rao K.R., 2019).* Takahashi T. proposed a comprehensive evaluation model for the vulnerability of water supply subsystem based on the catastrophe progression method, and a case study of a water distribution subsystem. The results show that the method has theoretical and practical feasibility and overcomes the subjectivity of previous vulnerability assessment methods *(Takahashi T, Ito T and Kim S Y. 2017)*.

Mandlate J.S. established a mathematical model of the logical structure of the urban water supply system to solve the systematic problem of water system risk assessment *(Mandlate J.S, Soares B.M. and Seeger T.S., 2017)*. Chen WL established a multi-objective simulation model for large-scale irrigation district water supply system based on system simulation technology. The research results show that this method can greatly improve the utilization of water resources in irrigation districts and give full play to the economic and social benefits of irrigation water resources (*Chen W L, Ho T.Y. and Huang J.W., 2018*).

It can be seen from the above studies that many scholars have established different methods for liquid level control water supply systems for different occasions, and verified the practicability and effectiveness of the system through experiments. However, most of these studies focus on the design and temperature control of centralized water supply systems, and there are few research results on the analysis of circuit control failures *(Pawlak M., 2018)*. Therefore, this paper has important significance for the research of fault analysis methods for the liquid level control circuit of a certain type of water supply system.

MATERIALS AND METHODS

NINE-POINT CONTROLLER MODEL BASED ON WATER SUPPLY LEVEL SYSTEM

In the current system control, PID control represented by proportional, integral and differential control is the most common control method, but the realization of this control is based on the engineers' full understanding of the system, and it also takes a long time to determine the parameters. Therefore, this study decided to adopt another kind of control, which is different from PID control. It is a logic science generated by simulating the human brain's transactional thinking mode. Therefore, this control method is also called logic control, and this control mode is similar to the current computer's arithmetic models such as addition and carry operation. This study adopts nine-point control. It is a logic control mode.

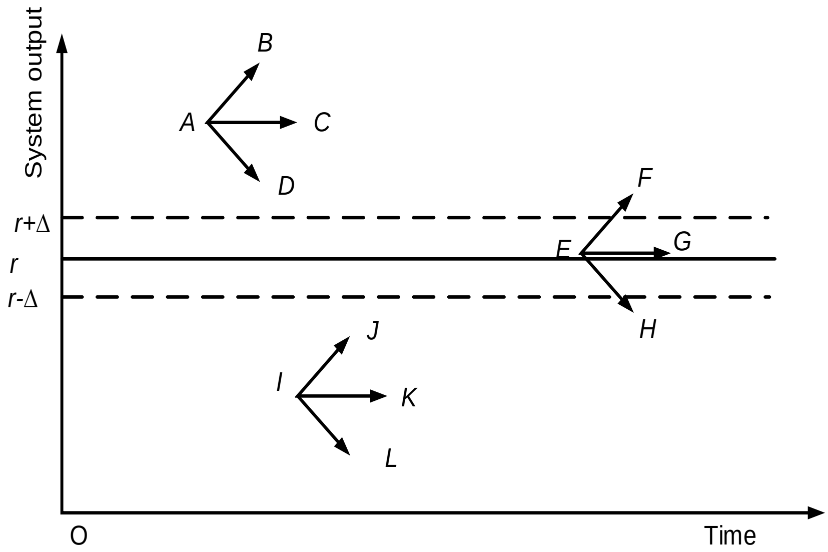

Fig. 1 - Nine-point controller system principle

The so-called nine-point controller refers to nine rules in the system control. Here, take Figure 1 as an example to illustrate. The first rule is that when the curve moves toward *AB* direction, the response curve is above the zero error band, which causes the negative deviation of the system to increase, the system needs to apply a strong reducing force to change the direction of the system movement; the second rule is that the curve moves toward *AC* direction, and the response curve is still above the zero error band, so that the negative deviation of the system remains unchanged, and the system needs to apply a "reducing" action The third rule is that the curve moves toward the *AD* direction, and the response curve is still above the zero error band, so that the negative deviation of the system is gradually reduced. At this time, the system needs to exert a "slightly reduced" force to ensure that the system enters the zero error band; the fourth rule is that the curve moves toward the *EF* direction, and the response curve is in the zero error band, so that the system gradually crosses the zero error. At this time, the system needs to exert a "micro reduction" force to ensure that the system does not cross the zero error band; the fifth rule, the curve moves toward the *EG* direction, the response curve is in the zero error band, and remains in the zero error band; at this time, the system needs to exert a "hold" force to ensure that the system does not cross the zero error band; the sixth rule, the curve moves toward the *EH* direction, and the response curve is in the zero error band, but it will cross the zero error band. At this time, the system needs to exert a "micro plus" force to ensure that the system does not cross the zero error band. In the seventh rule, the curve moves towards the IJ direction, and the response curve is under the zero error band, and moves towards the zero error band. In this case, the system needs to exert a "slight" force to ensure that the system enters the zero error band. In the eighth rule, the curve moves toward the *IK* direction, the response curve is under the zero error band, and maintains the current state. At this time, the system needs to apply "plus" force to ensure that the system enters the zero error band. In the ninth rule, the curve moves toward IL direction, and the response curve is under the zero error band, and gradually away from it. At this time, the system needs to apply "strong plus" force to change the system direction and make it enter the zero error band. The above nine rules are the basic principle of nine-point controller.

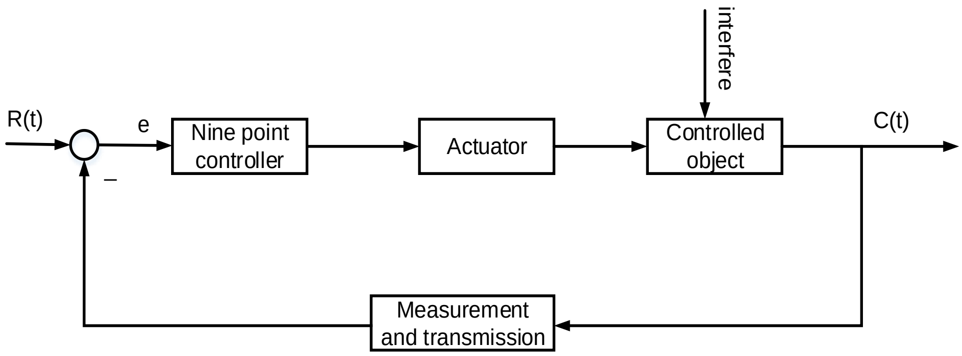

Fig. 2 - Schematic diagram of nine-point controller system

In order to play an effective control role, the nine-point controller must be in a closed-loop control loop. The control loop used in this study is shown in Figure 2. In Figure 2, *T* represents the sampling period, *R* represents the expected value of the system, *C* represents the measured value of the system, and *E = R (T) - C (T)* represents the deviation of the control system. *E '= (E i-ei-1) / T* represents the rate of change of deviation, *I* represents the number of adoption times. Then, according to the basic principle of nine-point controller, deviation and parameter change of deviation change rate, it can be divided into three categories as shown in Figure 3, and the whole nine-point controller design can be realized in nine cases. The modeling method of hybrid modeling is selected, and the mathematical model of the controlled object is constructed by using the open-loop step response curve method. Using a single-phase circulation pump to supply water to the water tank, in the manual control mode, adjusting the opening degree of the electric regulating valve, changing the water supply amount of the water tank, an interference signal is applied to the controlled water tank, and recording the system under the condition of step interference, level change data (*Bhuyan S K., Hota P K. and Panda B., 2018*). The opening of the electric control valve is adjusted manually. The initial stage valve opening is 35%, waiting for the system to reach equilibrium. At this time, the liquid level is stable at 8mm. Adjusting the electric adjustment opening to 45% is equivalent to adding a step signal into the system to break the original level balance. The system needs to be adjusted for a period of time, and the liquid level reaches a new equilibrium state to a height of 25 mm. After the test is completed, the data of the experiment is exported from the ACCESS database to EXCEL (*Manikandan P. and Khan F A., 2019*). The results are shown in Figure 4 below.

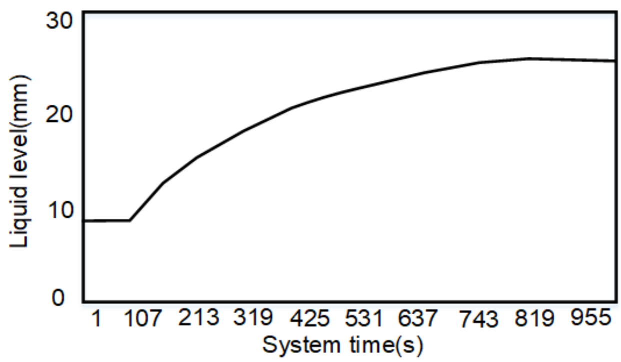

Fig. 3 - Drawing curves in EXCELL

By analysing the data in the graph, the two constants can be obtained, and the transfer function of the first-order liquid level control system composed of the single-capacity water tank is obtained.

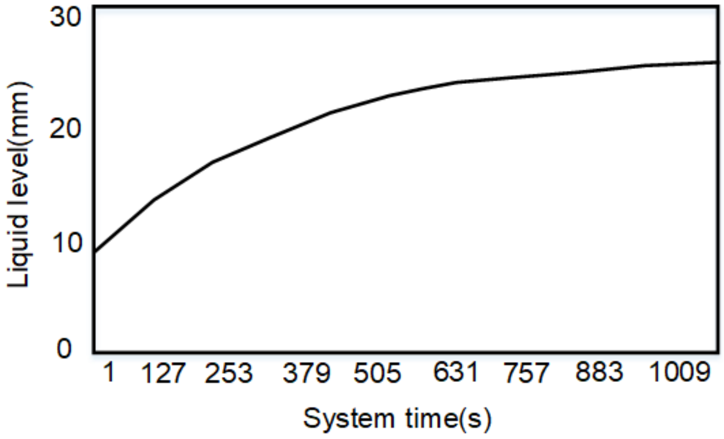

Fig. 4 - Rising section of response curve

Using the above calculation and analysis method, the transfer function of the obtained water tank is: $G(s)=\dfrac{K}{TS+1}$ Where k = 173; t = 190.

TEMPERATURE-RESISTANT CIRCUIT CONTROL METHOD BASED ON COAXIAL LINE PHASE METHOD

In order to realize the nine-point controller mentioned in this study, we need to design a corresponding control circuit to cooperate with the whole controller to complete the operation and control of the water supply system. The basic principle of the phase detector is to compare the phase of the input signal with the output signal of the phase-locked loop. The ideal phase detector frame is shown in Figure 5. It produces an error voltage V_e corresponding to the phase difference between the two signals. The stable output of the phase-locked loop circuit is guaranteed.

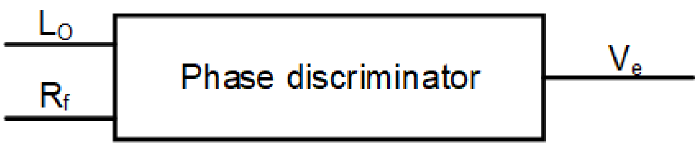

Fig. 5 - Principle block diagram of ideal phase discriminator

Phase detectors can be divided into two main categories, namely analog phase detectors and digital phase detectors. Both have their own advantages and disadvantages. The analog phase detector has a higher operating frequency, but there is zero drift and the sensitivity is not high. The digital phase detector has a faster operating frequency, and the main disadvantages are phase-detection dead zone and low operating frequency, but the high integration and stability of the digital phase detector are not available in the analog phase detector, and the phase detector requires that the input signal and the output signal remain fully synchronized, that is, the input signal and the output signal have the same frequency and the same phase (*Diao K., Sweetapple C. and Farmani R., 2016*). Analog phase detectors have a wide range of applications in areas such as automatic control, radar signal scanning and communications. According to the different circuit structure, it can be divided into sample-and-hold phase detector and mixing type phase detector. According to the different devices, it can be divided into passive phase detector and active phase detector. The waveforms of the phase detectors of the analog phase detector are also different, such as triangular wave type, sawtooth wave type and sine wave type (*Singh J., Singh S. and Singh A., 2019*). The diode balance phase detector is a common analog phase detector, which respectively applies the sum and difference of two input sinusoidal signals to the detection diode, and then the potential difference generated after the detection is the output voltage of the phase detector. In the coaxial phase method moisture meter, the mixer is the core part of the circuit. Based on the working environment requirements of the coaxial phase method water detector, high frequency signals are used to prevent interference, but the phase difference error of the direct measurement of the chirp frequency signal is relatively large, because the period of the high frequency signal is short and the resolution is relatively low. The measurement error is relatively large.

In order to solve this problem, the principle of integration and difference is used to preserve the difference frequency, which greatly reduces the measurement error of water content caused by the phase difference measurement (*Roy P. and Roy B K., 2016*). Let the phase-shifted signal input to the mixer be the signal sent by the local oscillator:

$$S_t = A_1 \cos(2\pi f_1 t + \Delta\phi) \tag{1}$$

$$S_i = A_2 \cos 2\pi f_i t \tag{2}$$

The performance of the mixer circuit is mainly considered from the following aspects: frequency conversion gain, noise figure, distortion and interference, and selectivity. The conversion gain can be mainly divided into variable frequency voltage gain and variable frequency power gain. The noise figure is the ratio of the noise power ratio of the input signal to the noise power ratio of the *IF* signal at the output. The distortion of the mixer is mainly the frequency distortion. In the mixer, various external factors will always be mixed into some interference signals that are close to the frequency of the intermediate frequency signal. In order to reduce the external interference, the intermediate frequency output loop should be better. The mixer circuit mainly includes a mixing part and a filter circuit *(Wee S Y. and Aris A Z., 2017)*. The transistor mixer is used to convert the high frequency signal of 75MHz into the intermediate frequency signal of 20KHz. The circuit of the transistor mixer has many types, and the frequency conversion circuit is mainly used to convert the nonlinear input characteristics of the transistor.

Common transistor mixers have a common emitter mixing configuration and a common base mixing configuration. The common-emitter mixing configuration may include the local oscillator voltage and the signal voltage is injected from the base and the local oscillator voltage is injected from the transmitter, and the signal voltage is injected by the base, and the common-base mixing configuration mainly includes the local oscillator voltage and the signal voltage. Both are injected from the transmitter. The designed mixer uses a transistor common emitter mixer. The measured signal voltage is input from the base and the local oscillator signal voltage is injected from the emitter. The advantage is mainly to suppress the traction phenomenon caused by mutual interference between the local oscillator signal and the input signal, and reduce the traction phenomenon. The reliability of the circuit *(Du J., Yang H. and Shen Z., 2017)*, the realization of the moisture meter circuit of the coaxial phase method water finder is designed by combining the discrete component circuits. In addition to the turbine flowmeter being a separate component, the five separate components are combined and the circuit board is used with each other, connected together to form a circuit system.

The first component is a 75.00MHz oscillating circuit assembly, the external dimensions are 30 × l2 × 0.8mm^3 Max, the working voltage is +12VDC, the operating current is ≤ 40mA, the operating temperature is 0-140 ° C, the nominal frequency is At 75.00MHz, the allowable frequency difference is ±0.5KHz at room temperature, the output waveform is sine wave, and the output amplitude is ≥10dm/50Ω. The circuit uses a double panel structure *(Abraham E. and Stoianov I., 2016)*.

The second component is the 75.02MHz oscillator circuit component, the external dimensions are 40 × l2 × 0.8mm^3 Max, the working voltage is +12VDC, the operating current is ≤ 40mA, the operating temperature is 0-140℃, the nominal frequency is at 75.00MHz, the allowable frequency difference is ±0.5KHz at room temperature, the output waveform is a quasi-sine wave, and the output amplitude is >0.8V/lKfl. The circuit is designed in a double-panel structure.

The third component is a mixer circuit component. There are two groups. The external dimensions are 30×l2×l.5mm^{3}Max, the working voltage is +12VDC, the working current is ≤30mA, and the working temperature is 0-140°C. The allowed frequency difference is ±1.0KHz at room temperature, the output waveform is square wave, the output amplitude is low level ≤1V, and the high level is 5V±0.5V. The circuit is designed in a double-panel structure. The fourth component is the phase detector circuit component, the external dimensions are 30 × l2 × 0.8tmn^3 Max, the working voltage is +12VDC, the operating temperature is 0-140°C, the circuit is designed with double panel structure *(Chen G., Ren L. and Xu Y., 2019)*. The fifth component is the voltage-frequency converter circuit component, the external dimensions are 30 × 12 × 0.8mm^3 Max, the operating voltage is +12VDC, the operating temperature is 0-140 ° C, the phase amplitude is in the range of 60° ~ 180°. When changing, the output amplitude varies from 1000 to 4000 Hz. The circuit is designed with a double panel structure.

RESULT ANALYSIS

EXPERIMENTAL ENVIRONMENT

This paper uses the ae2000 and cs4000 experimental devices produced by Zhejiang Zhongkong Company for laboratory verification simulation. The experimental device has three upper, middle and lower water tanks, stainless steel water storage tank, forced convection heat exchange system and three-phase 4.5kW electricity. Heat the boiler. There are two power circuits: one is composed of single-phase circulating pump, electromagnetic flow meter, electric regulating valve and related components; the other is composed of inverter, small flow pump, turbine flow meter and other components *(Wang S., Zhang H. and Wang S., 2016)*.

TEMPERATURE TEST AND FAULT ANALYSIS OF CONTROL CIRCUIT

The main purpose of agricultural water supply system is to protect the irrigation of agricultural crops, especially in the high temperature weather, which is more frequent. In addition, the long-term operation of the whole system will inevitably lead to the phenomenon of system heating. Therefore, whether the designed circuit can meet the requirements of high temperature environment in the underground, temperature testing is the most important link. Temperature test on the circuit board is to test whether the circuit can reach the temperature resistance of the high temperature environment in the well, and whether the design of the test circuit is reasonable, and finally whether the function can be realized. Therefore, it is very important to carry out high temperature experiments on the circuit. Temperature experiments are performed on each component of the circuit. The advantage of this is that it is convenient to modify each circuit, reduce the workload, and improve the overall temperature resistance of the circuit. At room temperature (from 30°C in winter), the data was tested every 10°C increase and continued to rise to 140°C (Although the temperature of the working environment will not be higher than 80°C, in order to ensure the safety of the whole circuit, it is still necessary to verify the safety of the circuit in some extreme cases). The temperature test was carried out using an incubator, and the wires were directly led out for testing. Temperature test on the oscillating circuit and the mixing circuit, starting from 30°C, every 10°C increase in temperature, test the data once, up to 140°C, record the experimental data, observe the two-way mixer circuit through the oscilloscope. The output frequency is obtained, and the experimental data as shown in Table 1 is obtained.

Table 1

Temperature experimental data of mixer circuit

Temperature(°C)	30	40	50	60	80	100	120	140
Mixer 1 Frequency (KHz)	19.49	19.51	19.58	19.62	19.81	20.11	20.35	21.03
Mixer 2 Frequency (KHz)	19.49	19.52	19.57	19.62	19.82	20.10	20.34	21.05

It can be seen from the temperature experimental data that as the experimental temperature increases, the frequency of the mixer 1 and the mixer 2 are substantially the same, and the magnitude of the change is substantially the same. It can be seen from the data in the table that the designed mixer circuit can almost eliminate the influence of temperature change on the phase measurement and reach the temperature resistance condition of 140°C. When the temperature continues to rise above 150°C, the measurement effect is distorted and the output is unstable. Temperature test on the phase detector circuit, starting from 30°C, every 10°C increase, tests the data once, up to 140°C, observes the output voltage value through the oscilloscope and records the experimental data. The experimental data obtained are shown in Table 2.

Table 2

Temperature experimental data of phase discriminator circuit

Temperature(°C)	30	40	50	60	70	80
Voltage(V)	3.83	3.83	3.84	3.84	3.85	3.86
Temperature (°C)	90	100	110	120	130	140
Voltage(V)	3.87	3.90	3.85	3.82	3.73	3.65

It can be seen from the data in the table that the magnitude of the voltage value remains basically constant. When the temperature rises to 100°C, the voltage gradually decreases. When the temperature rises to 150°C, the output voltage is unstable, so it can be satisfied the requirements for temperature measurement at 140°C in a downhole environment. Finally, the temperature test of the voltage-frequency conversion circuit is carried out. Starting from 30°C, the data is tested once every 10°C, and it is raised to 140°C. The output pulse signal frequency is observed by an oscilloscope and the experimental data is recorded. The experimental data is shown in Table 3.

Table 3

Experimental data of voltage-frequency conversion circuit temperature

Temperature (°C)	30	40	50	60	70	80
Frequency (Hz)	4169	4172	4183	4200	4215	4219
Temperature (°C)	90	100	110	120	130	140
Frequency (Hz)	4227	4188	4106	4003	3986	3942

It can be seen from table 3 that with the increase of temperature, the pulse signal frequency of the circuit increases slowly. When the temperature is 90°C, the pulse signal frequency reaches the maximum value of 4227Hz. When the temperature continues to increase, the pulse signal frequency tends to decrease. When the temperature reaches 140°C, the pulse signal frequency drops to 3942Hz, so within 150°C, the pulse signal frequency of the circuit. The maximum temperature drift is: 4227-3942=285Hz=0.285KHz. When the temperature exceeds 150°C, the output is unstable, so it can meet the requirements of 140°C temperature measurement. The turbine flowmeter is a separate part. A square wave signal with a frequency of 20 Hz and 3.5V is applied to the signal generator. Starting from 30°C, the data is tested once every 10°C, and it is raised to 140°C. The frequency of the pulse signal output by the oscilloscope is basically unchanged. Perform temperature experiment on the whole circuit, put it into the incubator, lead the wire, and energize the circuit. Starting from 30°C, every one degree (TC, test data) always rise to 140°C. Observe the record through the oscilloscope and obtain experimental data. It can be seen that the output of the two mixers is basically the same, the phase-detection circuit and the voltage-frequency conversion circuit have an increasing trend at 30~90 °C, and at 90~140°C. The output of C is declining. The maximum temperature drift is: 4221-3896=325Hz=0.325KHz. When the temperature rises to 150°C, the output frequency is unstable. Therefore, the circuit can work normally at 140°C. The temperature requirement of the coaxial line phase method is that the sub-module is designed and finally packaged. Each circuit is an independent unit, which is connected to each other through lines to realize the overall function. The circuit is on the experiment board. After the performance and temperature test, each part of the circuit is packaged in blocks, the bottom plate is installed, and the outer casing is purchased. The function of the outer casing is to isolate the circuit from the outside and reduce the interference of the external circuit. The size of the package must be selected according to the size of the circuit. Overall physical map is as shown in Fig.6.

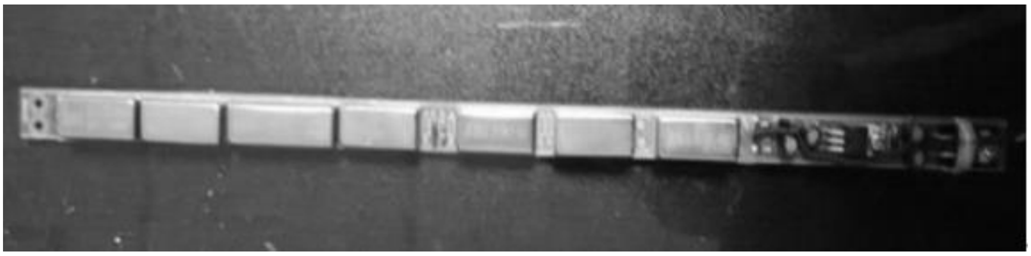

Fig. 6 - Circuit physical diagram

The peak period of the system test water supply is mainly concentrated in several time periods during the day. The water consumption at night decreases rapidly. The water supply is basically zero during the time from 1:00 to 4:00, and the liquid level of the water tank is basically maintained. At the high liquid level h2, the measurement accuracy of the pressure gauge is low, and the water injection port of the water tank is at the top of the water tank. Even if the submersible pump stops water injection, the water surface will maintain long-term fluctuation. All of the above result in a high on-off frequency when the contact signal of the high liquid level h2 is entered. When designing the circuit, only the relay ka3 is considered to be the pump stop relay of the submersible pump at the high level h2 of the inlet water. In the theoretical analysis, when the liquid level reaches the high liquid level h2, the relay ka3 only needs to send a pump stop signal to release the ka4. After the self-locking, the water injection is stopped, and the control requirement can be satisfied. Therefore, the design of the self-locking circuit is not performed, and the phenomenon that the contact signals of the relay ka3 with the high liquid level h2 of the inlet water is shaken, so that the long-term frequency of the relay ka3 coil occurs. The higher on and off level eventually ablates its coils and contacts.

PERFORMANCE TEST OF THE APPLICATION OF LIQUID LEVEL CONTROLLER IN A WATER SUPPLY SYSTEM

After the modeling work in the above chapters, it is now necessary to discuss and study the control performance of the nine-point controller in the liquid level control system. The unit positive step signal is applied to the control loop where the nine-point controller and the conventional PID control module are located, and the corresponding graph is obtained during the simulation time of 50s. The graph of the conventional PID is shown in Figure 7. The simulation curve of the nine-point controller is shown in Figure 8. In all of the following simulations, the abscissa is the time axis (unit: second) and the ordinate is the liquid level height (unit: cm).

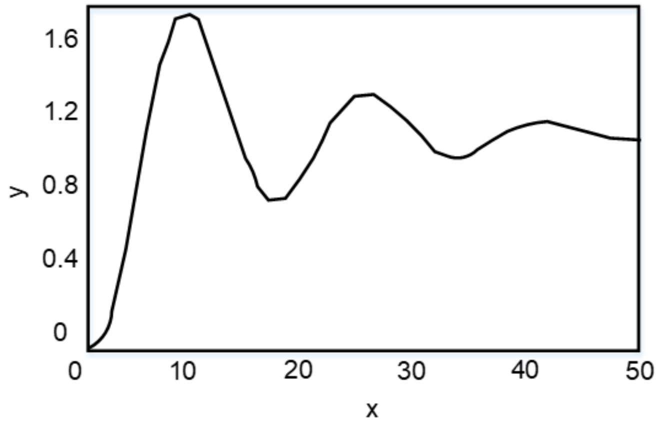

Fig. 7 - Conventional PID simulation curve

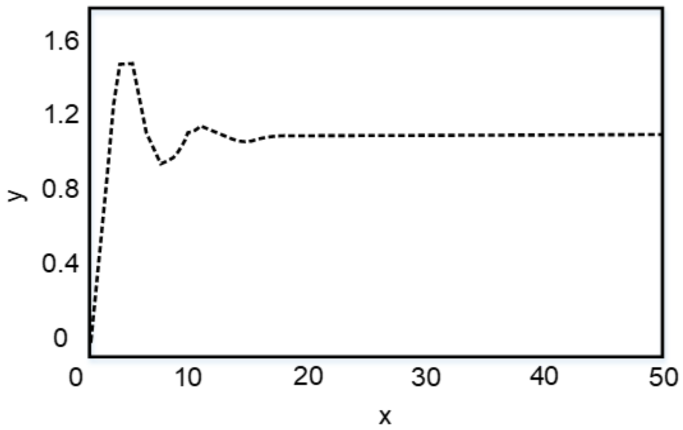

Fig. 8 - Nine-point controller simulation curve

From the overall shape of the above two simulation diagrams, the conventional PID control is not much different from the nine-point controller control, but the two curves are put into a graph from the system's rise time. The control time of the system is compared in three aspects, as shown in Figure 9.

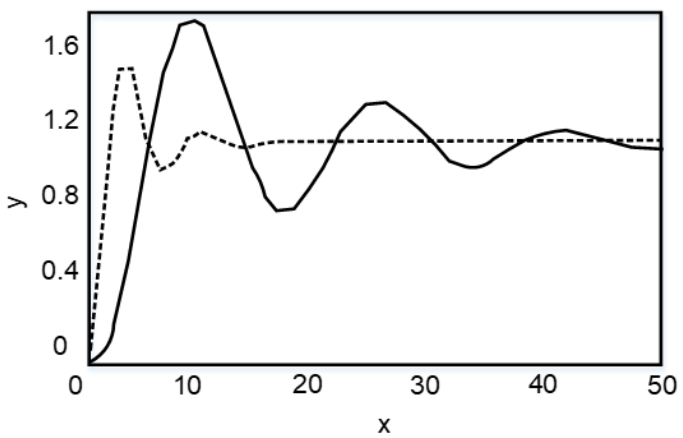

Fig. 9 - Contrast charts of control schemes

For the nine-point controller parameter tuning process, the attenuation ratio of the system response curve can be adjusted to between 1/4 and 1/10 by referring to the tuning mode of the conventional PID parameter. After that, consider what kind of interference you may encounter when the system is running, and what its strength is. Based on these analysis conclusions, according to the function of the nine-point controller parameters and the correlation between them, the corresponding parameter adjustment scheme is taken out. This not only greatly shortens the time for parameter setting, but also makes it possible to adjust the parameters more rationally when encountering complex conditions.

Table 4

Practical application of agricultural water supply control system

Time	Weather condition	System traffic (L/min)
13:00	Rain	0.00
13:30	Rain	0.00
14:00	Rain	0.00
14:30	Fine	42.54
15:00	Fine	42.66
15:30	Fine	36.24
16:00	Fine	35.16
16:30	Fine	30.12
17:00	Fine	24.06

The above table is the specific application results in agricultural irrigation. It can be seen from the table that when the weather is rainy, the whole water supply system has been completely closed because agricultural irrigation can be completed by relying on rainwater under natural conditions. After the weather turns sunny, the evaporation caused by the sun intensifies, so the water supply system begins to supply water to the irrigation system. However, as the time gradually approaches the evening, the natural environment temperature begins to decline, the evaporation decreases, and the water required for irrigation also decreases. The water supply control system gradually controls the water supply according to the irrigation demand, so the flow, appearing on the flow A, gradually decreases over time. From the perspective of the whole application, the response of the whole control system is very timely, and the whole water supply system can be controlled in real time and accurately according to the surrounding environment changes.

CONCLUSIONS

In the rapid development of agricultural modernization, there are many ambiguities in the understanding of the water supply system of large-scale facility agricultural parks and their use, and the liquid level is one of the common controlled objects in the agricultural production process, and its control sometimes happens. It affects the final agricultural production and sometimes even the safety of the entire agricultural production process. Therefore, this paper discusses the fault analysis method of the agricultural irrigation liquid level control circuit of a water supply system by establishing a nine-point controller model and using the temperature-resistant circuit design method based on the coaxial line hemotoxic method.

The implementation of the circuit adopts the PCB method, and the designed circuit is realized by Altium Designer software, and the circuit is reasonably wired, which improves its ability to resist high frequency interference. Temperature test is carried out for each circuit and the whole circuit, which satisfies the temperature resistance requirement that the circuit can work normally at 140°C, does not produce distortion, and improves the temperature resistance of the coaxial line phase water detector. Through the simulation comparison between the nine-point controller and the conventional PID controller on the MATLAB platform, it can be seen that the nine-point controller can better complete the industrial control task, and can make the overshoot and adjustment time of the agricultural water supply system of optimization. After a period of optimization, the control effect can even ensure that the system can control the phenomenon when the control parameters are adjusted in a small range, so that the system can transition to a new control state more smoothly. In the design of the circuit, there is room for improvement.

The selection of components in the agricultural irrigation system and the wiring of the high-frequency circuit PCB can also have a better solution, which is one of the directions of future research.

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