2019

Design and simulation of the control excitation system

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2019.12.5

CATALOG

1 overview

The excitation system of model rotor control is indispensable system to the ACF model rotor testing, and the excitation system of model rotor control is key facility to the realization of model rotor system controlling angle. This paper main introduced the design and simulation of the hydraulic excitation system of model rotor control, the main useful of the system is realizing the changing of model rotor control angle and offering classic excitation to model rotor control, in order to testing and judge the natural capacity of model rotor machine dynamics, and finish the experiment of model rotor machine dynamics, further by it we can research unsteady rotor aerodynamics and mechanics of maneuvering fight, and rotor aero elastic coupling and dynamic stability and other related issues. At last we use the simulation tool Simulink of matlab language designing and Simulink for it, the simulation result proof the system is reasonable.

2 Design of the control excitation system

2.1 Composed of the system

The synchronous hydraulic excitation system mainly includes hydraulic system and its control system, the longitudinal control system and the control software of the control system.

See fig.1 for the composition diagram of the hydraulic excitation system.

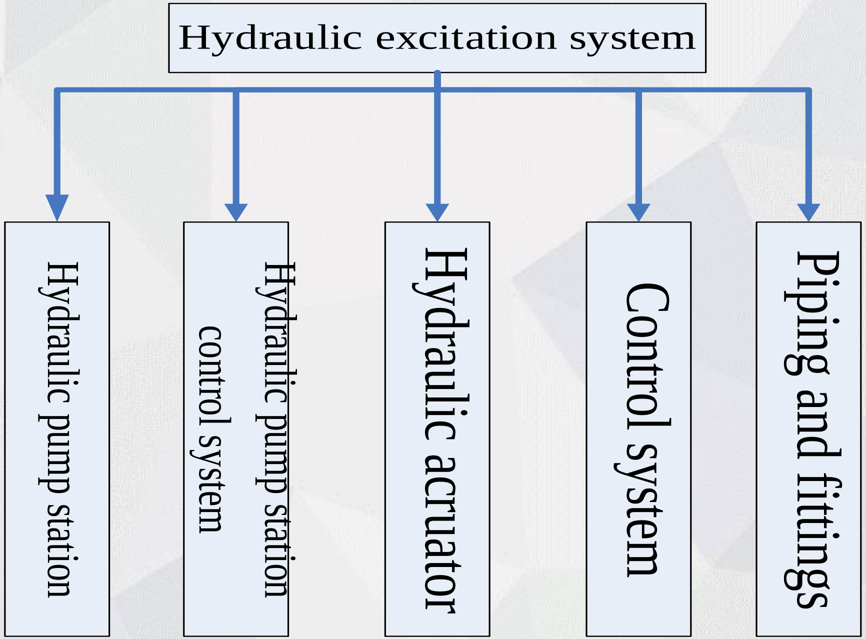

Figure 1 A block diagram of the hydraulic excitation system

2 Design of the control excitation system

2.1 Composed of the system

See fig.2 for the schematic diagram of model rotor dynamic test：

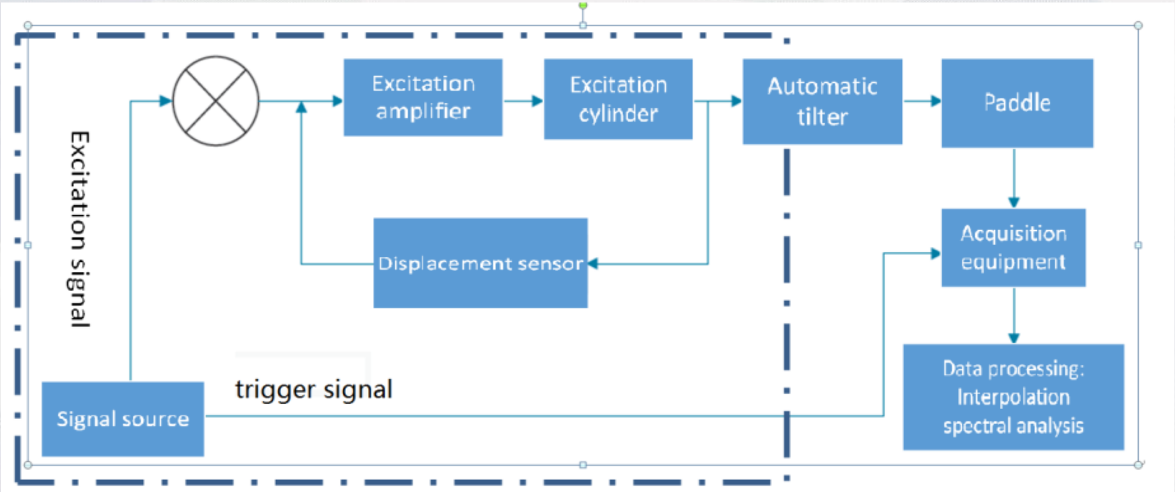

Figure 2 model rotor dynamic test principle block diagram

2 Design of the control excitation system

2.2 Control software design of the control excitation system

The system adopts double closed loop and the software is written by labview.
As the amplitude range of the control excitation system is required to be 60Hz@2mm and 40Hz@3mm, the maximum acceleration can be calculated to be about 30g. Considering the complexity of the working state, double closed loops of acceleration and displacement are adopted. The excitation control system can not only realize single-axis position control, but also realize multi-axis coordination position control and three-axis linkage. It can control according to the given coordination value or control angle in the coordination system by the user, and it can also realize manual (inching) feed motion through to the keyboard. And provides the user with motion control program module, the user may compile the main program by himself, through the data communication with the motion control program, realizes the corresponding control movement.

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.1 hydraulic excitation control system model

The hydraulic excitation control system is typical electro-hydraulic position servo control system. The basic principle of the electro-hydraulic servo control system is shown in figure 3, which consists of a regulator, a servo amplifier, a servo valve, a hydraulic cylinder, a load and a displacement sensor. System input voltage instruction for Ur, Ur with displacement sensor provide feedback voltage Uf, compared to produce the error signal Ue, Ue through regulator become signal Ue', after the servo amplifier is converted to the servo valve control current I, I with servo valve is the valve core displacement of Xv , is proportional to, so I can control into the oil flow and pressure of the hydraulic oil cylinder, which moves the position, together with the load to reduce the error direction, until the error is zero.

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.1 hydraulic excitation control system model

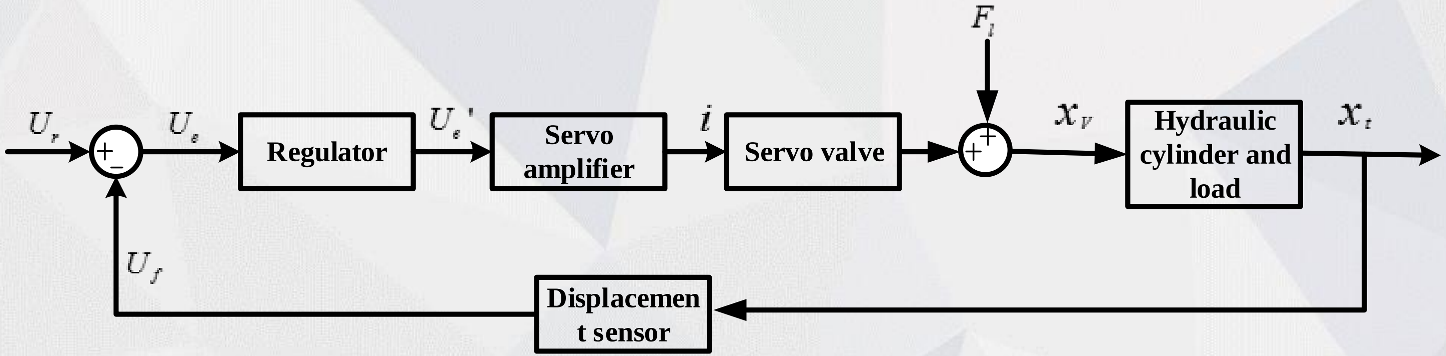

Figure 3 Principle block diagram of electro-hydraulic position servo control system

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.1 hydraulic excitation control system model

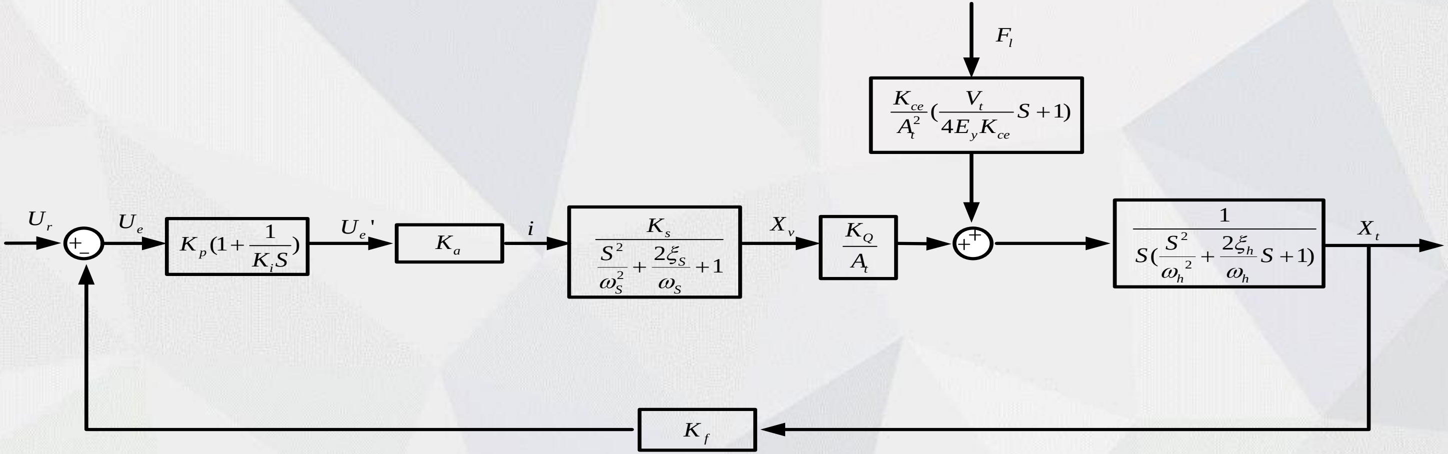

Figure 4 Dynamic structure block diagram of electro-hydraulic position servo control system

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2 simulation of the hydraulic excitation control system

According to the hydraulic position servo control system model established above, Simulink simulation tool in matlab language is used to simulate the system.

3.2.1 single cylinder excitation simulation

In the case of single cylinder excitation, the dynamic structure block diagram of the electro-hydraulic position servo control system shown in figure 5 is directly used for simulation in the Simulink simulation tool. The specific simulation results are shown as follows.

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.1 single cylinder excitation simulation

(1)Response to the step signal under constant load-static control response

The constant load on the load end of the actuator cylinder of the system is 5000N, and the given system input signal is a step signal with a signal amplitude of 1cm. The response curve of the system is shown in figure 5.

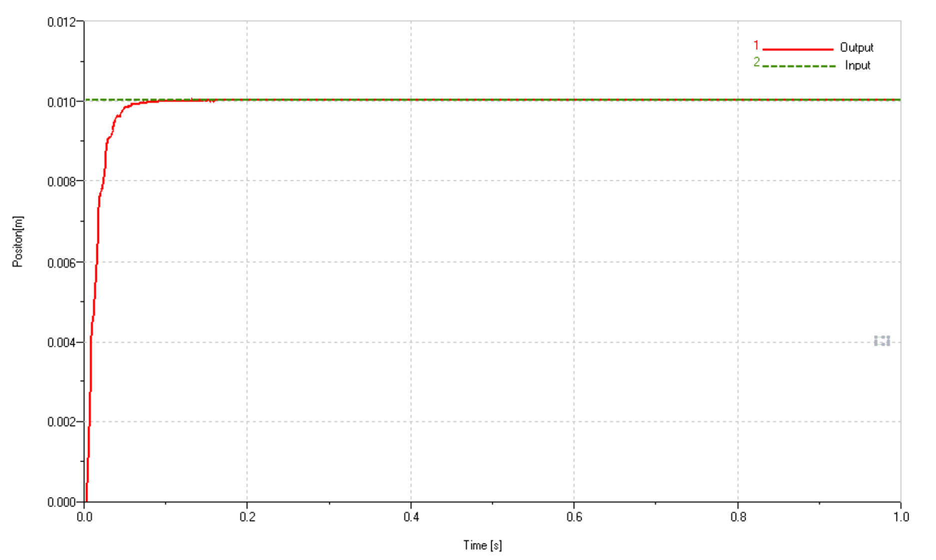

Figure 5 the response curve of the system to the step signal under constant load

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.1 single cylinder excitation simulation

The dotted line in figure 5 is the system given curve, and the solid line is the system response curve. As can be seen from the curve, the response time of the system is t_s≈0.08s, and the overshoot isσ≈0.. Figure 6 shows the error curve of the system in tracking the step signal under constant load. It can be seen from figure 6 that the steady-state error of the system is approximately zero after entering the steady-state state.

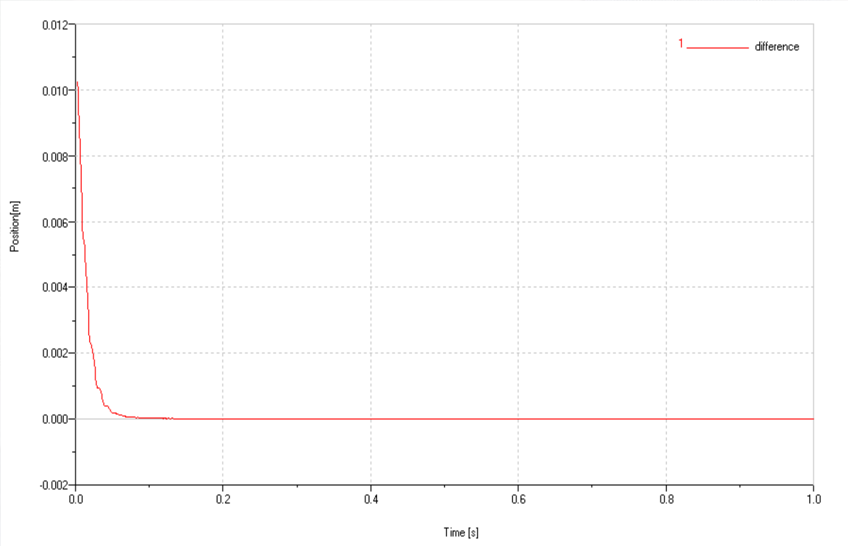

Figure 6 the error curve of the system tracking the step signal under constant load

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.1 single cylinder excitation simulation

(2)Response to a sinusoidal signal under constant load-Excitation control response

The constant load on the load end of the actuator cylinder of the system is 5000N, and the given system input signal is a sinusoidal signal, when the sinusoidal signal amplitude is 5mm and the frequency is 10Hz, the response curve of the system is shown in figure 7.

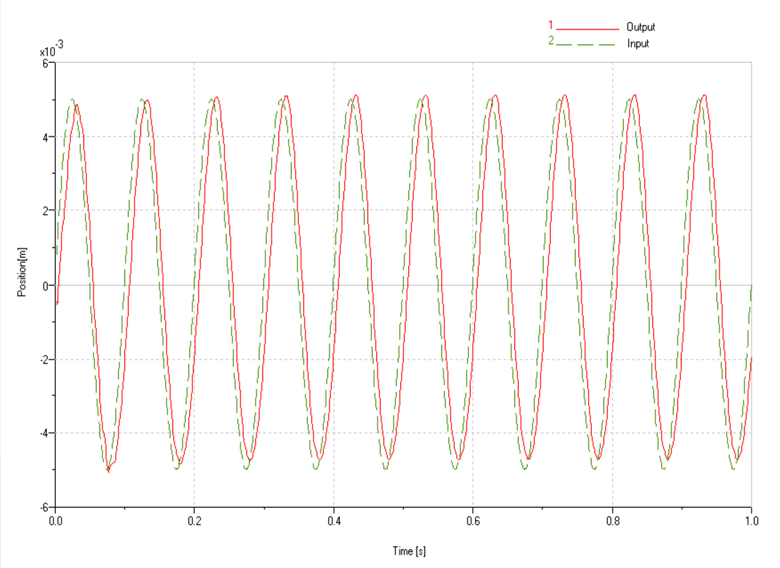

Figure 7 10Hz， ±5mm response curve of sinusoidal signal

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.1 single cylinder excitation simulation

When the sinusoidal signal amplitude is 5mm and the frequency is 40Hz, the response curve of the system is shown in figure 8.

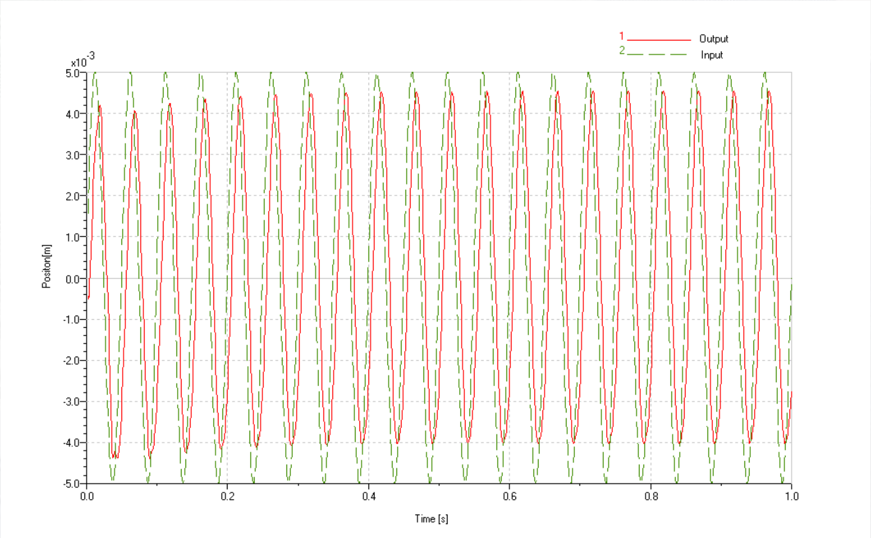

Figure 8 40Hz，±5mm response curve of sinusoidal signal

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.1 single cylinder excitation simulation

When the sinusoidal signal amplitude is 5mm and the frequency is 60Hz, the response curve of the system is shown in figure 9.

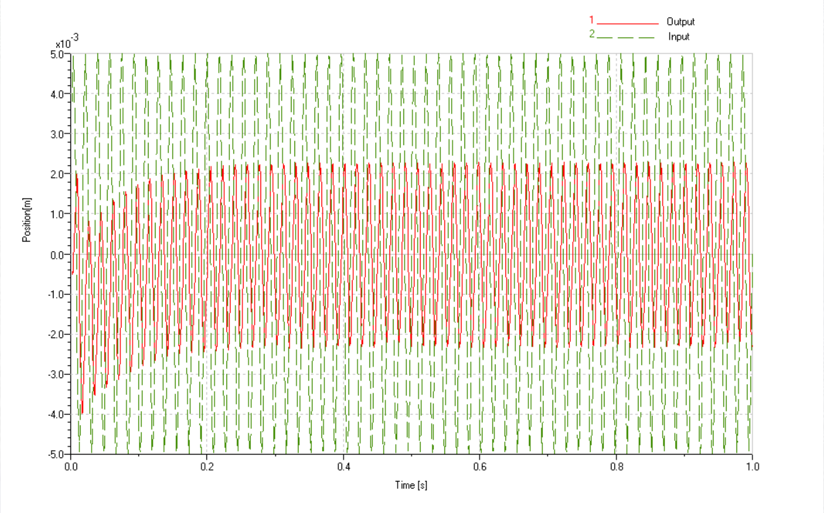

Figure 9 60Hz， ±5mm response curve of sinusoidal signal

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.1 single cylinder excitation simulation

As can be seen from FIG.7, 8and 9, when the given signal frequency is 10Hz, the system can be well tracked. As the given signal frequency decreases, which is reflected in the characteristics of the hydraulic cylinder. When the given signal frequency is 40Hz, the system can still follow, but the output amplitude drops to about 3mm. According to the requirements of the technical indicators , at 60Hz, the output curve of the simulation system is shown in figure 9. As can be seen from the figure, the amplitude of the system under this signal can be reach 2mm as required by the technical index.

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.1 single cylinder excitation simulation

(3)Response to the sinusoidal signal variable load

Under the condition of variable load mentioned above, the input frequency of given system is 40Hz and the amplitude is ±5mm, and the response curve of the system under this signal is shown in figure 10. It can be seen from the figure that the interference signal has little influence on the system vibration.

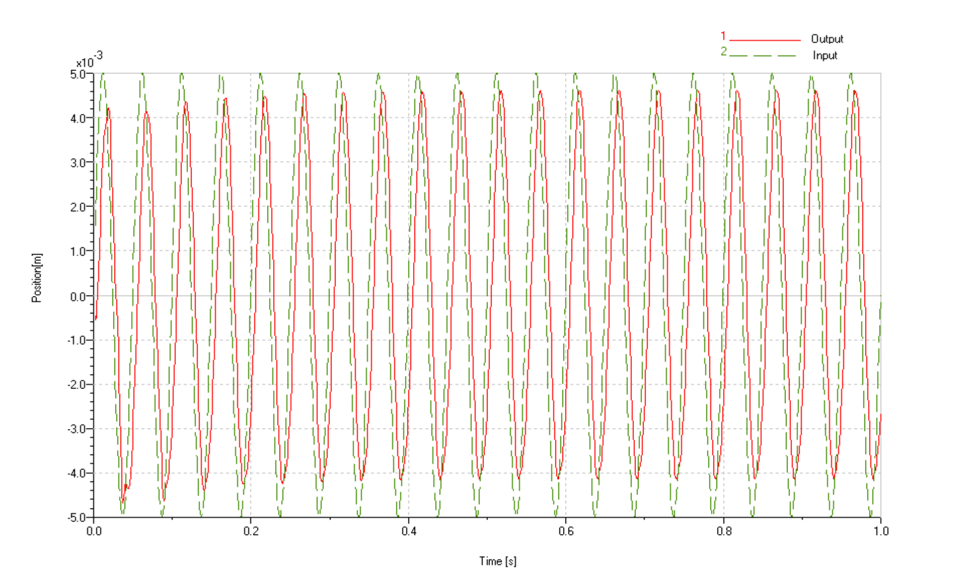

Figure 10 response curve of the system to sinusoidal signals of 40Hz and ±5mm under interference signals

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.2 Three cylinder synchronous excitation simulation

Single cylinder excitation belong the working condition of single input single output of relatively simple, and three cylinders synchronous excitation is more complex multiple input and multiple output work heavy, so considering the condition is complicated, need to be in single cylinder the condition excitation and synchronous phase control, because there are 3 cylinder synchronous excitation input signal ,output signal 3 road, therefore need to increase the synchronization between each two lines of the input signal phase closed-loop feedback. Talking signal 1 and signal 2 as examples, the following simulation is carried out.

Two sinusoidal signals are used to carry out synchronous phase control through phase delay. The simulation figure is as follows:

3 Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.2 Three cylinder synchronous excitation simulation

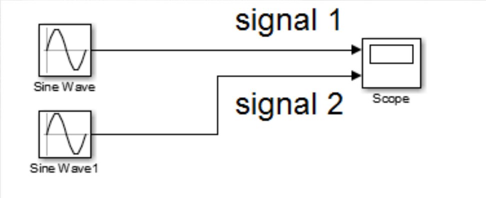

Figure 11 simulation diagram of sinusoidal signal synchronous phase control

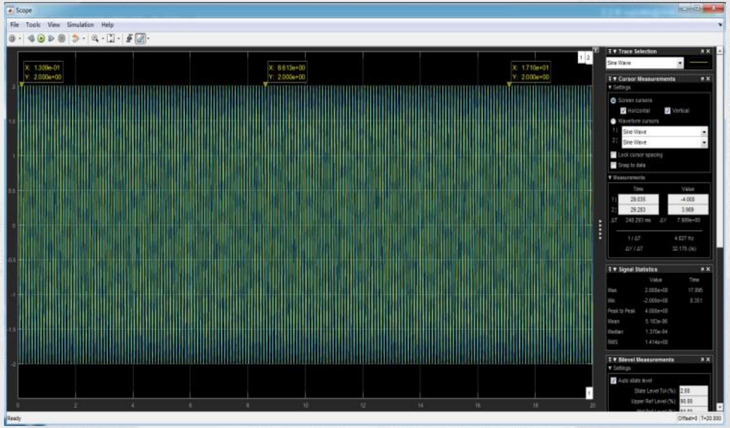

Figure 11 60Hz@2mm simulation of sinusoidal signal 120 degree phase control

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Modeling and simulation of the three-axis synchronous hydraulic excitation system

3.2.2 Three cylinder synchronous excitation simulation

Through the simulation measurement of oscilloscope, the amplitude can reach 3mm at 40Hz and 2mm at 60Hz, and the maximum phase error is 4.5 degree, which is in line with the initial technical requirements.

4 Conclusion

After deduction and solving the mathematical model of dynamical characteristics of asymmetric valve control cylinder, hydraulic servo control system model is established, and the simulation function of matlab software for the dynamical simulation of the proposed model, including the single cylinder excitation simulation and three cylinder synchronous excitation simulation, and the simulation results are compared with the actual measured value, have a good consistency, proved that the hydraulic excitation control system parameter setting is reasonable, the design is effective.

thanks！