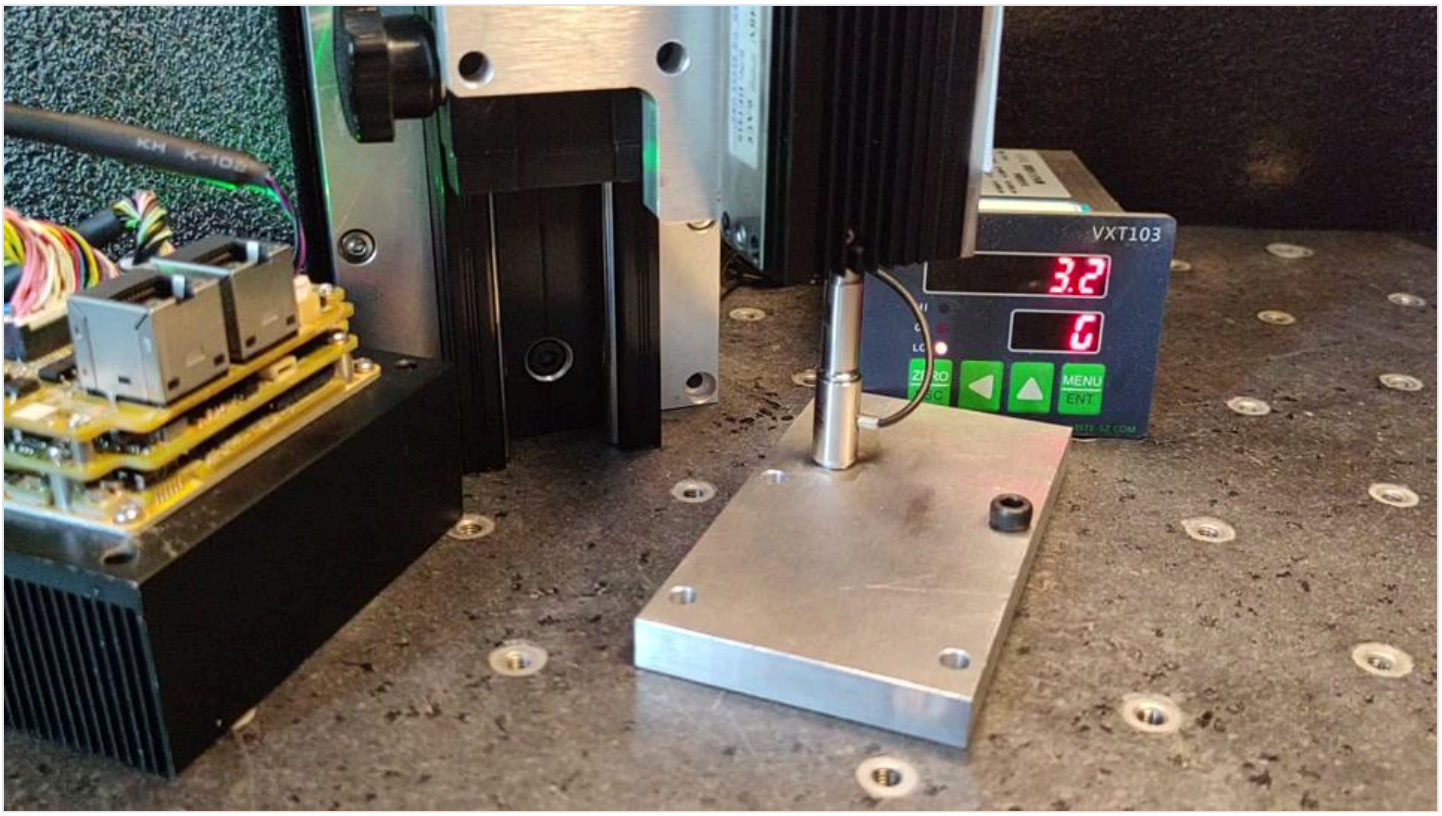
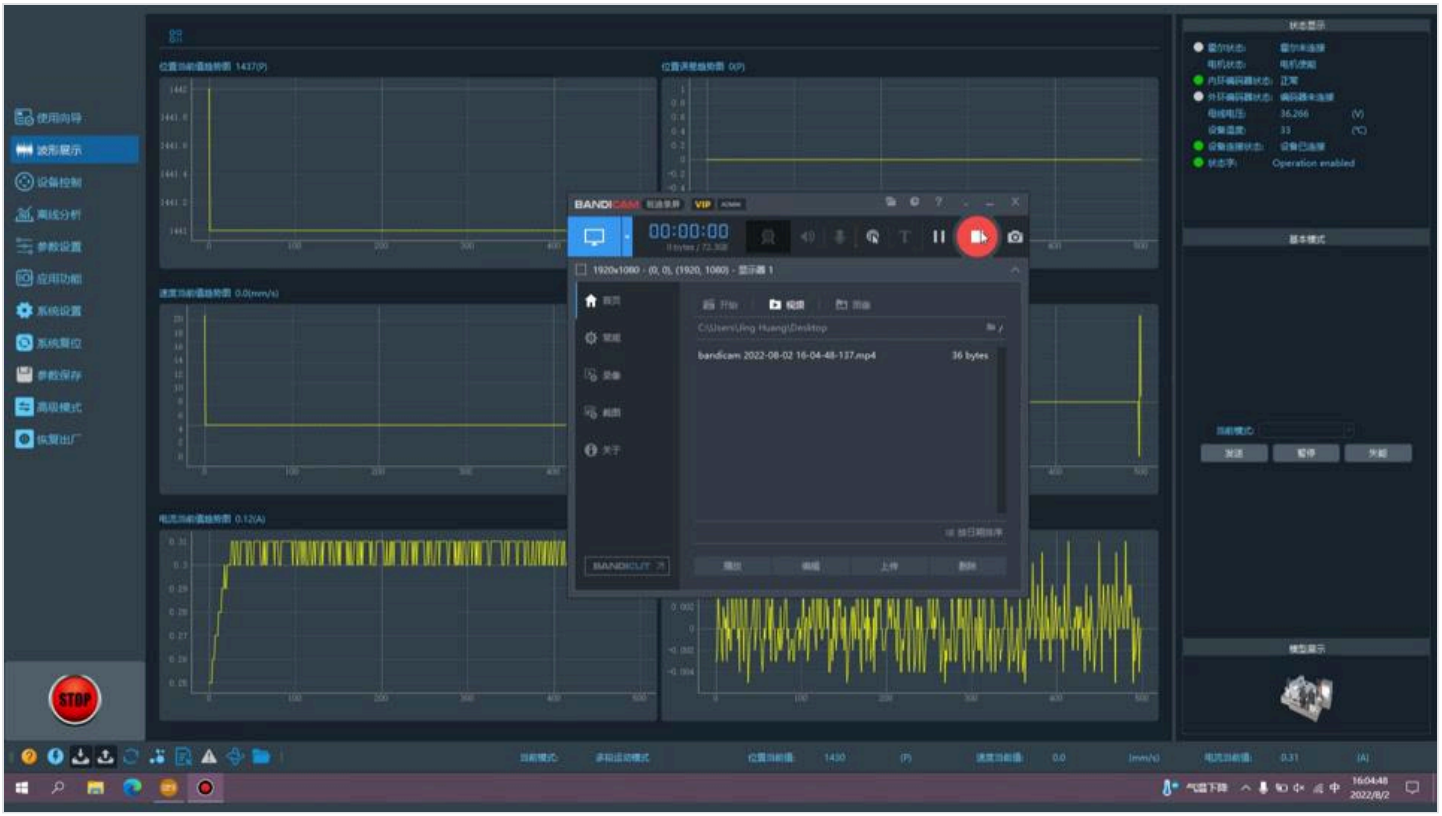
ForceControl Application

Force Control Effect Demonstration

Physical object video:



Host computer screen recording:

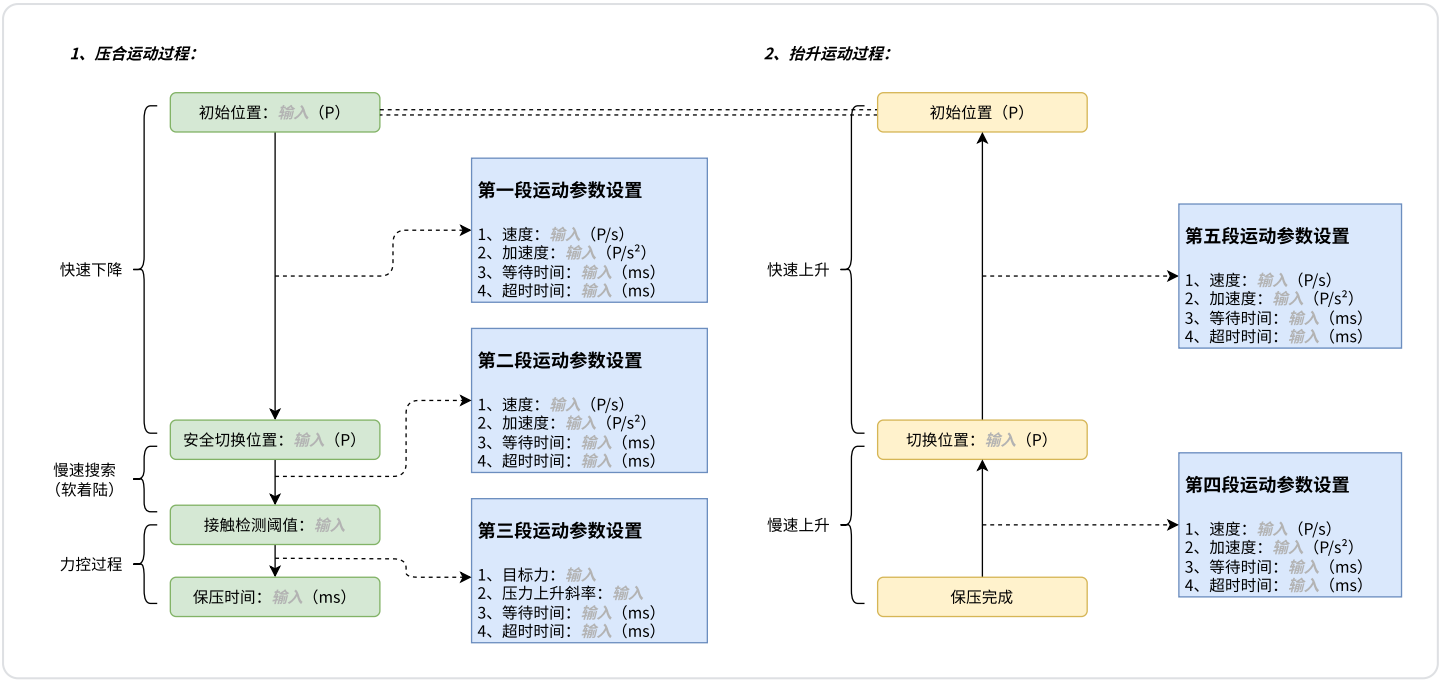


Understand the ForceControl operation process

> 👍 This force control application solution uses a hybrid control of position + force control, adopts a multi-segment operation mode, and can complete the process of switching from position mode to force control mode inside the driver without the need for users to switch manually.

The ForceControl operation process is shown in the following figure:

1. Starting from the initial position, it descends at a relatively fast speed until reaching the safe switching position;
2. There is no need to pause. After slow search reaches a certain pressure, then enter the force control mode to maintain pressure;
3. In force control mode, it reaches the target pressure with a certain rising slope and holds the pressure, then starts to rise after maintaining the pressure for a certain period of time;
4. First, slowly ascend to the safe switching position;
5. Then quickly rise back to the initial position, stay for a certain period of time, and then proceed to the next cycle of operation.



Next, we will explain the case operation:

💡 Case Description

In this case:

Motor parameters: rated current 1 A, peak current 3 A, voice coil motor;

Encoder resolution: incremental ABZ 0.5 um;

Host computer software version number: v3.0.4.0;

Drive software version number: 6.1.13;

✅ Demonstrations of open-loop force control and closed-loop force control will be conducted respectively.

1. Motor Debugging

1. Confirm that the motor operating environment is safe, refer to the 上位机调试软件使用手册 上位机调试软件使用手册 1. Quick Start, and perform **parameter settings, one-key identification , and basic operation** operations.
2. Confirm that the motor operating environment is safe, then attempt to run the reciprocating position mode. Proceed to the next step only after confirming that the motor operates without issues.



2. Force Sensor Debugging

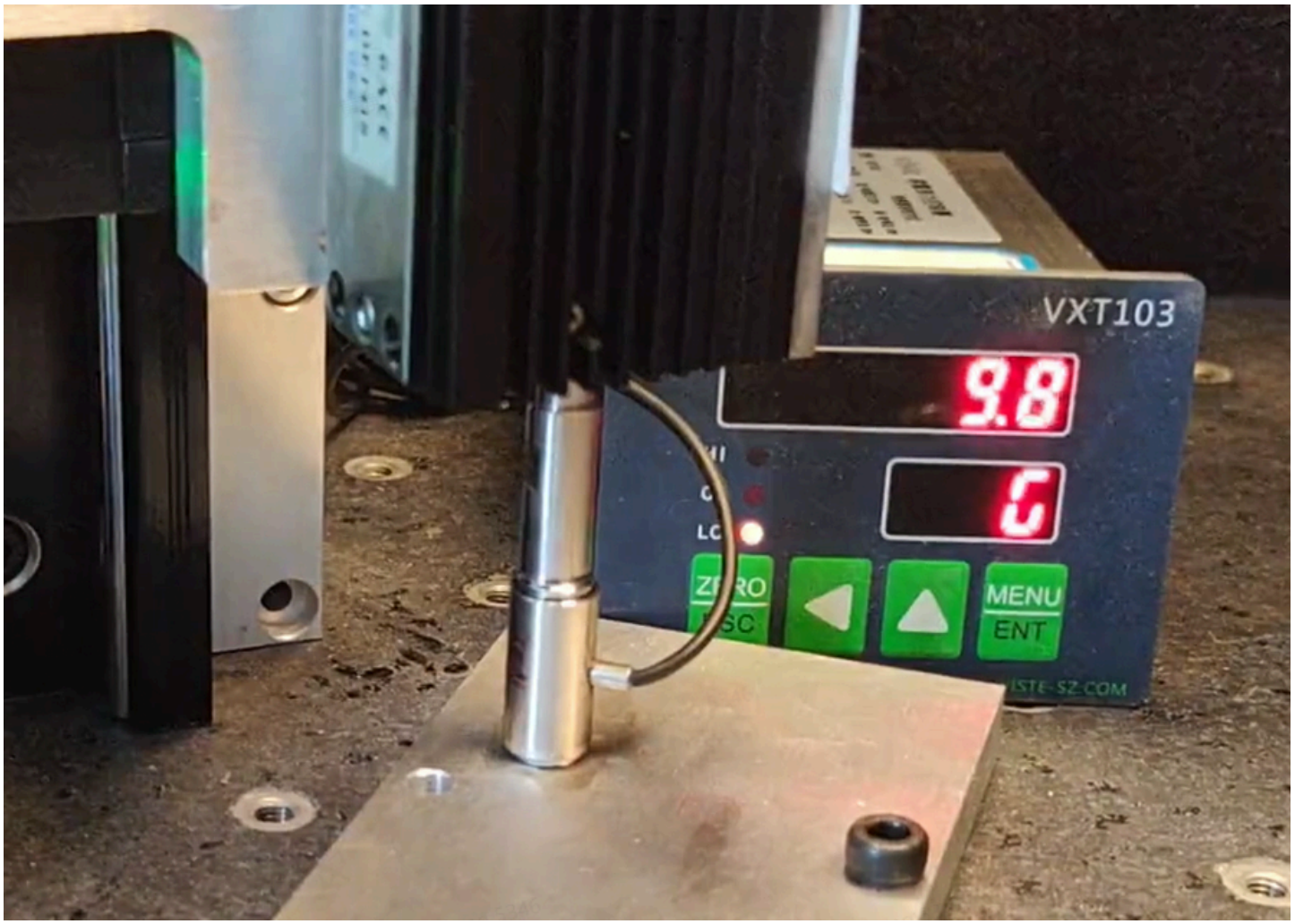
1. Refer to the operating instructions of the force sensor (to be provided by the force sensor manufacturer) to perform **the setup and calibration of the force sensor** , and confirm that the force sensor measures pressure accurately.
2. Adjust the motor installation position to ensure that the motor can press against the sensor and generate pressure.

3. Open-loop force control

3.1 Test the direction and magnitude of the target torque when reaching the target pressure

In torque mode, set the target torque to 0.3 A (users can adjust it according to actual conditions), confirm that the motor operating environment is safe , click Enable, the motor will press against the force sensor, observe the force sensor, and when it roughly reaches the target pressure of 10 g, click Disable to stop operation.



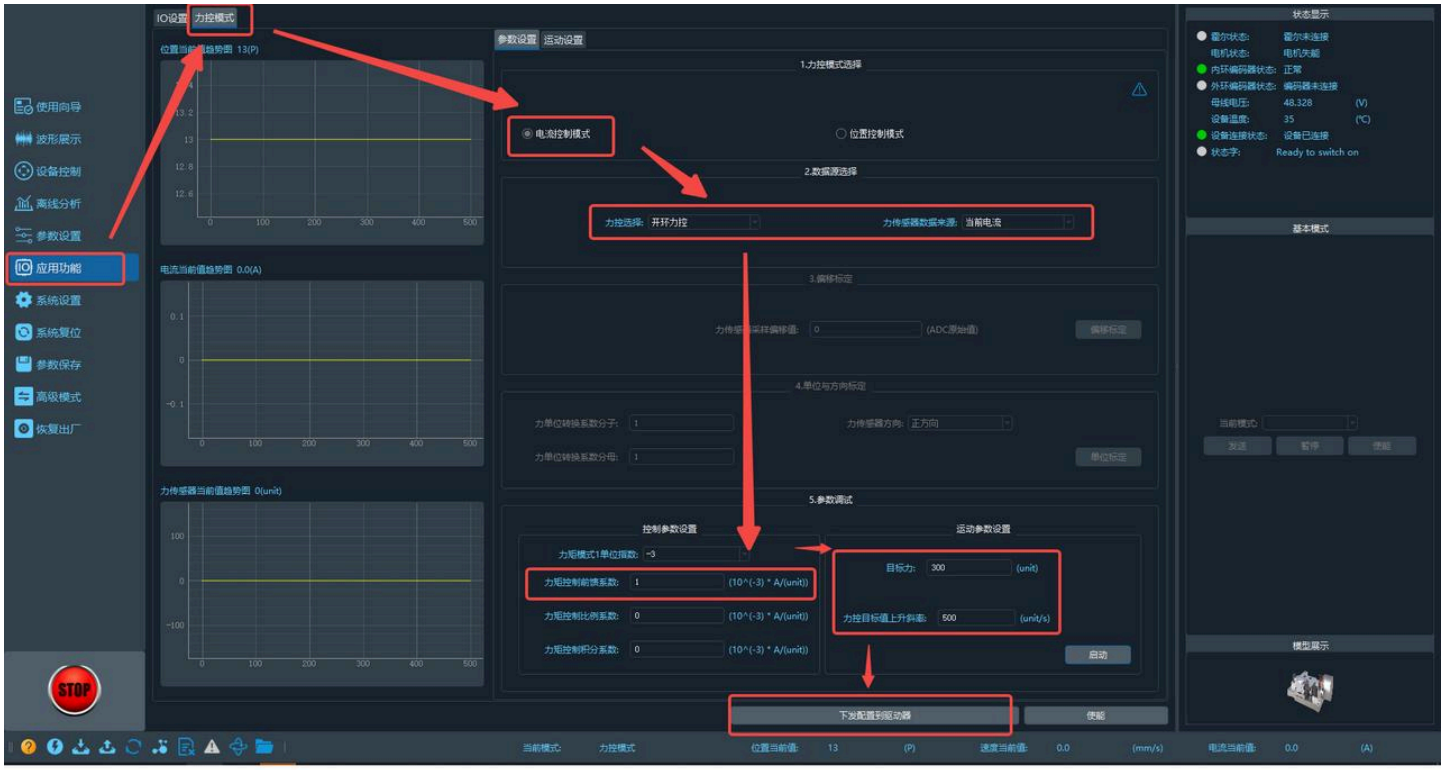


3.2 Force Control Mode Parameter Settings

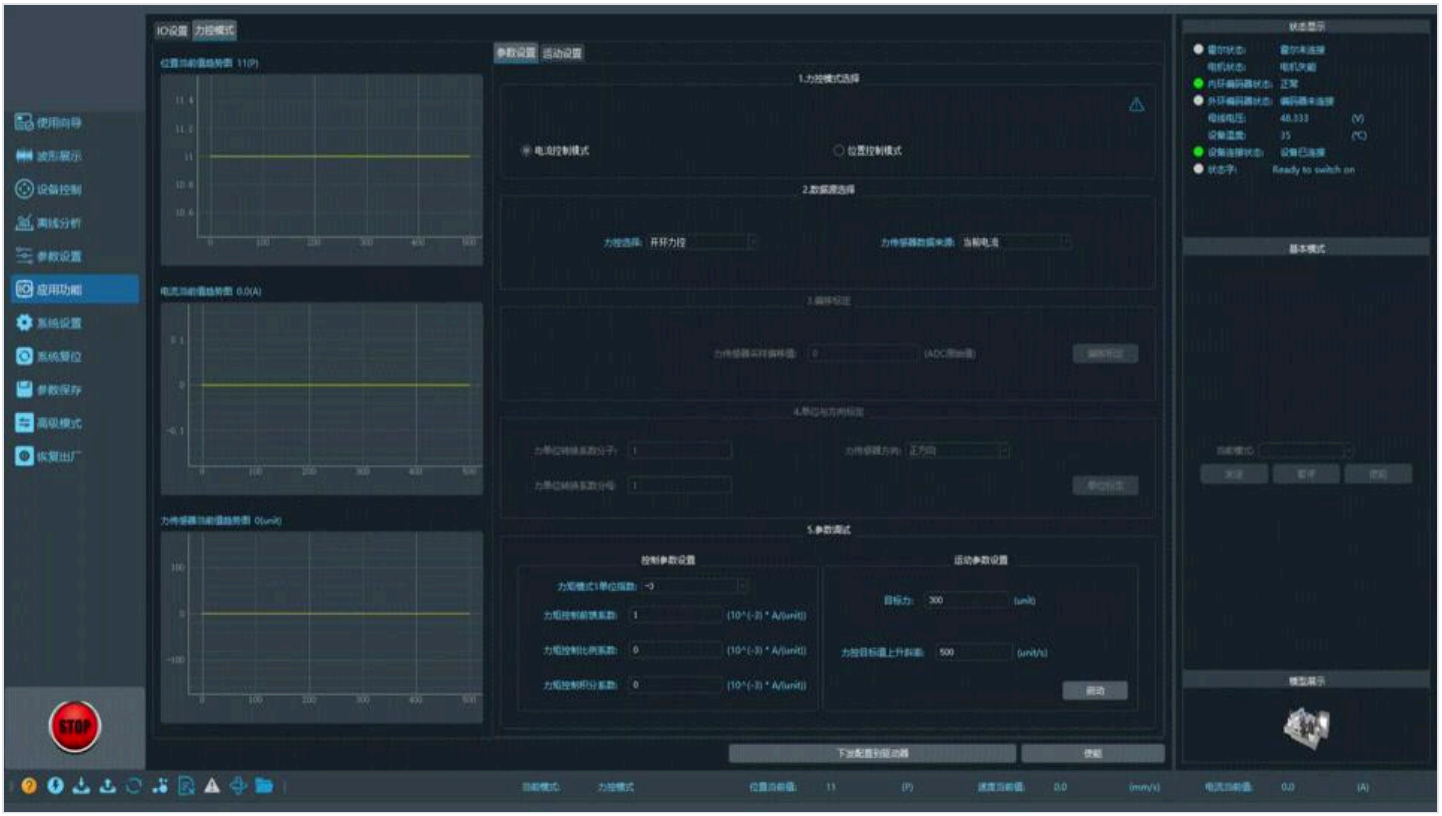
1. Enter the application function and click on the force control mode;
2. In the case, a voice coil motor is used, and the current control mode is selected;

> Note: When using a rotating motor and the encoder has high precision, the position control mode can be selected; in other cases, the current control mode is recommended;

3. Confirm that the force control selection is open-loop force control, and confirm that the data source of the force sensor is the current, i.e., use the current for feedback control to output pressure;
4. Set the unit exponent of torque mode 1 to -3 and the torque control feedforward coefficient to 1;
5. Set the target force to 300 units (i.e., 0.3 A), and set the rising slope of the force control target value to 500 units/s (i.e., 0.5 A/s);
6. Click to send the configuration to the drive;



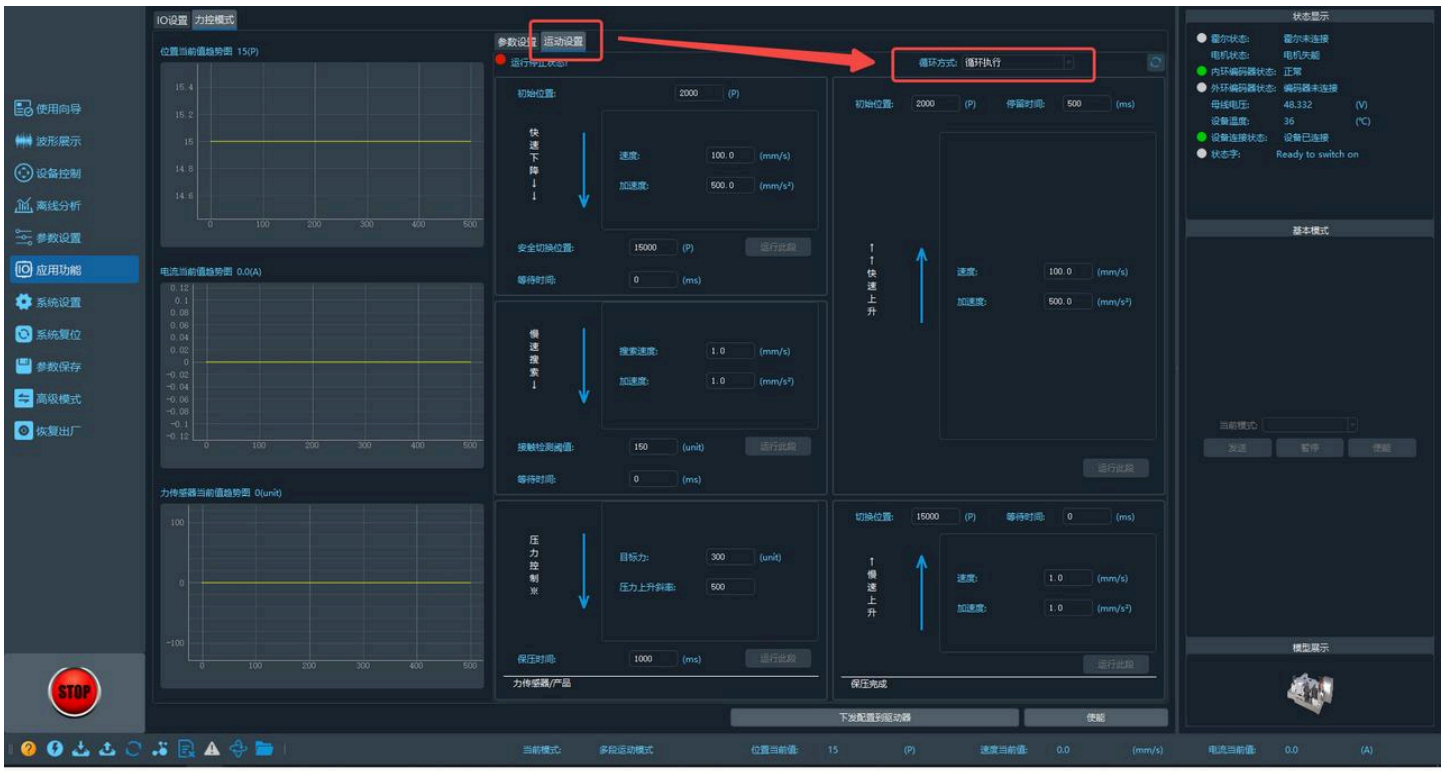
7. Confirm that the motor operating environment is safe , click Start, the motor will press against the sensor and maintain pressure, click Stop to disable the motor, and at this point, the force control mode (only controlling the output pressure) operation is completed.



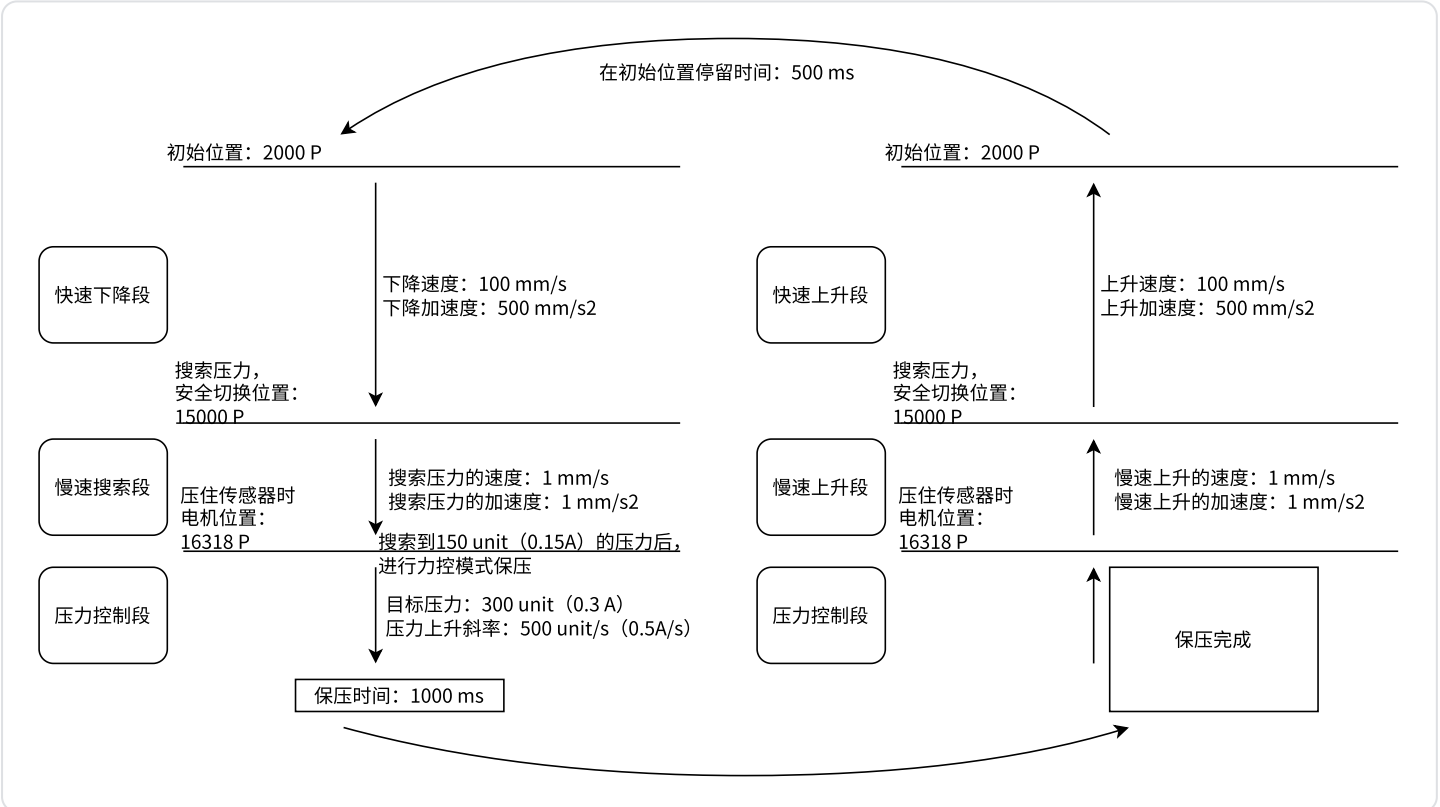
3.3 Force Control Mode Motion Settings

1. Switch to the motion settings page, select the loop mode for cyclic execution, that is, automatically cycle through the actions of pressing down - holding pressure - lifting up;

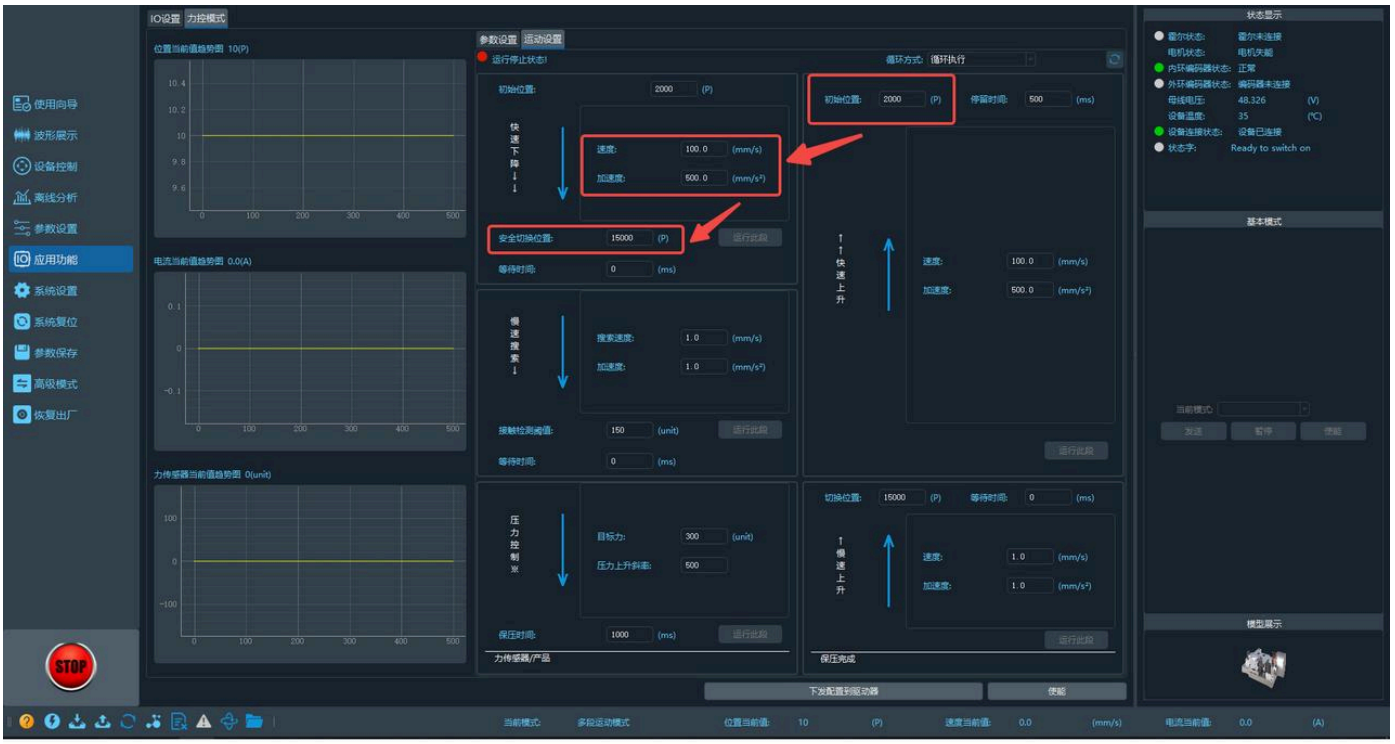
> Note: For explanations of other loop methods, seeMore Explanations



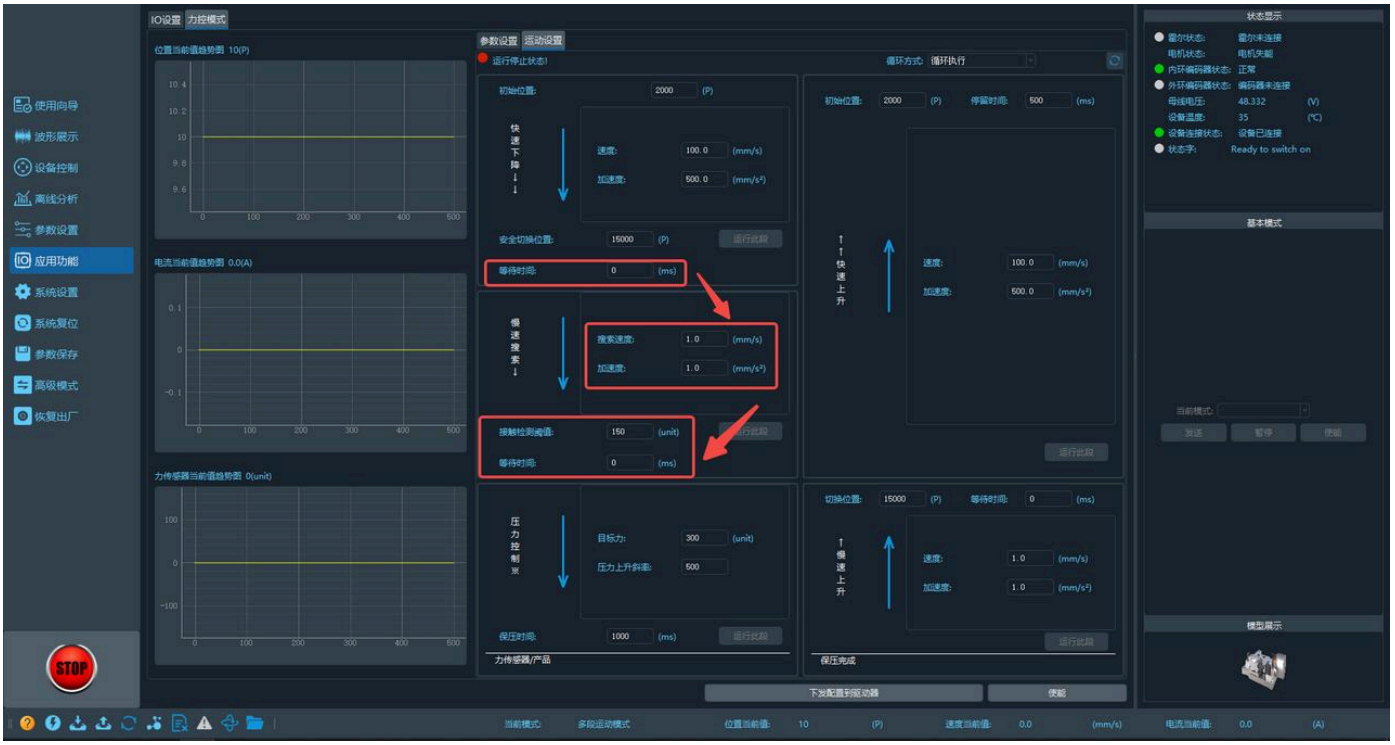
2. Push the motor by hand, record the initial position of the motor after lifting and the approximate position of the motor when pressing the sensor. In this case, set the initial position to 2000 P and the approximate position of the motor when pressing the sensor to 16318 P;
3. The expected ForceControl operation process is shown in the following figure:
    - Starting from the initial position 2000 P, descend at a relatively fast speed of 100 mm/s and an acceleration of 500 mm/s^2 to reach the safe switching position 15000 P;
    - There is no need to stop. Slowly search for pressure at a slower speed of 1 mm/s and an acceleration of 1 mm/s^2. After reaching a certain pressure of 150 units (0.15A), proceed to maintain pressure in force control mode;
    - In force control mode, it reaches the target pressure of 300 units (0.3 A) with a rising slope of 500 units/s (0.5 A/s), then holds the pressure. After maintaining the pressure for 1000 ms, it starts to rise;
    - First, slowly rise at a slower speed of 1 mm/s and an acceleration of 1 mm/s^2 to the safe switching position of 15000 P;
    - Then, quickly rise to the initial position 2000 P at a relatively fast speed of 100 mm/s and an acceleration of 500 mm/s^2, stay for 500 ms, and then proceed to the next cycle operation.



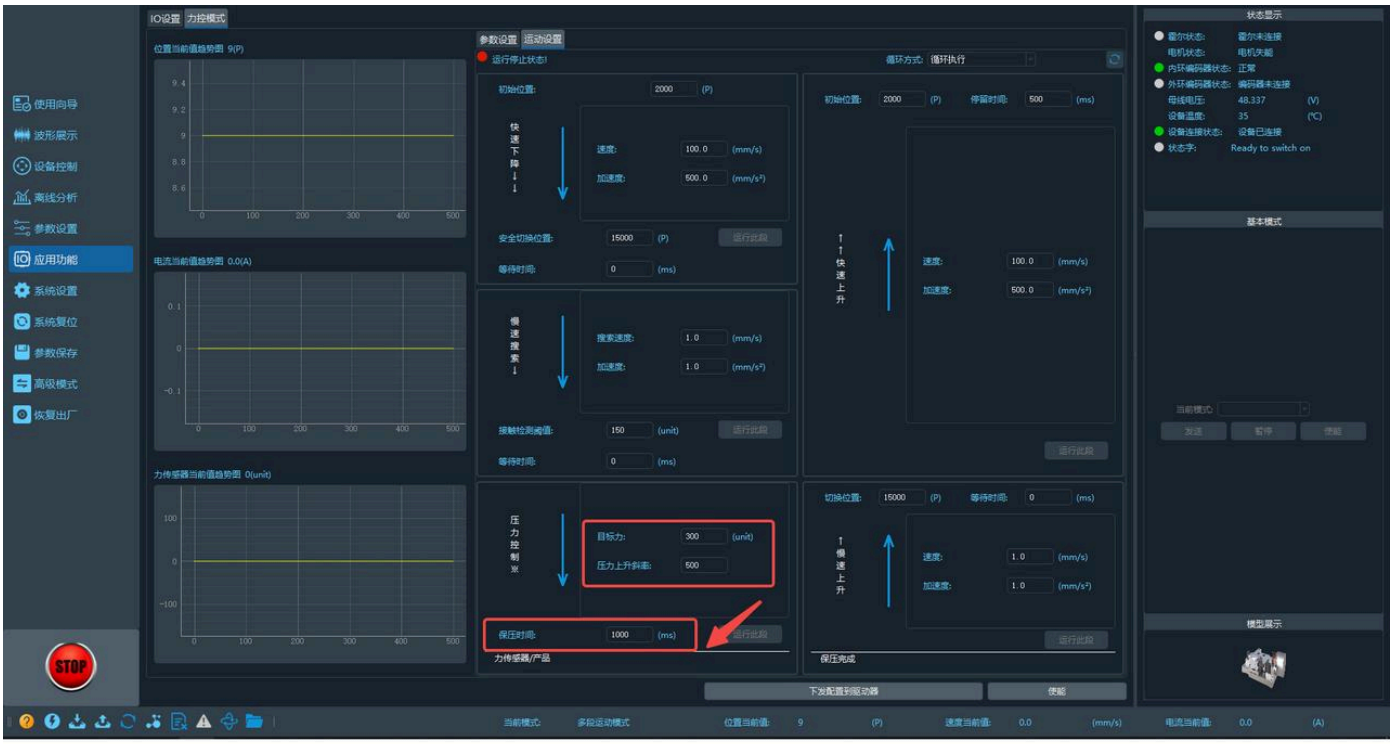
4. CompareForce Controloperating process, set parameters:
    - Starting from the initial position 2000 P, descend at a relatively fast speed of 100 mm/s and an acceleration of 500 mm/s^2 to reach the safe switching position 15000 P;



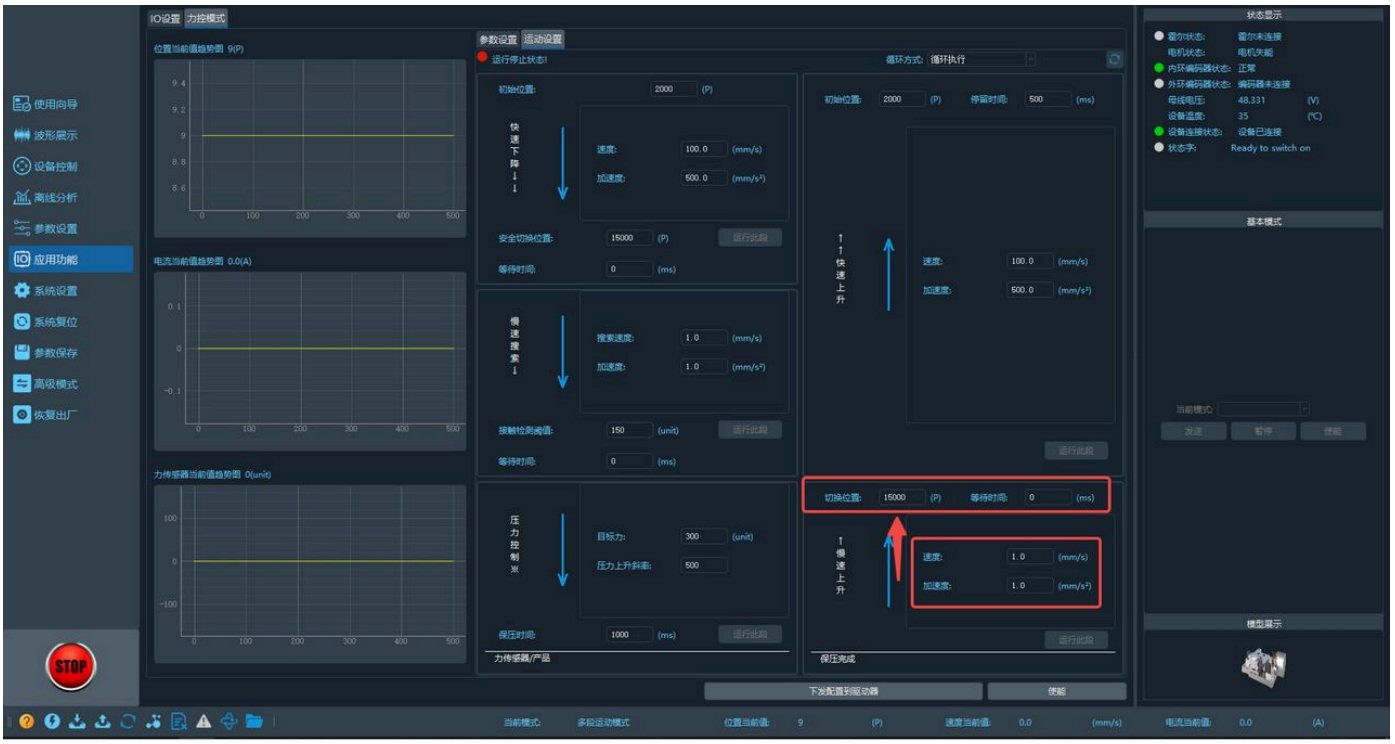
- There is no need to stop. Slowly search for pressure at a slower speed of 1 mm/s and an acceleration of 1 mm/s^2. After reaching a certain pressure of 150 units (0.15A), proceed to maintain pressure in force control mode;



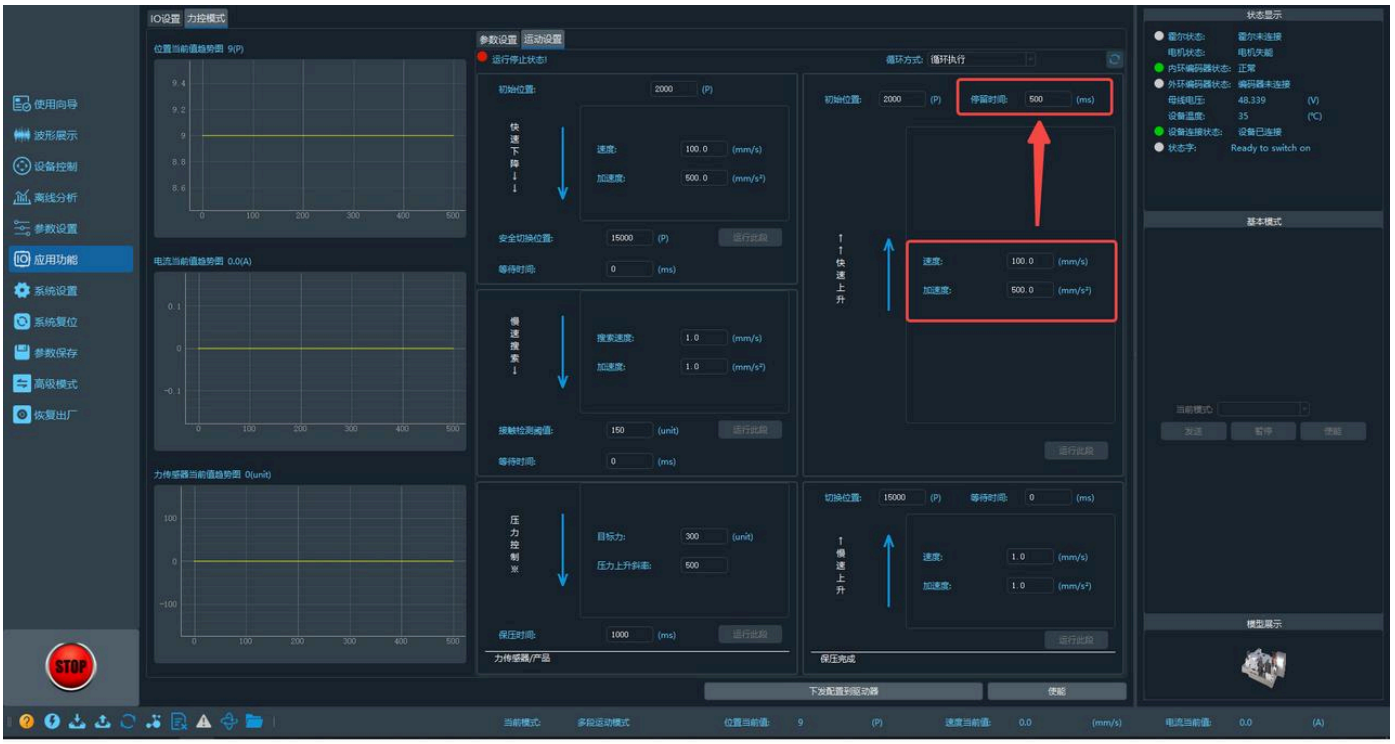
- In force control mode, it reaches the target pressure of 300 units (0.3 A) with a rising slope of 500 units/s (0.5 A/s), then holds the pressure. After maintaining the pressure for 1000 ms, it starts to rise;



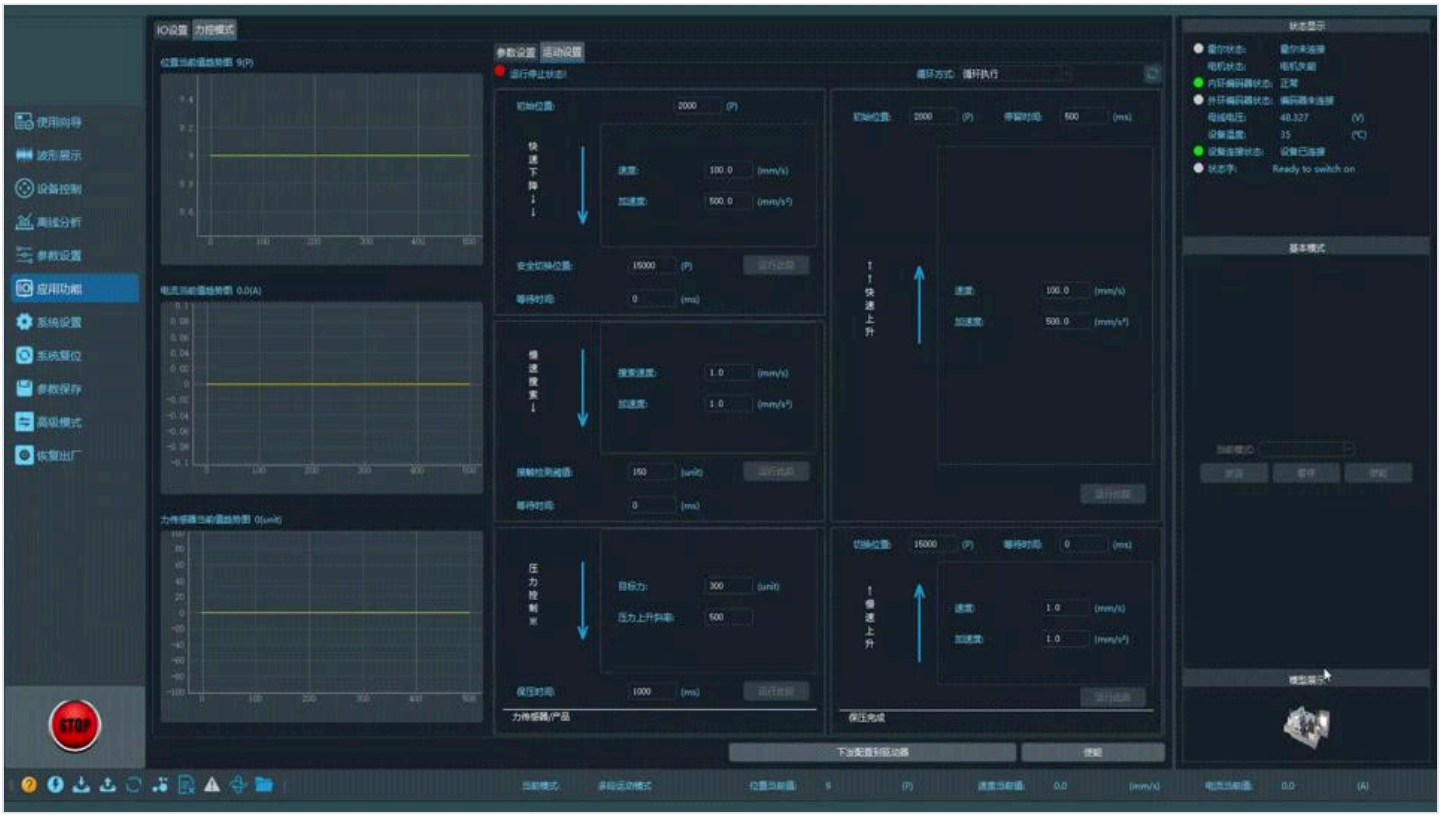
- First, slowly rise at a slower speed of 1 mm/s and an acceleration of 1 mm/s^2 to the safe switching position of 15000 P;



- Then, quickly rise to the initial position 2000 P at a relatively fast speed of 100 mm/s and an acceleration of 500 mm/s^2, stay for 500 ms, and then proceed to the next cycle operation.

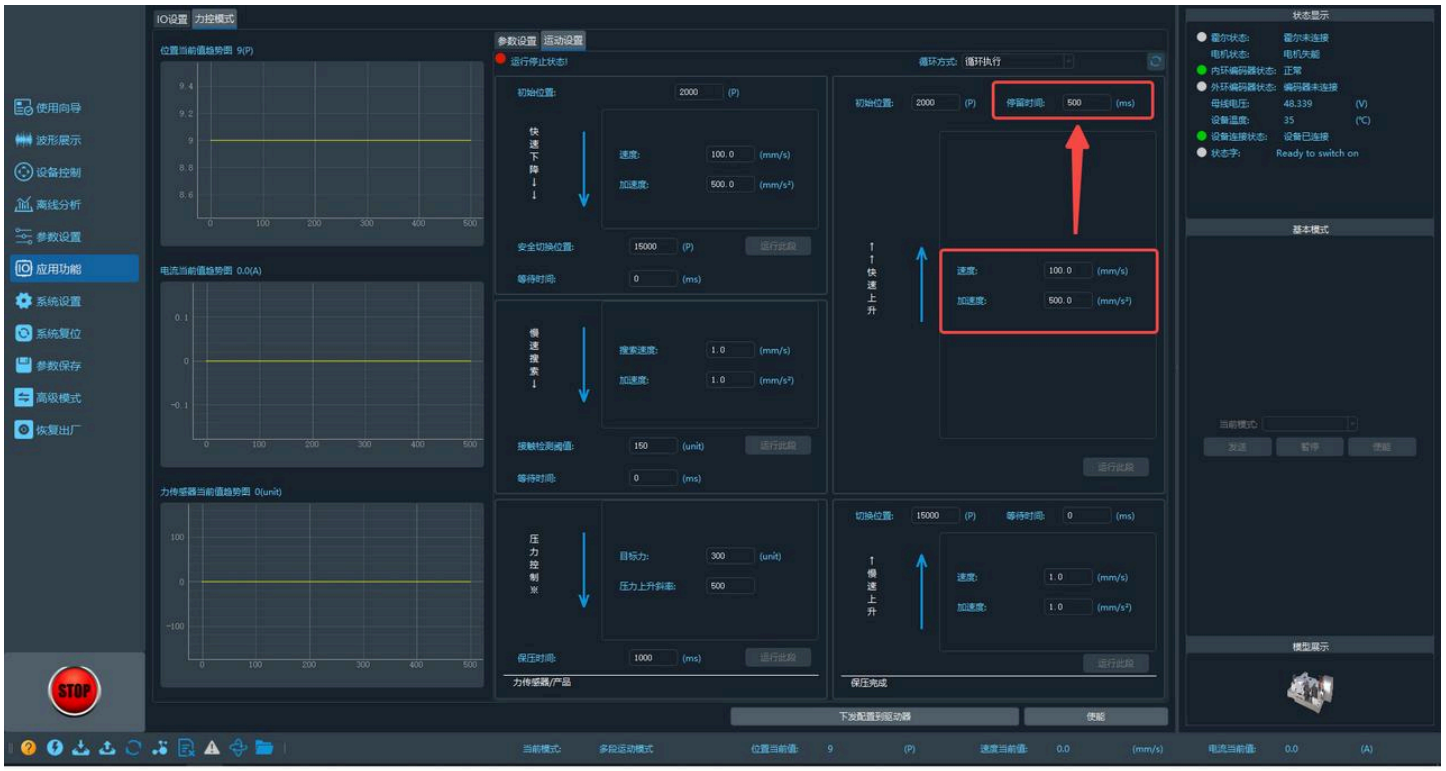


5. Click to send the configuration to the drive,confirm that the motor operating environment is safe, click Enable, the motor starts cyclic force control operation, click Disable to stop operation, and multi-segment force control operation is completed.

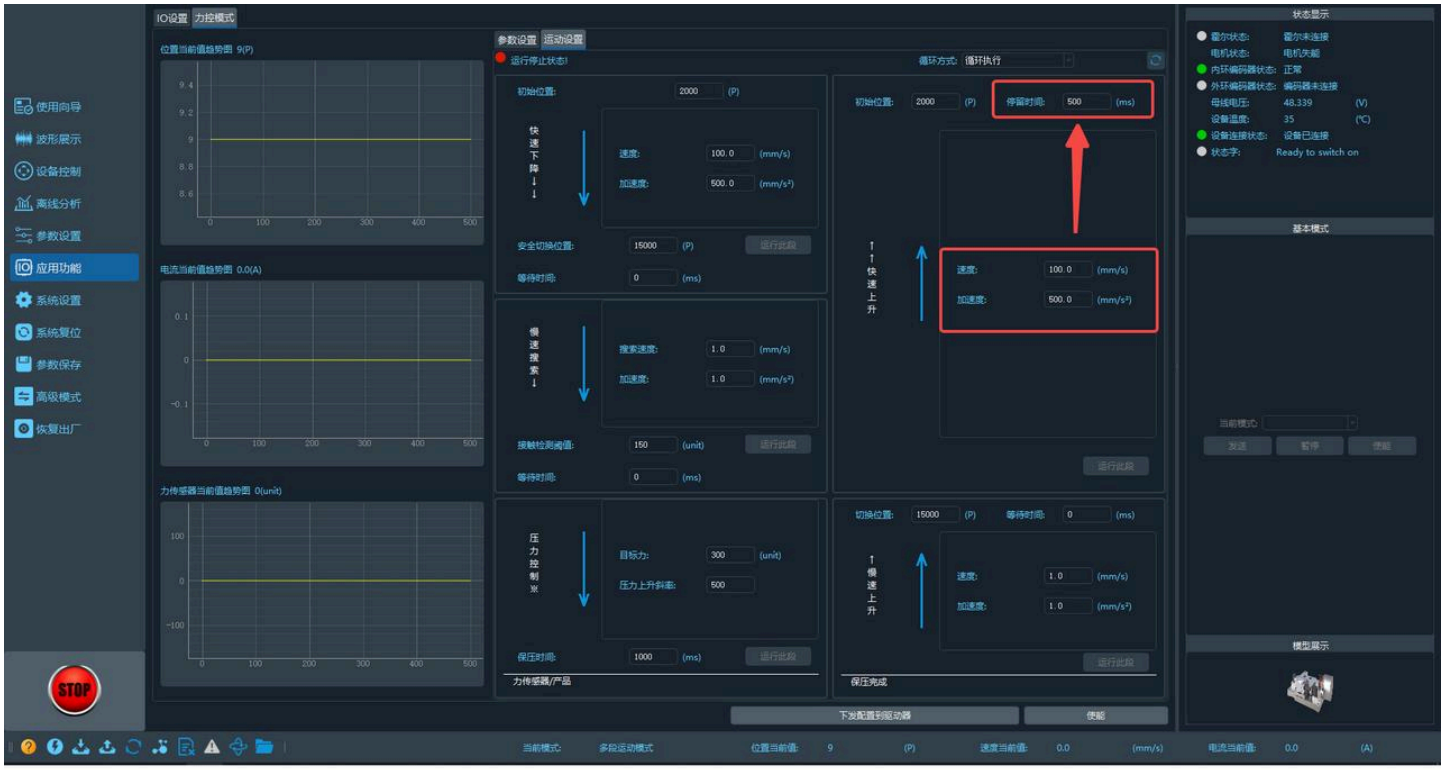


3.4 Multi-segment operation mode

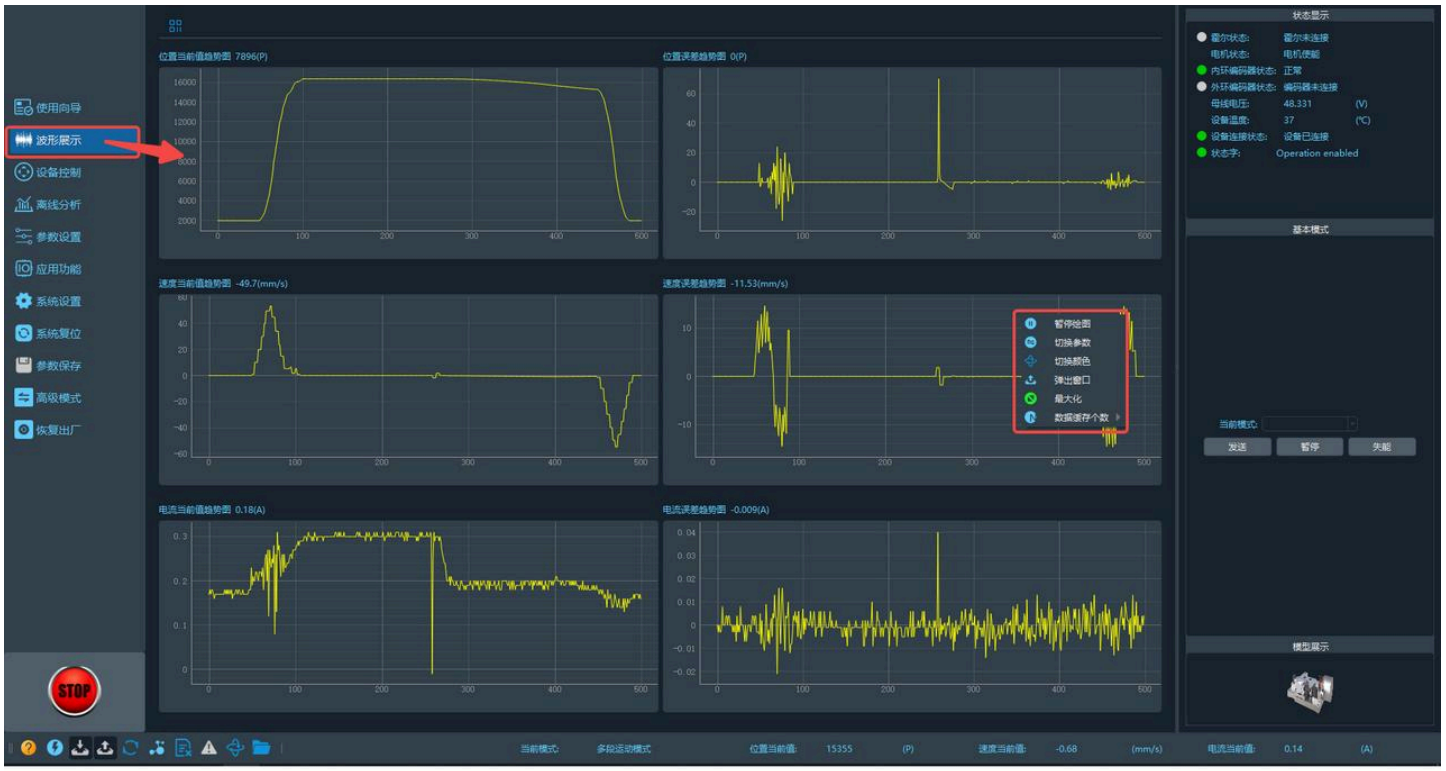
1. Switch to Device Control - Trajectory Planner to learn about the actual settings of each segment's parameters in the multi-segment operation mode;



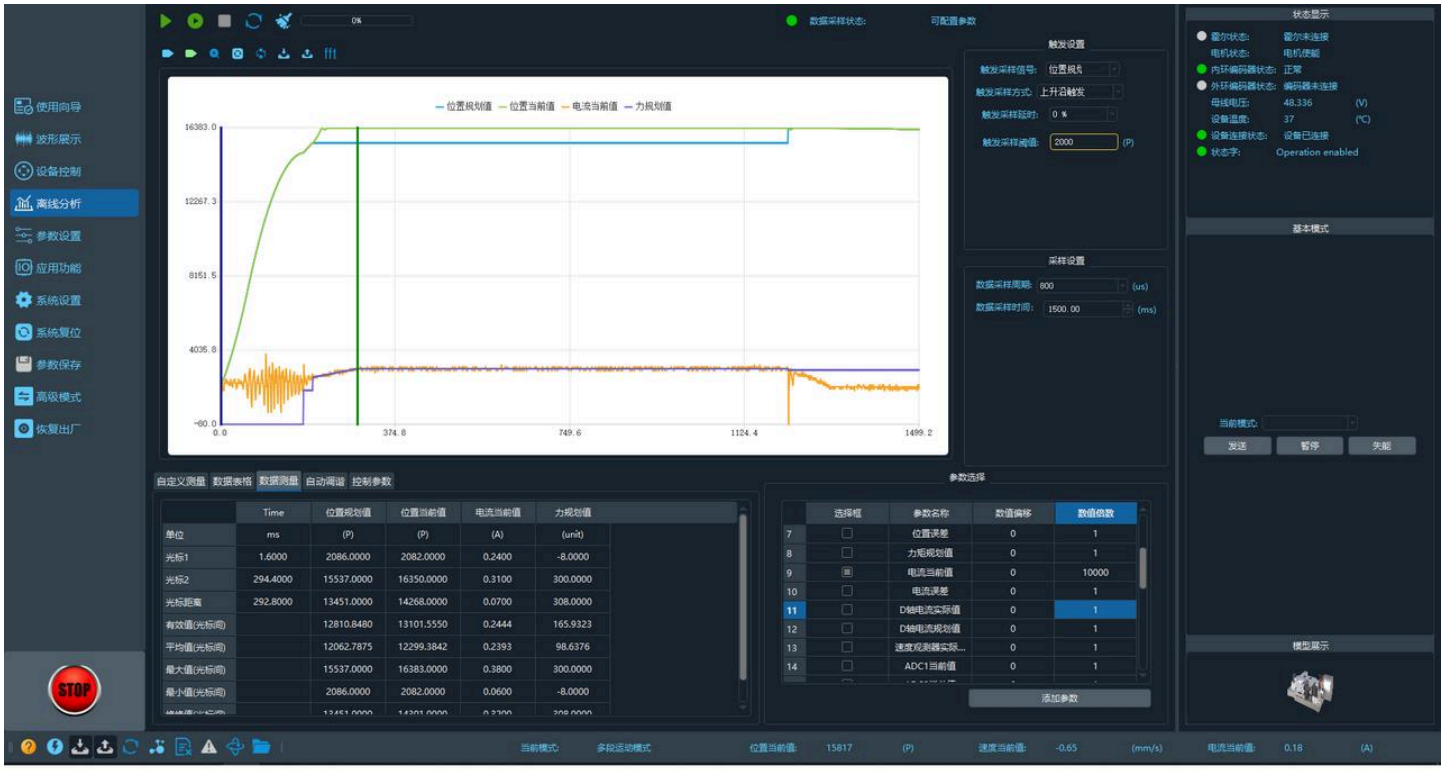
2. Observing the multi-segment operating status can assist you in determining information such as the current operating segment and the operating status of the current segment. For details, seeMore Instructions;



3. Observing the waveform display can assist you in determining the trends of various waveforms. For details on other operations in the waveform display, please refer toMore Instructions;



4. If you need to judge more data, you can collect it through offline analysis. For detailed operations of offline analysis, see More Instructions ;



3.5 Examples of Errors and Handling Measures

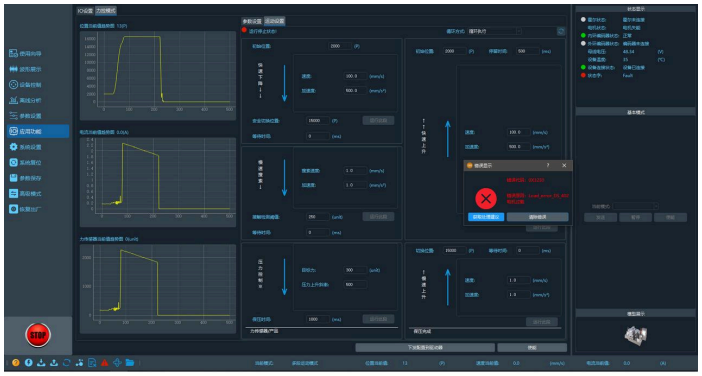
If a problem occurs, search for handling suggestions in the 用户FAQ document first.

Examples of issues:

?

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The motor operates normally in position mode, but reports an "motor overload" error when running multi-segment force control.



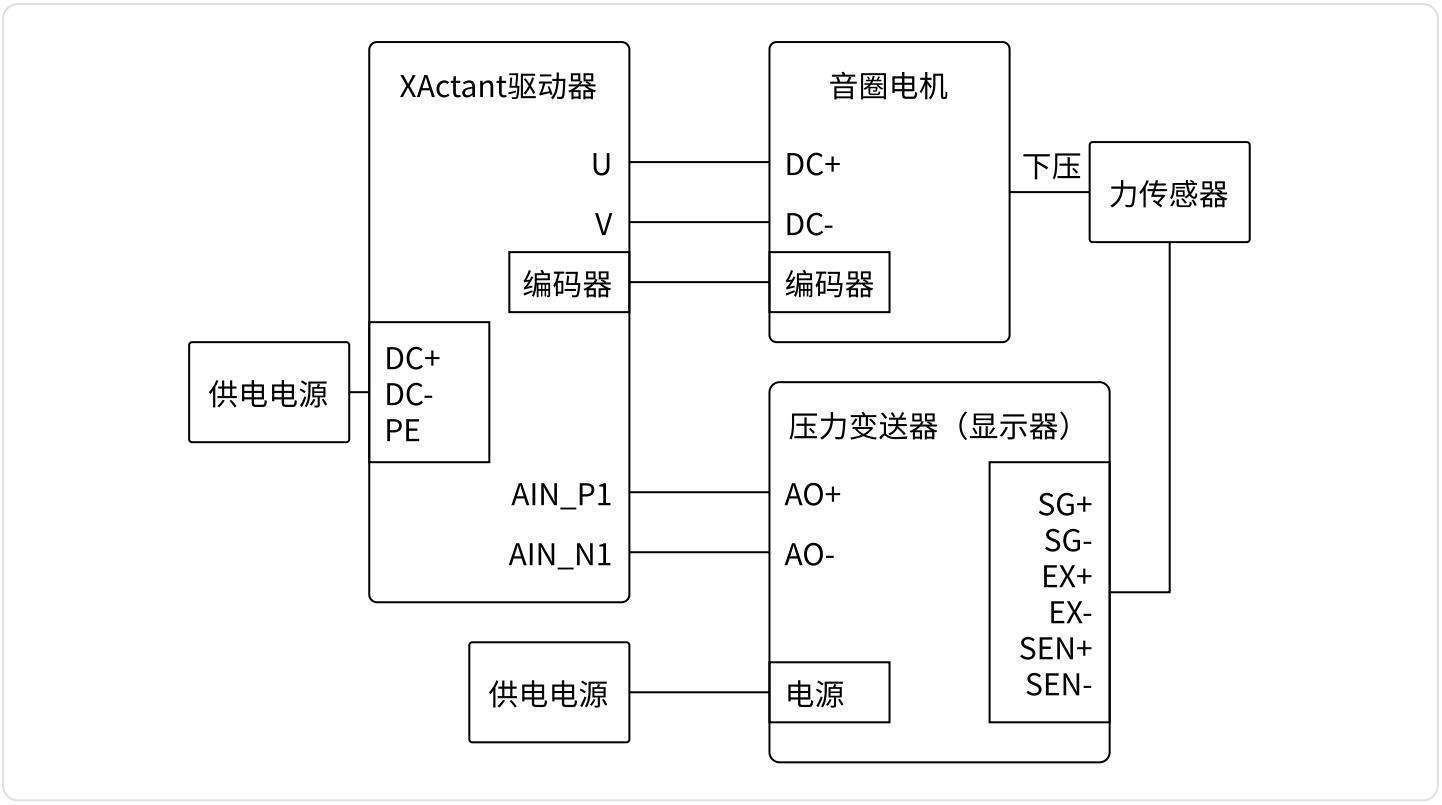
- Adjust the contact detection threshold for search pressure;
- Check whether there are any obstacles during the operation of the motor;
- Adjust the descent speed or search speed;
- Adjust the safety switching position;
- When the current required to reach the target pressure is less than the rated current of the motor, the application limit current (Parameter Settings - Limit Settings - Current Limit Parameter) can be set to the rated current or a smaller value to prevent motor overload caused by excessive current;

4. Closed-loop force control

4.1 Hardware wiring

In addition to the power cord, motor power cable, encoder cable, and debugging cable, it is also necessary to connect **the analog output of the force sensor** to **the analog input pin in the drive control cable** .

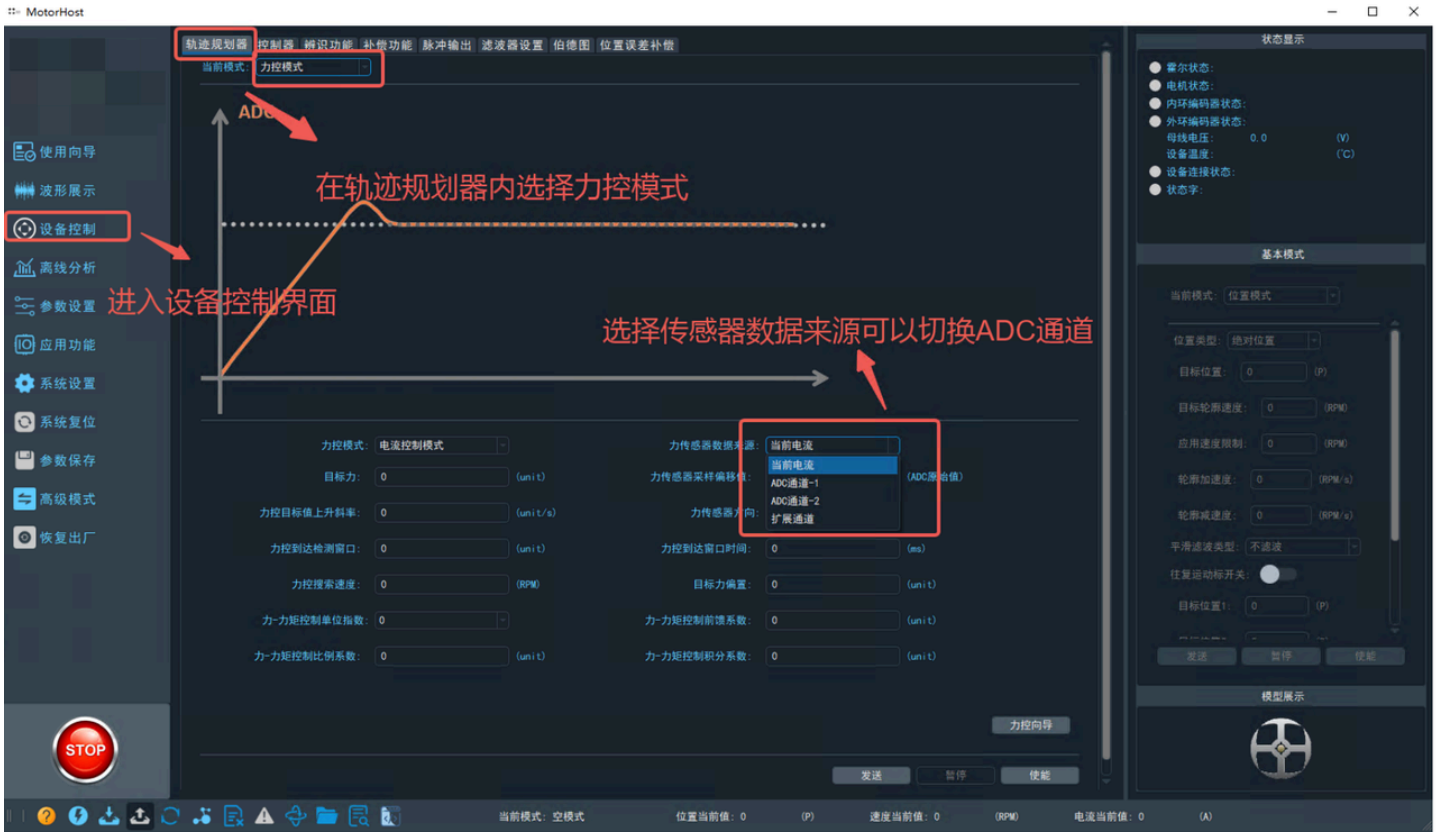
For specific wiring, refer to the wiring instructions for the corresponding product - the analog input section. The wiring instructions can be found directly from the corresponding product on the 客户帮助中心 客户帮助中心 homepage. For example, for the Uservo-Flex series, the wiring instruction link for the EtherCAT (UF-48VxxAEDx) communication drive: Flex-EtherCAT（UF-48VxxAEDx）接线引导与规范



4.2 Confirm that the analog input connection is correct

After connecting the wires and powering on, enter the waveform display interface of the host computer software. Right-click on any graph, click "Switch Parameters", find the current value of ADC1 (if the actual wiring is AIN_P1, select ADC1; if the wiring is AIN_P2, select ADC2), double-click to confirm, and adjust to obtain the force sensor value.

Switch ADC Channel:



Push the motor by hand to press against the force sensor, observe the trend graph of the current ADC value, and if there is a data change, the connection is successful.

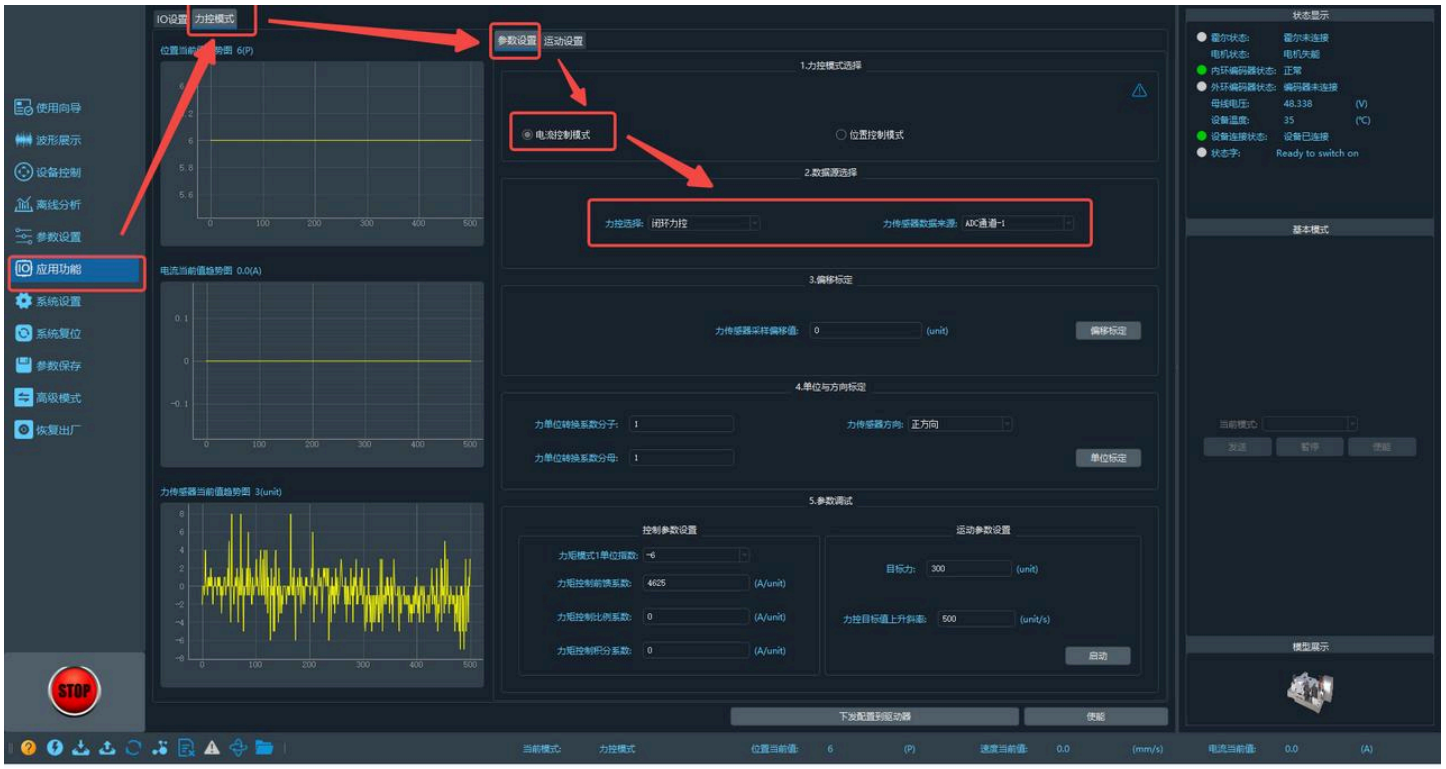


4.3 Force Control Mode Parameter Settings

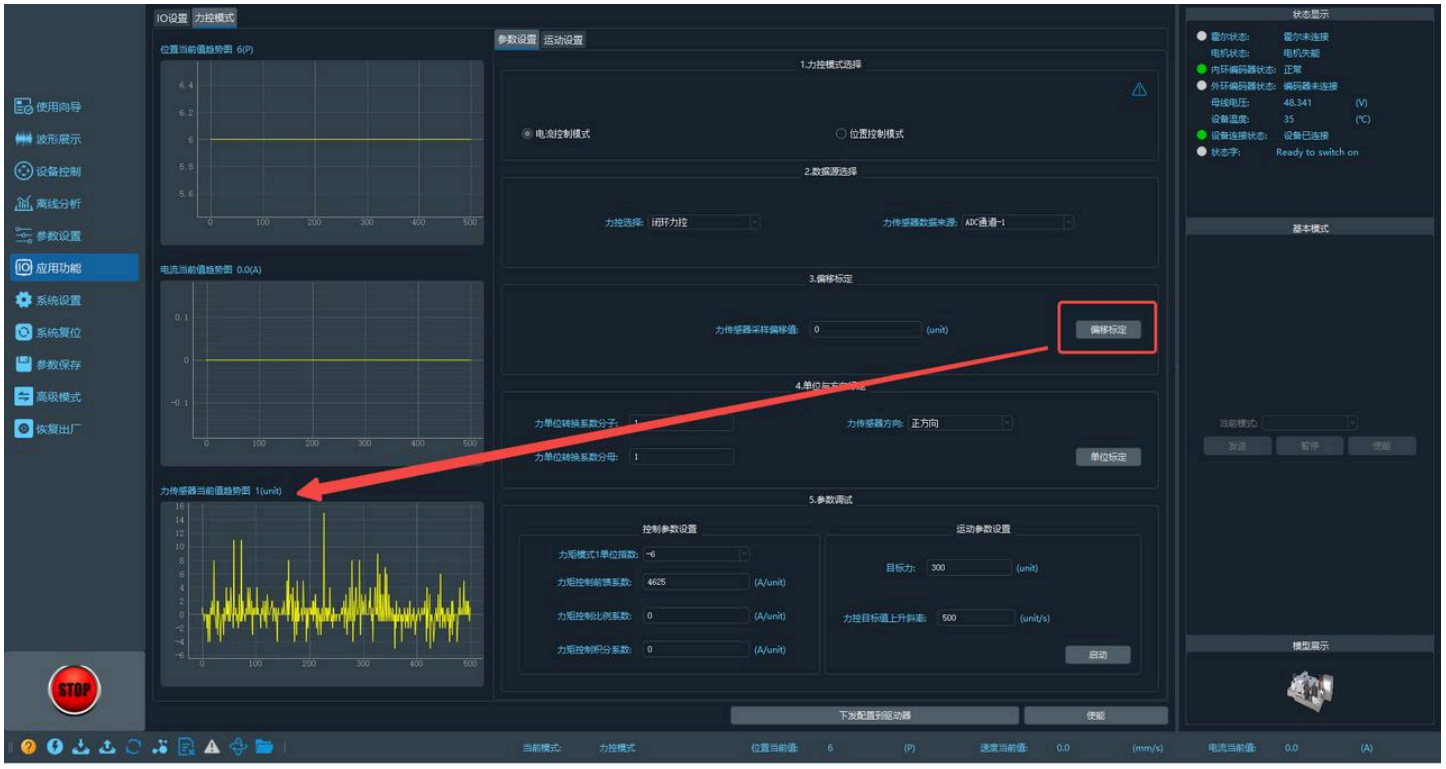
1. Enter the application function and click on the force control mode;
2. In the case, a voice coil motor is used, and the current control mode is selected;

   > Note: When using a rotating motor and the encoder has high precision, the position control mode can be selected; in other cases, the current control mode is recommended;

3. Set the force control selection to closed-loop force control, with the force sensor data source being ADC Channel -1 (if the actual wiring is AIN_P1, select ADC Channel -1; if the wiring is AIN_P2, select ADC Channel -2), that is, use the force sensor values for feedback control to output pressure;



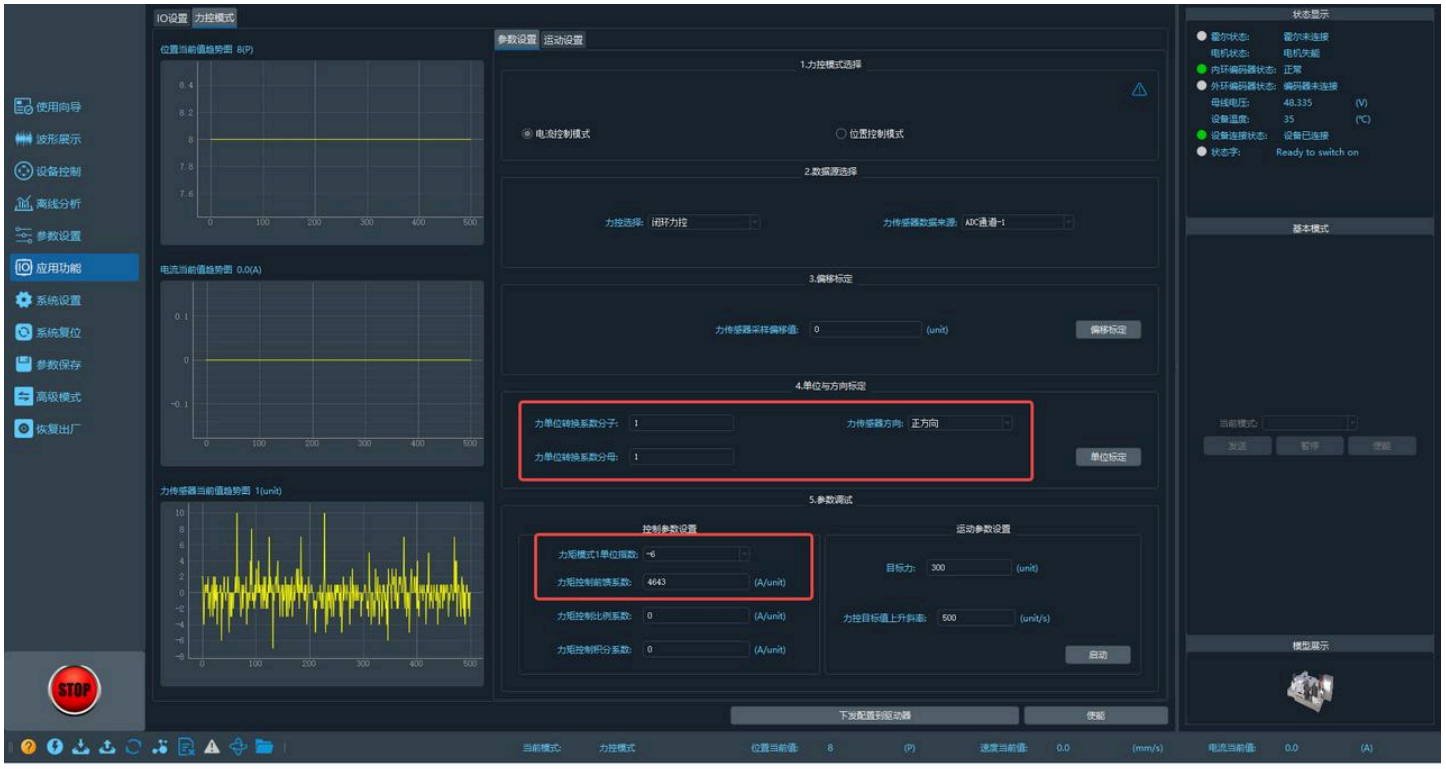
4. Click on offset calibration, and after completion, confirm whether the current value of the force sensor is near 0;



5. Confirm that the motor operating environment is safe, click onUnit Calibration, adjust the rated current percentage, and adjustCalibration Currentto make the output pressure reach the target pressure; after reaching it, click OK. In this case, select to inputthe value 66 unit in the trend graph of the current value of the force sensor, maintaining the unit as unit (you can also choose to inputthe pressure value displayed on the force sensormonitor and change the unit to g);



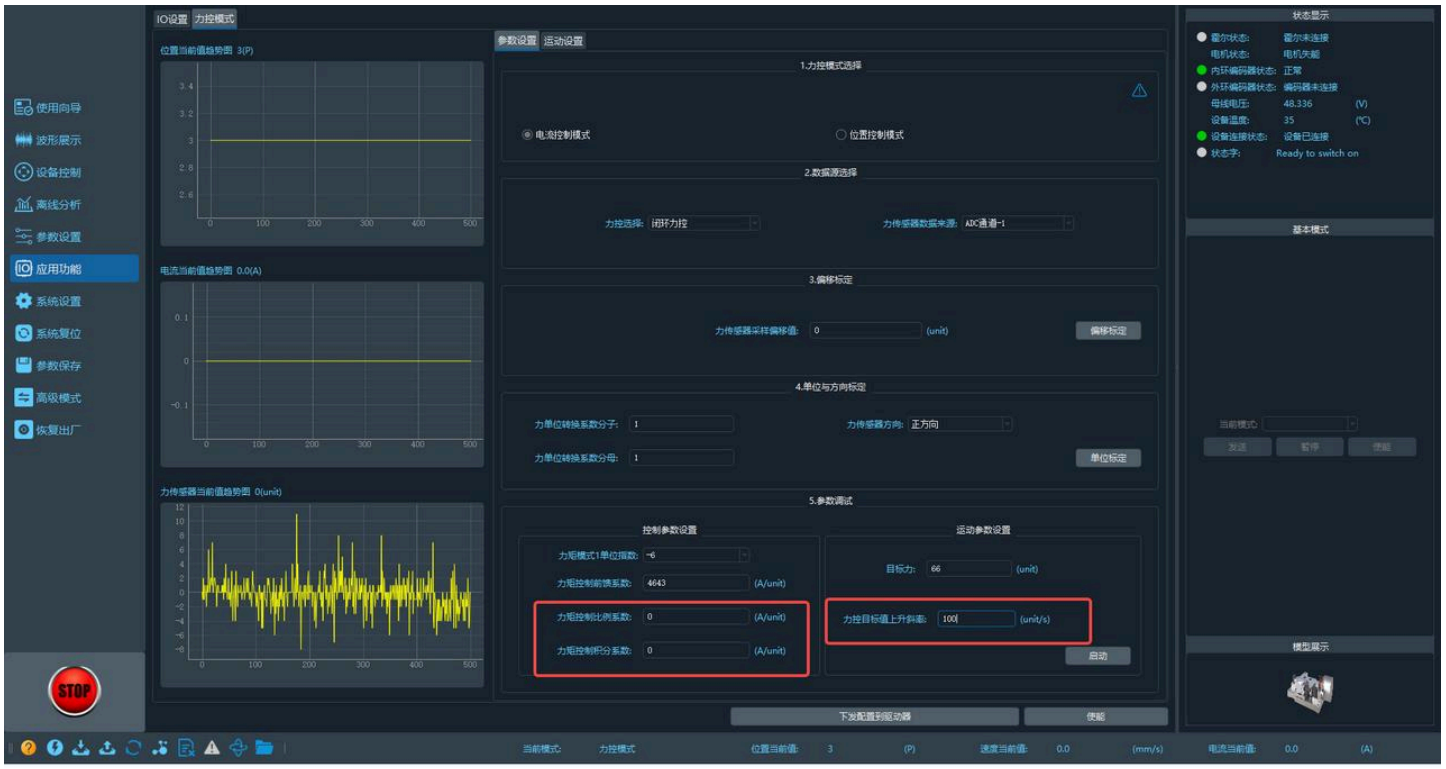
6. After unit calibration is completed, the force unit conversion coefficient, force sensor direction, torque mode 1 unit exponent, and torque control feedforward coefficient will be automatically changed;



7. Set the target force to 66 units (i.e., the current value of the force sensor corresponding to the target pressure), set the rising slope of the force control target value to 100 units/s, click Send Configuration to the drive; Confirm that the motor operating environment is safe, click Start, the motor will press on the sensor and maintain the pressure, click Stop, disable the motor, and at this point the force control mode (only controlling the output pressure) has completed its operation.



8. If you need to adjust the pressure curve, such as overshoot, time to reach the target pressure, etc., you can adjust the rising slope of the force control target value, the torque control proportional coefficient, and the torque control integral coefficient.



4.4 Force Control Mode Motion Settings

Refer toopen-loop force control, where it should be noted thatthe target forceshould be66 unit(i.e., the current value of the force sensor corresponding to the target pressure), and adjust parameters such as the search pressure (contact detection threshold) and pressure rise slope accordingly.

4.5 Performance Tuning Parameters

1. Arrival Detection Window / Arrival Detection Window Time

   To improve the operating cycle or adjust the force control operating state, you can try adjusting the force control arrival detection window and the force control arrival detection window time in the force control mode. For detailed parameter descriptions, see More Explanations .

2. Torque control proportional coefficient, torque control integral coefficient

   Perform PI adjustment on the force control curve. For detailed parameter descriptions, see More Explanations .

More Instructions

- Please refer to the 上位机调试软件使用手册 for instructions on operating the host computer debugging software.

  > Direct jump to some chapters:
  >
  > 5.2 Force Control Application

> 6.2.5 Force Control Mode
>
> 6.2.8 Multi-segment Operation Mode
>
> 7.1 Offline Analysis
>
> 7.2 Waveform Display

- When using the communication master station for control, please refer to 多段运行模式字典操作说明_V2.00.00_20231222.pptx