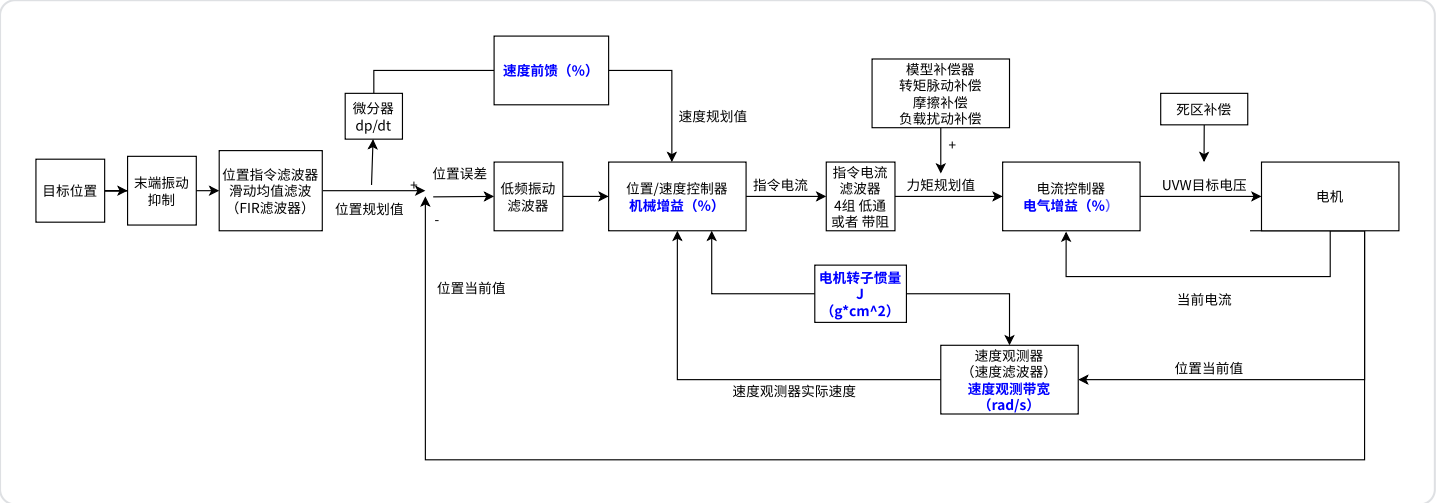
Detailed Explanation of Performance Tuning Special Topic

1. Overall System Control Block Diagram



1. Electrical Gain
2. Motor Rotor Inertia
3. Speed Observation Bandwidth
4. Mechanical Gain
5. Speed Feedforward
6. Resonance Suppression
7. End Vibration Suppression
8. Sliding MeanFilter
9. Model Compensator
10. Dead Zone Compensation



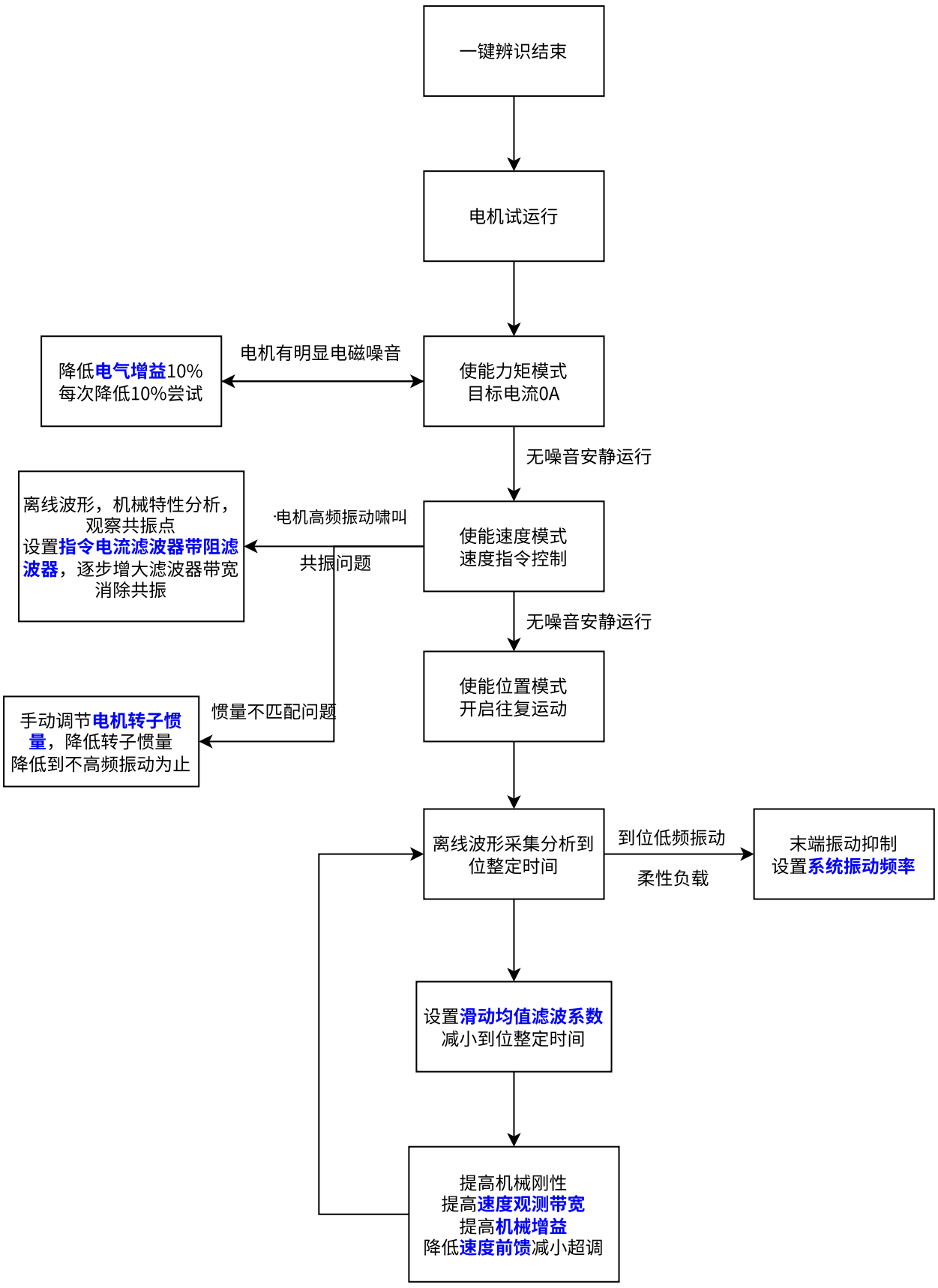
2. Control GainDetailed Explanation and General Debugging Steps

Example Environment:

Motor rated current 10A, peak 20A, maximum speed 3000 RPM, rated voltage 48V

Encoder AB Incremental Encoder 1000 Lines, 4000 Pulses per Revolution Pulses

2.1 Flowchart of General Debugging Steps



2.2 Electrical Gain

2.2.1 Current Loop Performance Test

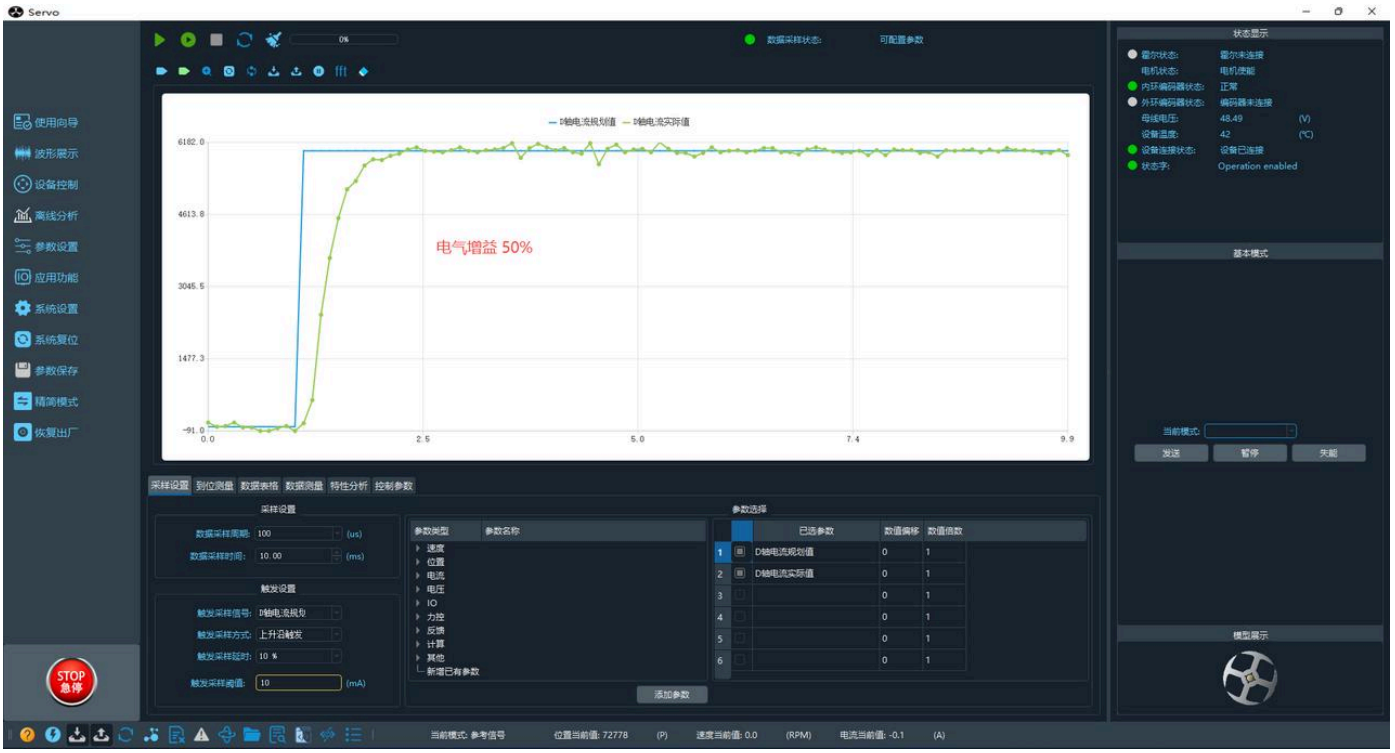
1. Current Loop Closed Loop Theoretical Bandwidth
2. Current square wave step response
3. Current sinusoidal response

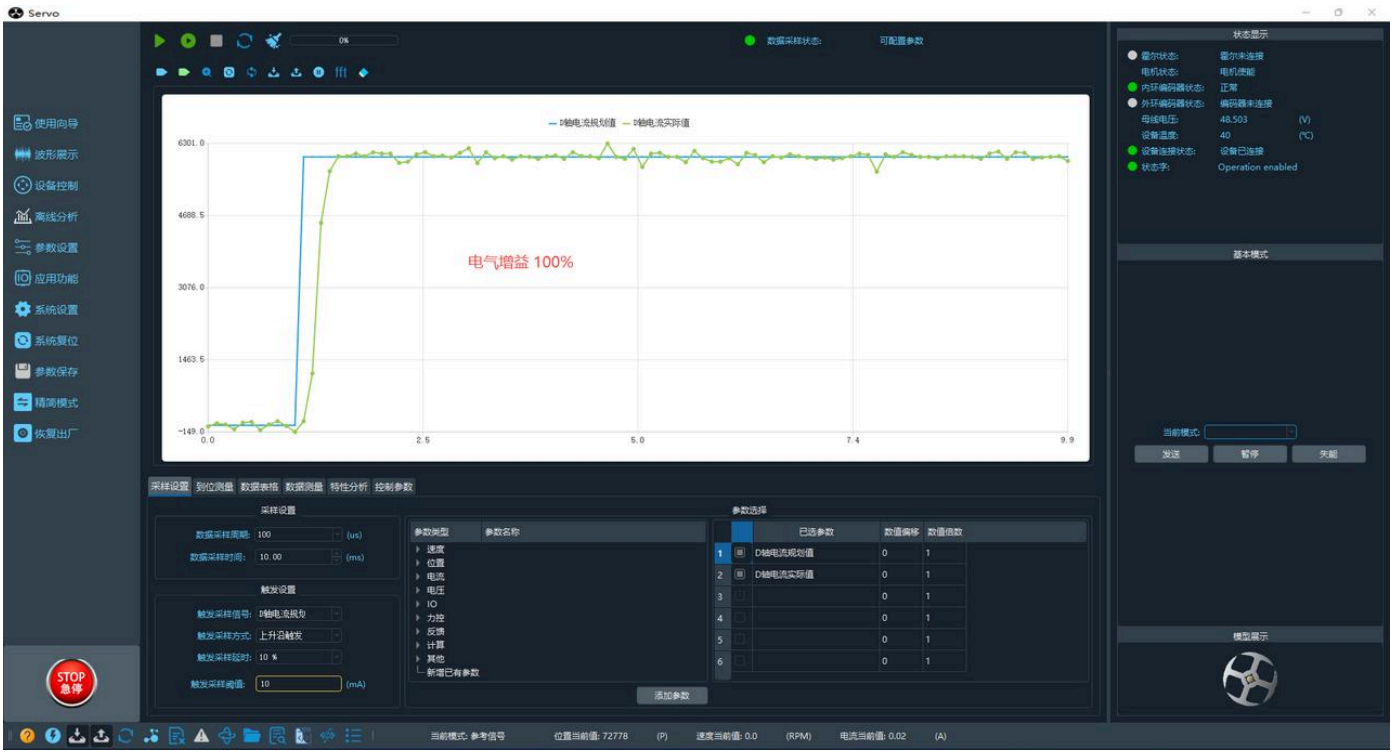


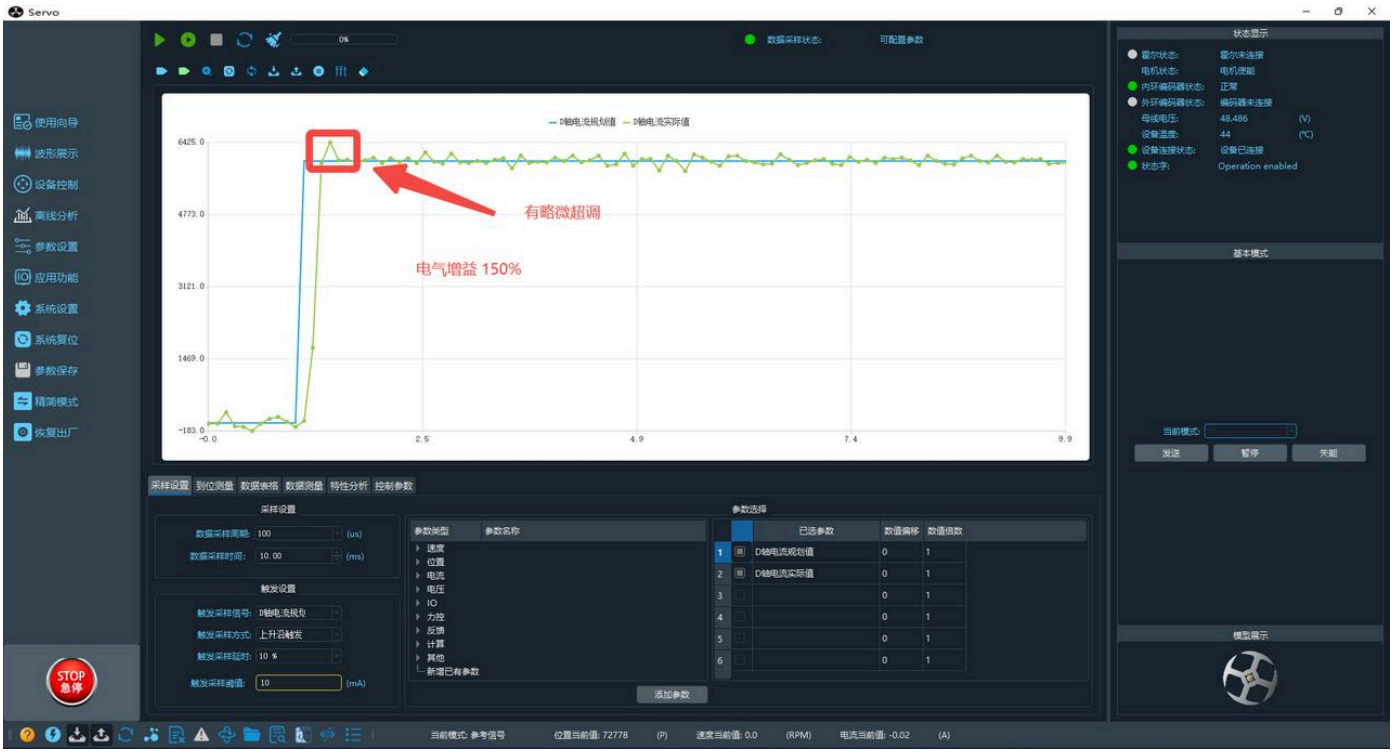
2.2.2 Performance under different gains

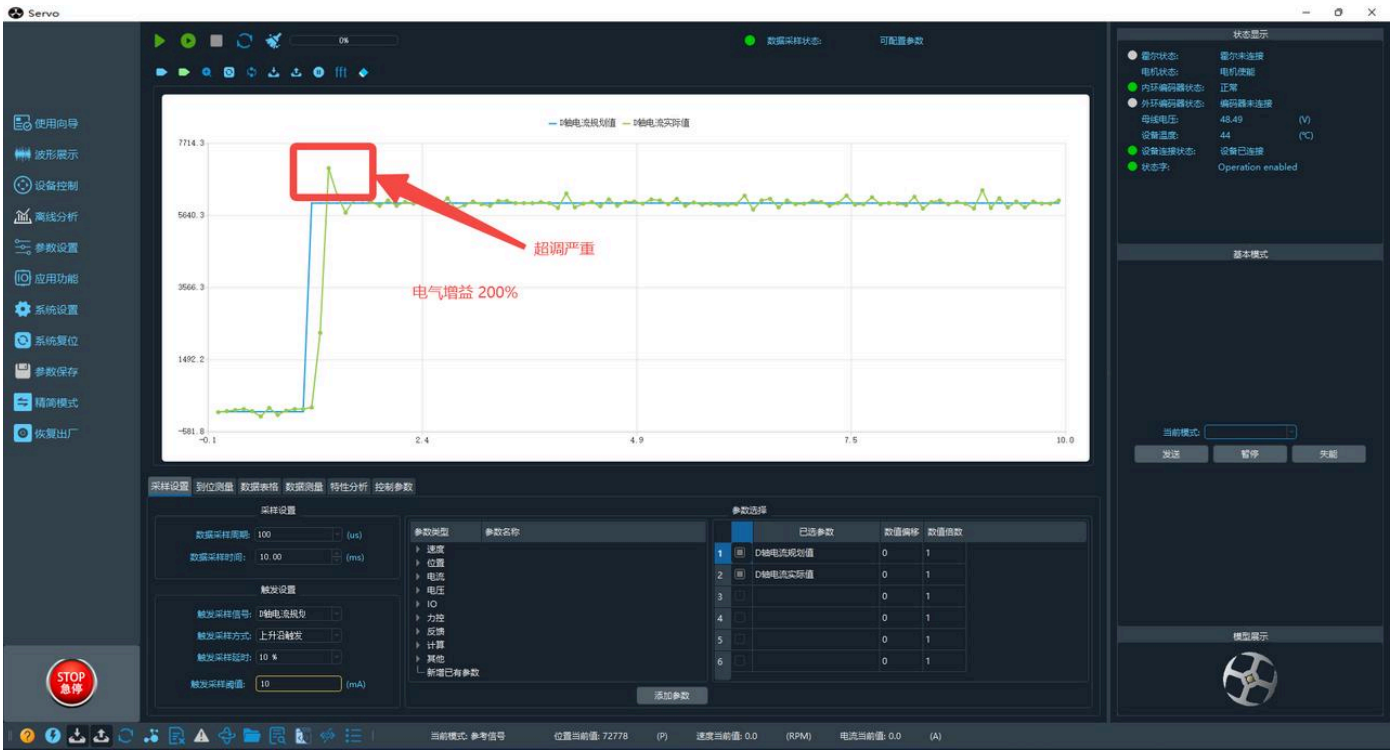
Meaning: The higher the **gain**, the faster the current **response**, the larger the overshoot**, and the larger the current** noise**.**

Electrical gaindefault value **100%,** general adjustment range **10%~200%** , the higher the gain, the higher the current loop control bandwidth and the better the current following performance; however, too high a gain may lead to electromagnetic noise.



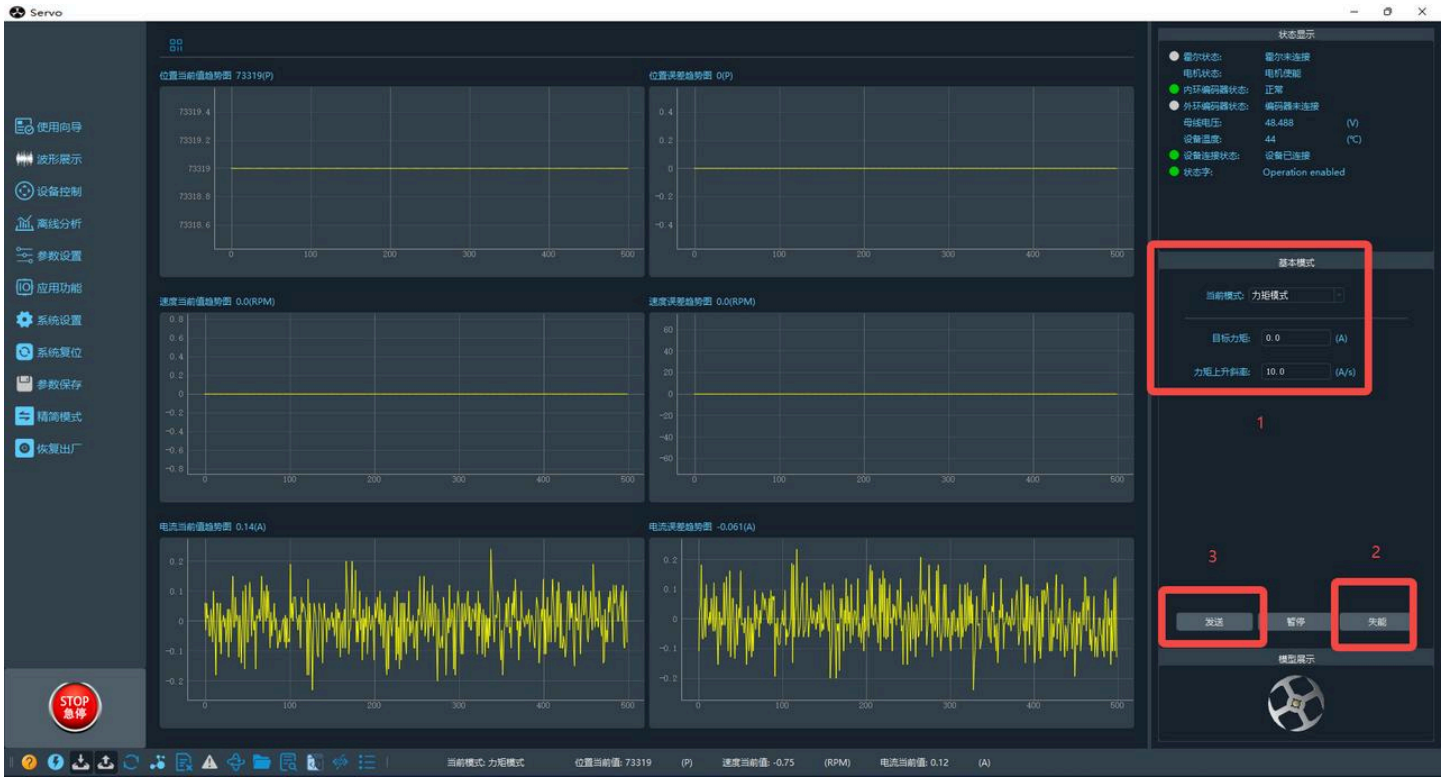

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STOP 急停
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可配置参数
D轴电流规划值
D轴电流实际值
6301.0
4688.5
3076.0
1463.5
-149.0
0.0
2.5
5.0
7.4
9.9
电气增益 100%
采样设置
到位测量
数据表格
数据测量
特性分析
控制参数
采样设置
数据采样周期: 100 (us)
数据采样时间: 10.00 (ms)
触发设置
触发采样信号: D轴电流规划
触发采样方式: 上升沿触发
触发采样延时: 10 %
触发采样阈值: 10 (mA)
参数类型
参数名称
速度
位置
电流
电压
IO
力控
反馈
计算
其他
新增已有参数
参数选择
已选参数
数值偏移
数值倍数
D轴电流规划值
D轴电流实际值
添加参数
状态显示
霍尔状态:
霍尔未连接
电机状态:
电机使能
内环编码器状态:
正常
外环编码器状态:
编码器未连接
母线电压:
48.503
(V)
设备温度:
40
(℃)
设备连接状态:
设备已连接
状态字:
Operation enabled
基本模式
当前模式:
发送
暂停
失能
模型展示
当前模式: 参考信号
位置当前值: 72778
(P)
速度当前值: 0.0
(RPM)
电流当前值: 0.02
(A)


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STOP 急停
数据采样状态:
可配置参数
D轴电流规划值
D轴电流实际值
6425.0
4773.0
3121.0
1469.0
-183.0
0.0
2.5
4.9
7.4
9.9
有略微超调
电气增益 150%
采样设置
到位测量
数据表格
数据测量
特性分析
控制参数
采样设置
数据采样周期: 100 (us)
数据采样时间: 10.00 (ms)
触发设置
触发采样信号: D轴电流规划
触发采样方式: 上升沿触发
触发采样延时: 10 %
触发采样阈值: 10 (mA)
参数类型
参数名称
速度
位置
电流
电压
IO
力控
反馈
计算
其他
新增已有参数
参数选择
已选参数
数值偏移
数值倍数
D轴电流规划值
D轴电流实际值
添加参数
状态显示
霍尔状态:
霍尔未连接
电机状态:
电机使能
内环编码器状态:
正常
外环编码器状态:
编码器未连接
母线电压:
48.486
(V)
设备温度:
44
(℃)
设备连接状态:
设备已连接
状态字:
Operation enabled
基本模式
当前模式:
发送
暂停
失能
模型展示
当前模式: 参考信号
位置当前值: 72778
(P)
速度当前值: 0.0
(RPM)
电流当前值: -0.02
(A)



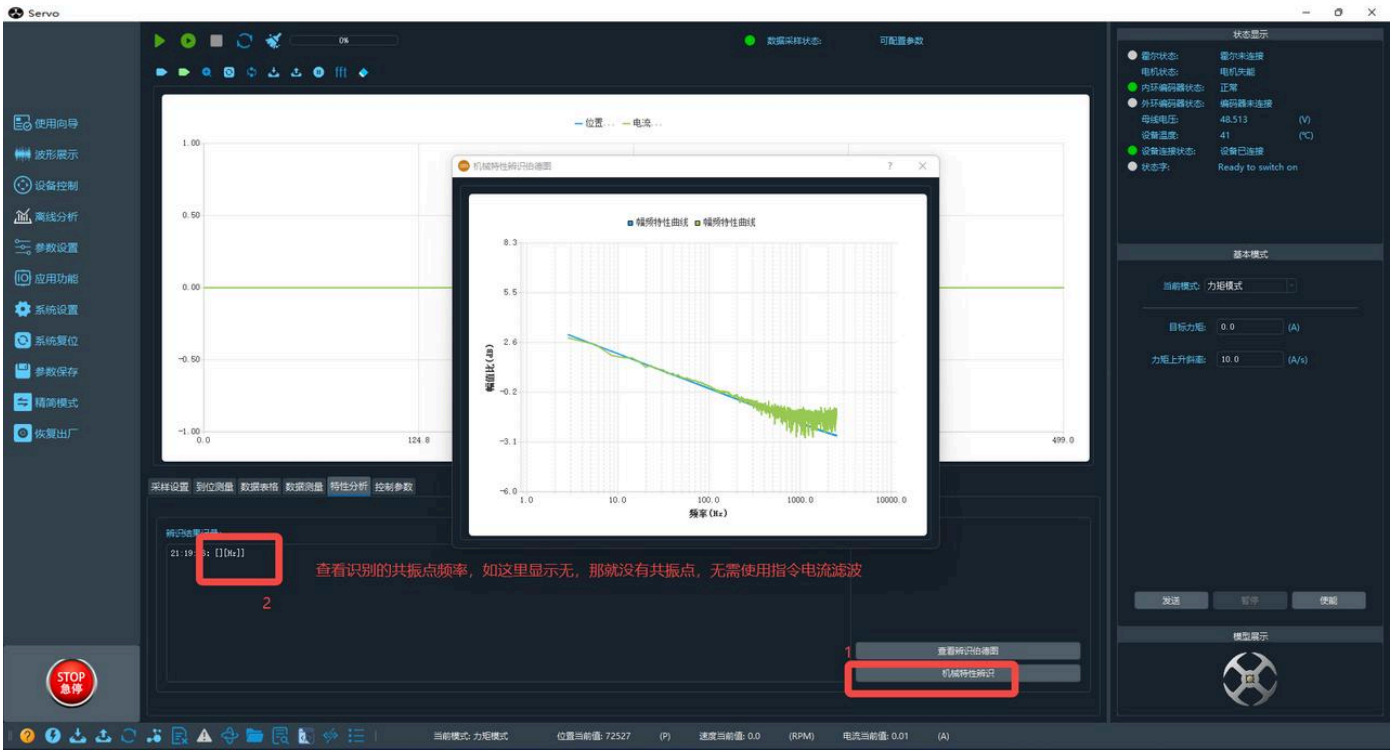
2.2.3 Parameter Confirmation Method

Generally, keep the default value of 100%, which results in better performance. Enter torque mode, input a target torque of 0A, and manually rotate the motor**. As long as there is no obvious current noise, it is acceptable**



2.3 Command CurrentFiltering

2.3.1 Identify resonance points



2.3.2 Usage Instructions

Applies to resonance frequencies above 100HZresonancefrequency, if anyresonance pointrefer to the video below to setcommand current filter

Mechanical characteristic identificationIdentificationResonance pointAnd suppression



ResonanceCollect the current value at the moment forFFT analysisto identifythe resonance point

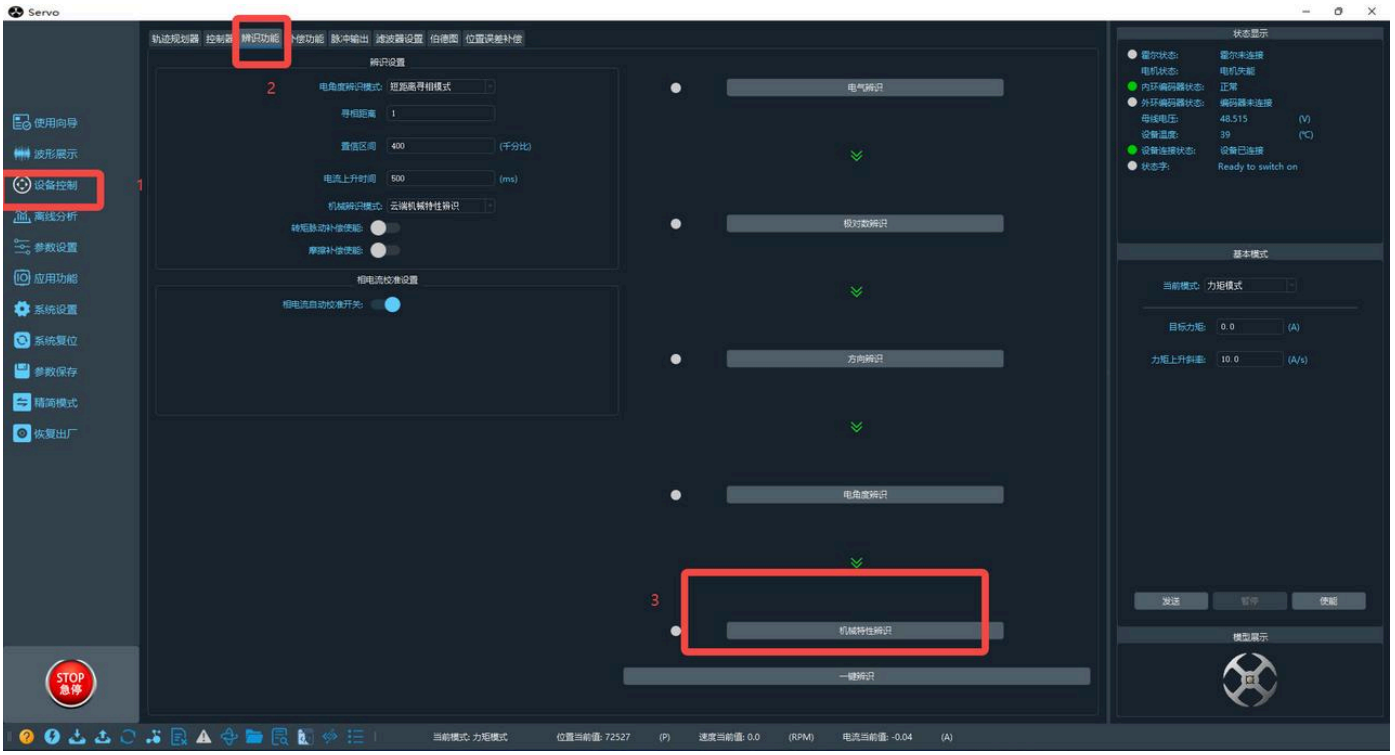


2.3 Motor Rotor Inertia

2.3.1 Identification Function - Mechanical Characteristic Identification to Obtain Accurate Rotor Inertia

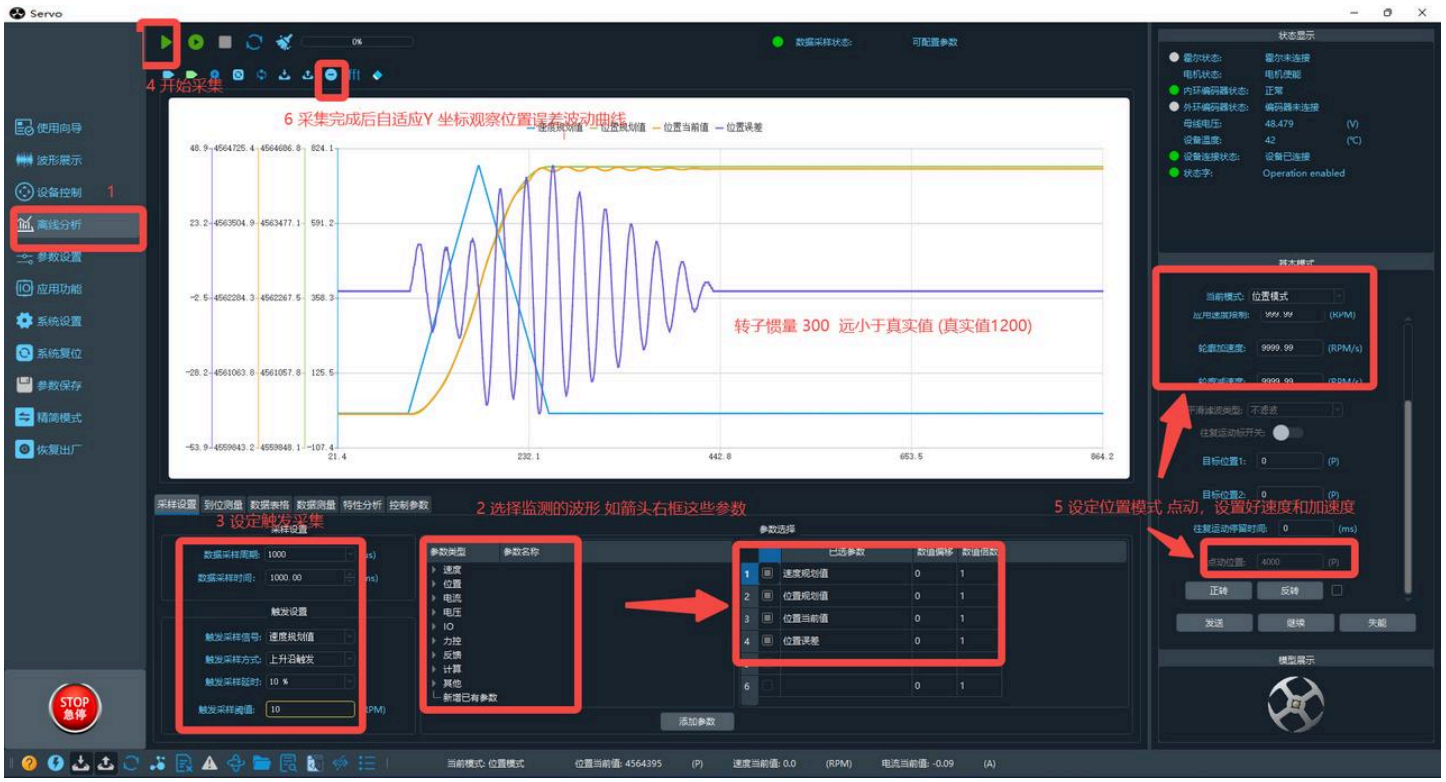
For example: previously, the motor passed the one-key no-load tuning, and there were no issues during operation. Finally, when the motor was installed on the actual equipment, the load changed significantly, and the motor operated abnormally. In this case, the identification function and mechanical characteristic identification should be used first to identify the rotor inertia.

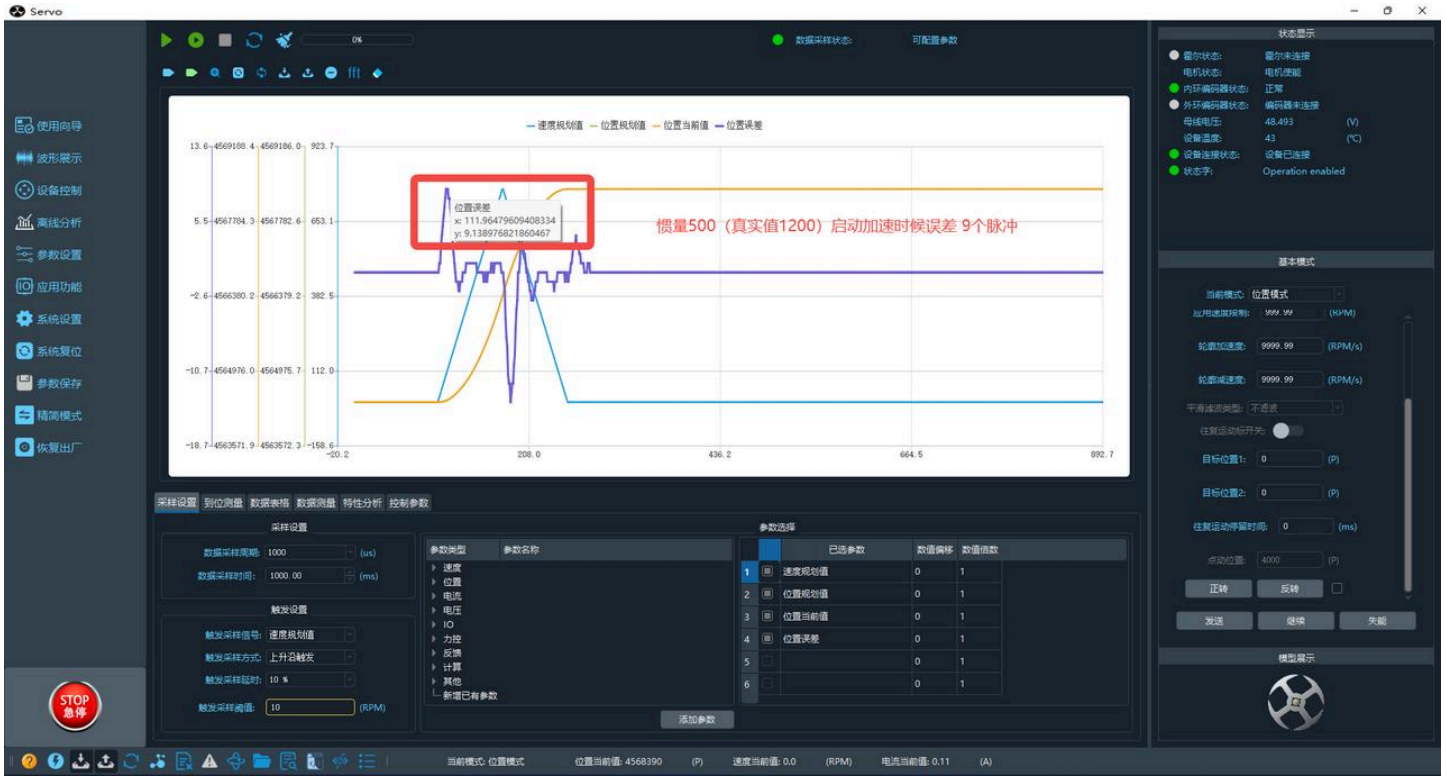
Inapplicable scenarios: For ultra-large inertia, where the inertia ratio exceeds 30 times, or during the identification process, if there is a locked rotor or the load disturbance torque is too large, it may lead to inaccurate identification of the rotor inertia, in which case manual adjustment is required.



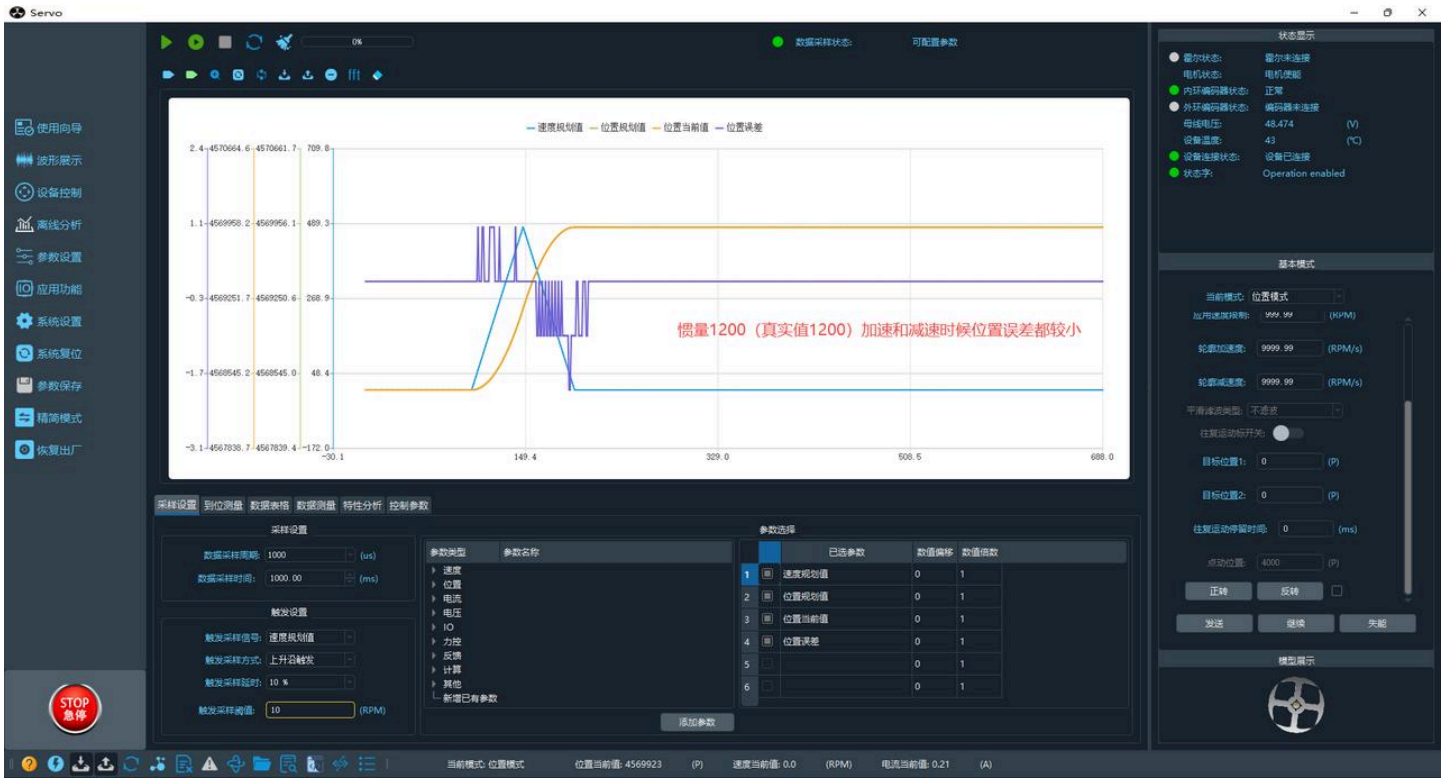
2.3.2 Manual adjustment method for rotor inertia

The inertia is far smaller than the true value, causing the system to experience low-frequency oscillations, even position control loss, and reporting excessive following error or overspeed control loss

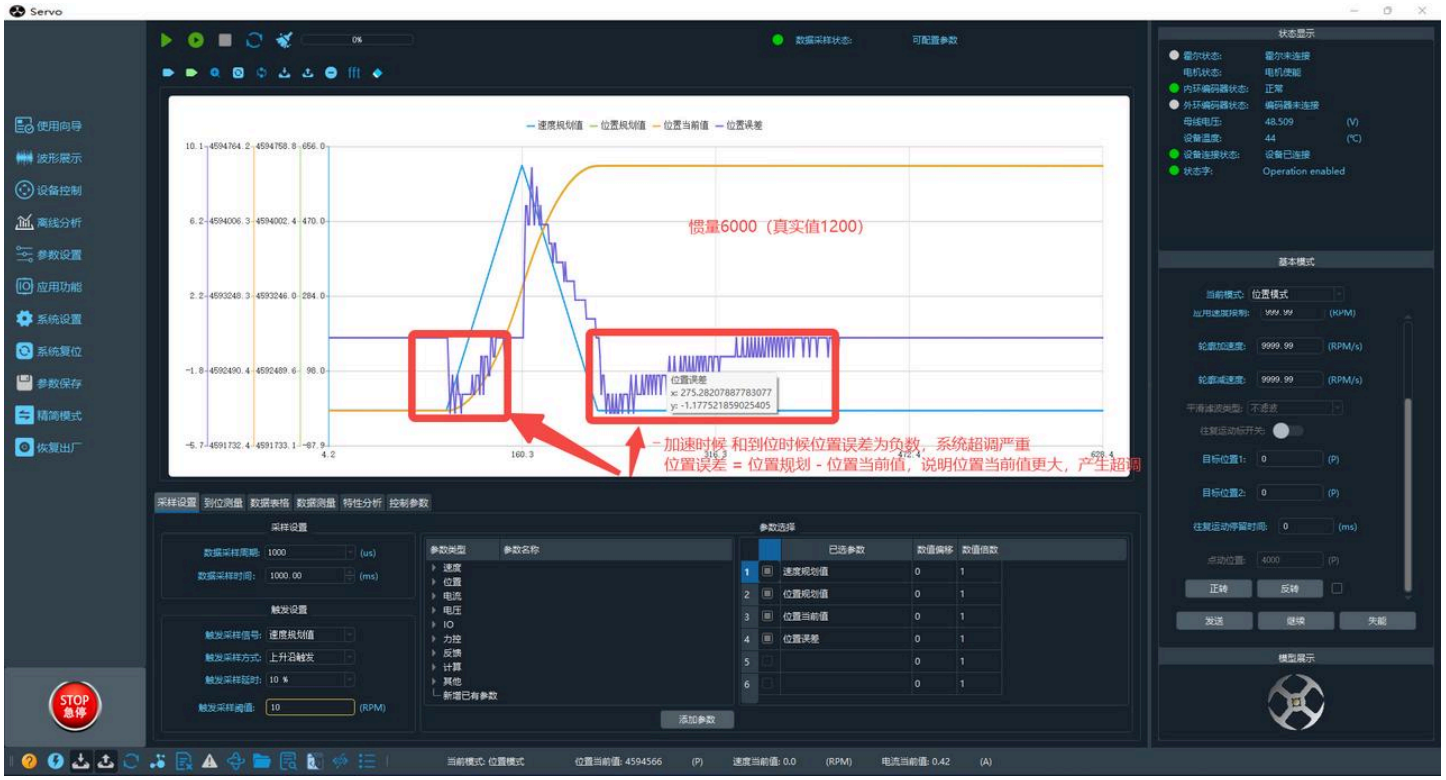




The inertia is just right, and the position error during the entire beat operation is small

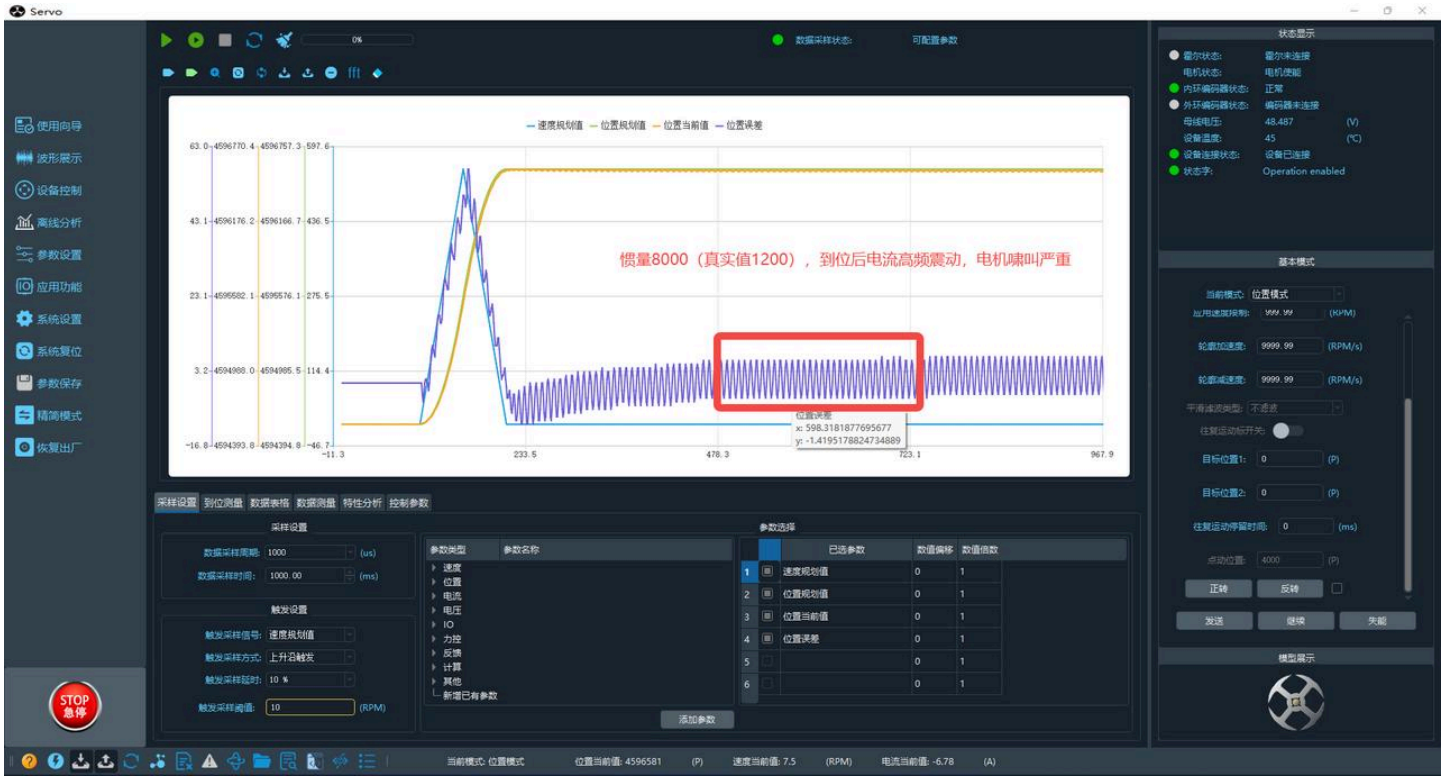


The inertia is too large, and the position response has severe overshoot



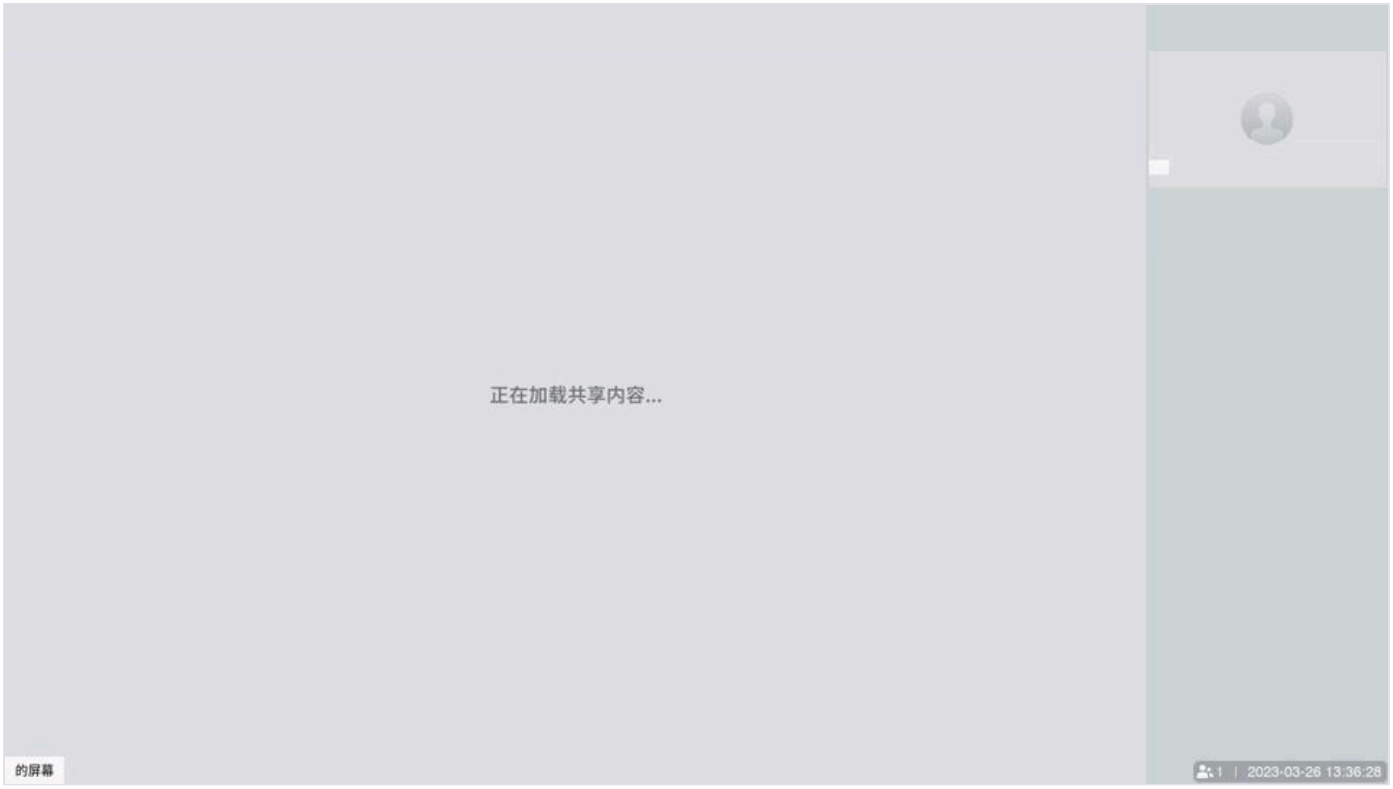
Setting the inertia is too large, generally more than 7-8 times the true value, the motor high-frequency vibration howling, causing the motor and driver to accumulate heat overload , and the current fluctuation is large





2.4 Position CommandFilter

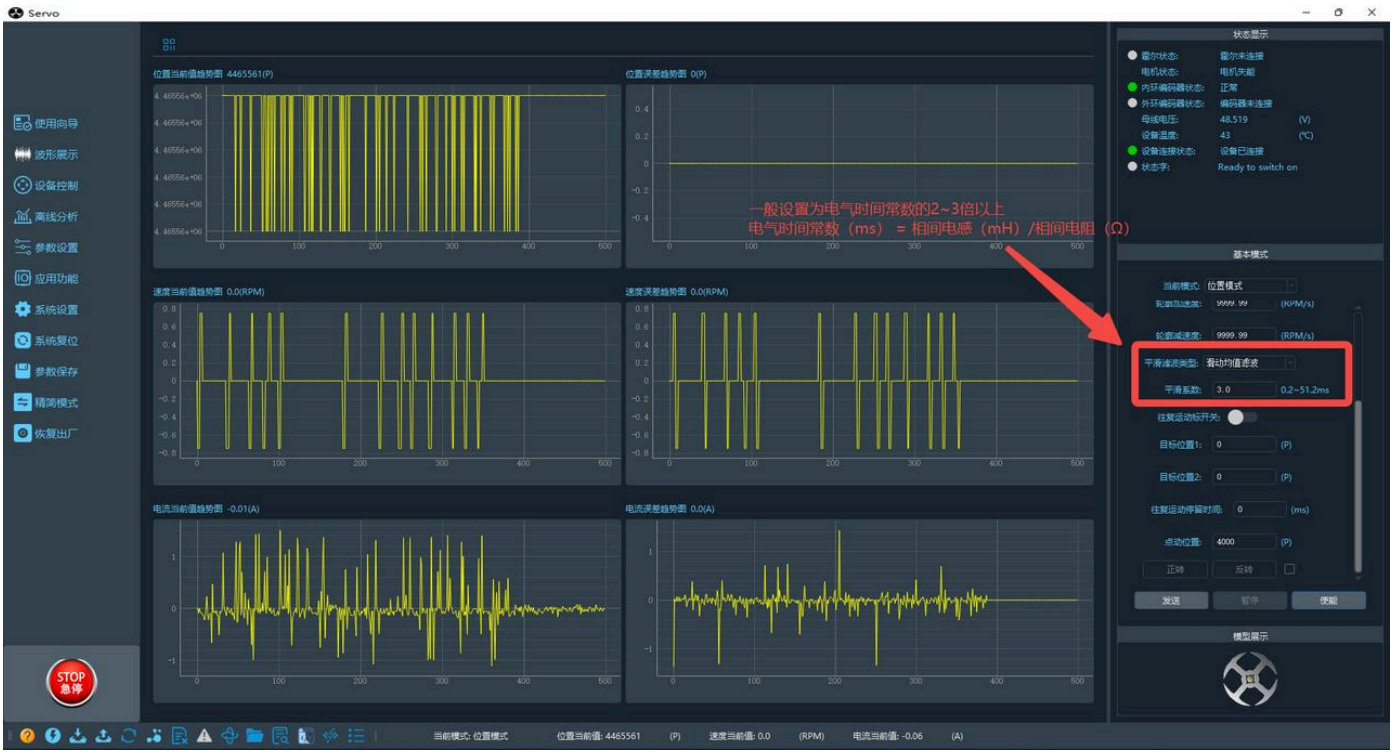
2.4.1 Sliding MeanFilter



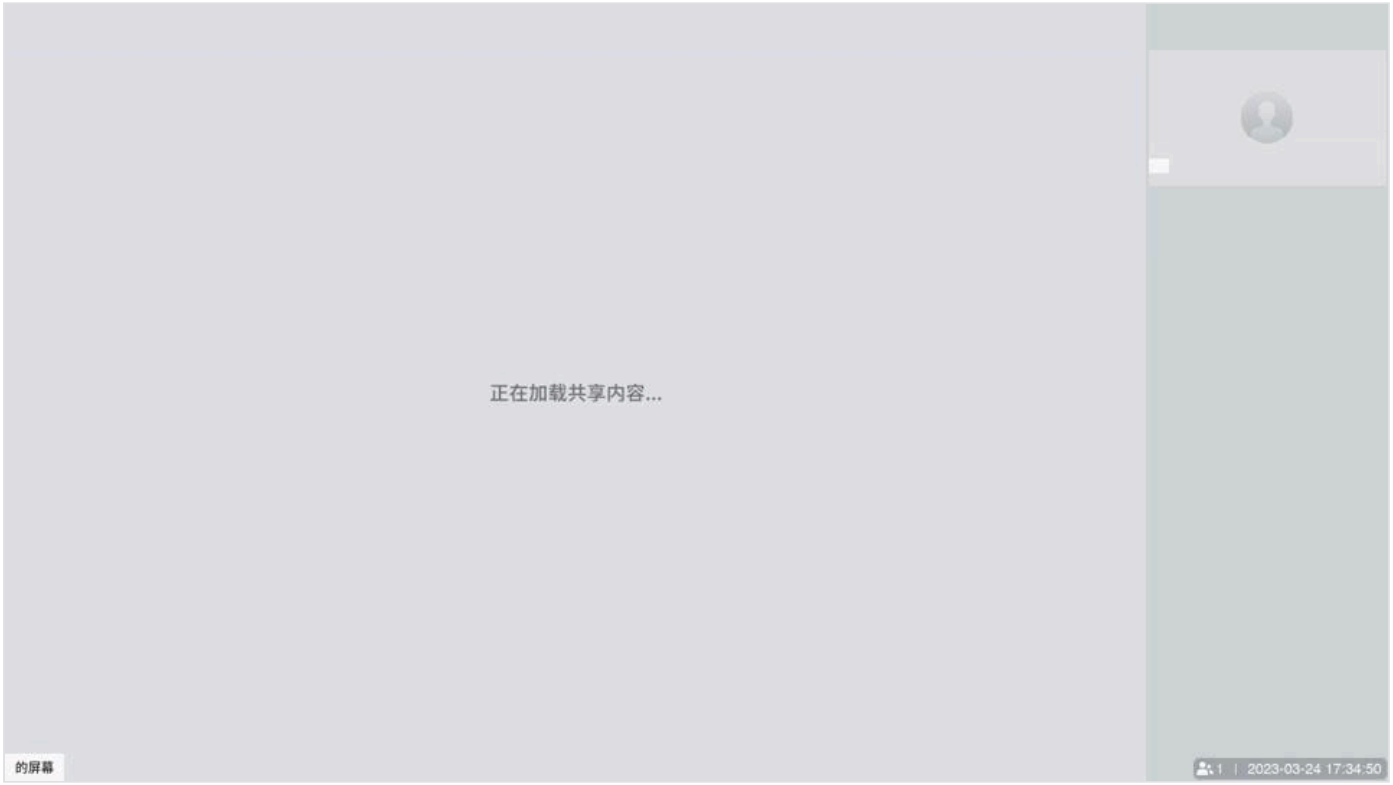
Smoothing Coefficient Setting Range **Smoothing Coefficient Range 0.2~51.2ms**

Parameter Description:

- The smoothing coefficient refers to the delay time, in milliseconds, for the commanded position to reach the target position set by the user after the acceleration of point-to-point position planning in PP mode is smoothed.
- The larger the smoothing coefficient, the smoother the acceleration, the **smaller the setting time in place** , but the planning time increases.
- can be set with reference to **electrical time constant** , and the calculation method refers to the following picture



2.5 Speed ObserverBandwidth



2.5.1 Affects speed and position control

2.5.2 Influence of Different Bandwidths on Rigidity

- **Speed observer bandwidth**, with the unit rad/s. The higher the bandwidth, the faster the response to speed control and the better the real-time performance of speed measurement. However, an excessively large bandwidth may lead to high-frequency noise, increased speed fluctuations, and increased position fluctuations. Generally, the adjustment range is **100~1200 rad/s**.

The following compares the effects of different speed observation bandwidths on stiffness under the same external load torque disturbance

The higher the bandwidth of the speed observer **, the stronger the** system's **anti-disturbance ability** , the higher the stiffness **. If it is too high** , it is prone to **high-frequency vibration**

The smaller the bandwidth of the speed observer, the smaller the equivalent cut-off frequency of the speed measurement filter, the larger the filter coefficient, the slower the speed control response, and the lower the control stiffness





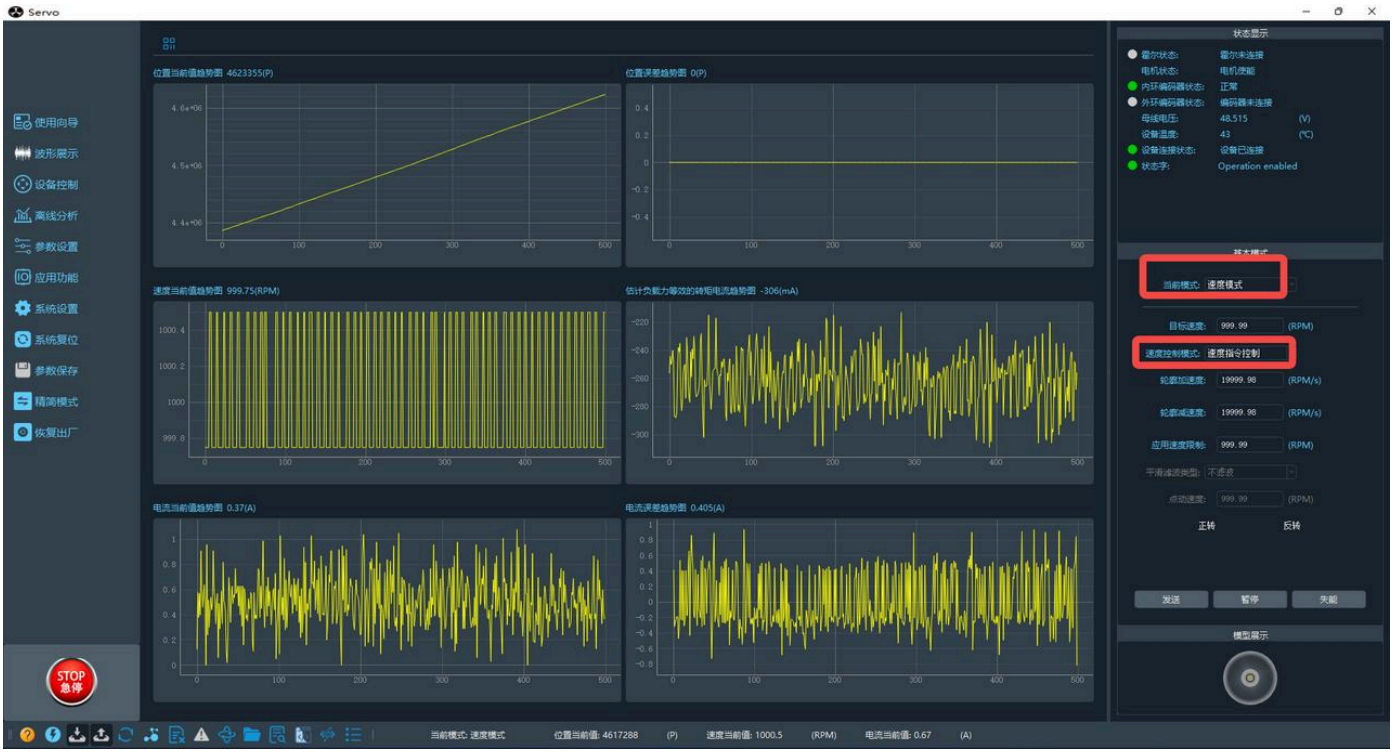


2.4 Mechanical Gain



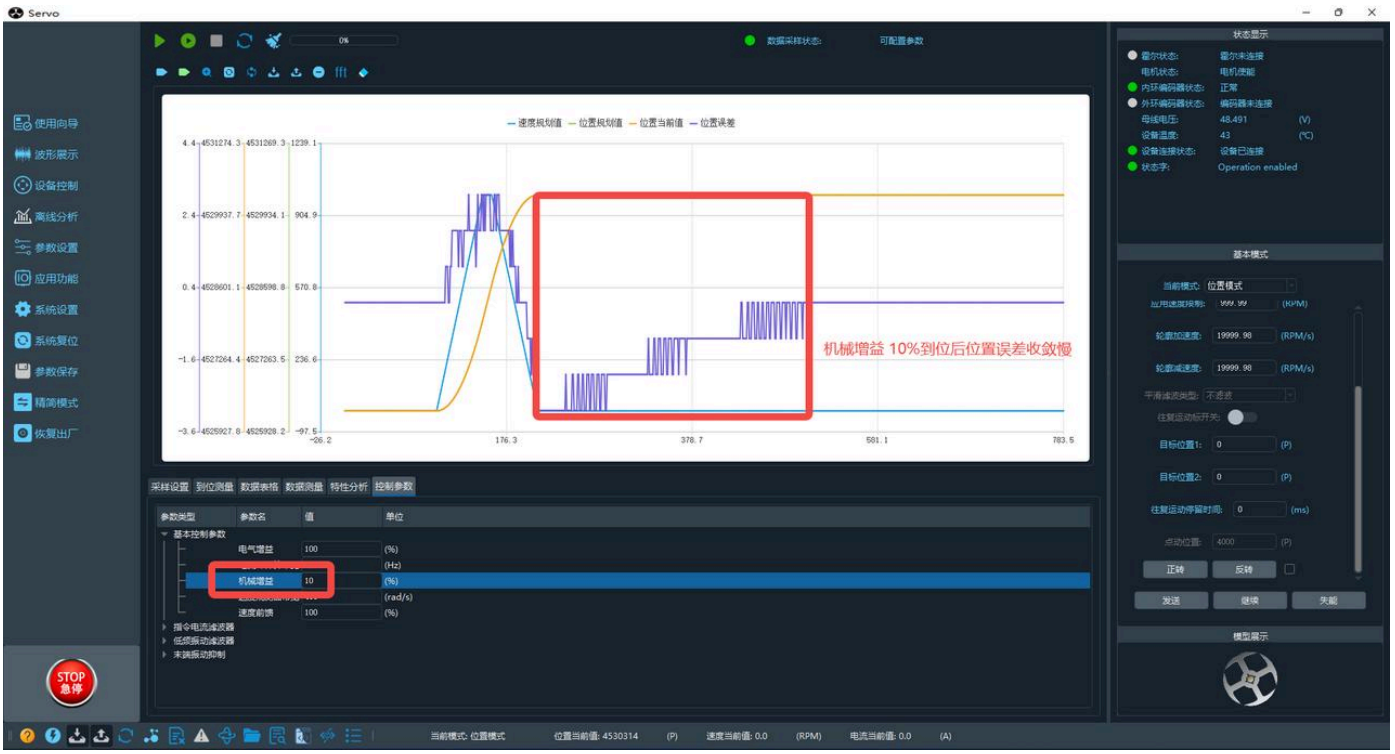
2.4.1 Only effective for position control

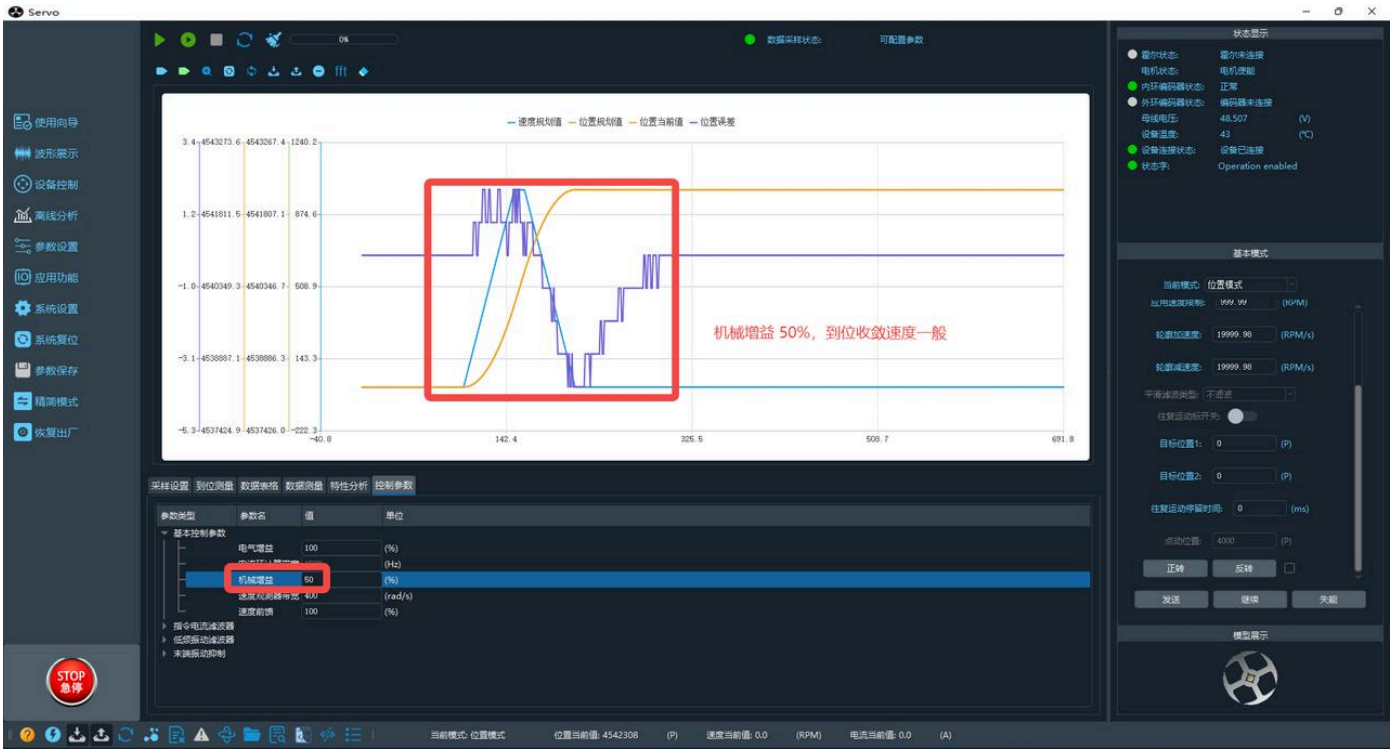
If the speed mode - speed command control is used, the mechanical gain does not work and only takes effect for all position control modes, as shown in the following figure:

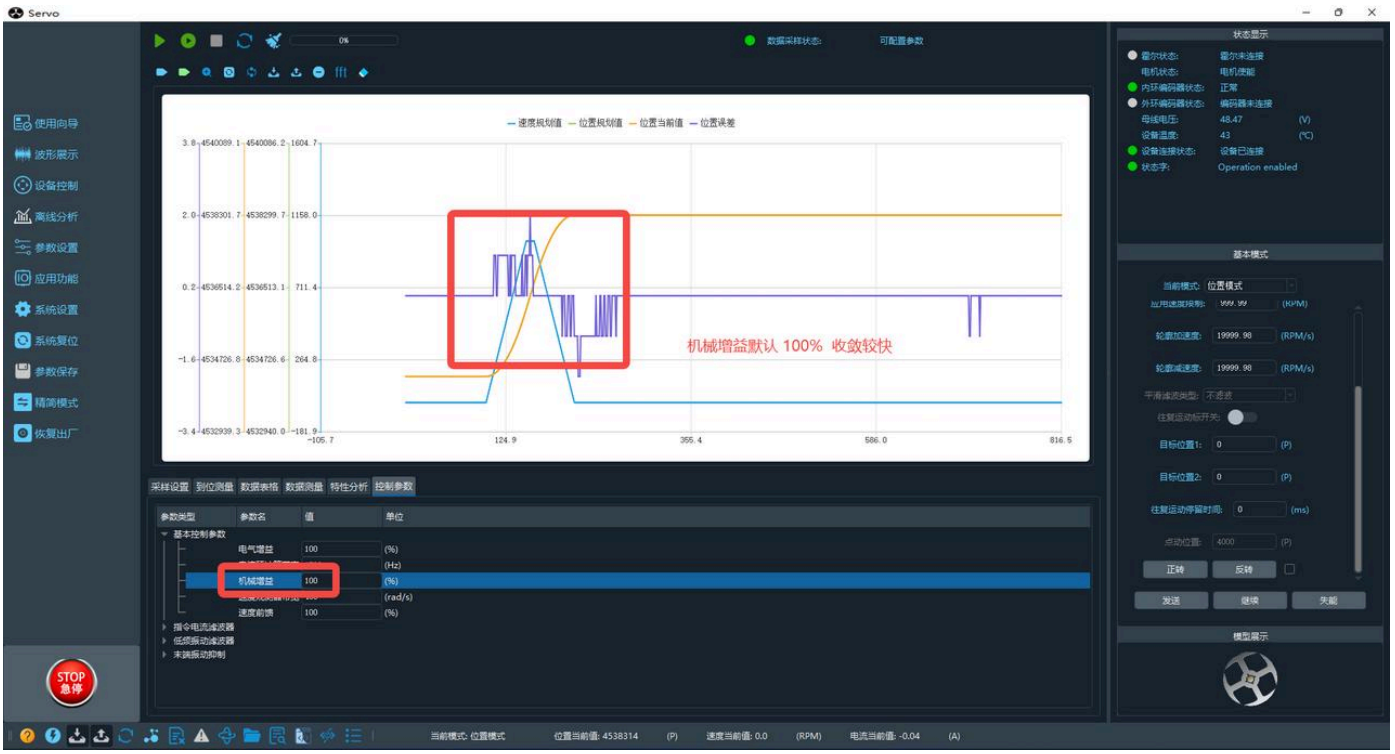


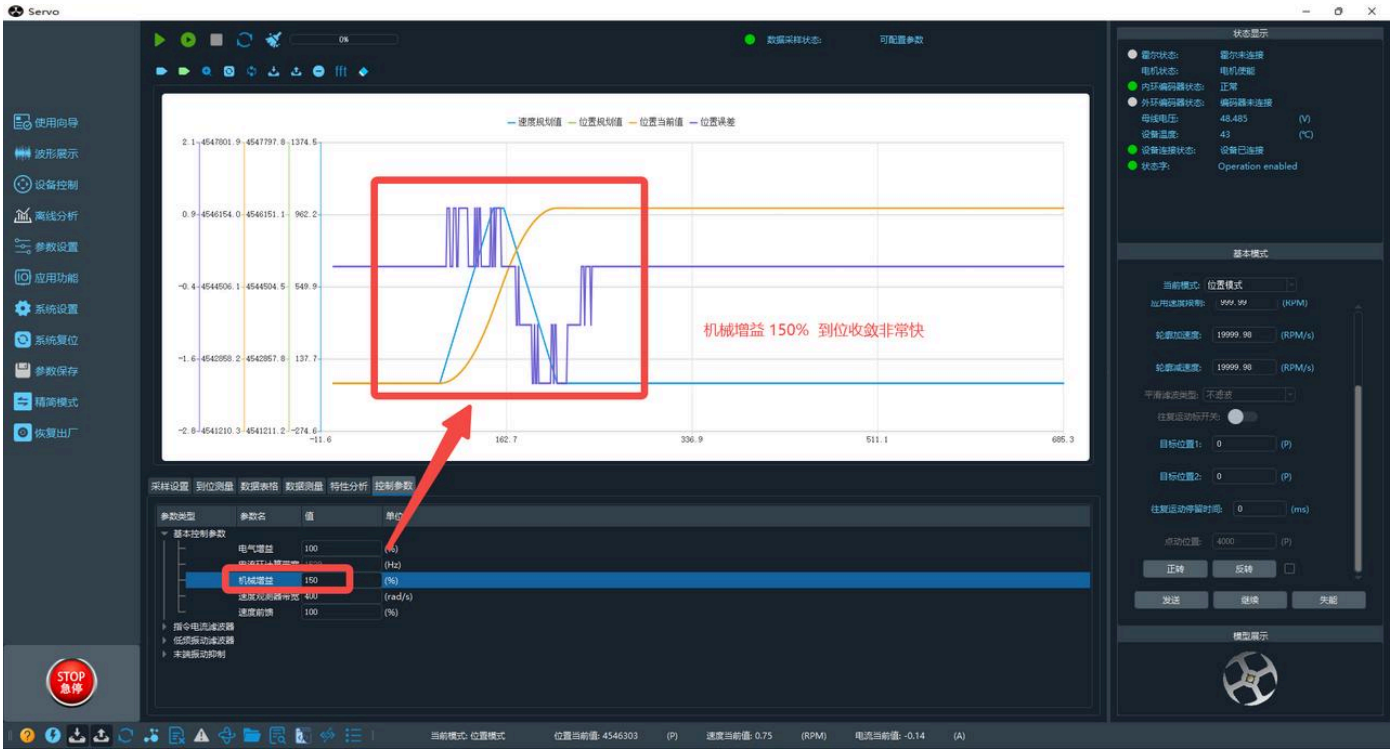
2.4.2 Influence of Different Mechanical Gains

- **Mechanical gain**default value 100%,**rotary motor**general adjustment range**1%~200%**, linear motor general adjustment range**1%~900%**, the higher the gain, the higher the control stiffness, the better the position dynamic following performance, the smaller the settling time, and excessive gain may cause high-frequency vibration and howling.


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急停
速度规划值
位置规划值
位置当前值
位置误差
机械增益 10%到位后位置误差收敛慢
采样设置
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数据测量
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参数类型
参数名
值
单位
基本控制参数
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机械增益
速度前馈
状态显示
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位置当前值: 4530314
速度当前值: 0.0
电流当前值: 0.0


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急停
速度规划值
位置规划值
位置当前值
位置误差
机械增益 50%，到位收敛速度一般
采样设置
到位测量
数据表格
数据测量
特性分析
控制参数
参数类型
参数名
值
单位
基本控制参数
电气增益
机械增益
速度前馈
状态显示
基本模式
模型展示
当前模式: 位置模式
位置当前值: 4542308
速度当前值: 0.0
电流当前值: 0.0


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速度规划值
位置规划值
位置当前值
位置误差
机械增益默认 100% 收敛较快
采样设置
到位测量
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数据测量
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控制参数
参数类型
参数名
值
单位
基本控制参数
电气增益
机械增益
速度前馈
指令电流滤波器
低频振动滤波器
未跳振动抑制
状态显示
霍尔状态:
电机状态:
内环编码器状态:
外环编码器状态:
母线电压:
设备温度:
设备连接状态:
状态字:
Operation enabled
基本模式
当前模式:
位置模式
目标位置1:
目标位置2:
正转
反转
发送
继续
失能
模型展示
当前模式: 位置模式
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速度当前值: 0.0
电流当前值: -0.04

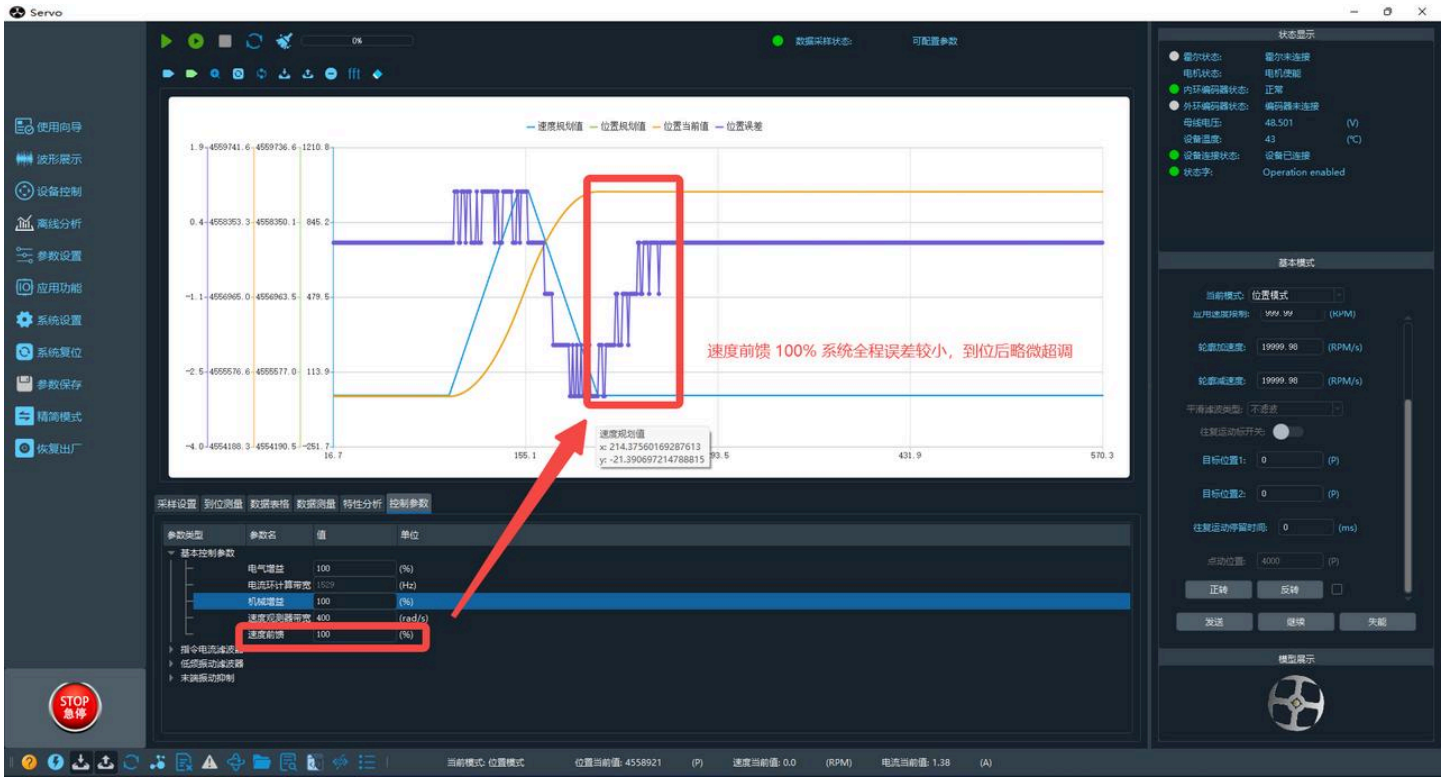

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速度规划值
位置规划值
位置当前值
位置误差
机械增益 150% 到位收敛非常快
采样设置
到位测量
数据表格
数据测量
特性分析
控制参数
参数类型
参数名
值
基本控制参数
电气增益
机械增益
速度前馈
指令电流滤波器
低频振动滤波器
未跳振动抑制
状态显示
霍尔状态:
电机状态:
内环编码器状态:
外环编码器状态:
母线电压:
设备温度:
设备连接状态:
状态字:
Operation enabled
基本模式
当前模式:
位置模式
目标位置1:
目标位置2:
正转
反转
发送
继续
失能
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电流当前值: -0.14

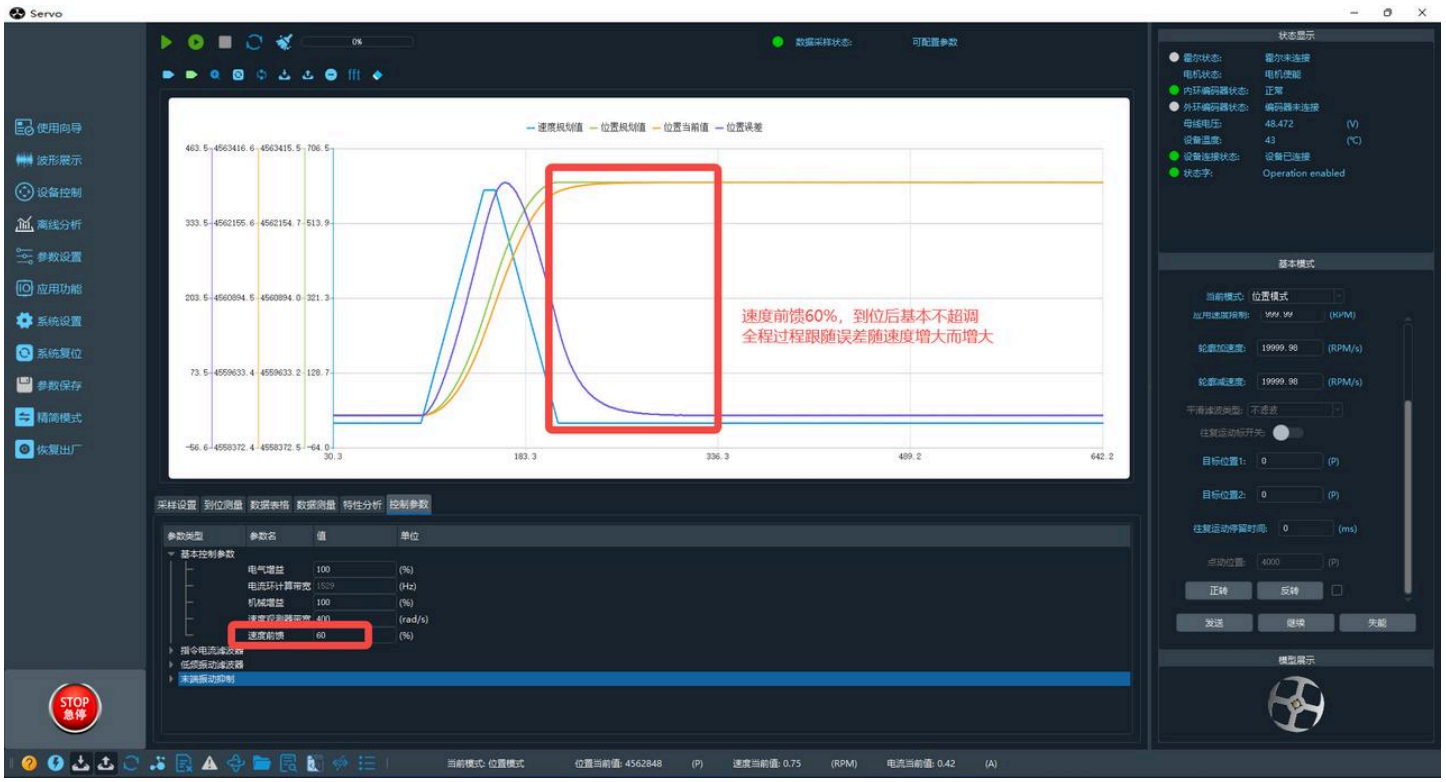


2.5 Speed Feedforward

Adjustment range 0~100%, default 100%

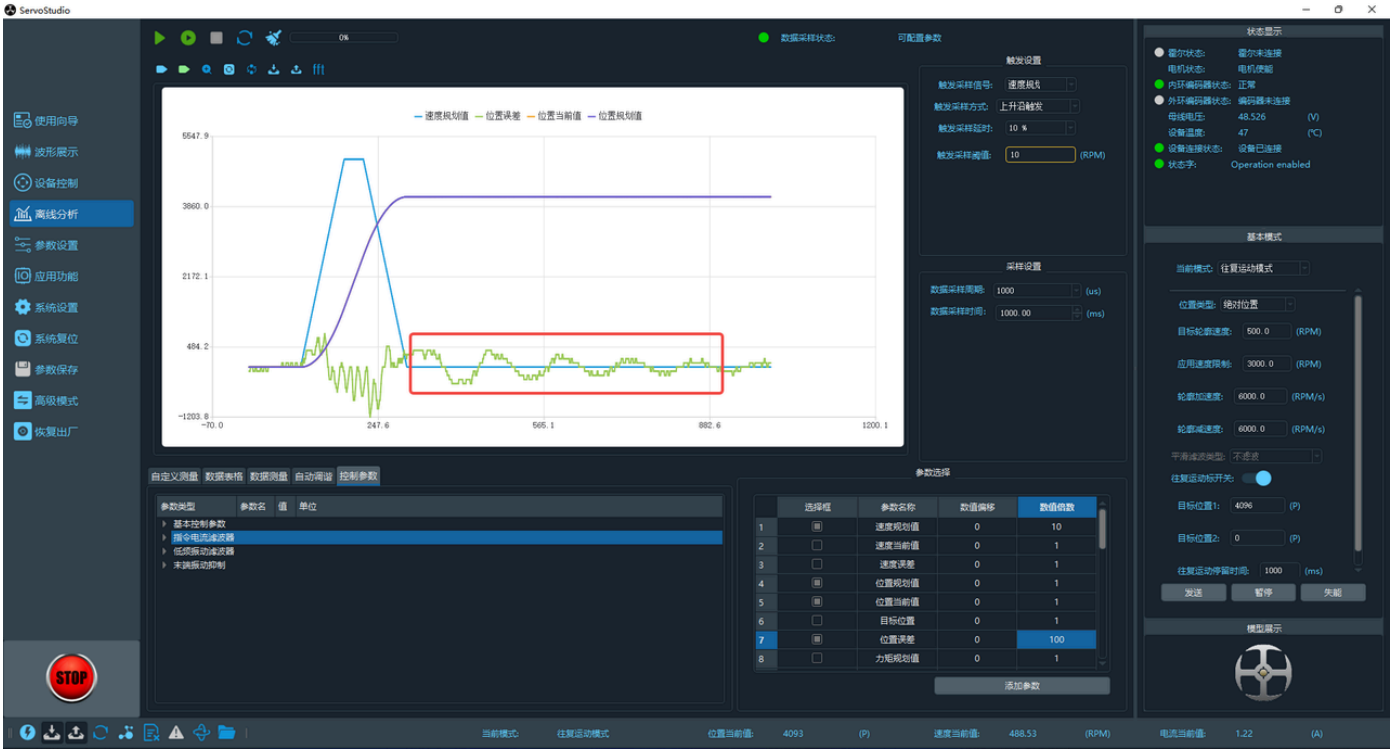
2.5.1 Influence of Different Speed Feedforward



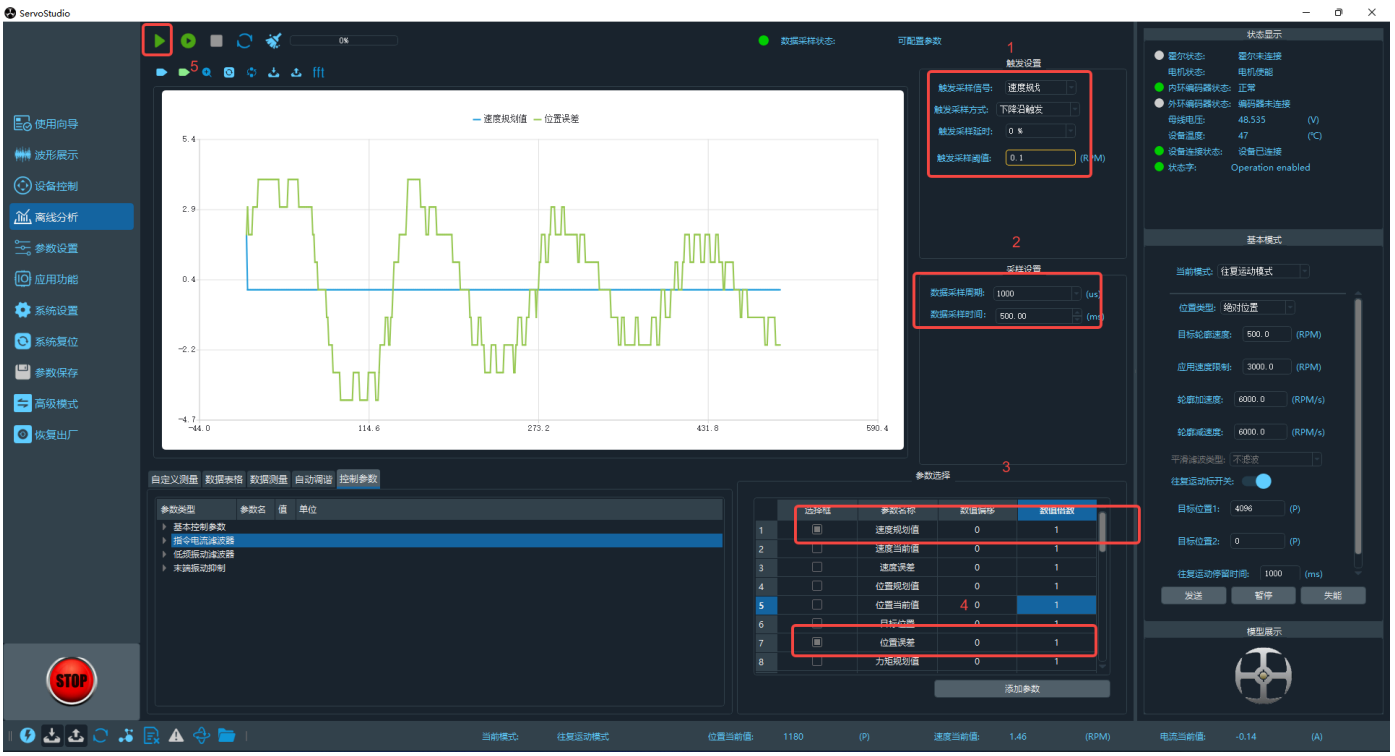


2.6 End Vibration Suppression

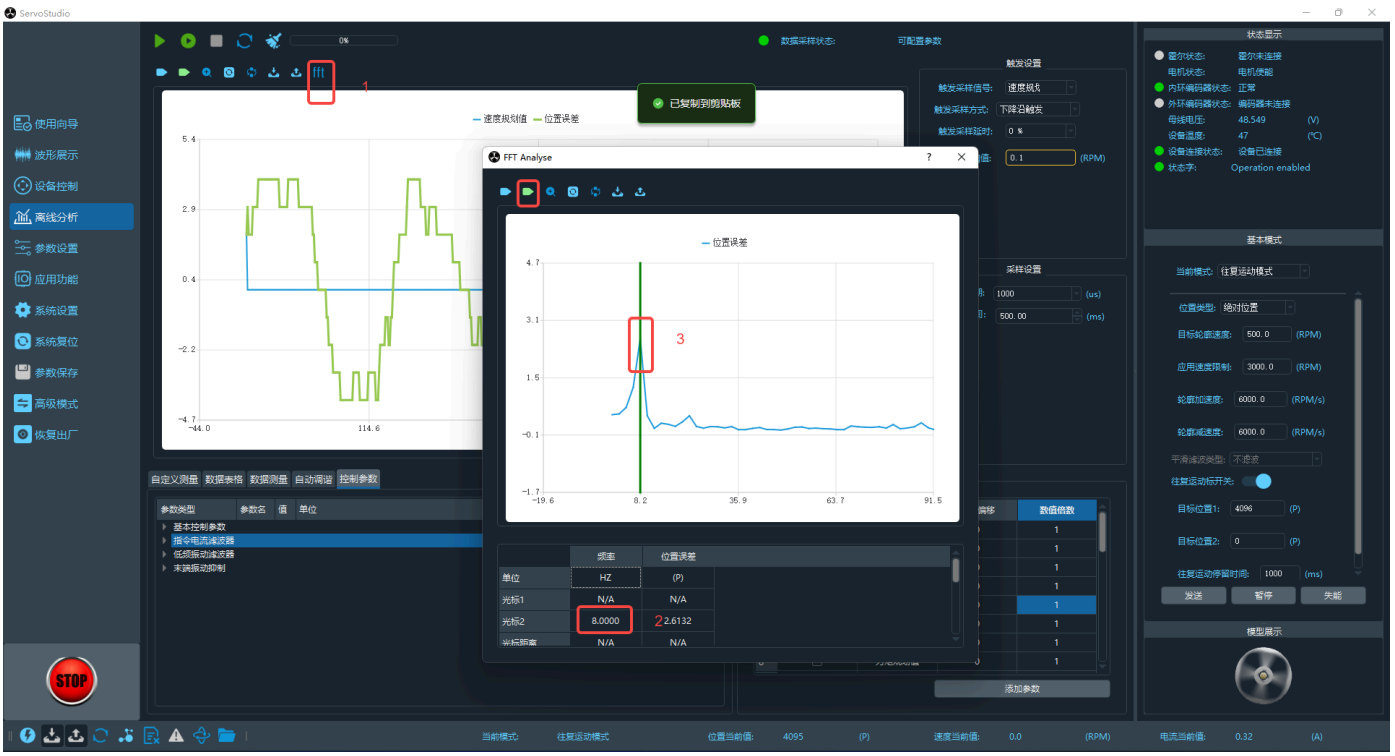
2.6.1 Vibration Frequency Measurement



- Use the position error vibration frequency after offline waveform analysis is in place



Use the FFT tool to click and analyze the vibration frequency of the position error, such as 8HZ as shown in the figure



2.6.2 Low-frequency vibration filter (not recommended for general use; priority should be given to using end vibration suppression to address the issue)

Suitable for low-frequency vibrations after reaching the position below 100HZ

Usage Case Video Explanation (TBD)

2.6.3 End Vibration Suppression

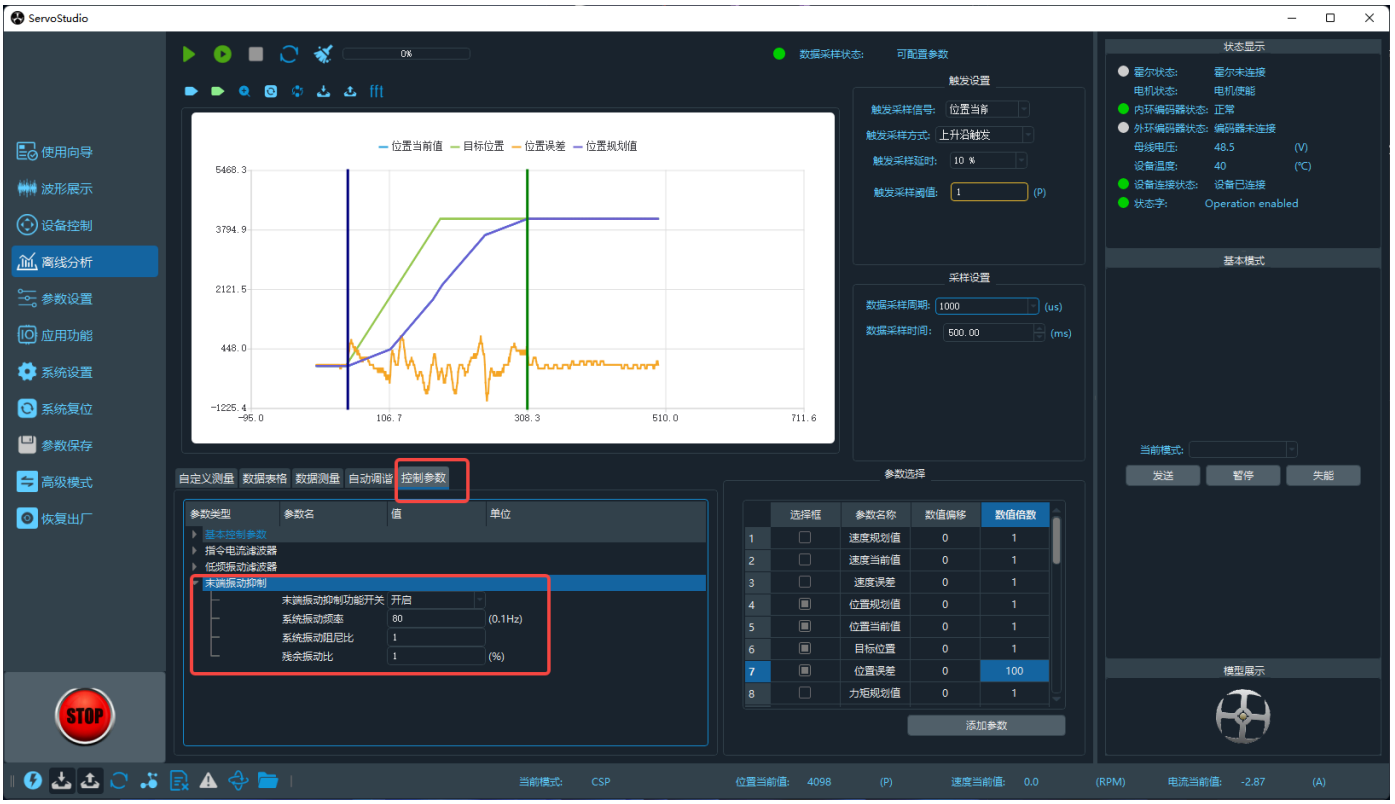
Suitable for low-frequency vibrations after reaching the position below 100HZ

Note: This feature is only available in CSP mode, and other modes such as PP, pulse control position, etc., are not currently supported.

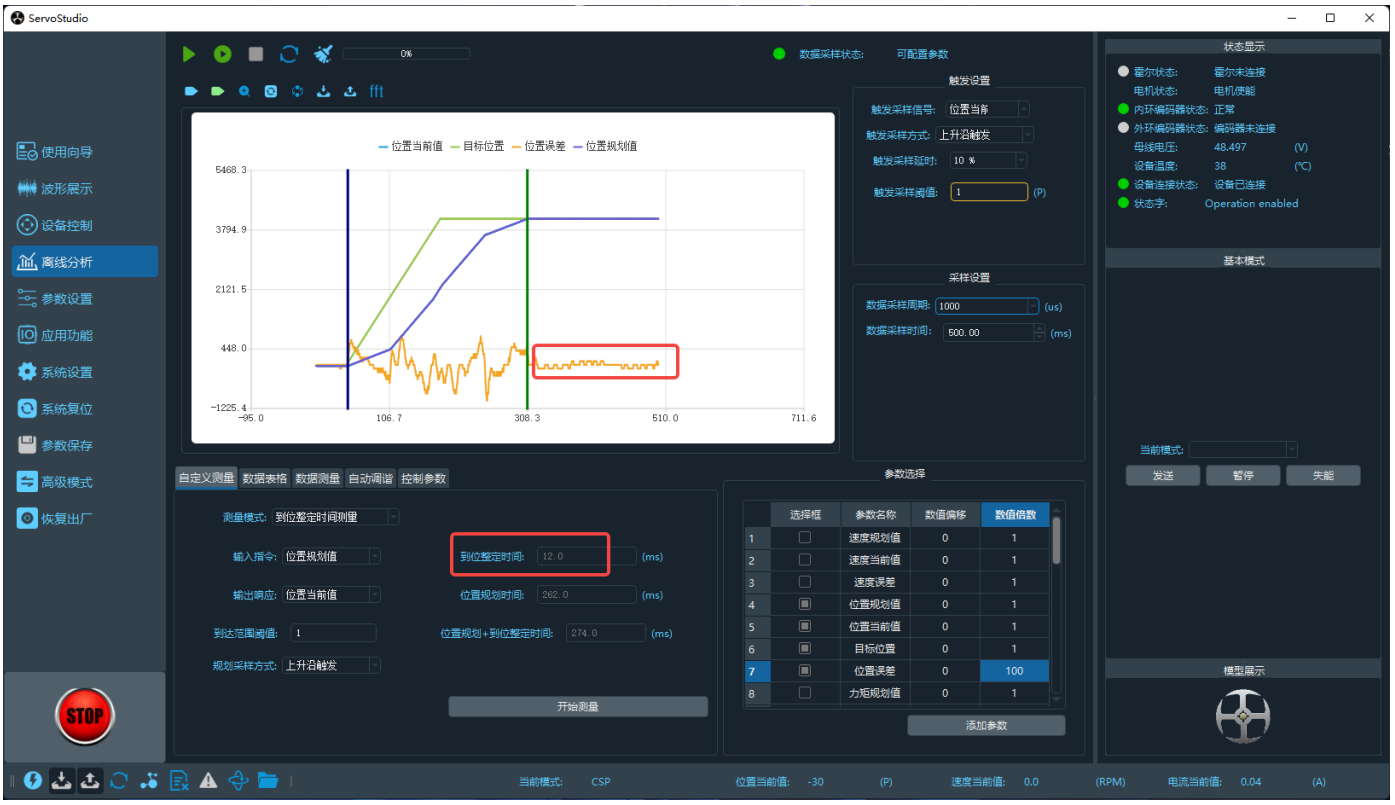
When used in CSP mode, there will be a slight delay in responding to user commands.

The end vibration suppression parameters can be directly set on the offline waveform - control parameter interface

Simply set the vibration frequency as shown in the example below



Under CSP mode, it significantly shortens the settling time to the target position and reduces the position error vibration after reaching the target position



Supplementary example video explanation (TBD)

2.7 Model Compensator

2.7.1 Load torque compensation (enabled by default)

2.7.2 Torque ripple compensation and friction compensation (not used in general applications)

1. Reasons for torque ripple: https://zhuanlan.zhihu.com/p/545483375
2. Explanation of Friction Modelhttps://blog.csdn.net/feisy/article/details/124757373
3. When to use it? Generally, it is not necessary to use it. No-load under identification (TBD to supplement usage cases)

