M Series Tutorial Electronic Gear Instructions

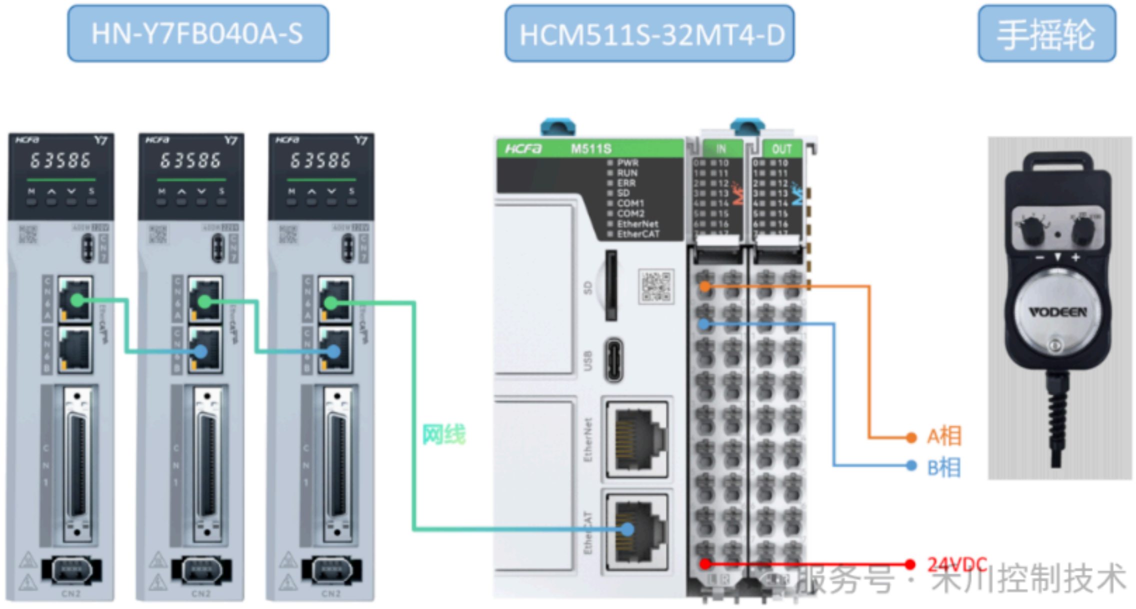
Software: Sysctrl Studio V2.4.0.1705 (PLC programming software)

Hardware: M series controller (taking M511S as an example)

Servo (taking HN-Y7FB040A-S as an example)

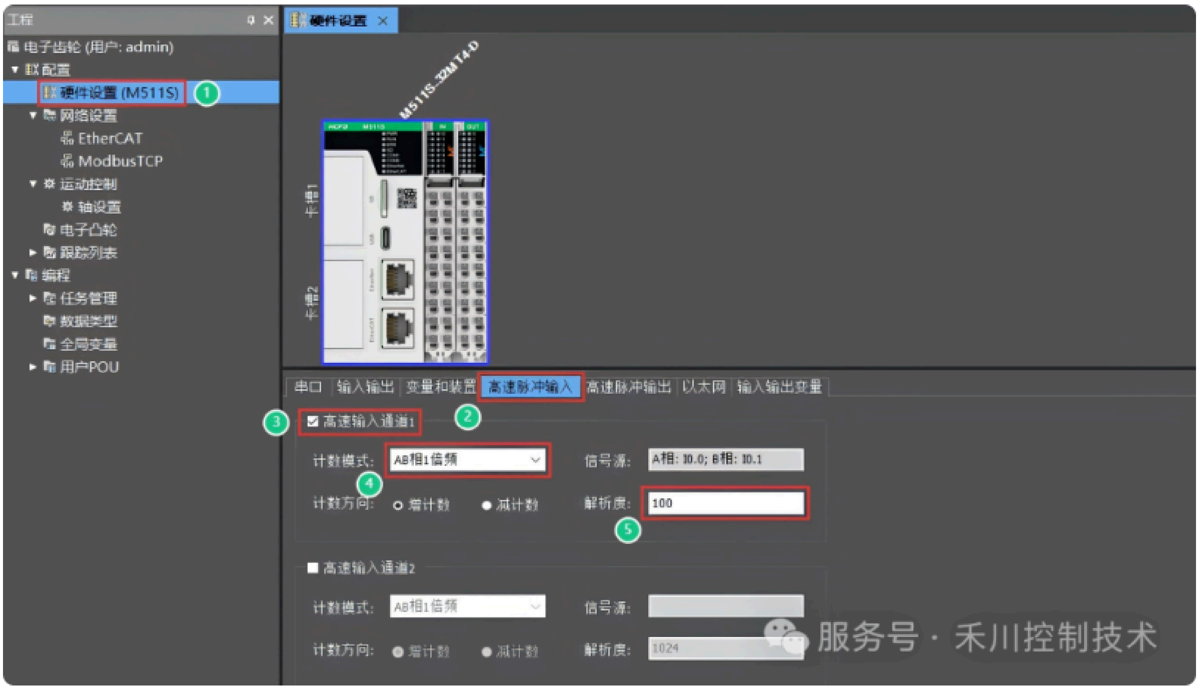
Wiring configuration

This tutorial uses the M controller HCM511S-32MT4-D and three HN-Y7FB040A-S servos, as well as a hand crank. The wiring is as shown below:


HN-Y7FB040A-S
HCM511S-32MT4-D
手摇轮
网线
A相
B相
24VDC
服务号・禾川控制技术

Sysctrl Studio project basic configuration

Basic Settings


工程
电子齿轮 (用户: admin)
配置
硬件设置 (M511S)
①
网络设置
EtherCAT
ModbusTCP
运动控制
轴设置
电子凸轮
跟踪列表
编程
任务管理
数据类型
全局变量
用户POU
硬件设置
M511S-32MT4-D
卡槽1
卡槽2
串口
输入输出
变量和装置
高速脉冲输入
②
高速脉冲输出
以太网
输入输出变量
③
④
⑤

☑ 高速输入通道1

计数模式: AB相1倍频

信号源: A相: I0.0; B相: I0.1

计数方向: ○ 增计数 ● 减计数

解析度: 100

☐ 高速输入通道2

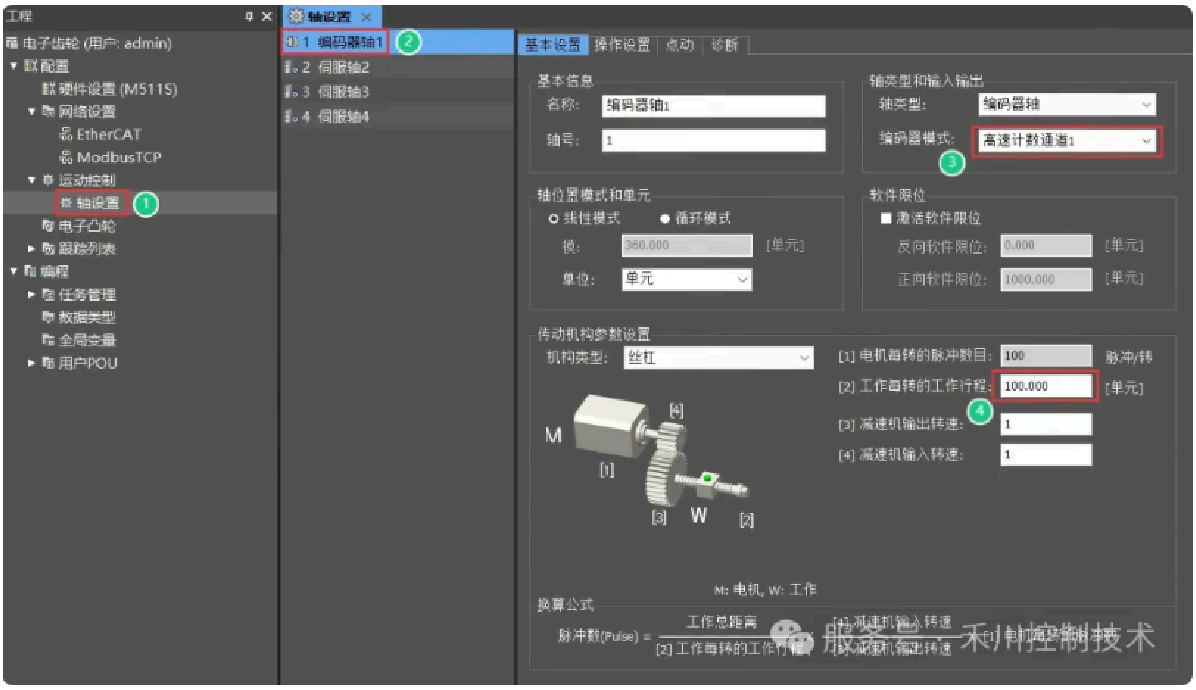
计数模式: AB相1倍频

信号源:

计数方向: ● 增计数 ● 减计数

解析度: 1024

服务号 · 禾川控制技术


工程
电子齿轮 (用户: admin)
配置
硬件设置 (M511S)
网络设置
EtherCAT
ModbusTCP
运动控制
轴设置
①
电子凸轮
跟踪列表
编程
任务管理
数据类型
全局变量
用户POU
轴设置
1 编码器轴1
②
2 伺服轴2
3 伺服轴3
4 伺服轴4
基本设置
操作设置
点动
诊断
③
④
M
W
[1]
[2]
[3]
[4]
M: 电机, W: 工作

基本信息

名称: 编码器轴1

轴号: 1

轴类型和输入输出

轴类型: 编码器轴

编码器模式: 高速计数通道1

轴位置模式和单元

○ 线性模式 ● 循环模式

模: 360.000 [单元]

单位: 单元

软件限位

☐ 激活软件限位

反向软件限位: 0.000 [单元]

正向软件限位: 1000.000 [单元]

传动机构参数设置

机构类型: 丝杠

[1] 电机每转的脉冲数目: 100 脉冲/转

[2] 工作每转的工作行程: 100.000 [单元]

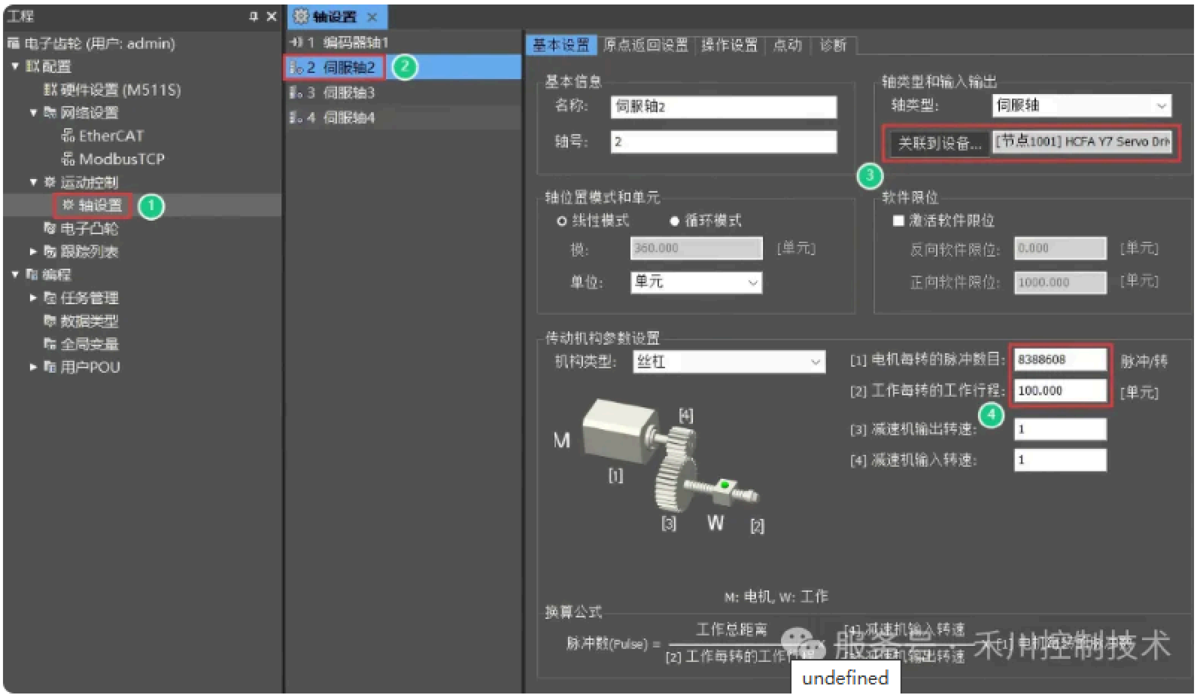
[3] 减速机输出转速: 1

[4] 减速机输入转速: 1

换算公式

脉冲数(Pulse) = 工作总距离 / [2] 工作每转的工作行程 × [4] 减速机输入转速 / [3] 减速机输出转速 × [1] 电机每转的脉冲数

服务号 · 禾川控制技术


工程
电子齿轮 (用户: admin)
配置
硬件设置 (M511S)
网络设置
EtherCAT
ModbusTCP
运动控制
轴设置
①
电子凸轮
跟踪列表
编程
任务管理
数据类型
全局变量
用户POU
轴设置
1 编码器轴1
2 伺服轴2
②
3 伺服轴3
4 伺服轴4
基本设置
原点返回设置
操作设置
点动
诊断
③
④
M
W
[1]
[2]
[3]
[4]
M: 电机, W: 工作

基本信息

名称: 伺服轴2

轴号: 2

轴类型和输入输出

轴类型: 伺服轴

关联到设备... [节点1001] HCFA Y7 Servo Dri

轴位置模式和单元

○ 线性模式 ● 循环模式

模: 360.000 [单元]

单位: 单元

软件限位

☐ 激活软件限位

反向软件限位: 0.000 [单元]

正向软件限位: 1000.000 [单元]

传动机构参数设置

机构类型: 丝杠

[1] 电机每转的脉冲数目: 8388608 脉冲/转

[2] 工作每转的工作行程: 100.000 [单元]

[3] 减速机输出转速: 1

[4] 减速机输入转速: 1

换算公式

脉冲数(Pulse) = 工作总距离 / [2] 工作每转的工作行程 × [4] 减速机输入转速 / [3] 减速机输出转速 × [1] 电机每转的脉冲数

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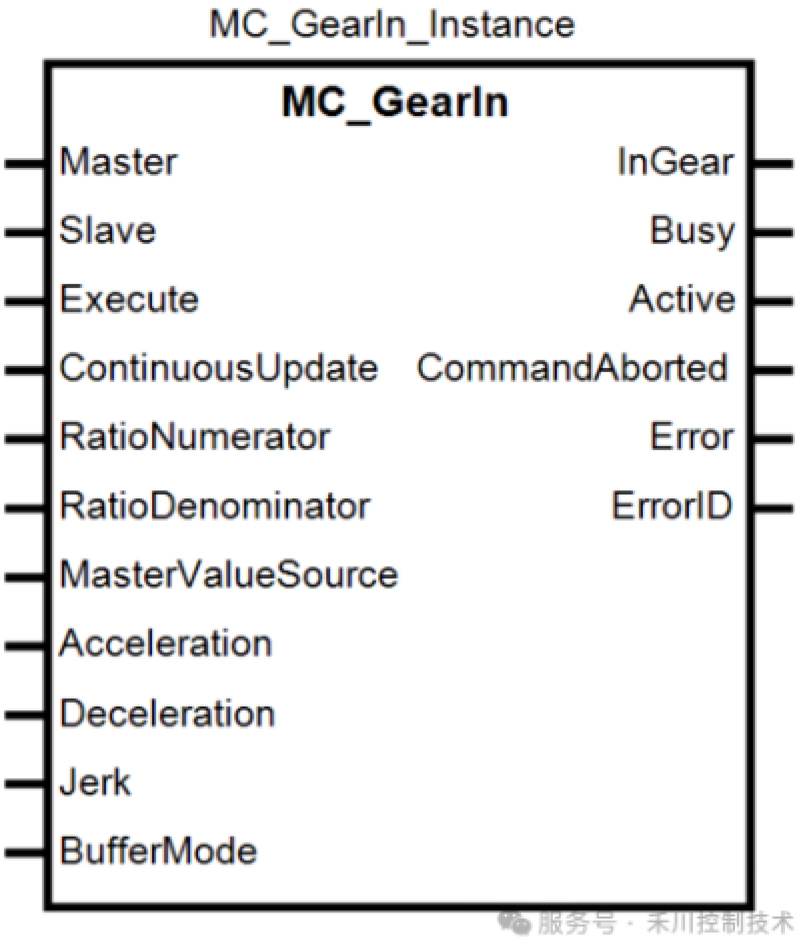
undefined

Electronic gear command

MC_GearIn


MC_GearIn_Instance
MC_GearIn
Master
Slave
Execute
ContinuousUpdate
RatioNumerator
RatioDenominator
MasterValueSource
Acceleration
Deceleration
Jerk
BufferMode
InGear
Busy
Active
CommandAborted
Error
ErrorID

服务号 · 禾川控制技术

① Functional description

This command controls the slave axis to follow the master axis, moving synchronously at the specified gear ratio. The slave axis displacement increment = master axis displacement increment × gear ratio numerator / gear ratio denominator. The gear ratio can be modified during command execution, and the modified gear ratio takes effect at the rising edge of Execute.

When meshing during motion, the speed at which the slave axis catches up with the master axis can be adjusted by the Acceleration and Deceleration parameters. The larger the value, the faster the catch-up, but it may cause a drastic change in the slave axis speed.

② Parameter Description

■ Input variable

Input variable	Meaning	Data type	Valid range	Default	Description
Master	Master axis number	USINT	Depends on model	Required field	Specify master axis number in the electronic gear.
Slave	Slave axis number	USINT	Depends on model	Required field	Specify slave axis number in the electronic gear.
Execute	Execute	BOOL	TRUE or FALSE	FALSE	Execute this instruction when the rising edge of this parameter is detected.
ContinuousUpdate	continually updated	BOOL	TRUE or FALSE	FALSE	Reserved
RatioNumerator	Gear ratio numerator	LREAL	Positive or negative number	Required field	Specify the numerator of the electronic gear ratio between the master and slave axes.
RatioDenominator	Gear ratio denominator	LREAL	Positive number	Required field	Specify the denominator of the electronic gear ratio between the master and slave axes.
MasterValueSource	Master position type setting	MC_Source	0: mcSetValue 1: mcActualValue	0	Setting the slave axis to follow the master axis command position or actual position. 0: Setting the slave axis to follow the master axis command position. 1: Setting the slave axis to follow the master axis actual position.
Acceleration	Acceleration	LREAL	Positive number	Required field	When the slave axis is coupling with the master axis, the slave axis acceleration rate. *1 (Unit :travel units/s^2) *2
Deceleration	Deceleration	LREAL	Positive number	Required field	When the slave axis is coupling with the master axis, the slave axis deceleration rate. *1 (The unit :travel units/s^2) *2
Jerk	Jerk	LREAL	Positive number	Required field	When the slave axis is coupling with the master axis, the slave axis jerk. *1 (The unit :travel units/s^3) *2
BufferMode	Buffer mode	MC_Buffer_Mode	0: mcAborting 1: mcBuffered	0	Specify the behavior when executing between the two motion instruction. *3 0: Aborting 1: Buffered

*1: For the relationship between Velocity, Acceleration, Deceleration and Jerk, please refer to the section 'Motion Control Command Parameter Description'.

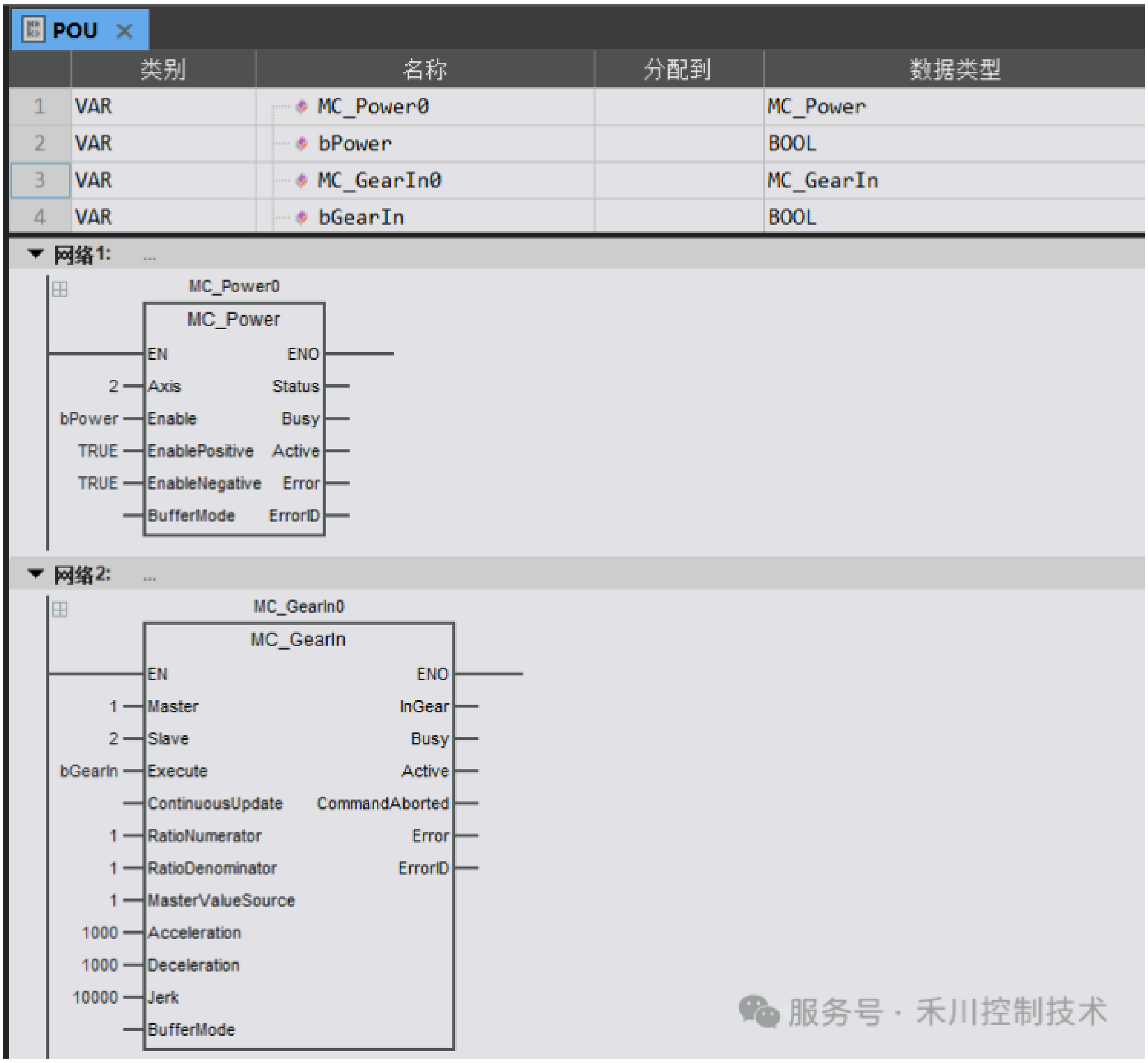
*2: Refer to the 'Motion Control Command Parameter Units' for details on travel units.

*3: For details of BufferMode, please refer to 'Description of Buffer Mode for Multi-Startup of Motion Control Instructions'.

■ Output Variables

Output variable	Meaning	Data type	Default	Description
InGear	Gear ratio achieved	BOOL	TRUE or FALSE	TRUE when the slave axis reaches the target velocity.
Busy	Executing	BOOL	TRUE or FALSE	TRUE when the instruction is acknowledged.
Active	Controlling	BOOL	TRUE or FALSE	TRUE when the axis is being controlled.
CommandAborted	Command aborted	BOOL	TRUE or FALSE	TRUE when the instruction is aborted.
Error	Error	BOOL	TRUE or FALSE	TRUE while there is an error.
ErrorID	Error code	WORD	0~65535	Refer to "Instruction Error Code Description" for the meaning of the output error code value when an instruction execution exception occurs.

③ Program editing



	类别	名称	分配到	数据类型
1	VAR	MC_Power0		MC_Power
2	VAR	bPower		BOOL
3	VAR	MC_GearIn0		MC_GearIn
4	VAR	bGearIn		BOOL

网络1: ...

MC_Power0
MC_Power
EN — ENO
2 — Axis — Status
bPower — Enable — Busy
TRUE — EnablePositive — Active
TRUE — EnableNegative — Error
BufferMode — ErrorID

网络2: ...

MC_GearIn0
MC_GearIn
EN — ENO
1 — Master — InGear
2 — Slave — Busy
bGearIn — Execute — Active
ContinuousUpdate — CommandAborted
1 — RatioNumerator — Error
1 — RatioDenominator — ErrorID
1 — MasterValueSource
1000 — Acceleration
1000 — Deceleration
10000 — Jerk
BufferMode

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④ FB testing

【Key parameter configuration】

RatioNumerator is set to 1: gear ratio numerator.

RatioDenominator set to 1: gear ratio denominator.

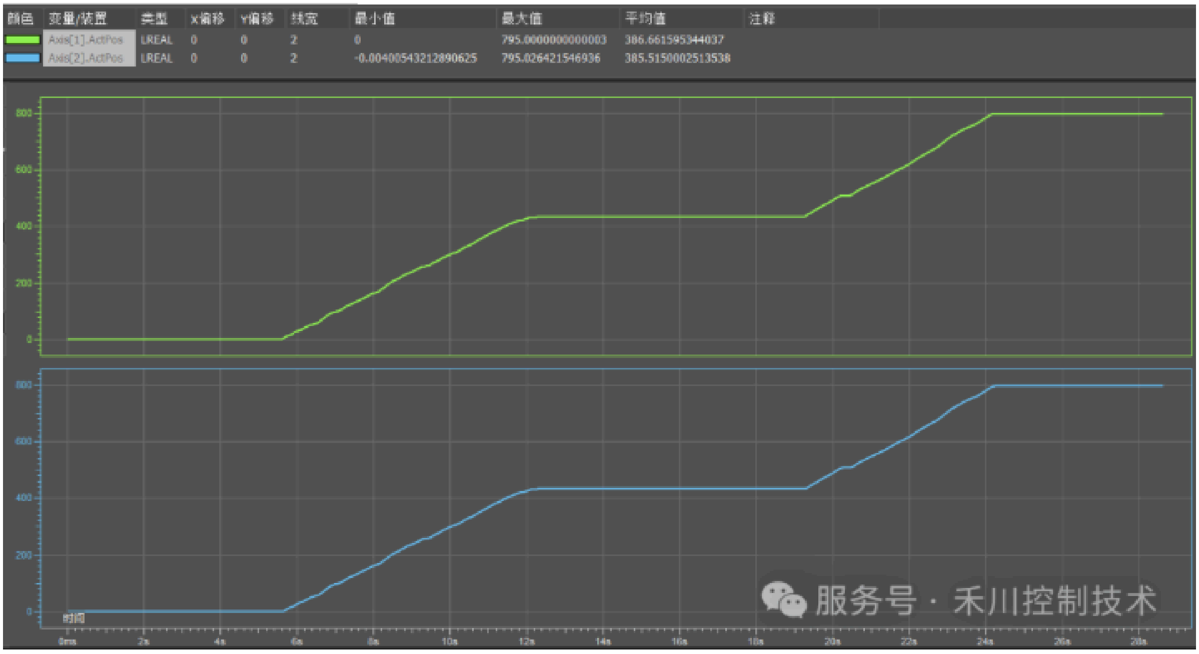
MasterValueSource is set to 1: Set the slave axis to follow the actual position of the master axis.

【Command running effect】

a. Set the bPower variable to enable Axis[2], then set the bGearIn variable to trigger the execution of the gear engagement instruction.

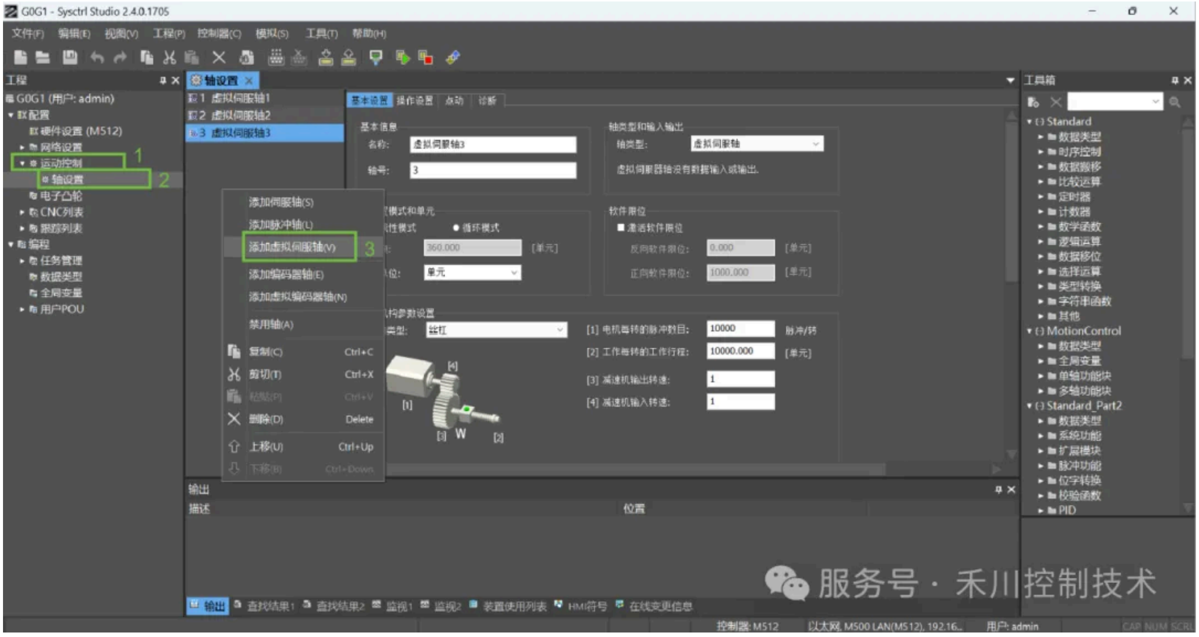
b. At this time, turn the hand wheel, and the servo axis will follow the hand wheel at a 1:1 ratio.

【Operation effect waveform】



颜色	变量/装置	类型	X偏移	Y偏移	线宽	最小值	最大值	平均值	注释
🟩	Axis[1].ActPos	LREAL	0	0	2	0	795.0000000000003	386.661595344037	
🟦	Axis[2].ActPos	LREAL	0	0	2	-0.00400543212890625	795.026421546936	385.5150002513538	

MC_GearOut



名称: 虚拟伺服轴3
轴号: 3
轴类型: 虚拟伺服轴
虚拟伺服器轴没有数据输入或输出.
● 循环模式
360.000 [单元]
单元
■ 激活软件限位
反向软件限位: 0.000 [单元]
正向软件限位: 1000.000 [单元]
类型: 丝杠
[1] 电机每转的脉冲数目: 10000 脉冲/转
[2] 工作每转的工作行程: 10000.000 [单元]
[3] 减速机输出转速: 1
[4] 减速机输入转速: 1

G0G1 - Sysctrl Studio 2.4.0.1705
文件(F)
编辑(E)
视图(V)
工程(P)
控制器(C)
模拟(S)
工具(T)
帮助(H)
工程
G0G1 (用户: admin)
配置
硬件设置 (M512)
网络设置
运动控制
1
轴设置
2
电子凸轮
CNC列表
跟踪列表
编程
任务管理
数据类型
全局变量
用户POU
轴设置
1 虚拟伺服轴1
2 虚拟伺服轴2
3 虚拟伺服轴3
添加伺服轴(S)
添加脉冲轴(L)
添加虚拟伺服轴(V)
3
添加编码器轴(E)
添加虚拟编码器轴(N)
禁用轴(A)
复制(C) Ctrl+C
剪切(T) Ctrl+X
粘贴(P) Ctrl+V
删除(D) Delete
上移(U) Ctrl+Up
下移(W) Ctrl+Down
基本设置
操作设置
点动
诊断
基本信息
轴类型和输入输出
模式和单元
线性模式
软件限位
构参数设置
[4]
[1]
[3]
W
[2]
工具箱
Standard
数据类型
时序控制
数据搬移
比较运算
定时器
计数器
数学函数
逻辑运算
数据移位
选择运算
类型转换
字符串函数
其他
MotionControl
数据类型
全局变量
单轴功能块
多轴功能块
Standard_Part2
数据类型
系统功能
扩展模块
脉冲功能
位字转换
校验函数
PID
输出
描述
位置
输出
查找结果1
查找结果2
监视1
监视2
装置使用列表
HMI符号
在线变更信息
控制器: M512
以太网 M500 LAN(M512), 192.16...
用户: admin
CAP NUM SCRL
服务号 · 禾川控制技术

① Functional description

This instruction controls the slave axis to disengage the gear relationship with the master axis. After disengagement, the slave axis continues to move at the speed at the time of disengagement. If you want to stop the slave axis, you need to use the MC_STOP instruction to stop the axis. You can also directly use the MC_STOP instruction to interrupt GearIn to achieve electronic gear disengagement.

② Parameter Description

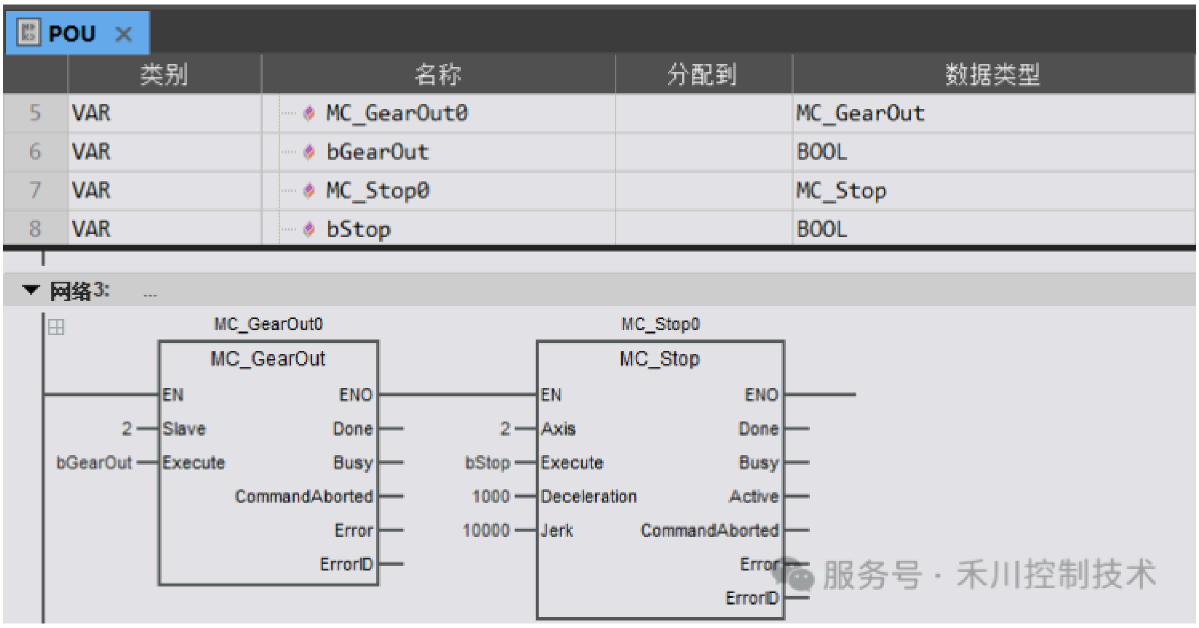
- Input variable

Input Variable	Meaning	Data type	Valid range	Default	Description
Slave	Slave axis number	USINT	Depends on model	Required field	Specify slave axis number in the electronic gear.
Execute	Execute	BOOL	TRUE or FALSE	FALSE	Execute this instruction when the rising edge of this parameter is detected.

- Output Variables

Output variable	Meaning	Data type	Default	Description
Done	End gear operation	BOOL	TRUE or FALSE	The electronic gear relationship between the slave axis and the master axis is also disengaged.
Busy	Executing	BOOL	TRUE or FALSE	TRUE when the axis is being controlled.
CommandAborted	Controlling	BOOL	TRUE or FALSE	TRUE when the instruction is aborted.
Error	Error	BOOL	TRUE or FALSE	TRUE while there is an error.
ErrorID	Error code	WORD	0~65535	Refer to "Instruction Error Code Description" for the meaning of the output error code value when an instruction execution exception occurs.

③ Program editing



POU

	类别	名称	分配到	数据类型
5	VAR	MC_GearOut0		MC_GearOut
6	VAR	bGearOut		BOOL
7	VAR	MC_Stop0		MC_Stop
8	VAR	bStop		BOOL

网络3:
MC_GearOut0
MC_GearOut
EN
ENO
2
Slave
Done
bGearOut
Execute
Busy
CommandAborted
Error
ErrorID
MC_Stop0
MC_Stop
EN
ENO
2
Axis
Done
bStop
Execute
Busy
1000
Deceleration
Active
10000
Jerk
CommandAborted
Error
ErrorID

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④ FB testing

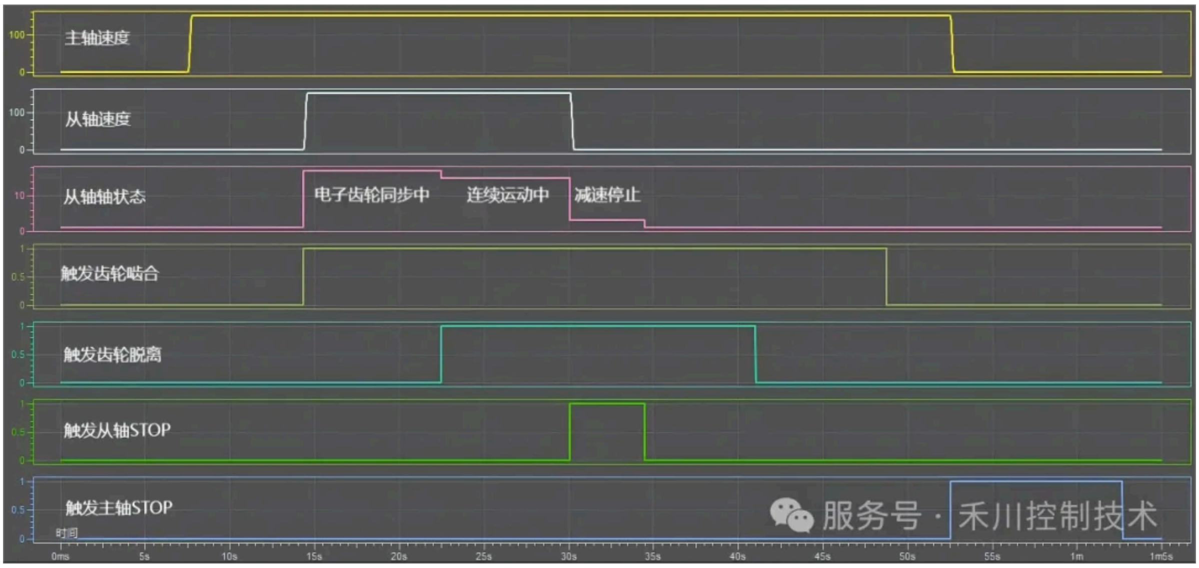
【Command running effect】

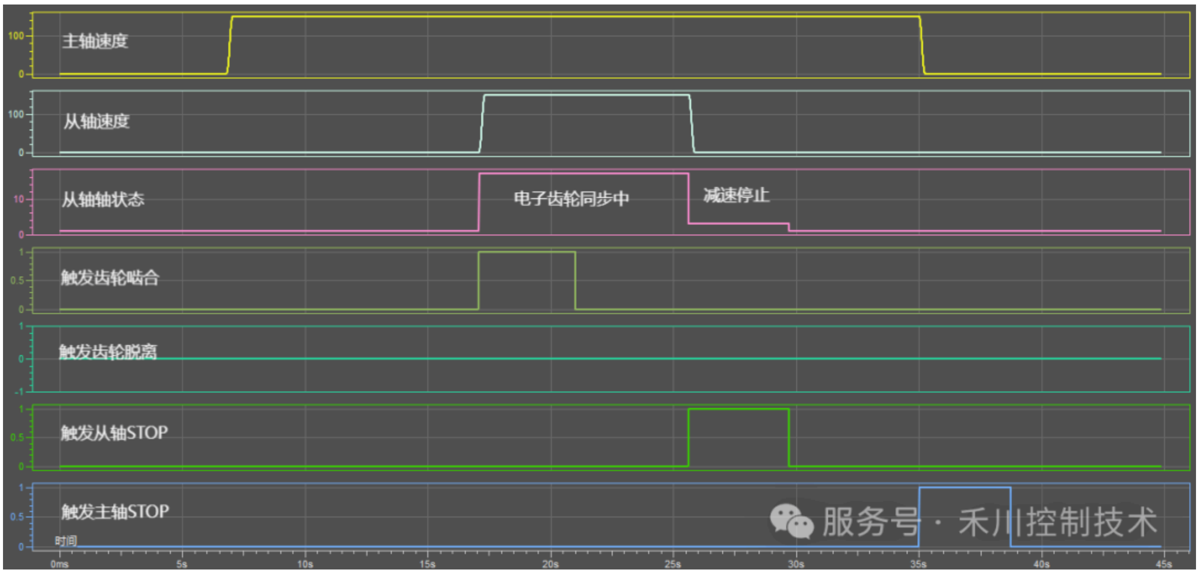
a. When the main axis moves at a constant speed, the electronic gear engagement command is triggered and the slave axis enters the "electronic gear synchronization" state.

b. At this point, trigger the electronic gear disengagement command, and the slave axis status will change to continuous motion, indicating that it has disengaged from the electronic gear, but it will maintain the speed before disengagement. The slave axis will stop running only when the MC_STOP command is triggered, as shown in Figure 1.

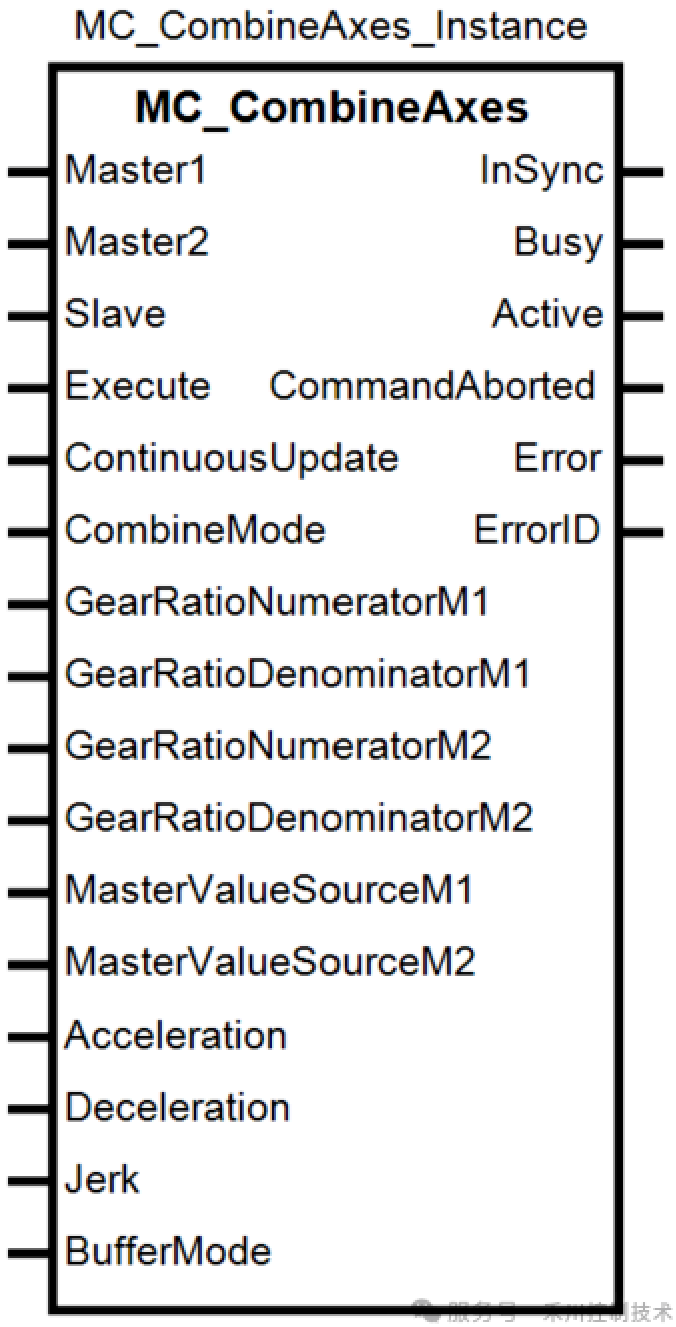
c. If the electronic gear is engaged, directly triggering the MC_STOP instruction will also disengage the electronic gear and stop, as shown in Figure 2.

【Operation effect waveform】


主轴速度
100
0
从轴速度
100
0
从轴轴状态
10
0
电子齿轮同步中
连续运动中
减速停止
触发齿轮啮合
1
0.5
0
触发齿轮脱离
1
0.5
0
触发从轴STOP
1
0.5
0
触发主轴STOP
1
0.5
0
时间
0ms
5s
10s
15s
20s
25s
30s
35s
40s
45s
50s
55s
1m
1m5s
服务号 · 禾川控制技术


主轴速度
100
0
从轴速度
100
0
从轴轴状态
10
0
电子齿轮同步中
减速停止
触发齿轮啮合
1
0.5
0
触发齿轮脱离
1
0
-1
触发从轴STOP
1
0.5
0
触发主轴STOP
1
0.5
0
时间
0ms
5s
10s
15s
20s
25s
30s
35s
40s
45s
服务号 · 禾川控制技术

MC_CombineAxes (dual-master electronic gear command)


MC_CombineAxes_Instance
MC_CombineAxes
Master1
Master2
Slave
Execute
ContinuousUpdate
CombineMode
GearRatioNumeratorM1
GearRatioDenominatorM1
GearRatioNumeratorM2
GearRatioDenominatorM2
MasterValueSourceM1
MasterValueSourceM2
Acceleration
Deceleration
Jerk
BufferMode
InSync
Busy
Active
CommandAborted
Error
ErrorID

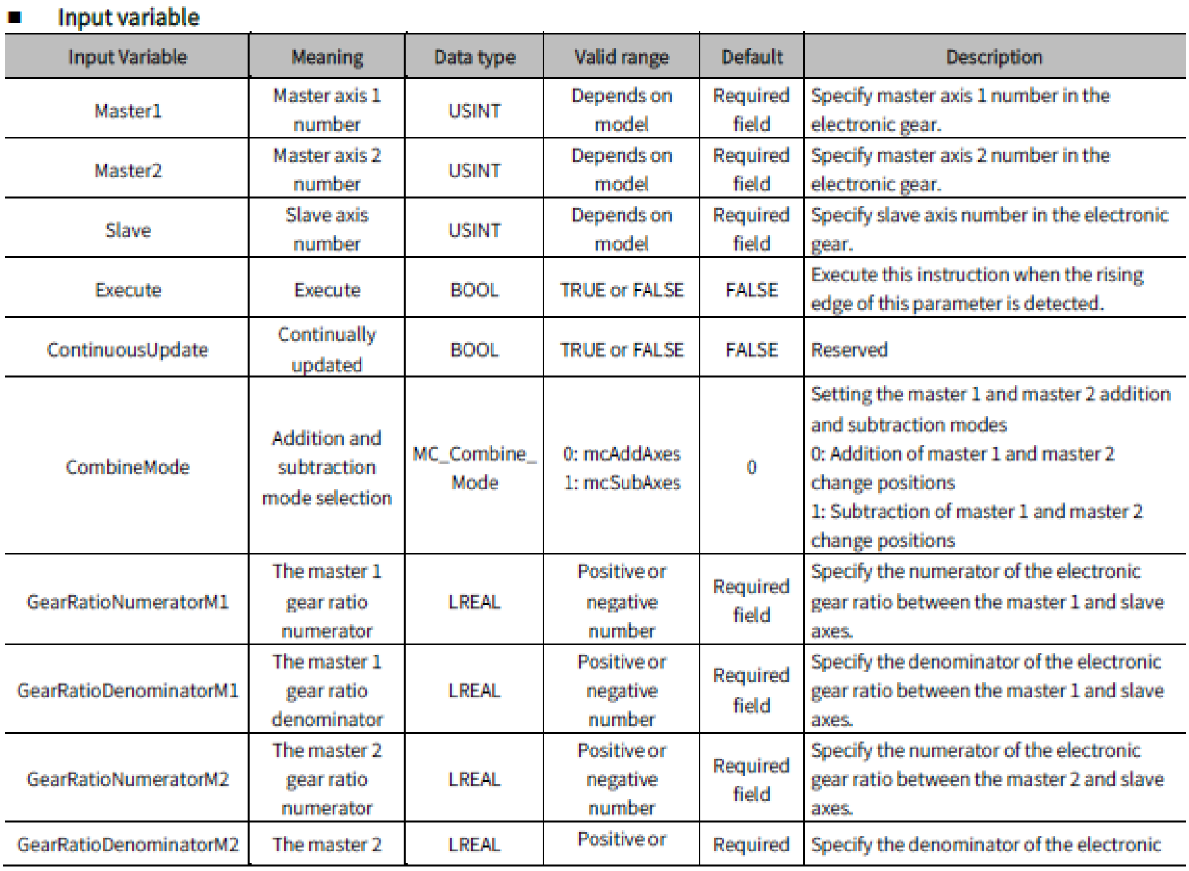
① Functional description

This instruction controls the slave axis to follow the two master axes and make synchronous motion at the gear speed according to the set gear ratio. The parameter CombineMode is used to set the superposition mode to addition or subtraction.

- **CombineMode = 0 (Addition Mode):**
  The slave axis displacement increment = (Master1 displacement increment × Master1 gear ratio numerator / Master1 gear ratio denominator) **+** (Master2 displacement increment × Master2 gear ratio numerator / Master2 gear ratio denominator).
- **CombineMode = 1 (Subtraction Mode):**
  The slave axis displacement increment = (Master1 displacement increment × Master1 gear ratio numerator / Master1 gear ratio denominator) **-** (Master2 displacement increment × Master2 gear ratio numerator / Master2 gear ratio denominator).

- **Termination Method:**
  The gearing operation with dual masters can be stopped (disengaged) using the `MC_STOP` command. The `MC_GearOut` command **must not** be used for this purpose.

②Parameter Description



■ **Input variable**

Input Variable	Meaning	Data type	Valid range	Default	Description
Master1	Master axis 1 number	USINT	Depends on model	Required field	Specify master axis 1 number in the electronic gear.
Master2	Master axis 2 number	USINT	Depends on model	Required field	Specify master axis 2 number in the electronic gear.
Slave	Slave axis number	USINT	Depends on model	Required field	Specify slave axis number in the electronic gear.
Execute	Execute	BOOL	TRUE or FALSE	FALSE	Execute this instruction when the rising edge of this parameter is detected.
ContinuousUpdate	Continually updated	BOOL	TRUE or FALSE	FALSE	Reserved
CombineMode	Addition and subtraction mode selection	MC_Combine_Mode	0: mcAddAxes 1: mcSubAxes	0	Setting the master 1 and master 2 addition and subtraction modes 0: Addition of master 1 and master 2 change positions 1: Subtraction of master 1 and master 2 change positions
GearRatioNumeratorM1	The master 1 gear ratio numerator	LREAL	Positive or negative number	Required field	Specify the numerator of the electronic gear ratio between the master 1 and slave axes.
GearRatioDenominatorM1	The master 1 gear ratio denominator	LREAL	Positive or negative number	Required field	Specify the denominator of the electronic gear ratio between the master 1 and slave axes.
GearRatioNumeratorM2	The master 2 gear ratio numerator	LREAL	Positive or negative number	Required field	Specify the numerator of the electronic gear ratio between the master 2 and slave axes.
GearRatioDenominatorM2	The master 2	LREAL	Positive or	Required	Specify the denominator of the electronic

	gear ratio denominator		negative number	field	gear ratio between the master 2 and slave axes.
MasterValueSourceM1	Master 1 position type setting	MC_Source	0:mcSetValue 1:mcActualValue	0	Setting the position type of master 1 0: Command position 1: Actual position
MasterValueSourceM2	Master 2 position type setting	MC_Source	0:mcSetValue 1:mcActualValue	0	Setting the position type of master 2 0: Command position 1: Actual position
Acceleration	Acceleration	LREAL	Positive number	Required field	When the slave axis couples the master axis, the slave axis acceleration rate. [*1] (The unit :travel units/s2) [*2]
Deceleration	Deceleration	LREAL	Positive number	Required field	When the slave axis couples the master axis, the slave axis deceleration rate. [*1] (The unit :travel units/s2) [*2]
Jerk	Jerk	LREAL	Positive number	Required field	When the slave axis couples the master axis, the slave axis jerk rate. [*1] (The unit :travel units/s2) [*2]
BufferMode	Buffer mode selection	MC_Buffer_Mode	0: mcAborting 1: mcBuffered	0	Specify the behavior when executing between the two motion instruction. [*3] 0: Aborting 1: Buffered

*1: For the relationship between Velocity, Acceleration, Deceleration and Jerk, please refer to the section 'Motion Control Command Parameter Description'.

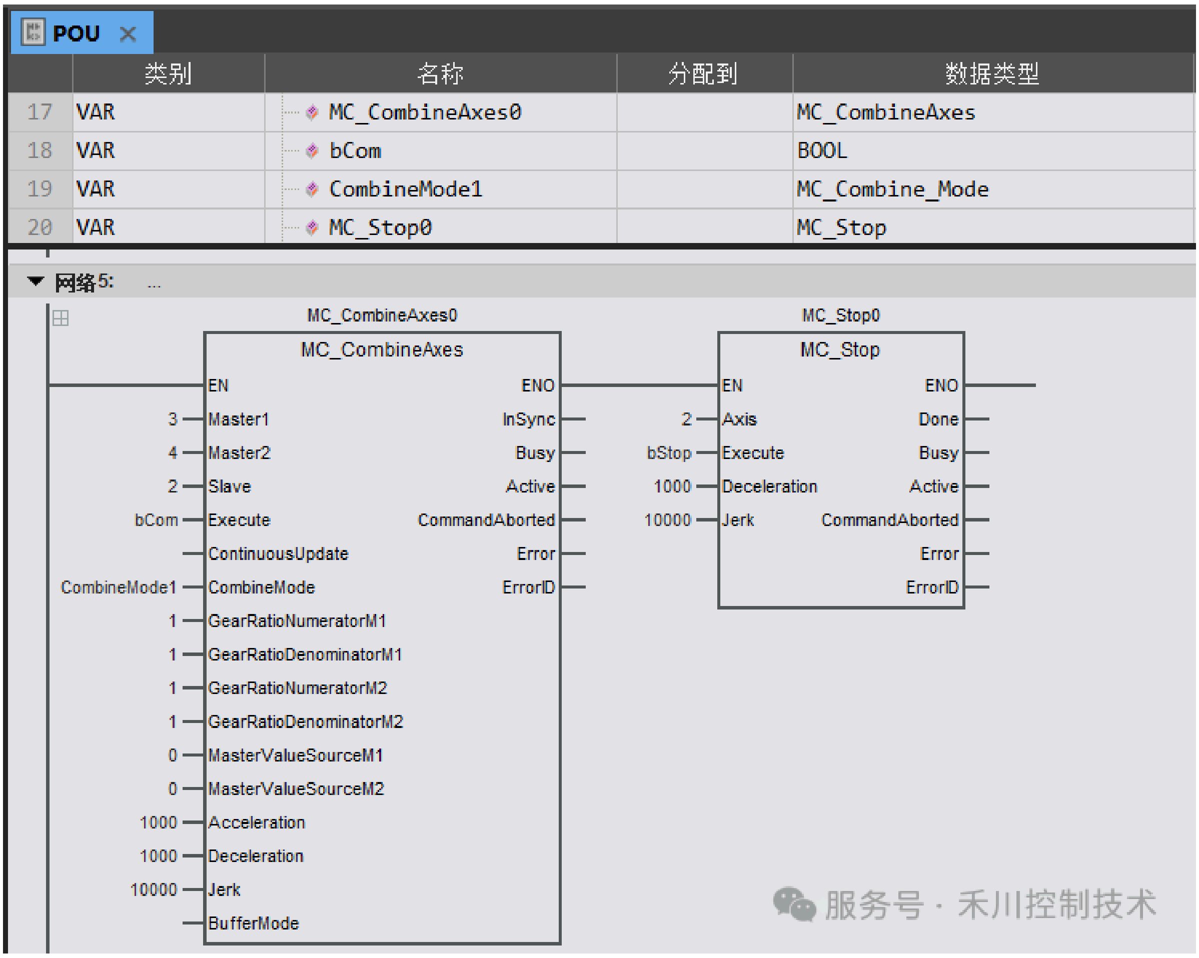
*2: Refer to the 'Motion Control Command Parameter Units' for details on travel units.

*3: For details of BufferMode, please refer to 'Description of Buffer Mode for Multi-Startup of Motion Control Instructions'.

■ Output Variables

Output variable	Meaning	Data type	Default	Description
InSync	Synchronizing	BOOL	TRUE or FALSE	TRUE when the slave axis reaches the target velocity.
Busy	Executing	BOOL	TRUE or FALSE	TRUE when the instruction is acknowledged.
Active	Under control	BOOL	TRUE or FALSE	TRUE when the axis is being controlled.
CommandAborted	Abortion	BOOL	TRUE or FALSE	TRUE when the instruction is aborted.
Error	Error	BOOL	TRUE or FALSE	TRUE while there is an error.
ErrorID	Error code	WORD	0~65535	Refer to "Instruction Error Code Description" for the meaning of the output error code value when an instruction execution exception occurs.

③Program editing



	类别	名称	分配到	数据类型
17	VAR	MC_CombineAxes0		MC_CombineAxes
18	VAR	bCom		BOOL
19	VAR	CombineMode1		MC_Combine_Mode
20	VAR	MC_Stop0		MC_Stop

网络5: ...

MC_CombineAxes0

MC_CombineAxes

Input	Pin	Output pin
	EN	ENO
3	Master1	InSync
4	Master2	Busy
2	Slave	Active
bCom	Execute	CommandAborted
	ContinuousUpdate	Error
CombineMode1	CombineMode	ErrorID
1	GearRatioNumeratorM1	
1	GearRatioDenominatorM1	
1	GearRatioNumeratorM2	
1	GearRatioDenominatorM2	
0	MasterValueSourceM1	
0	MasterValueSourceM2	
1000	Acceleration	
1000	Deceleration	
10000	Jerk	
	BufferMode	

MC_Stop0

MC_Stop

Input	Pin	Output pin
	EN	ENO
2	Axis	Done
bStop	Execute	Busy
1000	Deceleration	Active
10000	Jerk	CommandAborted
		Error
		ErrorID

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④ FB testing

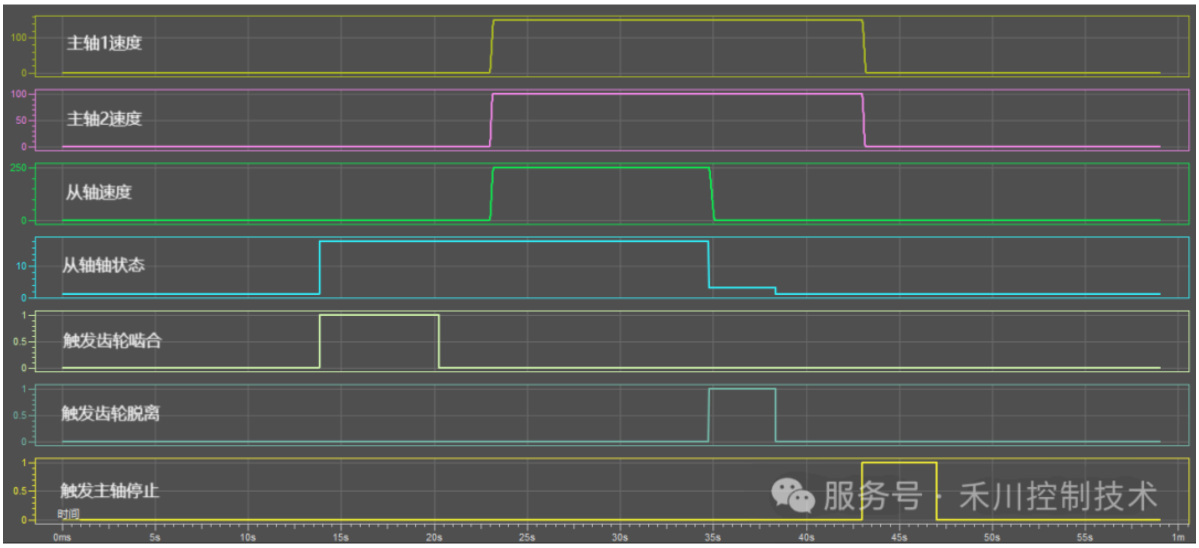
【Key parameter configuration】

- **GearRatioNumeratorM1** is set to 1: Defines the **Gear Ratio Numerator for Master 1**.
- **GearRatioDenominatorM1** is set to 1: Defines the **Gear Ratio Denominator for Master 1**.
- **GearRatioNumeratorM2** is set to 1: Defines the **Gear Ratio Numerator for Master 2**.
- **GearRatioDenominatorM2** is set to 1: Defines the **Gear Ratio Denominator for Master 2**.
- **MasterValueSourceM1** is set to 0: Sets the position type for Master 1 to **Command Position**.
- **MasterValueSourceM2** is set to 0: Sets the position type for Master 2 to **Command Position**.

【Command running effect】

a. Add constant velocity motion commands for the two master axes, trigger the dual-master electronic gearing engagement command, and then trigger the constant velocity motion of the two masters.
b. When `CombineMode` = 0, the **Slave Axis Velocity = Master1 Velocity + Master2 Velocity**.
c. When `CombineMode` = 1, the **Slave Axis Velocity = Master1 Velocity - Master2 Velocity**.

【Operation effect waveform】



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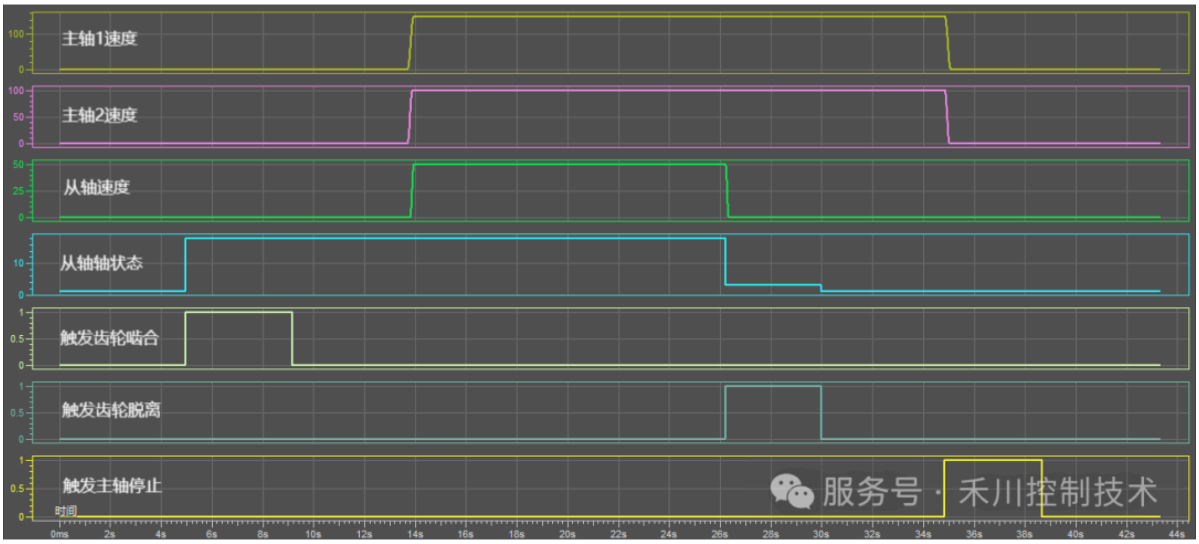

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