

S7-1500T

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功能概述

通过跨 PLC 同步操作,可以实现不同 CPU 上的轴之间的同步操作(齿轮同步或凸轮同步)。所有跟随轴均同时获得相同的引导值。

图 1-1 显示了基于一个应用案例的分布式同步结构,两个 CPU 上分别有两个跟随轴。 图 1-1 分布式同步结构



- 引导轴和本地跟随轴 1 位于 CPU 1 上。引导轴和跟随轴 1 互连在一起以进行同步操作。引导轴的引导值可用于跨 PLC 同步操作。
- 引导值报文通过带 IRT 的 PROFINET IO 传输到 CPU 2。
- 在 CPU 2 上,引导轴代理读取引导值。跟随轴 2 与作为引导轴的引导轴代理本 地互连。
- 跟随轴 1 和跟随轴 2 是同步的,并且跟随相同的引导值。

需注意:

S7-1500 和 S7-1500T CPU 可以生成用于跨 PLC 同步的引导值。 需要使用 S7-1500T CPU 作为通过引导轴代理来接收其他 CPU 的引导值。

2 项目配置

2.1 使用的软件及硬件

项目配置使用的软件及硬件如表 2-1 所示。 表 2-1 项目配置使用的软件及硬件

序号	组件	版本
1.	CPU 1511-1 PN	Fw2.8
2.	CPU 1517TF-3 PN/DP	Fw2.8
3.	TIA Portal STEP 7 Professional	V16
4.	TIA Portal StartDrive	V16

2.2 项目配置步骤

1. 组态硬件

在项目中配置两套 S7-1500T,此处使用的是 S7-1511T 和 S7-1517TF,配置网 络连接如图 2-1 所示。

图 **2-1** 网络视图



2. 通信组态

a. 首先确保所有的设备组态到同一 PROFINET 网络中,一个 PLC 设置为同步 主,其他设置为同步从。

S7-1517TF CPU 配置为同步主站,如图 2-2 所示。

	7TF 为同步主站	
PLC_S210_TO CPU 1517TF-3 P	S210_TO_47 S210 PN PLC_S210_TO PN/TE_TO	ET200SP_49 IM 155-6 PN HF PLC_5210_TO
PLC_V90_T0_1 CPU 1511T-1 PN PLC_V	TO_1 V90_TO_2 N V90 PN 01 1 PLC_V90_TO_1	
<		> 100%
PN/IE_TO [Industrial Ethernet]		
General IO tags Syste	m constants Texts	
PROFINET Subnet		
General	>>> Devices	
▼ Domain management	IO system	
 Sync domains 		
 Sync domains Sync-Domain_1 	IO system	Sync master
 Sync domains Sync-Domain_1 Uevices 	IO system PLC_S210_TO.PROFINET IO-System (100)	Sync master PLC_S210_TO
 Sync domains Sync-Domain_1 Devices Details 	IO system PLC_S210_T0.PROFINET IO-System (100) PLC_V90_T0_1.PROFINET IO-System (100)	Sync master PLC_5210_TO PLC_5210_TO
Sync domains Sync-Domain_1 Details MRP domains	IO system PLC_S210_TO.PROFINET IO-System (100) PLC_V90_TO_1.PROFINET IO-System (100)	Sync master PLC_5210_TO PLC_5210_TO
Sync domains Sync-Domain_1 Devices Details MRP domains Overview isochronous mode	IO system PLC_S210_TO_PROFINETIO-System (100) PLC_V90_TO_1.PROFINETIO-System (100)	Sync master PLC_5210_TO PLC_5210_TO
Sync domains Sync-Domain_1 [bevices] Details MRP domains Overview is ochronous mode PLC_S210_TO_PROFINETIO-Sy	IO system PLC_S210_TO.PROFINETIO-System (100) PLC_V90_TO_1.PROFINETIO-System (100)	Sync master PLC_5210_TO PLC_5210_TO
Sync domains Sync-Domain_1 Uevices Details MRP domains Overview isochronous mode PLC_S210_TO.PROFINETIO-Sy PLC_V90_TO_1.PROFINETIO-sy	IO system PLC_5210_TO.PROFINET IO-System (100) PLC_V90_TO_1.PROFINET IO-System (100)	Sync master PLC_5210_TO PLC_5210_TO
Sync domains Sync domains Sync domains Details NRP domains Overview isochronous mode PLC_S210_T0_PROFINETIO-sy PLC_V90_T0_1.PROFINETIO	IO system PLC_5210_TO_PROFINETIO-System (100) PLC_V90_TO_1.PROFINETIO-System (100) IO devices	Sync master PLC_5210_TO PLC_5210_TO
Sync domains Sync Domain_1 [bevices] Details NRP domains Overview isochronous mode PLC_S210_T0_PROFINETIO-5y PLC_V90_T0_1.PROFINETIO	IO system PLC_5210_T0_PROFINETIO-System (100) PLC_V90_T0_1.PROFINETIO-System (100) IO devices	Sync master PLC_5210_TO PLC_5210_TO
Sync domains Sync domains Devices Details MR domains Overview isochronous mode PLC_S210_70 RPGINETIO-Sy PLC_V90_T0_1.PROFINETIO	IO system PLC_5210_TO_PROFINETIO-System (100) PLC_S210_TO_1.PROFINETIO-System (100) PLC_V90_TO_1.PROFINETIO-System (100) IO devices PROFINET device name RT class Synchror	Sync master PLC_5210_TO PLC_5210_TO nization role Redundancy level DFP group
Sync domains Sync domains Sync domains Devices Details NRP domains Overview isochronous mode PLC_S210_T0.PROFINETIO-5y PLC_V90_T0_1.PROFINETIO	IO system PLC_S210_TD.PROFINETIO-System (100) PLC_V90_TO_1.PROFINETIO-System (100) PLC_V90_TO_1.PROFINETIO-System (100) IO devices PROFINET device name RT class Synchror plc_s210_to.profinet interface_1 RT * Sync ma	Sync master PLC_5210_T0 PLC_5210_T0 PLC_5210_T0 Inization role Redundancy level DFP group Ister No redundancy
Sync domains Sync domains Sync Domain_1 [bevices] Details NRP domains Overview isochronous mode PLC_S210_TO_PROFINETIO-5y PLC_V90_TO_1.PROFINETIO	IO system PLC_S210_TO_PROFINETIO-System (100) PLC_V90_TO_1.PROFINETIO-System (100) IO devices PROFINET device name RT class Synchror pl_S210_to profinet interface_1 RT. ▼ Sync sla et200sp-49 IRT Sync sla	Sync master PLC_5210_TO PLC_5210_TO PLC_5210_TO ster No redundancy level No redundancy Ve No redundancy
Sync domains Sync domains Details Details NRP domains Overview isochronous mode PLC_S210_DRADINETIOS PLC_V90_T0_1.PROFINETIO	IO system PLC_S210_TD.PROFINETIO-System (100) PLC_S210_TD_PROFINETIO-System (100) PLC_V90_TO_1.PROFINETIO-System (100) IO devices PROFINET device name RT class Synchror pL_s210_to profinet interface_1 RT § Synchror Synchror et200.pd-94 IRT Sync slav s210:47 IRT Sync slav	Sync master PLC_5210_TO PLC_5210_TO PLC_5210_TO Ster No redundancy level No redundancy ve No redundancy ve No redundancy ve No redundancy

S7-1511TCPU 配置为同步从,如图 2-3 所示。 图 2-3 配置 S7-1511T 为同步从站



 a. 配置数据交换区,首先选择引导轴所在的PLC,本文为S7-1517TF。选中S7-1517TF之后,在"IO communication"中拖拽接受PLC"S7-1511T" 到 Partner 2 列的"Drop or select the device here"位置中。



图 2-4 通过拖拽的方式建立直接数据交换

b. 在建立的"Direct data exchange"属性中,配置数据长度为48个字节

图 2-5 配置 48 个字节的发送数据

Network			Network overview Connections Offine configuration 2 Online assignm	I/O communication	VPN TeleContro	Ы				
PLC_5210_TO	\$210_TO_47	1	Partner 1	+ Partner 2	Interface partner 2	Mode	Optional IO-Device	Update time [ms]	Update time mode	
50 IS171P-S P	5210 HV	1	 MLC_S210_T0 							
• • • •		2	 PROFINET interface_1 		and an and a second sec	10 1 S				
	MC_5210_10	3	×1	↔ 5210_10_48	PROFINET Interface	IO device		2.000	Automatic	
		1	XI	↔ 5210_10_4/	PROPINCI Intensce	10 device		2.000	Automatic	
		16	x1	→ PLC_V90_T0_1	PROFINET interface_1	Direct data exchange	15	2.000	-	•
		- 7	PDOFINET interface 2				- 2			
		0	T DPinterface 1							
			or manage	Drop the device here of	14.					
	<u>. TO 1</u>	~								
I > 100%	·	•							_	
rect data exchange [DDX]									Properti	es
General IO tags System	constants Te:	xts								
Direct data exchange	irect data exchang	e								
Iranster atea 1	Transfer areas									
		_								
	F 🗠 🗹 Inputs					Outputs				
	Transfer area	1	Type Address PLC_S + Partner Par	ther address Length						
	Transferace		0 300 313 - MCV 13	FC 303 10.0 m						
	inditional disc.		Q 290	50505 40 byte						

c. 配置 IO 区属性,在"Organization block"属性中选择"MC-Servo"

图 2-6 配置直接交换数据

General IO tags 5	System constants Texts			
Direct data exchange Transfer area 1	Transfer area 1			
	Details of the transfer area			
	Transfer area :	Transfer area 1		
	Transfer area type:	DX		
		Local		Partner
	Data exchange between:	PLC_S210_T0	and	PLC_V90_T0_1
	Address type:	Output		Input
	Start address:	296		256
	Organization block:	MC-Servo		MC-Servo
	Process image:	PIP OB Servo		PIP OB Servo
	Data length [byte]:	48		
	Consistency:	Total length		Total length
	Comment:			

d. 创建引导轴的数据变量,数据类型为"DX_TEL_SyncOp",地址为创建的输出区的首地址:

图 2-7 在 S7-1517TF 中建立变量

DEMO_TCPU_S210		з	- 1	SynchronousAxis_48_Actor_In	"PD_TEL105_IN"	%1256.0
 Image: PLC_S210_TO [CPU 1517TF-3 PN/DP] 	=	4 5		sendLeadingValue	DX_TEL_SyncOp	∎ %Q296.0 ▼
Q Online & diagnostics		7	-	enable	Bool	%M0.1
Software units		8	-	home	Bool	%M0.2
Program blocks		9		<add new=""></add>		
Technology objects						
Energy objects						
External source files						
🕶 🌄 PLC tags						
Show all tags		Ge	eneral	Texts Supervisions		
Gefault tag table [91]		Та	9	Tag		

e. 创建跟随轴的数据变量,数据类型为"DX_TEL_SyncOp",地址为创建的输入区的首地址

图 2-8 在 S7-1511T 中建立变量

DEMO_TCPU_V90	^			N	Name	Data type	Address	Ret
▼ 🖬 TO 1511T		1	-		PositioningAxis_1_Actor_Interf	"PD_TEL105_IN"	%10.0	
PLC_V90_T0_1 [CPU 1511T-1 PN]		2			PositioningAxis_1_Actor_Interf	"PD_TEL105_0	%Q0.0	
Device consiguration		3		1	 PositioningAxis_1_Actor_Interf 	"PD_TEL750_IN"	%140.0	
Online & diagnostics		4		1	PositioningAxis_1_Actor_Interf	"PD_TEL750_O	%Q40.0	
Software units		5		1	 SynchronousAxis_1_Actor_Inte. 	. "PD_TEL105_IN"	%120.0	
🕨 🚘 Program blocks		6	-00	1	 SynchronousAxis_1_Actor_Inte. 	. "PD_TEL105_0	%Q20.0	
Technology objects		7	-00	1	 SynchronousAxis_1_Actor_Inte. 	. *PD_TEL750 🔳	%142.0	-
Energy objects		8	-671	,	SynchronousAxis 1 Actor Inte.	"PD TEL750 O	%046.0	
External source files		9		0	revLeadingValue	*DX_TEL_SyncO	%1256.0	
🔻 🌄 PLC tags		10			ellable	5001	76IVIU.U	
🝇 Show all tags		11	-	1	home	Bool	%M0.1	
add new tan table	=	12		_		Rool	N.MO.2	
🝟 Default tag table [87]		Syn						
PLC data typer				_	1			

f. 关联引导轴数据,在作为主轴的属性中选中输出变量:

图 2-9 在 S7-1517TF 中关联发送变量



g. 创建引导轴代理工艺对象,关联引导轴数据,在属性中选中输入变量:

图 2-10 在 S7-1511T 中建立引导轴代理



图 2-21 在 S7-1511T 中关联接收变量



2.3 延迟时间的说明

在主值的处理和传输过程中,在一个 CPU 的引导轴上生成主值与在其它 CPU 的引导轴代理上为跟随轴提供主值之间会产生延迟时间。这样会造成其它 CPU 的跟随轴 会延迟一段时间接收主值。有两种处理方法(延迟或者外推):

- 1. 延迟方式:通过延迟引导轴传递到同 CPU 的跟随轴数据,来保证同 CPU 的跟随轴与分布式同步的跟随轴一致。
 - a. 首先设置引导轴传递到本地 CPU 跟随轴的延时时间

图 2-32 引导轴的延时时间画面

🕆 🖶 E1 E1	
Basic parameters 🥑	
Hardware interface 🤣	Leading value settings
Drive 🥏	
Encoder 🤣	
Data exchange with the drive 📀	CPU of the reading axis
Leading value settings	Leading axis Following axis
Mechanics 🤣	
Dynamic default values 🤣	
Emergency stop 🤣	
🕶 Limits 🥏	
Position limits 🤡	
Dynamic limits 🤣	PROFINET IRT
Torque limits 🤣	Transferarea
Fixed stop detection 🤣	
🕶 Homing 🛛 🥑	Provision of leading value
Active homing 🤣	
Passive homing 🥏	Provide cross-PLC leading value
🕶 Position monitoring 🛛 🤡	Transfer area: sendLeadingValue
Position monitoring 🤣	
Following error 🤣	Delay time of local leading value
Standstill signal 🤡	
Control loop 🤣	Allow system calculation Interconnection overview
Actual value extrapolation	Delayti e: 80 ms

b. 延时时间的数值可以通过"Interconnection overview"自动计算: 自动计算的界面如下图所示(此界面只有在完成主从轴配置后才能出现):

图 2-43 自动计算分布式同步延迟

-Entertext filter-		Show delay:	imer		Show local supply		ionr		
	Leading value	Show delay	ames		Show local synchi	onous operat	aons		
PLC	Leading axis	DT	Leading val	PLC	Following axis	Routes	Leading axis proxy	DT	Inter
PLC_S210_TO	PositioningAxis_47	8.0	Local delayed	PLC_S210_TO	Synchronous Axis_48	•	-		
		8.0	Cross-PLC	PLC_V90_TO_1	Synchronous Axis_43	_	LeadingAxisProxy_1	0.0	
<				11					
			1. 10		9				
te SynchronousAxis_48	× 10	oute Synchronous#	xis_43	×					
		PLC_S210_TO							
		PositioningA	xis_47 DT	= 8 ms					
	•	🗸 🖶 4 ms							
RIC COLO TO		PLC_V90_T0_1							
FLC_5210_10									
ResitioningAxis_47	DT = 8 ms	🚀 LeadingAxisI	Proxy_1 DT	= 0 ms					

- c. 或者不勾选 "Allow system calculation"而自行设置。
 原则上,每个级联的延迟时间为:
 延迟时间 = 2 x 引导轴代理的 CPU 的应用周期(OB91周期)。
- d. 对于本地跟随轴,需要选择引导轴类型为"Delayed":

图 2-54 本地 CPU 的引导轴延迟选择

Project1_V16 → DEMO_TCPU_S210	0 → TO PLC_S210_TO [CPU 1517TF-3 PN/DP] → Technology objects → SynchronousAx	is_48 [DB3]
Basic parameters Hardware interface Drive	Leading value interconnections	
Encoder 🤡	Interconnection overview	
Data exchange with encoder	Possible leading val Leading value source Type of connection	
Leading value interconnections	Add>	_
• Extended parameters	Delayed	
Mechanics 🤣		
Dynamic default values 📀		
Emergency stop 🥏		
👻 Limits 📀		
Position limits		
Dynamic limits 🥏		
Torque limits 🥏		
Fixed stop detection		
Homing		
a da da da da 👗	A H	

2. 外推方式:通过在引导轴代理工艺对象中设置外推时间,如图 2-15 所示。

取消勾选 "Allow system calculation"复选框,手动输入分布式同步的级联延迟时间:

原则上,每个级联的延迟时间为:

延迟时间=2x引导轴代理的CPU的应用周期(OB91周期)。

图 2-65 设置引导轴代理的外推时间

	-
sic parameters ading value settings	Leading value settings
	CPU of the leading axis CPU of the following axis
	Leading axis proxy PROFINET IRT Leading value
	Transferarea Provision of leading value
	Transfer area: revLeadingValue
	Leading value monitoring Tolerance time invalid leading value: 0.0 s
	Delay time of local leading value
	Allow system calculation

2.4 程序编写



图 2-76 在 S7-1517TF 中编写主轴使能、回零及运行程序





Network 2:
 Comment

	%DB7 "MC_RESET_DB"			%DB8 "MC_RESET_DB_1"	
		MC_RESET		MC_RESET	
E	IN	ENO	EN	ENO	
%DB5 *LeadingAxisProxy		Busy — false	%DB 3 "Synchronous Axis	Busy — false	
_1*	- Axis	CommandAbort ed —Ifalse	_43" — Axis	CommandAbort ed —Ifalse	
%M0.3 "reset" — E	xecute	Error — false	%M0.3 "reset" — Execut	Error — false	
false — p	Restart	Errorld - 16#0	false — Restar	t Errorid — 16#0	



图 2-88 在 S7-1511T 中编写本 CPU 中的跟随轴与引导轴代理同步程序,进行分布同步 测试

3. 测试结果:

通过使用 Project trace 工具(Cross-device function 中),可以监控两个工艺对象的同步效果

图 2-19 CPU1 及 CPU2 中的跟随轴同步位置设定值的 trace 曲线(采用主值延迟方式)

