如何使用i.MX RT1180的EtherCAT与BECKOFF的TwinCAT3和SSC工具

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应用笔记

文档信息

信息	内容
关键词	AN14155、i.MX RT1180 MCU、评估套件(EVK)、MIMXRT1180-EVK、EtherCAT从控制器
	(ESC)、TwinCAT3软件、从站协议栈代码(SSC)工具、软件开发套件(SDK)
摘要	本文介绍了在基于MIMXRT1180-EVK开发板以及I.MX RT1180 SDK搭建的I.MX RT1180平台上使用
	EtherCAT外设的步骤。



1 介绍

i.MX RT1180平台集成了一个双端口EtherCAT从站控制器(ESC)。本文介绍了在基于i.MX RT1180 SDK和 MIMXRT1180-EVK开发板搭建的i.MX RT1180平台上使用EtherCAT外设的方法。还介绍了在EtherCAT工程中使用 EtherCAT从站协议栈代码(SSC)工具和TwinCAT3软件的方法。从站协议栈代码(SSC)工具是一个源代码示 例,可用作在自带处理器的设备中实现EtherCAT的开发基础。

2 硬件平台

2.1 i.MX RT1180跨界MCU

恩智浦的i.MX RTI180跨界MCU是一款双核器件,配备了一个Arm Cortex-M7(CM7)核和一个Cortex-M33(CM33)核。CM7核的运行速度高达800MHz,CM33核的运行速度高达240MHz,配有1.5MB片上RAM。该系列产品支持多种协议,能够在实时以太网和工业4.0系统之间进行通信桥接,并通过集成的EdgeLock安全飞地提供先进的安全性。

i.MX RTI180 MCU包含一个集成的干兆时间敏感网络(TSN)交换机和EtherCAT从站控制器(ESC)。这使其非 常适合工业和汽车通信应用。该MCU还支持使用MCUXpresso生态系统,其中包括SDK、多种IDE以及安全预处 理和配置工具,来实现快速开发。

2.2 i.MX RT1180 EtherCAT的主要特性

采用i.MX RT1180平台的典型工业自动化解决方案,通常具有以下主要特性:

- 传输速度为100Mbit/s的集成以太网收发器
- 2个EtherCAT端口、8个现场总线内存管理单元(FMMU)、8个同步管理器、128字节用户RAM和8K字节过程数据RAM
- 64位分布式时钟
- 过程数据接口(PDI)停用(无PDI)

2.3 MIMXRT1180-EVK开发板

MIMXRT1180-EVK开发板是一个硬件平台,可用于设计和评估i.MX RT1180处理器最常用的功能。

<u>表1</u>显示了MIMXRT1180-EVK开发板上的EtherCAT端口:

表1. MIMXRT1180-EVK上的EtherCAT端口

EtherCAT端口	连接器
EtherCAT端口0	J28
EtherCAT端口1	J32

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3 EtherCAT基本概述

EtherCAT是一种高性能的实时以太网通信协议,通常用于工业自动化领域的实时控制和通信,如伺服电机控制。 Beckhoff于2003年开发了EtherCAT,而国际电工委员会(IEC)将EtherCAT纳入IEC 61158标准,实现了其标 准化。

EtherCAT是一种工业以太网系统,使用以太网标准IEEE 802.3中定义的标准帧和物理层。EtherCAT还满足了自动化行业面临的特定要求,具体如下:

- 具有确定性响应时间的硬实时要求。
- 系统通常包含许多节点,每个节点只有少量的循环过程数据。
- IT管理员不负责现场总线系统的调试和维护。

EtherCAT的设计目标是实现低通信延迟和高带宽数据传输,同时满足高时间精度控制的需求。它通过主从架构实现。主站负责协调整个网络,而从站则负责提供输入和输出数据。

EtherCAT广泛应用于工业机器人、运动控制、自动装配系统和其他工业自动化领域。EtherCAT的主要优点包括: • 通信速度高,带宽可达100Mbit/s。

- 同步性能可达纳秒级。如果所有从站都拥有相同的时间信息,它们就能同时设置输出信号,并为输入信号贴上高精度的时间戳。
- 支持线型、树型、星型或菊花链拓扑结构: EtherCAT支持几乎所有拓扑结构。纯总线或具有多个节点的线型 拓扑结构都是可行的,没有限制。

EtherCAT通过单个帧向所有节点发送和接收控制数据。图1显示了主站和双端口从站之间的传播路径。当EtherCAT 帧到达从站时,从站从EtherCAT帧中读取数据并将数据写入EtherCAT帧。该帧通过每个从站,最终返回主站。



3.1 现场总线内存管理单元(FMMU)

现场总线内存管理单元(FMMU)通过内部地址映射的方法将逻辑地址转换为物理地址。<u>图2</u>显示了逻辑地址映射 到物理地址的方式。

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i.MX RTI180 MCU支持八个FMMU,由EtherCAT主站初始化。FMMU可以从EtherCAT主站定义的八个不同逻辑地址获取数据。"逻辑地址"指的是主站中的地址空间,而"物理地址"指的是从站中的地址空间。

3.2 同步管理器(SM)

ESC的内存用于在EtherCAT主站与本地应用程序(连接到PDI的微控制器)之间的数据交换,且不受任何限制。 这种使用内存进行通信的应用存在一些不足之处。ESC内置的同步管理器(SM)能够有效解决这些问题。这些不 足如下所列:

- •数据一致性得不到保证。必须在软件中实现信号量,用于以协调的方式交换数据。
- •数据安全性得不到保证。必须在软件中实现安全机制。
- EtherCAT主站和应用程序都必须轮询内存,以了解另一方的访问何时结束。

同步管理器(SM)支持缓冲模式和邮箱模式。i.MX RT1180支持八个同步管理器。通常,SMO和SM1用于邮箱通信, 而SM2和SM3用于过程数据的输出和输入。EtherCAT主站负责初始化这些同步管理器。EtherCAT主站通过SII接口 从EEPROM读取同步管理器的相关信息。因此,同步管理器的初始化信息是在SSC工具生成的XML文件中预先定义的。

3.3 EtherCAT分布式时钟

EtherCAT分布式时钟可使所有EtherCAT设备能够共享一个相同的系统时间。通过这种机制,EtherCAT从站设备可以实现相互同步,进而使得本地应用程序也能达到同步运行。为了实现整个系统同步,所有从站都需要与一个参考时钟同步。通常情况下,在一个网段内,主站之后第一个具有分布式时钟功能的ESC将持有参考时间(系统时间)。

从站设备根据系统时间输出同步信号。该信号能够触发中断。支持分布式时钟的从站设备称为DC从站设备。<u>图3</u>显示了分布式时钟以及传播延迟。



对于时钟同步, i.MX RT1180综合考虑了传播延迟、本地时钟源漂移和本地时钟偏移, 具体描述如下:

- 传播延迟:指信号从一个从站到其他从站的传播延迟。
- 时钟偏移:这一时间间隔表示本地时钟与参考时钟之间的偏移。它包括从持有参考时钟的ESC到采用从站时钟的设备之间的传播延迟。本地时间的初始差异是由于各个ESC的上电时间不同引起的。
- 时钟漂移:这一时间间隔是由于参考时钟和DC从站时钟由不同的时钟源驱动而引入的时间偏移。它们的时钟源 可能会受到时钟周期微小偏差的影响,从而导致时间上的偏差。



图4展示了每个从站之间的传播延迟。

- T_{px}表示从站x的处理延迟(经过EtherCAT处理单元,其中x的取值为A至C)。
- T_{wxy}表示从站x和从站y之间的线路传播延迟(假设两个方向的传播延迟是对称的,其中x/y的取值为A至C)。
- Tx0、Tx1分别表示从站x的接收时间端口0/1的值(即检测到第一个前导码位的时间, x的取值为A至C), 这些时间值通过写入分布式时钟接收时间0寄存器来进行测量。

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从站B和从站C之间的传播延迟计算如下:

- 1. $T_{BC}=T_{PB}+T_{WBC}$;
- 2. $T_{CB}=T_{PC}+T_{WBC}$;
- 3. $T_{B1}=T_{B0}+T_{BC}+T_{CB}$;

假设从站B和从站C的处理延迟一致,那么可以得出以下公式:

$T_{BC}=T_{CB}=(T_{B1}-T_{B0})/2;$

为了计算从站B和A之间的传播延迟,可定义以下参数:

- T_{FX}表示从站x的转发延迟(与EtherCAT处理单元一起, x的取值为A至C)
- T_{Diff}表示处理延迟和转发延迟之间的差值。即T_{Diff}=T_P-T_F。因此,以下表达式成立:
- 1. $T_{AB} = T_{PA} + T_{WAB}$;
- 2. $T_{BA} = T_{FB} + T_{WAB}$;
- 3. $T_{BA}=T_{AB}-T_{Diff}$;
- 4. $T_{A1} = T_{A0} + T_{AB} + T_{BC} + T_{CB} + T_{BA}$;
- 5. $T_{AB}+T_{BA}=(T_{A1}-T_{A0})-(T_{B1}-T_{B0})$;

因此,从站A与从站B之间的传播延迟为:

 $T_{AB} = ((T_{A1} - T_{A0}) - (T_{B1} - T_{B0}) + T_{Diff})/2;$

$$T_{BA} = ((T_{A1} - T_{A0}) - (T_{B1} - T_{B0}) - T_{Diff})/2;$$

i.MX RT1180同时考虑了时钟漂移和偏移。如需了解相关细节,请参阅《i.MXRT1180参考手册》。

3.4 EtherCAT运行模式

EtherCAT从站支持以下几种同步运行模式:

- 自由运行模式
- 同步管理器 (SM) 模式
- 分布式时钟(DC)模式(普通和增强型)

这些模式的说明如下。

1. 自由运行模式

在自由运行模式下,本地控制周期是由本地定时器中断来产生的, 图5显示了自由运行模式的时序。



2. SM模式

在同步管理器(SM)模式下,当数据输入或输出事件发生时,本地控制周期启动。图6显示了SM模式下的时序。



3. DC模式

a. 普通DC模式

在普通分布式时钟(DC)模式下,本地控制周期是由同步信号来产生的。在这种模式下,EtherCAT主站 必须在同步事件发生之前发送数据帧。图7显示了普通DC模式下的时序。

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b. 增强型DC模式

增强型分布式时钟(DC)模式旨在实现更高的同步性能。在这种模式下,EtherCAT从站必须在同步事件发生前拷贝并准备输出数据。一旦同步信号到达,本地操作将继续运行,从而实现更高的性能。图8显示了增强型DC模式的时序。



4 将EtherCAT从站协议栈代码集成到SDK演示工程中

按照以下步骤将EtherCAT从站协议栈代码集成到SDK演示工程中:

1. 下载并安装**Beckhoff**的**SSC**工具。要下载SSC工具,必须是EtherCAT技术小组(ETG)的会员。SSC工具 下载链接如下:

<u>http://www.ethercat.org/login.aspx?ReturnUrl=%2fmemberarea%2fstack_code.aspx</u> 图9所示为SSC工具的登录页面。

2. 启动SSC工具,如<u>图10</u>所示。

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4. 可以使用SSC配置文件来添加NXP Digital IO工程,该文件位于MIMXRT1180-EVK SDK的相应目录中,具体如 图12所示。本应用笔记中使用的SDK版本为2.14.1。 SSC配置文件的路径如下所示:

SDK_2_14_1_MIMXRT1180-EVK\boards\evkmimxrt1180\ecat_examples\digital_io \cm33\SSC\digital_io.xml

或

```
SDK_2_14_1_MIMXRT1180-EVK\boards\evkmimxrt1180\ecat_examples\digital_io
\cm7\SSC\digital_io.xml
```

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Custom FI 980012A	xis CiA402 Sample	~			
	Parata-		5.11		
All settings are available.	configuration.		5.11		
	Import Configuration file(s)		5.13		×
	← → × ↑ 📙 « ecat_example	s → digital_io → cm7 → S	SC > V Ö	, Search SSC	
	Organize 🔻 New folder			:=	· · · · · · · · · · · · · · · · · · ·
		▲ Name ^	Date modified	Туре	Size
	🖈 Quick access	Src	9/15/2023 12:52 PM	File folder	
Import	OneDrive - NXP	digital_io.xml	9/14/2023 12:53 PM	XML Document	6 KB
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	 INXL66633 3D Objects Desktop Documents Downloads Music Pictures Videos CSDisk (C:) FCL_LIB (\\ncl-sha.nxp.com) (Q Network 	k) V			

5. 在当前阶段,我们已经使用SSC工具(5.13版)成功添加了NXP ECAT Digital IO modular工程。可以在下拉菜单中查找此工程,具体位置如图13所示。

Slave Stack G	ode Tool New Project 🛛 🗙	
O Default		
Custom This configure Evaluation K The correspondence EL9800_CiA	EL9800 2Axis CiA402 Sample EL9800 2Axis CiA402 Sample EL9800 8Bit Digital I/O, 16Bit Analog Input EL9800 Bootloader Sample FC1100/FC1121 4Byte I/O Sample Application FC1100/Win8 or previous (x86) 4Byte I/O Sample Application Infineon XMC EtherCAT Slave Sample <infineon technologies=""> Microchip-HBI-INDEX-16 <microchip> Microchip-HBI-INDEX-8 <microchip> Microchip-HBI-MDP-16 <microchip> Microchip-HBI-MDP-8 <microchip> Microchip-HBI-MDP-8 <microchip> Microchip-HBI-SP1 <microchip> Microchip-HBI-SP1 NXP ECAT Digital IO modular <nxp> profichip PAAE1100-EC Profichip GmbH> Renesas R-IN32M3-EC <renesas electronics=""> Renesas RZ/N1L-DB <renesas electronics=""></renesas></renesas></nxp></microchip></microchip></microchip></microchip></microchip></microchip></infineon>	
Import 图13.在下拉菜单中查找恩智》	SK-FM3-176PMC-FA _ Hardware Only <spansion inc.=""> SK-FM3-176PMC-FA <spansion inc.=""> TI AM335x Sample <texas incorporated="" instruments=""> 訂程</texas></spansion></spansion>	

6. 单击**OK**打开与此工程相关的窗口,如<u>图14</u>所示。

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The Project loor help			
Slave Project Navigation	Slave Settings		
- EtherCAT Slave - SlaveInformation	SSC Version 5.13		
Generic	Config File Version 1.5.0.0		
Hardware	File name	Description	Version 🔺
- EtherCAT State Machine	aoeappl.c	AoE ADS over EtherCAT	5.11
	aoeappl.h		5.11
ProcessData	applInterface.h	EcatAppl EtherCAT application	5.13
Compiler	bootmode.c	ESM EtherCAT State Machine	5.12
Compiler	bootmode.h		5.11
	bootloaderappl.c	Bootloader Bootloader Sample	5.12
	bootloaderappl.h		5.12
	cia402appl.c	CiA402appl CiA402 Sample Application	5.13
	cia402appl.h		5.13
	coeappl.c	CoE CAN Application Profile over EtherCAT	5.13
	coeappl.h		5.13
			*
		Reload File Remo	ove File Add File(s)
	Conflicts		
	👥 Info 🛛 🔥 Warning	😮 Error	

7. 要创建或导入应用程序文件,请单击Tool > Application。选择Import或Create New,如图15所示。此应用程序文件也可在MIMXRT1180-EVK SDK中的以下应用程序文件路径下找到:

```
SDK_2_14_1_MIMXRT1180EVK\boards\evkmimxrt1180\ecat_examples\digital_io
\cm33\SSC\digital_io.xlsx
```

或

```
SDK_2_14_1_MIMXRT1180EVK\boards\evkmimxrt1180\ecat_examples\digital_io
\cm7\SSC\digital_io.xlsx
```

恩智浦半导体

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ECAT-IO - Slave Stack Code Tool		
File Project Tool Help		
Slave Project Navig: 🖌 Show Confli	ct Window	
ECAT-IO Options		i.13
EEPROM Pro	grammer	1.5.0.0
	•	Create new
···· Synchronisation	aoeappl.c	Import
⊟ Application	aoeappi.n	East Appl Ethod
··· Mailbox	bootmode c	ESM EtherCAT
I Compiler	bootmode.h	
	bootloaderappl.c	Bootloader Boo
	bootloaderappl.h	1
	cia402appl.c	CiA402appl CiA
	cia402appl.h	
图15. 导入或创建新的应用程序		

8. 也可通过Excel配置应用程序文件,如图16所示。SSC工具会根据此Excel文件自动生成XML文件。

File	2	Home Insert P	Page Layout Formulas Data Rev	view View Help	Team		
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D7		• · · · · · ·	Ĵx .				
12		В	C	D	E	F	G
	1	Device Profile:	5001	Modular Devic	e Profile	Usage Hotes:	
	2	Modul Profile:	0			 The PDU mapping object and SyncManager = The following objects are fixed include: 	4ssignment object does d in the SSC end shell
	3					- Entries less or equal one 8Bit shall not	t overlap byte borders
	5					- Entries greater 8Bit shall always start	at an exact word bord
	6						
	7						
	8	The object dictio	onary defined here shall be used comp	lementary with ETG.5	001 and ETG. 1000	1	
	10	Index	▼ ObjectCode	▼ ST	▼ DeteTume	Name	▼ Defoult ▼ May
	14	//0x8xx	Enums (0x0800 - 0xFFF)	04	Ducutype	ardan s	Der une man
	15						
	16	//0x16nn	RxPDO Mapping (0x1600 - 0x17FF)				
	17	Ux16UU	RECORD		1 1000032	KKPDU	0=70000101
	19				1 018132		02/000101
	20	//0x1Ann	TxPDO Mapping (0x1A00 - 0x1BFF)				
	21	0x1A00	RECORD			TxPDO	
	22				1 UINT32		0x60000101
+	42	//0x6ppx	Input Data of the Module (Ox6000 - Ox6	FFF)			
	43	0x6000	RECORD				
	44				1 BOOLEAN	LED	0x01
	45	//0x7nnx	Output Data of the Module (Ox7000 - Ox	7FFF)			
	46	0x7000	KELOKD		1 BOOLFAN	TED	0+01
	48	//0x8nnx	Configuration Data of the Module (Ox800	00 - 0x8FFF)			
	49						
	50	1/0.0	T.C	0.07777)			
	52	//Ux9nnx	Information Data of the Module (Ox9000	- Oxatkk)			
	53						
	54	//OxAnnx	Diagnosis Data of the Module (OxAOOO -	OxAFFF)			
	55						
	56	//048444	Device Objects (OwECOO - OwEEEE)				
	58	0xF000	RECORD			Modular Device Profile	
	59				1 UINT16	Index distance	0x10
	60				2 UINT16	Maximum number of modules	
	61						
Fx	cel	配置应田程区	.				

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9. 创建或导入应用程序文件后,创建新的从站文件,如图17所示。单击Project > Create new Slave Files。 ECAT-IO - Slave Stack Code Tool File Project Tool Help Find Setting Ctrl+F Slave Pr - ECA Create new Slave Files F5 Config File Ve Generic Hardware File nan EtherCAT State Machine aoeappl Synchronisation aoeappl Application 图17. 创建新的从站文件

10. 单击Start。新的工程文件由此生成,如图18所示。您可以在相关工程文件夹中找到XML文件和src文件夹。

Project File	C·\Lleere\nyf9(1529\Deekton\NYP\FC&T_IO esn	_
i toject file	Source Folder	C.\ Jsers\nyf90529\Deskton\NXP\Sm\	Change
	ESI Ela	C. 11-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-	Change
	ESTRIE		Change
	Doc Folder	C:\Users\nxf90529\Desktop\NXP	Change
"EtherCAI "SampleAg "SampleAg "applInte "coeappl. "ecatappl "ecatappl "ecatsly. "ecatsly. "ecatsly. "ecatsly. "ecatsly. "ecatsly. "ecatsly. "bojdef." "objdef." "sdoserv. Generate No Process Create SI	SampleLibrar oplicationInt pricationInt erface.h": n c": new fil h": new fil h": new fil c": new fil h": new fil c": new fil h": new fil h": new fil h": new fil c": new fil h": new fil h": new fil h": new fil h": new fil h": new fil c": new fil h": new fil h": new fil c": new fil h": new fil c": new fil h": new fil files finish evice descrip	<pre>y.h" : skipped (SAMPLE_APPLICATION_INTERFACE) erface.c" : skipped (SAMPLE_APPLICATION_INTERFACE) erface.h" : skipped (SAMPLE_APPLICATION_INTERFACE) ew file written e writ create Files Finished - X le writ le writ e writ e writ e writ e writ e writ e written e written e written e written e written e written e written e written i w</pre>	^
1			Ť
		Start	Close

11. 将工程文件从SSC工具创建的src文件夹拷贝并替换MIMXRT1180-EVK SDK中相应的src文件夹,如图19所示。

src文件夹路径:

```
C:\lxtdoc\2 SDK\SDK_2_14_1_MIMXRT1180-EVK\boards\evkmimxrt1180\ecat_examples\
digital_io\cm33\SSC\Src
```

或

C:\lxtdoc\2 SDK\SDK 2 14 1	MIMXRT1180-EVK\boards\evkmimxrt1180\ecat examples\
digital_io\cm7\SSC\Src _	

	Datemounted	iype	Size
Src	9/15/2023 12:52 PM	File folder	
💵 digital_io.xlsx	9/14/2023 8:29 AM	Microsoft Excel W	22 KB
digital_io.xml	9/14/2023 12:53 PM	XML Document	6 KB

图19. MIMXRT1180-EVK SDK演示文件夹

12. 构建并编译SDK工程并将其下载到MIMXRT1180-EVK开发板,如图20所示。将MIMXRT1180-EVK EtherCAT 端口0与EtherCAT主站连接。

Busy	
Starting debugger session: Loading debug file	
Downloading: Connecting	
Cancel	
图20. 将代码下载到MIMXRT1180-EVK开发板	

13. SM和FMMU配置信息可在SSC工具生成的XML文件中找到。

Outputs
⊂ <fmmu></fmmu>
Inputs
MBoxState
<pre></pre>
<pre></pre>
<pre></pre>
<pre></pre>

图21. XML文件中的SM和FMMU配置

14. 对象字典的映射如图22所示。其中,对象0x1C13决定采用对象0x1A0n,而对象0x1A0n决定采用对象0x600n。

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5 在配置模式下设置TwinCAT3

本节介绍了在配置模式下配置TwinCAT3软件的过程。

5.1 安装TwinCAT主站驱动程序并扫描EtherCAT设备

按照以下步骤安装TwinCAT主站驱动程序并扫描EtherCAT设备:

```
1. 打开TwinCAT3并新建一个新的TwinCAT工程,如图23所示。
```

	New Project		? ×
	▶ Recent	Sort by: Default	Search (Ctrl+E)
	▲ Installed	TwinCAT XAE Project (X TwinCAT Project	ts Type: TwinCAT Projects
	 Visual C++ Other Project Types TwinCAT Measurement TwinCAT Projects TwinCAT PLC 		TwinCAT XAE System Manager Configuration
	Online Not finding what you are looking for Open Visual Studio Installer	ad.	
	Name: TwinCAT Proje	ect7	
	Location: C:\TwinCAT Pr	roject\ •	Browse
	Solution: Create new so	lution	
	Solution name: TwinCAT Proje	ect7	✓ Create directory for solution
			Add to Source Control
			OK Cancel
图23. 创建一个新的TwinCA	T工程		

2. 将TwinCAT3设置为在配置模式下重新启动,如图24所示。

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图25. 选择 "Show Real-time Ethernet Compatible Devices"

4. 请确认系统中已正确安装EtherCAT主站设备驱动程序。本演示工程将PC作为主站, Intel (13)1219-LM作为PC 网络控制器,具体配置如图26所示。

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如果将PC用作TwinCAT主站,则PC网络控制器必须支持EtherCAT主站。有关支持TwinCAT3的网络控制器列表,请参阅以下网址:

https://infosys.beckhoff.com/english.php?content=../content/1033/tcsystemmanager/9810943 371.html&id=8751857768543711394

Installation of TwinCAT RT-Ethernet Adapters	×	
Ethemet Adapters Installed and ready to use devices(realtime capable) Installed and ready to use devices(for demo use only) Ethernet 2. Realtek USB 6bE Family Controller WiFi Intel(R) WiFi 6 AX201 160MHz Compatible devices Incompatible devices Disabled devices	Update List Install Update Bind Unbind Enable Disable Show Bindings	
图26.安装TwinCAT RT以太网适配器		

5. 将SSC工具创建的XML文件放到TwinCAT3配置文件夹中,如图27所示。TwinCAT3配置文件夹路径如下:

TwinCAT\3.1\Config\Io\EtherCAT

	Beckhoff EtherCAT Terminals.xml	3/25/2022 9:43 AM	XML Document	54 KB
	Beckhoff FB1XXX.xml	3/25/2022 9:43 AM	XML Document	49 KB
	Beckhoff FCxxxx.xml	3/25/2022 9:43 AM	XML Document	21 KB
	Beckhoff FM3xxx.xml	3/25/2022 9:43 AM	XML Document	367 KB
	Beckhoff ILxxxx-B110.xml	3/25/2022 9:43 AM	XML Document	8 KB
	ECAT-IO.xml	6/27/2023 12:08 PM	XML Document	30 KB
图27. TwinCAT3配置文件夹				

6. 单击**Reload Device Descriptions**更新XML文件,如<u>图28</u>所示。

T	Windows				
h.	Activate Configuration				
	Restart TwinCAT System				
	Restart TwinCAT (Config Mode)				
2	Reload Devices				
0	Scan				
	loggle Free Kun State				
	Show Online Data				
ia d	Show Sub Items				
RE4	Software Protection				
	Access Bus Coupler/IP Link Register				
	Cham Basking Ethanse Consectible Devices				
	File Handling				
	Selected Item				
	EtherCAT Devices	۰.	Update Device I	Descriptions (via ETG Website)	
63	TcProjectCompare		Reload Device [Descriptions	
8	Multiuser Explorer		Manage User D	efined Whitelist	
	Target Browser	•	Manage User D	efined Blacklist	
	AutomationML	- F			
	Bode Plot	•			
	Filter Designer	<u> </u>			
	About TwinCAT				

7. 右键单击Devices并选择Scan,如图29所示。

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8. 检测到EtherCAT主站设备(设备3),如图30所示。



图30. 检测到的主站设备

右键单击Device 3并单击 "Scan" 以查找相关的EtherCAT从站设备,如图31所示。



9. 在此阶段,将检测到Box。如果是第一次扫描EtherCAT从站设备,此Box的显示如图32所示。

ANALYTICS
▲ 2 I/O
▲ 📲 Devices
🔺 🧮 Device 3 (EtherCAT)
🚔 🐺 Image
🚔 Image-Info
SyncUnits
👂 🛄 Inputs
Outputs
InfoData
Box 1 (P26483052 R00020111)
图32. 检测到的EtherCAT从站设备

5.2 在配置模式下更新EEPROM数据并在线写入值

本节介绍了在配置模式下更新EEPROM数据并在线写入数值的步骤。

1. 单击Box1,并在EtherCAT窗格中选择Advanced Settings,如图33所示。

TwinCAT Project3 👳 🗙	
General EtherCAT	DC Process Data Plc Startup CoE - Online Online
Туре:	SSC-Device
Product/Revision:	-1840119807 / 65537
Auto Inc Addr:	0
EtherCAT Addr:	1001 Advanced Settings
Identification	0
Previous Port:	Master ~
则到的EtherCAT从站设备	

 2. 单击Write EEPROM并选择由SSC工具创建的XML文件。单击OK, EEPROM将按照所选配置写入, 如<u>图34</u> 所示。

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e - Mailbox e - Distributed Clock = ESC Access € - E ² PROM	Device Emulation (state machine emulation) SPI / 8 / 16 µC Interface BUSY Open Drain	Revison No.: Serial No.: Product Revision:	0x0000000
Configured Statio Enhanced Link De Smart View Hex Editor FPGA	32 Bit Interface	Mailbox CoE SoE AoE Bootstrap Configuration	EoE FoE
L. Memory	Sync Signal Configuration	Out Start/Length:	0 0 0 0
	SYNC1 Open Drain ⊻SYNC1 High Active SYNC1 Enabled ≥SYNC1 to PDI IRQ Impulse Length (µs): 25.600	Standard Configuration Out Start/Length: In Start/Length:	4096 128 4224 128
	Write EPROM 2		
General Mailbox Distribut ESC Acc F ² PR C C	Descriptions: Sutomation GmbH & Co. KG	how Hidden Devices	Cancel
图34. Smart View Editor显示可用	⁸⁷⁴⁰ [1 / 17] 3 ^년 月于写入EEPROM的选项		D D
3. 删除旧Box并再次扫描Box。如	35所示,可以找到已烧录EEPRON	M的新Box。	
	 ✓ I/O ✓ ¹ Devices ✓ Device 3 (Ether Stress and the second second	nerCAT)	
	SyncUnit	s	

图35. 可找到新Box

4. 激活Free Run , 如<u>图36</u>所示。

	Microsoft Visual Studio $ imes$	
	Activate Free Run	
	Yes No	
图36. 激活Free Run		
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Inputs Outputs

👂 🛄 InfoData

Box 1 (ECAT-IO)

⊳

⊳

如何使用i.MX RT1180的EtherCAT与BECKOFF的TwinCAT3和SSC工具

5. 确保EtherCAT从站处于运行(OP)模式,如图37所示。

	General	EtherCAT	DC	Process Data	Plc	Startup	CoE -	Online	Online	
	State Init Pre- Op	Machine Op	Boo Saf	otstrap fe-Op ar Error	Curren Reque	t State: ested State	e: [OP OP		
	DLL S Port A Port A Port	Status A: Ca B: No C: No D: No	mier / Op Carrier Carrier	/ Closed / Closed / Closed						
图37. EtherCAT从	File A	ccess over E wnload P模式	EtherCA	T Upload						

6. 在TwinCAT配置模式下,可以向EtherCAT从站传递"Online Write value"(**Online Write**"0"或**Online Write**"1")。例如,如果向RxPDO变量LED写入值"1",则MIMXRT1180-EVK开发板上的用户LED亮起。



6 在运行模式下使用TWINCAT3

本节介绍了在运行模式下配置TwinCAT3软件的过程。

1. 首先,新建一个PLC工程。右键单击PLC,然后单击Add New Item,如图39所示。

⊿ 🛄 U 🎦	Add New Item	Ins
Þ 🖥 🗖	Add Existing Item	Shift+Alt+A
⊳ थ् SAFE	Add Project from Source Cont	rol
% - C++ 台	Paste	Ctrl+V
ANA	Paste with Links	

2. 添加Standard PLC Project,如图40所示。

4 Installed		Cast hus	Default		Search (Ctrl+E)	0.
- mouned		SOR Dy:	Deraute		Search (cun+c)	P .
Plc Templates		0	Standard PLC Project	Plc Templates	Type: Plc Templates	
≬ Online			Empty PLC Project	Pic Templates	 Creates a new IwinCATPLC projection containing a task and a program. 	ct
Name	Untitled2					
Name: Location:	Untitled2 C:\Users\nxf90529\s	ource\rep	oos\TwinCAT Project7\Twi	nCAT Project7) *	Browse	

3. 编写PLC相关代码,如图41所示。

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^{4.} 将ESC输入和输出变量关联到PLC工程变量。为此,右击"LED"并选择Change Link(更改链接),如<u>图42</u> 所示。

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5. 切换至运行模式,如图43所示,并确保EtherCAT从站在OP模式下运行。

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TwinC	AT TwinSAFE PLC 团队(M) Scope 工具(
١	Vindows •
1. N	Activate Configuration
	Restart TwinCAT System
	Restart TwinCAT (Config Mode)
21	Reload Devices
12 1	ican
6	foggle Free Run State
و 🕥	Show Online Data
100 S	Show Sub Items
1	Hide Disabled Items
æ 9	oftware Protection
RE6	Access Bus Coupler/IP Link Register
I	Jpdate Firmware/EEPROM
	how Realtime Ethernet Compatible Devices

6. 然后,单击"Activate Configuration(激活配置)",如<u>图44</u>所示。

AN14155 **应用笔记**



7. 单击**Run PLC**按钮,如<u>图45</u>所示。现在,PLC工程开始运行,MIMXRT1180-EVK开发板上的用户LED指示灯每秒闪烁一次。

表达 ■	式	类型	店	
æ				7
	Delay	TON		
3	LedIn	BOOL	FALSE	
	LedIn1	BOOL	FALSE	
2	LedOut	BOOL	FALSE	
	A 1.JA	2001	lance.	
8	<pre>2 Delay(INFALSE := TRUE, PT</pre>	:= T#1S);		

7 运行模式和TwinCAT3中的模式切换

7.1 在TwinCAT3中切换EtherCAT运行模式

本节介绍了使用TwinCAT3软件配置运行模式的过程。

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1. 在TwinCAT3中配置SM模式。在TwinCAT3中设置SM模式的步骤如图46所示。

	Advanced	l Settings 2	
Advanced Settings			×
Distributed Clock	Distributed Clock		
	Cyclic Mode Operation Mode:	SM-Synchron	× 3
	Enable	Sync Unit Cycle (µs): 4000	
	SYNC 0		
	Cycle Time (µs):	Shift Time (µs):	
	Sync Unit Cycle	User Defined	
	O User Defined	+ SYNC0 Cycle	
		~	
		Based on Input Reference	
		+	
	Enable SYNC 0	=	
	SYNC 1		
	🔿 Sync Unit Cycle	Cycle Time (µs):	
	SYNC 0 Cycle	Shift Time (µs):	
	Enable SYNC 1		
	Use as potential Reference C	lock	

2. 在TwinCAT3中配置主站DC模式。在TwinCAT3中设置主站DC模式的步骤如图47所示。

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Advanced Settings	Z		X I Solution 'WinCAT Project?' (1 project)
State Machine Cyclic Fremes Cyclic Fremes Cyclic Fremes Disbudged Clacks Eo0 Suppon Redundancy Bernergency Diagnosis	Distributed Clocks DC Mode Atomatic DC Mode Selection DC in use Reference Clock: C Time controlled by TwinCAT Time (Save Mode) C Time controlled by TwinCAT Time (Save Mode) Adjust: Reference Clock DC Time controlled by External Sync Device (External Mode) External Sync Device Settings Sync Window Montoong Sync Windo	€d	MOTION PLC SAFETY C++ ANALYTICS VO Procestics Mappings 1 plution Explorer reperties Pevice 1 (EtherCAT) EtherCAT Master Pevice 1 (EtherCAT) EtherCAT Master Misc (Name) Device 1 (EtherCAT) Disabled Enabled
			ItemType 2 PathName TIID^Device 1 (EtherC
			Perciciant

3. 在TwinCAT3中配置从站DC模式。在TwinCAT3中设置从站DC模式的步骤如图48所示。

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-			
			Advanced Settings
10000		Distributed Clock Cyclic Mode	⊕ Distributed Clock
3	Sync Unit Cycle (µs): 4000 Shift Time (µs): 0 User Defined 0 + SYNC0 Cycle 0 Based on Input Reference + + 0 Cycle Time (µs): 4000 Shift Time (µs): 0	 ✓ Enable SYNC 0 Cycle Time (µs): ④ Sync Unit Cycle x 1 ④ User Defined 4000 ✓ Enable SYNC 0 4 SYNC 1 ○ Sync Unit Cycle x 1 ✓ Enable SYNC 1 5 	

8 结语

本应用笔记描述了在i.MX RT1180平台上使用EtherCAT外设的方法。其内容涵盖了现场总线内存管理单元 (FMMU)、同步管理器、64位分布式时钟的功能、传播延迟的计算以及EtherCAT的不同运行模式。此外,本文 还介绍了基于i.MX RT1180 SDK和i.MX RT1180评估套件(EVK-MIMXRT1180)开发板使用SSC工具和TwinCAT3的 方法。

9 相关文件

表2列出并详细说明了有关MIMXRTII80-EVK开发板的其他文档和资源,供读者进一步参考。请注意,下表中列出的一些文件可能仅在签署保密协议(NDA)下才能访问。如需获取这些文件,请与您当地的现场应用工程师(FAE) 或销售代表联系。

表2. 相关文件

文件	说明	链接/如何访问
i.MX RTI180参考手册(IMXRT1180RM)	详细介绍了有关i.MX RT1180及其功能 , 包括内存映射、电源和时钟。	请联系您当地的现场应用工程师(FAE) 或销售代表。
面向消费类产品的i.MX RT1180跨界MCU 数据手册(IMXRT1180CEC)	介绍了有关电气特性、硬件设计注意事 项和订购信息	
面向工业产品的i.MX RTI180跨界 MCU数据手册(IMXRT1180IEC)	介绍了有关电气特性、硬件设计注意事 项和订购信息	
MIMXRT1180-EVK-UM	详细介绍了有关MIMXRT1180-EVK开发 板的组件、接口和功能	
i.MX RT1180处理器的安全参考手册	详细介绍了有关各种芯片安全的组件	
MCUXpresso软件开发套件(SDK) 文件	MCUXpresso软件开发工具包(SDK) 是一个全面的软件支持包,旨在简化和 加速基于Arm Cortex-M内核的恩智浦 MCU的应用开发。	<u>MCUXpresso软件开发工具包(SDK)</u> <u>文件</u>

如需进一步了解有关i.MX RT1180 MCU的详细信息,请访问以下链接:

https://www.nxp.com/products/processors-and-microcontrollers/arm-microcontrollers/i-mx-rtcrossover-mcus/i-mx-rt1180-crossover-mcu-with-tsn-switch-and-edgelock:i.MX-<u>RT1180#documentation</u>.

10 缩略语

表3列出了本文中使用的缩略语。

表3. 缩略语

缩略语	说明
СМ33	Cortex-M33 core / Cortex-M33核
СМ7	Cortex-M7 core / Cortex-M7核
DC mode	Distributed Clock mode / 分布式时钟模式
EtherCAT	Ethernet for Control Automation Technology / 以太网控制自动化技术
EEPROM	Electrically Erasable Programmable Read Only Memory / 电可擦除可编程只读存储器
ESC	EtherCAT Slave Controller / EtherCAT从站控制器
FMMU	Fieldbus Memory Management Unit / 现场总线内存管理单元
IDE	Integrated Development Environment / 集成开发环境
PDI	Process Data Interface / 过程数据接口
SDK	Software Development Kit / 软件开发工具包
SM	Sync Manager / 同步管理器
SSC	Slave Stack Code / 从站协议栈代码
TSN	Time Sensitive Networking / 时间敏感网络
TwinCAT	The Windows Control and Automation Technology / 基于Windows的控制和自动化技术

11 修订历史

表4汇总了本文的修订情况。

表4. 修订历史

文档ID	发布日期	说明
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