

TwinCAT3

Matlab® / Simulink® Integration

TwinCAT 3: eXtended Automation



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 - 目标
 - TE1400 | 模块的生成
 - TE1400 | 模块的实例化
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 - TE1410 | 对Matlab的接口
 - 总结



Matlab®/ Simulink® 集成

集成Matlab®/Simulink®

- 著名的数学计算环境
- 各种工具箱 (例如: 模糊控制)
- 创建, 仿真以及优化控制回路
- 在Simulink® 和 TwinCAT之间建立调试接口

代码生成

- 在Simulink® 进行设计
- 通过Simulink® Coder自动生成C/ C++代码
- 利用Visual Studio® C 编译器进行编译
- 在TwinCAT3中进行参数设定
- 在TwinCAT3实时内核中下载并执行

Matlab®/ Simulink® 集成

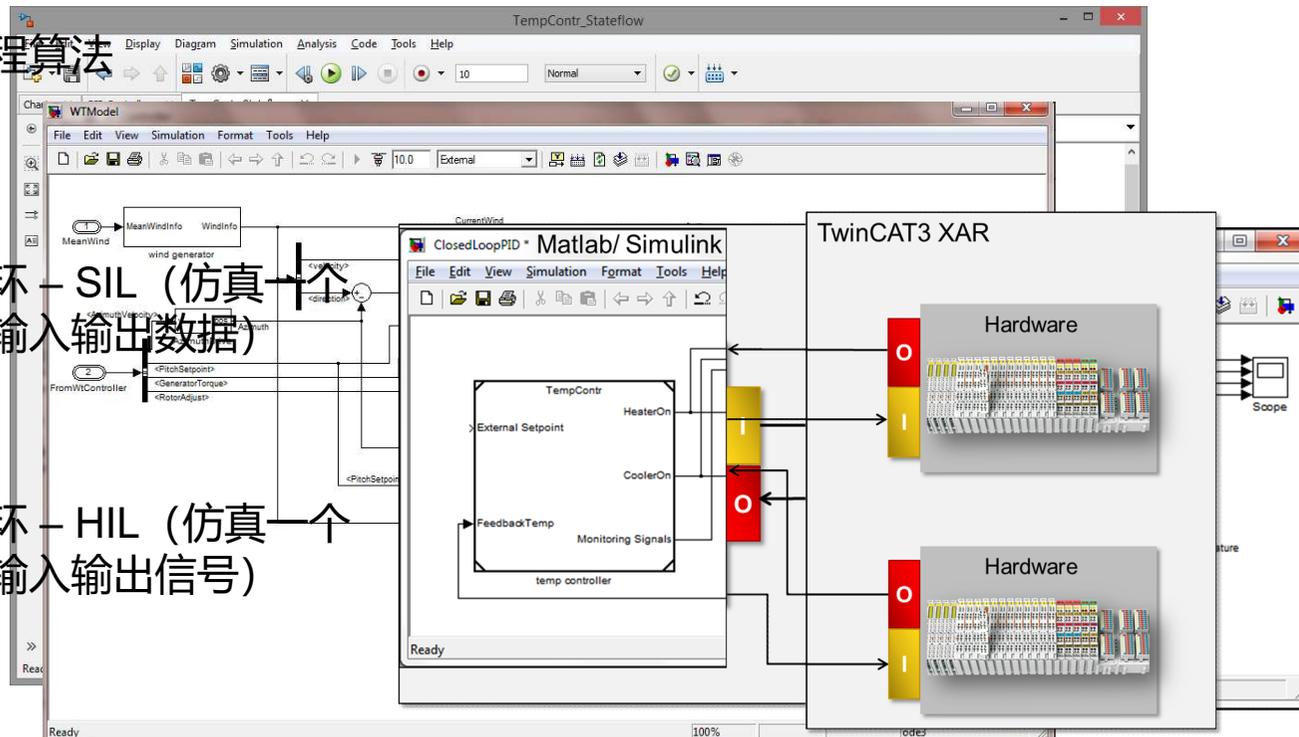
目的 | 应用案例：

- 设计，优化控制器

- 放在过程算法

- 软件再环 – SIL (仿真一个软件的输入输出数据)

- 硬件再环 – HIL (仿真一个硬件的输入输出信号)



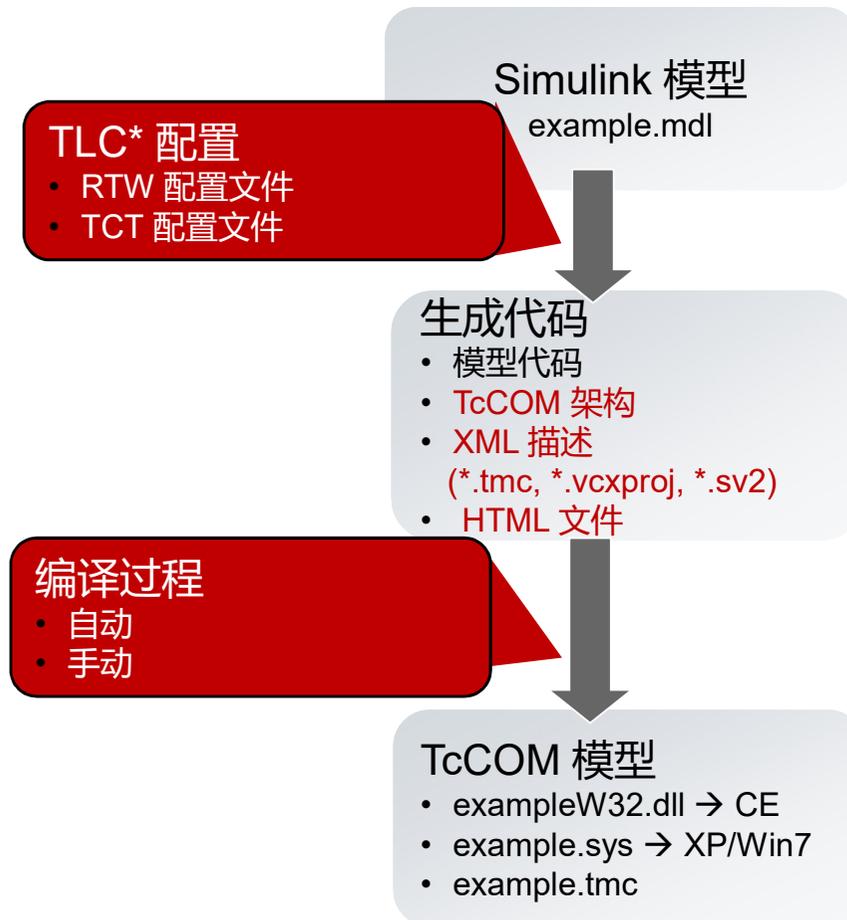
Beckhoff products to cover this use cases:

TE1400 | Target for Matlab Simulink

The image displays two overlapping software windows. The top window is the Simulink environment, titled 'TempContr_Stateflow'. It shows a control system model with two main sections: 'Heater control (closed loop control)' and 'User and Error control'. The heater control section includes an 'External Setpoint' input, a 'filter and scaling' block, a 'PID Controller', a 'Saturation' block, a 'Switch', and a 'PWM' output. The user and error control section includes 'Button1', 'Button2', 'PWMfan', 'PWMheater', and 'TempMeasurement' blocks. The bottom window is the MATLAB environment, titled 'MATLABSample - Microsoft Visual Studio'. It shows the same Simulink model loaded into the MATLAB interface, with the 'Project Explorer' on the left and the 'Block Identifier' on the right. A red arrow points from the Simulink window to the MATLAB window, indicating the integration of the two environments.



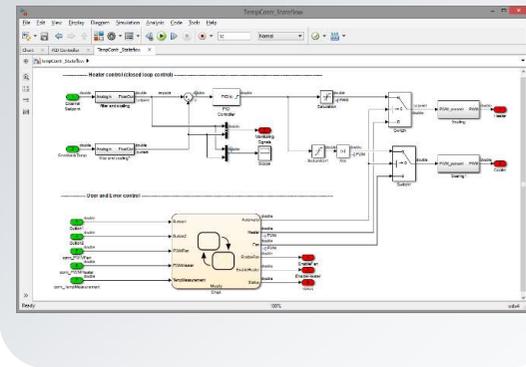
代码生成过程



*TLC: 目标语言编译器

从 Matlab/Simulink → 到TwinCAT 3 模块

Simulink-模型



TcCOM-模块

- exampleW32.dll for CE
- example.sys for NT/XP
- example.tmc

要求:

- Matlab/Simulink (> 版本2010a)
- Simulink Coder (Matlab Coder)
- Visual Studio 2010/2012/2013

1. 选择 TwinCAT 目标
2. Simulink Coder 生成 C 或 C++ 代码
3. Microsoft C/C++ 编译器生成二进制文件
4. TwinCAT 目标生成描述文件.tmc

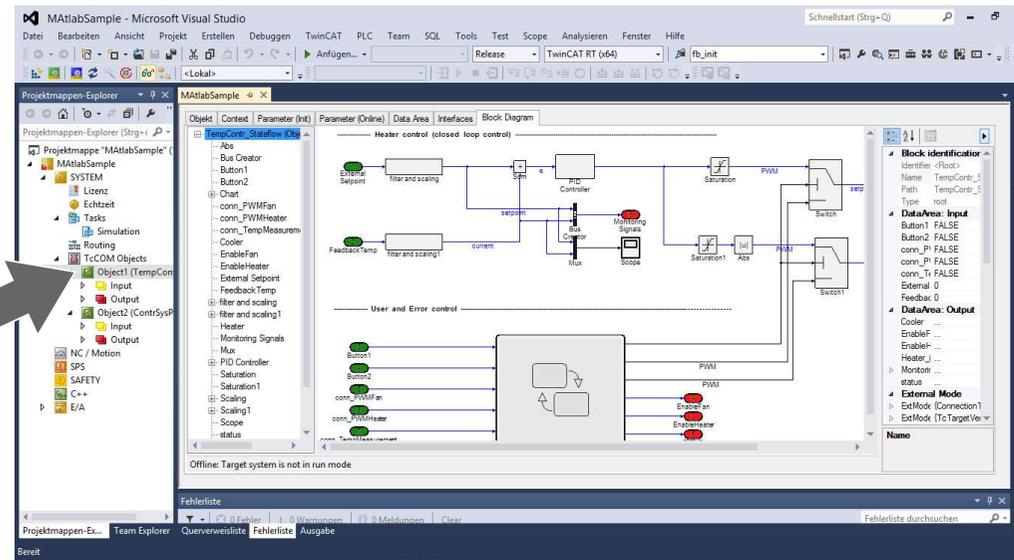
Matlab/Simulink + Simulink Coder 必须!

从 Matlab/Simulink → 到TwinCAT 3 模块

- 二进制文件可以直接在 TwinCAT 3 中使用
- 描述文件 .tmc 定义了接口
- 自动或者手动链接到实时task中
- 通过ADS下载都 TwinCAT 实时核内

TcCOM-模块

- exampleW32.dll for CE
- example.sys for NT/XP
- example.tmc

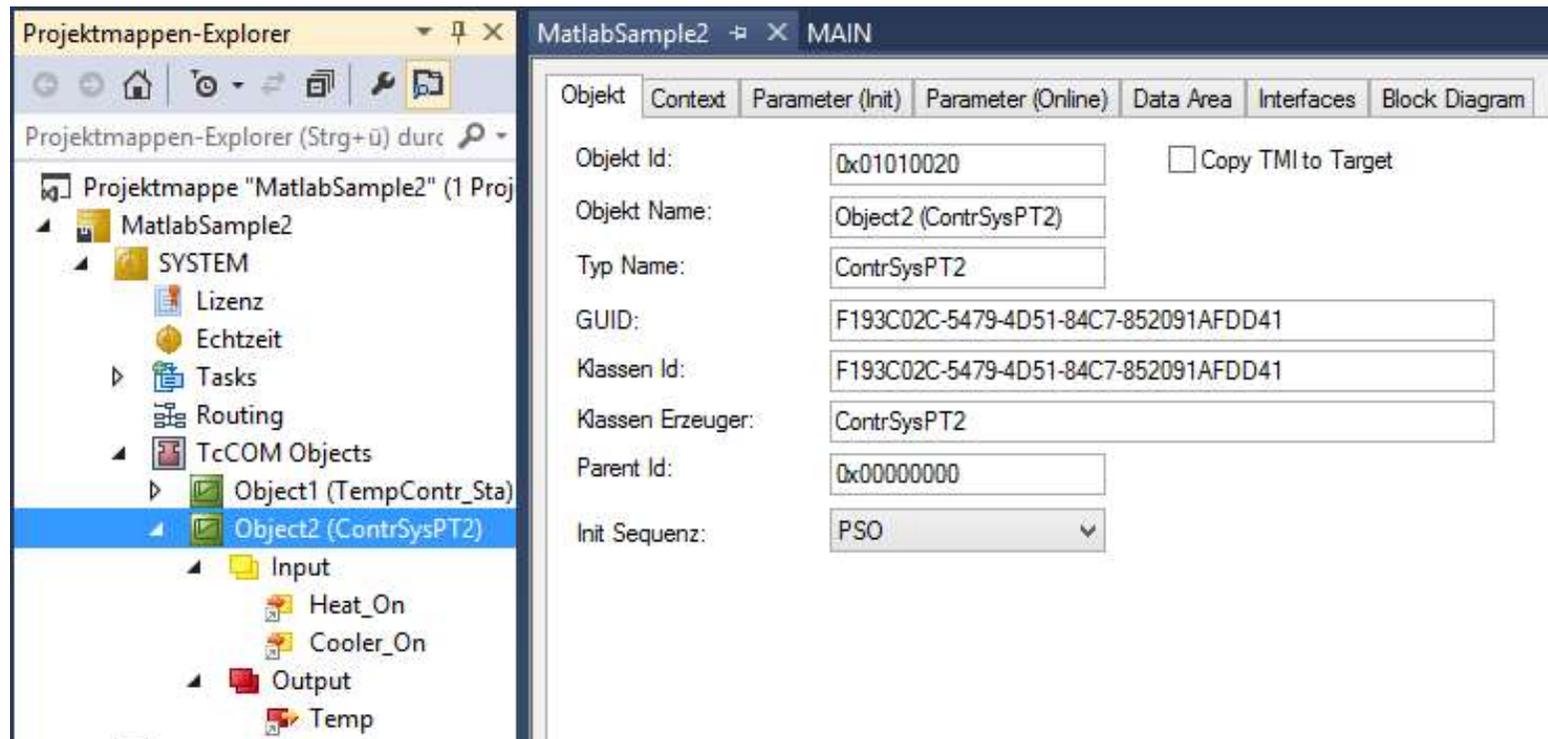


Matlab/Simulink + Simulink Coder 不需要!



集成到 TwinCAT 3

- 在TwinCAT 3 中插入模块



集成到 TwinCAT 3

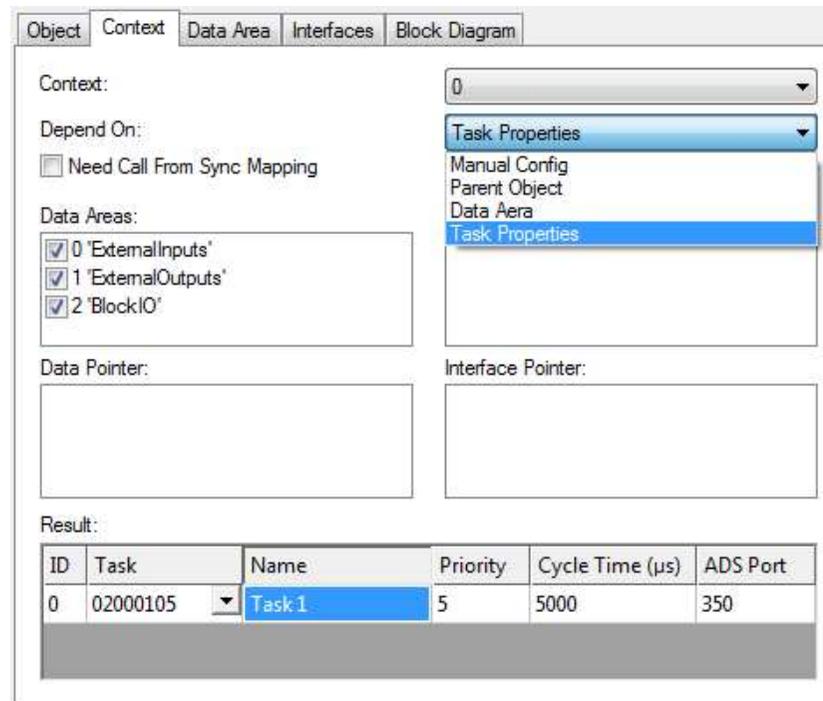
- Matlab/Simulink 模块参数化
 - 用方框图描绘 (如果选项打开)

The screenshot displays the TwinCAT 3 environment with a Simulink model for a heater control system. The 'Block Diagram' tab is active, showing a control loop with a PID Controller, Saturation blocks, and a Chart. The 'Export block diagram' option is checked in the top right menu. The right-hand panel shows the block's parameters and data areas.

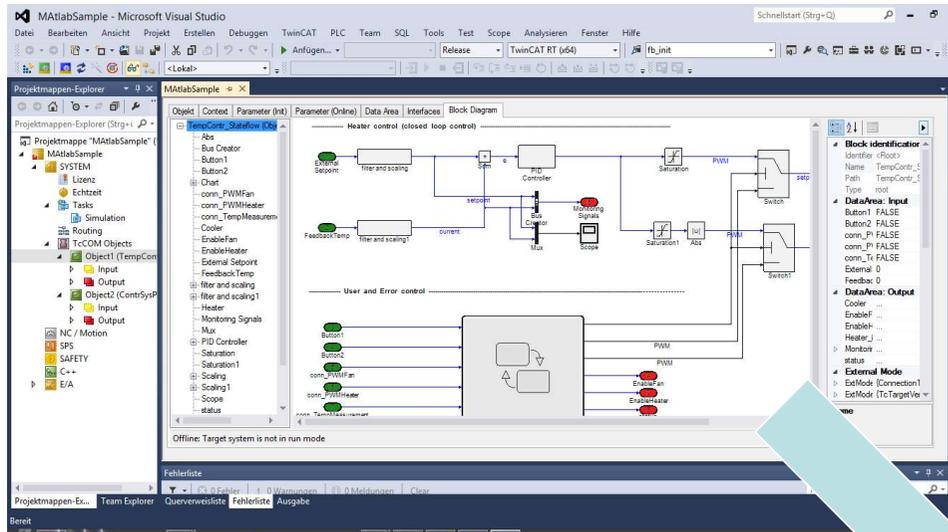
Block identification	
Identifier	<Root>
Name	TempContr_Stateflow
Path	TempContr_Stateflow
Type	root
DataArea: Input	
Button1	FALSE (FALSE)
Button2	FALSE (FALSE)
conn_PWMFan	FALSE (FALSE)
conn_PWMHeater	FALSE (FALSE)
conn_TempMeasurement	FALSE (FALSE)
ExternalSetpoint	0 (0)
FeedbackTemp	0 (238)
DataArea: Output	
Cooler	(19660)
EnableFan	(TRUE)
EnableHeater	(TRUE)
Heater_j	(0)
MonitoringSignals status	(setpoint=0; current=23.78 (Automatic))
External Mode	
ExtModeParameters	{ConnectionTimeout=3; Init1
ExtModeServerVersion	{Tc TargetVersion={1; 2; 1;
ExtModeStatus	{IncomingPktBufferSize=0;
Internal signals	
Bus Creator_Out1	{setpoint=0; current=23.78
Button1_Out1	FALSE (FALSE)
Button2_Out1	FALSE (FALSE)
Chart_Out4	(TRUE)
Chart_Out5	(TRUE)
Chart_Out6	(Automatic)

集成到 TwinCAT 3

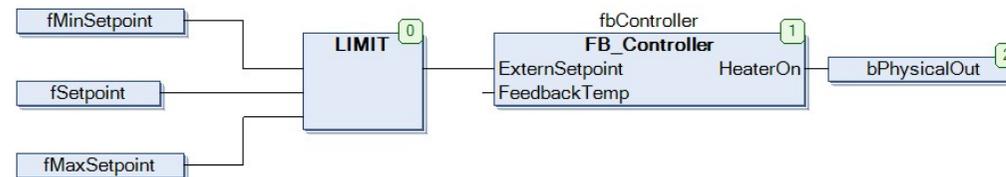
- Matlab/Simulink模块在任务配置中设置循环访问
 - 例如：优先级5，周期5ms的Task 1被附加到模块中



集成到 TwinCAT 3



- 也可以通过PLC访问 TwinCAT 3 模块



集成到 TwinCAT 3

- 用PLC功能块进行访问
- 不是周期访问!

The screenshot displays the TwinCAT 3 environment with a Simulink model for a heater control system. The model is divided into two main sections: "Heater control (closed loop control)" and "User and Error control".

Heater control (closed loop control): This section shows a control loop starting with an "External Setpoint" (0) and "FeedbackTemp" (37.3). Both signals pass through "filter and scaling" blocks. The scaled signals are summed (sum = -37.298) and fed into a "PID Controller". The controller's output (-60) passes through a "Saturation" block. The resulting signal is then fed into another "Saturation" block (Saturation1) to produce the final output "Ab".

User and Error control: This section shows a "Chart" block that receives various inputs: Button1, Button2, conn_PWMFan, conn_PWMHeater, conn_TempMeasurement, and status. The chart outputs "PWM" signals to "EnableFan" and "EnableHeater" blocks, and an "Automatic" signal to a "status" block.

Parameter Table: The right-hand side of the interface shows a table of parameters for the module. The "Module parameters" section is highlighted with red boxes, showing the following values:

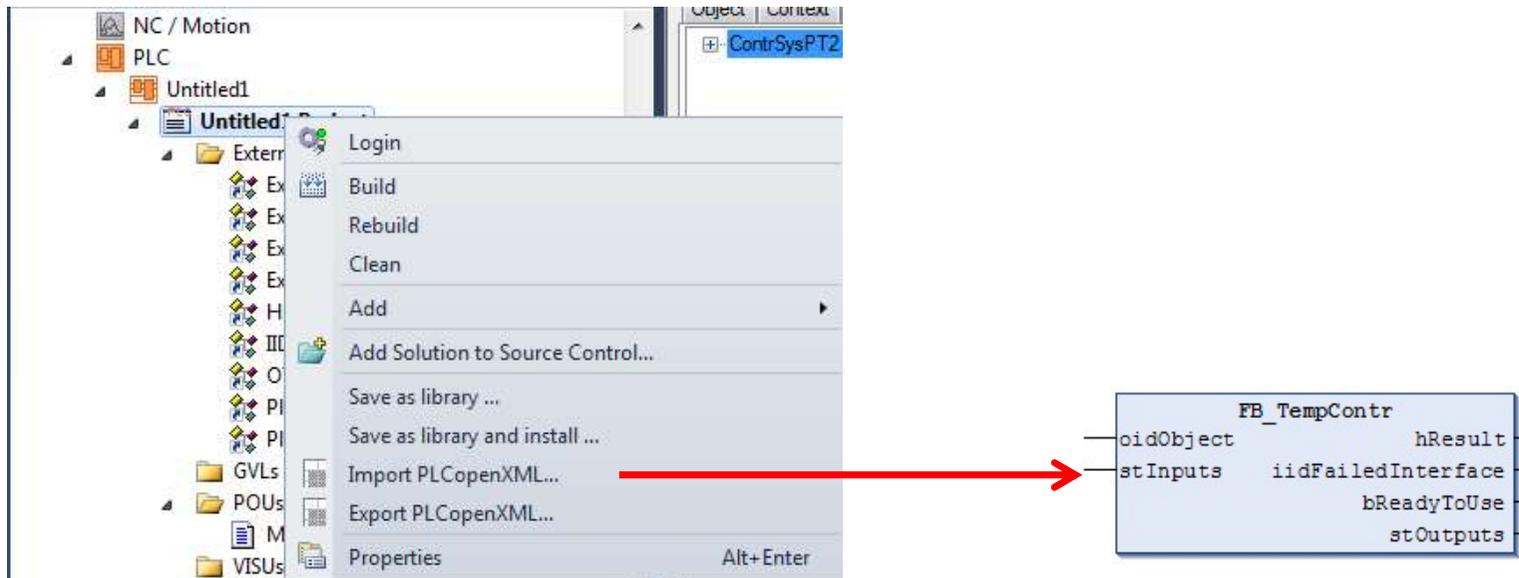
Parameter	Value
Task	Task
StateUpdateAfterOutputMap	StateUpdateAfterOutputMap
UseTaskCycleTime	UseTaskCycleTime

集成到 TwinCAT 3

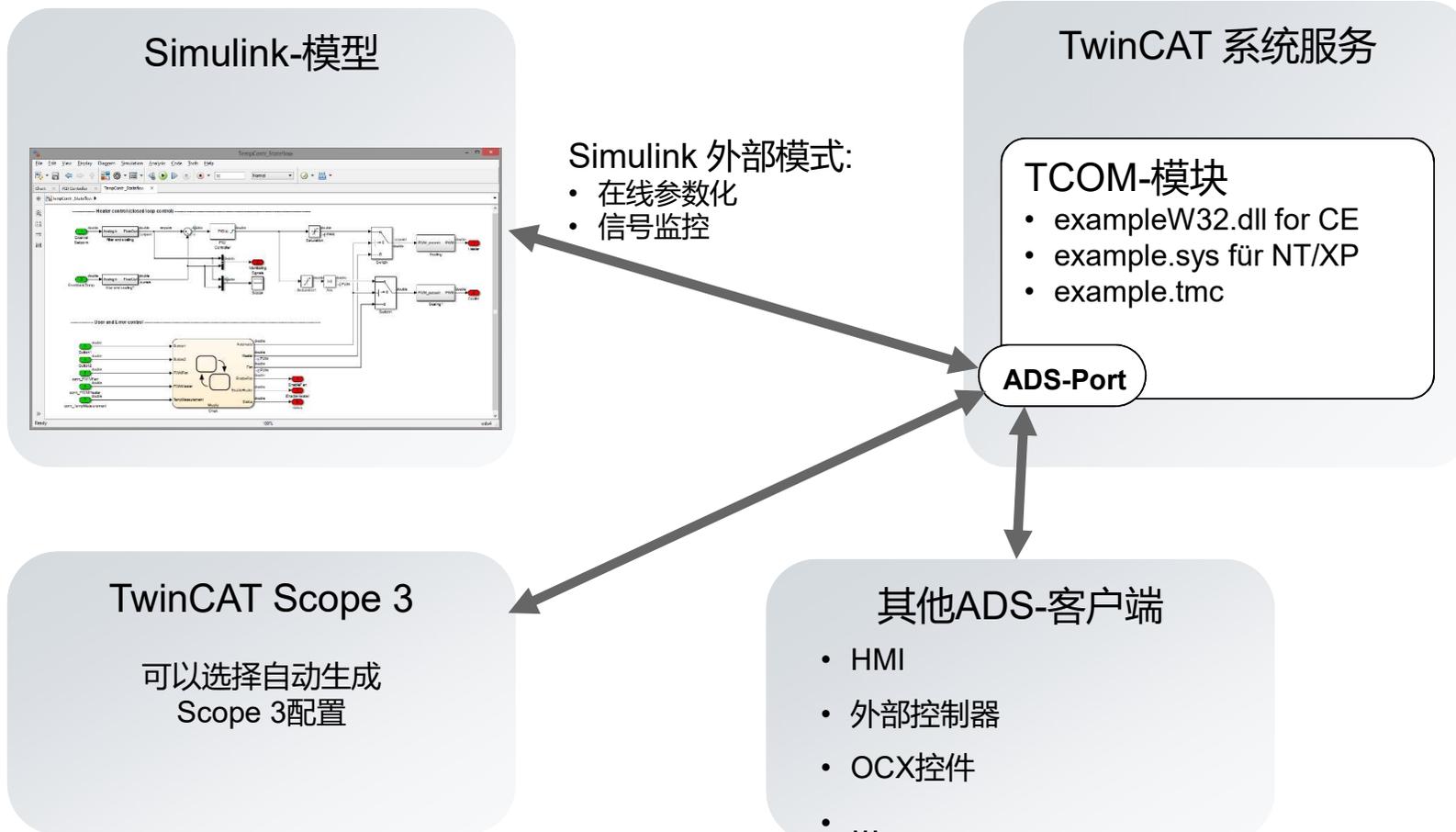
- 用PLC功能块访问
 - Context: PLC task!

Result:

ID	Task	Name
0	02000114	PlcTask



TC3 Simulink 模块的连通性



Simulink 外部模式:

- 在线参数化
- 信号监控

TwinCAT Scope 3

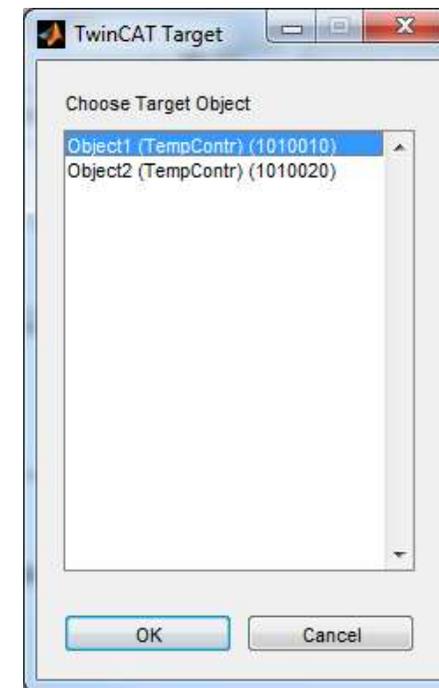
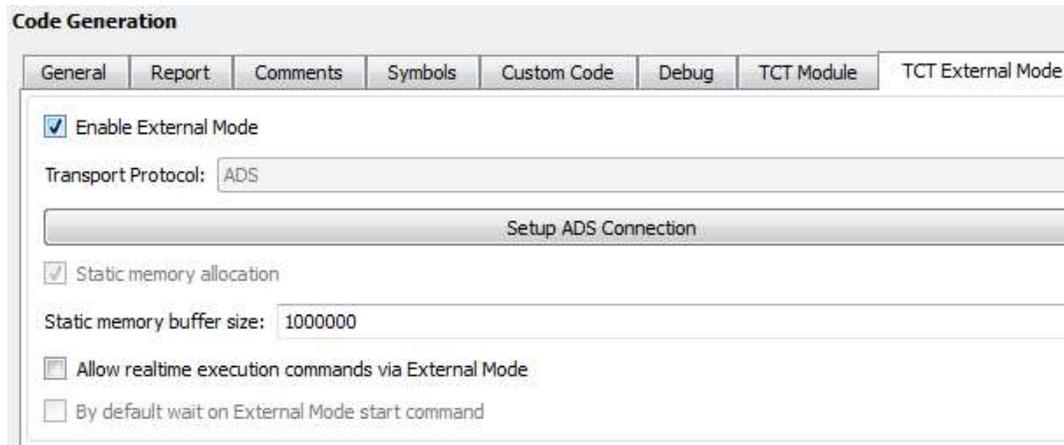
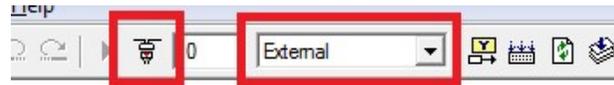
可以选择自动生成
Scope 3配置

其他ADS-客户端

- HMI
- 外部控制器
- OCX控件
- ...

集成到 TwinCAT 3

- 在Matlab/Simulink中调试
 - 外部模式



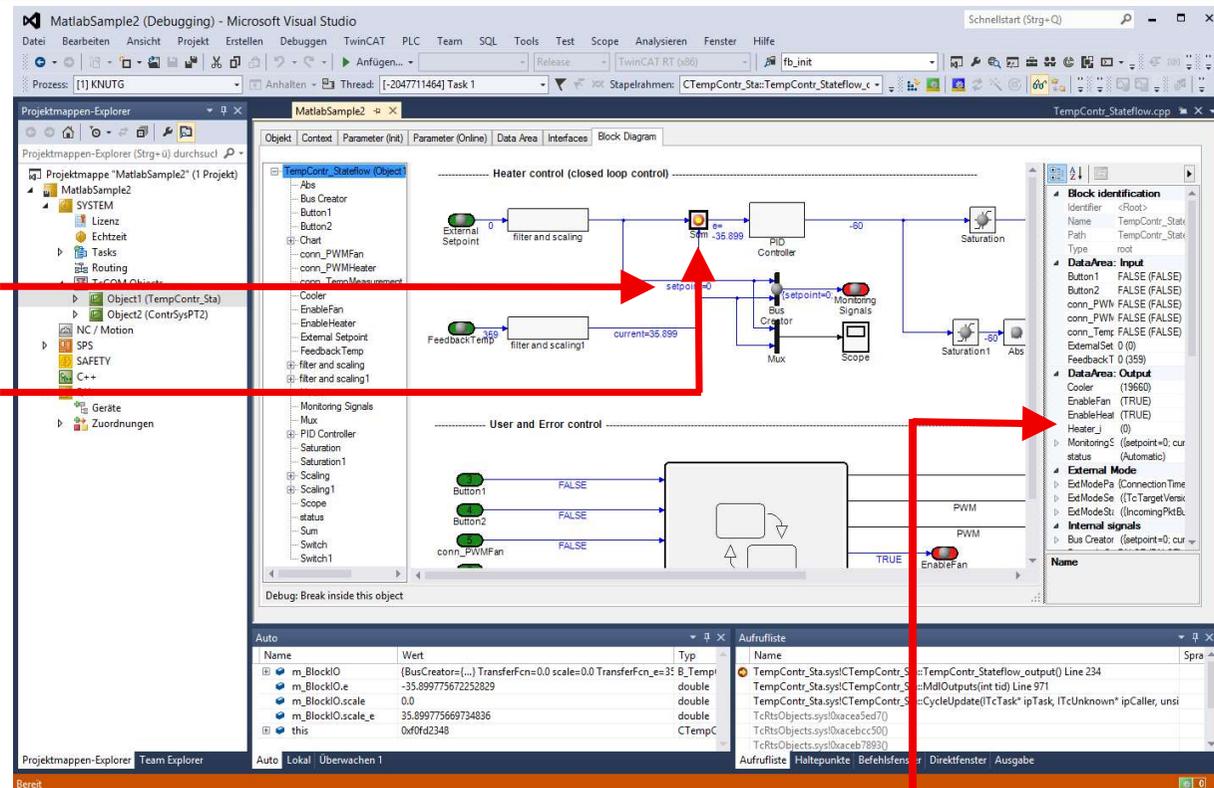
TE1400 | Target for Matlab Simulink

Matlab®/Simulink® 集成

在TwinCAT 3调试

在线监控信号值

支持设置断点



在线监控参数



TE1400 | Target for Matlab Simulink

Matlab®/Simulink® 集成

在TwinCAT 3调试

点击一个断点可以
查看调试信息

The screenshot shows the Visual Studio IDE with the following components:

- Project Explorer:** Shows the project structure for 'MatlabSample2', including 'TcCOM Objects' and 'NC / Motion'.
- Code Editor:** Displays the source code for 'TempContr_Stateflow.cpp'. A yellow highlight covers the 'Current break' information and the 'Code section' starting at line 233: `m_BlockIO.e = m_BlockIO.scale -`.
- Block Diagram:** Shows a control loop diagram with blocks like 'filter and scaling', 'setpoint', 'current=35.899', and 'Abs'.
- Block Identification:** Lists properties for the selected block, such as 'DataArea: Input' and 'DataArea: Output'.
- Auto Window:** Lists variables like 'm_BlockIO', 'm_BlockIO.e', 'm_BlockIO.scale', and 'm_BlockIO.scale_e' with their current values.
- Aufrufliste (Call Stack):** Shows the call stack, with the current frame being 'TempContr_Stateflow_output() Line 234'.



回调函数:

- PreCodeGeneration
- PostCodeGeneration
- PostPublish

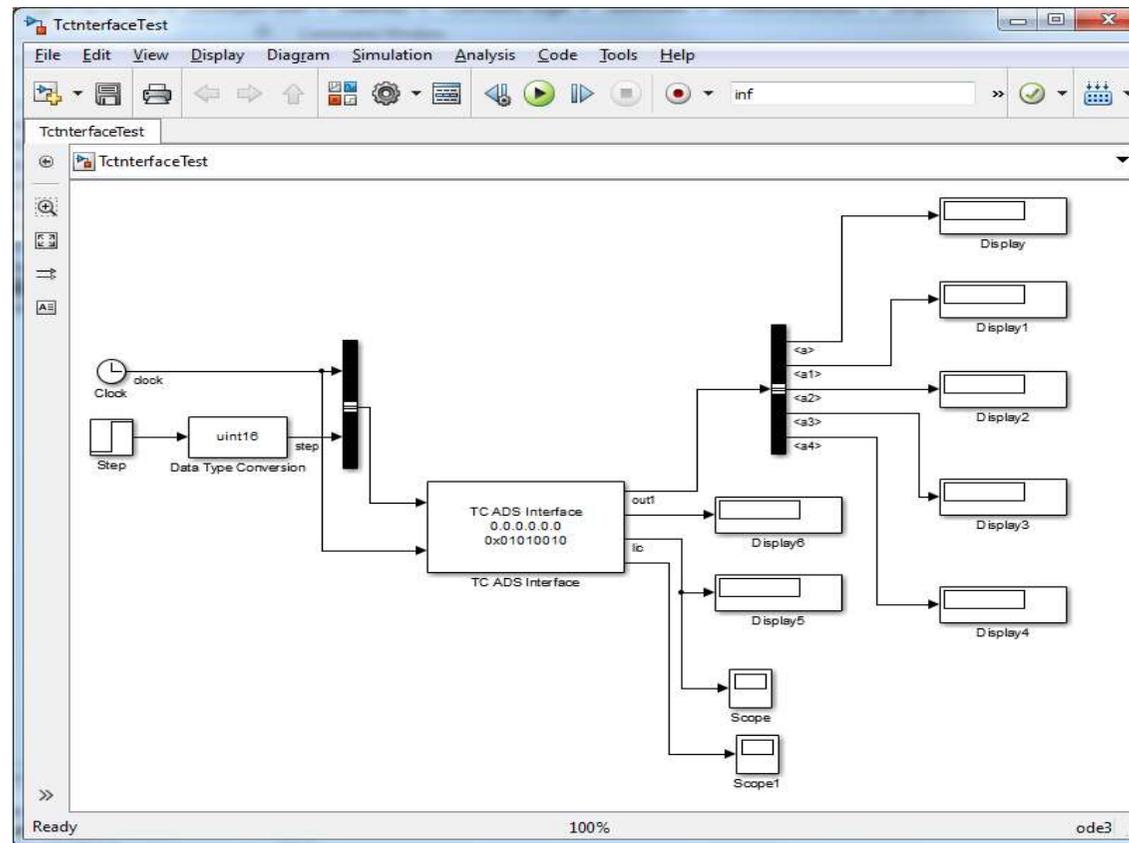
例子: 自动加载模块 (回调函数)

```

49 PostPublish.m x +
50
51 %% Add ToCom Module
52 parentTreeItem = sysManager.LookupTreeItem('TIRC^ToCOM Objects');
53 ToComObject = parentTreeItem.CreateChild(ModuleName,0,'',ClassID);
54
55 %% Add Task
56 Tasks = sysManager.LookupTreeItem('TIRT');
57 Task = Tasks.CreateChild(strcat('TaskFor',ModuleName),1,[],[]);
58 Task.ConsumeXml(strcat('<TreeItem><TaskDef><Priority>',num2str(Priority),'</Priority></TaskDef></TreeItem>'));
59 Task.ConsumeXml(strcat('<TreeItem><TaskDef><CycleTime>',num2str(str2num(CycleTime)*1000000),'</CycleTime>'));
60
61 %Get Task OID
62 xDocTask = System.Xml.XmlDocument;
63 xDocTask.LoadXml(Task.ProduceXml());
64 TaskOID = xDocTask.SelectSingleNode('TreeItem/ObjectId').InnerText;
65
66 %% Append TaskOID to ToCom Object
67 xDocToComObj = System.Xml.XmlDocument;
68 xDocToComObj.LoadXml(ToComObject.ProduceXml());
69 xContext = xDocToComObj.SelectSingleNode('TreeItem/TcModuleInstance/Module/Contexts/Context[Id=0]');
70 XManualConfig = xContext.OwnerDocument.CreateElement('ManualConfig');
71 xOTCID = xContext.OwnerDocument.CreateElement('OTCID');
72 xOTCID.InnerText = char(TaskOID);
73 XManualConfig.AppendChild(xOTCID);
74 xContext.AppendChild(XManualConfig);
75 ToComObject.ConsumeXml(xDocToComObj.InnerXml);
76
77 Project.Save();
78 Solution.SaveAs(SolutionPath);

```

TE1410 Interface for Matlab Simulink



TE1410 Interface for Matlab Simulink

ADS symbols

BlockPort	Name	Type	NetId	AmsPort	Index
1	Object 1 (TempCo...	ADST_INT16	172.17.36.176.1.1	350	16842

ADS symbols table (bottom):

Name	Type	Index...	Index...	Size	Full-Nam
Button1	BOOL	0x101...	0x800...	1	Object 1
Button2	BOOL	0x101...	0x800...	1	Object 1
conn_PWMFan	BOOL	0x101...	0x800...	1	Object 1
conn_PWMHeater	BOOL	0x101...	0x800...	1	Object 1
conn_TempMeasurement	BOOL	0x101...	0x800...	1	Object 1
ExternalSetpoint	INT	0x101...	0x800...	2	Object 1
FeedbackTemp	INT	0x101...	0x800...	2	Object 1

General Simulink block settings:

- Stop simulation: [dropdown]
- Sample time: 0.000000 s

Synchronisation:

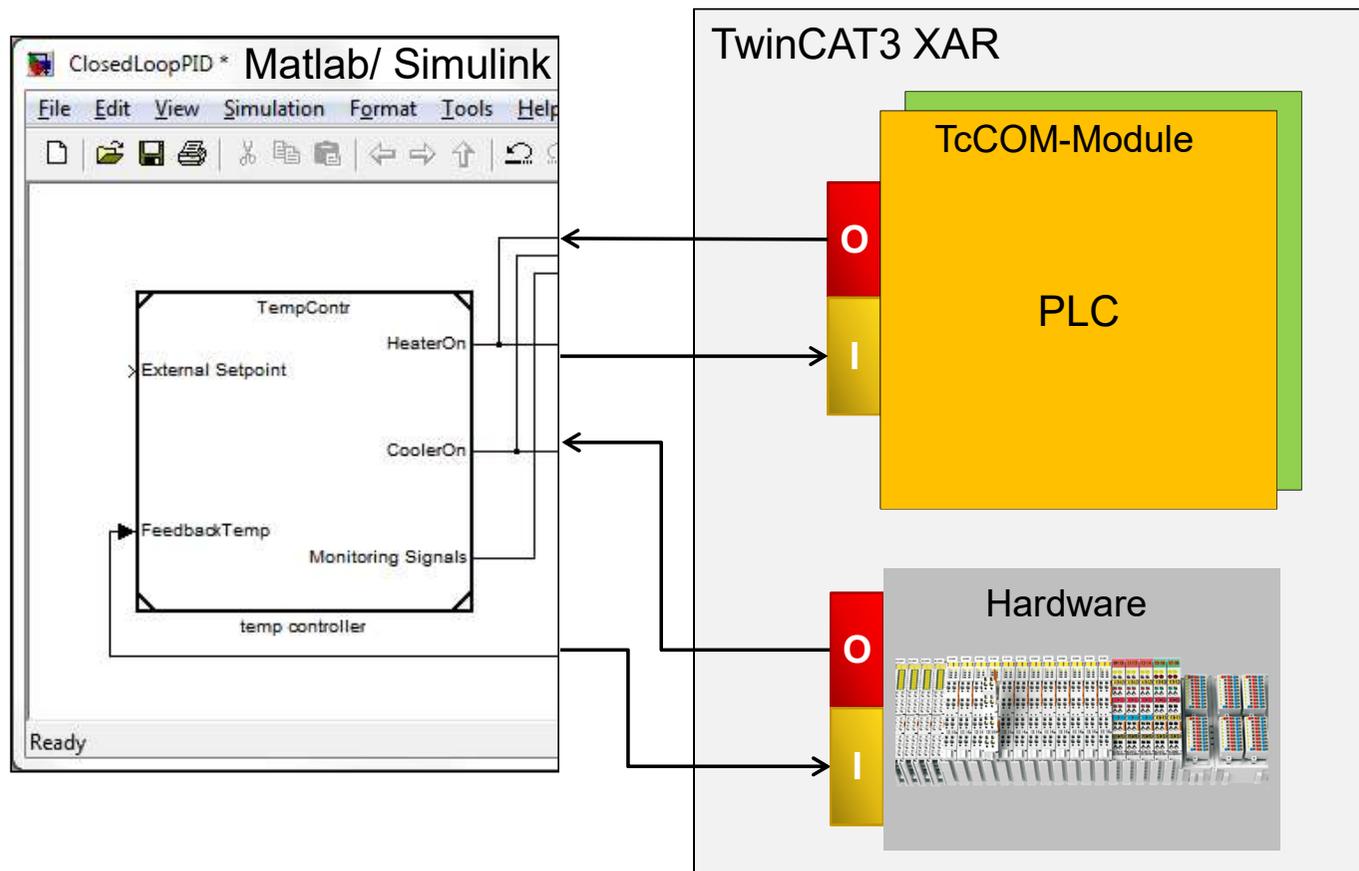
- No synchronisation
- Synchronised data exchange
- Buffer length: 10.0 s
- Time stamp output port

TC ADS Interface block:

```

TC ADS Interface
0.0.0.0.0
0x01010010
TC ADS Interface
    
```

TE1410 Interface for Matlab Simulink



Matlab®/ Simulink® 集成 | 总结

我们解决方案的优势:

- 模型生成过程中, Simulink中不需要 Beckhoff 定制块
 - > Simulink® 模块独立于硬件
 - > 映射的改变不需要对模型进行编译
- 通过图解方式显示在Tc3工程环境中
 - > 在线监控参数和信号
 - > 在线修改参数值
 - > 强大的调试机制 (断点,...)
- 在TwinCAT中不需要编译器就可以改变模块周期
- 模块可以不通过task被其他模块访问
 - > 无需编译自由切换模块
 - > 自动生成封装了模块的PLC功能块
- 通过映射与其他模块完成过程镜像连接
- 支持所有Simulink® Coder所支持的工具箱

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