

TwinCAT3

# Matlab® / Simulink® Integration

## TwinCAT 3: eXtended Automation



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  - TE1400 | 模块的实例化
  - TE1400 | 调试
  - 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

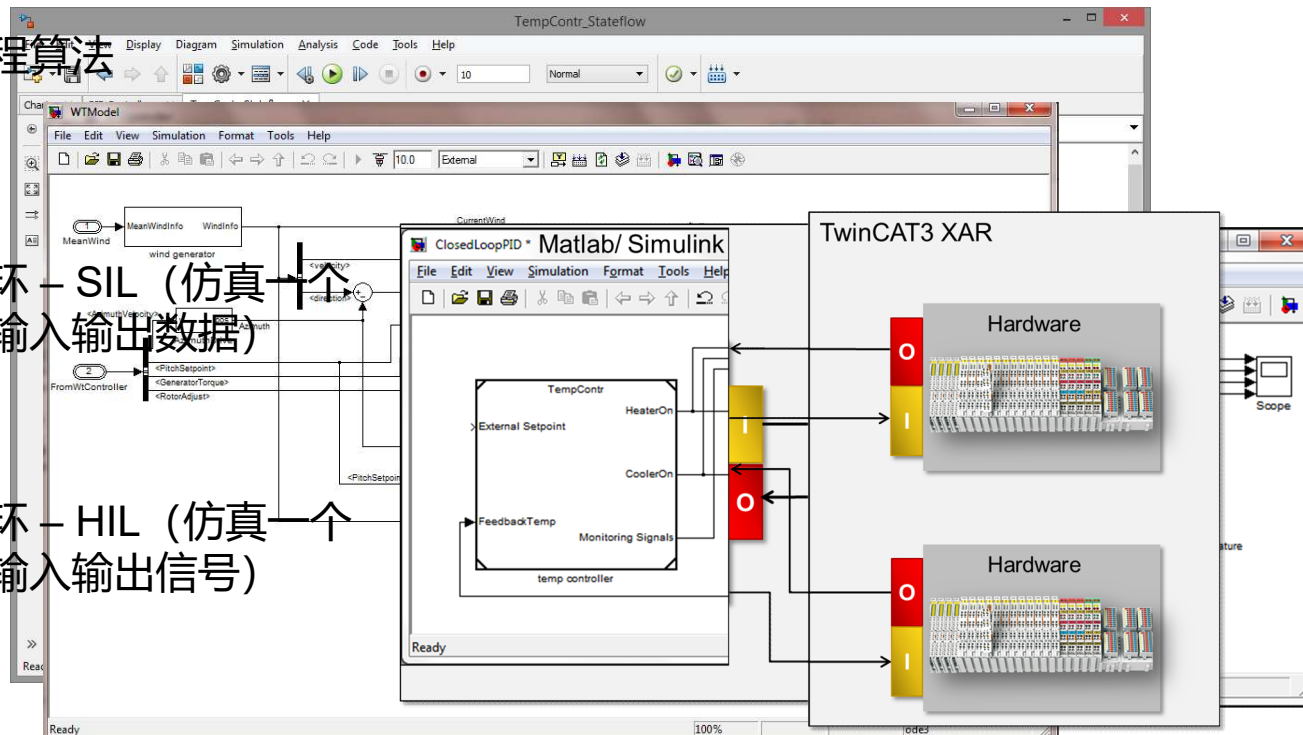
目的 | 应用案例：

- 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:

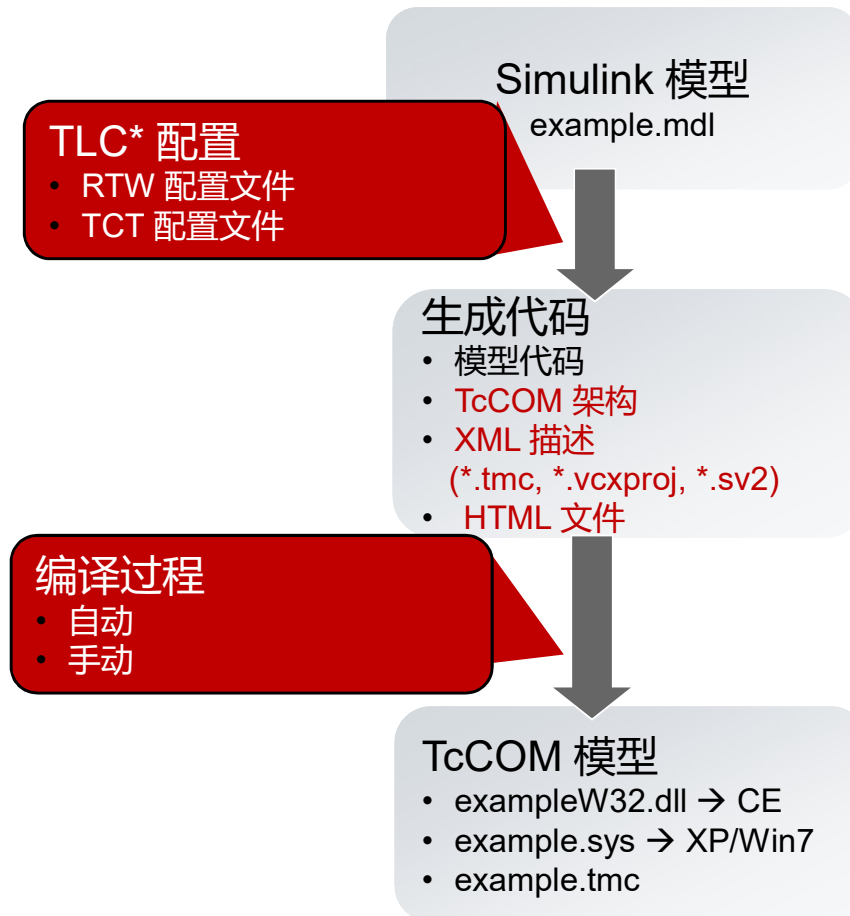
# TE1400 | Target for Matlab Simulink

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' block, a 'Saturation' block, a 'Switch' block, and a 'PWM' block. 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. The 'MATLABSample' window has a 'Projektmappe-Explorer' on the left, a 'MATLABSample' window in the center, and a 'Block Identifier' window on the right. A red arrow points from the 'MATLABSample' window to the 'Block Identifier' window. The 'Block Identifier' window shows the following information:

Block Identifier
Identifier: <Root>
Name: TempContr_S
Path: TempContr_S
Type: root
DataArea: Input
Button1: FALSE
Button2: FALSE
conn_P: FALSE
conn_PI: FALSE
conn_T: FALSE
External: 0
Feedback: 0
DataArea: Output
Cooler: ...
EnableF: ...
EnableH: ...
Heater: ...
Monitor: ...
status: ...
DataArea: External Mode
ExtMode: Connection1
ExtMode: IT:TargetVer...



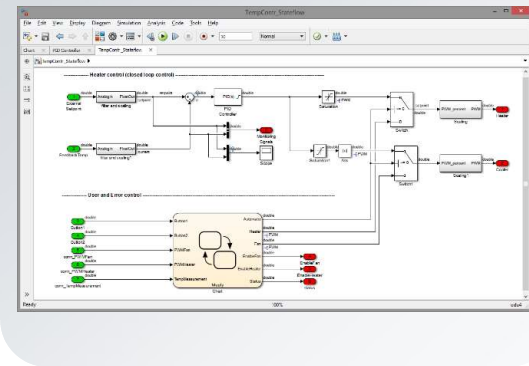
# 代码生成过程



\*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

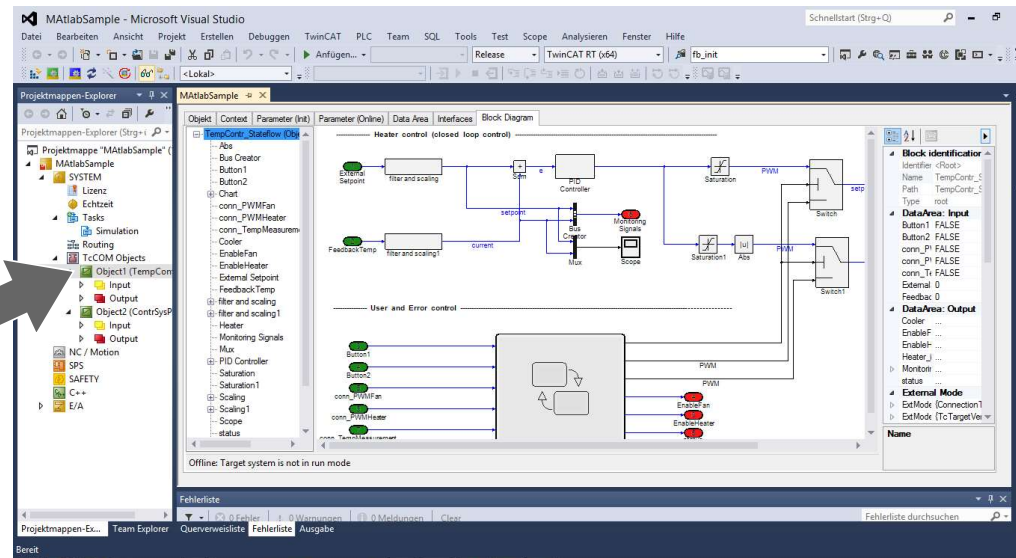
**Matlab/Simulink + Simulink Coder 必须!**

# 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



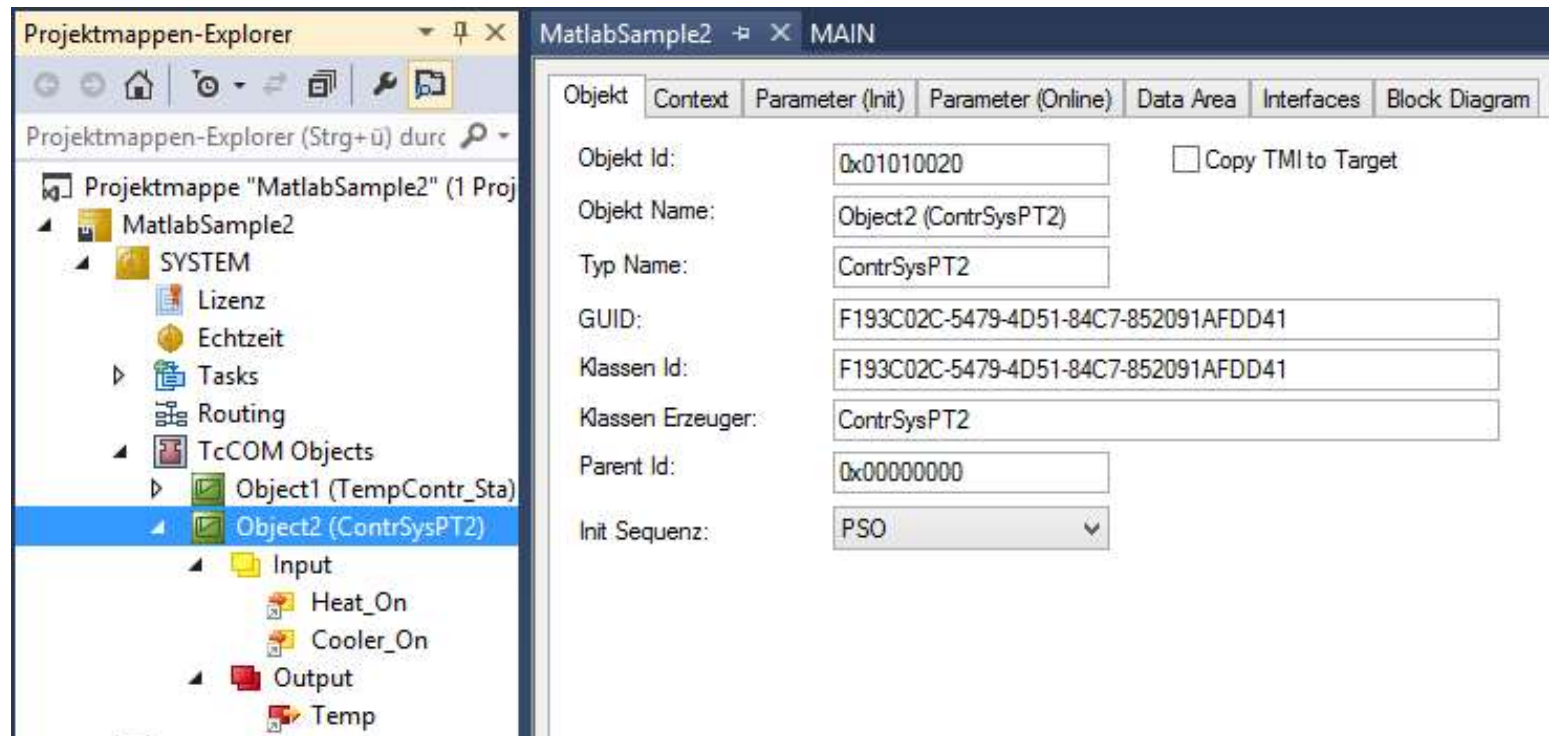
Matlab/Simulink + Simulink Coder 不需要!





## 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. The 'Report' menu is open, showing the 'Export block diagram' option checked. The main workspace shows a Simulink block diagram for a heater control system, divided into two sections: 'Heater control (closed loop control)' and 'User and Error control'. The 'Heater control' section features an 'External Setpoint' (0) and 'FeedbackTemp' (238) inputs, both passing through 'filter and scaling' blocks. The error signal 'e=' is calculated as the difference between the setpoint and feedback, which is then processed by a 'PID Controller'. The output of the PID controller is limited by a 'Saturation' block (-60) and then an 'Abs' block. The 'User and Error control' section shows a 'Chart' block receiving inputs from 'Button1' through 'conn\_TempMeasurement', all currently set to 'FALSE'. The chart outputs 'Pulse Width Modulation' (PWM) signals for 'EnableFan' and 'EnableHeater', and a 'status' signal.

Block identification	Value
Identifier	<Root>
Name	TempContr_Stateflow
Path	TempContr_Stateflow
Type	root

DataArea: Input	Value
Button1	FALSE (FALSE)
Button2	FALSE (FALSE)
conn_PWMFan	FALSE (FALSE)
conn_PWMHeater	FALSE (FALSE)
conn_TempMeasurement	FALSE (FALSE)
ExternalSetpoint	0 (0)
FeedbackTemp	0 (238)

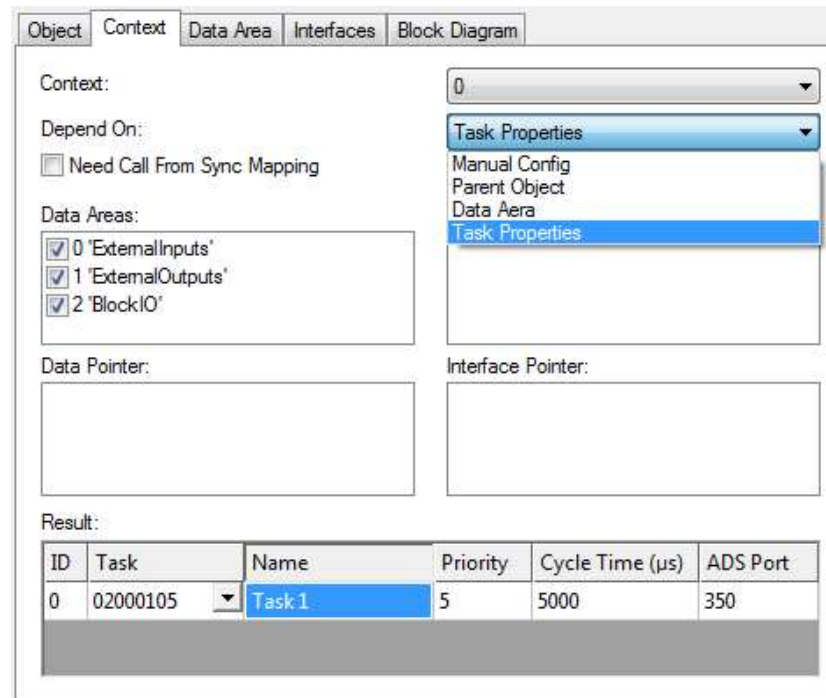
DataArea: Output	Value
Cooler	(19660)
EnableFan	(TRUE)
EnableHeater	(TRUE)
Heater_j	(0)
MonitoringSignals status	({setpoint=0; current=23.78 (Automatic)})

External Mode	Value
ExtModeParameters	{ConnectionTimeout=3; Init1
ExtModeServerVersion	{Tc TargetVersion={1; 2; 1;
ExtModeStatus	{IncomingPktBufferSize=0;

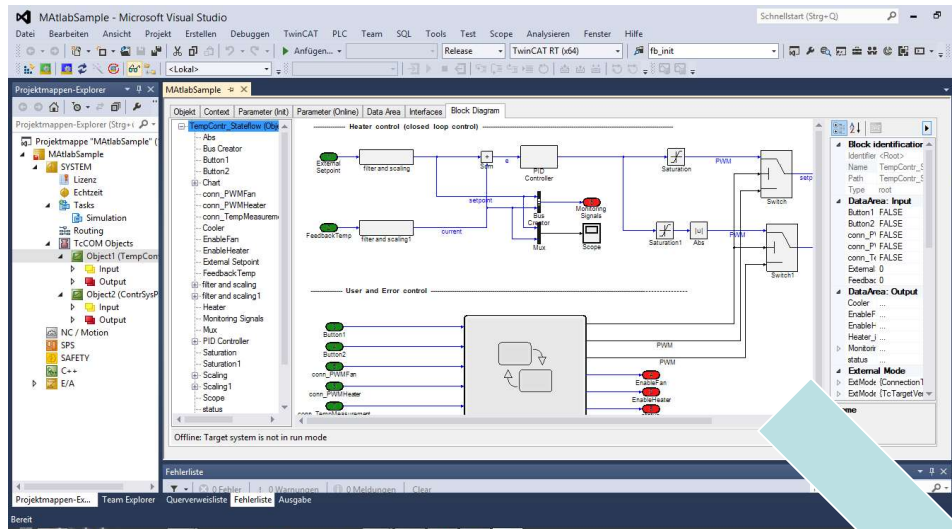
Internal signals	Value
Bus Creator_Out1	({setpoint=0; current=23.78
Button1_Out1	FALSE (FALSE)
Button2_Out1	FALSE (FALSE)
Chart_Out4	(TRUE)
Chart_Out5	(TRUE)
Chart_Out6	(Automatic)

## 集成到 TwinCAT 3

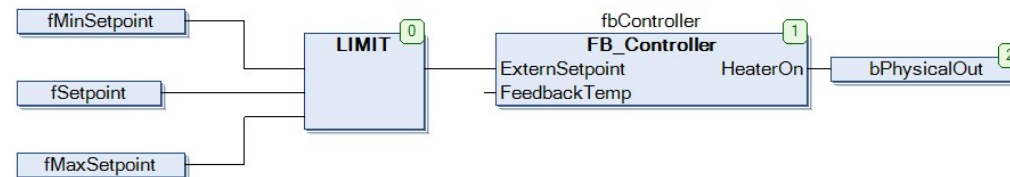
- Matlab/Simulink模块在任务配置中设置循环访问
  - 例如：优先级5，周期5ms的Task 1被附加到模块中



# 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 to produce the "IU" signal (-50). A "Bus Creator" block provides a "setpoint=0" signal to the PID controller and a "Monitoring Signals" block. A "Scope" block is connected to the monitoring signals.

**User and Error control:** This section shows a "Chart" block receiving various inputs: Button1 (FALSE), Button2 (FALSE), conn\_PWMFan (FALSE), conn\_PWMHeater (FALSE), conn\_TempMeasurement (FALSE), and status (FALSE). The chart outputs "PWM" signals, "EnableFan" (TRUE), "EnableHeater" (TRUE), and "Automatic" (Automatic).

**Parameter List:** The right-hand side of the interface shows a list of parameters. Several parameters are highlighted with red boxes:

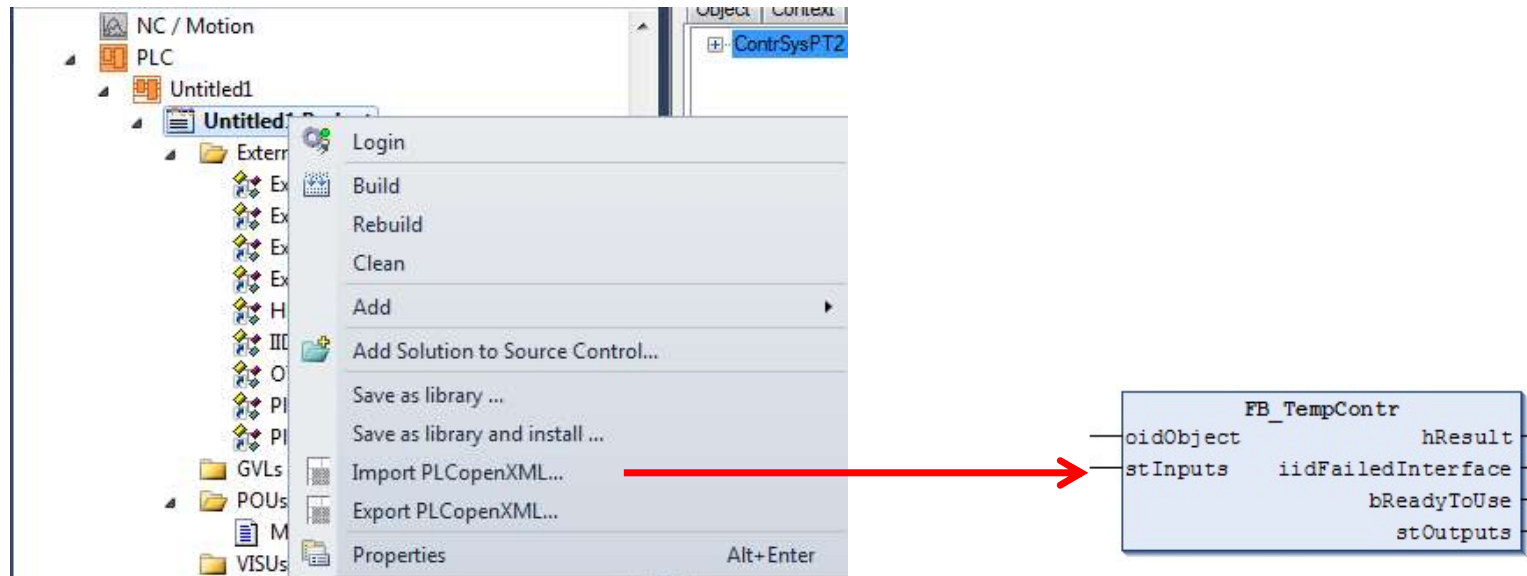
- Task
- StateUpdate/HerOutputMap
- UseTaskCycleTime

# 集成到 TwinCAT 3

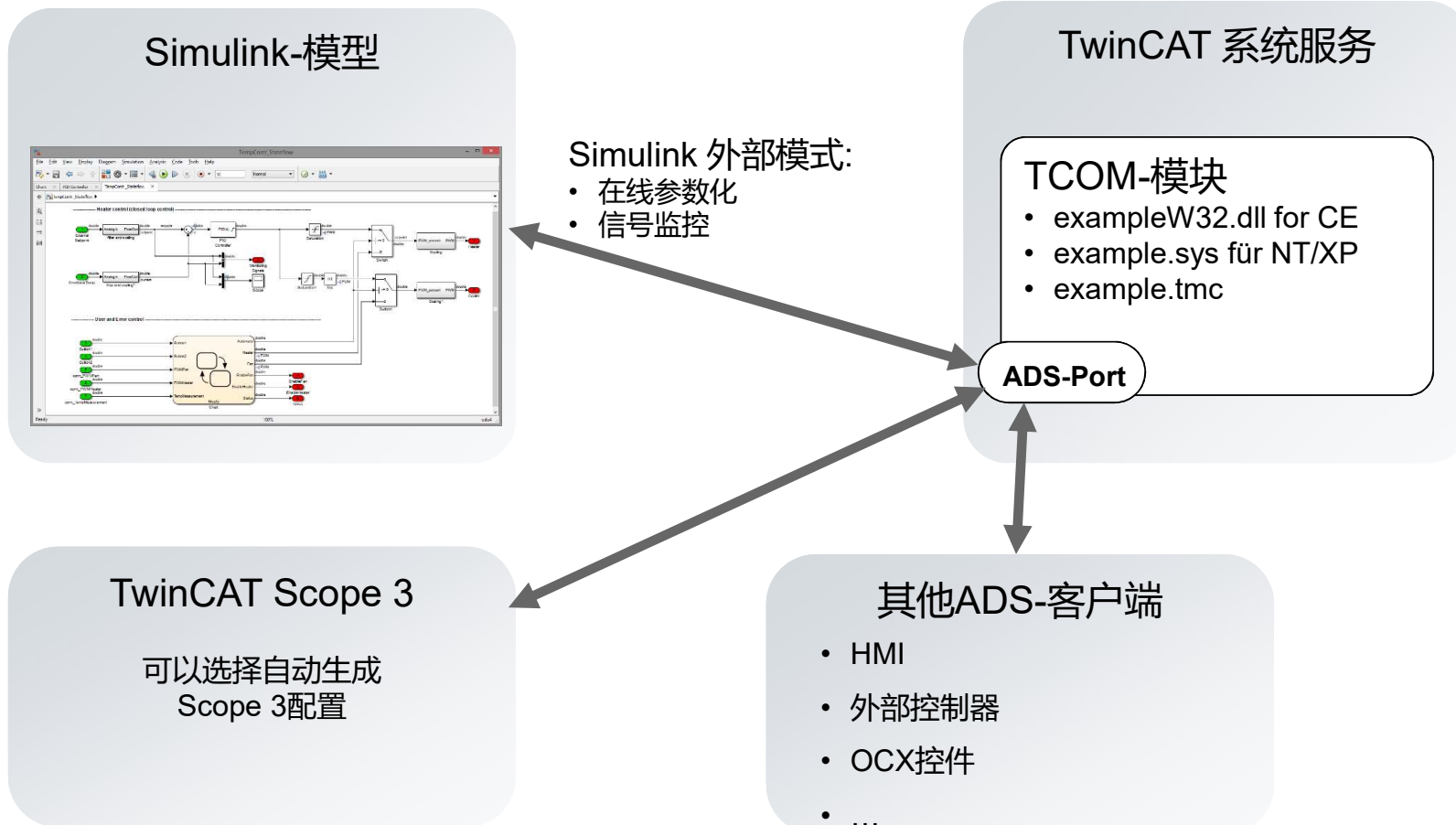
- 用PLC功能块访问
  - Context: PLC task!

Result:

ID	Task	Name
0	02000114	PlcTask

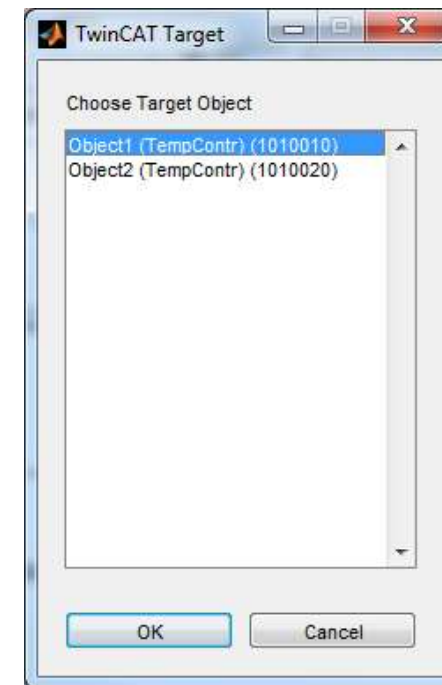
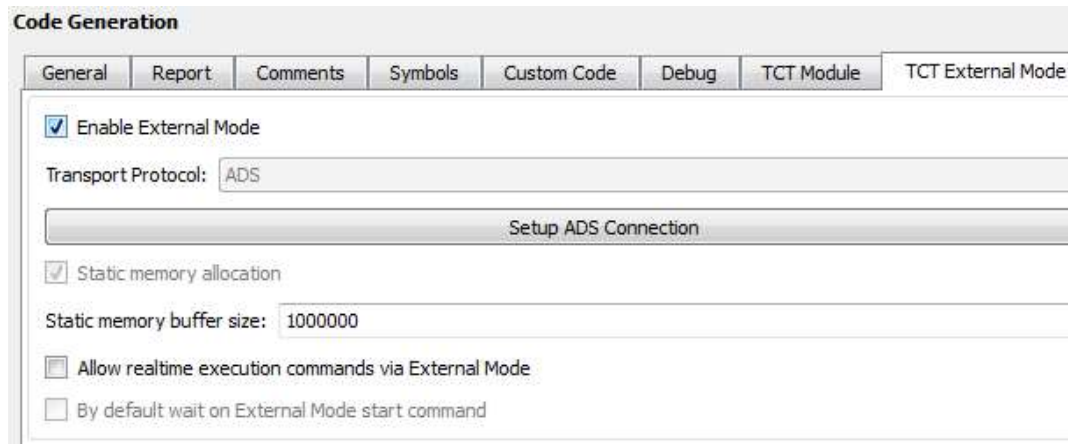
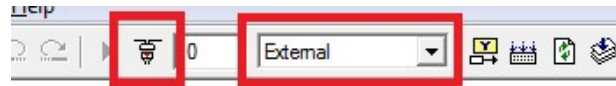


# TC3 Simulink 模块的连通性



## 集成到 TwinCAT 3

- 在Matlab/Simulink中调试
  - 外部模式





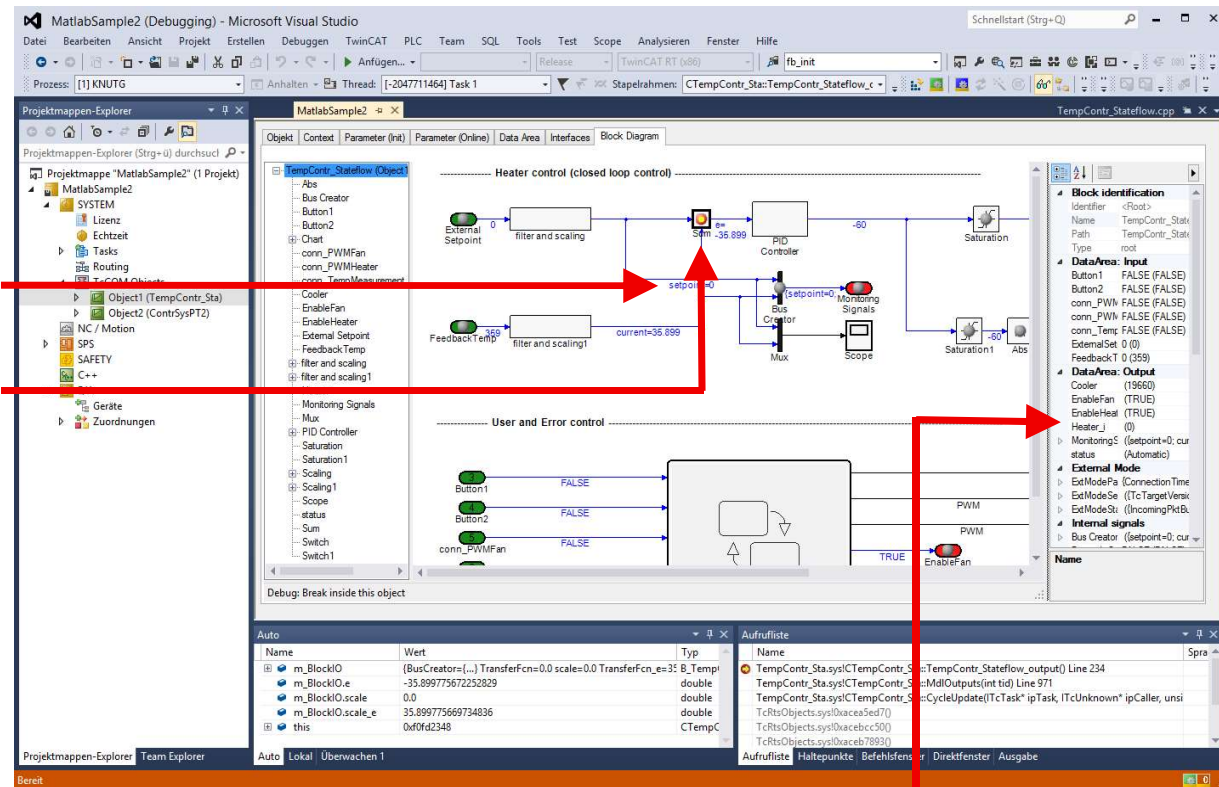
TE1400 | Target for Matlab Simulink

# 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:

- Code Editor:** A yellow highlight covers a code section in `TempContr_Stateflow.cpp`. The code includes a `setpoint` function call and a `BlockIO` object definition. The highlighted code is:  
`Code section:  
File: TempContr_Stateflow.cpp  
Method: CTempContr_Sta::TempContr_Stateflow_output  
Lines: 233, 235  
Code: 233: m_BlockIO.e = m_BlockIO.scale *  
234: m_BlockIO.scale_e;  
235:`
- Block Diagram:** Shows a control loop with blocks like 'filter and scaling', 'setpoint', 'Heater control (closed loop control)', and 'User and Error control'. A red arrow points from the text on the left to a break point in the diagram.
- Tool Windows:**
  - Auto:** A table showing variable values:

Name	Wert	Typ
m_BlockIO	{BusCreator=[...], TransferFcn=0.0, scale=0.0, TransferFcn_e=35, B_Temp	double
m_BlockIO.e	-35.899775672252829	double
m_BlockIO.scale	0.0	double
m_BlockIO.scale_e	35.899775669734836	double
this	0x0f0d2348	CTempC
  - Aufrufliste:** A list of function calls, with the top entry being `TempContr_Sta.sys!CTempContr_Sta::TempContr_Stateflow_output() Line 234`.



## 回调函数:

- PreCodeGeneration
- PostCodeGeneration
- PostPublish

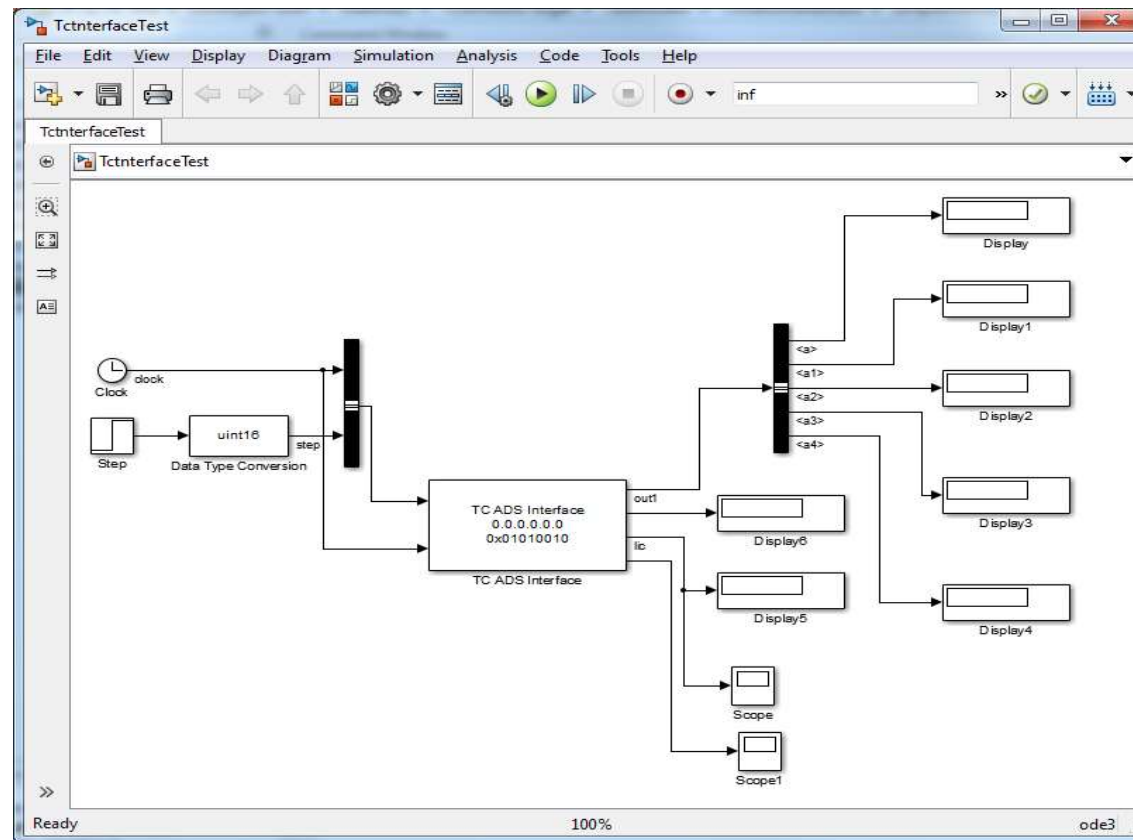
## 例子: 自动加载模块 (回调函数)

```

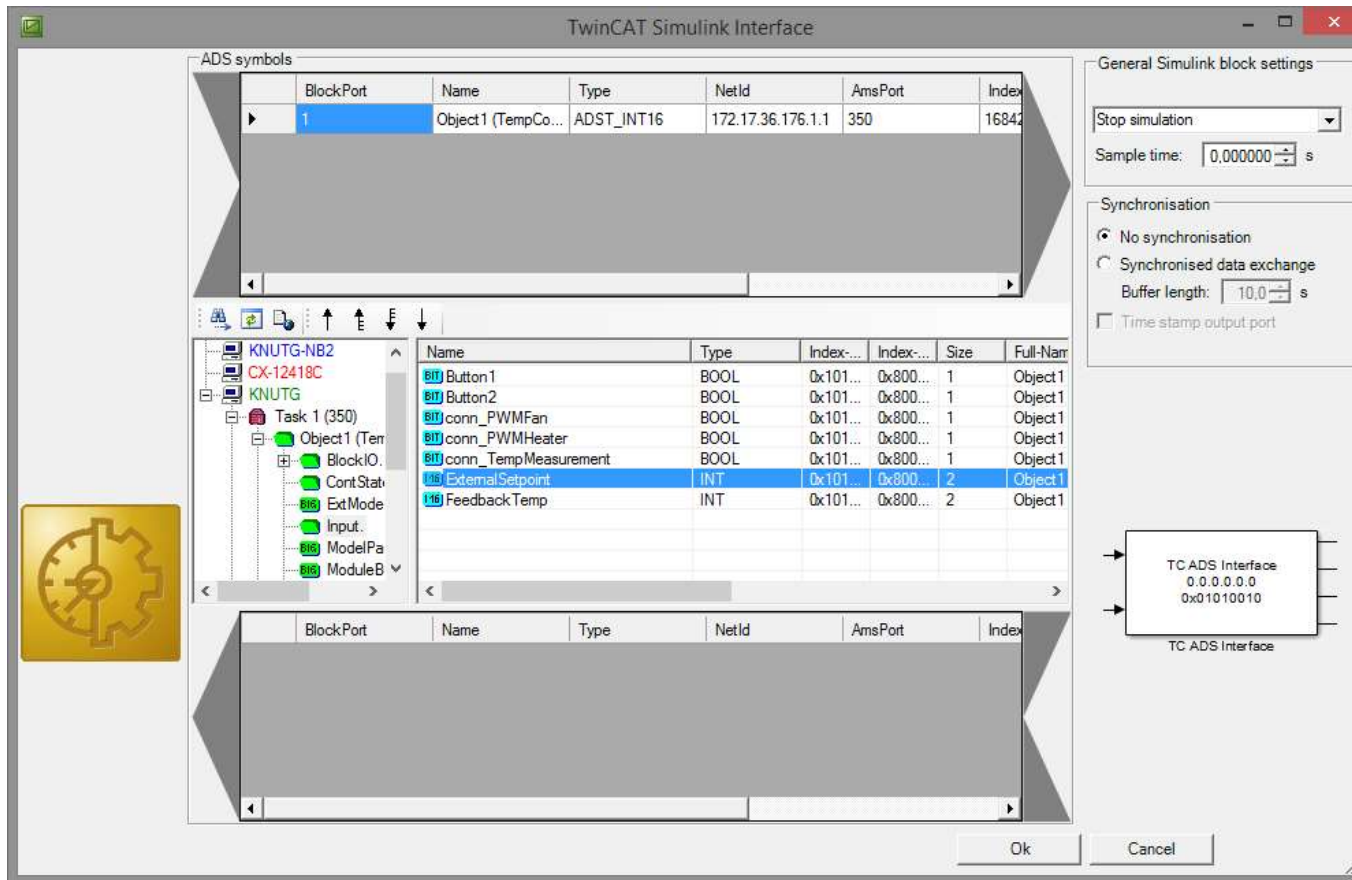
49 PostPublish.m x +
50
51 %% Add ToCom Module
52 parentTreeItem = sysManager.LookupTreeItem('TIRC^ToCOM Objects');
53 ToComObject = parentTreeItem.CreateChild(ModuleName,0,'',ClassID);
54
55 %% Add Task
56 Tasks = sysManager.LookupTreeItem('TIRT');
57 Task = Tasks.CreateChild(strcat('TaskFor',ModuleName),1,[],[]);
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);

```

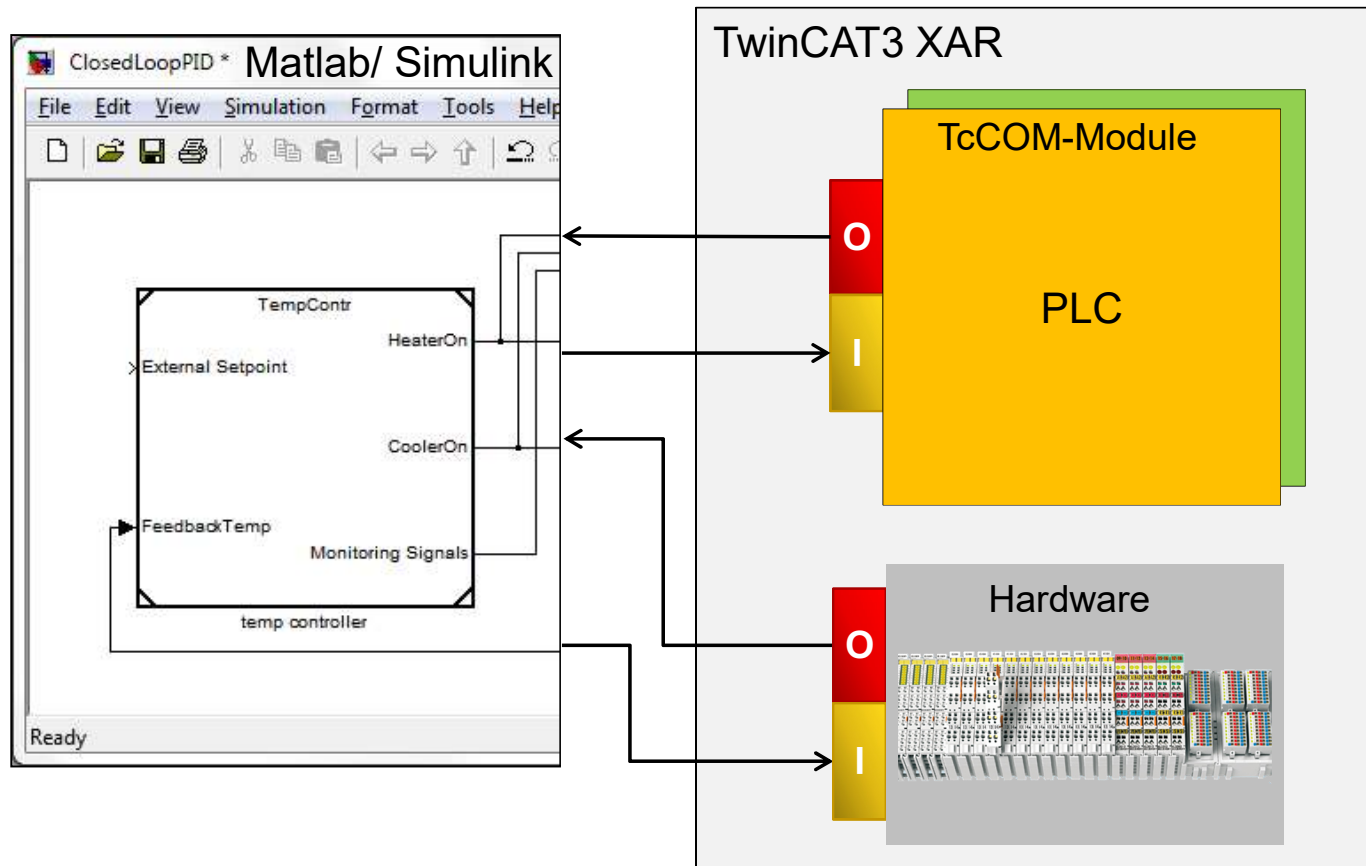
# TE1410 Interface for Matlab Simulink



# TE1410 Interface for Matlab Simulink



# 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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