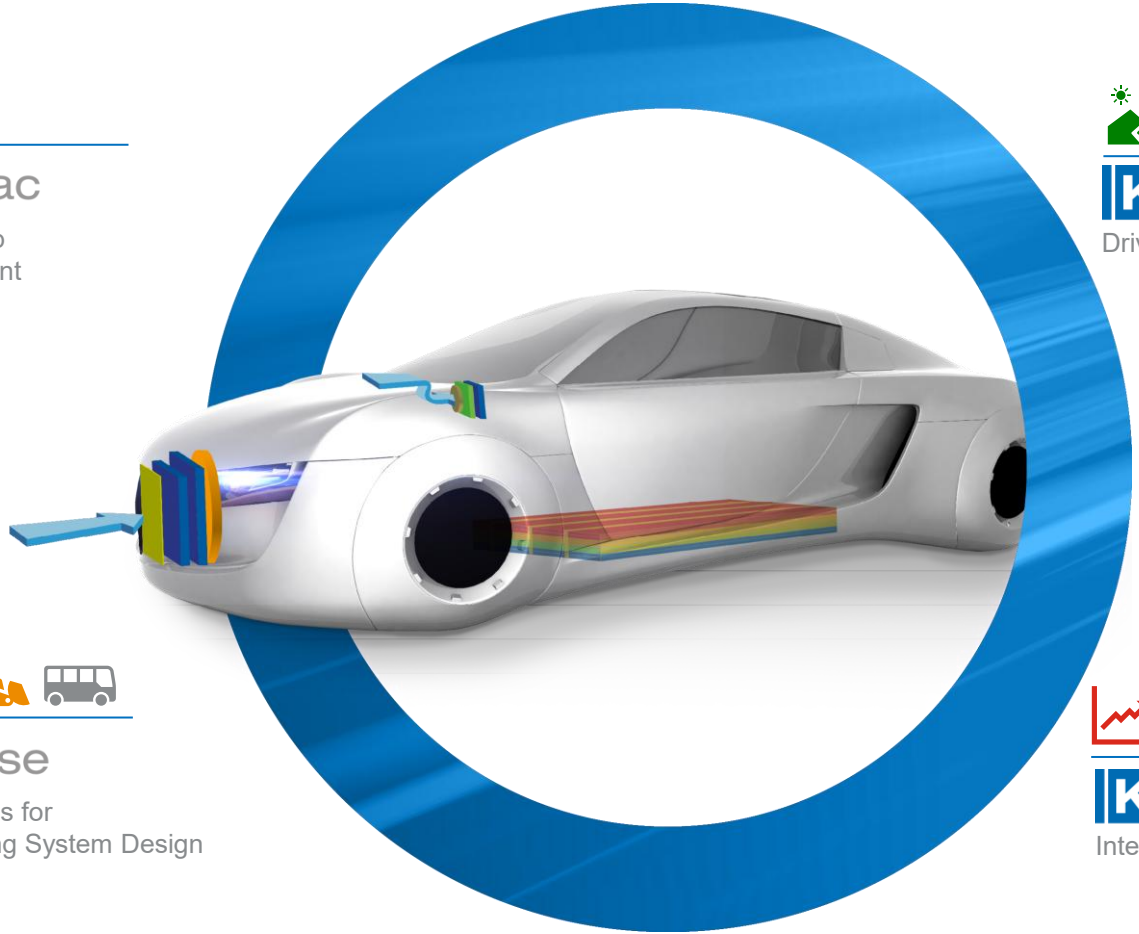
Introduction: KULI advanced
KULI高级模块介绍

Christian Rathberger
Department Energy & Fluid Simulation
Engineering Center Steyr GmbH & Co KG,
4300 St. Valentin, AUSTRIA

What is KULI advanced?
什么是KULI高级模块?

KULI Modules



KULI hvac

A/C and Heat Pump
System Development

KULI drive

Drive Cycles and Engine Model

KULI eco

EV Battery to Powertrain

KULI base

All your Basic Needs for
Steady State Cooling System Design

KULI advanced

Interfaces, CFD and Optimization

KULI advanced 高级模块

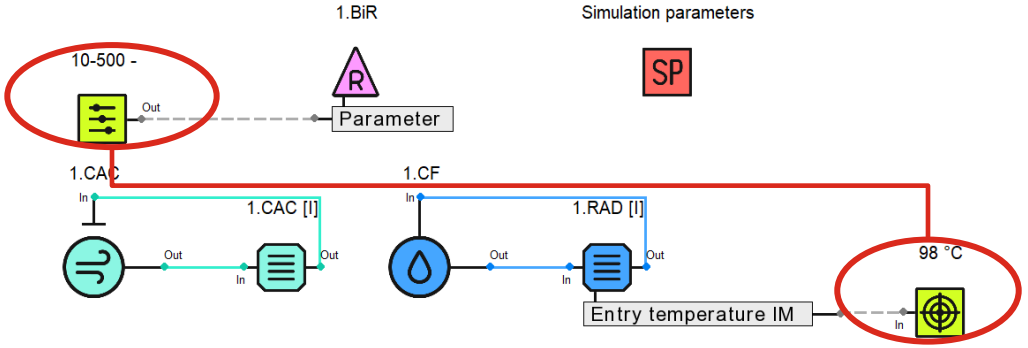
KULI cfd
Integration of 3D effects from CFD analysis
集成CFD分析的三维影响因素

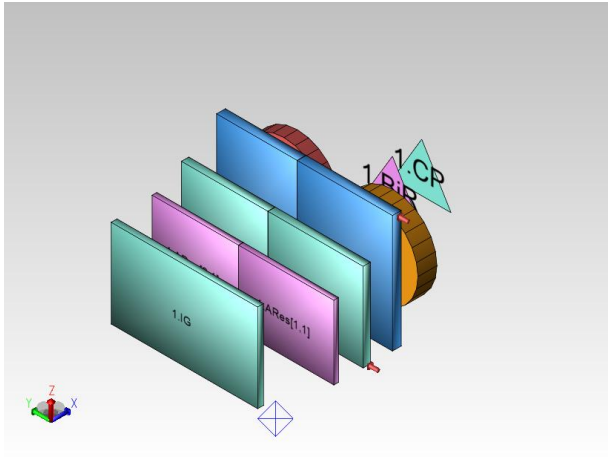
KULI com
Open interface to other programs
KULI与其它软件的开放接口

KULI optimize
Toolbox for automatic variations and optimization
用于自动参数和最优化的工具

Typical Application – System Calibration (Optimization)
典型应用 – 系统标定（最优化）

Find loss coefficient of Built-In Resistance such that measured coolant top tank temperature from Vehicle Test is met!
寻找BIR压力损失系数以匹配测试得到的发动机出水温度

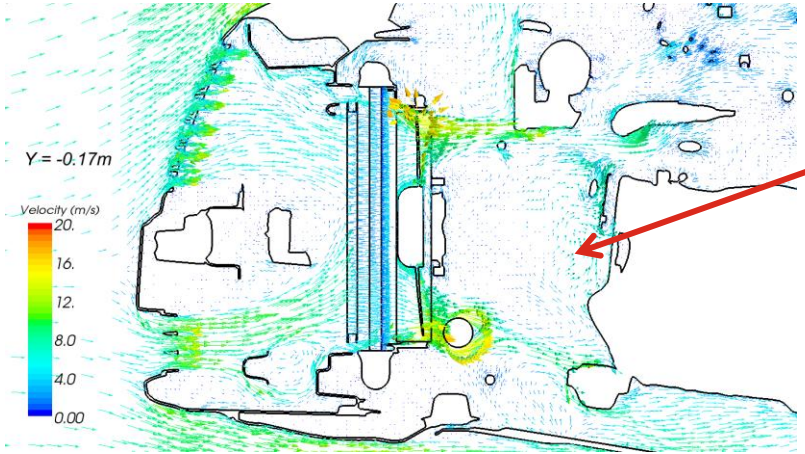


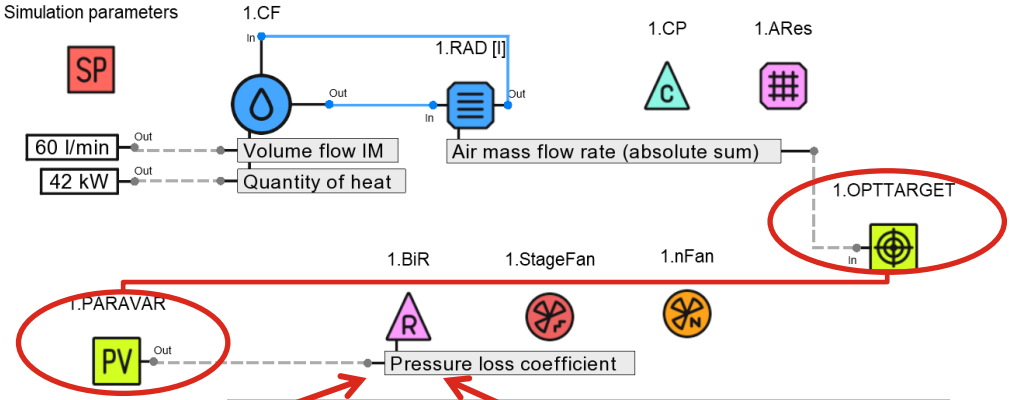


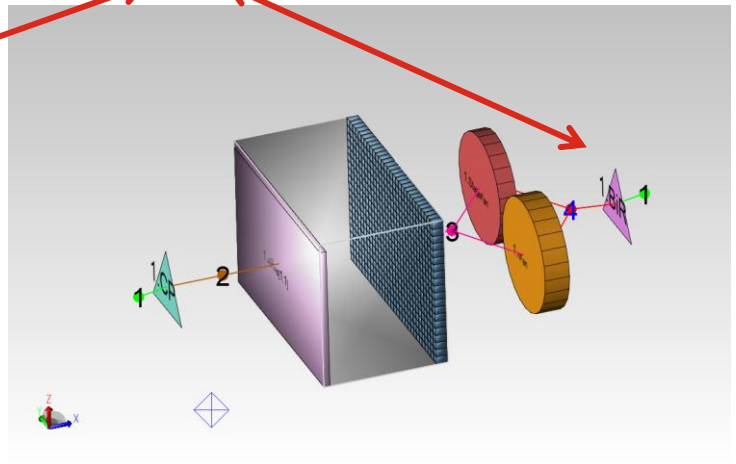
Typical Application – System Calibration (Optimization + CFD)
典型应用 – 系统标定 （最优化+CFD）

Find loss coefficient of Built-In Resistance such that mass flow rates from CFD-Calculation are met!

寻找合适BIR压力损失系数以匹配CFD计算得到的流量



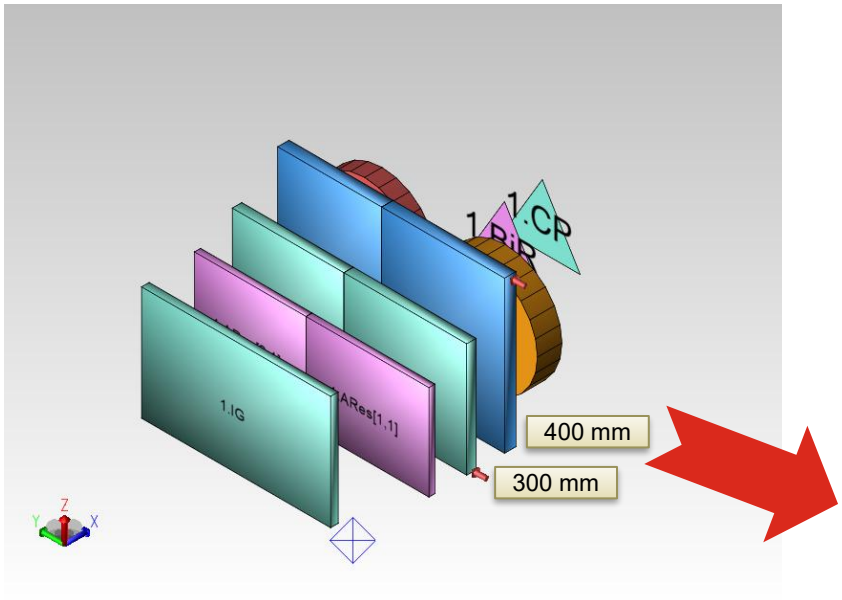


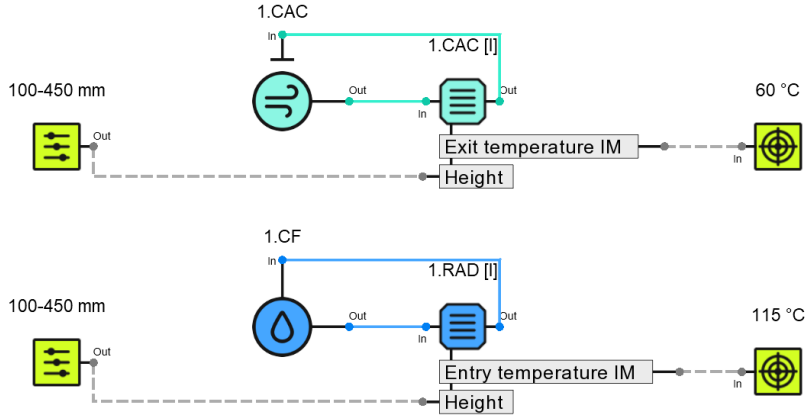


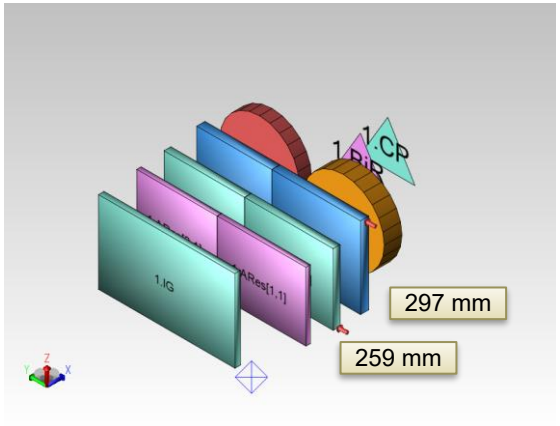
Typical Application – Minimize Package Size (Optimization)
典型应用 – 最小化模块尺寸（最优化）

Reduce heat exchanger sizes according to performance limits

根据性能表现减小换热器尺寸







Typical Application – Multiple Configurations (Parameter Variation)
典型应用 – 多参数配置（多参数计算）

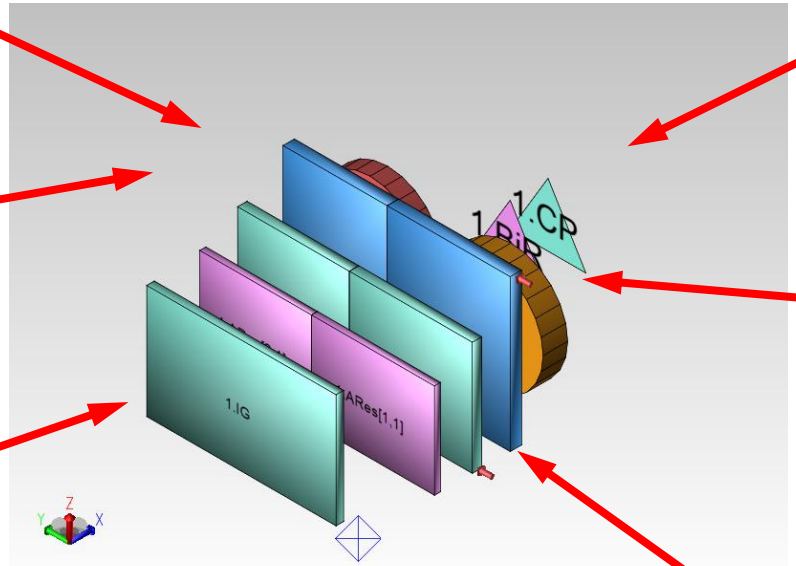
Quickly evaluate multiple configurations using parameter variation

采用多参数计算快速评估不同配置

Flow Directions
流动方向

Flow Rates
流量

Ambient Parameters
Temperature
Driving Speed
环境参数
温度、行驶速度



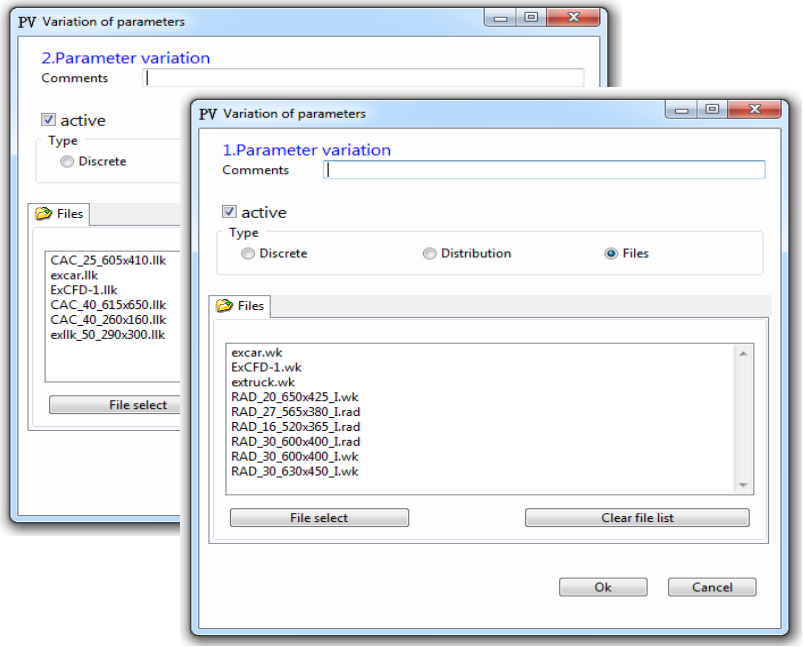
Build in Situation
Overlapping
零部件位置

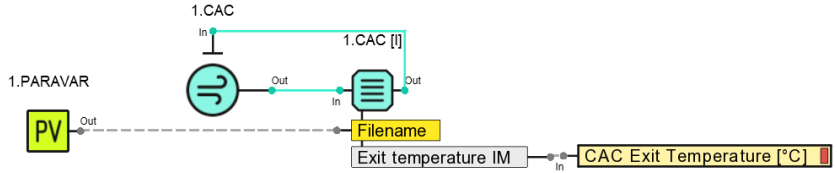
Fan Type
Fan Diameter
Fan Speed
风扇类型
尺寸、转速

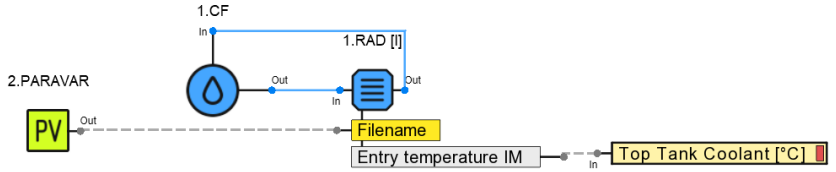
Heat Exchanger Type
Dimensions
换热器类型、尺寸

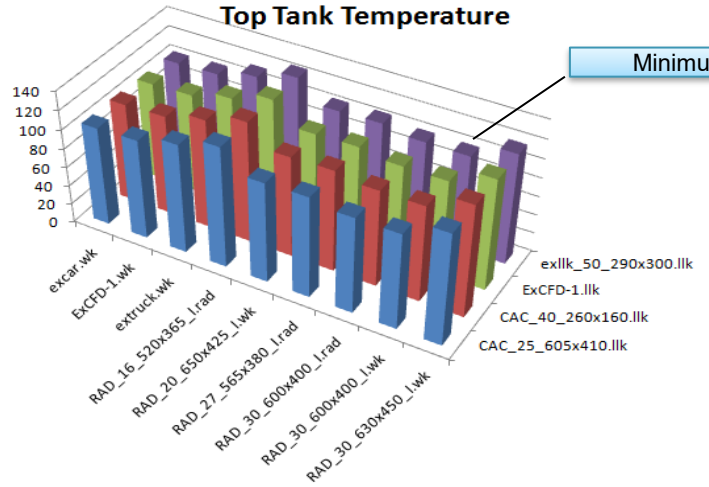
Typical Application – Best Fitting Components (Parameter Variation)
典型应用 – 寻找最佳零部件（多参数计算）

Find best performing component selection from your library
在零部件库中寻找最合适的零部件





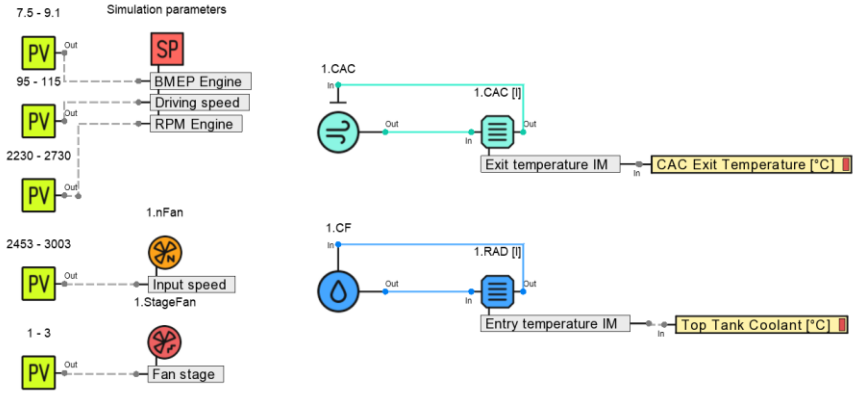


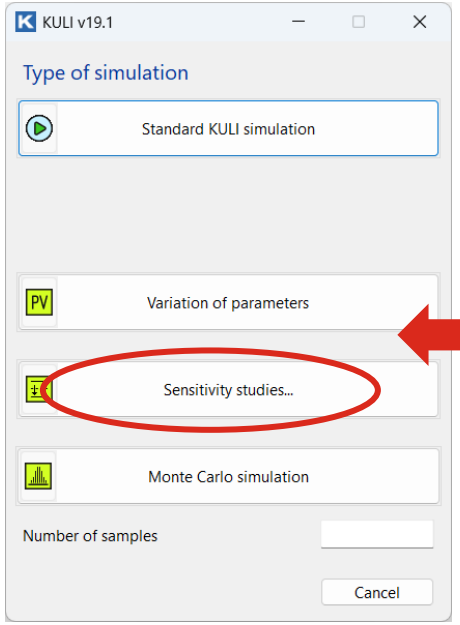


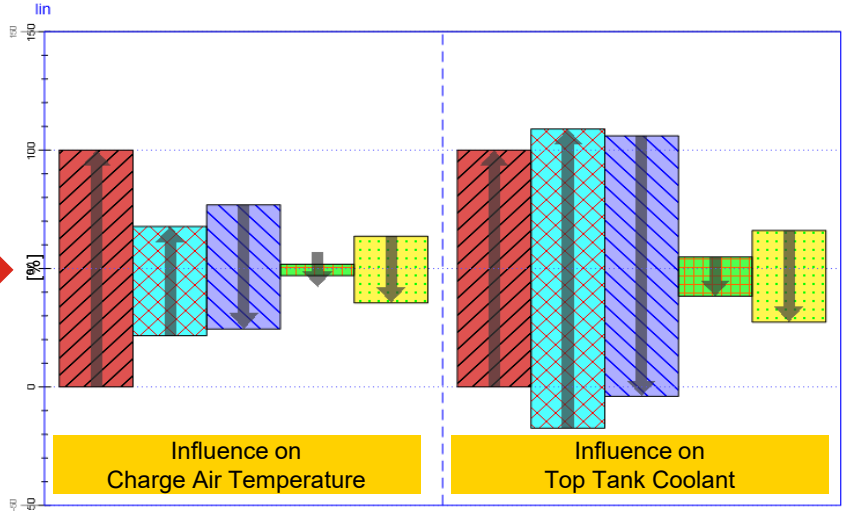
Typical Application – Sensitivity Studies
典型应用 – 参数灵敏度分析

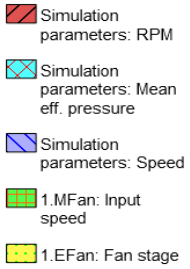
Find out which parameter can influence the cooling system the most!

寻找哪个参数对系统影响最大









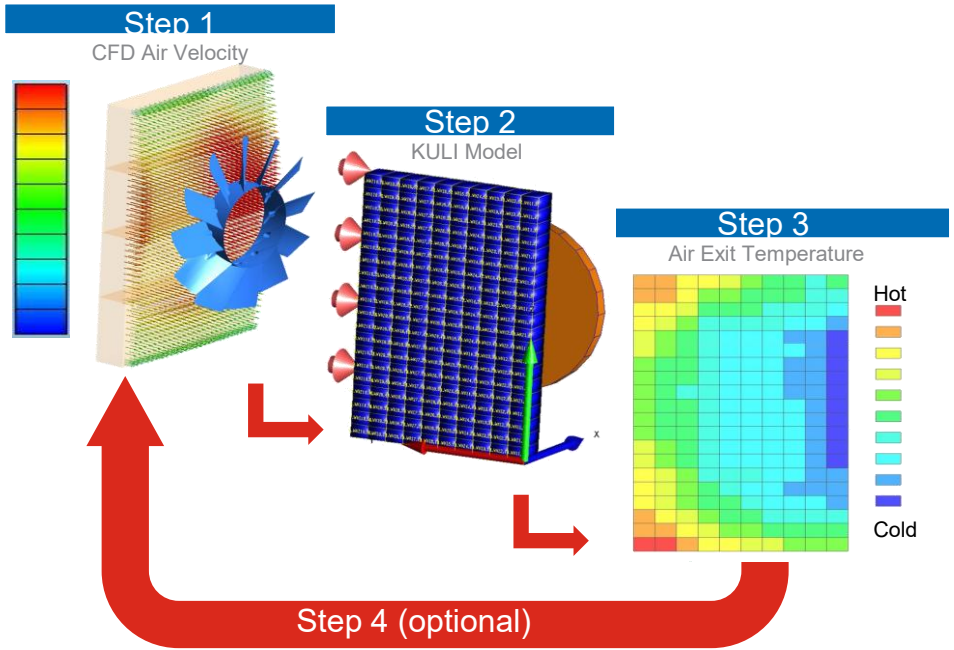
KULI cfd – Interface CFD接口

Step 1
- Run (isothermal) CFD calculation
  计算冷流场CFD
- Generate Velocity Map
  建立速度分布曲面

Step 2
- Input Velocity Map to KULI
  输入速度曲面至KULI
- Run KULI Calculation
  运行KULI计算

Step 3
- Generate Rejected Heat Map of HX
  建立散热器换热曲面
- Input Rejected Heat Map to CFD Code
  输入换热曲面至CFD

Step 4
- Go to Step 1 (-> “hot” CFD calculation)
  返回第一步（->计算“热流场” CFD）



KULI com – KULI controlled from Excel ® (Interfaces)
KULI com – 从Excel（接口）控制KULI

Run KULI from Excel and fill your Excel sheet automatically with calculation data!

从Excel运行KULI并自动将计算数据写入Excel表

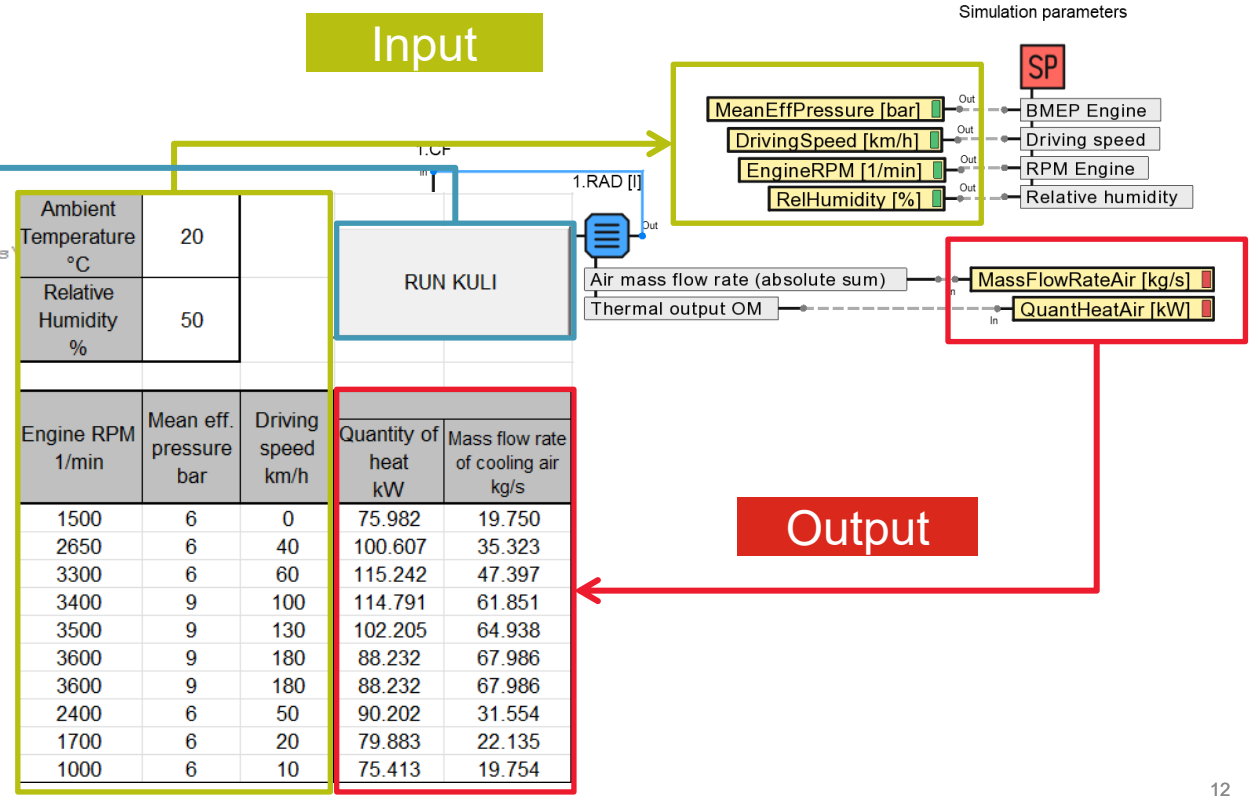
```
Private Sub CommandButton1_Click()
    Dim calcOK As Boolean

    'set a new KULI-controller
    Set KULI = New KuliAnalysisCtr2
    'Definition of coolingsystem
    KULI.KuliFileName = "C:\CoolingSystems\
    'initialize the cooling system
    calcOK = KULI.Initialize()
    ...
```

VBA Macro

Input

Ambient Temperature °C	20
Relative Humidity %	50

Engine RPM 1/min	Mean eff. pressure bar	Driving speed km/h	Quantity of heat kW	Mass flow rate of cooling air kg/s
1500	6	0	75.982	19.750
2650	6	40	100.607	35.323
3300	6	60	115.242	47.397
3400	9	100	114.791	61.851
3500	9	130	102.205	64.938
3600	9	180	88.232	67.986
3600	9	180	88.232	67.986
2400	6	50	90.202	31.554
1700	6	20	79.883	22.135
1000	6	10	75.413	19.754



Python in KULI

Interface KULI – Python

KULI – Python接口

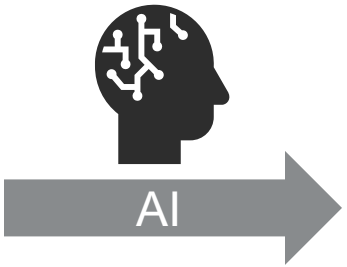
- KULI advanced contains the Python controller
  KULI高级模块包含了Python控制器
  - Introduced with version 17.1
    从版本17.1开始

- Functionality 功能
  - Part of signal path
    信号路径的一部分
  - Receives multiple inputs
    接收多个输入
  - processes the inputs
    (by running a Python script)
    处理输入（通过运行Python脚本）
  - Returns an optional number of outputs
    返回可选数量的输出

What is Python? 什么是Python？

- High-level, general-purpose programming language
  高级通用编程语言
- One of the most popular languages 最流行的语言之一
  - Focus on high code readability 注重代码高可读性
  - Well-known by AI such as Chat GPT被Chat GPT等AI广泛使用
- Free and open-source
  免费且开源

"give me a python routine with inputs time, value, interval that returns the moving average for the given time interval"
给我一个Python程序，输入时间、数值和间隔，返回指定时间间隔的移动平均值

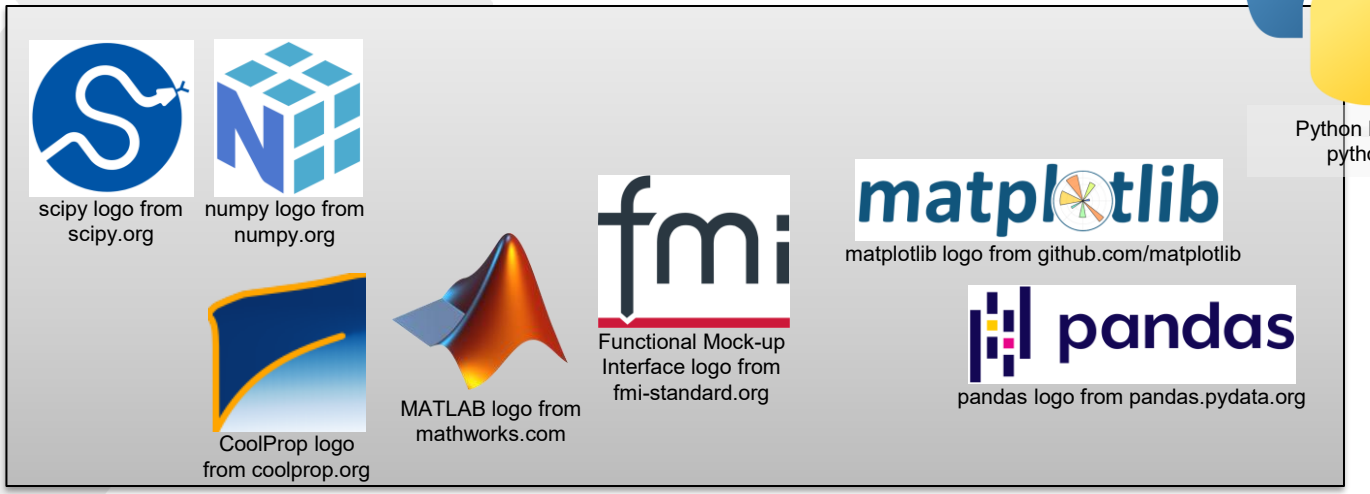


Copy

```
def calculate_moving_average(time, value, interval):
    moving_average = []
    for i in range(len(value) - interval + 1):
        average = sum(value[i:i+interval]) / interval
        moving_average.append(average)
    return moving_average
```

What is Python? 什么是Python?

- Comprehensive Modules
  功能全面的模块
  - broad standard library
    标准库广泛
  - wide range of (commercially applicable) modules
    涵盖各类（商业适用）模块
  - huge community with open-source mentality
    and many out-of-the-box solutions
    拥有庞大开源社区并提供众多开箱即用的解决方案



Applications of the PYC
PYC的典型应用

Process data
数据处理

draw plots (matplotlib)
绘制图表（matplotlib）

extract results or import boundary conditions (pandas)
提取结果或导入边界条件（pandas）

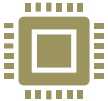
Modeling
建模

simplification of signal paths/control strategies
信号路径/控制策略的简化

Maths & Physics
数学&物理

mathematical functions and optimizers (numpy, scipy, etc.)
数学函数与优化器（如 numpy、scipy 等）

physical models (e.g. coolant properties and other fluids with CoolProp)
物理模型（例如通过 CoolProp 实现冷却剂及其他流体的物性计算）



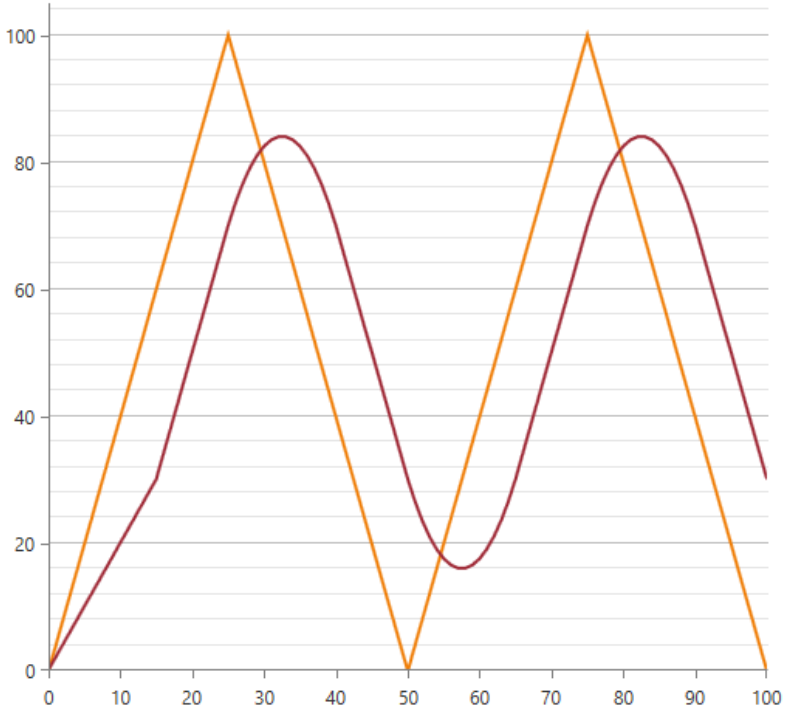
Co-simulations with Python as interface
采用Python接口耦合仿真

MATLAB Simulink (MATLAB engine API)
MATLAB Simulink（通过MATLAB引擎API调用）

FMUs (FMPy) any other app with a Python API...
FMU模块（使用FMPy工具包）以及任何支持Python接口的应用程序...

Examples – KULI with Python Controller component
参考案例 – 在KULI中使用Python控制器

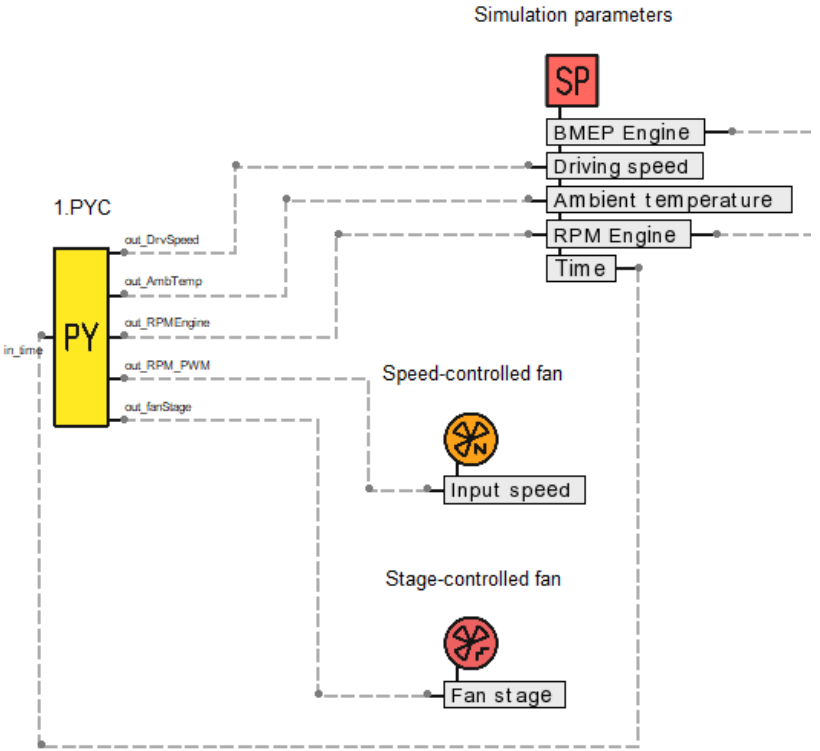
Calculate moving average over time
(AI generated code)
根据时间计算移动平均数
（AI生成代码）



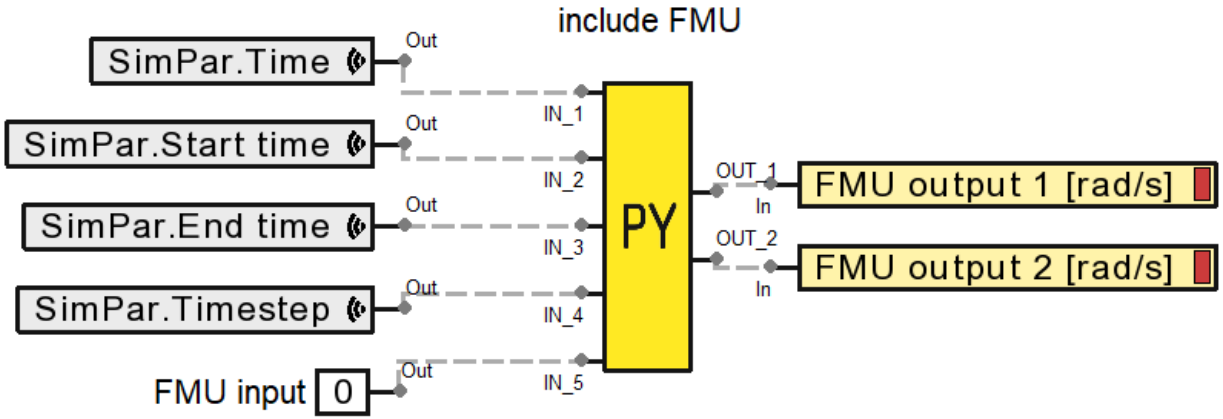
Examples – KULI with Python Controller component
参考案例 – 在KULI中使用Python控制器

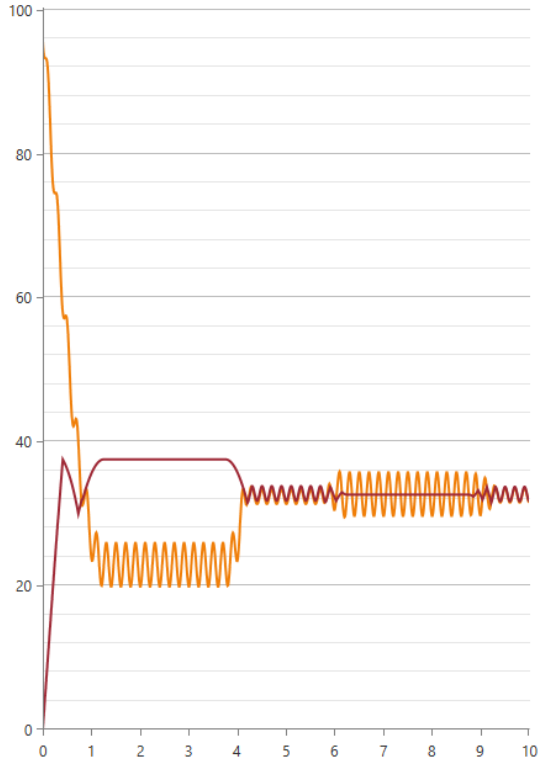
Read external data base (Excel sheet) to import simulation parameters

读取外部数据（Excel表）导入仿真参数



Examples – KULI with Python Controller component
参考案例 – 在KULI中使用Python控制器





Import FMU (“blackbox component”) into KULI using the Python interface

使用Python接口导入FMU（“零部件黑盒”）至KULI

Existing Solutions/Examples for PYC
PYC控制器现有解决方案/案例

Import boundary conditions from Excel®
从Excel导入边界条件

MATLAB® Simulink co-simulation Matlab/Simulink
联合仿真

Statistical quantities (moving average)
统计量（移动平均）

Export results to other formats (.mf4, .csv, …)
输入结果为其它格式

Transient optimization
瞬态优化

Live plots
实时作图

FMU co-simulation
FMU联合仿真

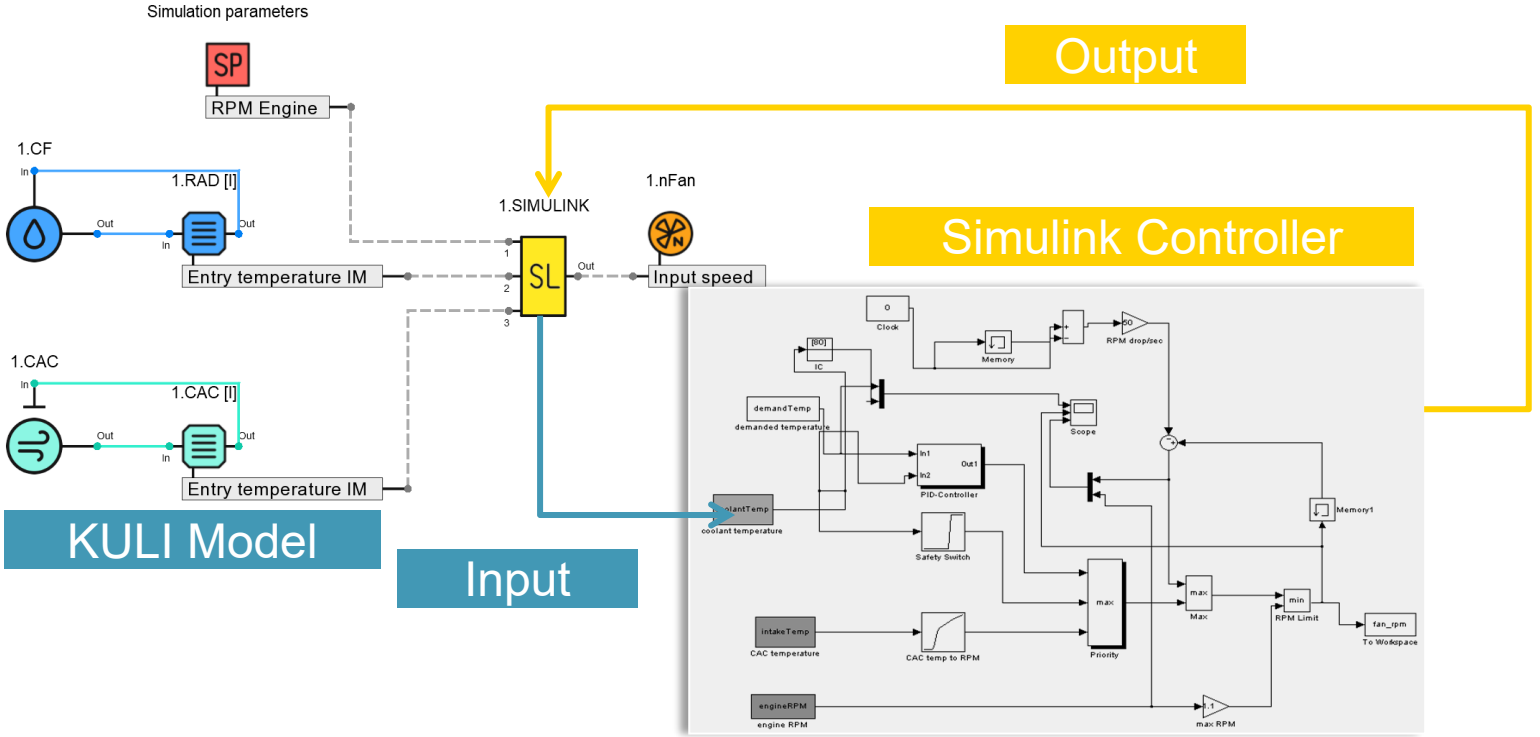
Draw Mollier diagrams of refrigerants
画出制冷剂摩里尔图

control COM interface
控制COM接口

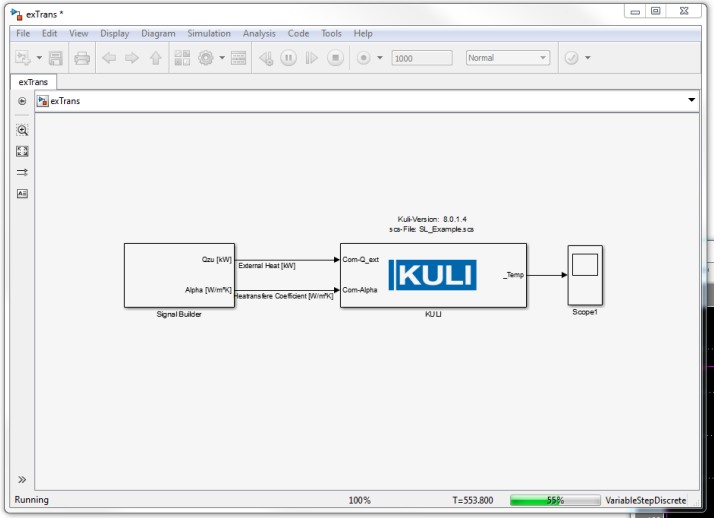
Visit our Online Library访问我们的在线数据库: https://kulihelp.magna.com/wiki/spaces/KOL

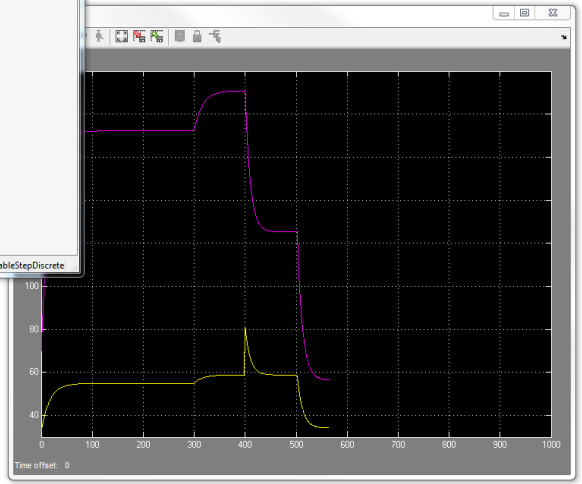
Typical Application – KULI and Matlab/Simulink ®
典型应用 – KULI和Matlab/Simulink ®

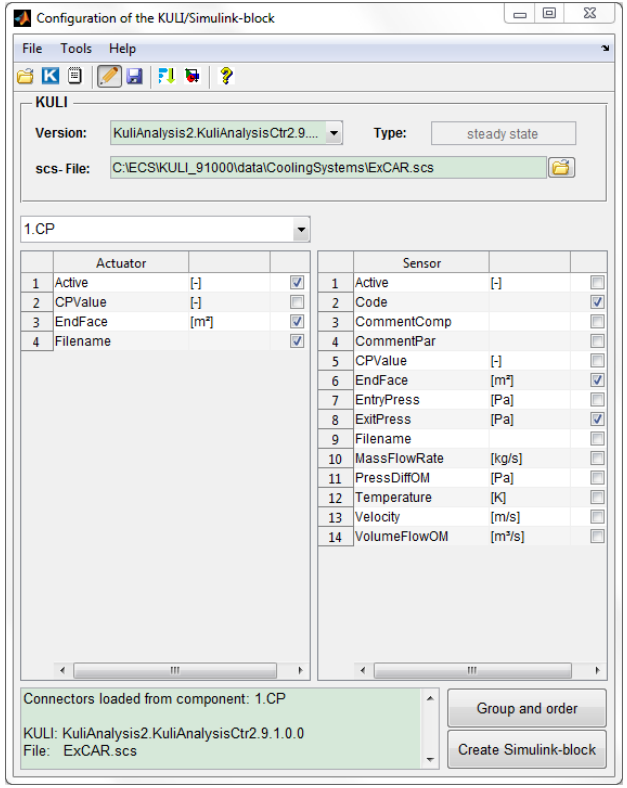
Input Simulink-Controllers to operate your auxiliary components
输入Simulink-控制器用于附件控制



KULI Simulink ® Toolbox
KULI的Simulink ®工具箱







MAGNA
Forward. For all.

DRIVING **EXCELLENCE.**
INSPIRING **INNOVATION.**