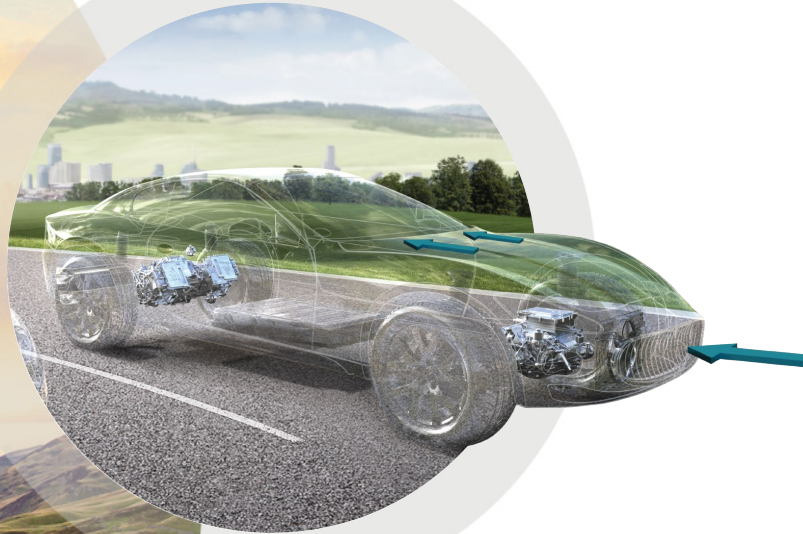


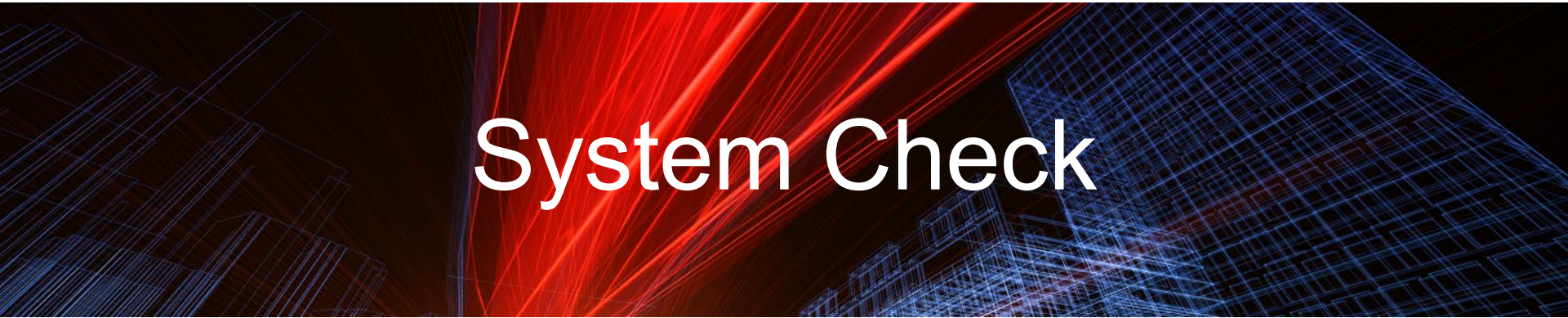


Improved Simulation using the latest KULI Features

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Magna

ECS Simulation Conference, 10th-11th May 2023
Linz, Austria



A horizontal banner with a dark background. It features a central burst of bright red light rays emanating from the left. On either side of the red burst are blue wireframe structures that resemble architectural blueprints or complex data networks.

System Check

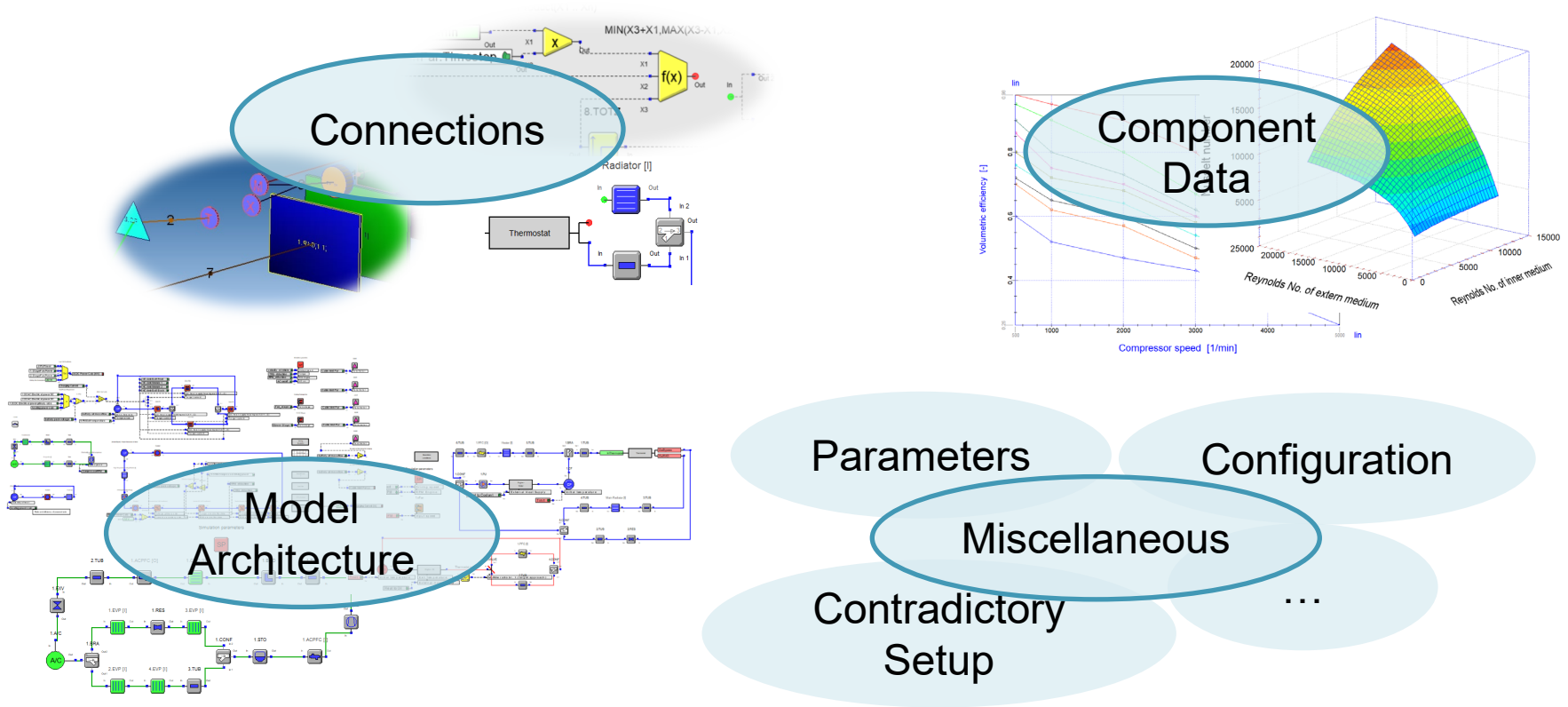
System Check is a tool to quickly detect and resolve modelling issues

System Check Overview



- System Check consists of a list of checks that are executed to detect modelling errors, faulty data, inconsistencies, etc.
 - It is based on years of experience of our support and application teams
- The result of the System Check is collected in a single place
 - the System report panel
- The System report contains links to quickly navigate to the root of a problem
- System check is fast – even for really large systems
- System check will be continuously extended

System Check – Types of Checks



System Check – Severities

Error

Simulation not possible

Something serious went wrong!

e.g. missing connection in signal path

Warning

Simulation possible, but issue can have a significant impact on results → topic should be checked!

e.g. very low operating characteristics

Information

Simulation possible, information message might include hint to get better results

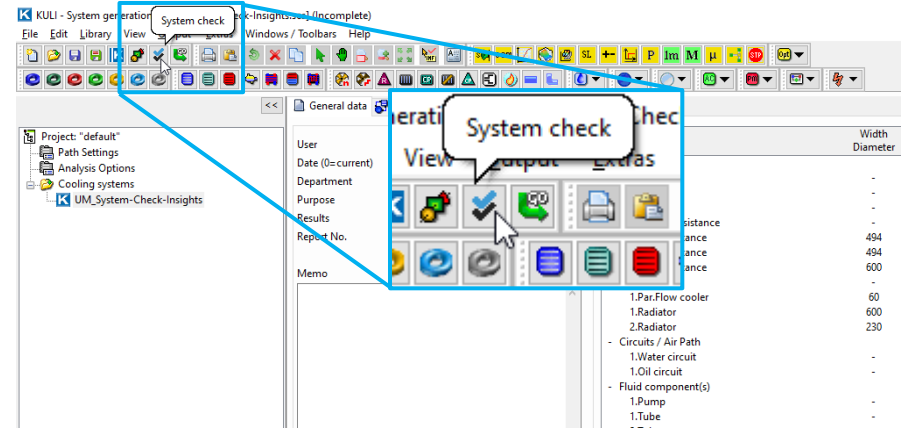
e.g. user defined calculation object doesn't use all inputs

Rising importance / need for action



System Check – When and Where?

- System Check is initiated
 - when the model is being saved (Subsets of checks)
 - when the model is being run (Subsets of checks)
 - when the dedicated System check button in the toolbar is pressed (Full set of checks)
- Start and finish of System Check are noted in Output panel
 - Includes a summary of findings



System time ▼	Severity ▼	Occurrence ▼	Description
2/14/2022 5:44:34 PM	Status		Error check started
2/14/2022 5:44:34 PM	Status		Error check finished: 32 checks executed. 0 Errors / 0 Warnings / 0 Informations found.

System Report – the Result of System Check



- Table with a collection of all issues
- Basic concept of a message:

Float

Drag a column header and drop it here to group by that column

Severity ▲ ▼	Elements ▼	Description ▼						
Information	1.CALC	The formula in the controller does not use all input values.						
Warning	1.ARes 2.ARes	▼ Components are overlapping on the air side.						
Warning	2.RAD [I]	▼ The operating characteristic exceeds the limit and will be reduced to a physically possible value during the simulation.						
Error	3.BL							
			Outer flow [kg/min]	Inner flow [l/h]	Measured phi [-]	Maximum phi [-]	Phys. max. heat [kW]	Heat flow error [l/h]
			1.500	250.000	1.161	0.951	1.927	0.425

Link to component

Details

Link to online help

- Some checks include a detailed message
- Filtering, grouping, and sorting possibilities for every column
- Float/Dock/Hide of System report panel (same as for Output panel)

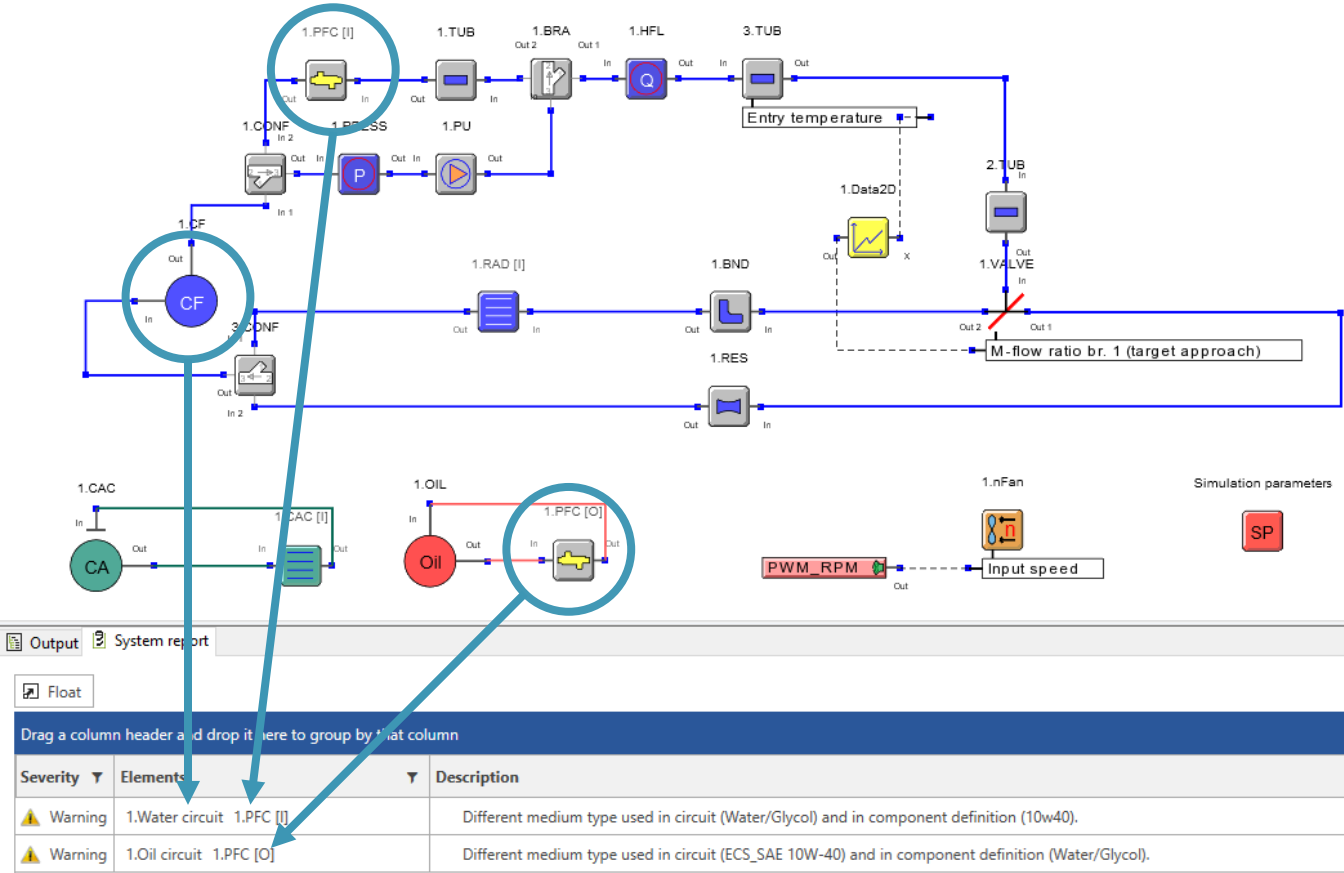
Examples for Checks performed

Check for Medium Incompatibility



- There is a system check that alerts if the medium inside a component is different to the medium defined in the circuit in which the component is located
 - A warning is issued if the medium type is different (e.g. oil vs. coolant)
 - An information is issued if the medium type is the same but the medium is different (e.g. different types of oil)
- Possible modelling errors that can be detected with this feature
 - Wrong placement of inner and outer side of PFCs or PHEs
 - Wrong choice of component
 - Wrong definition of medium in circuit

Check for Medium Incompatibility



Checks regarding Modelling



- Several checks are executed to assist the user in setting up a proper simulation model
 - System check point out modelling mistakes during design time

Severity ▾	Elements ▾	Description
 Error	2.EXV	▾ The 'Controller input: superheating' at a TXV needs to be directly connected to a sensor providing the superheating temperature.

- Various runtime checks ensure the validity during simulation when the configuration changes due to modifications in the lock-status of the valves.

System time ▾	Severity ▾	Occurrence ▾	Description
2/16/2022 10:00:06 AM	Status	1. OP	Simulation No.: 1
2/16/2022 10:00:06 AM	 Error	1. OP	1.A/C: It is not allowed to place an accumulator (1.STO) in a locked branch.
2/16/2022 10:00:06 AM	 Information	1. OP	1.A/C: Multiple subsequent locked valves detected. The 3.SOV is considered locked, the other valves (2.SOV) are considered open.

Check regarding Missing Information

- If the source of a signal receiver cannot be found, an error is given
 - This can happen when deleting or misspelling COM-objects, importing subsystems, etc.

Severity ▾	Elements ▾	Description
 Error	41.SRcv	The source of the signal receiver cannot be found.

- In this context also the “Find source...” functionality of the signal receivers was improved

System Check – Conclusion



- Check the model before running the simulation
- Find hidden issues
- Fast fixing of issues via link to affected elements
- Get more information about potentially problematic modelling
- Link to online help for more information
- Beneficial for very complex systems but also for small systems
- Beneficial for novice KULI users and for KULI experts

An abstract background image featuring a blue wireframe grid structure on the right side, and a series of bright red, glowing light streaks or fiber-optic cables on the left side, creating a dynamic and technological feel.

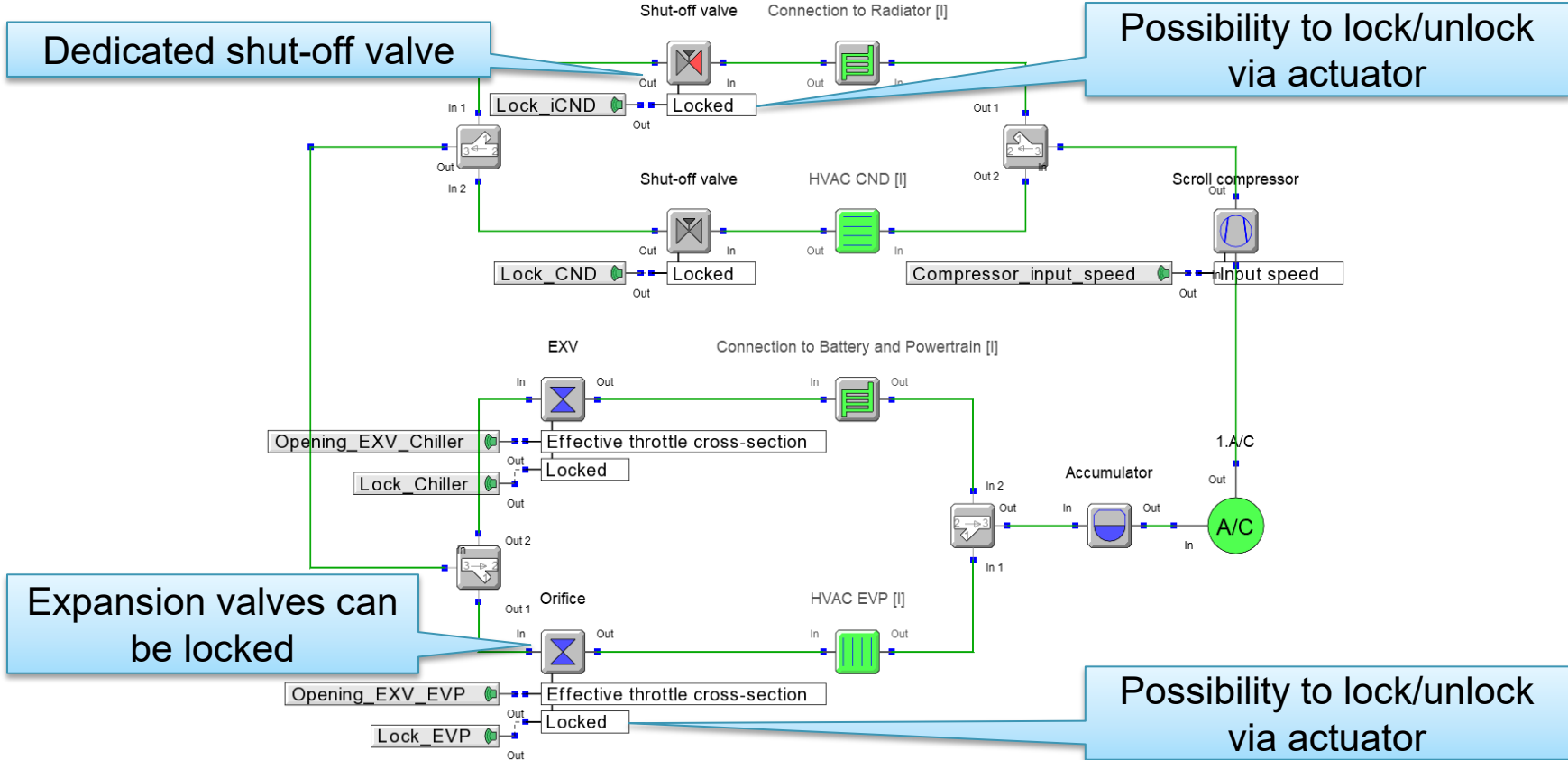
Lockable A/C Branches

Lockable A/C Branches



- With this new feature it is possible to fully lock branches in an A/C circuit. This can be accomplished in two ways:
 - With the help of the new component "Shut-off valve"
 - With the help of the newly added "Locked"-actuator at the expansion valve
- Branches can be locked or unlocked at each time step or operating point.
- Ideal for modelling more complex hvac systems in a single model!

Lockable Valves



Behavior of Components in Locked Branches



- Pressure drop on the “other side” (air, coolant) is still considered
 - Important for correct simulation of air side, coolant circuits, etc.
- No heat exchange takes place
- Refrigerant mass inside components is considered
 - State of refrigerant (gaseous, liquid) depends on position of component in circuit and on position of component relative to lock valve

An abstract background featuring a dark field with glowing red and blue wireframe structures. Red light streaks radiate from the center, creating a sense of dynamic energy and movement.

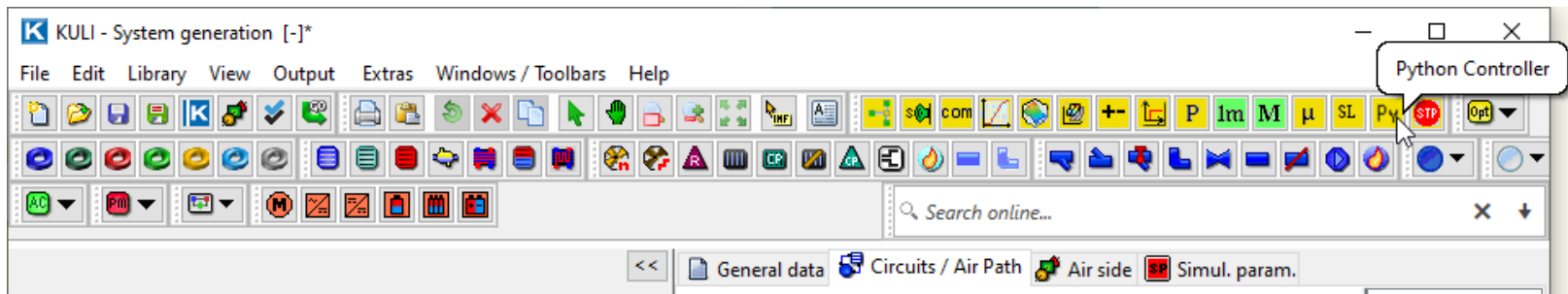
Python Controller

Python Controller Interface

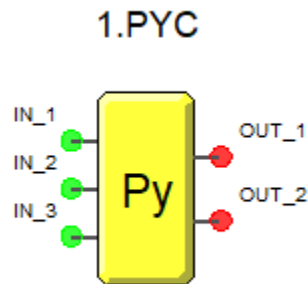


- Starting with KULI 17 it is possible to include Python scripts into a KULI model
- Python scripts are handled within a new controller component “Python Controller”
- The Python Controller can be inserted into the signal path as any other signal path component
 - It is also possible to use multiple Python controllers in a single KULI file
- The Python Controller has an arbitrary number of input and output parameters
 - In particular a single script can have multiple output parameters!

The Python Controller



- Can be found in “Controllers” icon bar
- In-/outputs connect to signal path
- Multiple different in-/outputs are possible

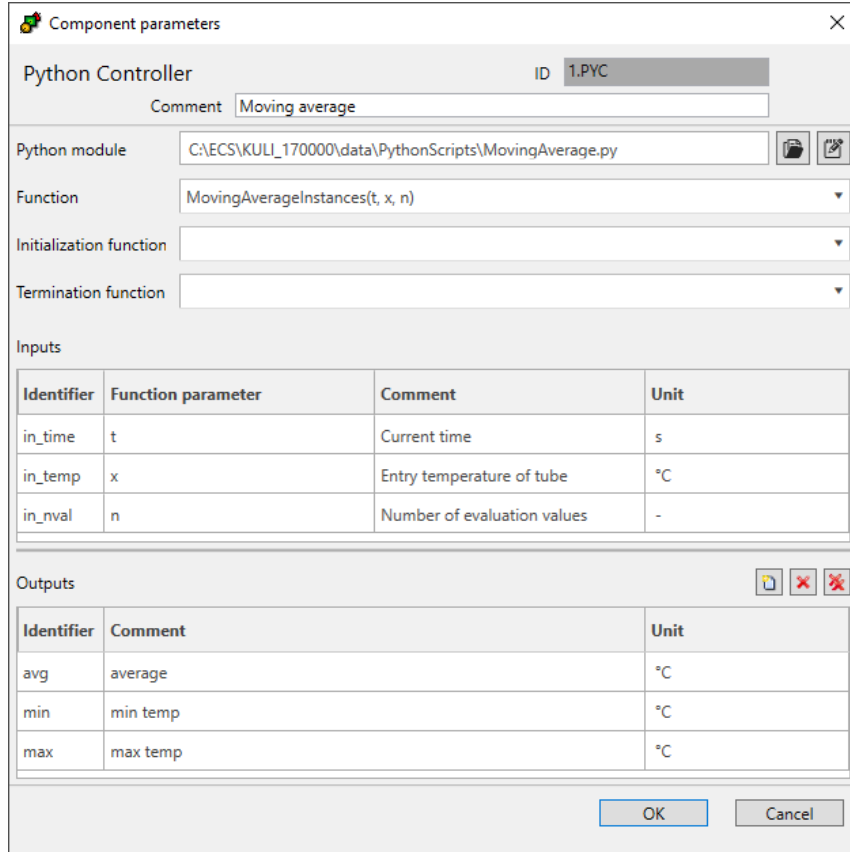


Overall Functionality



- Calls Python function every time PYC is called
- Each input of PYC represents an argument of selected python function
- Returns arbitrarily many outputs (numeric values only)
- Use of global values that maintain their state between function calls
- Optional parameter-less functions:
 - initialize used resources on start of simulation
 - clean at end of simulation

Selection of Python Script



Component parameters

Python Controller ID 1.PYC

Comment Moving average

Python module C:\ECS\KULI_170000\data\PythonScripts\MovingAverage.py

Function MovingAverageInstances(t, x, n)

Initialization function

Termination function

Inputs

Identifier	Function parameter	Comment	Unit
in_time	t	Current time	s
in_temp	x	Entry temperature of tube	°C
in_nval	n	Number of evaluation values	-

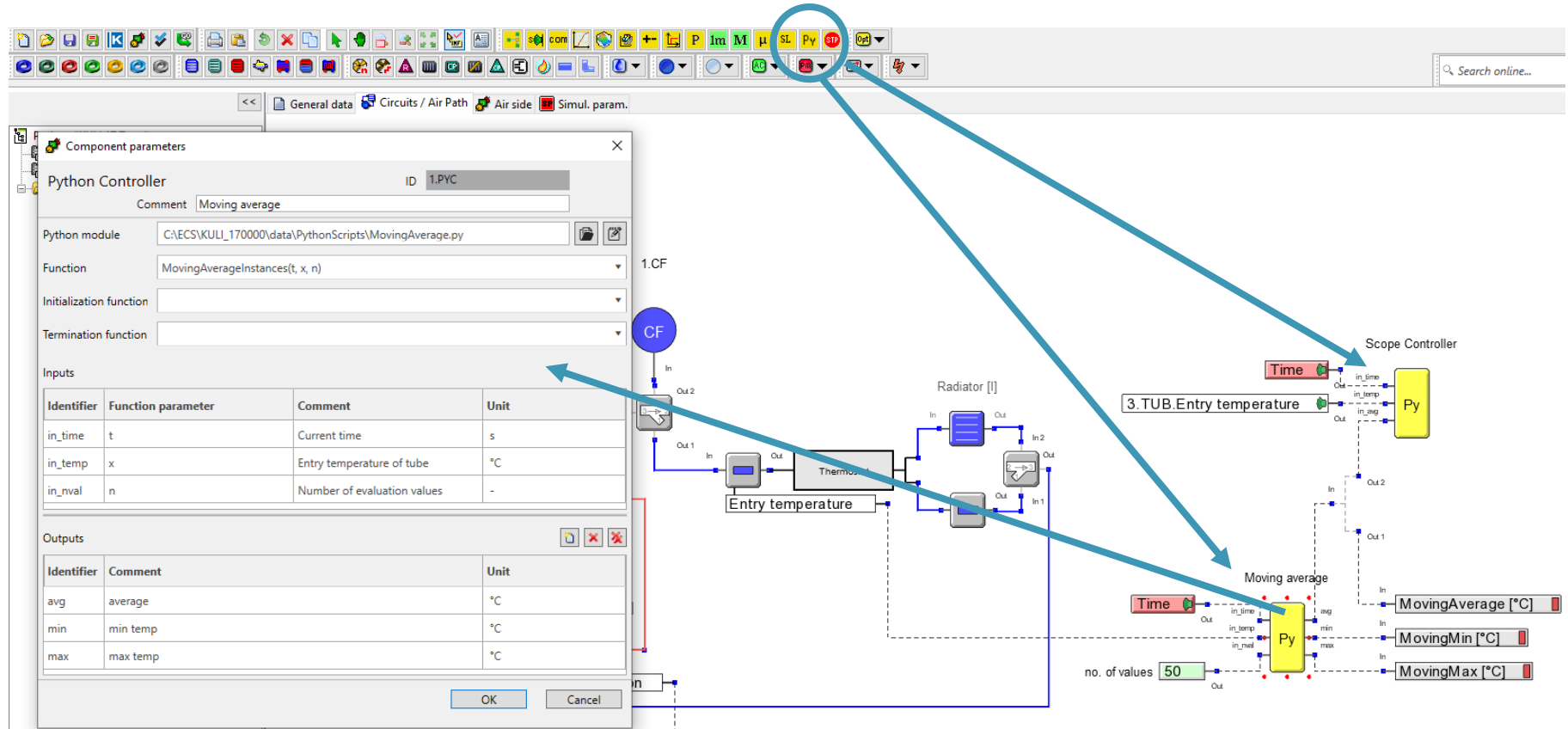
Outputs

Identifier	Comment	Unit
avg	average	°C
min	min temp	°C
max	max temp	°C

OK Cancel

- Any .py-file can be selected
- A function within the Python file can be chosen
 - docstrings are displayed as tooltips
- Inputs and outputs need to be defined
 - Inputs are automatically pre-filled with information from script
 - Full set of units available

Python Controller GUI



Other Modifications and Improvements

Easier Readability for Long Formulas

- The tooltip at a user defined formula inside of a calculation controller now shows the full formula, making it easier to read long formulas

38.Calculation controller

Comment

Operation

=

Number of Inputs

Function =

☒ Take boundaries into account

Minimum

Maximum

☒ Take units into account

Output

...

...

...

...

...

X2

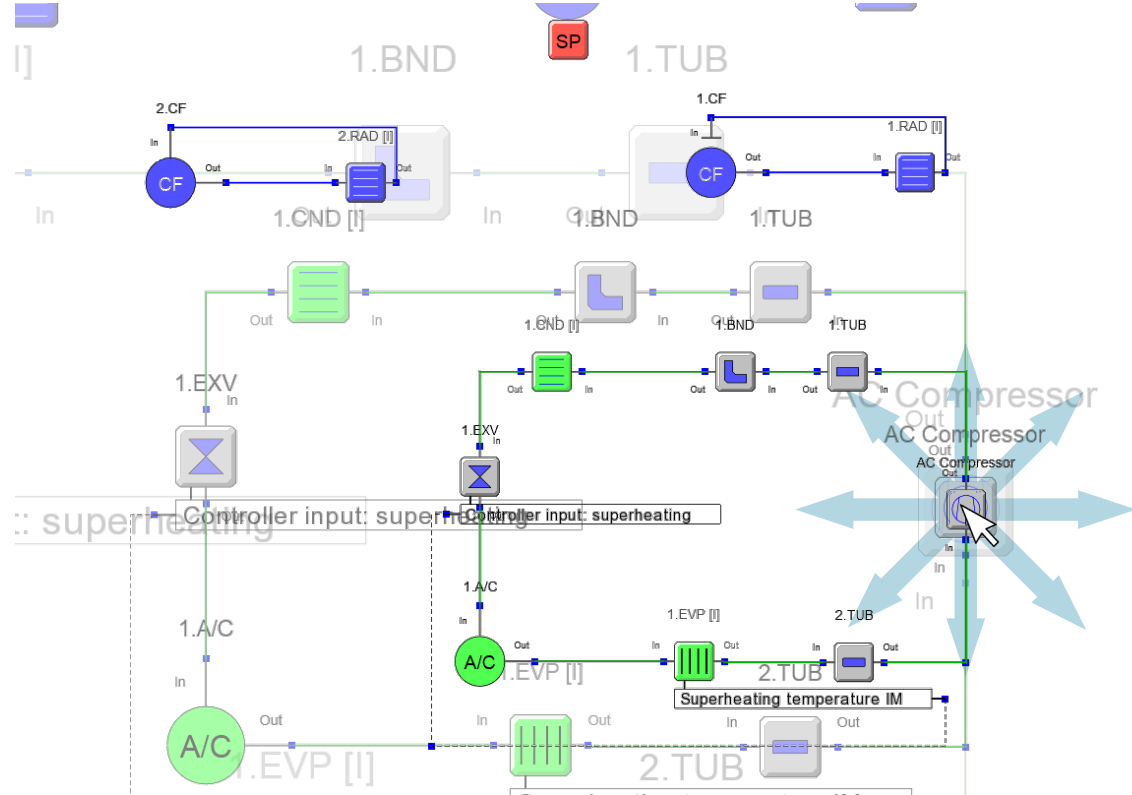
X3

X4

Tooltip: IIF(x1>=x3,x2+1,IIF(x1>=x4*1.02,x2,x2-1))

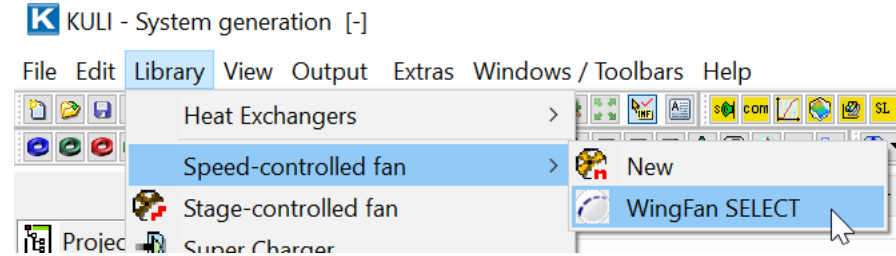
Zoom In & Out to Mouse Cursor

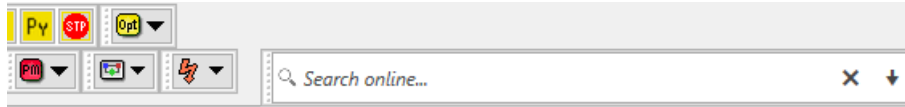
- Zoom via scroll wheel is centered to mouse position
 - Easier navigation in bigger systems



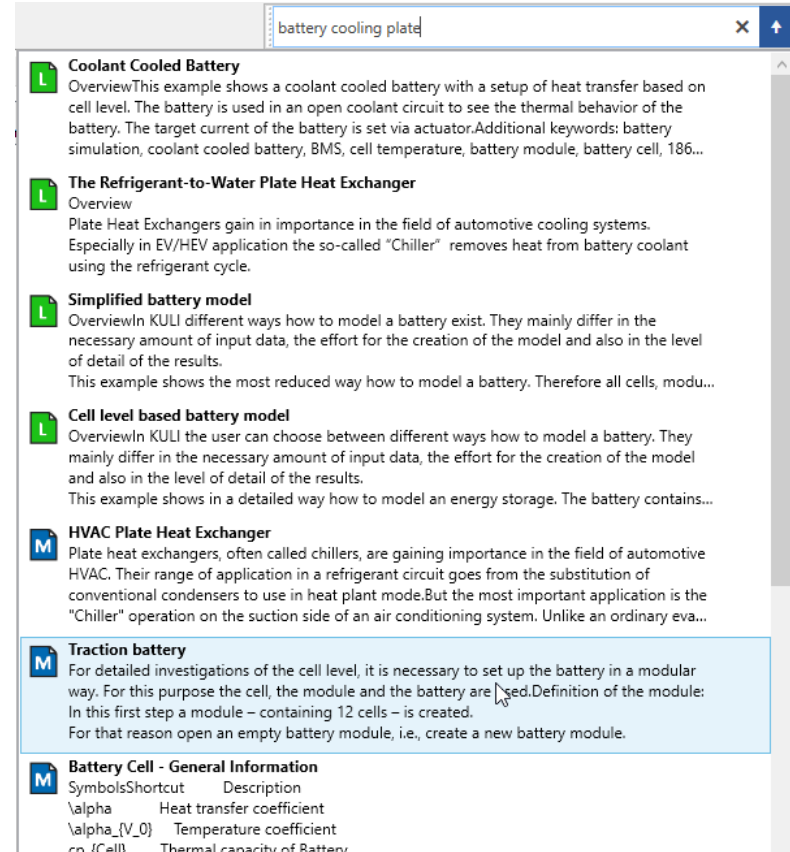
Interface to WingFan SELECT

- Direct access to WingFan SELECT software via Library menu
- WingFan SELECT enables a quick search for a suitable fan and exports a KULI component file
- Operating point and fan dimension can be directly taken from KULI model
- WingFan SELECT can be downloaded from www.wingfan.com/software



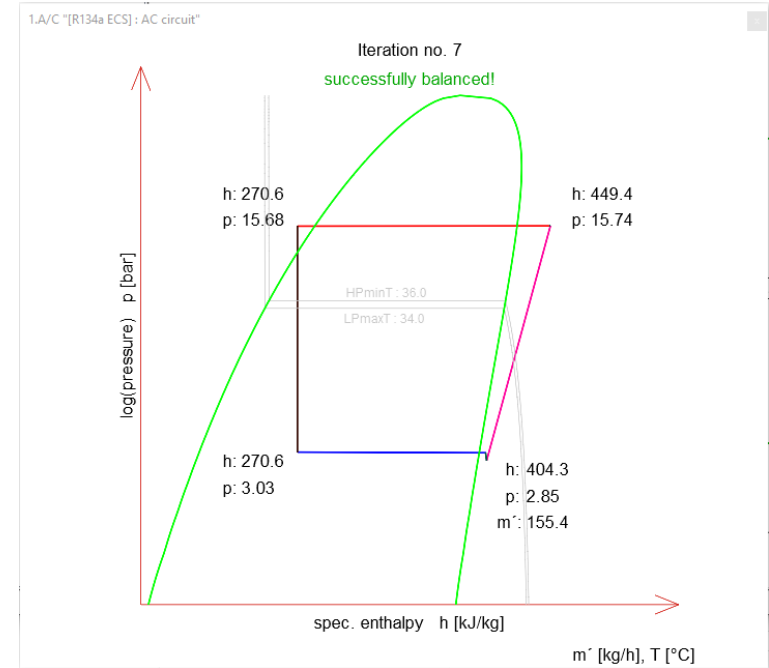


- There is a search field in the toolbar of KULI for direct access to the online resources
 - KULI manual
 - KULI online library
 - KULI knowledge base
- A quick overview of the search results is given
- A link to the online resource is provided



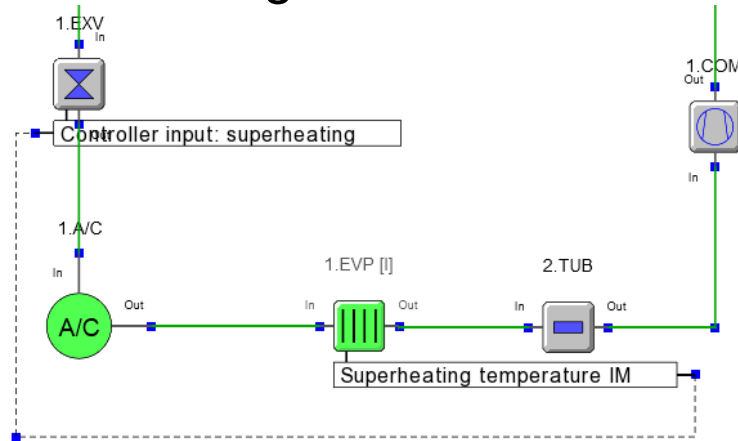
Speed Improvement with ph-Diagrams

- New method for drawing the ph-diagram during A/C simulations drastically reduces time required to draw the diagram
 - Depending on complexity of the complete model the overall simulation time reduction can be significant, even up to a factor of 3



Definition of Superheating Source

- The superheating temperature reference required for TXVs is now mandatory
 - If the 'Controller input: superheating' of a TXV is not connected to a 'Superheating IM' or 'Superheating OM' sensor, System check reports an error
 - This eliminates possible ambiguities and enforces a clean model set up

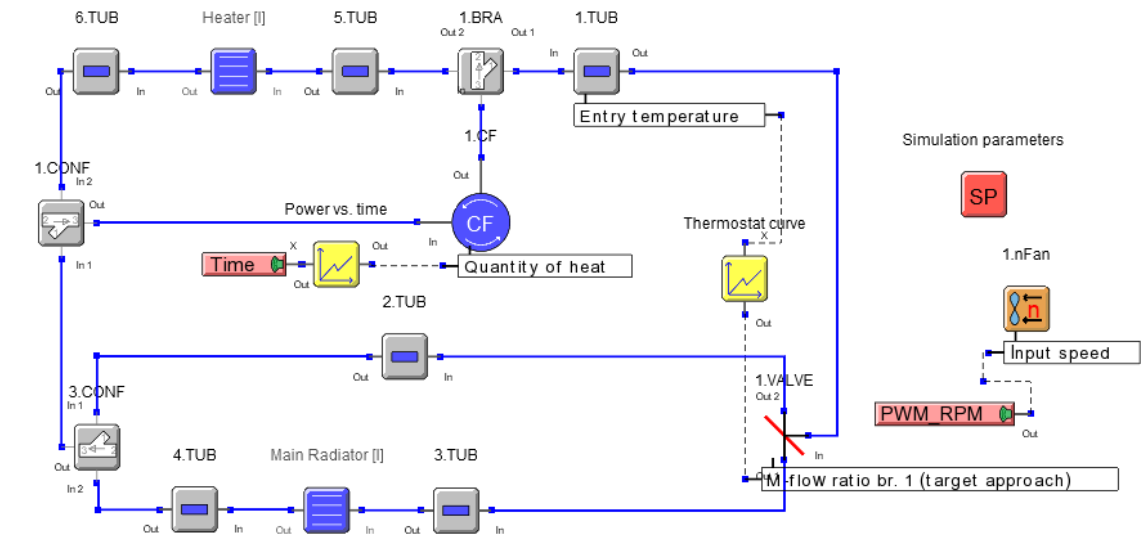


Initial Temperatures



- For each circuit simulated by the dynamic solver the minimum and maximum initial temperatures are displayed
 - A short summary is given in the output panel
 - A detailed information is given in KULI lab
 - This makes it easy to detect components that might have been initialized with the wrong temperature
- The handling of initial temperatures at point masses, batteries, etc. has been unified
 - Initial temperatures are only set during the initialization phase
 - This might require small changes in existing scripts

Initial Temperature in Output Panel



Output System report

Float

Drag a column header and drop it here to group by that column

System time	Severity	Occurrence	Description
8/11/2022 2:25:45 PM	Status		Initializing fluid network ...
8/11/2022 2:25:45 PM	Status		Initializing the internal sensoric network ...
8/11/2022 2:25:46 PM	Information	0.0 s	1.Water circuit - Initial temperatures: Minimum: 20.00°C (1.CF, 1.TUB, 2.TUB) / Maximum: 30.00°C (1.RAD, 2.RAD)

1.Water circuit - Initial temperatures: Minimum: 20.00°C (1.CF, 1.TUB, 2.TUB) / Maximum: 30.00°C (1.RAD, 2.RAD)

Initial Temperatures in KULI lab



Enter search term... X > >

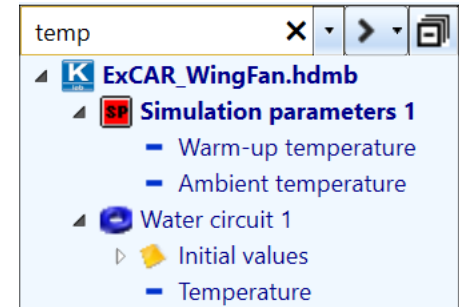
Ex_Fluid_DynamicSolver.hdm
Simulation parameters 1
Water circuit 1
Initial values
Components
Initial temperature IM
1.Tube
2.Tube
3.Tube
4.Tube
5.Tube
6.Tube
1.Confluence
3.Confluence
1.Valve
1.Branch
1.Radiator
2.Radiator

Data view 1 X

Data source	Component	Parts/Cells	Value	Element	Unit	1
Ex_Fluid_D...	Water circuit 1	Components	Initial temperature IM	1.Tube	°C	20
				2.Tube	°C	20
				3.Tube	°C	20
				4.Tube	°C	20
				5.Tube	°C	20
				6.Tube	°C	20
				1.Confluence	°C	20
				3.Confluence	°C	20
				1.Valve	°C	20
				1.Branch	°C	20
				1.Radiator	°C	30
				2.Radiator	°C	30

KULI lab Improvements

- Parallelized loading of hdmb files
 - Multicore CPUs are fully supported during loading of hdmb files
 - This typically speeds up loading of larger hdmb files by a factor of at least two
 - Faster loading is also included in HDMB Comparer
- Improved navigation for result filter
 - Keyboard shortcut to put focus into filter text box
 - Ctrl + f
 - “Clear filter” icon for quick mouse-only removal of current filter



Further Improvements



- The unit groups for torque and energy have been separated
 - The unit group for energy has been extended with Ws, Wh, kWh, and BTU
- Numerous smaller improvements and fixes throughout all modules
- Full list can be found in Release Notes
 - Release Notes for each version are given directly in KULI in the menu Help → Release Notes
 - Release Notes for all versions (KULI 9 – KULI 17.1) are available in the KULI online help
 - <https://kulihelp.magna.com/km/17.1/release-notes>



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

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