Ansys 2025 R2

POWERING INNOVATION THAT DRIVES HUMAN ADVANCEMENT



# Twin Builder® Components: Hydraulic

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# 1 - Multiphysics: Hydraulic Library

Hydraulic equipment and models are operated (or powered) by the resistance offered or the pressure transmitted when a quantity of liquid (such as water or oil) is forced through a comparatively small orifice or through a tube. Devices within this family derive their power from pressurized flow, or are designed to maintain, measure, restrict, or filter the pressurized flow.

Hydraulic models have a permanent place in modern drive technology. As is not the case with electric or pneumatic drives, the project designer must design and dimension the power source (pump unit) as well as the actuators (cylinders or motors). Since the hydraulic pump is a flow source, simultaneous operation of multiple loads requires corresponding decoupling components to create a constant pressure source to minimize the mutual effect of the drives. Additionally, since the control principles of hydraulics are based almost without exception on flow resistances, for example the pressure loss in the resistance through which the oil flows, the resulting quantity of heat as energy loss becomes particularly important. At higher power, circuits with actuating pumps combined with hydraulic fluid reservoirs have a special role.

The hydraulic library provides all essential models of hydraulic drives for building complex circuits: accumulators, actuators, measurement devices, orifices, passive elements, sources, switches, and valves. The models, represented by the symbols according to DIN ISO 1219, simulate the stationary behavior, that means the state magnitudes (pressure, oil flow, speeds and so on) are calculated according to the laws of hydraulic for the steady state and shown graphically. The models simulate possible oscillations and instabilities, which can occur in practice as the result of volume compressibility and masses.

To limit the parameter number of models only typical properties are calculated (e.g. delivery flow reduction of pumps with increasing delivery pressure as the result of volumetric efficiency).

The hydraulic models do not support AC and DC analysis.

By default, models and wires of the fluidic domain are represented in green in the graphical representation of the Schematic. Select Sheet>Properties to change the wire color of the domain. You can only change the wire color. The symbol color is not affected by the setting.

To define parameter values, most of the hydraulic models use a dialog with a simple listing of the used parameters. Some hydraulic models use special wizards for parameter input.

In general, all parameters of hydraulic models can be changed during simulation. Only initial values are set only once at the start of the simulation.

The Hydraulic library consists of the following types of models:

- Accumulators
- Actuators
- Measurement
- Orifices
- Passive Elements
- Sources

• Switches

• Valves

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## References

[1] Fitch, E.C.  and I.T. Hong. *Hydraulic Component Design and Selection*, BarDyne, Inc., 1997.

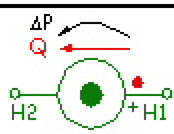
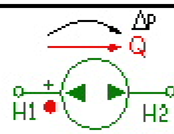
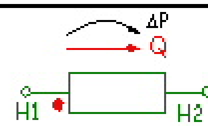
[2] Keller, George. *Hydraulic System Analysis, Hydraulics and Pneumatics*. Second Edition, 1974.

[3] Merritt, Herbert. *Hydraulic Control Systems*. John Wiley & Sons, Inc., 1967.

[4] Will, Dieter, et al. *Hydraulik, Grundlagen, Komponenten, Schaltungen*. Springer Verlag, 1999.

## Hydraulic Reference Arrow System

The direction of Positive current and voltage is marked by the red point or the plus sign at the symbol of electrical components as shown in the table.

| | Difference Sources | Flow Sources | Passive Components |
|---|---|---|---|
| Fluidic |   |   |   |

# Across and Through Quantity of the Fluidic Domain

| Across | Through | Equation |
|---|---|---|
| Pressure [Pa] | Flow Rate [$m^3/s$] | $q(t) - K \cdot p(t)$ |

The fluidic domain uses the pressure as Aross and the flow rate as Through quantity.

# Accumulators

A hydraulic accumulator stores potential power (liquid under pressure) for future conversion into work. This work can used for operating cylinders and fluid motors, maintaining the required system pressure in case of pump or power failure, and compensating for pressure loss due to leakage. Accumulators are used mainly on the lift equipment to provide positive clamping action on heavy loads when a pump's flow is diverted to lifting or other operations.

Accumulators can prevent pump and actuator damage by acting as a shock absorber in systems where spiking or wide pressure variations occur faster than a relief valve can respond.

The hydraulic library provides two types of accumulators: a spring-loaded type and two gas-charged variants. The spring-loaded accumulator uses the energy stored in a spring to create a constant force on the liquid, the gas-charged types use the compressibility of a gas (nitrogen).

- Gas-Charged Isothermal Accumulator (ACC_ISO)
- Spring-Loaded Accumulator (ACC_SPR)
- Gas-Charged Adiabatic Accumulator (ACCU_ADIA)

# Gas-Charged Isothermal Accumulator

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

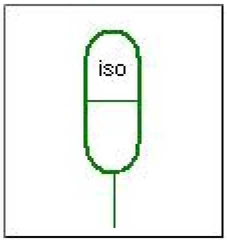



**Figure 1. Component symbol**



## Description

The model represents an Isothermal Accumulator that uses the compressibility of gas (nitrogen). The change in the gas volume takes place so slowly that there is sufficient time for the complete heat exchange to take place between the gas and its surroundings. The result is a constant temperature.

The hydraulic fluid reservoir is a tank with a gas-filled (for example nitrogen) rubber bladder. If system pressure is applied, the gas is compressed, so that fluid is stored in the tank. When the system pressure falls, the gas bladder forces the stored fluid volume back into the system. This achieves a storage effect corresponding to the effect of a large capacitor in electrical circuits.

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## Assumptions and Limitations

The model is based on the following assumptions:

- The gas temperature is constant at ambient temperature.
- Loading on the separator, such as inertia, friction, and so on, is not considered.

• Fluid compressibility is not taken into account.

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## Mathematical Description

The following equations are used to model isothermal state change of the gas:

$$\mathrm{const} = P_{GAS} \cdot VOL = P \cdot (VOL - VOL\_FLUID)$$

$$P_{GAS}(VOL\_FLUID=0) = CHARGE$$

$$P(t=0) = P0$$

This state change occurs when the reservoir is filled and emptied slowly (> 3 minuntes, for example to equalize leakage losses in tensioning devices).

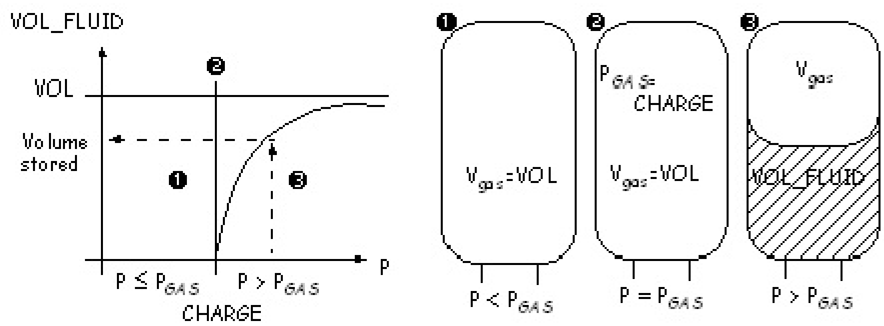


**Figure 2. Three working conditions of the Gas-Charged Isothermal Accumulator**

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## Netlist Syntax

MODEL ACC_ISO ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0 ( VOL:= @VOL, P0:= @P0, CHARGE:= @CHARGE, B:= @B) SRC: DB(Lib:=@ModelLibraryName) ;

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |

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## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| VOL | Accumulator Capacity | real | 10m [$m^3$] |
| P0 | Initial Fluid Pressure | real | 0 [Pa] |
| CHARGE | Gas Pre-charge Pressure | real | 0.1Meg [Pa] |
| B | Bulk Modulus | real | 1G [pa] |

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## Input/Output Quantities

**Table 3**

| Name | Description [Unit] | Direction | Data Type |
|---|---|---|---|
| P | Fluid Pressure [Pa] | Output | real |
| VOL_FLUID | Fluid Volume [$m^3$] | Output | real |

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## Example

In this example, the Gas-Charged Isothermal Accumulator is discharged by a laminar orifice. The typical pressure drop is observed up emptying of the fluid. The schematic of the example is shown in Figure 3, system parameters listed in Table 4 and the simulation results are shown in Figure 4.

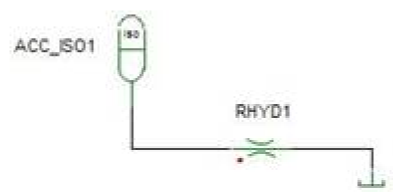


**Figure 3. Application example of the Gas-Charged Isothermal Accumulator**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Gas-Charged Isothermal Accumulator ACC_ISO1 | VOL | 1m [$m^3$] |
| | P0 | 10Meg [Pa] |
| | CHARGE | 5Meg [Pa] |

| | | |
|---|---|---|
| | B | 1E9 [Pa] |
| Linear Orifice RHYD1 | Conductance | 1n [$m^3$/(Pa s)] |

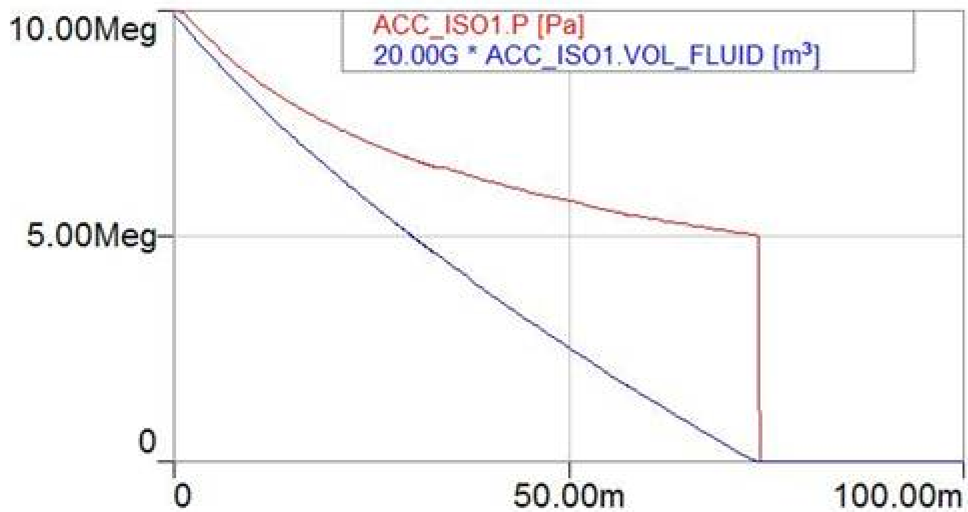


**Figure 4. Simulation results – fluid pressure and volume of the Gas-Charged Isothermal Accumulator**

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## References

# Spring-Loaded Accumulator

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

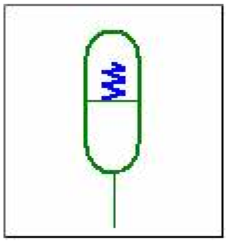

**Figure 1. Component symbol**



## Description

The Spring-Loaded Accumulator represents an accumulator that uses the energy stored in a spring to create a constant force on the liquid. If system pressure is applied, the spring is compressed, so that fluid is stored in the tank. When the system pressure falls, the spring forces the stored fluid volume back into the circuit. This achieves a storage effect corresponding to the effect of a large capacitor in electrical circuits.

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## Assumptions and Limitations

The model is based on the following assumptions:

- The spring has linear characteristics.
- No loading on the separator, such as inertia, friction, and so on, is considered.
- Fluid compressibility is not taken into account.

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## Mathematical Description

The Spring-Loaded Accumulator can be described using the following set of equations:

$$AREA = \frac{PI}{4} \cdot DIA^2$$

$$VOL(t) = VOL0 + S \cdot AREA$$

$$F\_PRE = CHARGE \cdot AREA$$

$$Q = V \cdot AREA + \frac{VOL(t)}{B} \cdot \frac{dP}{dt}$$

$$P \cdot AREA - C \cdot S - KVSC \cdot V - F\_PRE = M\frac{dV}{dt}$$

where *F_PRE* is the pre-charge spring force.

The three working conditions of the Spring-Loaded Accumulator described earlier are illustrated in Figure 2 (*F* stands for spring force). The piston movement is limited by *STROKE*.

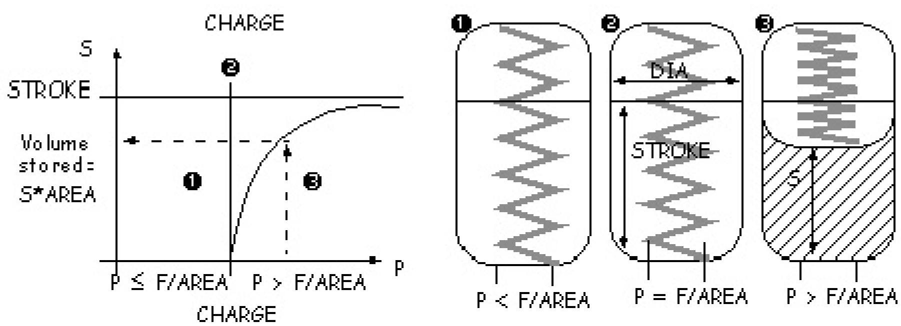


**Figure 2. Three working conditions of the Spring-Loaded Accumulator**

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## Netlist Syntax

MODEL ACC_SPR ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0 ( DIA:= @DIA, STROKE:= @STROKE, M:= @M, C:= @C, CHARGE:= @CHARGE, KVSC:= @KVSC, B:= @B, VOL0:= @VOL0) SRC: DB(Lib:=@ModelLibraryName) ;

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |

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## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| DIA | Piston diameter | real | 10m [m] |
| STROKE | Piston stroke | real | 10m [m] |
| M | Piston mass | real | 1m [kg] |
| C | Spring rate | real | 1K [N/m] |
| CHARGE | Pre-charge pressure | real | 0.1Meg [Pa] |
| VOL0 | Initial volume | real | 1u [$m^3$] |
| B | Bulk modulus | real | 1G [Pa] |
| KVSC | Viscous friction coefficient | real | 1 [N s/m] |

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## Input/Output Quantities

**Table 3**

| Name | Description [Unit] | Direction | Data Type |
|---|---|---|---|
| P | Fluid pressure [Pa] | Output | real |
| Q | Flow rate [$m^3/s$] | Output | real |
| S | Position [m] | Output | real |
| V | Velocity [m/s] | Output | real |
| VOL_FLUID | Fluid volume [$m^3$] | Output | real |

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## Example

In this example, the Spring-Loaded Accumulator is charged by a constant flow source. The pressure increases significantly when the accumulator spring reaches its limit. The schematic of the example is shown in Figure 3, system parameters are listed in the table 4, and the simulation results are shown in Figure 4.

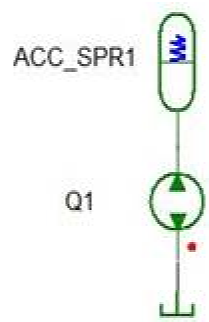


**Figure 3. Application example of the Spring-Loaded Accumulator**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Spring-Loaded Accumulator ACC_ SPR1 | DIA | 100m [m] |
| | STROKE | 100m [m] |
| | M | 0 [kg] |
| | C | 100K [N/m] |
| | CHARGE | 3Meg [Pa] |
| | VOL0 | 0.4m [$m^3$] |
| | B | 1G [Pa] |
| | KVSC | 0 [N s/m] |
| Flow Source Q1 | Value | 100u [$m^3$/s] |

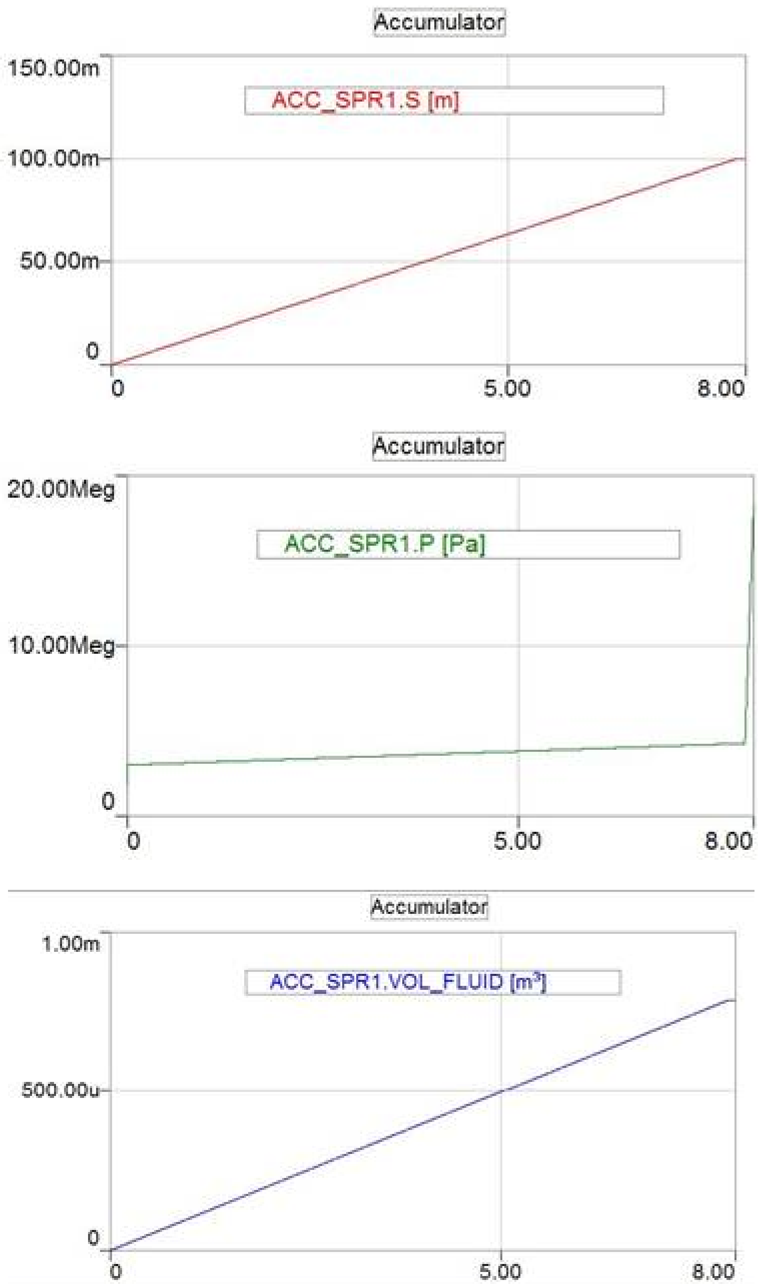


**Figure 4. Simulation results – fluid volume, position and fluid pressure of the Spring-Loaded Accumulator**

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## References

# Gas-Charged Adiabatic Accumulator

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

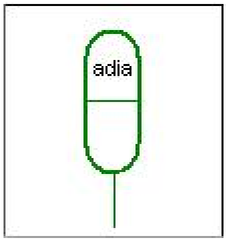


**Figure 1 . Component symbol**



## Description

The model represents an Adiabatic Accumulator that uses the compressibility of gas (nitrogen). The change of state in the gas volume takes place so rapidly that the temperature of the gas also changes.

The hydraulic fluid reservoir is a tank with a gas-filled (for example nitrogen) rubber bladder. If system pressure is applied, the gas is compressed, so that fluid is stored in the tank. When the system pressure falls, the gas bladder forces the stored fluid volume back into the circuit. This achieves a storage effect corresponding to the effect of a large capacitor in electrical circuits.

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## Assumptions and Limitations

The model is based on the following assumptions:

• There is no heat transfer from the gas.

• Loading on the separator, such as inertia, friction, and so on, is not considered.

• Fluid compressibility is not taken into account.

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## Mathematical Description

The following equations are used to model adiabatic state change of the gas:

$$\mathrm{const} = P\_gas \cdot VOL^{\kappa} = P \cdot (VOL - VOL\_FLUID)^{\kappa}$$

$$\kappa = 1,4$$

$$P\_gas(VOL\_FLUID{=}0) = CHARGE$$

$$P(t{=}0) = P0$$

This state change occurs when the reservoir is filled and emptied quickly.

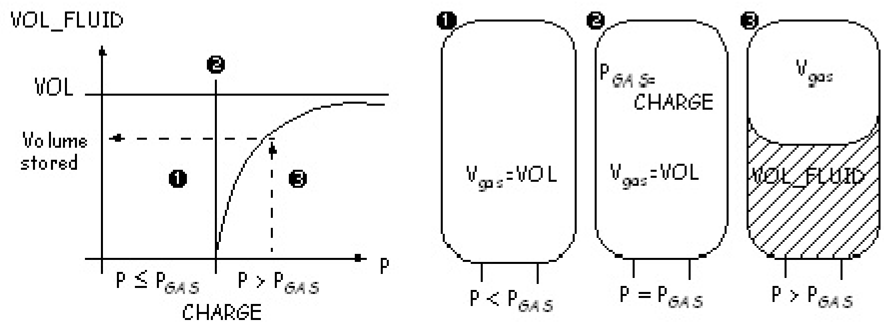


**Figure 2. Three working conditions of the Gas-Charged Adiabatic Accumulator**

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## Netlist Syntax

MODEL ACCU_ADIA ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0 ( VOL:= @VOL, P0:= @P0, CHARGE:= @CHARGE, B:= @B) SRC: DB(Lib:=@ModelLibraryName) ;

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |

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## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| VOL | Accumulator Capacity | real | 10m [$m^3$] |
| P0 | Initial Fluid Pressure | real | 0 [Pa] |
| CHARGE | Gas Pre-charge Pres-sure | real | 0.1Meg [Pa] |
| B | Bulk Modulus | real | 1G [pa] |

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## Input/Output Quantities

**Table 3**

| Name | Description [Unit] | Direction | Data Type |
|---|---|---|---|
| P | Fluid Pressure [Pa] | Output | real |
| VOL_FLUID | Fluid Volume [$m^3$] | Output | real |

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## Example

In this example, the Gas-Charged Adiabatic Accumulator is discharged by a laminar orifice. The typical pressure drop is observed up emptying of the fluid. The schematic of the example is shown in Figure 3, system parameters listed in Table 4 and the simulation results are shown in Figure 4.

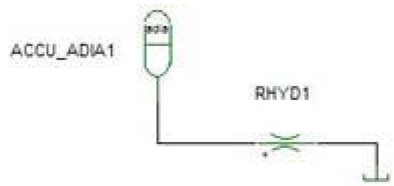


**Figure 3. Application example of the Gas-Charged Adiabatic Accumulator**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Gas-Charged Adiabatic Accumulator ACC_ADIA1 | VOL | 1m [$m^3$] |
| | P0 | 10Meg [Pa] |
| | CHARGE | 5Meg [Pa] |
| | B | 1E9 [Pa] |

| | | |
|---|---|---|
| Linear Orifice RHYD1 | Conductance | 1n [$m^3$/(Pa s)] |

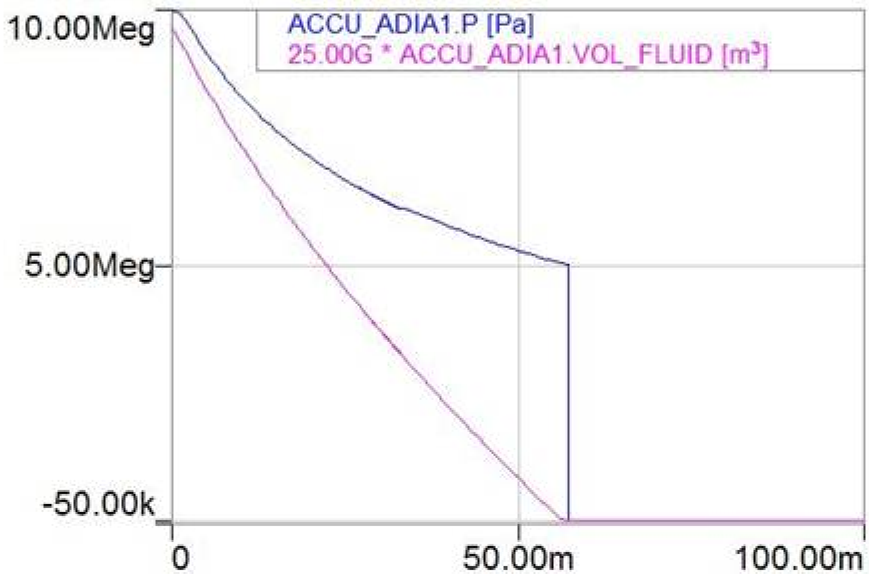


**Figure 4. Simulation results – fluid pressure and volume of the Gas-Charged Adiabatic Accumulator**

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## References

# Actuators

A hydraulic actuator converts fluid power into mechanical force and motion. Cylinders, motors, and turbines are the most common types of actuating devices used in fluid power systems.

The hydraulic library provides three cylinder actuators with limits and friction characteristic: a single-acting actuator, a double-acting actuator, and a equal movement cylinder. An actuating cylinder is a device that converts fluid power to linear, or straight line, force and motion. The cylinder consists of a piston operating within a cylindrical bore. The following figure shows the used Stick-Slip characteristic.

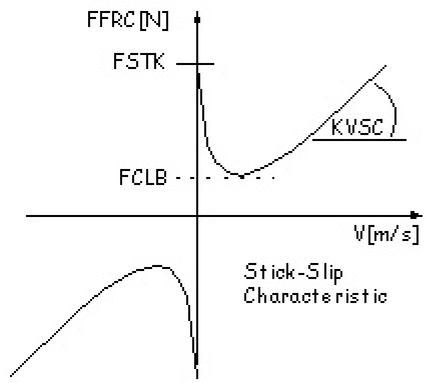


**Figure 1. Stick-slip characteristics of the Cylinder Actuators**

The single-acting actuator applies fluid power only in one direction. To move the piston back into the cylinder a mechanical force can be applied. The double-acting actuator and equal movementcylinder applies fluid power in both directions.

- Double-Acting Actuator (DOUBLE_ACT)
- Equal Movement Cylinder (DOUBLE_CYL)
- Single-Acting Actuator (SINGLE_ACT)

# Double-Acting Actuator

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

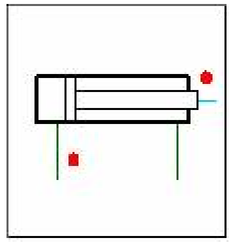

**Figure 1 . Component symbol**



## Description

The model represents a Double-Acting Actuator with limits and stick-slip-characteristic. The model applies fluid power in both directions. In addition, a mechanical force can be applied.

The multidomain model has two fluid ports to apply the fluid powers and one translational port to apply the mechanical force. The used mechanical domain is the translational displacement-force representation.

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## Assumptions and Limitations

The model is based on the following assumptions:

- Leakage, internal or external, is not taken into account.
- Loading on piston rod, such as inertia, friction, spring, and so on, is taken into account.

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### Mathematical Description

The model calculating the damping areas is identical to the Limit Stop model in the Basics library. The upper limit corresponds to the *STROKE* value, the lower limit is equal to *S*=0.

$$Q1 = V \cdot AREA1 + CHYD1 \cdot \frac{d}{dt}P1$$

$$Q2 = V \cdot AREA2 - CHYD2 \cdot \frac{d}{dt}P2$$

$$AREA1 = \frac{\pi}{4} \cdot DIA1^2$$

$$AREA2 = \frac{\pi}{4} \cdot (DIA1^2 - DIA2^2)$$

$$CHYD1 = \frac{VOL0\_1 + \Delta S \cdot AREA1}{B}$$

$$CHYD2 = \frac{VOL0\_2 + (STROKE - \Delta S) \cdot AREA2}{B}$$

$$M \cdot ACC = P(H1) \cdot AREA1 - P(H2) \cdot AREA2 - FFRC + F(TRB1)$$

$$FFRC = sgn(v) \cdot \left( (FSTK - FCLB) \cdot e^{-\frac{|V|}{K}} + FCLB + KVSC \cdot |V| \right)$$

Friction: Stick Coulomb Viscous

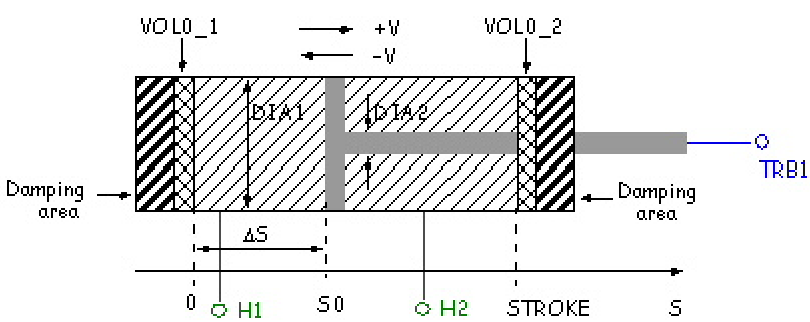


**Figure 2 . Structure of the Double-Acting Actuator**

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## Netlist Syntax

MODEL DOUBLE_ACT ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, TRB1:= %1, H2:= %2 ( S0:= @S0, STROKE:= @STROKE, M:= @M, B:= @B, VOL0_1:= @VOL0_1, DAMPING:= @DAMPING, VOL0_2:= @VOL0_2, DIA1:= @DIA1, DIA2:= @DIA2, KVSC:= @KVSC, C:= @C, V0:= @V0, FCLB:= @FCLB, FSTK:= @FSTK, K:= @K) SRC: DB (Lib:=@ModelLibraryName) ;

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |
| TRB1 | Translational Mechanical Pin | Mechanical terminal |

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## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| DIA1 | Piston Diameter | real | 50m [m] |
| DIA2 | Piston Rod Diameter | real | 10m [m] |
| STROKE | Piston Stroke | real | 0.1 [m] |
| M | Piston Mass | real | 1 [kg] |
| KVSC | Viscous Friction Coef-ficient | real | 0.1k [N s/m] |
| K | Slop Coefficient | real | 1 [m/s] |
| FSTK | Slip Friction Force | real | 0 [N] |
| FCLB | Coulomb Friction Force | real | 0 [N] |
| VOL0_1 | Initial Volume at H1 | real | 1u [$m^3$] |
| VOL0_2 | Initial Volume at H2 | real | 1u [$m^3$] |
| B | Bulk Modulus | real | 1G [Pa] |
| C | Spring Rate (Limit) | real | 1Meg [N/m] |
| DAMPING | Damping Coefficient (Limit) | real | 1Meg [N s/m] |

| | | | |
|---|---|---|---|
| S0 | Initial Position | real | 0 [m] |
| V0 | Initial Velocity | real | 0 [m/s] |

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## Input/Output Quantities

**Table 3**

| Name | Description [Unit] | Direction | Data Type |
|---|---|---|---|
| S | Position [m] | Output | real |
| V | Velocity [m/s] | Output | real |
| ACC | Acceleration [m/s$^2$] | Output | real |
| FFRC | Friction Force [N] | Output | real |

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## Example

Tthis example demonstrates the acceleration, rerouting and deceleration of a Double-Acting Actuator. After the piston position reaches 5mm, a force is applied to act against the movement of the piston. The valve is controlled by a state diagram. The schematic of the example is shown in Figure 3, system parameters listed in Table 4 and the simulation results are shown in Figure 4.

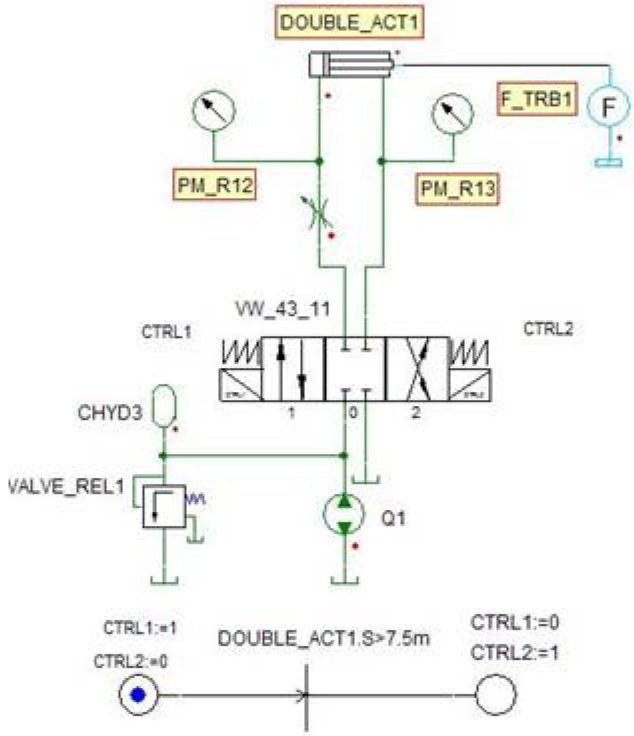
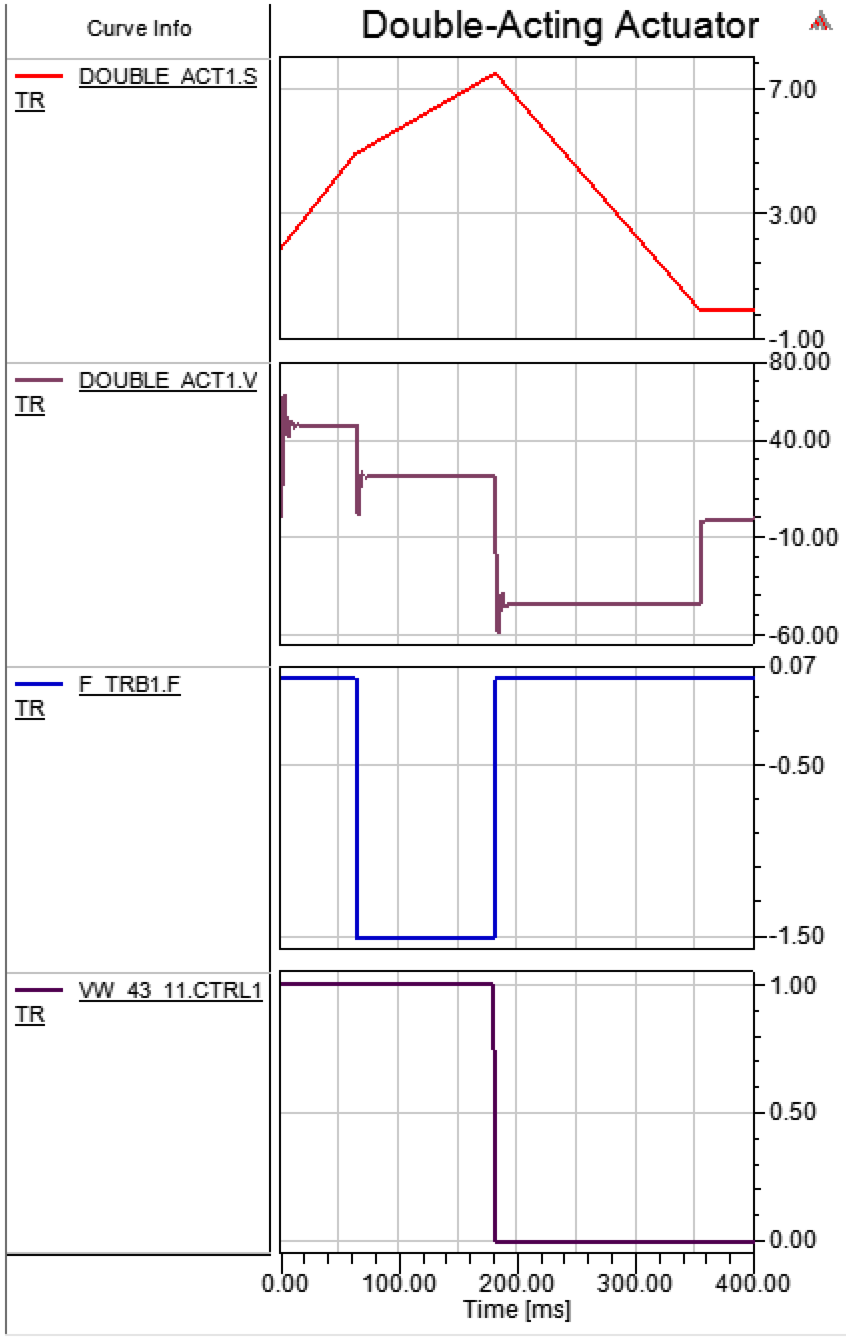



**Figure 3. Application example of the Double-Acting Actuator**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Double-Acting Actuator DOUBLE_ACT1 | DIA1 | 50m [$m^3$] |
| | DIA2 | 20m [$m^3$] |
| | STROKE | 0.02 [m] |
| | M | 30 [Kg] |
| | KVSC | 5K [N s/m] |
| | K | 1 [m/s] |
| | FSTK | 0 [N] |
| | FCLB | 0 [N] |
| | VOL0_1 | 0.1m [$m^3$] |
| | VOL0_2 | 0.1m [$m^3$] |
| | B | 1G [Pa] |
| | C | 100Meg [N/m] |
| | DAMPING | 1Meg [N s/m] |

| | | |
|---|---|---|
| | S0 | 0.002 [m] |
| | V0 | 0 [m/s] |
| Force Source F_TRB1 | Value | -1500*(DOUBLE_ACT1.S>5m AND DOUBLE_ACT1.V>0 ) [N] |
| Turbulent OR_TURB1 | CONDUCTANCE | 0.1u [$m^3/s*Pa^{0.5}$] |
| Directional Control Valves (4-3, Function 1) VW_43_11 | CTRL1 | CTRL1 |
| | CTRL2 | CTRL2 |
| Hydraulic Capacitance CHYD3 | VOL | 0.5Meg [$m^3$] |
| | B | 1G [Pa] |
| | P0 | 1Meg [Pa] |
| Pressure Controlled Valve (Pressure Relief) VALVE_REL1 | PSET | 1Meg [Pa] |
| | SLOPE | 1Meg [Pa s/$m^3$] |
| Flow Source Q1 | VALUE | 500u |


Curve Info
Double-Acting Actuator
DOUBLE_ACT1.S TR
DOUBLE_ACT1.V TR
F_TRB1.F TR
VW_43_11.CTRL1 TR
7.00
3.00
-1.00
80.00
40.00
-10.00
-60.00
0.07
-0.50
-1.50
1.00
0.50
0.00
0.00
100.00
200.00
300.00
400.00
Time [ms]

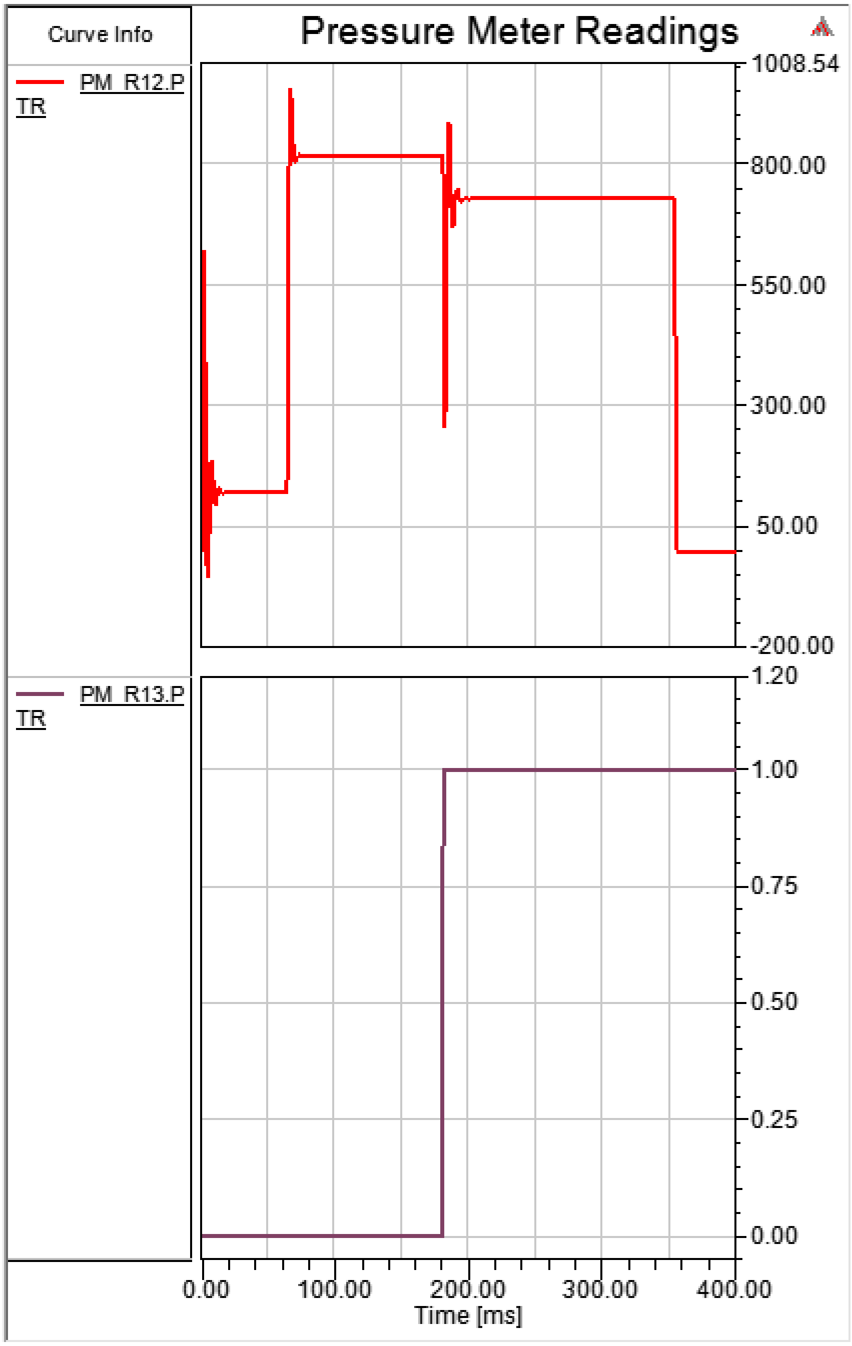



**Figure 4. Simulation results**

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## References

See *Limit Stop* in the Basic Elements Library help.

# Equal Movement Cylinder

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

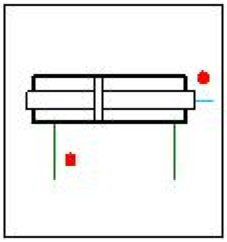

**Figure 1 . Component symbol**



## Description

The Equal Movement Cylinder model represents an Equal Movement Cylinder with limits and stick-slip-characteristic. The model applies fluid power in both directions. Because of the cylinder design, the pressure areas are identical for both directions. In addition, a mechanical force can be applied.

The multidomain model has two fluid ports to apply the fluid powers and one translational port to apply the mechanical force. The translational displacement-force representation of the mechanical domain is used.

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## Assumptions and Limitations

The model is based on the following assumptions:

• Leakage, internal or external, is not taken into account.

• Loading on piston rod, such as inertia, friction, spring, and so on, is taken into account.

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## Mathematical Description

The model calculating the damping areas is identical to the Limit Stop model in the Basics library. The upper limit corresponds with the STROKE value, the lower limit is equal to S=0.

$$Q1 = V \cdot AREA + CHYD1 \cdot \frac{d}{dt}P1$$

$$Q2 = V \cdot AREA - CHYD2 \cdot \frac{d}{dt}P2$$

$$AREA = \frac{\pi}{4} \cdot (DIA1^2 - DIA2^2)$$

$$CHYD1 = \frac{VOL0\_1 + \Delta S \cdot AREA}{B}$$

$$CHYD2 = \frac{VOL0\_2 + (STROKE - \Delta S) \cdot AREA}{B}$$

$$M \cdot ACC = AREA(P(H1) - P(H2)) + FFRC + F(TRB1)$$

$$FFRC = sgn(v) \cdot \left((FSTK - FCLB) \cdot e^{-\frac{|V|}{K}} + FCLB + KVSC \cdot |V|\right)$$

Friction: Stick Coulomb Viscous

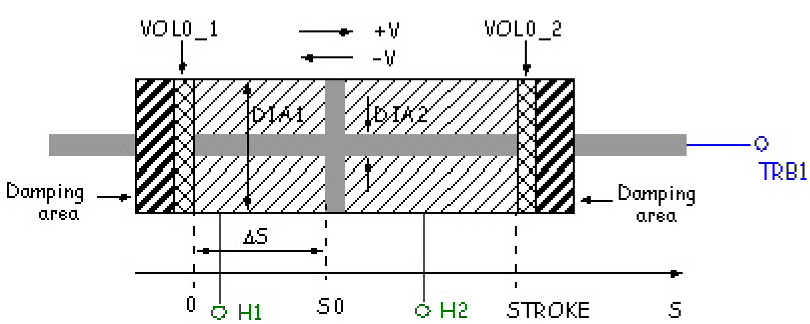


**Figure 2 . Structure of the Equal Movement Cylinder**

Top

## Netlist Syntax

MODEL DOUBLE_CYL ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, TRB1:= %1, H2:= %2 ( S0:= @S0, STROKE:= @STROKE, M:= @M, B:= @B, VOL0_1:=

@VOL0_1, DAMPING:= @DAMPING, VOL0_2:= @VOL0_2, DIA1:= @DIA1, DIA2:= @DIA2, KVSC:= @KVSC, C:= @C, V0:= @V0, FCLB:= @FCLB, FSTK:= @FSTK, K:= @K) SRC: DB (Lib:=@ModelLibraryName) ;

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |
| TRB1 | Translational Mechanical Pin | Mechanical terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| DIA1 | Piston Diameter | real | 50m [m] |
| DIA2 | Piston Rod Diameter | real | 10m [m] |
| STROKE | Piston Stroke | real | 0.1 [m] |
| M | Piston Mass | real | 1 [kg] |
| KVSC | Viscous Friction Coefficient | real | 0.1k [N s/m] |
| K | Slop Coefficient | real | 1 [m/s] |
| FSTK | Slip Friction Force | real | 0 [N] |
| FCLB | Coulomb Friction Force | real | 0 [N] |
| VOL0_1 | Initial Volume at H1 | real | 0 [$m^3$] |
| VOL0_2 | Initial Volume at H2 | real | 0 [$m^3$] |
| B | Bulk Modulus | real | 1G [Pa] |
| C | Spring Rate (Limit) | real | 1Meg [N/m] |
| DAMPING | Damping Coefficient (Limit) | real | 1Meg [N s/m] |
| S0 | Initial Position | real | 0 [m] |
| V0 | Initial Velocity | real | 0 [m/s] |

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## Input/Output Quantities

**Table 3**

| Name | Description [Unit] | Direction | Data Type |
|---|---|---|---|
| S | Position [m] | Output | real |
| V | Velocity [m/s] | Output | real |
| ACC | Acceleration [m/s$^2$] | Output | real |
| FFRC | Friction Force [N] | Output | real |

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## Example

See example under Double-Acting Actuator

Top

## References

See *Limit Stop* in the Basic Elements Library help.

# Single-Acting Actuator

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

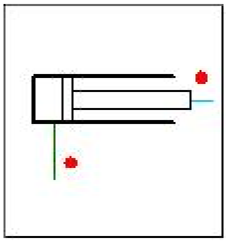

**Figure 1 . Component symbol**



## Description

The model represents a Single-Acting Actuator with limit and stick-slip characteristic. The model applies fluid power in one direction. To move the piston back into the cylinder a mechanical force can be applied. This forces the fluid back to the reservoir.

The single-acting actuator is often used in the hydraulic jack. The elevators, which are used to move aircraft to and from the flight deck and hangar deck on aircraft carriers, also use cylinders of this type.

The multidomain model has one fluid port to apply the fluid power and one translational port to apply the mechanical force. The translational displacement-force representation of the mechanical domain is used.

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## Assumptions and Limitations

The model is based on the following assumptions:

- Leakage, internal or external, is not taken into account.

• Loading on piston rod, such as inertia, friction, spring, and so on, is taken into account.

Top

### Mathematical Description

The model calculating the damping area is identical to the Limit Stop model in the Basics library. The upper limit corresponds with the STROKE value, the lower limit is equal to S=0.

$$M \cdot ACC = P \cdot AREA - FFRC + F(TRB1)$$

$$FFRC = sgn(v) \cdot \left( (FSTK - FCLB) \cdot e^{-\frac{|V|}{K}} + FCLB + KVSC \cdot |V| \right)$$

Friction: Stick Coulomb Viscous

$$Q = V \cdot AREA + CHYD \cdot \frac{dP}{dt}$$

$$AREA = \frac{\pi}{4} \cdot DIA^2$$

$$CHYD = \frac{(VOL0 + \Delta S \cdot AREA)}{B}$$

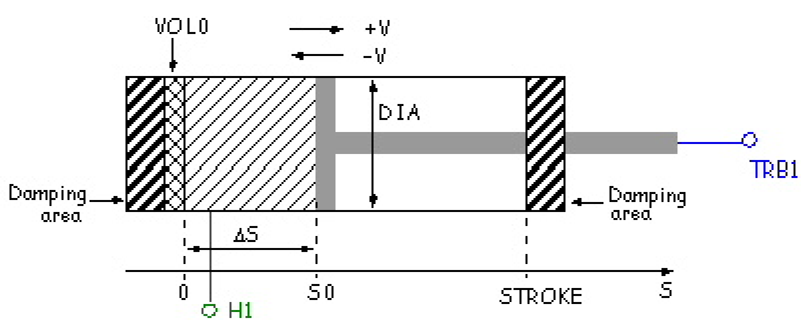


**Figure 2 . Structure of the Single-Acting Actuator**

Top

### Netlist Syntax

MODEL SINGLE_ACT ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, TRB1:= %1 ( STROKE:= @STROKE, M:= @M, DIA:= @DIA, B:= @B, VOL0:= @VOL0, DAMPING:= @DAMPING, C:= @C, KVSC:= @KVSC, V0:= @V0, S0:= @S0, FCLB:= @FCLB, FSTK:= @FSTK, K:= @K) SRC: DB(Lib:=@ModelLibraryName) ;

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| TRB1 | Translational Mechanical Pin | Mechanical terminal |

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## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| DIA | Piston Diameter | real | 10m [m] |
| STROKE | Piston Stroke | real | 0.1 [m] |
| M | Piston Mass | real | 1m [kg] |
| KVSC | Viscous Friction Coef-ficient | real | 0 [N s/m] |
| K | Slop Coefficient | real | 1 [m/s] |
| FSTK | Slip Friction Force | real | 0 [N] |
| FCLB | Coulomb Friction Force | real | 0 [N] |
| VOL0 | Initial Volume | real | 1u [$m^3$] |
| B | Bulk Modulus | real | 1G [Pa] |
| C | Spring Rate (Limit) | real | 1Meg [N/m] |
| DAMPING | Damping Coefficient (Limit) | real | 1Meg [N s/m] |
| S0 | Initial Position | real | 0 [m] |
| V0 | Initial Velocity | real | 0 [m/s] |

Top

## Input/Output Quantities

**Table 3**

| Name | Description [Unit] | Direction | Data Type |
|---|---|---|---|
| S | Position [m] | Output | real |

| | | | |
|---|---|---|---|
| V | Velocity [m/s] | Output | real |
| ACC | Acceleration [m/s$^2$] | Output | real |
| FFRC | Friction Force [N] | Output | real |

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## Example

See example under Double-Acting Actuator

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## References

See *Limit Stop* in the Basic Elements Library help.

# Measurement

Fluidic meters provide pressure (Across quantity), flow rate (Through quantity), and power for fluidic domain components. The flow meter symbol shows the direction of the flow rate with an arrow (animated symbol function). The one pin manometer provides the differential pressure between the pin and the fluidic reference ground.

- Manometer (PM)
- Manometer 1-Pin (PM_R1)
- Flowmeter (QM)
- Wattmeter (WM_HYD)

# Manometer

See *Fluidic Meters* in the Basic Elements Library help.

# Manometer (1Pin)

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

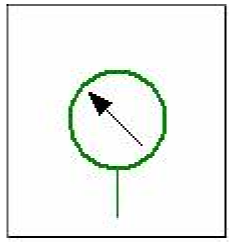

**Figure 1 . Component symbol**



## Description

The Manometer represents a model with 1 pin. A laminar orifice ($K$=1E-20 $m^3/(s*Pa)$) is connected in parallel to ensure numeric stability.

The differential pressure is measured between the pin H1 and the fluidic reference ground.

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## Assumptions and Limitations

The model is based on the following assumptions:

- Leakage, internal or external, is not taken into account.

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## Mathematical Description

The structure of the Manometer model is shown in Figure 2, and its mathematical representation is:

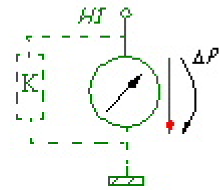


**Figure 2. Equivalent structure of the Manometer model**

$$q(t) = K \cdot p(t)$$

$$K = 10^{-20}\left[\frac{m^3}{s \cdot Pa}\right]$$

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### Netlist Syntax

MODEL PM_R1 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0 ( ) SRC: DB (Lib:=@ModelLibraryName) ;

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### Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |

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### Input/Output Quantities

**Table 2**

| Name | Description | Data type |
|---|---|---|
| P | Differential Pressure [Pa] | real |

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### Example

In this example the hydraulic capacitor is charged by an ideal pressure source through a laminar orifice. The time constant of the system is 1ms. The schematic of the example is shown in Figure 3, system parameters listed in Table 4 and the simulation results are shown in Figure 4.

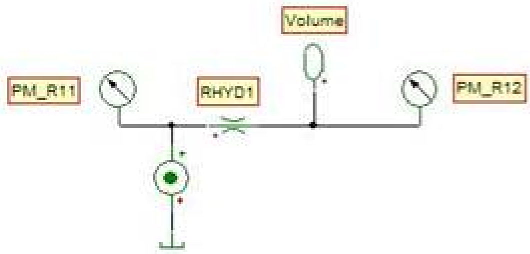


**Figure 3. Application example of the Manometer model(1 pin)**

**Table 3. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P1 | Value | 1Meg [Pa] |
| Linear Orifice RHYD1 | CONDUCTANCE | 1n [$m^3/s*Pa^{0.5}$] |
| Hydraulic Capacitance Volume | VOL | 1m [$m^3$] |
| | B | 1G [Pa] |
| | P0 | 0 [Pa] |

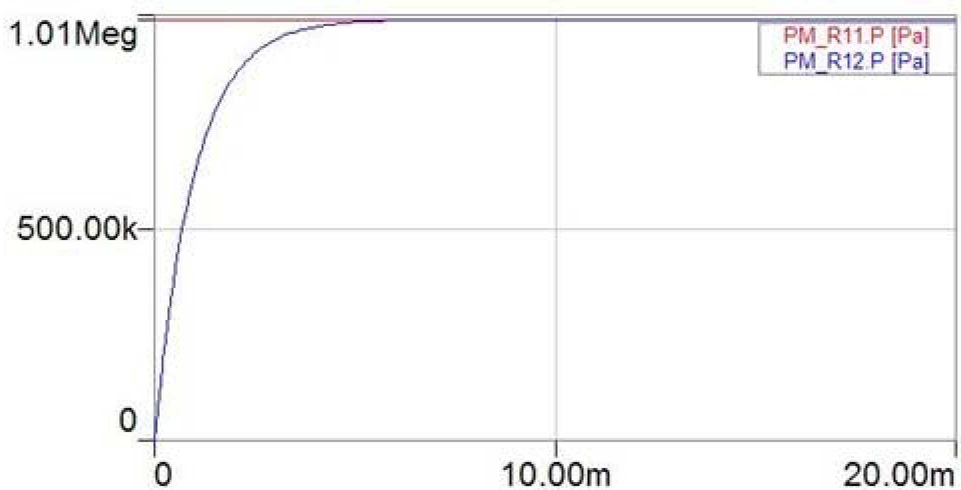


**Figure 4. Simulation results**

Top

## References

# Flowmeter

See *Fluidic Meters* in the Basic Elements Library help.

# Wattmeter

See *Fluidic Meters* in the Basic Elements Library help.

# Orifices

A orifice is a fluid resistance whose length is relatively short compared to its diameter or its cross-sectional dimension.

The hydraulic library provides orifices with several cross-section areas and characteristics.

- Annular Orifice (OR_ANN)
- Sharp-Edge Orifice (OR_SE)
- Turbulent Orifice (OR_TURB)
- Variable Orifice (OR_VAR)
- Laminar Orifice (RHYD)
- Characteristic Orifice (RHYD_NL)

# Annular Orifice

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

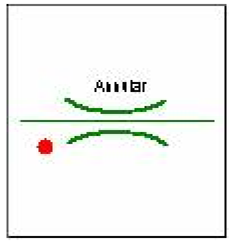


**Figure 1. Component symbol**



## Description

The Annular Orifice represents a fluid resistance with laminar leakage between close fits.

The characteristics are based on flow through a close fitting cylindrical fit. This flow is analogous to flow between infinitely long parallel plates where the gap is small compared to the length or width. The flow for this case is assumed to always be laminar.

In translating, this characteristic to close fitting cylindrical fits care must be taken when selecting the parameters, or generics for the model. The analogy equates the flat plate-type width to the circumference of the cylindrical parts, and the length to the length of the cylindrical fit. The laminar flow equation used is only valid if the clearance of the fit is very small as compared to both the length and circumference. Rule of thumb, the radial clearance should be less than 1/10 of both the length and circumference.

The eccentricity is also accounted for in this model, with the effect of increasing the flow by 2.5 times when full eccentricity is specified, (eccentricity = 1.0), as compared to the fully concentric case (eccentricity = 0.0).

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## Assumptions and Limitations

The model is based on the following assumptions:

• Fluid inertia is not taken into consideration.

• The fluidic flow is assumed to be laminar.

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## Mathematical Description

The characteristics are described by the following equation, and the cross-sectional area of the orifice with different eccentricity is shown in Figure 2.

$$Q = P \cdot \pi \cdot \frac{DIA \cdot CLEAR\_R^3}{12 \cdot VSC \cdot LEN} \cdot \left(1 + \frac{3}{2} \cdot ECC^2\right)$$

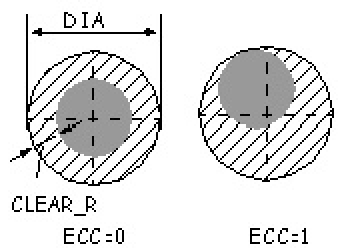


**Figure 2. Cross sectional area of the orifice with different eccentricity**

Top

## Netlist Syntax

UMODEL OR_ANN ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1 ( DIA:= @DIA, LEN:= @LEN, CLEAR_R:= @CLEAR_R, ECC:= @ECC, VSC:= @VSC) SRC: DB (Lib:=@ModelLibraryName) ;

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

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## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| DIA | Piston Diameter | real | 1m [m] |
| LEN | Length | real | 10m [m] |
| CLEAR_R | Radical Clearance | real | 0.1m [m] |
| ECC | Eccentricity | real | 0 |
| VSC | Absolute Viscosity | real | 1 [Pa s] |

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## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| P | Differential Pressure [Pa] | real |
| Q | Flow Rate [$m^3$/s] | real |

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## Example

In this example, a constant pressure develops a constant flow through the annular orifice. After 0.5 second, the eccentricity of the orifice changes from 0 to 1, which causes the change of the flow rate by a factor of 2.5. The schematic of the example is shown in Figure 3, system parameters listed in Table 4 and the simulation results are shown in Figure 4.

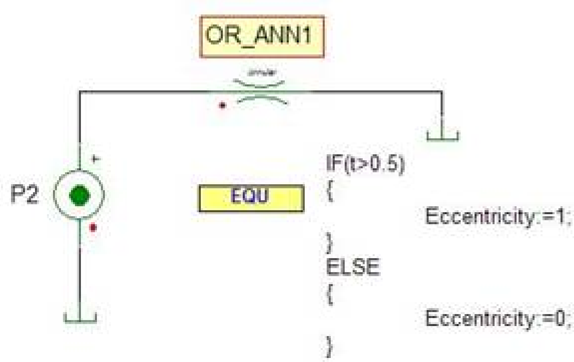


**Figure 3. Application example of the Annular Orifice**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|

| Pressure Source P1 | Value | 1Meg [Pa] |
|---|---|---|
| Annular Orifice OR_ANN1 | DIA | 10 [m] |
| | LEN | 0.5 [m] |
| | CLEAR_R | 1m [m] |
| | ECC | Eccentricity |
| | VSC | 10m [Pa s] |


**Figure 4. Simulation results**

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## References

# Sharp-Edge Orifice

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

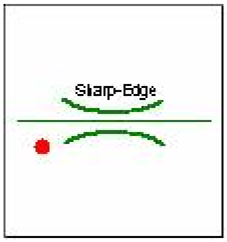


**Figure 1 . Component symbol**



## Description

The Sharp-Edge Orifice represents a fluid resistance with laminar and turbulent flow depending on the selected type.

The characteristics are based on equations for laminar and turbulent flow through a sharp-edge orifice. The model uses generic shape parameters, as opposed to shape-specific dimensions so that it can be used as a building block for many other orifice models. Within the dialog you can select a generic, round, rectangular, or pintle type.

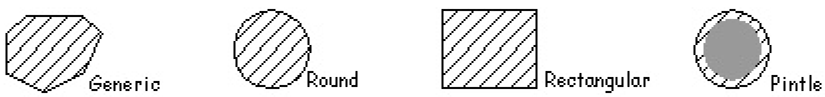


**Figure 2. Different cross-sectional shapes of the Sharp-Edge Orifice**

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## Assumptions and Limitations

The model is based on the following assumptions:

• Fluid inertia is not taken into consideration.

• The transition between laminar and turbulent regimes is assumed to be sharp and taking place exactly when the Reynolds numbers reaches the critical value, *i.e.* REY = REY_TRANS.

Top

## Mathematical Description

The equations used for the model characteristics change as the flow changes from laminar to turbulent flow, and care is taken to ensure continuity at the transition(s).

$$Q = CD(REY) \cdot AREA(TYPE) \cdot \sqrt{\frac{2 \cdot P}{RHO}}$$

$$REY = \frac{abs(Q) \cdot DIA(Hyd) \cdot RHO}{Area(TYPE) \cdot VSC}$$

$$REY < REY\_TRANS$$

$$\text{Laminar Flow} \quad CD(REY) = CD^* \sqrt{\frac{REY}{REY\_TRANS}}$$

$$REY \geq REY\_TRANS$$

$$\text{Turbulent Flow} \quad CD\,(REY) = CD$$

$$DIA(Hyd) = \frac{4 \cdot Area(Type)}{Peri(Type)}$$

| | | |
|---|---|---|
| Generic | $Area = AREA$ | $Peri = PERI$ |
| Round | $Area = \frac{\pi}{4} \cdot DIA^2$ | $Peri = \pi \cdot DIA$ |
| Rectangular | $Area = LEN \cdot WIDTH$ | $Peri = 2 \cdot (LEN + WIDTH)$ |
| Pintle | $Area = \frac{\pi}{4} \cdot (DIA\_OUT^2 - DIA\_IN^2)$ | $Peri = (DIA\_OUT + DIA\_I$ |

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## Netlist Syntax

Netlist generated by Special Component Dialog.

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| AREA | Flow Area | real | 1u [m$^2$] |
| CD | Discharge Coefficient | real | 0.6 |
| PERI | Perimeter | real | 3m [m] |
| REY_ TRANS | Reynolds Number (Trans- ition) | real | 300 |
| RHO | Fluid Density | real | 1K [kg/m$^3$] |
| VSC | Absolute Viscosity | real | 10m [Pa s] |
| DIA | Diameter | real | 1m [m] |

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## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| P | Differential Pressure [Pa] | real |
| Q | Flow Rate [m$^3$/s] | real |
| REY | Reynolds Number | real |
| ST_LAMINAR | Laminar State | real |
| ST_TURBULENT | Turbulent State | real |

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## Example

In this example, the output pressure from Pressure Source P1 increases linear with simulation time. The rising pressure causes the behavior of the Sharp-Edge Orifice OR_SE1 to switch from laminar to turbulent flow when the Reynolds number reaches the transition Reynolds. The schematic of the system is shown in Figure 3, system parameters are listed in Table 4, and the simulation results are shown in Figure 4.

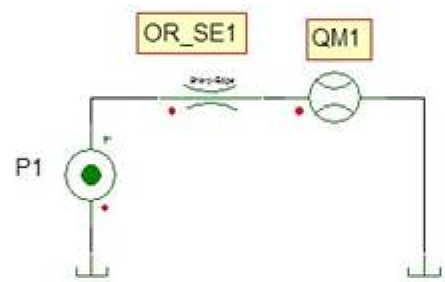


**Figure 3. Application example of the Sharp-Edge Orifice**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P1 | Value | 10Meg*t [Pa] |
| Sharp-Edged Orifice OR_SE1 | Type | Round |
| | CD | 0.6 [m] |
| | PERI | 1m [m] |
| | REY_TRANS | 3K |
| | RHO | 1K [kg/m$^3$] |
| | VSC | 10m [Pa s] |
| | DIA | 1m [m] |

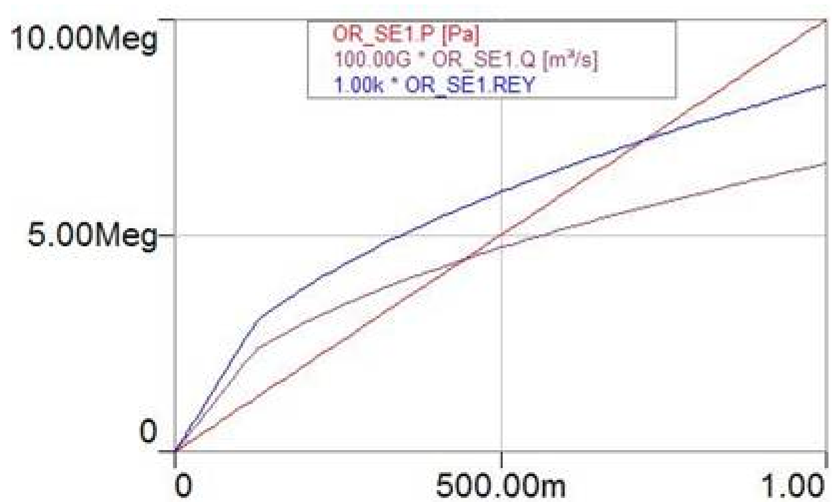


**Figure 4. Simulation results**

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## References

# Turbulent Orifice

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

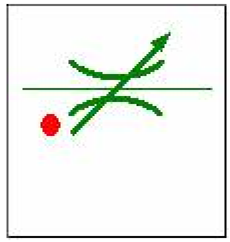

**Figure 1 . Component symbol**



## Description

The Turbulent Orifice represents a fluid resistance with turbulent flow (non-linear flow characteristic curve) if no cavitation occurs. A shape which is designed with sudden changes of cross-section means that there is turbulent flow even at low flow speeds, so that the flow is largely viscosity-independent and thus temperature-independent. The conductance *K* describes the flow for high Reynolds numbers.

The Turbulent Orifice is used for speed setting of loads, or as a decoupling element to feed multiple loads from a constant pressure source.

Top

## Assumptions and Limitations

The model is based on the following assumptions:

- Fluid inertia is not taken into account.

Top

## Mathematical Description

$$Q = K \cdot \sqrt{P}$$

Top

## Netlist Syntax

UMODEL OR_TURB ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1 ( K:= @K) SRC: DB(Lib:=@ModelLibraryName) ;

Top

## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| K | Conductance | real | 0.1u [$m^3/(s*Pa^{0.5})$] |

Top

## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| P | Differential Pressure [Pa] | real |
| Q | Flow Rate [$m^3/s$] | real |

Top

## Example

This example demonstates that a rising flow rate causes a nonlinear pressure drop in the turbulent orifice. The schematic of the example is shown in Figure 2, system parameters listed in Table 4 and the simulation results are shown in Figure 3.

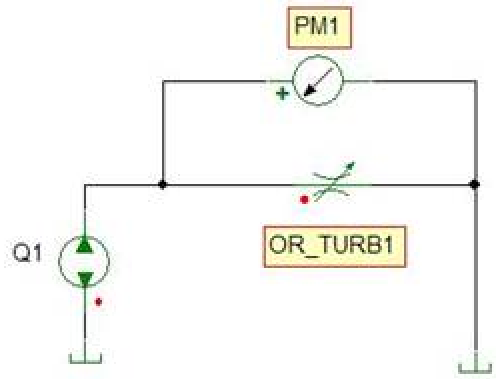


**Figure 2. Application example of the Turbulent Orifice Model**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Flow Source Q1 | Value | 100u*t [$m^3/s$] |
| Turbulent Orifice OR_ TURB1 | CONDUCTANCE | 3e-7 [$m^3/s*Pa^{0.5}$] |

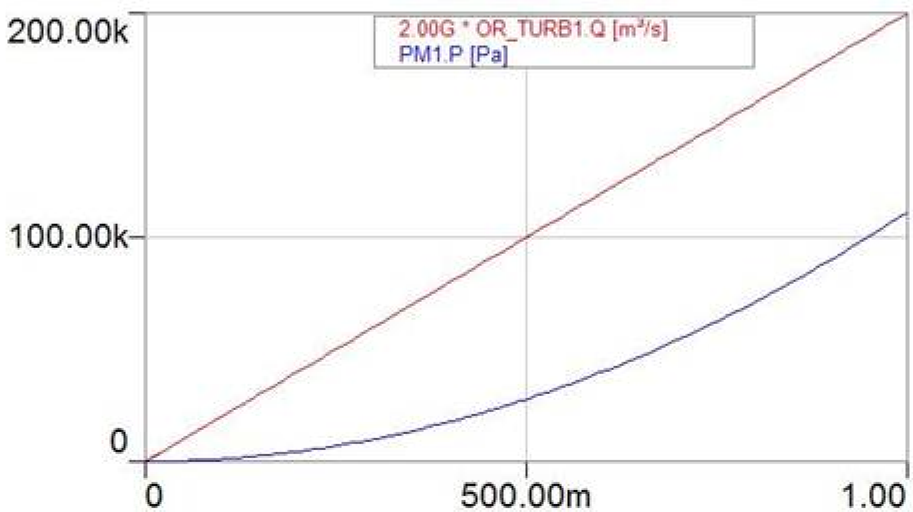


**Figure 3. Simulation results**

Top

## References

# Variable Orifice

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

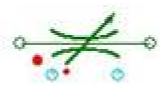

**Figure 1. Component symbol**



## Description

The Variable Orifice represents a variable fluid resistance. The characteristics are based on equations for laminar and turbulent flow through a sharp-edge orifice, and allows the flow area to vary as a function of the relative positions of the translational connections. This model uses linear shape parameters to facilitate modeling of spool-type valves where the spool opens a rectangular slot. This slot can be any width and length, the dimensions of which are determined by the Parameters for maximum flow area and displacement of the mechanical connections for the closed and full open points.

Top

## Assumptions and Limitations

The model is based on the following assumptions:

- Fluid inertia is not taken into consideration.
- The transition between laminar and turbulent regimes is assumed to be sharp and taking place exactly when the Reynolds numbers reaches the critical value, *i.e.* REY = REY_TRANS.

Top

## Mathematical Description

The equations used for the model characteristics change as the flow changes from laminar to turbulent flow, and care is taken to ensure continuity at the transition(s).

There are no pressure-induced forces calculated in this model. The only forces modeled are those due to steady state flows. This flow force is calculated based on equations for typical steady state momentum based reactions. This flow force is multiplied by the value of FACT, which when set = 1.0 gives the force reaction calculated. The default for the factor is '0', so there is no flow force in default.

$$Q = CD(REY) \cdot AREA(TYPE) \cdot \sqrt{\frac{2 \cdot P}{RHO}}$$

$$REY = \frac{abs(Q) \cdot DIA(PERI) \cdot RHO}{AREA(TYPE) \cdot VSC}$$

$$REY < REY\_TRANS$$

$$\text{Laminar Flow} \quad CD(REY) = CD * \sqrt{\frac{REY}{REY\_TRANS}}$$

$$REY \geq REY\_TRANS$$

$$\text{Turbulent Flow} \quad CD(REY) = CD$$

$$F = FACT \cdot POLARITY \cdot 2 \cdot CD \cdot CV \cdot AREA \cdot \cos\left(69 \cdot \frac{\pi}{180}\right) \cdot P \qquad CV = 0.98$$

There are three types of areas defined in this model:

• Linear Type

In this case, the flow area depends on the actual displacement(s).

AREA_MIN ≤ AREA ≤ AREA_MAX;

If s ≤ S_MIN then AREA=AREA_MIN;

If s ≥ S_MAX then AREA=AREA_MAX

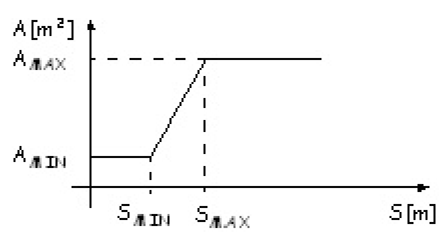

**Figure 2. The relation between the Flow Area (Area) and the Displacement (s) for Variable Orifice model with linear area**

- Ball-Seat Type
- Poppet Type

Top

## Netlist Syntax

Netlist generated by Special Component Dialog.

Top

## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |
| TRB1 | Translational Mechanical Pin | Mechanical terminal |
| TRB2 | Translational Mechanical Pin | Mechanical terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| CD | Discharge Coefficient | real | 0.6 |
| FACT | Flow Force Factor | real | 0 |
| REY_TRANS | Reynolds Number (Transition) | real | 10 |
| RHO | Fluid Density | real | 1k [kg/m$^3$] |
| VSC | Absolute Viscosity | real | 10m [Pa s] |
| S_MAX | Relative Displacement for Maximum Area of Linear Type | real | 1m [m] |
| S_MIN | Relative Position for Minimum Opening | real | 0 [m] |
| AREA_MAX | Maximum Flow Area of Linear Type | real | 1E-6 [m$^2$] |

| | | | |
|---|---|---|---|
| AREA_MIN | Minimum Flow Area of Linear Type | real | 1E-9 [$m^2$] |
| DIA | Diameter | real | 1m [m] |
| POLARITY | Polarity for Open Direction of Ball-Seat and Poppet Type | real | 1 |
| PHI | Seat Included Angle of Ball-Seat and Poppet Type | real | MATH_PI/2 [rad] |
| OPEN_MIN | Minimum Opening of Ball-Seat and Poppet Type | real | 1n [m] |

Top

## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| P | Differential Pressure [Pa] | real |
| Q | Flow Rate [$m^3/s$] | real |
| S | Displacement [m] | real |
| F | Force [N] | real |
| REY | Reynolds Number | real |
| AREA | Flow Area [$m^2$] | real |
| DIA_HYD | Hydraulic Diameter [$m^2$] | real |
| PERI | Perimeter [m] | real |
| ST_LAMINAR | Laminar State | real |
| ST_TURBULENT | Turbulent State | real |

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## Example

In this example, the Pressure Source P2 provides a constant pressure level. The flow through the Variable Orifice OR_VAR1 is controlled by its variable flow area. The schematic of the system is shown in Figure 3, system parameters are listed in Table 4, and the simulation results are shown in Figure 4.

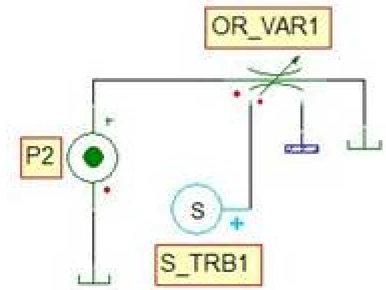


**Figure 3. Application example of the Variable Orifice model**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P2 | Value | 11.5Meg [Pa] |
| Variable Orifice OR_VAR1 | Area Type | Linear |
| | CD | 0.6 |
| | FACT | 1 |
| | REY_TRANS | 10 |
| | RHO | 1K [kg/m$^3$] |
| | VSC | 10m [Pa s] |
| | S_MAX | 1m [m] |
| | S_MIN | 0 [m] |
| | AREA_MAX | 1E-6 [m$^2$] |
| | AREA_MIN | 1E-9 [m$^2$] |

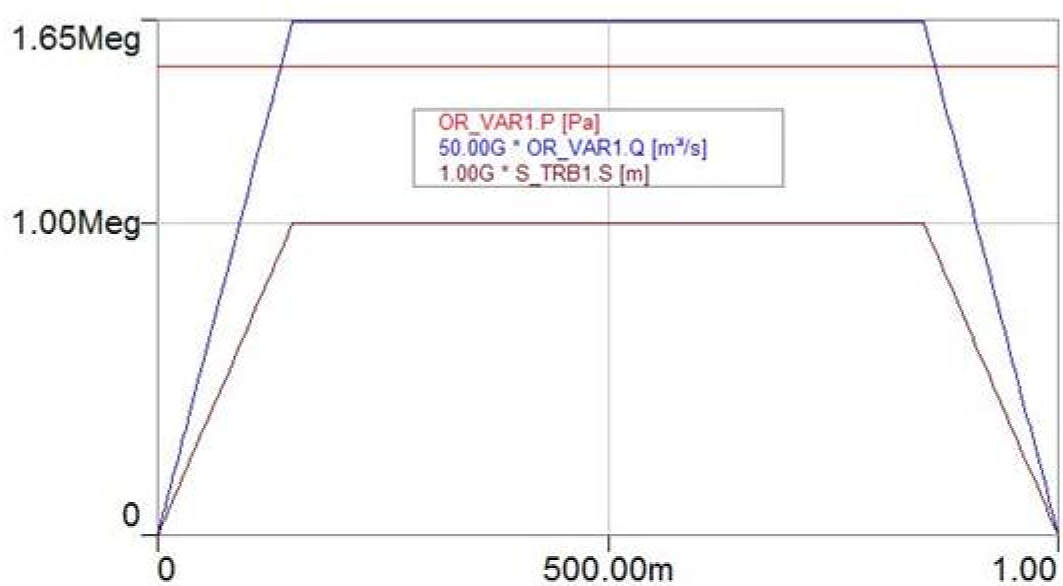

**Figure 4. Simulation results**

Top

## References

[1] Fitch, E.C. and I.T. Hong. *Hydraulic Component Design and Selection*. BarDyne, Inc.,1997

# Laminar Orifice

The Laminar Orifice represents a fluid resistance with laminar flow (linear flow characteristic curve). The conductance K describes the flow for very small reynolds numbers. The Laminar Orifice is used for long lines, leakage in valves, hydrostatic slipper bearings, etc. The Laminar Orifice is the same model as Linear Orifice in the Basic Elements library.

See *Linear Orifice* in the Basic Elements Library help.

# Characteristic Orifice

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

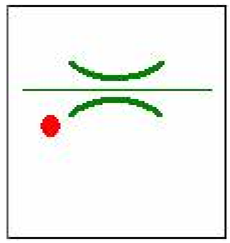

**Figure 1. Component symbol**



## Description

The Characteristic Orifice represents a fluid resistance with a user-defined Q-P characteristic.

The last slope is effective for all values outside the X-range. If you want to have a constant value outside the X-range, you have to define two data-pairs with the same Y-value at the end.

Top

## Assumptions and Limitations

Top

## Mathematical Description

The fluid resistance of the Characteristic Orifice model is defined by a user-defined Q-P characteristic. Figure 2 shows the symmetrical and nonsymmetrical characteristics for both fluid flow directions.

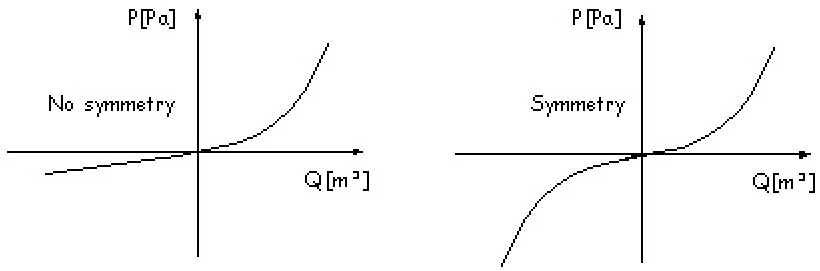


**Figure 2. Symmetrical and non-symmetrical Q-P characteristics**

Top

## Netlist Syntax

Netlist generated by Special Component Dialog.

Top

## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| CH | Characteristic P=f(Q) | real | n/a |

Top

## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| P | Differential Pressure [Pa] | real |

| | | |
|---|---|---|
| Q | Flow Rate [$m^3$/s] | real |

Top

## Example

Top

## References

# Passive Elements

- Volume (CHYD)
- Pipe (PIPE)
- Blind Plug (PLUG)

# Volume

See *Hydraulic Capacitance* in the Basic Elements Library help.

# Pipe

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

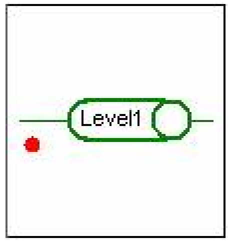


**Figure 1. Component symbol**

- Description
- Assumptions and Limitations
- Mathematical Description
- Netlist Syntax
- Conservative Pins
- Parameters
- Input/Output Quantities
- Example

### Description

The Pipe represents a fluid resistance element that can include the effects of fluid inertia, or hydraulic inductance, as well as fluid compressibility, or hydraulic capacitance. The characteristics are based on equations for laminar and turbulent flow through a smooth round/rectangular pipe, and are supplemented with the differential equations for the effect of fluid mass and acceleration, and compressibility of the fluid volume.

Top

### Assumptions and Limitations

Top

### Mathematical Description

The Level 1 model calculates the laminar and turbulent flow through a smooth round/rectangular pipe. The following equations based on the Darcy-Weisbach equations are used:

$$P = FACT\_FRIC \cdot \frac{LEN}{DIA} \cdot \frac{RHO \cdot V^2}{2} = P\_VSC$$

$$V = \frac{Q}{AREA}$$

$$REY = \frac{|Q| \cdot RHO \cdot DIA}{VSC \cdot AREA}$$

The round pipe, the AREA is:

$$AREA = \frac{\pi}{4} \cdot DIA^2$$

For rectangular pipe, the AREA is:

$$AREA = HEIGHT \cdot WIDTH \qquad WIDTH \geq HEIGHT$$

The Level 2 model calculates the flow characteristic and includes the effects of fluid compressibility, or hydraulic capacitance. The following equations based on both the Darcy-Weisbach equations and the fluid compressibility differential equation are used:

$$P = P\_VSC$$

The fluid compressibility is modeled by dividing the volume of fluid in the pipe by 2 and placing each half volume at each end of the pipe. The flow into each of the volumes is governed by the following equation.

$$Q = \frac{AREA \cdot LEN}{B} \cdot \frac{dP}{dt}$$

The Level 3 model calculates the flow characteristic and includes the effects of fluid compressibility, or hydraulic capacitance, as well as fluid inertia, or hydraulic inductance. The following equations based on the Darcy-Weisbach equations, the inductive differential equation, and the capacitive differential equations are used:

$$P = P\_VSC + P\_IND$$

$$P\_IND = \frac{RHO \cdot LEN}{AREA} \cdot \frac{dQ}{dt}$$

The flow characteristics include three separate regions described as follows:

- Laminar flow, where reynolds_number < reynolds_laminar

• Turbulent flow, where reynolds_number > reynolds_turbulent

• Transition flow, where the characteristic are interpolated between the laminar and turbulent, transition points, *i.e.* reynolds_laminar ≤ reynolds_number ≤ reynolds_turbulent

For the laminar flow region the friction factor, friction_factor, is calculated using the Hagen-Poiseuille law as follows:

$$FACT\_FRIC = \frac{64}{REY}$$

For the turbulent flow region the friction factor, friction_factor, is calculated using the Blasius law as follows.

$$FACT\_FRIC = \frac{0.316}{REY^{0.25}}$$

For the transition region the flow characteristics are obtained by interpolating between the laminar and turbulent transition points. There is also a relative smoothness factor that increases the characteristic pressure drop in proportion. For example, if the pipe can be described as having roughness on the surface that is double that of a smooth pipe, the factor would be set equal to 2.0.

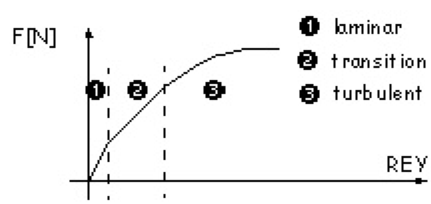


**Figure 2. Relation between Fluid Force(F) and Reynolds Number (REY)**

Top

### Netlist Syntax

Netlist generated by Special Component Dialog.

Top

### Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| LEN | Length | real | 1 [m] |
| DIA | Diameter of round pipe | real | 10m [m] |
| HEIGHT | Height of the rectangular pipe | real | 10u [m] |
| WIDTH | Width of the rectangular pipe | real | 0.1m [m] |
| FACT | Flow Force Factor | real | 1 |
| REY_LAMINAR | Reynolds Number (laminar) | real | 2k |
| REY_TURBULENT | Reynolds Number (Turbulent) | real | 4k |
| RHO | Fluid Density | real | 1k [kg/m$^3$] |
| VSC | Absolute Viscosity | real | 10m [Pa s] |
| B | Bulk Modulus for Model Level 2 and 3 | real | 1G [Pa] |

Top

## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| P | Differential Pressure [Pa] | real |
| Q | Flow Rate [m$^3$/s] | real |
| REY | Reynolds Number | real |
| ST_LAMINAR | Laminar State | real |
| ST_TRANS | Transition State | real |
| ST_TURBULENT | Turbulent State | real |

Top

## Example

## Reference:

[1] Keller, George. *Hydraulic System Analysis, Hydraulics and Pneumatics*, Second Edition, 1974.

# Blind Plug

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

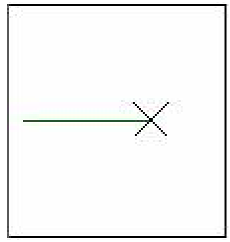

**Figure 1. Component symbol**

- Description
- Assumptions and Limitations
- Netlist Syntax
- Conservative Pins
- Example
- References

## Description

The Blind Plug represents a blocked line connection. It consists of a laminar orifice with a conductance of $K$=1E-20 $m^3/(s*Pa)$, which is connected to ground level.

The Blind Plug is used for closing open pins (conservative nodes) on hydraulic components. Unused line connections on directional valves can be blocked.

Top

## Assumptions and Limitations

The Blind Plug model is based on the following assumptions:

- No leakage, internal or external, is considered.

Top

## Netlist Syntax

MODEL PLUG ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0 ( ) SRC: DB (Lib:=@ModelLibraryName) ;

Top

## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |

Top

## Example

In this example, a constant pressure causes a constant flow in the Laminar Orifice RHYD1. After 1s the valve switches and the pressure is then applied to RHYD2, resulting a flow there. The Blind Plug PLUG1 is used to close the open hydraulic pin at the valve. The schematic of the system is shown in Figure 2, system parameters are listed in Table 2, and the simulation results are shown in Figure 3.

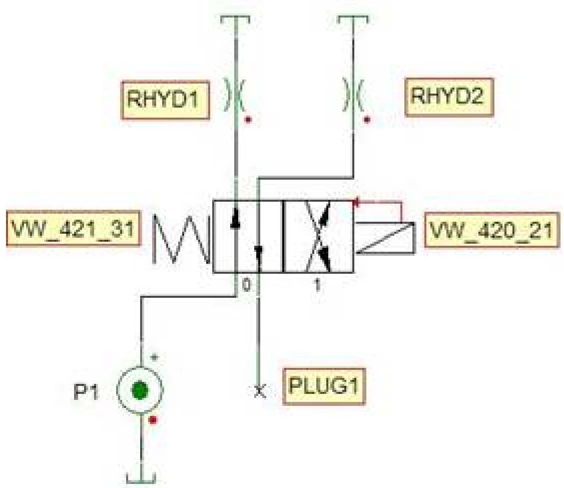


**Figure 2. Application example of the Blind Plug model**

**Table 2. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P1 | Value | 11.5Meg [Pa] |
| RHYD1 | K | 1n [$m^3$/(Pa s)] |
| RHYD3 | K | 3n [$m^3$/(Pa s)] |
| Direction Control Valve (ON Function 3) VW_421_31 | CTRL | t>1 |
| Direction Control Valve (OFF Function | SET | VW_421_ |

| | | |
|---|---|---|
| 2) VW_420_21 | | 31.SET |

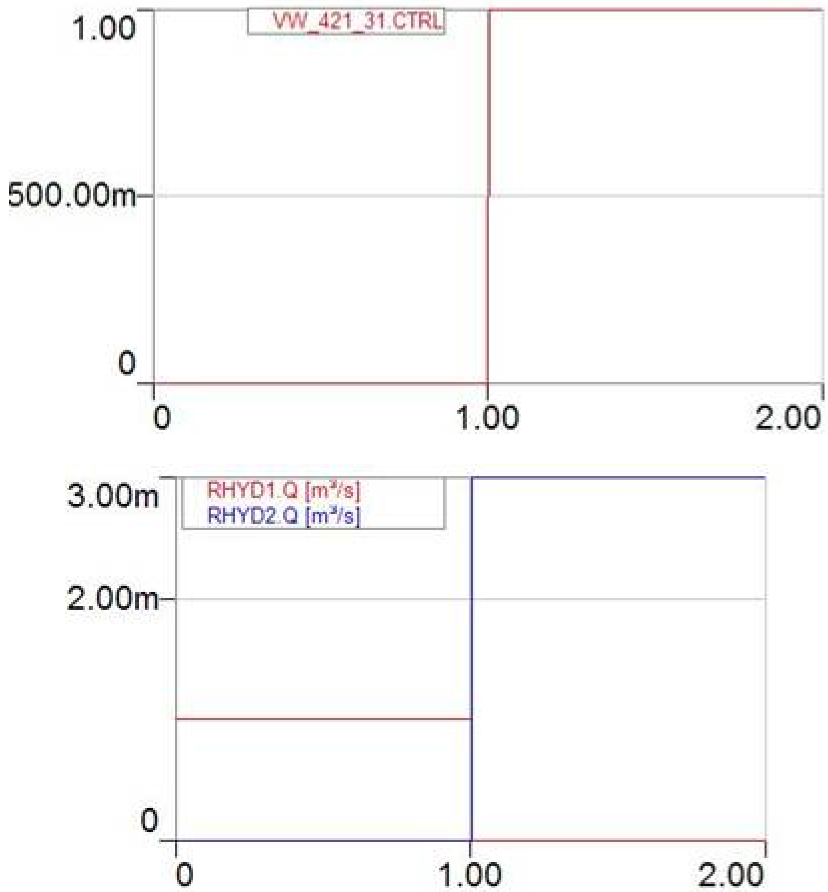


**Figure 3. Simulation Results**

Top

## References

# Hydraulic Sources

- Pressure Source (P)
- Pump (PUMP)
- Flow Source (Q)

# Pressure Source

See *Pressure Source* in the Basic Elements Library help.

# Pump

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

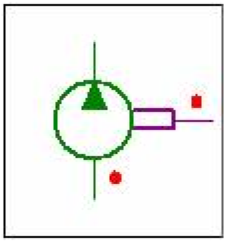

**Figure 1. Component symbol**


• Description

• Assumptions and Limitations

• Mathematical Description

• Netlist Syntax

• Conservative Pins

• Parameters

• Input/Output Quantities

• Example

• References


## Description

The Pump represents an ideal flow source which supplies the defines flow rate, which depends on the geometrical displacement volume *VOLG* and the angular velocity *OMEGA* of the drive. The angular velocity is provided as an across quantity at the rotational pin *ROT1*.

Top

## Assumptions and Limitations

Top

## Mathematical Description

If *OMEGA*<0 or if *P(H1)*<-1E5, an error message occurs. If *P* > *PUL*, a warning is displayed.

The flow and torque equations are shown as follows:

$$Q = VOLG \cdot \frac{OMEGA}{2\pi} \cdot \frac{ETAV}{100}$$

$$ETAV = f(P)$$

$$TORQUE = VOLG \cdot \frac{P}{2\pi}$$

Top

### Netlist Syntax

Top

### Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
| --- | --- | --- |
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |
| ROT1 | Rotational Mechanic Pin | Mechanic Terminal |

Top

### Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
| --- | --- | --- | --- |
| VOLG | Volumetric Displacement | real | 10u [m] |
| CH | Characteristic ETAV=f(P) | real | |
| PUL | Maximum Pressure, Maximum x-value of Characteristic | real | 10Meg [Pa] |
| WIDTH | Width of the Rectangular Pipe | real | 0.1m [m] |

For more details about the parameters, see Special Component Dialog..

Top

## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| P | Differential Pressure [Pa] | real |
| Q | Flow Rate [$m^3/s$] | real |
| OMEGA | Angular Velocity [[rad/s]] | real |
| TORQUE | Torque [Nm] | real |
| N | Rotational Speed [rpm] | real |
| ETAV | Volumetric Efficiency [%] | real |

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## Example

In this example, the angular velocity output from the Angular Velocity Source V_ROT1 increase with time. The increasing angular velocity causes an increasing flow in the Pump PUMP1. The flow is routed through the Directional Control Valve VW_32_31 to the Laminar Orifice RHYD1. After 1s, the valve switches and flow path changes to RHYD2. The difference in the slops of *OMEGA* and Flow Rate is due to the pressure dependency of the pump efficiency. The schematic of the system is shown in Figure 2, system parameters are listed in Table 4, and the simulation results are shown in Figure 3.

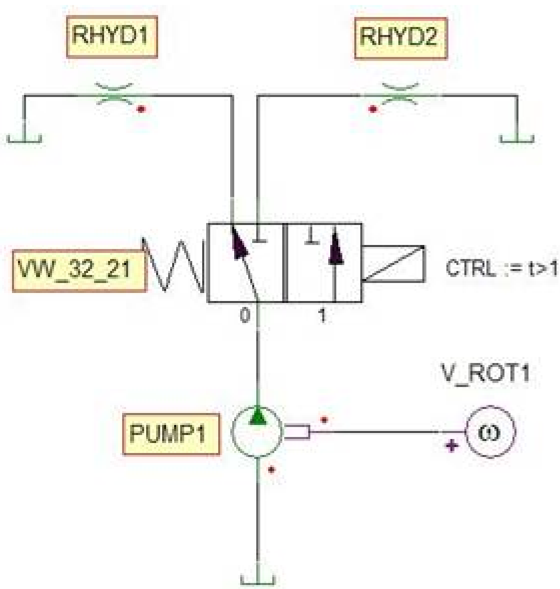
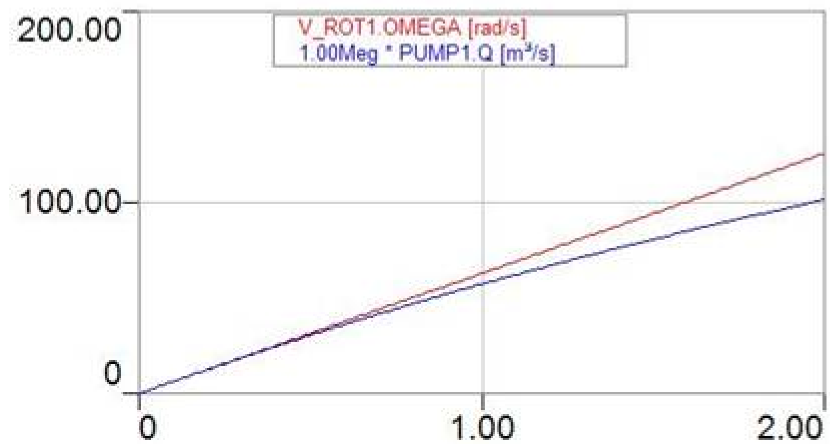
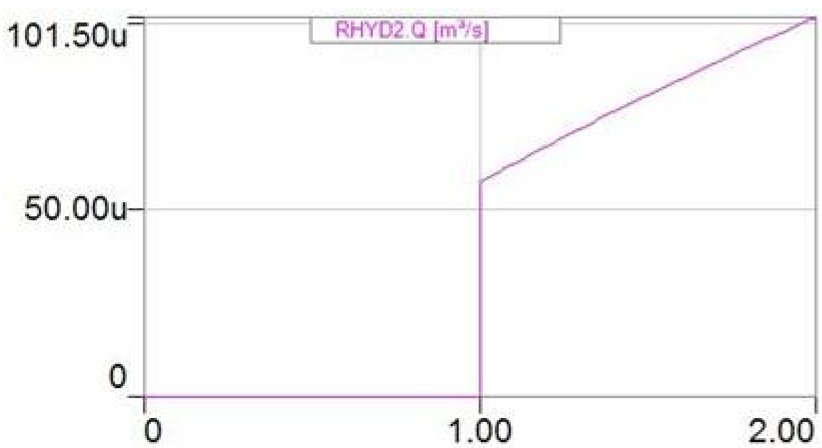



**Figure 2. Application example of the Pump model**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P1 | Value | 11.5Meg [Pa] |
| RHYD1 | K | 5e-12 [$m^3$/(Pa s)] |
| RHYD2 | K | 5e-12 [$m^3$/(Pa s)] |
| Direction Control Valve (ON Function 2) VW_321_21 | CTRL | t>1 |
| PUMP | VOLG | 2*PI*1u |
| Angular Velocity Source | V_ROT1 | 2*PI*10*t |



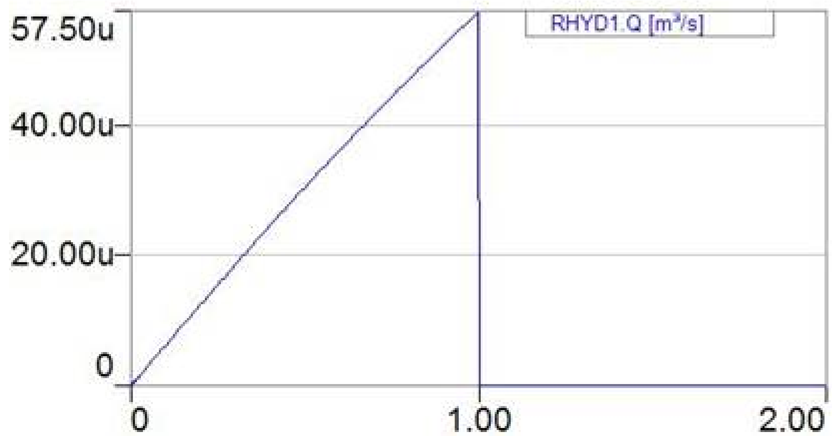



**Figure 3. Simulation results**

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## References

# Flow Source

See *Flow Source* in the Basic Elements Library help.

# Hydraulic Switches

- Limit Switch 1 (LS1)
- Limit Switch 2 (LS2)
- Limit Switch 3 (LS3)
- Limit Switch 4 (LS4)
- Normally Closed (SC_HYD)
- Change Over (SCO_HYD)
- Normally Open (SO_HYD)
- Pressure Switch (SP_HYD)

# Limit Switch 1

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

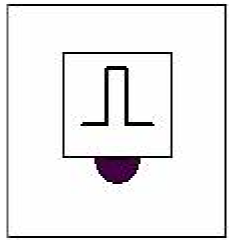

**Figure 1. Component symbol**



## Description

The model represents a limit switch. If the input signal INPUT crosses the threshold value THRES, the model returns the value '1' for a time of maximum time step HMAX, otherwise the model returns the value '0'. The switch return value (switch closed: 1, switch open: 0) is shown visually during the simulation with a red mark in the symbol.

Top

## Assumptions and Limitations

Top

## Mathematical Description

Limit switches are contact elements which are controlled by mechanical magnitudes (for example cylinder paths).

If INPUT ≥ THRESHOLD, then VAL = 1 for a time of maximum time step HMAX.

Else VAL = 0.

Top

## Netlist Syntax

MODEL LS1 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( THRES:= @THRES, INPUT:= @INPUT) SRC: DB(Lib:=@ModelLibraryName) ;

Top

## Parameters

**Table 1**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| THRES | Threshold Value | real | 0 |

Top

## Input/Output Quantities

**Table 2**

| Name | Description | Data type |
|---|---|---|
| INPUT | Input Signal | real |
| VAL | Return Value | real |

Top

## Example

Top

## References

# Limit Switch 2

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

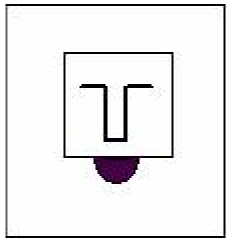

**Figure 1. Component symbol**

- Description
- Assumptions and Limitations
- Mathematical Description
- Netlist Syntax
- Parameters
- Input/Output Quantities
- Example
- References

## Description

The model represents a limit switch. If the input signal INPUT crosses the threshold value THRES, the model returns the value '0' for a time of maximum time step HMAX, otherwise the model returns the value '1'. The switch return value (switch closed: 1, switch open: 0) is shown visually during the simulation with a red mark in the symbol.

Top

## Assumptions and Limitations

Top

## Mathematical Description

Limit switches are contact elements which are controlled by mechanical magnitudes (for example cylinder paths).

If INPUT ≥ THRESHOLD, then VAL = 0 for a time of maximum time step HMAX.

Else VAL = 1.

Top

## Netlist Syntax

MODEL LS2 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( THRES:= @THRES, INPUT:= @INPUT) SRC: DB(Lib:=@ModelLibraryName) ;

Top

## Parameters

**Table 1**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| THRES | Threshold Value | real | 0 |

Top

## Input/Output Quantities

**Table 2**

| Name | Description | Data type |
|---|---|---|
| INPUT | Input Signal | real |
| VAL | Return Value | real |

Top

## Example

Top

## References

# Limit Switch 3

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

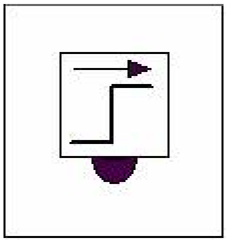

**Figure 1. Component symbol**



## Description

The model represents a limit switch. If the input signal INPUT is greater than the threshold value THRES, the model returns the value '1', otherwise the model returns the value '0'. The switch return value (switch closed: 1, switch open: 0) is shown visually during the simulation with a red mark in the symbol.

Top

## Assumptions and Limitations

Top

## Mathematical Description

Limit switches are contact elements which are controlled by mechanical magnitudes (for example cylinder paths).

If INPUT $\geq$ THRESHOLD, then VAL = 1.

Else VAL = 0.

">

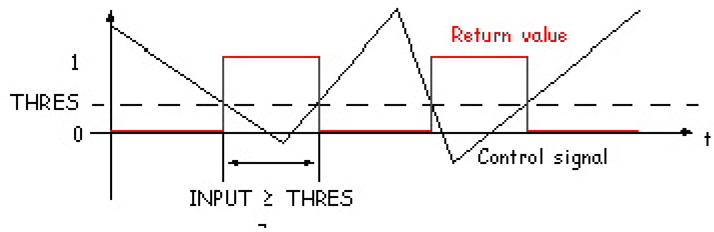


**Figure 2. Input signal INPUT AND return value VAL of the Limit Switch 3 model**

Top

### Netlist Syntax

MODEL LS3 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( THRES:= @THRES, INPUT:= @INPUT) SRC: DB(Lib:=@ModelLibraryName) ;

Top

### Parameters

**Table 1**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| THRES | Threshold Value | real | 0 |

Top

### Input/Output Quantities

**Table 2**

| Name | Description | Data type |
|---|---|---|
| INPUT | Input Signal | real |
| VAL | Return Value | real |

Top

### Example

Top

### References

# Limit Switch 4

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

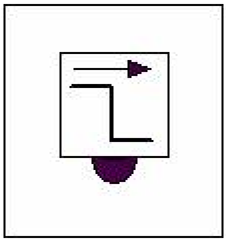

**Figure 1. Component symbol**



## Description

The model represents a limit switch. If the input signal INPUT is greater than the threshold value THRES, the model returns the value '0', otherwise the model returns the value '1'. The switch return value (switch closed: 1, switch open: 0) is shown visually during the simulation with a red mark in the symbol.

Top

## Assumptions and Limitations

Top

## Mathematical Description

Limit switches are contact elements which are controlled by mechanical magnitudes (for example cylinder paths).

If INPUT ≥ THRESHOLD, then VAL = 0.

Else VAL = 1.

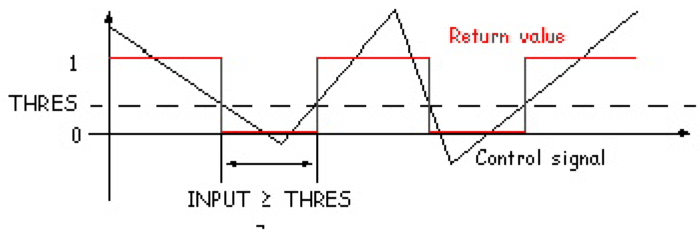


**Figure 2. Input signal INPUT AND return value VAL of the Limit Switch 3 model**

Top

## Netlist Syntax

MODEL LS4 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( THRES:= @THRES, INPUT:= @INPUT) SRC: DB(Lib:=@ModelLibraryName) ;

Top

## Parameters

**Table 1**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| THRES | Threshold Value | real | 0 |

Top

## Input/Output Quantities

**Table 2**

| Name | Description | Data type |
|---|---|---|
| INPUT | Input Signal | real |
| VAL | Return Value | real |

Top

## Example

Top

## References

# Ideal Switch, Normally Closed

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

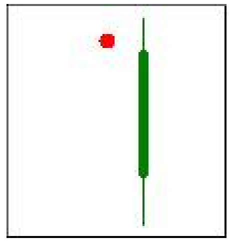

**Figure 1. Component symbol**

- Description
- Assumptions and Limitations
- Mathematical Description
- Netlist Syntax
- Conservative Pins
- Parameters
- Example
- References

## Description

The model represents an ideal fluid switch. If the control signal is greater than '0', the two terminal nodes of the switch are disconnected. Because it is an ideal switch, the resistance of the line connection is zero. If the control signal is lower than or equal to '0', the line is connected and the resistance is infinite. A logical signal controls the state of the switch. The initial state of the switch is ON. The ideal switch is represented as an Animated Symbol; that means the switch symbol changes during the simulation depending on the control signal.

**Note:** Since the switch behaves as an ideal, physically meaningful circuits must be obtained in both ON and OFF switching states.

Top

## Assumptions and Limitations

The model is based on the following assumptions:

• The switch is ideal, *i.e.* the resistance of the line connection is zero when the switch is ON, and infinity when the switch is OFF.

Top

## Mathematical Description

If CTRL <= 0, then P = 0.

If CTRL > 0, then Q = 0.

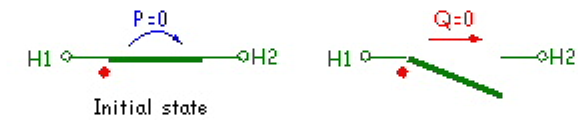


**Figure 2. The Ideal Switch model under both ON and OFF operation conditions**

Top

## Netlist Syntax

MODEL SC_HYD ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1 ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

Top

## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| CTRL | Control Signal | real | 0 |

Top

## Example

In this example, the Ideal Switch (Normally Close) SC_HYD1 is switched by a control signal, which is a predefined function that causes switching every 0.5 second. The schematic of the system is shown in Figure 3, system parameters are listed in Table 4, and the simulation results are shown in Figure 4.

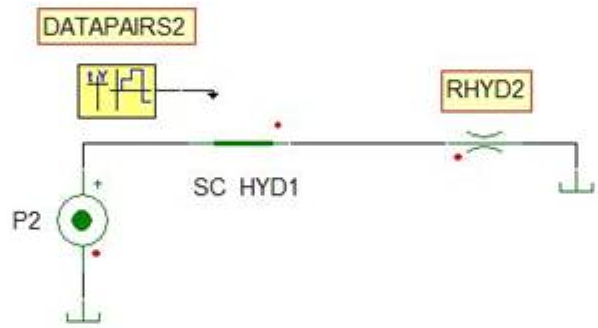


**Figure 3. Application example of the Ideal Switch (Normally Close)**

**Table 3. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P2 | Value | 1Meg [Pa] |
| RHYD2 | K | 5n [$m^3$/(Pa s)] |
| SC_HYD1 | CRTL | DATAPAIRS.VAL |

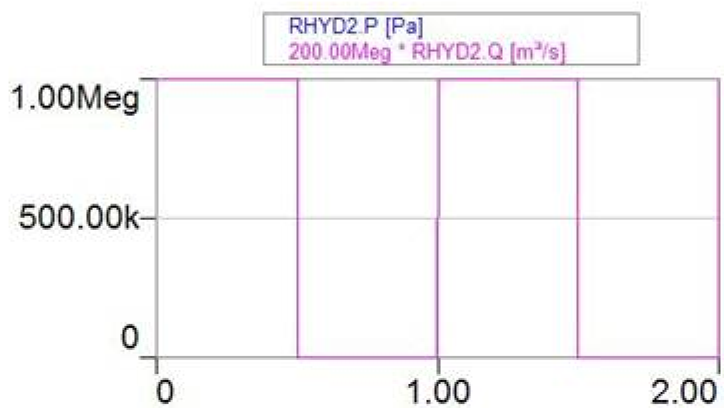


**Figure 4. Simulation results**

Top

## References

# Ideal Switch, Change Over

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

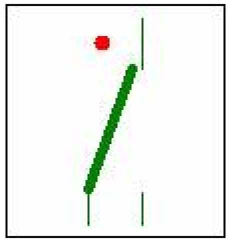

**Figure 1. Component symbol**

- Description
- Assumptions and Limitations
- Mathematical Description
- Netlist Syntax
- Conservative Pins
- Parameters
- Example
- References

## Description

The model represents an ideal fluid transfer switch. If the control signal is greater than '0', the nodes H1 and H2 are connected and the nodes H1 and H3 are disconnected. Because it is an ideal switch, the resistance of the line connection is zero and the resistance of the disconnection is infinite. If the control signal is lower than or equal to '0', the line between H1 and H3 is connected. The initial state of the switch is OFF. The ideal switch is represented as an Animated Symbol; that means the switch symbol will change during the simulation depending on the corresponding control signal.

**Note:** Since the switch behaves as an ideal, physically meaningful circuits must be obtained in both ON and OFF switching states.

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## Assumptions and Limitations

The model is based on the following assumptions:

• The switch is ideal, *i.e.* the resistance of the line connection is zero when the switch is ON, and infinity when the switch is OFF.

Top

## Mathematical Description

If CTRL <= 0, then P(H1 → H3) = 0 and Q(H1 → H2) = 0.

If CTRL > 0, then P(H1 → H2) = 0 and Q(H1 → H3) = 0.

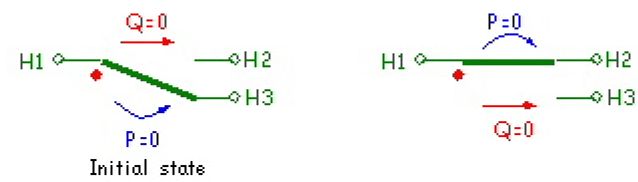



**Figure 2. The Ideal Switch model under both ON and OFF operation conditions**

Top

## Netlist Syntax

MODEL SCO_HYD ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2 ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

Top

## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |
| H3 | Fluidic Pin | Fluidic terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| CTRL | Control Signal | real | 0 |

Top

## Example

In this example, the Ideal Switch (Change Over) SCO_HYD1 is switched by a control signal, which is a predefined function that causes switching every 0.5 second. The schematic of the system is shown in Figure 3, system parameters are listed in Table 4, and the simulation results are shown in Figure 4.

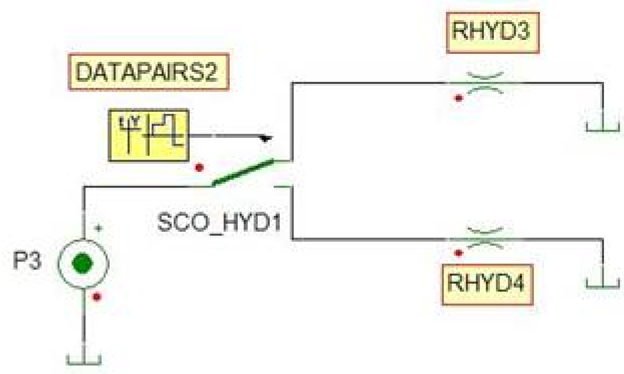
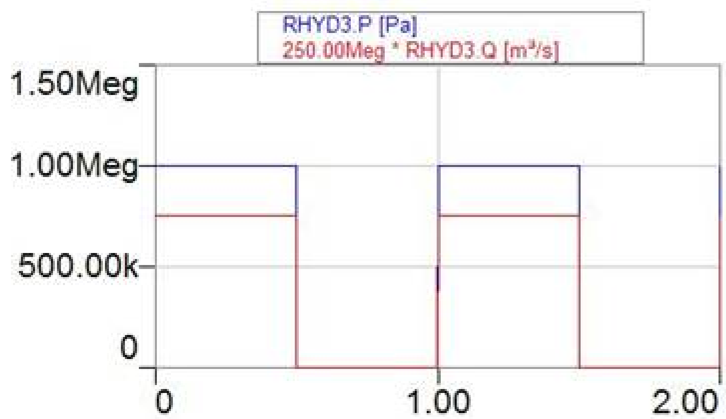



**Figure 3. Application example of the Ideal Switch (Change Over)**

**Table 3. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P3 | Value | 1Meg [Pa] |
| RHYD3 | K | 3n [$m^3$/(Pa s)] |
| RHYD4 | K | 5n [$m^3$/(Pa s)] |
| SCO_HYD1 | CRTL | DATAPAIRS.VAL |



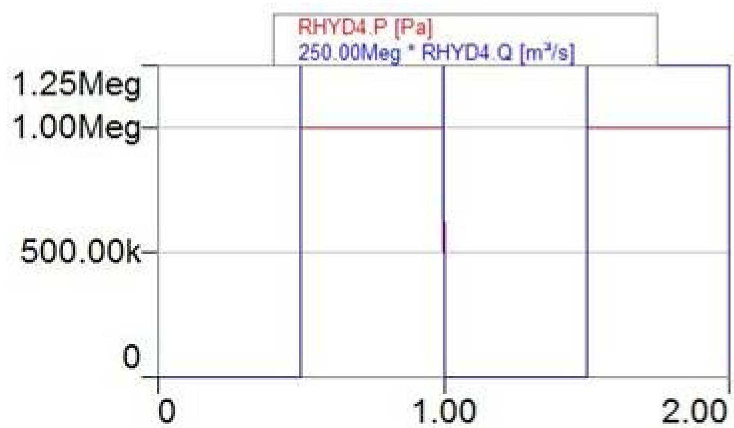



**Figure 4. Simulation results**

Top

## References

# Ideal Switch, Normally Open

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

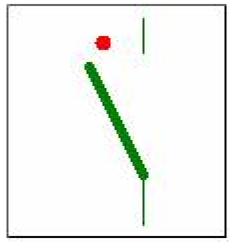


**Figure 1. Component symbol**



## Description

The model represents an ideal fluid switch. If the control signal is greater than '0', the two terminal nodes of the switch are connected. Because it is an ideal switch, the resistance of the line connection is zero. If the control signal is lower than or equal to '0', the line is disconnected and the resistance is infinite. A logical signal controls the state of the switch. The initial state of the switch is OFF. The ideal switch is represented as an Animated Symbol; that means the switch symbol changes during the simulation depending on the control signal.

**Note:** Since the switch behaves as an ideal, physically meaningful switch, circuits must be obtained in both ON and OFF switching states.

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## Assumptions and Limitations

The model is based on the following assumptions:

• The switch is ideal, *i.e.* the resistance of the line connection is zero when the switch is ON, and infinity when the switch is OFF.

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## Mathematical Description

If CTRL <= 0, then Q = 0.

If CTRL > 0, then P = 0.

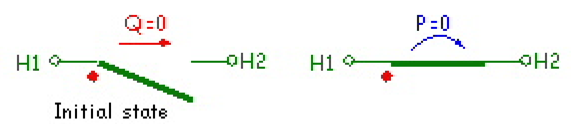


**Figure 2. The Ideal Switch model under both ON and OFF operation conditions**

Top

## Netlist Syntax

MODEL SO_HYD ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1 ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

Top

## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| CTRL | Control Signal | real | 0 |

Top

## Example

In this example, the Ideal Switch (Normally Open) SO_HYD1 is switched by a control signal, which is a predefined function that causes switching every 0.5 second. The schematic of the system is shown in Figure 3, system parameters are listed in Table 4, and the simulation results are shown in Figure 4.

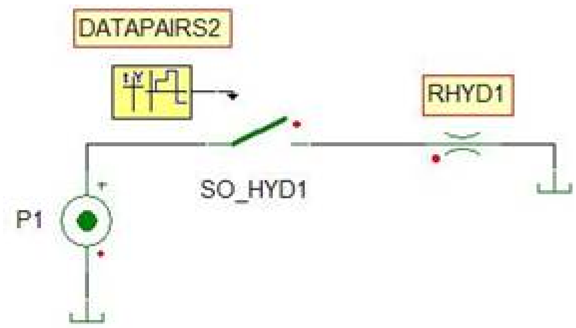


**Figure 3. Application example of the Ideal Switch (Normally Open)**

**Table 3. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P1 | Value | 1Meg [Pa] |
| RHYD1 | K | 5n [$m^3$/(Pa s)] |
| SO_HYD1 | CRTL | DATAPAIRS.VAL |

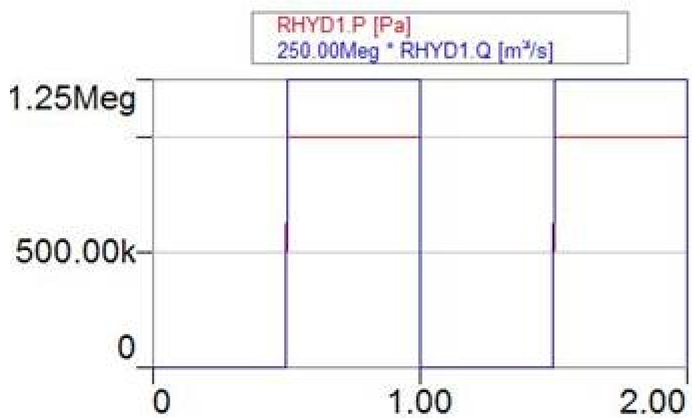


**Figure 4. Simulation results**

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## References

# Pressure Switch

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

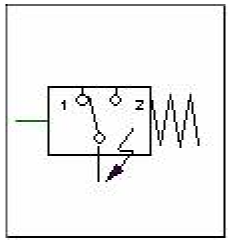

**Figure 1. Component symbol**

- Description
- Assumptions and Limitations
- Mathematical Description
- Netlist Syntax
- Conservative Pins
- Parameters
- Input/Output Quantities
- Example
- References

## Description

The model represents a pressure switch that switches one break contact *VAL1* (default value '1') and one make contact *VAL2* (default value '0') if the applied oil pressure at the fluidic pin exceeds the set switching pressure *THRES*. The switch has a hysteresis *HYST*, which is necessary for stability when the model is used for 2-point regulation (for example switching pumps ON and OFF depending on pressure).

Top

## Assumptions and Limitations

Top

## Mathematical Description

The simulator synchronizes on the switching points with minimum time step HMIN. The switch setting is shown during the simulation.

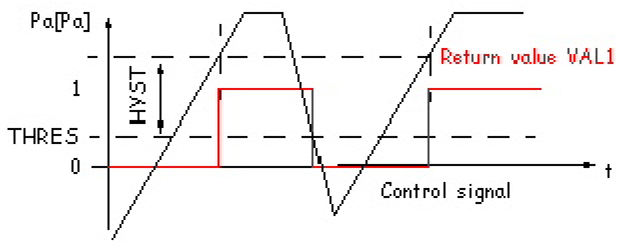


**Figure 2. Control signal response to applied pressure at H1 of the Pressure Switch.**

Top

## Netlist Syntax

MODEL SP_HYD ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0 ( HYST:= @HYST, THRES:= @THRES) SRC: DB(Lib:=@ModelLibraryName) ;

Top

## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| HYST | Hysteresis [Pa] | real | 0 |
| THRES | Threshold Value [Pa] | real | 0 |

Top

## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| VAL1 | Value 1 (represents break contact) | real |
| VAL2 | Value 2 (represents make contact) | real |

Top

## Example

Top

## References

# Hydraulic Valves

The actuating units which are shown as magnets stand symbolically for any arbitrary actuating unit (hydraulic, mechanical etc.), since this is not significant for the hydrostatic simulation. The same applies to pre-controlled directional valves. Pressure losses in the valves during oil flow are not modeled. During the simulation, the valve switch setting is shown by animation. The Hydraulic>Valves library is organized as follows:

- Directional Control Valves
- Non-Return Valves
- Pressure Control Valves

## Directional Control Valves

The models represent ideal directional control valves that release or block paths for the oil flow. The directional control valves folder consists of sub-types 2-2, 3-2, 4-2, and 4-3 as listed below.

**NOTE:** Because of the commonality between models in each type, the documentation for all models of a given type is provided in a common topic link.

• Directional Control Valves, 2-2

Because of commonality between type 2-2 Directional Control Valve models, documentation is provided in the common 2-2 topic.

The following 2-2 valve models are available:
• Function 1 (VW_22_1)
• Function 2 (VW_22_2)

• Directional Control Valves, 3-2

Because of commonality between type 3-2 Directional Control Valve models, documentation is provided in the common 3-2 topic.

The following 3-2 valve models are available:
• Function 1 (VW_32_1)
• Function 2 (VW_32_2)

• Directional Control Valves, 4-2

Because of commonality between type 4-2 Directional Control Valve models, documentation is provided in the common 4-2 topic.

The following 4-2 valve models are available:
OFF Function
• Function 1 (VW_420_1)
• Function 2 (VW_420_2)
• Function 3 (VW_420_3)
• Function 4 (VW_420_4)
• Function 5 (VW_420_5)
• Function 6 (VW_420_6)
• Function 7 (VW_420_7)
• Function 8 (VW_420_8)

ON Function
• Function 1 (VW_421_1)
• Function 2 (VW_421_2)
• Function 3 (VW_421_3)
• Function 4 (VW_421_4)
• Function 5 (VW_421_5)
• Function 6 (VW_421_6)

• Function 7 (VW_421_7)
• Function 8 (VW_421_8)

• Directional Control Valves, 4-3

Because of commonality between type 4-3 Directional Control Valve models, documentation is provided in the common 4-3 topic.

The following 4-3 valve models are available:
• Function 1 (VW_43_1)
• Function 2 (VW_43_2)
• Function 3 (VW_43_3)
• Function 4 (VW_43_4)
• Function 5 (VW_43_5)
• Function 6 (VW_43_6)

# Directional Control Valves, 2-2

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

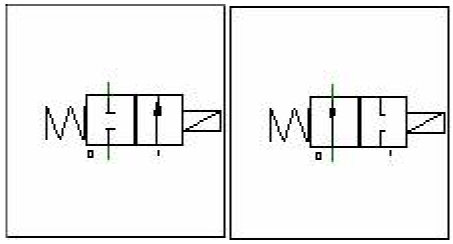

**Figure 1. Component symbols**



## Description

The model represents an ideal directional control valve that releases or blocks paths for the oil flow. The 2-2 valve has two controlled connections and two switch settings. The model Function 1 releases the path in position 1, the model Function 2 releases the path in position 0. During the simulation, there is an animation of the directional valve switch setting.

Top

## Assumptions and Limitations

Top

## Mathematical Description

If CTRL > 0, then Valve is in Position 1.

If CTRL <= 0, then Valve is in Position 0.

Top

### Netlist Syntax

MODEL VW_22_1 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1 ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_22_2 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H2:= %0, H1:= %1 ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

Top

### Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

Top

### Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| CTRL | Control Signal | real | 0 |

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### Example

In this example, both valves switch at t = 0.5 s, and stop the flow through them. The schematic of the system is shown in Figure 2, system parameters are listed in Table 3, and the simulation results are shown in Figure 3.

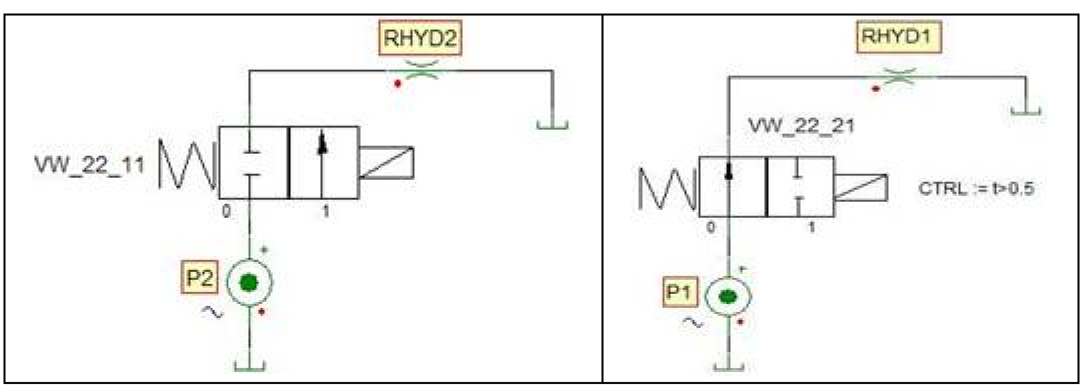
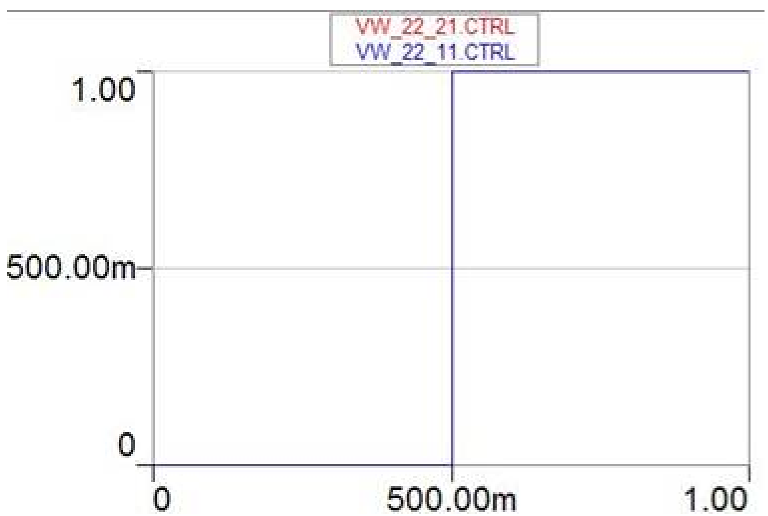


**Figure 2. Application example of the Directional Control Valve (2-2) Function 1 and Function 2**

**Table 3. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P1 (Time Controller_ Sine) | Amplitude | 500K [Pa] |
| | Frequency | 1 [Hz] |
| | Delay | 0 [s] |
| | Phase | 0 [Deg] |
| | Offset | 1Meg [Pa] |
| Pressure Source P2 (Time Controller_ Sine) | Amplitude | 500K [Pa] |
| | Frequency | 1 [Hz] |
| | Delay | 0 [s] |
| | Phase | 0 [Deg] |
| | Offset | 1Meg [Pa] |
| Directional Control Valve VW22_11 | CTRL | t > 0.5s |
| Directional Control Valve VW22_21 | CTRL | t > 0.5s |
| RHYD1 | K | 3n [$m^3$/(Pa s)] |
| RHYD2 | K | 3n [$m^3$/(Pa s)] |



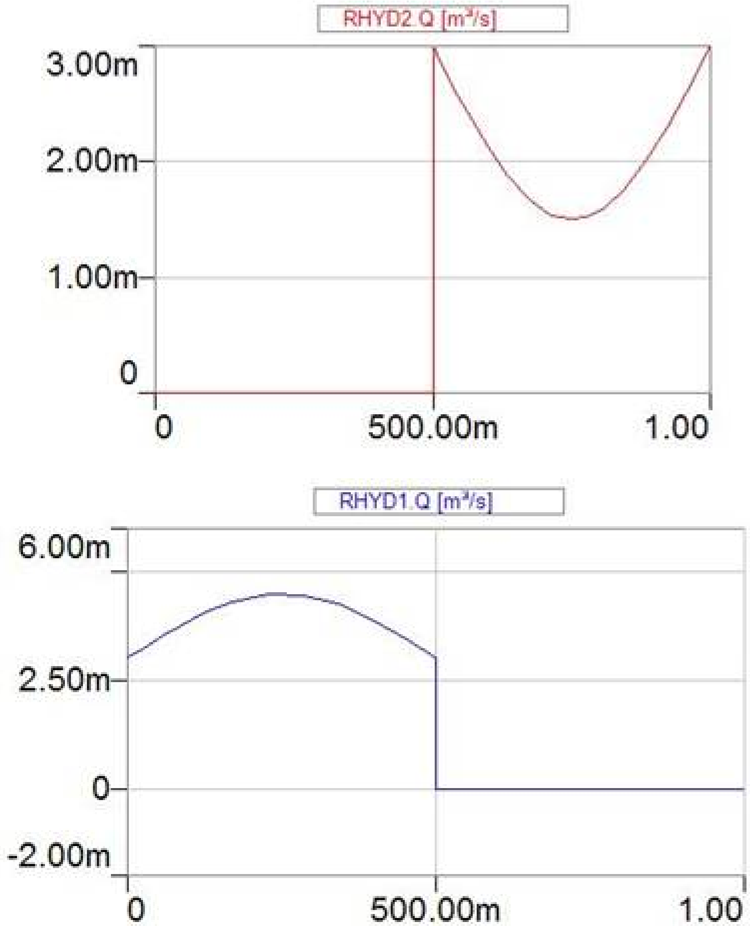



**Figure 3. Simulation results**

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## References

# Directional Control Valves, 3-2

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

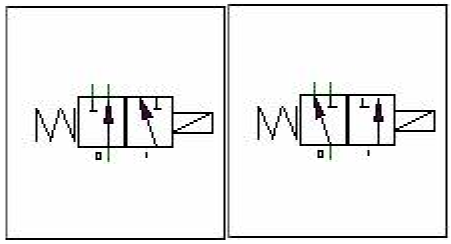

**Figure 1. Component symbols**



## Description

The model represents an ideal directional control valve that releases or blocks paths for the oil flow. The 3-2 valve has three controlled connections and two switch settings. The model Function 1 releases the path H1-H2 in position 0 and H1-H3 in position 1, the model Function 2 releases the path H1-H2 in position 1 and H1-H3 in position 0. During the simulation, there is an animation of the directional valve switch setting.

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## Assumptions and Limitations

Top

## Mathematical Description

If CTRL > 0, then Valve is in Position 1.

If CTRL <= 0, then Valve is in Position 0.

Top

## Netlist Syntax

MODEL VW_32_1 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2 ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_32_2 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2 ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

Top

## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |
| H3 | Fluidic Pin | Fluidic terminal |

Top

## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| CTRL | Control Signal | real | 0 |

Top

## Example

In this example, the Direction Control Valve (3-2) Function 2 VW_32_21 switch at t = 1 s, and redirect the flow from RHYD1 to RHYD2. The schematic of the system is shown in Figure 2, system parameters are listed in Table 3, and the simulation results are shown in Figure 3.

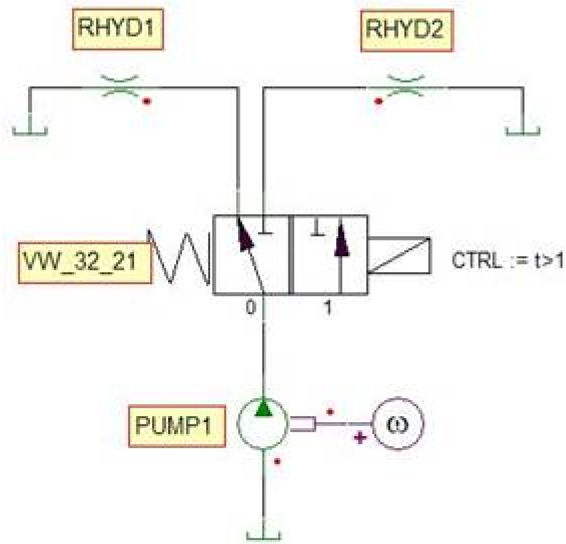
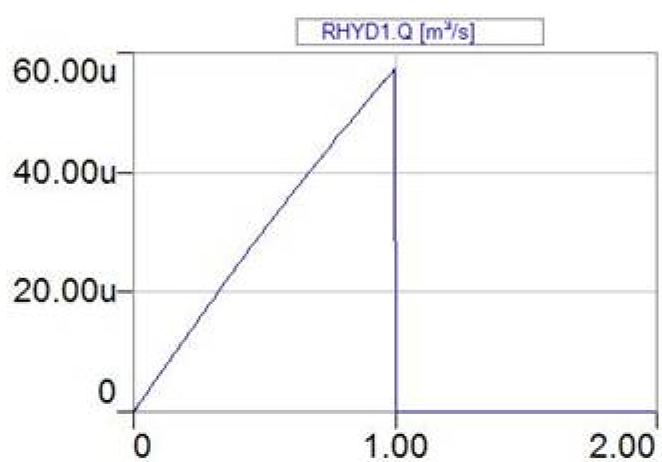



**Figure 2. Application example of the Direction Control Valve (3-2) Function 2 model**

**Table 3. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pump PUMP1 | VOLG | 2*PI*1u [$m^3$] |
| Angular Velocity Source V_ROT1 | VALUE | 2*PI*10*t [rad/s] |
| Directional Control Valve VW32_21 | CTRL | t > 1 s |
| RHYD1 | K | 5E-12 [$m^3$/(Pa s)] |
| RHYD2 | K | 5E-12 [$m^3$/(Pa s)] |



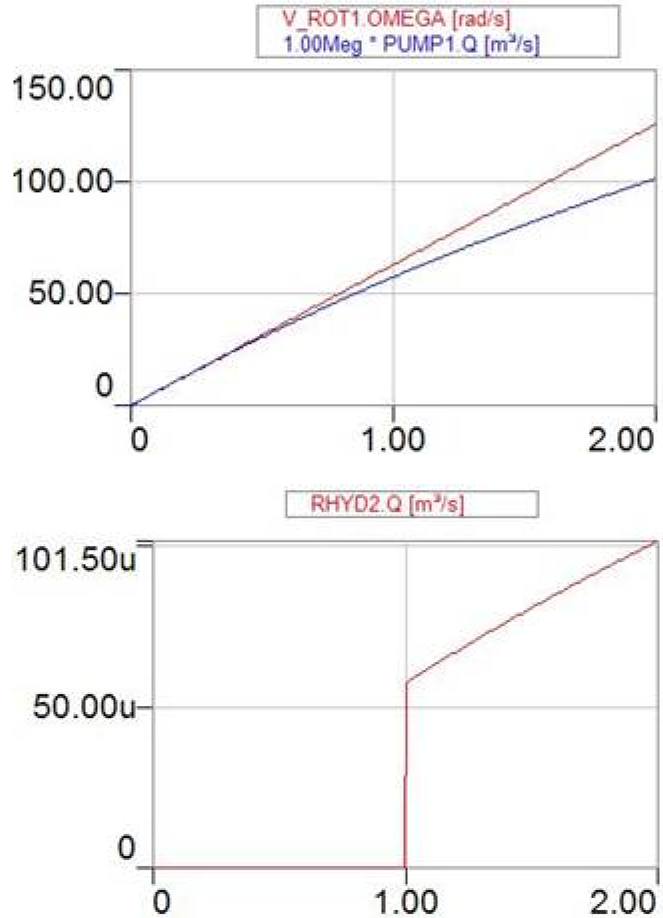



**Figure 3. Simulation results**

Top

## References

# Directional Control Valves, 4-2

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

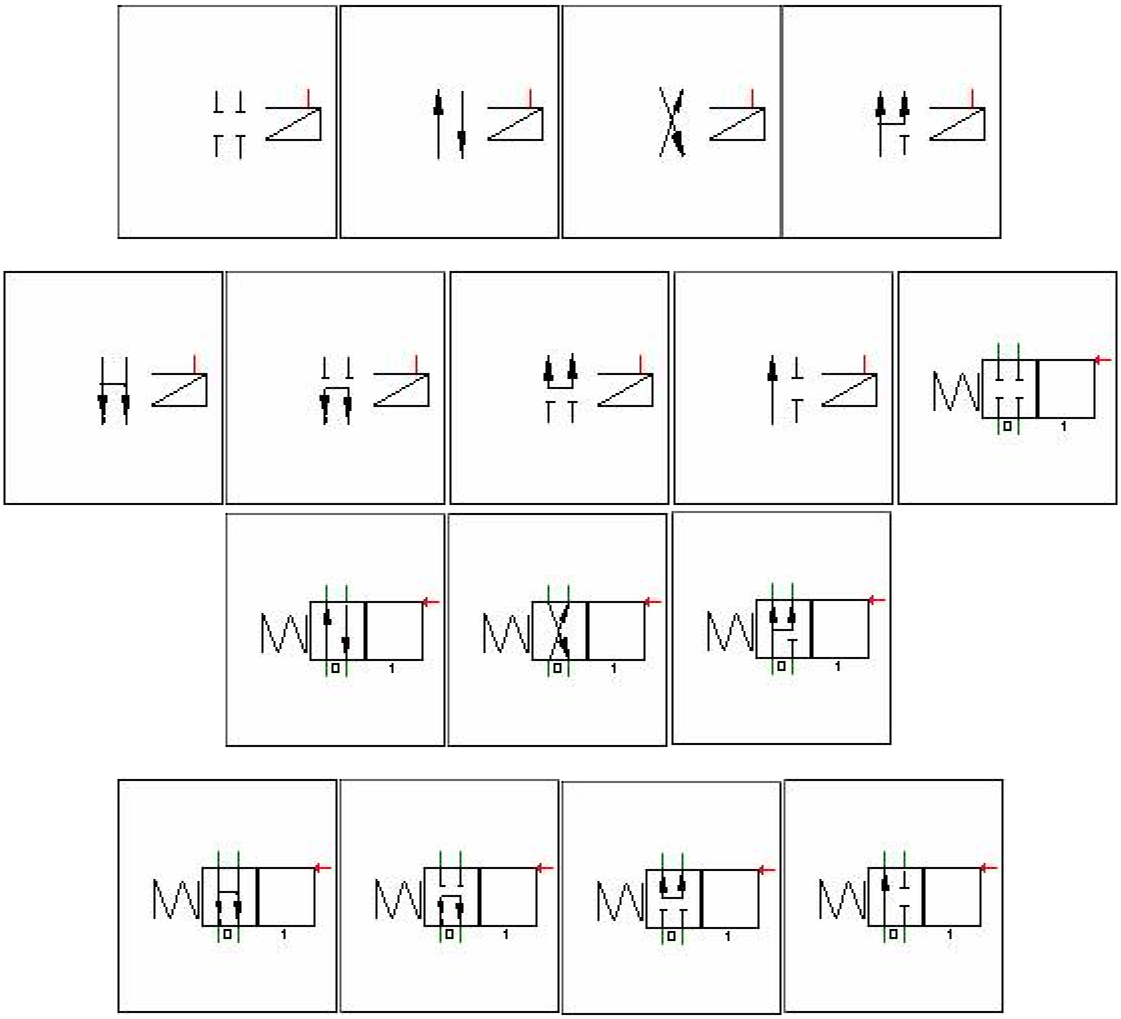


**Figure 1. Component symbols**

- Description
- Netlist Syntax
- Conservative Pins
- Parameters
- Input/Output Quantities
- Example
- References

## Description

The models represent ideal directional control valves that release or block paths for the oil flow. The 4-2 valve has four controlled connections and two switch settings. During simulation, there is an animation of the directional valve switch setting.

OFF Functions (Controlling Units)

The number of different channel connections in a switch setting is limited. The Hydraulic Library provides the 8 most important channel connections, which are shown in the following figure in the valve idle setting (unpowered actuating unit).

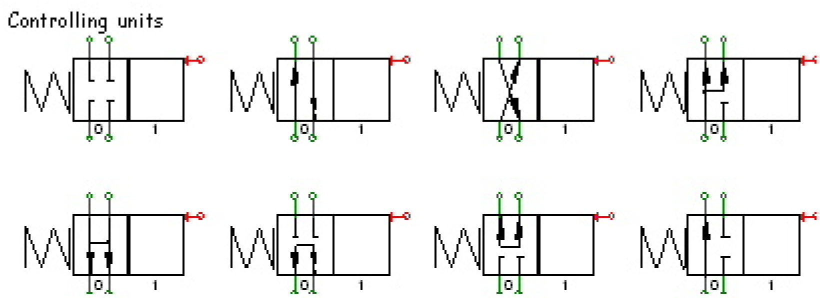



**Figure 2. Eight most important channel connections in the Hydraulic library**

ON Functions (Actuating Units)

The same channel connections exist for the working position of the valve (actuated actuating unit).

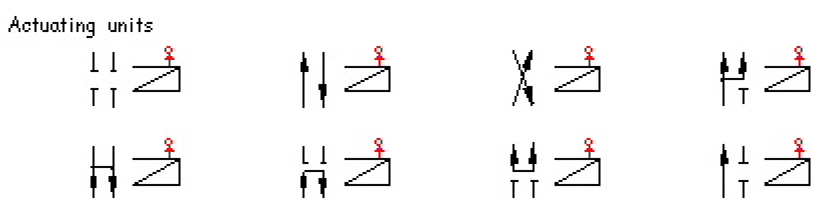



**Figure 3. Working positions of the valve**

Combination of Controlling and Actuating Units

All possible combinations of a controlling and an actuating unit leads to 112 different valves. One controlling and one actuating unit must be placed on the top of each other. The control signal CTRL is defined in the actuating unit (control signal ≤ 0 idle setting, control signal > 0 working setting). The set output value of the actuating unit must be connected with the set input value of the controlling unit (red pins).

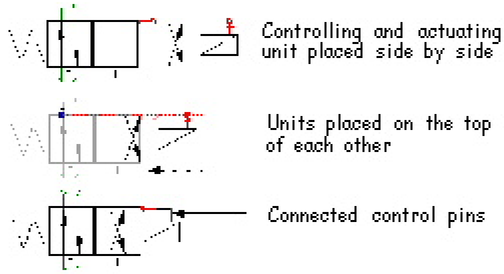



**Figure 4. Combinations of controlling and actuating units**

Valve Positions

During simulation, there is an animation of the directional valve switch setting. The idle and working position is displayed on the sheet depending on the control signal.

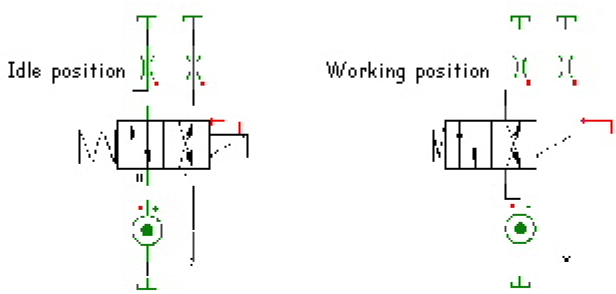



**Figure 5. Directional valve under working and idle conditions**

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## Netlist Syntax

MODEL VW_421_1 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_421_2 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_421_3 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_421_4 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_421_5 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_421_6 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_421_7 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_421_8 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) ( CTRL:= @CTRL) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_420_1 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( SET:= @SET) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_420_2 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( SET:= @SET) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_420_3 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( SET:= @SET) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_420_4 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( SET:= @SET) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_420_5 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( SET:= @SET) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_420_6 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( SET:= @SET) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_420_7 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( SET:= @SET) SRC: DB(Lib:=@ModelLibraryName) ;

MODEL VW_420_8 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( SET:= @SET) SRC: DB(Lib:=@ModelLibraryName) ;

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### Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |
| H3 | Fluidic Pin | Fluidic terminal |
| H4 | Fluidic Pin | Fluidic terminal |

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### Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|

| | | | |
|---|---|---|---|
| CTRL | Control Signal | real | 0 |

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## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| SET_ INPUT | Value of controlling unit to set position, (control signal 0 idle setting, control signal 0 working setting) | real |
| SET_ OUTPUT | Control signal of actuating unit to set position, (control signal 0 idle setting, control signal 0 working setting) | real |

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## Example

In this example, a constant pressure causes a constant flow in the laminar orifice RHYD1. After 1sec the valve switches and the the pressure is then provided to RHYD2, resulting in a flow through RHYD2. The blind plug is used to close the open hydraulic pin at the valve. The schematic of the system is shown in Figure 6, system parameters are listed in Table 3, and the simulation results are shown in Figure 7.

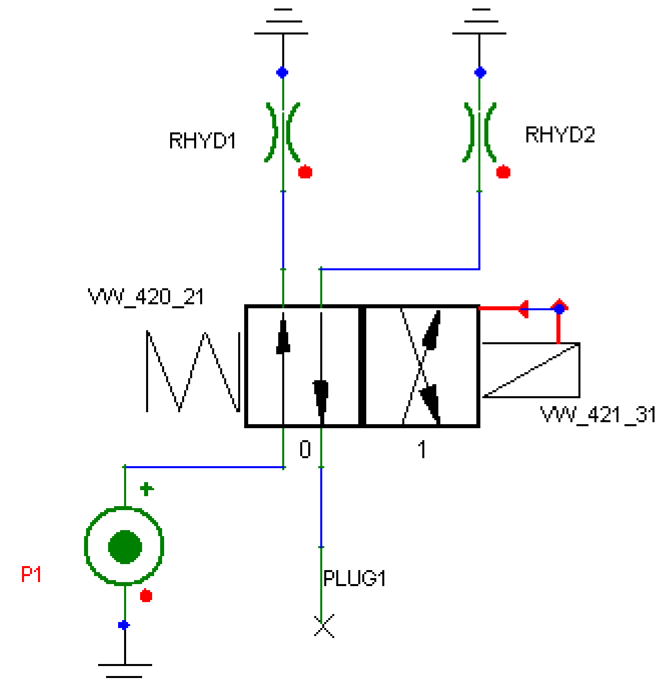
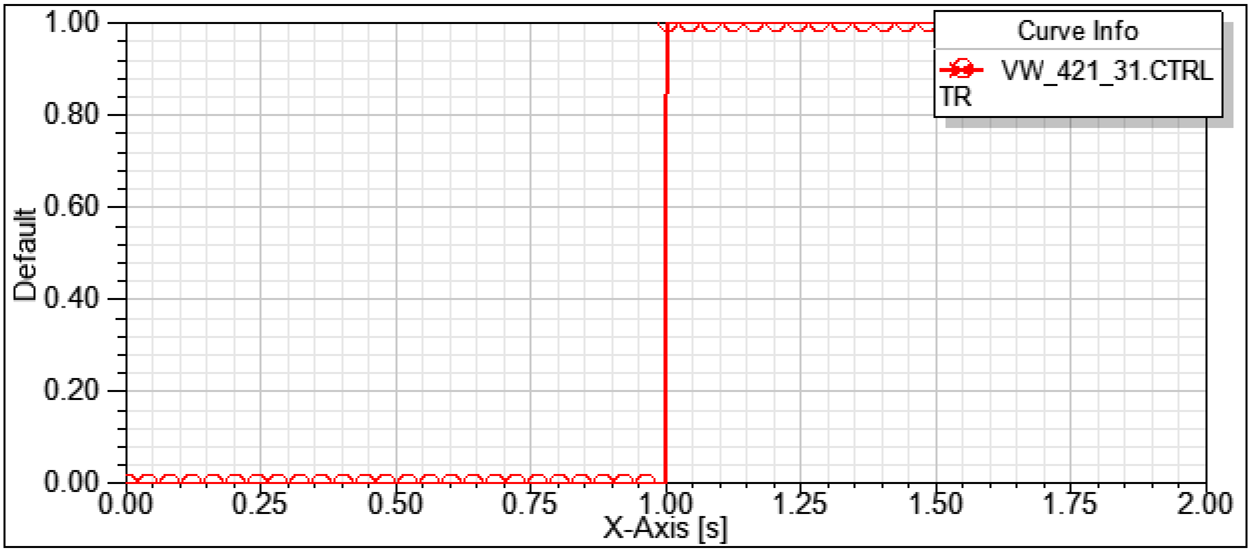



**Figure 6. Application example of the Directional Control Valve (4-2).**

**Table 3. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P1 | Amplitude | 1e+006 [Pa] |
| Linear Orifice RHYD1 | Hydraulic Conductance | 1e-009 [$m^3$/Pa] |
| | Differential Pressure | 0 [Pa] |
| | Flow Rate | 0 [$m^3$/s] |
| Linear Orifice RHYD2 | Hydraulic Conductance | 3e-009 [$m^3$/Pa] |
| | Differential Pressure | 0 [Pa] |
| | Flow Rate | 0 [$m^3$/s] |
| Directional Control Valve VW_420_21 | Value to set ON function (SET) | VW_421_31.SET |
| Directional Control Valve VW_421_31 | CTRL | time > 1s |
| | Value to set ON function(SET) | 0 |



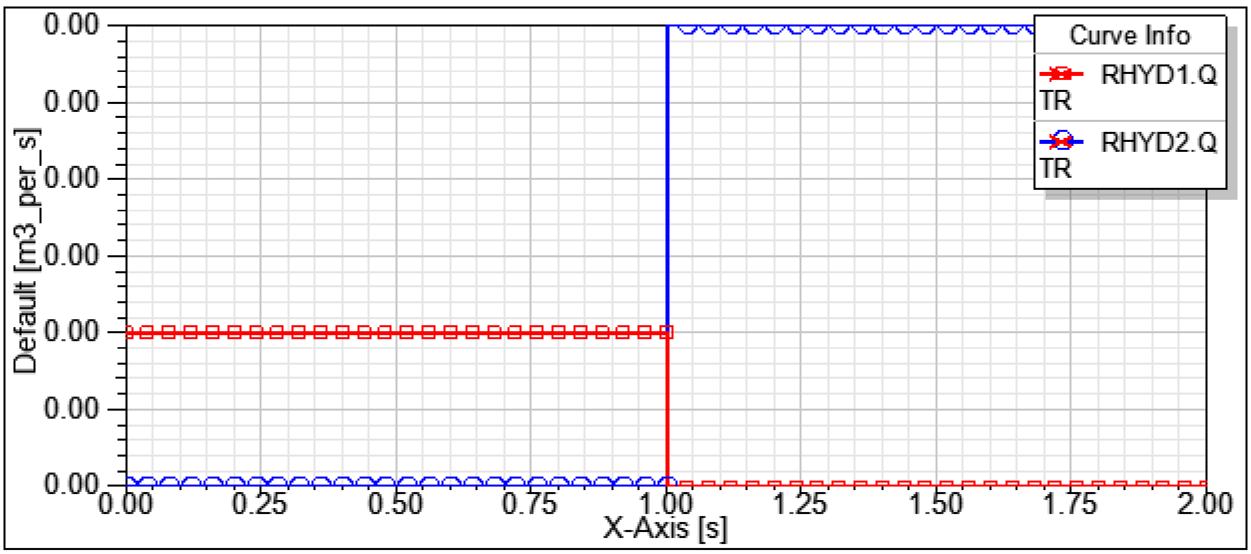




**Figure 7. Simulation results**

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## References

# Directional Control Valves, 4-3

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

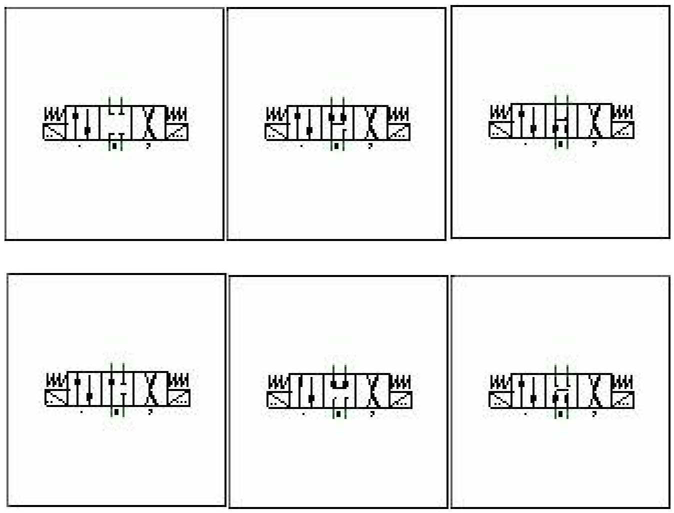

**Figure 1. Component symbol**

- Description
- Assumptions and Limitations
- Mathematical Description
- Netlist Syntax
- Conservative Pins
- Parameters
- Example
- References

## Description

The models represent ideal directional control valves that release or block paths for the oil flow. The 4-3 valve has four controlled connections and three switch settings. During simulation, there is an animation of the directional valve switch setting.

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## Assumptions and Limitations

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## Mathematical Description

If CTRL = 0, the actuating unit is not actuated. If CTRL = 1, the actuating unit is switched ON. If the switch setting is CTRL1=CTRL2=1, then an error message is displayed and the simulation is interrupted.

If CTRL1 <= 0 AND CTRL2 <= 0, then Valve is in Position 0.

If CTRL1 > 0 AND CTRL2 <= 0, then Valve is in Position 1.

If CTRL1 <= 0 AND CTRL2 > 0, then Valve is in Position 2.

If CTRL1 > 0 AND CTRL2 > 0, then Error.

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## Netlist Syntax

MODEL VW_43_1 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( CTRL1:= @CTRL1, CTRL2:= @CTRL2) SRC: DB(Lib:-:=@ModelLibraryName) ;

MODEL VW_43_2 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( CTRL1:= @CTRL1, CTRL2:= @CTRL2) SRC: DB(Lib:-:=@ModelLibraryName) ;

MODEL VW_43_3 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( CTRL1:= @CTRL1, CTRL2:= @CTRL2) SRC: DB(Lib:-:=@ModelLibraryName) ;

MODEL VW_43_4 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( CTRL1:= @CTRL1, CTRL2:= @CTRL2) SRC: DB(Lib:-:=@ModelLibraryName) ;

MODEL VW_43_5 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( CTRL1:= @CTRL1, CTRL2:= @CTRL2) SRC: DB(Lib:-:=@ModelLibraryName) ;

MODEL VW_43_6 ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1, H3:= %2, H4:= %3 ( CTRL1:= @CTRL1, CTRL2:= @CTRL2) SRC: DB(Lib:-:=@ModelLibraryName) ;

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

| | | |
|---|---|---|
| H3 | Fluidic Pin | Fluidic terminal |
| H4 | Fluidic Pin | Fluidic terminal |

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## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| CTRL1 | Control Signal 1 | real | 0 |
| CTRL2 | Control Signal 2 | real | 0 |

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## Example

In this example, the control signals CTRL1 and CTRL2 of Direction Control Valve (4-3) Function 1 VW_43_11 are decided by two predefined time function, illustrated as follows:

• 0s ≤ t ≤1s, the valve is in setting 0, there is no fluid flow through either RHYD1 or RHYD2;

• 1s ≤ t ≤2s, the valve is in setting 1, the Pressure Source P1 is connected to RHYD1, and P2 is connected to RHYD2;

• 2s ≤ t <3s, the valve is in setting 2, the Pressure Source P1 is connected to RHYD2, and P2 is connected to RHYD1;

• t = 3s, Error setting, simulation either aborts or uses previous setting.

The schematic of the system is shown in Figure 2, system parameters are listed in Table 3, and the simulation results are shown in Figure 3.

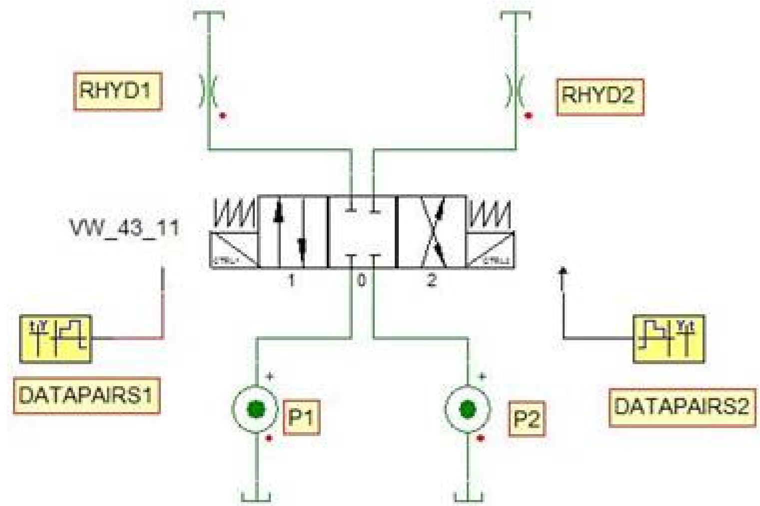
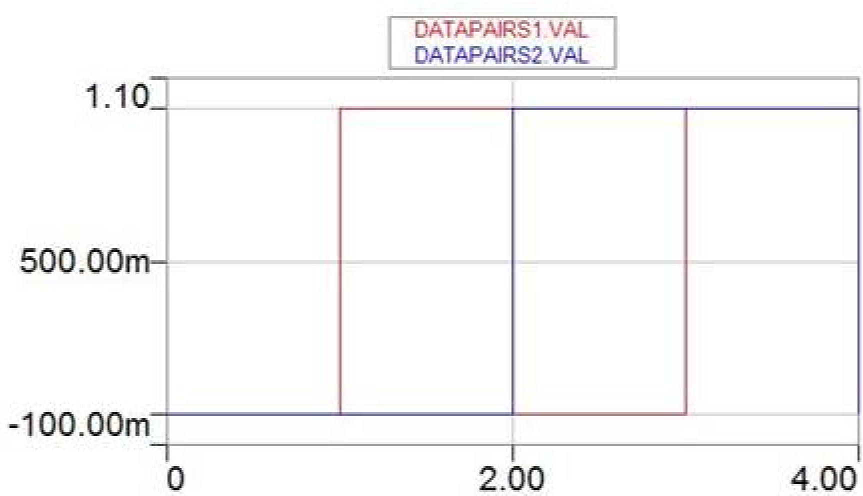



**Figure 2. Application example of the Direction Control Valve (4-3) Function1 model**

**Table 3. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P1 | VALUE | 1Meg [Pa] |
| Pressure Source P2 | VALUE | 0.5Meg [Pa] |
| VW43_11 | CTRL1 | DATAPAIRS1.VAL |
| | CTRL2 | DATAPAIRS2.VAL |
| RHYD1 | K | 1n [$m^3$/(Pa s)] |
| RHYD2 | K | 3n [$m^3$/(Pa s)] |



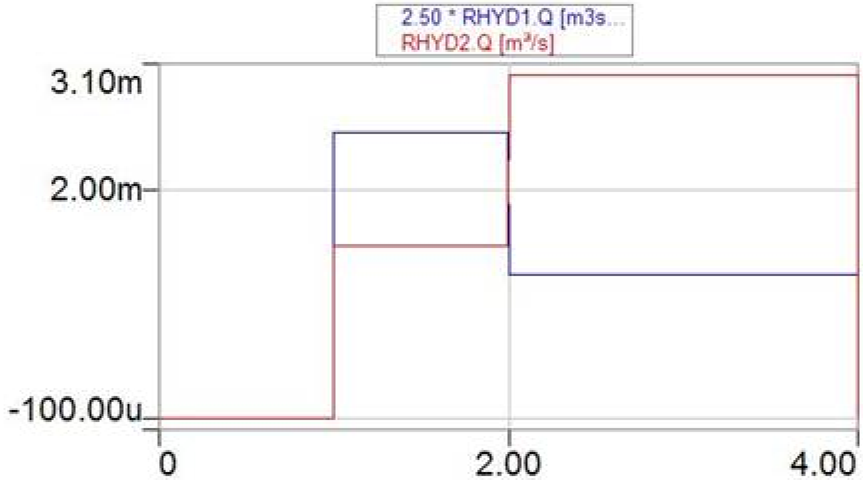



**Figure 3. Simulation results**

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## References

## Non-Return Valves

Non-Return Valves let the oil flow through in the flow-permitting direction and blocks it in the other direction (diode function). An opening pressure is required for flow to be permitted. This library contains the following model:

- Spring Loaded (VALVE_NR_SPR)

# Non-Return-Valve, Spring-Loaded

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
| --- | --- | --- |

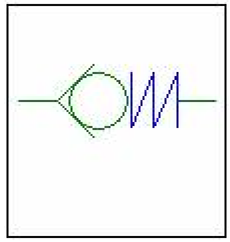

**Figure 1. Component symbol**



## Description

The Non-Return Valve lets the oil flow through in the flow-permitting direction and blocks it in the other (diode function). An opening pressure is required for flow to be permitted.

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## Assumptions and Limitations

Top

## Mathematical Description

$$\text{If} \quad P \geq POPEN \quad Q = \frac{P - POPEN}{SLOPE}$$

$$\text{If} \quad P < POPEN \quad Q = \frac{P}{10^{12}}$$

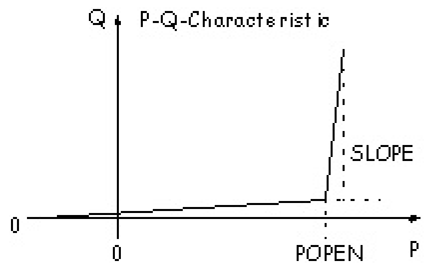


**Figure 2. P-Q Characteristic of the Spring Loaded model**

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## Netlist Syntax

MODEL VALVE_NR_SPR ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1 ( POPEN:= @POPEN, SLOPE:= @SLOPE) SRC: DB(Lib:=@ModelLibraryName) ;

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## Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

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## Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|
| SLOPE | Slope in Control Range | real | 0 [Pa/(m$^3$/s)] |

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## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| POPEN | Opening Pressure [Pa] | real |
| P | Differential Pressure [Pa] | real |

| | | |
|---|---|---|
| Q | Flow Rate [$m^3$/s] | real |

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## Example

In this example, when the Pressure output of the Pressure Source P1 reaches the predefined level POPEN, the Spring Loaded Valve VALVE_NR_SPR1 allows the flow in the outlet direction while blocks it in the other direction. The schematic of the system is shown in Figure 3, system parameters are listed in Table 4, and the simulation results are shown in Figure 4.

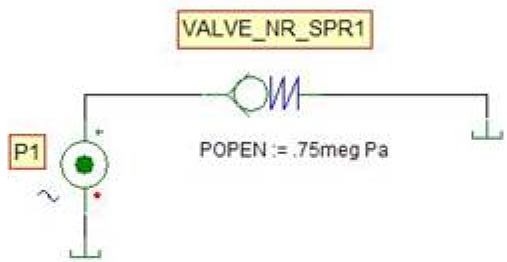
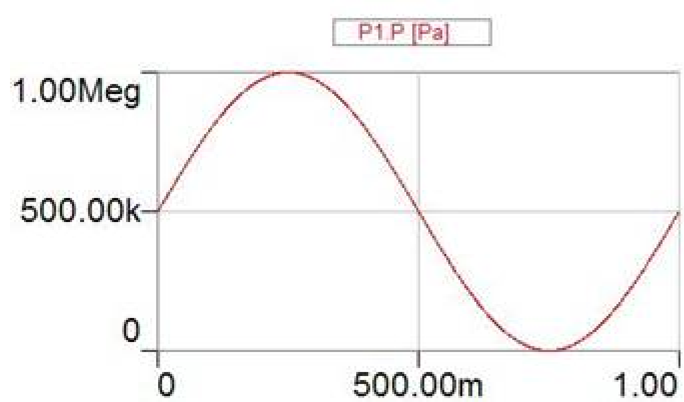



**Figure 3. Application example of the Spring LoadedValve model**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Pressure Source P1 (Time Controller_ Sine) | Amplitude | 500K [Pa] |
| | Frequency | 1 [Hz] |
| | Delay | 0 [s] |
| | Phase | 0 [Deg] |
| | Offset | 0.5Meg [Pa] |
| Spring-Loaded Valve VALVE_NR_ SPR1 | POPEN | 0.75Meg [Pa] |
| | SLOPE | 1G [Pa/ ($m^3$/s)] |



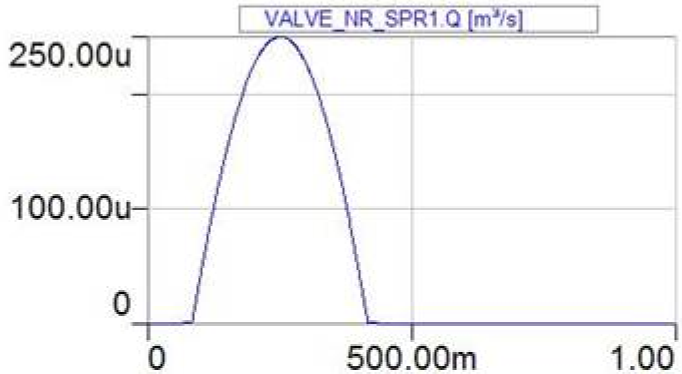



**Figure 4. Simulation results**

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## References

## Pressure Control Valves

Pressure Control Valves control the pressure in the valve inlet at the pressure set point. This library contains the following model:

- Pressure Relief (VALVE_REL)

# Pressure Relief Valve

| Library: Hydraulic | Modeling Language: SML | Version Number: Twin Builder 2025.2 |
|---|---|---|

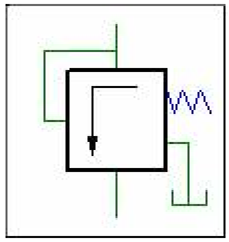

**Figure 1. Component symbol**



## Description

The Pressure Relief Valve controls the pressure in the valve inlet at the pressure set point *PSET* depending on the applied pressure *P*. The *SLOPE* is limited to 100m to avoid numerical instabilities.

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## Assumptions and Limitations

Top

## Mathematical Description

For control pressure $P < PSET$, the valve is closed. Any pressure is possible at the valve input.

For control pressure $P > PSET$, the valve opens with a steep opening characteristic, so that the input pressure falls to a very low value.

The valve is used, for example, in pressure supply equipment with constant delivery pump combinations for energy saving. Since the valve has no switching hysteresis, a hydraulic fluid reservoir is required in such circuits for stable working.

$$\text{If} \quad P \geq P_{LIMIT} \quad Q = \frac{P - P_{LIMIT}}{SLOPE}$$

$$\text{If} \quad P < P_{LIMIT} \quad Q = \frac{P}{10^{14}}$$

$$P_{LIMIT} \approx (PSET - P(H2)) \geq 0$$

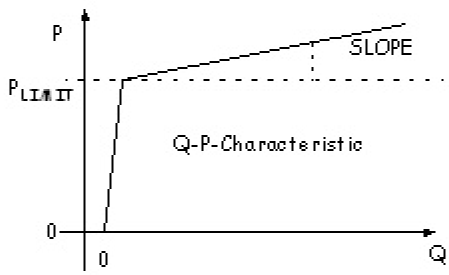


**Figure 2. Q-P characteristic of the Pressure Relieve Valve**

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### Netlist Syntax

MODEL VALVE_REL ?InstanceName(@InstanceName):(@(Refbase)@(ID)) H1:= %0, H2:= %1 ( PSET:= @PSET, SLOPE:= @SLOPE) SRC: DB(Lib:=@ModelLibraryName) ;

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### Conservative Pins

**Table 1**

| Name | Port/Terminal description | Nature/Data type |
|---|---|---|
| H1 | Fluidic Pin | Fluidic terminal |
| H2 | Fluidic Pin | Fluidic terminal |

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### Parameters

**Table 2**

| Name | Description | Data Type | Default Value [Unit] |
|---|---|---|---|

| | | | |
|---|---|---|---|
| SLOPE | Slope in Control Range | real | 0.5G [Pa/(m$^3$/s)] |

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## Input/Output Quantities

**Table 3**

| Name | Description | Data type |
|---|---|---|
| PSET | Set Pressure [Pa] | real |
| P | Differential Pressure [Pa] | real |
| Q | Flow Rate [m$^3$/s] | real |
| POWER | Power [W] | real |

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## Example

In this example, the flow output of the Flow Source Q1 increases linearly with time. When the pressure reaches the predefined level PSET, the valve VALVE_REL1 opens and the flow through the Orifice RHYD1 stays almost constant. The schematic of the system is shown in Figure 3, system parameters are listed in Table 4, and the simulation results are shown in Figure 4.

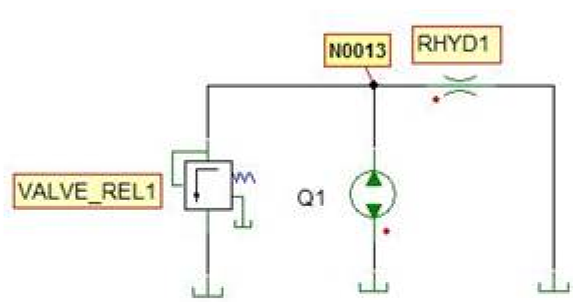


**Figure 3. Application example of the Pressure Relieve Valve model**

**Table 4. System Parameters**

| Component | Parameter | Value [unit] |
|---|---|---|
| Flow Source Q1 | VALUE | 30m*t [m$^3$/s] |
| Pressure Relieve Valve VALVE_REL1 | PSET | 1Meg [Pa] |
| | SLOPE | 1E6 [Pa/(m$^3$/s)] |
| RHYD1 | K | 10n [m$^3$/(Pa s)] |

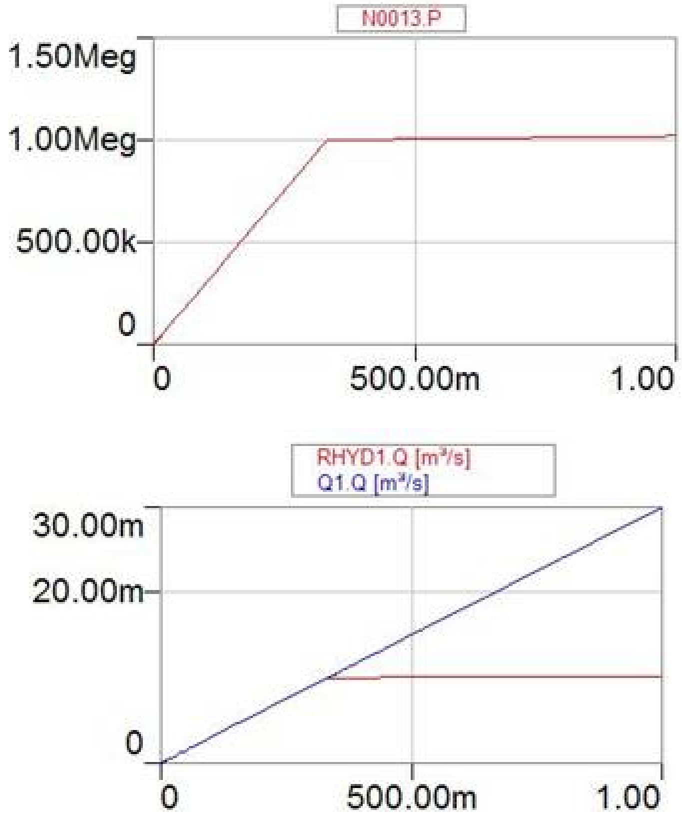


**Figure 4. Simulation result**

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## References

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